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?

- ‘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?

TC8 Orebody

5.5Moz Au; 188,000t Cu
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
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 = $0.18 \times 10^{-3}$
Talc with minor dolomite stringers

**Dolomite Rock**
Mag Susc = $0.249 \times 10^{-3}$
Banded dolomite; originally described as dolomite quartz rock

**VNIR / SWIR**
Strong talc response with diagnostic absorptions at 1392nm, with ‘rippling’ features between 2077 and 2227nm

**TIR**
Diagnostic 2320nm dolomite absorption.

**VNIR / SWIR**
Diagnostic 2320nm dolomite absorption.

**TIR**
Strong talc response at 9445nm

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

Quartz>white mica>magnetite>hematite

Chlorite-hematite

Distinctly different TIR spectral response; quartz-rich vs quartz-poor
“Unaltered” Sediments

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 AIOH wavelength (~2198nm vs 2205 – 2209nm)
Chlorite not apparent in SWIR

[Graph showing reflectance and AIOH absorptions]

AIOH absorptions (2198nm) but little/no chlorite (!)
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 AIOH (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

SWIR – mainly ‘aspectral’

quartz hematite ironstone

hematite ironstone

quartz hematite ironstone

TIR – mainly quartz

VIS – minor hematite, ‘unknown’
Gigantic Prospect DD84GI1
Differentiating the ‘ironstone’

Change in colour; Change in vis spectra
Matched to similar spectra in library ‘only showed as ‘unknown’ in TSAV
Conclusions

• Mislabeled mineral identification – possibly need to standardize rock names when logging?
  – (‘quartz dolomite’; ‘chlorite magnetite’)

• Atlas could be used as a reference tool to standardize 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?
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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

Chlorite rock and chalcopyrite
1m @ 53g/t Au

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