Airborne mineralogic cross section through a porphyry copper – epithermal – skarn system

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Porphyry-Cu and epithermal alteration are two alteration facies of the same system but at different depths. Where the porphyry system meets neighbouring sediments, Cu-skarn alteration is produced. As fluids circulate through the system towards the surface, changes in fluid chemistry, temperature and pressure create distinct zones with variable mineral assemblages. Most of these minerals are infrared active and can be measured from hyperspectral imagery. Traditional, ground-based studies to map individual minerals or alteration zones are based on point observations and are not ideal for distinguishing patterns.

In this study we use hyperspectral imagery from the ProSpecTIR (visible to short-wave infrared) and SEBASS (thermal infrared) sensors to map patterns of mineral distributions over the Yerington Batholith in Nevada, USA. We use the minimum wavelength mapping technique to highlight mineralogic patterns of the dominating mineral assemblages, and use the complementarity of the two wavelength bands to map alteration zones and fluid pathways exposed at the surface. Preliminary results show that hard classification based only on the dominating mineral is resulting in a lot of speckles but that the intermediate results shows mineral distribution patterns that are directly and simply interpretable by experienced field geologists.
AIRBORNE MINERALOGIC CROSS SECTION THROUGH A PORPHYRY COPPER – EPITHERMAL – SKARN SYSTEM

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GENERALIZED PORPHYRY-CU ALTERATION MODEL

Source: Sillitoe, 2010
STUDY AREA: YERINGTON BATHOLITH, NEVADA
GEOLOGIC OVERVIEW YERINGTON (ANN-MASON)

cross section from 1 to 6 km paleodepth

Source: Hecker (2012) PhD
GEOLOGIC OVERVIEW YERINGTON (ANN-MASON)

cross section from 1 to 6 km paleodepth

Source: Hecker (2012) PhD
AIRBORNE IMAGING SPECTROSCOPY DATA

Data courtesy Aero.org and SpecTIR

VNIR-SWIR ProSpecTIR sensor
128 bands LWIR SEBASS sensor
SWIR – TIR COMPLEMENTARITY

- No SWIR features for non OH-bearing Silicates => TIR emissivity spectra needed
TECHNIQUES USED

- Minimum Wavelength Mapping
  => Dominant minerals in SWIR & TIR

- LWIR Lab analysis on field samples
  => determine thresholds for classification

- Decision tree classification
  => combine step 1 and 2 into SWIR&TIR mineral assemblages
WAVELENGTH OF LOCAL MINIMA

Continuum removed

Dominant absorption features:

<table>
<thead>
<tr>
<th></th>
<th>wav.</th>
<th>depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.205μm</td>
<td>0.37</td>
</tr>
<tr>
<td>2</td>
<td>2.165μm</td>
<td>0.28</td>
</tr>
<tr>
<td>3</td>
<td>2.386μm</td>
<td>0.09</td>
</tr>
</tbody>
</table>
Second order fit on 3 points:

\[ f(w) = ax^2 + bx + c \]

\[ w_{\text{min}} = -\frac{b}{2a} \]

\[ \text{depth} = 1 - f(w_{\text{min}}) \]

Shifts in the order of 1 nm can be detected.

Source: van Ruitenbeek et al (2014)
Planetary and space science, 101, pp. 108-117
HSV FUSION OF WAVELENGTH & DEPTH

Fused image

Legend

Minerals

calcite

white micas

alunite

buddingtonite
Wavelength mapping on ProspectTIR-VS between 2.1-2.4µm

A: Skarn and Hornfels
Epidote, amphibole, carbonate

B: Porphyry regime
Actinolite, chlorite, epidote, sericite
Wavelength mapping on SEBASS between 8.05-11.65µm

A: Skarn and Hornfels
   Garnet and carbonate

B: Porphyry regime
   Plagioclase and quartz
COMBINED MINWAV INTERPRETATION

SWIR

LWIR
CONCLUSIONS

- Min Wavelength Mapping
  - Works for LWIR too!
  - Highlight minerals and compositions
  - Intuitive; great for overview, across flightline
  - but ignoring spectral details

- Acknowledgements
  The Aerospace Corporation for the SEBASS and Prospectir data collection as part of an Internal Research and Development Grant awarded to Dean Riley when he was that The Aerospace Corporation.
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AIRBORNE HYPERSPECTRAL IMAGING

YERINGTON TIR COLOUR COMPOSITE RGB = (11.1, 9.64, 9.06)

- Epithermal Au advanced argillic
- Porphyry Cu K-alteration
- Cu-Skarn
- Tailings

UNIVERSITY OF TWENTE.