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COMPOSITE IMAGES AND URANIUM MIGRATION STUDY OF THE SPECTROMETRIC DATA, TALET SELEIM AREA, SOUTHWESTERN SINAI, EGYPT

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ABSTRCT

The present study deals with the application of two recent techniques on the recorded geophysical data. The first technique is the composite image while the second is the migration in and out of the mobile mineralization. The geophysical measurements were carried out on the exposed rocks of southwestern Sinai in the area which lies at the intersection of Lat. 29" 2\ N and Long. 33" 22\ E. The investigated area is characterized by the presence of two distinguishable geomorphological features. The elevated Abu-Thora sandstone cap rock, reaches an elevation of around 450m above sea level. The second feature is dominated by low topography and consists mainly of Um-Bogma Formation. The composite image technique combines any three parameters of the radioelement concentrations and/or their ratios to form composite color image maps. These resulting maps can be used to help and add valuable information to the geological and mineral distribution maps. Interpretation of the false colored composite images of the geophysical data in the area could help outline potential zones of anomalous radioelement contents which may be considered as good targets for radioactive mineral exploration (Um Bogma Formation). The second technique evaluates the amount of minerals migrated in and out of the rocks. It depends on the presence of the paleo thorium and uranium under the same condition, where U is more mobile than Th which is more stable. The difference between the amount of paleo and recent U concentrations reflects the rate of migration in and out the rocks. The present study shows that there is a close relationship between the distribution of radioelements and the lithology. It also shows that migration of uranium took place insid the lower member of Um Bogma Formation. It migrated out in the case of the other rocks. The present work is also an attempt to relate the mineral occurrence to the structural trends. The study reflects that the NW, NNW and NE faults have a significant role on the mineral distribution.

1. INTRODUCTION

The main objective of gamma-ray spectrometric surveying is to locate anomalous zones of gamma-radiation fields and to determine the nature, as well as the concentration of the causing radioisotopes. By means of gamma-ray spectrometry, it is possible to determine the individual concentrations of the three naturally occurring radioelements in the rocks. 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).

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Accordingly, spectrometric contour maps emphasize the special nature of the radioelement distribution and are thus better suited to the recognition of the geological features, which have important special characteristics. The relationship of the contoured radioelement pattern and the distribution of the major anomalous lithologies have formed the basis for the present interpretation. It can be seen that the spectrometric contours show a general relationship to principal rock units and the structural trends.

The study area is located 45 km to the northeast of Abu Zenima town on the Gulf of Suez at the intersection of latitude 29° 2' N and longitude 33° 22' E (Fig.1).

II. Geological and Structural Setting

Southwestern Sinai is considered one of the promising mineral resource areas in Egypt, being rich in economic mineral deposits such as manganese, iron ores, kaolin, turquoise and glass sand. The discovery of uranium deposits, occuring in the Paleozoic sedimentary rocks, raised the economic potentiality of the area (Fig. 2).

II.I. Geological Setting:

The most abundant type of sedimentary rocks exposed in the study area blong to the Carboniferous period. According to Klitzsch (1990), the Carboniferous strata of Egypt differ more in facies than other Paleozoic sediments. The Carboniferous sediments range from fully marine carbonates, shallow and deep marine clastics, deltaic and continental fluviatile sandstones to lacustrine deposits. The exposed rock units arranged from base to top are: -

II.I.A . Um Bogma Formation:

The economic importance of this formation is attributed to the presence of diverse and widespread mineralizations. These include manganese and iron ores, secondary copper minerals and uranium mineralizations.

According to El-Agami (1996), this formation is subdivided into three members; a lower shaly ore – sandy dolostone member, a middle marly dolostone – siltstone member and an upper dolostone – sandstone member.

The lower shaly ore-sandy dolomite member :

This member includes most of the economic minerals. El-Agami (1996) Classified this member into three facias:-

i- The ferruginous siltstone and silty shale facies:

This facies forms the base of the lower member of siltstone to sandy or silty shale beds characterized by the presence of radioactive anomalies.

ii.The sandy dolomite-gibbsite ore facies:

This facies is represented by sandy dolomite . It is rich in ferruginous lenses and gibbsite mineral.

iii. The shale to silty facies:

This facies is composed mainly of shales and characterized by the presence of copper and uranium mineralizations.

The middle marly dolostone-siltstone Member:

This member rests conformably over the lower member and is composed mainly of soft marl with few interbeds of highly compact dolostone. It is characterized by the presence of some evaporite minerals as gypsum, anhydrite and halite

The upper dolostone-sandstone member:

It is found over the middle shaly marly dolostone member and is conformably overlain by the Abu Thora Formation. This member is mainly of crystalline dolomite.

II.I.B. Abu Thora Formation:

Abu Thora Formation contact is easily identified by marked differences in lithology between its sandstone and the dolomite of Um Bogma Formation. This formation is composed mainly of sandstone with siltstone and mudstone interbeds.

II.2. Structure of the Area

Meshref (1990) concluded that the main tectonic trends along the Gulf of Suez, Red Sea region are the N-S Precambrian trend, the E-W Paleozoic -Jurassic trend, the WNW-ESE Abu Darag trend of Early Cretaceous, the ENE Syrian arcs trend of Late Cretaceous to Early Tertiary age and the NW Red Sea trend.

The faults are the main factor which controls the structural pattern of the area under study, where 20 major faults with their segments were detected and mapped (Fig. 2). The length of each fault was measured on the field map(Fig.2). The Northwest (NW) faults form the prodominent trend, followed by the WNW, NNE, N-S, E-W and other less frequent trends as the NNW and ENE.

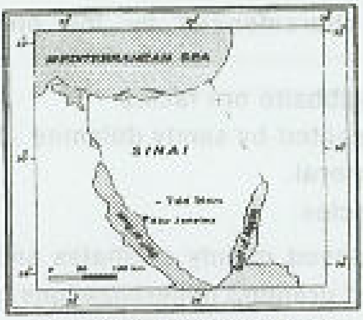

Fig. (1): Location map of Talet Seleim area Southwestern Sinai, Egypt.

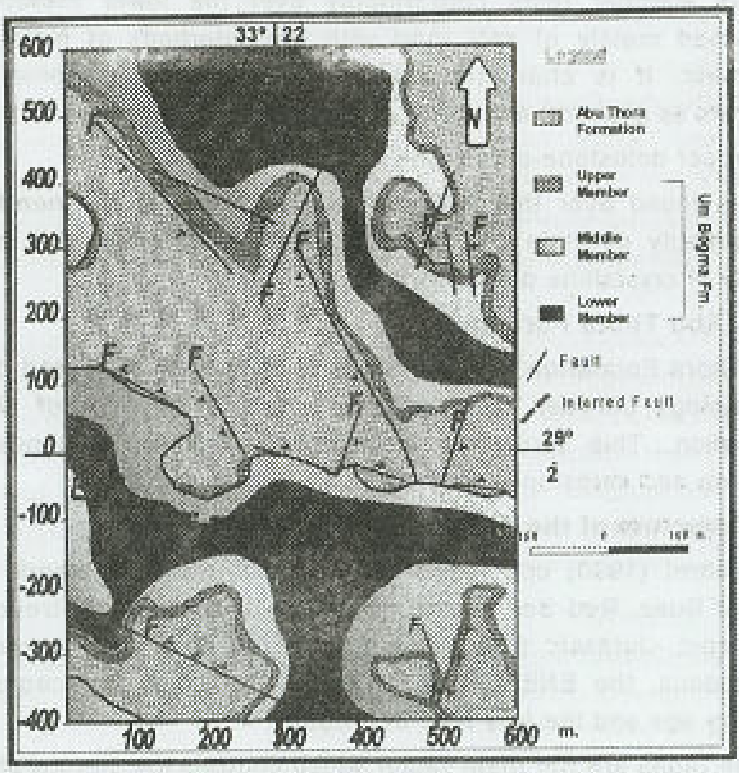

Fig. (2): Detailed Geological and structural map of Talet Seleim area, Southwestern Sinai, Egypt.

III. Qualitative Interpretation of Ground Spectrometric Maps

Ground spectrometric surveying provided valuable information on four parameters namely: total-count (TC, in Ur), potassium: (K, in %), equivalent uranium (eU, in ppm), and equivalent thorium (eTh in ppm).

The TC map (Fig. 3) could be divided into three distinct levels. The low radioactive level extends over the sandstone of Abu-Thora Formation (Fig. 2). This level varies between 1.5 and 10 Ur. The intermediate radioactive level ranges from 10 to 20 Ur and is associated mainly with the upper and middle Members of Um Bogma Formation. High radioactive level is more than 20 Ur. It is related to gibbsite of the Um Bogma Formation. It is considered as the highest radioactive level located at the eastern and southwestern parts of mapped area.

The eU map (Fig. 4) reflected the occurrence of three radioactive levels. The first, (less than 5-ppm) is found mainly over the Abu Thora Fm. (Fig. 2). The second level, (from 5 to 20 ppm) is recorded over the Um Bogma Formation, while the third level possesses high uranium content (more than 20 ppm) over gibbsite mineral of Um Bogma Formation.

The eTh map (Fig.5) shows three radioactive levels. The first level, less than 6-ppm, has great areal coverage over the study area. The second shows moderate range from 6 to 10 ppm, and is recorded on marly dolostone siltstone. The third is the highest thorium level, more than 10 ppm, is concentrated mainly over shaly ore-sandy dolostone.

In the K contour map (Fig. 6) there are three levels of radioactivity. The first one is the lowest which less than 0.4 %, and is associated with Abu Thora Formation (Fig. 2). The second level, moderate range from 0.4 to 0.8 %, is mainly associated with the middle Member of Um Bogma Formation, while the third level, more than 0.8 %, represents the highest value in the mapped area, associated with the middle and lower Members of Um Bogma Formation.

IV. Composite color images of ground gamma-ray spectrometric data

Composite color images-particularly composite images produced from gamma-ray spectrometric data-provides the interpreter with a useful synthesis of the data that can be used to aid geological and geochemical mapping and mineral exploration (Duval, 1983). However, four various composite color image maps were produced for the following variable combinations:

1. K, eU and eTh (three radioelement composite color image map (Fig.7).

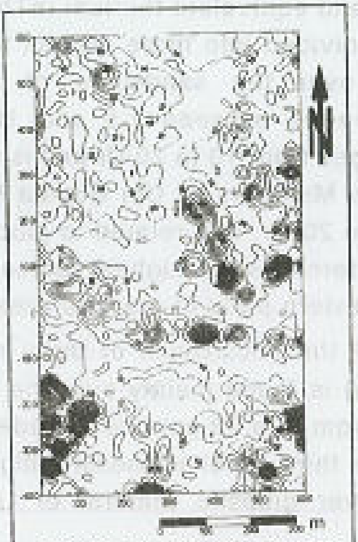

Fig.(3): Total count radiometric contour map.

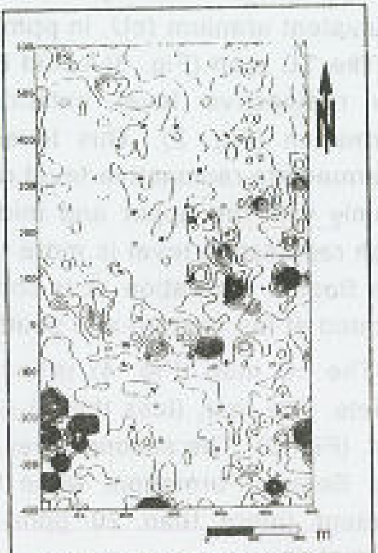

Fig.(4): Equivalent Uraium contour map.

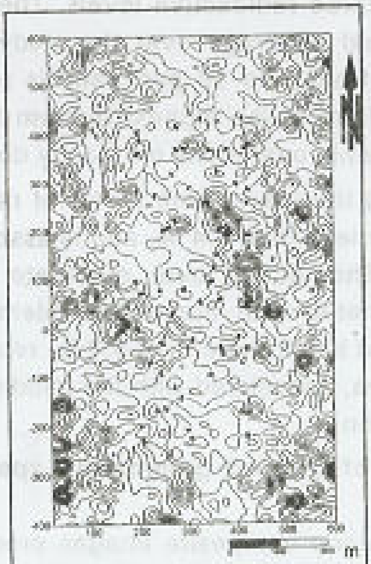

Fig.(5): Equivalent Thorium contour map.

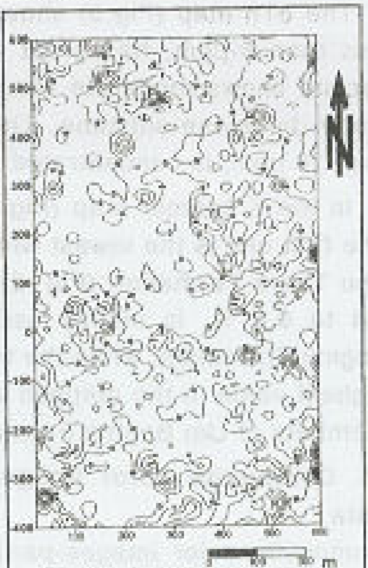

Fig.(6): Potassium contour map.

2. eU, eU/eTh and eU/K (equivalent uranium composite color image map, (Fig. 8).

3. eTh, eTh/eU and eTh/K (equivalent thorium composite color image map,(Fig.9).

4. K, K/ eTh and K/ eU (potassium composite color image map, (Fig.10).

IV.1. Radioelement Composite Image

The three radioelement composite image map of the study area (Fig. 7) generated from the gamma-ray spectrometric data of K, eU, eTh shows the variations occurring in the three radioelement concentrations, which mainly reflect lithologic variations. The color index at each corner of the triangular legend (K in red, eU in blue and eTh in green) indicates 100% concentration of the indicated radioelement. The colors at each point inside the triangle represent different ratios of the radioelements according to the color differences on the absolute three radioelement composite image map, three interpreted gamma-ray spectrometric zones (Fig.11).

A. Interpreted Spectral- Radiometric (ISR) Zone No. (1)

This ISR zone no. (1) occurs in four locations in the study area . The first one occurs at the SE part, the second location of this zone at the SW part, the third location at the middle part passing through NW direction, while the last one occurs at the NE part of the study area. This zone represents the sandstone of Abu Thora Formation, and is characterized by relatively low values of K, eU and eTh (0.3%, 4.8 ppm and 5.5 ppm) respectively. The visualization of this zone on the three-radioelement composite image map is dark green in color.

B. Interpreted Spectral- Radiometric (ISR) Zone No. (2)

The ISR zone no. (2) could be considering the second zone in the area under investigation from the point of view of surface area, next to ISR zone no. (1), where it occurs in seven locations. This zone occurs around zone no (1) and conforms with the middle member of Um Bogma Formation (middle marly dolostone-siltstone member) on the geological map (Fig.2). It is characterized by low K value (0.6%), relatively high eU (9.3 ppm) and eTh value (7.3 ppm). It was discriminated from the three-radioelement composite image map as light blue color.

C. Interpreted Spectral- Radiometric (ISR) Zone No. (3)

The ISR zone no. (3) is the most important one. It occurs at the background of the study area and encountered in two locations at the southern and northeastern parts of the mapped area. It coincides with lower member of Um Bogma Formation (The lower shaly ore-sandy dolomite member)on the geological map (Fig.1). This zone is characterized by low K values (0.4 %), high eU and eTh values (11.1

ppm and 6.3 ppm) and also discriminated from the three- radioelement composite image map as dark blue color.

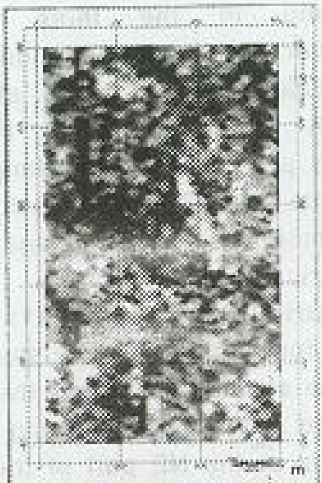

Fig.(7): Three-radioelement composite image map, Talat Gebeln area, Sinai Egypt.

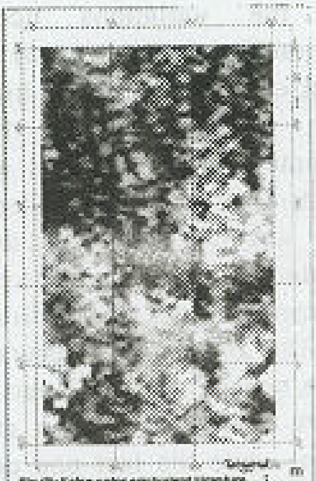

Fig.(8): False-color equivalent Uranium (eU) composite image map, Talat Gebeln area, Sinai Egypt.

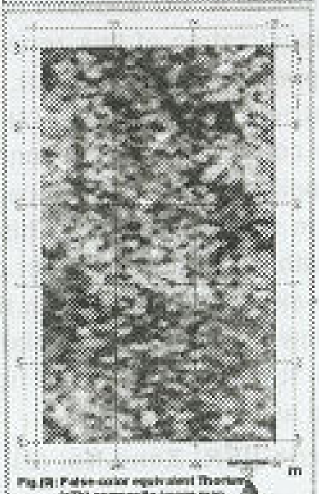

Fig.(9): False-color equivalent Thorium (eTh) composite image map, Talat Gebeln area, Sinai Egypt.

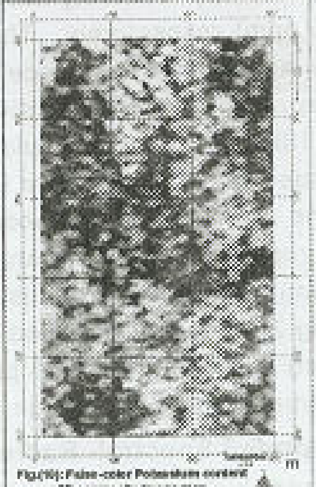

Fig.(10): False-color Potassium content (K) composite image map, Talat Gebeln area, Sinai Egypt.

IV.2. Uranium Composite Image

The eU composite image (Fig 8) combines eU (in red) with the ratios eU/ eTh in green and eU/K (in blue). The relative concentration of uranium with respect to both potassium and thorium is an important diagnostic factor in the recognition of possible uranium deposits (IAEA 1988). The uranium composite image also reflects lithologic differences and could be useful in geological mapping problems (Duval, 1983). Therefore, the eU composite image map provides useful information regarding the identification of anomalous zones of enriched uranium concentration. The uranium anomalous zones are displayed as white areas on the uranium composite image map. These eU zones showed spatial correlation with some of the mapped lithologic exposures in the surveyed area and described as the following (Fig. 12):

Zone No.1: This zone is associated with the lower member of Um Bogma Formation. It has the highest radioactive level in the area (exceeds X±3S). This zone is located in the southwestern part with an elongated shape trending EW.

Zone No.2: It is located at the southeastern part of the investigated area. The anomalies of this zone are associated with the lower and middle Members of Um Bogma Formation, which are characterized by high values of eU anomalies (more than X ± 2S).

Zone No.3: It is associated with the lower, middle and upper Members of Um Bogma Formation. This zone is located in the eastern part, which is characterized by high values of eU anomalies (exceeds X±S).

Zone No.4: It is located at the middle part of the study area and has an elongated shape changing in trend from the NW to the EW directions. The anomalies of this zone are associated with the middle and lower members of Um Bogma Formation. This zone has high values of eU (exceeds X±3S).

Zone No.5: This zone is located at the southern part and has an elongated shape trending in a NW direction. It posseses moderate values of eU. The anomalies of this zone are associated with the middle member of Um Bogma Formation and sandstone of Abu Thora Formation. Beside all the above-described groups of anomalies, there is a lot of single point anomalies of eU, especially at the lower and middle Members of Um Bogma Formation.

IV.3. Thorium Composite Image

The composite image map (Fig. 9) combines eTh (in red) with the ratios eTh/K (in green) and eTh/eU (in blue). This image emphasizes the relative distribution of thorium and highlights areas of thorium enrichment. The bright color on this image map is a good pointer to areas where thorium has been enriched relative to both potassium and uranium.

These areas are mainly associated with the sandstone of Abu Thora Formation, upper and middle members of Um Bogma Formation.

IV.4. Potassium Composite Image

The composite image map (Fig.10) combines K% (in red) with the ratios K/eTh (in green) and K/eU (in blue). This image shows the overall spatial distribution of the relative potassium concentrations. Locations of anomalous relative potassium concentrations can be distinguished on the potassium composite image as local bright spots (high values). These anomalies are well correlated with the middle and lower members of Um Bogma Formation. The dark color is associated mainly with the sandstone of Abu Thora Formation.

V. Uranium Migration in Different Geological Units in the Study Area

The U and Th have the same ionic radii; they are formed under the same condition in the magma chamber. While the uranium is easy to mobilize and migrate under the action of oxygen from groundwater and atmosphere during its evolution, whereas Thorium is relatively stable in oxidation zone, and stays in place. As a result, breaking the original U-Th state is indicating by the present Th- high area which could be considered as the original U high area.

The U/Th ratio is a very important geochemical index for U migration. It is approximate by constant in the same type rock or geologic unit in a relatively closed environment. The Uranium migration (out or in) has the same probability within geological units in relatively closed geologic environment. Analysis of uranium migration is shown from the following steps in from of calculation of:

1. Paleo-uranium background (original uranium content Uo), which means multiplying the average Th content detected in each geologic units by average regional U/ Th ratio (Benzing, Uranium Institute).

$$Uo = eTh \cdot U/Th \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where eTh is the average thorium content in a certain geologic unit (ppm); U/ Th means the average regional U/ Th ratio in different geologic units.

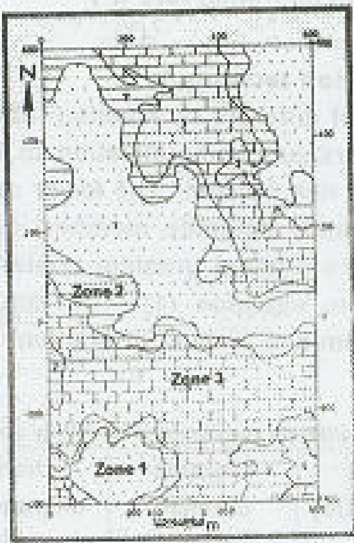

Fig. (11): Interpreted Radio-Spectrometric Zonation (R.S) map

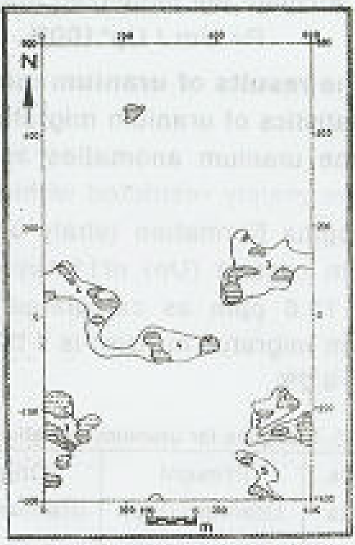

Fig. (12): Key map showing the Identified Uranium anomalies

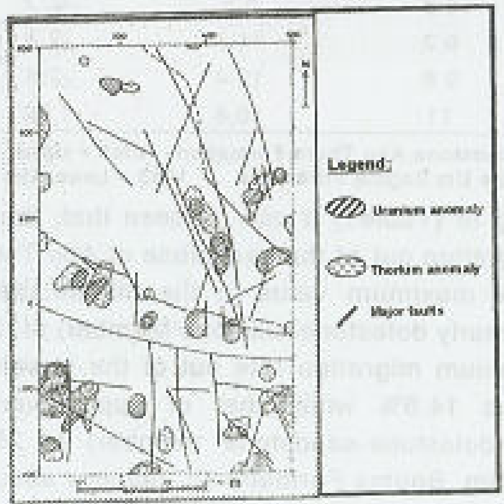

Fig. (13) Distribution of Uranium and Thorium anomalies with the structure lineaments.

2. Amount of mobilized Uranium (i.e. amount of uranium migration Um).

$$Um = Up - Uo \ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where Up means average uranium content in certain geologic unit.

If Um > 0, uranium migrated in to the geologic body during late evolution.

If Um < 0, uranium was lost in the geologic body during late evolution.

3. Calculate the mobilized uranium migration rate (P).

$$P = Um / Up*100\% \quad \ldots\ldots\ldots\ldots (3)$$

V.1. The results of uranium migration technique

The statistics of uranium migration of different rock units (Table1) show that, the uranium anomalies and uranium mineralization in the study area are mainly restricted within U- rich horizon. The lower member of Um Bogma Formation (shaly ore-sandy dolomite member) has recent uranium content (Up) of11.1ppm. Its original uranium content (Uo) is about 10.8 ppm as calculated from equation (1). The mount of its uranium migrated in (Um) is 1.02 ppm and amount of uranium migration rate is 9.2%.

Table (1): Statistics for uranium migration in different rock units in the study area.

Rock units	Present Uranium (Up)	Original uranium (Uo)	Migrated uranium (Um)	Uranium migration rate (P)
S.S	4.8	5.5	-0. 7	-14.6
Um1	9.3	11.7	-2.4	-25.6
Um2	9.8	12.4	-2.6	-26.6
Um3	11	10.8	1.02	9.2

S.S. = Snadstone Abu Thora Formation. Um1 = Upper Um BogmaFormation.
Um2 =middle Um Bogma Formation. Um3 = Lower Um Bogma Formation

According to (Table1) it can be seen that, the average amounts of uranium migration out of the sandstone of Abu Thora Formation is - 0.7 ppm, with a maximum value in the middle member of Um Bogma Formation (marly dolostone-siltstone Member) of -2.6ppm. However, the average uranium migration rate out of the in sandstone of Abu Thora Formation is 14.6% while that of upper member of Um Bogma Formation (dolostone-sandstone member) is 25.6%. In the middle member of Um Bogma Formation it reaches about 26.6%.

The geologic units whose negative amounts of uranium migration can be called uranium source horizons, which provided uranium for uranium anomalies and mineralization in the study area.

VI. Correlation between structural lineaments and radioactive anomalies

The structural elements frequently play a significant role in the localization of ore deposits. The most important control is provided by faults and related structures. Hence, the identified uranium and /or thorium anomalies of the study area have been examined in conjunction with the surface faulting pattern as traced from the geological map (Fig. 2) and the interpreted surface lineaments as traced from the total count radiometric map.

This correlative examination shows clearly that the identified anomalies are not randomly distributed, but display a distinct close relationship to the faulting pattern in the study area (Fig.13). In that regard, it was evident that among the prevailing fault trends in the study area are the NW, NNW, EW and NE have a significant impact on the distribution of the radioelements forming the spectrometric anomalies, where these faults can act as preferred vertical pathways for the migration of the radioactive mineralized solutions.

This may prove the importance of the structural features as controlling factors in the localization of potential radioactive mineral deposits associated with these anomalies.

Garson and Krs (1976) reported that in the Egyptian Eastern Desert, the intersection between the transverse faults striking NE with NW trending faults are in several cases focalize of mineralization. This may give support to the conclusions that the NW, NNW and NE faults had a significant role on the distribution of the identified U and/or Th anomalies, and consequently on the localization of potentially radioactive mineralizations.

CONCLUSIONS

Color composite images technique can be applied to any gamma- ray spectrometric data and can be considered a useful tool in exploration for minerals other than uranium. According to the color differences on the absolute three radioelement composite image map, three interpreted gamma- ray spectrometric zones (ISR) can be mentioned.

The eU composite image has displayed three of the highest anomalous zones. The first zone is associated with the lower member of Um Bogma Formation at the southwestern part in the mapped area. The second zone is located at the southeastern corner, related to the lower and middle members of Um Bogma Formation, while the third zone is closely related to all Um Bogma members (Lower, Middle and Upper) and it is located at the eastern part of the studied area. These anomalies can be interpreted as reflecting the presence of geochemical environment favorable for the formation of uranium deposits. These anomalies can be used as an exploration guide to search for additional uranium deposits.

The study of uranium migration revealed that the outward migration tack place in Abu Thora Formation, Upper and middle Members of Um Bogma Formation with different degrees. On the other hand inward uranium migration into the units is indicated in the lower member of the Um Bogma Formation.

The two techniques reflect great matching which indicated that the Lower Um Bogma member is a good target for uranium mineralization zone.

This study shows the strong relationship between mineral deposits and structural trends, where the NW, NNW and NE fault trends have significant role on the mineral distribution.

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أستخدام تقنيتي الصور المركبة وهجرة اليورانيوم لدراسة البيانات الطيفية الأشعاعية لمنطقة طلعت سليم بجنوب غرب سيناء – مصر

*محمود غالب –** محمود ميرة –** عادل خليل – **باهر غيث – **حامد ميرة
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تعتمد هذه الدراسة علي أستخدام تقنيتين حديثتين على البيانات الجيوفيزيائية المسجلة. التقنية الأولي هي دمج الصور الملونة بينما الثانية هي هجرة التمعدنيات القابلة للحركة .

تمت القياسات الجيوفيزيائية لهذه الدراسة في منطقة الواقع عند تقاطع خط عرض ٢ / ٢٩ ° وخط طول ٢٢/ ٣٣ ° جنوب غرب سيناء – مصر .

تتميز منطقة الدراسة بوجود ظاهرتين جيومورفولوجيتين واضحتين. الأولي الغطاء الصخري من الحجر الرملي لتكوين أبو تورا الممثل للمناطق العالية والذي يصل أرتفاعة حوالي ٤٥٠م من سطح الأرض تورا والثانية توجد في المناطق المنخفضة وهي تكوين أم بجمة.

تعتمد تقنية الصور المركبة علي دمج تركيزات العناصر الأشعاعية الأساسية (اليورانيوم والثوريوم و البوتاسيوم) مع أو نسبهم وأنتاج خرائط ملونة.

ومن تفسير خرائط الصور المركبة تم تحديد نطاقات التمعدنات الأشعاعية العالية والتي ترتبط بتكوين أم بجمة.

واما التقنية الثانية والتي تعبر عن هجرة المواد المشعة القابلة للتحرك من والي الصخور المختلفة. والمعتمدة إساسا علي تواجدات اليورانيوم والثوريوم القديمة والمتكون تحت نفس ظروف تكوين المجما، وحيث أن اليورانيوم ذات قابلية عالية للتحرك – والفرق بين كمية اليورانيوم الحديث والقديم يعكس معدل هجرة اليورانيوم من والي الصخور المختلفة. وأظهرت الدراسة أرتباط كبير بين توزيعات المواد المشعة لتكوينات الصخور المختلفة. وأن معدل هجرة اليورانيوم كبير الي الطبقات السفلة من تكوين أم بجمة وأظهرت الدراسة أرتباط كبير بين الأتجاهات التركيبة السائدة وتوزيع المواد المشعة بالمنطقة خاصة الصدوع في أتجاهات شمال غرب وشمال شرق.