Mineral Exploration in Semi-arid Environment Using Hyperion (EO-1) Hyperspectral Data

A. Bannari[1], K. Staenz[2], S. Brunet[3], A. Saquaque[3], A. Zegan[3], A. Radnaoui[3], and R. Hitchcock[4]
[1] Remote Sensing and Geomatics of Environment Laboratory, Department of Geography, University of Ottawa, Ottawa (Ontario) K1N 6N5, Canada; Phone (613) 562-5800 (Ext. 1042), Fax (613) 562-5145;
[2] Alberta Terrestrial Imaging Centre, 817- 4ht Avenue South, Lethbridge (Alberta) T1J 0P3, Canada
[3] Reminex, Groupe de l'ONA, Marrakech, Morocco
[4] Prologic Systems Limited, Ottawa (Ontario) K1P 5E7, Canada

Multispectral remote sensing has been widely used in the past decades to discriminate different rocks and minerals based on the dissimilarity that exist among their spectral properties. Geological applications could greatly take advantage of this technology because it allows observing and mapping the surface of the Earth over large areas. However, the low spectral resolution of multispectral sensors obstructs geological and mineralogical applications. Many minerals and rocks have unique spectral signatures with characteristic absorption features that are 10 to 20 nm wide. Imaging spectrometry or hyperspectral remote sensing allows depicting these narrow features and thus mapping surface mineralogy based on spectral image characterization. The significance of hyperspectral remote sensing relies in its capability to acquire a full reflectance spectrum for each pixel in the imagery. The reflectance spectrum in the 400-2500 nm region can be utilized to identify a large variety of surface cover materials, which is not possible with broadband sensor technology. Moreover, digital image classification is a technique that is widely used to classify each individual pixel in an image based on the spectral information in order to create lithological or geological maps. Various classification algorithms have been used in the past decades in a variety of applications for mapping. The main disadvantage of these algorithms is that each pixel in the image is compared to the training site signatures identified by the analyst and labelled as the class it most closely "resembles" digitally. Linear spectral mixture analysis (LMSA) is different from these standard classification methods. The fundamental assumption of LSMA is that generally each pixel on the Earth surface is a physical mixture of several constituents weighted by surface abundance. The NASA has used the LSMA successfully for geological mapping and for identifying potential mineral exploration sites with the use of the "USGS Spectral Library" as reference spectrum.

This research reports on the geological and mineralogical mapping of central Jebilet near to Marrakech in Morocco using hyperspectral Hyperion (EO-1) imagery and LSMA. This study area is located in the Paleozoic terrain of central Jebilet, which is characterized by a lithological diversity, semi-desert environment, significant mineral potential and consistent geological setting. The Hyperion data were acquired on May 23, 2005 over the study area. The data were corrected for a spatial shift between the VNIR and SWIR detectors, striping, dead column, noise, and gain and offset errors. Then, atmospherically corrected using the MODTRAN 4.2 code, and transformed to surface reflectance, corrected for sensor smile (1-3 nm shift in VNIR and SWIR), and post-processed to remove residual errors. Finally, geometric distortions and relief displacement effects were corrected using a digital elevation model. In order to extract the rocks and minerals fractions, the image was unmixed using a constrained linear spectral unmixing algorithm considering the entire spectral range (427- 2355 nm). Endmember spectra were collected in the field on December 2004 from different rock samples using an Analytical Spectral Devices (ASD) Spectroradiometer operating in the visible and the infrared (325 to 2500 nm). The average of twenty spectra was convolved with Gaussian response profiles to match the bandwidths and the band centres of the Hyperion EO-1 sensor. Fractions for each sample point were extracted from unmixing results and compared to the reference measurements in the field. The results will be presented, discussed and validated to the ground truth.