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Mapping the Mineralogy and Lithology of Canyonlands, Utah with Imaging Spectrometer Data and the Multiple Spectral Feature Mapping Algorithm

Roger N. Clark, Gregg A. Swayze, and Andrea Gallagher

U. S. Geological Survey, MS 964
Box 25046 Federal Center
Denver, Colorado 80225

The sedimentary sections exposed in the Canyonlands and Arches National Parks region of Utah (generally referred to as "Canyonlands") consist of sandstones, shales, limestones and conglomerates. Reflectance spectra of weathered surfaces of rocks from these areas show two components: 1) variations in spectrally detectable mineralogy and 2) variations in the relative ratios of the absorption bands between minerals. Both types of information can be used together to map each major lithology and we are applying the Clark *et al.* (1990, 1991) spectral features mapping algorithm to do the job.

AVIRIS was flown over Upheaval Dome in Canyonlands National Park and over Arches National Park in May 1991. The data were calibrated to ground reflectance using multiple ground calibration sites to derive the offset due to path radiance as well as a set of multipliers to correct to ground reflectance. The resulting data set (about 11 km wide by 30 km in length for each of two flight lines) shows reflectance spectra of well exposed sedimentary units. Several vegetation communities, microbiotic soils, lichens, and desert varnish are also present and add to the difficulty of mapping lithologies.

In the Canyonlands region, several formations of Pennsylvanian through Cretaceous age are exposed (Table 1). Many of the same minerals are present in the different formations, with variable band strengths, usually related to abundance changes. Mapping these different lithologies requires not only the detection of the individual minerals but also their relative proportions. Such analysis can be accomplished by mapping specific minerals (e.g. Clark et al. 1990, 1991) and examining the ratios of the band depths of indicator minerals. Another approach is to use spectra representative of each unit as a reference spectrum. The minerals in these spectra display absorption bands in their different proportions, and the "Multiple Spectral Feature Mapping Algorithm" weights each feature according to the area between the continuum and the reflectance curve, thus restricting allowable mineralogy. Examples of the success of this method in mapping the above units will be presented.

Table 1
Detectable (0.4-2.5 μm) Mineralogy of Geologic Formations in Canyonlands, Utah, as Indicated by Reflectance Spectroscopy

Mancos Shale:	(S) calcite (W) gypsum	(M) kaolinite (t) goethite
Dakota Sandstone:	(M) illite (W) kaolinite	(M) goethite (t) calcite
Morrison Formation:	(S) Fe-illite (M) hematite (W) V-illite	(M) Chert (W) calcite
Entrada Sandstone:	(M) kaolinite	(M) hematite
Navajo Sandstone:	(M) hematite (M) illite/smectite	(t) kaolinite
Kayenta Formation:	(M) hematite (t) kaolinite	(M) calcite
Wingate Sandstone	(S) hematite (W) muscovite	(M) kaolinite
Chinle Formation	(S) muscovite (W) kaolinite	(S) hematite (W) calcite
Moenkopi Formation	(M) hematite (W) kaolinite	(M) muscovite (t) calcite
Cutler Formation	(S) kaolinite (t) calcite	(W) goethite
Paradox Formation	(S) illite/smectite (M) goethite	 (M) Gypsum

Spectral band intensity:
(S)= strong, (M)= medium, (W)= weak (t)= trace

References

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