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Relationships between ground and airborne gamma-ray spectrometric survey data, North Ras Millan, Southern Sinai Peninsula, Egypt

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ABSTRACT

In the last decades of years, there was considerable growth in the use of airborne gamma-ray spectrometry. With this growth, there was an increasing need to standardize airborne measurements, so that they can be independent of survey parameters. Acceptable procedures were developed for converting airborne to ground gamma-ray spectrometric measurements of total-count intensity as well as, potassium, equivalent uranium and equivalent thorium concentrations, due to natural sources of radiation.

The present study aims mainly to establish relationships between ground and airborne gamma-ray spectrometric data, North Ras Millan, Southern Sinai Peninsula, Egypt. The relationships between airborne and ground gamma-ray spectrometric data were deduced for the original and separated rock units in the study area. Various rocks in the study area, represented by Quaternary Wadi sediments, Cambro-Ordovician sandstones, basic dykes and granites, are shown on the detailed geologic map. The structures are displayed, which located on the detailed geologic map, are compiled from the integration of previous geophysical and surface geological studies.

1. Introduction

Procedures for standardizing airborne and ground gamma-ray measurements were developed in mid 1970s, as a result of the large uranium exploration programs; such as those carried out in the United States and Canada (Darnley et al., 1975; Duval, 1991). The International Atomic Energy Agency (IAEA) has dealt with the calibration and processing procedures to convert airborne measurements to ground radioactive concentrations of potassium, uranium and thorium (IAEA, 1991, 2003).

The study area is delimited by latitudes 27° 57′ 31″ N & 27° 58′ 20″ N and longitudes 33° 58′ 11″ E & 33° 59′ 12″ E (Fig. 1). The present study deals essentially with the correlation between the ground and airborne gamma-ray spectrometric data, trying to reach empirical mathematical relations between them to standardize the airborne gamma-ray spectrometric data in the surveyed area. These will provide a data base, which can be used as a reference to determine the relationship between airborne and ground gamma-ray spectrometric data in mathematical equations, form that can be used to convert the airborne data to the equivalent ground data in this area.

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2. Aim of the study

The main objectives of the present study are to deduce relationships between the airborne and ground gamma-ray spectrometric data, in conjunction with the available geologic information. This objective is accomplished by examining the available detailed ground and high resolution airborne gamma-ray spectrometric data, in combination with the individual rock units.

3. Geologic setting

Stratigraphically, the geological field investigations of the exposed rock units showed that, the area under study is covered with older to younger units, mostly by Pre-Cambrian basement, as well as Palaeozoic and Quaternary rocks (Fig. 2). The Pre-Cambrian granites are unconformably overlain by relatively thick clastic successions of Cambro-Ordovician rocks. The Pre-Cambrian granitoid rocks comprise quartz monzogranite and granite, which are exposed at the north central, northeastern and southeastern parts of the study area. They are fractured, highly jointed, highly weathered and dissected by basic dyke (Youssef, 2011).

The Cambro-Ordovician rocks include dark sandstone beds of Araba Formation. Issawi et al. (1999) proved that this type of rocks belongs to Post Cambrian – Late Ordovician age. The dark tone of

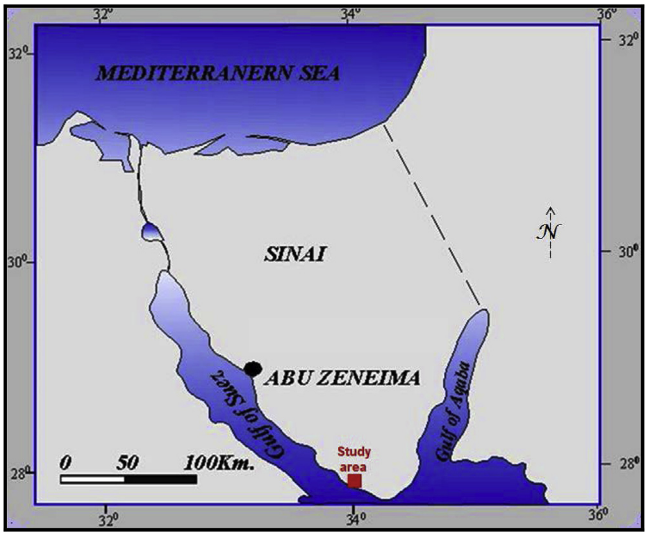

Fig. 1. Location map of the study area, Southern Sinai Peninsula, Egypt.

the "A" member of the Araba Sandstones was attributed to the thermal effect of granitic magma emplaced along their contacts with basement rocks. Uranium mineralizations are concentrated within the unconformity surface between the irregular surface of the granitoid rocks and the non-conformable sandstones of the Araba Formation (Shata, 2002).

The Araba Formation was divided into four members (A, B, C and D), they arranged from bottom to top as: 1) Member "A" unconformably overlies the Pre-Cambrian Basement rocks and conformably underlies the Member "B". Lithologically, it consists of sandstones with comparatively thin bands and lenses of conglomerates. It was first introduced by Ahmed and Osman (1998) in Abu-Durba area, 2) Member"B" conformably overlies the "A" Member and conformably underlies the "C" Member. Lithologically, it is a multi-coloured fine-grained sandstones, siltstones and shales. It, also, was first described by Ahmed and Osman (1998) in Abu Durba area, 3) Member "C" is composed of fine-grained laminated and cross-bedded sandstones alternating with siltstones and claystone beds. Besides, it is described by Ahmed and Osman (1998) in Abu-Durba area, and 4) Member "D" is formed from cross-bedded and tabular planner sandstones, as well as laminated sandstones. In the study area, the upper member "D" Member of the Araba Formation is exposed as small spots and characterized by hard sandstones with some shales and ferruginous siltstone layers. The sandstone is brown, coarse to fine grained and rounded to subangular. It hosts the important minerals of uranium and thorium (Shata, 2002). The upper member is the only exposed member in the southwestern, northwestern and south central parts of the study area (Fig. 2).

The Quaternary rocks are covered mostly by Wadi sediments (alluvial sediments) along Wadi courses. They, also, appear as aeolian sand sheets and dunes.

4. Gamma-ray spectrometric survey

4.1. Ground data acquisition

Field gamma-ray spectrometric measurements were carried out using a portable Czeck Geofyzika Brno (GS-512) multi-channel detector, Czeck republic. This instrument was calibrated using the calibration pads of the Nuclear Materials Authority (NMA) of Egypt. The calibration constants were used in correcting the data for Compton scattering and energy interference between windows (stripping ratios), in order to convert the net counts of the interested windows into radio-element concentration values.

The technique used for the conversion of the range values of the three windows (K, eU and eTh) into elemental concentrations is described by Grasty et al. (1991). The data acquisition was executed in 11st, 12nd and 13rd November, 2008, along a grid pattern of 36 N–S oriented profiles with 25 m station separation and 50 m line separation.

4.2. Airborne data acquisition

In 18th September, 2002, the Airborne Geophysics Department of the Nuclear Materials Authority of Egypt conducted a high-resolution multi-channel gamma-ray spectrometric survey over the Gulf of Suez and its shoulders, which cover the study area. The data were acquired along flight-lines spaced at 250 m and station separation of 60 m at azimuth of N51°E. The Tie-lines were spaced at 400 m for the gamma-ray spectrometric data orthogonal to the flight lines. Nominal flying elevation was about 100 m (330 feet) above the ground surface.

The data were corrected for the background radiation resulting from cosmic rays and aircraft contamination, variations caused by changes in the aircraft altitude relative to the ground and Compton scattered gamma-rays in potassium and uranium energy windows. The uranium and thorium concentrations are, therefore, expressed as equivalent concentrations, eU and eTh, in part of the radioactive material per million pares of rock (ppm). Potassium (^{40}K) is processed to produce the equivalent ground concentrations in percent (%). Total counts are here converted from (μRh^{-1}) to unit of radiometric element (Ur). The corrected data provide an estimate of the apparent surface concentrations of potassium, equivalent uranium and equivalent thorium (K, eU and eTh), as well as the total-count (TC) values.

The collected data for both ground and airborne surveys involved the total radiation count (TC, in Ur) and the concentrations of the equivalent uranium (eU, in ppm), equivalent thorium (eTh, in ppm) and potassium (K, in %).

4.3. Data analysis and interpretation

Both the collected field data were qualitatively and quantitatively interpreted, either airborne or ground; in order to distinguish between the various lithologic units, from the point of view of radioelement concentrations, and delineate surface contacts between these interpreted radiometric lithologic units. The fully-processed gamma-ray spectrometric survey data can be presented in a variety of ways to enable interpretation of the radioelement profiles and grids.

4.4. Qualitative interpretation

Qualitative interpretation of the gamma-ray spectrometric maps of the study area depends mainly upon the excellent correlation between the general patterns of the recorded radioactivity measurements for both data (airborne or ground) and the surface distribution of the various types of rock units and exposures.

Investigation of the patterns of the radioelement maps could be an aid in the course of interpretation of the surface geology. For example, faults and certain lithological contacts may be manifested by disruption of the contours of the spectrometric maps. Linear trends may indicate strikes of sedimentary lithologies. It is possible to identify the lithologic boundaries from the overall changes in the levels of radiation shown in the contour maps. The degree of this identification can be either obvious or subtle, depending on the