UNMIXING AVIRIS DATA TO PROVIDE A METHOD FOR VEGETATION FRACTION SUBTRACTION

J. A. Zamudio

Center for the Study of Earth from Space (CSES)
Cooperative Institute for Research in Environmental Sciences (CIRES)
and
Department of Geological Sciences
University of Colorado, Boulder, Colorado 80309

1. DATA CHARACTERISTICS AND CALIBRATION

Five flight lines of AVIRIS data were acquired over the Dolly Varden Mountains in northeastern Nevada on June 2, 1989 (Zamudio and Atkinson, 1990). Signal-to-noise ratio values are given in figure 1.

The empirical line method (Conel et al., 1987) was used to convert AVIRIS radiance values to reflectance. This method involves calculating gain and offset values for each band. These values are based upon a comparison of the imaging spectrometer data and field reflectance measurements, both taken over the same ground targets. The targets used in this study were a dark andesite flow and a bright playa.

2. STUDY AREA

The study area contains a variety of geologic materials, including sedimentary, volcanic, plutonic and contact metamorphic rocks. Carbonate-dominated formations underlie much of the area.

Other than some high relief areas of 100% outcrop, vegetation cover typically ranges from about 10% to 50%, with some places along drainages and on high, north-facing slopes where vegetation cover approaches 100%. Vegetation is primarily sagebrush at lower elevations, with piñon pine and juniper prevalent from about 2000 meters on up. Little soil is found in the area.

3. ANALYSIS TECHNIQUES

Three-band color composites were made of the AVIRIS segments in order to view different rock types in their spatial context. Also, in order to produce geologic maps derived from spectral data, pixels with spectra characteristic of various rock types were selected from the reflectance data and then, using a binary encoding algorithm (Goetz et al., 1985), other pixels whose spectra matched within a certain tolerance were selected and color coded.

A linear unmixing routine (Boardman, 1991) was also applied to the data to aid in the mapping of rock units. A spectral library of materials found on the ground was compared to each spectrum in a particular scene. The proportions of each library endmember found in each pixel were then calculated. The result is a series of fraction images showing, in gray levels correlating with abundance, the areal distribution of each library endmember. Noisy bands, located in the atmospheric water absorption regions around 1.4 and 1.9 μm, were not used in the unmixing. Using the unmixing results, a routine to subtract out the vegetation fraction on a pixel-by-pixel basis was applied to the AVIRIS data.

4. RESULTS

Three-band color composites were linearly stretched to enhance the contrast between various rock units. Deformation of the rock units is apparent in some of these scenes.

The AVIRIS reflectance spectra were analyzed and various minerals were identified, including goethite, calcite and dolomite. Binary encoding enabled the delineation of certain limestone-dominated and dolomite-dominated formations. In some areas, faults that did not appear on published maps are evident in the encoded data.

The unmixing routine was applied to an area where the limestone-dominated Gerster Formation, the dolomite-dominated Plympton Formation and Triassic shale and limestone of the Thaynes Formation crop out. The library of materials used in the unmixing includes limestone, dolomite, chert, brown limestone from the Thaynes, intermediate volcanic rocks and a mix of materials from the Thaynes Formation. Because the Thaynes is comprised of limestone and shale commonly interbedded on a finer scale than the AVIRIS pixel size, the Thaynes library spectrum was obtained from a mix of those materials. The Thaynes also includes a sizeable section of distinctive brown limestone which was used as another endmember. The Plympton contains abundant chert as well as dolomite, so chert was included in the library. The library spectra were obtained in the laboratory from samples collected in the field. The resulting six fraction images generally show good differentiation between rock types.

Also calculated in the unmixing is the sum of all endmember fractions for each pixel. If the sum for any pixel is less than one, then it is likely that either that pixel contains some material not represented in the library, or that the remaining fraction is a measure of how much the illumination conditions vary from 100%. Figure 2 shows the distribution of significant amounts of the limestone, dolomite and Thaynes fractions. As can be seen by comparison with figure 3, which shows formational contacts as mapped in the field, the differentiation between the three formations is good. In some places, the contacts in figure 2 reflect the extent of significant amounts of colluvium and alluvium, and therefore do not exactly match the bedrock contacts in figure 3. The distribution of the three formations in figure 2 suggests that they are deformed.

5. VEGETATION SUBTRACTION

Using the unmixing results and a vegetation spectrum obtained in the field, a routine was applied which subtracts the vegetation fraction from each pixel in a scene. This is accomplished by first multiplying the field vegetation spectrum by the fraction that represents the amount of vegetation present in a particular pixel. Then, this resulting fractional vegetation spectrum is subtracted from the pixel in the original scene. For example, if the unmixing routine showed that a certain pixel in the scene contains 50% vegetation, then the vegetation spectrum (100% vegetation) would be multiplied by 0.5, resulting in a fractional vegetation spectrum. Then, this spectrum would be subtracted from the spectrum for that pixel. Figure 4 compares a spectrum from a pixel containing vegetation to the resulting spectrum after the fraction of vegetation present has been subtracted. The vegetation removal can be viewed in a spatial context as well. A color image was made using a band near 0.8 μm displayed as green. Some areas of the scene have a green tint due to the high reflectance of vegetation at that wavelength. After vegetation subtraction, another color image was made using the same band combination. This scene is less green and drainages which contain close to 100% vegetation are almost black.

Color composite images made in this manner consequently show just geologic information. Any worker considering that some part of the data is masking what is important, either in a spatial or a spectral context, could consider using this technique. The ability to subtract out part of the spectrum might enable one to see features that are hidden in the total spectral signature.

REFERENCES

Boardman, J.W., and Goetz, A.F.H., 1991, Sedimentary facies analysis using AVIRIS data: a geophysical inverse problem: Proceedings of the Third Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) Workshop, Jet Propulsion Laboratory: JPL Publ. 91-28, p. 4-13.

Conel, J.E., Green, R.O., Vane, G., Bruegge, C.J., Alley, R.E. and Curtiss, B.J., 1987, Airborne Imaging Spectrometer-2: Radiometric spectral characteristics and comparison of ways to compensate for the atmosphere in Vane, G., ed., Imaging

Spectroscopy II, Proceedings of SPIE-Society of Photo-Optical Instrumentation Engineers, v. 834, p. 140-157.

Goetz, A.F.H., Vane, G., Solomon, J. E., and Rock, B. N., 1985, Imaging spectrometry for Earth remote sensing: Science, v. 228, p. 1147-1153.

Zamudio, J.A., and Atkinson, W.W., Jr., 1990, Analysis of AVIRIS data for spectral discrimination of geologic materials in the Dolly Varden Mountains, Nevada: Proceedings of the Second Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) Workshop, Jet Propulsion Laboratory: JPL Publ. 90-54, p. 162-166.

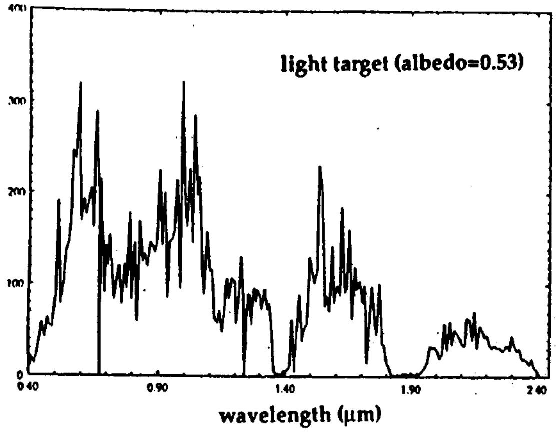

Figure 1. Signal-to noise ratio values for a playa target.

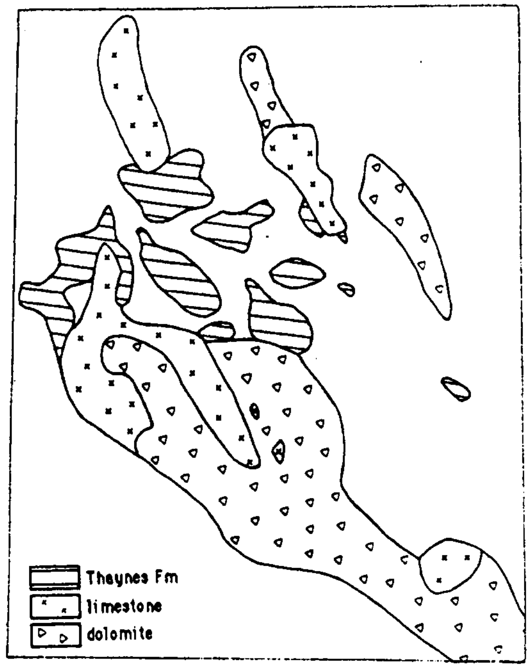

Figure 2. Extent of significant amounts of three fractions: dolomite, limestone, and the Thaynes Formation.

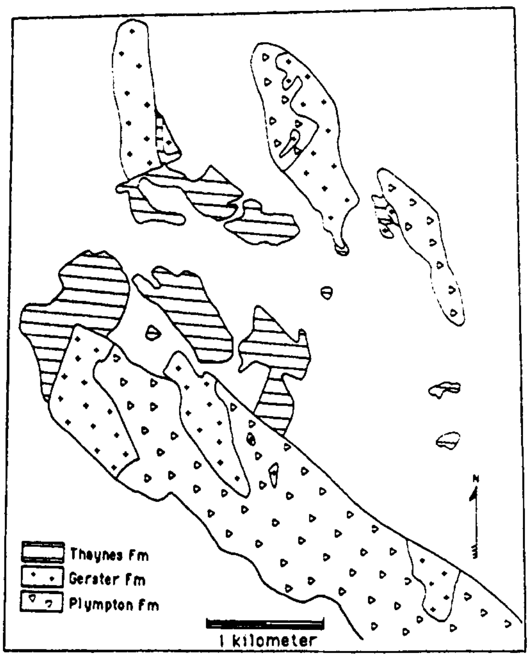

Figure 3. Extent of the dolomite-dominated Plympton, limestone-dominated Gerster, and the Thaynes Formation as mapped in the field.

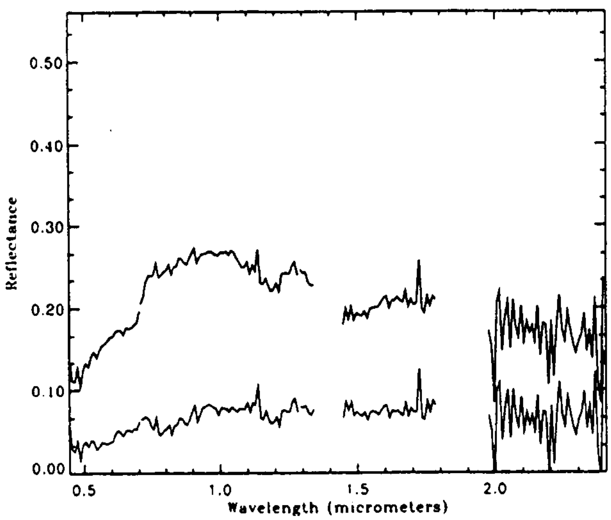

Figure 4. Comparison of AVIRIS reflectance spectra before (top spectrum) and after (bottom spectrum) vegetation subtraction.