

A Case Study of Alteration Mapping and Targeting on a Regional Scale from Satellite Spectral Data: An Example from the Iran-Pakistan Sectors of the Tethyan Belt

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The remote identification of altered rocks, as well as mineral zoning in those altered rocks, is of intense interest to an exploration geologist in the early phases of mineral exploration. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) provides relevant data that can be interrogated at a regional scale. The Iranian and Pakistan sectors of the Tethyan Belt contain several large to giant ore deposits, including Sar Chesmeh, Reko Diq, Sungun, and Saindak. ASTER can be applied to identify sites with potential for porphyry and epithermal mineralization to aid exploration of this region, as has been shown by several local studies.

An extensive program of testing and analysis was developed and completed to define the most useful criteria for identifying the alteration systems present, given the geology, types of mineralization, and prevailing climate. The main components of this evaluation program were the detailed evaluation of 23 mineralized sites from Sungun in northwest Iran to Reko Diq in Pakistan to determine which spectra best defined the known alteration and mineralization, and mineral zonation within those systems; these selected sites were evaluated using the spectral libraries available, including spectra for global porphyry systems, and high sulfidation/acid sulfate and low sulfidation precious metal systems. From this process a short list of 12 spectra were identified that have allowed the rapid screening of whole mineral belts.

It was concluded that, given the inherent variability of the scenes acquired under different conditions on different dates, a simple spectral angle matching (SAM) algorithm was most likely to give comparable results across scenes. Threshold analysis of the spectral angle mapping was applied to each of the 12 spectra. The 0.5% of individual ASTER images with signatures most like these spectra were interrogated separately. The output from the SAM analysis was then used to develop an “alteration end-member index” for each scene.

The results of this investigation include the following:

- The criteria developed for the rapid targeting, particularly the alteration end-member index, identified the majority of the known porphyry and epithermal deposits in these sectors of the Tethyan Belt, plus a large number of less well known or new targets.
- Zonal mineral patterns are clearly visible in the ASTER data, indicating the nature and relative intensity of porphyry and epithermal alteration assemblages present at surface.
- Approximately 300 spectral features have been identified in Iran and Pakistan as being of interest; these features have a combined surface area which is 0.12 of the total area (approx. 300,000 km²) assessed.
- The targets can be readily ranked using the publically available geological, geophysical, geochemical, and other data.
- However, careful analysis is required to differentiate areas of interest from false anomalies, as with most remotely sensed data sets.