Section 5

SWIR Example:
Mineral Identification (Cuprite, NV)

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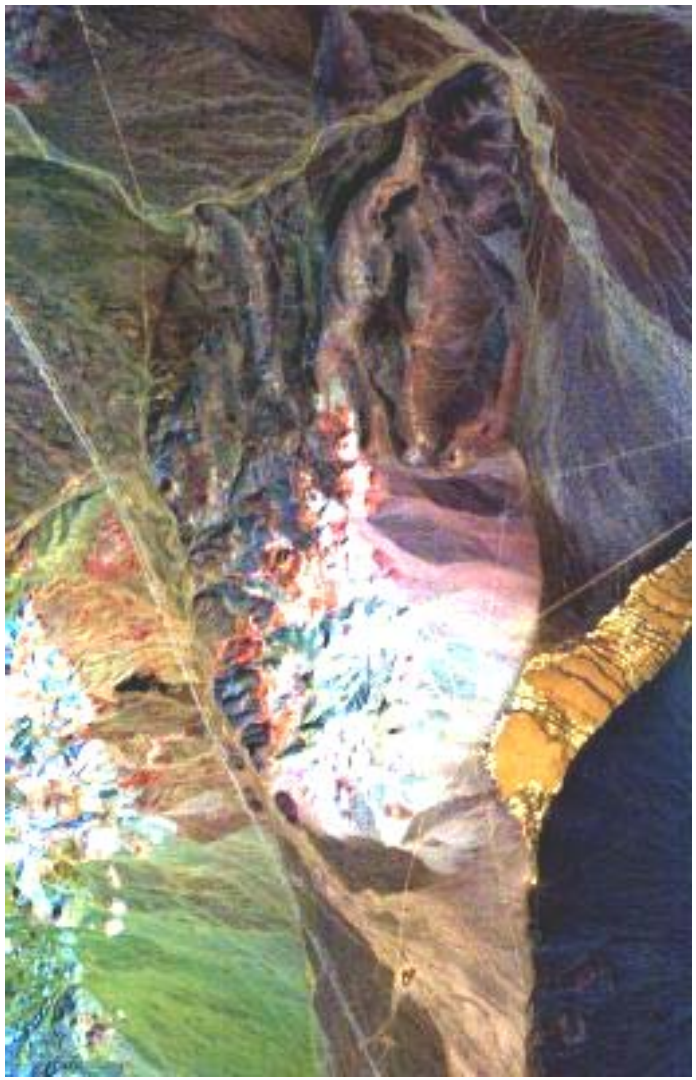
SWIR Example: Mineral Identification

- ***Description of Cuprite and Reference Material***
- ***Simple example of identification***
- ***Advanced analysis of Cuprite***
- ***Demonstration***

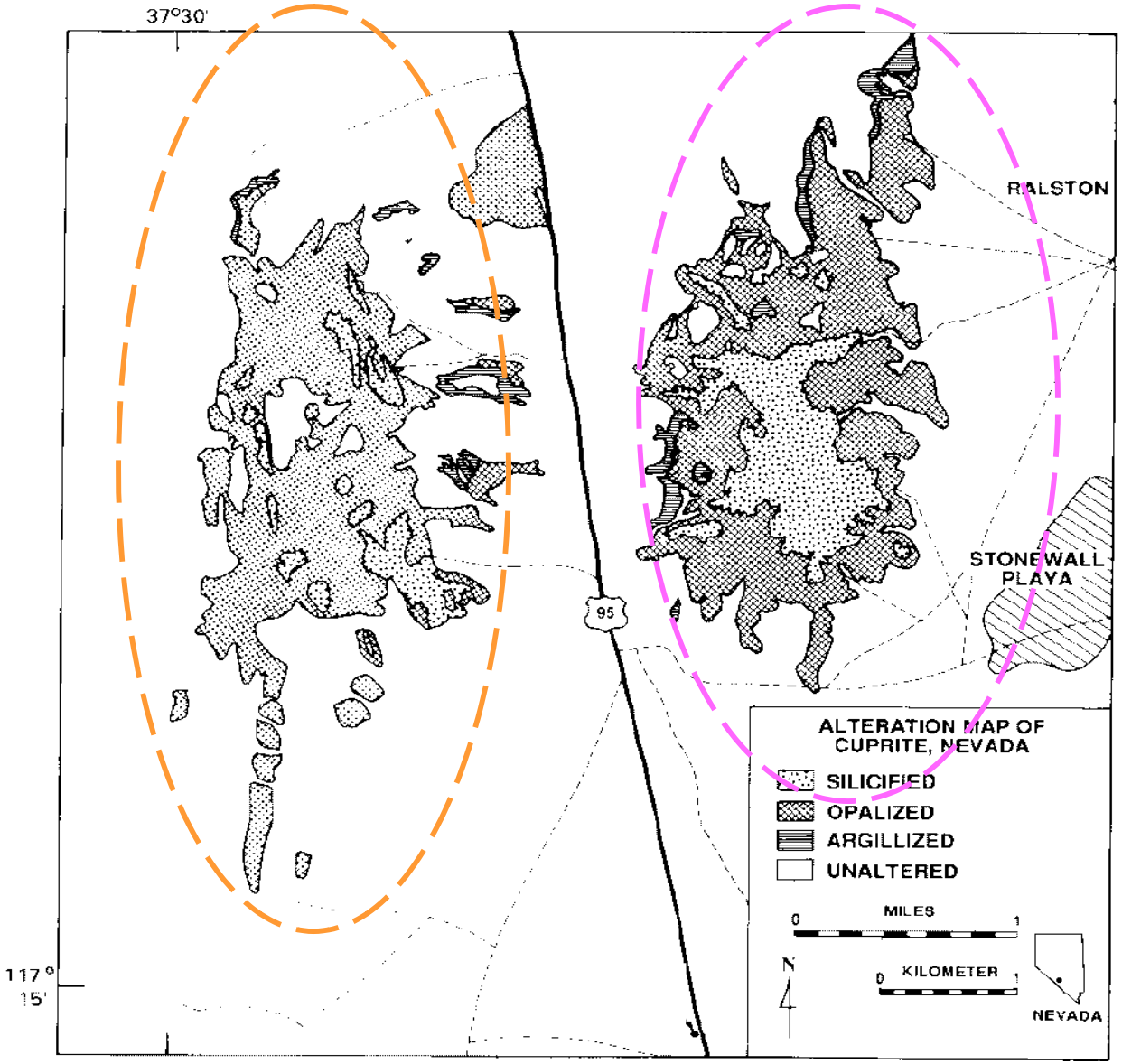
Reference Site: Cuprite



Hyperion True Color Image

- ***Reference Site used to evaluate Remote Sensing Instruments (Airborne and Spaceborne):***
  - *AVIRIS (http://speclab.cr.usgs.gov/cuprite.html) (Airborne Visual and Infra-Red Imaging Spectrometer)*
  - *SFSI (http://www.borstad.com/papers/) (SWIR Full Spectrum Imager)*
  - *Landsat ETM+ (http://edcdaac.usgs.gov/samples/)*
- ***Located in arid and sparsely vegetated region along the California/Nevada border near death valley***
- ***Geology dominated by siliceous to basic volcanic rocks of Tertiary age***

Cuprite Ref. Maps: Alteration Example



Ref: 1,2,3

Note encircled regions

Cuprite References

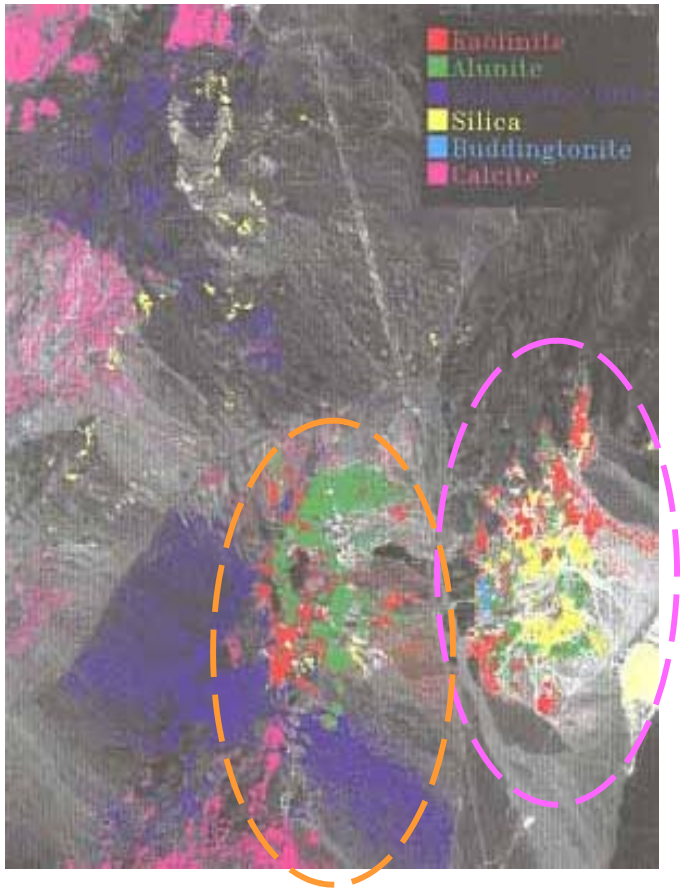
1) *http://speclab.cr.usgs.gov/PAPERS/cuprite.clark.93/mineral.map.html*

2) *Abrams, M.J., and Ashley, R.P., 1980, Alteration mapping using multispectral images - Cuprite Mining District, Esmeralda County, Nevada: U.S. Geological Survey Open File Report 80-367.*

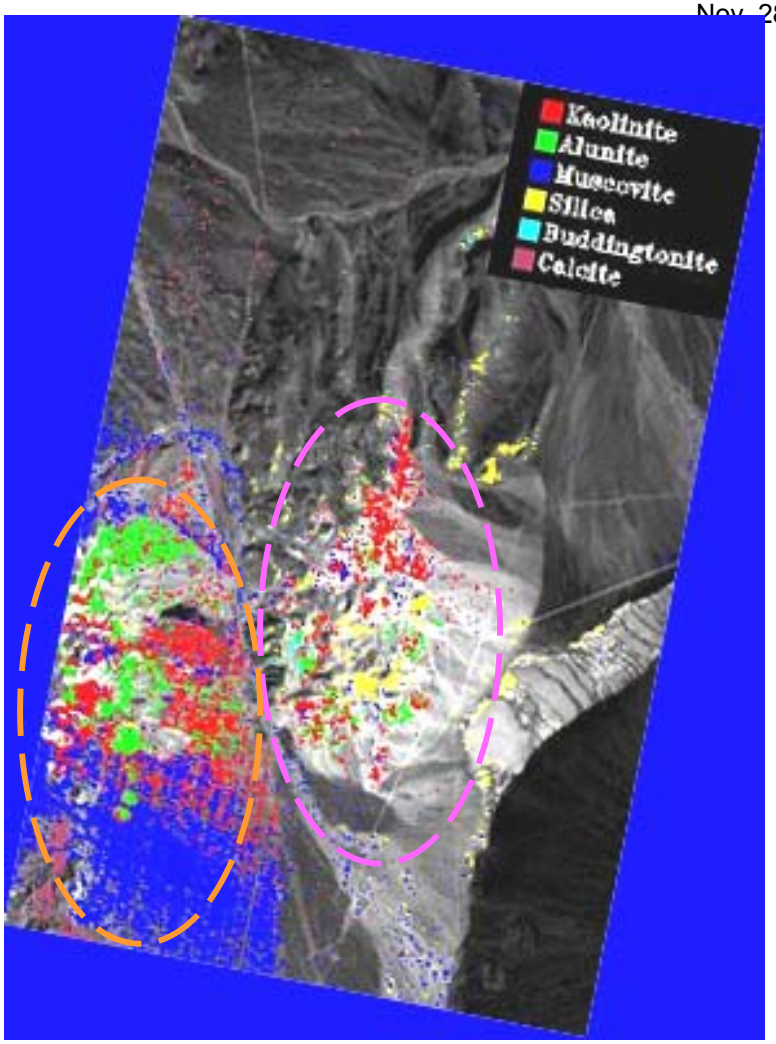
3) *Hook, S.J., 1990, The combined use of multispectral remotely sensed data from the short wave infrared (SWIR) and thermal infrared (TIR) for lithological mapping and mineral exploration: Fifth Australasian Remote Sensing Conference, Proceedings, Oct., 1990, vol.1, p. 371-380.*

4) *http://edcdac.usgs.gov/samples/goldfield.html*

Remotely Sensed Map: Hyperion & AVIRIS



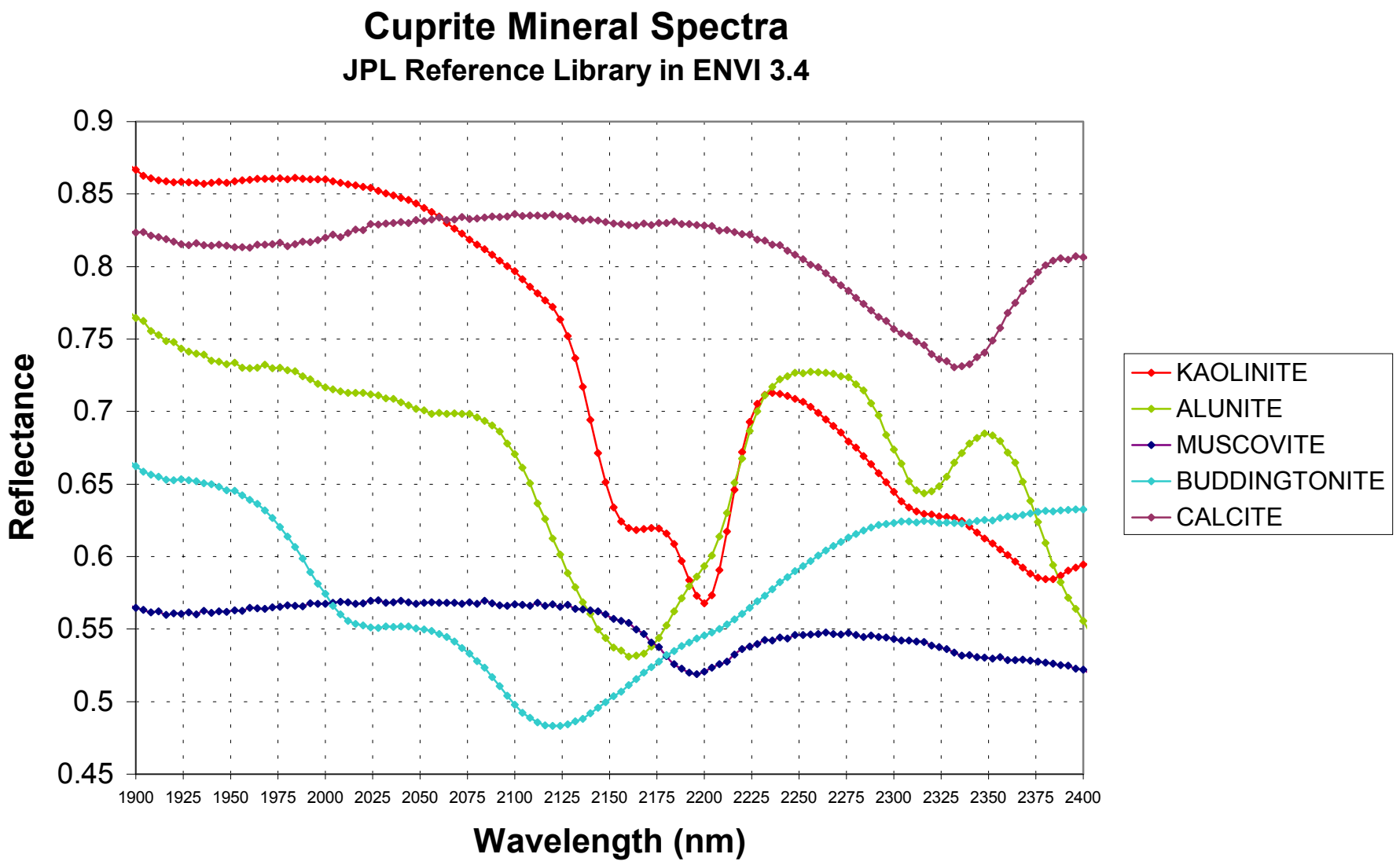
July, 1995
AVIRIS Mineral Map



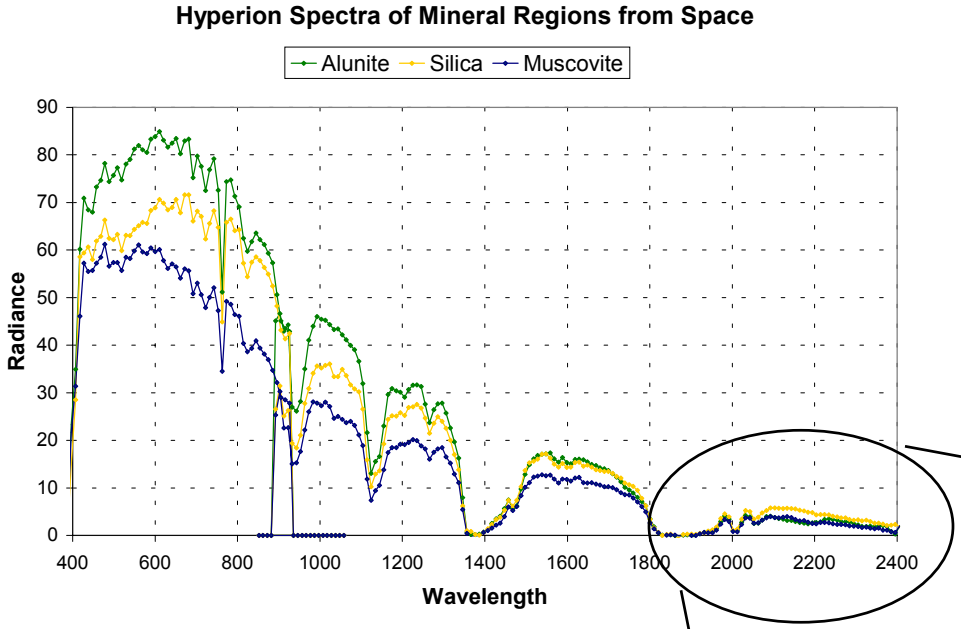
March, 2001
Hyperion Mineral Map – 30 m resolution

Courtesy of Fred Kruse AIGLLC

Reference Spectra for Cuprite Minerals



SWIR Spectra used for Mineral Map

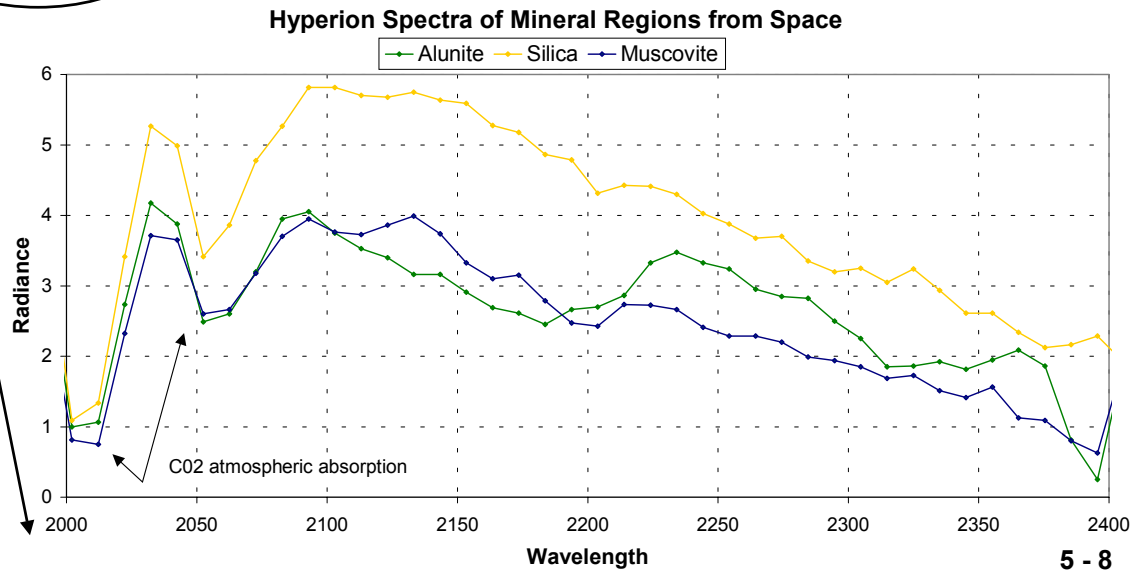


Spectral signature is a combination of the solar irradiance profile, reflectance and atmospheric absorption

Mineral map based on the far region in the SWIR.

This region has the lowest signal level and the lowest SNR.

Slight variations in the spectra are used



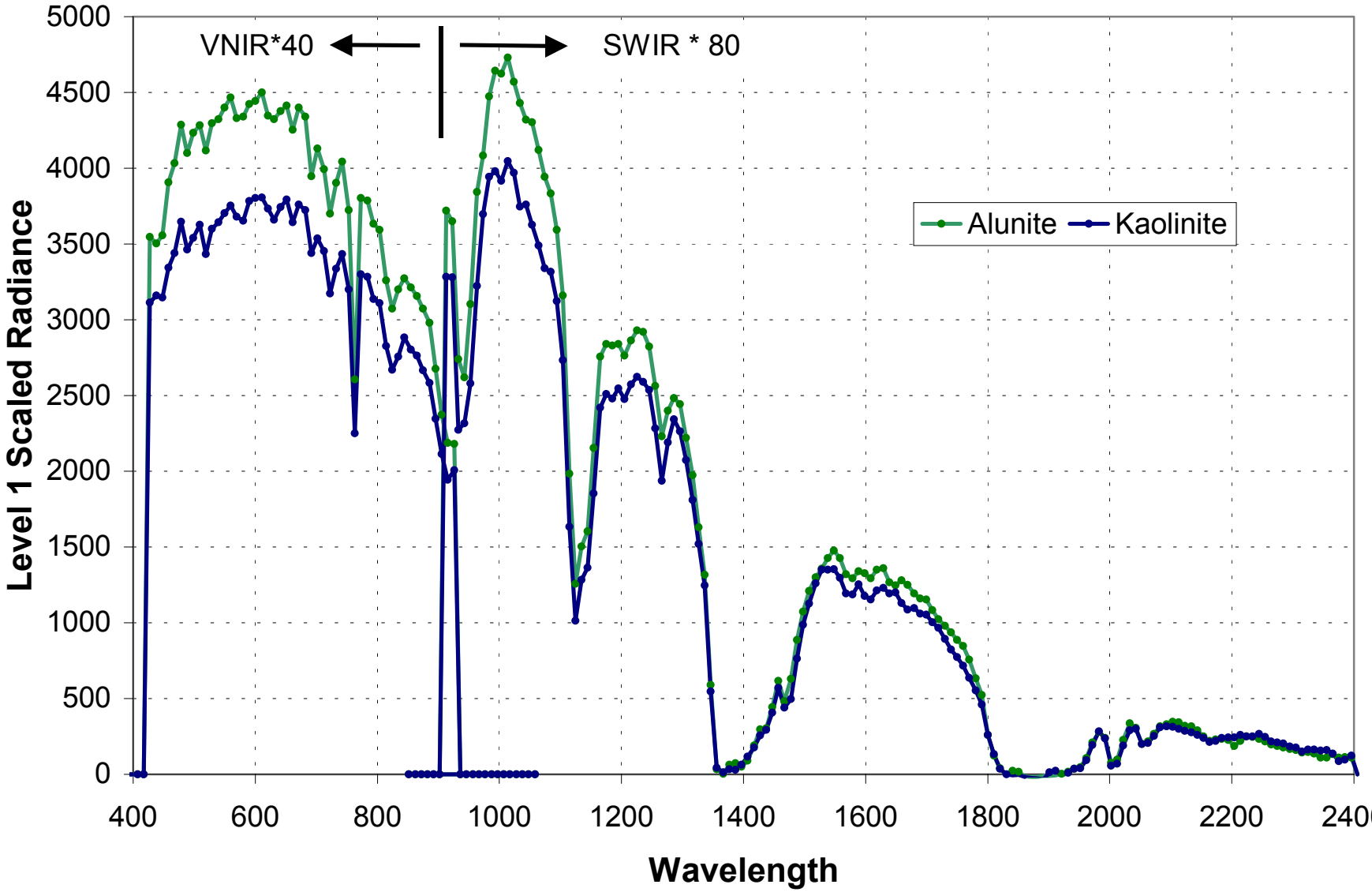
Importance of Alteration

- ***Studying the presence and distribution of minerals provides insight into the history of what occurred in the area***
- ***History of region can be combined with knowledge of the formation of minerals to provide valuable information about the area***
- ***Remote sensing enables environmental assessment of areas around the world***
- ***Pattern and distribution of visible minerals (alunite and kaolinite) can point to precious minerals which are not visible (gold)***
- ***For example: deposits of gold and silver associated with mineralizing events that occurred during Tertiary time and were associated with late stage volcanic events (ref 4.)***

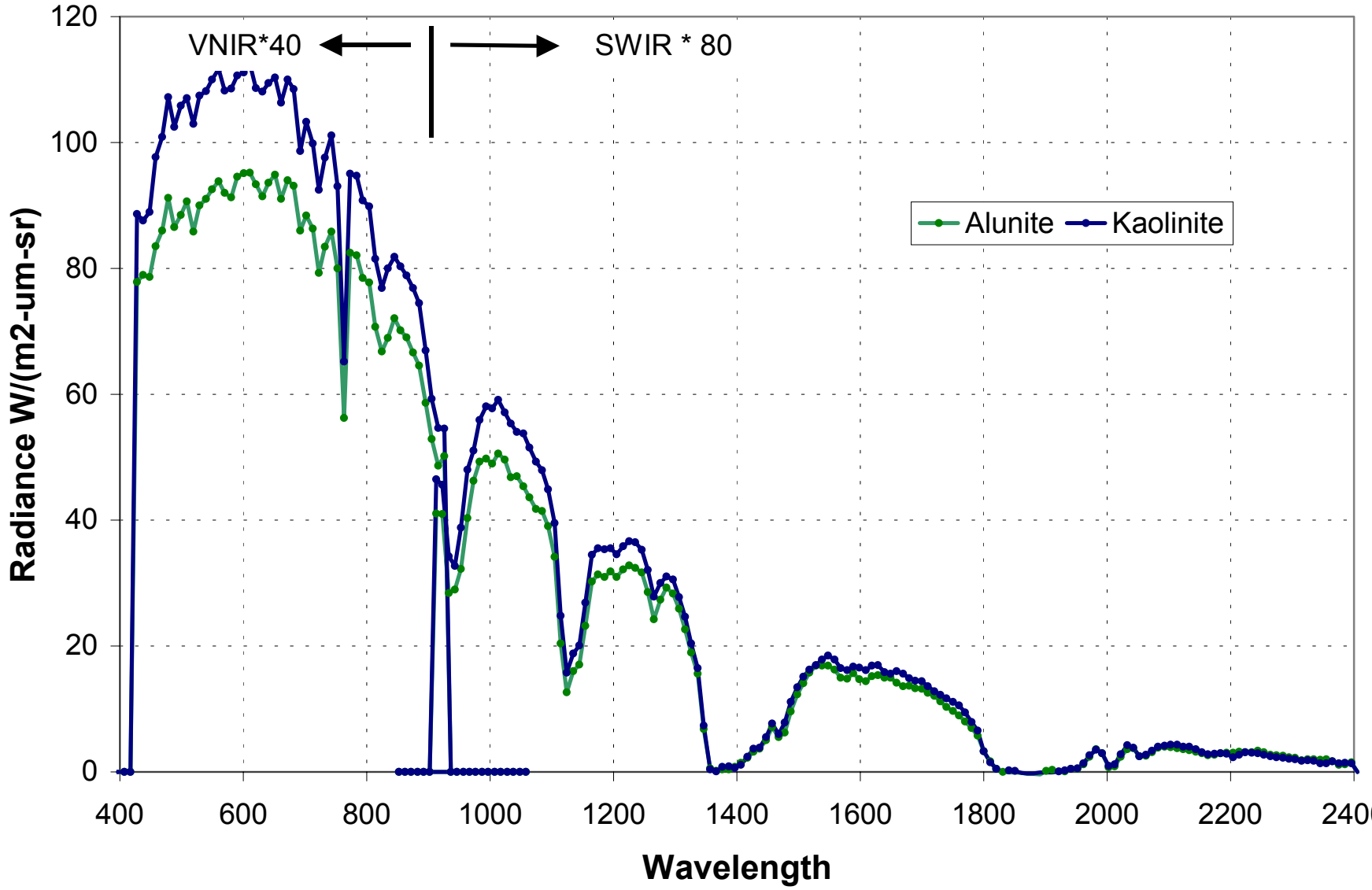
Steps in Simple Example

- ***Review Level 1 data, select spatial and spectral region of interest***
- ***Return to unscale the Level 1 data***
- ***Perform atmospheric correction***
- ***Selected spectral subset: Bands 195 = 2102 nm, to 220 = 2355 nm***

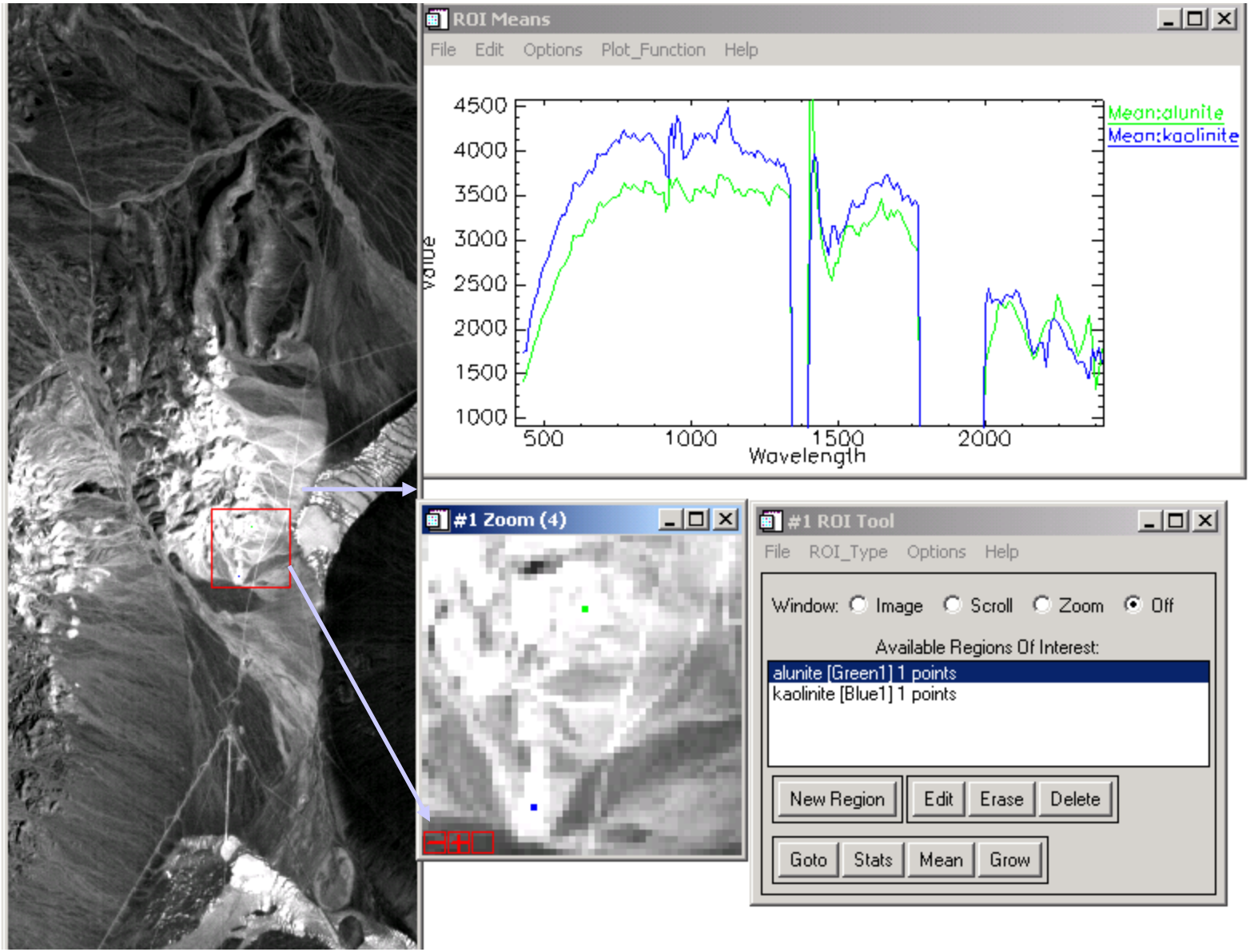
Example of Level 1 Scaled Radiance



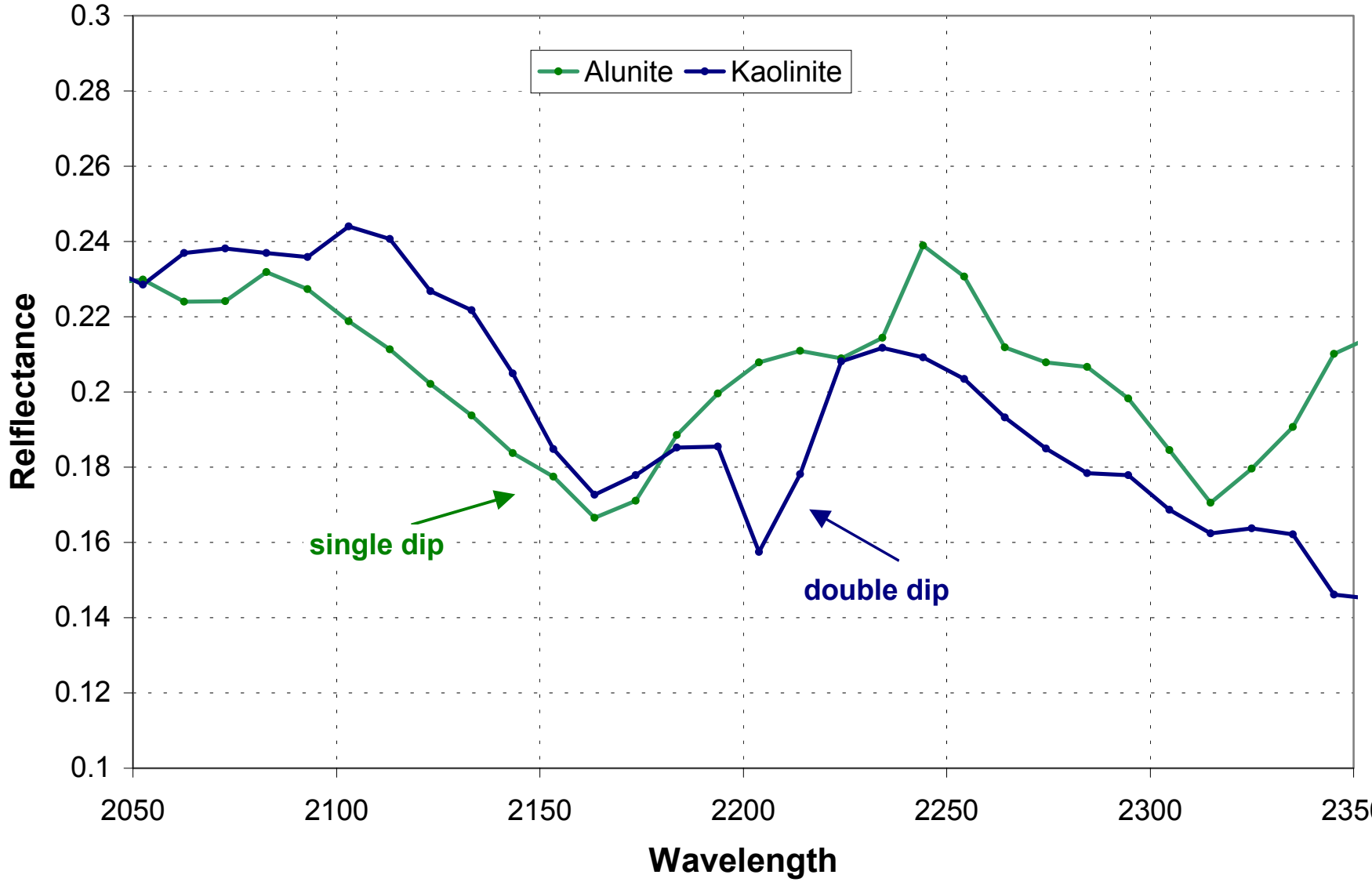
Example of Absolute Radiance



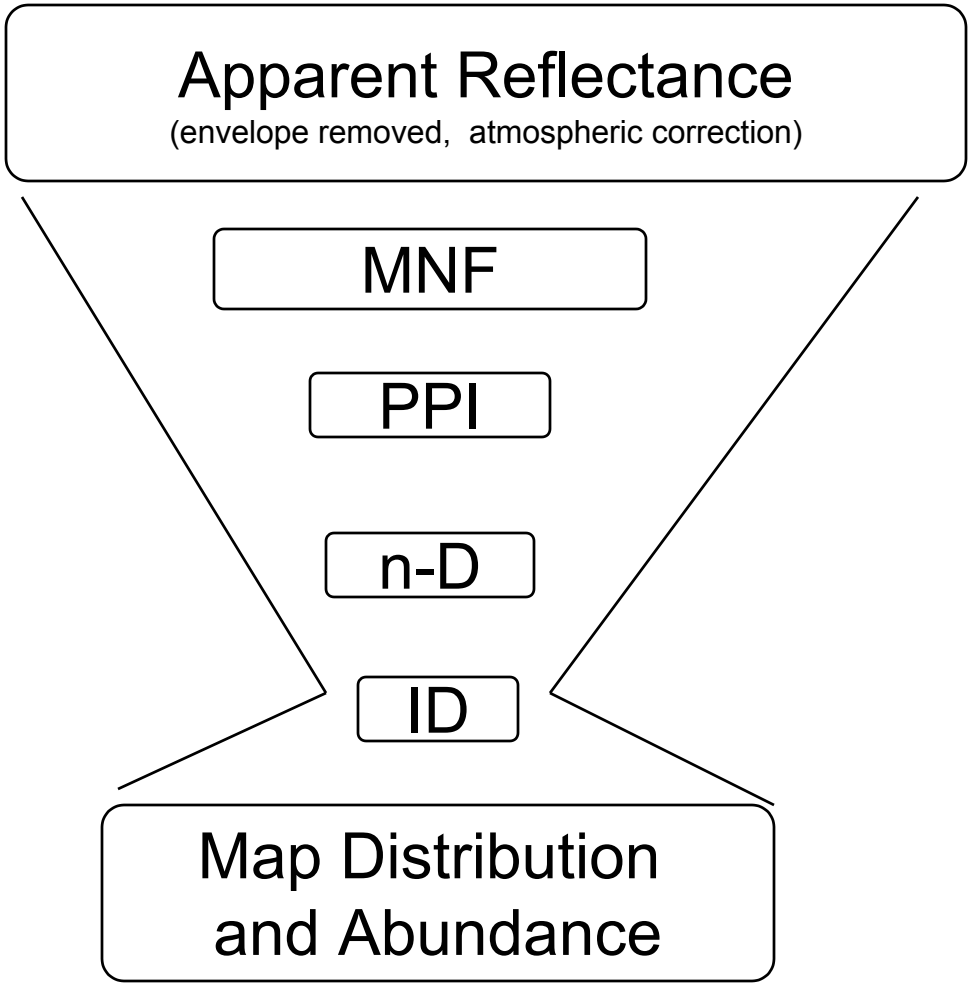
Alunite and Kaolinte Samples



Alunite & Kaolinte Samples



Deriving Mineral Maps with Hyperspectral Processing



Spatial/spectral Browsing

Spectral Data Reduction

Spatial Data Reduction

Visualization

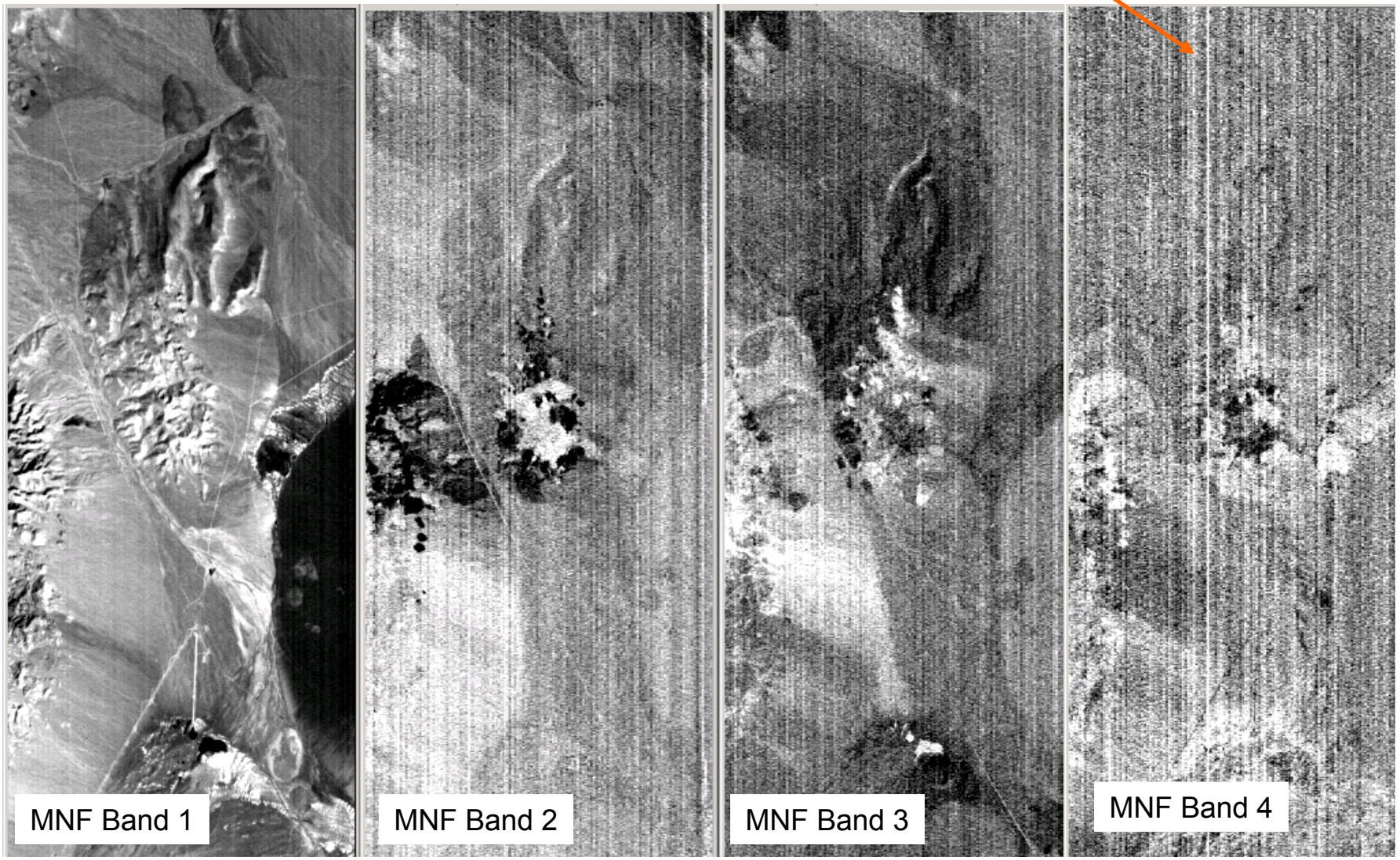
Identification

Mapping
Binary/SAM/Unmix/
MF/MTMF

From ENVI 3.4 Tutorials and slightly modified

MNF Results pass 1

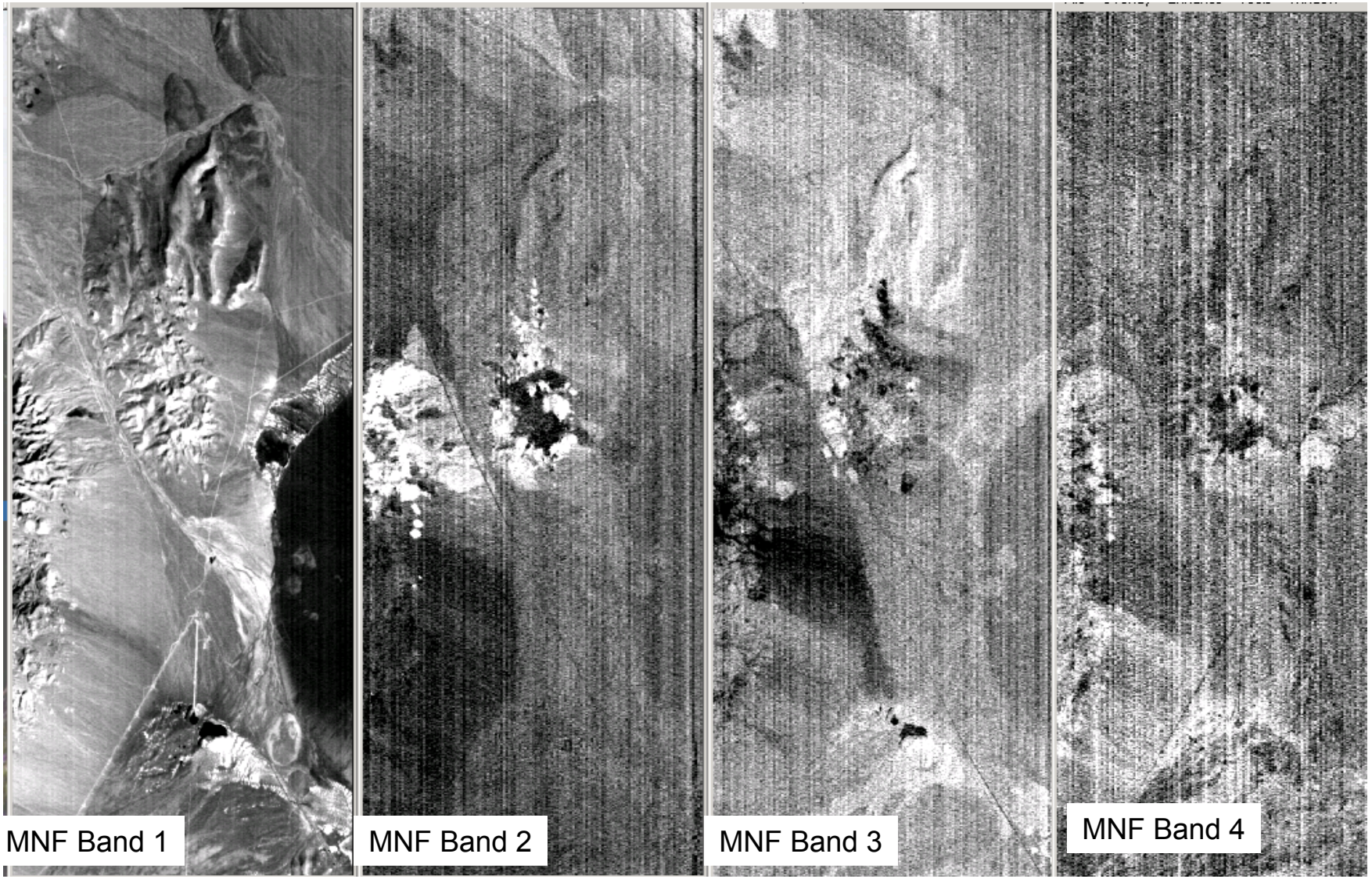
Unexpected outlier pixel



Review Data

- ***MNF reveals streaks – pixels that are outliers cause vertical streaks in the data of pushbroom systems***
- ***Streak in MNF 4 is at field-of-view 103***
- ***Plot the spectrum of the Hyperion L1B data at field-of-view 103 to determine band number that contains streak, band 203***
- ***Replace band 203, fov 103 with average of adjacent pixels***

MNF Results Pass 2



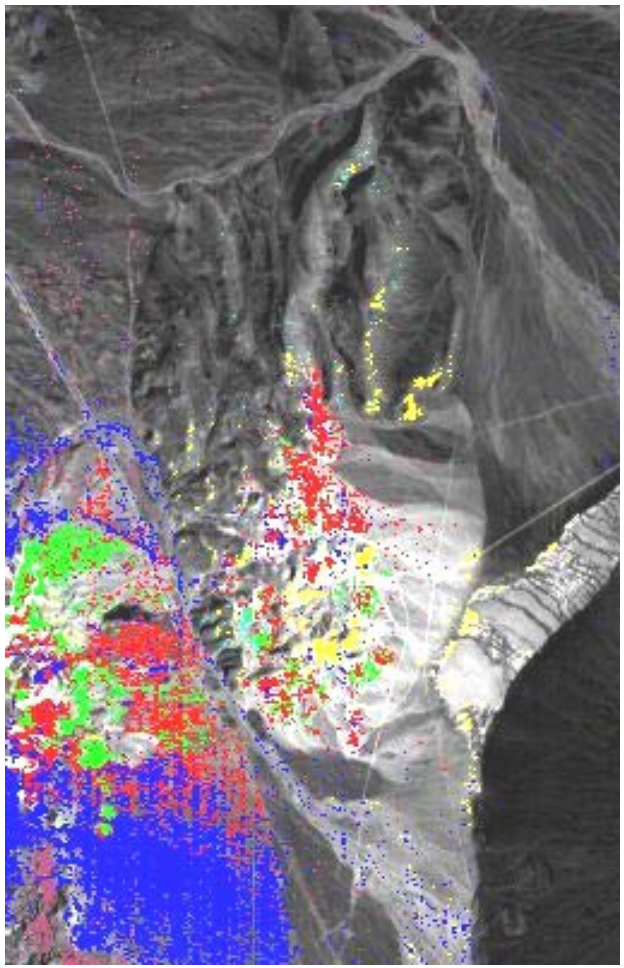
Review Data

- ***MNF processing enables easy identification of outlier pixels***
- ***Nominal VNIR pixel-to-pixel variation < .25%***
- ***Nominal SWIR pixel-to-pixel variation < 1.5%***
- ***Streak with larger than nominal variation suggests outlier pixel***
- ***Remaining pixel-to-pixel variations can be removed with advanced processing***

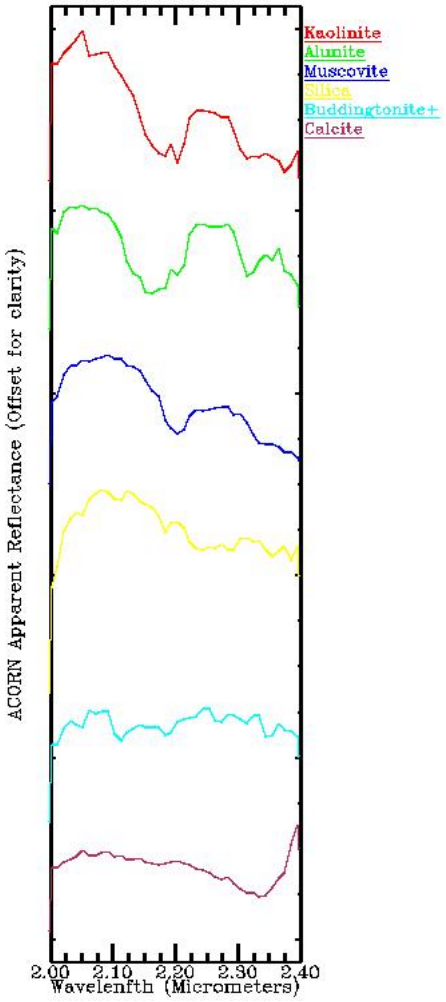
Advanced Mineral Map Processing

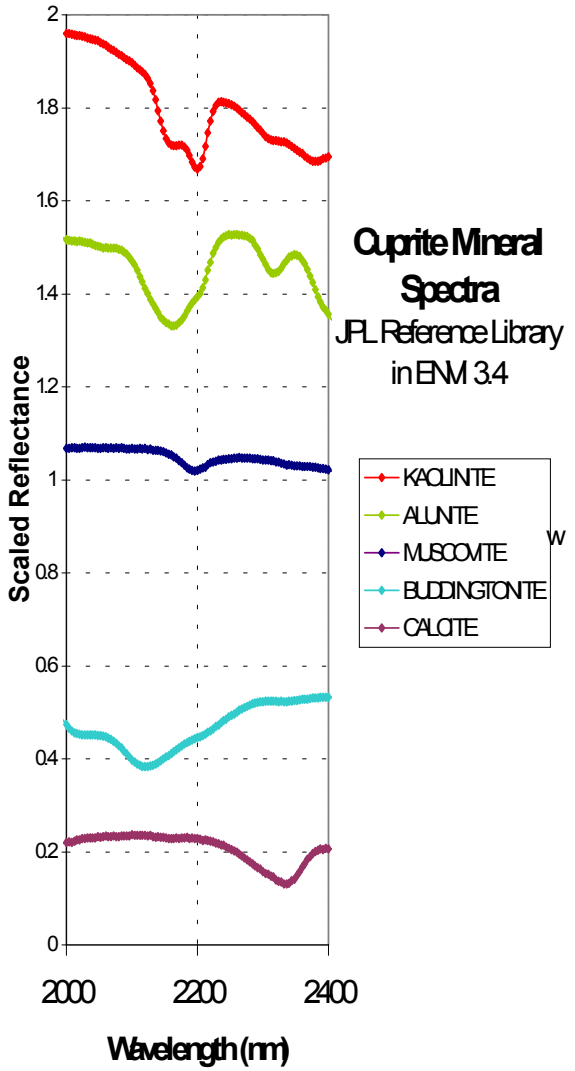
- ***Performed by – Fred Kruse AIGLLC***
- ***1 March 2001 Hyperion Collection, Level 1 data***
- ***Reflectance correction using ACORN and minerals mapped using commercially available software (ENVI)***
- ***Comparison to 1995 AVIRIS mineral mapping results shows good correspondence and verifies successful mineral mapping from space***

EO1 Hyperion Cuprite Mineral Map



Hyperion SWIR Mineral Map By AIGLLC





Hyperion SWIR End member Spectra

Mt Fitton Advanced Analysis

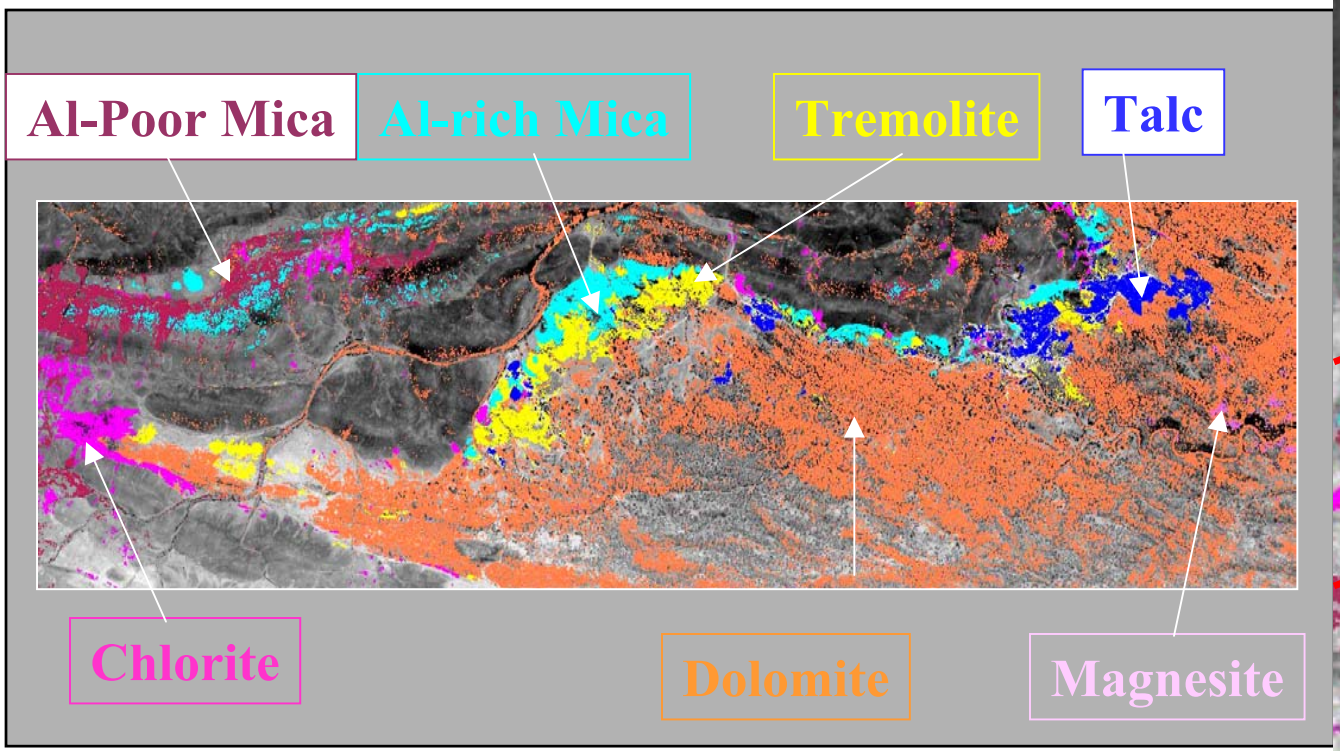
- ***Mt Fitton, South Australia***
  - ***Semi-arid (<250 mm per year)***
  - ***Sheep (wool) and mining (talc)***
  - ***-29°55'S, 139° 25'E 700 km NNW of Adelaide***
- ***T.J Cudahy, R. Hewson, J.F. Huntington, M.A. Quigley, CSIRO Exploration and Mining***

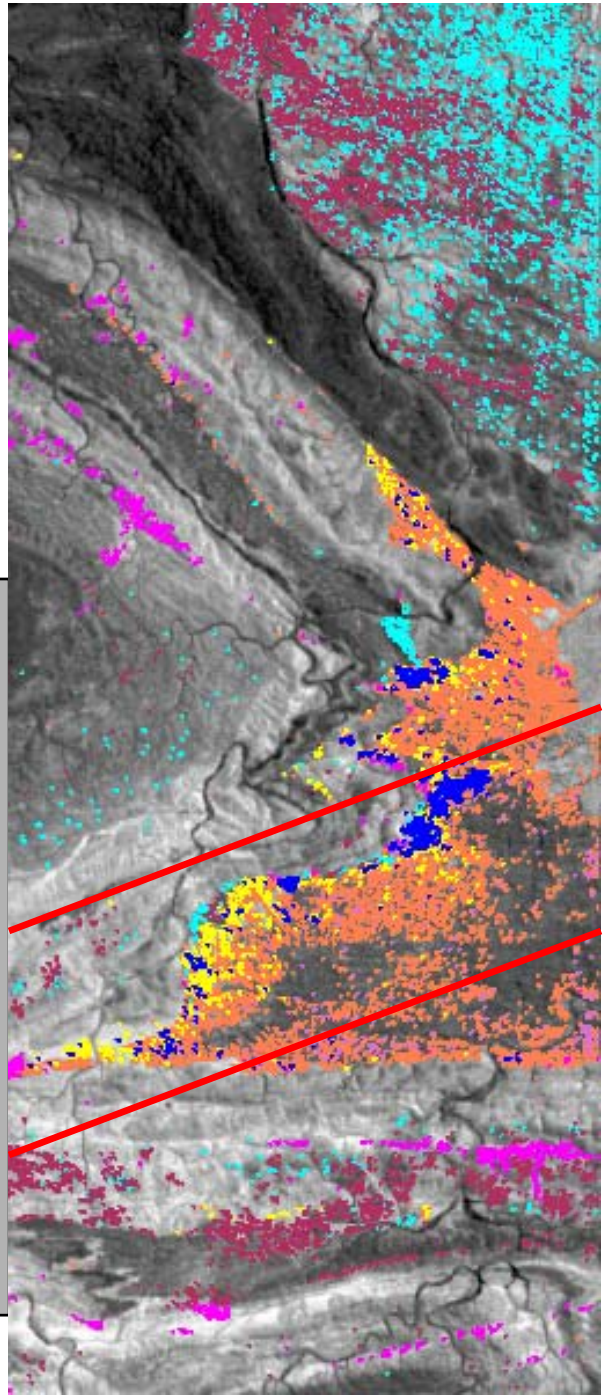
Mt Fitton: Data Processing

- ***Performed by T.J Cudahy, R. Hewson, J.F. Huntington, M.A. Quigley, CSIRO Exploration and Mining***
- ***ACORN atmospheric correction***
- ***Focused on SWIR bands***
- ***Bad detector-cell fix* (column- and λ-dependent)**
  - ***Linear interpolation and extrapolation to correct for null data***
- ***256 column correction for each λ***
  - ***Column-means (Cm) adjusted to mean of Cm***
  - ***Matrix of 256 gains for 32 SWIR bands***
- ***Noise removal in MNF space***
  - ***Signal in first 8 MNF bands***

Hyperion vs HyMap Mineral Maps

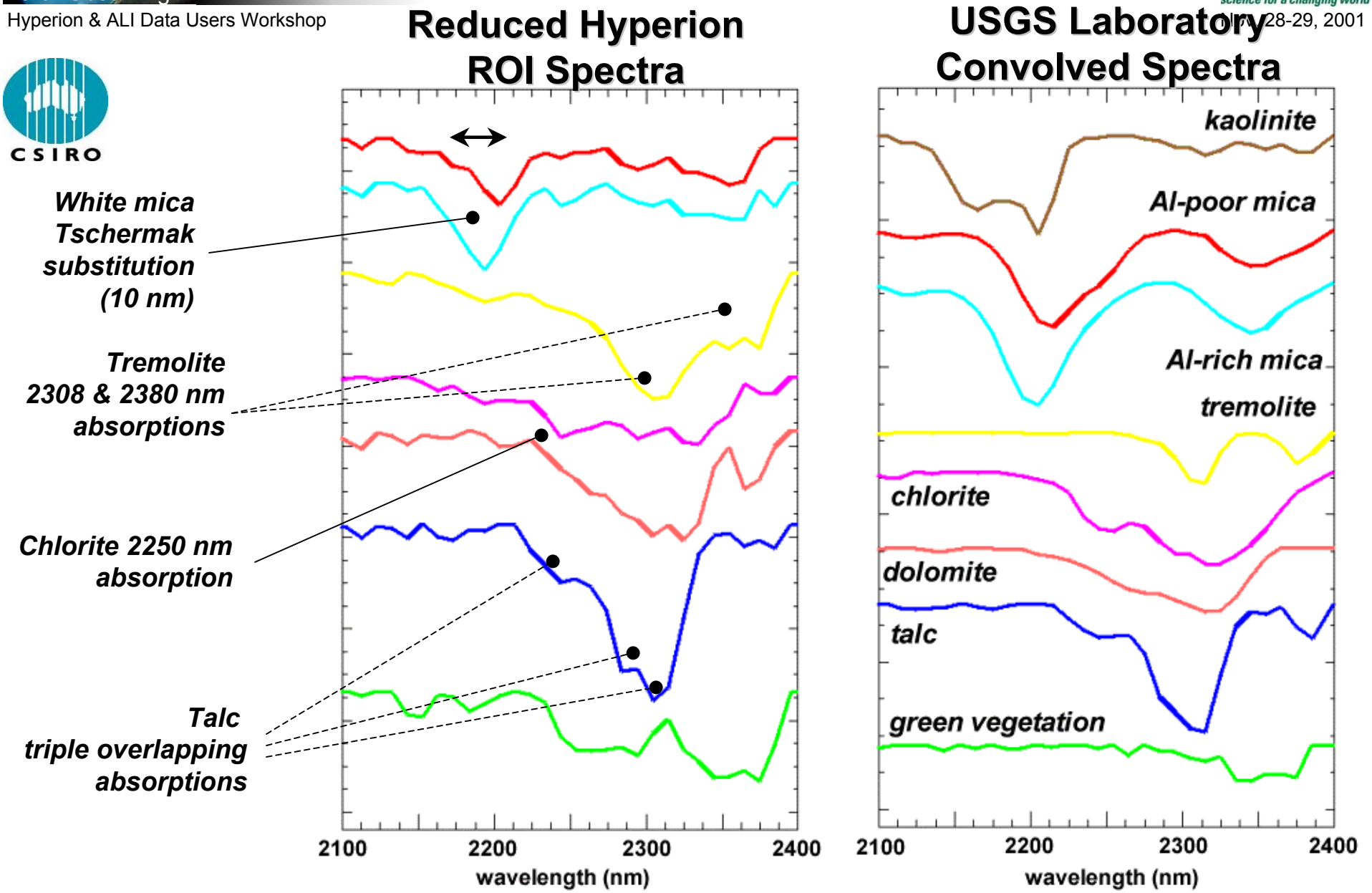
CSIRO Exploration and Mining





SWIR Spectrum

CSIRO



SWIR Example: Mineral Identification

- ***Hyperion spectra compares with reference spectral libraries***
- ***Identification capabilities proven in the most challenging region of the Hyperion spectrum***
- ***Identification algorithms depend on the users needs and availability of reference material***
  - ***Compare to reference spectra***
  - ***Compare to instrument spectra***
  - ***Compare to library spectra***
  - ***Compare to statistics of scene***