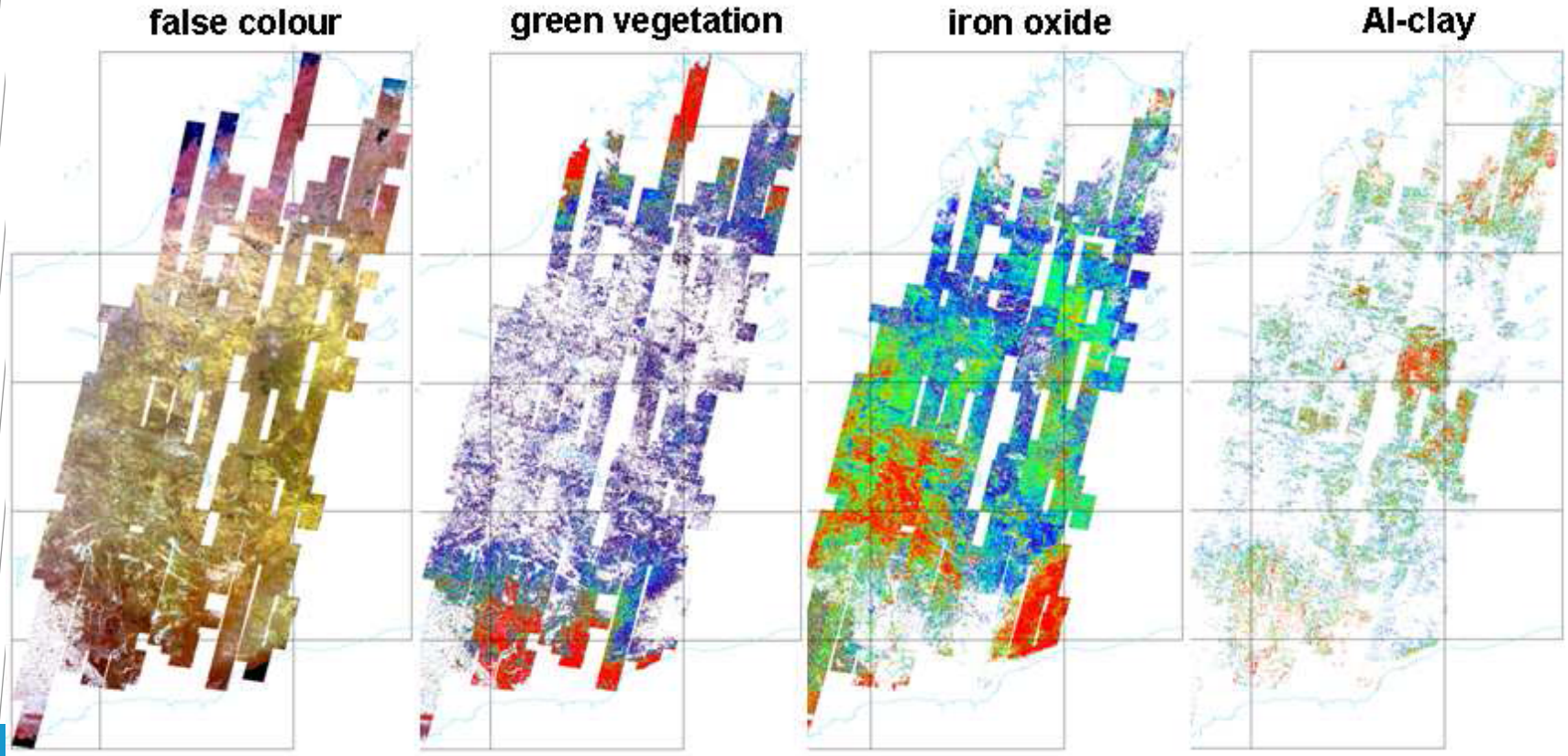

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WA ASTER Project

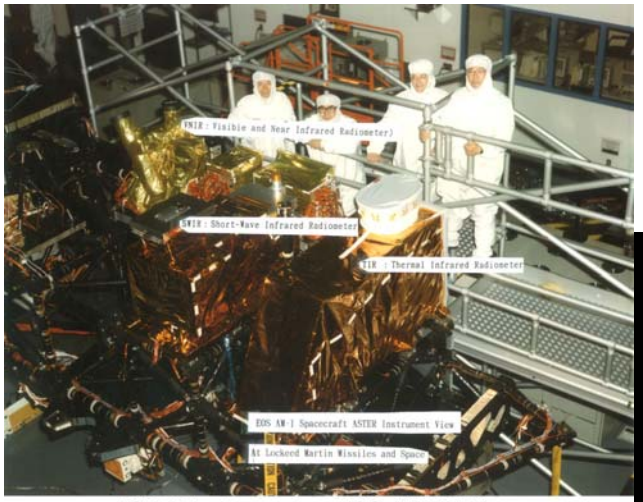
Mike Caccetta & Carsten Laukamp

Tom Cudahy, Joanne Chia, Simon Collings, Cindy Ong
Matilda Thomas, Rob Hewson

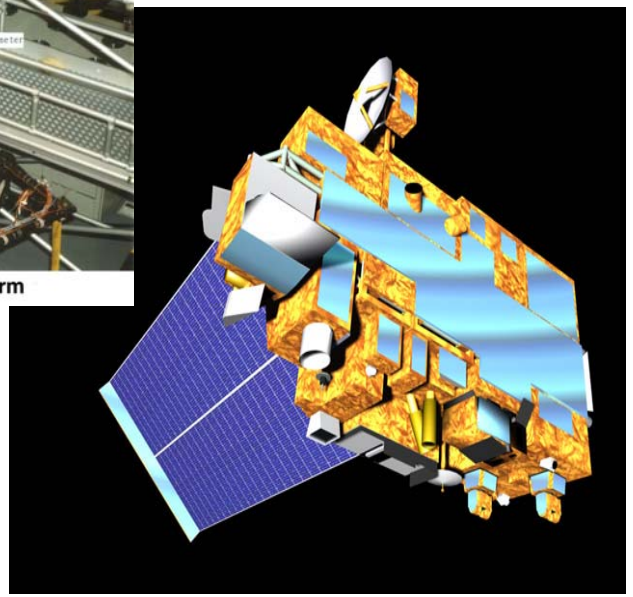
CSIRO

Presentation Overview

- C3DMM/CSIRO ASTER Vision
- Project Status
  - Deliverables
  - Status
- ASTER Instrument
- ASTER Workflow
  - Complicating factors
  - Methodology
- Case Study
- Questions / Discussion

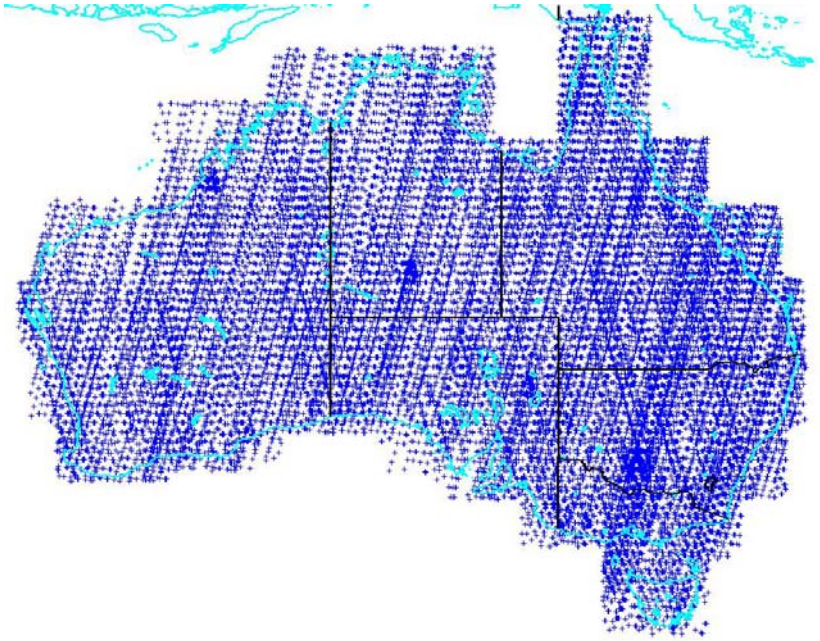


ASTER Instrument on EOS-AM1 Platform



ASTER Geoscience Map of Australia

- To develop, in collaboration with the geological surveys (federal and state), a national set of standard, publicly available, web accessible geoscience products derived from ASTER satellite data
  - Previous ASTER mapping studies (Qld and SA, +110 scenes)
  - Software for handling large volumes ASTER imagery
  - Project proposal submitted to ASTER science team resulting in access to ASTER imagery over Australian continent.
  - Access to CSIRO HyMap archive for calibration and validation
- WA June, 2011
- SA, December, 2011
- Qld, NT, NSW, Vic, Tas, proposed June, 2012
- 34th IGC, August 2012 – public release of Australian ASTER geoscience map



Project Aims and Deliverables

- A set of ~15 GIS compatible geoscience maps derived from available ASTER ***VNIR-SWIR*** data over WA. Products include:
  - False colour
  - Green vegetation content
  - CSIRO “regolith” ratios
  - Ferric oxide content
  - Ferrous iron content
  - Opaques
  - AlOH group (clay) content
  - AlOH group composition
  - Kaolin and “Advanced argillic”
  - Fe-OH group content
  - MgOH/carbonate group
  - MgOH group composition
  - Ferrous iron content in MgOH
  - Ferric iron content in MgOH
  - “Water content” (new)

TIR products *(not delivered by June 2011)*:
- carbonate content
- SiO2 content
- quartz index
- mafic mineral index (incl. pyroxene, garnet)

- GSWA/CSIRO internal workshop
- Open file publication

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Project Status

- June, 2010 - 1st pass preliminary products derived from the GA ASTER archive were delivered.
  - 450 scene (~50% coverage of state) were processed
  - archive consists of pre 2004 data

- Through ASTER Science Team, NASA-JPL, ERSDAC and USGS secured agreement to access ASTER archive.
  - Requested all scenes over Aus from 1999-onward with <75% cloud cover = +35,000 ASTER scenes
  - +9000 scenes over WA requested
  - datasets have latest calibrations

- Processing of the “complete” USGS WA ASTER data has commenced!

- March 2011 - GSWA ASTER workshop

- June, 2011 - Scheduled to deliver the final results and technology transfer report to GSWA

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ASTER – Sensor Characteristics

- Advanced Spaceborne Thermal Emission and Reflective Radiometer
- Japanese developed sensor launched December 1999
- consists of three separate instrument subsystems: VNIR, SWIR and TIR

Instrument	VNIR	SWIR	TIR
Bands	3	6	5
Spatial resolution	15m	30m	90m
Swath Width	60km	60km	60km
Dectector	Si-CCD (5000x4)	PtSi-CCD(2048x6)	HgCdTe (10x5)
Scan	Pushbroom	Pushbroom	Whiskbroom
Crosstrack pointing	±24.0°	±8.55°	±8.55°

- <16 day repeat cycle; stereo

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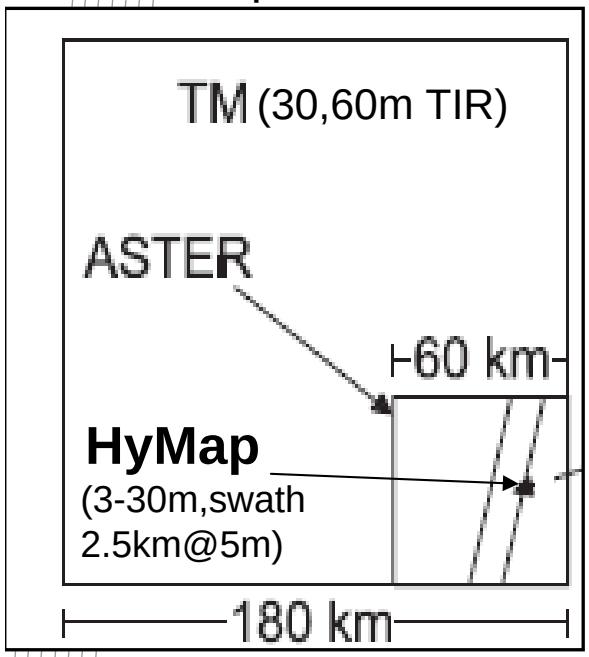
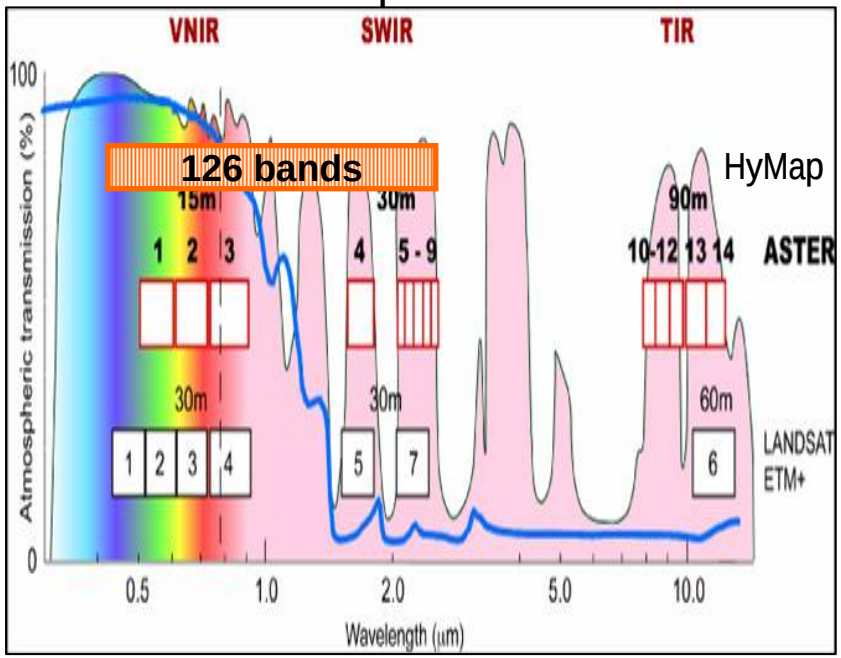
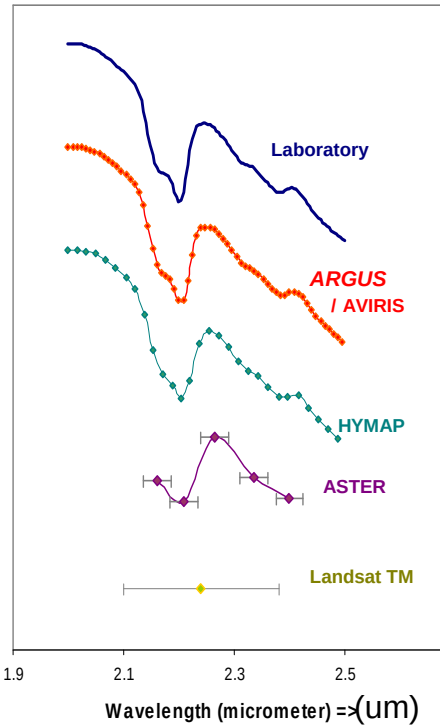
ASTER v Landsat v HyMap sensor comparison

Spatial



Spectral





- ASTER designed for geological mapping applications
- ASTER has five additional bands in the 2.10-2.45um region in order to distinguish additional mineral groups
- Increased spectral resolution => increased mineral identification
- Hyperspectral satellites with +200 channels planned for the near future (201

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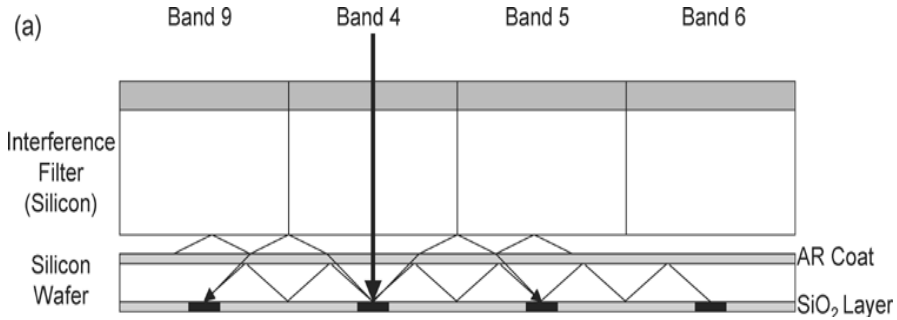
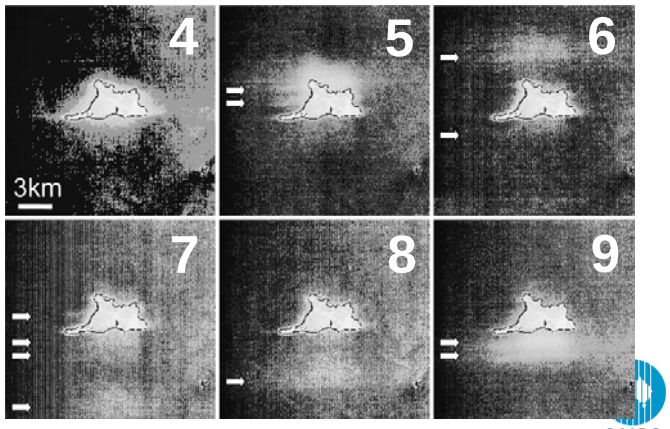
Workflow considerations

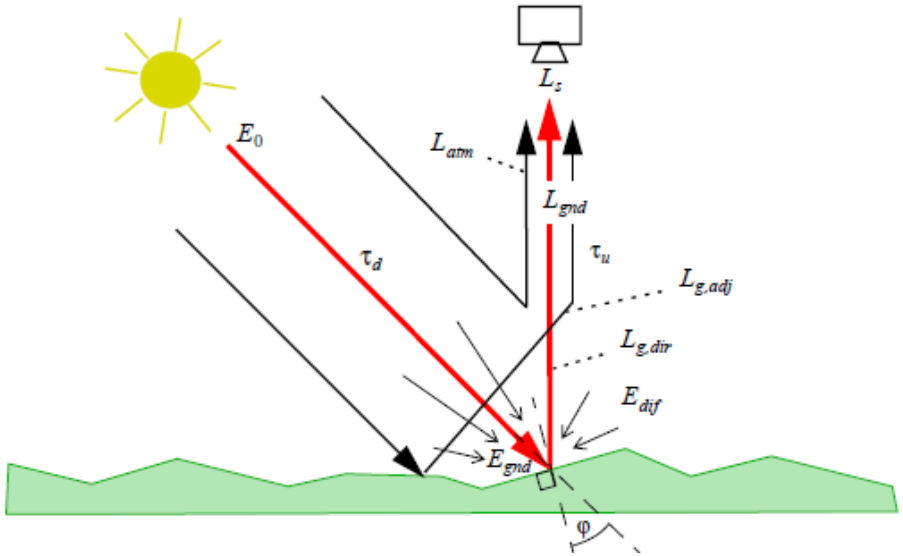
- Processing methodology must correct for instrument and atmospheric effects before mineral information can be extracted.
- ASTER Instrument Effect – Crosstalk
  - Leakage of photons from band 4
  - Caused by multiple reflections between aluminum coatings in detector
  - Effects all bands but most apparent in bands 5 and 9
  - Additive, spatially varying effect
  - ERSDAC software available which partially compensates for effect. Residual effects can remain





Workflow considerations - Atmosphere

- Atmosphere distorts measured signal
- Additive (path radiance) and multiplicative effects (transmission)
- Need to transform measured radiance@sensor to apparent surface reflectance which relates to the physical properties of the surface material



Courtesy Schläpfer (1998)

Methodology - Overview

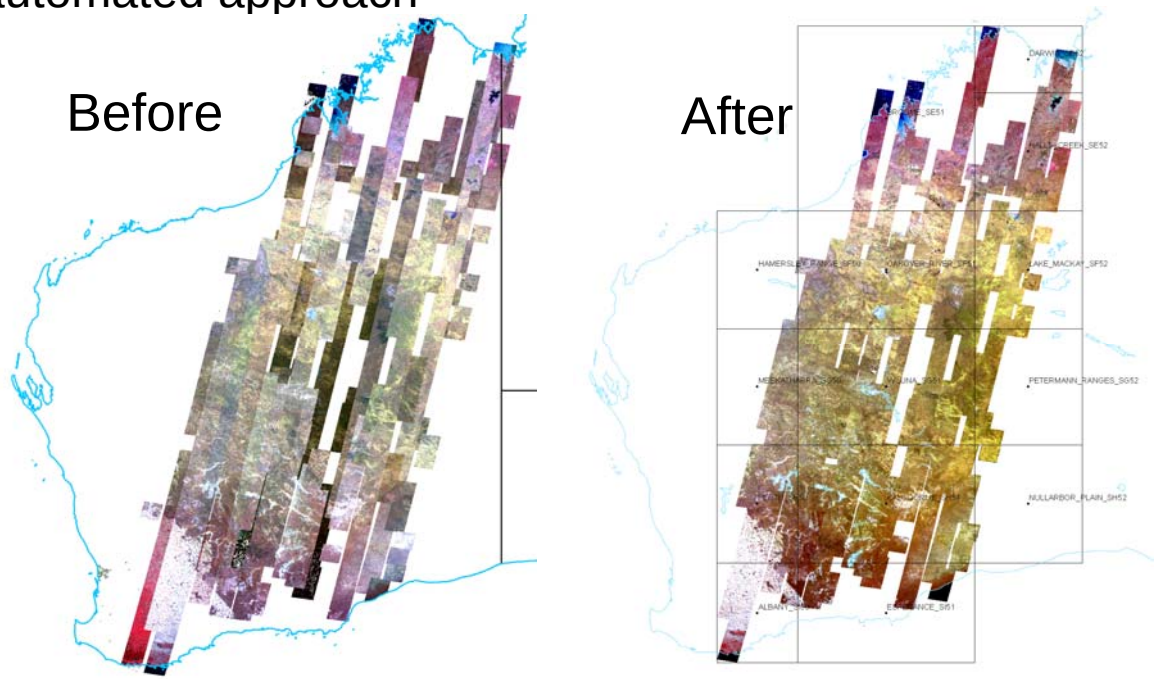
- Scene selection
  - L1B radiance@sensor data
  - where possible summer, cloud free scenes are used.
- Crosstalk correction
  - Standard ERSDAC software see Iwasaki* for algorithm details
- VNIR and SWIR re-sampled into single 30m dataset
- Conversion to exo-atmospheric reflectance
  - Solar irradiance, sun zenith

$$\rho_p = \frac{\pi \cdot L_\lambda \cdot d^2}{ESUN_\lambda \cdot \cos\theta_S},$$

*Iwasaki & Tonooka (2005) Validation of Crosstalk Correction Algorithm fo ASTER/SWIR. IEEE TRANS ON GEOSCIENCE AND REMOTE SENSING, VOL. 43, NO. 12, DECEMBER

Methodology – Overview (continued.)

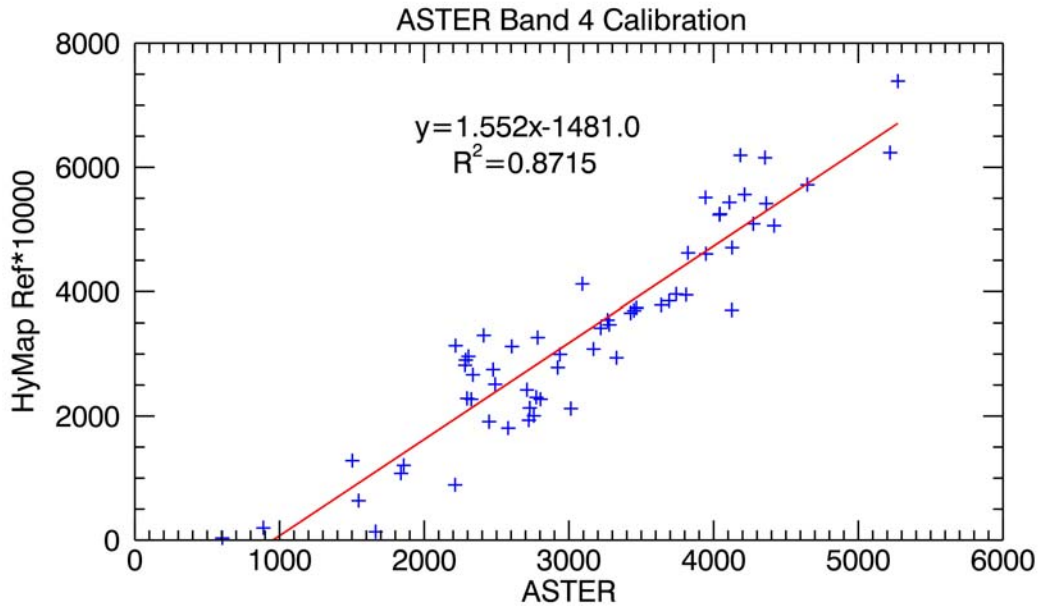
- **Cross scene calibration**
  - CSIRO in-house developed calibration software*
  - Developed by group that established calibration techniques for Australian continental Landsat mosaic
  - Empirical approach utilising statistics of invariant sites in the areas of scene overlap to calculate per scene per band calibration coefficients.
  - Semi automated approach



**Collings S. et al. (2010) Techniques for BRDF Correction of Hyperspectral Mosaics. IEEE Trans. on Geos. and Remote Sensing, Vol 48 (10) pg3733*

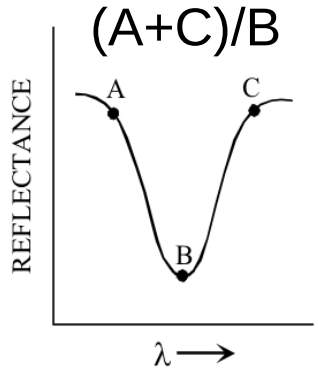
Methodology – Overview (continued.)

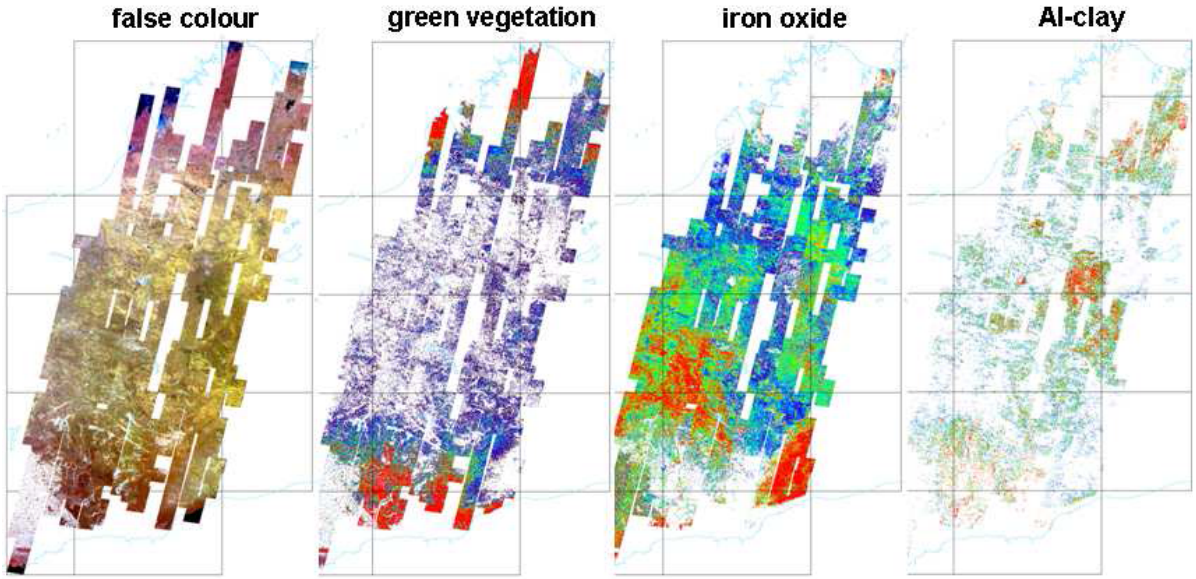
- **Calibration to apparent surface reflectance**
  - ASTER mosaic calibrated to HyMap data
  - CSIRO HyMap archive used. +100 HyMap flightlines processed to apparent surface reflectance.
  - Least squares regression
  - Calibration curves with $R^2 > 0.8$ for each band established.



Methodology – Overview (continued.)

- **Information Extraction** – Mineral Mapping
  - Ratios and continuum band ratios used to identify geoscience information e.g.
    - (B5+B7)/B6 = AlOH group abundance
    - B5/B7 = AlOH group composition etc.
    - B4/B3 = Ferric oxide abundance
  - Robust measures which normalise out topographic differences
  - Ratios map absorption features specific to mineral groups
  - Geoscience products further refined by masking for green veg, cloud, water bodies and recent fire scars





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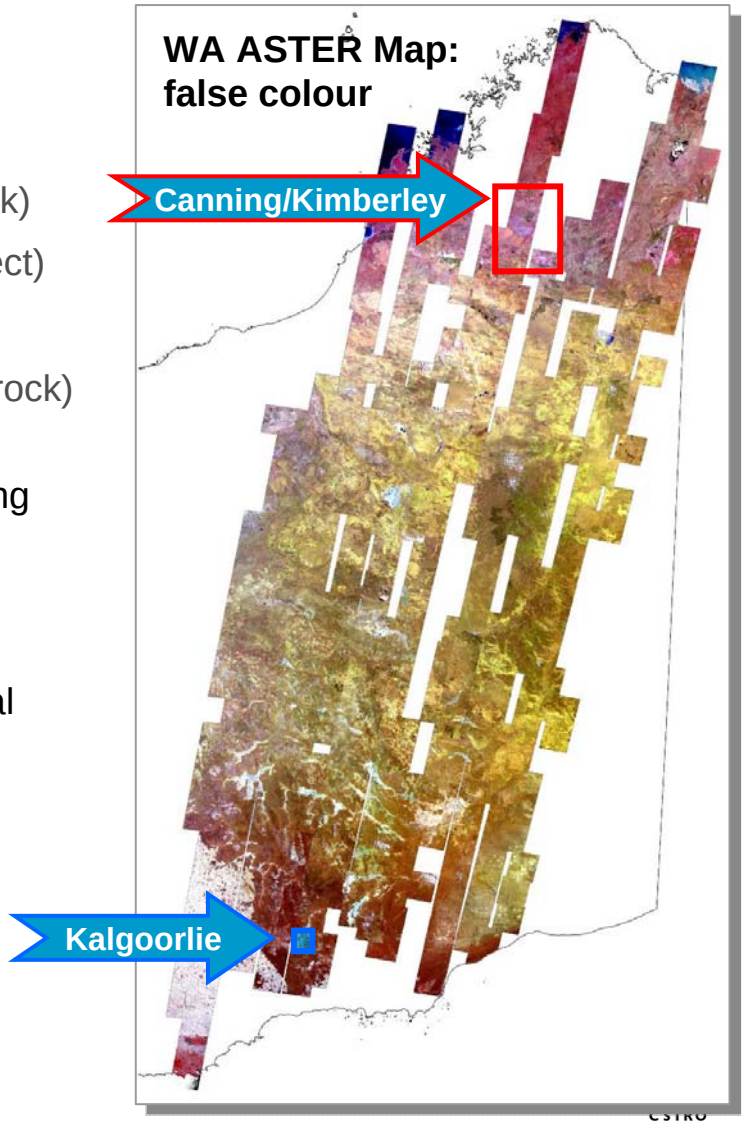
Case Histories (today)

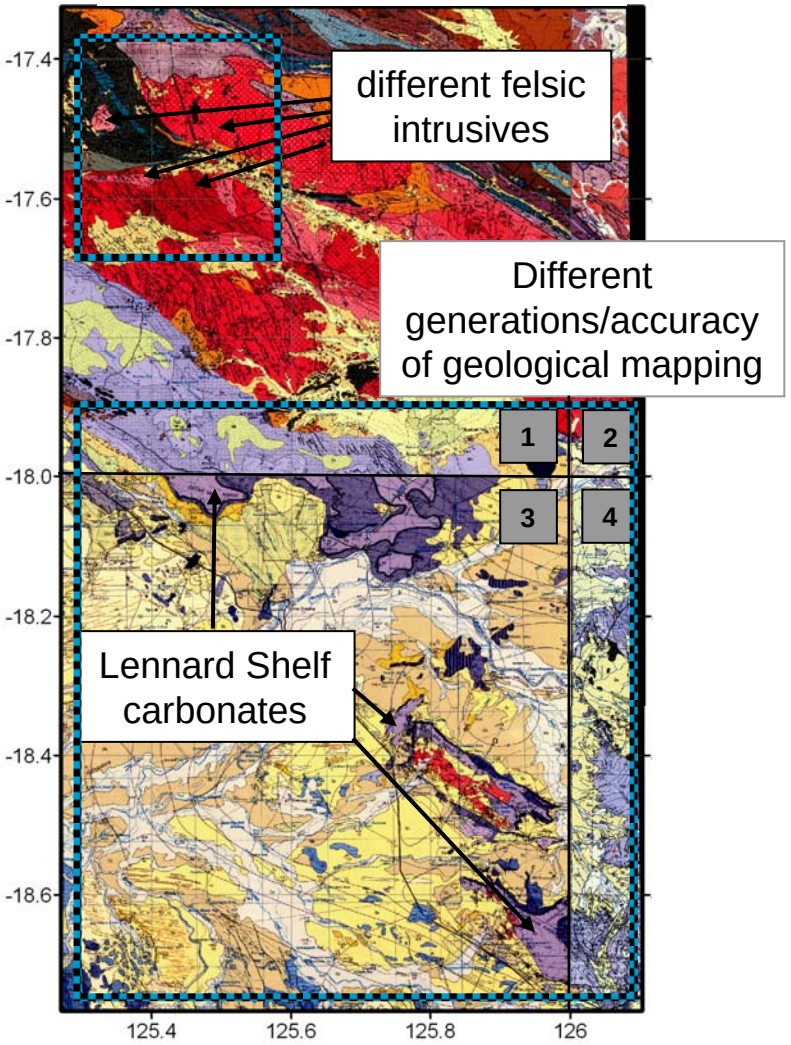
- **Kalgoorlie**
  - Validation with:
    - end of drill hole (EOH) fresh rock PIMA data (Barrick)
    - airborne HyMap (2005 survey – MERIWA 370 project)
  - Regolith issues with accurate Al-OH clay mapping
    - kaolin (regolith) and white mica composition (fresh rock)
  - Dry vegetation issues with accurate Fe-OH (chlorite, gypsum) and Mg-OH (chlorite, talc, amphibole) mapping

- **NE Canning/Kimberley**
  - Regolith Al-OH clay mineralogy can work for geological mapping
  - Hydrothermal Au kaolin and white mica alteration?
  - Carbonate mapping (Lennard Shelf)
    - alteration and base metal exploration
    - geological mapping

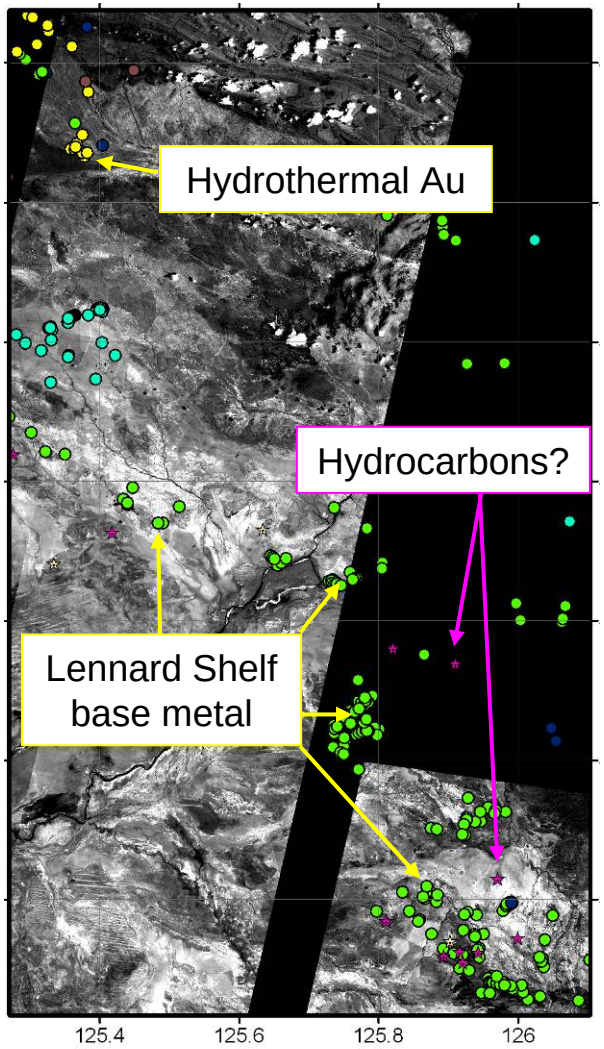


NE Canning/Kimberley

published 250K geology



ASTER coverage, mines/wells



wa_wells1
STATUS
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STEEL ALLOY METAL

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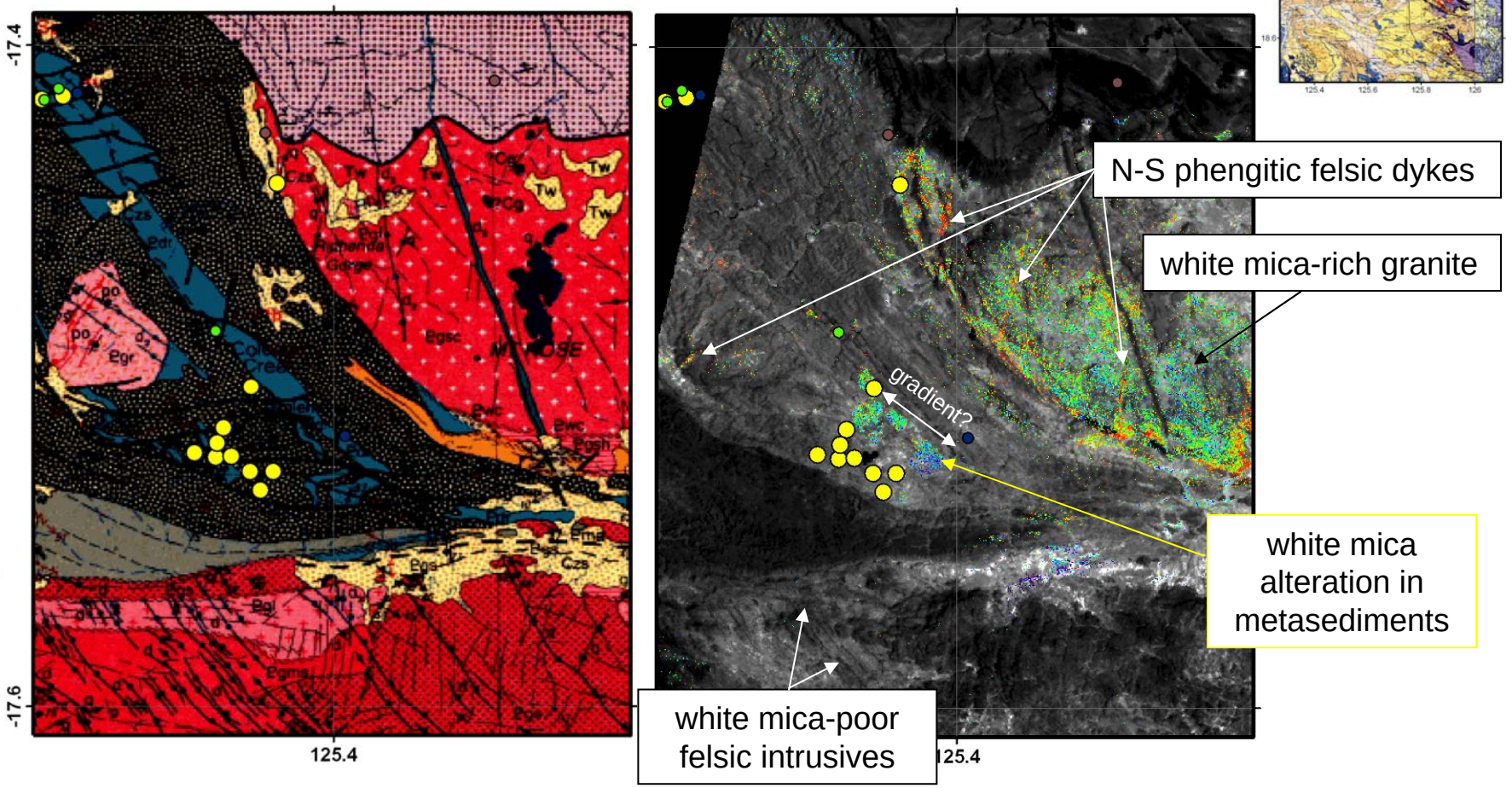
NE Canning/Kimberley – AlOH group & Au

published 250K geology

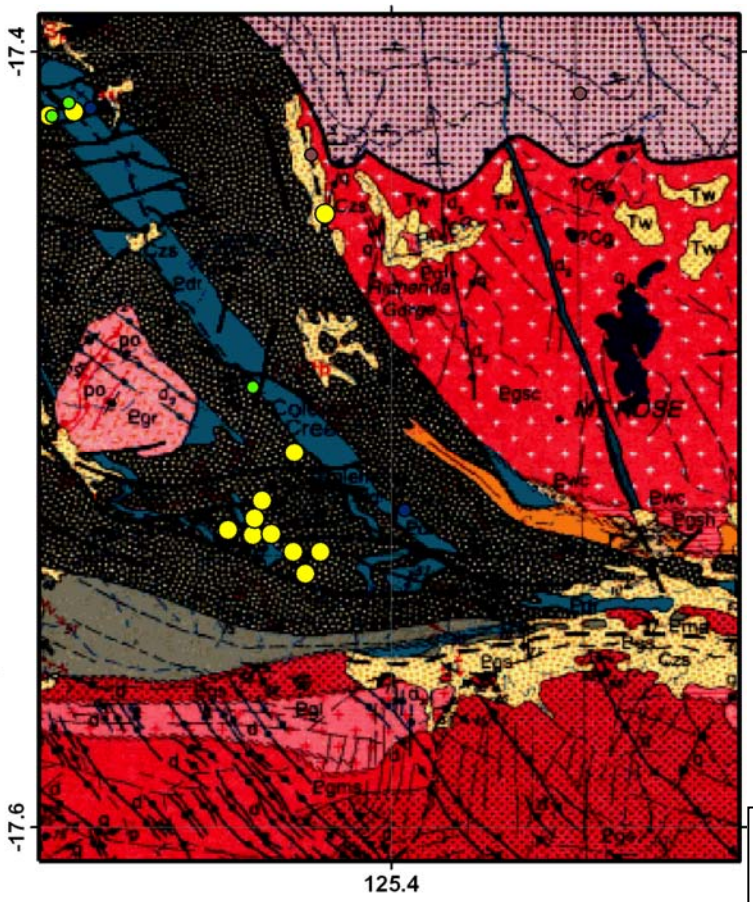
ASTER AlOH group composition

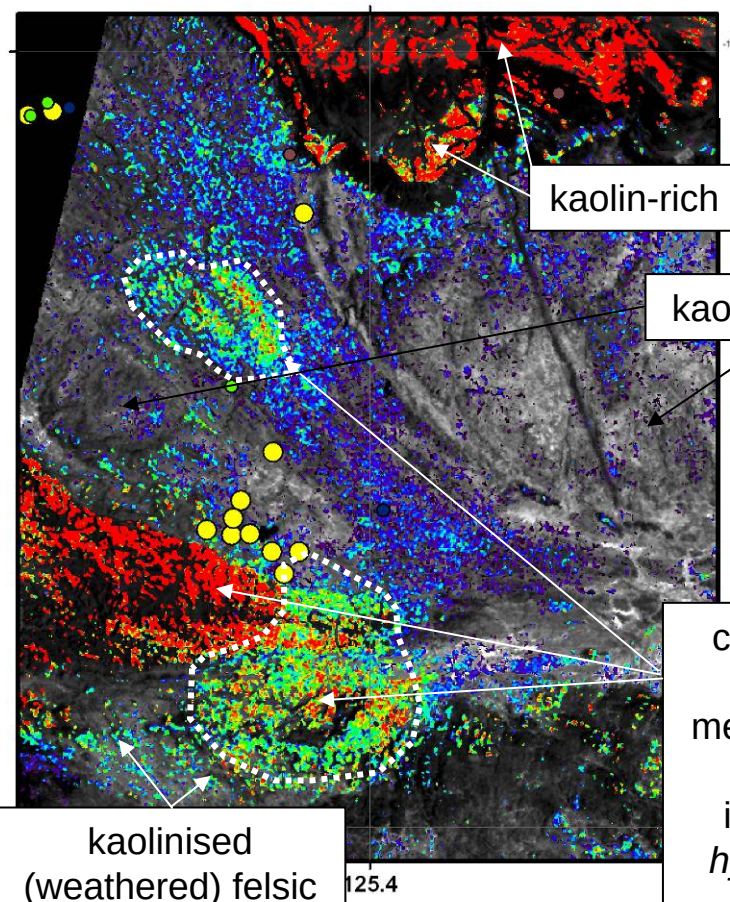


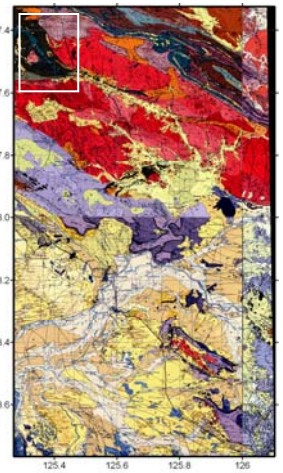
NE Canning/Kimberley – Ferric iron & Au

published 250K geology

ASTER “advanced argillic”







kaolin-rich metasediments

kaolin-poor granite

cross-cutting kaolin in metasediments and felsic intrusives – *hydrothermal alteration?*

kaolinised (weathered) felsic intrusives

low high

abundance of e.g. pyrophyllite, alunite, kaolinite

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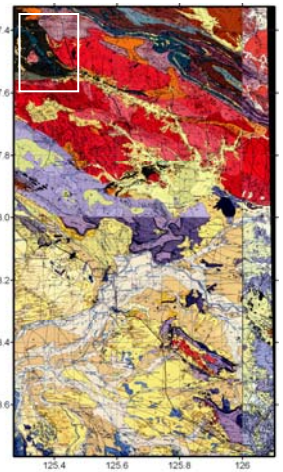
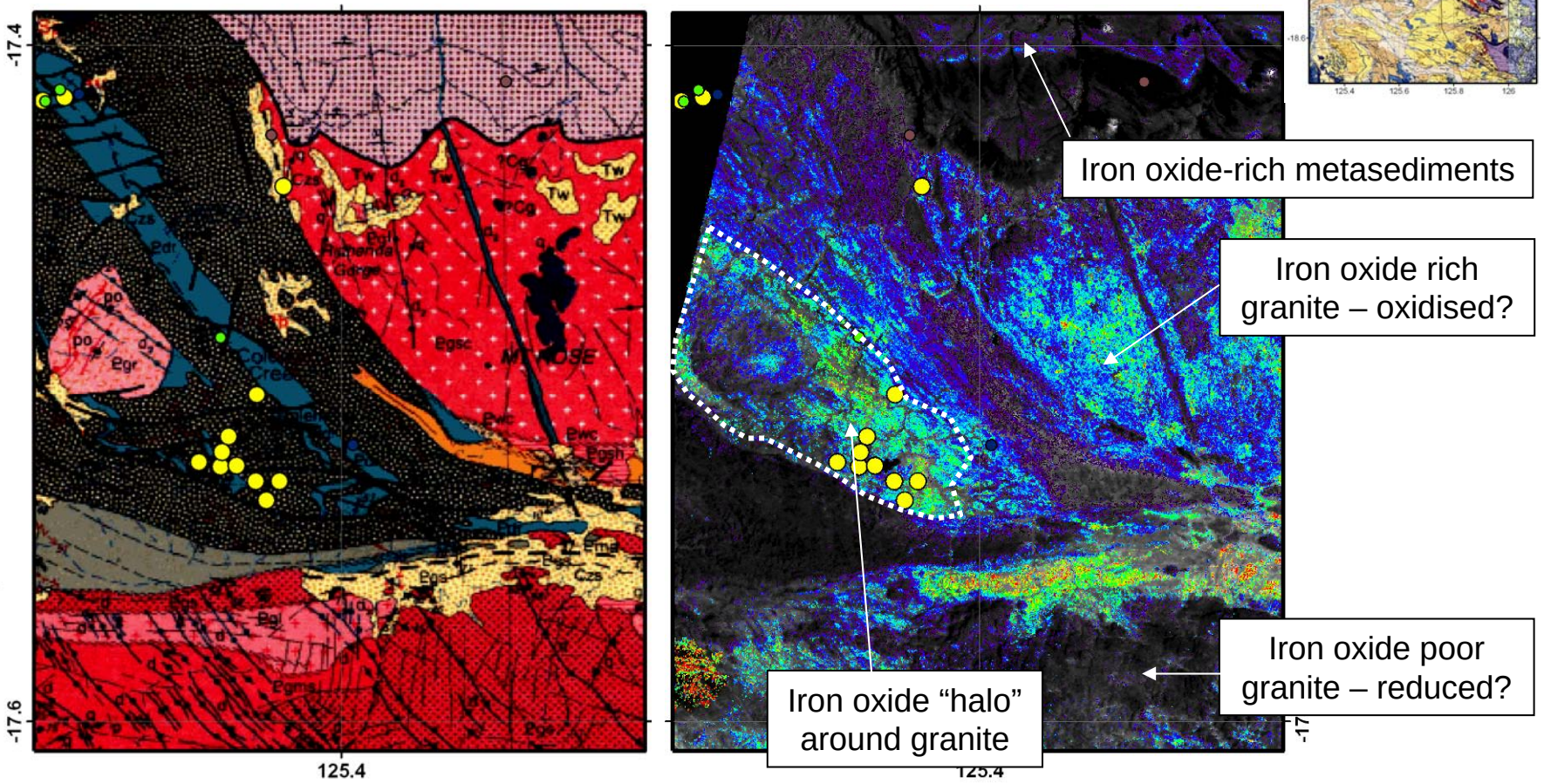
NE Canning/Kimberley – Ferric iron & Au

published 250K geology

ASTER ferric oxide content

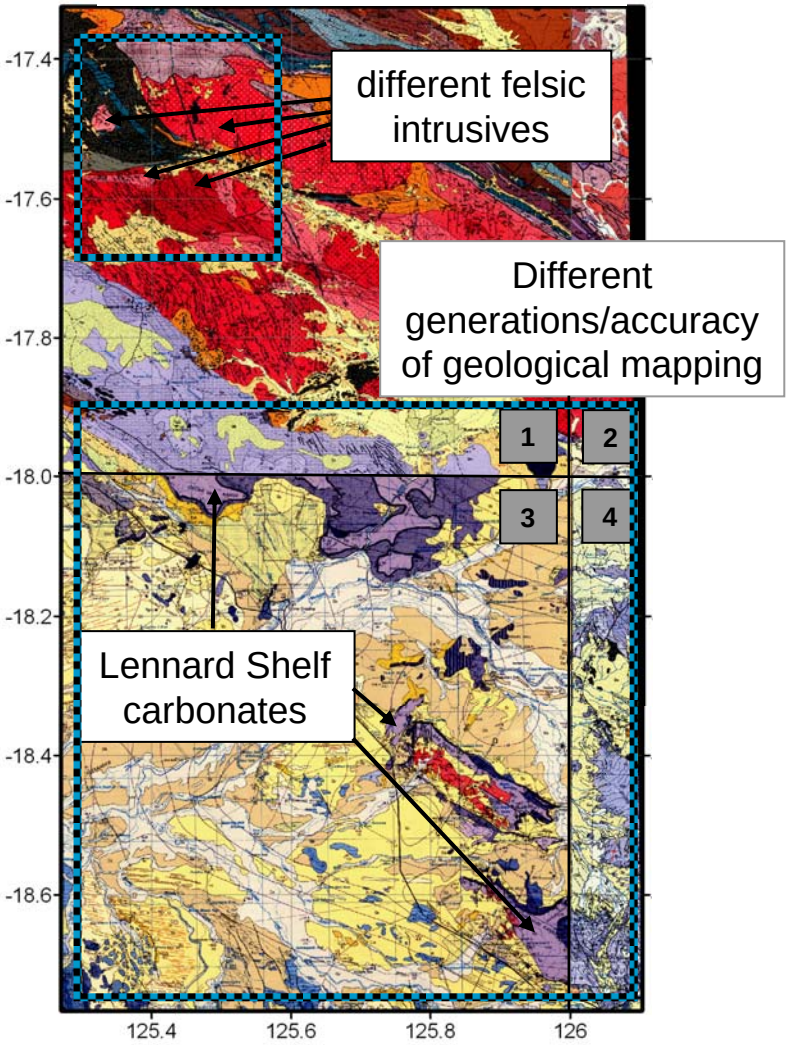




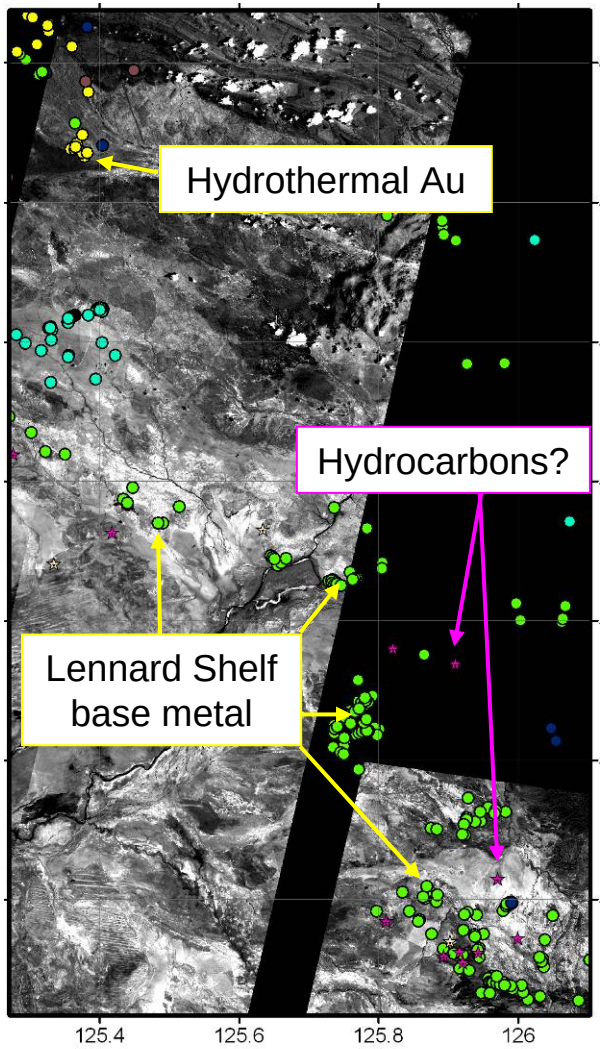
low high

NE Canning/Kimberley

published 250K geology



ASTER coverage, mines/wells



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ENERGY
INDUSTRIAL MINERAI
IRON
PRECIOUS METAL
PRECIOUS MINERAL
SPECIALITY METAL
STEEL ALLOY METAL

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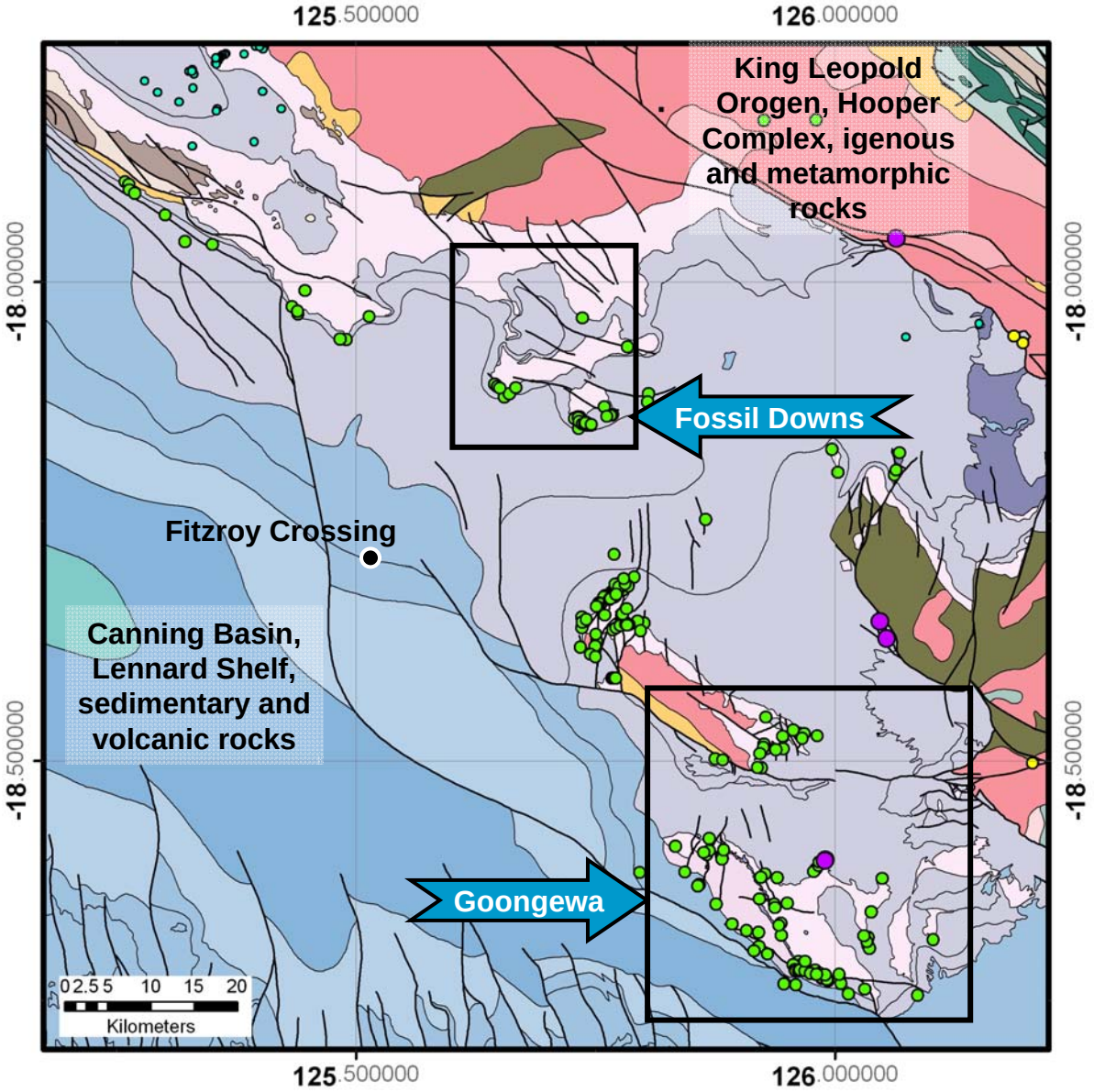
Application of ASTER for exploration in the Canning Basin

- Lennard Shelf MVT Pb-Zn deposits (Canning Basin, WA):
  - located along margins of the Canning basin and intrabasin highs
  - stratabound, hosted in carbonate rocks of reefal or platformal origin
  - proximity to extensional normal faults (fluid pathways)
  - fault and dissolution breccia ore
  - can be ass. with dolomite halo (e.g. Goongewa)

after Dörling et al. (1998)



Application of ASTER for exploration in the Canning Basin - Goongewa

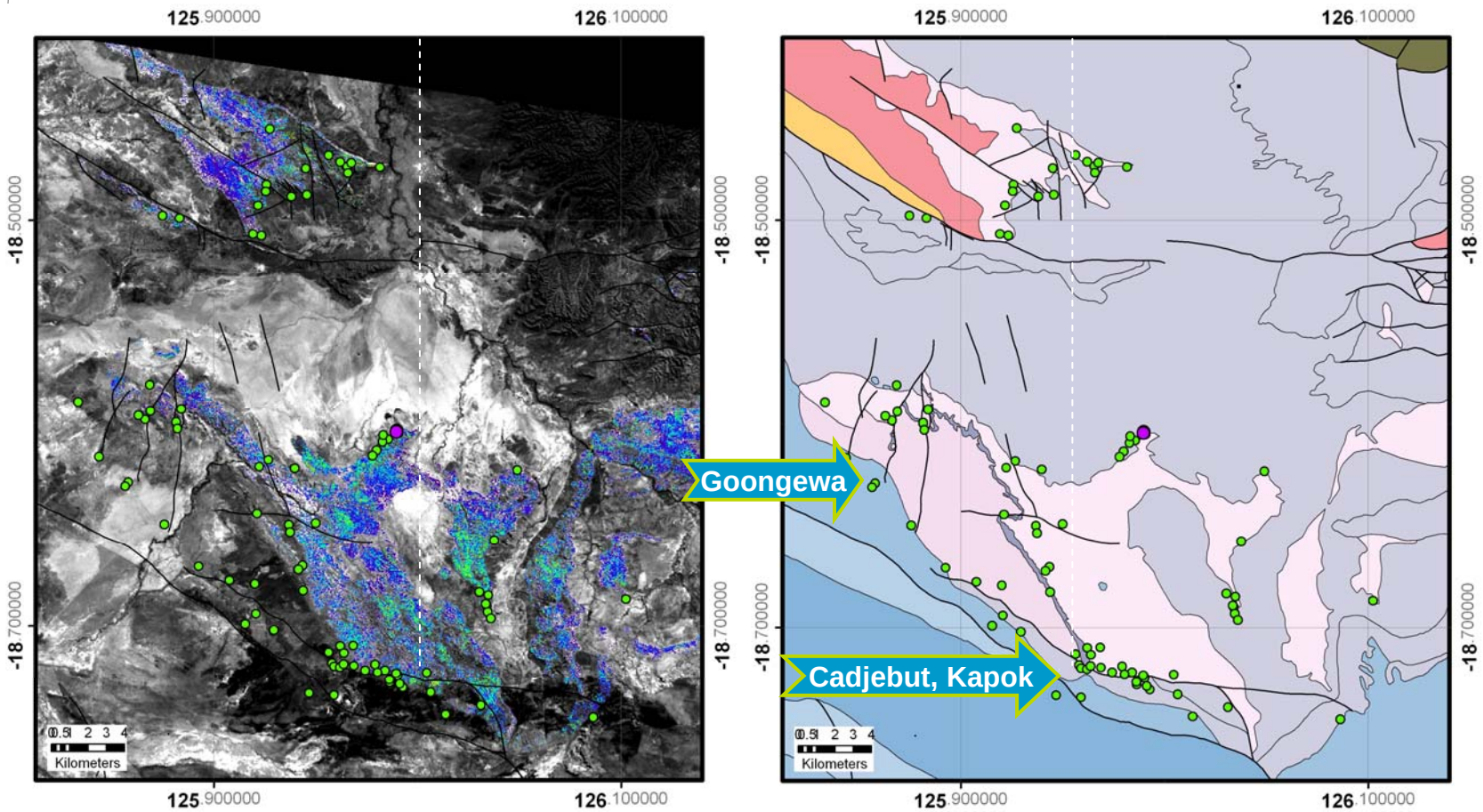
MVTs at contact between foot wall limestones and hanging wall calcarenite/siltstone

ASTER MgOH composition index

dolomite — calcite

in carbonate rocks

Geological Map 500K



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Application of ASTER for exploration in the Canning Basin - Goongewa

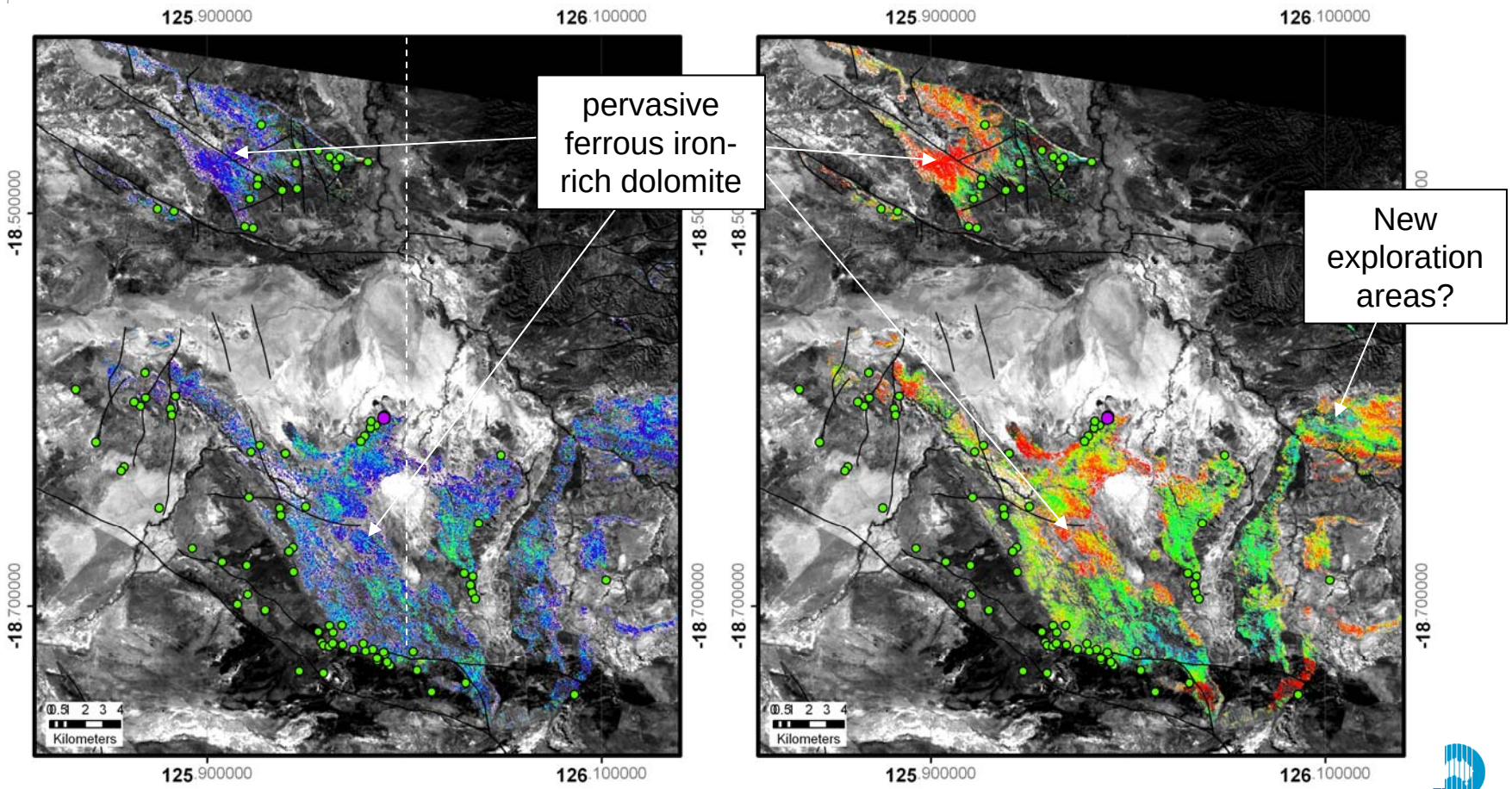
ASTER MgOH composition index

dolomite — calcite

in carbonate rocks

ASTER Ferrous iron abundance index

low — high



CSIRO

Application of ASTER for exploration in the Canning Basin - Goongewa

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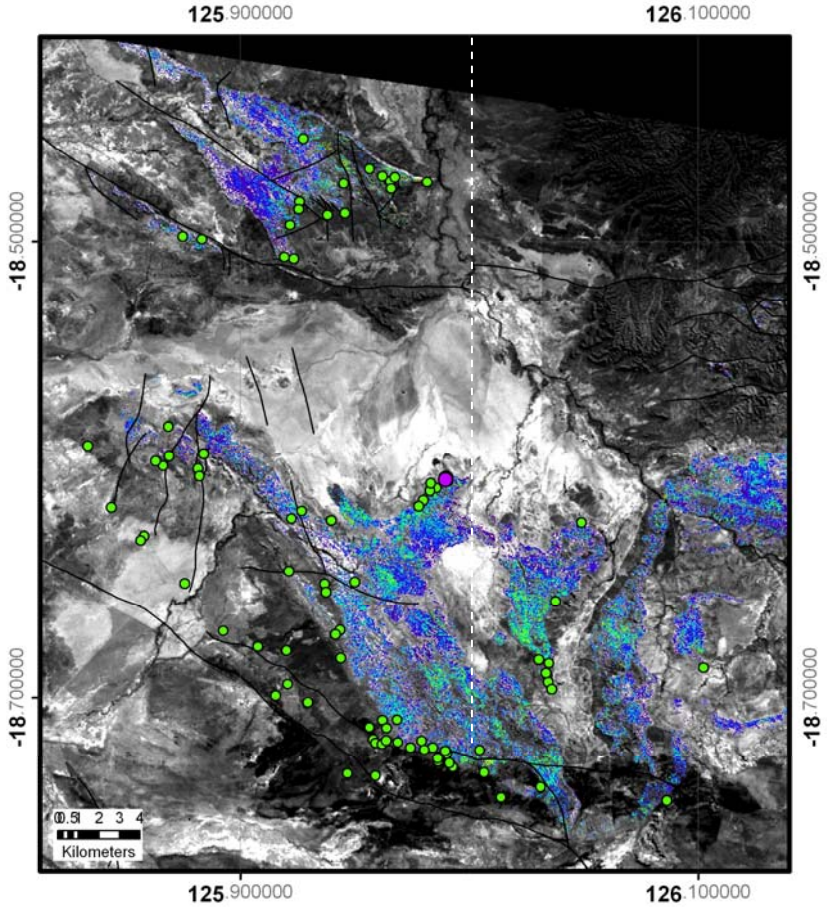
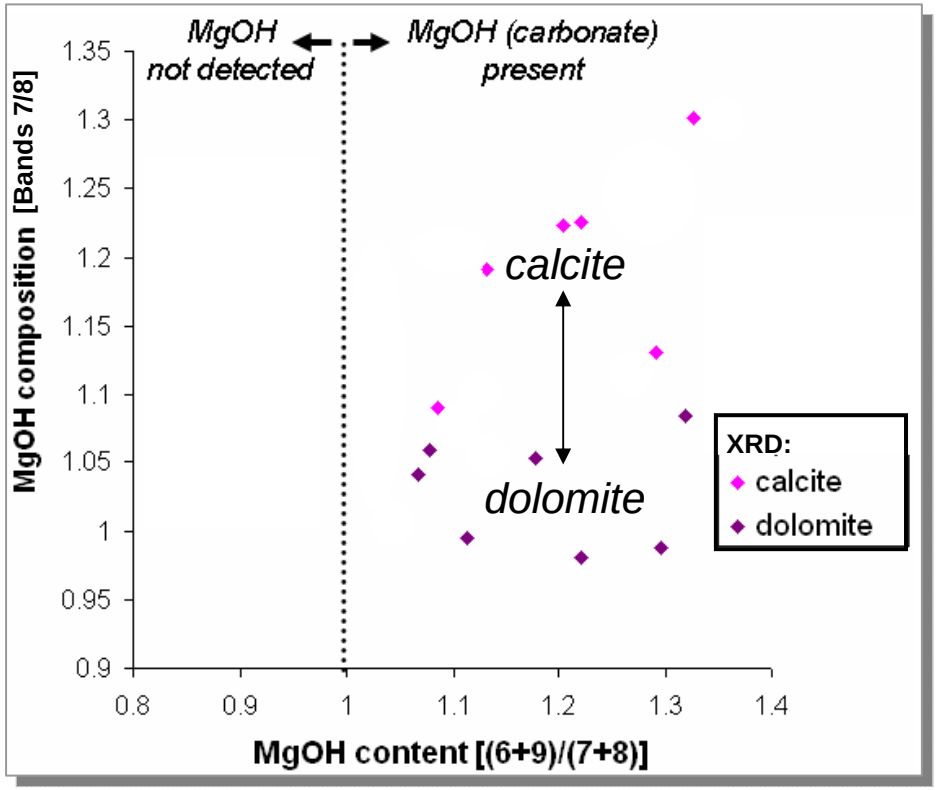


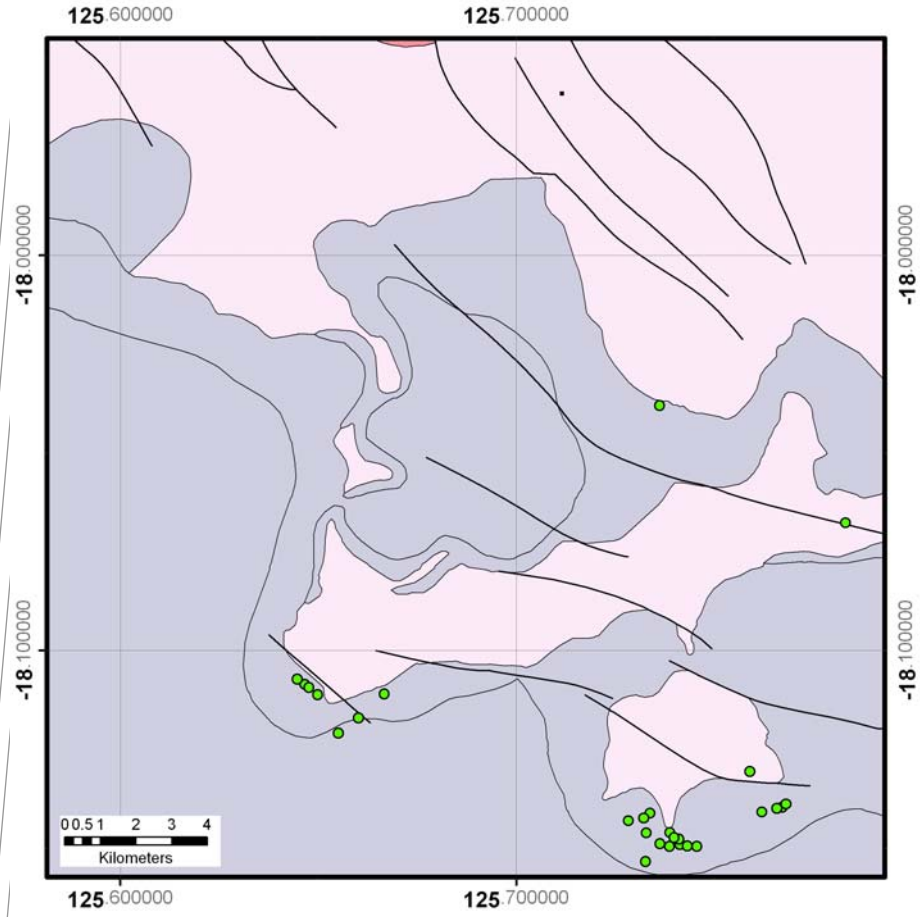


modified after Fig. 24 - Cudahy et al, 2008. GSQ North Qld Project Final report

Application of ASTER for mapping and exploration in the Canning Basin - Fossil Downs area MVTs:

MVTs at contact between foot wall limestones and hanging wall calcarenite/siltstone

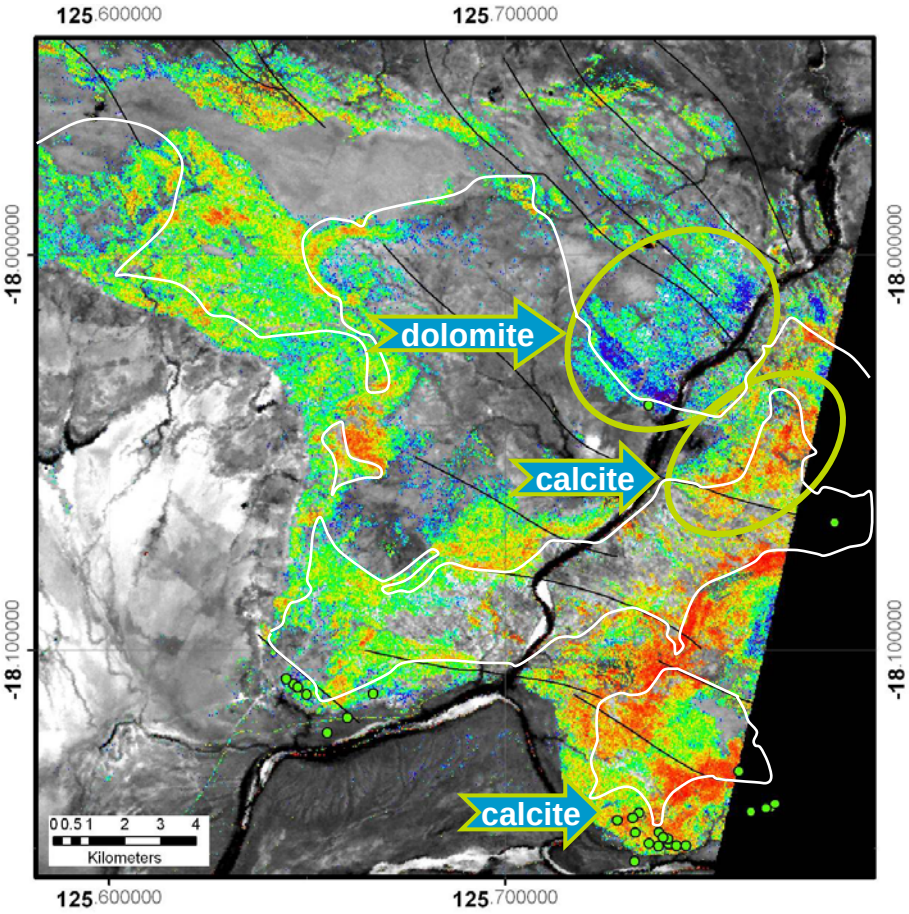
Geological Map 500K



MgOH composition index

dolomite — calcite

in carbonate rocks



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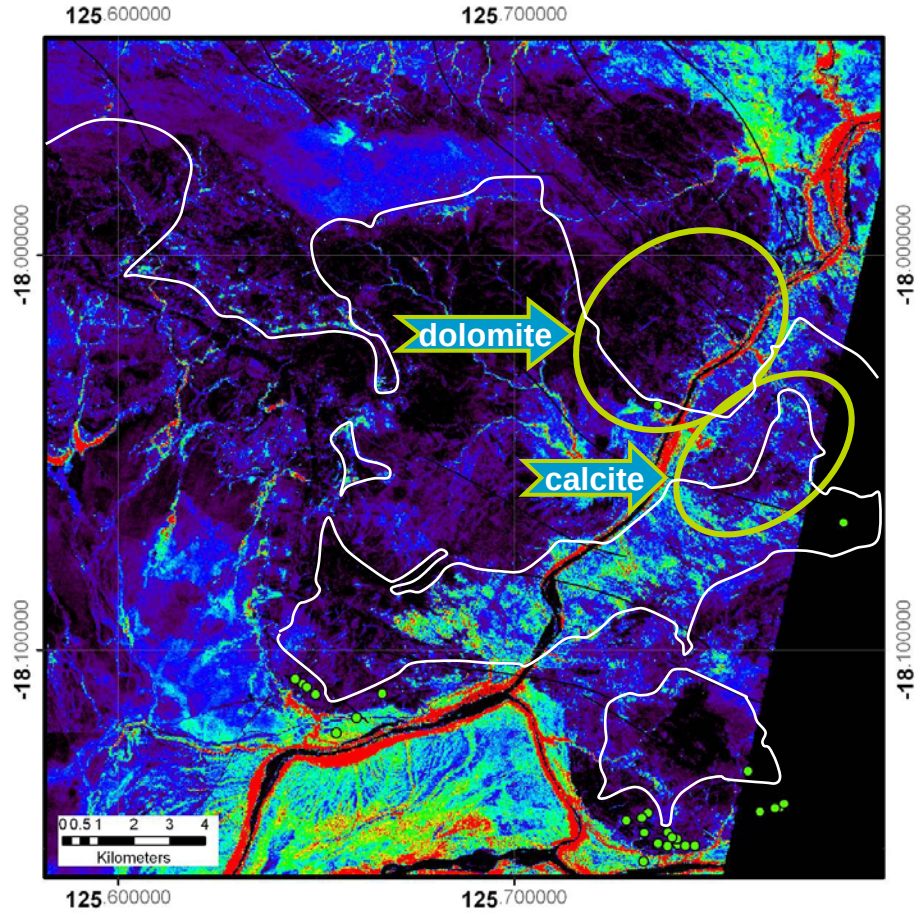
Application of ASTER for mapping and exploration in the Canning Basin - Fossil Downs area MVTs:

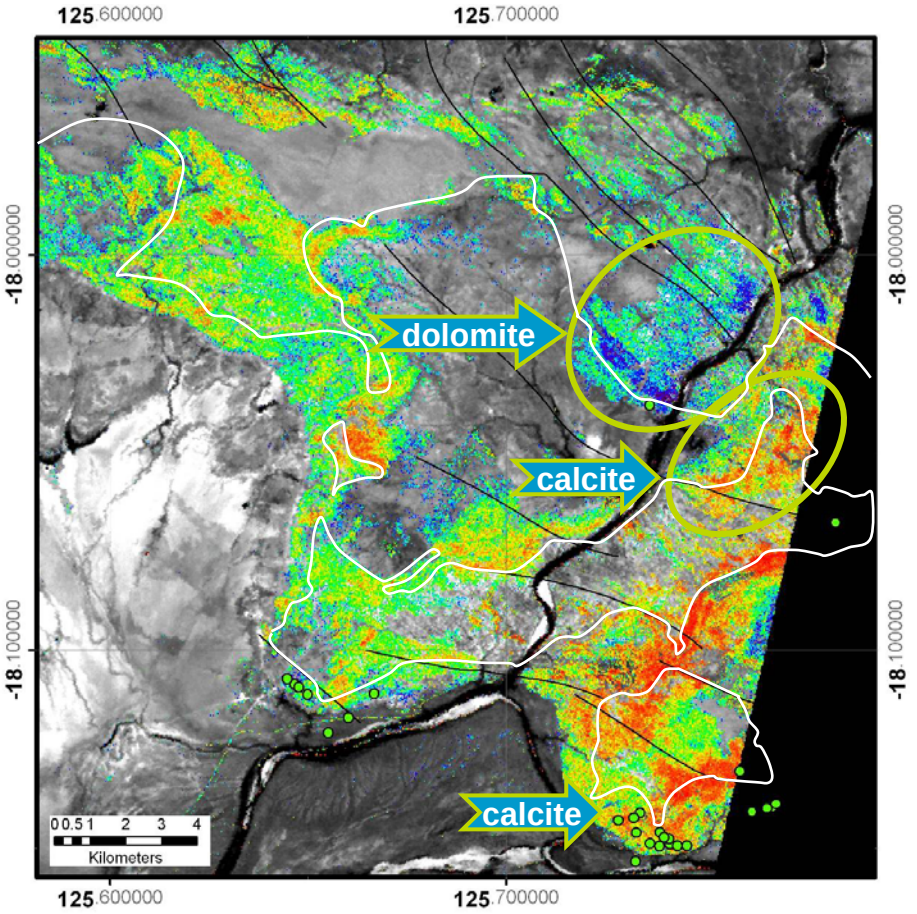
Green veg. abundance index

low — high



MgOH composition index

dolomite — calcite
in carbonate rocks



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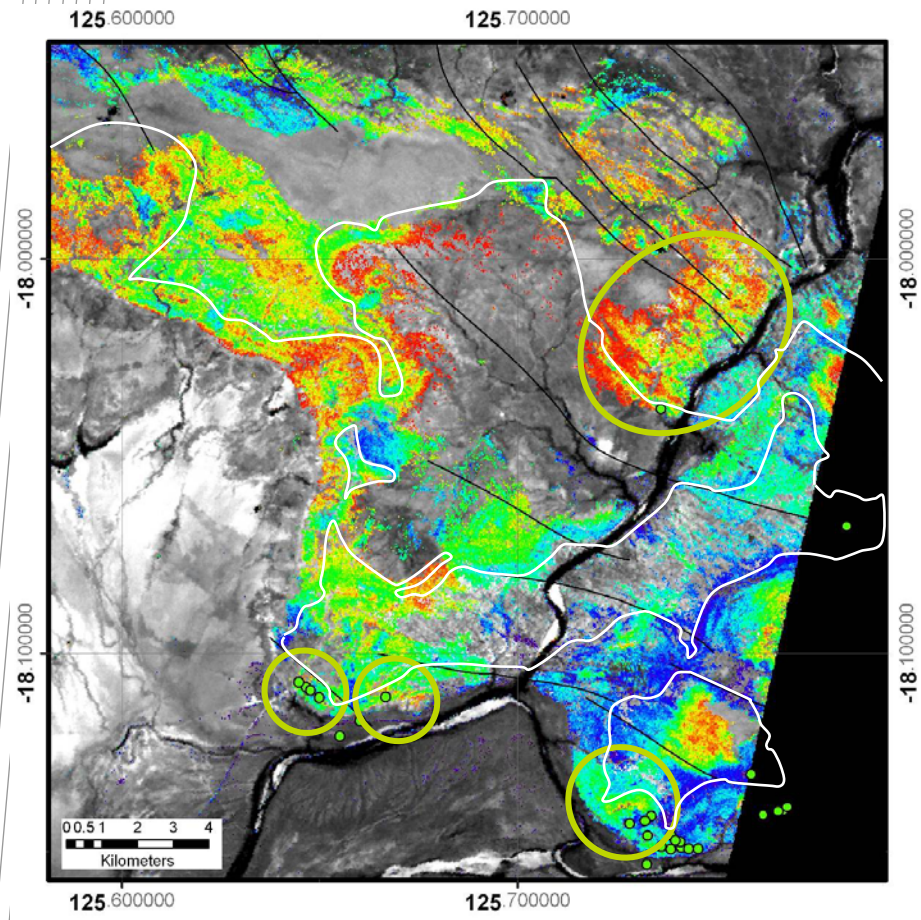
Application of ASTER for mapping and exploration in the Canning Basin - Fossil Downs area MVTs:

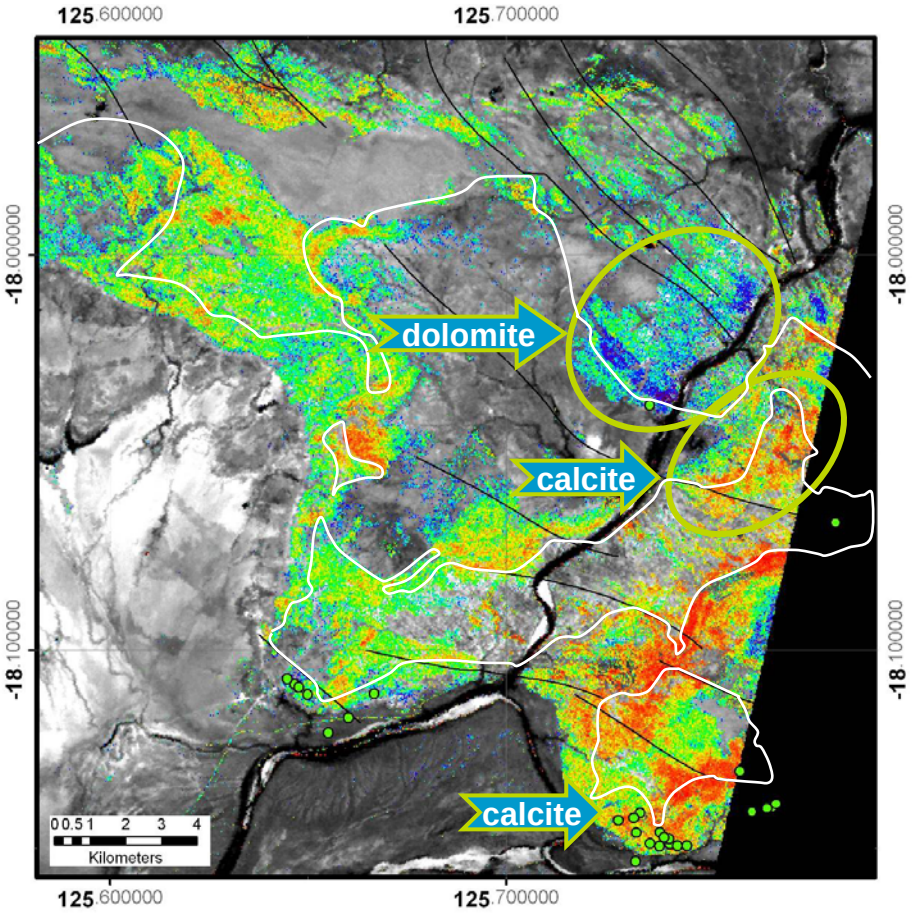
Ferrous iron abundance index

low high



MgOH composition index

dolomite calcite
in carbonate rocks



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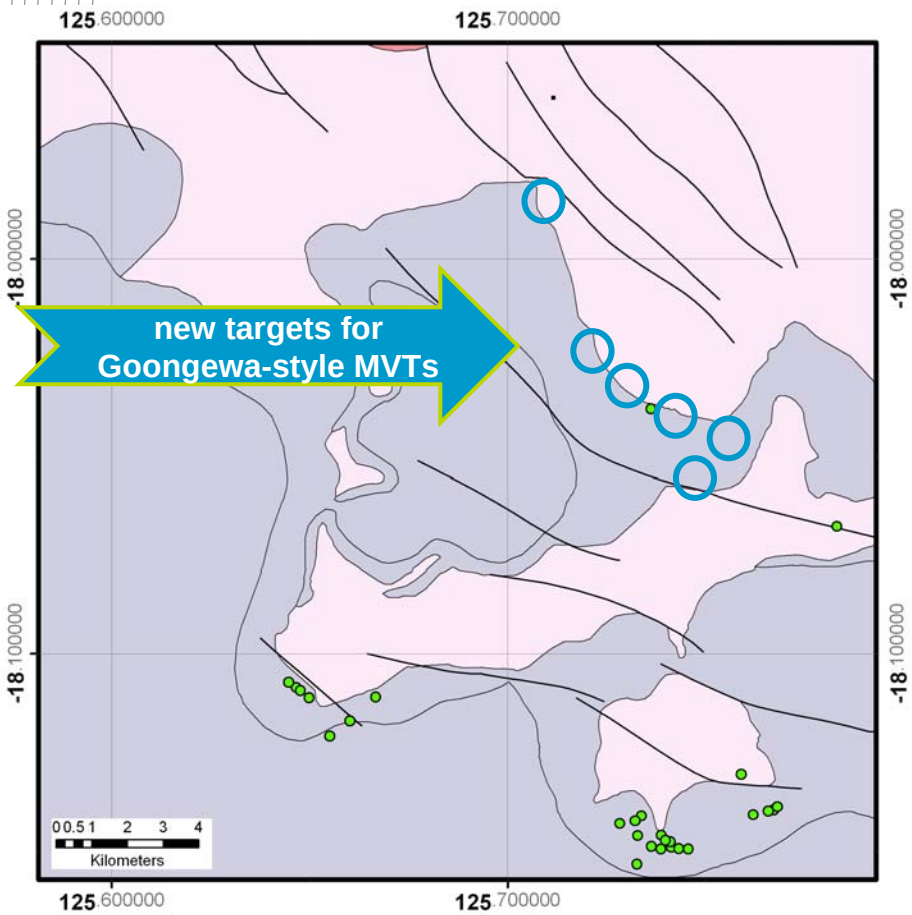
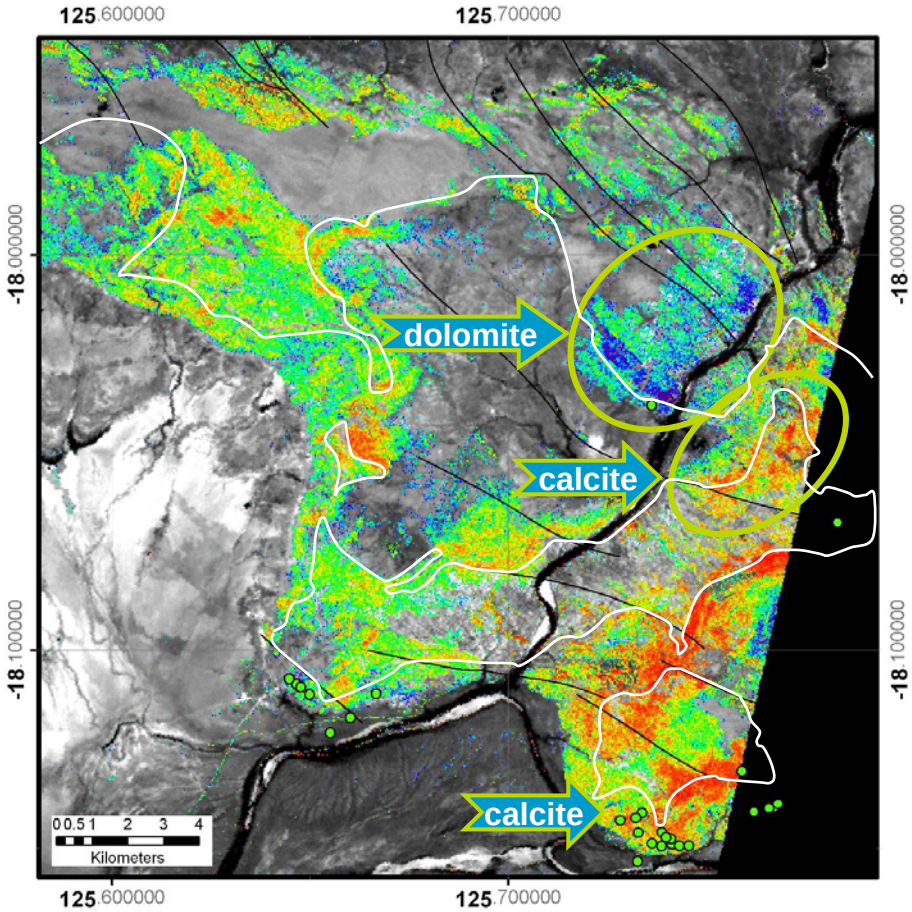
Application of ASTER for mapping and exploration in the Canning Basin - Fossil Downs area MVTs:

Geological Map 500K



MgOH composition index

dolomite — calcite
in carbonate rocks



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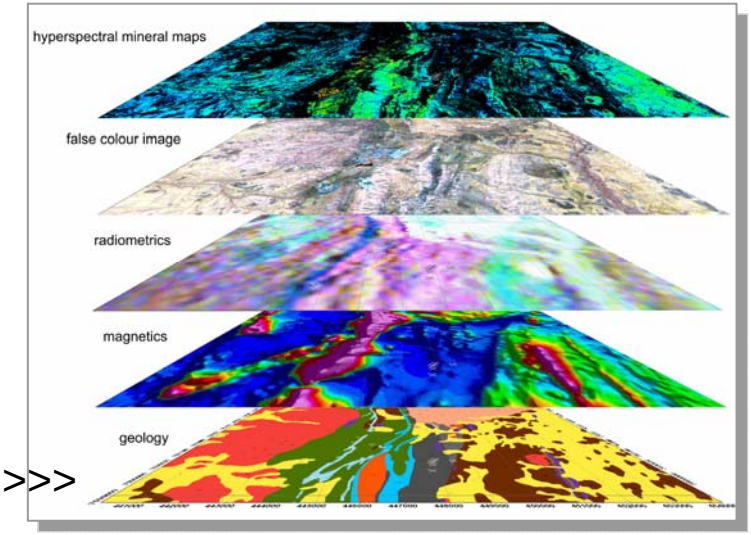
Conclusions

WA ASTER Map:

- Mapping:
  - Geology
  - Regolith
  - Hydrothermal alteration
- Exploration (MVTs, Archean Au, ...)
- Integration with other geoscience data sets >>>



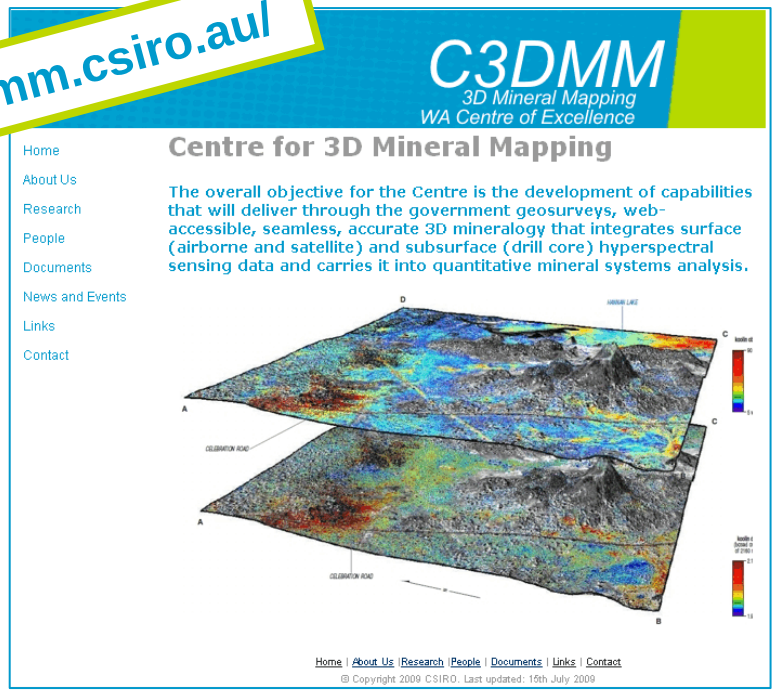
GSWA ASTER workshop

2 day hands-on workshop end of March 2011

- ENVI processing of L2 (reflectance mosaic), intermediate .bsq and final full masked products
- Application of ASTER products in GIS environment (ArcGIS) including comparison with published geology, geophysics, airborne hyperspectral and other available geoscience data
- Geoscience product accuracy issues

CSIRO

http://c3dmm.csiro.au/



www.csiro.au

Thank you

C3DMM

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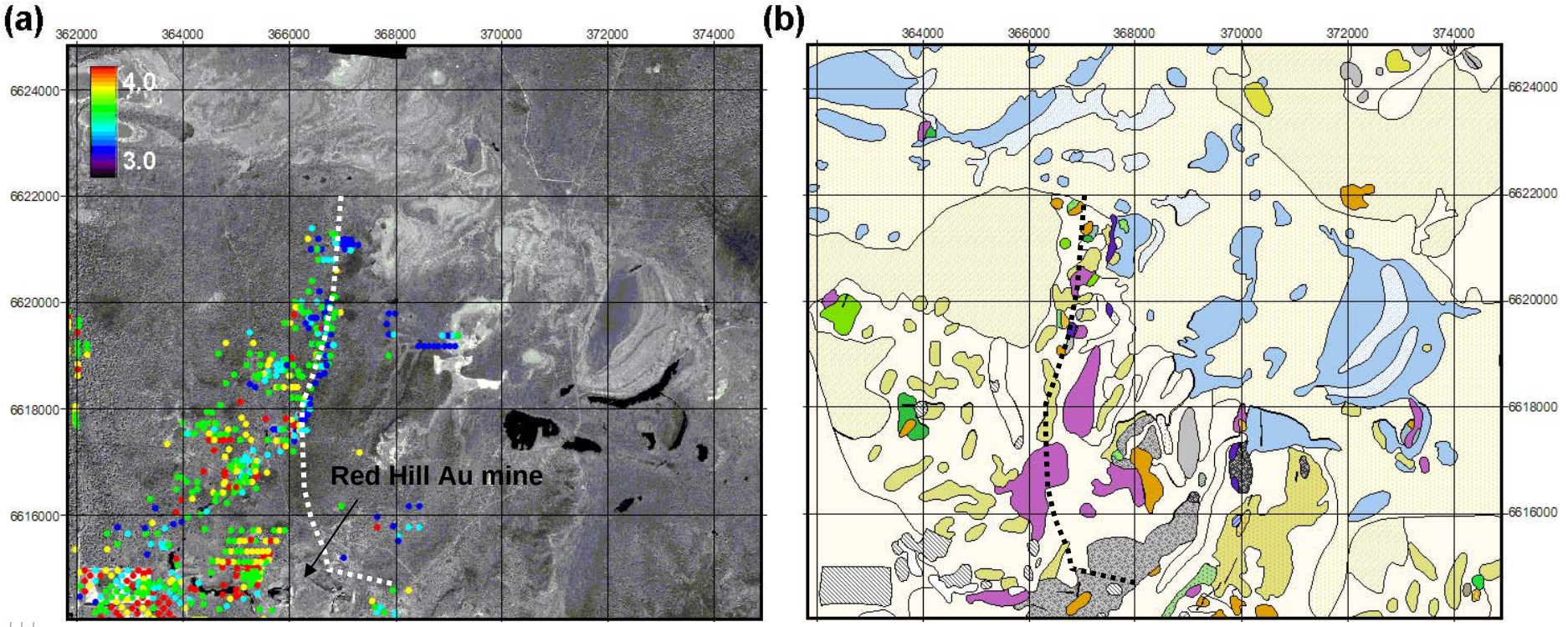
CSIRO

AlOH group composition – Hymap validation

Fig. 57 - Cudahy et al, 2005. MERIWA M370 Project Final report

Barrick's BOH PIMA mica composition

GSWA published 100K geology



- Fresh rock spectra show apparent large white mica composition gradient change (across dotted line), except in UM rocks (purple)
- Al-rich in E and Si-rich in W/SW, including associated with Au deposits

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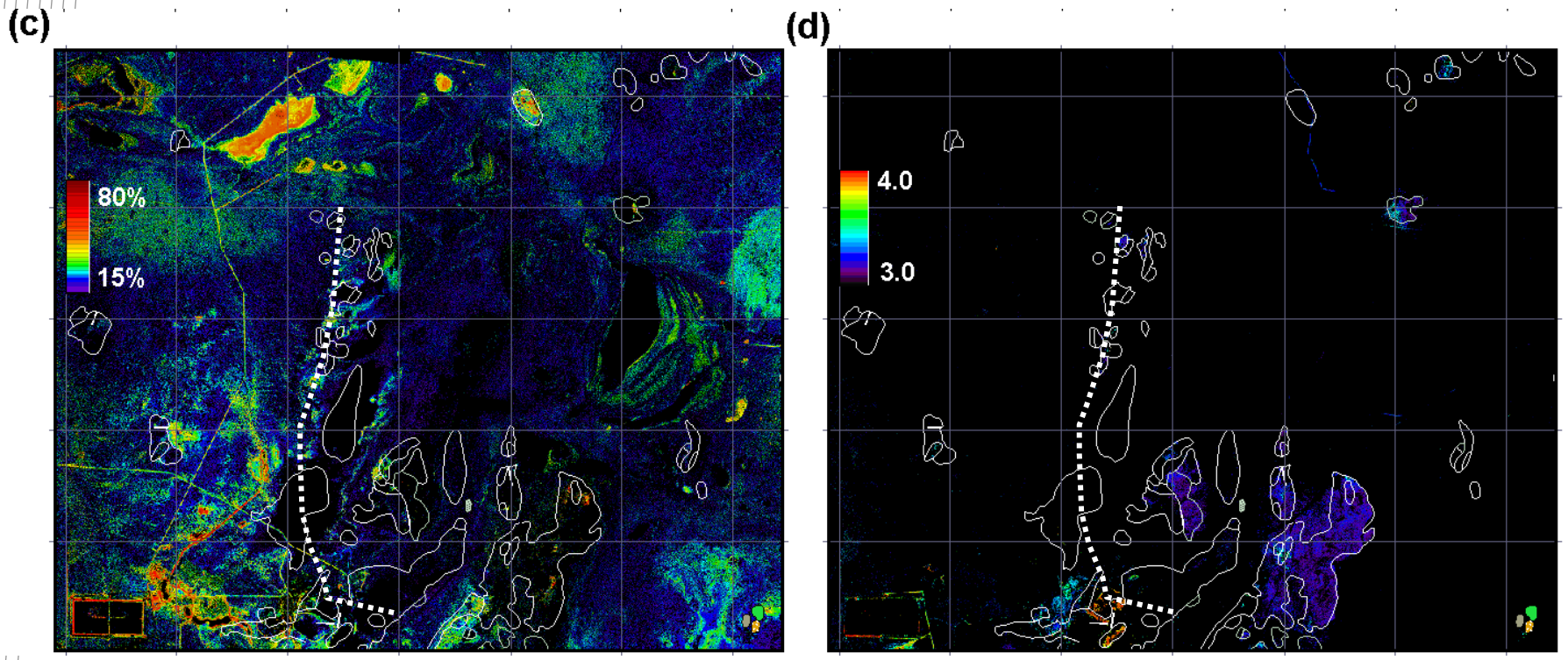
AlOH group composition – Hymap validation

Fig. 57 - Cudahy et al, 2005. MERIWA M370 Project Final report

Hymap kaolin abundance

HyMap white mica composition



Detailed airborne hyperspectral data maps:

- pervasive development of kaolin (AlOH clay) in regolith
- white mica information in exposed “felsic rock” including similar pattern as BOH PIMA (previous slide) and open pit Au mine (Si-rich mica)

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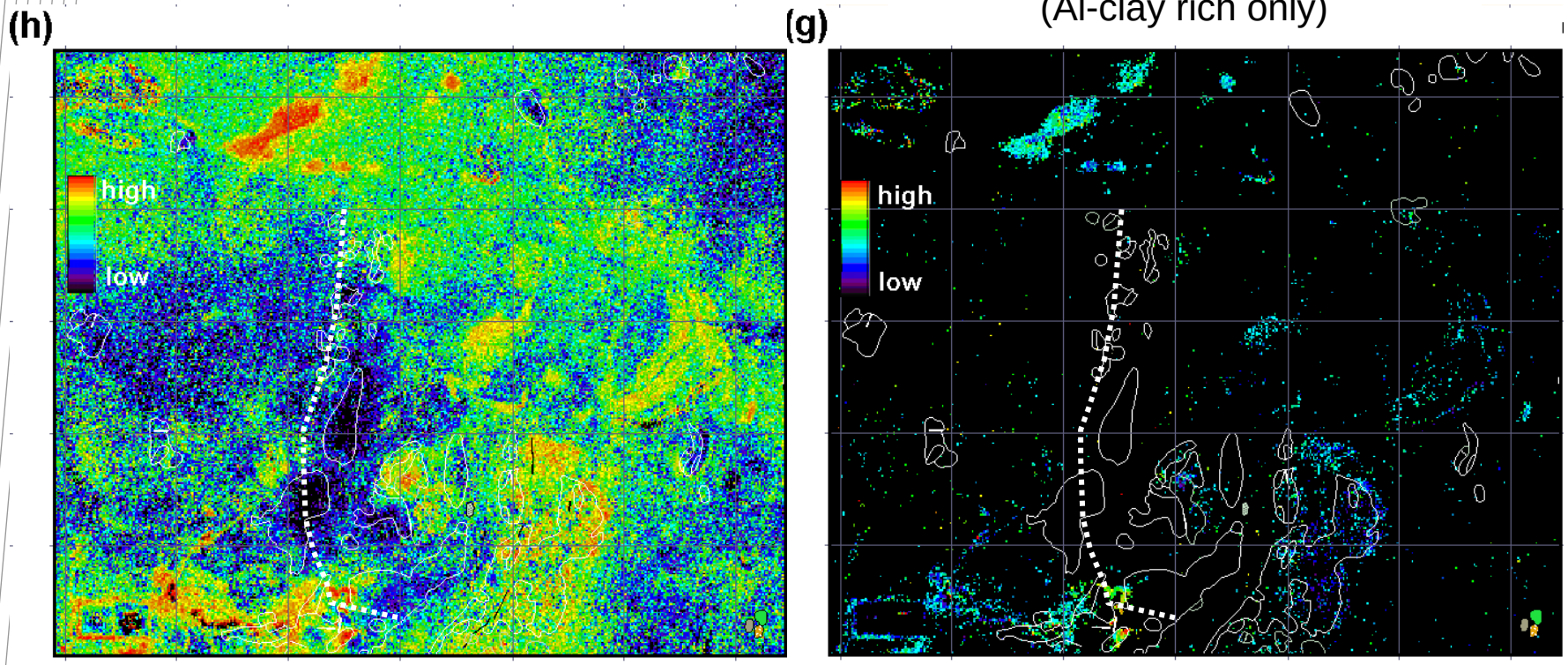
AlOH group composition – Hymap validation

Fig. 57 - Cudahy et al, 2005. MERIWA M370 Project Final report

ASTER AlOH group content

ASTER AlOH composition
(Al-clay rich only)



- ASTER products show pervasive AlOH clay, both in regolith and “fresh rock”
- Assuming (1) white mica is from Al-clay-rich only; and (2) 6/5 ratio can be used to isolate kaolin-rich Al-OH pixels, then a ***masked*** map of white mica composition with some corre;ation with PIMA and HyMap is acheivable

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