Hyperspectral Outcrop Imaging of the Orange Hill Porphyry Copper Deposit, Alaska, USA


1. U.S. Geological Survey, Denver, Colorado, USA
2. U.S. Geological Survey, Reston, Virginia, USA
3. School of Earth Sciences and Resources, China University of Geosciences, Beijing, China
4. University of Alaska Fairbanks, Fairbanks, Alaska, USA

OUTLINE

Application of hyperspectral imaging to mineral exploration has been expanding in the past decade, with airborne imaging spectrometer data collected at increasingly higher latitudes, field-based scanning of exposures, and operationalized imaging of drill core and hand specimens. Field-based hyperspectral imaging offers the promise of mineral information at the centimeter scale which could be used to guide field sampling in exploration, to assess open pit bench faces, and for highwall mapping. Multi-scale hyperspectral data sets spanning laboratory, field, and remote sensing scales, though rarely collected, allow direct validation of mineral maps produced at the outcrop scale using results obtained from laboratory scanning of samples and core and mineral maps derived from airborne imaging spectrometers.

In July, 2015, tripod-mounted, field-based HySpex™ systems (HyLab, University of Alaska Fairbanks; www.hyperspectral.alaska.edu), covering the visible/near-infrared (VNIR; 400-1000 nm) and shortwave infrared (SWIR; 1000-2500 nm), were used to scan a Cu-Mo-Au mineralized outcrop Orange Hill, Alaska. The hillside, approximately 1000 m wide and 100 m high, was imaged at 7 cm pixel size in the VNIR and 30 cm pixel size in the SWIR. Areas of light and dark rocks in the outcrop were measured with a field spectrometer in order to convert the HySpex data from radiance to reflectance using empirical line correction. The reflectance data were analyzed with the USGS PRISM (Processing Routines in IDL for Spectroscopic Measurements) software to map mineral distributions across the hillside. For selected hand samples, a laboratory imaging spectrometer system Corescan™ (Corescan Pty Ltd, Australia) was used to collect hyperspectral data with a 0.5 mm pixel size. In addition, geochemical, XRD, and electron microprobe analyses were performed on the samples. At the regional scale, HyMap™ (HyVista Corp., Australia) airborne imaging spectrometer data were collected over the Orange Hill deposit and nearby deposits at 6 m pixel size.

Airborne hyperspectral data indicate that muscovite is the dominant mineral associated with kilometer-scale magmatic-hydrothermal alteration at and around the Orange Hill porphyry Cu-Au-Mo deposit. Finer-scale mapping from field-based HySpex scans detect muscovite as well as additional minerals, including gypsum and chlorite, consistent with existing geologic information determined during past regional mapping. Analysis of the Corescan imagery shows the same distribution of hydrothermal minerals within multiple field samples. An empirical relation to mineralization is shown through detected variations in the wavelength position of the 2200 nm muscovite absorption feature; higher wavelength position was correlated with higher Cu concentrations in stream sediments and locations of known occurrences of mineralization and deposits. Computed wavelength positions of the muscovite absorption were found to be consistent between the field, lab, and airborne levels of hyperspectral imaging.

Airborne hyperspectral remote sensing in Alaska faces many challenges, which include a short acquisition season and poor illumination due to low solar elevation. Additional complications are encountered in the identification of surface minerals because minerals of interest commonly are exposed on steep terrain, further challenging reflectance retrieval and detection of mineral signatures. We overcame these obstacles by taking a multiple steps in our calibration process. First, the radiance data were converted to apparent surface reflectance using the radiative transfer correction program ATCOR-4 (ReSe Applications, Zurich, Switzerland). ATCOR-4 incorporates a digital elevation model to account for the local slope and azimuth of each pixel and to adjust the illumination. Apparent surface reflectance computed using ATCOR-4 was further adjusted using ground-based reflectance measurements from a calibration site for a single flight line that was designed to cross the other flight lines in the data collection. This step removes residual atmospheric contamination. Finally, for each of the normal flight lines, the area of overlap with the ground-calibrated tie line was used to empirically adjust the apparent surface reflectance. The result is a nearly seamless mineral map produced from the PRISM analysis of the reflectance data.

Field-based hyperspectral scanning of outcrop and mine walls, as tested by HySpex in our study, can provide mineral compositions at the tens of centimeters scale. These data can be collected rapidly over moderately large areas and, with processing, could be utilized for guiding sampling, informing material processing, and assisting development of 3-dimensional deposit modeling throughout exploration and mining activities. A significant challenge to wider application of hyperspectral data at this scale is posed by the need to georegister the fine scale images to a 3D topography. Coordinated collection of terrestrial lidar can provide the data needed to register hyperspectral imagery and derived mineral characterizations. ’Structure-from-Motion’ (SfM) photogrammetry may provide a lower-cost solution but requires more time spent on setup and post-processing.

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