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ENVIRONMENTAL MONITORING OF RAMLET HOMAYYER AREA, EAST ABU-ZENEIMA, SOUTHWESTERN SINAI, EGYPT

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الرصد البيئي لمنطقة رملة حمير ، شرق ابو زنيمة ، جنوب غرب سيناء ، مصر

الخلاصة: تقوم هيئة المواد النووية بإجراء مسح إشعاعي جوي طيفي لبعض المناطق في جمهورية مصر العربية من أجل تحقيق هدفين: الكشف عن مناطق جديدة لوجود العناصر المشعة ومسح الأثر البيئي لهذه العناصر علي سكان هذه المناطق ، وهو ما حدث في هذا البحث. بعد المسح الجوي لهذه المناطق يتم اختيار المناطق ذات الشاذات المرتفعة ومن ثم يتم تتبع هذه الشاذات الاشعاعية علي الارض حتي يتم التحقق منها وتحقيقها.

من هذه المناطق التي تمت دراستها رملة حمير ، التي تقع بين خطي طول ٣٣° ٣٠′ ٣٠″ شرقًا و ٣٣° ٣٢′ ٣٠″ شرقًا وخط عرض ٢٩° ٠′ ٣٠″ شمالاً و ٢٩° ١′ ٣٠″ شمالاً. في هذا البحث ، تم الانتهاء من المسح الأرض باستخدام مطياف أشعة جاما GS-512 على طول خطوط مسح في اتجاه شمال جنوب.

تبلغ القيمة القصوى لليورانيوم المكافئ ٢٩° (eU) والثوريوم والبوتاسيوم (K) وإجمالي العد حوالي ٨٤,٠ جزء في المليون و ٦٨,٩ جزء في المليون و ١٦٪ و ١٠١ على التوالي.

يختلف معدل التعرض في القيم من ٦,٦ ميكرورونتيجن / ساعة إلى ١٣١,٨ ميكرورونتيجن / ساعة ، بمتوسط حسابي ١٠,٤ ميكرورونتيجن / ساعة يختلف معدل الجرعة في القوة من ٠,٥ ملي سيفرت / سنة إلى ١٠,٩ ملي سيفرت / سنة ، بمتوسط حسابي يصل إلى ٠,٨ ملي سيفرت / سنة.

ABSTRACT: *The Nuclear Materials Authority (NMA) is carrying out a spectral aerial radiation survey of some areas in the Arab Republic of Egypt in order to achieve two objectives: the detection of new areas for the existence of radioactive elements and environmental impact survey of these elements on the inhabitants of these areas, which is what happened in this area. After the aerial survey of these areas, the locations with high anomalies are tracked on land until they are verified and assessed.*

One of these areas studied is Ramlet Homayyer, which is located between longitudes 33º 30′ 30″ E and 33º 32′ 30″ E and latitudes 29º 0′ 30″ N and 29º 1′ 30″ N. In the current study, ground survey was performed using GS-512 gamma rays spectrometer along N-S profiles, with average length of about 2.5 km.

The maximum values of equivalent uranium (eU), equivalent thorium, potassium (K) and Total-Count are approximately 84.0 ppm, 68.9 ppm, 16.0% and 101.3 Ur, respectively.

The exposure rate varies in values from 6.6 mR/ h to 131.8 mR/ h, with an arithmetic mean 10.4 mR/h. The dose rate varies in strength from 0.5 mSv/y to 10.9 mSv/ y, with a computed arithmetic mean reaching 0.8 mSv/ y.

1. INTRODUCTION

An airborne geophysical survey of a part of Sinai was conducted by NMA in Egypt in 1998 (Fig. 1). It included gamma ray spectrometric survey, with two main goals: the discovery of new sites for potential radioactive deposits and the second is to study the environmental impact of radiation on the citizens of these Bedouin regions and this is what we will try to study in this paper. Accordingly, Ramlet Homayyer (RH) area was chosen as a promising target for uranium mineralization (Fig. 1). Hence, ground geophysical follow-up survey was performed to cover this area.

RH area is located on the eastern coast of Gulf of Suez, Egypt (Fig. 2). The Paleozoic rocks of the area are subdivided into seven formations, which are (from the newest to the oldest), Abu Zarab, Magharet El Maiah, El Hashash, Um Bogma, Adedia, Abu Hamata and Sarabit El Khadim, which were carefully studied to discover and exploit any economic minerals.

Regional Geology

RH area and its surroundings range from Precambrian to Quaternary (Fig. 3). The Precambrian includes granites and granodiorites. The Paleozoic rocks consist of seven formations. The basaltic sheets and dykes are related to the Mesozoic; besides, Upper Cretaceous and Eocene rocks are exposed near the study area.

Um-Bogma formations have unconformity surfaces with their lower and upper formations (Soliman, M.S. and Abu El-Fetouh M.A., 1969, Alshami A. S., 2003 and 2018 b). The major rock kinds in study area are sandstones, siltstones, shales, the conglomerates are associated with Paleozoic (Fig. 4), where Farsh Elazrag volcanics to the Triassic-Early Jurassic.

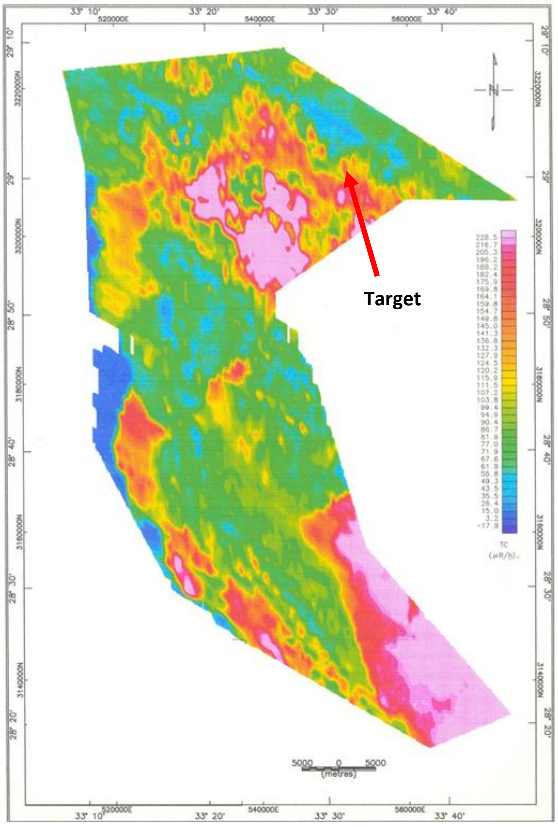


Fig. 1: Total-Count radiometric map of Abu-Zeneima / Al-Tur area, Southwestern Sinai, Egypt (NMA, 1998).

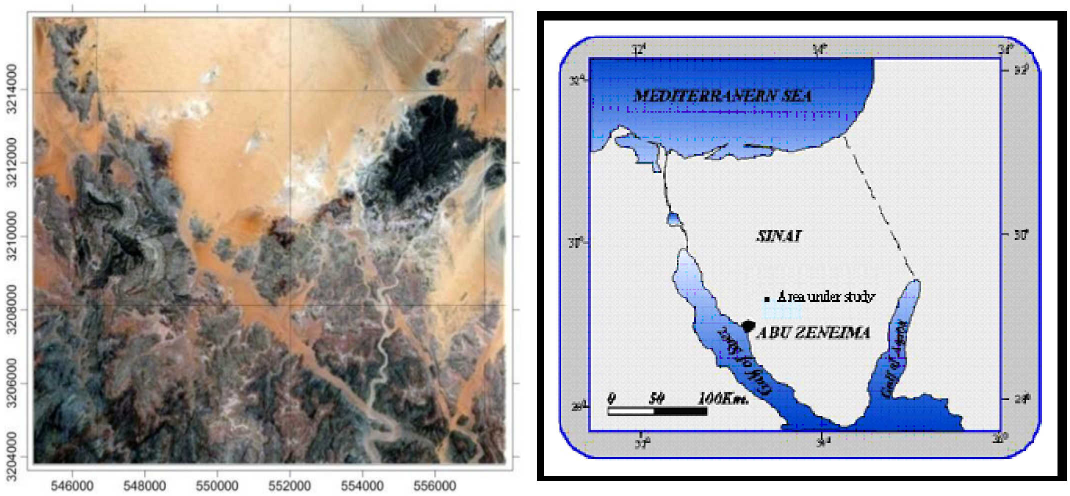


Fig. 2: Location map of the Ramlet Homayyer area, and the Geomorhological features of the region according to Earth Google East Abu-Zeneima city, Southwestern Sinai, Egypt.

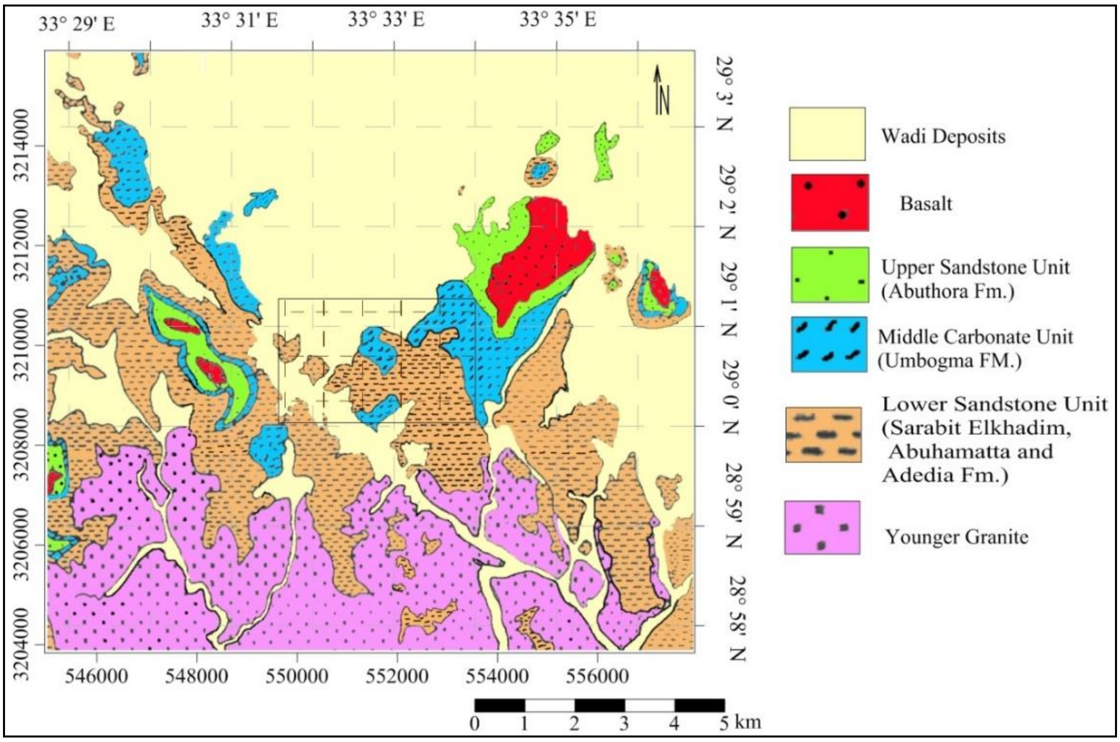


Fig. 3: Regional geological map of Ramlet Homayyer area, Southwestern Sinai, Egypt.

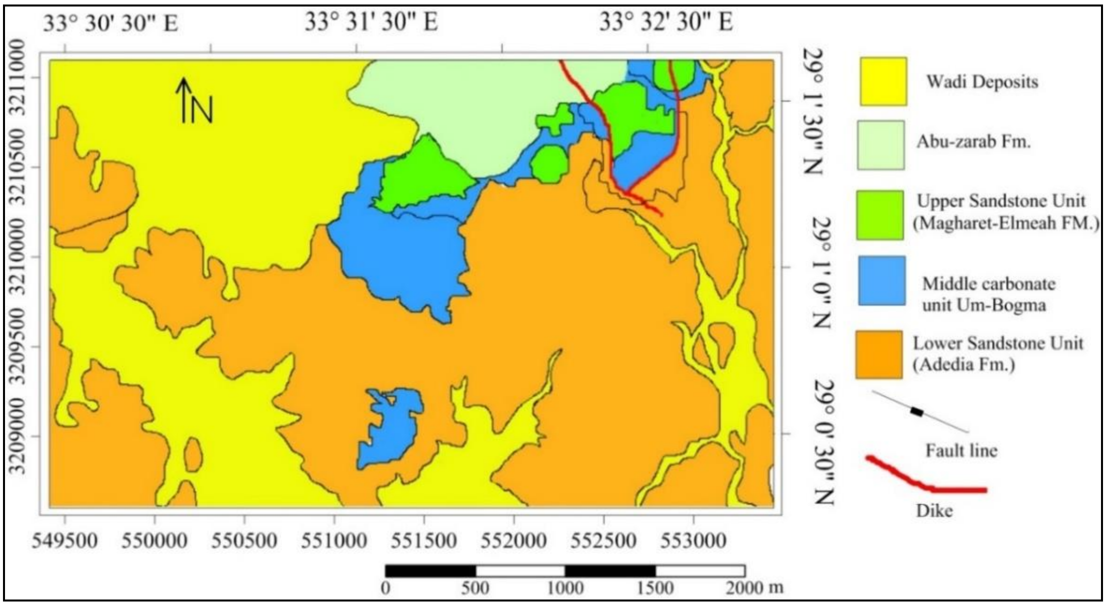


Fig. 4: Detailed geological map of Ramlet Homayyer area, Southwestern Sinai, Egypt.

In the northwestern part, basement rocks are mainly covered by El-Adedia Formation. In some other parts, the Adedia formation is overlain by either black shales equivalent to Um-Bogma Formation, or Abu-Thora Formation.

GROUND RADIOSPECTROMETRIC SURVEY

The main goal of gamma-ray spectrometric survey is to locate anomalous gamma radiation fields. The gamma-ray spectrometry technique is simply to move the convenience spectrometer system through the area of interest This can be done systematically in a grid pattern for exploration and mapping purposes (IAEA, 1979).

Gamma-ray survey were Implemented using a mobile gamma-ray spectrometer, model GS-512, manufactured by Geofyzika Brno, Czeck Republic, calibrated using NMA's locally constructed calibration pads of the NMA of Egypt. The survey was completed along profiles, N-S oriented with an average length of 2.5 km, to cover a surface area reaching nearly 10 km^2. The space between the profiles ranged from 20 m to 50 m, according to the importance of the area and its topography, when in the interval between the stations is 20 m perpendicular to the strike of the general geologic trend of the area. The obtained data were reduced and represented as colored contour maps.

INTERPRETATION OF THE RESULTS

Qualitative interpretation

The qualitative interpretation of the γ-ray survey data is mainly concerned with the visual inspection of the colour contour maps of the measured radioelement concentrations as well as the total-count radioactivity. This inspection aims to classify the study area into zones, based on the contrasts in their spectral γ-ray emission response levels.

Total count (T.C.) radiometric values range from 1.0 Ur to 58.6 Ur. The high anomalies differ in shape from circular to extended. Their trends are NNW, N-S and NW trends. There are some very high spots representing significent anomalies,which range from 140 to 375 Ur approximately. K content ranges from 1.0 % to 16.0 %. The maximum value of eTh is about 57.3 ppm, while the minimum value is 1.0 ppm. The minimum eU value is 1.0 ppm, while the extreme value is up to about 51 ppm. There are some other point anomalies which coincide with corresponding T.C. anomalies ranging from about 130 to 346 ppm. (Alkhateeb et al., 2019)

Quantitative interpretation

Composite false-colour images

composite color images are produced from a data set grouped together in one screen, which facilitates the in-situ linking of features in different input data sets (Broome, 1990). The best image is the image that is produced by specifying different colors for grid cells based on data values. The interpretation of images is easier than analyzing the line drawings and interpreting the values associated with these lines (Gibson, 1992).

The composite image map (Fig. 5), created from K, eU and eTh data, shows diversity of the three radioelements and provides, in one view, a total picture of the distribution of radioelements in the study area. In the triangle legend (eTh in blue, eU in green, and K in red), at every angle the color indicates 100% of the radioelement.

The colors inside the triangle at each point represent different proportions of the three radioelements. This image reflects lithologic differences based on colour variations. The areas of the observed radioelements display a clear spatial correlation with the lithology map (Fig. 4). lithological contact derived from the geological map are defined on the radioelements composite image with good agreement with the mapped units which can be seen in many sites of the study area. These agreements point out that the resulting radioelement concentrations are usually representative of the underlying lithology.

Specific activity transformation

Specific activity (activity per unit mass) is the number of atomic decays per unit time per unit mass. It is used to describe the contents of radionuclides for rocks and building materials (IAEA, 2003). It is expressed in Becquerel per kilogram. Potassium (K, %), equivalent uranium (eU, ppm) and eTh (ppm) in the investigated areas were transformed into specific activities, using factors in Table1, as recommended by the International Atomic Energy Agency

Table 1. Transformations of radioelement concentrations into specific activities

1 % K in rock	313 Bq kg^{-1} ^{40}K
1ppm U in rock	12.35 Bq kg^{-1} ^{238}U
1ppm Th in rock	4.06 Bq kg^{-1} ^{232}Th

Effective dose rate conversions

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).

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):

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

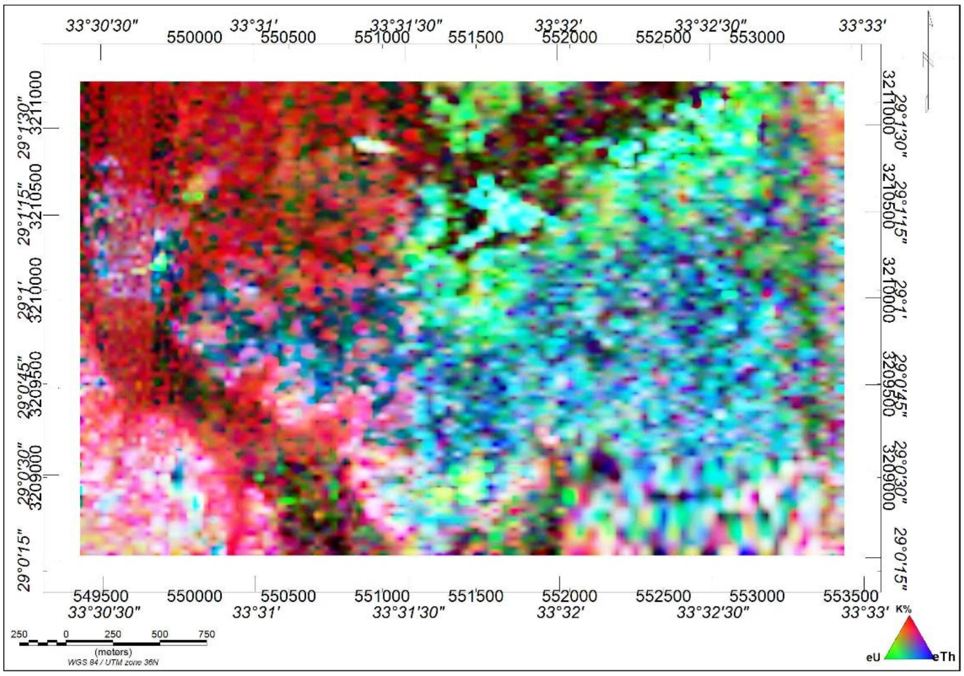


Fig. 5: Composite image map of (K, eU and eTh) in (R:G:B) of of Ramlet Homayyer area, Southwestern Sinai, Egypt.

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

Dose rate (mSv/y) = 0.0833 * E (μR/h)

Table 2. Computed statistical characteristics of specific activity and equivalent dose rate of Ramlet Homayyer area, East Abu-Zeneima, Southwestern Sinai, Egypt. Egypt.

Variable	Min.	Max.	$\overline{X}$	S	$\overline{X}$+3S
K (activity) (Bq kg^{-1})	375.6	5101.9	728	210	1358
eU activity (Bq kg^{-1})	12.35	4276	47.6	59	224.6
eTh activity (Bq kg^{-1})	37.4	279	63.4	17.3	115.3
Exposure Rate (mh^{-1})	6.6	131.8	10.4	2.9	19.1
Effective dose rate (mSv y^{-1})	0.5	10.9	0.8	0.24	1.52

Min, minimum; Max, maximum;X; arithmetic mean and S, standard deviation

For employees who are exposed to NORM (Naturally Occurring Radioactive Materials) sources of radiation as a result of their regular duties, doses should not exceed a total effective dose of 100 mSv over a 5 year period with a maximum dose of 20 mSv in 1 y. Incidentally, workers at risk are employees whose regular duties do not include exposure to natural radiation sources. They are considered members of the public who work in an occupational exposure environment. The dose limit for these workers, as well as other members of the public, is 1 mSv y^{-1} (Canadian NORM Working Group).

Gama-Ray Specific Activities

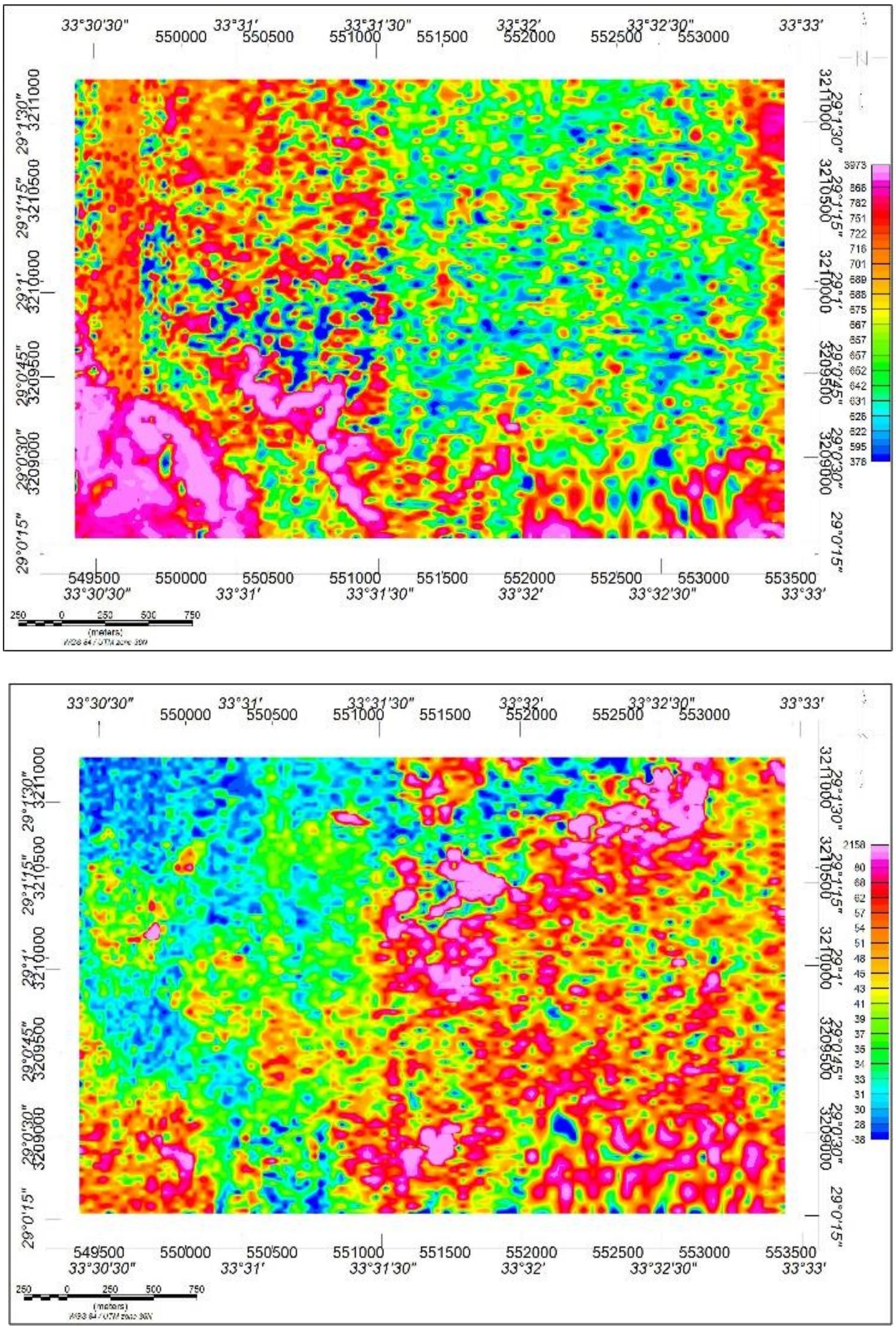
Figs 6A, B and C show the detailed distrbution of the three natural gamma emitters in the dominant rock exposures in the area (K% . eU and eTh).

Potassium activity map

Potassium activity map (Fig. 6 A) shows activity values ranging from 375.6 Bq kg^{-1} related to the small scattered parts of the study area to 5101.9 Bq kg $^{-1}$ related to its southwestern and southeastern parts with an average value of about 728 Bq kg^{-1}. Most of the area set under the maximum limit of background level of arithmetic mean plus three standard deviations without abnormal changes except at the southwestern corner and and some scattered parts at southeastern, (Fig. 6 A).

Equivalent uranium activity map

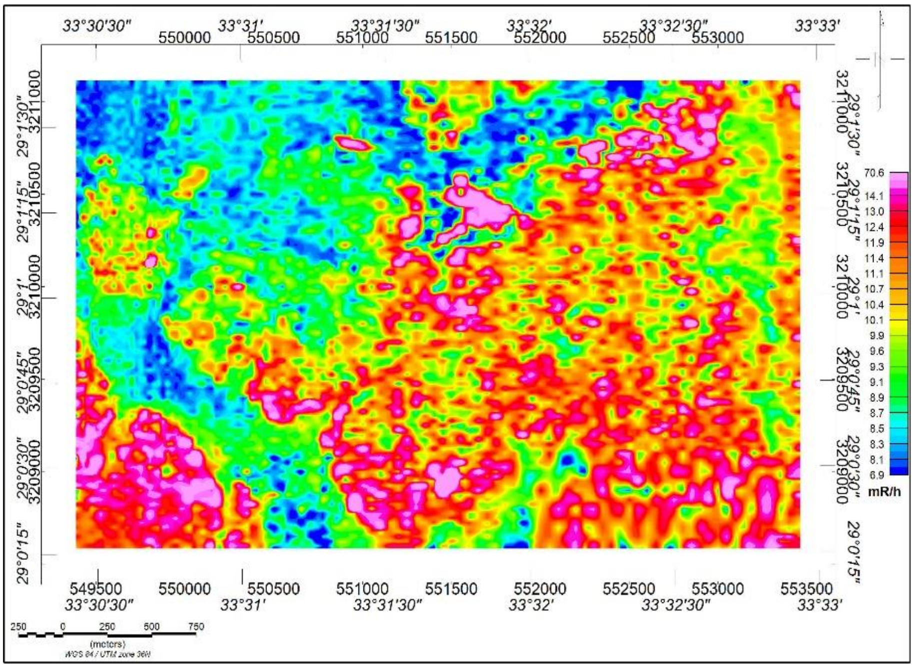
Equivalent specific uranium activity map (Fig. 6B) exhibits values varying from 12.35 Bq kg^{-1} related to with Wadi Khameila which has a northwest trend and northwestern part to 4276 Bq kg $^{-1}$ related to northeast trend and scattered locations. At the southeastern borders. Equivalent uranium activity have an arithmetic mean of 47.6 Bq kg^{-1}. The majority of the study area is within the maximum limit of background level except of some scattered locations, (Fig. 6B).



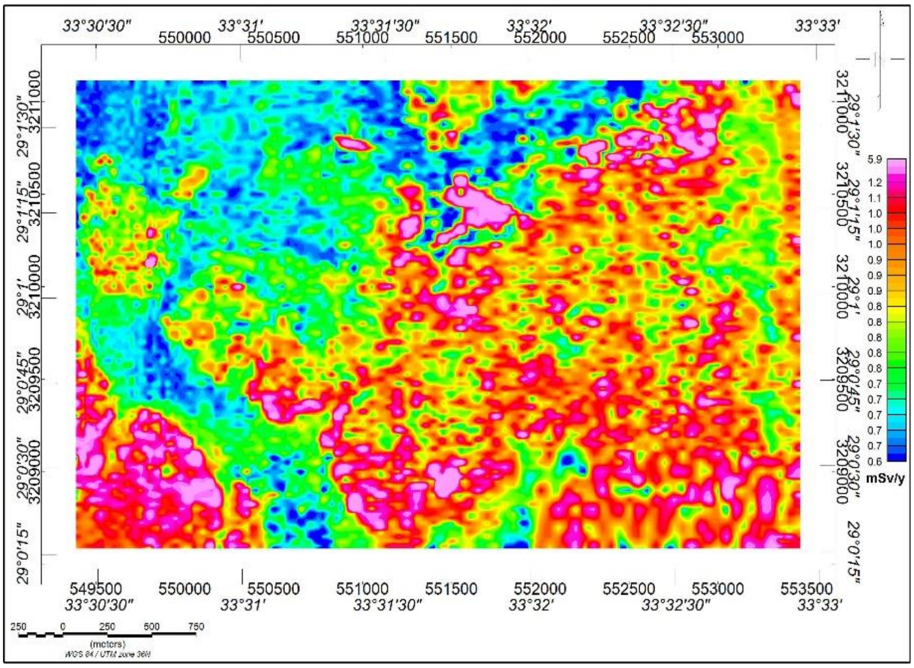
A

B

Fig. 6: Filled colour contour maps of specific activity of Ramlet Homayyer area, Southwestern Sinai, Egypt (a) Potassium activity map, (b) Equivalent uranium activity map and (c) Equivalent thorium activity map.



A



B

Fig. 7: Environmental monitoring filled colour contour maps of Ramlet Homayyer area, Southwestern Sinai, Egypt (a) Exposure rate map and (b) Equivalent dose rate map.

Equivalent thorium activity map

By examining the Equivalent thorium specific activity map (Fig. 6C), it was observed that the value of activity ranged from 37.4 Bq kg^{-1} to 279 Bq kg^{-1} , with an average value of about 63.4 Bq kg^{-1} . It is noticed that the distribution of Equivalent thorium activity is very similar to that of Equivalent uranium.

Exposure rate map

The exposure rate map (Fig.7A) of the study area varies in value from 6.6 mRh^{-1} to 131.8 mRh^{-1} with an average of about 10.4 mRh^{-1} . This map can be divided into three levels according to exposure rate values . The low level ranges from 6.9 to 8.7 mRh^{-1} related to Wadi Khameila at the northwestern parts . The high level varies in value from 11.5 to more than 70 mRh^{-1} , and represented at the eastern part and southwestern corner of the study area. The third level is spread over the area overlapping the other two and varing in values from 8.7 to 11.50 mRh^{-1} .

Dose rate map

The dose rate map of the study area (Fig.7B) varies in value from 0.5 to 10.9 mSv y^{-1}, with an arithmetic mean of 0.8 mSv y^{-1}. This map shows the same features of the exposure rate map. With regard to the study area, the mean natural dose rate reaches 0.8 mSv y^{-1}. This value stays on the safe side and within the maximum permissible safe radiation dose without harm to the individual, except at some locations around Wadi Khameila which attains more than 1.0 mSv y^{-1} in value. This could cause some problems for the inhabitants of these areas, especially that the rain water which falls on these high areas leaks into the wells.

CONCLUSIONS

By studying the total-count (T.C.) the values range between 3.4 Ur to 101.3 Ur. The potassium content varies between 1.2 % to more than 7.0 %. The equivalent thorium content has a maximum value reaching about 68.9 ppm. The equivalent uranium content arrives its maximum value about 84.0 ppm.

To detect the environmental impact of radioactive elements, the values of potassium (K,%), equivalent uranium (eU, ppm) and eTh (ppm) were converted to the exposure rate and the equivalent dose rate. The exposure rate varies in values from 6.6 mR h^{-1} to 131.8 mR h^{-1}, with an arithmetic mean 10.4 mRh^{-1}. The dose rate varies in intensity from 0.5 mSv y^{-1} to 10.9 mSv y^{-1}, with a computed arithmetic mean reaching 0.8 mSv y –1 . Both maps show the same features. Concerning the area under study, the average natural equivalent radiation dose rate from all earthly gamma-radiations 0.8 mSv y^{-1} which remains on the safe side and within the maximum permissible dose of safe radiation, without harming the individual, except for some places that reach more than 1.0 mSv y^{-1} . so, some risk may exist for the population who might dwell on these locations.

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