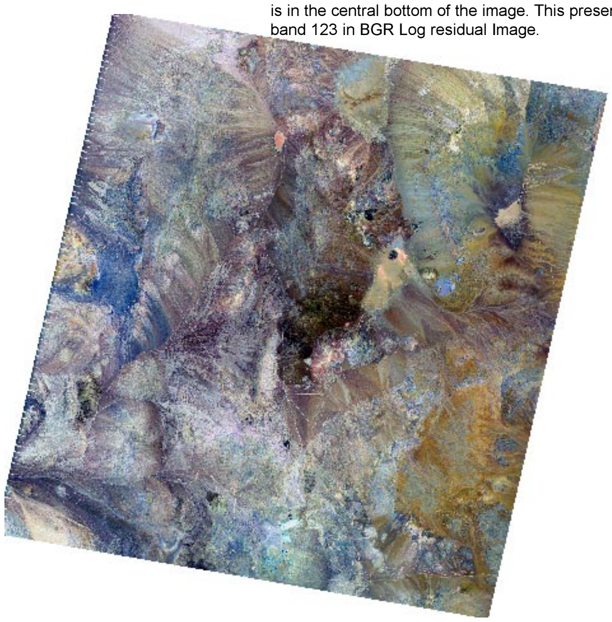
SPECTRAL UNMIXING OF ASTER DATA ESCONDIDA NORTH, CHILE

The ASTER image used in this study was collected on 26-Nov-2000 and the Zaldivar Mine / Escondida North prospect is in the central bottom of the image. This presentation is a band 123 in BGR Log residual Image.



This presentation reports the results of a spectral unmixing exercise carried on an ASTER image in Northern Chile in the Escondida region. The work was carried out by Mr Mike Hornibrook of Spectral Geology and show the information that can be obtained spectrally in an area without any detailed prior knowledge of the geology of the area. It should however be realized that the arid environment and lack of vegetation in northern Chile lends itself ideally to this type of spectral work.

Conclusions from the work were-

The Aster reflective data promise enhanced discrimination of mineral assemblages relative to existing Landsat TM and SPOT satellite data.

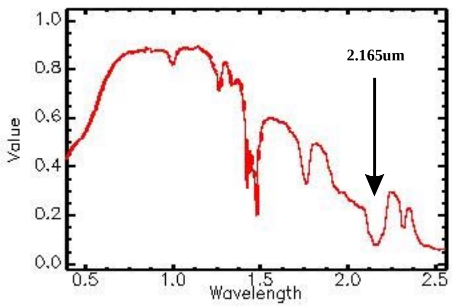
The Aster SWIR Reflective bands are capable of limited identification of mineral assemblages that include:

- Mineralogy generated by the passage of low pH fluids
- Kaolinite group minerals
- Al-OH bearing minerals illite-muscovite-smectite as a group
- Mg-OH / carbonate minerals as a group

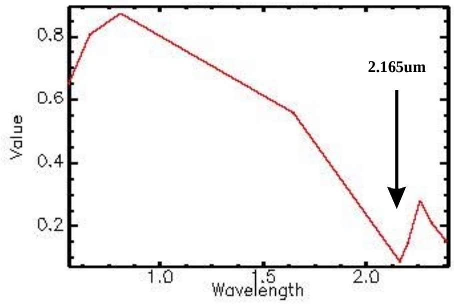
This is a significant improvement over Landsat TM data.

- Mineralogy is extractable via relatively simple and robust (to a point) linear unmixing, SAM, etc.. methodology available within ENVI.
- Aster derived information has significant role in mineral exploration (arid environments) and environment related mine site monitoring.

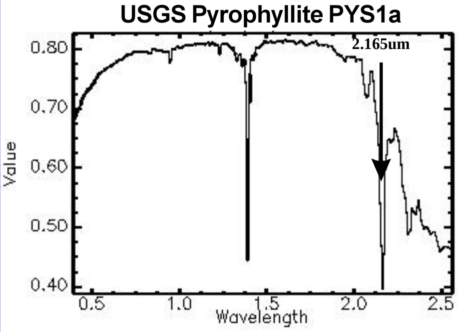
USGS Alunite HS295.3b



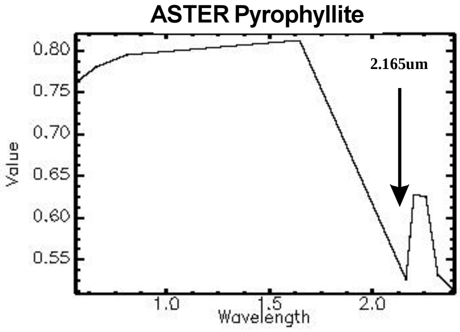
ASTER Alunite



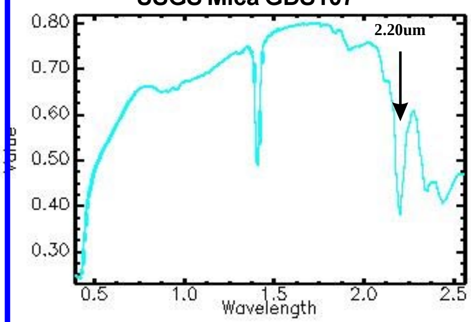
USGS Pyrophyllite PYS1a



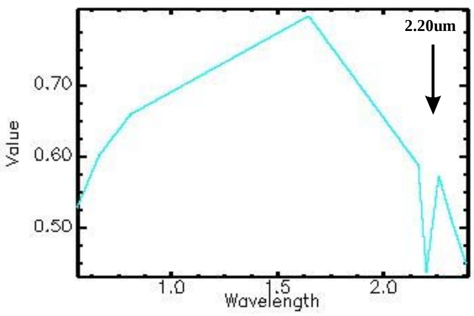
ASTER Pyrophyllite



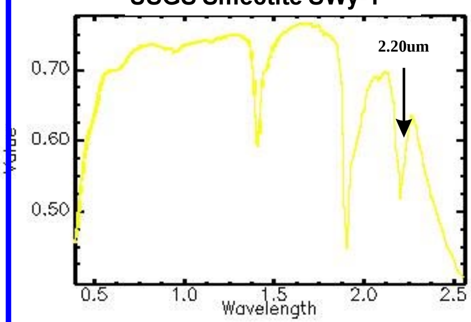
USGS Mica GDS107



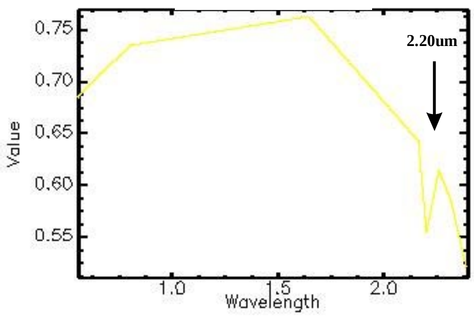
ASTER Mica



USGS Smectite SWy-1



ASTER Smectite



The spectra of several clay/carbonate minerals have been taken from the USGS Spectral Library and these spectra have been resampled to ASTER VNIR and SWIR bandpasses for comparison purposes. The results of four of these comparisons are shown here however several other minerals have been compared and are discussed below.

The spectra of advanced argillic minerals alunite and pyrophyllite are characterised by a diagnostic absorption feature near 2.165um. When resampled to Aster bandpasses the gross curve shape curve is preserved and the diagnostic features are depicted by a significant spectral absorption in band 5 (centred 2.165um). Whilst Aster probably can not separately identify these minerals species, it should identify the low pH / acid environments in which these minerals occur.

The spectra of muscovite and montmorillonite are characterised by a single diagnostic absorption feature near 2.200um. When resampled to Aster bandpasses the gross shape of the curve is preserved and the diagnostic features are depicted by a significant spectral absorption in band 6 (centred 2.205um). Whilst Aster probably can not identify these minerals species directly, Al-OH bearing minerals (muscovite-illite-Al smectite) could be identified as a group.

USGS Library spectra of dickite and kaolinite are characterised by a doublet shaped diagnostic absorption feature near 2.175/2.210um. When resampled to Aster bandpasses the gross shape of the curve is preserved and the diagnostic features are depicted by an asymmetric absorption in band 6 (centred 2.205um). Whilst Aster probably can not identify these minerals species directly, kaolinite minerals as a group should be identifiable.

The spectra of calcite and chlorite are characterised by a single diagnostic absorption feature near 2.350um. When resampled to Aster bandpasses the gross shape of the curve is preserved and the diagnostic features are depicted by a symmetric absorption in band 8 (centred 2.320um). Other common Mg-OH bearing minerals including talc and amphibole which are depicted by absorption features near 2.320 and 2.390um, have similar Aster band 8 responses. Whilst Aster probably can not separate carbonate from Mg-OH bearing mineral, these minerals are be identified as a group. This is a significant enhancement over Landsat TM which can not detect Mg-OH/CO radicals directly.

METHODOLOGY

In this example, a 30km by 30km subset of the Escondida North ASTER Reflectance image was processed in the ENVI software using linear spectral unmixing. Steps in this process involved-

- Preparation of a decorrelation stretched band 6 3 1 band composite (Figure below). The spectra of individual pixels in this image were examined and compared to the USGS spectra (subsampled to ASTER bandpasses) as shown in in the figure.

- In this way, four regions of interest were selected that were considered to have spectra responses dominated by one of the four mineral groups that might be distinguishable on the basis of their SWIR response – alunite/pyrophyllite, kaolin group, Mica/smectite and Mg-OH/carbonate.

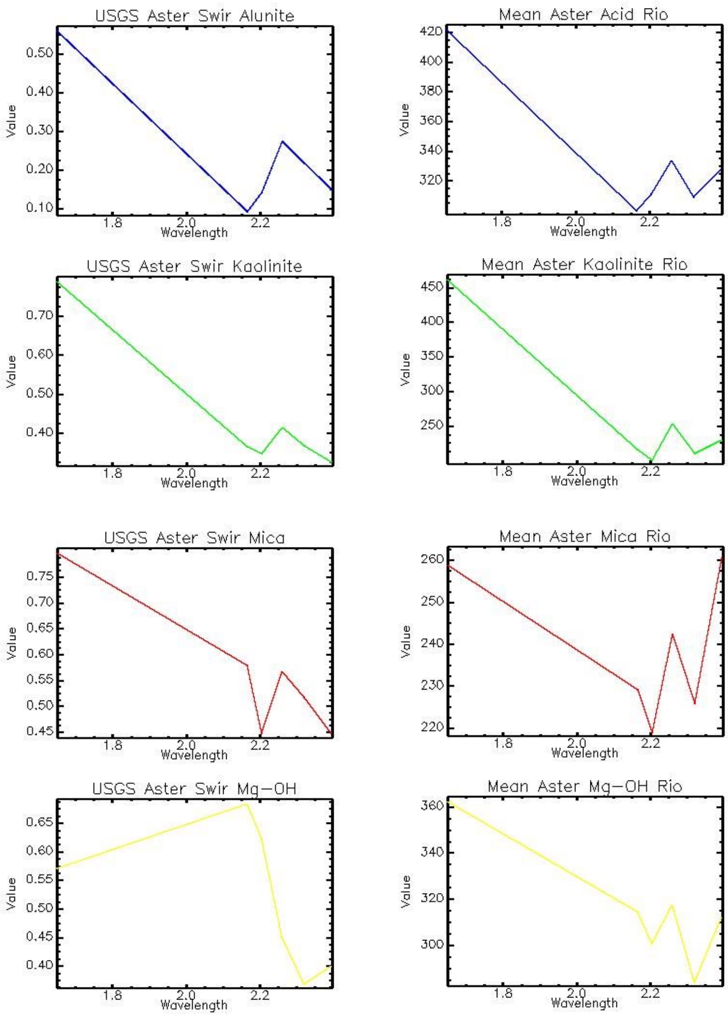
- The mean spectra of these Regions of Interest were compared to the ASTER resampled USGS spectra (see Figure on right). This comparison suggests that Aster conversion to reflectance over-estimates reflectance in band 9. The result is an apparent absorption feature in band 8. Distribution and relative abundance of Mg-OH/CO mineral maybe overestimated. However, the effect appears to be systematic and affects all pixels. Never-the-less, diagnostic bands for low pH environments, kaolin group, Al-OH and Mg-OH/CO minerals remain recognisable and usable.

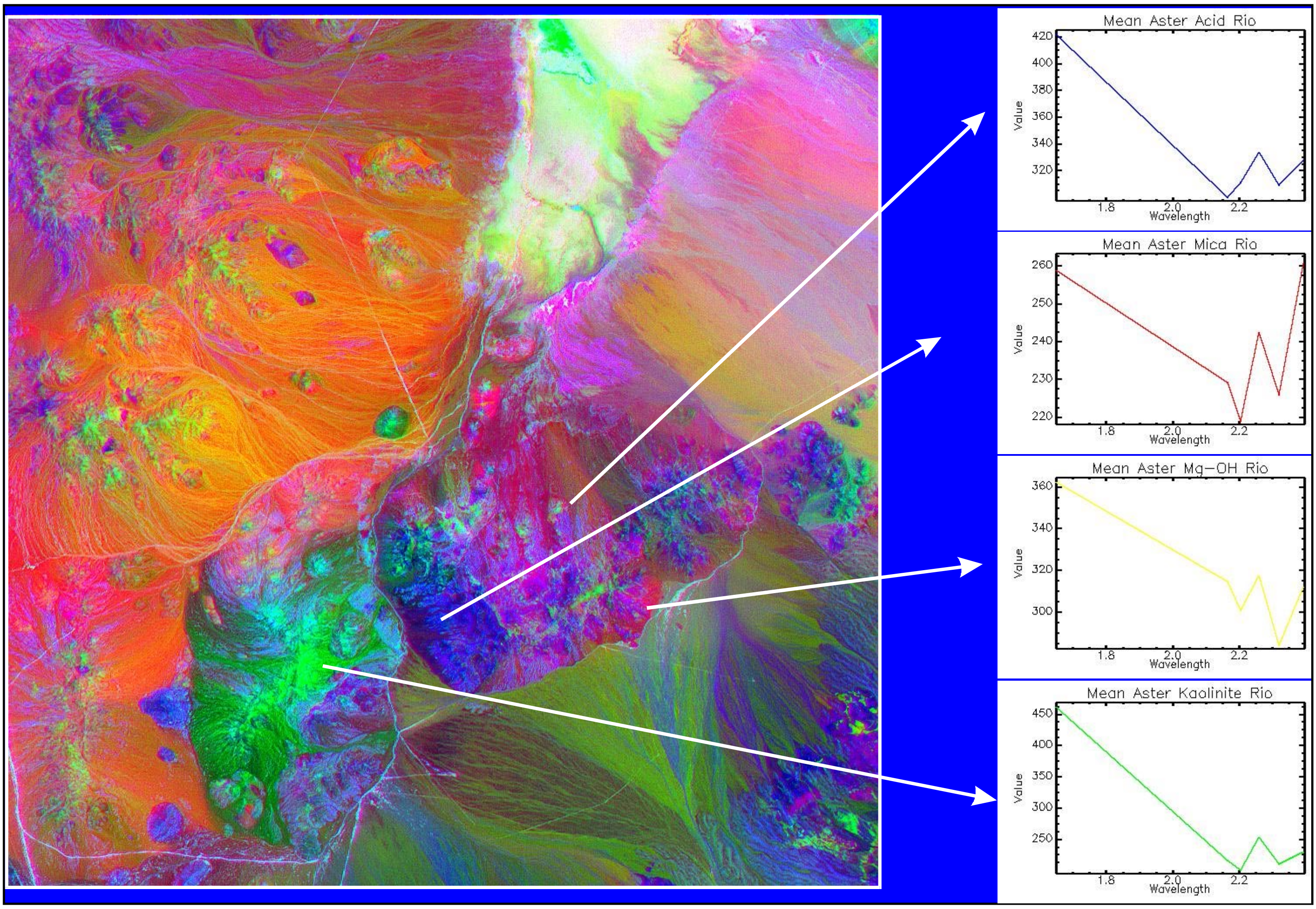
- Linear Spectral Unmixing, available within the ENVI software package, was used to determine the distribution and relative abundances of of the four end members in the ASTER image. The unmixing relies on the assumption that the reflectance at each pixel of the image is a linear combination of the reflectance of each endmember present within the pixel.

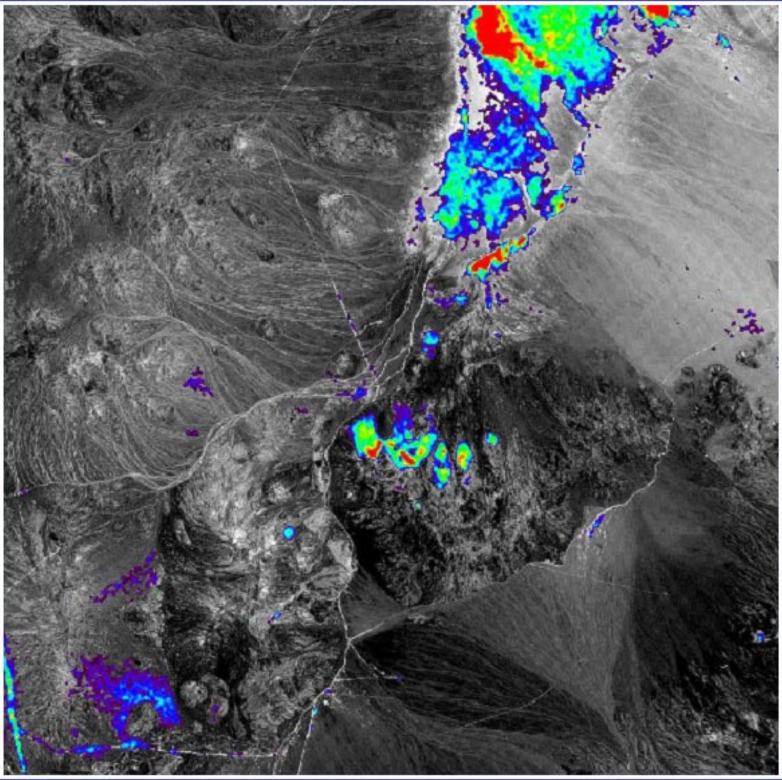
- Spectral unmixing results can be displayed either -

As a series of grey-scale images, one for each endmember where higher abundances are represented by brighter pixels.
As rainbow coloured 85% thresholded single end member images on an albedo greyscale background image, or
Three colour composite of three end members on an albedo greyscale background image.

Although Reflectance data was used in this example, the same results would have been expected from Level 1B Log Residual data.







Acid Environment / Low pH Map

Legend

Al-OH Minerals-probably Alunite &/or Pyrophyllite

Mineralogy

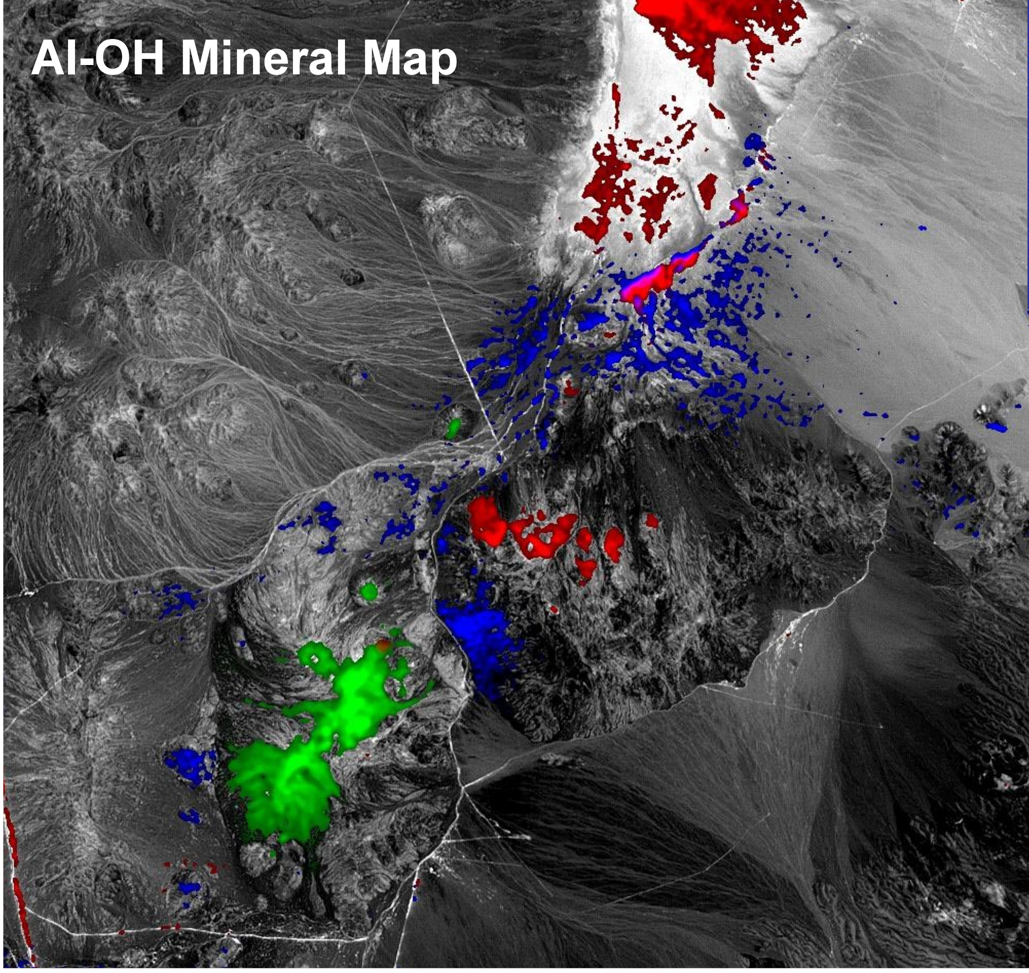
Sparse → Abundant

The image maps the distribution and relative abundance of alunite and / or pyrophyllite. Advanced argillic style hydrothermal alteration is characterised by strong enrichments of these minerals. The coloured patches near subscene centre are probable examples of this alteration style. Significantly, Landsat TM has no capability to detect this mineralogy.

Alunite is not unique to hydrothermal alteration and the accumulations within the playa must be vetted in the light of what is known about the geology and landscape.

This presentation style probably better depicts the relative mineral abundance than the ternary diagram below.

Aster Three Class Al-OH Mineral Map



Legend

Al-OH Minerals-probably Alunite &/or Pyrophyllite

Al-OH Minerals-probably Kaolin Group Minerals

Al-OH Minerals-probably Illite, Mica &/or Smectite

This image, derived by linear unmixing of SWIR Aster data, maps the distribution and relative abundance of Al-OH bearing minerals. It is suggested that Aster can identify three (3) "classes" of aluminium hydroxyl bearing minerals as indicated above.

The most significant being the detection of strongly acid environments (red hues). Advanced argillic phases are indicated by the red hues near the subscene centre. Similar hues near the northern edge of the subscene are related to playa deposits, presumably alunite formed in the weathering environment.

There are some location related variation in the illite-mica-smectite style signatures suggesting "subclasses" may define illite or sericite mineralogy. The blue hues derived from one region of interest and represents only one possible "subclass" .

The green hues are sourced in kaolin group minerals and probably highlight argillic altered environments.

Without geological background it is difficult to comments further about the derived mineral patterns.

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