Fri. Apr. 14, 2018

• Hewson paper: Geological Map using ASTER data
• Sabins Ch. 10 Oil Exploration Overview

• Reading:
  – Skim Sabins Chapter 10. Oil Exploration
Hewson et al. Objectives

1. Characterize SWIR crosstalk
2. Characterize atmospheric effects
3. Characterize cloud/cloud shadow effects
4. Find methods for generating “seamless” geological products
5. Identify diagnostic spectral features
6. Devise algorithms for mapping mineral groups
7. Validate results using field/airborne data and scene-based methods
8. Compare to published geology
9. Contribute results to existing map collections
“Seamless geological map generation using ASTER in the Broken Hill-Curnamona province of Australia

R.D. Hewson, T.J. Cudahy, S. Mizuhiko, K. Ueda, A.J. Mauger

Maps of Al-OH and Mg-OH/carbonate from ASTER SWIR
Map of Quartz from ASTER TIR
Garnet and Feldspar rich regions not well mapped using TIR
Test result using field sampling and spectral mapping, HyMap survey
Covers 52,000 km² area (i.e. ~230 km on-a-side square)
Hewson et al. Objectives

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Hewson et al. 2005
• ASTER scenes from 14 different dates (in different colors)
  – One of complications is different atmospheric transmission on different dates
Varying Transmission in SWIR Bands

- MODTRAN 4 estimates of atmospheric transmission in ASTER SWRI bands
- Main variable is atmospheric water vapor
- For SWIR bands 4-9 they use Level 1b (radiance at sensor) data then correct for atmospheric effects themselves
- Level 1b data may also require “cross-talk” correction
- Using Band Ratios helps remove effects due to varying solar illumination
- For TIR they use Level 2 data which gives surface emissivity – already separated from surface temperature effects
Hewson et al. 2005 Preprocessing

• Preprocessing:
  • Correct for crosstalk (light scattered in instrument)
  • Convert to radiance at sensor
  • Then ideally:
    – Correct for atmospheric transmission
    – Divide by solar flux to obtain reflectance

– Because of imperfect correction in standard data – different day (Part. A) boundaries are apparent in part C: B7/B9 where varying H₂O is important. Effect less in part B: B4/B7
– They develop special techniques to better correct data – Per frame gain correction factors by comparing overlapping images
Testing Spectra with Ground-Truth

- ASD (Analytical Spectral Devices, Inc.) field spectra show large reflectance difference between gravel and bitumen runways (Airfield 1 vs. 2)
- ASTER Level 2 produces do not show difference as well
- ASTER Level 2 products don’t get shape right in Band 5-9
- This is why Hewson et al. use more “Raw” Level 1b products then correct that data for cross-talk and atmospheric transmission themselves
  - It would be nice if they showed a plot of their corrected results.

Hewson et al. 2005
Hewson et al. 2005 Cloud identification

- Clouds
  - Both **clouds** and their **shadows** can confuse data.
  - Can recognize by comparing Band 3 (NIR) and Band 10 (TIR) images above:
    • Clouds bright in NIR, dark (cold) in TIR, Shadows darker in both images
  - Create cloud “mask” (0 or 1 image) based on above two band
    • Have to manually adjust threshold
  - Ignore data where clouds or shadows are present. (With luck have other images.)

Band 3 showing reflected light effects of clouds and shadows
Band 10 (TIR) showing clouds are dark (cold)
Hewson et al. 2005 Cloud masks

- AlOH Anomaly map shows mineral features – but many in cloud shadows
- Ignoring results where clouds or shadows are present
  Hope that you have another cloud-free image
Mineral Spectra at Aster Resolution

- Need hyperspectral data to identify **unknown** minerals
  – but can use multispectral Aster data to “map” relative amounts of a few known minerals

- VNIR + SWIR discussion on next page
- Diopside (Mg,Ca pyroxene) has 0.9 μm band due to minor Fe components
- Quartz and feldspar have no significant VNIR or SWIR features --- do have ~9 μm emissivity features.
  – Qtz has shorted wavelength band in this region – so shows 9 vs 11 μm difference.

Hewson et al. 2005
Mineral Spectra at Aster Resolution

- Al-OH (usually mica) minerals have B6 (2.16 μm) feature
  - \((B5+B7)/B6\) (call this \(y\)) gives Al-OH abundance
    - Note: \(I_c \approx (B5+B7)/2\) so \(y \approx (B5+B7)/B6 \approx 2I_c/I\)
    - Band Depth \(\equiv 1-I/I_c = 1-2/y\)
  - Wavelength of band center tells if mica is Al-rich or Al-poor.
    - Estimate band center from ratios \(B5/B6\), \(B7/B6\), \(B7/B5\)
      - High \(B5/B6\), low \(B7/B6\) \(\Rightarrow\) longer \(\lambda\) \(\Rightarrow\) Al-poor
      - Low \(B5/B6\), high \(B7/B6\) \(\Rightarrow\) shorter \(\lambda\) \(\Rightarrow\) Al-rich
  - Kaolinite distinguished from mica by \(B7/B5\)

- Mg-OH minerals (chlorite, hornblende) have B8 (2.34 μm) feature
  - \((B6+B9)/B8\) (\(\Rightarrow\) band depth) gives Mg-OH abundance

- Calcite also has B8 (2.34 μm) feature

- Ferrous iron in MgOH silicates gives steady rise in reflectance from 1 to 2 μm, as estimated from \(B5/B4\)

Hewson et al. 2005
AL-OH Abundance

- Brighter areas (highest Al-OH abundance) correspond with mica-rich outcrops and associated colluvium shown on map.

- Brightest areas correspond to Broken Hill (A) and Olary (B) domains

- Next side – comparison on Aster vs. Hyperspectral “HyMap” Al-OH results in box marked A (Region I)
Al-OH Aster vs airborne hyperspectral maps

- Close up look at Region 1 from previous slide

- a) and b) compare Al-OH results from ASTER and HyMap – match reasonably well
  - Broken Hill mine (X) is in an Al-OH poor area

- c) Don’t have K abundance from ASTER, but Al-OH seems to mimic K abundance from radiometric airborne data

Hewson et al. 2005  Fig. 10
MgOH and Carbonate Abundance

• Brighter areas match carbonate-rich Adelaidean unit south of Olary Domain plus amphibolite-rich units within Broken Hill Domain.

Hewson et al. 2005
Close-up study of Region II

- Dark green in middle amphibolite/calcalbite units show on both Mg-OH and ferrous Fe images

- Can they distinguish between amphibolite and carbonates?
  - Amphibolite region here shows bright in both MgOH+Carbonate image and in Ferrous Iron Silicate Image
  - Carbonate region here shows bright only on MgOH_Carbonate image

- They also tried to distinguish between MgOH and carbonates using TIR data (MNF transformation – an elaboration of Principal Components) but results too noisy.

**Hewson et al. 2005**
Traverse test over ~150 m (5-6 Aster Pixels)

- Mineral composition shifts to Al-poor mica as you move south in traverse across 150 m region.
- In field spectrometer data (B) 2.2 μm band shifts to longer wavelength as you move south.
- Same effect visible in well calibrated ASTER data (C)
  - but at level marginal for mapping given typical signal-to-noise ratios
Al-OH (usually mica) minerals have B6 (2.16 \( \mu \)m) feature
- \((B5+B7)/B6\) (call this \(y\)) gives Al-OH abundance
  - Note: \(I_c \approx (B5+B7)/2\) so \(y \approx (B5+B7)/B6 \approx 2I_c/I_c\)
  - Band Depth \(\equiv 1-I/I_c = 1-2/y\)

- Wavelength of band center tells if mica is Al-rich or Al-poor.
  Estimate band center from ratios B5/B6, B7/B6, B7/B5
  - High B5/B6, low B7/B6 \(\Rightarrow\) longer \(\lambda\) \(\Rightarrow\) Al-poor
  - Low B5/B6, high B7/B6 \(\Rightarrow\) shorter \(\lambda\) \(\Rightarrow\) Al-rich

Kaolinite distinguished from mica by B7/B5

Mg-OH minerals (chlorite, hornblende) have B8 (2.34 \( \mu \)m) feature
- \((B6+B9)/B8\) \(\Rightarrow\) band depth gives Mg-OH abundance

Calcite also has B8 (2.34 \( \mu \)m) feature

Ferrous iron in MgOH silicates gives steady rise in reflectance from 1 to 2 \( \mu \)m, as estimated from B5/B4