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Application of gamma ray spectrometric measurements and VLF-EM data for tracing vein type uranium mineralization, El-Sela area, South Eastern Desert, Egypt

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Abstract This study is an attempt to use the gamma ray spectrometric measurements and VLF-EM data to identify the subsurface structure and map uranium mineralization along El Sela shear zone, South Eastern Desert of Egypt. Many injections more or less mineralized with uranium and associated with alteration processes were recorded in El Sela shear zone. As results from previous works, the emplacement of these injections is structurally controlled and well defined by large shear zones striking in an ENE–WSW direction and crosscut by NW–SE to NNW–SSE fault sets. VLF method has been applied to map the structure and the presence of radioactive minerals that have been delineated by the detection of high uranium mineralization. The electromagnetic survey was carried out to detect the presence of shallow and deep conductive zones that cross the granites along ENE–WSW fracturing directions and to map its spatial distribution. The survey comprised seventy N–S spectrometry and VLF-EM profiles with 20 m separation. The resulted data were displayed as composite maps for K, eU and eTh as well as VLF-Fraser map. Twelve profiles with 100 m separation were selected for detailed description. The VLF-EM data were interpreted qualitatively as well as quantitatively using the Fraser and the Karous–Hjelt filters. Fraser filtered data and relative current density pseudo-sections indicate the presence of shallow and deep conductive zones that cross the granites along ENE–WSW shearing directions. High uranium concentrations found just above the higher apparent current-density zones that coincide with El-Sela shear zone indicate a positive relation between conductivity and uranium minerals occurrence. This enables to infer that the

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anomalies detected by VLF-EM data are due to the highly conductive shear zone enriched with uranium mineralization extending for more than 80 m.

1. Introduction

Radioactive minerals occur naturally in the geological environment associated with geological features such as unconformity contact, veins, shear zones, and so forth (Tuncer et al., 2006).

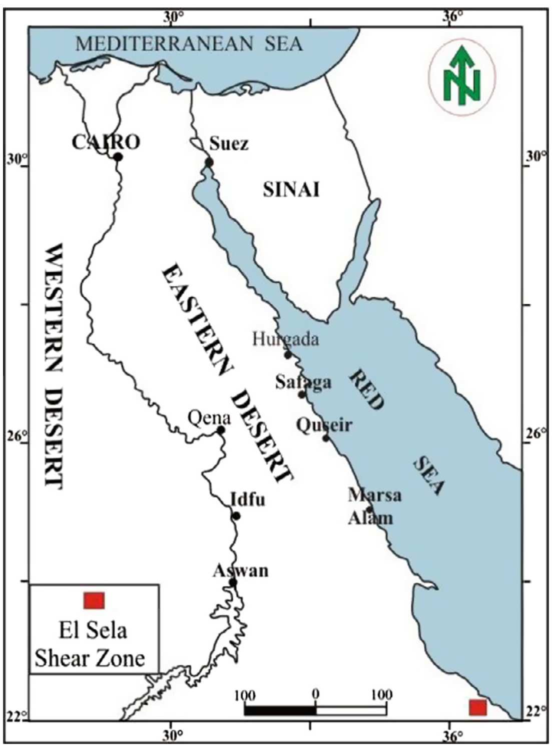

Figure 1 Location map of El-Sela shear zone, South Eastern Desert (S E D), Egypt.

The nature of mineralization varies from hydrothermal vein type, strata bound deposit, disseminated type, and brecciated complex in the form of vertical, dipping, and horizontal sheet type structures. This is dependent primarily on the prevailing geological environment and the valence state of uranium, respectively. Such shallow subsurface structures can be best delineated by very low frequency electromagnetic method due to its advantage in detecting conducting structures. Uranium, being a metal, is highly conducting and, therefore, its presence in the subsurface rocks provides an excellent conductivity contrast between its deposit and the neighbouring formations (Legault et al., 2008; Nimeck and Koch, 2008). Moreover, to prove the presence of radioactive mineralization, radiometric survey is an essential aspect which can differentiate, with a better resolution, between a probable mineralization and that of an economic prospect. Their occurrences in outcrop enhance the background radiation of the area.

Gamma-ray maps reflect the geochemical variations of K, U and Th in the upper 30 cm of the earth's surface. This thin layer is subject to weathering which leads to the loss U and Th concentrations, while K may increase in altered rocks. Th may show increase or decrease during hydrothermal alteration. Detailed interpretation of gamma-ray survey requires the delineation of major geological units and examination of subtle variations with the aid of other data (Charbonneau and Ford, 1979).

Very low frequency-EM method is a semi-passive electromagnetic induction method which utilizes distant high power vertical transmitters as a source for the primary field. These transmitters are meant for long distance marine communications and situated on the coastal areas worldwide. They operate in the lower band (15–30 kHz) of communication frequency. These signals travel a long distance and can be utilized for geophysical measurements several thousand km away from transmitters. Since the primary field is horizontal, VLF

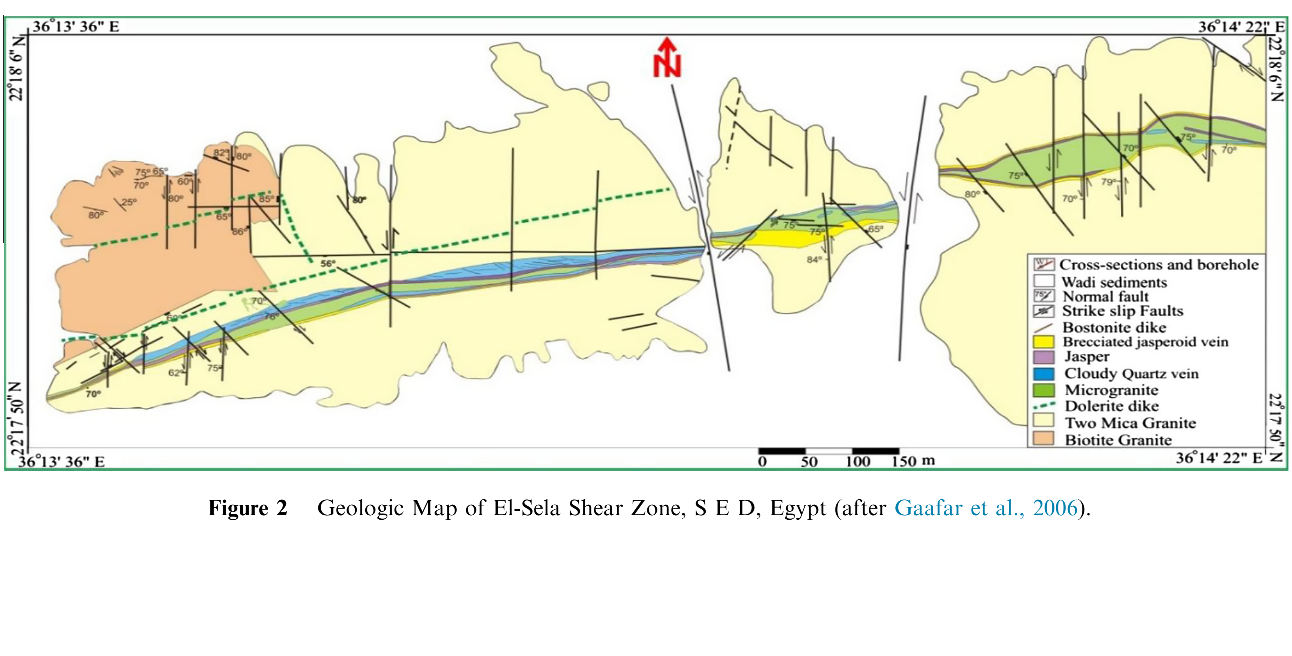

Figure 2 Geologic Map of El-Sela Shear Zone, S E D, Egypt (after Gaafar et al., 2006).