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Using ASTER data for gold metallogeny synthesis of the South Eastern Desert, Egypt

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ABSTRACT: Processed visible near-infrared and short wave infrared reflectance data of ASTER bands are integrated with mine-scale geological maps, geochemical and mineralogical information of gold deposits within the Allaqi-Heiani and Hodein areas. The results reveal the efficiency of spectral analysis techniques in delineation structural elements and geologic setting controlling the gold lodes. We conclude that gold metallogeny of the South Eastern Desert correlates with major post-accretionary shortening structures (~630-550 Ma), particularly the high–order splays that are associated with signs of concomitant magmatic or metasomatic activities.

Keywords: *ASTER data processing, Geological and structural controls, Post-accretionary structures, Gold metallogeny, South Eastern Desert, Egypt.*

General Geology: Gold orebodies and related hydrothermal alteration halos occur in three main geologic/structural settings, namely: (I) steeply-dipping anastomosing silicified shear zones between allochthonous listvenized ophiolitic blocks and island arc metavolcanics and metasediments (e.g., El-Beida, El-Anbat, Korbiai, Egat, Um El-Tuyor, Haimur and Um Gariat deposits), (II) reactivated shears along intrusive contacts of arc-related gabbroid-granitoid intrusions and carbonaceous metapelitic/psammopelitic metasediments, commonly close to granitic dyke-like bodies (e.g., B**eta**m and Um El Tuyor El Tahtani deposits), and (III) moderately-dipping mylonitic zones, along which sheared syn-orogenic granitoid sheets tapered into variably sheared island arc volcanic / volcaniclastic host rocks (e.g., Wadi Khashab, Seiga and Shashoba deposits).

The endowed shear zones commonly strike between N20-40°W, and cut through a variety of greenschist facies rock types, folded into broad or close antiforms (e.g., Betam, El-Beida, Seiga, Shashoba). It seems likely that antiformal fold closures provide fluid traps for mineralizing fluids and help focus regional mineralization. Broad anticlines, cut by a zone of intense shearing might play an important role in disturbing and focusing regional hydrothermal fluids fluid flow. Exceptions include Haimur and Romite deposits, which occur in NE-trending shear zone cutting tight folded carbonatized serpentinite and ferruginated metasedimentary matrix in Haimur and cut highly foliated metavolcanics and quartz-diorite in Romite. It is interpreted that where rock flow is perturbed by the presence of rigid bodies of complex geometry, centres of dilation (divergent flow) and of compression (convergent flow) are developed, leading to fluid focusing and mineralization at dilational spots. (Fig.1

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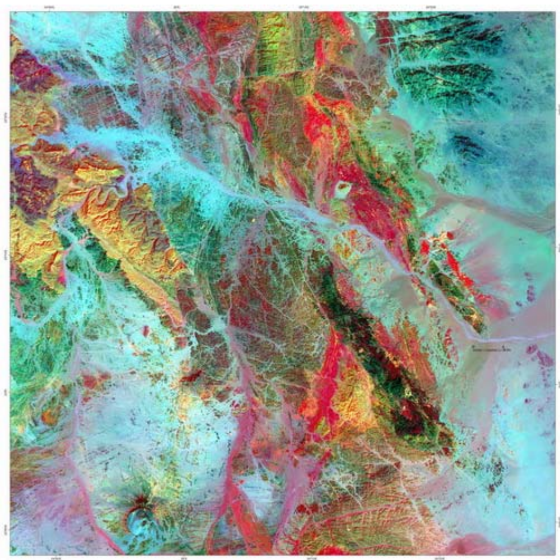

Fig. (1) NW-trending Hodein Kharit wrench faulting corridor imposed on early WNW and ~E-W foliations. Hydrothermal alteration haloes and associated auriferous lodes occur within this post-accretionary system.

Remote sensing data analysis and results:

In this study, a cloud-free level 1B ASTER VNIR & SWIR data has been processed using the ENVI v.4.7 software. Image processing techniques including band ratioing, principal component analysis (PCA), false-color composition (FCC), and frequency-domain filtering (i.e., FFT-RWT) have been applied for detailed mapping of the lithological units, structures and alteration zones in the study area. The USGS spectral library of rock forming minerals was used to evaluate the ASTER image spectral signatures, considering already identified mineral composition of the different lithological units in the study area.

Band Ratio: ASTER band ratio (4/7) (Fig.2a) image identifies serpentinite and talc-rich rocks by a bright image signature, and further allow discrimination between the highly sheared, carbonatized, serpentinite and talc-carbonate schist from less-deformed (massive) serpentinite and ultramafites. Granitoid rocks have bright tones on band ratio (2/4) images, whereas, amphibolite and highly sheared ophiolites appear as dark gray or black pixels. ASTER band ratio (6/8) (Fig.2b) image identifies granitoid intrusions

(a) (b)

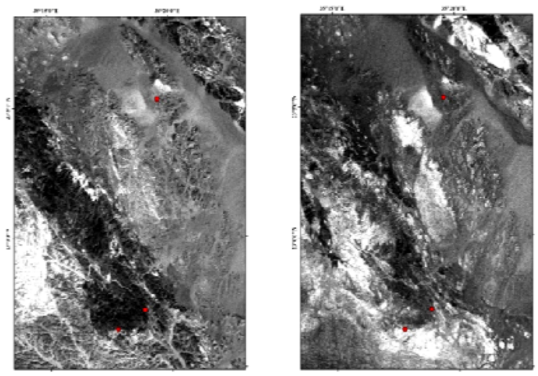

Fig.2. (a) ASTER Band ratio (4/7) image, showing carbonatized serpentinite and talc-carbonate schist as bright pixels, (b) ASTER Band ratio (6/8) image discriminate between the mafic/ultramafic rocks (bright tone) from granitoids (dark tone).

Principal Component Analysis (PCA) and Fast Fourier Transform (FFT): These are efficient image processing techniques aid geological and structural mapping. Eigenvector statistics in each PCA would identify the PC image in which the spectral information of a mineral under examination is loaded. This information usually represents, in quantitative terms, a very small fraction of the total information content of the original bands, but it is expected that the loading information indicates the spectral signature of the desired mineral (Crosta and Moore, 1989). By looking for high Eigenvector loadings for bands 2 and 4 in PCs where these loadings are also in opposite sign, we can predict that iron oxides can be distinguished by bright pixels in PC5. Iron oxide minerals have low reflectance in visible (band 2) and higher reflectance in near infrared (band 4). Distinctly, serpentinite and talc-carbonate schist (Mg–OH-rich rocks) appear in black and dark gray, respectively.

The FFT provides better visual interpretation of the image for the purpose of extracting structural information, while the richness in spectral information in the RGB color combination image can sometimes mask structural continuity. Some selective ASTER PCA images appear to emphasize regional structural trends relative to spectral variations. Therefore, they have been selected for applying the frequency filtering to trace the geological structures (e.g., Richards and Jia, 1999; Ren and Abdelsalam, 2006). Apply the frequency filtering for these PC images was carried out through ASTER PCA conversion into frequency domain images using the FFT technique. Subsequently, a low-pass circular filter is designed to retain or eliminate data with desired frequencies, therefore reducing the high frequency noise in the frequency domain images. Finally, inverse FFT is applied to transfer the frequency-filtered information back into spatial domain images.

Conclusions:

Integrated image transformation methods (e.g., band ratioing, PCA, FCC and FFT) on selective bands of the ASTER data, have been found to be self-calibrating, scene-dependent, and complimenting each other for identification of lithologies and hydrothermal altered zones. In addition, highlighting the intensely deformed/sheared rocks Fig. 3) in the area aided understand the setting of gold-quartz lodes in relation to the major structures, particularly the post-accretionary ones. For the lode gold mineralization spreading over the vast terrains, characterizing a model is a challenging job for which the used ASTER processing techniques would certainly assist exploration programs. Resulting from our study, highly foliated belts of stacked metamorphosed ophiolites and island arc assemblages, especially close to major post-accretionary transpression zones are suggested as a model for hydrothermal gold targets in the South Eastern Desert of Egypt.

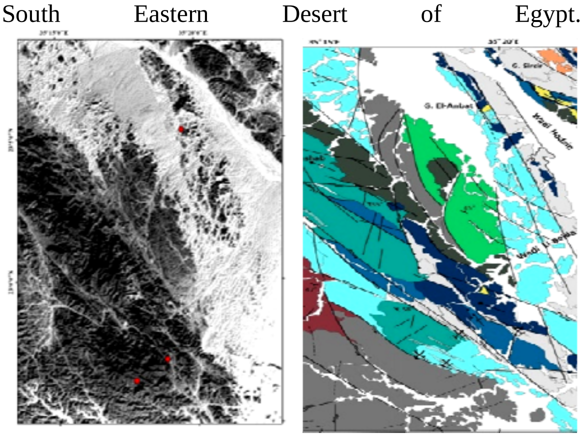

Fig.3. PC5-FFT-RWT ASTER image & Interpretation map compiled from both produced images and field observation

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