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Radioactive content in the investigated granites by geochemical analyses and radiophysical methods around Um Taghir, Central Eastern Desert, Egypt

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Radioactive content in the investigated granites by geochemical analyses and radiophysical methods around Um Taghir, Central Eastern Desert, Egypt

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Abstract. Um Taghir area is restricted along a shear zone of the Qena-Safaga road, actually it belongs to the Central Eastern Desert that represents one of the most important occurrences of radioactive elements in Egypt. The current study aims to calculate the content of the radioactive elements of the investigated granitic rocks by radiative methods for the geochemical analyses, are determined by (X-ray fluorescence (XRF) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The average concentrations values of ^{226}Ra, ^{232}Th are lower than that of world's average and the average activities in Egyptian soil. While in ^{40}K series is higher than that of world's average and the average activities in Egyptian soil. The range of measured activities differed widely as their presence in rocks samples depends on their physical, chemical and geo-chemical properties and the pertinent environment.

1. Introduction

The natural radionuclides of the uranium (^{238}U) and thorium (^{232}Th) series and ^{40}K as well as the artificial radionuclides of ^{137}Cs, ^{90}Sr and $^{239+240}$Pu are the major long-lived radionuclides already present [1, 2]. Among the former elements, the most abundant are potassium-40 and the radioisotopes of the natural series of uranium, actinium and thorium including the parent nuclei ^{235}U, ^{238}U and ^{232}Th and the decay products from the successive alpha or beta decays, whereas the most abundant of the cosmogenic origin nuclei are ^{14}C, ^{10}Be and ^{26}Al [3, 4].

Thorium isotopes have been widely used as tracers for particle dynamics in marine geochemistry. Particle-reactive radionuclides are useful as particle transport tracers. Particles of all sizes play a central role in the scavenging of particle-reactive radionuclides and pollutants in estuaries, coastal and open oceans [5, 6] documented that the environmental radiotracers can be used to understand the underlying processes of the environment where they are found. Investigators have reported a wide variation in the concentrations of uranium and radium in samples from various parts of the world. For uranium, a range from 3 to 400 ppm, corresponding to 37–4900 Bq ^{238}U kg^{-1} (1 ppm U = 12.23 Bq ^{238}U kg^{-1}) and for ^{226}Ra, a range from 100 to 10000 Bq kg^{-1} is reported.

The present work aims to study radiological hazards to the human health of the natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in investigated granitic rocks in the Um Taghir area. On the other hand, real and inevitable knowledge uses these granites in the field of construction and adornment or not and the extent of their impact on those who use them in their homes or for other purposes.

2. Experimental methods

2.1. Sampling and sample preparation

A total of 28 samples have been selected and collected from the investigated granitic rocks in the Eastern Desert of Egypt. Cartographic material was studied in the foundations of the Geological Survey of Egypt and in the faculty of science, Assiut branch at Al Azhar University, Figure 1.

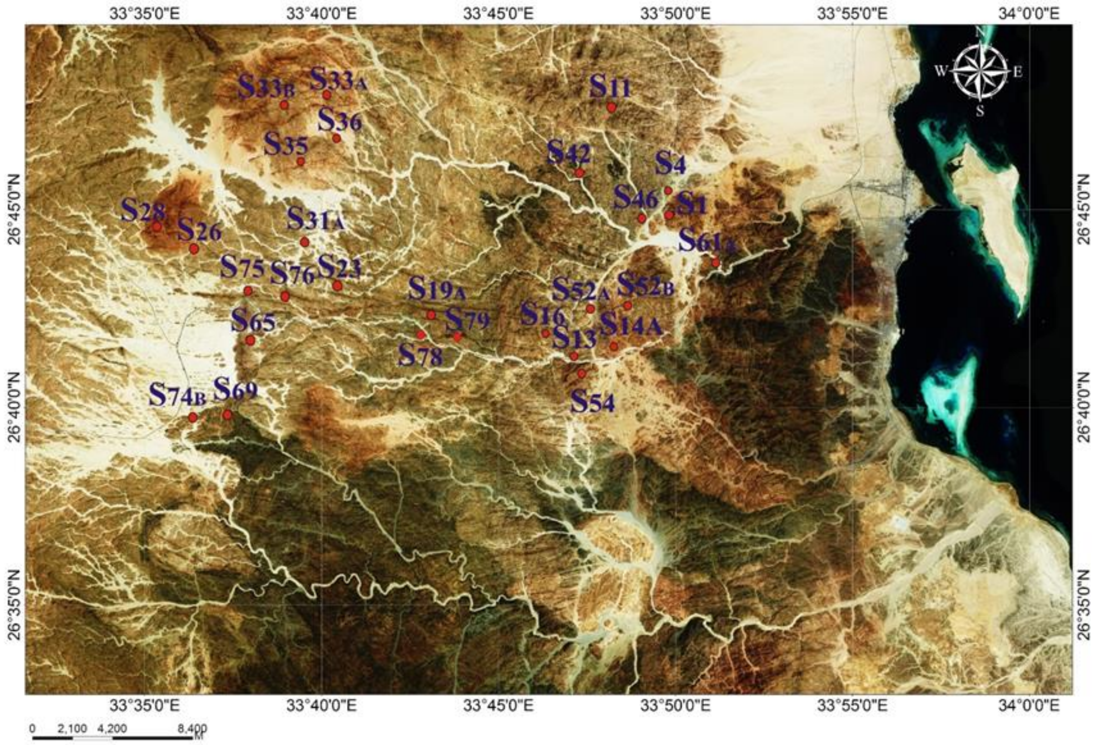

Figure 1. Sample location map of the investigated granitic rocks in the study area

2.2. Geochemical analyses

They are measured by X-ray fluorescence (XRF) at the Institute of Biology, Southern Federal University, and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) at the Central Laboratory of Russian Geological Institute VSEGEI.

2.3. Natural radionuclides

Activity concentrations of radioactive elements (ppm) in the samples are shown in Figure 2. While the radiological measurements were defined by the activity concentration (Bq kg^{-1}) instead of the content (ppm) as shown in (Table 2), according to the IAEA, 1989 Conversion factors, as see in (Table 1).

Table 1. Conversion of radioelement content to activity concentration (IAEA. 1989).

Radioelement	Content	Activity conc.
^{40}K	1 c/o K in rock	313.0 Bq kg^{-1}
^{238}U	1 ppm U in rock	12.35 Bq kg^{-1}
^{232}Th	1 ppm Th in rock	4.060 Bq kg^{-1}

3. Results and discussion

The average activity (range) of ^{238}U series, ^{232}Th series and ^{40}K were 15.7 (8.7-25.7), 13.2 (4.7 – 11.7) and 703.8 (195.1–1371.8) Bq/kg, respectively. The average activities (range) of ^{226}Ra (^{238}U) series, ^{232}Th series and ^{40}K in Egyptian soil are 17 (5–64), 18 (2–96) and 320 (29–650) Bq/kg, respectively [7]. Also, the World's average Activity concentrations (Bq kg^{-1}) of ^{226}Ra, ^{232}Th and ^{40}K measured worldwide were 35, 30 and 400, respectively [8].

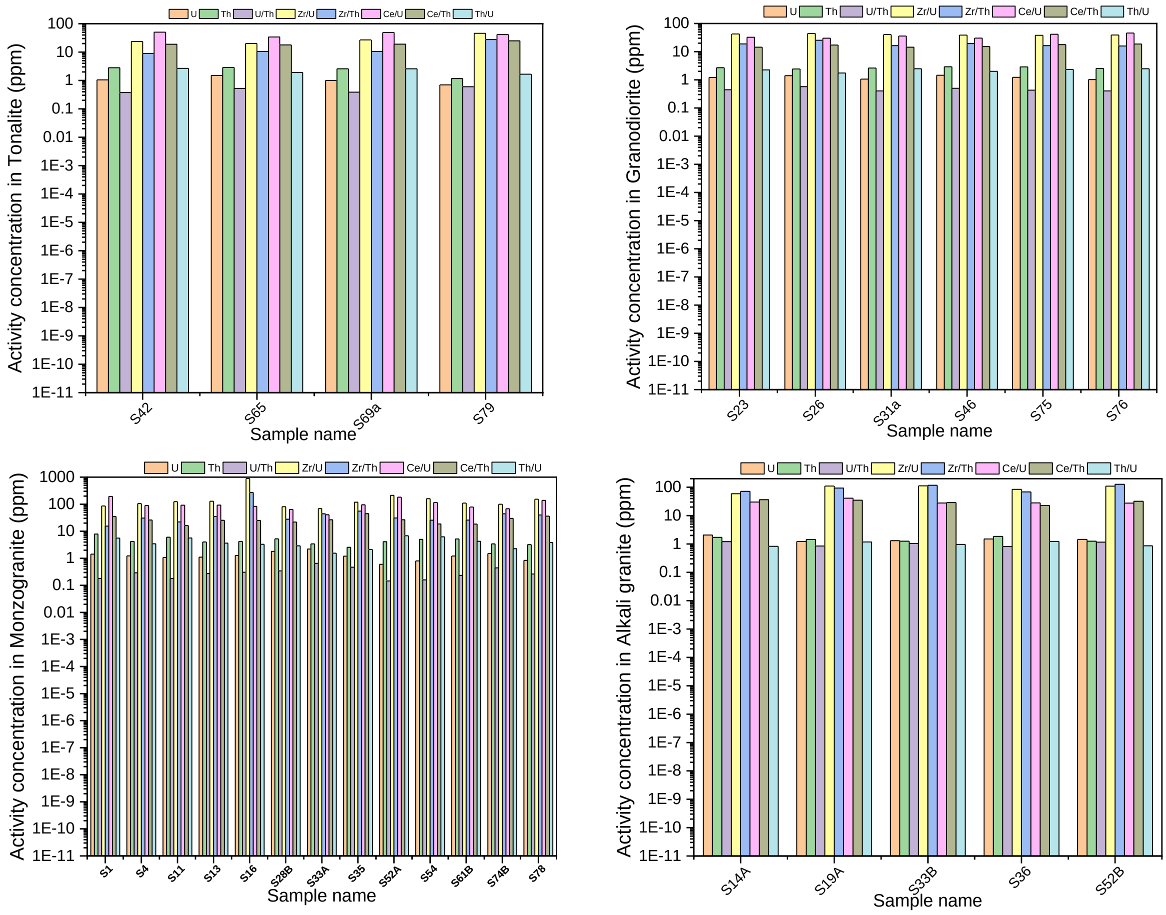

Figure 2. The activity concentrations of radioactive elements (ppm) for four investigated granitic rocks

The average concentrations values of ^{226}Ra, ^{232}Th are lower than that of world's average and the average activities in Egyptian soil. While in ^{40}K series is higher than that of world's average and the average activities in Egyptian soil. The range of measured activities differed widely as their presence in rocks samples depends on their physical, chemical and geo-chemical properties and the pertinent environment {1.2} [9, 10].

Table 2. The activity concentrations U-238, Th-232, and K-40 (Bq kg^{-1}) for investigated granitic rocks.

	sample code	U-238 Bq kg^{-1}	Th-232 Bq kg^{-1}	K-40 Bq kg^{-1}		sample code	U-238 Bq kg^{-1}	Th-232 Bq kg^{-1}	K-40 Bq kg^{-1}
Tonalite	S42	13.1	11.3	195.1	**Monzogranite**	S1	17.6	31.9	1013.9
	S65	18.6	11.5	437.3		S4	15.3	17.1	780.2
	S69a	12.4	10.4	330.1		S11	13.3	24.3	750.2
	S79	8.7	4.7	216.5		S13	13.7	16.2	900.3
Granodiorite	S23	14.9	10.9	229.4		S16	15.9	17.0	780.2
	S26	17.4	9.9	336.5		S28B	22.4	21.1	986.0
	S31a	13.2	10.6	392.3		S33A	27.3	13.7	1028.9
	S46	18.0	11.7	418.0		S35	14.9	10.3	836.0
	S75	15.3	11.6	362.3		S52A	7.5	16.6	664.5
	S76	12.7	10.2	319.4		S54	9.9	20.2	793.1
Alkali feldspar granite	S14A	25.7	6.9	996.7		S61B	15.2	21.0	921.7
	S19A	15.2	5.8	1371.8		S74B	18.6	13.7	645.2
	S33B	16.2	5.1	1050.3		S78	10.4	12.9	827.4
	S36	18.6	7.5	1071.8					
	S52B	18.0	5.1	1050.3					

3.1. U vs Th/eU:
Occasionally, thorium is represented three times as abundant as uranium in natural rocks. When this ratio is disturbed, it refers to depletion or enrichment of uranium. The relationship between U and Th/U ratio, indicates a decreasing trend for the granodiorite, monzogranite and alkali feldspar granite, while an increasing trend for the tonalite. The data represented of granitic rocks indicate effects of hydrothermal fluids for the granodiorite, monzogranite and alkali feldspar granite, while no effect of hydrothermal fluids for the tonalite as shown in Figure 3.

3.2. U vs Th and trace elements
The U-Th binary diagrams indicate positive correlation between the two radioactive elements in tonalite and alkali feldspar granite, while granodiorite and monzogranite have negative correlation between them. Sometimes, the positive correlation could be related to the differentiation trends suggesting the syngenetic origin of radioactivity, on the other hand the negative correlation between thorium and uranium may indicate post-magmatic processes which played an important role for uranium occurrence as shown in Figures 4 a, b, c and d.

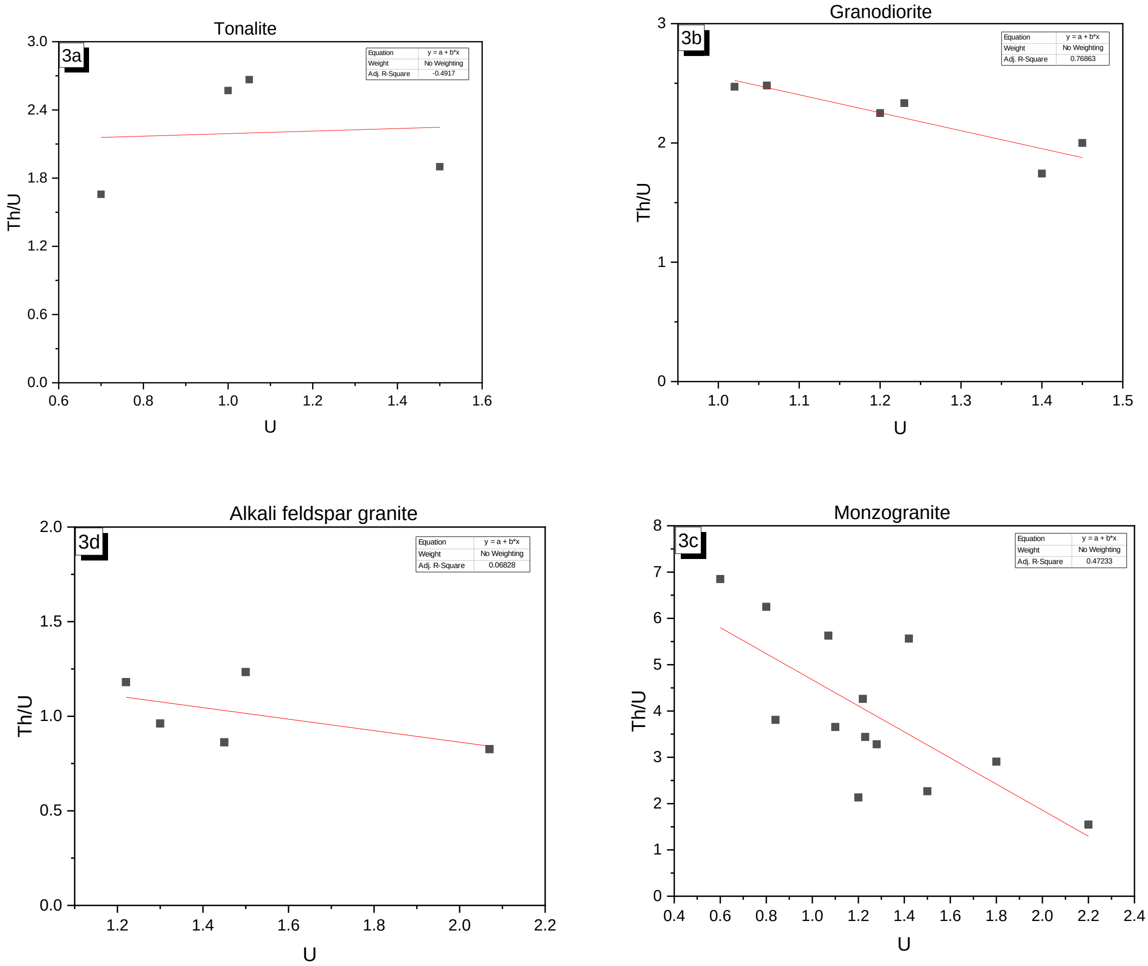

Figure 3. Binary relation between U vs. Th/U for four investigated granitic rocks

All of tonalite and monzogranite, U is positively correlated with Rb, Ba, and Sr, while negative correlation with Nb and Zr behave incompatibly in a granitic melt so that, where U concentration is controlled by magmatic processes, these elements would be expected to increase [11]. Positive correlation of U with Rb, Ba and Sr indicate their incompatible behavior during their formation, where U concentration is controlled by such process Figures 4 a, b.

Referring to the granodiorite, there is positive correlation between uranium with Zr and Ba and negatively correlated with Rb, Sr and Nb. Positive correlation due to their incompatible behavior during their formation, while negative correlation related to incompatibly in a granitic melt as shown in Figure 4 b. Alkali feldspar granite has positive correlation between U with Zr, Sr and Nb and negatively correlated with Rb and Ba.

Occasionally, positive correlation according to compatibly in melting of granite, on the other hand the negative correlation may be due to their incompatible behavior during their formation by magmatic processes as shown in Figures 4 c, d. The suggestions of link between high U and Ba concentrations [12] are not valid for the studied granitic rocks.

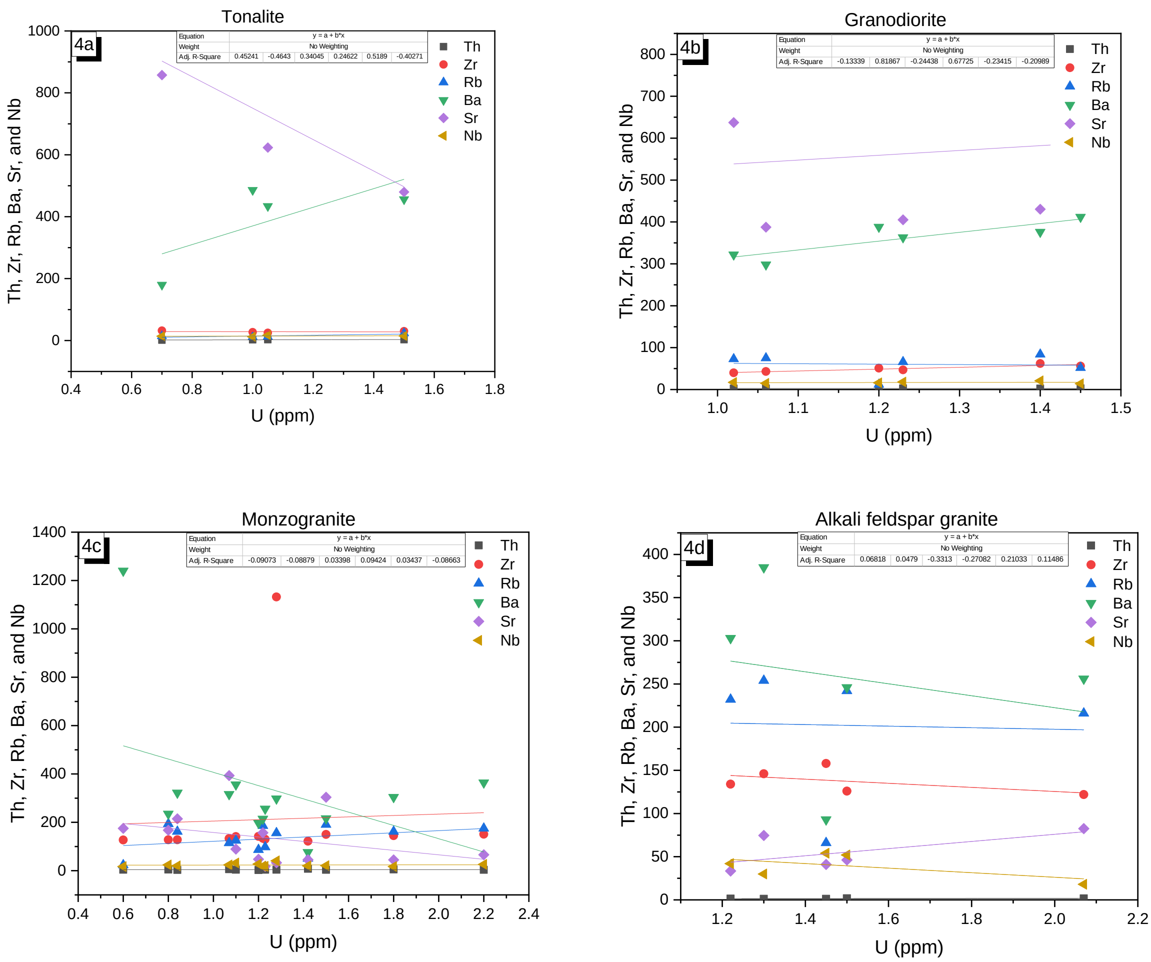

Figure 4. Binary relation between Th vs. Th, Zr, Rb, Ba, Sr, and Nb for four investigated granitic rocks.

4. Conclusion

The radioactive contents and distribution of natural terrestrial radionuclides of ^{226}Ra, ^{232}Th and ^{40}K were carried out by ICP for samples of granitic rocks collected from Um Taghir area. The activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K were found to be normal. Our results suggest that the variation in trace elements distribution is one of the most important factors influencing the spatial variations of ^{226}Ra, ^{232}Th and ^{40}K in granitic rocks. The extracted values are in general comparable to the corresponding ones obtained from other countries and they all fall within the average worldwide ranges. All measured radiological parameters are lower than the permissible limit. Usually, the positively correlated could be related to the differentiation trends suggesting the syngenetic origin of radioactivity as well as the negative correlation between U and Th may indicate post-magmatic processes that played an important role for uranium occurrence.

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