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DETAILED GEOLOGIC AND SPECTRAL RADIOMETRIC STUDIES, NORTH ELEREDIYA GRANITIC PLUTON, CENTRAL EASTERN DESERT, EGYPT

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الخلاصة: اكتشفت تمعدنات اليورانيوم عام ١٩٧٠ م في كتلة جرانيت العرضية بعد التكتونى مصاحبة لعروق الجاسبر التي توجد في نطاقات القص و الشقوق، والتى توجد في وسط الصحراء الشرقية بمصر. و قد كشفت أعمال الأنفاق و الخنادق عن و جود البتشبلند (كتلي و مبعثر) بالإضافة إلى مصاحبة حباته الثانوية في نطاقات القص المستكشفة. و قد وجد أن الجرانيت على طول نطاقات القص غالبا ما يكون متحلل. انحصرت معظم الدراسات الجيوفيزيائية الحديثة على الجزء الجنوبي لكتلة جرانيت العرضية. يتميز الجزء الشمالي لكتلة جرانيت العرضية بألوانه الخاصة. حيث يعطى التحول الهيماتيتى ألوان محمرة للصخر بينما ينتج المظهر البرتقالي المصفر من معادن الليمونيت و السريست و الطين. و تعتبر الدراسة الحالية أول دراسة مكثفة تجرى لمسح إشعاع جاما الطيفي في موقع شمال العرضية للأنفاق الاستكشافية بالإضافة إلى التخريط الجيولوجي المفصل على خطوط الشبكية المساحية. لقد عولجت البيانات إحصائيا لكي يتم نقييم احتمالية وجود اليورانيوم وتحدد اتجاهات هجرته. و قد أوضحت الدراسة وجود علاقة قوية بين توزيع العناصر المشعة ونوع الصخور. وقد بينت الدراسة أيضا أن محتوى الثوريوم أكبر من محتوى اليورانيوم تقريبا في معظم الوحدات الصخرية في موقع الدراسة. وقد بلغت أقصى قيم للإشعاع الكلى و البوتاسيوم و اليورانيوم و الثوريوم (٢٨٠UR، ٦,٥% ، ٥٥ PPM، ١٥٦ PPM) على الترتيب. و قد ثبت من دليل احتمالية وجود اليورانيوم أن الجرانيت الوردي و نطاقات الشاذات في و حول الخنادق تعطى أكبر احتمالية . وقد بينت الدراسة أيضا حدوث هجرة لليورانيوم من النطاقات الشاذة و الترنشات إلى داخل معظم الوحدات الصخرية حولهم عن طريق الخطوط التركيبية. وأن الجرعة الإشعاعية في موقع الدراسة أكبر من المستوى المسموح به من قبل الوكالة الدولية للطاقة الذرية عام ٢٠٠٠ وهى ١ مليسيفرت/عام

ABSTRACT: *Uranium mineralization was discovered in 1970 in Elerediya post-tectonic granitic mass, Central Eastern Desert, Egypt. It is connected with jasperoid veins, which occupy shear and fracture zones. Excavation works revealed the presence of massive and disseminated pitchblende, as well as its secondary associations, in some sections of the explored shear zones. The granite along the shear zone is altered. Most of recent the geophysical studies are restricted to the southern part of Elerediya granitic pluton. Special colours characterize the northern part of Elerediya granitic pluton, where the intense hematitization gives the rock reddish colouration, and limonite with sericite and clay minerals produce the yellowish orange tones. The present study is considered the first extensive gamma ray spectrometric survey carried out in the northern part of Elerediya pluton, besides the detailed geologic mapping on grid survey lines. Spectrometric data were statistically treated in order to evaluate the uranium potentiality and its controlled trend. The study shows that there is a close relationship between the distribution of radioelements and the lithology. It also shows that eTh contents are higher than eU contents in nearly most lithologic units of the study area. The maximum readings reach 280 Ur, 6.5 %, 55ppm and 156 ppm for Tc, K, eU and eTh respectively. The uranium favourability index value shows that the pink granite and the anomalous zones in and around the trenches show relative high potentiality for uranium. The migration of uranium in and out of granite is indicated, where the leached components are found in some parts of the high radioactivity trench sites, while the precipitation parts (migrated in) are represent most of lithologic units in the prospect area including anomalous zones. The precipitation processes increased along and around the lineament features as faults and fractures especially near the trenches and anomalous zones. The radiation dose rates in the study area are higher than the level of the IAEA (2000) recommendation which is 1mSv/y.*

INTRODUCTION

Eleredyia post-tectonic granitic mass is located some 25 km to the south of km 85, Qena-Safaga highway (Fig.1). The studied area (the northern part of Elerediya granitic pluton) is located at the intersection of longitude $33^{o}\ 28^{-}\ 15^{=}$ E and Latitude $26^{o}\ 22^{-}\ 30\ ^{=}$ N (Fig.1). The northern part was studied by Elkassas, (1974), includes the geology, total count measurements, trenches and channel samples from these trenches for the purpose of radiometric analysis. The Gamma-ray spectrometric method is a powerful tool in geological mapping; it is possible to determine the individual concentrations of the three naturally occurring radioelements in the ground. The method depends upon the fact that the absolute and relative concentrations of the radioelements, K, U, and Th vary measurably and significantly with lithology (Darnley and Ford, 1989). The main topic of this work is to study the distribution of the radioelements in north Elerediya tunnels prospect in order to clarify their relation to the different lithologic units and to detect some radiometric parameters related to the uranium mineralization. An extensive gamma-ray spectrometric survey was carried out on north Elerediya exploratory tunnels prospect. The present spectrometric survey was carried out by calibrated Gs-256 spectrometer (with sodium iodide crystal detector 3 inches in diameter by 3 inches long). The measurements were taken through a uniform grid survey of line spacing 20 m. and station separation 20 m.

The data are represented as maps for total count radioactivity, K, eU, and eTh and their ratios.

Statistical analysis of the spectrometric data was carried out using a computer program in order to define the distribution pattern of the radioelements in the granite and its alteration products in the prospect area of study. Generally, there is a strong relationship between the distributions of different lithologic units in the north Elerediya exploratory tunnels prospect and the levels of the spectrometric measurements. Therefore, the spectrometric data were divided into a number of levels, each of which is related to one of the lithologic units with the same radiometric signature. The favourable areas for radioelements exploration are the anomalous zones in the middle of the studied area and the pink granite. The migration process of uranium from the anomalous zones to precipitate in the nearest parts is indicated. The exposure dose rates, for all-lithologic units in the prospect area of study, are estimated and revealed that the prospect area of study is harmful for humanity and animals , because the radiation dose rates in the study area are higher than the level of the IAEA (2000) recommendation which is 1mSv/y, except the areas of basic units.

GEOLOGIC SETTING OF ELERIDIYA PLUTON

Eleredyia post-tectonic granitic mass is located some 25 km to the south of km 85, Qena-Safaga highway (Fig. 1). It is emplaced, within the Precambrian basement rocks (Stern and Hedge, 1985).

It forms a an oval sheet (6.5*2.5 km), trending in NW direction parallel to the Red Sea, intruded mainly into metamorphosed basic rocks comprising parts of the ophiolitic-island arc sequence (Fig.2). In some parts, the surrounding country rocks have undergone thermal metamorphism along their contact with the granite, As dykes and veins of aplites, porphyries, pegmatite and jasper. Few basaltic dykes dissect the granite. It has been emplaced during the post-tectonic episode in Egypt, about 600 Ma (Greenberg, 1981) or 583+ 21 Ma that has been determined by Abu-Deif (1992). The granitic mass of Elerediya is greyish pink to red in colour, medium-to coarse-grained. It is essentially composed of alkali feldspars (microcline and orthoclase), some of that occur as large elongated crystals, sodic plagioclase, and quartz (sometimes smoky in colour) and subordinate amounts of biotite. Accessory minerals are sphene, apatite, magnetite and zircon (Elkassas, 1974; Eltahir, 1985 and Ahmed, 1991). Pyrite, galena, monazite, muscovite, rutile and cassiterite are also present as accessories (Abu-Deif, 1992).

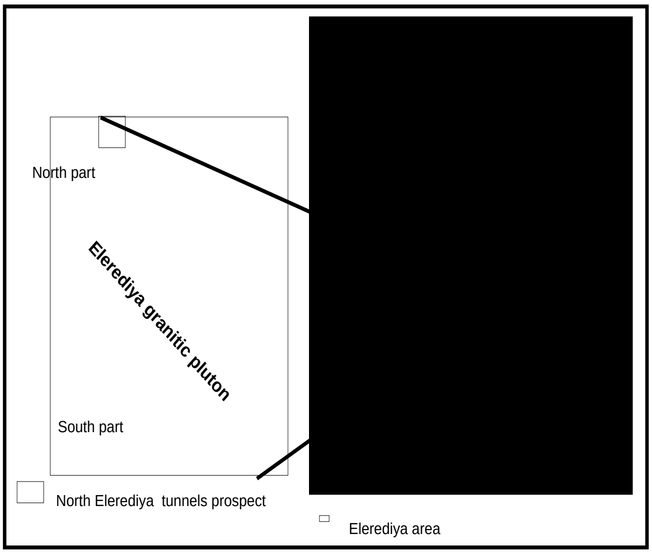


Fig. 1: Location Map of Elerediya Pluton and Studied Area.

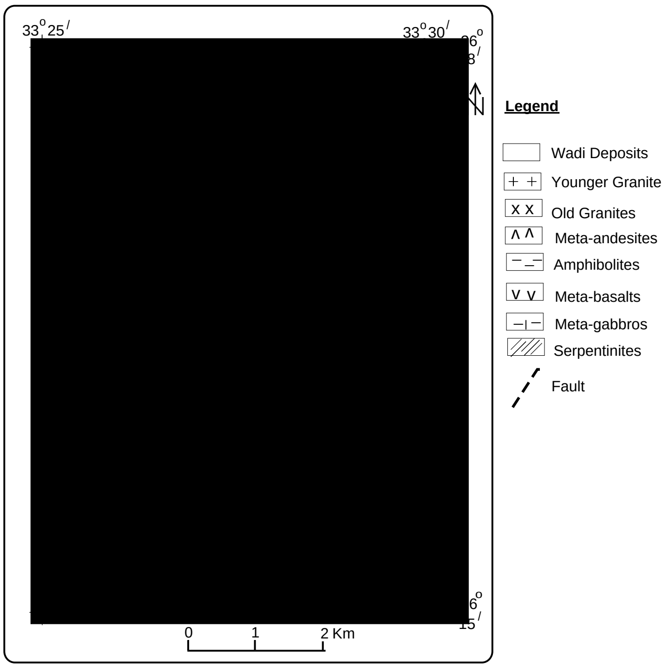


Fig. (2): Regional Geological Map of North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

Hydrothermal alterations are common in the form of silicification, kaolinization and argillic alteration as well as sericitization. Jasper is commonly developed as fracture fillings in association with hematitization and limonitization and manganese and iron oxides (El Kassas, 1974; Eltahir, 1985; Mohamed, 1988).

Structurally, the granitic mass of Elerediya is bound from the northeast and southwest sides by NW trending faults. Some other faults trending in NE-SW and N-S directions cut across this mass. Uranium mineralization, connected mainly to jasperoid veins, trending in N to NE directions, was recorded in the form of small segregation pods and lenses of pitchblende and its secondary alteration products (Elkassas, 1974). Elerediya uranium occurrence was considered a case of siliceous vein type deposit by Hussein et al. (1986).

LOCAL GEOLOGY OF NORTHERN PART OF ELEREDIYA PLUTON

In the present work the area under study is traced geologically and structurally in a grid survey of 20 m spacing. All rock units, structures and lineament features are recorded in the detailed geologic map (Fig.3) by scale 1:2000. This part is described in detail by Elkassas (1974), He described this part as formed of highly hydrothermally altered coarse grained reddish pink granite invaded by some pegmatite veins, aplite and quartz veins especially along the marginal zone. The granite exposure here is surrounded by wadi deposits in its north and northwest sides, while it is intruded into the basic metavolcanic rocks on its western side. Although it has a sharp contact which can be easily delineated even from the aerial photographs, there is a considerable zone of granitization in metavolcanic rock., which is highly metamorphosed and characterized by the development of rosy potash feldspars, green epidote and other components.

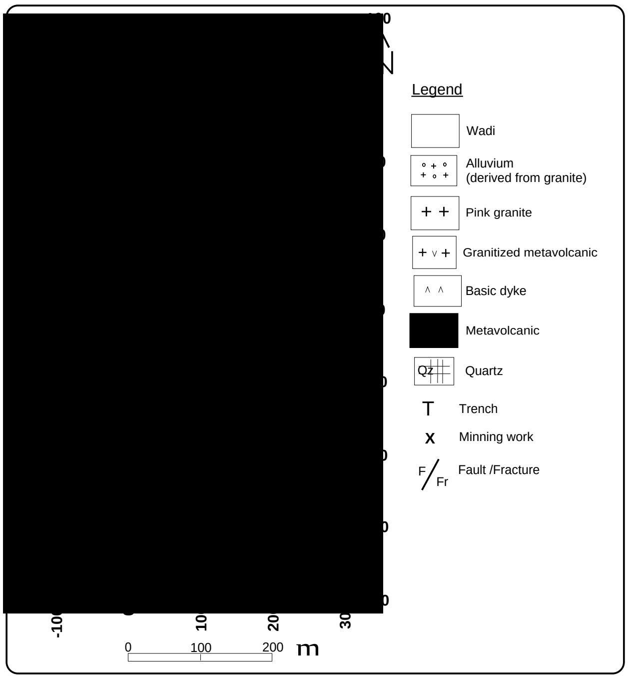


Fig. (3): Detailed Geological Map, North Elerediya Granitic Pluton ,Central Eastern Desert , Egypt.

This zone is of variable thickness ranging from 50 to 200 m., but it may reach up to 500 m. in some areas especially where the granite pluton sends some prophases into the surrounding rocks. On the other hand, the granite rocks along the contact zone include some rounded to oval shape black xenoliths of other metavolcanic rocks. The different rocks exposed at the northern part of the pluton are usually fractured and intensely jointed in various directions with different intensities.

The most abundant joint set in the granitized metavolcanic rocks is that striking in NW-SE trend. However, the pink granites, aplite and quartz veins exhibit abundant jointing generally in N-S and ENE-WSW directions, although sets of other directions are not uncommon. Some of these joints are found to be associated with different features as hydrothermal alteration represented mainly by intense hematitization giving the rock reddish colouration. Limonite is also present commonly with sericite and clay minerals which produce the yellowish orange tones, as well as the dark grey to black dendritic patches of manganese oxides.

SPECTROMETRIC STUDIES.

An extensive gamma-ray spectrometric survey was carried out along girded area (640 m. X 400 m.) where the grid size is 20 m. The present spectrometric survey was carried out by Gs-256 spectrometer (with sodium iodide crystal detector 3”diameter by 3” inches long). The flowing processes were done:

- The data are represented as maps for T.C, eU, eTh and K% as well as maps of their ratios.
- Statistical analysis of the spectrometric data was carried out using a computer program in order to define the distribution pattern of the radioelements in the area of study as tabulated in table (1).
- The spectrometric maps were divided into a number of levels, each of which is related to one of the lithologic unit with the same radiometric signature.
- Transformation of spectrometric data by applying some equations to compute the uranium migration index, exposure dose rate and favorable radioelement index

METHODS OF INTERPRETATION

- Qualitative and-Quantitative Interpretation of spectrometric data

In this study, statistical computations were applied on the original data without employing any type of transformation. This is in accordance with the work of Sarma and Cock (1980), who recommended the performance of statistical computations on the original data. A variable possesses a coefficient of variability (CV%) is examined [CV % = (S/X *100)], where S is the standard deviation and X is the arithmetic mean. If (CV %), for a certain unit, is less than 100 %, the radioelement variability in the unit tends to exhibit normal distribution.

The ground gamma ray spectrometric maps (TC , K%, eU, eTh and their ratios are given in figures (4 to 10), and are described qualitatively .

The computed values for (S) and (X) of the total count radioactivity (in Ur), the absolute potassium (K in %), equivalent uranium (eU in ppm), and equivalent thorium (eTh in ppm) concentrations as well as their ratios in the study area are shown in (table 1).

- Uranium migration index contour map: (eU-eTh/3.5 contour map)

The determination of the degree of uranium remobilization in the area under study can be determined qualitatively as determined by Clarke et al., (1966). It is very helpful in defining the remobilization of uranium and trends of uranium migration. This was done by constructing the contour map of the (eU-eTh/3.5) which enables the delineation of the limits between the negative contours (leaching) and positive ones (deposition) especially in the granitic rocks.

- Determination of the Exposure and Equivalent Dose Rates

The exposure rate (E) can be calculated from the apparent concentrations of K (%), eU (ppm), and eTh (ppm) using the expression (IAEA, 1991):

E (μR/h) = 1.505 K (%) + 0.653 eU (ppm) + 0.287 eTh (ppm)

The exposure rate can be converted to the equivalent dose rate using the following relation (Grasty et al., 1991): D (mSv/y) = 0.0833*E (μR/h)

The equivalent dose rate data were statistically treated and tabulated in table (1).

- Locating Favorable Areas for Radioelements Exploration

Sunders and Potts (1978) attempted to determine a general "uranium favorability index" by plotting histograms of various possible indices such as the eU/eTh ratio for about 30 different areas where existing mines and occurrences were known to be favorable. They concluded that the median values of aerial gamma ray spectrometer parameters for geologic map units could be used as a guide to identify uraniferous provinces, reasoning that where the crustal abundance of uranium is high it is available to be chemically concentrated in economic deposits. They further reasoned that geochemical processes must have concentrated a part of the uranium in deposits. Removal of uranium from average rocks, separating it from thorium and potassium, results in low eU/eTh and eU/K median values.

Based on the observation that high mean uranium content indicates that there is sufficient uranium for possible geochemical concentrating processes to work, and that low mean eU/eTh and eU/K values indicate that these processes took place, they derived the index U_2 for uranium :

$$U_2 = \frac{MeU}{\frac{MeU}{M\,eTh} * \frac{MeU}{MK}} = \frac{MeTh * MK}{MeU} \quad (1)$$

Then we can derive two other indices for thorium and potassium as follows:-

$$Th_2 = \frac{MeU * MK}{MeTh} \quad (2)$$

$$Th_2 = \frac{MeU * MeTh}{MK} \quad (3)$$

DISCUSSION AND INTERPRETATION

A-Qualitative Interpretation of spectrometric data:

1- The total count contour map (in Ur): The total count contour map (Fig.4) has a wide range of radioactivity ranging from 2 Ur to 280 Ur. It shows differences in radiometric levels according to the variations in lithologic units. The level <10 Ur represents the metavolcanics and basic dykes, while the level ranging from 10-20 Ur represent the total radioactivity of basic wadi sediments which are mainly derived from metavolcanics, granitized metavolcanics and basic dykes north and east of the granitic body and around the basic dykes. The acidic sediments and alluvium, derived from granites, are mainly encountered in the level ranges between 20-30 Ur. The pink granite level is bounded by 30 Ur, which increases towards the anomalous zone whose in the center of the map to reach 100 Ur. The anomalous zones level ranges from 100 to 280Ur. This map shows some lineaments and structural features trending in NW-SE, NE-SW, N-S and E-W trends.

2- Potassium contour map (in %): Potassium contour map (Fig.5) can be divided into number of levels that represent different lithologic units. Level >1.5 K% represents the basic dykes and metavolcanics. The level ranging from 1.5 to 3 represents the basic sediments, north and east of the granitic body and around the basic dykes and granitized metavolcanics. The level encountered between 3 and 4 k % represents the acidic sediments and alluvium granitic origin around the granitic pluton and along the major fault zones. The level ranging from 4 to 5.5 % k mainly represents the pink granite which means that this granite is potassium rich granite. The anomalous zones have very high level of K contents >5.5 % and most of the high reading in the anomalous zones take the trend of faults and fractures found in that part.

Table (1): Results of the statistical treatment to the ground gamma-ray spectrometric survey data, North Elerediya Granitic pluton, Central Eastern Desert, Egypt.

Rad.Par.	Pink Granite (442)							Anomalous zones (48)						
	Min	Max	X	S	CV	X+2S	X+3S	Min	Max	X	S	CV	X+2S	X+3S
T.C. (Ur)	19	70	44.6	9.8	0.22	64.2	74	71	280	114	49	0.40	212	261
K(%)	2	6.19	4.65	0.89	0.19	6.43	7.3	2	6.5	5.3	0.9	0.17	7.1	8
eU (ppm)	2	29	11.7	3.98	0.34	19.7	23.6	1.7	55	25	11.8	0.47	48.6	73.6
eTh (ppm	9	56.4	27.2	8.3	0.3	43.8	52.1	39	158	72.3	37.3	0.51	146.9	184.2
eU/eTh	0.05	1.11	0.46	0.18	0.39	0.82	1.0	0.03	0.82	0.39	0.19	0.47	1.13	1.30
eU /K	0.49	6.3	2.6	0.37	0.34	4.3	5.2	0.85	10	4.6	2.0	0.44	6.6	10.6
eTh /K	2.3	16.2	5.9	1.8	0.3	9.5	11.3	6.2	43.1	14.3	8.7	0.61	31.7	46
eU-eTh/3.5	-13	18.9	3.9	4.0	1.03	11.9	15.9	-37	21.5	4.2	12.7	3.0	29.6	42.3
Dose Rate	0.83	3.2	1.4	0.4	0.21	2.2	2.6	1.9	7.1	3.8	1.3	0.34	6.4	7.7
Rad.Par.	**Granitic origin Alluvium (63)**							**Granitized metavolcanic (30)**						
	Min	**Max**	**X**	**S**	**CV**	**X+2S**	**X+3S**	**Min**	**Max**	**X**	**S**	**CV**	**X+2S**	**X+3S**
T.C. (Ur)	7.5	40	26.6	7.8	0.29	27.2	35.24	4.1	37	13.2	9.9	0.75	33	42.9
K (%)	1.3	5.4	3.8	0.99	0.26	5.6	6.6	0.6	4.1	1.97	1.11	0.57	4.19	6.3
eU (ppm)	1.5	14	8.5	3.35	0.39	15.3	19.65	0.5	14	4.12	3.9	0.94	11.9	15.8
eTh (ppm)	2	27	14.6	5.8	0.39	26.2	32	1.1	22.9	6.7	5.8	0.88	18.5	24.4
eU/eTh	0.16	1.8	0.69	0.38	0.56	1.45	2.14	0.12	1.77	0.67	0.42	0.62	1.51	1.93
eU /K	0.75	3.9	2.3	0.35	0.36	3	3.35	0.2	7.7	2.0	1.5	0.8	5	6.5
eTh /K	1.1	7.5	3.96	1.47	0.37	3.31	3.68	0.9	9.1	3.2	2.0	0.63	7.2	9.2
eU-eTh/3.5	-2.4	8.9	4.4	3.4	0.78	11.2	14.6	-0.73	10.3	2.2	2.8	1.27	7.8	10.6
Dose Rate	0.38	1.8	1.3	0.34	0.27	1.98	2.33	0.14	1.58	0.63	0.45	0.71	1.5	1.95
Rad.Par.	**Metavolcanic (21)**							**Basic Dykes (30**						
	Min	**Max**	**X**	**S**	**CV**	**X+2S**	**X+3S**	**Min**	**Max**	**X**	**S**	**CV**	**X+2S**	**X+3S**
T.C. (Ur)	2	24	10.5	7.4	0.7	25.3	32.7	4	24	11.8	5.7	0.48	23.2	28.4
K(%)	0.4	1.5	1.1	0.26	0.24	1.6	2.7	0.3	4.1	1.97	1.17	0.60	4.31	6.28
eU(ppm)	0.1	9	1.7	2.2	1.25	6.1	7.8	1.4	10.4	3.8	2.04	0.53	7.88	9.92
eTh(ppm	0.1	17	5.5	5.2	0.94	15.9	21.4	2.5	11	5.6	2.2	0.4	10	12.2
eU/eTh	0.05	8	1.02	1.9	1.9	4.8	6.7	0.46	1	0.67	1.06	0.23	0.99	1.55
eU /K	0.08	8.2	1.7	1.98	1.2	5.7	7.4	1.12	6.7	2.4	1.4	0.58	5.2	6.6
eTh /K	0.25	21.3	5.1	5.5	1.1	16.1	21.1	1.6	8.3	3.68	1.9	0.5	7.46	9.38
eU-eTh/3.5	-3.5	5.9	0.16	2.1	13.6	4.28	6.36	0.69	7.3	2.2	1.5	0.68	5.2	6.7
Dose Rate	0.01	0.9	0.37	0.2	0.55	0.87	1.07	0.17	1.2	0.6	0.29	0.50	1.28	11.57
Rad.Par.	**Granitic Wadi Sediments (73)**							**Basic Wadi Sediments (73**						
	Min	**Max**	**X**	**S**	**CV**	**X+2S**	**X+3S**	**Min**	**Max**	**X**	**S**	**CV**	**X+2S**	**X+3S**
T.C. (Ur)	8.6	42	26.7	8.1	0.30	42.9	51	5.2	25	11.9	4.4	0.38	20.7	32.6
K (%)	1.4	5.3	3.3	0.82	0.25	4.9	8.2	0.4	4.5	1.9	0.84	0.43	3.6	5.5
eU (ppm)	2	13.8	8	3.0	0.38	14	17	0.5	9	3.3	1.96	0.59	7.2	10.5
eTh (ppm)	4	29	15.4	6	0.39	27.4	33.4	1.2	23	6.3	4.3	0.68	14.9	21.2
eU/eTh	0.19	2	0.59	0.34	0.58	1.3	1.9	0.05	3.9	0.7	6.6	0.94	2	2.7
eU /K	0.96	4.4	2.4	0.84	0.35	4.1	6.5	0.38	4.5	1.8	0.89	0.49	3.6	5.4
eTh /K	1.3	9.3	4.7	1.7	0.35	8.1	9.8	0.5	50	4.3	6.2	1.4	16.7	21
eU-eTh/3.5	-1.8	10.8	3.6	3.0	0.84	9.6	12.6	-4.7	8.3	1.5	2.3	1.5	6.1	7.6
Dose Rate	0.55	2.0	1.2	0.31	0.26	1.8	3	0.24	1.3	0.57	0.21	0.39	0.99	1.56

Rad.Par.= Radiometric parameters (75) = Number of readings Min= minimum
Max= maximum X= mean S= Standard deviation CV= Coefficient of variability

3- Equivalent uranium contour map (in ppm): Equivalent uranium contour map (Fig.6) shows clearly five levels of radioactivity, each of which represents one or more lithologic units. The very low level < 2 ppm represents the metavolcanics, granitized metavolcanics, basic dykes and basic wadi sediments. The low level of uranium radioactivity, ranging between 2 and 6 ppm, recorded over the basic wadi sediments north and east of the granitic body and around the basic dykes. The moderate level ranging between 6 and 10 ppm is recorded over the alluvium granite and over the acidic wadi sediments beside the leached parts inside the pink granite especially along the fault and fracture lines. The high level representing the pink granite ranges from 10 to 26 ppm. The fifth level is very high (>26 ppm and reaches to 54 ppm) and recorded over the anomalous zones in the center of the map. These zones take the same trends found in the total count map (Fig. 4).

4- Equivalent thorium contour map (in ppm): Equivalent thorium contour map (Fig.7) shows clear levels for the different lithologic units, where the value < 5 ppm eTh represents the lowest level recorded over the metavolcanics, granitized metavolcanics and basic dykes. The second level ranging between 5 and 10 ppm eTh, and represents the basic sediments north and east of the granitic body and around the basic dykes. The acidic wadi sediments and alluvium granites surrounding the granitic body represent the third level that ranges between 10 and 20 ppm eTh. The pink granite represents the fourth level starts from 20 ppm to 50 ppm eTh, which means that this granite is thorium- rich. The fifth and highest level of eTh radioactivity recorded over the anomalous zones in the center of the map has values > 50 ppm eTh shows a wide range which reaches 158 ppm eTh. This map shows the same lineament trends as in the case of total count map.

5- eTh/eU ratio contour map (Fig. 8): It shows that the study area has thorium content more than uranium except at the sites where the silica veins are found in the north of the study area. The thorium is more than uranium to reach maximum values over some parts of the anomalous zones.

6- eU/K ratio contour map (Fig. 9): It shows that the area of study has uranium content four times the potassium content and increases to reach 10 times in the area of uranium precipitation in low topography, near the anomalous zones, and in the sites of silica veins in the north of the map.

7- eTh/K ratio contour map (Fig. 10): This map shows that the area of study has thorium content higher than potassium. The map can be divided into three levels. The low level <4 recorded over granitized metavolcanics, wadi sediments and basic dykes. The second level ranging between (4 and 12) covers a wide area and it is corresponding to pink granite, granitic alluvium and metavolcanics. The third level is >12 and reaches 48 is recorded over the anomalous zones in the center of the map and over the silica veins in the north of the map (Figs. 3 & 10).

8- Uranium migration index contour map: eU-eTh/3.5 contour map in ppm (Fig.11) is considered as an index for uranium migration in and out of the different lithologic units especially the granitic ones. The locations of negative readings (leaching parts) show outward migration, they are found in some parts of the high radioactivity (trench sites), while the positive readings (precipitation parts) or inward migration, represent most of lithologic units in the area of study surrounding the anomalous zones. The precipitation processes increased along and around the lineament features as faults and fractures especially near the trenches and anomalous zones; it also increases on the alluvium granite in the northeast and southeast of the map. The migration of uranium is indicated by El Kassas,(1974). He made radiometric analysis of eighteen channel samples from the trenches found in the area of study, the results of which reveal that the equilibrium factor for the samples is ranging generally from 0.7 to 0.9 with an average value of 0.78. This indicates that the uranium mineral at this locality is in a state of disequilibrium in favour of excessive radium daughters and the relative deficiency in the beta activity. This is due to leaching of uranium, which is most probably caused by some secondary processes after the deposition of original mineralization.

9- Dose rate map (in mSv/y): This map shows that contour line 1 mSv/y (Fig.12) is the contact between the harmful lithologic units (anomalous zones, pink granite, alluvium granite and acidic wadi sediments) and safe lithologic units <1 mSv/y (metavolcanics, granitized metavolcanics, basic dykes and basic wadi sediments) according to the recommendation of IAEA, 2000. The minimum value reaches 0.01 mSv/y which is related to metavolcanics, while the maximum value attains 7.1 mSv/y over anomalous zones in pink granite. Table 1 shows the different values of equivalent dose rates (in mSv/y) for each rock unit in the study area.

B- Quantitative Interpretation of spectrometric data:

1- Statistical treatments: The computed values for (S) and (X) of the total count activity (in Ur), the absolute potassium (K in %), equivalent uranium (eU in ppm), and equivalent thorium (eTh in ppm) concentrations as well as their ratios in the area of study are shown in table (1). The main results of the statistical treatment are clear from this table and that the anomalous zones and pink granite have the highest contents of radioactive elements (Total count, K%, eU and eTh) among the other units (the mean of the anomalous zone are 114 Ur, 5.3 %, 25 ppm and 72.3 ppm respectively) and the mean of these elements for the pink granite are 44.6 Ur, 4.65%, 11.7 ppm and 27.2 ppm respectively.

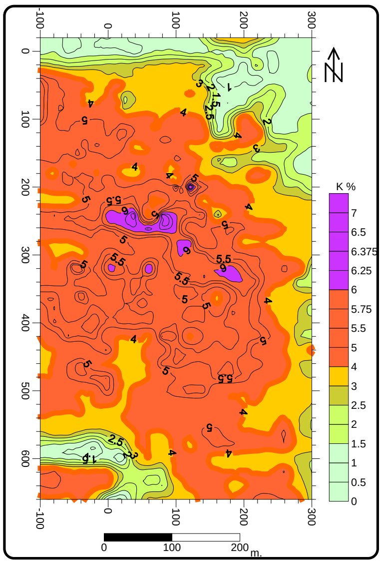


Fig. (4):Total Count Radioactivity Contour map (in Ur), North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

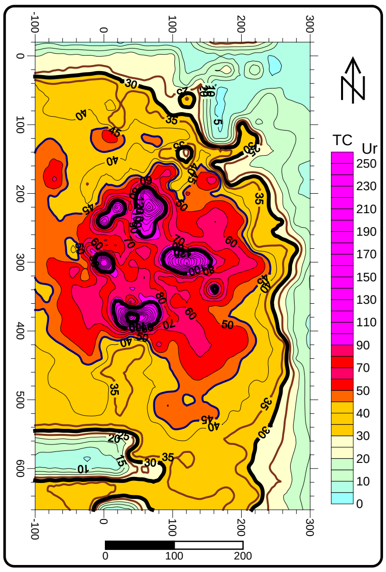


Fig. (5): Potassium Contour map (in %), North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

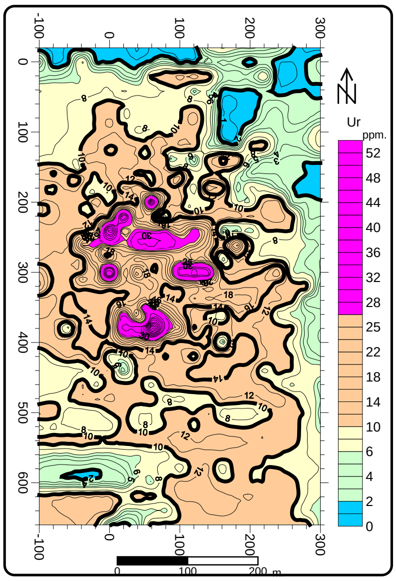


Fig. (6): Equivalent Uranium Contour map (in ppm), North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

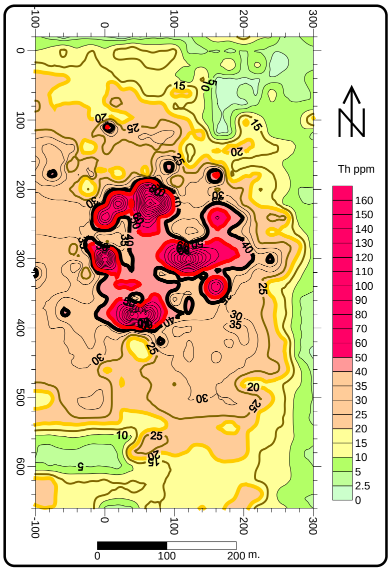


Fig. (7): Equivalent Thorium Contour map (in ppm), North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

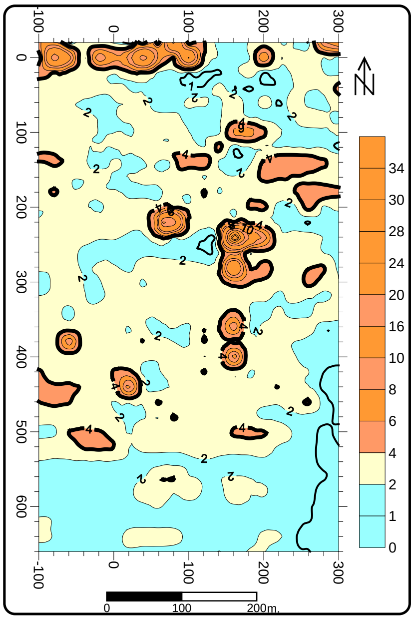


Fig. (8): eTh/eU Ratio Contour map, North Elerediya Granitic Pluton, Central Eastern Desert, Egypt.

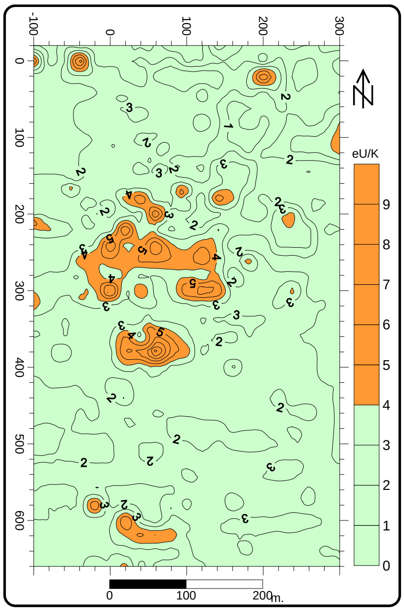


Fig. (9): eU/K Ratio Contour map, North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

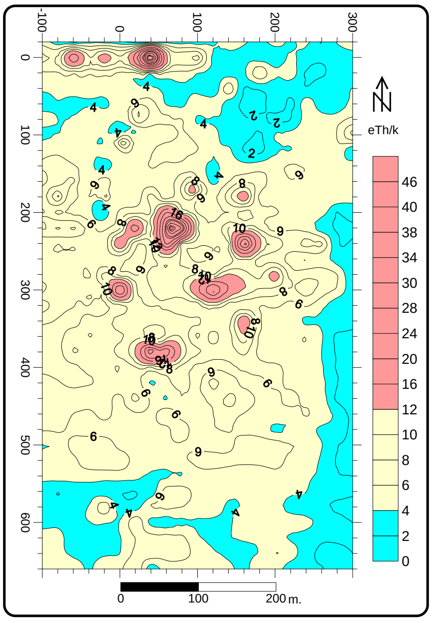


Fig. (10): eTh/K Ratio Contour map, North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

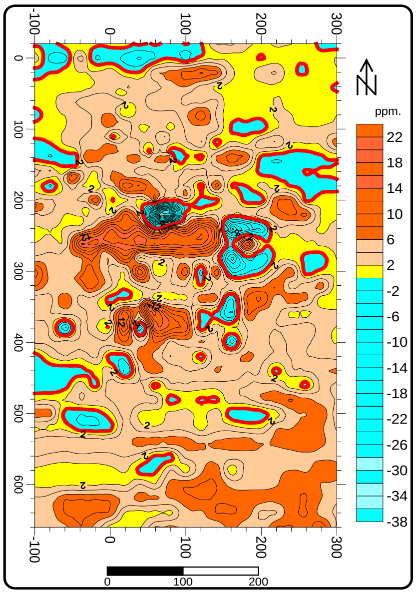


Fig. (11): eU-eTh/3.5 Contour map (in ppm), North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

Elkassas,(1974) measured the total count of this area and he reported that the mean of anomalous pink granite (X) = 79 µR/h (48.9 Ur) , while the mean for the granitized metavolcanics rocks along the contact zone (X) = 9.7 µR/h (6.0 Ur). It is clear also from this table that the equivalent thorium contents is greater than the equivalent uranium contents in most of lithologic units in the study area. As a result, the eU/eTh and eU/K ratios decrease in case of pink granite and anomalous zones, where thorium and potassium contents increase.

On the other hand, these ratios increase in the case of basic units and wadi deposits, where potassium and thorium contents decreased and the uranium contents may have increased as a result of uranium precipitation in these units. The pink granite in this study is relatively eTh-rich, as eTh/K ratio >5 while the eU/eTh <1, which means that this granite is relatively depleted in uranium according to Ong and Mior Shallehhuddin (1988), who reported that: if eTh/K ≥ 2 the rock is thorium rich, if eTh/K≤ 1, the rock is potassium rich and if eU/eTh and eU/K≥1, the rock is uranium rich. It is clear also from this table that the anomalous zones and pink granite have the highest dose rates among the other units.

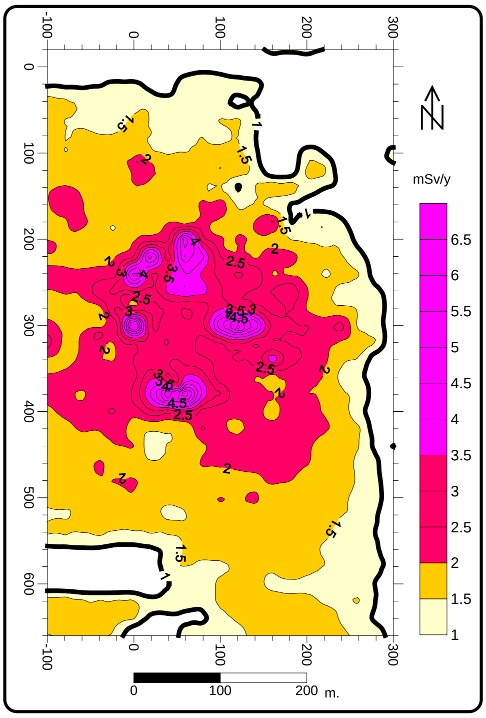


Fig. (12): Dos Rate Contour map in mSv/y, North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

- **Locating Favorable Areas for Radioelements Exploration:**

Although the principal of favourability index was based on data obtained from areas known to have workable uranium deposits in Canada, there is some logic for using it to throw light on areas without such high economic uranium contents. The histograms in (Figs. 13 a, b and c) show the vertical bar charts of radioelements favorability indices for the whole rock units forming north Elerediya granitic pluton.

A- Uranium favorable lithologic units

The rock units forming the studied area can be classified, based on their calculated uranium favourability indices, into three main groups of relatively low, medium and high potentials (Fig.13-a)

- Low potential: with a uranium favorability index value lower than 4.0 which includes basic dykes, metavolcanics, basic wadi sediments (mainly derived from metavolcanics) and granitized metavolcanics.

- Medium potential: with a uranium favourability index value ranging from 6.0 to < 10.0, which includes alluvium of granitic origin and acidic wadi sediments.

- High potential: With uranium favorability index value > 10.0, including pink granite and the anomalous zones in and around the trenches.

B- Thorium favorable lithologic units

The rock units forming the studied area can be classified based on their calculated thorium favourability indices, into three main groups of relatively low, medium and high potentials (Fig.13-b).

- Low potential: With a thorium favorability index value lower than 1.5 including basic dykes, metavolcanics, basic wadi sediments (mainly derived from metavolcanics) and granitized metavolcanics.

- Medium potential: With thorium favorability index value ranging from 1.5 to < 2.0 and includes anomalous zones and acidic wadi sediments (mainly derived from granites and silica veins and dykes).

- High potential: With a thorium favorability index value ≥ 2 and includes pink granite and alluvium granitic origin

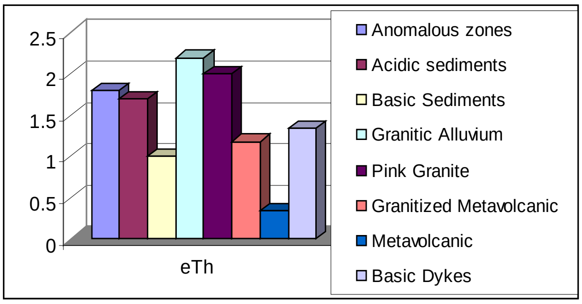
C- Potassium favorable lithologic units

The rock units forming the studied area can be classified based on their calculated K% favorability indices into three main groups of relatively low, medium and high potentials (Fig.13-c).

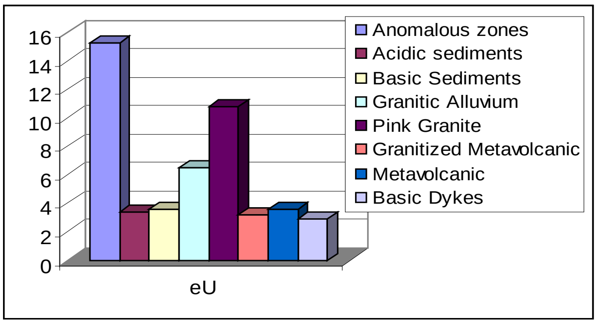
- **Low potential**: With potassium favourability index value lower than 14.3 and includes metavolcanics, basic dykes, basic wadi sediments (mainly derived from metavolcanics) and granitized metavolcanics respectively.

- **Medium potential**: With potassium favorability index value ranging from 14.3 to 37.3 and include acidic wadi sediments and alluvium granitic origin.

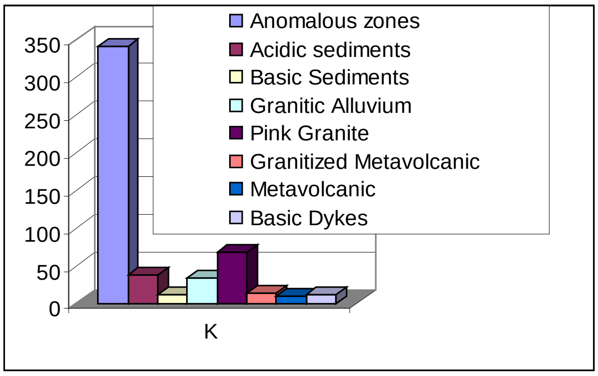
- **High potential**: With potassium favorability index value >37.3 and contains pink granite and anomalous zones in and around the trenches. They have values of 68.4 and 341 respectively.



C



B



A

Fig. (13):Histogram showing the favorability index of : K%, B- eU and C- eTh, North Elerediya Granitic Pluton, Central Eastern Desert , Egypt.

CONCLUSIONS

- The pink granite of the north part of Elerediya granitic pluton in the study area is relatively Th-rich, as Th/K ratio > 5 while the eU/eTh <1, which means that this granite is relatively depleted in uranium.

- The high potentiality of the three radioactive elements (eU, eTh and K%) are concluded as: high potential uranium: With uranium favourability index value > 10 including pink granite and the anomalous zones in and around the trenches. High potential eTh: With thorium favourability index value ≥ 2 and includes pink granite and alluvium granitic origin. High potential K%: With potassium favourability index value >37.3 and contains pink granite and anomalous zones in and around the trenches. They have values up to 68.4 and 341 respectively

- The migration of uranium is indicated in the study area, where the leached parts migrated out, they are found in some parts of the high radioactive anomalous zones (trench sites), while the precipitation parts or migrated in, represent most of lithologic units in the prospect area of study surrounding the anomalous zones. The precipitation processes increased along and around the lineament features as faults and fractures especially near the trenches and anomalous zones; it also increased on the alluvium granite in the northeast and southeast of the map

- The acidic lithologic units in the prospect area have radiation dose rate over the safety level (1 mSv/y according to the recommendation of (IAEA, 2000). The maximum dose rate readings are concentrated in the center of the studying prospect area, where the trenches and anomalous zones are found to reach about 7.1 mSv/y.

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