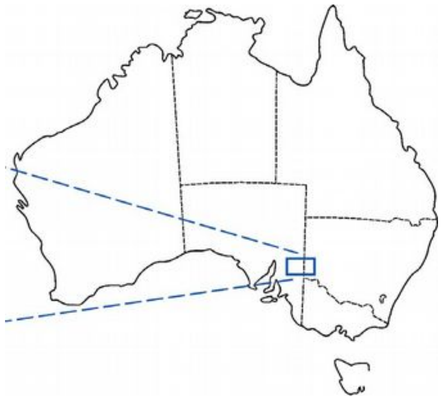
Fri. Apr. 14, 2018

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

- Reading:
  - Skim Sabins Chapter 10. Oil Exploration

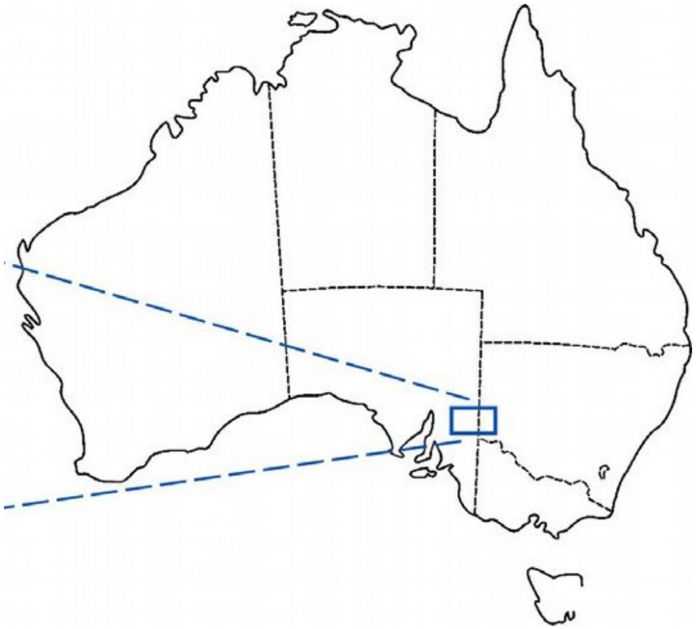
Hewson et al. Objectives

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



Hewson et al. 2005

Hewson et al. 2005



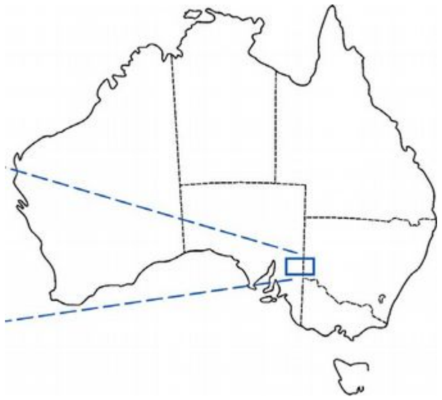
Hewson et al. 2005

- "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 km^2 area (i.e. ~230 km on-a-side square)

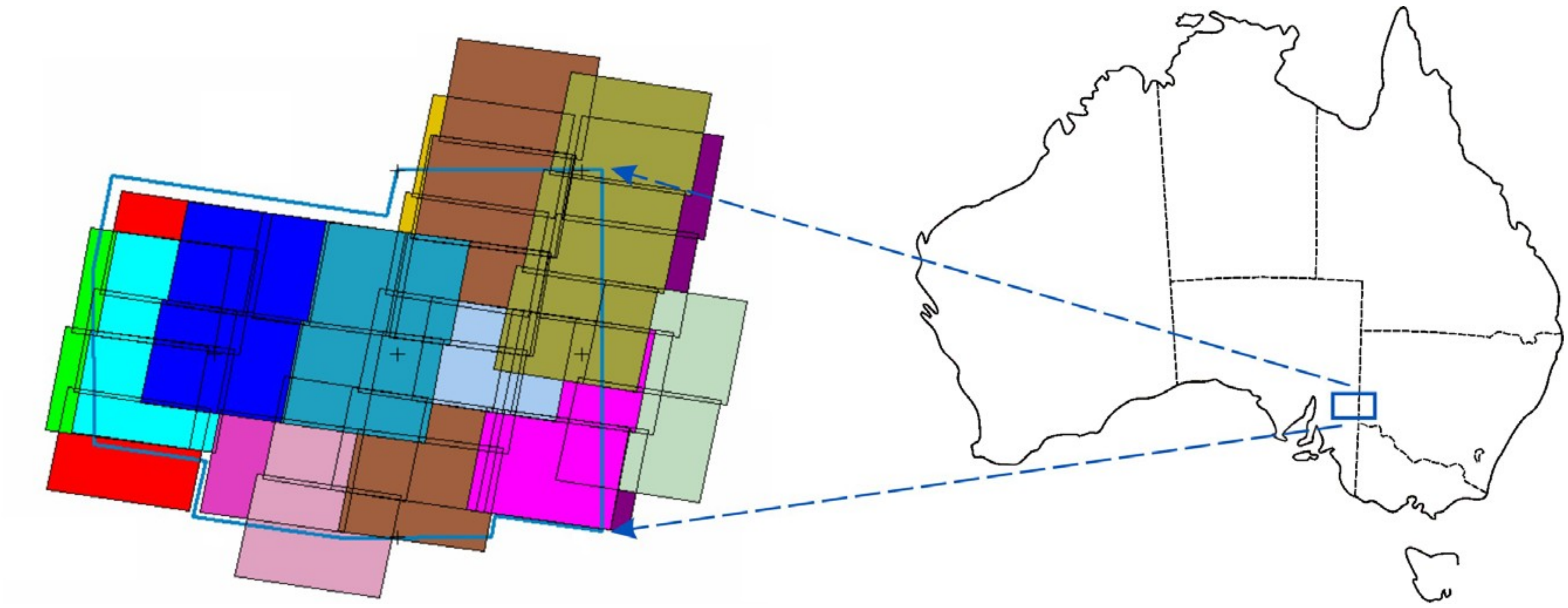
Hewson et al. Objectives

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



Hewson et al. 2005

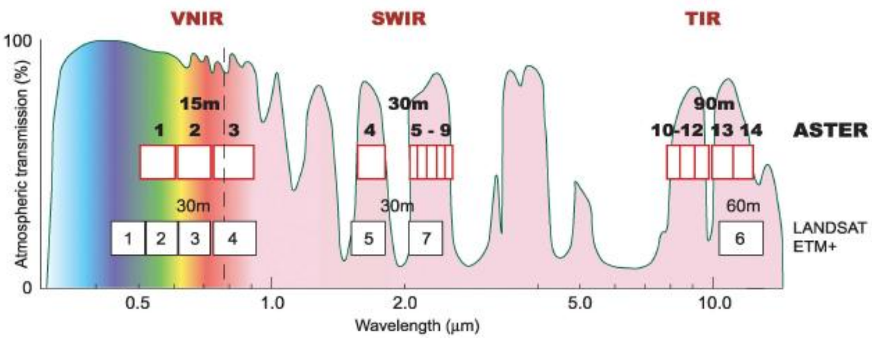
Hewson et al. 2005 Overview

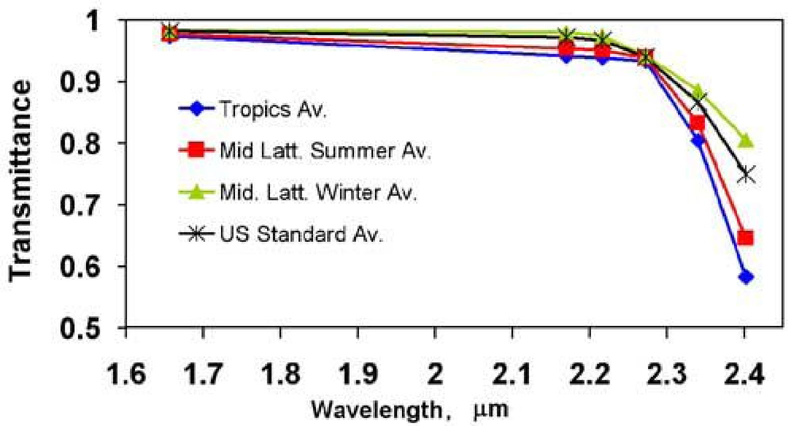


Hewson et al. 2005

- ASTER scenes from 14 different dates (in different colors)
  - One of complications is different atmospheric transmission on different dates

Varying Transmission in SWIR Bands





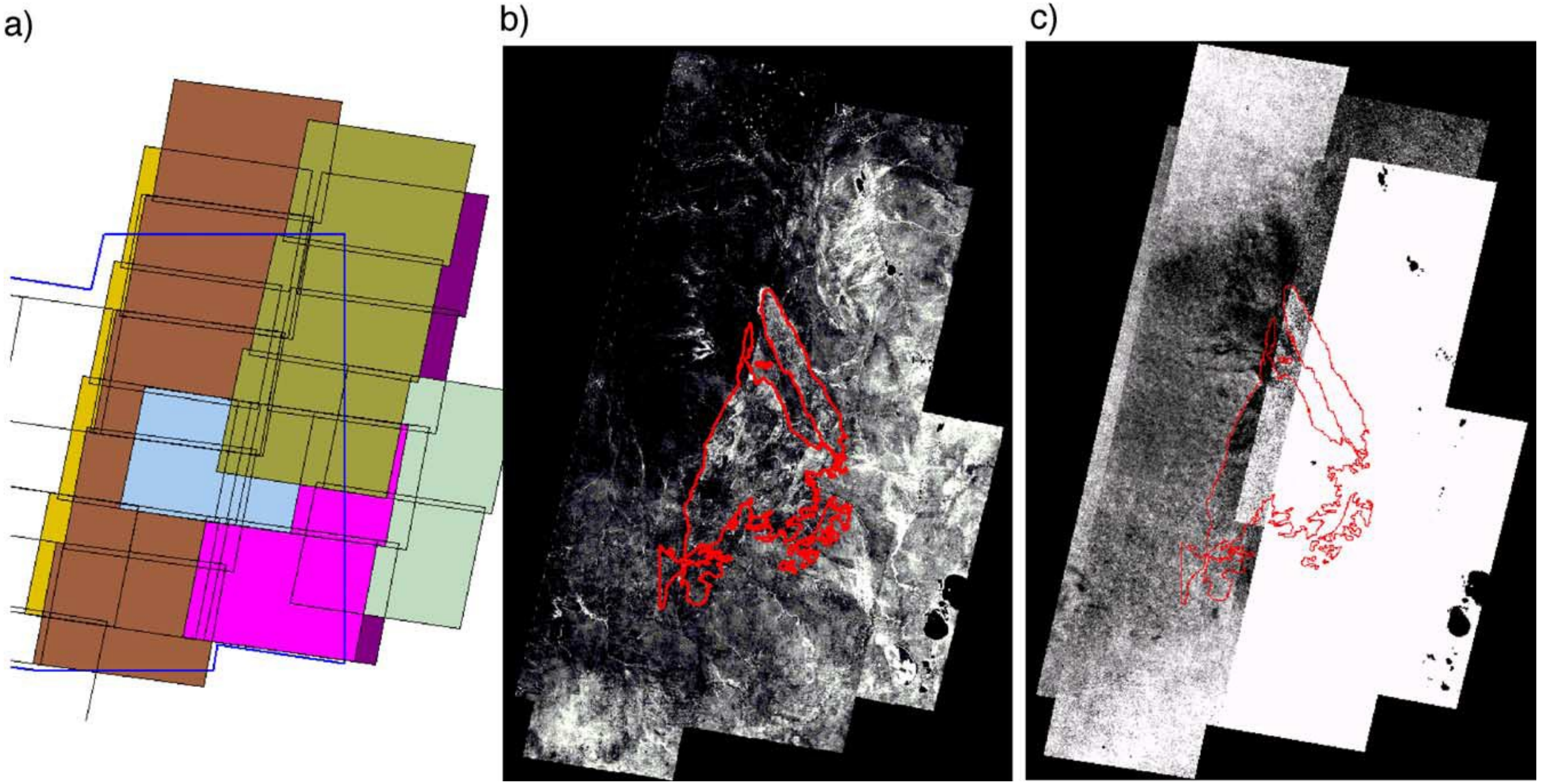
Hewson et al. 2005 Fig. 2

- 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

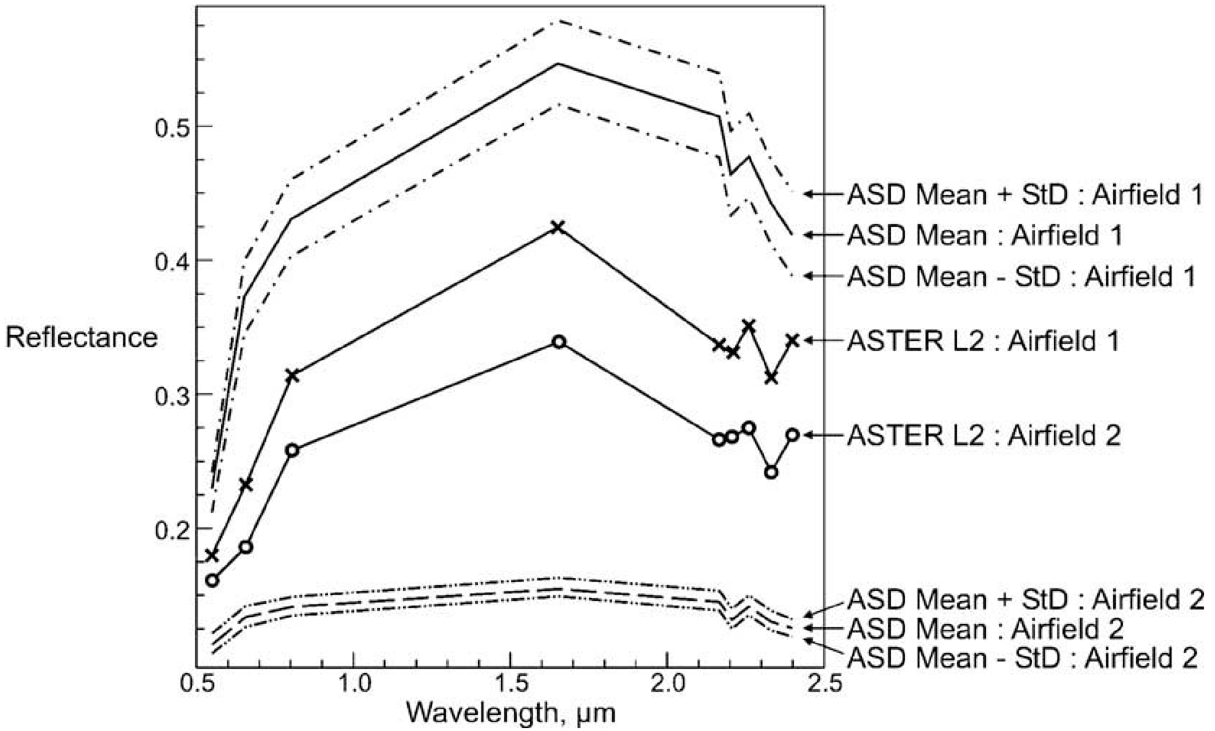


Hewson et al. 2005

- 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 H_2O 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

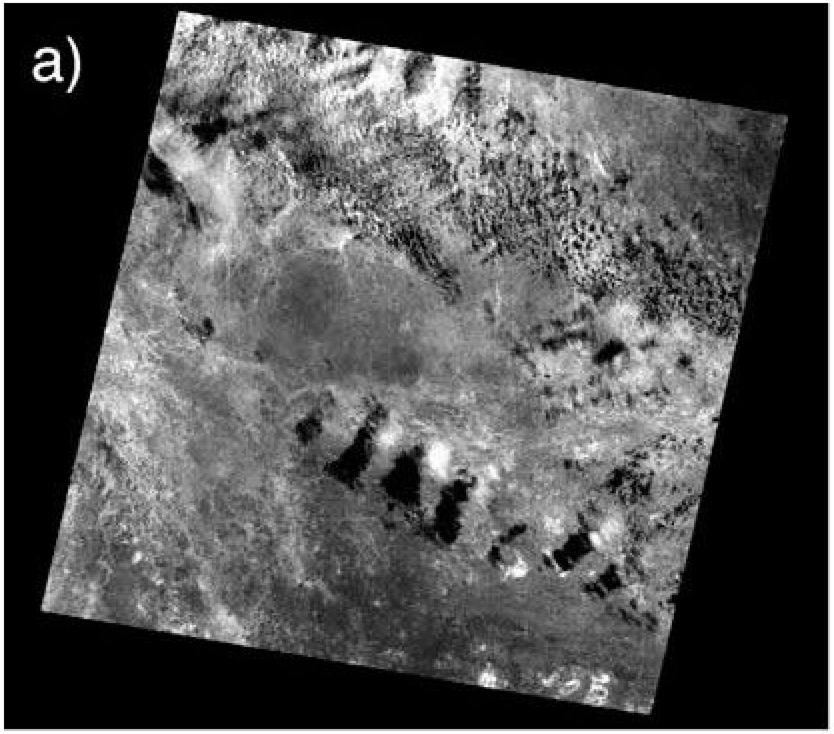
Testing Spectra with Ground-Truth



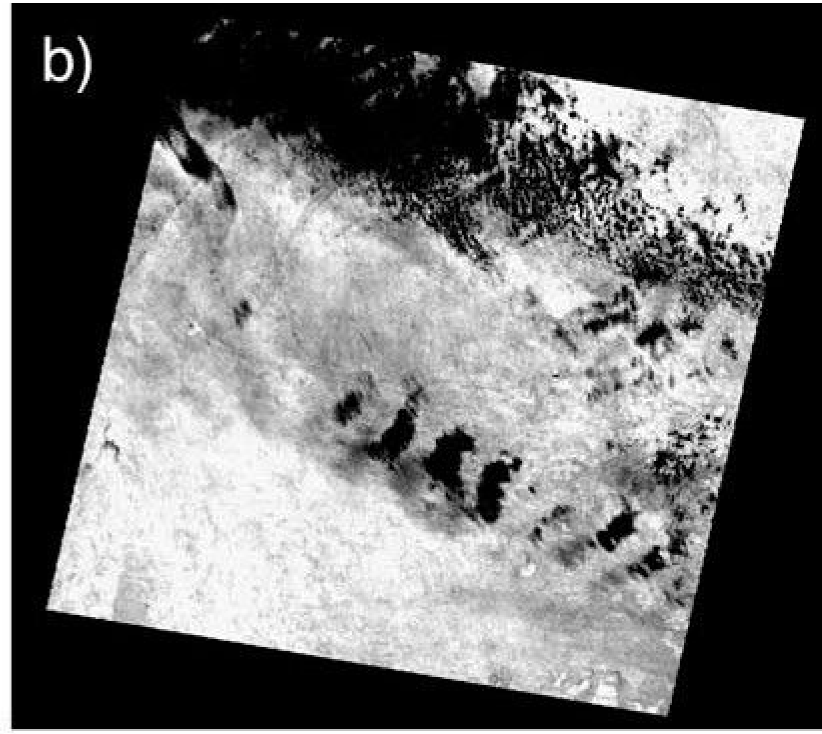
Hewson et al. 2005

- 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 Cloud identification



Band 3 showing reflected light effects of clouds and shadows

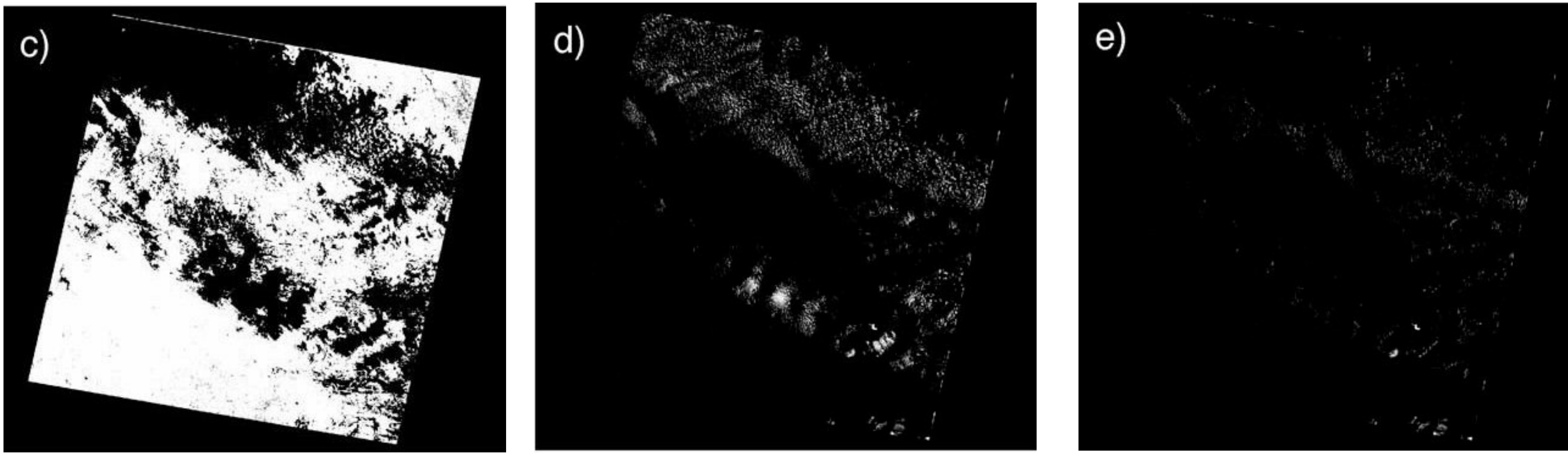


Band 10 (TIR) showing clouds are dark (cold)

Hewson et al. 2005

- Clouds
  - Both <u>clouds</u> and their <u>shadows</u> 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.)

Hewson et al. 2005 Cloud masks



Cloud Mask (dark=cloud or shadow)

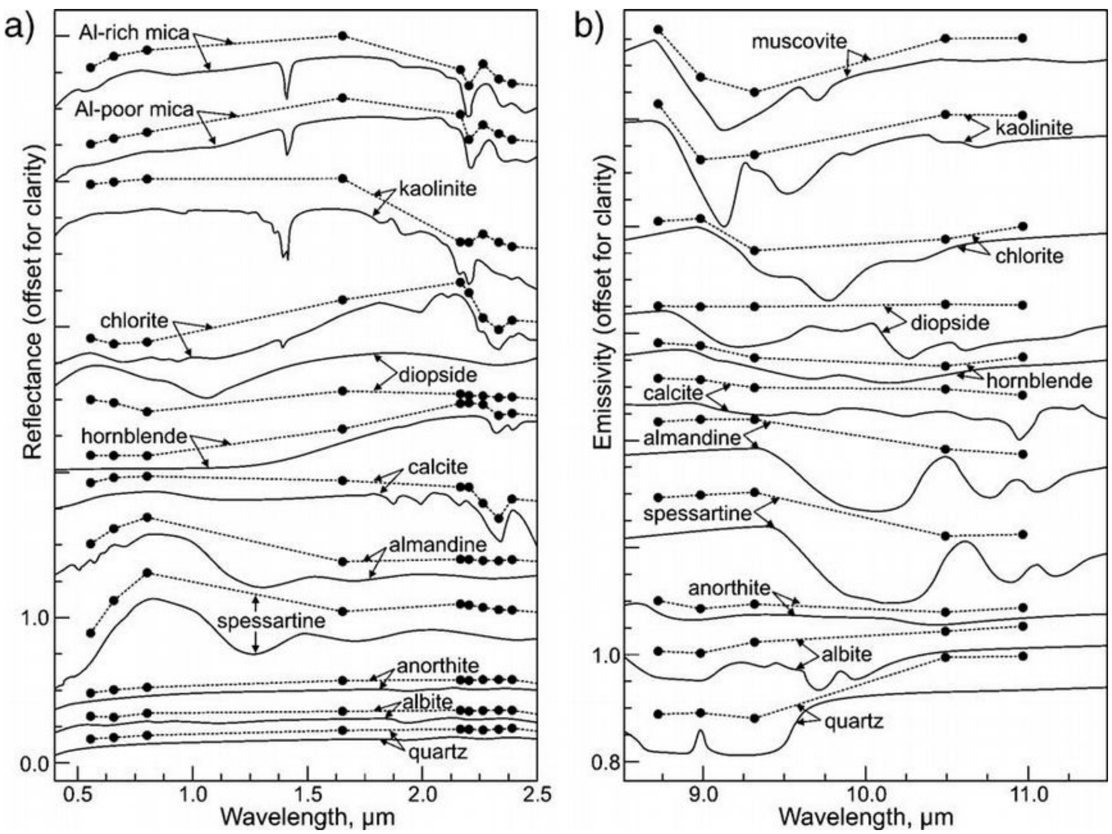
AlOH Anomalies Mask

AlOH Anomalies × Cloud

Hewson et al. 2005

- 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

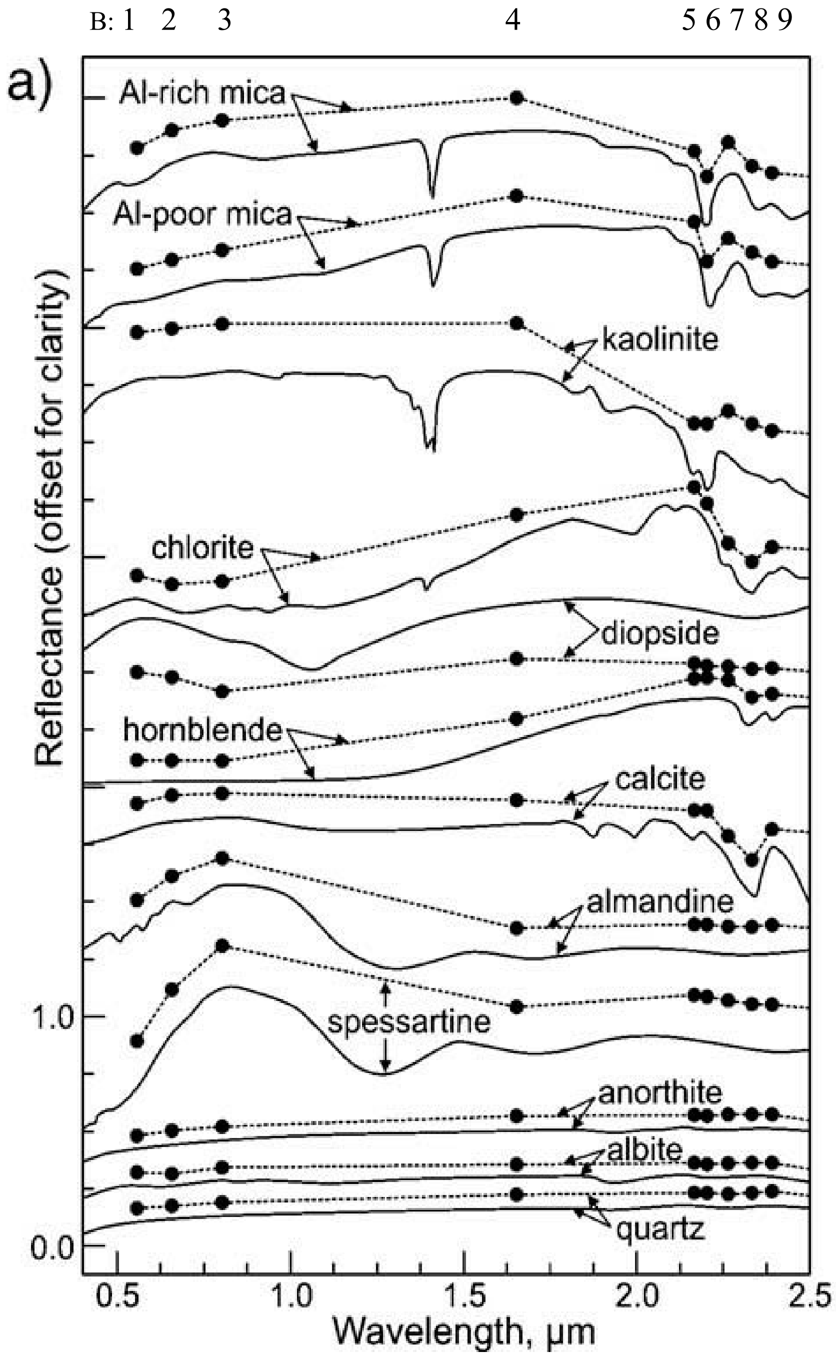
Mineral Spectra at Aster Resolution



Hewson et al. 2005

- Need hyperspectral data to identify <u>unknown </u>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
- Quart 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.

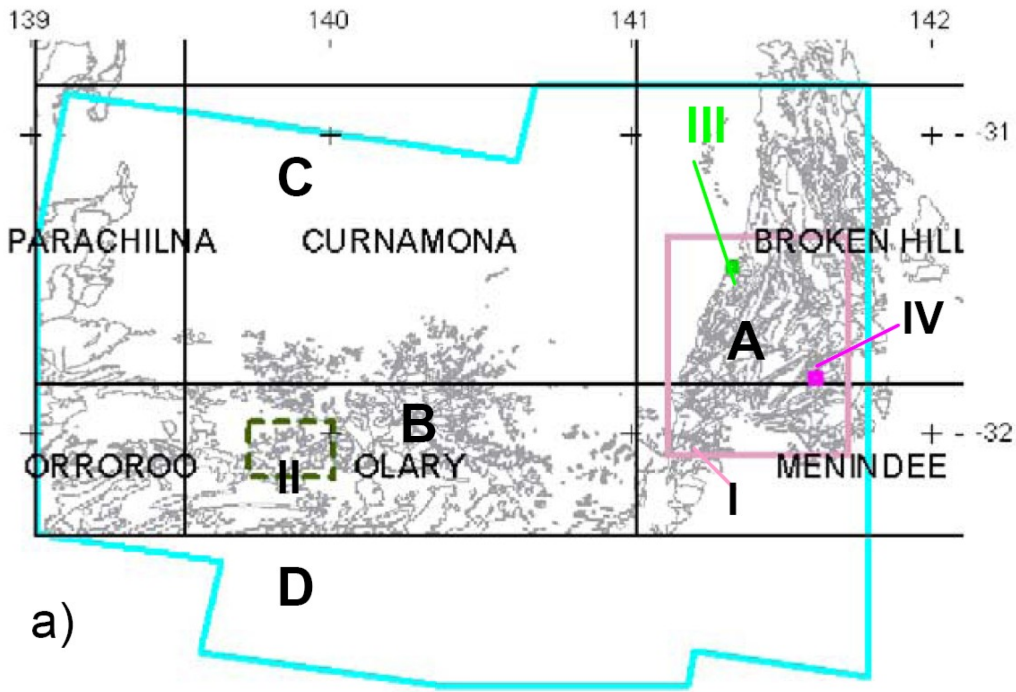


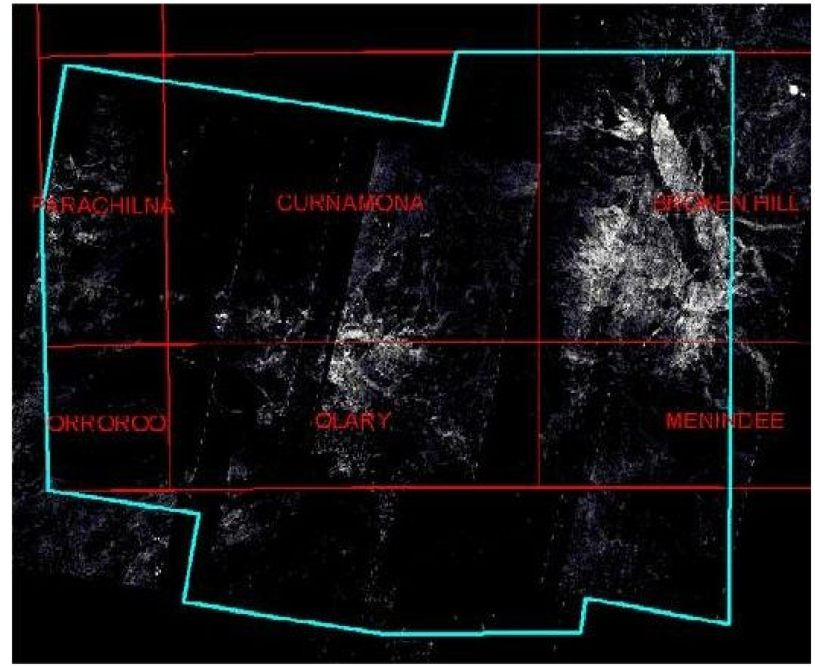
Hewson et al. 2005

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: $I_c \sim (B5+B7)/2$ so $y \equiv (B5+B7)/B6 \sim 2I_c/I$
      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 ⇒longer λ ⇒ Al-poor
    - Low B5/B6, high B7/B6 ⇒shorter λ ⇒ Al-rich
  - Kaolinite distinguished from mica by B7/B5
- Mg-OH minerals (chlorite, hornblende) have B8 (2.34 µm) feature
  - (B6+B9)/B8 (⇒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

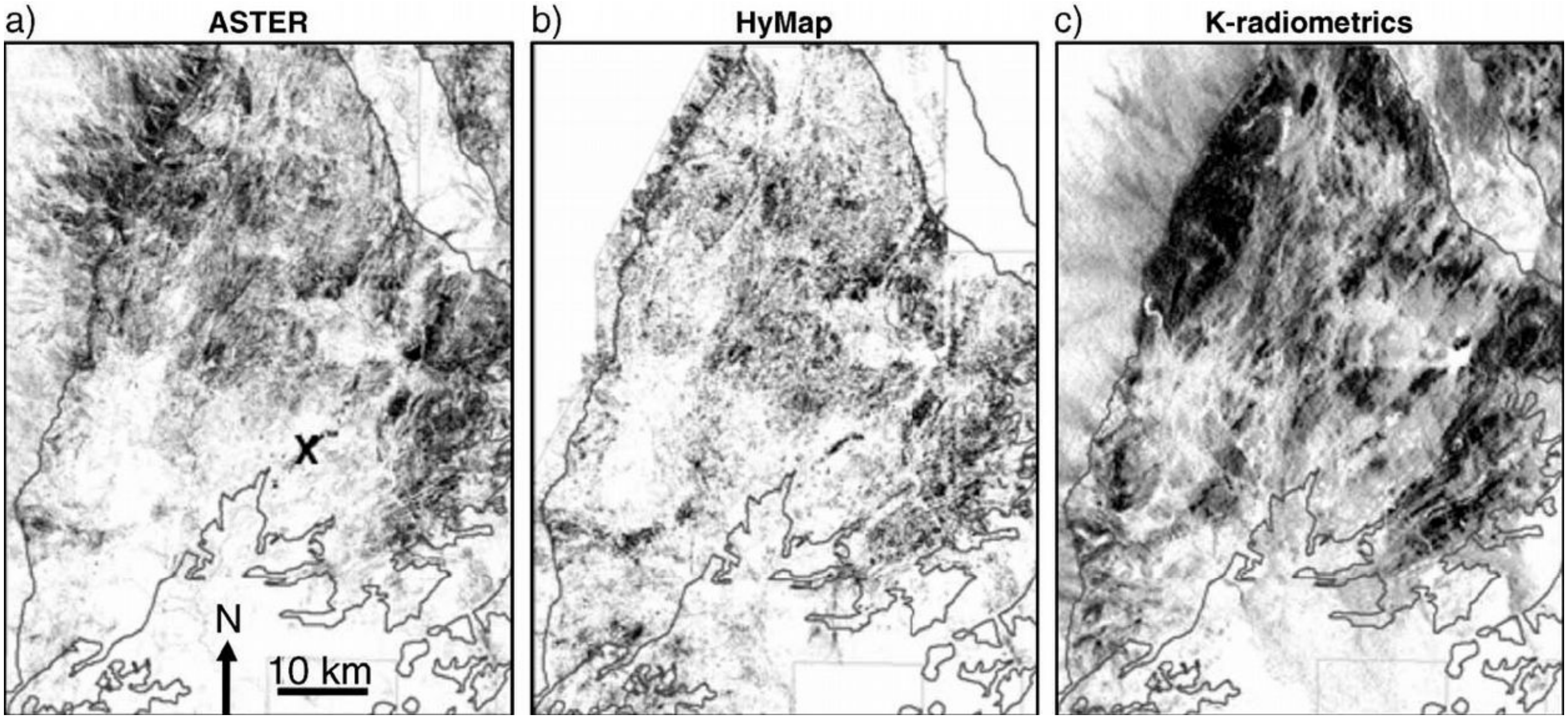
AL-OH Abundance





- 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)

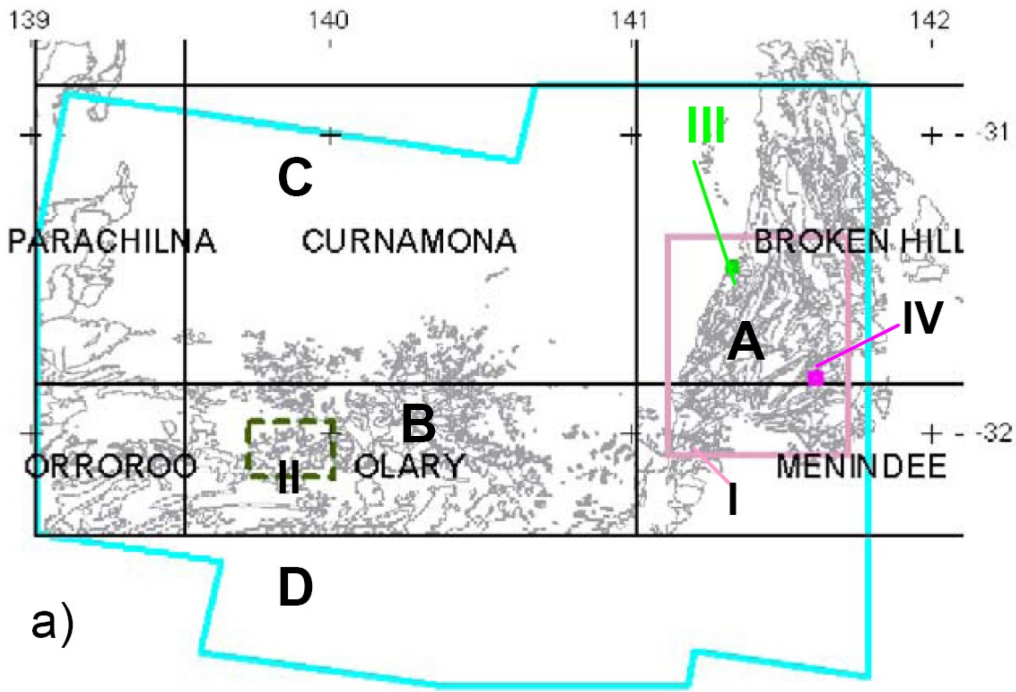
Al-OH Aster vs airborne hyperspectral maps

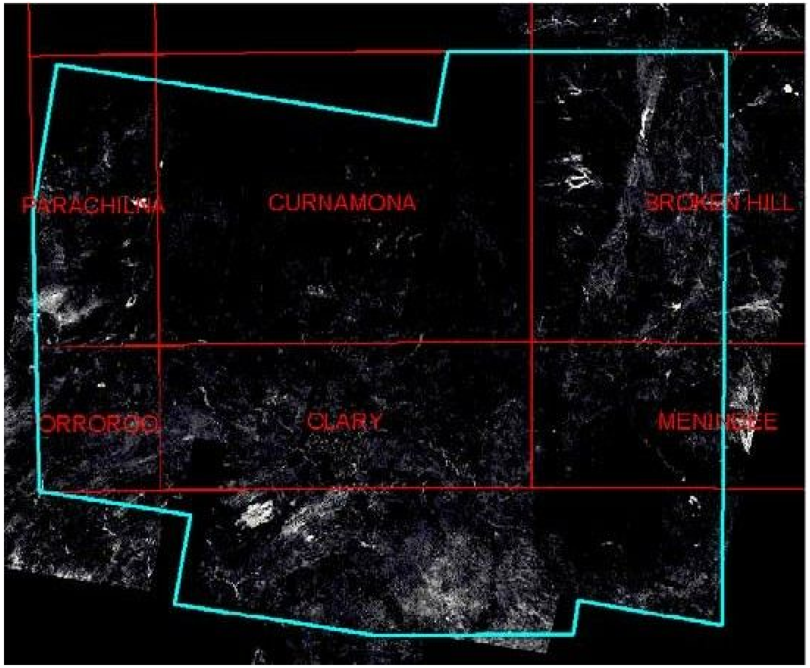


Hewson et al. 2005 Fig. 10

- 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

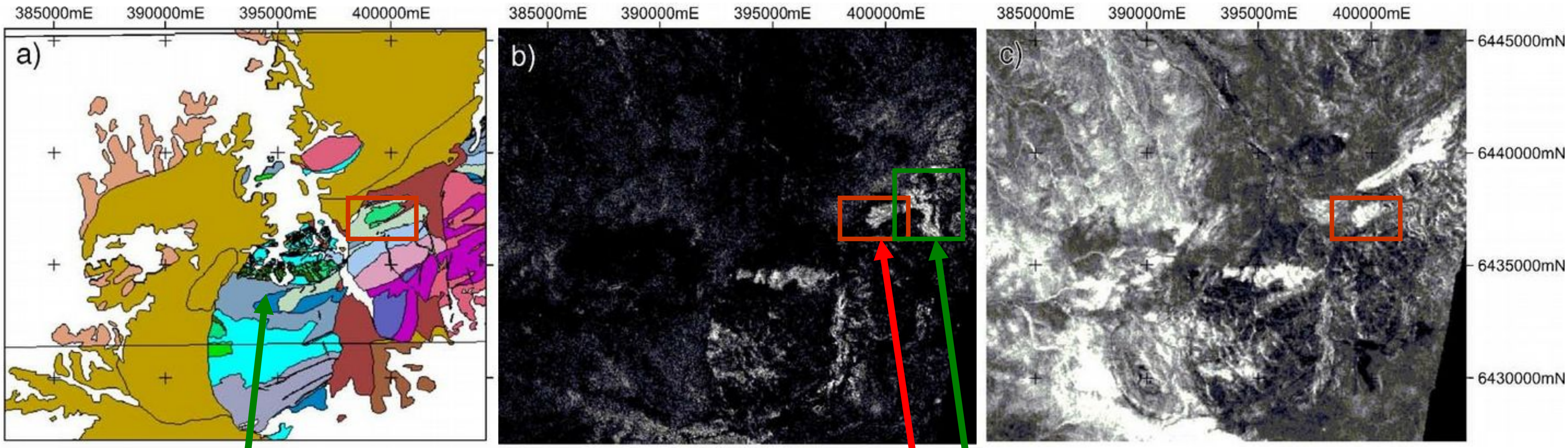
MgOH and Carbonate Abundance





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

Close-up study of Region II



Geological Map

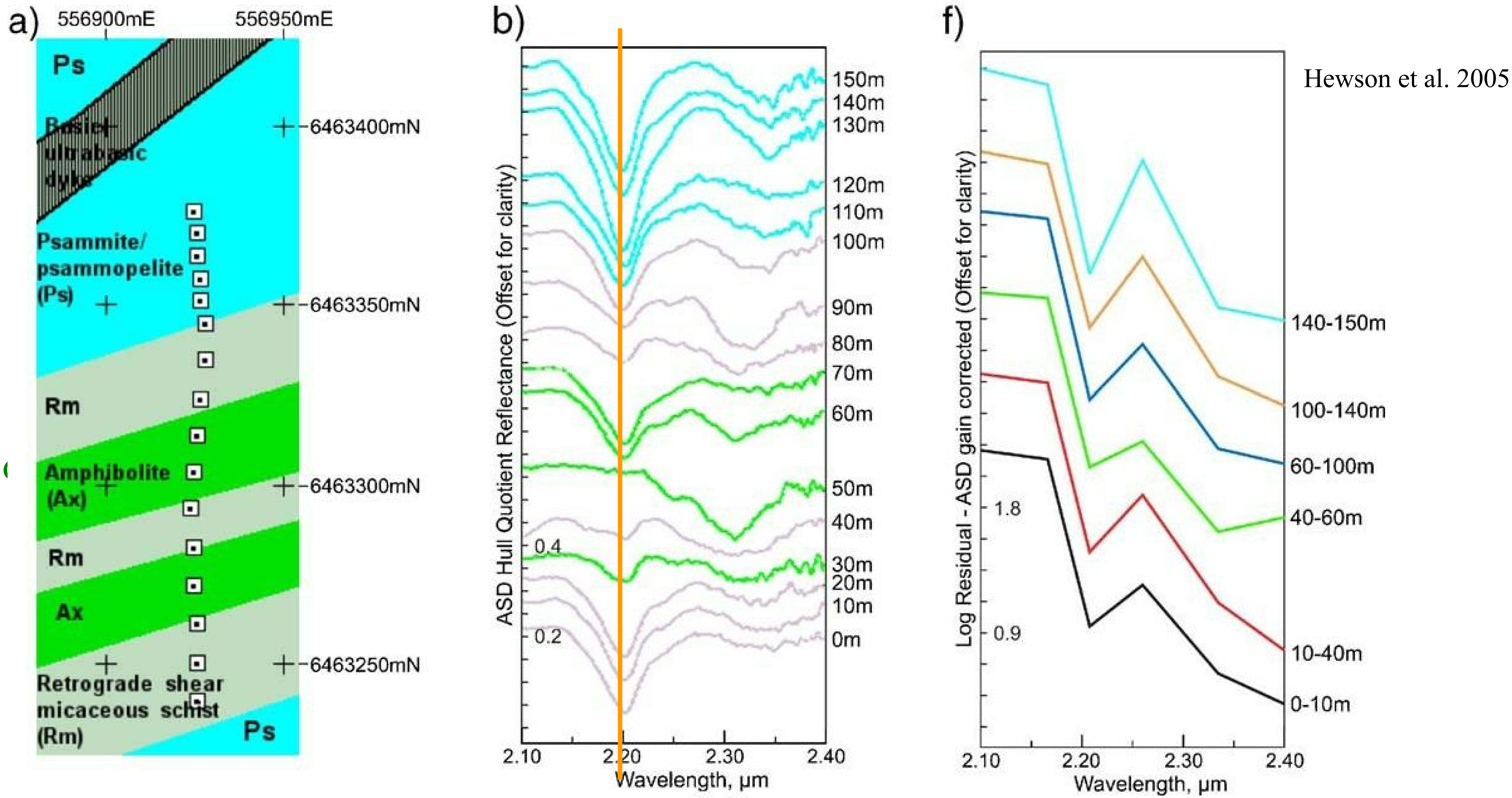
Aster MgOH+Carbonate

ASTER Ferrous Iron Silicates

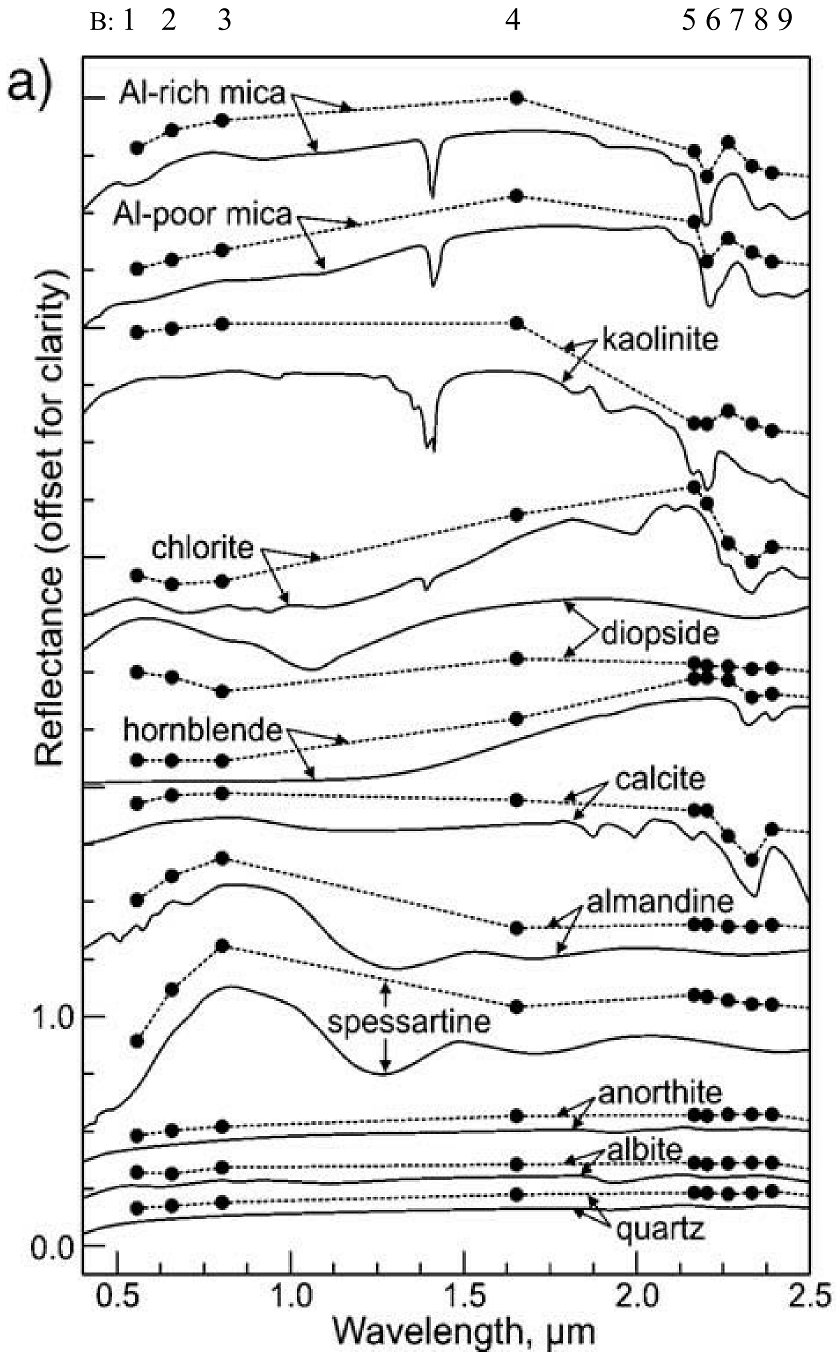
Hewson et al. 2005

- 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.

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



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: $I_c \sim (B5+B7)/2$ so $y \equiv (B5+B7)/B6 \sim 2I_c/I$
      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 ⇒longer λ ⇒ Al-poor
    - Low B5/B6, high B7/B6 ⇒shorter λ ⇒ Al-rich
  - Kaolinite distinguished from mica by B7/B5
- Mg-OH minerals (chlorite, hornblende) have B8 (2.34 μm) feature
  - (B6+B9)/B8 (⇒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