Mapping mine waste using hyperspectral imaging spectrometry data

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NATURAL ENVIRONMENT RESEARCH COUNCIL

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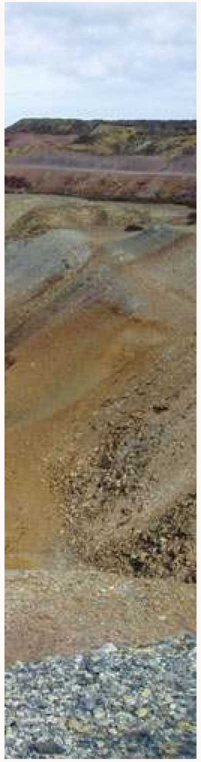
Context

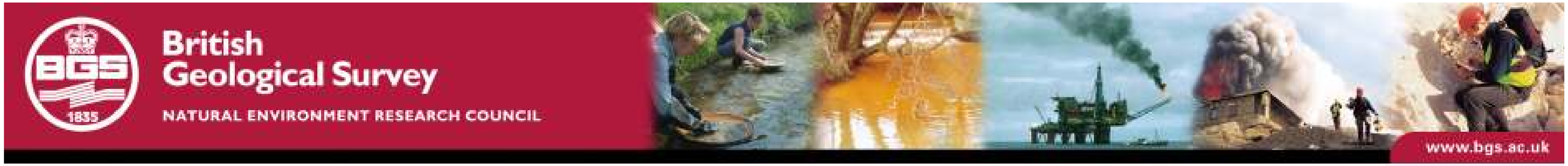


- A long history of mining in the UK has left a legacy of waste in various forms.
- Certain minerals present within this waste are harmful to people and the environment.
- Governments, Agencies and Industry need a cost effective way of mapping mine waste

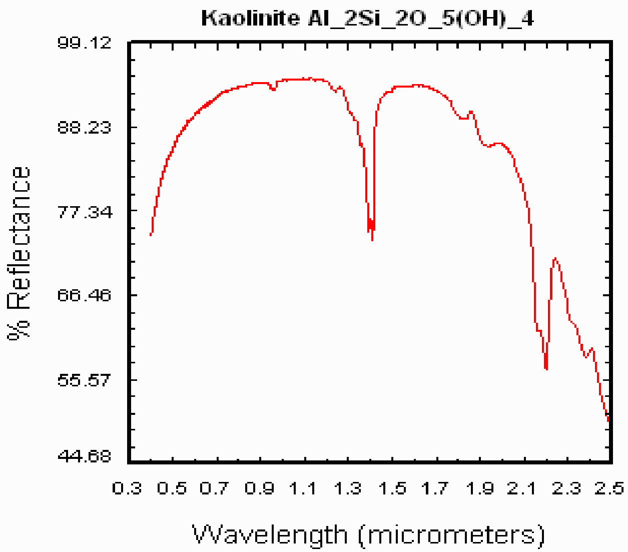
Remote Sensing

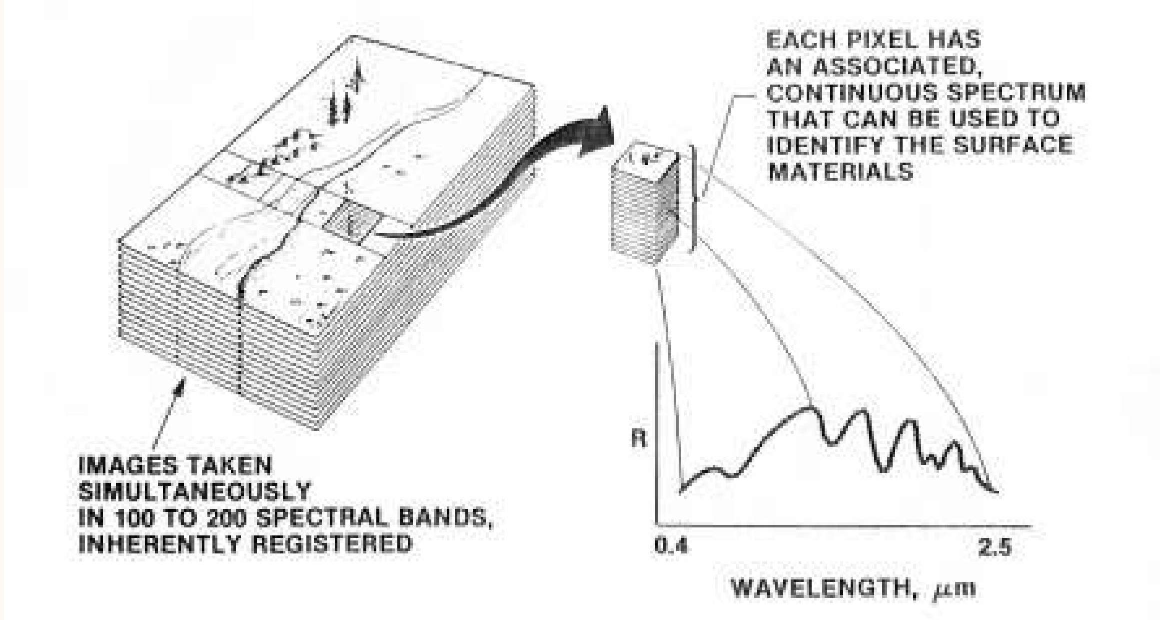
- **Minerals can be mapped remotely using hyperspectral airborne remote sensing.**

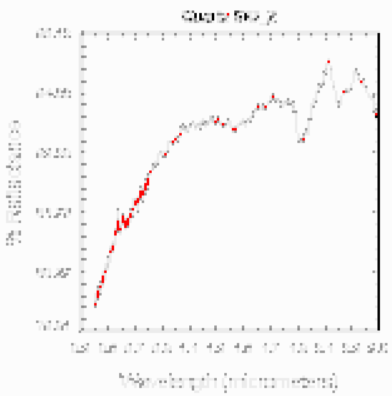
- **Mine waste will contain characteristic minerals which can be mapped**
  - **Faster**
  - **Cheaper**
  - **Safer**
  - **Non-invasively**

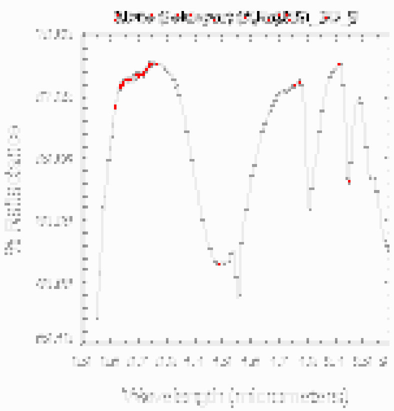


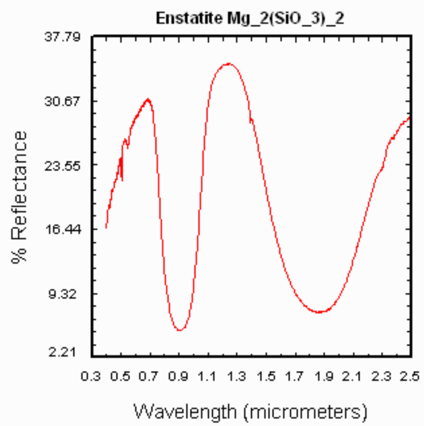
HYPERSPECTRAL MINERAL MAPPING

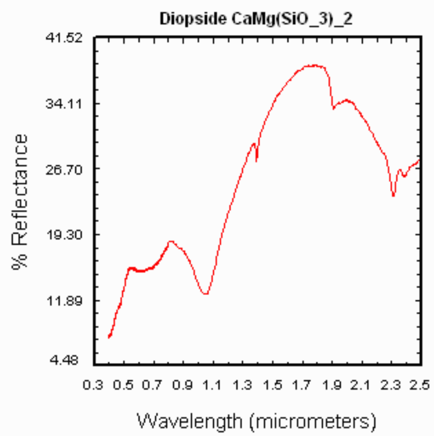












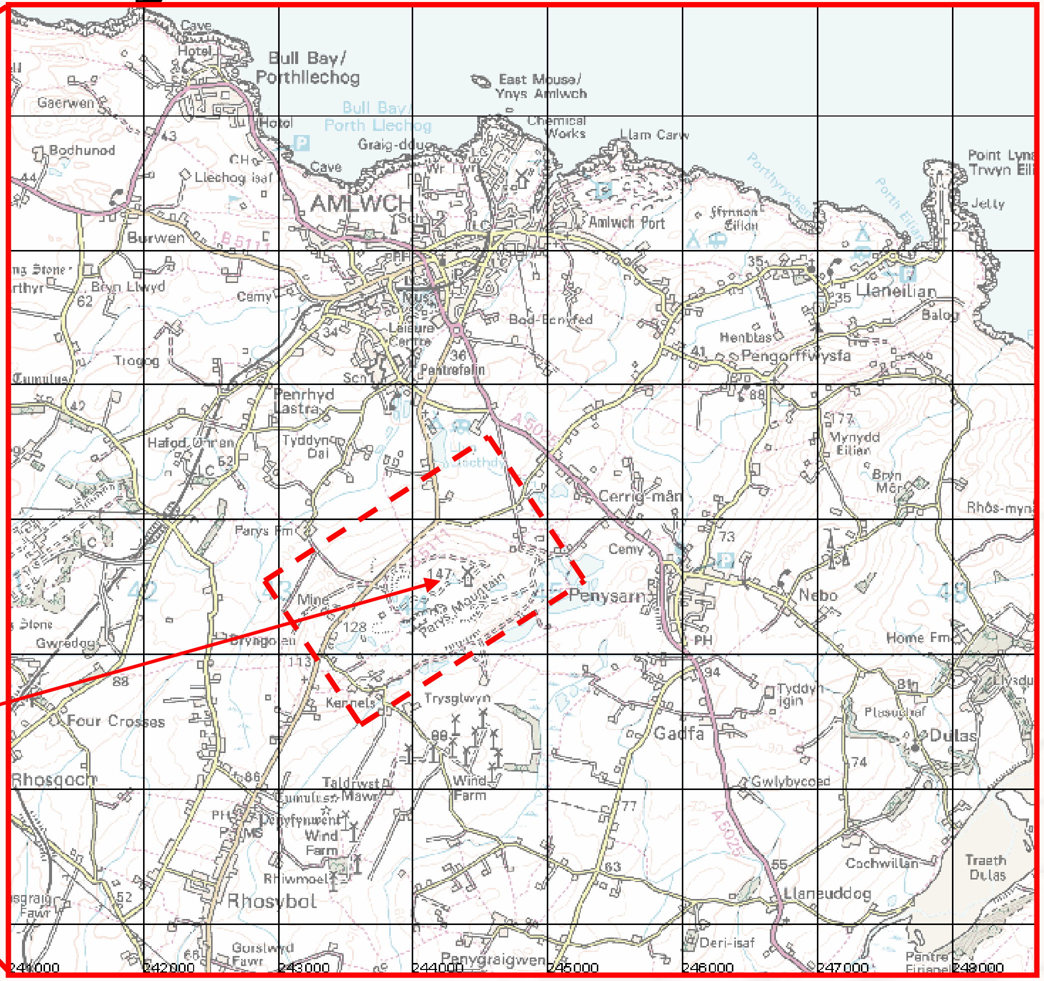
Previous Studies - MINEO

- MINEO was an EC 5th Framework R & D project
- The aim was to develop and test Hyperspectral data analysis tools in a European context
- Focusing on mine pollution rather than mineral exploration
- Work in a populous, temperate environment, rather than arid conditions

Introduction – Parys Mountain

- Parys Mountain copper mine has a unique variety of lithologies and minerals, flora and fauna
- Sites of Special Scientific Interest (SSSI)
- Weathering is harsh with sulphuric acid generated by the oxidation of pyrite and other sulphide minerals
- This process results in colourful red and yellow Iron oxides and sulphate minerals
- It is this diversity of minerals and weathering products that make this site so challenging to characterize and map

Study Site



Parys Mountain

Geology

- Mineralisation at Parys Mountain extends 3km NNE-SSW in a 1 km wide band
- Primary mineralisation resulted from exhalative volcanic-sedimentary mineralisation in the late Ordovician
- A secondary phase remobilization occurred during the Caledonian metamorphism
- The lodes themselves are zones of maximum chalco-pyritisation, and would have been formed during the great Post-Silurian Caledonian earth-movements

Mining History

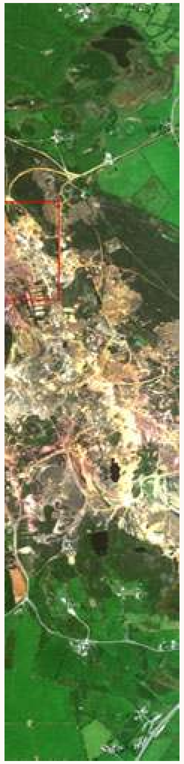
- Mining began in the Bronze age
- Beach pebbles used as hammers
- Crushed ore smelted, mixed with tin to make bronze objects
- Main period of mining began in 18th Century
- Left landscape devoid of vegetation

HyMap Data

Sensor used is HyMap

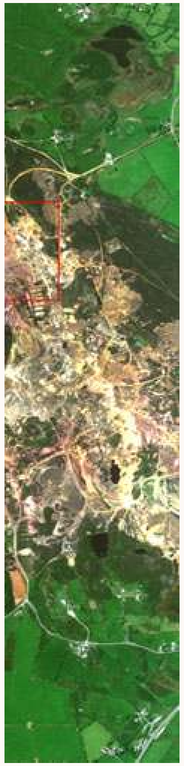
- Hyperspectral Airborne Scanner
- 126 Bands
- Wavelength region 0.45 - 2.5 µm
- Bandwidth between 15 and 20 nm
- Pixel size between 3 and 10 m
- Owned and operated by HyVista
- Data flown as part of SHAC project

Methodology



- Atmospheric correction - ATREM
- End member selection
- Minimum Noise Fraction (MNF)
- Pixel Purity Index (PPI)
- 2-D scatter plots

Methodology



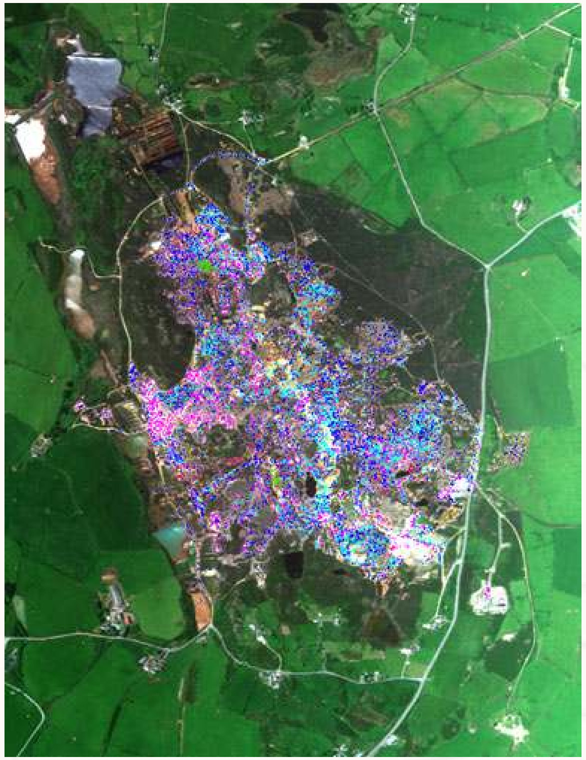
- Visual Inspection of end members
- Comparison with field spectra
- SAM classification
  - ➢ Physically based spectral classification
  - ➢ Uses n-dimensional angle to match pixels
  - ➢ Algorithm calculates the angle between spectra

Parys Mountain - Results

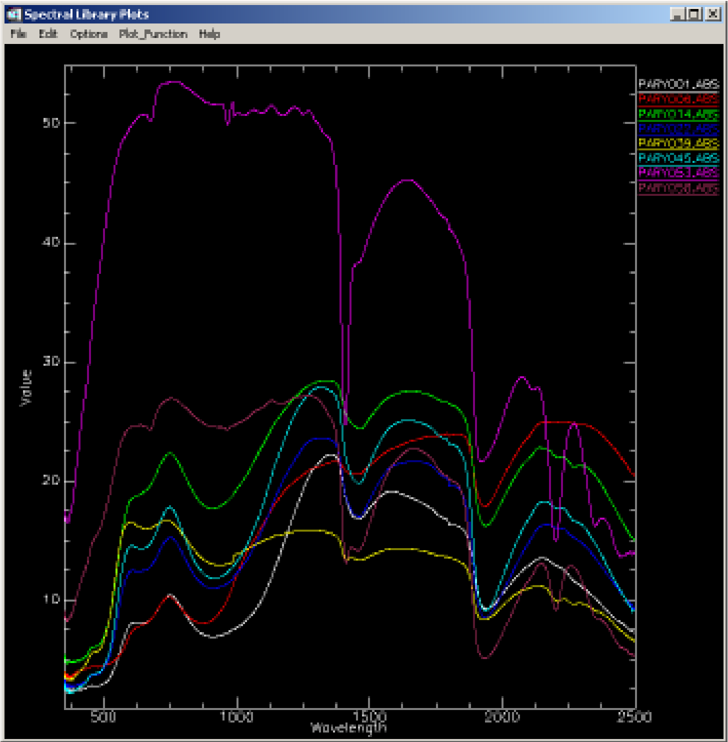
Spectral Interpretation of mine waste at the Parys Mountain Mine on Anglesey

- Jarosite & goethite
- Jarosite & hematite
- Jarosite
- Muscovite and albite
- Albite and goethite

Mine waste of differing mineralogy can be mapped using hyperspectral imagery

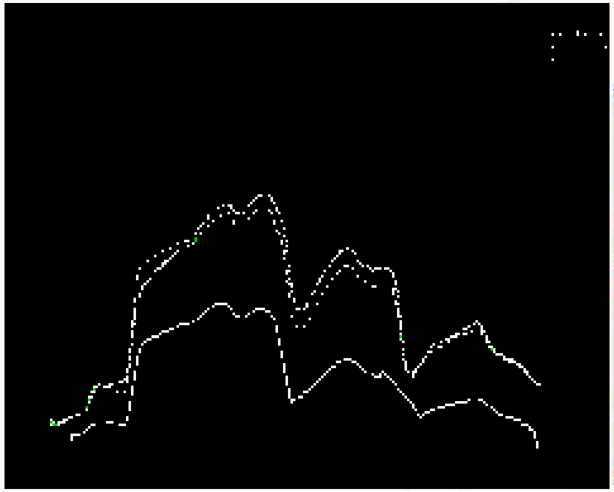


Field Spectra

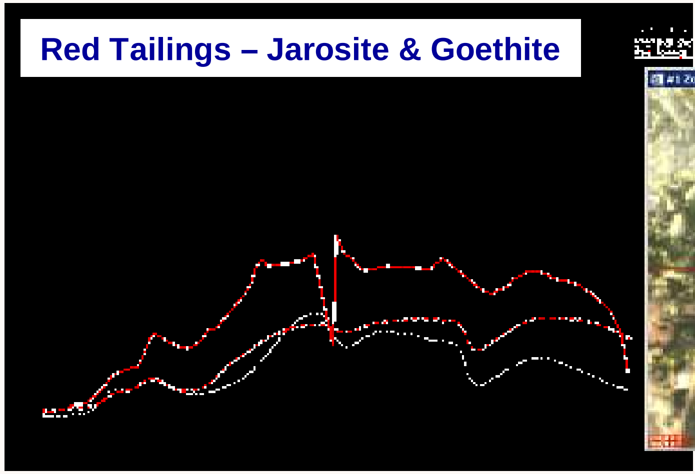


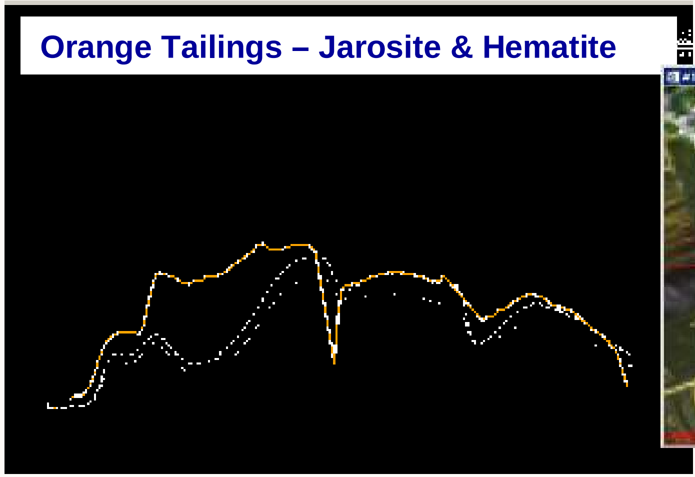
- Spectral library developed
- Characterise tailings
- XRD analysis
- Other materials measured
  - ➢ Tarmac
  - ➢ Concrete

➢ Vegetation



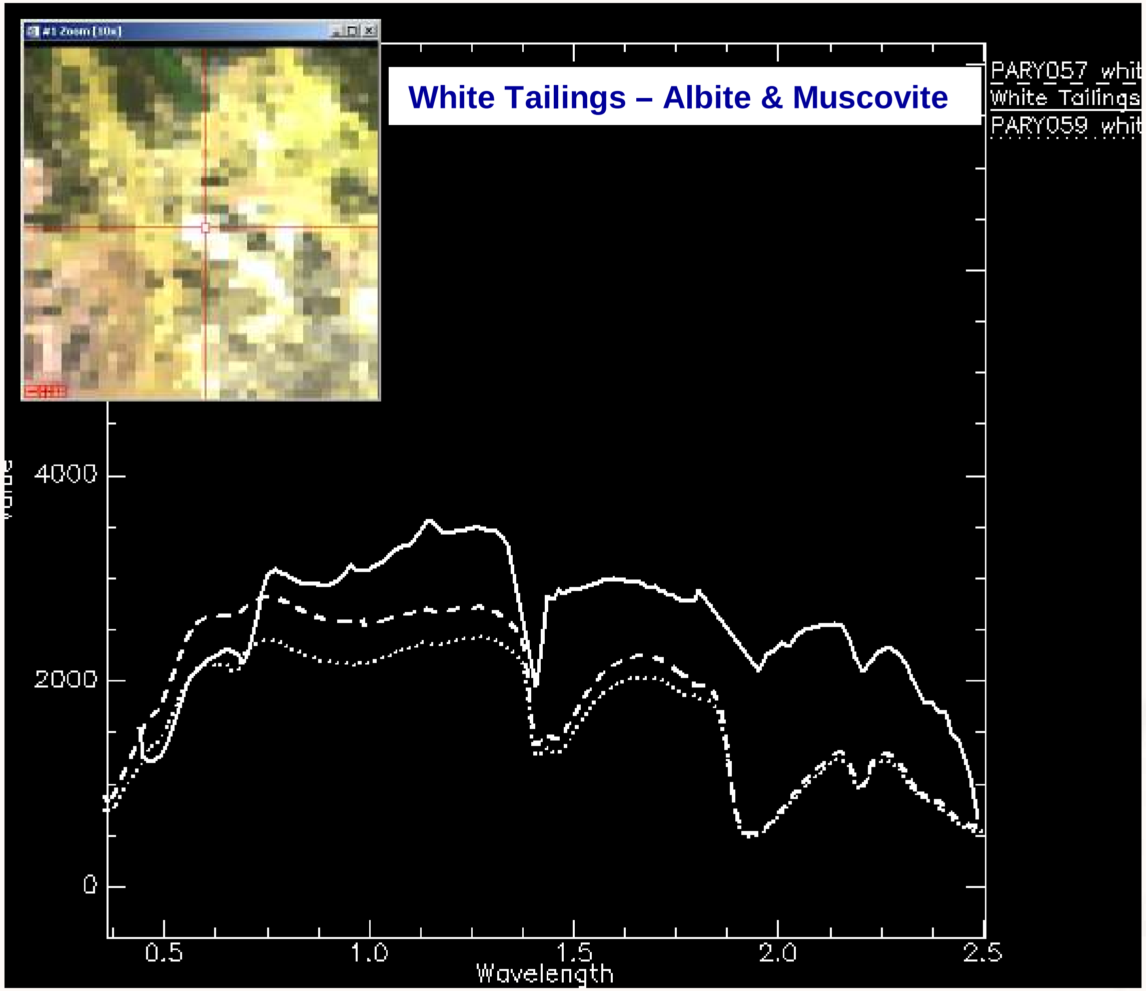
Verification





- USGS pure mineral spectra gave spurious results
- Field spectra gave much better verification results
- Spectral feature fitting and visual analysis

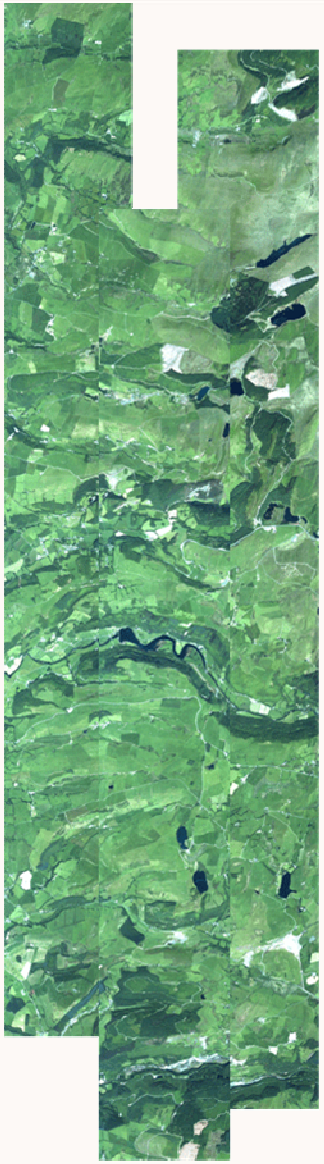
Verification



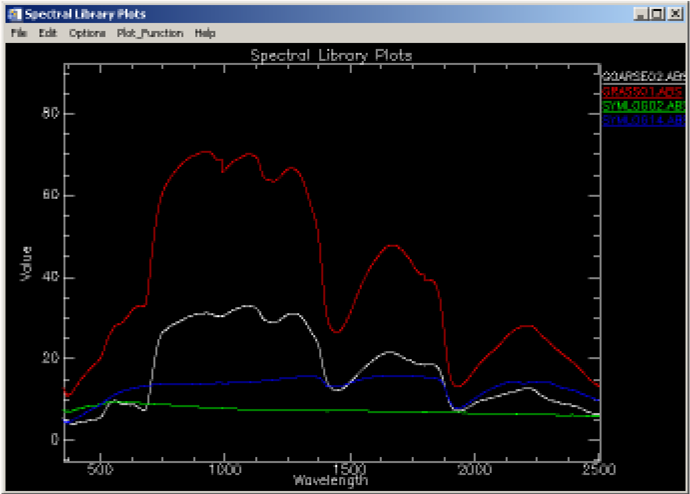
- **Feature at 1410nm**
- **Feature at 2206nm**
- **Consistent with muscovite**
- **Other features in the spectrum do not match**
- **Mixing of minerals**
- **Comparisons between field and image spectra show strong correlation**

Conclusions

- Pure mineral spectra from a commercially available spectral library don't always match image spectra
- Field spectra can be used much more effectively to develop a site-specific spectral library
- Characterisation and verification of classifications can then be based on these reference spectra
- Further verification can then be carried by undertaking geochemical analysis
- A suite of "materials" of interest can then be built up to produce a site-specific spectral library.

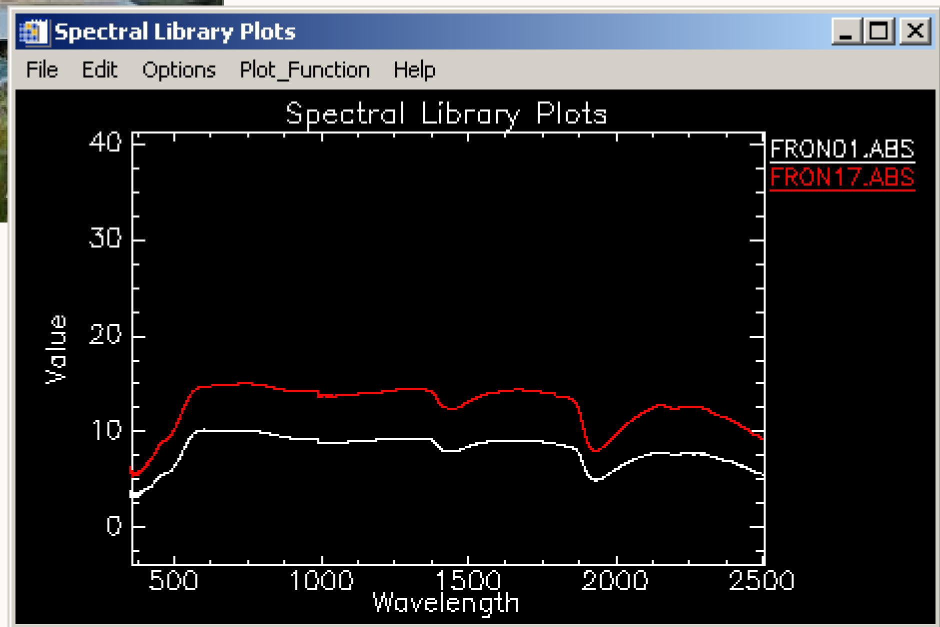


Rheidol Valley



Rheidol Valley

Frongoch Mine field spectra



Acknowledgements

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