Egypt. J. Geo. **Vol. 65,** pp: 91-103 (2021)

Egyptian Journal of Geology
https://egjg.journals.ekb.eg

Field Features, Mineral assemblages and Geochemistry of Radioactive Pegmatite in the Wadi Abu Zawal Area, North Eastern Desert, Egypt

Abdel Hamid, Amr Abdel and **Abdel Hamid, Hicham Mahmoud**
Nuclear Materials Authority of Egypt

GRANITIC pegmatites of the Wadi Abu Zawal area, North Eastern Desert of Egypt, intruded the syn-tectonic granites, younger gabbros and post-orogenic granites. Two unzoned pegmatite masses are quarried for feldspars and quartz, which injected within the older granites. One of them shows high radioactivity related to formation of U-Th-REEs mineralization. The mineralization occurs at the margins of this pegmatite body in close proximity to contacts with the host older granite. Hydrothermal hematite, kaolinite and epidote are dominant along the contact zone. Petrographic observations showed that the mineralized parts are mainly albite-rich with minor quartz and muscovite. The hydrothermal mineral assemblage contains secondary uranium minerals (uranophane and kasolite), uranothorite and monazite-Ce. The mineralization occurs as stains or crystallizes in the microsfractures of the pegmatite. Whole-rock analytical data of albite-rich samples display high contents of Na_2O, CaO and Al_2O_3 with significant lower concentrations of SiO_2 and K_2O. The analyzed samples are enriched with U, Th, REEs, Zn, Pb, Sr and Ba. Detailed field, mineralogical and geochemical data have provided evidence that the investigated pegmatite has similar characters to other fractionated NYF-type pegmatites in the North Eastern Desert of Egypt.

Keywords: Wadi Abu Zawal, Pegmatites, Radioactivity, U-Th-REE mineralization, Uranophane.

Introduction

Many geologists are increasingly paying attention to granitic pegmatites since they are important sources of rare metals (London, 2008). Rare-element pegmatites are classified into LCT (rich in Li, Cs, and Ta), NYF (rich in Nb, Y and F), and mixed petrogenetic families (Ĉerny and Ecrit 2005). LCT family is suggested to be associated usually with I- or S-type granite derived from a sedimentary source in a late- or post-orogenic setting. The NYF family is suggested to be associated with A-type granite derived from a mixed source of lower crust.

In the Eastern Desert of Egypt, the granitoid rocks are the target for uranium exploration efforts by the Nuclear Materials Authority of Egypt (NMA). Granitic pegmatites were essentially hosted by such rocks. U-Th-REEs mineralization, found in these pegmatites, have been intensively exploited by many researchers (*e.g.* Ali 2007; Raslan and Ali 2011; Abu Steet, *et al*. 2018; Mahdy 2021).

In the Wadi Abu Zawal area, granitic pegmatites are common, which constitute a characteristic feature in this area. Some pegmatite exposures are mined for oversize feldspars and quartz. Two quarry pegmatite occurrences were selected for

Correponding author: Abdel Hamid, Amr Abdel, Email: amr_ahamid@yahoo.com
Accepted; 30/09/2021; Received; 07/11/2021
DOI: 10.21608/egjg.2021.98782.1004

ground radiometrical survey with reference to previous investigations on the Wadi Abu Zawal pegmatites (Asran et al. 2013; El Sundoly 2021). Extensive studies of radioactive zones in the quarry pegmatites are presented in this work. Detailed field, mineralogical and geochemical data are given with the aim to evaluate the radioactive zones and discussing their effect on the mined feldspars.

Geologic Setting

The Wadi Abu Zawal area occurs some 60 km west of Safaga city on the Red Sea coast and about 10km to the north of Safaga-Qena road, which located along the boundary between the northern and central Eastern Desert of Egypt (Fig. 1). The region around the Wadi Abu Zawal consists of highly sheared metavolcanics incorporated in a ductile shear zone and intruded by syn-tectonic (older) granites, post-tectonic gabbroic, and post-orogenic to anorogenic (younger) granitic intrusions (El-Gaby and Habib 1982). The rocks exposed in the Wadi Abu Zawal area comprise older granites of tonalite and granodiorite associations intruded by gabbroic and younger granitic rocks (Fig. 2). These rocks are dissected by a network of dikes of mafic and felsic composition as well as quartz veins, aplites and pegmatites.

The older granites are part of a huge mass extending around Qena-Safaga road and across the entire width between the North and Central Eastern Desert. It was the subject of many contributions (e.g., Habib 1987a; Habib 1987b; Masoud 1997; Abdel El-Wahed and Abu Anbar 2009). The intrusion age of these granitoids is 680–620 Ma (Fowler et al. 2006). The older granites of the study area are forming large masses of moderate relief and consist of heterogeneous bodies ranging from tonalite to granodiorite. They are medium- to coarse-grained and show variation in color from gray to grayish white or whitish pink. The older granites commonly possess marginal zones with well-developed planar foliation and occasionally enclose spheroidal mafic enclaves. They are highly sheared and jointed, and traversed by numerous dikes and veins (Fig. 3a). They are intruded by younger gabbros and younger granites through sharp and irregular contacts.

The younger gabbros form an elongate body trending NE-SW in the southern part of the mapped area. It is intruded within the older granites and forms separated masses in the northwestern part of the study area. This rock is rugged, of moderate to high topography with sharp summits. It is medium-grained, hard, and compact with black color. Swarms of gabbroic xenoliths are enclosed within the granitic intrusions. The xenoliths are angular, possess sharp boundaries and are highly dissected by granitic veinlets (Abu El-Ela 1996).

The post-tectonic younger granites, occurring in the Abu Zawal area, comprise monzogranite and syenogranite. They form the highest mountains with characteristic rugged peaks, fracturing and undeformed appearance. They are invading all the different rocks of the earlier formations; older granites and younger gabbros (Fig. 3b). The monzogranite is restricted to the western parts of the study area and extending over large area outside the mapped region. It is medium-to coarse-grained pink granite with characteristic porphyritic textures and occurrence of megacrysts of k-feldspar. Rb–Sr whole-rock dating of Gabal El-Urf monzogranite (south of the study region) yielded an age of 600 ± 11 Ma (Moghazi 1999). The syenogranite forms elongated bodies, extend in the NNE-SSW direction, bounded by or following major fault lines. It displays considerable textural and mineralogical variations, compared to the monzogranite. It is medium- to coarse-grained and display red color. It is characterized by high abundances of K-feldspar and quartz with minor biotite and hornblend (Moghazi 1999).

Field features of pegmatites

Granitic pegmatites, aplites and quartz veins cut all rock units within the Wadi Abu Zawal region, but appear to be more common in the older granites. It is a characteristic feature in the investigated area, where many pegmatitic dikes and veins are shown cutting the peripheries of the older granites. Their lengths vary from a few meters up to 100m and their widths from a few centimeters to a few meters. They appear usually as individual dike-like bodies or form planar lenses of variable dimensions concordant to the regional fabric. Most of the pegmatite dikes have NNE-SSW and NE-SW trends. They are also occurring as granitic pegmatite masses injected into the fractures of the older granites. Based on field observations, the pegmatites can be divided into zoned and unzoned pegmatites; the unzoned variety is common. The pegmatites are varying in grain size from coarse-grained to pegmatitic.

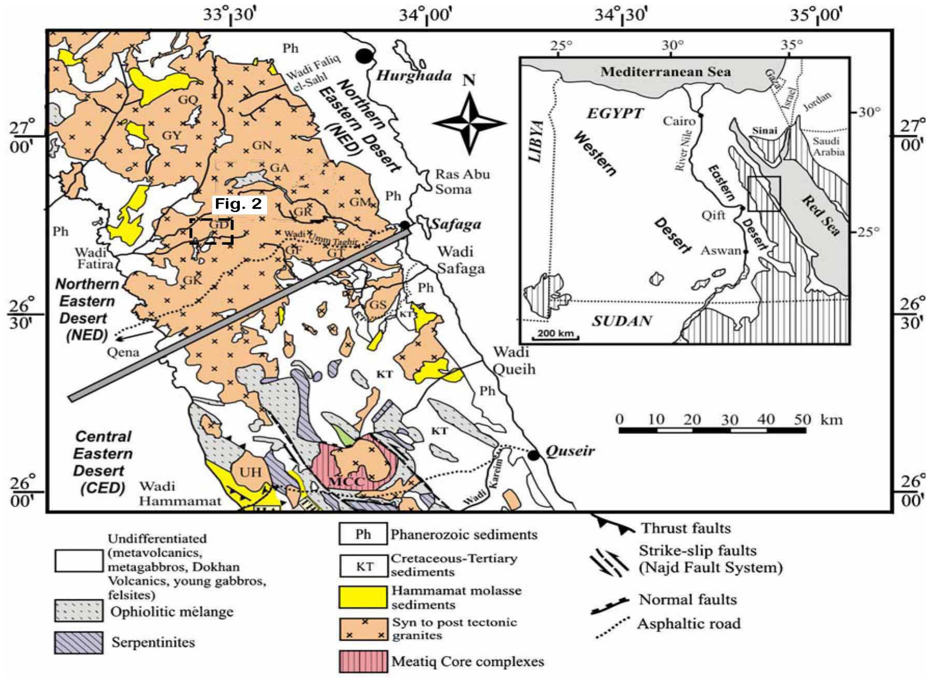

Fig. 1. Simplified geological map of the area around Qena-safaga road showing the location of the study area (after Abd El-Wahed and Abu Anbar 2009). The thick gray line is the Qena-Safaga line of El-Gaby (1994) and represents the approximate boundary between North and Central Eastern Desert.

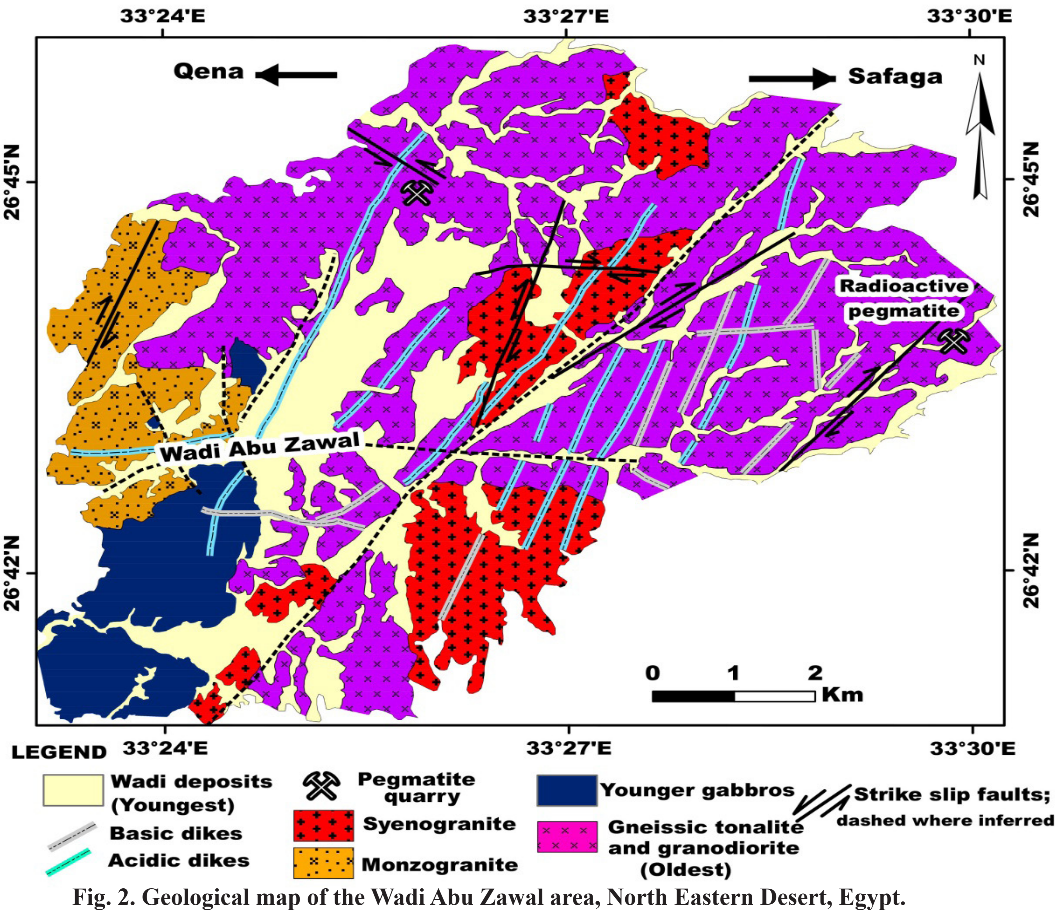

Fig. 2. Geological map of the Wadi Abu Zawal area, North Eastern Desert, Egypt.

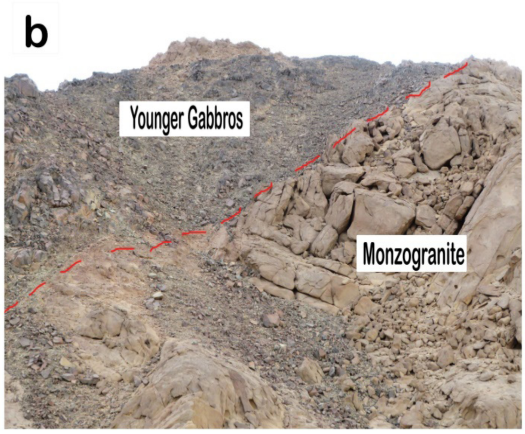

Fig. 3. (a) Older granites cut by felsic dike, (b) Younger gabbros intruded by monzogranite through sharp contact in the Wadi Abu Zawal area.

Two large pegmatite masses are mined for feldspars and quartz along the Wadi Abu Zawal. They occur as semicircular to oval-shaped bodies in the older granites, slightly oriented toward the NNE direction. These two bodies are unzoned and show internal differentiations for big crystals of feldspars, quartz and micas (Fig. 4a). One of these bodies is host to U, Th and REEs mineralization, which shows different shapes of hydrothermal alterations, especially along its contacts with the older granites (Fig. 4b). Radioactivity measurements in the field indicated erratic variations of U and Th within a distance of about 1m across some contacts between this body and its surrounding older granite. The mineralized zones are dominantly less than 1m long and less than 0.5m width. They are invariably fractured and overprinted by a moderate to strong hematite, kaolinite and epidote. The alterations occur as fracture-fillings through to pervasive in highly altered zones. Secondary uranium minerals of bright yellow color are visibly stains the rock surfaces of the pegmatite (Fig. 4c). Other radioactive minerals of dark color were also recorded in the mineralized zones of the pegmatite. They crystallize in fractures as thin linings and surrounded by halo of alterations, especially hematite (Fig. 4d). Northwest-trending fractures that cross-cut the pegmatite and the host rock are mineralized, which gives an indication of localized U–Th remobilization.

Methods

Gamma-ray ground measurements were collected within the radioactive pegmatite and its boundaries. A portable gamma ray scintillometer detector, model RS-230, that measures the total gamma activity (cps), U (ppm), Th (ppm) and K (ppm) was used. Representative samples were collected from the highly radioactive areas in the pegmatite and from the surrounding older granite. Thin sections were prepared to identify the main rock-forming minerals and their textures. Accessory minerals, especially U-, Th- and REE-bearing phases, were identified by using an Environmental Scanning Electron Microscope (ESEM) model Philips XL 30, attached with energy dispersive X-ray spectra (EDX) microanalyzer at an operating voltage of 25 KV, 1-2mm diameter, 60-120 second counting time and high resolution backscattered electron images (BSE) at the NMA. Six pegmatite samples were analyzed at the ACME Analytical Laboratory, Vancouver, BC. Major-oxide with rare-earth and refractory elements were determined using a lithium metaborate fusion and nitric acid digestion of a >0.5 g sample prior to ICP-MS analyses. A separate >0.5 g sample was split and digested in an Aqua Regia, and analyzed by ICP-MS.

Results and Discussions

Petrography and mineralogy of radioactive pegmatite

Thin sections from the older granite near the mineralized and altered parts of radioactive pegmatite were examined. The older granite is gneissic tonalite. It is medium-grained and consists of subhedral plagioclase, anhedral quartz, and acicular to prismatic green hornblende and biotite with minor amounts of iron oxides, apatite, chlorite and sphene (Fig. 5a,b).

The mineralized parts of the studied pegmatite are albite-rich with minor quartz and muscovite. Albite occurs as euhedral to anhedral prismatic crystals characterized by lamellar twinning. Some albite crystals have bent and broken twin planes (Fig. 5c). Muscovite occurs as inclusions within the feldspars or as aggregates around them. It is associated with hematite, chlorite, and epidote. Micas of secondary origin are filling the micro-fractures of the albite crystals (Fig. 5d). Radioactive pegmatite is fractured and contains brightly coloured radioactive materials. Thin section examinations of the stained fractures and of mineral interstices indicated that U-, Th- and REEs-bearing minerals are primarily occur as fracture-fillings and in the cracks of plagioclase (Fig. 5e,f).

Mineralogical studies of the secondary uranium minerals confirm the existence of uranophane $[Ca(UO_2)_2SiO_3(OH)_2 \cdot \circ H_2O]$ and kasolite $[Pb(UO_2)(SiO_4).H_2O]$. Uranophane is present as massive, radiated or tufted aggregates. The crystals display poorly developed faces. The grains are very soft with pale yellow colors. Some grains are stained with hematite and become brownish in color. The BSE images display that it has a tabular crystals with radial fibrous aspect (Fig. 6a). The EDX analysis confirmed the structural formula of this mineral with essential elements U, Si and Ca.

Kasolite is characterized by its bright colors (canary lemon, yellow and brown of different intensities). Compared to other secondary uranium minerals, kasolite grains are relatively harder. In the studied samples, kasolite occurs as massive grains (Fig. 6b). The grains are characterized by their waxy or greasy luster. The EDX analysis of kasolite shows that U and Pb occur as principle elements with considerable amount of Si and K.

Th-orthosilicate minerals represented by uranothorite are widespread in the mineralized samples. Uranothorite appears as aggregates with monazite-Ce and magnetite. Crystals are found as subhedral tabular crystals and scarce well-formed crystals with brown to deep red colours. Its components is highly variable, with U up to 10 wt.% and Th down to 72 wt.% (Fig. 6c).

Monazite-Ce is identified in the mineralized samples and forms the main carrier of REEs in the pegmatites of the Wadi Abu Zawal area. The grains are subhedral tabular crystals with honey yellow color. The EDX data shows that the studied grains are rich with Ce as LREE while U and Th present in appreciable amounts (Fig. 6c).

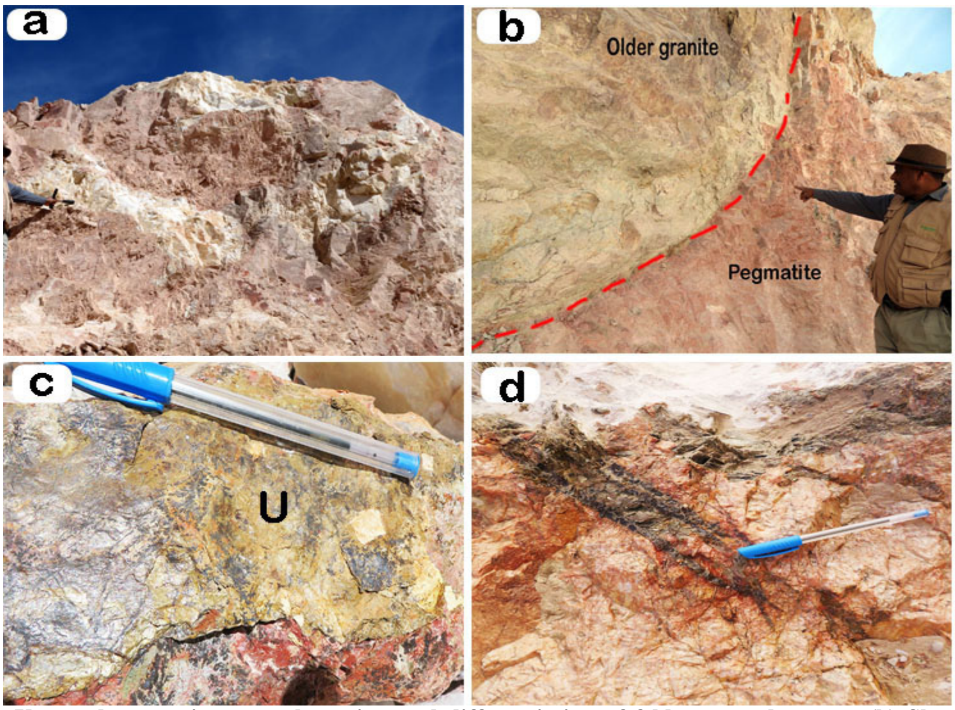

Fig. 4. (a) Unzoned pegmatite mass shows internal differentiation of feldspars and quartz, (b) Sharp contact between radioactive pegmatite and older granite showing different shapes of wall-rock alterations, (c) Bright yellow secondary uranium minerals staining the rock surface of the pegmatite, (d) Fracture-filling dark radioactive minerals in the pegmatite.

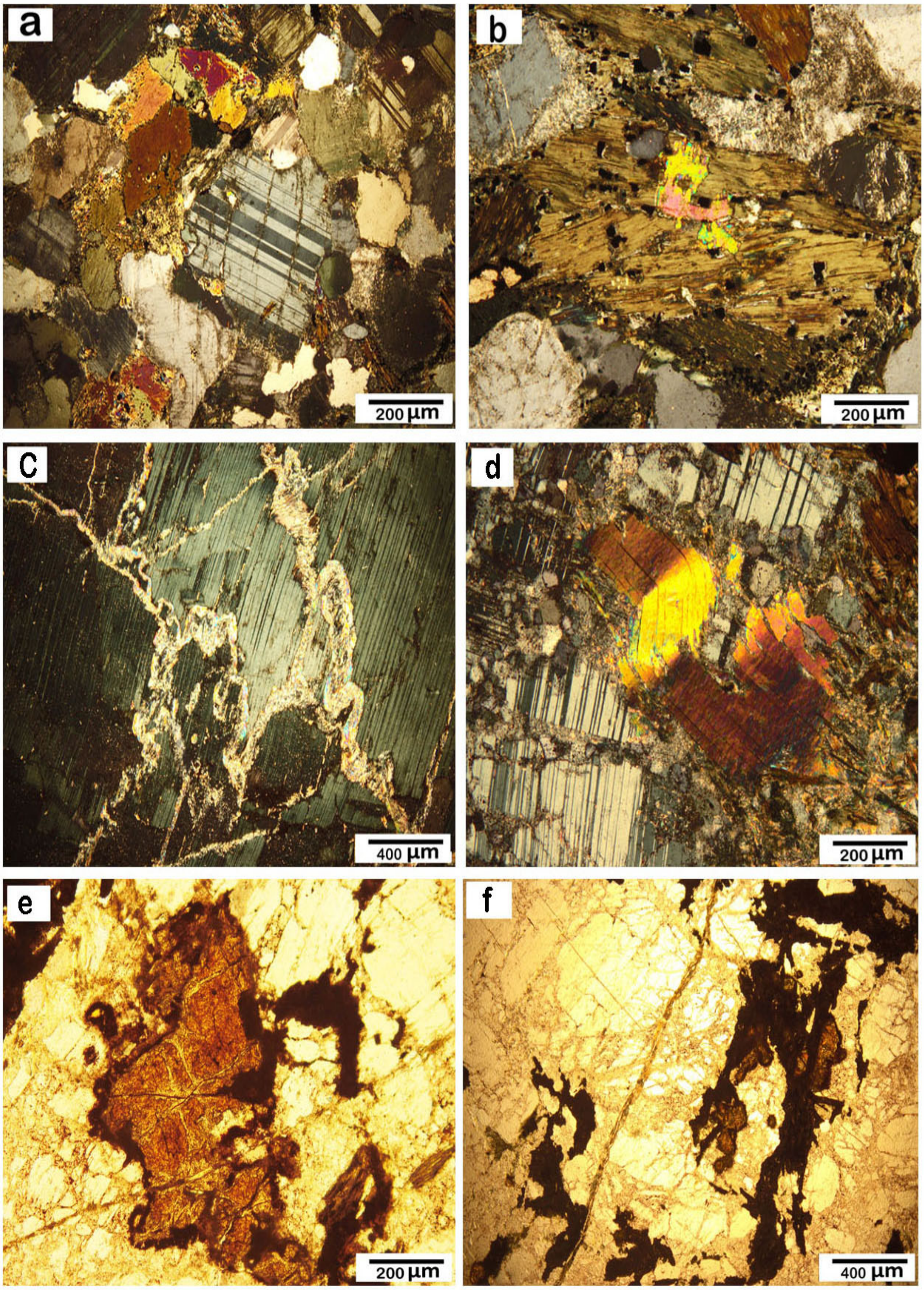

Fig. 5. Textural pattern of gneissic tonalite and mineralized pegmatite; (a) Gneissic tonalite consisting of subhedral plagioclase, hornblende and minor quartz, C. N., (b) Secondary hornblende replacing biotite encloses apatite and epidote, C. N., (c) Secondary micas crystallized in the cracks of plagioclase in mineralized pegmatite, C. N., (d) Plagioclase and muscovite crystals have bent and broken in mineralized pegmatite, thus providing evidences of several episodes of fracturing, C. N., and (e), (f) Uranium minerals filling the microfractures and cracks of plagioclase in mineralized pegmatite , P. L.

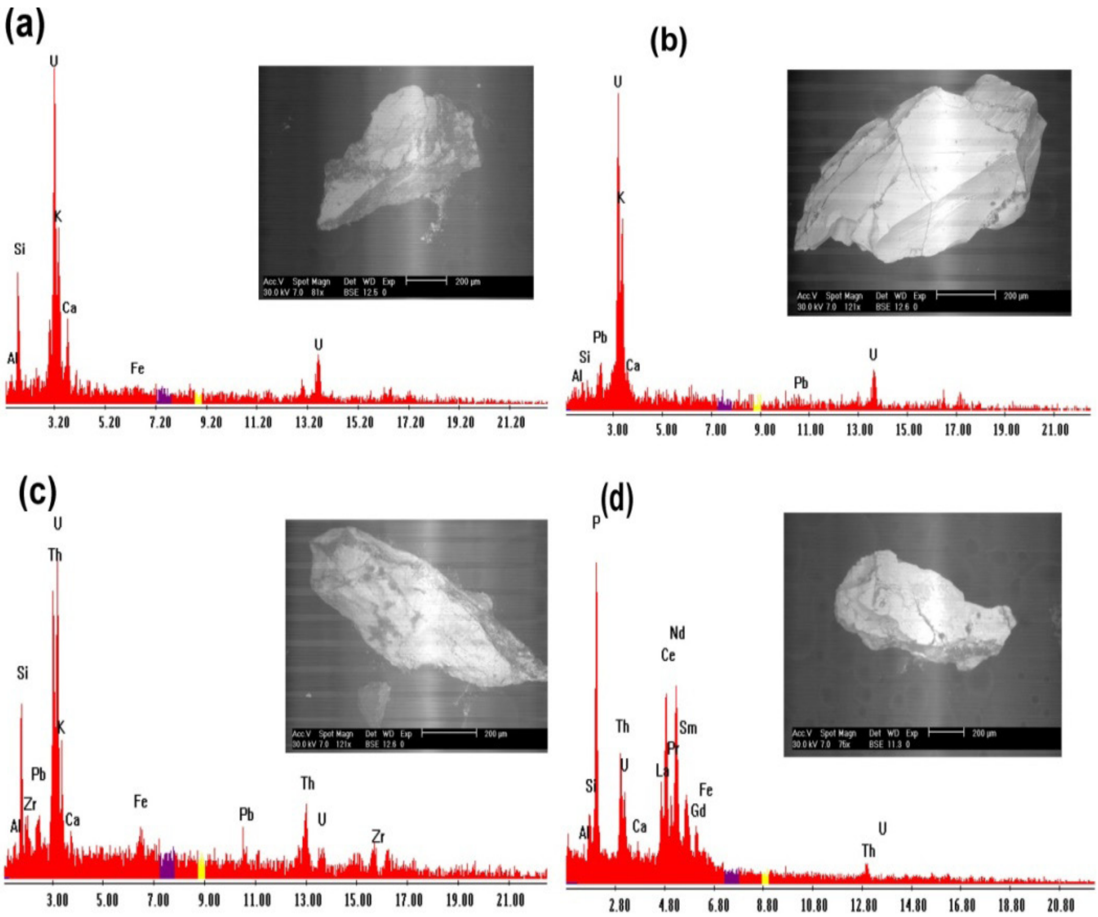

Fig. 6. Identification of U-, Th- and REEs-bearing minerals by Scan Electron Microscope; BSE image and EDX spectrum of (a) Uranophane, (b) Kasolite (Fe), (c) Uranothorite, and (d) Monazite-Ce.

Geochemistry of radioactive pegmatite

Six samples representing the mineralized parts of the radioactive pegmatite in the Wadi Abu Zawal area were analyzed quantitatively for U, Th, major constituents and trace elements (Table 1). The hydrothermal alterations and mineralization of the albite-rich parts of the pegmatite are recorded within the whole rock data. The occurrence of albite was documented by higher values of Na_2O (av.=7.05%) and CaO (av.=5.76%) and lower concentrations of K_2O (av.=1.65%). The average of Al_2O_3 contents is 15.22% along the analyzed samples. Fe_2O_3t displays relatively high contents (av.=3.42%), especially in the hematitized samples while Mg shows lower concentrations (Table 1).

Generally, the trace element data are more variable, mainly owing to their heterogeneous distribution. Primitive mantle normalized plot (McDonough and Sun 1995) of the studied pegmatite samples is shown in Figure (7). The elements Ba, Sr, Pb, Zn, Th and U have high concentrations, while Rb and Zr show lower contents (Table 1). The average of Nb/Ta ratios of the radioactive pegmatite is 3.05, which is extremely lower than the average ratio of primitive-mantle melts 17.5 ± 2 (Hofmann et al. 1986; Green 1995). Such decreasing in Nb/Ta ratios is typical of NYF granitic pegmatites and may indicate a high activity of F, promoting the fractionation of Nb and Ta (Černý et al. 1986; Černý 1991).

The REEs abundance of albite-rich mineralized pegmatite from the study area is presented in Table (2). The ΣREEs show high concentrations, which varying between 176ppm and 488ppm (Table 2). The chondrite-normalized REEs pattern (Anders and Grevesse 1989) is characterized by strong negative Eu anomaly and slightly positive Ce anomaly with enrichment trend from LREEs to MREEs and HREEs (Fig. 8).

TABLE 1.Major oxides (wt. %) and trace elements (ppm) analyses with some parameters and ratios of the albite-rich mineralized pegmatite of the Wadi Abu Zawal area.

Elements	Albite-rich mineralized pegmatite						Average
	Pg-M1	Pg-M2	Pg-M3	Pg-M4	Pg-M5	Pg-M6	
Major oxides (wt. %)							
SiO_2	64.21	67.19	61.79	63.45	65.72	66.45	64.8
TiO_2	0.52	0.09	0.05	0.15	0.07	0.18	0.18
Al_2O_3	15.39	15.14	16.4	14.58	15.2	14.59	15.22
Fe_2O_3t	3.81	2.84	3.22	5.69	1.5	3.44	3.42
MnO	0.04	0.08	0.07	0.05	0.04	0.07	0.06
MgO	0.35	0.29	0.61	0.21	0.47	0.58	0.42
CaO	5.89	5.61	7.14	5.19	6.31	4.39	5.76
Na_2O	6.49	6.35	8.71	6.64	8.23	5.89	7.05
K_2O	1.87	1.56	0.67	1.95	0.97	2.86	1.65
P_2O_5	0.05	0.03	0.40	0.05	0.27	0.08	0.15
L.O.I	1.32	0.84	1.18	1.63	1.21	1.41	
Trace elements (ppm)							
Ba	410	438	653	547	604	214	478
Rb	55	51	35	57	48	63	52
Sr	590	688	945	710	850	388	695
Ga	66	65	69	61	72	57	65
Ta	14	8	25	9	18	12	14
Nb	41	29	52	34	46	39	40
Hf	5.6	4.6	7.5	5.4	6.2	5.1	6
Zr	79	68	98	85	91	71	82
Y	38	36	45	40	41	36	39
Ni	1.3	2.1	2.5	1.8	1.3	1.5	1.75
Cr	6	6	8	5	6	5	6
Co	0.8	1.1	1.2	0.5	0.6	-	0.70
V	6	4	10	7	8	4	7
Cu	1	-	2	-	1	-	-
Pb	345	90	1270	65	648	120	423
Zn	566	320	2530	210	1050	290	828
Th	87	59	171	79	120	70	85
U	151	108	326	131	204	125	174
Nb/Ta	2.9	3.6	2.1	3.8	2.6	3.3	3.05
Th/U	0.58	0.55	0.52	0.60	0.59	0.78	0.60

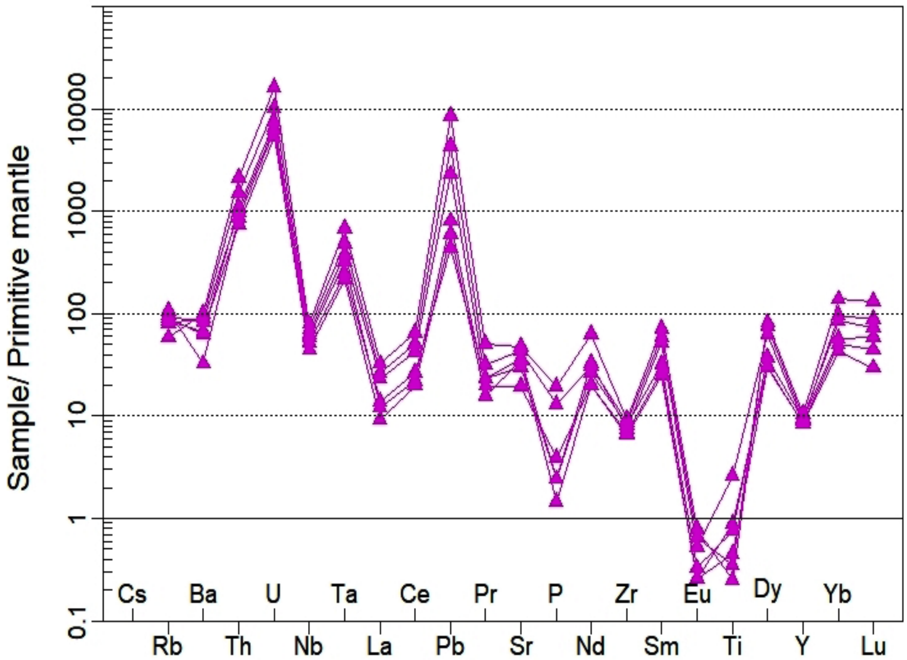

Fig. 7. Primitive-mantle normalized multi-element diagram (McDonough and Sun 1995) of the albite-rich mineralized pegmatite of the Wadi Abu Zawal area.

TABLE 2. REEs concentrations (ppm) of the albite-rich mineralized pegmatite in the Wadi Abu Zawal area.

Elements	Albite-rich radioactive pegmatite					
	Pg-M1	Pg-M2	Pg-M3	Pg-M4	Pg-M5	Pg-M6
La	15	6	21	9	17	8
Ce	71	33	108	44	85	37
Pr	6	4	13	6	8	5
Nd	41	25	78	33	38	25
Sm	21	10	29	13	24	11
Eu	0.08	0.04	0.12	0.05	0.1	0.04
Gd	27	12	46	15	35	14
Tb	6	3	7	4	7	5
Dy	42	20	55	25	51	21
Ho	7	4	12	7	8	5
Er	29	15	43	21	28	17
Tm	4	2	6	4	6	3
Yb	43	19	61	25	38	22
Lu	6	2	9	4	5	3
ΣREE	319	155	488	210	350	176

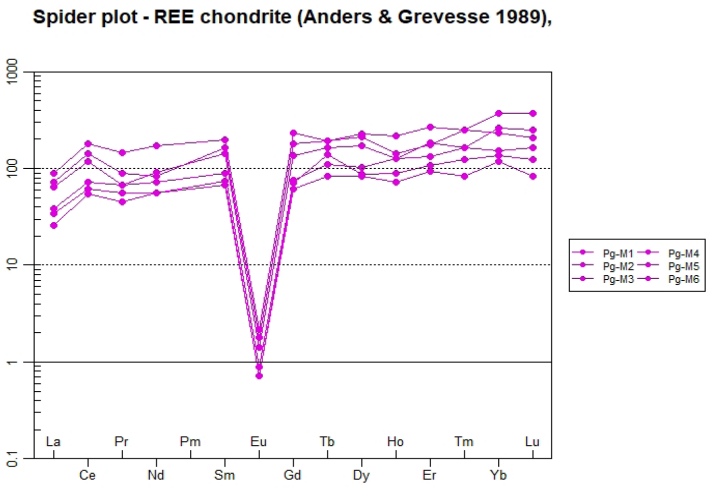

Fig. 8. Chondrite-normalized REEs pattern (Anders and Grevesse 1989) of the investigated radioactive pegmatite of the Wadi Abu Zawal area.

The U and Th contents have average of 174ppm and 85ppm, respectively (Table 1). The concentrations of U and Th in the individual mineralized sample are primarily depending on the abundances of U- and Th-bearing minerals such as uranophane, kasolite, uranothorite and monazite-Ce. The strong positive correlation between U and Th (Fig. 9a), indicated that these two elements are connected together in the mineralization processes and mainly incorporated in uranothorite. The average of Th/U ratio is 0.6 lower than suggested by Rogers and Adams (1969) for granitic rocks (3–4.5). The lower Th/U ratios indicate post-magmatic enrichment of U in the mineralized parts of the pegmatite. The analyzed samples display strong correlation between U-ΣREEs and Th-ΣREEs (Fig. 9c,d). The stronger link between Th, U and ΣREEs, is interpreted to the high abundance of monazite-Ce in some samples.

Discussions

In the Wadi Abu Zawal area, gamma-ray spectrometry proved that the contact (border) zones correspond to the greatest enrichment in U, Th and REEs. Detailed mineralogical and petrographical studies have provided further evidence that U-, Th-, and REEs-bearing minerals (uranophane, kasolite, uranothorite and monazite-Ce) are concentrated along the contact zone, similar to other fractionated NYF-type pegmatites (e.g. Shearer et al. 1992).The margins of the pegmatite bodies are areas that can concentrate volatiles, and therefore high concentrations of U, Th, and/or REEs, are located along the pegmatite-wall rock contact (Rogers et al. 1978).

Several examples from global pegmatites showed that the pegmatites rich in rare metals (U, Th and REEs) are associated with volatiles and/or fluids during late-stage, high temperature magmatic processes that assist in partitioning the elements (U, Th, REEs) out of the primary pegmatite zone and into the final residual fluids (Cerny et al. 1986; Stern et al. 1986; Simmons et al. 1987; Plant et al. 1999; Cuney and Kyser 2009). Metasomatic interaction between pegmatites and host rock has been the focus of many investigations that describe the processes in which host rock interactions enrich the pegmatite margins in U, Th, and REEs accessory phases (e.g., Williams, 1987; Owen 1989; Kretz et al. 1989; Lentz 1996).

The evaluation of the mineralized zones in the radioactive pegmatite of the Wadi Abu Zawal area and the compositions of samples is in agreement with moderate level of U-Th-REEs mineralization, which restricted only along the boundary of the pegmatite body. It is recommended that the mining of feldspars, from the Wadi Abu Zawal pegmatites, should be generally excavated away from the contact zone.

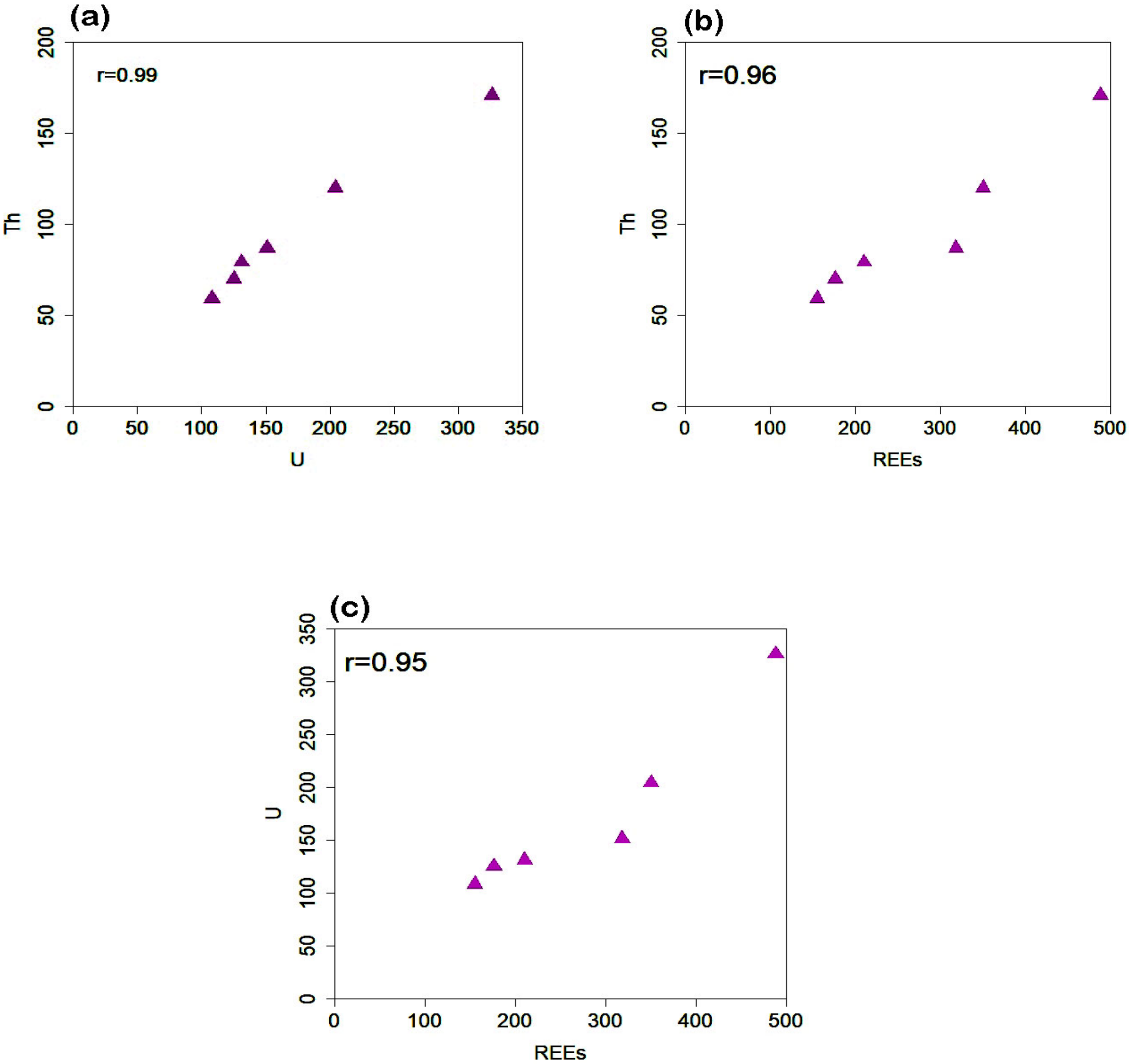

Fig. 9. Variation diagrams between (a) U and Th, (b) REEs-Th and (c) REEs-U for the studied radioactive pegmatite of the Wadi Abu Zawal area.

Conclusions

Field observations revealed that pegmatites of the Wadi Abu Zawal area, North Eastern Desert of Egypt, frequently occur as dikes, veins and large masses in mostly the gneissose older granites of tonalite to granodiorite composition. Some of these bodies are mined for feldspars and quartz. Two quarry pegmatite masses were chosen and surveyed radiometrically. One of them is radioactive and shows deposition of U, Th and REEs mineralization along its contacts with the host older granite. Hematite, kaolinite and epidote are dominantly pervasive along the contacts and in the mineralized zones. Petrographical studies indicated that the mineralized parts are composed essentially of plagioclase with minor quartz and muscovite. Thin section examinations revealed that the hydrothermal radioactive minerals crystallize in the microfractures and cracks of the plagioclase. The mineralogical studies confirmed that uranophane, kasolite, uranothorite and monazite-Ce are the main carriers of U, Th and REEs. The analyzed albite-rich samples exhibit high contents of U, Th, Zn, Pb and REEs which are the major mineralization indices for pegmatites in the Egyptian Basements. The evaluation of the mineralization in the present work indicated that the boundary of the quarry pegmatite is highly radioactive in some parts and the mining of feldspars should take place away from the contacts with the older rocks.

References

Abd El-Wahed, M.A. and Abu Anbar, M. (2009) Synoblique convergent and extensional deformation and metamorphism in the Neoproterozoic rocks along Wadi Fatira shear zone, Northern Eastern Desert, Egypt. *Arab J. Geosci.,* **2**: 29-52.

Abu El-Ela, F.F. (1996) The petrology of the Abu Zawal gabbroic intrusion, Eastern Desert, Egypt: an example of an island-arc setting. *J. Afric. Earth Scie.,* **22**: 147-157.

Abu Steet, A.A., El Sundoly, H.I. and Abdel Hamid, A.A. (2018) Rare elements distribution and mineralization potentiality of pegmatites in Gabal Abu Samyuk granite, north Eastern Desert. *Egypt J. Geol.,* **62**: 299-311.

Ali, B.A. (2007) Geochemistry of U-Th-REE bearing minerals, in radioactive pegmatite in Um Swassi-Dara area, north eastern desert, Egypt. *AEC Jordan,* **1**: 197-209.

Anders, E. and Grevesse, N. (1989) Abundances of the elements: meteoritic and solar. *Geochim. Cosmochim.,* **53**: 197-214.

Asran, A.M.H., El Mansi, M.M., Ibrahim, M.E. and Abdel Ghani, I.M. (2013) Pegmatites of Gabal El Urf, Central Eastern Desert, Egypt. The 7th international conference of the geology of Africa, P-P IV-1 – IV-22, Assuit, Egypt.

Černý, P. (1991) Rare-element granitic pegmatites. 1. Anatomy and internal evolution of pegmatite deposits. *Geoscience Canada,* **18**: 49-67.

Černý, P. and Ercit, T.S. (2005) The classification of granitic pegmatites revisited. *Canad. Mineral.,* **43**, 2005–2026.

Černý, P., Goad, B.E., Hawthorne, F.C. and Chapman, R. (1986) Fractionation trends of the Nb and Ta-bearing oxide minerals in the Greer Lake pegmatitic granite and its pegmatite aureole, southeastern Manitoba. *Am. Mineral.,* **71**, 501-517.

Cuney, M. and Kyser, K. (2009) Recent and not-so-recent developments in uranium deposits and implications for exploration. *Mineral. Assoc. Canada, Short Course Series,* **39**, 272p.

El Sundoly, H.I. (2021) Impact of tectonic factors on the emplacement of the radioactive mineralized pegmatites of Wadi Abu Zawal area, North Eastern Desert, Egypt. *Curr. Sci. Int.,* **10**, 178-199.

El-Gaby, S. (1994) Geology and tectonic framework of the Pan-African orogenic belt in Egypt. Proceedings of the 2nd International Conference on the Geology of the Arab World, Cairo University, **2**, pp. 3–17.

El-Gaby, S., Habib, M.S. (1982) Geology of the area southwest of Port Safaga, with special emphasis on the granitic rocks, Eastern Desert, Egypt. *Ann. Geol. Surv. Egypt,* **XII**: 47-71.

Fowler, A., Ali K., Omar, S.M. and Eliwa, H.A. (2006) The significance of gneissic rocks and synmagmatic extensional ductile shear zones of the Barud area for the tectonics of the North Eastern Desert, Egypt. *J. Afr. Earth Sci.,* **46**: 201-220.

Green, T.H. (1995) Significance of Nb-Ta as an indicator of geochemical processes in the crust–mantle system, *Chem, Geol.,* **120**: 347-359.

Habib, M.E. (1987a) Arc ophiolites in the Pan-African basement between Meatiq and Abu Furad, Eastern Desert, Egypt, *Bull. Fac. Sci. Assiut Univ.,* ***16***: 241-283.

Habib, M.F. (1987b) Microplate accretion model for the Pan-African basement between Qena–Safaga and Qift-Quseir roads, Egypt. *Bull. Fac. Sci. Assiut Univ.,* **16**: 199-239.

Hofmann, A.W., Jochum, K.P., Seufert, M. and White, W.M. (1986) Nb and Pb in oceanic basalts: new constraints on mantle evolution. *Earth Planet. Sci.,* **79**, 33-45.

Kretz, R., Hartree, R. and Jones, P. (1989) Metasomatic crystallization of muscovite in granite and tourmaline in schist related to pegmatite emplacement near Yellowknife, Canada. *Contrib. Mineral. Petrol.,* **102**: 191-204.

Lentz, D. (1996) U, Mo, and REE mineralization in late-tectonic granitic pegmatites, southwestern Grenville Province. *Ore Geol. Rev.,* **11**, 197-227.

London, D. (2008) Pegmatites. The Canadian Mineralogist, Special Publication, **10**, 347p.

Mahdy, N.M. (2021) Textural and chemical characteristics of zircon, monazite, and thorite, Wadi Al-Baroud area, Eastern Desert of Egypt: Implication for rare metal pegmatite genesis. *Ore Geol. Rev.* https://doi.org/10.1016/j.oregeorev.2021.104225.

Masoud, A.A. (1997) Geology and tectonic evolution of the area around Gabal Abu Furad, Northern Eastern Desert of Egypt. M.Sc. Thesis, Tanta University, p88.

McDonough, W. F. and Sun, S. (1995) The composition of the Earth, *Chem. Geol.,* **120**, 223-253.

Moghazi, A.M. (1999) Magma source and evolution of the late Neoproterozoic granitoids in the Gabal El Urf area, Eastern Desert, Egypt: geochemical and Sr–Nd isotopic constraints, *Geol. Mag.,* **136**: 285-300.

Owen, J.V. (1989) Metasomatically altered amphibolite inclusions in zoned granitic tonalitic pegmatite near Chicoutimi, Quebec. *Can. Mineral.,* **27**: 315-321.

Plant, J.A., Simpson, P.R., Smith, B. and Windley, B.F. (1999) Uranium Ore Deposits-Products of the Radioactive Earth. In: Burns, P.C. and Finch, R., Eds., Uranium: Mineralogy, Geochemistry and the Environment. Reviews in Mineralogy, **38**, *Mineralogical Society of America*, pp: 255-319.

Raslan, M.F. and Ali, M.A. (2011) Mineralogy and mineral chemistry of rare-metal pegmatites at Abu Rusheid granitic gneisses, South Eastern Desert, Egypt. *Geologija*, **54**: 205-222.

Rogers, J.J.W. and Adams, J.A.S. (1969) Uranium and Thorium, In: Wedepohl, K.H., Ed., Handbook of Geochemistry, **113**, Springer, Berlin, 92-B-1 to 92-0-8 and 90-Bb-1 to 90-00-5.

Rogers, J.J.W., Ragland, P.C., Nishimori, R.K., Greenberg, J.K. and Hauck, S.A. (1978) Varieties of granitic uranium deposits and favorable exploration areas in the Eastern United States, *Econ. Geol.,* **73**, 1539-1555.

Shearer, C.K., Papike, J.J. and Jolliff, B.L. (1992) Petrogenetic links among granites and pegmatites in the Harney Peak rare-element granite-pegmatite system, Black Hills, South Dakota, *Can. Min.,* **30**, 785-809.

Simmons, W.B., Maxie, L.T., Brewster, R.H. (1987) Geochemistry and evolution of the South Platte granite-pegmatite system, Jefferson County, Colorado, *Geochim. Cosmochim.,* **51**, 455-471.

Stern, L.A., Brown, G.E., Bird, D.K., Jahns, R.H., Foord, E.E., Shigley, J.E. and Spaulding, L.B. (1986) Mineralogy and geochemical evolution of the Little Three pegmatite aplite layered intrusive, Ramona, California. *Am. Mineral.,* **71**: 407-427.

Williams, P.J. (1987) Metasomatic phenomena adjacent to a granite pegmatite, Garry-asair, Benbecula, Outer Hebrides. *Min. Mag.,* **51**: 735-738.

الصفات الحقلية، التجمعات المعدنية وجيوكيميائية البجماتيت المشعة في منطقة وادي أبو زوال، شمال الصحراء الشرقية، مصر

عمرو عبدالعاطي عبدالحميد، وهشام محمود عبدالحميد
هيئة المواد النووية، المعادي، القاهرة، مصر

تتواجد صخور البجماتيت فى منطقة وادي أبو زوال، شمال الصحراء الشرقية، داخل صخور الجرانيت القديم، صخور الجابرو الحديث وصخور الجرانيت الحديث. يوجد موقعين للبجماتيت يتم استخراخ الفلسبار والكوارتز منهم. تتواجد البجماتيت على هيئة أجسام كبيرة الحجم داخل صخور الجرانيت القديم، واحد من هذه الموقعين يعطى شاذات إشعاعية عالية نتيجة وجود بعض التمعدنات المشعة داخل هذه الكتلة من البجماتيت مرتبطة وموزعة على نطاق التماس بينها وبين الجرانيت القديم. النطاقات المتمعدنة يوجد بها بعض التغيرات الصخرية نتيجة تأثير المحاليل الحرمائية وتكوين معادن اليورانوفين والكازوليت واليورانوثورايت والمونازيت. تكونت هذه التمعدنات على سطح الصخر أو داخل الشقوق الصغيرة فى البجماتيت. التحليل الكيميائى لبعض العينات المتمعدنة أكدت أنها تحتوي على نسب عالية من الصوديوم والكالسيوم والألومينا والحديد ونسب قليلة من السيليكا والبوتاسيوم. أما بالنسبة للعناصر الشحيحة فتحتوي على نسب عالية من اليورانيوم والثوريوم والعناصر الأرضية النادرة بالإضافة إلى الزنك والخارصين. الدراسات الحقلية تؤكد أن نطاق التماس هو أكثر الأماكن فى وجود التمعدنات حيث توصي الدراسة بأن يتم استخراج الفلسبار فى منطقة أبو زوال عمومًا بعيدًا عن نطاقات التماس مع الصخور القديمة أو الصخور الحاوية لهذه البجماتيت.