Spectral discrimination of hydrothermal minerals by using ASTER data: Case Study in Um Nar area, Egypt

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Abstract

ASTER data are attractive to many geological researchers due to their high spatial and spectral resolutions. This work examines ability of ASTER data to map hydrothermal minerals in an arid area in Central Eastern Desert, Egypt, using spectral analysis techniques. Visible, near infrared and short wave infrared reflectance data (first 9 bands) are utilized. Minimum noise fraction (MNF) transformation is executed on the data and then pixel purity index (PPI) run on the new data set. N-dimensional visualization is carried out on the PPI to extract pure pixels. Extreme pure pixels are identified from the pure pixels. Spectra of these extreme pure pixels are compared with NASA JPL spectra of minerals available in the study area, by both spectral angle mapper (SAM) and spectral feature fitting (SFF) giving two lithological maps. Against reference lithological data, the overall accuracies of the two maps are 78.85%, 70.33% respectively, Proving applicability of ASTER data in lithological mapping.

Keywords: Aster, Hydrothermal Minerals, Um Nar,

1. Introduction

The Neoproterozoic basement complex of Egypt is composed mainly in the Eastern Desert as a ~ 800 km long belt that parallels the Red Sea coast. It presents ~10% of the total area of Egypt and forms part of the Nubian Shield, which is the western segment of the Arabian-Nubian Shield. The study area represents the south most banded iron formations (BIF) occurrence in the Central Eastern Desert of Egypt. It is bounded between latitudes 25° 14′ 45″N and 25° 16′ 18″N and longitudes 34° 15′ E and 34° 17′ 27″E and represents one of more than fifteen BIF occurrences in The Eastern Desert. The mineable reverse of the Um Nar BIF is evaluated at 13.7 Mt. (El Ramly et al, 1970). Up to date, no commercial mining operation has taken place in Um Nar because of the high silica content of the ore (El Habaak, 2004). The Um Nar BIF proved to be gold and silver bearing with gold contents with average of 0.82 ppm. The type of gold associated with the Um Nar BIF is classified by as stratabound gold deposits associated with Alogma-type BIF. The source of gold in Um Nar is suggested to be associated with ancient oceanic crust represented by the serpentinites of Gabal El Mayit. The gold content has been found to be higher in the highly deformed areas because the resulting shear zones and tectonic fractures have acts as channel ways and depositional loci for the gold –bearing fluids and that the hematite bands of the Um Nar BIF are slightly richer in gold than the magnetite.

2. Data used

The ASTER data used in this study are two cloud free level 1A data scenes acquired on Febrauary 18, 2007. The images have been pre-georeferenced to UTM Zone 35 North projection with WGS-84 datum. To preserve the spectral characteristics of the SWIR bands, the VNIR bands were Spatially resized (nearest neighbor algorithm) to match the spatial resolution of the SWIR bands. and then clipped to the study area. The SWIR bands were corrected for the crosstalk effect (Rowan and Mars, 2003) by using the crosstalk correcting software provided by (ERSDAC 2001).

MODTRAN4 software was used to calculate the solar irradiance and to convert ASTER data into surface reflectance images.

2.1. SWIR Pre-processing

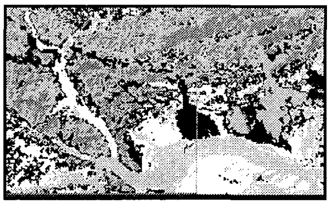
SWIR crosstalk is an offset or additive error in radiance due to the leakage of photons from one detector element to another (Iwasaki et al., 2001). So it was corrected by using the crosstalk effect software provided by the Japanese ASTER Ground Data System (GDS), solar irradiance values were calculated by using MODTRAN4. And the images were calibrated to reflectance values. To be able to analyze spectral responses of surface cover types, it is necessary to apply residual log residual algorithm on SWIR bands to reduce noises from Topography and sun illumination.

3. Methodology

Analysis of ASTER data for lithologic mapping is based on determination of the relationship between spectral reflectance and spectral emittance and the mineral composition of the rock units of interest. The Spectral Angle Mapper (SAM) technique (Kruse et al., 1993) was applied to test the similarity between pixel spectra and mineral reference spectra for 7 minerals and by using the Spectral feature Fitting method (SFF) "Absorption features" to measure the absorption depth. The reference spectra were extracted from the National Aeronautics and Space Administration/Jet Propulsion Laboratory/ (NASA/JPL) spectral library, and were re-sampled to the same ASTER bands widths, using filter functions. Similarities between image spectra and reference spectra were calculated. Small SAM angles indicate great similarity between pixel spectra and reference spectra. To enhance variations in the depth of the 2200 nm absorption bands on a per-pixel basis, the continuum removal method (Clark, 1999) was applied on bands 5 to 8. For endmember selection, a semi-automatic procedure, based on the sequential use of the minimum noise fraction (MNF) and pixel purity index (PPI) techniques, was applied to the surface reflectance values of the ASTER VNIRSWIR bands (Boardman and Kruse, 1994). End members were selected from the inspection of extreme pixel spectra extracted from PPI and projected as points in *n*-dimensional scatter plots of the higher-order four MNF images.

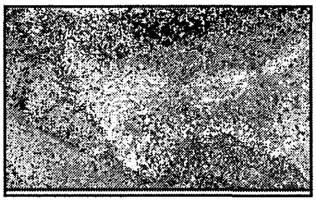
4. Summaries and Conclusion

The paper has investigated the usage of the ASTER data for mapping the geology for an arid area in Egypt. Several spectral image-processing techniques were used. In general, not one spectral analysis procedure is consistently superior to others judged by the comparison of our analysis results with the reference data. Each of the three-hyperspectral classification techniques has its unique strengths and limitations. The spectral analysis method based on MLH has a relative advantage in terms of better definition of the intercalation nature of layered rocks. However, in terms of overall classification accuracy, SAM and SFF procedures seem to yield classification results closer to the reference data, with total accuracies of 78.85%, 70.33% respectively. SAM and SFF proved to be effective techniques in mapping lithological units in an arid area and their results can be improved further if data calibration can be applied with the support of atmospheric information. SAM demonstrated strength in mapping distribution detail for lithological units, while SFF was good at achieving the best balance of classification accuracy among different rock types.

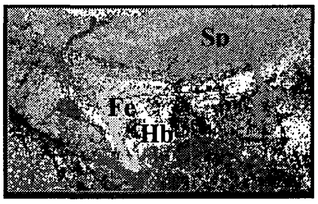


CLASSICIFATION OF ISO DATA

CLASSICIFATION OF MLH



CLASSICIFATION OF SFF



CLASSICIFATION OF SAM

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