Geologic Mapping with ASTER, EO-1, AVIRIS, and Landsat Imagery

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Remote sensing imagery has become increasingly important to worldwide geologic and mineral mapping. With economic and exploration frontiers expanding globally, the use of multispectral and hyperspectral systems plays a significant role in mapping and evaluating developing countries, overseeing reconstruction efforts in foreign lands, and monitoring international mining and environmental conditions. Airborne and spaceborne sensors provide valuable digital imagery that allow lithologic and stratigraphic identification, geomorphic and structural interpretation, rock alteration and mineral prediction, as well as geobotanical observations, all on a worldwide scale.

From an orbiting platform, multispectral sensors dominate. Six Landsat missions have provided nearly 33 years of continuous multispectral earth observation. Since 2000, ASTER multispectral imagery has offered improved spectral and spatial detail as compared to Landsat and has been shown effective in identifying and mapping surface geology down to 1:50,000 map scale. Together, Landsat and ASTER data comprise the bulk of satellite imagery used by geologists and explorationists. Depending on terrain, Landsat Thematic Mapper (TM) imagery can be enhanced to map iron oxides and clays but has difficulties characterizing carbonates and silicates as well as problems differentiating certain clay, mica, and sulfate minerals. ASTER shortwave infrared (SWIR) bands are excellent for mapping clastic and carbonate stratigraphy and volcanic environments plus have been shown effective in predicting mineral groups and specific minerals (i.e., kaolinite, alunite, illite, muscovite, montmorillonite, chlorite, calcite, dolomite, serpentine, and others). Unfortunately, ASTER has limited utility in mapping and characterizing FeOx and Fe minerals due to narrow visible and near infrared (VNIR) bandwidth.

The geological community has used hyperspectral imagery acquired from airborne systems to provide rock, soil, and mineral information on Earth’s surface. Hyperspectral imagery provides unique geologic information collected by hundreds of continuous bands in both VNIR and SWIR spectral wavelengths. Since the early 1980's, the bulk of hyperspectral research and development have utilized the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), flown by NASA JPL. AVIRIS is a 224-channel imaging system sampling the 0.4 to 2.5 micrometer wavelength range collected at spatial footprints (or pixels) of 20 meters down to 3.5 meters. Two decades of application research have shown AVIRIS to be effective in all sorts of geologic mapping plus detailed mineral identification, even on a sub-pixel level. The launch of EO-1 Hyperion imaging spectrometer in November 2000 introduced a new source of hyperspectral geologic mapping with the first spaceborne hyperspectral sensor. Hyperion collects 220 continuous VNIR and SWIR bands at 30 meter pixel size. Initially planned as experimental, Hyperion proved to be comparable to airborne hyperspectral systems although signal-to-noise and swath width posed problems for commercial operation.
Examples to be briefly discussed include:

1) Bighorn Basin, Wyoming USA – Landsat TM used for geologic mapping
2) Four Corners, Colorado/Utah USA – Landsat TM for structural mapping
3) Huarez, Peru – Landsat and ASTER for geologic and mineral mapping
4) Cuprite, Nevada USA – AVIRIS and ASTER comparison for mineral mapping
5) Goldfield, Nevada USA – alteration mineral prediction using ASTER
6) Patagonia, Argentina – Landsat, ASTER, AVIRIS, & Hyperion for mineral mapping
7) Northern Grape Vine Mountains, Nevada/California USA – AVIRIS and Hyperion