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STANDARDIZATION OF AIRBORNE GAMMA-RAY SPECTROMETRIC SURVEY DATA OF GABAL GHARAMUL AND ITS SURROUNDING, NORTHERN EASTERN DESERT, EGYPT

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قياسية معطيات المسح الجوى لأشعة جاما الطيفية على جبل غرامول والمناطق المتاخمة فى شمال شرق الصحراء الشرقية بمصر

الخلاصة: يشرح هذا البحث الخطوة الأولى لمسح أشعة جاما الطيفية فى منطقة جبل الغرامول والتخوم بناحية الشمال الشرقى من الصحراء الشرقية واستخدام ذلك فى البحث عن تركيزات اليورانيوم والثوريوم والبوتاسيوم، وقد تم ذلك بأسلوب قياسية المعطيات الطيفية والتى تم جمعها فى عام ٢٠٠٣ تبعتها دراسة حقلية فى عام ٢٠١٢ وقد تضمن هذا الأسلوب حساب معدلات العدات الجوية الخطية التراجع (التابعة) مقابل التركيزات الأرضية (المستقلة) فى كل نقطة قياس أرضية، وقد تم عرض ومناقشة العلاقات الخطية بين المعطيات الأرضية والأخرى الجوية لكل من eU و eTh و K، ولما كان ميل خط التراجع قد تأكد فى حساسيته الإشعاعية فإنه يمكن بالتالى استخدام المعادلات الخطية الناتجة فى تحديد القيم الأرضية لتلك التركيزات الإشعاعية.

ABSTRACT: *The present work explains the first step of putting the airborne gamma ray spectrometric data of Gabal Gharamul area and its surrounding, North Eastern Desert into use in radioactive source search at ground concentration of uranium, thorium and potassium. This is done through applying the standardizing procedure of these spectrometric data. Such data were collected in 2003 then a field trip was conducted in 2012. Initially, the procedure involved a linear regression of the airborne count rates (the dependent) against the ground concentrations (the independent) for each measurement point on the ground.*

These linear relationships with zero intercept between the ground data and the airborne data for eU, eTh and K were illustrated. Since the slope of the regression line was assured to be the radioactivity sensitivity, the resultant linear equations will be used to determine the values of the ground data.

INTRODUCTION

Standardization is the procedure for unifying disparate data by converting them to either radioelement concentrations or dose rate units and ensuring the data are levelled. The procedure of standardizing airborne gamma-ray measurements were developed in the mid of 1970s as a result of large government uranium exploration programs such as those carried out in the United States and Canada (Darnley *et al.*, 1975; Duval, 1991). Data standardization requires knowledge of the survey parameters, and some insight into the quality of the survey data. An important prerequisite is an acceptable accuracy of the geographical positioning of the survey data points. The International Atomic Energy Agency (IAEA) has dealt with the calibration and processing procedures to convert the airborne measurements to ground concentrations of potassium, uranium and thorium (IAEA, 1991). Recently, the Australian Geological Survey Organization (Grasty and Minty 1995) have described in more detail the specifications for airborne gamma-ray surveys. The present study deals essentially with the correlation between the ground and airborne gamma-ray data trying to reach mathematical relation between them to standardize the airborne gamma ray spectrometry data in G. Gharamul area and its surrounding. These will provide base-line information that can be used as a reference to determine the relation between the airborne gamma ray spectrometric data and the ground spectrometric data in other areas to convert the airborne data to the ground data.

Geologic setting of the study area:

The G. Gharamul area lies in the northern part of the Eastern Desert, Egypt between latitudes 27° 49′ & 28° 25′ N and longitudes 32° 50′ & 33° 32′ E (Fig. 1). The regional geological setting is depicted in (Fig. 1). It is covered mainly by a variety of rock formation from Quaternary, Tertiary and Cretaceous Eras. The study area contains man made features such as several oil fields (Kareem and Shukhier oil fields) and water wells (Bir Abu Nakhla).The western part of the area under investigation is dominated by several mountains having average height ranging from 100 to 300 meters above sea level (Fig. 2), while the eastern parts represent a part of the Gulf of Suez coast. Gabal Gharamul is located at the central part of the mapped area and is characterized by height reaching 300 meters above sea level.

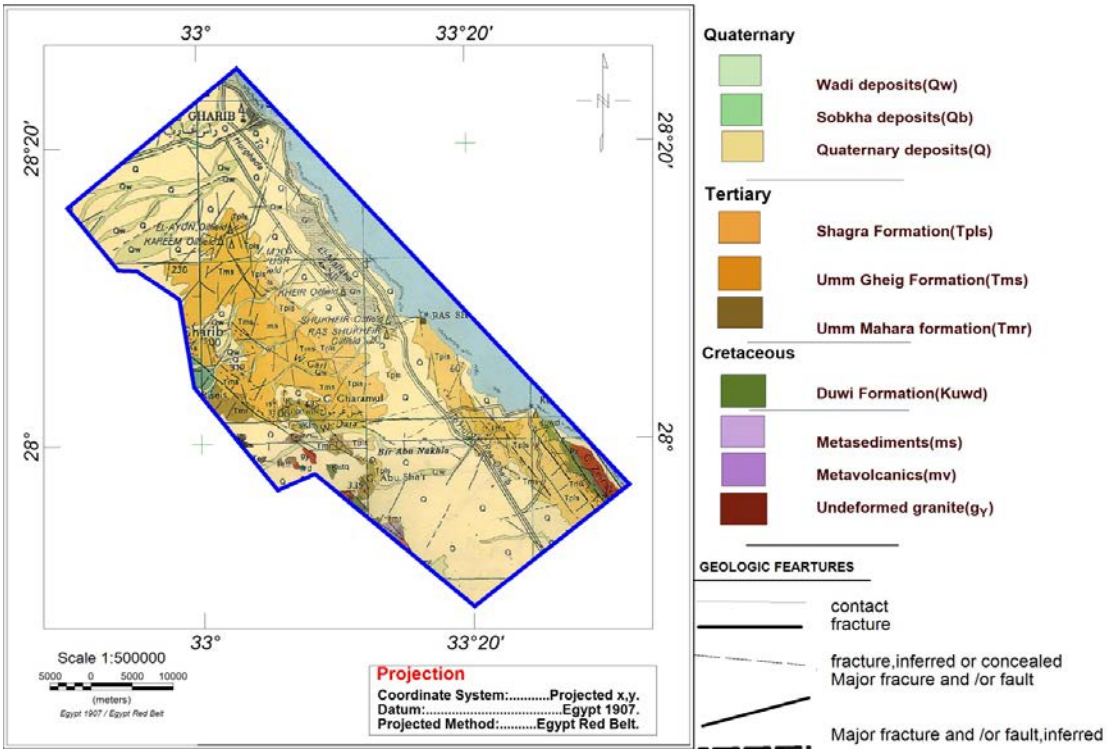

Figure (1): Surface geologic map, G. Gharamul and its surrounding, North Eastern Desert, Egypt (After Conoco & EGPC, 1987).

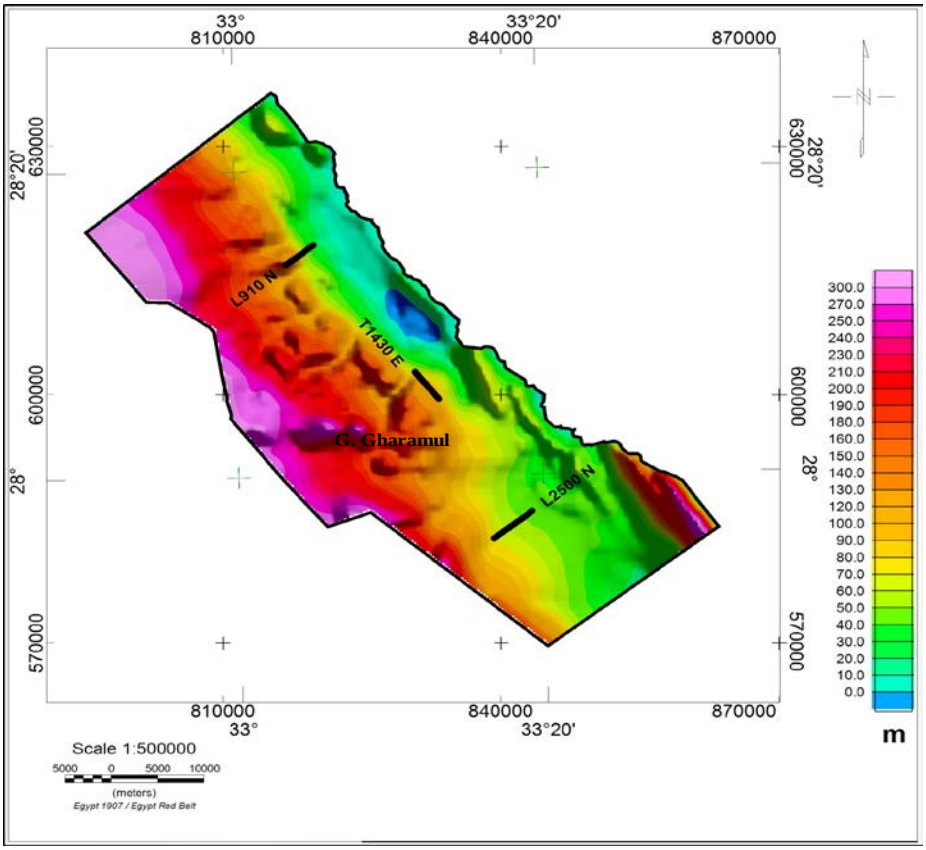

Figure (2): Shaded color topographic map, G. Gharamul and its surrounding, North Eastern Desert, Egypt.

It is formed of Shagra Formation, which is mainly sandstone and Umm Ghieg Formation which is composed of crystalline carbonate**.** Gebel Zeit at the south eastern part of the mapped area which is formed of undeformed alkali feldspar granitic rocks, while El Malha at central eastern part of the mapped area is formed of sabkha deposits, silt, clay, evaporate sand, algal and reefal limestone. Most of the area is covered by Quaternary deposits.

Airborne Spectrometric Survey Data:

During May 2003, the Airborne Geophysics Department of the Nuclear Materials Authority (NMA) of Egypt conducted a multi-channel gamma-ray survey covering 1,900 km^2 (12,907 line km) over Gabal Gharmul area and its surroundings, Northern Eastern Desert, Egypt.

Data were acquired along primary lines spaced at 250 m and along control lines spaced at 400 m. Nominal flying elevation was about 100 m (330 ft.) above ground surface (terrain clearance). The direction of the survey was 51-231 azimuth degrees for primary lines and 141-321 azimuth degrees for control lines. The average speed of the survey was 250 km/h which is equivalent to 70 m per second.

Calibration Pads of Portable Gamma Ray Spectrometer (GS-512):

Comprehensive descriptions of calibration and data processing for airborne and ground gamma ray spectrometry are presented by the International Atomic Energy Agency (2003), Grasty et al. (1997), Minty et al.(1997) and Grasty and Minty (1995). Calibration of gamma ray spectrometric system is required to determine parameters for the various correction stages which lead to ground level radioelement concentrations. This is done through IAEA approved calibration pads occurred in NMA in Cairo. Calibration pads have two purposes:

a- To determine the various striping ratios of the airborne system; and
b- To calibrate the ground spectrometer used to measure the ground concentration of the airborne calibration range.

Stripping ratios account for the spectral overlap of radiation from different radioelement sources. They are determined experimentally using standard concrete calibration pads containing known concentrations of potassium, uranium and thorium plus the blank pad. A minimum of four pads are required to determine potassium, uranium and thorium sensitivity and stripping factors as well as to remove the background.

The stripping ratios are the ratios of the counts detected in one window to those in another window for pure sources of potassium, uranium and thorium. A notation has been adopted in which α, ß and γ are ratios of counts in a lower energy window to those in a higher energy window and a, b and g are ratios of counts detected in a high energy window to those detected in a low energy window.

The time spent for recording the window count rates on each pad controls the accuracy of the calibration constants. A longer counting time reduces uncertainties in the window count rate, which, in turn, will increase the accuracy of the calibration. For GS-512 gamma-ray spectrometer detector, six minutes counting time is realistic, providing calibration constants that are sufficiently accurate for all practical purposes.

The stripping ratios and infinite source sensitivities can then be determined using the program PADWIN. This program has the advantage over the straightforward matrix inversion technique in that the calibration constants and their associated errors are both calculated. These errors take into consideration Poisson counting errors as well as uncertainties in the concentrations of the pads.

Table (1) gives calibration constants for GS-512 gamma-ray spectrometer. For the standard window positions recommended by the International Atomic Energy Agency (IAEA, 1976), no counts should be recorded in the uranium and thorium windows from a pure source of potassium, consequently the reverse stripping ratios ‘b’ and ‘g’ should be zero. This is a useful check that the windows have been set in the correct position and the spectrometer was functioning correctly.

Table (1): Calibration constants for sodium iodide, thallium activated NaI (TI) 76*76 mm scintillation crystal of GS-512 gamma-ray spectrometer.

Type	Coefficient	Calibration constant
Sensitivity	K (cpm per pct)	143.7
Sensitivity	U (cpm per ppm)	14.64
Sensitivity	Th (cpm per ppm)	5.582
Stripping ratio	α	0.6344
Stripping ratio	β	0.7375
Stripping ratio	γ	0.9102
Stripping ratio	a	0.0306
Stripping ratio	b	0
Stripping ratio	g	0

Field trip:

Between 7th October 2012 to 11th October 2012 the field trip was conducted. The ground gamma ray spectrometric survey was carried out along three profiles. Two of them are traverse lines trending 51º and one tie line trending 141º. Firstly, using the global positioning system was necessary to determine the ground points accurately with the same aircraft coordinate; the crew used the GPS to determine the points that will take the reading on it. To determine the

background values, gamma ray spectrometric readings were taken directly over Red Sea water surface at each-day-survey morning.

Stripping Corrections:

The stripping correction is used to correct each of the K, U and Th window count rates for those gamma rays not originating from their particular radioelement or decay series, (IAEA, 2003). The parameters of sensitivity and stripping ratios (α, β, γ and a) determined from calibration pads, as well as, over water background measurements were used to correct the values of potassium in percent, uranium and thorium in ppm according to the following equations (1, 2, and 3), IAEA (2003).

$K_{corrected} = K_{(cps)} - k_{(background)}/30) - \beta * Th_{(corrected)} - \gamma * Ur_{(corrected)}$ …… (1)

$Ur_{corrected} = (Ur_{(cps)} - Ur_{(background}/30) - \alpha*(Th_{(cps)} - Th_{(background)}/30) / (1-a* \alpha)$…… (2)

$Th_{corrected} = (Th_{(cps)} - Th_{(background)}/30) - a*(Ur_{(cps)} - Ur_{(background)}/30) / (1-a* \alpha)$……..(3)

where:

α: are the counts in the U window per unit count in the Th window for a pure Th source,

β: are the counts in the K window per unit count in the Th window for a pure Th source,

γ: are the counts in the K window per unit count in the U window for a pure U source, and

a: are the counts in the Th window per unit count in the U window for a pure U source (Fig. 3).

After correcting the ground data there should be a good correlation between the ground and the airborne measurements. Figures (4, 5 and 6) show a comparison of the ground and airborne gamma count rates in the eU, eTh and K channels respectively, where as the pattern of eU, eTh and K in the airborne gamma ray spectrometric data closely resembles the ground values.

Correlation of the airborne and ground gamma ray spectrometric data:

After correction and processing steps applied on the airborne data from such as calculation of Standard Temperature and Pressure (STP) altitude, subtraction of cosmic and aircraft backgrounds, radon background, calculation of stripping ratios and height correction, the airborne and ground readings still different. So, our target for airborne gamma ray spectrometric data will be done through linear relationships between the ground and airborne data measured at the same points. The resultant linear equations among the ground and airborne potassium, uranium and thorium data, as shown in (Figs. 7, 8 and 9 respectively) are expressed as follow:

K (Ground) =1.8041*K (Airborne)……..(4)

eU (Ground) =0.4216*eU (Airborne)..…….…(5)

eTh (Ground) =0.4521* eTh (Airborne)…….....(6)

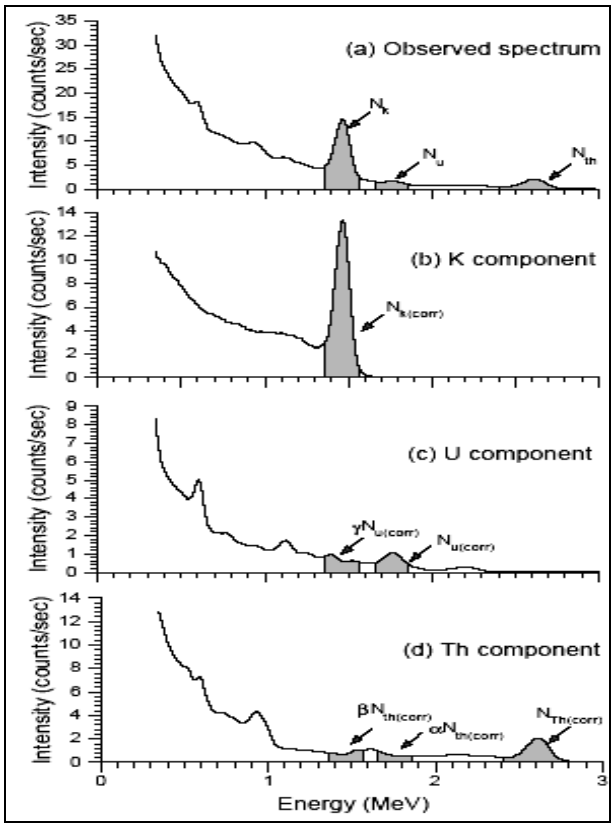

Figure (3): Potassium, uranium, thorium spectra showing the positions of the conventional potassium, uranium and thorium windows and the parameters used for stripping (after IAEA, 2003).

Generation of the spectrometric data after standardization

After getting the three relations between the ground data and the airborne data, applying these equations to the data was very necessary, so the resultant maps are similar to the airborne maps but the values are different due to standardization, as shown in (Figs. 10, 11 and 12).

CONCLUSIONS

After correction and processing steps applied to the airborne data from such as calculation of STP altitude, subtraction of cosmic and aircraft backgrounds, subtraction of radon background, calculation of stripping ratios and height correction, the airborne and ground readings still different. Our target for airborne gamma ray spectrometric data will be done through linear relationships between the ground and airborne data which are measured at the same points.

By using the airborne and ground spectrometric data and making a mathematical relation between them we found that, initially the procedure involved a linear relation with zero intercept of the airborne count rates against the ground concentrations for each measured point on the ground. K (Ground) =1.8041*K (Airborne), eU (Ground) =0.4216*eU (Airborne) and eTh (Ground) = 0.4521* eTh (Airborne).

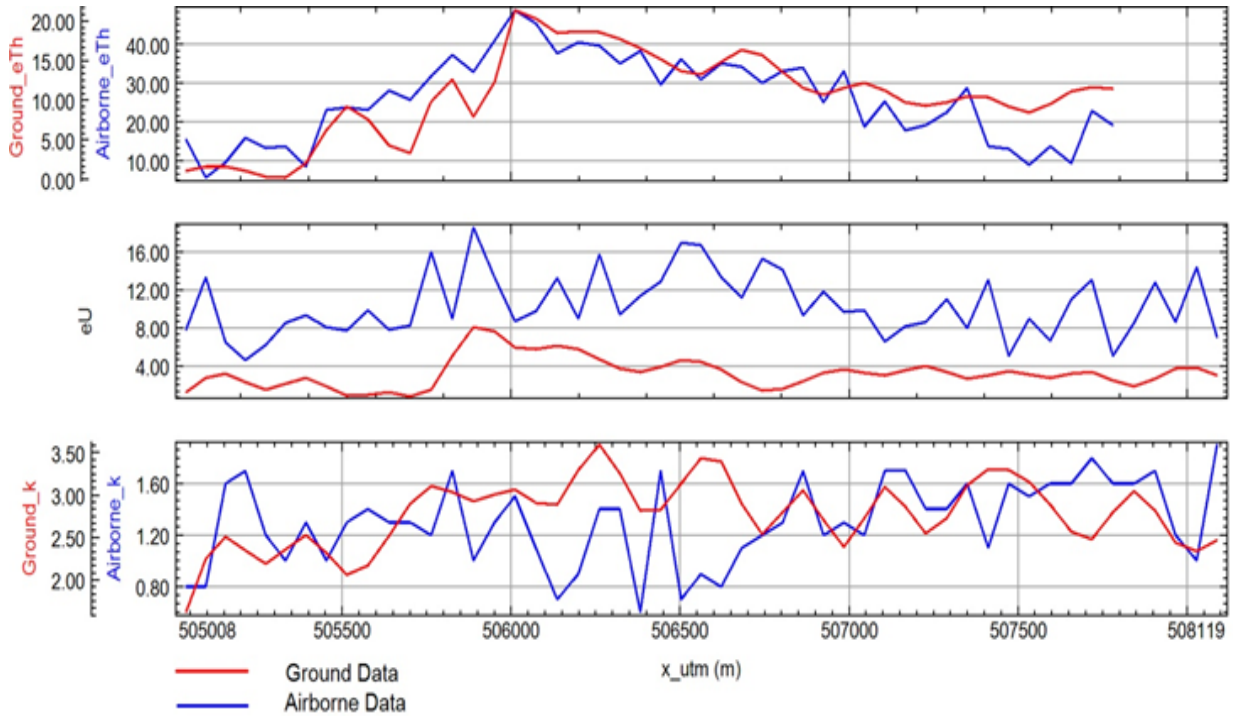

Fig. (4): The ground and airborne gamma ray spectrometric data of L910 profile (its location shown in Fig. 2).

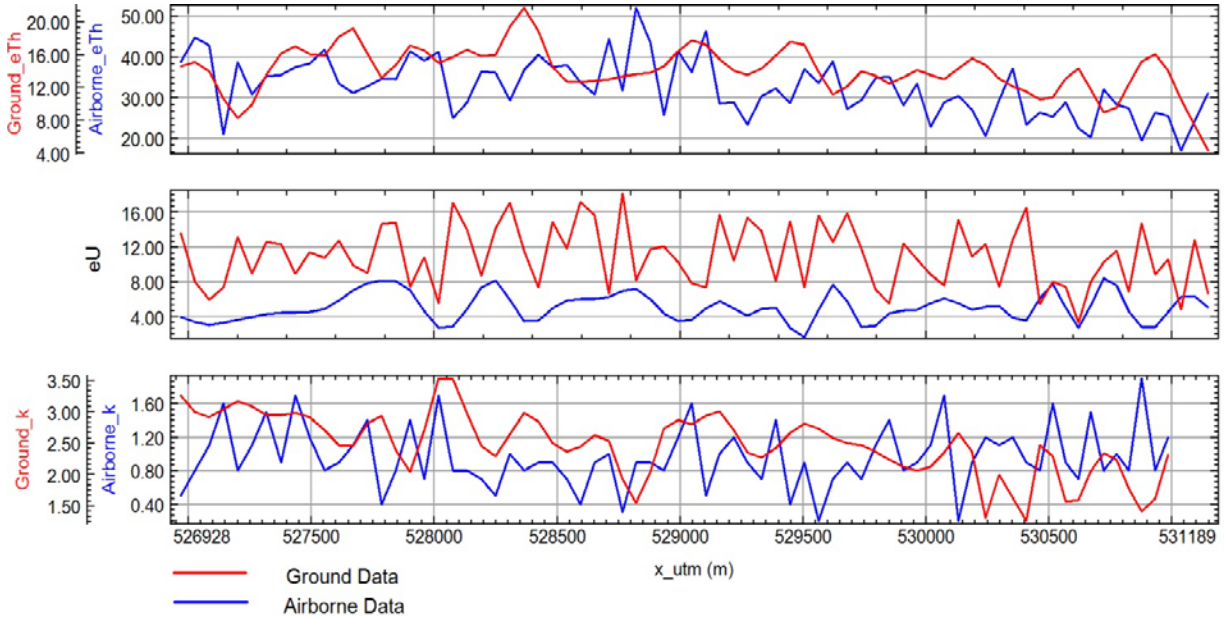

Fig. (5): The ground and airborne gamma ray spectrometric data of L2500 profile (its location shown in Fig. 2).

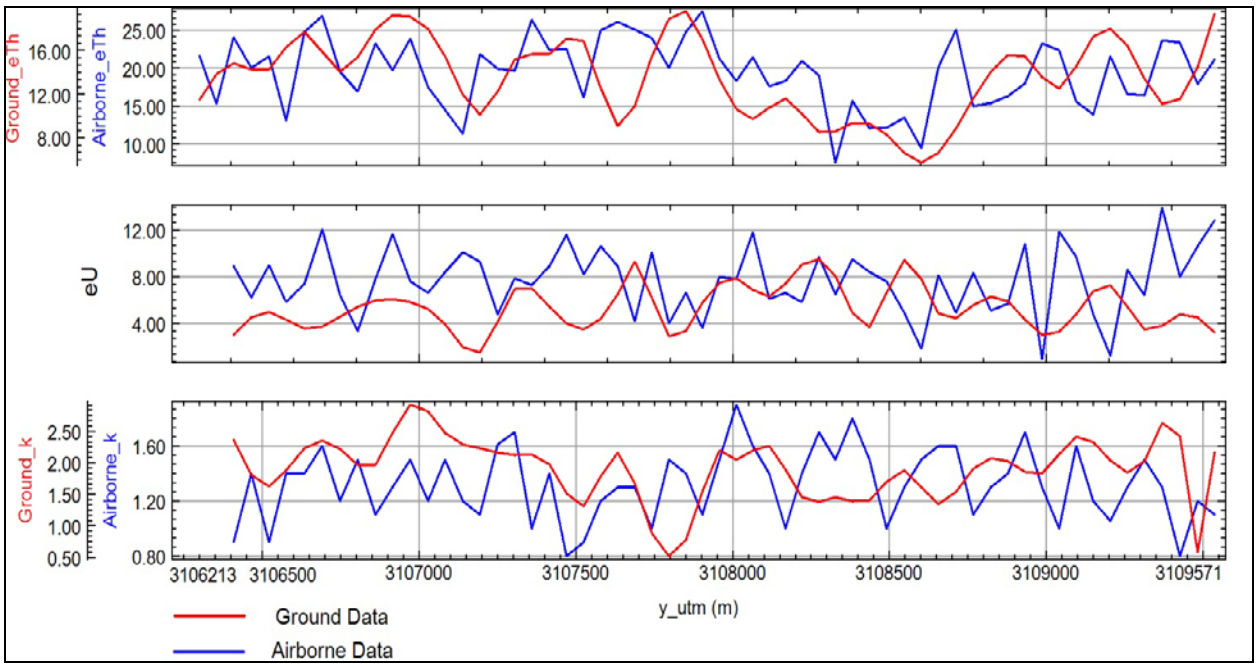

Fig. (6): The ground and airborne gamma ray spectrometric data of T1430 profile (its location shown in Fig. 2)

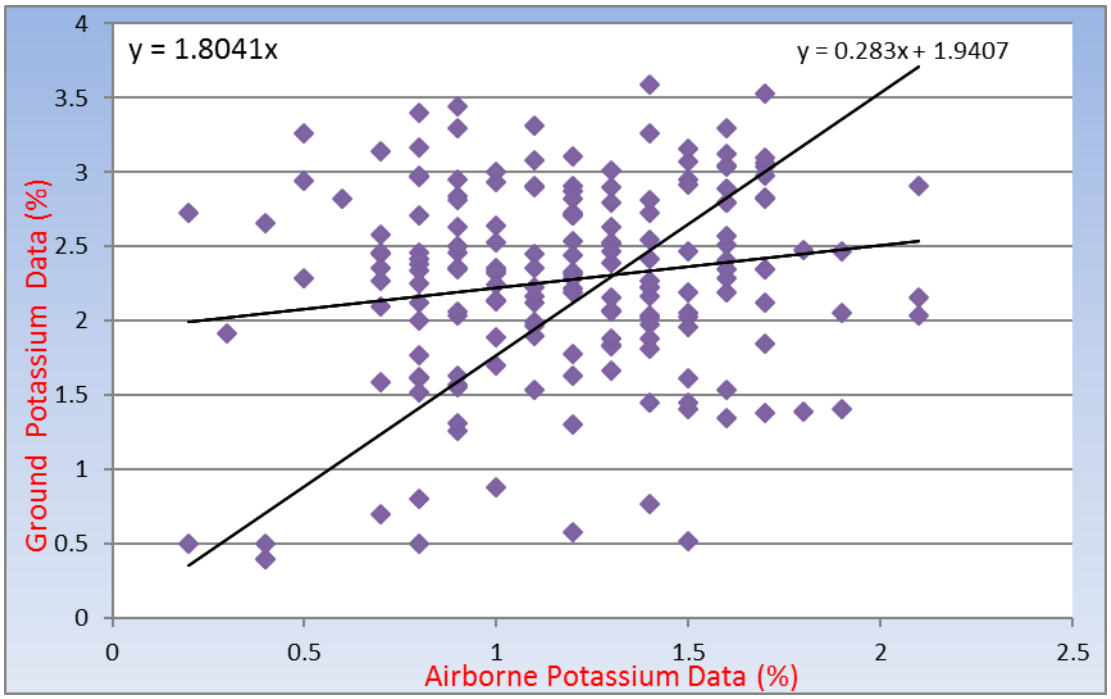

Fig. (7): The relationship of the airborne potassium count rates with ground Concentration for all profiles measured at G. Gharamul area and its surrounding, Northern Eastern Desert, Egypt.

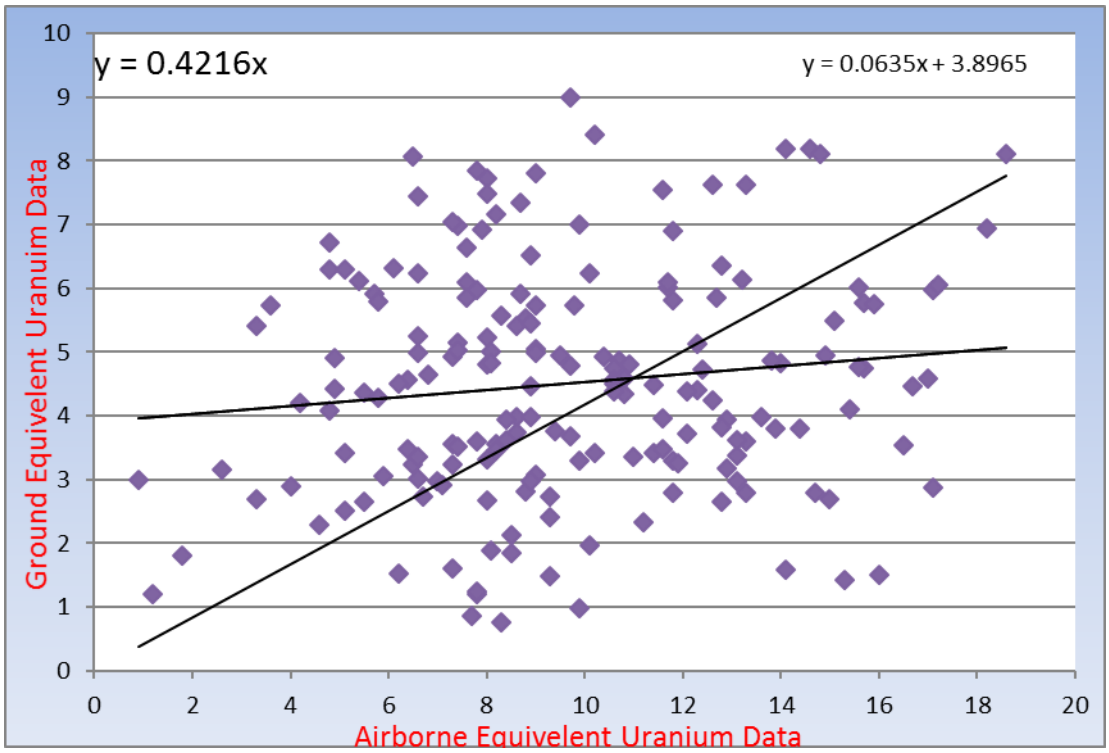

Fig. (8): The relationship of the airborne equivalent uranium count rates with ground Concentration for all profiles measured at G. Gharamul area and its surrounding, Northern Eastern Desert, Egypt.

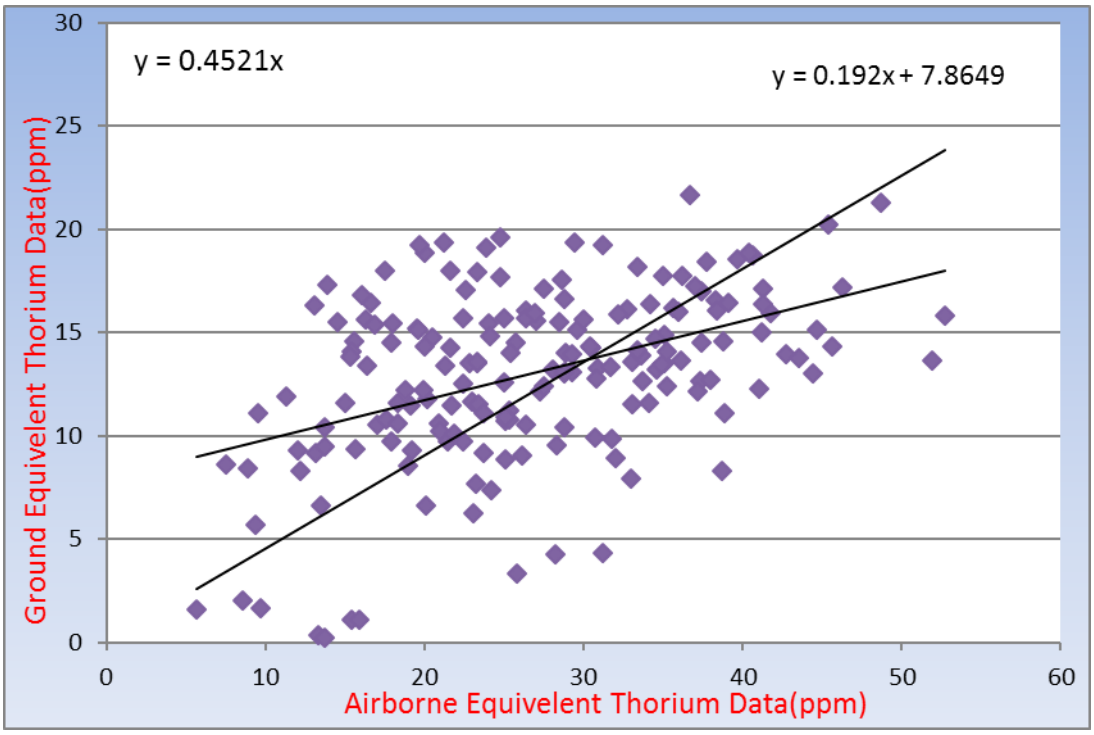

Fig. (9): The relationship of the airborne equivalent thorium count rates with ground Concentration for all profiles measured at G. Gharamul area and its surrounding. Northern Eastern Desert, Egypt.

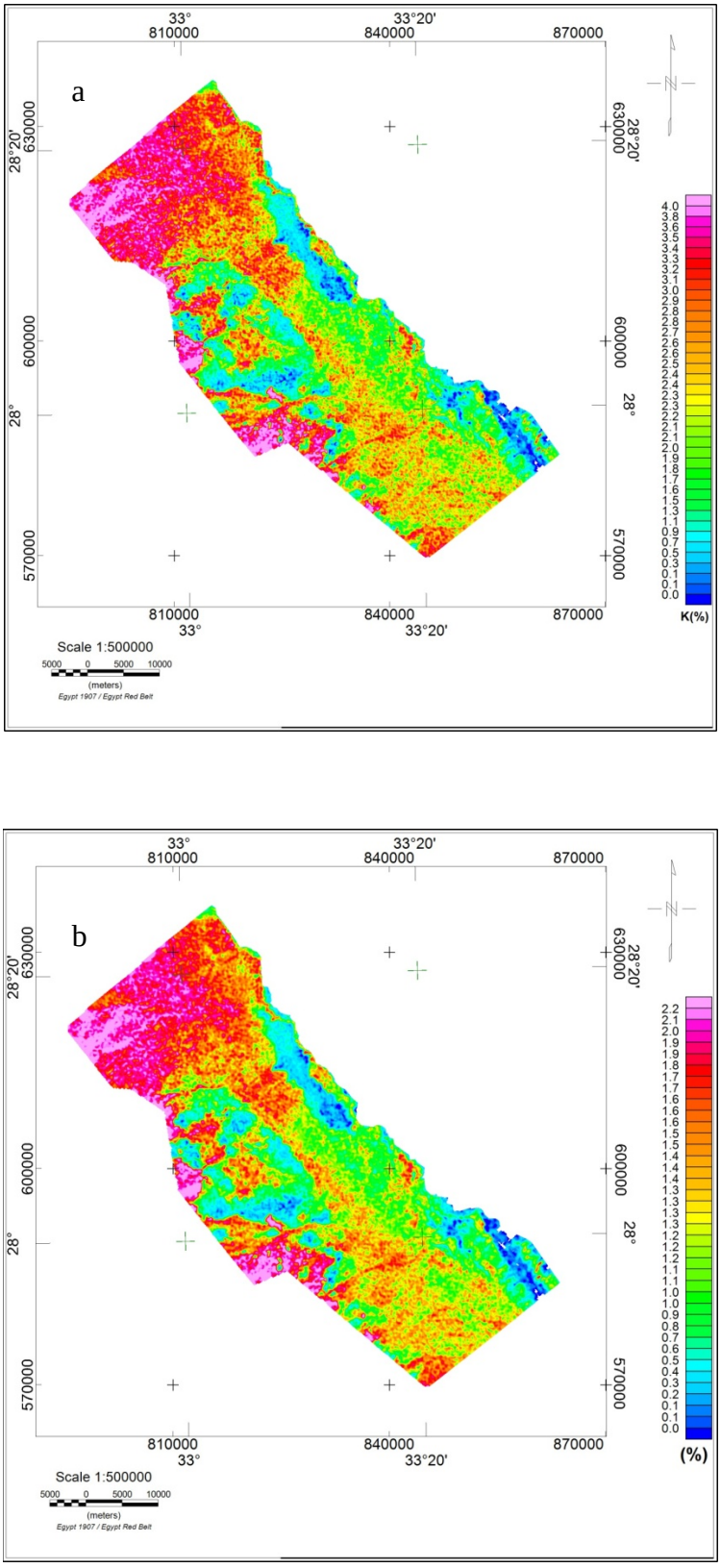

Figure (10. a, b): Filled Color Contour Map of the standardized (a) and airborne (b) Potassium Concentration of G. Gharamul and its surrounding area, Northern Eastern Desert, Egypt.

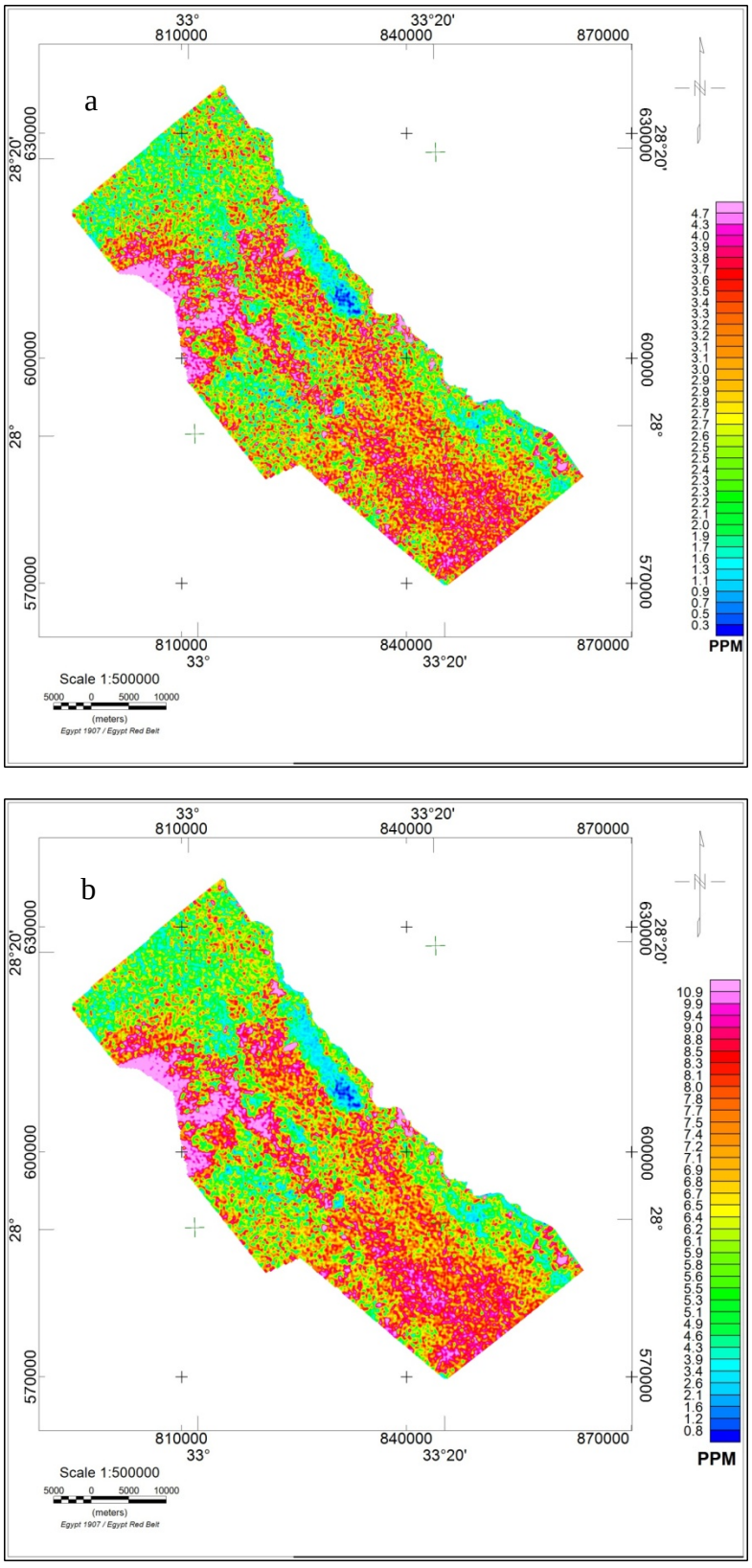

Figure (11. a, b): Filled Color Contour Map of the standardized (a) and airborne (b) equivalent uranium Concentration of G. Gharamul and its surrounding area, Northern Eastern Desert, Egypt.

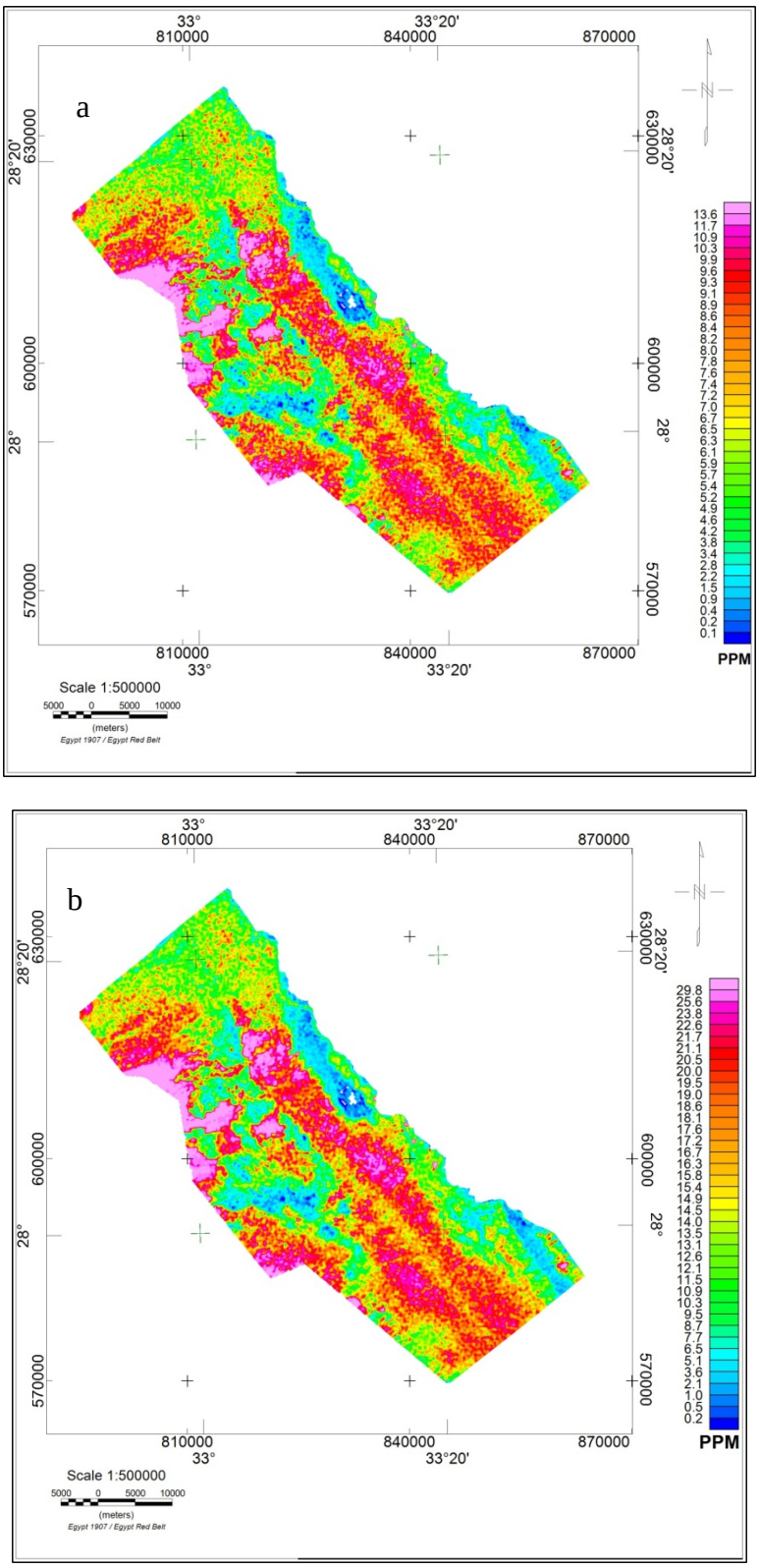

Figure (12. a, b): Filled Color Contour Map of the standardized (a) and airborne (b) equivalent thorium Concentration of G. Gharamul and its surrounding area, Northern Eastern Desert, Egypt.

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