ENVI Tutorial: Geologic Hyperspectral Analysis

Geologic Hyperspectral Analysis

This tutorial presents a case history for use of hyperspectral techniques in geologic analysis, using 1999 HyMap data from Cuprite, Nevada, USA. It quickly guides you through ENVI's end-to-end hyperspectral tools (EFFORT to MNF to PPI to n-D Visualization to Spectral Mapping to GLT georeferencing) to produce image-derived endmember spectra and image maps. For more detail and step-by-step procedures on performing a complete hyperspectral analysis, refer to the series of ENVI hyperspectral tutorials (introductory through advanced) before attempting this tutorial, and refer to ENVI Help when necessary.

Objectives

- Apply ENVI end-to-end hyperspectral processing methodology to a geology case study
- Gain hands-on experience running the procedures rather than reviewing preprocessed results (althrough preprocessed results are provided for comparison)
- Perform data exploration in a loosely structured framework
- Compare analysis results with known ground information

Files Used in this Tutorial

All files are on the ENVI Resource DVD.

Directory: `Data\cup99hym`

File	Description
`cup99hy.eff (.hdr)`	EFFORT-corrected HyMap data
`cup99hy_geo_glt (.hdr)`	ENVI geographic lookup table (GLT)
`cup99hy_geo_igm (.hdr)`	ENVI input geometry file
`cup99hy_mnf (.hdr)`	MNF results of 32 SWIR bands, using data to estimate noise covariance
`cup99hy_mnf.sta`	MNF stats from MNF run
`cup99hy_mnfevs.txt`	ASCII file of MNF eigenvalues
`cup99hy_mtmf (.hdr)`	MTMF results using endmembers from `cup99hy_mtmf.roi` mean
`cup99hy_mtmf.roi`	ROIs of classes picked in n-D Visualizer
`cup99hy_mtmfems.txt`	ASCII file of MTMF endmember spectra
`cup99hy_noi.sta`	Noise statistics from MNF run
`cup99hy_ppi (.hdr)`	PPI image
`cup99hy_ppi.cnt`	PPI count file
`cup99hy_true.img (.hdr)`	HyMap true-color image

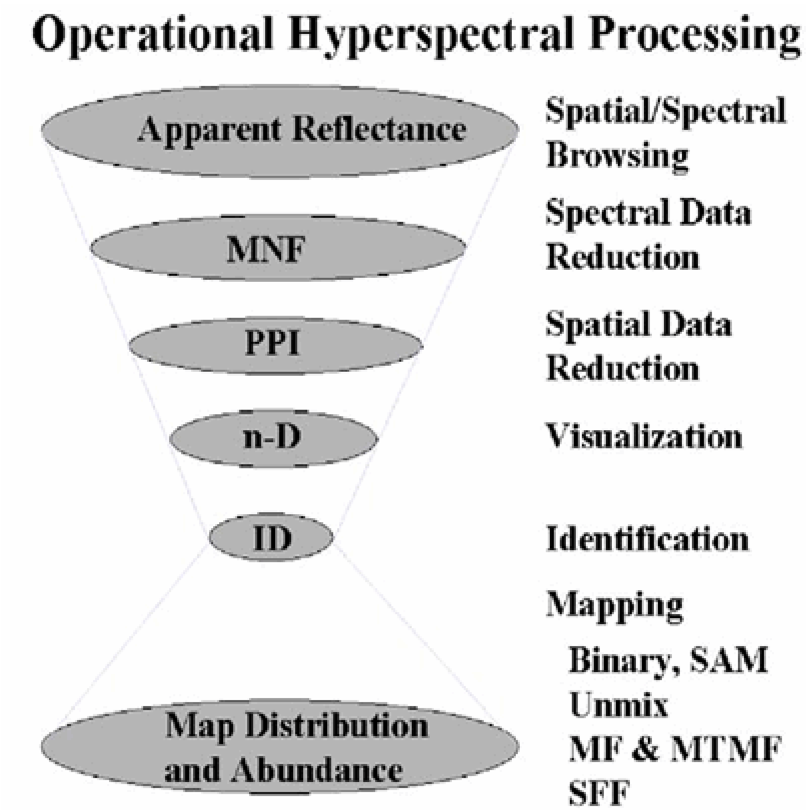
Directory: `Data\c95avsub`

File	Description
`usgs_min.sli (.hdr)`	USGS spectral library

Cuprite, Nevada has been used extensively as a test site for remote sensing instrument validation (Abrams et al., 1978; Kahle and Goetz, 1983; Kruse et al., 1990; Hook et al., 1991). See the tutorial Hyperspectral Signatures and Spectral Resolution for an alteration map of Cuprite, NV.

Processing Flow

The following figure shows the hyperspectral processing flow implemented in ENVI.



Geologic Hyperspectral Analysis

1. **Examine HyMap apparent reflectance data:** Display a gray scale or color-composite image. Start a spectral profile and examine spectra for residual atmospheric absorption features (CO2 bands near 2.0 µm). Use the file cup99hy.eff for this step.
2. **Conduct spatial and spectral browsing:** Display a gray scale image. Extract reflectance signatures and examine them for mineral spectral features. Animate the data and extract spectra for areas of high variability. Determine bad spectral bands. Load color-composite images designed to enhance spectral contrast. Determine spectral subset(s) to use for mineral mapping. Extract reflectance signatures for vegetation and geologic materials. Compare to spectral libraries.
3. **Apply MNF transform and determine data dimensionality:** Review MNF eigenvalue plot to determine the break in slope and relate to spatial coherency in MNF eigenvalue images. Determine MNF cut-off between signal and noise for further analysis. Make your own MNF-transformed dataset or review the results in the files below.

File	Description
`cup99hy_mnf.sta`	MNF stats from MNF run
`cup99hy_ppi (.hdr)`	PPI image
`cup99hy_ppi.cnt`	PPI count file
`cup99hy_mtmf.roi`	ROIs of classes picked in n-D Visualizer
`cup99hy_mtmfems.txt`	ASCII file of MTMF endmember spectra

4. **Apply PPI analysis to the MNF output:** Rank the pixels based on relative purity and spectral extremity. Use the FAST PPI option to perform calculations quickly in system memory, creating the PPI image. Display the PPI image, examine the histogram and threshold, and create a list of the purest pixels, spatially compressing the data. Generate your own PPI results and ROIs or review the results in the files below.

File	Description
`cup99hy_ppi (.hdr)`	PPI image
`cup99hy_ppi.cnt`	PPI count file

5. **Perform n-D Visualization of the high PPI value pixels:** Use the high-signal MNF data bands to cluster the purest pixels into image-derived endmembers. Rotate the MNF data interactively in three dimensions, or spin in several dimensions and paint pixels that occur on the points (extremities) of the scatter plot. Use Z Profiles connected to the EFFORT apparent reflectance data and the n-D Visualizer to evaluate spectral classes. Use class collapsing to iteratively find all of the endmembers. Evaluate mixing and endmembers. Save your n-D results to a saved state file (.ndv). Export classes to ROIs and extract mean spectra. Compare mean spectra to spectral libraries. Use spectral/spatial browsing to compare image spectra to ROI means. Extract endmembers and make your own ROIs or review the results below:

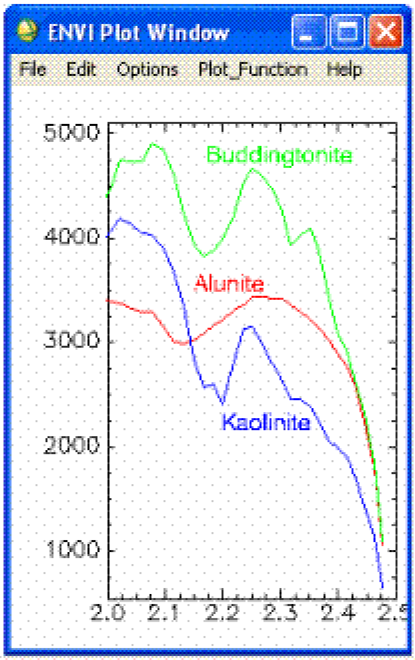
File	Description
`cup99hy_mnf (.hdr)`	MNF results of 32 SWIR bands, using data to estimate noise

File	Description
	covariance
cup99hy_mnf.sta	MNF stats from MNF run
cup99hy_mtmf.roi	ROIs of classes picked in n-D Visualizer
cup99hy_mtmfems.txt	ASCII file of MTMF endmember spectra
cup99hy_noi.sta	Noise statistics from MNF run
cup99hy_ppi (.hdr)	PPI image
cup99hy_ppi.cnt	PPI count file

6. **Use ENVI's mapping methods:** Map the spatial occurrence and abundance of materials at Cuprite. As a minimum, try the Spectral Angle Mapper (SAM) and Mixture Tuned Matched Filter (MTMF) methods. Use SAM to determine spectral similarity to image endmember spectra. If time permits, try a SAM classification using spectral libraries. Be sure to evaluate the rule images. Use the MTMF mapping method to determine material abundance. Be sure to use both the MF and infeasibility images in a 2D scatter plot to select the best matches (high MF and low infeasibility score). Compare abundance image results to the endmember spectra and spectral libraries using spatial and spectral browsing.

   Use the provided GLT file (`cup99hy_geo_glt`) or IGM file (`cup99hy_geo_igm`) to produce georeferenced output images of the MTMF processing. Follow the procedures described in the tutorial Georeferencing Using Input Geometry to georeference mineral maps. Add map grids and annotation, and produce a final map.

   The following figure shows selected endmember spectra (left) and a portion of a georeferenced image-map result for Cuprite (right), using 1999 HyMap data.


ENVI Plot Window
File Edit Options Plot_Function Help
5000
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Buddingtonite
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