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Texture analysis of aeromagnetic data for enhancing geologic features using co-occurrence matrices in Elallaqi area, South Eastern Desert of Egypt

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ABSTRACT

Enhancement of aeromagnetic data for qualitative purposes depends on the variations of texture and amplitude to outline various geologic features within the data. The texture of aeromagnetic data consists continuity of adjacent anomalies, size, and pattern. Variations in geology, or particularly rock magnetization, in a study area cause fluctuations in texture. In the present study, the anomalous features of Elallaqi area were extracted from aeromagnetic data. In order to delineate textures from the aeromagnetic data, the Red, Green, and Blue Co-occurrence Matrices (RGBCM) were applied to the reduced to the pole (RTP) grid of Elallaqi district in the South Eastern Desert of Egypt. The RGBCM are fashioned of sets of spatial analytical parameters that transform magnetic data into texture forms. Six texture features (parameters), i.e. Correlation, Contrast, Entropy, Homogeneity, Second Moment, and Variance, of RGB Co-occurrence Matrices (RGBCM) are used for analyzing the texture of the RTP grid in this study. These six RGBCM texture characteristics were mixed into a single image using principal component analysis. The calculated texture images present geologic characteristics and structures with much greater sidelong resolution than the original RTP grid. The estimated texture images enabled us to distinguish multiple geologic regions and structures within Elallaqi area including geologic terranes, lithologic boundaries, cracks, and faults. The faults of RGBCM maps were more represented than those of magnetic derivatives providing enhancement of the fine structures of Elallaqi area like the NE direction which scattered WNW metavolcanics and metasediments trending in the northwestern division of Elallaqi area.

1. Introduction

Aeromagnetic data are presently considered primary components of mineral investigation programs and are frequently being utilized for exploring petroleum. These datasets provide the mapping of varieties in rock magnetization. Wherever this magnetization is relatively strong and there are well-defined differences among units the process is notably powerful as a mapping mechanism (Dentith et al., 2000).

The definition of the texture is not easy however it is an inherent property of any image. Texture provides us by the information related to the spatial pattern of the tones or intensities in an image. It is a key attribute for many image analysis applications and it contains beneficial information concerning the deep structure of the area. So, the enhancement of texture can be employed to identify various spatial properties or patterns that are existing in the image. Geologic features like rock boundaries, dyke like structures, faults and fractures can be distinguished on processed filtered grids (such as Tilt derivative map) of the RTP data. However, these features are often difficult to be delineated on original magnetic maps but the can be much more reliably recognized on the magnetic texture maps. Textures obtained from magnetic maps indicate variations in physical properties and magnetic intensities of rocks including changes in geologic structures and rock composition (Hassan and Goussev, 2011).

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Textures performed on aeromagnetic texture data reveal variations in physical characteristics of rock units including differences in geologic structures and types of rocks. Haralick et al. (1973) introduced a set of powerful analytical features to estimate multiple properties of an image character. These statistical features are regularly assigned to them as Co-occurrence Matrices (CM) and utilized widely by experts since 1973 for analyzing the texture, segmentation, and classification of the image. We applied CM to the magnetic RTP data of the in Red, Green, and Blue (RGB) form to create RGBCM texture images of Elallaqi region.

Elallaqi territory has been studied by many researchers like Eldosouky et al. (2017) who studied the area using aeromagnetic and remote sensing data to produce a mineral potential image of Elallaqi area. El Shimi (2005) and Abdel Salam and Stern (1996) investigated the structural pattern and zones of alteration of Elallaqi area. Elkhateeb and Eldosouky (2016) used aeromagnetic data to study the relation of porphyry intrusions to mineralization at Elallaqi region.

Texture analysis of aeromagnetic data in Elallaqi area, that can be used for geologic mapping and for identifying fine structures, is the main aim of the present study.

2. Geologic setting

Elallaqi district (Fig. 1a) extends between latitudes 22°22′50″ and 23°00′00″N, and longitudes 33°15′ and 34°15′ E covering an area about 7050 km2 in the South Eastern Desert of Egypt. Elallaqi territory is dominated by the Allaqi-Heiani suture (Stern et al., 1989; Stern, 1994; Abdelsalam and Stern, 1996). The main structural trends dominating Elallaqi district are the NW, NE, and NNE directions (Ramadan and Sultan, 2004) and Elallaqi area is dominated by the shear zone that was progressed amongst the four Neoproterozoic deformation grades (Abdelsalam and Stern, 1996). Elkhateeb and Eldosouky (2016) and Eldosouky et al. (2017) studied the shallow and deep geologic structures in Elallaqi area. These structures describe the favorable positions of hydrothermal movements; therefore, Enhancements of the satellite images were utilized to Elallaqi district to classify the regions of alteration.

Elallaqi area (Fig. 1b) occupied by the Mesozoic volcanic and sub-volcanic, Cretaceous sandstone, and basement crystalline rocks (Geologic map of Wadi Gabjabah Quadrangle, Egypt, 1996).

The southwestern part of Elallaqi area is occupied by the Cretaceous sequences including Abu Sumbul, Al Jilf, Abu Ajjaj, and Al Burj Formations whilst the wadies are filled by Quaternary sediments. The basement rocks occupy the majority of Elallaqi district. Island-arc, Late to post-tectonic granitoids, and Ophiolitic assemblages are the main basement types that occupy Elallaqi area.

The central part of Elallaqi territory is occupied by the ophiolitic assemblages which are composed of metagabbros, talc carbonate schist, and serpentinites. The island-arc assemblages are formed of meta-sedimentary and metavolcanic layers that are intruded by plugs of gabbro and diorite. Diorite, gabbro, quartz-diorite, and tonalite are the main constituents of the gabbro-diorite plugs. Island-arc assemblages are less numerous than meta-sedimentary and metavolcanic rocks. El-Nisr (1997) studied the geochemical characteristics of the metavolcanics which showed that there are transitional circumstances between continental-arc and continental margin. The late-post tectonic granitoids have an abundant presence in the central part of Elallaqi area, especially at Wadi El Shelman (Fig. 1b). They appear as separated circular eroded cliffs that are displayed by recent sand deposits.

3. Materials and enhancement techniques

3.1. Aeromagnetic data

Fig. 2 shows The magnetic intensity (TMI) or magnetic anomaly map of Elallaqi area used in the present investigation was acquired from the Egyptian Mineral Resources Authority that was accomplished by Aero Service Company (1984). The Aeromagnetic surveying was operated with a 120 m flight elevation and an average magnetic inclination of 32.8 N and declination of 1.9 E. So as to apply the RGBCM technique, a pole reduction (RTP) enhancement was applied to magnetic anomaly (TMI) map (Fig. 3).

RTP enhancement is applied to TMI data of Elallaqi territory to reduce or even decrease the distortion of the magnetic anomalies and makes the magnetic sources appear as if located at the pole and to change the asymmetric pattern of the anomalies to the symmetric mode (Baranov, 1957).

3.2. Co-occurrence Matrix Filtering (CM)

A set of flexible and important mathematical features, that were adopted to calculate different texture characteristics of an image, was explained by Haralick et al. (1973). The textural properties of the aeromagnetic grids were qualified in the present work using a technique based on co-occurrence matrices (CM). Dentith and

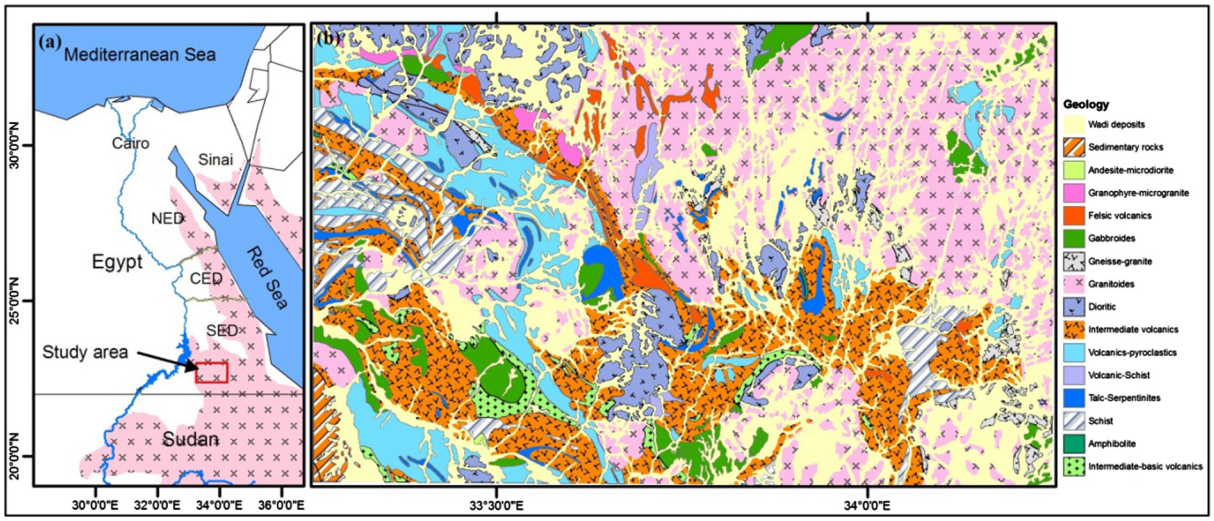

Fig. 1. (a) Regional geology of the Eastern Desert of Egypt, (b) Geologic map of Elallaqi territory (After EGSMA., 1996).

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