Nuclear Materials Authority
P.O.Box 530 Maadi, Cairo, Egypt

ISSN 2314-5609
Nuclear Sciences Scientific Journal
vol. 3, p 55 - 66
2014

CONTRIBUTION TO THE RADIOACTIVITY, MINERALOGY AND REE$_S$ DISTRIBUTION IN THE GRANITOIDS OF GEBEL EL NEKEIBA, SOUTH EASTERN DESERT, EGYPT

EHAB K. ABU ZEID
Nuclear Materials Authority, Cairo, Egypt.

ABSTRACT

Gebel El Nekeiba is composed mainly of quartz-syenite surrounding syenogranite. Syenogranite is characterized by the presence of allanite, zircon and fluorite. Qz-syenite is more radioactive and characterized by the presence of violet and deep violet fluorite, zircon and columbite besides thorium minerals (thorite and orangite). The latter were transformed to thorogummite by hydrolysis. The studied rocks are characterized by low Th/U ratio. Quartz syenite and syenogranite rocks show high concentrations of REEs; the former is characterized by higher concentration of HREEs than LREEs. Distribution of REEs in Gebel El Nekeiba is controlled by the elements concentration in the parent magma, and degree of fractionation in the hosting rocks and minerals.

INTRODUCTION

Gebel El Nekeiba occurs as moderately high mountain (570 m) located at the intersection of lat. 23°52' and long. 34°22' (Fig.1) covering more or less a triangular area (about 4.0 km2), (Fig.2).

Khaleal et al. (2007) concluded that the younger granites of G. El Nekeiba are high temperature granitoids formed as a result of high fractionation and emplaced during within-plate regime.

Abdel Gawad (2011) described the central part of the mountain as syeno- granite surrounded by qz-syenite covering the eastern, northern and western parts of G. El Nekeiba. It is dissected by many fault sets and bounded by Wadi Road El Sayalla that extends from the western side, passing south the mountain to the eastern side (Fig.3). He attributed the radioactivity of the area mainly to the quartz-syenite and partly to the felsic dykes.

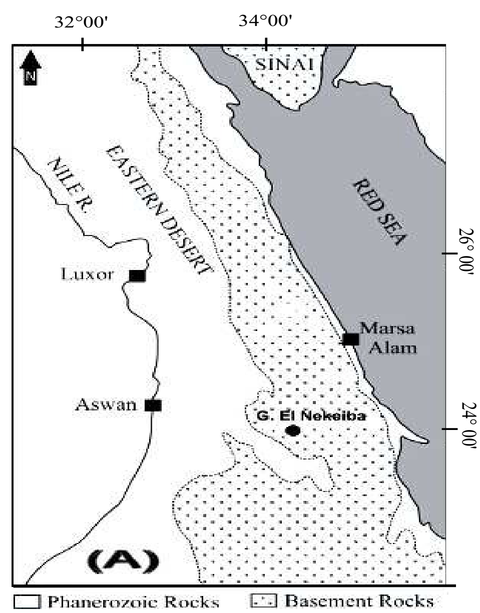

Fig. 1: Location map of G. El Nekeiba

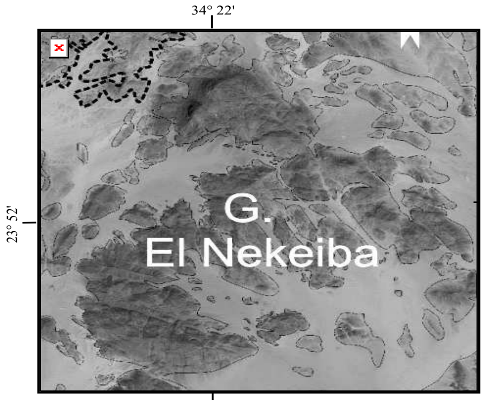

Fig.2: Arial photograph for G. El Nekeiba south Eastern Desert, Egypt

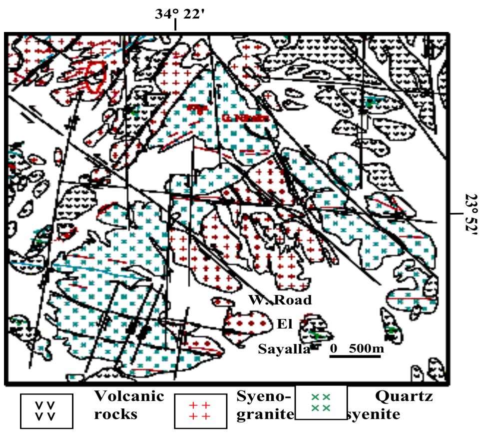

Fig. 3: Geological map for G. El Nekeiba, south Eastern Desert, after Abdel Gawad (2011).

The present work aims to 1-Recognize the minerals responsible for the radioactivity of G. El Nekeiba; 2- Investigate the relation between the distribution of REE and these minerals and 3- Characterize the factors controlling the distribution of REEs in G. El Nekeiba granitoids.

PETROGRAPHY

Gebel El Nekeiba is composed mainly of syenogranite and Qz-syenite. Syenogranite is characterized by an equigranular texture composed mainly of potash feldspar, plagioclase, quartz and biotite with rare crystals of sodic hornblende. Potash feldspars are the main feldspar represented by string perthite, orthoclase perthite and microcline. Allanite, zircon and colorless fluorite are the main accessory minerals. This rock is intensely sheared in the southern part, and characterized by mortar texture and granulation where the fault sets and wadis are common. The minerals show straining, andulose extinction and alteration (sericitization of feldspars and chloritization of biotite) (Fig. 4). Qz-syenite is composed mainly of potash feldspar, quartz, biotite, riebeckite and arfvedsonite (Fig. 5). The rock is characterized by low content of quartz (<20%) but fluorite, zircon and columbite are the common accessory minerals present, besides the radioactive minerals thorite, orangite and thorogummite.

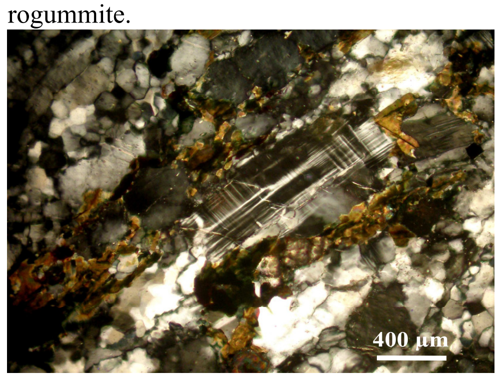

Fig.4:Photomicrograph of G. El Nekeiba sheared syenogranite showing strained microcline fractured biotite, quartz and perthite, XPL.

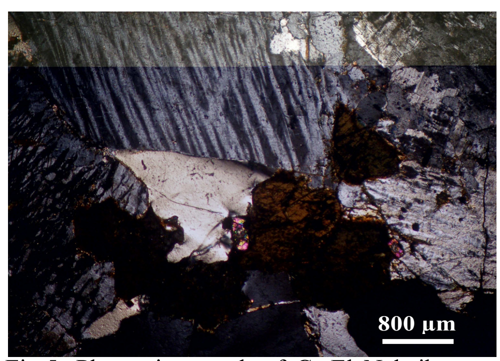

Fig.5: Photomicrograph of G. El Nekeiba qz-syenite showing string perthite associated with, arfvedsonite quartz and well-formed crystals of zircon,XPL.

RADIOACTIVITY

Both rocks (syenogranite and Qz-syenite) composing G. El Nekeiba are radioactive with different degrees; the former is characterized by lower radioactivity relative to the latter. Uranium and thorium contents are measured chemically by fluorometric method in ten samples (6 samples syenogranite and 4 samples qz-syenite). U ranges from 49 to 86 ppm with an average of 61.7 ppm while Th ranges from 62 to110 ppm with an average of 83.8 ppm in the syenogranite. Quartz-syenite shows U ranging from 76 to 95 ppm with an average of 86.3 ppm and Th from 110 to 124 ppm with an average of 116.5 ppm (Table 1).

Plotting U versus Th of the two rocks on the binary diagram shows a positive relation in the syenogranite. The relationship is disturbed in the qz-syenite showing a slightly negative relation referring to a possible addition of uranium epigenetically (Fig. 6a). Th/U ratio in the syenogranite ranges from 1.27 to 1.58 with an average of 1.37, while in the qz-syenite it ranges from 1.16 to 1.48 with an average of 1.36 (Table 1). The low value of this ratio refers to highly differentiated rocks (Chatterjee and Muecke, 1982) and may be attributed to a post-magmatic enrichment of uranium. The plot of Th versus Th/U ratio shows clearly that the quartz syenite is more differentiated than the syenogranite (Fig.6b).

MINERALOGICAL STUDIES

The studied syenogranite and Qz-syenite were ground and sieved. The grains sized between 0.63 mm and 0.5 mm were treated with

Table 1: U, Th and REEs analyses of Syenogranite and Quartz-syenite, G. El Nekeiba

Rock				Syenogranite						QZ-Syenite			Cond.
Sample	NG1	NG4	NG5	NG6	NG7	NG8	Av	NS2	NS3	NS9	NS10	Av	values
Radioelements (ppm)													
U	49	60	86	54	56	62	*61.7*	90	84	76	95	*86.3*	0.0122
Th	62	84	110	69	80	98	*83.8*	120	124	112	110	*116.5*	0.0425
REEs (ppm)													
La	14.6	27.88	1.24	116.4	11.8	17.64	*31.59*	71.39	23.94	31.97	6.33	*33.41*	0.367
Ce	24.7	59.18	4.1	212.0	23.25	31.42	*59.11*	150.1	134.3	82.65	15.2	*95.56*	0.957
Pr	0.92	5.13	0.85	19.81	0.6	2.65	*5.0*	19.64	20.25	7.23	1.74	*12.22*	0.137
Nd	5.5	17.0	3.4	46.97	6.0	12.78	*15.28*	121.6	162.9	109.0	6.5	*100.0*	0.711
Sm	1.99	5.5	2.3	14.13	1.7	2.31	*4.66*	21.65	23.0	25.0	2.3	*17.99*	0.231
Eu	0.25	0.37	0.44	0.53	0.33	0.18	*0.35*	0.9	0.38	0.38	0.53	*0.55*	0.087
Gd	2.73	8.12	7.13	19.43	8.43	3.7	*8.26*	20.07	32.49	17.35	0.44	*17.57*	0.306
Tb	1.39	2.53	3.52	6.66	2.31	3.0	*3.24*	6.6	46.6	8.35	3.4	*16.24*	0.058
Dy	14.26	13.88	25.24	18.51	15.07	11.41	*16.4*	29.81	177.4	46.87	15.75	*67.46*	0.381
Ho	3.28	3.02	9.15	3.16	1.92	4.63	*4.19*	9.5	89.49	16.46	5.98	*30.36*	0.0851
Er	7.46	9.81	15.11	9.39	8.45	6.64	*9.48*	13.38	127.5	27.99	26.39	*48.82*	0.249
Tm	1.53	1.8	3.65	1.7	2.19	1.74	*2.1*	3.56	35.2	7.35	4.99	*12.78*	0.0356
Yb	11.27	18.2	36.06	9.39	15.33	15.12	*17.73*	26.39	337.9	58.22	37.83	*115.0*	0.248
Lu	1.53	2.81	5.14	1.32	1.89	2.37	*2.51*	3.68	53.2	8.98	5.66	*17.88*	0.0381
Geochemical Parameters													
Th/U	1.27	1.40	1.28	1.28	1.42	1.58	*1.37*	1.33	1.48	1.47	1.16	*1.36*	---
Ce/U	0.4	0.99	0.05	3.9	0.42	0.51	*1.045*	1.67	1.6	1.09	0.16	*1.13*	---
Ce/Th	0.5	0.7	0.04	3.1	0.29	0.32	*0.825*	1.25	1.08	0.74	0.14	*0.803*	---
∑LREE	45.72	109.2	9.59	395.2	41.65	64.49	*111.0*	362.7	341.4	230.9	29.77	*241.2*	---
∑HREE	45.69	66.04	107.7	84.22	57.62	51.1	*68.73*	135.5	923.2	217	103.3	*344.8*	---
Total REEs	91.4	175.3	117.3	479.4	99.3	115.6	*179.7*	498.2	1265	447.9	133.1	*586.0*	---
LREE/HREE	1.0	1.65	0.09	4.69	0.72	0.44	*1.432*	2.77	0.37	1.06	0.29	*1.123*	---
La_N/Yb_N	0.88	1.04	0.02	8.38	0.52	0.79	*3.92*	1.83	0.05	0.37	0.11	*0.59*	---
Ce_N	25.81	61.89	4.28	221.5	24.30	32.83	*61.77*	156.8	140.3	86.36	15.88	*99.86*	---
$\sqrt{(Sm_N)(Gd_N)}$	8.77	25.14	15.23	62.32	14.23	11.0	*22.78*	78.4	102.8	78.33	12.0	*67.88*	---
Eu_N	2.873	4.25	5.057	6.091	3.793	2.069	*4.022*	10.34	4.367	4.367	6.091	*6.29*	---
Eu anomaly	0.33	0.17	0.33	0.10	0.27	0.19	*0.23*	0.13	0.04	0.06	0.51	*0.18*	---

The subscript (N) means that the element is normalized by chondrite (Taylor & McLennan (1985) ; Eu anomaly= $(Eu_N)/\sqrt{(Sm_N)(Gd_N)}$, (Henderson,1984)

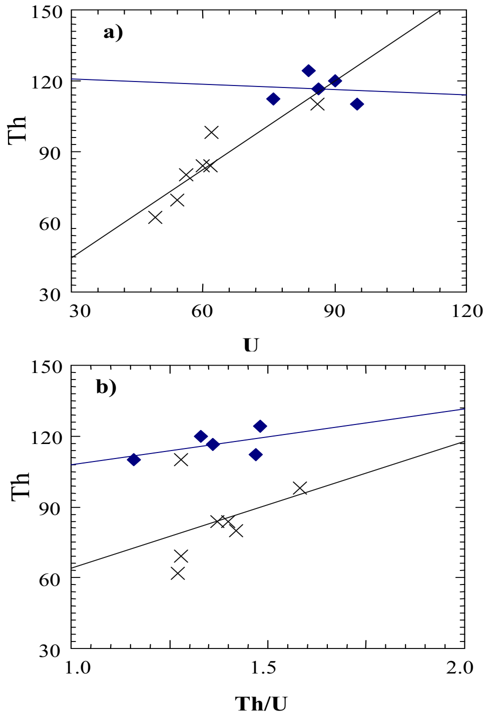

Fig. 6: Binary diagrams of a) Th vs U and b) Th vs Th/U ratio for G. El Nekeiba.Syenogranite (x) and Qz-syenite (♦).

bromoform for heavy minerals separation and studied by stereomicroscope and XRD techniques.

The Low-radioactive Rock (Syenogranite)

Gebel El Nekeiba syenogranite contains accessory minerals such as colorless fluorite, allanite, and zircon. Allanite occurs as well-formed crystals with masked interference colors included in biotite (Fig. 7). The biotite itself encloses pleochroic halos that refer to the presence of radionuclides (Hussein, 1978) (Fig. 8). Zircon occurs as zoned crystals exhibiting its characteristic interference colors (Fig. 9). It also occurs as well-formed zoned crystals characterized by intensely metamictized core (isotropic) (Fig. 11). Both of them are identified by XRD techniques showing the characteristic peaks of typical zircon (Fig. 10)

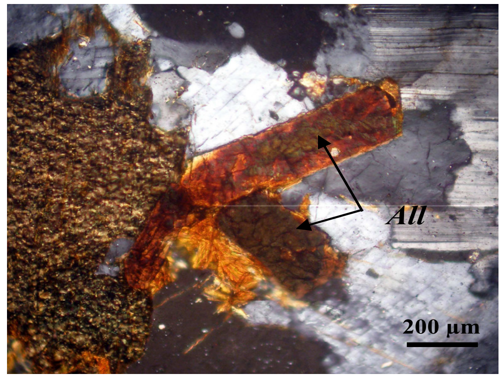

Fig.7: Well-formed crystals of allanite (All) within biotite , G. El Nekeiba syenogranites ,XPL

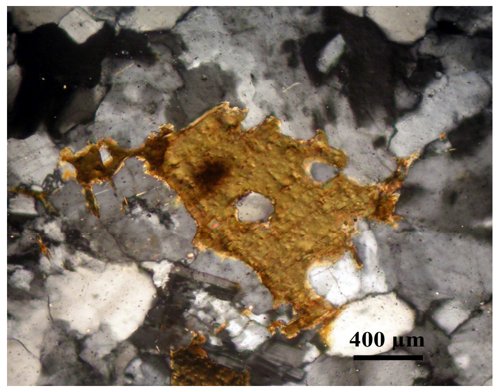

Fig. 8: Resorbed biotite crystal , G. El Nekeiba syenogranites ,XPL

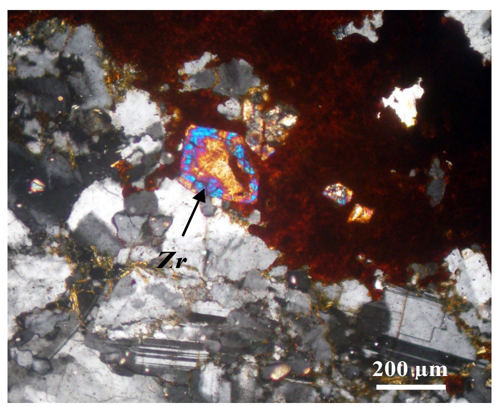

Fig.9: Well-formed crystals of zircon (Zr) surrounded by iron oxides, G. El Nekeiba syenogranites ,XPL

and metamictized zircon (Fig. 12). The radioactive minerals in the syenogranite are nearly absent.

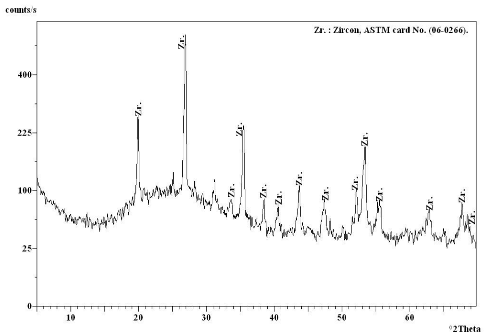

Fig. 10: XRD diffractogram for typical zircon , G. El Nekeiba syenogranites

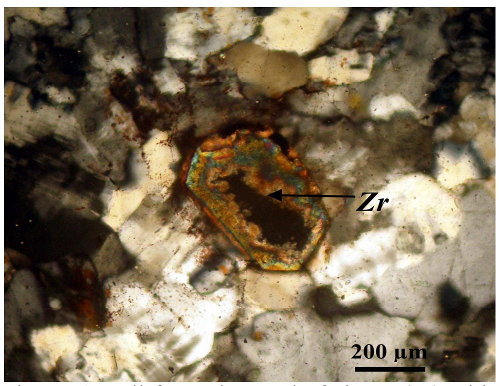

Fig.11: A well-formed crystal of zircon (Zr) with metamictized core (isotropic), G. El Nekeiba syenogranites ,XPL

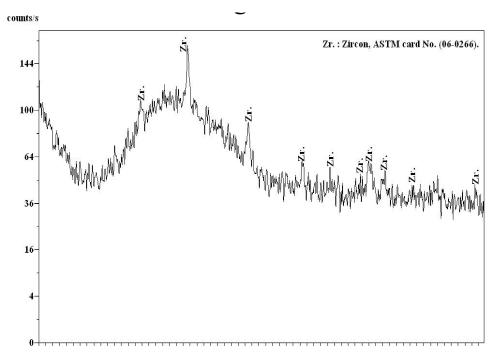

Fig.12: XRD diffractogram for metamictized zircon, G. El Nekeiba syenogranites

The Highly-radioactive Rock (Qz-syenite)

The quartz-syenite of G. El Nekeiba comprises the following minerals:

The Metallic minerals

The metallic minerals are represented by molybdenite, ilmenite and pyrite. Molybdenite occurs as platy crystals of hexagonal system characterized by grey color with metallic luster (Fig. 13a) while ilmenite occurs as prismatic crystals of trigonal system characterized by black color, metallic luster and moderate magnetism (Fig.13b). Pyrite is present as rare fractured crystals.

The Radioelements-bearing minerals

The radioelements-bearing minerals in the qz-syenite of G. El Nekeiba are mainly fluorite, zircon and columbite. Fluorite displays several colors from colorless, violet (Fig.14a)

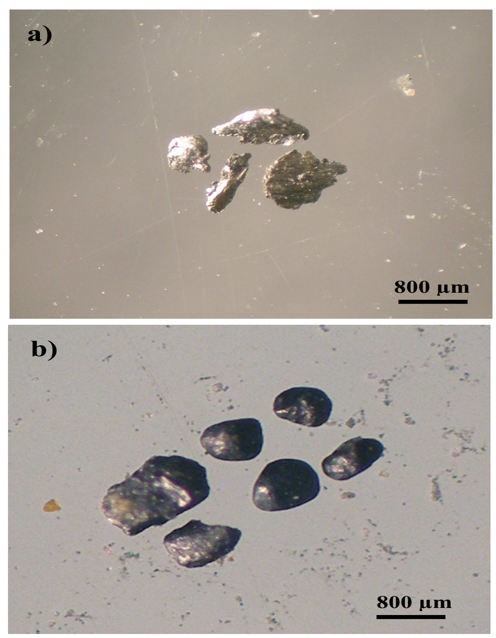

Fig.13: Stereophotographs of metallic minerals separated from G. El Nekeiba Qz-syenite showing: a) Platy crystals of molybdenite and b) Well-formed crystals of ilmenite.

to deep violet (Fig. 14b) & it is confirmed by XRD (Fig. 15). The colored varieties are good carrier of U ions (Cunningham et al., 1998). Cunningham et al., 1998 reported that uranium is transported as uranyl trifluoride complex and deposited when fluids react with the wall rock. Zircon is the most common heavy mineral in the studied rock characterized by yellow to yellowish grey colors. It forms short prismatic crystals of the tetragonal system (Fig. 16a) exhibiting its characteristic XRD diffractogram (Fig.16b). Columbite occurs as well-formed orthorhombic crystals exhibiting its characteristic black color and submetallic luster (Fig. 17a) & it was recognized by XRD (Fig. 17b).

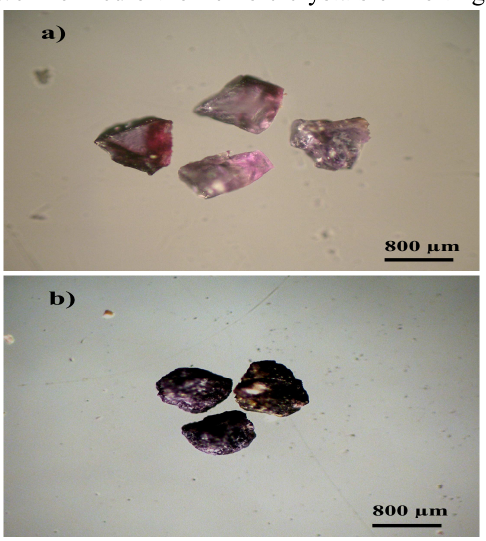

Fig. 14: Stereophotographs of fluorites separated from G. El Nekeiba Qz-syenite showing: a) Anhedral crystals of violet fluorite and b) Anhedral crystals of deep violet fluorite.

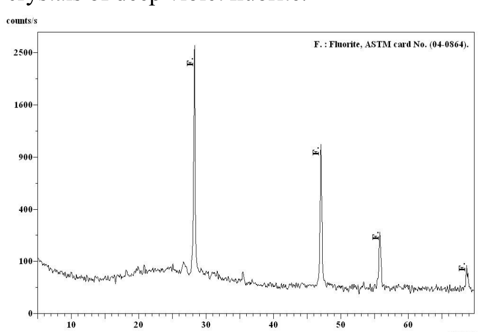

Fig.15 : XRD diffractogram for violet fluorite, G. El Nekeiba Qz-syenite

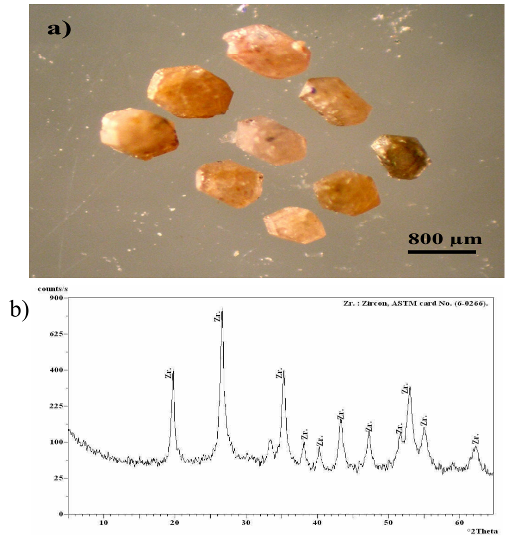

Fig. 16: Stereophotographs of Zircon separated from G. El Nekeiba Qz-syenite showing: a) Well-formed crystals of zircon and b) XRD diffractogram for zircon.

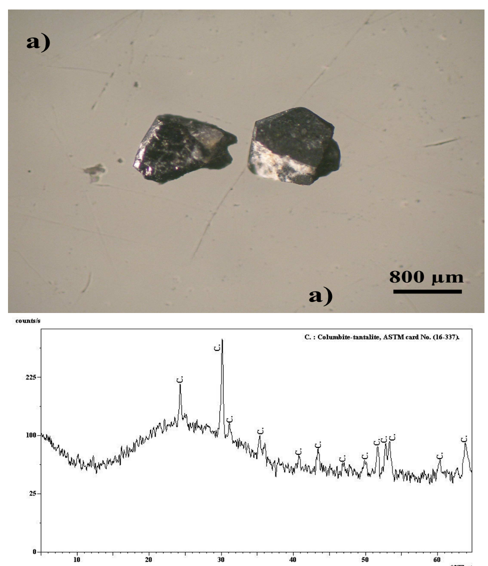

Fig. 17: Stereophotographs of columbite separated from G. El Nekeiba Qz-syenite showing:a) Well-formed crystals of columbite and b) XRD diffractogram for columbite.

The Radioactive minerals

The main radioactive mineral in the Qz-syenite of G. El Nekeiba is thorite ($ThSiO_4$). It is represented by three varieties (thorite, orangite and thorogummite).

Thorite ($ThSiO_4$)

It is a translucent mineral characterized by brown color and earthy luster, crystallizes in the tetragonal system. The crystals are fractured and occasionally associated with orangite $(Th,U)SiO_4$ (Fig. 18). It was identified by XRD and its diffractogram shows the characteristic peaks of thorite (Fig.19).

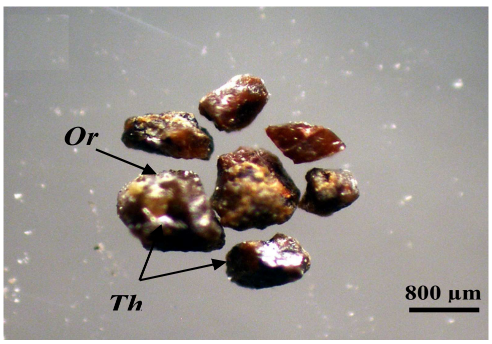

Fig. 18: Stereophotograph of thorite (Th) separated from G. El Nekeiba Qz-syenite (some crystals are associated with orangite (Or)

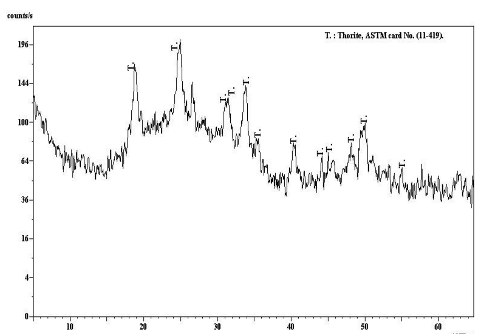

Fig.19: X-ray diffractogram for thorite, G. El Nekeiba Qz-syenite

Orangite (Th,U)SiO4

It is orange-colored thorite (Berry et al., 2000) occasionally present attached to the proper thorite (Fig. 20a&b). This mineral is characterized by the presence of U ions beside Th ions which is proved by transformation to thorogummite $(Th,U)[SiO_4, (OH)_4]$. It was identified by XRD giving a diffractogram of thorite mineral (Fig. 21), as there is no a specific ASTM card for orangite.

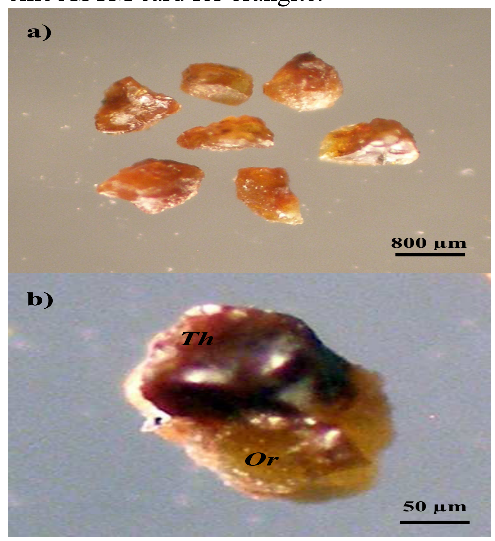

Fig.20: Stereophotographs of thorium minerals separated from G. El Nekeiba qz-syenite showing: a-Anhedral crystals of orangite and b-Thorite (Th) associated with orangite(Or)

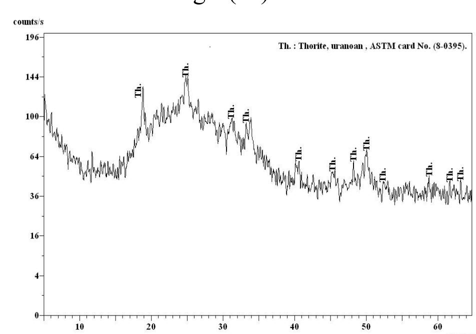

Fig. 21: X-ray diffractogram of orangite separated from G. El Nekeiba Qz-syenite

Thorogummite $(Th,U)[SiO_4, (OH)_4]$

Thorogummite occurs as an alteration product of thorite and orangite. It occurs as hydrated mantle enveloping the proper thorite (Fig.22a). Generally, it crystallizes in the tetragonal system as short prismatic crystals (Berry et al., Op. Cit.). It is very soft and characterized by a yellow color with earthy luster and gum appearance (Fig.22b). The preliminary examination of this mineral by XRD technique identified it as thorite, while examination, after heating of the mineral, it was found to be thorogummite mixed with fergusonite and zircon (Fig. 23)

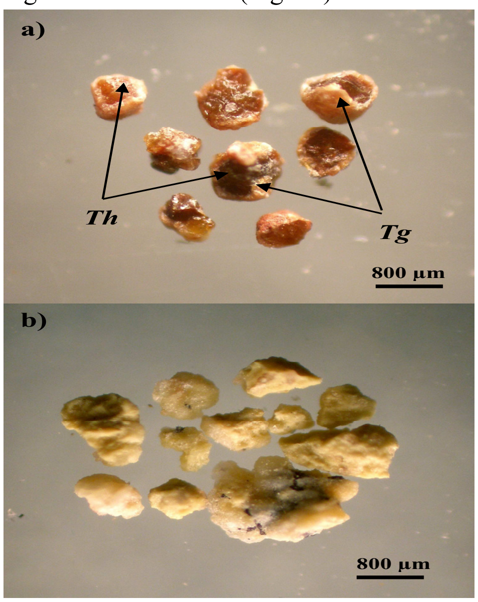

Fig.22:stereophotograph of thorite minerals separated from G. El Nekeiba Qz-syenite showing: a- Hydrated thorite with thorite core (Th) and thorogummite mantle (Tg) and b- Brittle crystals of thorogummite

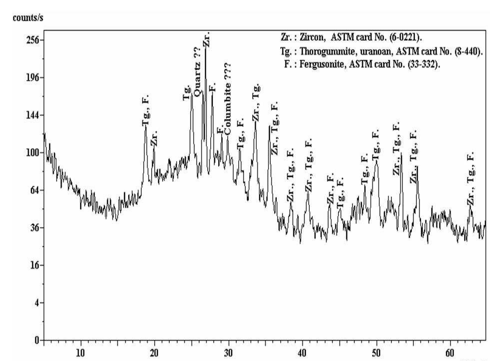

Fig.23: X-ray diffractogram of thorogummite (Tg) , G. El Nekeiba Qz-syenite showing associations of fergusonite (F) and zircon (Zr).

RARE EARTH ELEMENTS (REE_S) DISTRIBUTION

Ten samples from G. El Nekeiba are prepared and analyzed for REEs by Induced Couple Plasma Spectrometer (ICP) at the Egyptian Nuclear Materials Authority Labs (NMA). The data are normalized to chondrite. (Taylor and McLennan, 1985) and are plotted on the spider diagram (Fig. 24).

On the diagram, Eu exhibits negative anomaly (Fig. 24) this is related to the fact that Eu^{2+} is compatible with plagioclase and the removal of plagioclase from the felsic melt by crystal fractionation give rise to negative Eu anomaly. The ratio $(Eu_N)/\sqrt{(Sm_N)(Gd_N)}$ is proposed by Henderson (1984) (Table 1). When the value is >1.0 indicating positive anomaly whilst a value <1.0 points to a negative anomaly. As seen from the table the rocks under consideration are characterized by negative Eu anomaly with an average of 0.23 for the syenogranite and 0.18 for the Qz-syenite (Table1).

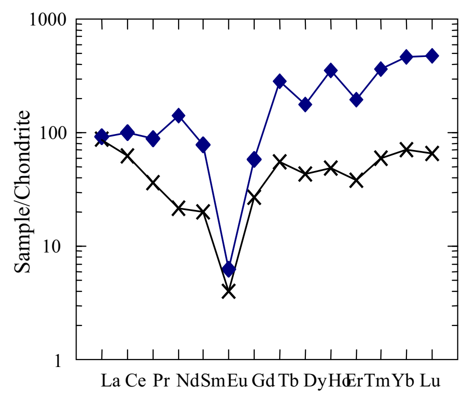

Fig.24:Chondrite-normalized REEs pattern of G. El Neckeiba syenogranite (x) and Qz-syenite (♦)

The distribution of trace and rare earth elements between phases may be described by a partition coefficient (McIntire, 1963). The interpretation of the REEs pattern is based upon the partition coefficients (P.C.) of the rare earth elements in some minerals characterizing G. El Nekeiba rocks (calculated for quartz and ilmenite after Nash and Crecraft, 1985) and for zircon and allanite by Mahood and Hildreth (1983) (Table 2). In the felsic liquids, the accessory phases such as zircon, allanite and sphene strongly influence REE pattern although they are present in small quantities; zircon is depleted in the HREE (Sm-Lu), allanite is depleted in LREE (La-Nd). (Rollinson, 1994.

Both rocks of G. El Nekeiba (quartz syenite and syenogranite) are rich in the accessory minerals (zircon, allanite and ilmenite). They are rich in REEs (Table 1) and have high partition coefficients (Table 2). The studied syenogranite is characterized by lower REEs contents (179.7 ppm) than the qz-syenite (see Fig. 24) due to presence of quartz which comprises about 35% of the rock and has the lowest partition coefficient. Qz-syenite is rich in the total REEs (up to 1265 ppm) with an average of 586.0 ppm and characterized by ∑HREE higher than ∑LREE (up to three times in sample NS3). Kozlov (2009) concluded that the high content of HREEs is related to a high content of volatiles (this is supported by the presence of different varieties of fluorite in G. El Nekeiba) and considered as good indicator for rare metals potentiality.

Table 2: Partition coefficients of REEs in some minerals

Mineral	Quartz (P.C.)	Ilmenite (P.C.)	Zircon (P.C.)	Allanite (P.C.)
La	0.015	7.1	16.9	2594.5
Ce	0.014	7.8	16.75	2278.5
Pr	---	---	---	---
Nd	0.016	7.6	13.3	1620.0
Sm	0.014	6.9	14.4	866.5
Eu	0.056	2.5	16.0	111.0
Gd	---	---	12.0	---
Tb	0.017	6.5	37.0	273
Dy	0.015	4.9	101.5	136.5
Ho	---	---	---	---
Er	---	---	135.0	---
Tm	---	---	---	---
Yb	0.017	4.1	527.0	30.8
Lu	0.014	3.6	641.5	33.0

The binary relationship of U versus Ce/U for the two rock types shows a negative correlation (Fig. 25) indicating that uranium is not hosted mainly in the accessory minerals. Plotting of Th versus Ce/Th ratio shows negative correlation in syenogranite and positive correlation in quartz-syenite (Fig. 26) indicating that Th has two different behaviors in the two rocks of G. El Nekeiba.

The average of LREE/HREE ratios is plotted versus the average of Eu anomaly for the two rock types showing that syenogranite has higher ratio and higher Eu anomaly with less electronegativity than qz-syenite due to presence of plagioclase (Fig. 27).

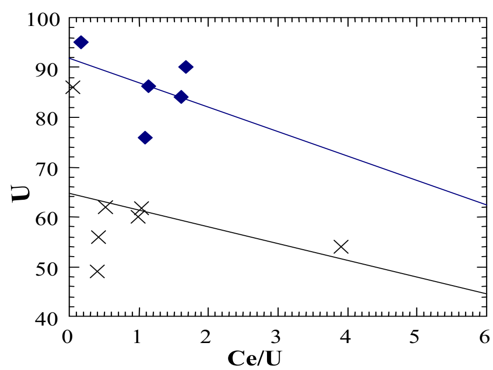

Fig. 25: Binary diagram of U vs Ce / U ratio for G. El Nekeiba syenogranite (x) and Qz-syenite (♦)

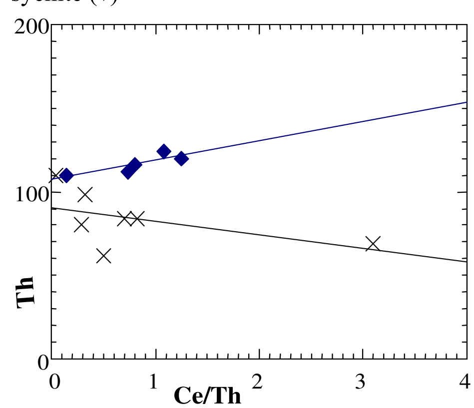

Fig. 26 : Binary diagram of Th vs Ce/Th ratio for G. El Nekeiba syenogranite and Qz- syenite

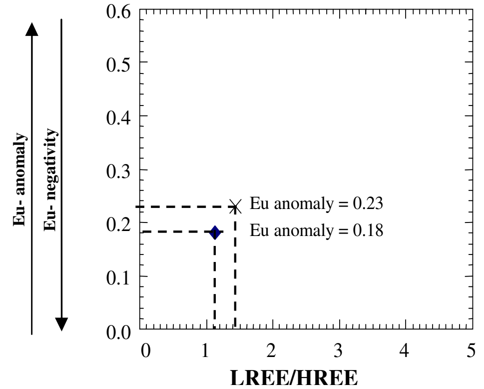

Fig.27 : Average of LREE/HREE vs average of Eu-anomaly for G. El Nekeiba syenogranite and Qz-syenite.

Degree of Fractionation of REEs

Rollinson (1994) considered the ratio La_N/Yb_N as a measure of the degree of fractionation of REEs. When plotting this ratio on the binary diagram versus Ce_N it defines the degree of fractionation with changing REEs contents. Applying this relation for G. El Nekeiba syenogranite and Qz-syenite, it is evident that the REEs are highly fractionated in the former (with an average of 3.92) rather than the latter (with an average of 0.59) (Fig. 28) indicating that the same Ce content fractionates by different degrees in the two melts depending upon the melt composition.

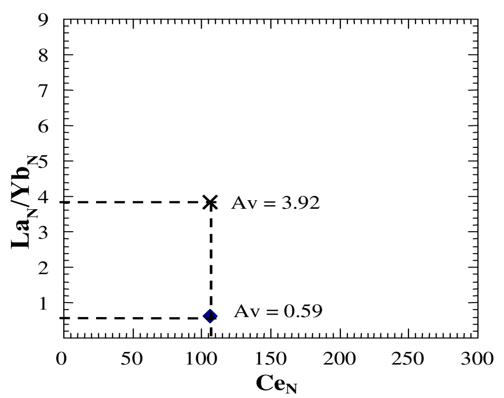

Fig.28: Average of Ce_N vs average of La_N/Yb_N for G. El Nekeiba syenogranite and Qz-syenite

CONCLUSIONS

1-G. El Nekeiba is composed mainly of qz-syenite and syenogranite. The two rocks are moderately radioactive. radioactivity of syenogranite is attributed to the accessory minerals (allanite and zircon). Qz-syenite has higher uranium and thorium contents than syenogranite and its radioactivity is attributed to the thorium minerals (thorite, orangite and thorogummite) in addition to the other accessory minerals.

2- Accessory minerals play an important role in supporting REEs contents in the two rocks; some of them enhance HREEs (allanite) and others enhance LREEs (zircon). Qz-syenite has higher total REEs due to the low content of quartz that possesses the lowest partition coefficient for REEs. Qz-syenite have ΣHREEs higher than ΣLREEs and higher than the corresponding value in syenogranite proved by the presence of rare metals potentiality like molybdenite as well as the high contents of volatiles (fluorite).

3- The normalized-Ce content of the quartz syenite and syenogranite corresponds to two degrees of fractionation (3.92 and 0.59) indicating that the degrees of fractionation depend upon the rock composition (mineralogical and chemical).

4- Finally, the factors that control the distribution of the rare earth elements in the granitoides of G. El Nekeiba are: a) The concentrations of REEs in the parent magma. b) The degree of fractionation of REEs in the hosting rock.

Acknowledgements

I would like to express my gratitude to Prof. Dr Mohamed El Ahmady, the head of research department (NMA) for his scientific aids and facilities during the progress of this work. My great thanks to Prof. Dr. Hamdy M. Abdalla (NMA) for his field facilities, picking samples and reviewing the manuscript. The author is deeply indebted to Prof. Dr. Bataa H. Ali, the head of ICP Lab (NMA) for REEs analyses. The author is also grateful to Prof. Dr. El Sayed H. El Sawy, XRD Lab (NMA).

REFERENCES

Abdel Gawad, A. E., 2011. Geology and radioelements potentialities of unconformable basement-sedimentary rocks at G. Nikeiba and G. Fileita areas, south Eastern desert, Egypt. Ph. D. thesis, Minufiya Univ., Egypt.

Berry, L. G.; Mason, B., and Deitrich, R.V., 2000. Mineralogy: Concepts, descriptions, determinations. CBS publisher and distributors, New Delhi, India, p479.

Chatterjee, A. K., and Muecke, G. K., 1982. Geochemistry and the distribution of uranium and thorium in the granitoid rocks of the South Mountain Batholith, Nova Scotia: some genetic exploration implications. In: Uranium in Granites (Mourice, Y. T.,Ed.): Geol. Surv. Canada, Ottawa, Paper 81-23,11-17.

Cunningham, C. G.; Ramussen, J. D.; Steven, T. A.; Rye, R. O.; Rowley, P. D.; Romberger, S. B., and Selverston, j., 1998. Hydrothermal uranium deposits containing molybdenum and fluorite I the Marysvale volcanic field, West central Utah. Mineralium Deposita, 33, 477-494.

Henderson, P., 1984. Rare Earth element geochemistry. Elsevier, Amestrdam, 467-499.

Hussein, A. H., 1978. Lecture course in Nuclear geology. 101p.

Khaleal, F. M.; Rashed, M. A., and Saleh, W. H., 2007. Uranium potentiality of Gabal Nikeiba area, South Eastern Desert, Egypt. The 5th inter. conf. Geol. Africa. 1, III, 41-54.

Kozlov, V. D., 2009. Rare-earth elements as indicators of ore sources and degree of differentiation and ore potential of rare metal granite intrusions, Eastern Transbaikalia. Russian Geol. Geophy., No. 50, 29-42.

Mahood, G., and Hildreth, W., 1983. Large partition coefficients for trace elements in high silica rhyolites. Geochim. Cosmochim, Acta., 47, 11-30.

McIntire, W. L.,1963. Trace element partition coefficients- a review of theory and applications to geology. Geochim. Cosmochim. Acta, 27, 1209-1264.

Nash, W. P., and Crecraft, H. R., 1985. Partition coefficients for trace elements in silicic magmas. Geochim. Cosmochim. Acta, 49, 2309-2322.

Rollinson, H. R.,1994. Using geochemical data; evaluation, presentation, interpretation. Longman Scientific & Technical, Singapore, 352p.

Taylor, S. R., and McLennan, S. M.,1985. The continental crust; its composition and evolution. Blackwell, Oxford.

إسهامات فى الإشعاعية والتمعدن وتوزيع العناصر الأرضية النادرة بالصخور الجرانيتية المكونة لجبل النكيبة، جنوب الصحراء الشرقية – مصر

إيهاب قرنى أبو زيد

يقع جبل النكيبة فى جنوب الصحراء الشرقية عند نقطة تقاطع خط العرض٥٢` ٢٣° مع خط الطول٢٢` ٣٤° شاغلا مساحة مثلثة الشكل تقطعها الوديان و الصدوع. يتكون الجبل من صخور جرانيتية (سيانوجرانيت و كوارتز سيانيت). تحتوى صخور جبل النكيبة على العديد من المعادن الثقيلة المصنفة كمعادن فلزية (مثل الإلمنيت و الموليبدينيت بالكوارتز سيانيت) و معادن لافلزية حاملة للإشعاعية (مثل الألانيت و الزيركون) أو تتكون أساسا من العناصر المشعة)معادن الثوريوم بالكوارتز سيانيت). قامت الدراسة بتحديد المستوى الإشعاعى لكل من الصخرين كيميائيا و أشارت إلى أن صخر السيانوجرانيت هو الأقل إشعاعية بمتوسط ٦٢ جزء فى المليون لليورانيوم و ٨٧ جزء فى المليون للثوريوم بينما يصل متوسط اليورانيوم إلى ٨٤ جزء فى المليون والثوريوم إلى ١١٦ جزء فى المليون فى الكوارتز سيانيت. و أرجعت إشعاعية الأول إلى وجود المعادن الحاملة للعناصر المشعة)الألانيت و الزيركون (بينما ترجع إشعاعية الكوارتز سيانيت إلى وجود معادن الثوريوم ممثلة بمعادن الثوريت و الأورانجيت و الثوروجميت التى أمكن التعرف عليه ميكروسكوبيا وبواسطة أشعة إكس الحيودية. أشارت الدراسة إلى إنخفاض نسبة الثوريوم / اليورانيوم عن معدلها الطبيعى (بمتوسط ١,٣٧ فى السيانوجرانيت و ١,٣٦ فى الكوارتز سيانيت) مشيرة إلى إنخفاض محتوى الثوريوم وإرتفاع اليورانيوم مما يدفع أيونات اليورانيوم للمشاركة فى تكوين معادن الثوريوم (أورانجيت) لمواجهة هذا النقص وتتحول هذة المعادن لاحقا إلى معدن الثوروجميت من خلال عملية التميوء التى تسمح بدخول أربع جزيئات (OH) كبديل لجزئ (SiO_4). إهتمت الدراسة بتوزيع العناصر الأرضية النادرة فى كلا الصخرين موضحة وفرتها فى الكوارتز سيانيت وأرجعت ذلك إلى إنخفاض تمثيل معدن الكوارتز(أقل معامل توزيع للعناصر الأرضية) بالإضافة إلى وجود المعادن ذات معامل التوزيع المرتفع مثل الإلمنيت و الزيركون. أشارت الدراسة إلى دور المعادن الثقيلة حيث أن بعضها يدعم مجموعة العناصر الأرضية الخفيفة LREES (مثل الزركون) و الآ خر يدعم مجموعة العناصر الأرضية الثقيلة HREES (مثل الألنيت). كما أشارت الدراسة لوجود عامل آخرمؤثرا على توزيع العنصر وهو درجة التمايز والتى ترتبط بتكوين الصخر نفسة فنجد أن درجة التمايز الأعلى (٣,٩٢) فى السيانوجرايت و الأقل (٠,٥٩) فى الكوارتز سيانيت. إنتهت الدراسة إلى التعرف على معدنى الأورانجيت والثوروجميت كإضافة إلى المعادن المشعة بصخور جبل النكيبة. وأشارت إلى تعددية العوامل المؤثرة على توزيع العناصر الأرضية فأوضحت أن توزيع العناصر لايتوقف على كميتها فى الصهير فقط بل أيضا على معامل توزيعها بالمعادن المختلفة و درجة تمايزها فى الصخور المتنوعة والتى تتوقف على تكوين الصخر ذاتة.