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GEOLOGIC AND RADIOMETRIC STUDIES OF SEDRI-UM TOMYEM AREA, SOUTHWESTERN SINAI, EGYPT

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الخلاصة: تعتبر رسوبيات حقب الحياة القديمة (الباليوزوي) التى تتكشف على السطح فى منطقة سدري–أم تميم جنوب غرب سيناء مهمة فى ضوء محتواها من الخامات المعدنية و التى تشمل خامات اليورانيوم و المنجنيز، و تتقسم رسوبيات الباليوزوى فى هذه المنطقة الى سبع تكاوين صخرية اساسية، وتترتب هذه التكاوين الصخرية الرئيسية من الأقدم إلى الأحدث كالآتى: ١– نسق الحجر الرملى الأسفل و ينقسم الى ثلاثة تكاوين رئيسية هى تكوين سرابيت الخادم، تكوين ابو حماطة و تكوين إعدادية. ٢– نسق أم بجمة والذى يضم ثلاثة أعضاء هى الأسفل و الأوسط و الأعلى. ٣– نسق الحجر الرملى الاعلى وينقسم الى ثلاثة تكاوين رئيسيه هم تكوين الحشاش، تكوين مغارة المياه و تكوين ابو زراب. يعتبر تكوين أم بجمة و تكوين الإعدادية هما الأكثر أهمية فى منطقة الدراسة لاحتوائهما على اليورانيوم بتركيز يصل الى ١٣٥٦جزء فى المليون فى تكوين أم بجمة.

وأظهرت خرائط أشعة جاما– الطيفى أن أعلى المستويات الاشعاعية تقع فى الجزء شمال غرب– جنوب شرق وبعض الأجزاء المتناثرة فى منطقة الدراسة وتكون غالباً مصاحبة لنسق أم بجمة . ومن خلال تفسير هذه الخرائط وجد أن منطقة الدراسة تظهر قراءات للعد الكلى مابين ٠,٨ إلى ٣٥ ميكرورونتيجن /ساعة ، وبوتاسيوم (٠,١ % – ٢,٥%) ، يورانيوم مكافىء (٠,١ جزء فى المليون – ٤٢ جزء فى المليون) ، ثوريوم مكافىء (٠,٧ جزء فى المليون – ٣٦ جزء فى المليون).. كما تم أيضاً دراسة بيئية من خلال حساب الجرعة الإشعاعية حيث وجدد أن منطقة الدراسة آمنة إشعاعياً وأقل من الحد المسموح به عالمياً وأن معدل الجرعات لا يسبب أضراراً للأفراد ولكن هناك بعض الأجزاء غير آمنة وربما تسبب بعض الضرر لمن يتواجد فى هذه الأماكن.

هذه الدراسة لفتت النظر إلى حوض سدرى والذى لم يأخذ الاهتمام من الدراسات الجيولوجية مثل غيره من الأحواض الأخرى الموجودة فى جنوب غرب سيناء مثل حوض بعبع وحوض نخل. هذا وقد سجلت الدراسة مكافىء اليورانيوم أكثر من ١٣٠٠ جزءا فى المليون فى تكوين أم بجمة لأول مرة .

ABSTRACT: *The Paleozoic basin exposed sediments in Sedri-Um Tomyem area is considered a part of a uranium promising district in the northern part of south Sinai. The study area is a part of this promising district. It is bounded by long. 33^o 21 ’ 09" - 33° 21 ’ 27" E and lat. 28° 53 ’ 08" - 28° 53 ’ 33" N. and classified stratigraphically into three main stratigraphic units that include from base to top, Lower Sandstone Series, Carboniferous Limestone Series (Um Bogma Formation), Upper Sandstone Series (Abu Thora Formation). The Lower Sandstone Series is classified into three formations from base to top as Sarabit El Khadim Formation, Abu Hamata Formation and Adedia Formation of the Cambro-Ordovician period. In the scope of uranium mineralization, Adedia and Um Bogma Formations have the priority and are considered the main target for uranium ore prospecting and exploration. The study area contains high content of uranium (more than 1300 ppm U), copper and iron-manganese minerals and other trace elements.*

The gamma-ray spectrometric survey has been conducted in the study area along a number of profiles directed N-S. The spacing between the survey lines was set at 50 m, while the interval between stations was 20 m, with a profile length of about 900 m. The gamma-ray spectrometric maps show different levels over the area, which reflect contrasting radioelement contents for the various exposed rock types. The highest radio-spectrometric levels are located along the northwest-southeast trend and of some scattered parts all over the study area. They are mainly associated with Um Bogma Formation outcrops. The area possesses gamma radiation ranging from 0.8 and 35.6 Ur as a total count, 0.1 to 2.5 % K^{40}, 0.1 to 42.3 ppm eU, 0.7 to 36.6 ppm eTh , in addition to some anomalous zones of uranium which show values greater than 1300 ppm eU. A uranium composite image map is constructed to identify and outline the uranium anomalous zones. This map indicates that seven anomalous uranium occurrence zones of relatively wide extension have been delineated and can, therefore, be used as exploration leads for additional uranium deposits.

INTRODUCTION

In previous studies**,** of the study area, the high U content was found associated with some facies as ,ferruginous siltstone, ferruginous sandstone, shale, carbonaceous shale, Fe-Mn ore, marl, gibbsite bearing sediments, and sandydolostone .In the present study the high U-content was found to be restricted within the carbonaceous shale and ferruginous sandstone of the lower member of Um Bogma Formation.

GEOLOGICAL SETTING

The study area which is considered a part of East Abu Zeneima area. This area is covered mainly with the Paleozoic basin exposed sediments which has some importance owing to its content of economic ores as cool, copper, manganese, kaolin, glass sands, rare earth elements and uranium. The topography of the study area reveals moderate to low topography and is covered in part with Precambrian younger granites while are partly overlain nonconformably by Paleozoic succession.

The Paleozoic outcrops of southwestern Sinai were subdivided by *Barron (1907)* into: Lower Sandstone Series, Carboniferous Limestone Series and Upper Sandstone Series. *Wiessbrod, (1969)* applied the term Um Bogma Formation to The Carboniferous Limestone Series of *Barron (1907)*.

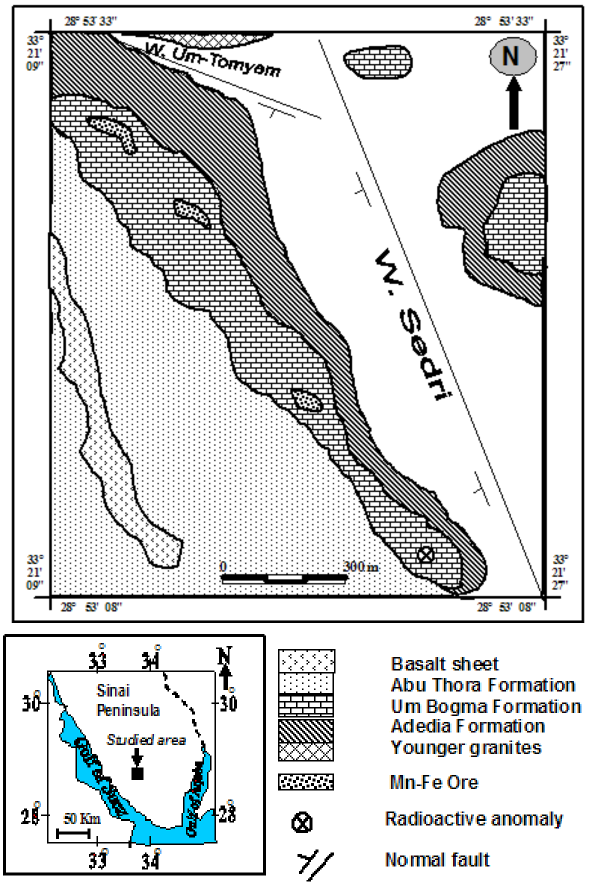

Fig. (1): Geological map of Sedri-Um Tomyem area.

Lower sandstone Series:

The Cambrian sediments of Lower sandstone Series are made up of clastic sequence underlying the Lower Carboniferous carbonate rocks in the region. These rocks were given the Cambrian age by *Wiessbrod (1969)*, and extended to cover the the Cambro-Ordovician age by *Isswai and Jux (1982)*. They are classified into three formations from base to top as Sarabite El Khadim Formation, Abu Hamata Formation and Adedia Formation. *Soliman and Abu El Fetouh (1969)* recorded a whole of thickness more than 25m (Fig. 2).

Sarabit El Khadim Formation nonconformably overlies a peneplained surface of the Precambrian granitoid rocks and conformably overlain by Abu Hamata Formation.

Sarabit El Khadim Formation consists of a basal conglomerate bed followed by rhythmic alteration of fining grain sandstone upward cycles which increases gradually from conglomerate, conglomeratic sandstone, pebbly sandstone, coarse-grained sandstone, fine-grained sandstone up to siltstone with red coloration. It reveals thickness about 5m and either trough and tabular stratification or tabular cross-bedding. The rock fragments and pebbles are mainly composed of quartzite and granite fragments.

Abu Hamata Formation conformably overlies Sarabit El Khadim Formation and conformably underlies Adedia Formation with thickness up to 12m. Abu Hamata Formation is a fossiliferous unit. Several fossils were recorded by several authors. These fossils comprise Trilobite tracks *(Wiessbrod, 1969, and El Agami, 1996)*, Skolithos and Cruzina *(Issawi and Jax, 1982)*, Arthropod Claw marks, Cruziana, Worm burrows and scribbling grazing traces *(Kora 1984)*. Lithologically, Abu Hamata Formation is subdivided into two parts, the lower part is mainly composed of successive fining upward cycles which consist of red-pink color sandstone, gravelly sandstones and siltstones, its appearance looks like chocolate. The upper part is composed of silty, very fine grained arkosic sandstone pinkish-white and greenish-white in color and micaceous shale layers appear at top of the formation. Some primary structures ware shown such as variety of ripple types and cross-bedding. The sediments of Abu Hamata Formation contain Mn and Cu mineralization.

Adedia Formation overlies Abu Hamata Formation and uncoformably underlies Um Bogma Formation. Its thickness reaches up to 8m. *Wiessbrod (1969)* assumed its age as Cambrian-Pre early Carboniferous. Adedia Formation is made up of coarse to fine grained, hard ferruginous sandstone, siltstone, pink to brown in color with tabular and trough cross-bedding. The copper mineralization (turquoise) is recorded in the upper part of the Formation. Also, Fe-Mn veinlets in addition to some radioactive anomalous spots were recorded in the Adedia Formation.

Carboniferous Limestone Series (Um Bogma Formation):

In the study area, Um Bogma Formation unconformably overlies Adedia Formation and underlies Upper Sandstone Series. It is considered the important Paleozoic rock unit in the study area due to its content of uranium, Fe-Mn ore deposits and secondary copper mineralization. It exhibits a thickness about 10m at the extreme north of the study area which gradually decreases to the south (Fig. 2). Several authors subdivided Um Bogma Formation into either four members *(Wiessbrod, 1969, and Mart and Sass, 1972)* or three members *(Omara and Concil, 1965, and Kora, 1984)*. In this article the authors agree with classification of Kora 1984 which is from base to top as:

1- The lower member is resting unconformably on Adedia Formation with distinguishable contact due to different lithology. It is enriched by manganese and iron ores. This member exhibits three different lithologic facies which include a) Mn-Fe ore, ferromanganese siltstone and silty shale facies with black, black brown and reddish brown colors; b) sandy dolomite facies, it is thickly bedded, of pink color and is sometimes horizontally laminated; c) black carbonaceous shale, siltstone facies which is considered more important facies for the uranium mineralization. It is usually of variegated colors, such as purple, yellow, yellowish green, brown and grey within the oxidation zone, but the dark gray to black color is dominant in the reduction zone. Uranium mineralization is developed by two modes of occurrence. The first, within the black shale, is found as clusters of crystals within scattered ambient spots. The second mode of occurrence is found within facies (a) and (b) and is well developed at the intersections of faults and in the interbedded fracture zone.

2- The middle member is composed of intercalations of marly dolostone, shale and siltstone with rhythmic variation beds of discontinuous carbonates interbedded with clastics with yellow earthy black colors and fossils content such as Corals, Crinoids, Brachiopods and Mollusca. The middle member is characterized by the distribution of the highly radioactive anomalous values in addition to evaporate minerals such as gypsum, anhydrite and halite minerals in fibrous and platy habits in the form of parallel veinlets and/or intersection with bedding planes. Also, white and black gibbsite horizon was observed at the boundary between middle member and lower member of Um Bogma Formation with highly radioactive anomalies.

3- The upper member is composed of yellow, pink, and grayish crystalline dolomite and minor sandstone. It conformably overlies the middle member and reveals cliff and step outcrop. The upper member of Um Bogma Formation can be lithologically subdivided into five lithofacies which include, a) medium crystalline dolomite facies, b) bio-dolosparite association facies, c) sandy oo-dolosparite association facies, d) quartz-wake association facies, e) quartz-arenite association facies.

Upper Sandstone Series (Abu Thora Formation):

Upper Sandstone Series in the light of uranium mineralization is considered less important than the lower part of the Paleozoic section in the area (Lower sandstone series and Um Bogma Formations) owing to its rare content of radioactive anomalies. It has oscillatory thickness ranging between 25m up and 40m (Fig. 2). It unconformably overlies Um Bogma Formation and is covered by basaltic sheet. Upper Sandstone Series is characterized by small scale sedimentary structures that include hummocky cross-lamination, small scale through cross-lamination, tabular cross-bedding, graded in the middle part of the section to the interbedded carbonaceous shale and kaolinitic clay with plant remains. Upper Sandstone Series was studied by *Soliman and Abu El Fetouh (1969)*. They subdivided it into three Formations comprising from base to top, El-Hashash, Magharet El-Maiah and Abu Zarab Formations described as the follows:

El Hashash Formation consists of brownish sandstone partly intercalating with very fine sandstone and claystone.

Magharet El-Meyah Formation consists of sandstone with claystone and carbonaceous shale and kaolin. Exploratory quarry of kaolin is found around the area at the end of Wadi Um Tomyem.

Abu Zarab Formation consists of white, semi friable, sandstone with siltstone and shale. This formatin is considered the main source of glass sand ore in Sinai. Abu Zarab Formation is locally capped by a basaltic sheet which metamorphosed the contacted underlying part to quartzite. The thickness of the basaltic sheet reaches to 5m.

Five lithostratigraphic sections were compiled for the study area (Fig. 2A) to shed light on the lithostratigraphic concept and correlate the thickness variation along N-S extension for the study area. The Lower Sandstone Formation is ranging in thickness from 15 to 25 m, which decreases toward the south. The Carboniferous Limestone Series (Um Bogma Formation) is ranging from 5 to 10 m and is also decreasing toward the south. On the other hand, the Upper Sandstone Series (Abu Thora Formation) is ranging from 25 to 40 m. finally; the basaltic sheet and sill reach about 5 m.

A new anomalous horizon:

During the previous exploration of U at the east of Abu Zenema district, high U anomalies at the north at Gabal Hazbar and Zobeir area were recorded as well as at the center as Allouga, Abu Thour, Talet Seleim, Nasib and Elsahu areas .On the other hand ,the present work discovered the new promising area at south of east Abu Zenema district (Sedri-Um Tomyem).

The anomalous horizon is located within the lower member of Um Bogma Formation (Fig. 2 B & C). The mode of occurrence shows a yellow mineral inside the cavities of fine grained sandstone. The high U-content (more than 1300 ppm) is recorded in this area for the first time by Gamma–Ray spectrometry model (RS 230.B.G.O)

These anomalies extended for more than 5 m in thickness and it needs more detailed studies and follows up of this promising horizon.

The anomalous horizon is very near to Wadi Sidri Um Tomyem (low topography) and lies within the downthrown side of Wadi Sedri normal fault (structural control). From the field observation, the high U values are restricted within the specific horizon, Um Bogma Formation (lithologic control). So, the factors affecting the deposition of U at the horizon are topography, structure and lithology.

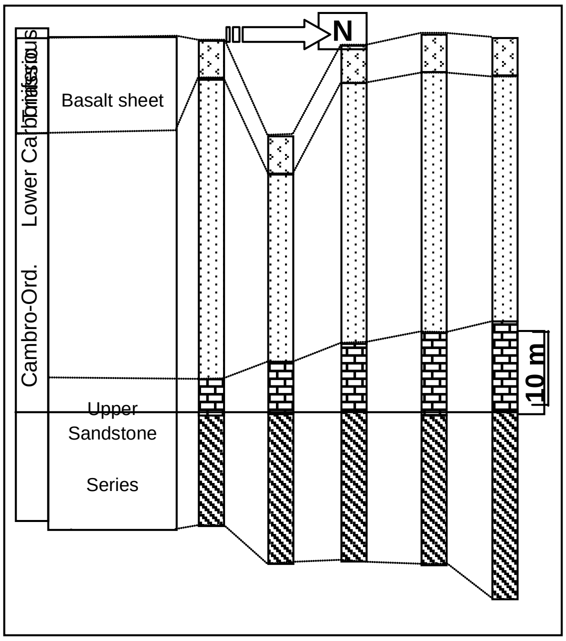

Fig. (2A): Lithostratigraphic correlation, Sedri-Um Tomyem area, Southwest Sinai.

(B)

(C)

(Fig. 2 B & C): Anomalies horizon at lower member of Um Bogma Formation at Sedri-Um Tomyem area. loking NW.

GROUND GEOPHYSICAL SURVEYS

Surveying for radioactive elements has become important owing to the demand for nuclear fuels. Radiometric surveying is employed in the search for deposits necessary for this application, and also for non-radioactive deposits associated with radioactive elements. Radiometric survey is a rapid and powerful tool providing information about the distribution and concentration of uranium (U), thorium (Th), and potassium (K^{40}).ref

Gamma ray is the most penetrating radiation from natural and manmade sources. Gamma ray surveys are used in several fields of science. They are used for geological, geochemical, environmental mapping, and allow the interpretation of regional features over large areas.

INSTRUMENTATION AND FIELD MEASUREMENTS

A systematic ground spectrometric survey has been performed on a grid pattern that consists of a set of parallel profiles trending N-S. The line spacing is 50 m, while the observations have been taken at 20 m intervals along the survey lines. The spectrometer used for natural radionuclide mapping monitor energy windows centered on the 1461 KeV (40K), 1765 KeV (214Bi) and 2615 KeV (208Tl) photopeaks for the estimation of K, U and Th concentration respectively *(IAEA, 1989)*. The instrument used in the study area for measuring the gamma radiation is (RS 230 B.G.O).

DATA INTERPRETATION

Qualitative Interpretation:

The gamma-ray spectrometric maps show different levels over the surveyed area, which reflect contrasting radioelement contents for the exposed various rock types. It is shown that the highest radio-spectrometric levels are trended NW-SE located within Um Bogma Formation and some scattered parts along the study area. They are mainly associated with the outcrops of Um Bogma Formation and its Mn-Fe ore occurrences.

1- Total-Count (T.C.) radiometric map:

The TC radiometric contour map (Fig. 3) shows a wide range of radioactivity oscillating from a very low level (blue colour) reaching 0.8 μR/h in value located at the western part of the investigated area to a very high (violet colour) level reaching 865.3 μR/h situated in the NW-SE part, with an average value of 33.2 μR/h (Table 2). Some of the delineated high radiometric anomalies are circular in shape and others are elongated.

The total-count (T.C.) radiometric colour contour map (fig. 3) was classified into three relative zones ranging from blue (lowest T.C.) to light violet (highest T.C.). These three relative zones of radioactivity could be described in the following:

Low radioactivity zone:

The low radioactivity level is encountered mainly at the western part of the study area, and coincides with outcrops of Abu zarab sandston and the overlaying basaltic cover. This level is coloured by blue (Fig. 3), and varies in radiometric intensity from 0.6 to 3.3 μR/h.

Intermediate radioactivity level:

The intermediate radioactivity level is located in the northern, western and southern zones and recorded mainly over Adadia Formation, and wadi deposits. It is coloured by green, yellow and orange (Fig. 3), and ranges in radioactivity from 3.3 to 7.6 μR/h.

High radioactivity level:

The high radioactivity level extends essentialy over Um Bogma Formation and some parts of Adadia and Magharet Elmiah Formations. It is represented by an elongated and circular anomaly zones. These anomalies are arranged in NW-SE trend. It is coloured by red and violet (Fig. 3) and attain in radioactivity more than 7.6 μR/h. There are some anomalous points which reach 865.3 μR/h. These anomalies are located inside the investigated area but not on the surveyed profiles.

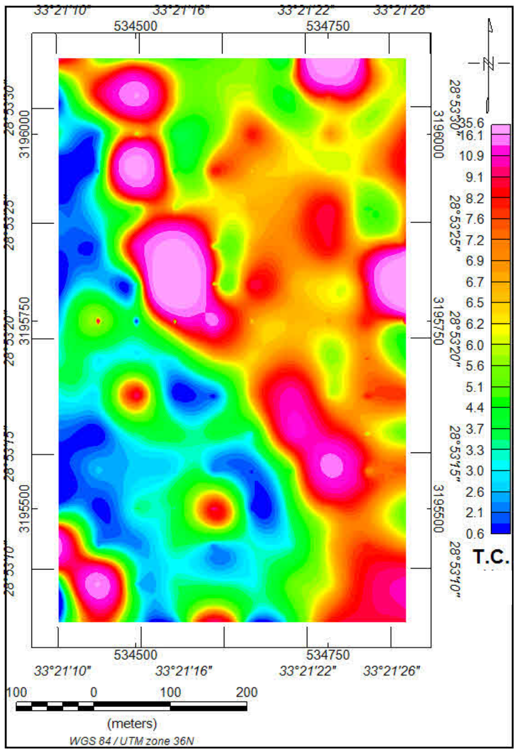

Figure (3): Total Count (T.C. in μR/h) colored contour map of the surveyed area.

Radiospectrometric map:

The potassium map (Fig. 4) shows that the study area is divided nearly into two parts, eastern side that reflects high K-content and the western that reflect the lowest K-content part. The values of K-content are varying from 0.1 % to 2.5 %, with an average value of about 1.5 % (Table 2). The highest values are located at the eastern side of the study area associated mainly with wadi deposits and lower Um Bogma Formation. Meanwhile, the lowest values are situated at the western side of the study area associated with ElHashash, Magharet Elmaiah and Abu Zarab formations . The K concentration map shows nearly opposite views to the other two γ-ray spectrometric (eU and eTh) maps.

2- Potassium content (K^{40} %):

The potassium content contour map (Fig. 4) was divided into three relative zones that change in colour from blue (low intensity), to red and violet (high intensity). These three relative and distinct levels can be described in the following:

Low K-content zone:

The low K zone is appearing as elongated trend parallel to the basaltic cover and some scattered parts coincide with outcrops of basalt and Abu Zarab formation. It ranges in K intensity from 0.1 to 0.2 %. This zone was coloured in blue.

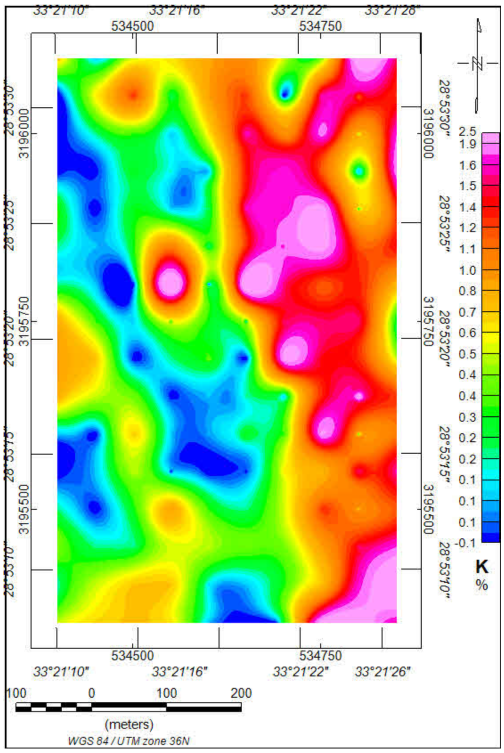

Figure (4): Potassium (K%) colored contour map of the surveyed area.

Intermediate K-content zone:

The intermediate K zone extents mainly along the Paleozoic rock units at the eastern side. This zone varies in K intensity from 0.2 to 1.2 %.

High K-content zone:

The high K zone mainly conforms with wadi deposits at the eastern side of the study area. This zone varies in K intensity more than 1.2 %.

3- Equivalent uranium (eU ppm) radiospectrometric map

The equivalent uranium content (ppm) of the study area reaches 1350 ppm in some spots (Table 1). The highest values are mainly located at the northwest part of the study area and some scattered parts which are associated with Um Bogma Mn-Fe ore bearing Formation. Meanwhile, the lowest values are observed at the western side associated mainly with Basaltic cover. The equivalent uranium content ranges from 0.1 ppm to 42.3 ppm with arithmetic mean 4.7 ppm (Table 2).

Table (1): Values of some high anomalous points in the study area.

X	Y	T.C. μR/h	K [%]	U [ppm]	Th [ppm]
534509	3195935	50.5	1	73.7	10.9
534533	3195886	27.7	0.8	26.2	33.6
534551	3195856	33.5	0.4	47.7	11.3
534555	3195860	41.9	0.7	58.6	15.1
534563	3195786	53.7	0.7	60.9	48.8
534564	3195787	63.5	1.2	77.1	45.6
534565	3195788	96.1	1.5	126.2	51.1
534594	3195761	89.1	0.4	122.9	40.7
534664	3195639	175.7	1.5	265.5	29.7
534709	3195581	469	5.6	724.5	39.6
534710	3195582	711.9	6.4	1106.7	55.8
534710	3195581	789.2	11.1	1217.2	61.8
534711	3195580	865.3	5.2	1356.8	57
534723	3195580	284.5	2.2	445	18.6

Table (2): Descriptive statistics of the ground gamma-ray spectrometric survey data, of the study area.

	T.C. Ur	K %	U ppm	Th ppm
Min	0.8	0.1	0.1	0.7
Max	35.6	2.5	42.3	36.6
Mean (X)	6.3	0.7	4.7	7.6
Standard deviation (S)	5.1	0.6	5.7	5.7
X+1S	11.4	1.3	10.4	13.3
X+2S	16.5	1.9	16.1	19
X+3S	21.6	2.5	21.8	24.7

The eU contour map (Fig. 5) can be separated into three zones ranging inrelative intensity from less than 1.5 ppm eU to more than 42.3 ppm eU. This division helped much in the interpretation of the eU radiospectrometric survey data. These relative and distinct three zones can be described in the following:

Low eU zone:

The low eU zone is located at the western side of the study area mainly related to basaltic outcrops. This level is coloured by blue (Fig. 5), and varies in eU intensity from less than 1.5 to 2.2 ppm.

Intermediate eU zone:

The intermediate eU zone is occuping a large part of Sedri-Um Tomyem outcrops at the eastern and central parts, related mainly to Paleozoic rock units and wadi deposites. This zone (Fig. 5) varies in eU intensity from 2.2 ppm to 5.3 ppm.

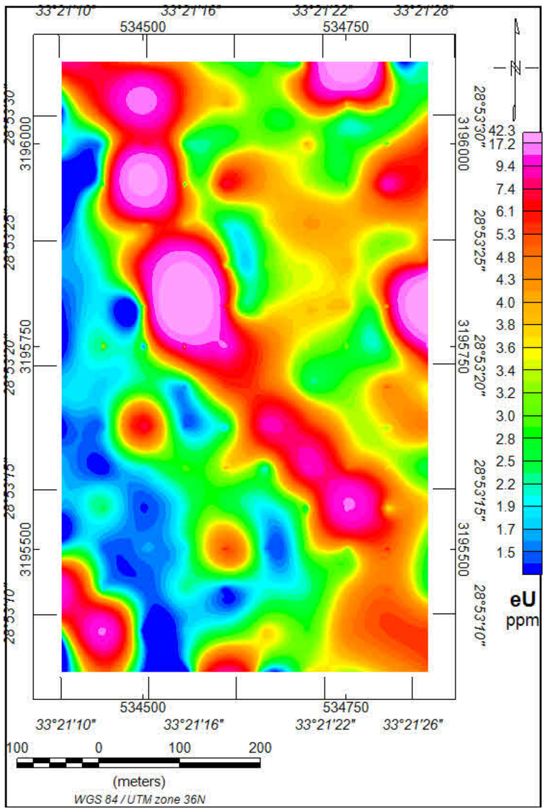

Figure (5): Equivalent uranium (eU ppm) colored contour map of the surveyed area.

High eU zone:

The high eU zone is arranged in NW-SE trend and some scattered anomalies across the study area. This zone is associated with Um Bogma formation and Fe-Mn bearing deposits .It varies in eU intensity from 5.3 ppm up to 42.3 ppm. There are some anomalous zones which are as high as 1350 ppm. These anomalies are located inside the investigated area but not on the surveyed profiles.

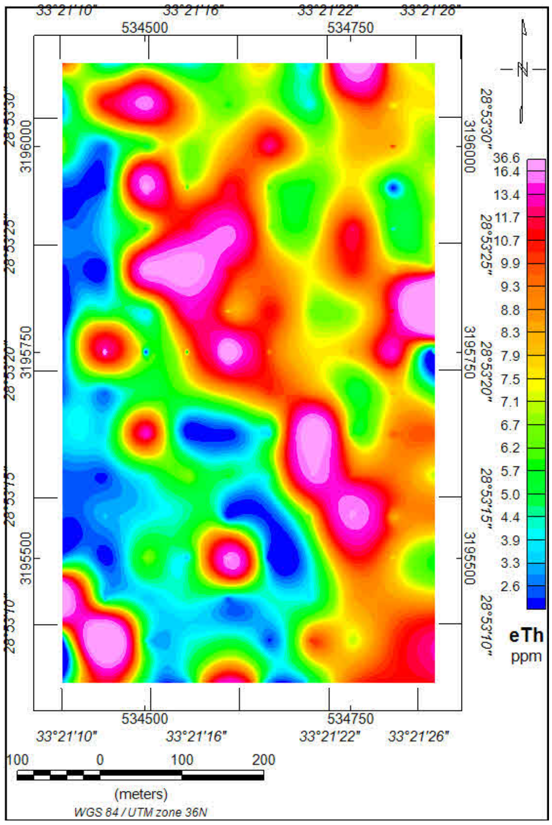

Figure (6): Equivalent thorium (eTh ppm) colored contour map of the surveyed area.

4- Equivalent thorium (eTh ppm) map:

Sedri-Um Tomyem area possesses also a wide range of eTh content varying between 0.7 ppm and 36.6 ppm, with an average value of about 7.6 ppm (Fig. 6). The highest eTh values are mainly observed at the Northwest Southeast trend and some scattered parts allover the area.

The eTh contour map could be classified into three remarkable and relative zones ranging in intensity between less than 0.7 ppm eTh and more than 36.6 ppm eTh, and in colour from blue to violet. These relative and distinct three zones are described in the following:

Low eTh zone:

The low eTh zone is encountered mainly at the western side of the study area, coincides with basaltic outcrops. some small scatter elongated shapes were found along the study area related to ElHashash, Magharet Elmaiah and Abu Zarab formations. This level varies in eTh intensity from less than 2.6 ppm to 4.4 ppm.

Intermediate eTh zone:

Most of the study area is occupied by the intermediate eTh zone. This zone is related to Abu Thora Fm, Adedia Fm and Wadi deposits, and varies in eTh intensity from 4.4 ppm to 9.3 ppm.

High eTh zone:

The high eTh zone which is arranged in NW-SE trend is mainly associated with Mn-Fe bearing deposits, representing part of Um Bogma formation. Some outcrops of Adedia formation., and Magharet El-Maiah formation represented by an elongated and rounded anomaly occurrences located in the southwestern and eastern parts of the study area. This zone has a radioactivity values greater than 9.3 ppm.

5- eU/eTh ratio map:

Ratios between radioelement concentrations (eU/eTh, eTh/K and eU/K) are often used to reduce the effect of terrain geometry on the estimated concentrations. Anomalous ratios are often indicative of mineralization and rock alteration. The difference in the absolute concentrations of the radio-elements between different geologic units or over homogenous ones can be highly variable and is dependent on a number of factors including the area of outcrop, topography, ground moisture, inversion trapping of radon, the distance (both horizontal and vertical) between an exposure and a survey line, and others. The ratios of the observed radioelement concentrations are much less affected by the above mentioned factors and are better indicators of preferential accumulation. Inspection of ratios greatly aid in Uranium and/or thorium anomalies identification by overburden *(Boyle, 1982).*

The eU/eTh ratio map (Fig. 7) exhibits values varying between 0.04 and 4.75 with an average value of about 0.69. This ratio is important for uranium exploration because it determines the uranium-enriched areas. The high eU/eTh values (> 1) are distributed allover the area with variable sizes and amplitudes. These anomalies are arranged in the NW-SE trend parallel mainly to outcrops of Um Bogma Fm. These anomalies may be the result of enrichment of uranium which has higher mobilization than thorium.

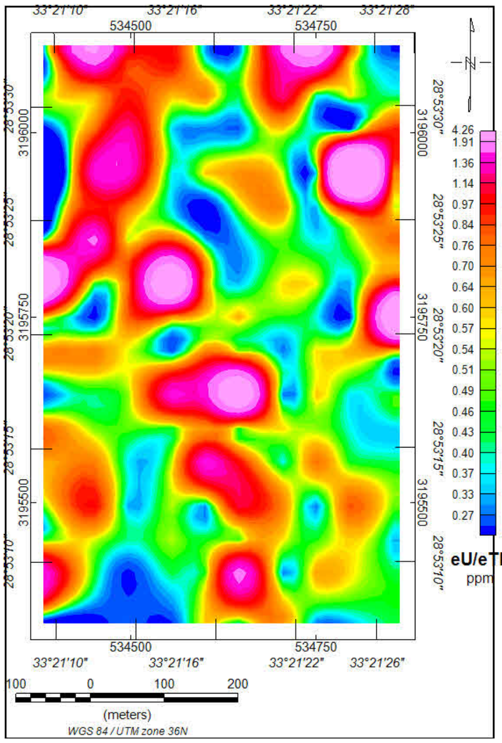

Figure (7): eU/eTh ratio colored contour map of the surveyed area.

Outlining of uranium anomalous zones:

Combination of two or more data sets into a single display creates composite colour images. Such images facilitate the spatial correlation of features in the various input data sets *(Broome, 1990)*. The most common type of image is a colour-coded intensity image produced by assigning different colours to grid cells based on the magnitude of the geophysical parameter. The human visual system is more adapt at interpreting images than the analysis of line drawings and the interpretation of values associated with these lines *(Gibson, 1992)*. Displaying geophysical data in image form can often reveal information that is hidden in contour or profile maps *(Cordell and Knepper, 1987)*.

The standard image processing technique can be applied to the geophysical data sets produced from gamma-ray spectrometric data and illustrates the synthesis of these multi-source geophysical data into a composite colour images. These images have been compared with each other and with the geologic map of the study area to evaluate their effectiveness for displaying the geological and geochemical relevant content of the data sets. It can also provide the interpreter with a useful synthesis of the data that can be used to aid mineral exploration in the area under consideration.

The examination of high regions of eU, eU/eTh and eU/K indicates uranium enrichment over the other two natural radioelements (eTh and K). As for economic potential, the most promising uranium anomalies should have a high eU abundance coinciding with high eU/eTh and eU/K ratios *(Saunders and Potts, 1976)*. Accordingly, a uranium composite image map (Fig. 8) is constructed to identify and outline the uranium anomalous zones. The red, green and blue (RGB) colour combination has been used to produce these composite images.

The absolute radioelement composite image map (Fig. 8) generated from the gamma-ray spectrometric data of K in red color, eU in blue color and eTh in green shows variations occurring in the three radioelements. From radioelement composite image map a blue trend in the NW-SE direction reflect high concentration of eU than the other two radioelements eTh and K, beside this trend there are some scatter white areas reflect high concentration of three radioelements.

The eU composite image map (Fig. 8) can provide useful information regarding the identification of anomalous zones of enriched uranium concentration. This map combines eU (in blue) with the two ratios eU/K (in red) and eU/eTh (in green). Uranium anomalous zones, displayed as white portions on the uranium composite image map. These uranium-enriched sites offer good prospects for uranium, since their relatively high concentrations of uranium with respect to both potassium and thorium are important diagnostic factors in the recognition of possible uranium deposits *(IAEA, 1988)*. This map shows the following:

1) The white (high) regions are mainly associated with the outcropping of Um Bogma Formation.
2) Seven anomalous uranium zones are mainly observed in the study area. So, these zones can be interpreted as reflecting good geochemical environments favorable for the formation of uranium deposits and can, therefore, be used as exploration guides to search for additional uranium deposits *(Duval, 1983)*.

From the potassium composite image map (Fig. 9) K is represented in red with the two ratios K/eU in blue and K/eTh in green. The anomalous zones on potassium composite image appear as light colour which may be reflecting alterations zone. These zones do not coincid with high zones of eU and eTh. It is associated with wadi deposits.

The Thorium composite image map (Fig.9) shows eTh in green with eTh/eU in blue and eTh/K in red. There are some small and scatter green zones which reflect high concentration of eTh than the other two ratios. The light zones which reflect the concentration of three ratios coincides with the trend of Um Bogma formation.

Quantitative Interpretation:

The data acquired by the spectrometric gamma ray method applied in the study area has been subjected to quantitative statistical analysis in order to draw a valid conclusion regarding the nature and significance of the distribution of the radioelement in it. The applied statistical analysis includes bivariate statistics.

Table (3): Matrix of correlation coefficients of the seven radio-spectrometric data variables area, of the study area.

	T.C.	**K[%]**	**eU**	**eTh**	**eU/eTh**	**eU/K**	**eTh/K**
T.C.	1.000						
K[%]	0.352	1.000					
eU	0.936	0.127	1.000				
eTh	0.820	0.216	0.628	1.000			
eU/eTh	0.215	-0.190	0.444	-0.173	1.000		
eU/K	0.382	-0.454	0.519	0.310	0.522	1.000	
eTh/K	0.221	-0.443	0.200	0.485	-0.060	0.673	1.000

Comparative examination of the results of bivariate correlation indicates that:

1. Significant positive correlations (direct relationships) differ in values exist between t.C. and other six variables.
2. Significant negative correlations (reverse relationships) exist between K. and eU/eTh, eU/K and eTh/K range from low to moderate.
3. Significant positive correlations exist between eU and the other variables.
4. Significant positive correlations exist between eTh and other variables expect eU/eTh where negative correlation between them.

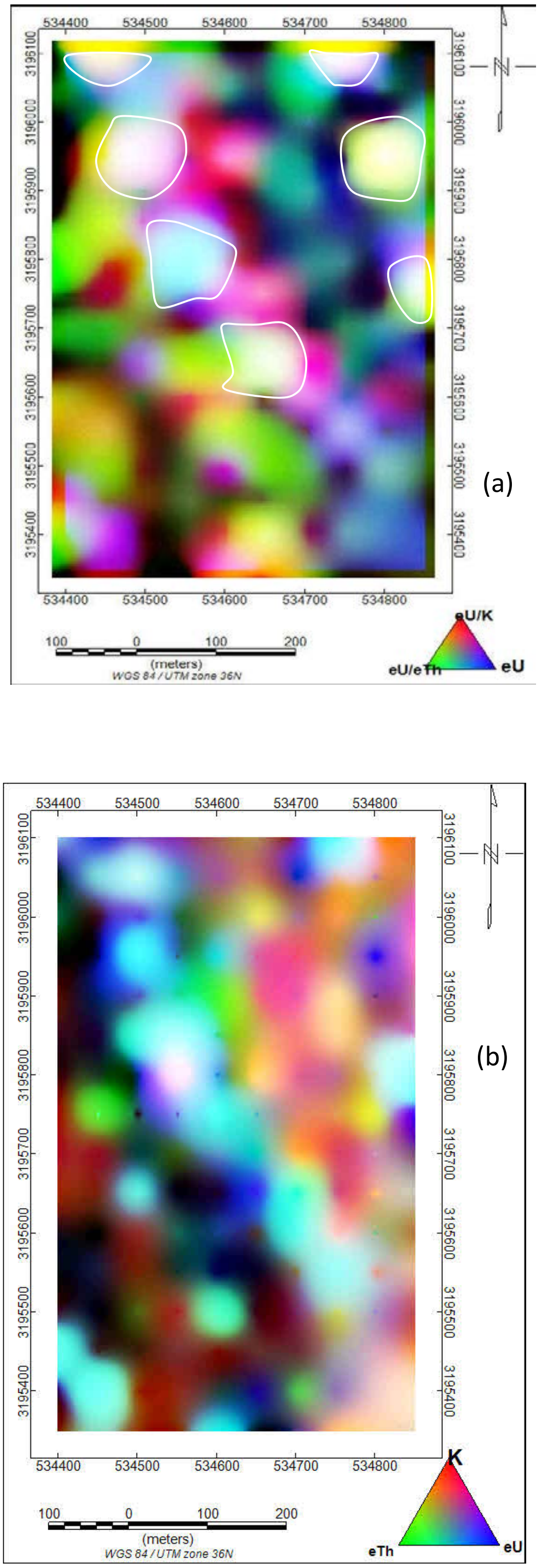

Figure (8): (a) eU False colour composite image (b) Radioelement False colour composite image, Sedri-Um Tomyem area,Southwestern Sinai, Egypt.

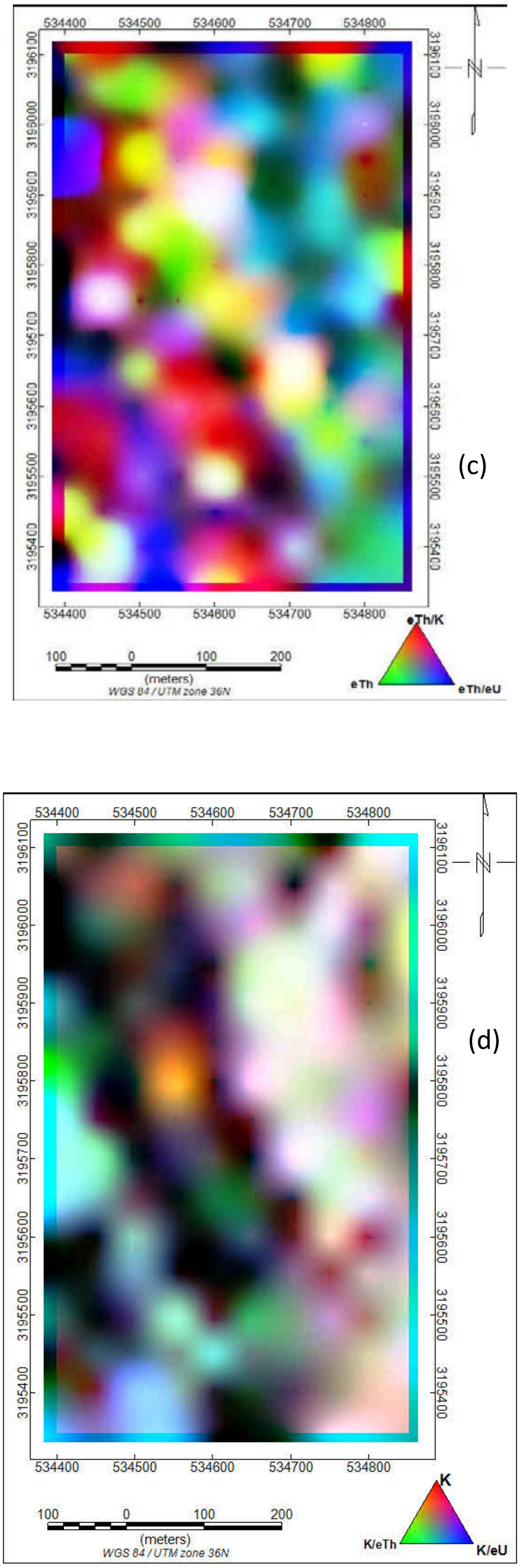

Figure (9): (c) eTh False colour composite image (d) K False colour composite image, Sedri-Um Tomyem area, Southwestern Sinai, Egypt.

ENVIRONMENTAL IMPLICATIONS

Radioactivity is a part of our physical environment. The largest contribution to the radiation field is of natural origin; it is due to cosmic rays, the natural radioactivity of the ground, and the radioactive decay products of radon in the air. Artificial radioactivity is emitted by nuclear power plants, industrial plants, and some research laboratories. These emissions are very small in normal operation, although large amounts of radioactivity can be released to the environment through accidents *(Sharma,1997).*

The radiation dose absorbed by the body tissues is of prime interest in health physics. The absorbed dose defines the energy that is transferred to the body and is measured by the unit Gray, rad, or Sievert. Since the emission of alpha particles (by radon and other nuclides) can have harmful health effects, the working level (WL) is used to define the total alpha energy to which the body is exposed *(Sharma, 1997).*

A knowledge of the environmental background level of the natural radiation, its nature, and its variability is, for various reasons, of considerable interest. This knowledge is essential for the evaluation of the human exposure to such radiation and for researching on its pathological effects. It also provides a basic information that can be used as a reference to detect and determine the amount and extent of any possible future changes in the environmental radioactivity.

Radiation Exposure Rate (RER) and Equivalent Radiation Dose Rate (ERDR)

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

$$E\ (\mu R/h) = 1.505\ K\ (\%) + 0.653\ eU\ (ppm) + 0.287\ eTh\ (ppm)$$

The radiation exposure rate can be converted to equivalent radiation dose rate through the use of the following relation *(Grasty et al., 1991)*:

$$\text{Dose rate (mSv/y)} = 0.0833 * E\ (\mu R/h)$$

Consequently, the radiation exposure rate and equivalent radiation dose rate maps are constructed as shown in figures (10&11). The radiation exposure rate (RER) map of the study area (Fig. 10) varies in values from less than 1.6 to 36.1 µR/h. However, the equivalent radiation dose rate (ERDR) map of the study area (Fig. 11) varies in intensity from less than 0.1 mSv/y to 3 mSv/y. This map shows the same features of the radiation exposure rate (RER) map.

The International Commission of Radiological Protection (ICRP) has recommended that, no individual should receive radiation dose which exceeds one millisievert per year *(IAEA, 2000).*

Most parts of the study area remain on the safe side and within the maximum permissible safe radiation dose, without harm to the individual, but there are some parts which show values of more than 1.0 mSv/y (nearly 3), and may cause some harm for population living in these places. These places are mainly covered by Um Bogma Formation.

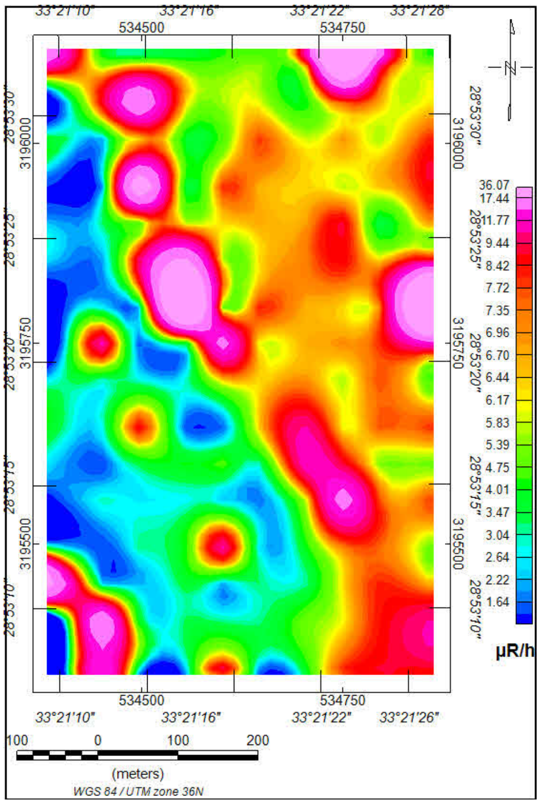

Figure (10): Exposure rate in µR/h Colour Contour Map of the surveyed area.

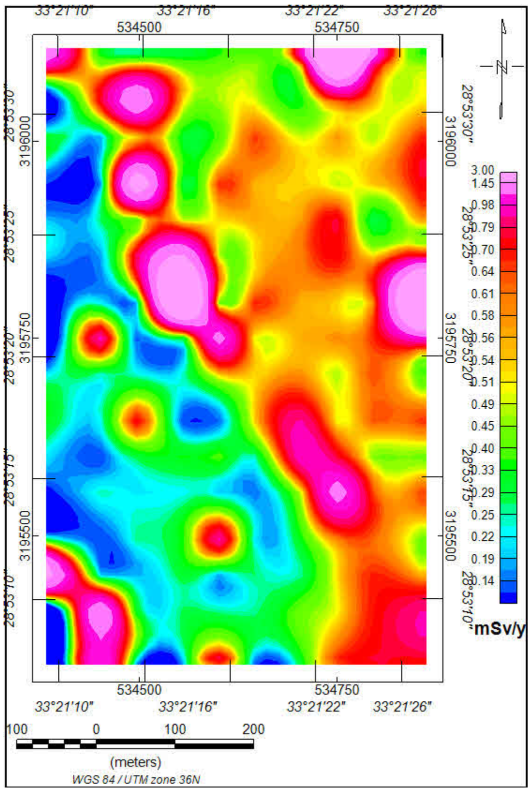

Figure (11): Dose rate in mSv/y colour contour map of the surveyed area.

CONCLUSION

The stratigraphic section within the investigated area has three main rock units. Each rock unit is subdivided into three Formations. The major rock units include from base to top, i): Lower Sandstone Series given Cambro-Ordovician age and is subdivided into three formations from base to top as Sarabite El Khadim Formation, Abu Hamata Formation and Adedia Formation, ii): Carboniferous Limestone Series (Um Bogma Formation) given Lower Carboniferous age and is subdivided from base to top into three members as Lower member, middle member and upper member, iii): Upper Sandstone Series (Abu Thora Formation) given Lower Carboniferous age and is subdivided into three formations from base to top as El Hashash Formation, Magharet El-Maiah, Formation and Abu Zarab Formation. Um Bogma Formation and Adedia Formation are the most important for uranium mineralization in addition to Fe-Mn ore restricted to Um Bogma Formation in the area.

The gamma-ray spectrometric maps show that the highest radio-spectrometric levels are located in the eastern side and some scattered parts along the study area. They are mainly associated with Um Bogma Formation. Therefore, Um Bogma Formation is considered the main target for uranium exploration. The interpretation of gamma-ray spectrometric data indicated that the study area possesses gamma radiation ranging between 0.8 and 35 Ur as a total count, 0.1 to 2.5 % for K, 0.1 to 42 ppm for eU and 0.7 to 36 ppm for eTh. Environmentally the area as a whole remains safe side as far as the radiation dose rate is concerned, and remains below the maximum permissible safe radiation dose rate of more than 1.0 mSv/y, mainly associated with Um Bogma Formation which may cause some harm for population living in these places.

This study should attract the attention of researchers to this Sedri basin as a promising uranium prospect area, in view of the high eU disclosed level of more than 1300 ppm, as a new finding.

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