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BEHAVIOR OF THE TRACE AND RARE EARTH ELEMENTS IN THE PEGMATITIC ROCKS OF EL MISSIKAT-EL EREDIYA AREA, CENTRAL EASTERN DESERT, EGYPT

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ABSTRACT

The pegmatitic rocks of El Missikat-El Erediya area are granitic pegmatites composed mainly of potash feldspar and quartz. They are low radioactive rocks without any radioactive minerals and have rare crystals of zircon, xenotime, cassiterite and violet fluorite that considered as good hostile for the rare earth elements. El Missikat pegmatite follow the trend of primitive rock, while El Erediya pegmatite is more evolved proved by lower Ba/Rb ratio (0.048), higher Rb/Sr ratio (187.08) and lower Eu concentrations (<0.05) rather than El Missikat pegmatite. The study concluded four reasons for poverty of the radioelements in the studied pegmatites 1) Consuming of the radioelements in the earlier rocks (granites), 2) Rarity of the post-magmatic processes, 3) The studied pegmatites originated from low-volatile melt and 4) Leachability of uranium by meteoric water as proved by high Th/U ratio and D-factor.

INTRODUCTION

The pegmatitic rocks, accompanying the anomalous granites of Gabal (G.) El-Missikat and G. El-Erediya, are characterized by low radioactivity and low trace and rare earth elements. This phenomenon pays to study the mysterious behavior of uranium and thorium in the pegmatitic rocks of the studied area. Several authors studied El Missikat and El Erediya areas e.g. Mohamaden (1996), Omran (1999), Abdallah (2004), Ammar (2007), Raslan (2009), Shalaby et al. (2010) and El-Sherif (2013).

Kley (1968) stated that any trace element, found in a rock, must be generally present as an integral component of the lattice structure in one or more of the rock-forming minerals. Trace elements may also occur as: a) stoichiometric components of certain rare minerals, b) surficially adsorbed atoms or ions, c) anomalous inclusions occupying structural defect positions or interstices between regular structural positions, or as d) constituents of intra-granular fluid inclusions. He added; there are many factors, including pressure, Eh, pH, the nature and proportions of coexisting mineral phases, and both the relative and absolute abundances of all trace elements in the geochemical environment, that may have an effect upon the amount of a given element incorporated in a specific mineral at any given temperature.

Jahns and Burnham (1969) explained that

the magma became saturated with water after initial crystallization of the anhydrous minerals (feldspar and quartz). Consequently, a fine-grained aplite margin had been created retrograding the boiling and then created a separate aqueous phase in which the large crystals readily grew. They concluded that the parental magma of most granitic pegmatites crystallizes in three main stages:

a) Crystallization of essentially anhydrous minerals such as the feldspars and quartz.

b) Crystallization of minerals from both a silicate liquid and coexisting aqueous fluid of considerably lower viscosity followed by rapid diffusion of constituents through the aqueous fluid and the upward movement of the fluid phase. All contribute to the formation of pods and zones of different composition and texture.

c) Crystallization and metasomatism by aqueous fluids after the crystallization of the silicate liquid.

Černý (1982a) proposed four principal categories of the granitic pegmatites that associated with late- to post-tectonic granitoid magmatism or orogenic environment:

1) Abyssal class: Typical of anatectic zones in kyanite-and sillimanite-bearing upper amphibolite to granulite facies of metamorphism; near-allochthonous; derived by partial melting of enclosing high-grade metamorphic rocks at 5-8 kbars; locally enriched in U, Th, REE, Nb, Ti and Zr.

2) Muscovite class: characteristic of Barrovian high-pressure metamorphic facies series, and hosted by schists of the kyanite + almandine subfacies of Winkler (1979) almandine-amphibolite facies. They originate by either anatexis or restricted fractionation of primitive, more or less autochthonous granites at 4-6 kbars and consolidate close to the loci of magma generation; muscovite and feldspar deposits occasionally carry subordinate Be, Nb, REE, U and Th.

3) Rare-element class: occur in Abukuma-type low-pressure metamorphic facies series generated by fractionation of allochthonous differentiated granites and consolidated at 2-4 kbars, mainly in the rocks of the andalusite + corderite + muscovite subfacies of Winkler (1979) corderite-amphibolite facies.

4) Miarolitic class: confined to cupolas of allochthonous, epizonal to subvolcanic, occasionally hypersolvus granites and their close vicinity, and consolidated at 1-2 kbars as fracture-filling veins or pods.

Lagache (1984) studied the natural feldspar and reported that K and Rb feldspar form a continuous solid solution series at 400C. His study of low temperature feldspar shows that a solvus must exist below 400C to exsolve an early generation of (K, Rb)-feldspar from $KAlSi_3O_8$-$RbAlSi_3O_8$ solid solution system.

Teertstra et al. (1998a) identified the rubidium-rich feldspar as rubicline that recognized as the Rb-K-analogue of microcline where Rb>K. Rubidium feldspars form under low temperature conditions in the interior zones of many pollucite in rare-element granitic pegmatites; pollucite is Cs-feldspar (Cs-Na $AlSi_3O_8$) and Cs can be replaced metasomatically by Rb forming the Rb-feldspar (Teertstra et al., 1998b).

Larsen (2002) studied the potash feldspars in two pegmatite fields in Norway and concluded some petrogenetic criteria. He concluded that the concentration of Sr, Ba and Eu decreases as differentiation proceeds, whereas the concentration of Rb, Pb and Ga increases. For Sr, Ba, Rb and Eu, the evolutionary paths followed by the pegmatites coincide, whereas for Ga the trends are distinctively different for the two fields. These features, together with conspicuous differences in the REE and U distributions, indicate that pegmatite-forming melts were derived from different sources.

Abd El-Naby (2008) proposed a two-stages metallogenetic model for the alteration processes and uranium mineralization in El-

Erediya area. The primary uranium minerals were formed during the first stage of the hydrothermal activity that formed jasperoid veins (130–160 Ma). Then, they were subjected to a late stage of hydrothermal alteration encompassing argillization, dissolution of iron bearing sulfide minerals, formation of iron-oxy hydroxides, and corrosion of primary uranium minerals.

Omran et al. (2014) revealed that there are three main anomalous shear zones named as Er1, Er2 and Er3. The most important one (Er1) has already been checked out by 9 small trenches. The spectrometric survey of the trenches reveals that trench No.7 reflect the highest radioelement concentrations (eU= 4313. 4 pprn, eTh= 424.3 pprn), followed by trench No.9 (eU=3969 pprn, eTh=326.7 ppm) followed by trench No.5 (eU= 788.2 ppm and eTh= 160ppm) and trench No.8 (eU= 595.6 ppm and eTh= 52.5 ppm). They also concluded that the pegmatite bodies are only found as small bodies encountered mainly in the pink granites and in the amphibolite rocks along the contact zones. They are composed of intergrowth of orthoclase and quartz and they are characterized by low level of radioactivity.

AIM OF THE WORK

The present work aims to study the pegmatitic rocks of El Missikat-El Erediya area to throw light on the behavior of trace and rare earth elements and to give reasons for depletion of the radioelements in these rocks.

METHODOLOGY

To perform the aim of the study, microscopic, chemical and mineralogical studies were carried out in the labs of Nuclear Materials Authority (NMA). The rocks examined microscopically by polarized light microscope attached with digital camera. Trace elements analyzed by XRF technique while the REEs and the radioelements analyzed by inductively coupled plasma-optical emission spectrometry (ICP-OES).

The radioelements also measured radiometrically by using quantitative gamma-ray spectrometry techniques consisting of a Bicron scintillation detector NaI (Tl) 76×76 mm, hermetically sealed with the photomultiplier tube in aluminum housing. The measurements were carried out in sample plastic containers, cylindrical in shape, 212.6 cm^3 volumes with 9.5 cm average diameter and 3 cm height. The rock sample is crushed to about 1 mm grain size and then the container is filled with about 300-400 gm of the crushed sample sealed well and left for at least 21days to accumulate free radon to attain radioactive equilibrium, (Matolin, 1991).

The heavy minerals were separated by bromoform and studied by stereo-microscope and electron scanning environmental microscope (ESEM) and their compositions confirmed by EDX analysis.

GEOLOGICAL OUTLINES

The investigated area is bounded by Lat. 26º 15’ and 26º 33’N and Long. 33º15’ and 33º 30’E. Gabal El-Missikat is an oval shaped pluton (covering an area of about 75 km^2), with its maximum length 12.5km trending NW. El Missikat is occupied by the younger granites of late-orogenic pluton beside the granite gneiss (Fig. 1). The younger granites intrude the older granitoids with sharp contact (Fig. 2) but is locally gradational and is marked by the frequent presence of dykes, pegmatites, silica and quartz veins.

Pegmatites of El Missikat are of limited distribution and found in two stats, the first is encountered along the contact zones between the quartz diorites and the younger granites and the second is encountered in younger granite where they form lenticular and small irregular vein-like bodies (Fig. 3). They are of variable sizes ranging from few centimeters to few meters in width and extend for more than 10 meter occasionally (Abu Deif,1985).

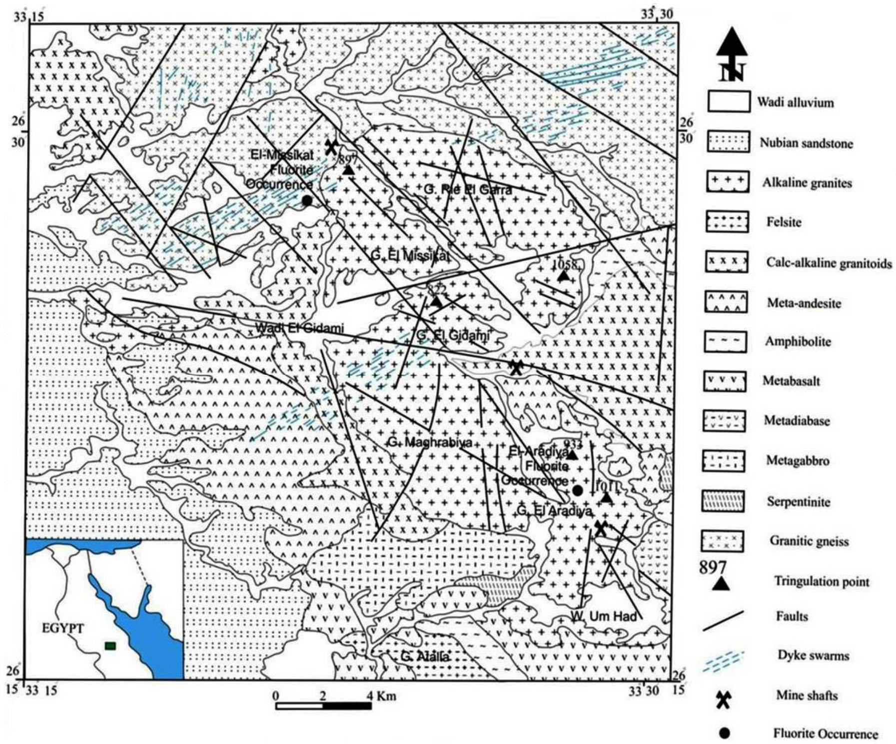


Fig. 1: Geological map of El Missikat-El Erediya area (Abu Dief, 1992)

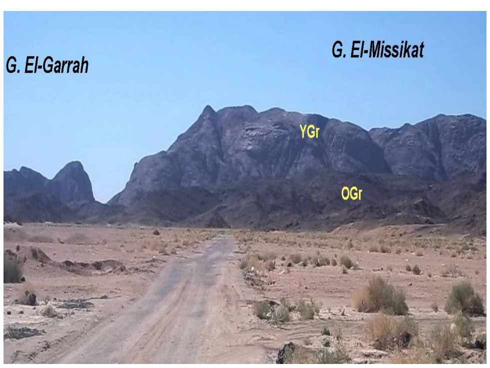


Fig. 2: Sharp contact between younger granites (YGr) and older granitoids (OGr) in G. El Missikat

Fig. 3: Vein-like bodies of pegmatite in El Missikat younger granite

These rocks are coarse grain size and reddish pink color and essentially composed of K-feldspars and quartz with or without mica.

Gabal EI-Erediya (Fig. 1) is oval shaped pink granite elongated in NW-SE direction with a length of 6.5 km and width of 2.5 km (Fig. 4). The granite is dissected by dikes and veins of aplites, porphyries, pegmatite and jasper as well as few basaltic dikes. It is followed by the formation of pegmatites, aplites, quartz veins and jasperoid veins. The pegmatite bodies of El Erediya are only found as small bodies encountered mainly in the pink granites and in the amphibolite rocks along the contact zones. They are composed of intergrowth of orthoclase and quartz (Fig. 5).

PETROGRAPHIC INVESTIGATIONS

Microscopic investigation revealed that El Missikat and El Erediya pegmatitic rocks are mostly of granitic composition. El Missikat pegmatite composed of potash feldspar and quartz while El Erediya pegmatite composed of potash feldspar and quartz with few crystals of plagioclase.

In El Missikat pegmatite, the potash feldspar present as megacysts of string perthite and microcline. The contact between the two crystals is occupied by secondary crystals of quartz and albite (Fig. 6) representing the third stage of crystallization by metasomatism that described by Jahns and Burnham (1969). The rock also contains veinlets of quartz injected along weakness planes (Fig. 7) and accompanied by processes of sericitization (Fig. 8) and hematization (Fig. 9).

In El Erediya pegmatite, the potash feldspar present as megacysts of microcline perthite, patchy perthite and antiperthite; the process of albitization is more limited appearing on the border of antiperthite (Fig. 10). Quartz and plagioclase (An_6) are less common than the potash feldspar and present as anhedral crystals where quartz corrodes the albite crystals (Fig. 11).

Accessory minerals are rare in the two pegmatites represented mainly by zircon that recorded as fine crystals included in the albite crystals of El Erediya pegmatite (Fig. 11).

CHEMICAL CHARACTERISTICS

The gamma rays radiometric analysis that carried out by Omran, et.al., (2014) for uranium of 34 selected samples of granite from the Er1 shear zone revealed that the U content reaches up 1712 ppm with an average 547.2 ppm, while the radiometric analysis of the same 34 samples revealed that the eU

Fig. 4: Part of the general view of El Erediya pink granite

Fig. 5: Pegmatite body in El Erediya pink granite

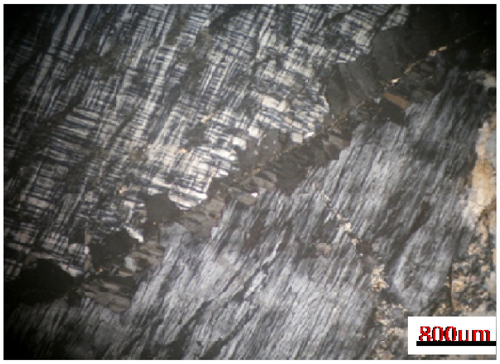


Fig. 6: Contact boundaries between microcline and string perthite, the boundary occupied by secondary quartz in the microcline and albite in the perthite of El Missikat pegmatite, XPL

Fig. 7: Veinlet of quartz injected in megacryst of microcline of El Missikat pegmatite, XPL

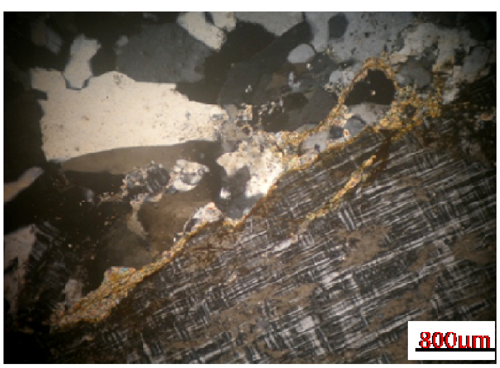


Fig. 8: Contact between quartz and microcline marked by sericite of El Missikat pegmatite, XPL

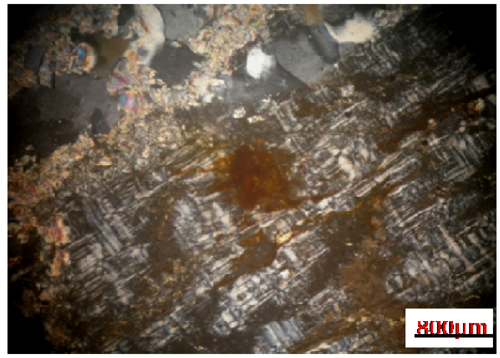


Fig. 9: Fractured megacryst of microcline filled by hematite and sericite of El Missikat pegmatite, XPL

Fig. 10: Contact boundaries between microcline perthite, patchy perthite and antiperthite; the boundary occupied by secondary albite in the antiperthite of El Erediya pegmatite, XPL

content reaches up 1656 ppm with an average 578.8ppm value and eTh reaches up 193 ppm in the silicified granite with an average 38.75 ppm. On the other hand, the chemical analysis (XRF) indicates that this granite is characterized by high concentrations of some trace elements such as Zr, Zn, Rb, Pb and Ga while the other trace elements (Cr, Ni, Ba, V, Sr, Nb, Y and Cu) are of moderate to low concentrations.

The studied pegmatites have high concen-

Fig. 11: Anhedral quartz corroding albite and fine crystal of zircon included in albite of El Erediya pegmatite, XPL

trations of Rb (up to 995 ppm in El Missikat and up to 1143 ppm in El Erediya). El Erediya pegmatite possess higher concentrations of Rb rather than El Missikat suggesting that the former is more evolved rather than the latter. Also they contain high Y-concentrations (up to 281 ppm in El Missikat and up to 324 ppm in El Erediya). In the same time, both Rb and Y are more than twice the corresponding in the anomalous granite of El Erediya. Zr, Cu, Sr and Nb are present in appreciable concentrations approaching that of El Erediya anomalous granite. Zr in El Missikat (average 151.5 ppm) is higher than that in El Erediya (136.8 ppm). The other trace elements are relatively

Table 1: Chemical analyses of trace and rare earth elements (ppm) for the pegmatitic rocks of El Missikat-El Erediya area

Sample No.	El Missikat					El Erediya						Granite Av. (Omran et al., 2014)
	Ms1	**Ms2**	**Ms3**	**Ms4**	**Av.**	**Er6**	**Er7**	**Er8**	**Er9**	**Er10**	**Av.**	
Trace elements												
Ba	83.0	6.0	32.0	4.0	**31.3**	30.0	11.0	22.0	22.0	4.0	**17.8**	**42.8**
Rb	995	153	952	14.0	**528.5**	902	1143	950	620	27.0	**728.4**	**250.3**
Cu	9.0	10.0	9.0	10.0	**9.50**	9.0	10.0	9.0	9.0	11.0	**9.60**	**10.9**
Sr	3.0	6.0	3.0	6.0	**4.50**	2.0	<2.0	5.0	5.0	7.0	**4.20**	**2.98**
Y	281	47.0	258	47.0	**158.3**	304	180	324	196	28.0	**206.4**	**64.9**
Zr	145	177	111	173	**151.5**	136	12.0	164	158	214	**136.8**	**159.6**
Nb	27.0	33.0	22.0	32.0	**28.5**	26.0	5.0	36.0	31.0	38.0	**27.2**	**23.4**
Pb	26.0	<2.0	23.0	<2.0	**13.2**	2.0	<2.0	4.0	8.0	<2.0	**3.60**	**36.9**
Ga	6.0	14.0	7.0	7.0	**8.50**	<2.0	<2.0	4.0	<2.0	15.0	**5.00**	**34.2**
Zn	35.0	18.0	39.0	14.0	**26.5**	198	143	279	303	52.0	**185**	**56.1**
Geochemical parameters												
Ba/Rb	0.083	0.039	0.034	0.285	**0.297**	0.033	0.001	0.023	0.035	0.148	**0.048**	**0.171**
Rb/Sr	331.7	25.5	317.3	2.3	**169.2**	46.0	571.5	190.0	124.0	3.9	**187.08**	**83.99**
REEs												
La	6.42	8.66	4.32	11.32	**7.68**	2.11	<0.01	2.80	2.00	2.50	**1.88**	---
Ce	17.1	24.55	12.80	31.10	**21.4**	2.70	<0.01	7.20	3.85	5.10	**3.77**	---
Pr	2.50	1.70	2.00	4.70	**2.73**	0.57	2.80	1.10	0.40	0.70	**1.11**	--
Nd	11.44	17.90	11.18	24.10	**16.16**	5.00	<0.01	5.90	2.10	3.90	**3.38**	--
Sm	3.90	5.10	4.80	7.50	**5.33**	1.72	0.13	1.90	0.80	1.70	**1.25**	--
Eu	0.30	0.70	0.10	0.30	**0.35**	0.01	<0.01	0.01	0.01	0.05	**0.02**	--
Gd	3.90	4.10	2.70	5.56	**4.07**	3.90	0.18	4.10	1.90	0.76	**2.17**	--
Tb	0.76	0.60	0.51	0.94	**0.70**	0.69	<0.01	0.74	0.32	0.20	**0.39**	--
Dy	4.10	2.40	2.83	6.10	**3.86**	4.40	<0.01	4.90	2.10	0.91	**1.58**	--
Ho	0.76	0.52	0.74	0.85	**0.72**	0.74	<0.01	0.98	0.40	0.20	**0.46**	--
Er	1.72	1.30	1.57	1.38	**1.49**	1.40	0.14	2.10	0.72	0.50	**0.97**	--
Yb	0.86	1.10	4.40	1.68	**2.01**	4.90	0.30	2.57	0.39	0.96	**1.82**	--
Lu	0.27	0.07	0.34	0.28	**0.24**	0.50	0.04	0.50	0.04	0.16	**0.25**	--
∑LREE	45.46	62.71	37.9	84.58	**48.19**	16.1	3.15	23.01	11.06	14.71	**13.61**	--
∑HREE	8.47	10.39	10.39	11.23	**7.87**	12.63	0.51	11.79	3.97	2.93	**6.37**	--
Radioelements												
Th	12.30	11.20	13.90	8.10	**11.38**	<0.01	<0.01	2.00	29.82	14.3	**9.22**	--
U	<0.01	<0.01	45.0	<0.01	**11.23**	<0.01	<0.01	<0.01	40.0	<0.01	**8.01**	**547.2**

- Detection limit for trace elements is 2 ppm, for REEs & radioelements by (ICP) is 0.01 ppm low (Table 1).

The trace elements normalized to chondrite (Taylor and McLennan, 1985) and plotted on the spider diagram; the two spiders are nearly similar except Pb concentrations. Both El Missikat and El Erediya have high concentrations of trace elements rather than the chondrite except for Sr that depleted and characterized by negative anomaly referring to absence of plagioclase according to similarity of its ionic radius to that of calcium ions of the plagioclase (Fig. 12).

The REEs are divided into light and heavy groups based on their atomic weights. The light elements group from lanthanum to gadolinium and the heavy elements group from terbium to lutetium (Walther, 2005). The studied pegmatites have low contents of the rare earth elements; the ∑LREEs (48.19 ppm in El Missikat & 13.61 ppm in El Erediya) is higher than the ∑HREEs (8.47 ppm in El Missikat & 6.37 ppm in El Erediya). Kozlov (2009) concluded that the high content of HREEs is related to a high content of volatiles and vice versa. Generally, El Missikat pegmatite has higher concentrations of the rare earth elements rather than El Erediya pegmatite (Table 1).

The chondrite-normalized REEs exhibits gull wings-pattern for the two pegmatites, the right wings (Eu, Gd, Tb and Dy) and the center (Eu) are similar while the left wings (La, Ce, Pr, Nd and Sm) are slightly different. Both El Missikat and El Erediya have high concentrations of the rare earth elements rather than the chondrite except Eu that depleted and characterized by negative anomaly referring to absence of plagioclase (Fig. 13).

The geochemical ratios Ba/Rb versus Rb/Sr used to evaluate the degree of evolution of the granitic pegmatite (Larsen, 2002). The samples of El Missikat follow the trend of primitive pegmatite, while those of El Erediya follow the trend of more evolved pegmatite (Fig. 14). Eu also used to differentiate between the primitive and more evolved rocks;

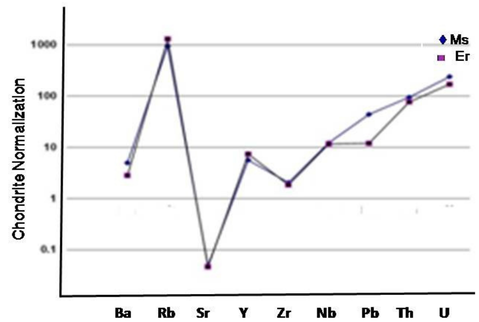


Fig. 12: Spider diagram of chondrite-normalized trace elements for the pegmatitic rocks of El Missikat (Ms)-El Erediya (Er) area

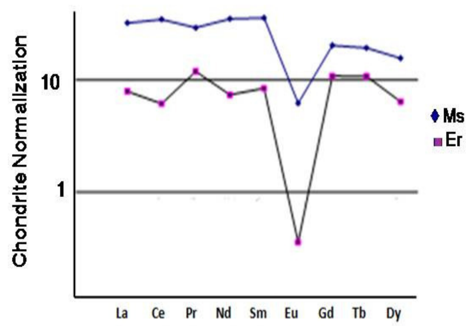


Fig. 13: Spider diagram of chondrite-normalized RRE's for the pegmatitic rocks of El Missikat (Ms)-El Erediya (Er) area

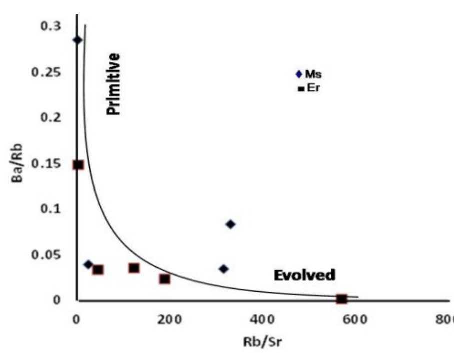


Fig. 14: Ba/Rb ratio-Rb/Sr ratio variation diagram for the pegmatitic rocks of El Missikat (Ms)-El Erediya (Er) area

it is found to increase in the trend of primitive granitic pegmatite (El Missikat pegmatite) and decreases as the Rb/Sr ratio increases in the direction of evolved pegmatite (El Erediya pegmatite), (Fig. 15).

The studied pegmatite compared with the granitic pegmatites of Larsen (2002), they exhibit higher concentrations of Rb rather than those of Larsen values and El Erediya pegmatites have the highest Rb-content (up to 1143 ppm). They have very low Ba and Sr concentrations and hence the Ba/Rb ratio is very low and Rb/Sr is very high. The chemically analyzed uranium and thorium of the studied pegmatites are relatively high (U up to 45 ppm and Th up to 29.82 ppm) if compared with the pegmatites of Larsen. Eu in El Missikat is higher than that of Larsen, while in El Erediya, it is very low (<0.05 ppm) ,(Table 2).

RADIOACTIVITY AND MINERALOGY

The contents of uranium and thorium in the studied pegmatites were measured radiometrically and they are considered as low radioactive rocks where eU-content is <13.0 ppm and eTh-content is < 25.0 ppm in El Missikat, while in El Erediya eU-content is <6.0 ppm and eTh-content is <14.0 ppm. El Missikat

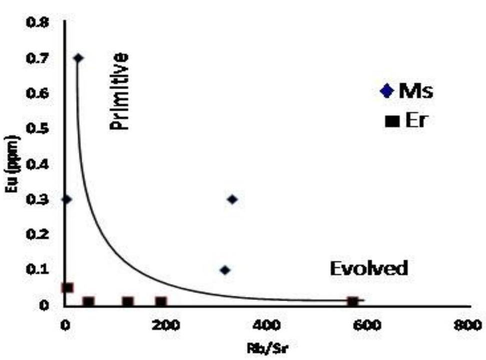


Fig. 15: Eu-Rb/Sr ratio variation diagram for the pegmatitic rocks of El Missikat (Ms)-El Erediya (Er) area

Table 2: Chemical comparison between the pegmatites of El Missikat-El Erediya area and the world pegmatites (Larsen, 2002)

Element (ppm)	Present work		Larsen (2002)
	El Missikat	El Erediya	
Rb	14.0- 995	27.0-1143	748 - 874
Ba	4.0-83.0	4.0-30	360 – 576
Sr	3.0-6.0	<2.0-7.0	65.0 - 99.0
U	<0.01-45.0	<0.01-40.0	0.39 - 1.14
Th	8.1-13.9	<0.01-29.82	0.08 - 0.31
Eu	0.1-0.7	<0.01-0.05	0.22 - 0.38
Ba/Rb	0.297	0.048	0.601
Rb/Sr	169.2	187.08	9.179

pegmatite is characterized by high average Th/U ratio (5.48) rather than the earth crust ratio (3.5-4.0), (Greenwood and Earnshaw, 1985), while El Erediya pegmatite equals this ratio (3.57). The two ratios indicate that there is no U-enrichment and the effect of hydrothermal solution is subsidiary but uranium may be leached by the meteoric water especially in El Missikat. Both of them characterized by high K-contents (up to 9.27 El Missikat and up to 10.65 in El Erediya), (Table 3).

The equilibrium state for uranium in the studied pegmatites also could be deduced from the D-factor that defined by Hansink (1976) as the ratio between the chemically determined uranium (Uc) and the radiometrically determined one (eU). This factor is very low (< unity) for most samples of El Missikat pegmatite except the sample (Ms3) where D-factor is calculated as 45.0/<1.0 and equal >45 and it is very low (< unity) for most samples of El Erediya pegmatite except the sample (Ms9) where it is calculated as 40.0/6.0 and equal 6.67 (Table 3).

Plotting of eU versus eTh exhibited positive relation with strong correlation (Fig. 16) and Rb versus K also exhibits positive relation (Fig. 17) referring to the geochemical coherence controlled by similarity of their valences and ionic radii especially in the highly differentiated rocks (pegmatites).

Table 3: Radiometric measurements for the pegmatitic rocks of El Missikat-El Erediya area

	Sample No.	eU (ppm)	eTh (ppm)	Ra (ppm)	K (%)	eTh/eU	D-Factor
El Missikat	Ms1	13.0	25.0	12.0	9.27	1.92	<0.001
	Ms2	1.0	4.0	2.0	1.34	4.0	<0.01
	Ms3	<1.0	15.0	9.0	7.05	>15.0	>45
	Ms4	1.0	1.0	2.0	0.76	1.0	<0.01
Average		4.0	11.25	6.25	4.61	5.48	----
El Erediya	Er6	<1.0	4.0	2.0	8.95	>4.0	0.01
	Er7	<1.0	<1.0	5.0	10.65	1.0	0.01
	Er8	<1.0	4.0	6.0	8.86	>4.0	0.01
	Er9	6.0	11.0	6.0	5.32	1.83	6.67
	Er10	2.0	14.0	8.0	6.09	7.0	<.005
Average		2.0	6.8	4.14	7.97	3.57	---

-Detection limit (radiometrically) =1 ppm.

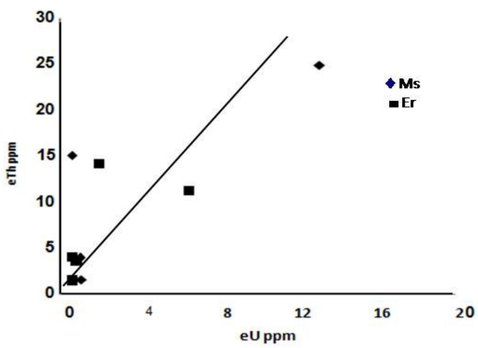


Fig. 16: eU-eTh variation diagram for the pegmatitic rocks of El Missikat (Ms)-El Erediya (Er) area

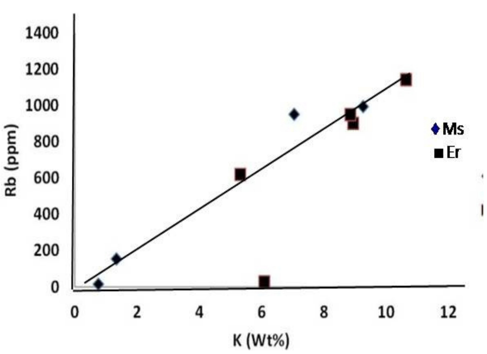


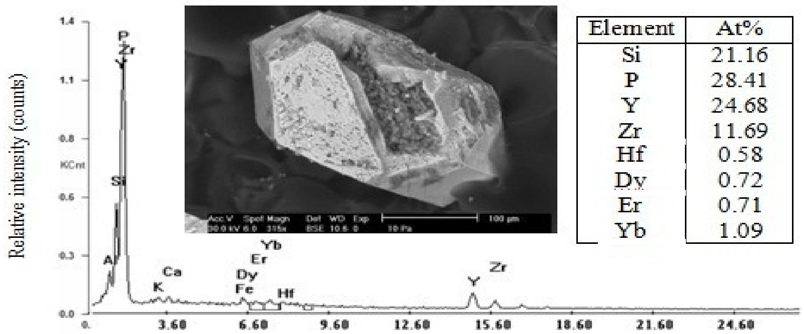
Fig. 17: K-Rb variation diagram for the pegmatitic rocks of El Missikat (Ms)-El Erediya (Er) area

Mineralogical studies revealed that the studied pegmatites have rare crystals of the accessory minerals. These minerals separated and examined by the stereomicroscope and their composition recognized by the electron scanning environmental microscope (ESEM). The investigation revealed that they are mainly zircon, xenotime, cassiterite, and violet fluorite. Zircon recorded as rare minute crystals enclosed in the feldspars and as zirconium participating yttrium in the xenotime crystals. The EDX semiquantitative analysis (since oxygen not measured) of xenotime confirmed presence of zirconium beside yttrium and phosphorous as the main constituents; it has also appreciable percentages of the REEs (Er, Yb and Dy), (Fig. 18).

Cassiterite is present as reddish brown specks in the potash feldspar characterized by presence of Sn and Nb as the main constituents associated with Fe, Ta, and Ti (Fig. 19). Fluorite is rarely recorded in the studied pegmatites as violet crystals composed mainly of fluorine and calcium with traces of yttrium (Fig. 20)

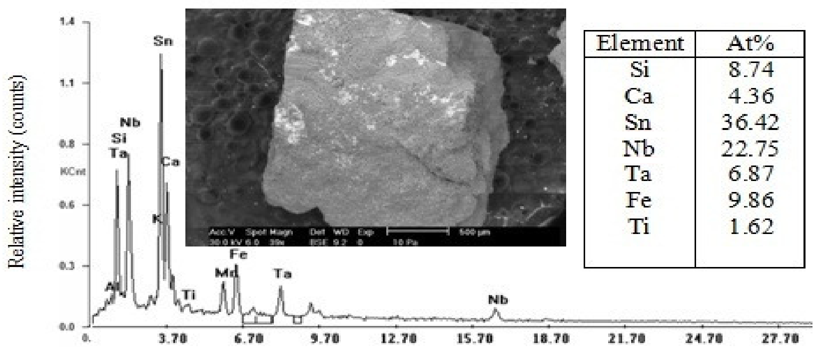
CONCLUSIONS

The pegmatitic rocks of El Missikat-El Erediya area are granitic pegmatite composed mainly of potash feldspar and quartz. They



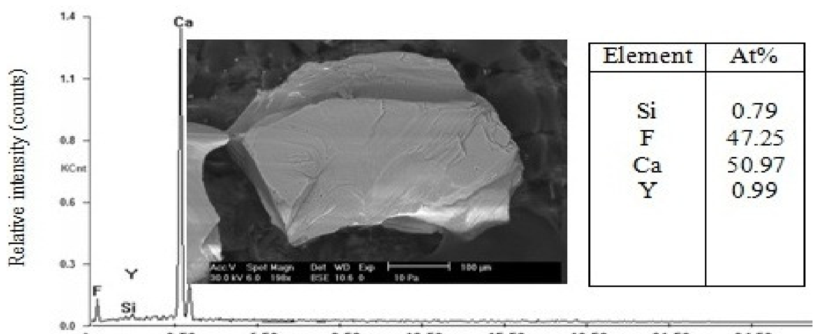
Element	At%
Si	21.16
P	28.41
Y	24.68
Zr	11.69
Hf	0.58
Dy	0.72
Er	0.71
Yb	1.09

Fig. 18: ESEM spectrograph and BSE image tailed with EDX semiquantitative analysis for xenotime included in El Missikat pegmatitic feldspar



Element	At%
Si	8.74
Ca	4.36
Sn	36.42
Nb	22.75
Ta	6.87
Fe	9.86
Ti	1.62

Fig. 19: ESEM spectrograph and BSE image tailed with EDX semiquantitative analysis for cassiterite separated from El Erediya granitic pegmatites.



Element	At%
Si	0.79
F	47.25
Ca	50.97
Y	0.99

Fig. 20: ESEM spectrograph and BSE image tailed with EDX semiquantitative analysis for violet fluorite separated from El Erediya granitic pegmatites

are low radioactive rocks without any radioactive minerals and have rare crystals of zircon, xenotime, cassiterite, and violet fluorite that considered as good hostile for the rare earth elements. The radioelements may be induced in the structure of feldspars or associate the secondary minerals such as the sericite and hematite.

The studied pegmatites have high concentrations of Rb up to 995 ppm in El Missikat and up to 1143 ppm in El Erediya). El Erediya pegmatite possesses higher concentrations of Rb rather than El Missikat suggesting that the former is more evolved rather than the latter. Also they contain high Y-concentrations (up to 241 in El Missikat and up to 306 ppm in El Erediya). In the same time, both Rb and Y are more than twice the corresponding in the anomalous granite of El Erediya. Zr, Cu, Sr and Nb are present in appreciable concentrations approaching that of El Erediya anomalous granite; Zr in El Missikat (average 151.5 ppm) is higher than that in El Erediya (136.8 ppm). The other trace elements are relatively low.

Some samples are Rb-low (in El Missikat from 14 to 153 ppm and in El Erediya 27 ppm) and others are enriched by Rb (in El Missikat from 952 to 995 ppm and in El Erediya from 620 to 1143 ppm). Hence, the author postulates that the rubidium content of the pegmatitic feldspar in El Missikat-El Erediya area may be enriched by metasomatic substitution of K^+ by Rb^+ in the potash feldspars.

The studied pegmatites are highly differentiated rocks. El Missikat pegmatite follow the trend of primitive rock, while El Erediya pegmatite is more evolved proved by lower Ba/Rb ratio (0.048), higher Rb/Sr ratio (187.08) and lower Eu concentrations (<0.05) rather than El Missikat pegmatite.

The present work concluded four reasons for poverty of the radioelements in the studied pegmatites:

1-The pegmatitic rocks are late-stage magmatic rocks; radioelements may be consumed in the earlier rocks (granites) enhanced by the low concentrations of the trace and rare earth elements.

2-The post-magmatic processes (sericitization, hematization and Rb-enrichment) are limited and rarely recorded. They are mostly restricted to the shear zones in El Missikat-El Erediya granites.

3-Previously mentioned, the melts that generate the radioactive pegmatites are high-volatile melts that characterized by wide-spreading fluorite and rare metals and high HREEs (Koslov, op. cit.). The studied pegmatites originated from low-volatile melt proved by rarity of the fluorite crystals, complete absence of the rare metals and low HREEs.

4-Leachability of uranium by meteoric water proved by the high eTh/eU ratios especially in El Missikat where the ratio reached up to 15.0. The D-factor is very low (< unity) for most samples of El Missikat pegmatite except the sample (Ms3) where it equals > 45. It is also very low (< unity) for most samples of El Erediya pegmatite except the sample (Ms9) where it equals 6.67. Thus, uranium migrates from the location of the samples Ms1, Ms2 and Ms4 to the location of the sample Ms3 via the fractures and simultaneously for El Erediya.

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سلوك العناصر الشحيحة والأرضية النادرة في صخور البجماتيت بمنطقة المسيكات-العرضية، وسط الصحراء الشرقيـــة، مصر

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تقع منطقة المسيكات-العرضية وسط الصحراء الشرقية المصرية بين خطى عرض ٢٦° ١٥' و٣٣' ٢٦° شمالاً وخطى طول١٥' ٣٣° و ٣٠' ٣٣° شرقاً. تهدف الدراسة لفحص صخور البجماتيت من حيث المحتوى الإشعاعي ومحتوى العناصر الشحيحة والعناصر الأرضية النادرة لإلقاء الضوء على أسباب انخفاض المستوي الإشعاعي بها على الرغم من ارتفاعه بالمنطقة وخاصة مناطق القص.

أوضح الفحص الميكروسكوبي أن هذه الصخور من نوع البجماتيت الجرانيتي الذي يتكون من البرثيت والكوارتز مع ندرة البلاجيوكليز وندرة المعادن الثقيلة (زرقون، زينوتيم، كاستيريت وفلوريت) مشيراً إلى أنها من الصخور عالية التمايز، وأضافت نتائج الفحص أن العمليات الفوق صهيرية محدودة ولا تتعدى إلا وجود القليل من السيريسيت والهيماتيت.

أثبتت التحاليل الكيميائية أن هذه الصخور منخفضة من حيث المحتوي الإشعاعي والعناصر الشحيحة فيما عدا عنصر الروبيديوم الذي أرتفع في بعض العينات إلي ١١٤٣ جزء من المليون ويرجع ذلك إلي العمليات الفوق صهيرية المحدودة، كما أضافت النتائج أن العناصر الأرضية النادرة أيضا منخفضة وأن العناصر النادرة الخفيفة أعلي من الثقيلة. وباستخدام المعاملات الكيميائية المختلفة ثبت أن صخور البجماتيت بمنطقة العرضية أكثر تطورا من تلك التي بمنطقة المسيكات.

قامت الدراسة بتحديد المستوى الإشعاعي لصخور المنطقة بالعد الإشعاعي وقد وجد أنها منخفضة أيضا حيث لم يتعد محتوي اليورانيوم ١٣جزءاً من المليون ومحتوي الثوريوم ٢٥ جزءاً من المليون وأن متوسط نسبة الثوريوم/اليورانيوم ٥,٤٨ لصخور البجماتيت بمنطقة المسيكات و٣,٥٧ لصخور البجماتيت بمنطقة العرضية وتكون أعلى (في منطقة المسيكات) أو مساوية (في منطقة العرضيه) للنسبة في القشرة الأرضية (٣,٥-٤) مما يدل على أنه لم يحدث أي اثراء باليورانيوم.

وخلُصت الدراسة إلى أن هذا الإنخفاض في المستوي الإشعاعي يرجع إلى أربعة أسباب رئيسة:

-إستهلاك العناصر المشعة بالصخور الأقدم (الجرانيت) مما أدى إلى إنخفاضها في صهير المرحلة

الأخيرة المكون للبجماتيت مستدلة على ذلك بانخفاض العناصر الشحيحة والنادرة.

-ندرة العمليات الفوق صهيرية بحيث لا يوجد مصدر ثانوي للإثراء باليورانيوم، ويرجع ذلك إلى توجه المحاليل الحارة إلى مناطق القص بالصخور الجرانيتية بالمنطقة لإثرائها باليورانيوم.

-إنخفاض المكونات الخفيفة من الصهير المكون للبجماتيت (ندرة الفلوريت) حيث يمثل الصهير الغني بالمكونات الخفيفة وسطاً مناسبا للعناصر المشعة تبعاً للدراسات السابقة.

- تأثير المياه السطحية بإذابة اليورانيوم وإزالته من صخور البجماتيت وخاصة بمنطقة المسيكات حيث ترتفع نسبة الثوريوم/اليورانيوم إلي ١٥.