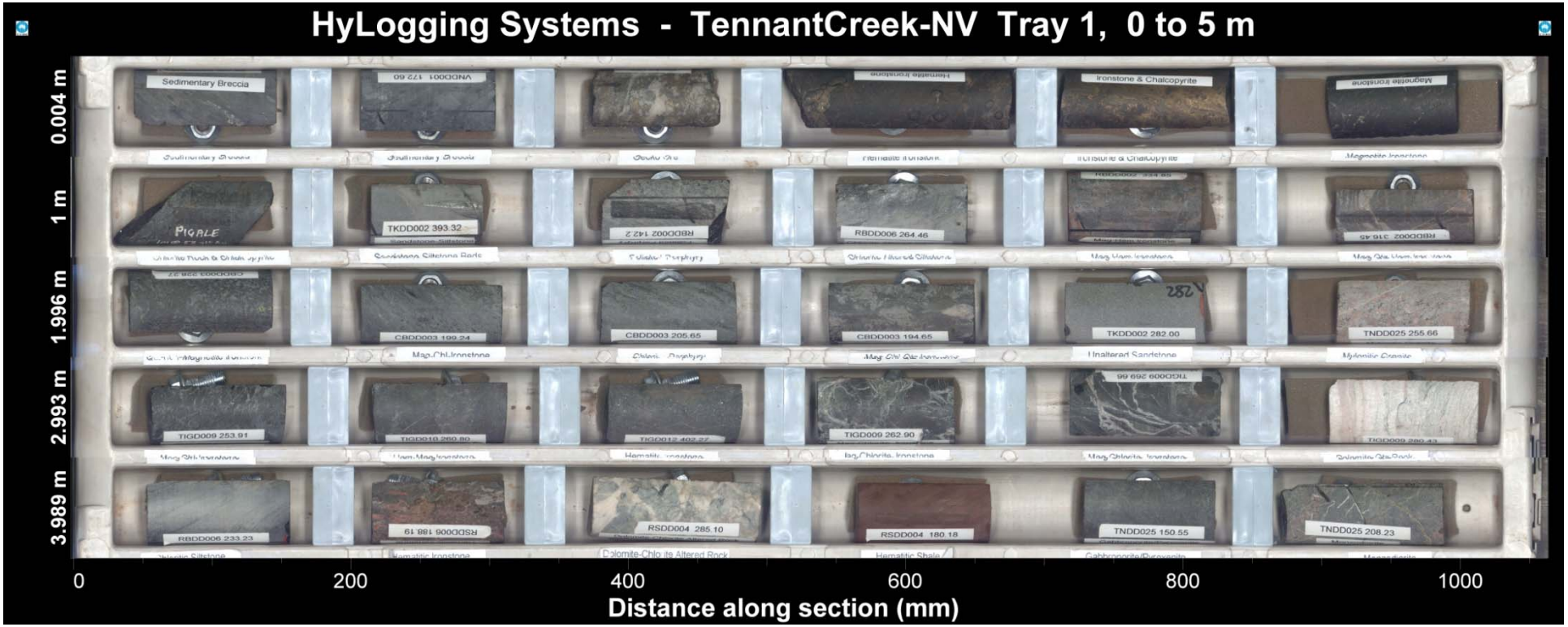
Spectral reflectance characteristics of type rocks from the Tennant Creek mineral field, Northern Territory, Australia



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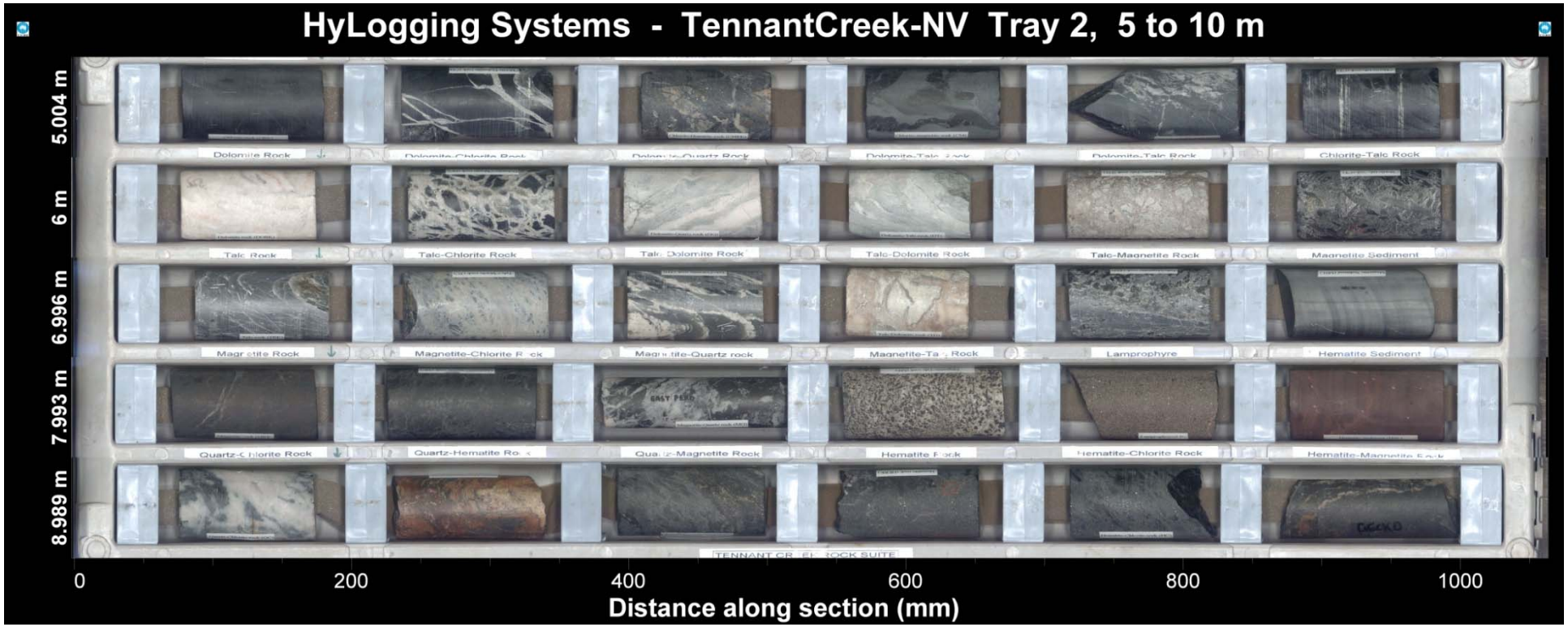
Aims of the Project

- Digitise type example rocks from Tennant Creek to produce an Atlas (reference library)
- Check mineralogy of type example rocks
- Assist geologists in becoming familiar with Tennant Creek lithologies
- Encourage consistency with geological logging
- Highlight mineralogy changes within and between rock types with implications for increasing the understanding of regional geology

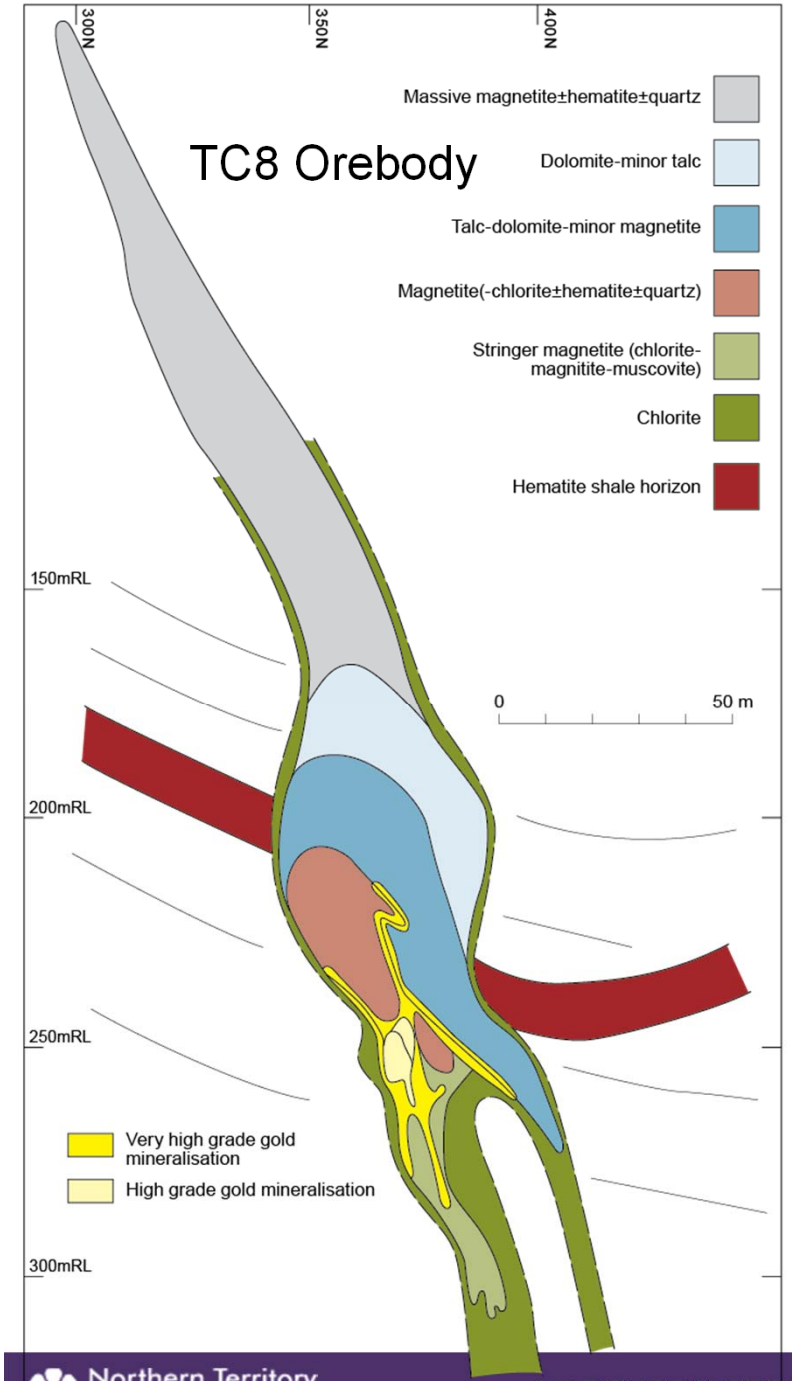
Previous Work

- Company-specific ‘Rock Boards’ (Emmerson Resources)
- Data Metallogenica

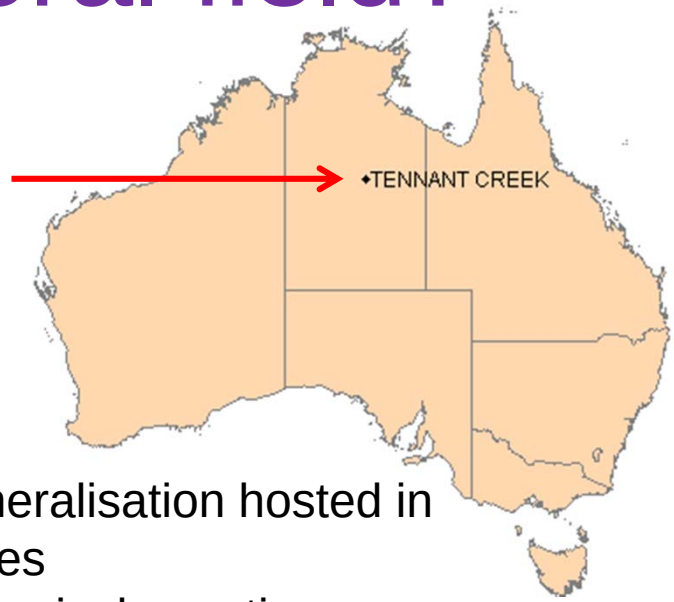


Labelled rock names; mineralogy not always noted

Why Tennant Creek mineral field?



5.5Moz Au;
188,000t Cu



- 'Traditional' mineralisation hosted in 'ironstone' bodies
- Distinct mineralogical zonation associated with Cu, Au, Bi mineralisation
- Alteration can be mapped using the HyLogger
- Can cataloguing the spectral characteristics help answer questions on mineralogy changes associated with mineralisation?

Previous Work

Data Metallogenica – Tennant Creek

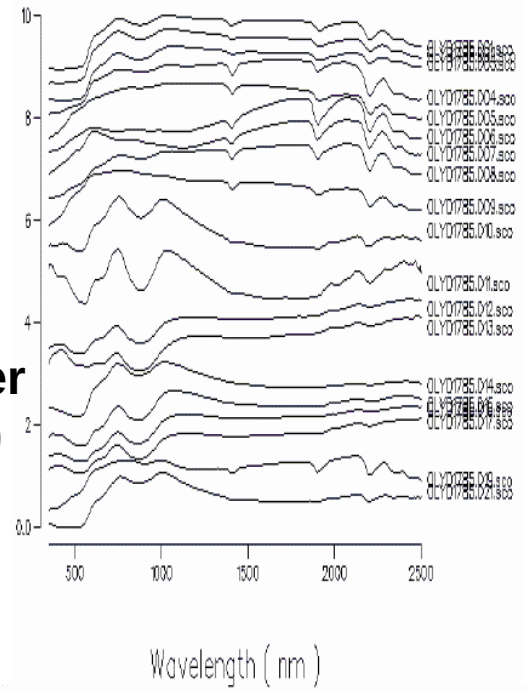
Seven plates of samples from Tennant Creek
None with spectral data
Thirty-three plates with spectral data (graphs) from Australia
No spectra (TSG or other format) supplied
No TIR

Samples 1 – 4: massive hematite, quartz>> magnetite ironstone
Samples 3, 4,9, 10: pyrite, chalcopyrite, bismuthinite stringers and disseminations
Samples 11 – 17, 8: chlorite and quartz-chlorite alteration of schist; dolomitised breccia
Samples 18 – 20: metasiltstone to fine metagreywacke
Samples 5 – 7: Jasper and hematitic shale

Previous Work

Olympic Dam
With spectra on paper
(not in digital format)

VNIR and SWIR
no TIR



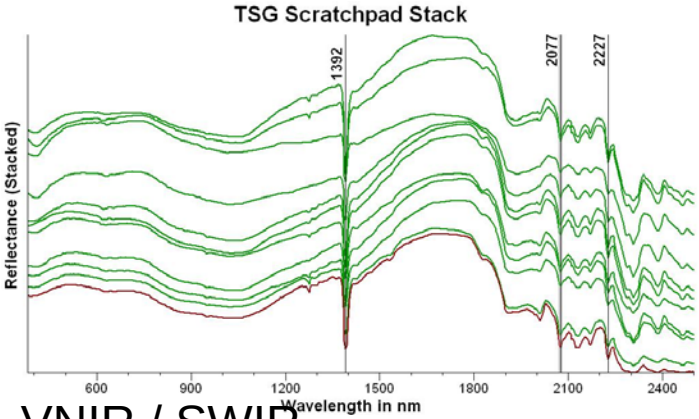
Olympic Dam Roxby Downs Cu-U-Au 1 Fe oxide -Cu-Au; breccia IOCG Deposits

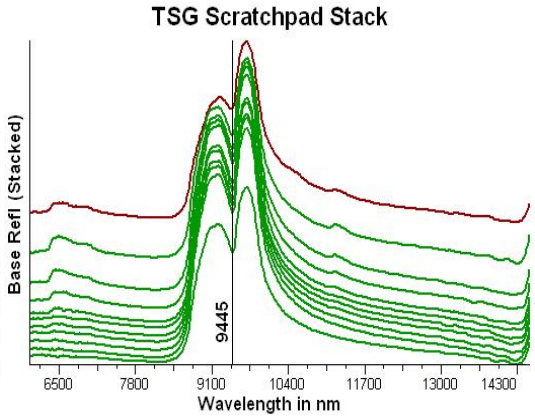
Sample	Mineral1	Mineral2	Mineral3	Mineral4	Possible Mineral1	Possible Mineral2	Dominant Illite/muscovite composition
001r	illite	carbonate					muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
002r	illite	chlorite	carbonate				muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
003r	illite	chlorite					muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
004r	illite	carbonate			+/-chlorite		muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
005r	illite	chlorite	carbonate				tending to phengitic (i.e. Mg/Fe substituted and/or low octahedral Al)
006r	illite	carbonate			+/-chlorite		muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
007r	illite	carbonate			+/-chlorite		muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
008r	illite				+/-carbonate	+/-chlorite	muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
009r	illite				+/-carbonate	+/-chlorite	muscovitic (i.e. potassic or of "normal" muscovite or illite compositions)
010r	illite?						tending to paragonitic (i.e. sodic and/or high octahedral Al)
011r	noise						
012r	noise						
014r	noise						
015r	noise						
016r	noise						
017r	noise						
018r	noise						
019r	illite						tending to paragonitic (i.e. sodic and/or high octahedral Al)
020r	illite						tending to phengitic (i.e. Mg/Fe substituted and/or low octahedral Al)

What did we do?

- Scan Emmerson ‘rock board’ core using HyLogger™ 3-7
- Samples already selected by Emmerson Resources
  - 934 spectra from 60 samples
- Imported into TSG; matched to TSA and also used RSM (Restricted Set of Minerals) for TIR
- Averaged spectra for type example rocks (n = 10) to use for comparison with similarly named rocks
- Only averaged spectra that were relatively homogenous
- Created Atlas of type example rocks
- Compare / Contrast spectra for similarly-named samples – are there differences not seen visually?

Tennant Creek Atlas





Talc dolomite rock

Mag susc = 0.18 x10^{-3}

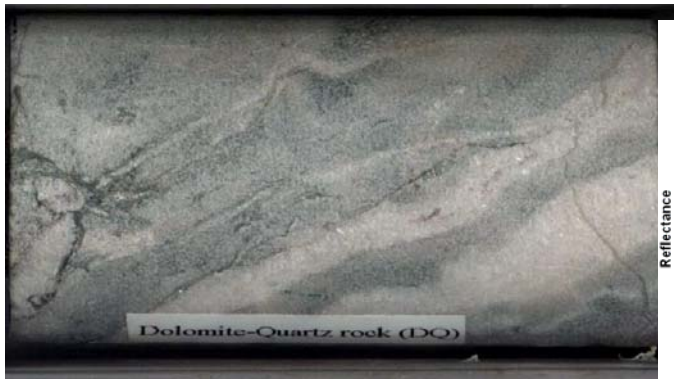
Talc with minor dolomite stringers

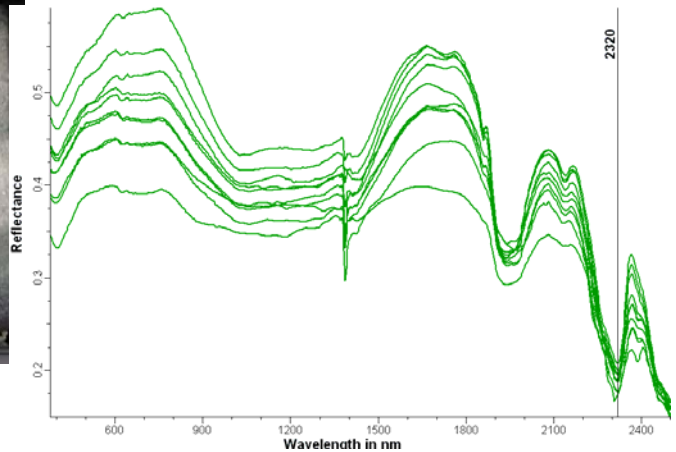
VNIR / SWIR

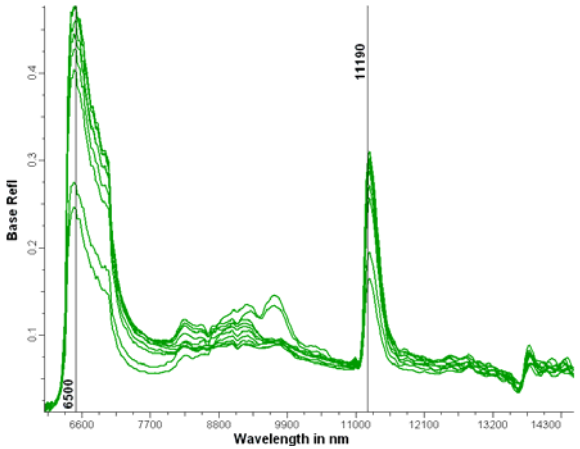
Strong talc response with diagnostic absorptions at 1392nm, with 'rippling' features between 2077 and 2227nm

TIR

Strong talc response at 9445nm







Dolomite Rock

Mag Susc = 0.249x10-3

Banded dolomite; originally described as dolomite quartz rock

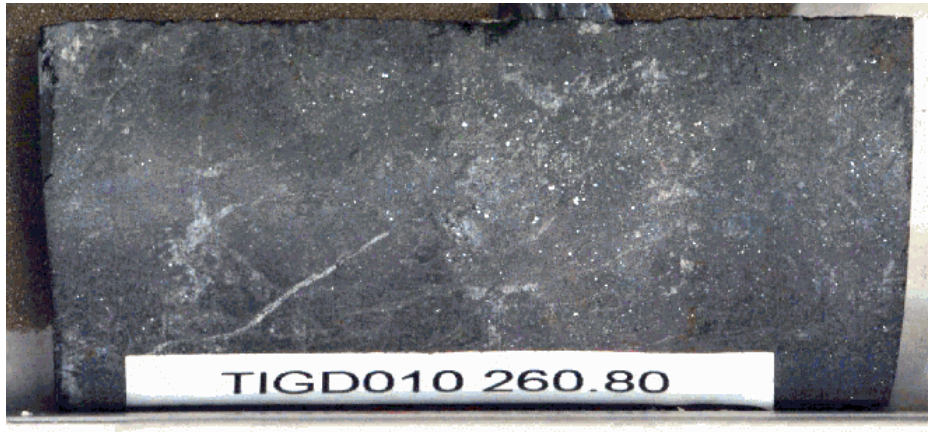
VNIR / SWIR

Diagnostic 2320nm dolomite absorption.

TIR

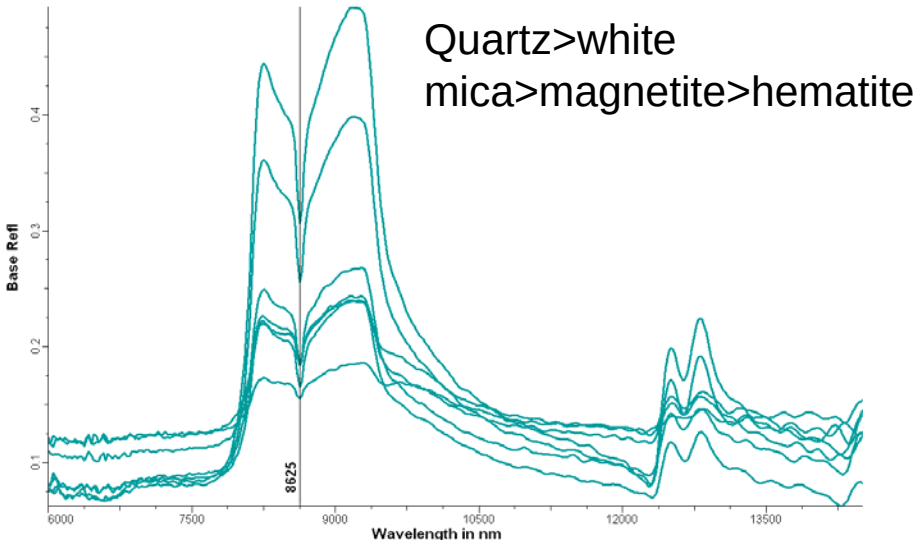
Diagnostic dolomite responses; quartz absent

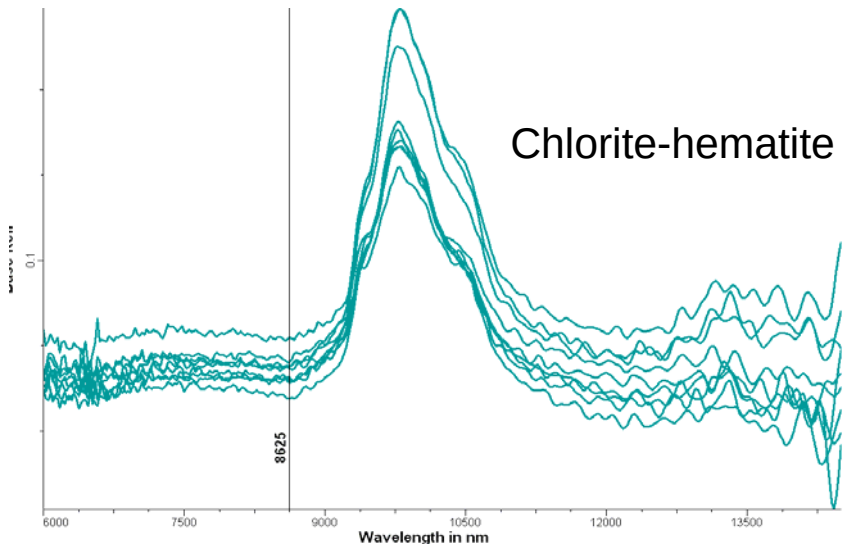
Visually similar… Tinto ‘ironstone’



Tinto Magnetite Hematite; mag susc 1476 x 10^{-3} SI units

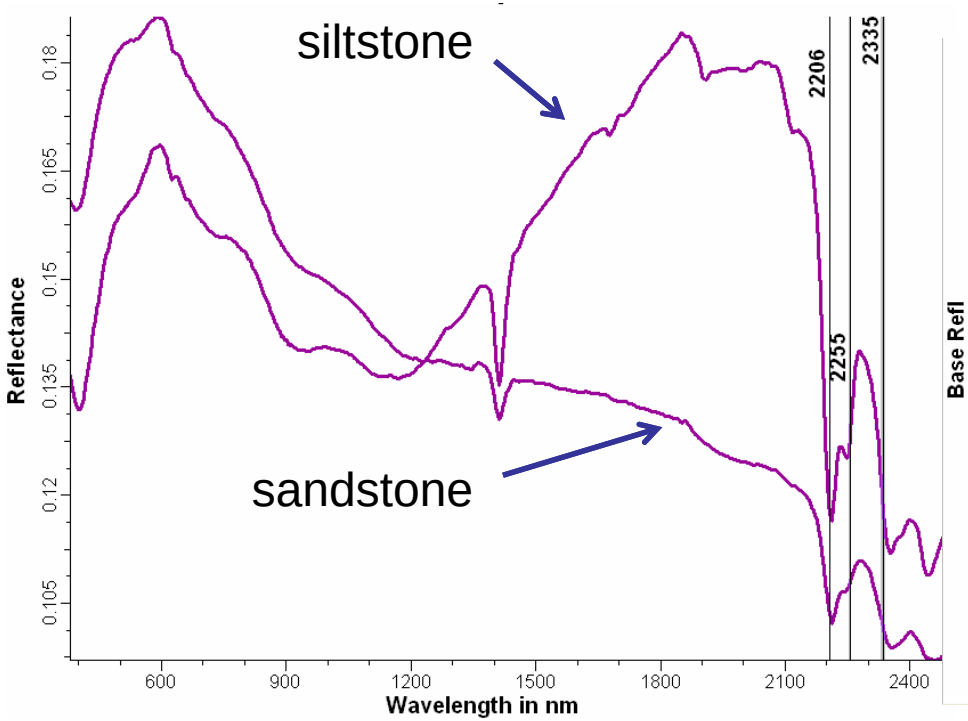
Tinto Hematite rock; mag susc 300 x 10^{-3} SI units

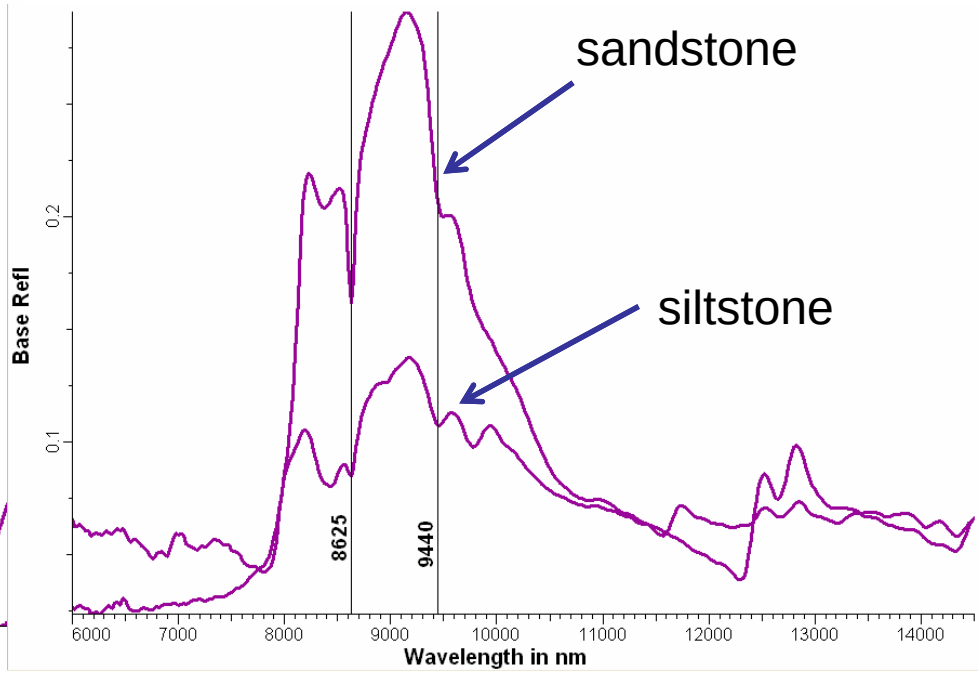




Distinctly different TIR spectral response; quartz-rich vs quartz-poor

“Unaltered” Sediments





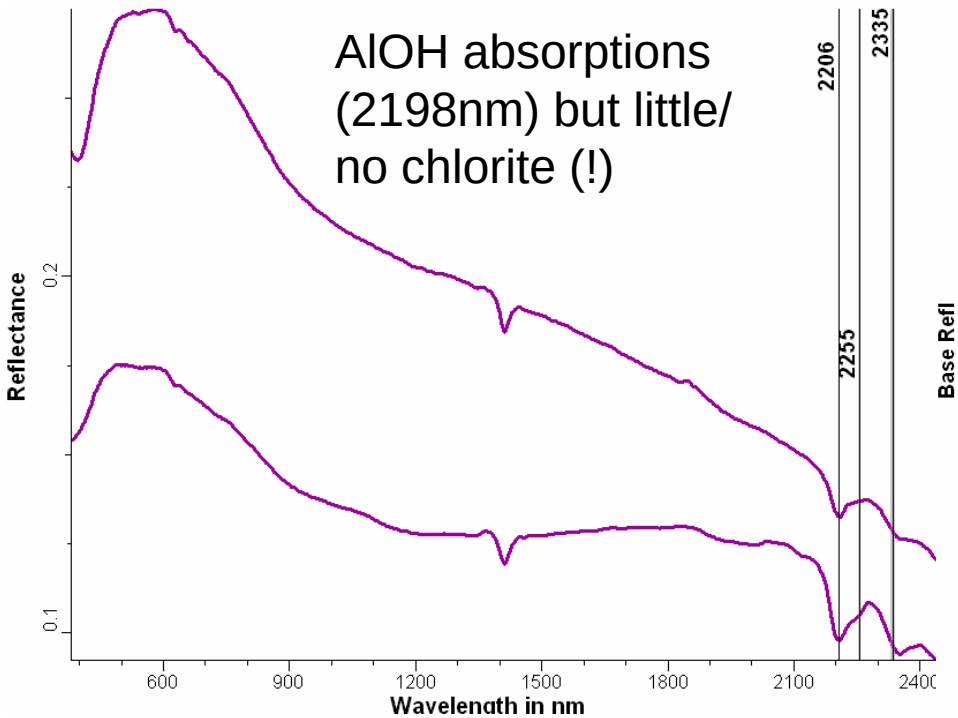
VNIR-SWIR (380 – 2500nm)

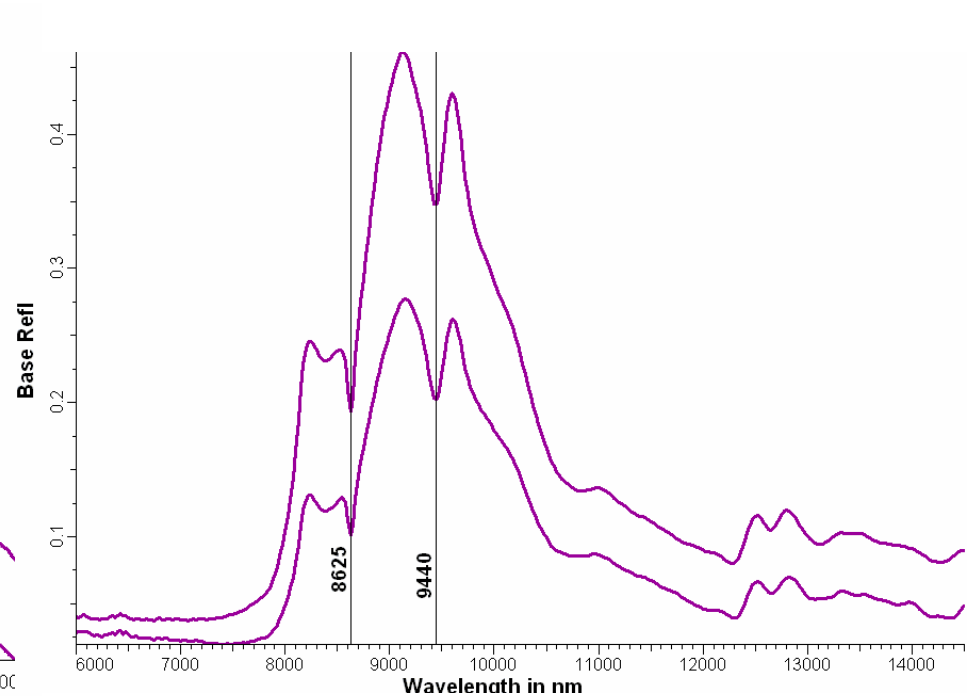
TIR (6000 – 15000nm)

Muscovite and quartz-rich; minor chlorite. Sandstones have a higher quartz: white mica component than siltstones.
Sandstone has ~2209nm AlOH feature (no variation)

‘Chlorite alteration’ of Sediments

Chlorite alteration often noted in sediments (potential indicator of proximity to mineralisation?)
Greenish tinged sediments – ‘chloritic’ sediments
Compare with ‘unaltered’ sediments; lower AlOH wavelength (~2198nm vs 2205 – 2209nm)
Chlorite not apparent in SWIR





Domaining in the TIR using RSM (Restricted Set of Minerals)

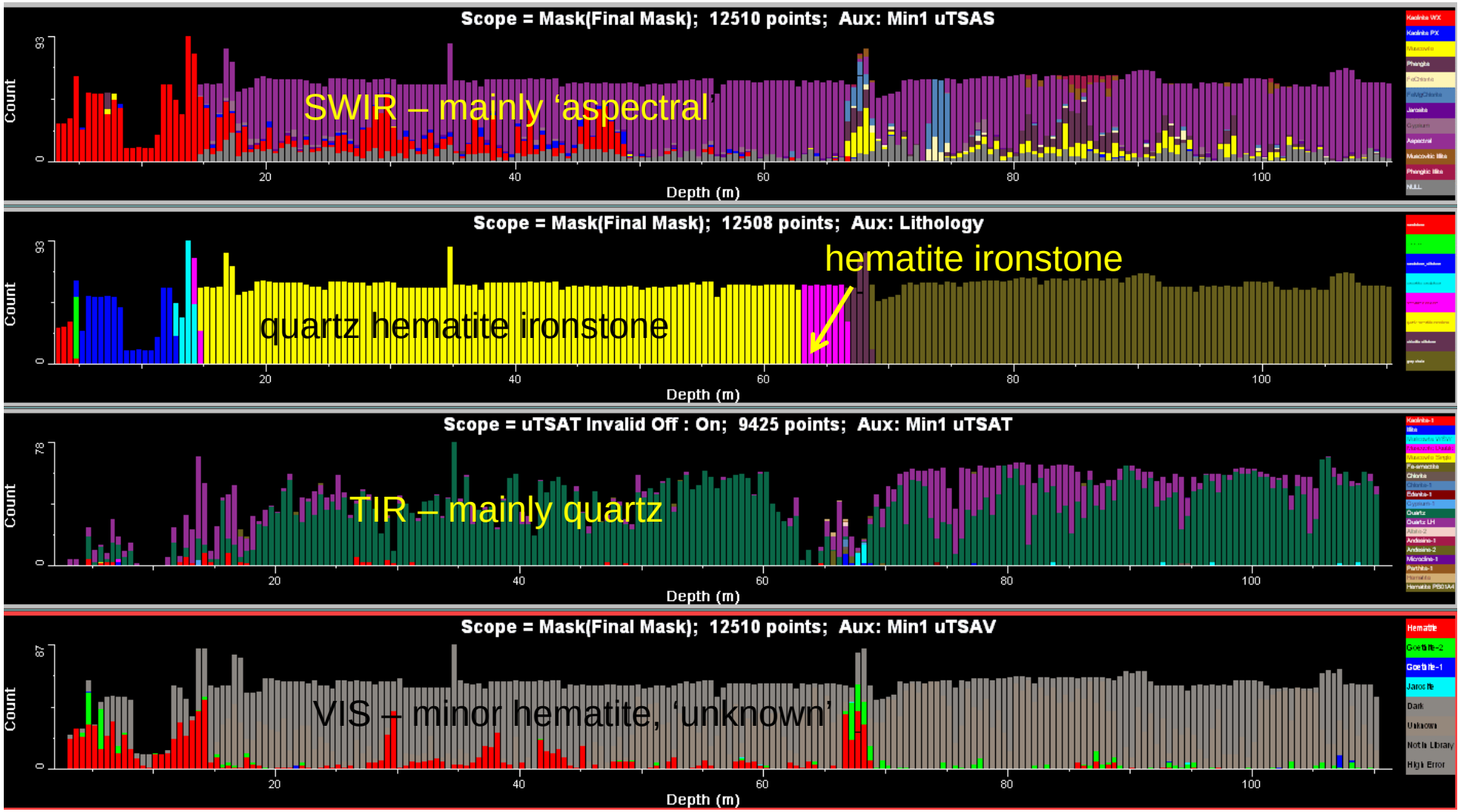
- Modelling using the RSM (to minimise ‘mixing non-uniqueness’)
- Gives normalised average unmixing weights for minerals
  - Quartz-rich and quartz-poor ‘ironstones’ with white mica common in quartz-rich; chlorite common in quartz-poor ironstones
  - ‘chlorite – altered’ sediments are chlorite-poor
  - carbonates are quite uniform (11.2µm)

Findings from HyLogging the Type Example Rocks

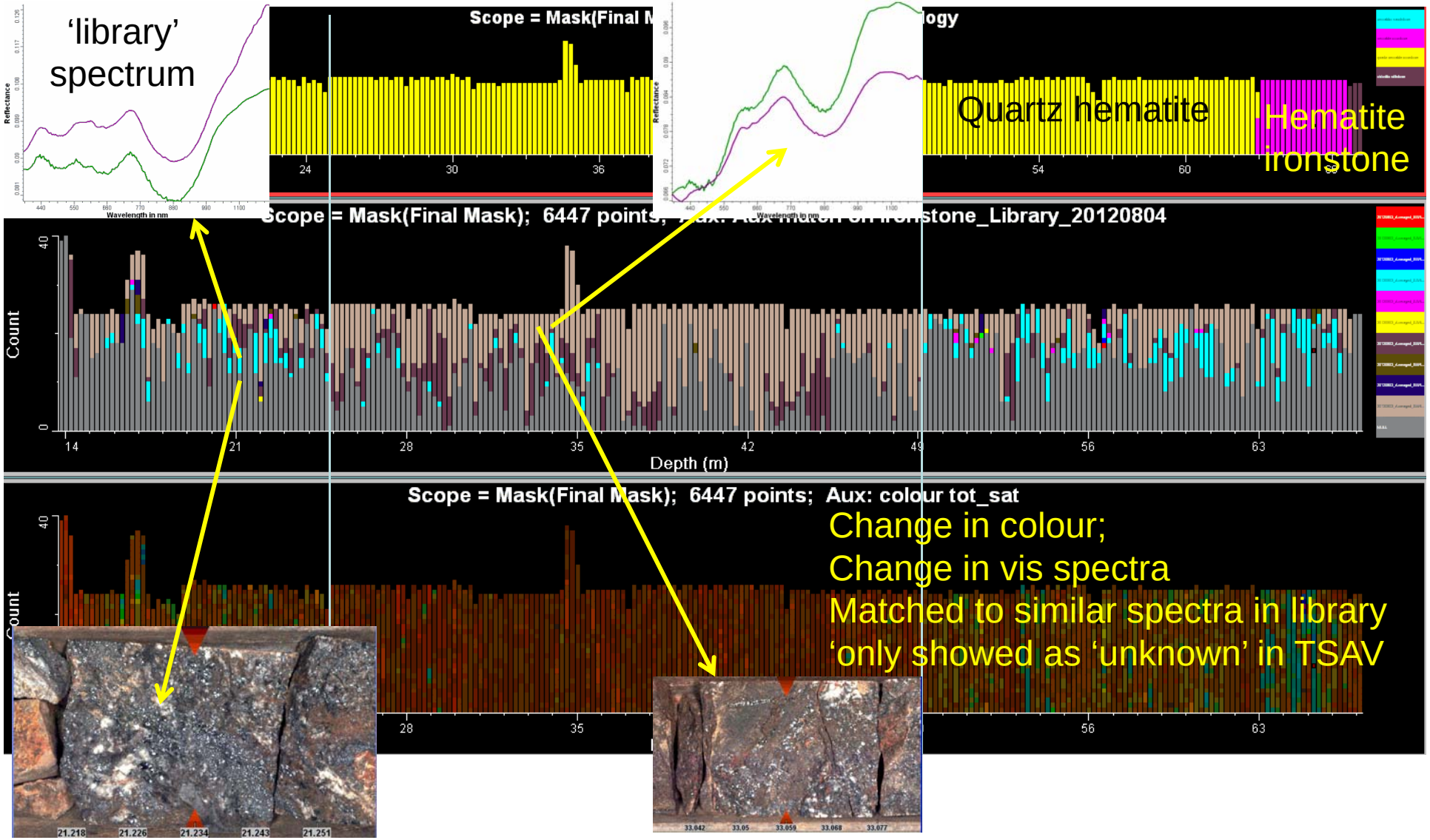
- ‘Ironstone’ rock types are quartz-rich or quartz-poor (not always visually apparent)
- ‘Chlorite alteration’ of sediments considered an important indicator of proximity to alteration associated with mineralisation. ‘Greenish’ sediments are not necessarily chlorite-altered
- Some changes in AlOH (white mica) composition noted in different sediments;
    - unaltered sediments 2205 - 2209nm
    - ‘chlorite-altered’ sediments are around 2198nm

- **Can the Library spectra be used to map changes within a logged rock type?**

Using the Library Spectra
Gigantic Prospect DD84GI1



Gigantic Prospect DD84GI1
Differentiating the ‘ironstone’



Conclusions

- Mislabelled mineral identification – possibly need to standardise rock names when logging?
  - (‘quartz dolomite’; ‘chlorite magnetite’)
- Atlas could be used as a reference tool to standardise logging amongst TC geologists
  - Need to add and validate more reference rocks
- Library spectra can highlight spectral differences in ‘ironstones’ (rocks with few diagnostic TSA matches)

Further Work

- Add to the Library – current Library has only ‘TC8’ mineralisation style rocks
  - Recently identified different mineralisation style (‘shear-zone’ at Monitor / Goanna)
  - West Warrego ‘ironstones’ have ?epidote
- Are there mappable changes in AlOH and chlorite composition related to mineralisation?

Acknowledgments

‘Rocky’ Osborne and Steve Russell; Emmerson Resources

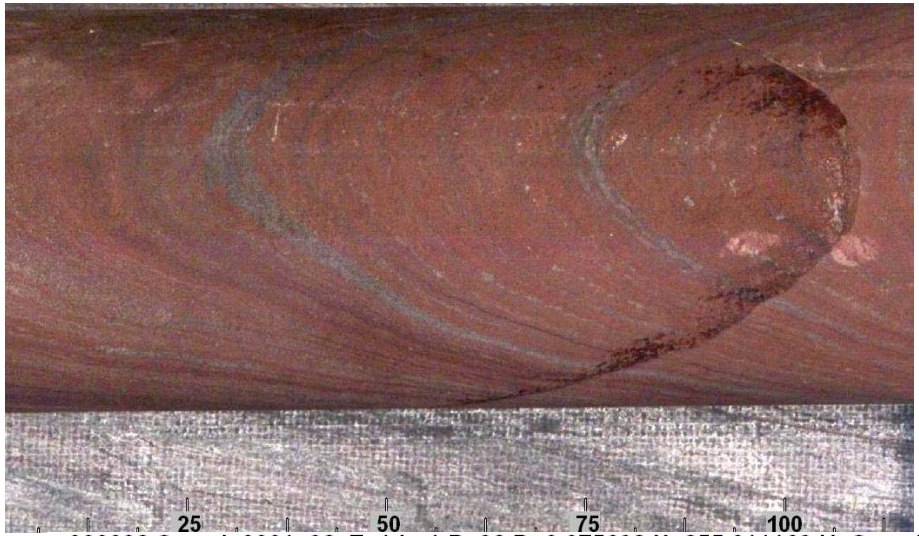
Martin Schodlok, CSIRO

Ralph Bottrill and Richie Woolley; MRT

Darren Bowbridge; NTGS

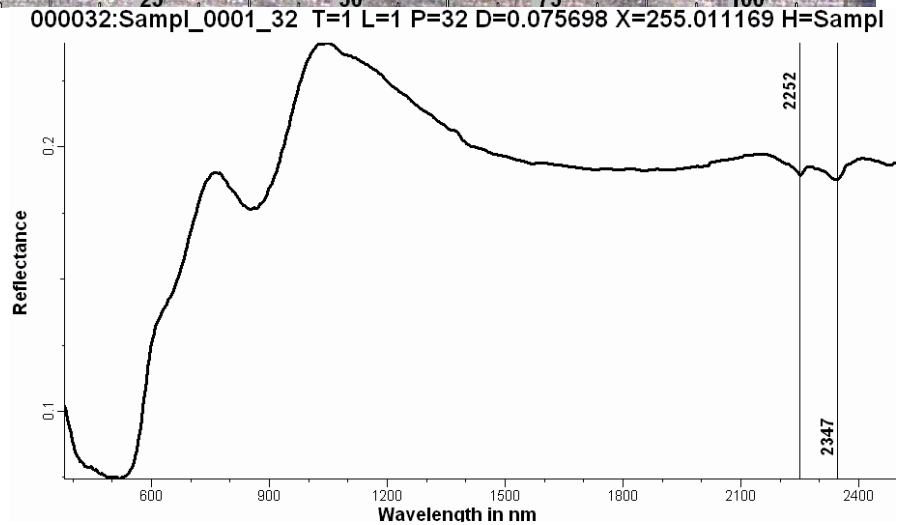
XRD Validation

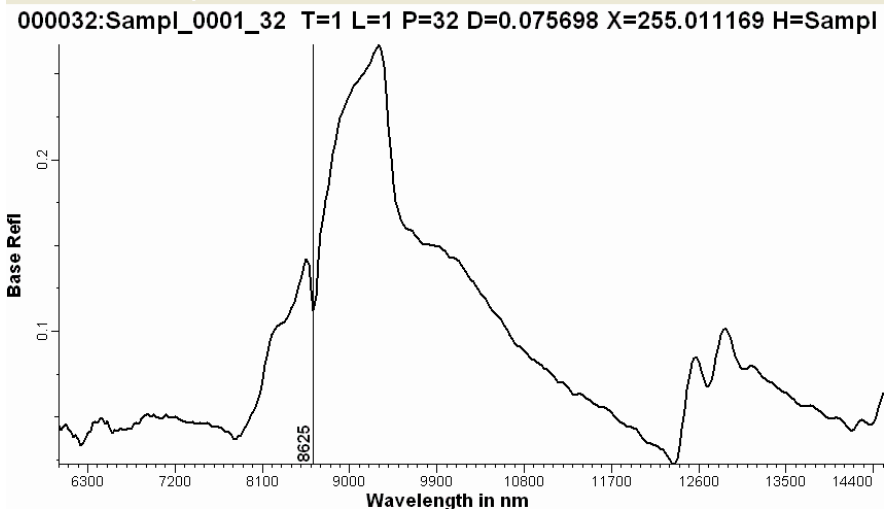
- Hematite Shale (RSDD004 180.18m)



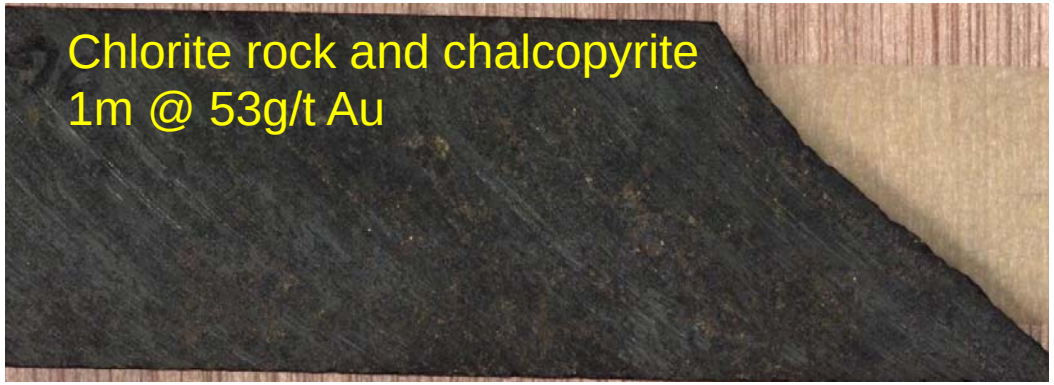
TSG shows hematite (Vis), minor chlorite; quartz + white mica (TIR)

XRD indicates Quartz (50%-65%), Hematite (15%-25%), Fe-Chlorite (15%-25%), Mica (2%-5%), Siderite (<2%)



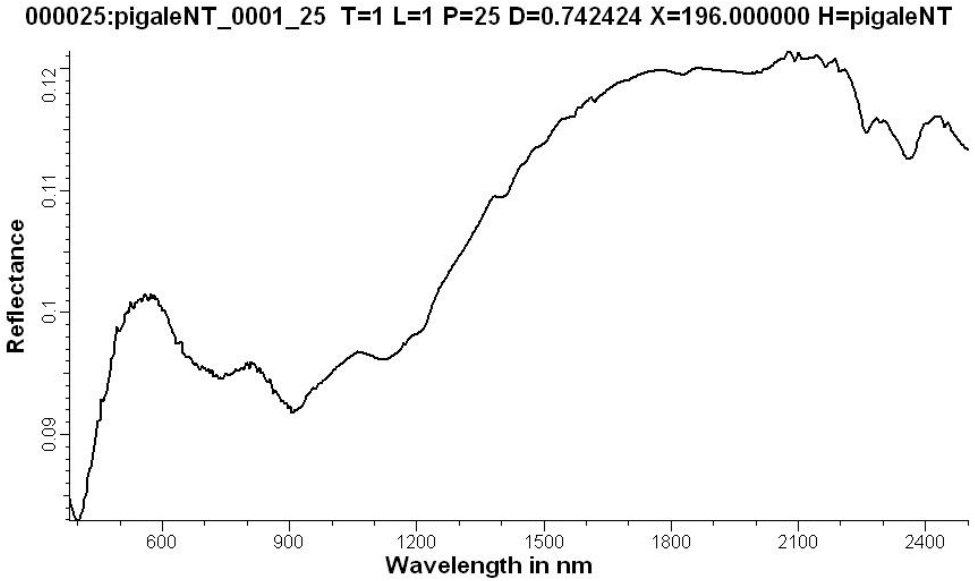


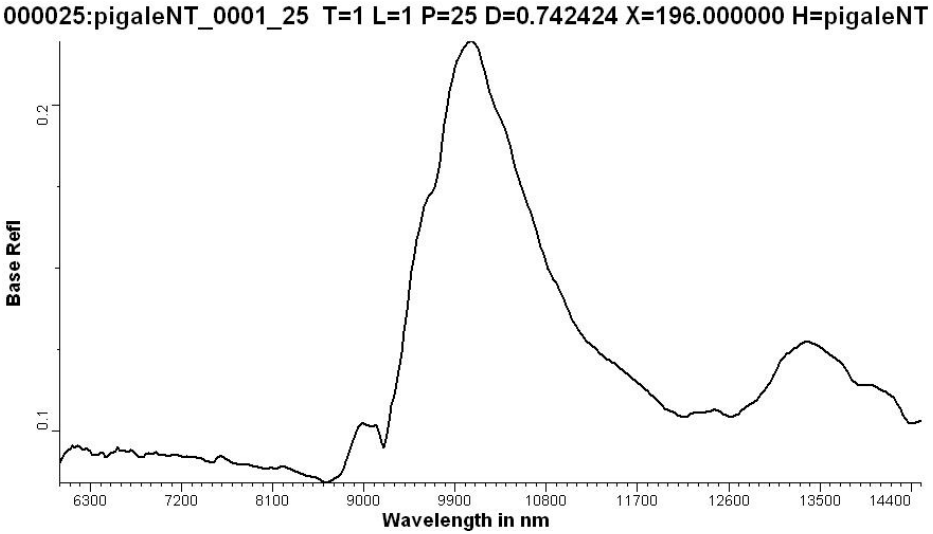
Validation of Pigale



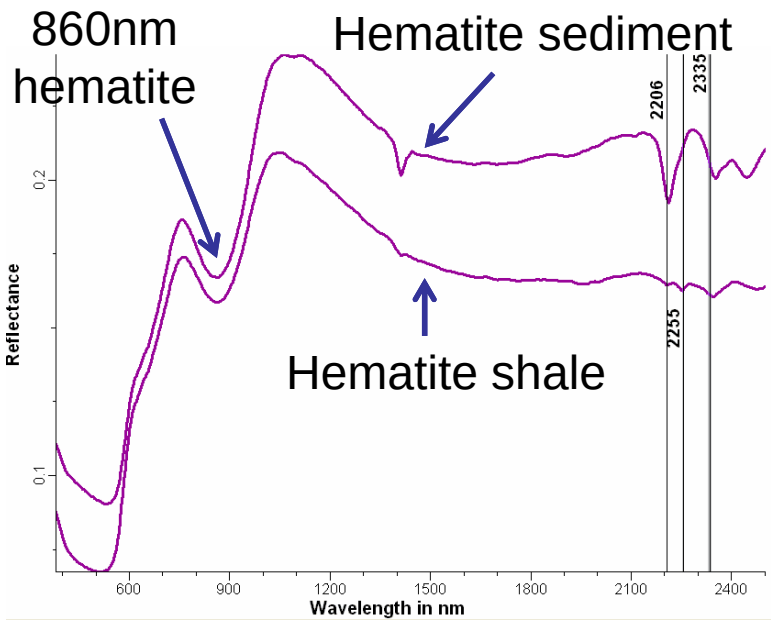
TSG: FeMg chlorite / aspectral (SWIR) ‘edenite’ and chlorite (TIR) ‘amphibole’>chlorite>magnetite

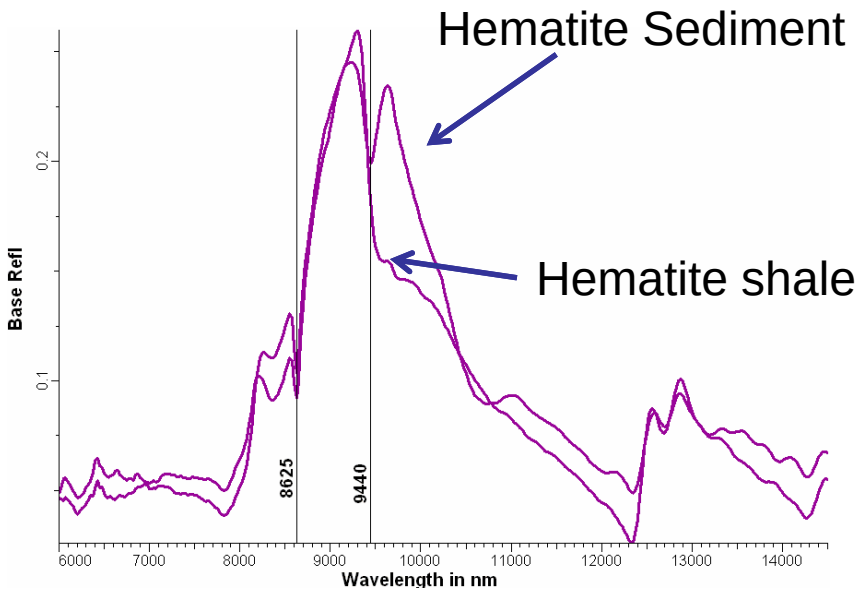
XRD: Fe-Chlorite (65%-80%), Magnetite (10%-15%), Pyrite (5%-10%), Chalcopyrite (2%-5%), Quartz (2%-5%), Arsenopyrite (<2%)

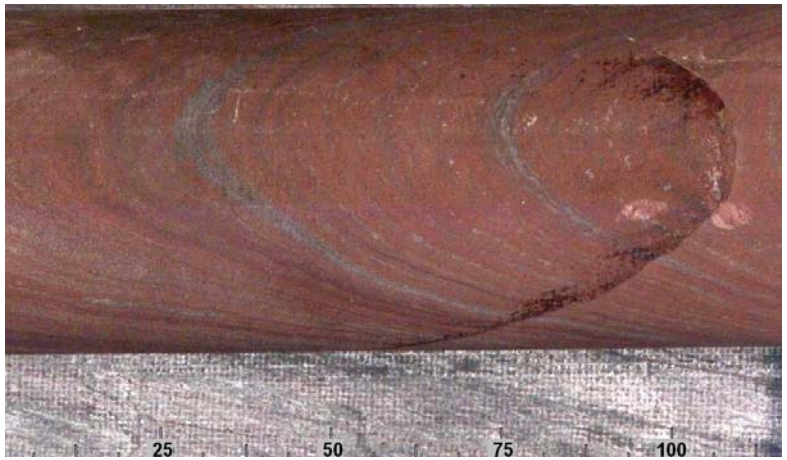




Hematite Shale / Hematite Sediment







Hematite sediment; hematite, quartz, white mica
Hematite shale; hematite, quartz, white mica, minor chlorite
Dominant hematite feature in VIS
Subdued muscovite, chlorite in SWIR
Quartz , white mica in TIR