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GENERATION OF INTERPRETED SPECTRAL RADIOMETRIC LITHOLOGIC UNIT (ISRLU) MAP OF GEBEL MIZRAIYA, SOUTH WEST SINAI, EGYPT

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بناء خريطة تفسير النطاق الإشعاعى لمنطقة جبل ميزرايا، جنوب غرب سيناء، مصر

الخلاصة: تهدف الدراسة لتقييم وتفسير البيانات الإشعاعية لأغراض عديدة وهى التخريط الجيولوجى وتحديد أماكن تجمعات اليورانيوم والثوريوم. ولقد تم إنتاج بعض الخرائط المركبة ذات الدلالة والتي تعتمد أساساً علي خلط صور الألوان الزائفة المختارة للعناصر المشعة الثلاثة (البوتاسيوم ومكافئ اليورانيوم ومكافئ الثوريوم) التي نحصل منها علي الخرائط الإشعاعية المركبة مثل خريطة العناصر المركبة وخريطة اليورانيوم المركبة والثوريوم المركبة ولقد أسفر التفسير الكيفي لخرائط صور الألوان الزائفة المخلوطة عن وجود خمسة نطاقات في خريطة تفسير النطاق الإشعاعى. لقد أوضحت النظرة الفاحصة إلي صورة اليورانيوم مخلوطة الألوان الزائفة عن وجود أربع من شاذات اليورانيوم والتي يتراوح متوسط قيمها من ٧,٨ الي ١٠,٣ جزء في المليون. ولقد أوضحت النظرة الفاحصة إلي صورة الثوريوم مخلوطة الألوان الزائفة عن وجود ثلاث من شاذات الثوريوم والتي يتراوح متوسط قيمها من ٢٠,٥ الي ٢٨ جزء في المليون. وقد تم عمل زيارة الي منطقة الدراسة لتأكيد نتائج الخريطة المفسرة إشعاعيا بالإضافة الي تأكيد قيم شاذات كل من اليورانيوم والثوريوم.

ABSTRACT: *Gamma-ray spectrometry (GRS) can be very helpful in mapping radioelement data. The method provides estimates of apparent surface concentrations of the most common naturally occurring radioactive elements: potassium (K), uranium (eU), and thorium (eTh). The use of the method is based on the assumption that absolute and relative concentrations of these radioelements vary measurably and significantly with lithology. The composite image technique is used to display simultaneously three parameters of the radioelement concentrations and ratios on one image. The technique offered much in terms of lithologic discrimination based on color differences. In this study, the airborne gamma-ray spectrometric survey data were interpreted to construct the Interpreted Spectral Radiometric Lithologic Unit (ISRLU) map, determine the uranium and thorium anomalies (four uranium leads and three thorium leads), and confirming the result by field check.*

INTRODUCTION

The gamma-ray spectrometry method is widely used in diverse fields. Initially developed as uranium exploration tool, the application of the method now includes geological mapping (Andrson and Nash, 1997; Graham, and Bonham-carter, 1993; Jaques et al., 1997; Charbonneau et al., 1997), mineral exploration (Grasty and Shives, 1997; Lo and Pitcher, 1996), soil mapping (Cook et al., 1996; Wilford et al., 1997), and environmental radiation monitoring (Lahti et al., 2001; Ford et al., 2001; Sanderson et al., 1995). Wilford et al., (1997) demonstrated that airborne gamma-ray spectrometry patterns provided important information for soil, regolith, and geomorphology studies used for land management and mineral exploration decisions. Darnley and Ford (1989) show that, in many situations, gamma-ray spectrometry is probably more useful than any other single airborne geophysical or remote sensing technique in providing information directly interpretable in terms of surface geology.

The airborne gamma-ray spectrometry measure the abundance of Potassium (K), Thorium (eTh) and Uranium (eU) in rocks and weathered materials by detecting gamma ray emitted due to natural radioelement decay of these elements. Gamma ray emanate from the top 30 cm of dry rock and soil (Minty, 1997).

This work presents a case study in which the airborne gamma-ray spectrometric data were presented and interpreted qualitatively to map the surface radioelement distribution of the study area and confirm the interpreted spectral radiometric lithologic unit (ISRLU) map. Image display and ternary image techniques were applied to enhance discrimination of the different lithologic units based on the spatial differences in the radioelement contents.

GEOLOGY OF THE STUDY AREA

The study area covers relatively a variety of rock formations from Quaternary to Cretaceous Eras. The western part of the study contains man-made features such as oil and water wells that are considered fixed features (in situ). The eastern part of the study area represents part of the topography of the Sinai Peninsula of Egypt which is compromised with mountains averaging from 400 to 550 meters above sea level (Fig. 2) such as Gebel Mizraiya. Those mountains are formed from outcropping coarse to medium-grained monzogranite, locally megacrystic and foliated basement rock, and are dissected by a group of valleys (wadis) of different directions such as wadi Mahash, wadi Lithi and wadi Umm Markgah. These wadis pour into the gulf through a coastal plain of rugged irregular shape, in some parts of which sabkha deposits are developed in addition to coral reefs. The stratigraphic units of the area include Taref formation covered by Quseir formation. Taref formation consists of cross bedded sandstone with minor clay interbeds during Coniacian Period.

AIRBORNE SPECTROMETRIC SURVEY DATA

In 18th September, 2002, Airborne Geophysics Department of the Nuclear Materials Authority conducted a high resolution multi-channel gamma-ray spectrometric survey over the Gulf of Suez and its shoulder which cover the study area. Data were acquired along flight-lines spaced 250 m a part, at an azimuth of N51°E and tie-lines spaced at 400m. Nominal flying elevation was about 100 meters (330 feet) above ground surface.

The present study area is located in south west Sinai adjacent to Gulf of Suez between latitude 27° 45′ to 28° 10′ N and longitude 33° 45′ to 34° 10′ E. The area is about 622 km^2 and lies 20km North West Sharm El Sheikh resort (Fig.1).

The acquired spectrometric data were calibrated and processed using the national standard procedures. The airborne gamma ray spectrometry was corrected for dead time, cosmic and aircraft background and radon, as well as the height attenuation, stripping ratios and system sensitivity.

DATA PRESENTATION

With the advances of the computer-image processing technology, different methods of presenting, displaying and processing radiometric data have been developed. The basis of this technology is the presentation of the radiometric data in a digital raster format that contain both amplitude (color) and spatial information. In this format, the data can be statistically analyzed, enhanced for visual inspection and combined arithmetically or statistically with other types of data forming color composite images. Composite images provide a simultaneous display of up to three parameters on one image and facilitates the correlation and delineation of areas based on subtle differences in numerical values. The following combinations are developed by the United States Geological Survey (USGS) (Duval, 1983):

1. The radioelement composite image combines the data of K (in red), eU (in green), and eTh (in blue) (Fig.3).
2. The uranium composite image combines the data of eU (in red) with the ratios eU/K (in green) and eU/eTh (in blue) (Fig.4).
3. The thorium composite image combines the data of eTh (in red), with the ratios eTh/K (in green), and eTh/eU(in blue) (Fig.5).

The radioelement composite image provides on one display an overall pattern of the radioelement distribution. This image offers much in term of lithologic discrimination based on color differences. The uranium, thorium, and potassium images highlight areas where the particular radioelement has an absolute and relatively higher concentration (Duval, 1983).

CONSTRUCTION OF THE INTERPRETED SPECTRAL RADIOMETRIC LITHOLOGIC UNITS (ISRLU) MAP

The radioelement composite image (Fig.3) was used first to outline the major lithological units which describe different radioactivity levels. Figure 6 shows the interpreted lithologic units as inferred from the radioelement composite image which was differentiated into five various ISRLU zones and describe different spectral radioactivity levels. These five zones are highly correlated chronologically with the surface geologic map:

Zone No. 1: This zone is colored by blue color on the ISRLU map (Fig.6). It is correlated with water (Gulf of Suez), and represents no radiometric effect and is located at the western side of the study area.

Zone No. 2: This zone is colored by cyan color on the ISRLU map (Fig.6). It is highly correlated with Pleistocene sabkha deposits (silt, clay and evaporite), located at the western side of the study area. This zone is characterized by very low radiometric response and shows values of 13.6 μR/h in Tc, 2.8 % in K, 2.9 ppm in eU and 7.8 ppm in eTh.

Zone No. 3: This zone is colored by yellow color on the ISRLU map (Fig.6). It is spread all over the area and correlated with Quaternary sediments which characterize Wadi deposits and Undifferentiated Quaternary deposits (Alluvial fans, wadi deposits, sand, gravel, recent coastal deposits). This zone exhibits low radiometric response and reveal values of 16.5 μR/h in Tc, 3.1 % in K, 2.8 ppm in eU and 9.3 ppm in eTh.

Zone No. 4: This zone is colored by green color on the ISRLU map (Fig.6). It is correlated with Quaternary sediments (QW, Q) and Campanian-Turonian (Kutq), Upper Cretaceous Taref Formation. This zone is characterized by relatively moderate radiometric response and shows value 22.4 μR/h in Tc, 3.4 % in K, 4.6 ppm in eU and 16.3 ppm in eTh.

Zone No. 5: This zone is colored by brown color on the ISRLU map (Fig. 6). This zone occupies localities at the central and south eastern parts of the area. It is highly correlated with granitic rocks which is characterized by Calc-alkaline weakly deformed granitic rocks, (previously “Pink Granite” or “Younger Granite” in part; deeply weathered) and Calc-alkaline usually foliated quartzdioritic rocks, (previously “Gray Granite” or “Older Granite”) in part; deeply weathered. This zone is characterized by a relatively high radiometric response and display values of 36 μR/h in Tc, 4.5 % in K, 13 ppm in eU and 22 ppm in eTh.

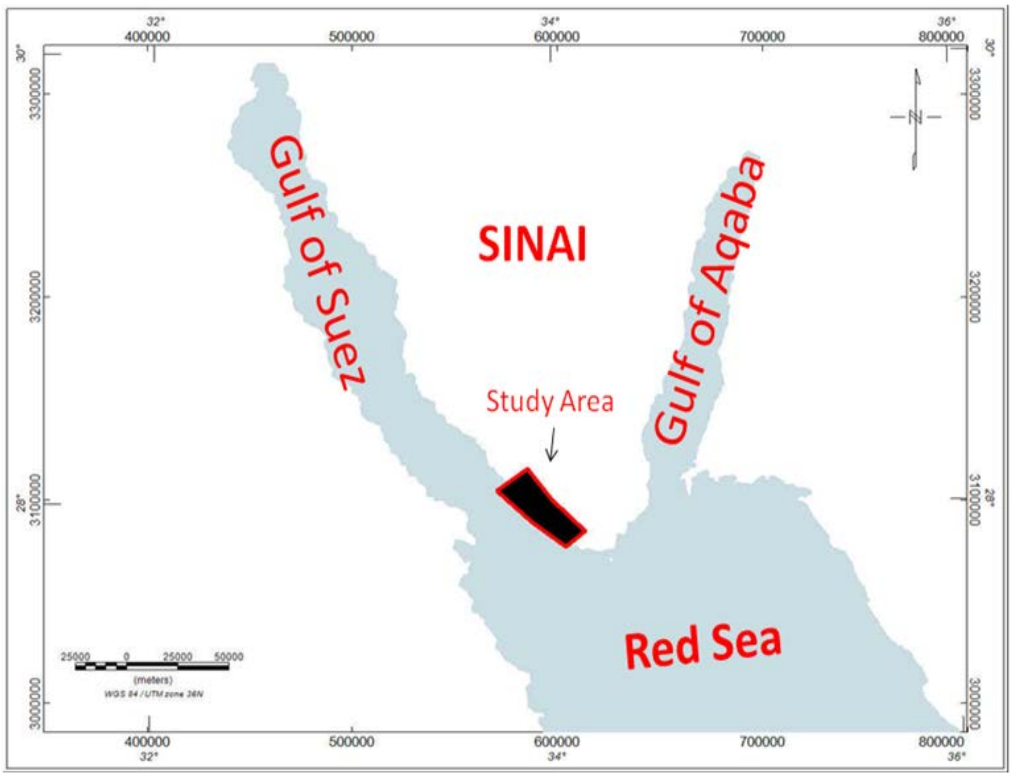

Fig. (1): Location Map of Gebel Mizraiya Area, SW Sinai, Egypt.

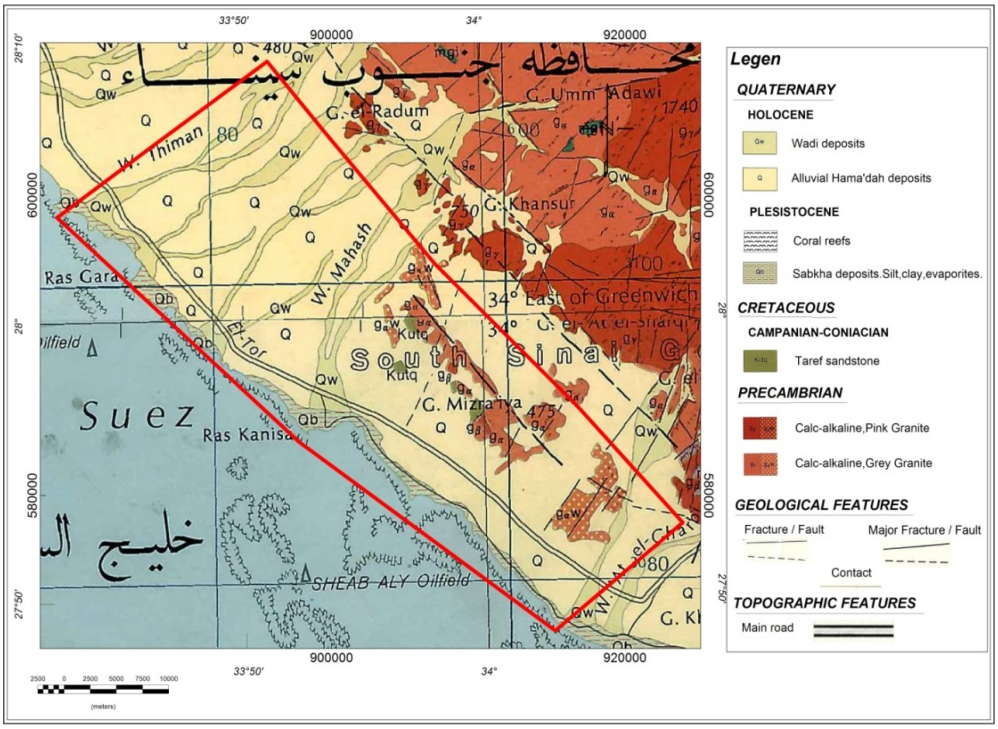

Fig. (2): Surface geologic map, south west Sinai, Egypt (After Conoco, 1987).

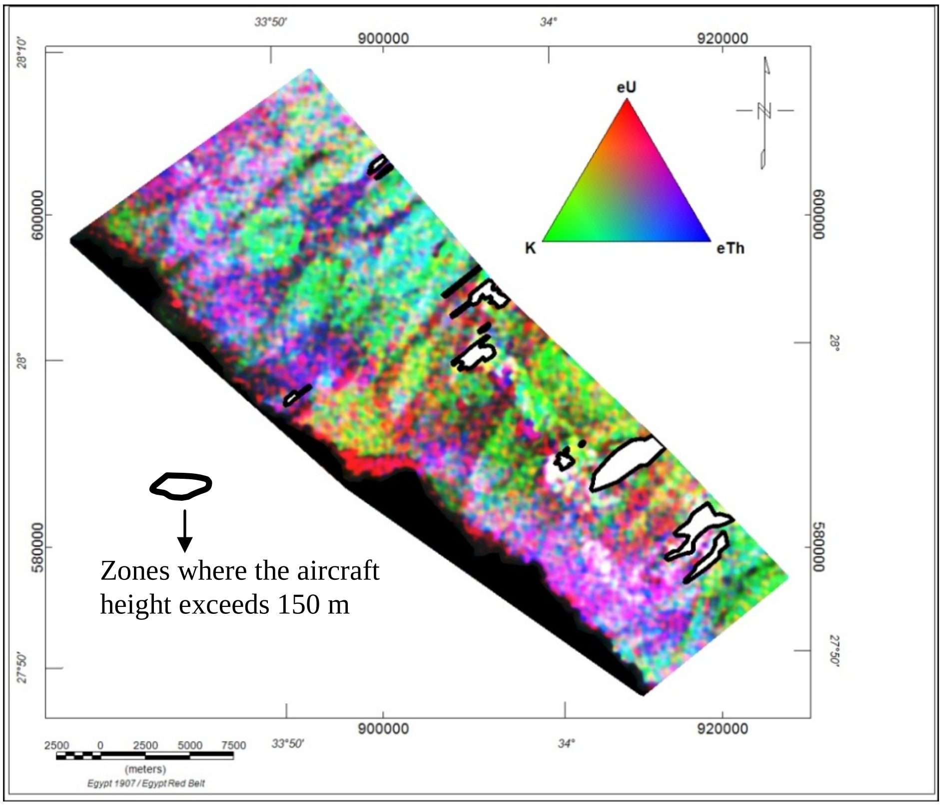

Fig. (3): False-color radioelement composite image, Gebel Mizraiya, South West Sinai, Egypt.

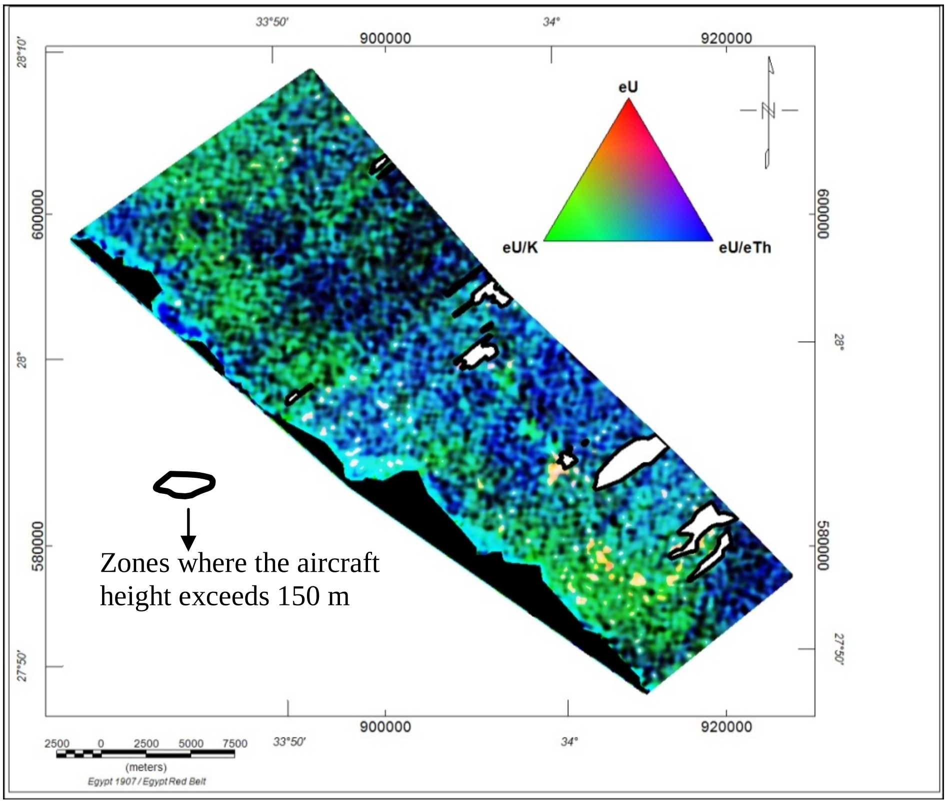

Fig. (4): False Color Equivalent Uranium Composite Image Map, Gebel Mizraiya, South West Sinai, Egypt.

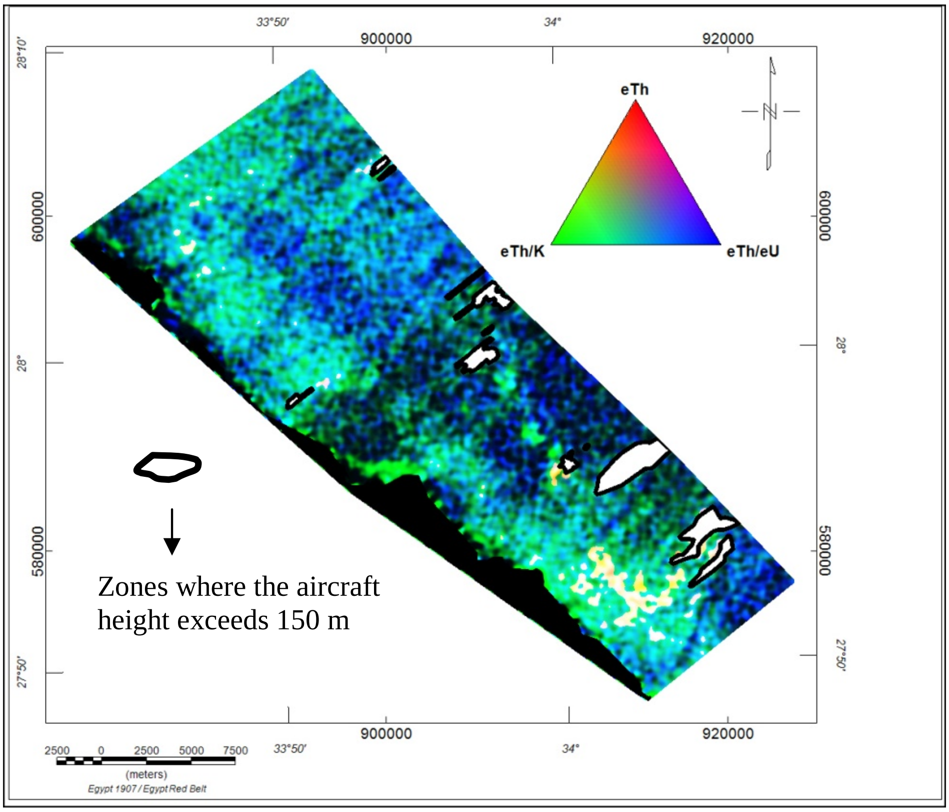

Fig. (5): False-Color Equivalent Thorium Composite Image Map, Gebel Mizraiya, South West Sinai, Egypt.

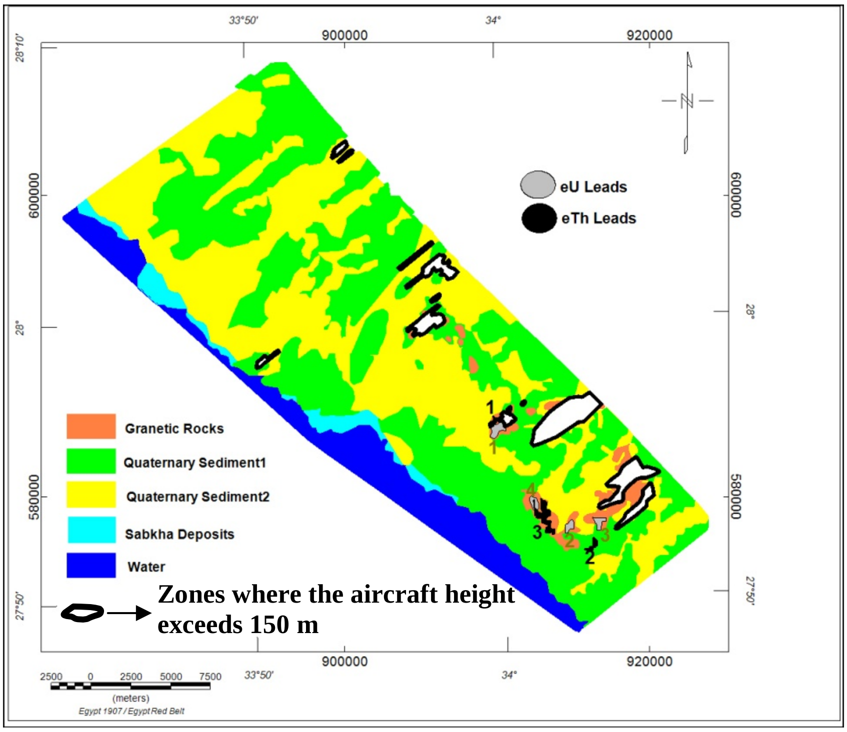

Fig. (6): Interpreted Spectral Radiometric Lithologic Unit (ISRLU) map, Gebel Mizraiya, South West Sinai, Egypt.

URANIUM AND THORIUM LEADS

Uranium Leads: The bright color areas on the Uranium composite image map (Fig. 5) show high values in all three data sets (eU, eU/K and eU/eTh). Four uranium leads are extracted from Uranium composite image map, These four (4) Uranium leads (Table1) are donated on the ISRLU map as gray color.

Thorium leads: The bright color on the composite thorium image map (Fig. 5) having high values in all three data sets (eTh, eTh/K and eTh/eU). Three thorium leads are extracted from the thorium composite image map. These three (3) thorium leads (Table1) are donated by black color in ISRLU map.

According to the surface geological map:

i- Uranium lead number one and thorium lead number one are correlated with Precambrian pink granite.

ii- Uranium leads number two, three and thorium lead number two are correlated with Precambrian gray granite

iii- Uranium lead number four and thorium lead number three are correlated with quaternary sediments.

The majority of Uranium and Thorium leads are correlated with granitic rocks.

RADIOMETRIC MEASURMENTS FOR GROUND FOLLOW UP

The target of this ground follow up is to confirm the data of ISRLU map and to prove the uranium and thorium leads which result from uranium and thorium composite images. The GS-512 spectrometer was used in this study. Ground calibrations are performed on four standard pads owned by Nuclear Material Authority (NMA) for determining the stripping ratios and spectrometer sensitivities. Ground positioning system (GPS 315) was used to determine the location of anomaly locations. The device is calibrated and the error percent was within 3-8%.

One reading was taken for each zone donated on ISRLU map (Table1). At each field anomaly points the measuring time was set to be 120 second (Table 2).

Four samples of rock units from the field which represented thorium anomaly numbers one and two, uranium anomaly numbers two and three was selected for more geological and geophysical studies (Fig. 7).

TABLE (1): Characteristic Radionuclide Concentration of the Four Interpreted Zones.

Rock unit	ISRLU zones	Tc (μR/h)	K (%)	eU (ppm)	eTh (ppm)
Sabkha deposits	Lactic zone	13.6	2.8	2.9	7.8
Quaternary deposits 1	Yellow zone	22.4	3.4	4.6	16.3
Quaternary deposits 2	Green zone	16.5	3.1	2.8	9.3
Granitic rock	Brown zone	36	4.5	13	22

Table (2): Radioelements Anomaly Assessment from airborne and ground data.

Radioelement	Lead Number	Lat	Long	Airborne Data (ppm)	Ground Data (ppm)	Rock unit
eU (ppm)	1	27.52	34.02	16.9	12.16	Calck-alkaline,Pink granite
	2	27.56	33.59	16	21	Calck-alkaline,Gray granite
	3	27.53	34.01	14.3	10.34	Calck-alkaline,Gray granite
	4	27.52	34.03	14.2	13.18	Calck-alkaline,Pink granite
eTh (ppm)	1	27.51	34.03	36	20	Calck-alkaline,Pink granite
	2	27.53	34.01	43.1	22.36	Calck-alkaline,Gray granite
	3	27.56	33.59	41	21.73	Calck-alkaline,Pink granite

(a): Granodirorite (old granite)

(b): Granodirorite (old granite)

(c): Monzogranite (younger granite)

(d): Syenogranite (younger granite)

Fig. (7): Samples of granitic rock, Gebel Mizraiya, South West Sinai, Egypt.

There are two observation after measurements ,the first is during taking measurements of field anomaly in the study area, I observed that thorium lead number three and uranium lead numbers two and four which correlate with Quaternary sediments (according to the surface geological map) are correlated with granitic rock unit which covered by Quaternary sediments. The second observation, measurement of zones number two and three (Table 1) show the Quaternary deposits in the study area divided into two levels according to the radiometric data and these observations confirm the ISRLU map which shows two levels of quaternary sediments according to difference in the radioelement content data.

CONCLUSIONS

High-sensitivity airborne spectrometry survey data were useful for mapping the radioelement data of the study area. The composite image technique was applied to the spectrometry data to facilitate the correlation and delineation of lithologic units based on subtle differences in the radioelement concentrations and ratios. The method showed practical success to construct ISRLU map, highlights those rock types characterized by low content of radioelements, and determined four uranium leads from uranium composite image map and three thorium leads from thorium composite image map. Moreover, the method provided discrimination and subdivision of Quaternary deposits in the study area which is confirmed by field check.

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