



<http://www.uncoverminerals.org.au/>

# Queensland's Version 2 ASTER mineral maps unmixed of the effects of green and dry vegetation

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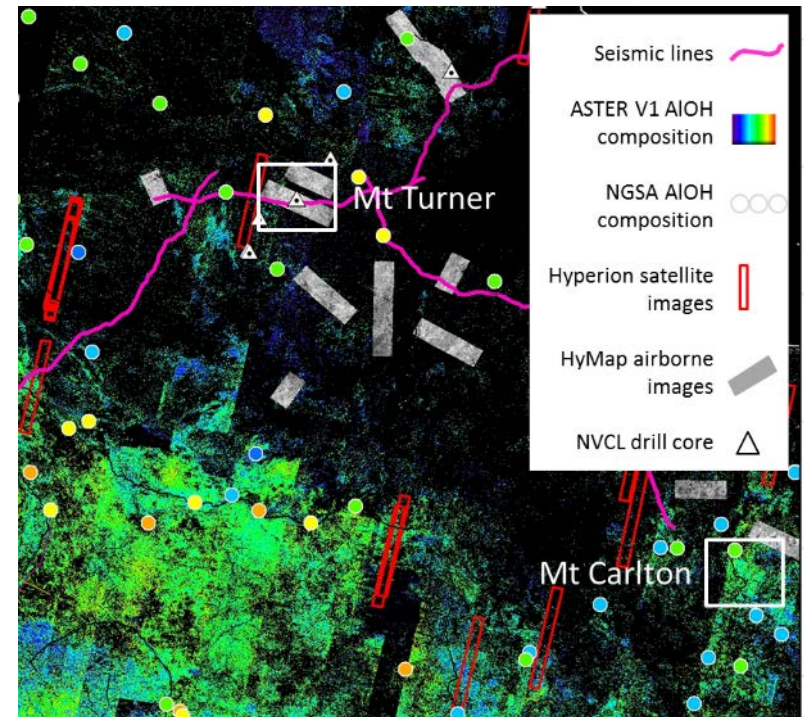
<sup>1</sup> CSIRO; <sup>2</sup> C3DMM Pty Ltd; <sup>3</sup> Geological Survey of Queensland; <sup>4</sup> Tenth Symphony Pty. Ltd

MINERAL RESOURCES FLAGSHIP  
[www.csiro.au](http://www.csiro.au)

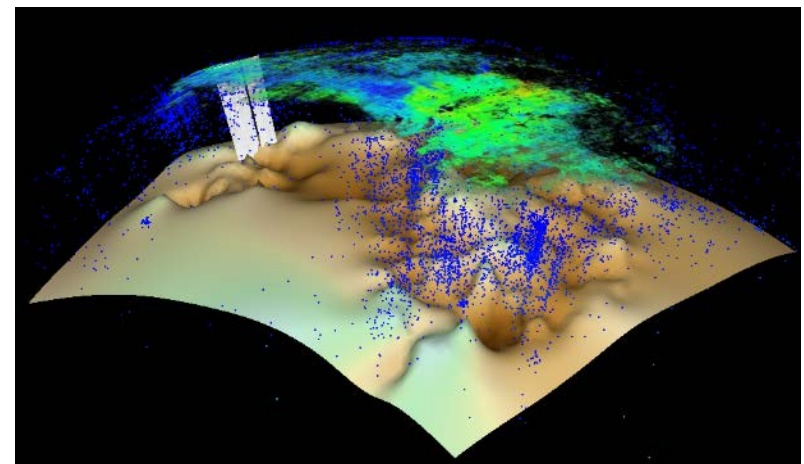


# Project Background

- 2 year collaborative CSIRO-GSQ project (and JCU and GA)
  - Industry Priorities Initiative, Queensland Government's Future Resources Program
  - Dec 2004 to Dec 2006
- Why do the work?
  - Explorers empowered with spectral-mineralogy (measurable regolith, geology and alteration geoscience information)
  - Improve the mineral information content of the published ASTER Version 1 products
  - Integrate the public spectral-mineral data collected from different sensor data types
  - Scalable (State to deposit scales) 3D mineral information
- Broader implications
  - Extend products/methods nationally/globally
  - Combine public and private spectral data



[www.ga.gov.au/data-pubs/interactive-3d-models/world-wind-3d-data-viewer](http://www.ga.gov.au/data-pubs/interactive-3d-models/world-wind-3d-data-viewer)



# Project public spectral data

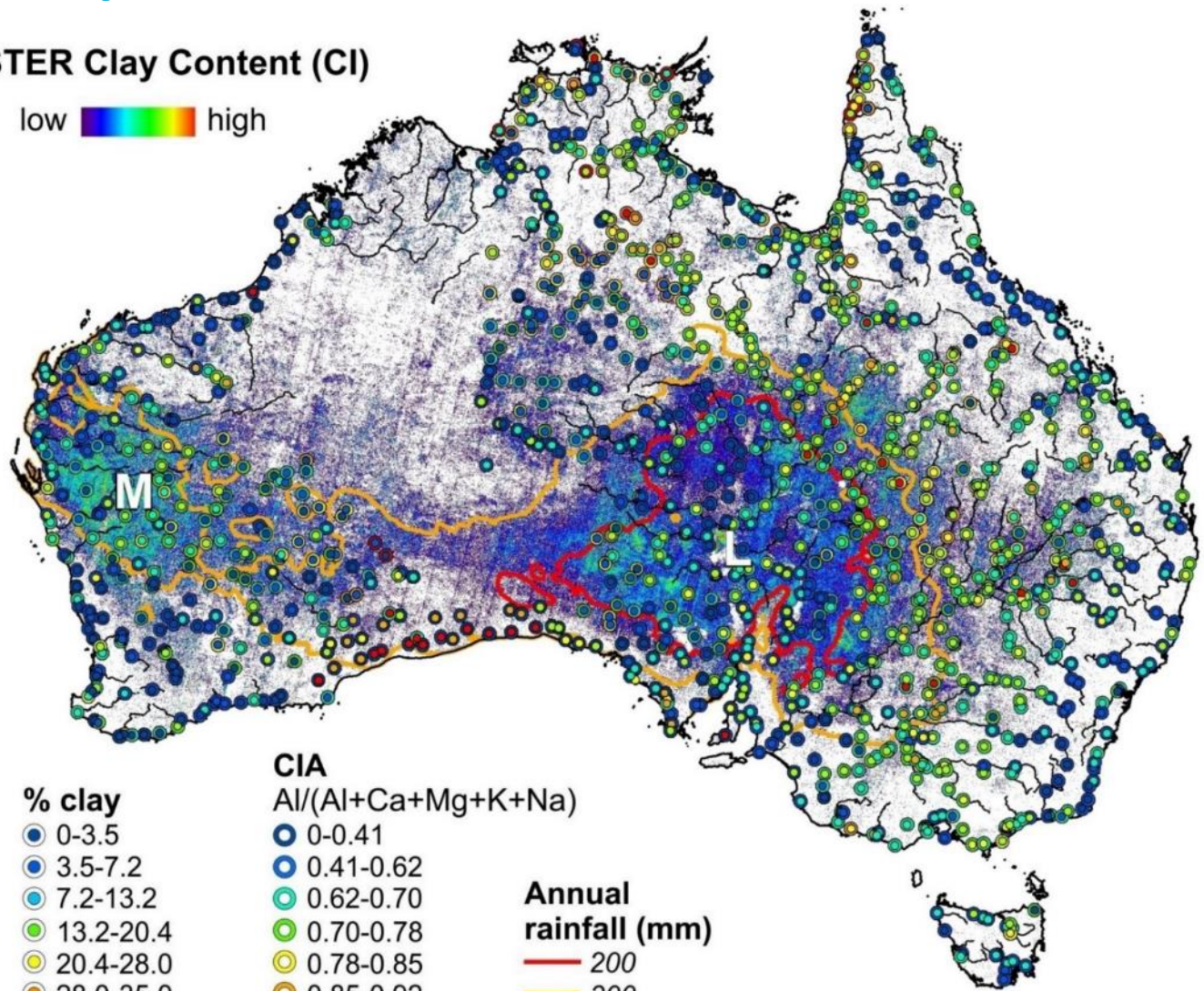
- ~800 satellite ASTER multispectral VNIR-SWIR-TIR images (each image being 60 by 60 km with both 30 and 90 m pixel footprints, i.e. provides complete state coverage at two spatial scales);
- An archive ~100 satellite Hyperion hyperspectral VNIR-SWIR images with each image being ~7 by 100 km, i.e. a total 60,000 km<sup>2</sup> or ~3% state coverage.
- An archive ~250 airborne hyperspectral VNIR-SWIR HyMap flight-lines from a GSQ survey in 2006-2008 (Cudahy *et al.*, 2008) with each flight-line being ~2.5 by 20 km and covering ~25,000 km<sup>2</sup> across northern Queensland;
- ~300 field spectrometer (ASD Fieldspec) (VNIR-SWIR) and laboratory FTIR (Bruker Vertex 70/80v with an integrating sphere) (TIR) measured by CSIRO from the National Geochemical Survey of Australia (NGSA) sample suite; and
- ~20 NVCL hyperspectral VNIR-SWIR-TIR drill-cores were selected from the Georgetown seismic line (07GA-IG2).



# ASTER AIOH Group content V1

## ASTER Clay Content (CI)

low  high



## NGSA validation data

<http://www.ga.gov.au/about/projects/minerals-archive/concluded/national-geochemical-survey>

### % clay

- 0-3.5
- 3.5-7.2
- 7.2-13.2
- 13.2-20.4
- 20.4-28.0
- 28.0-35.0
- 35.0-56.0

### CIA

$Al/(Al+Ca+Mg+K+Na)$

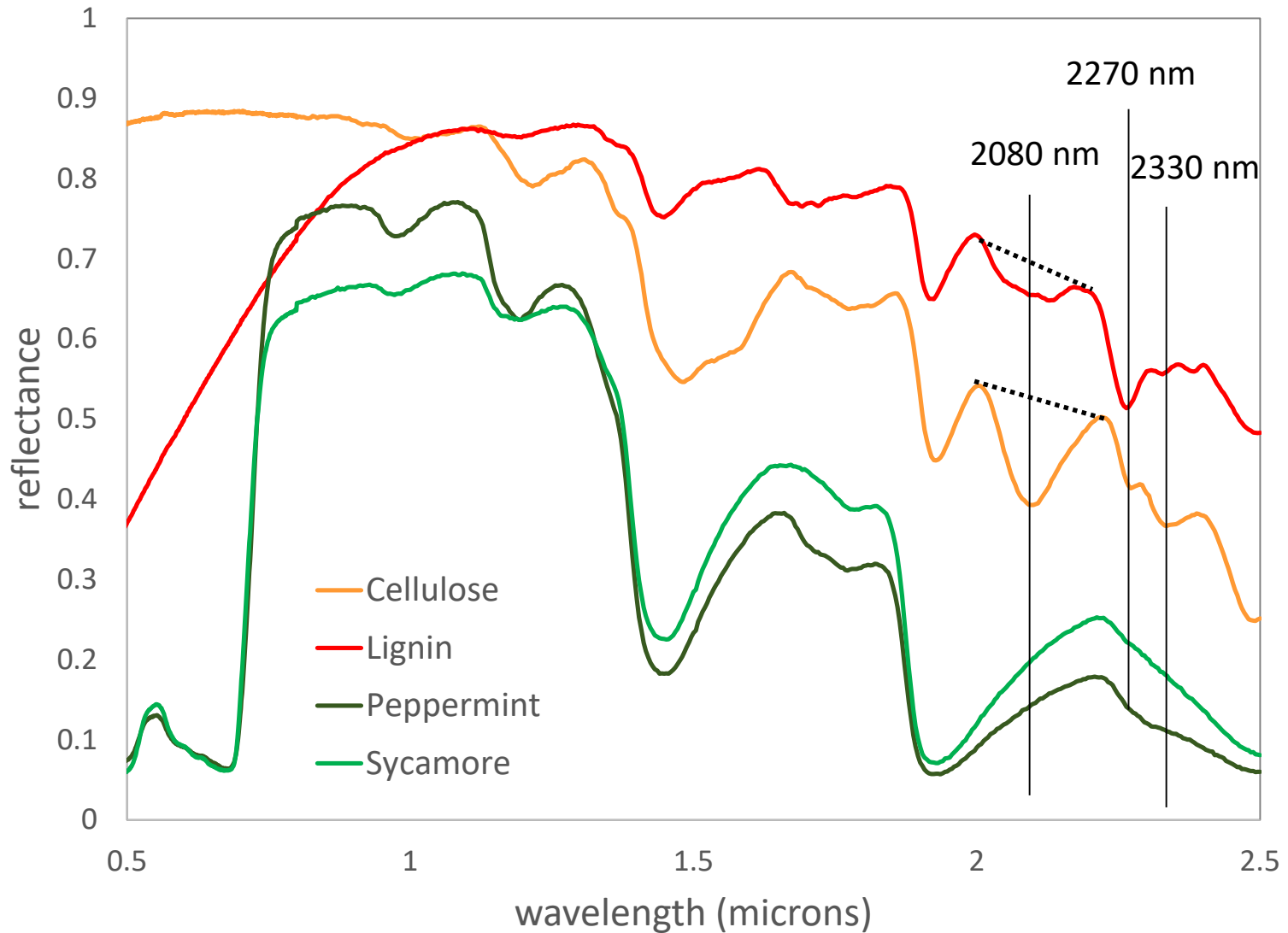
- 0-0.41
- 0.41-0.62
- 0.62-0.70
- 0.70-0.78
- 0.78-0.85
- 0.85-0.92
- 0.92-0.99

### Annual rainfall (mm)

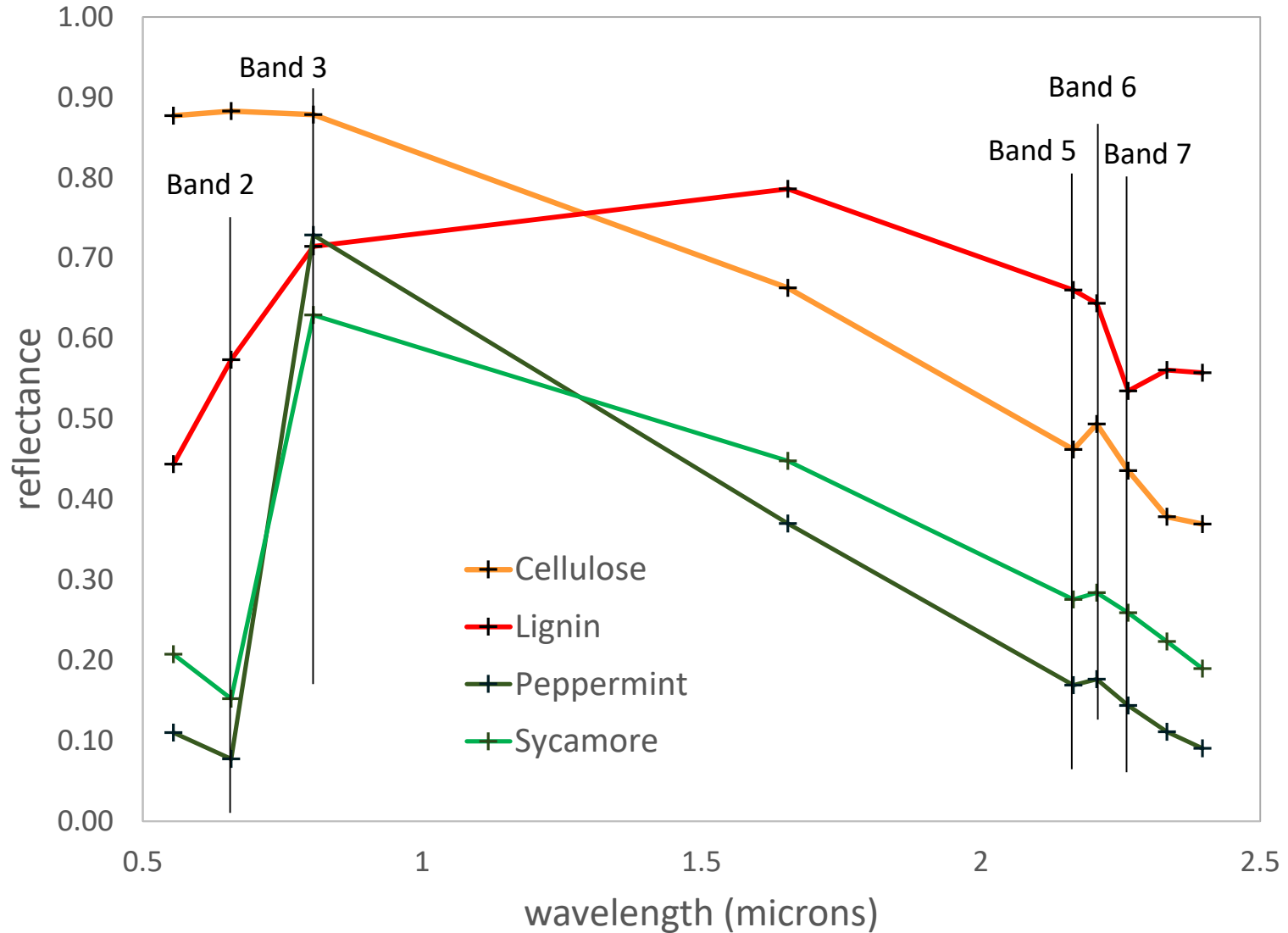
- 200
- 300

Cudahy et al., 2016; <http://www.nature.com/articles/srep23702>

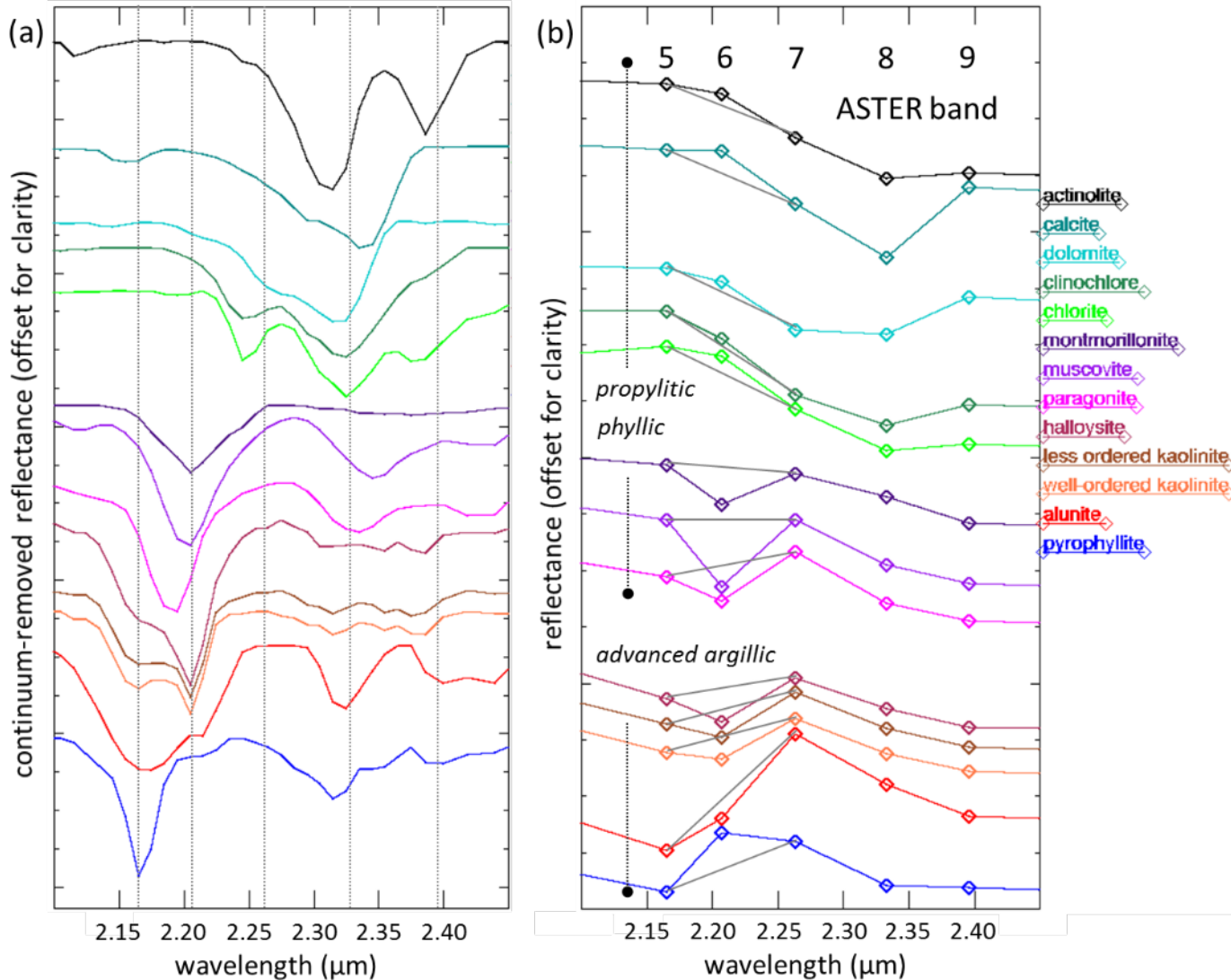
# USGS Library @ hyperspectral resolution



# USGS Library @ ASTER spectral resolution



# Mineral Mapping - 10 vs 40 nm spectral resolution

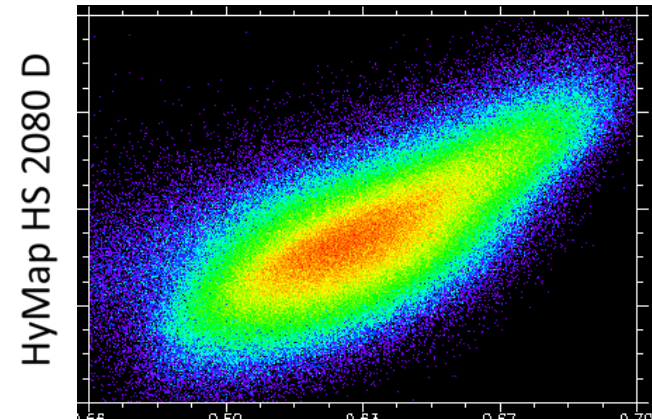
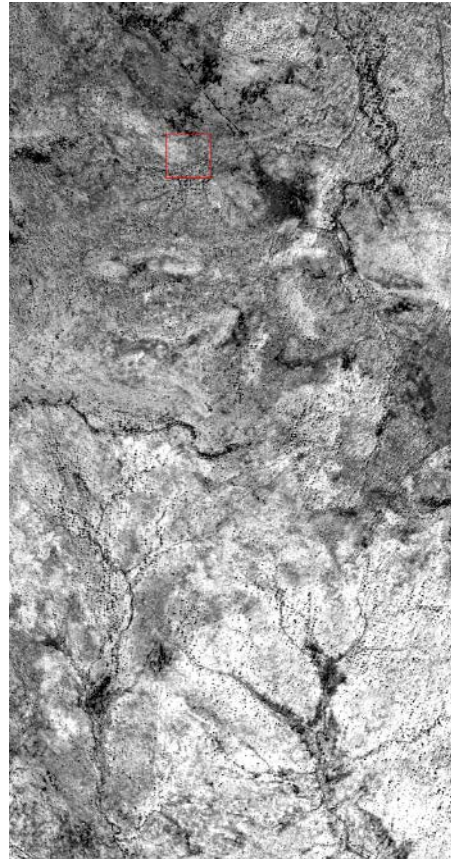
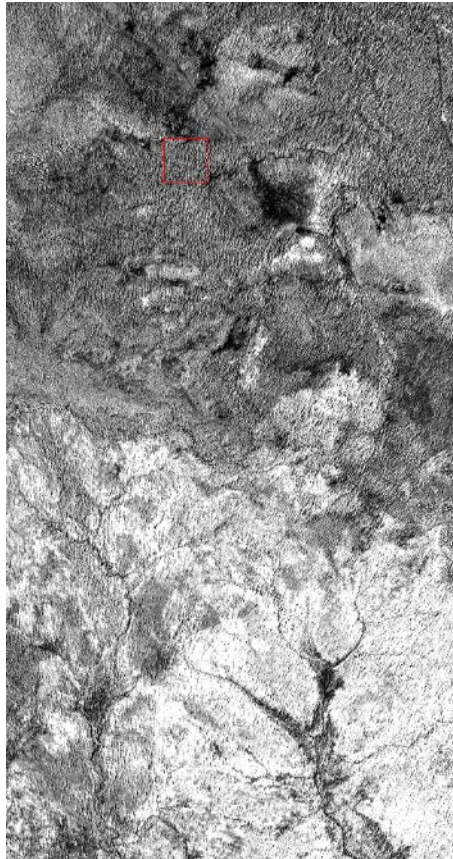




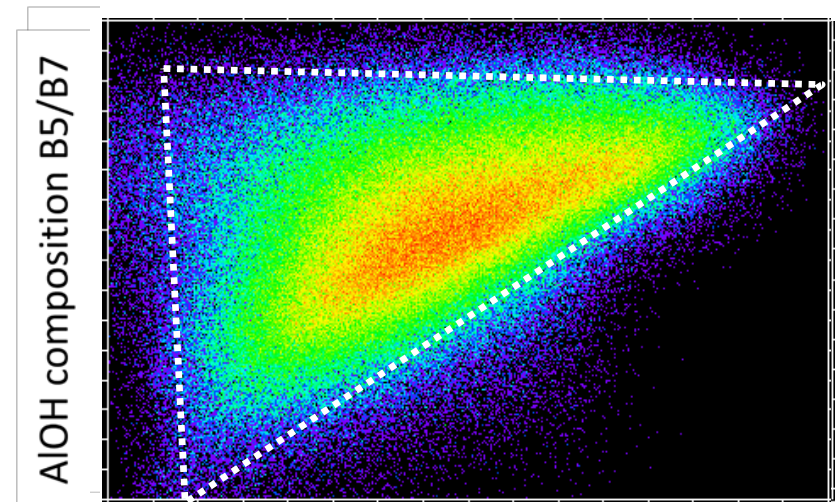
# Estimation of dry vegetation @ASTER spectral resolution

HyMap HS 2080 nm  
continuum-depth

HyMap @ASTER  
dry vege index



ASTER dry vege index

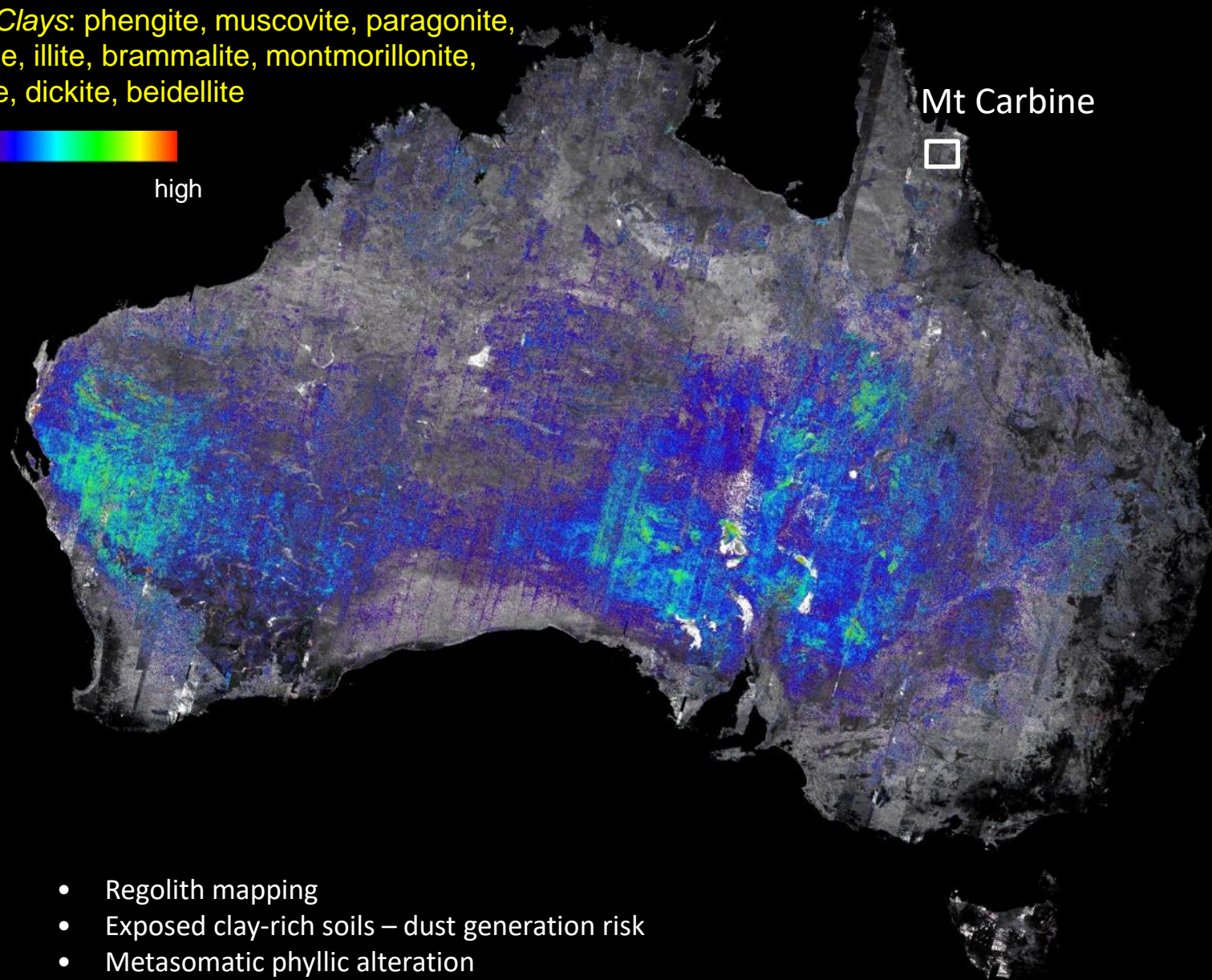
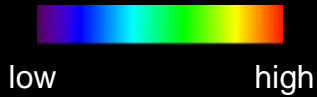


ASTER dry vege index



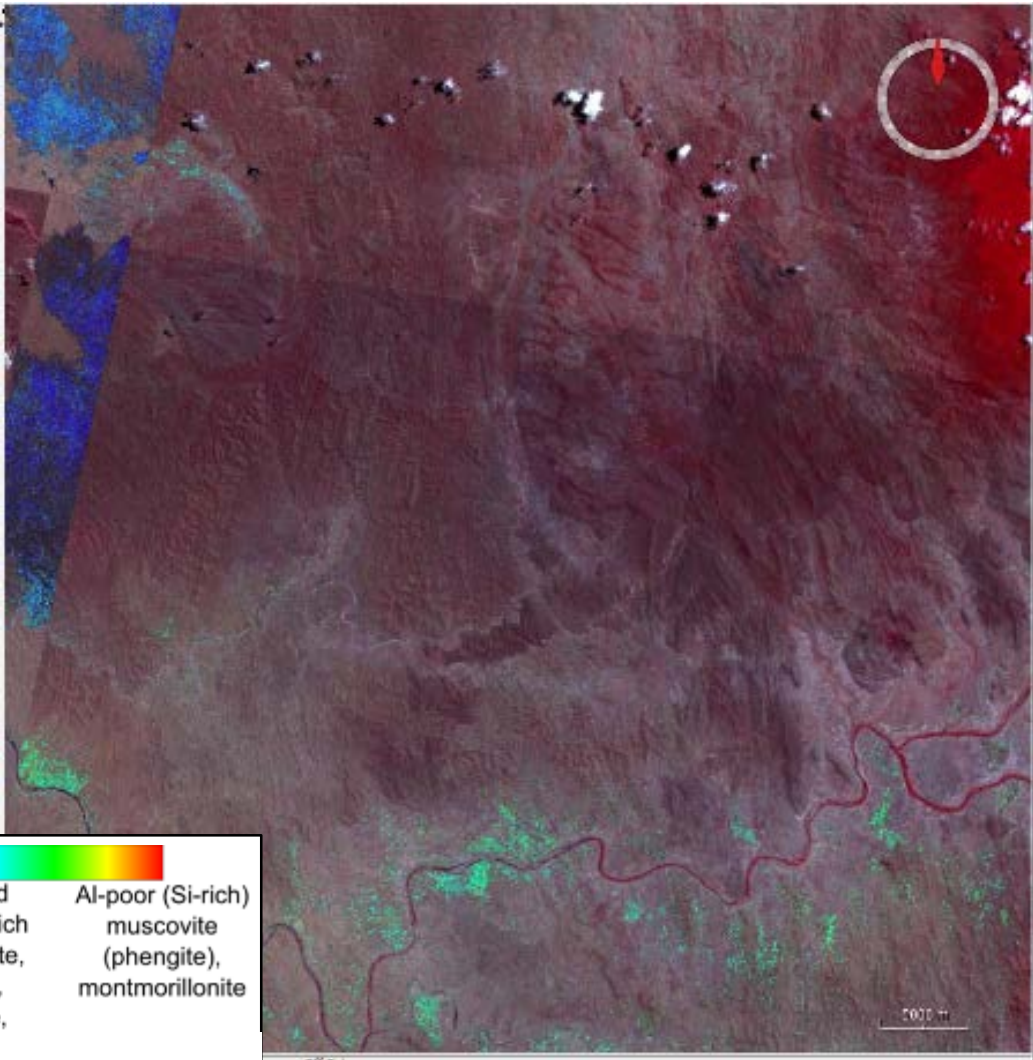
# V1 ASTER AIOH group content

e.g. *Al-Clays*: phengite, muscovite, paragonite, lepidolite, illite, brammalite, montmorillonite, kaolinite, dickite, beidellite



- Regolith mapping
- Exposed clay-rich soils – dust generation risk
- Metasomatic phyllic alteration

# Mt Carbine - ASTER V1 ALOH group composition

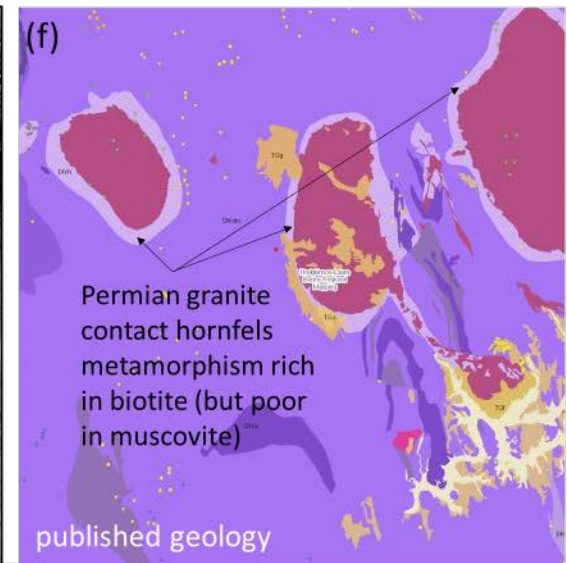
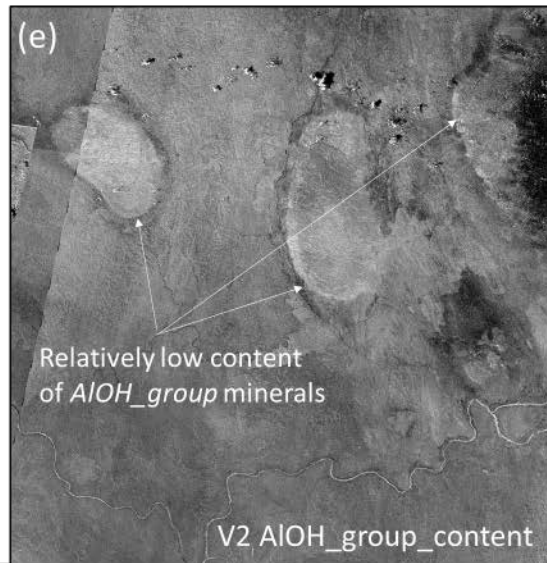
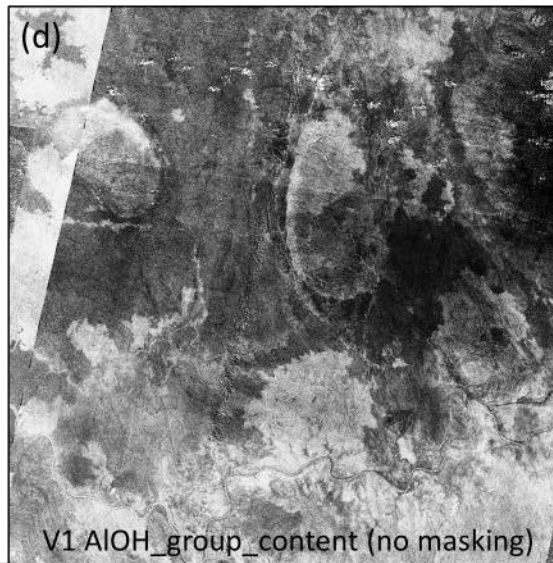
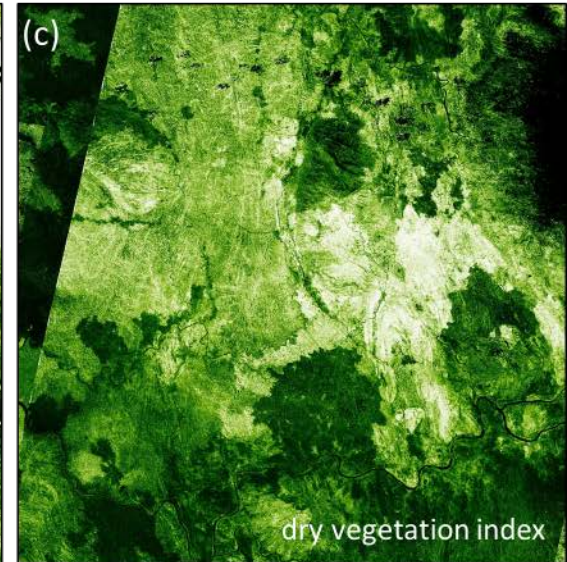
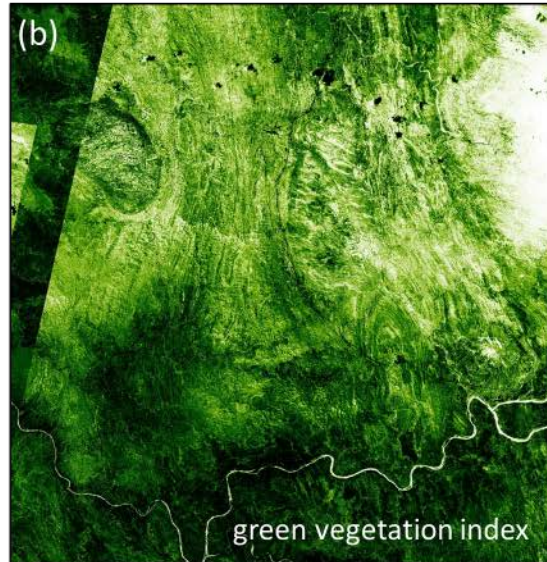
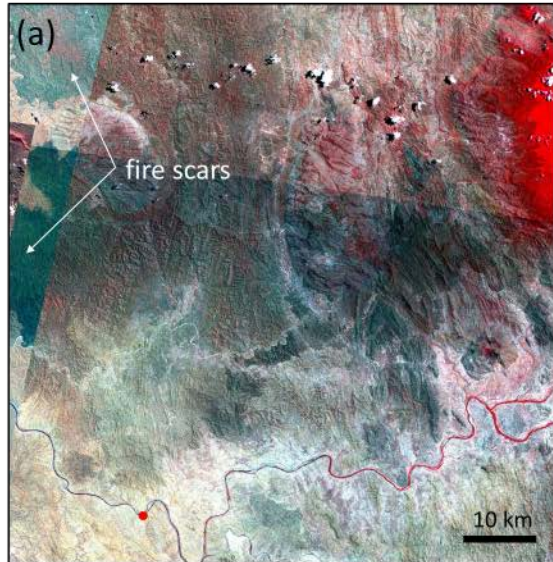


<http://portal.geoscience.gov.au/gmap.html>





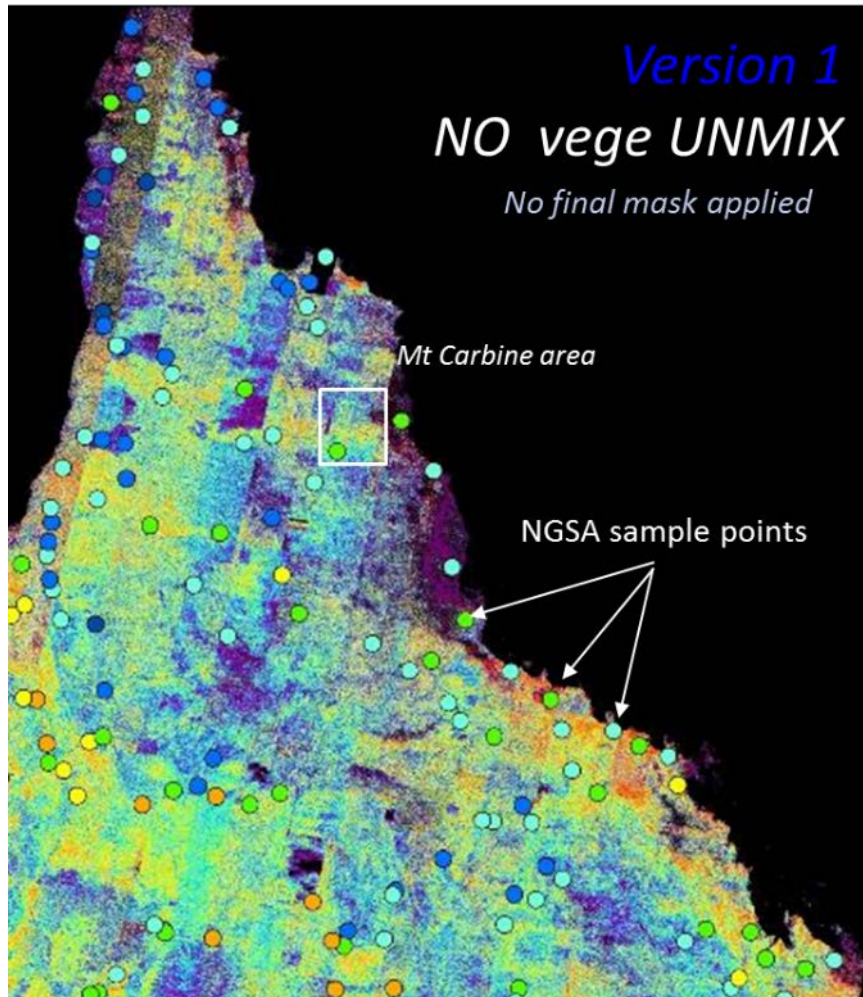
# V2 vegetation unmixing – Mt Carbine area



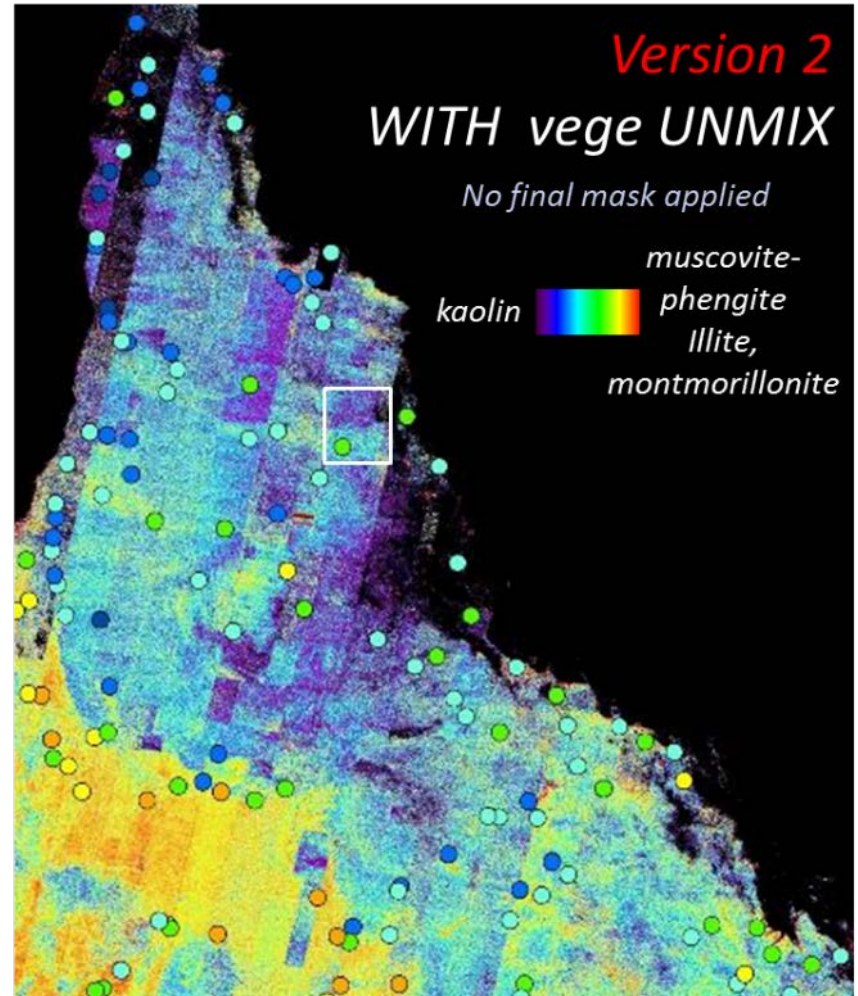
Cudahy 2016, <http://www.mdpi.com/2076-3263/6/4/52>



# NGSA validation of ASTER AIOH Composition



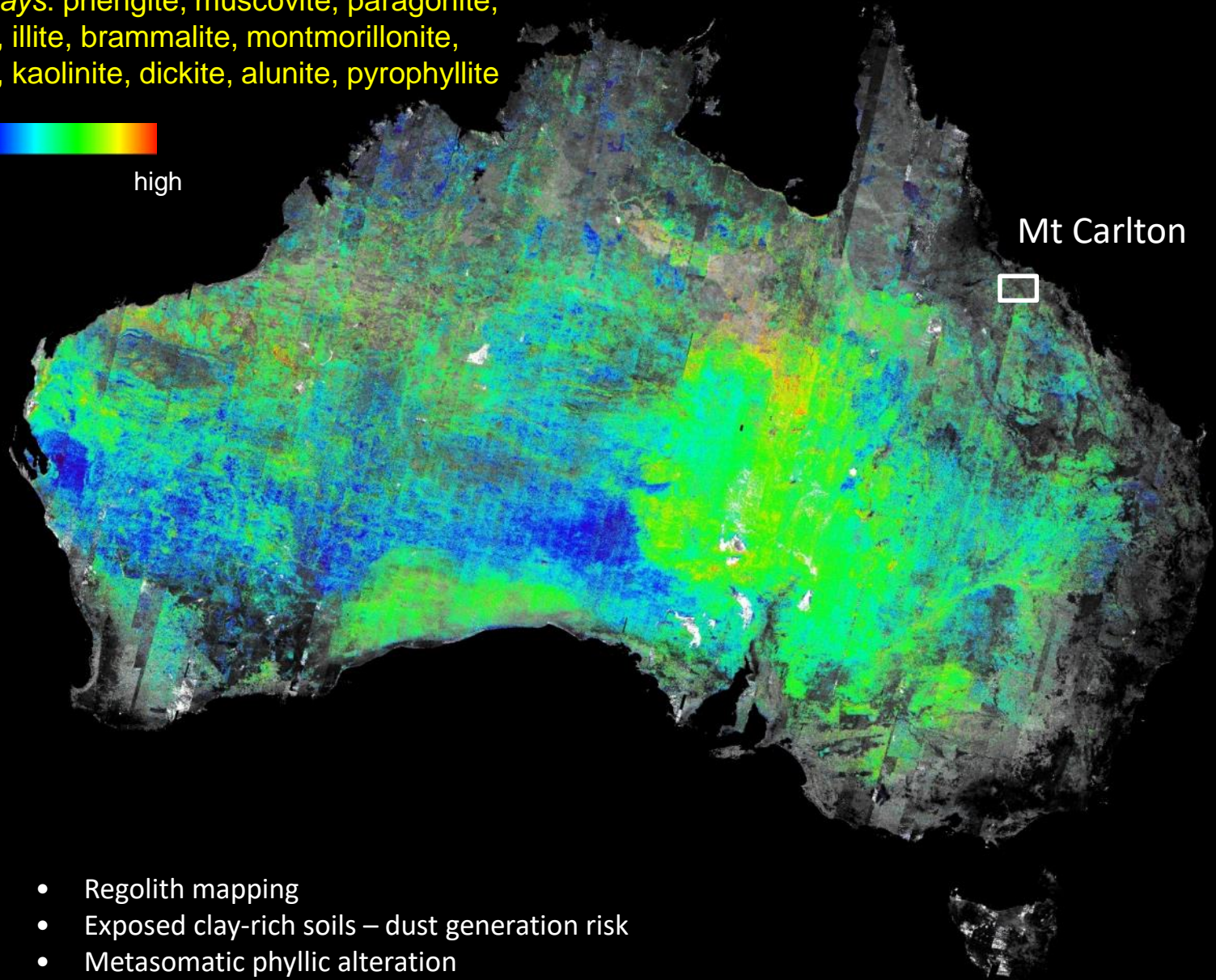
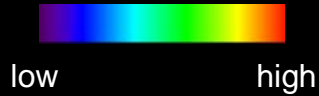
$R^2=0.09$



$R^2=0.31$

# V1 ASTER AIOH group composition

e.g. *Al-Clays*: phengite, muscovite, paragonite, lepidolite, illite, brammalite, montmorillonite, beidellite, kaolinite, dickite, alunite, pyrophyllite



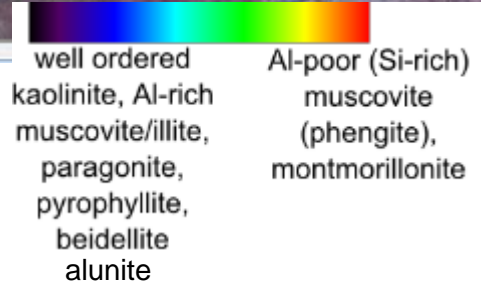
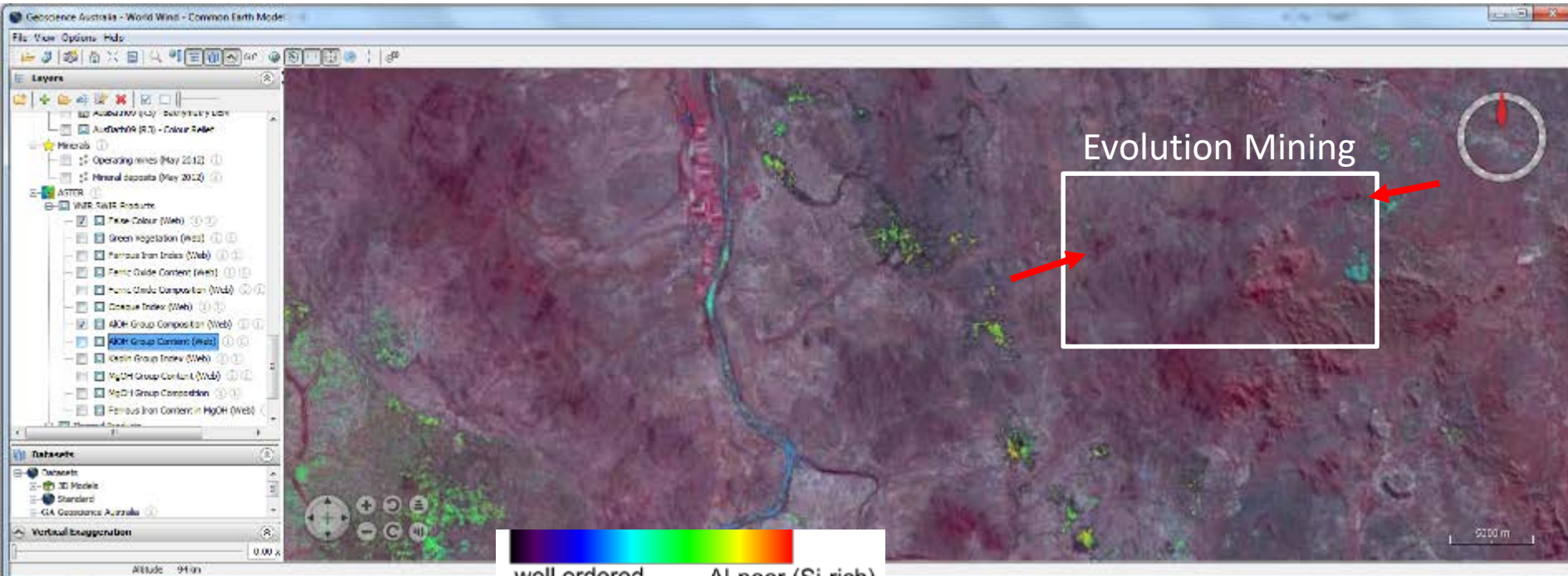
Mt Carlton

- Regolith mapping
- Exposed clay-rich soils – dust generation risk
- Metasomatic phyllic alteration



# Mt Carlton, ASTER Version 1 AIOH composition

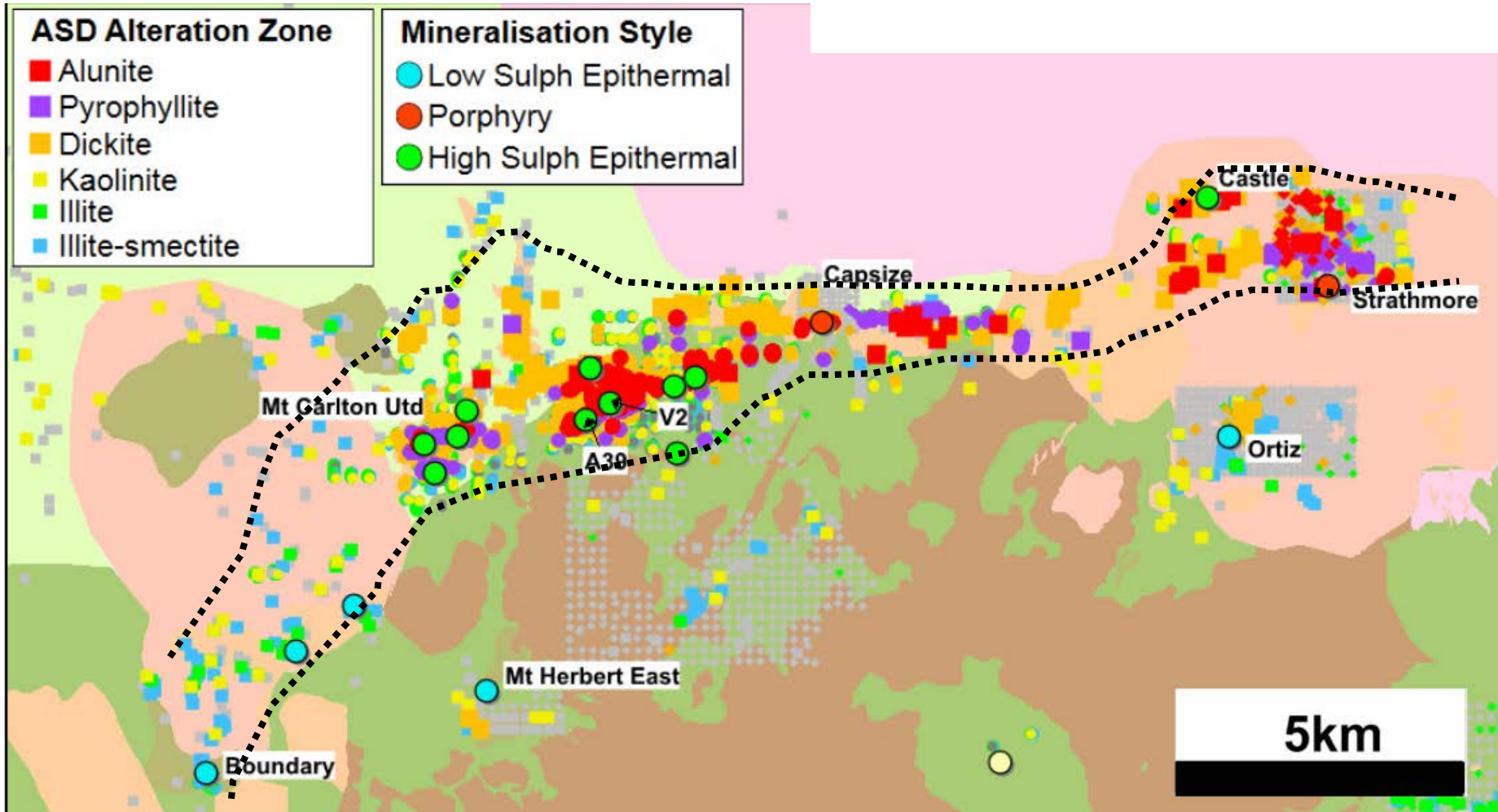
<http://www.ga.gov.au/data-pubs/interactive-3d-models/world-wind-3d-data-viewer>



15 km

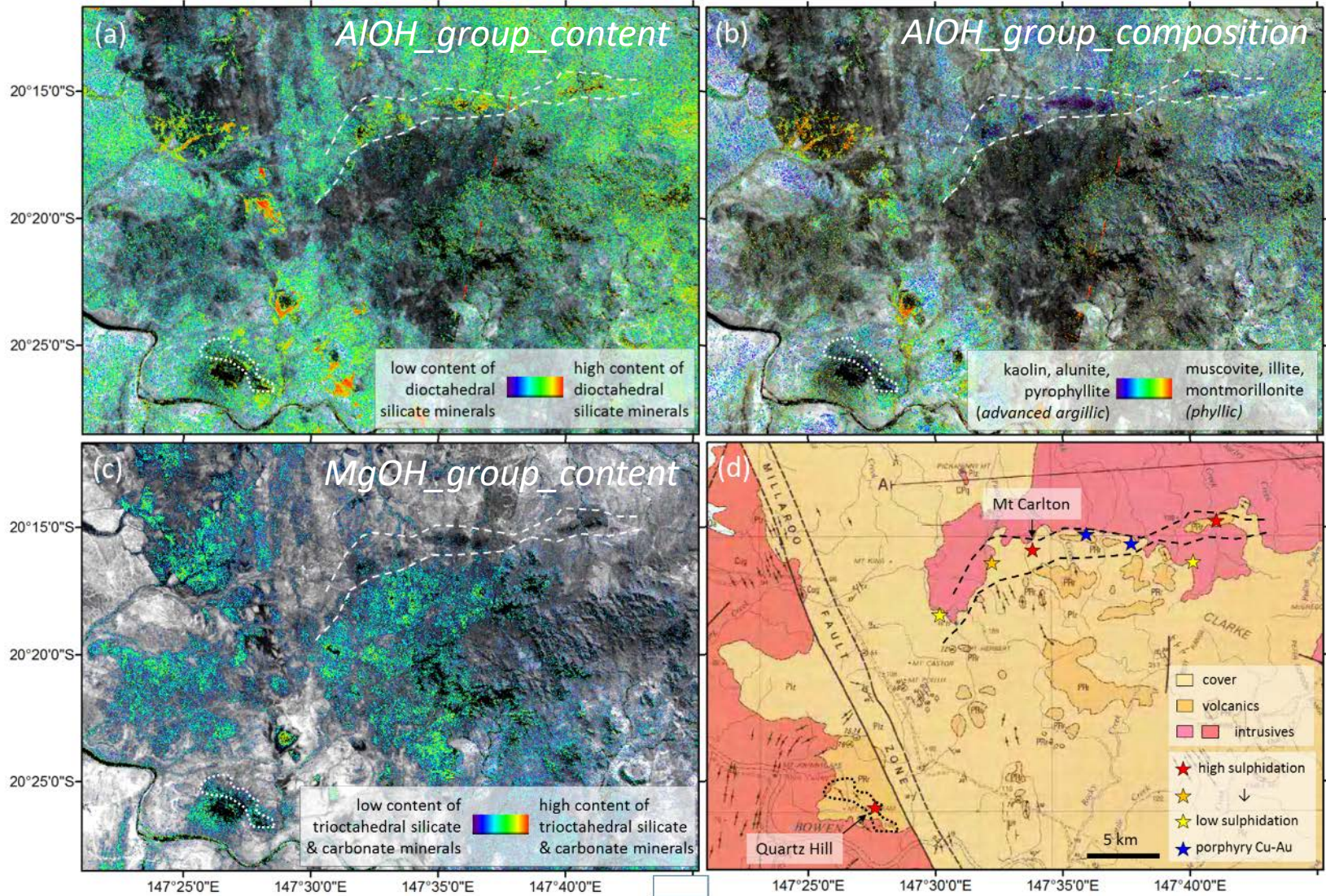


# Alteration mapping with ASD





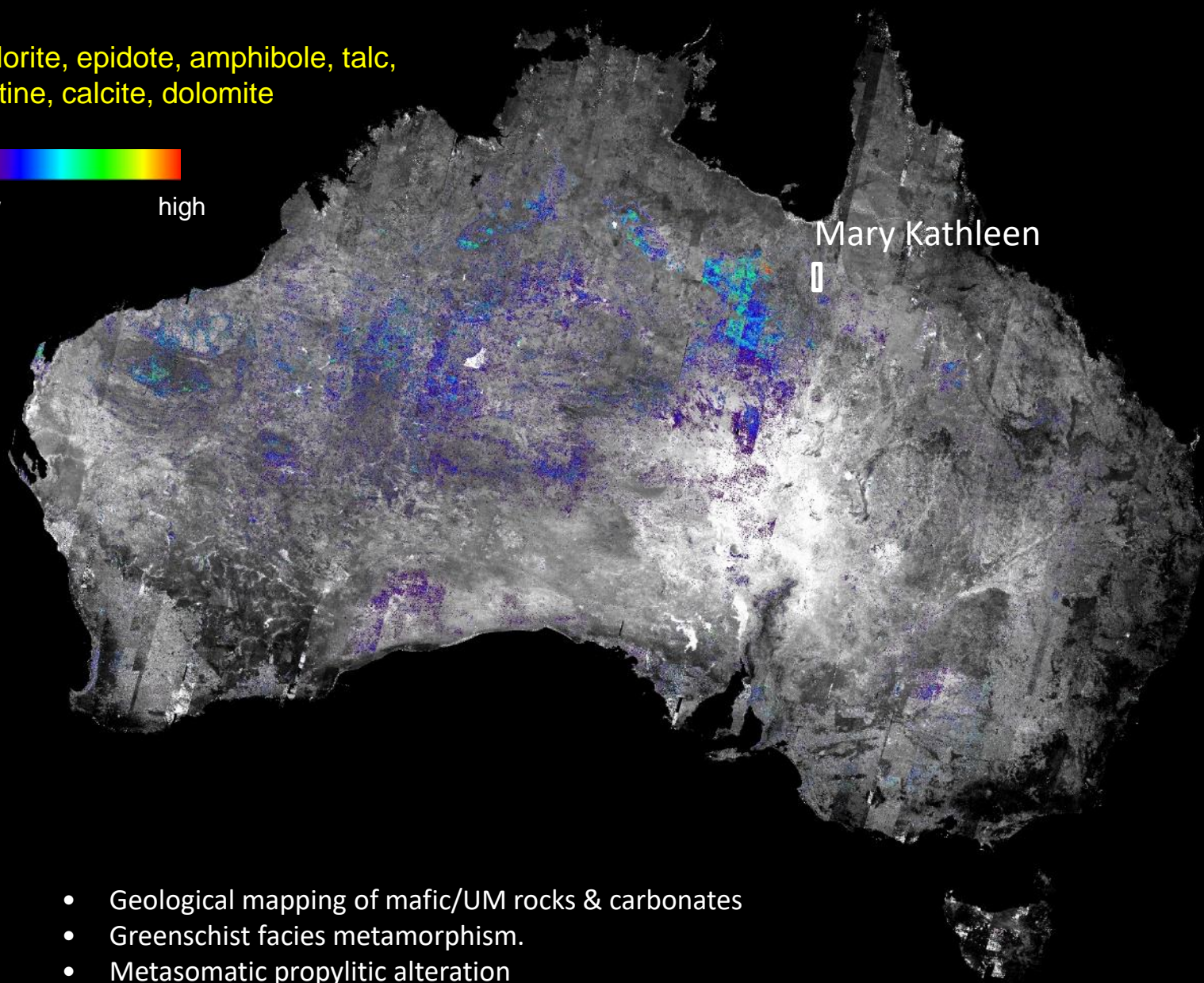
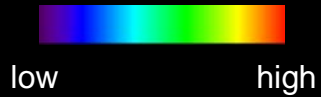
# Mt Carlton high sulphidation epithermal Au-Ag district: V2 ASTER





# V1 ASTER MgOH group content

e.g. chlorite, epidote, amphibole, talc,  
serpentine, calcite, dolomite

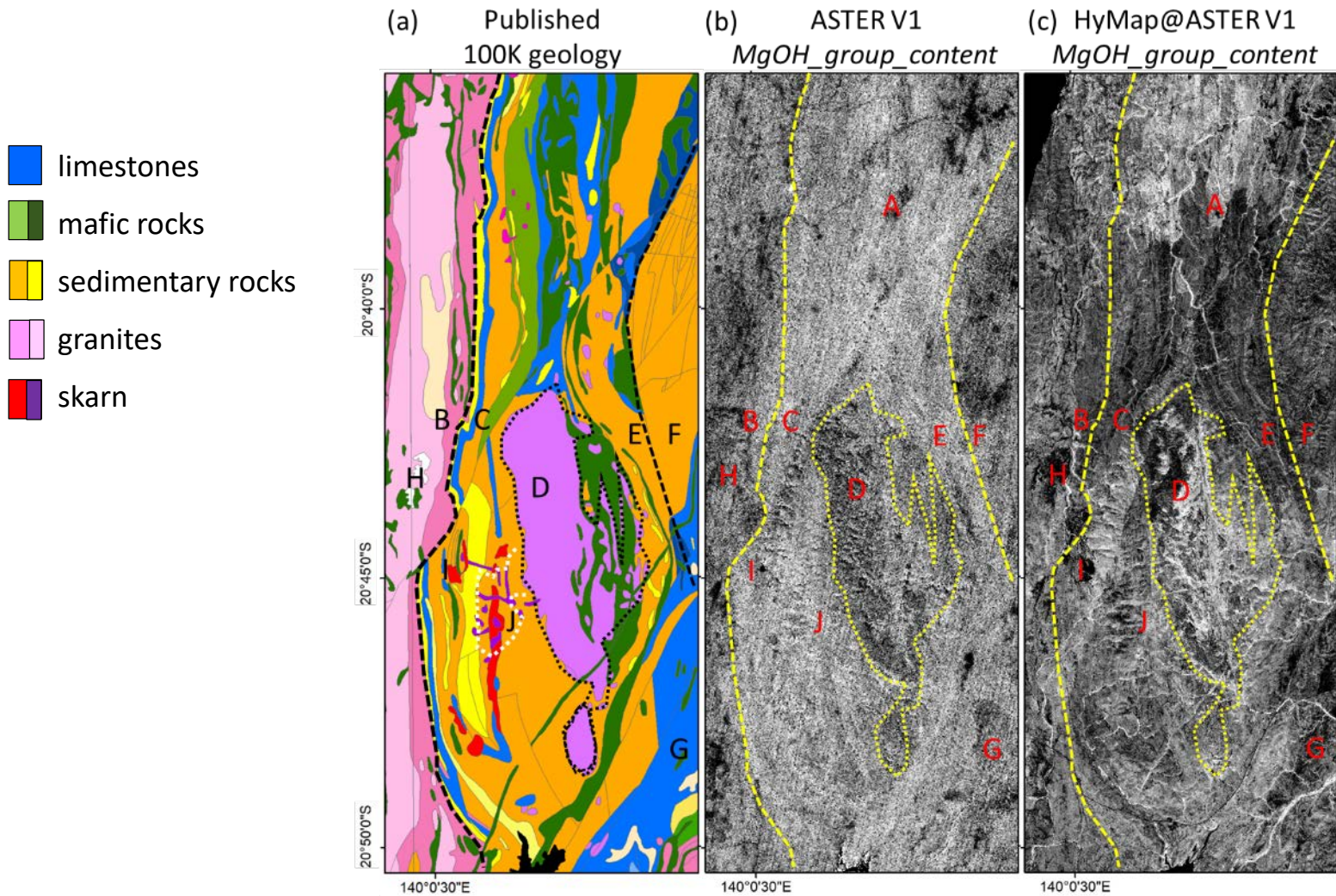


- Geological mapping of mafic/UM rocks & carbonates
- Greenschist facies metamorphism.
- Metasomatic propylitic alteration



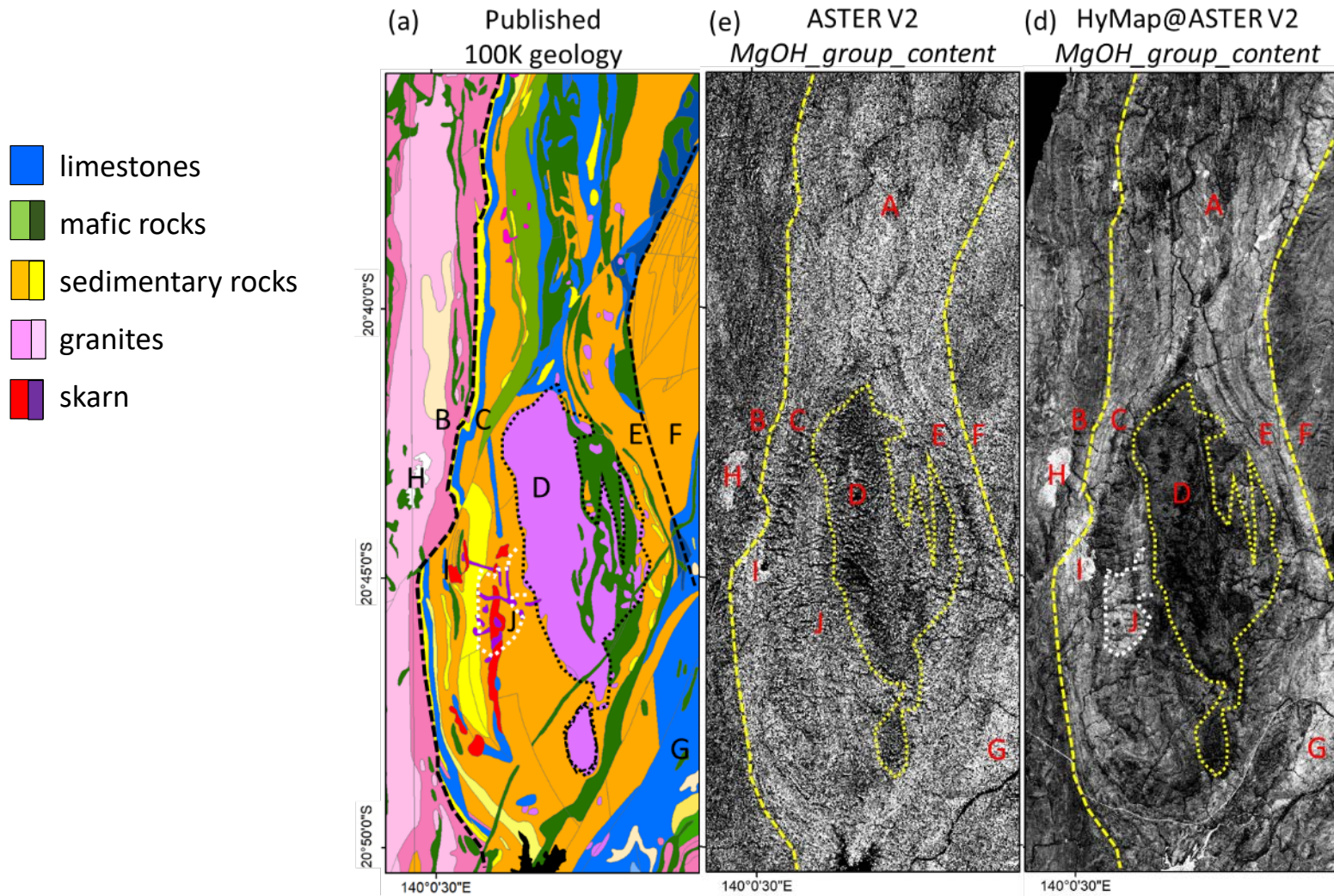
# Mary Kathleen, Mt Isa *MgOH* group ASTER & HyMap

before vegetation unmixing



# Mary Kathleen, Mt Isa *MgOH* group ASTER & HyMap

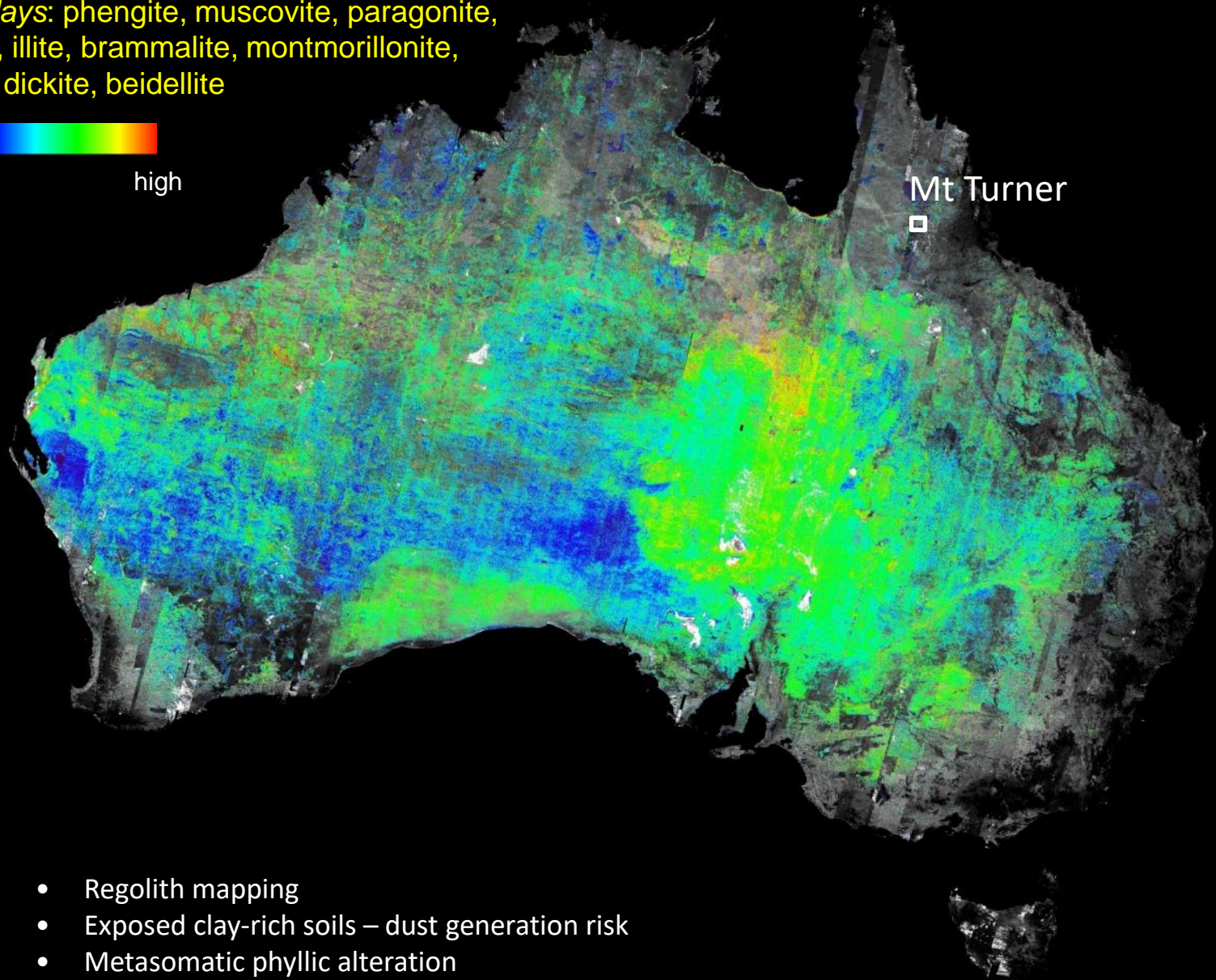
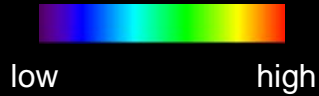
after vegetation unmixing





# V1 ASTER AIOH group composition

e.g. Al-Clays: phengite, muscovite, paragonite, lepidolite, illite, brammalite, montmorillonite, kaolinite, dickite, beidellite

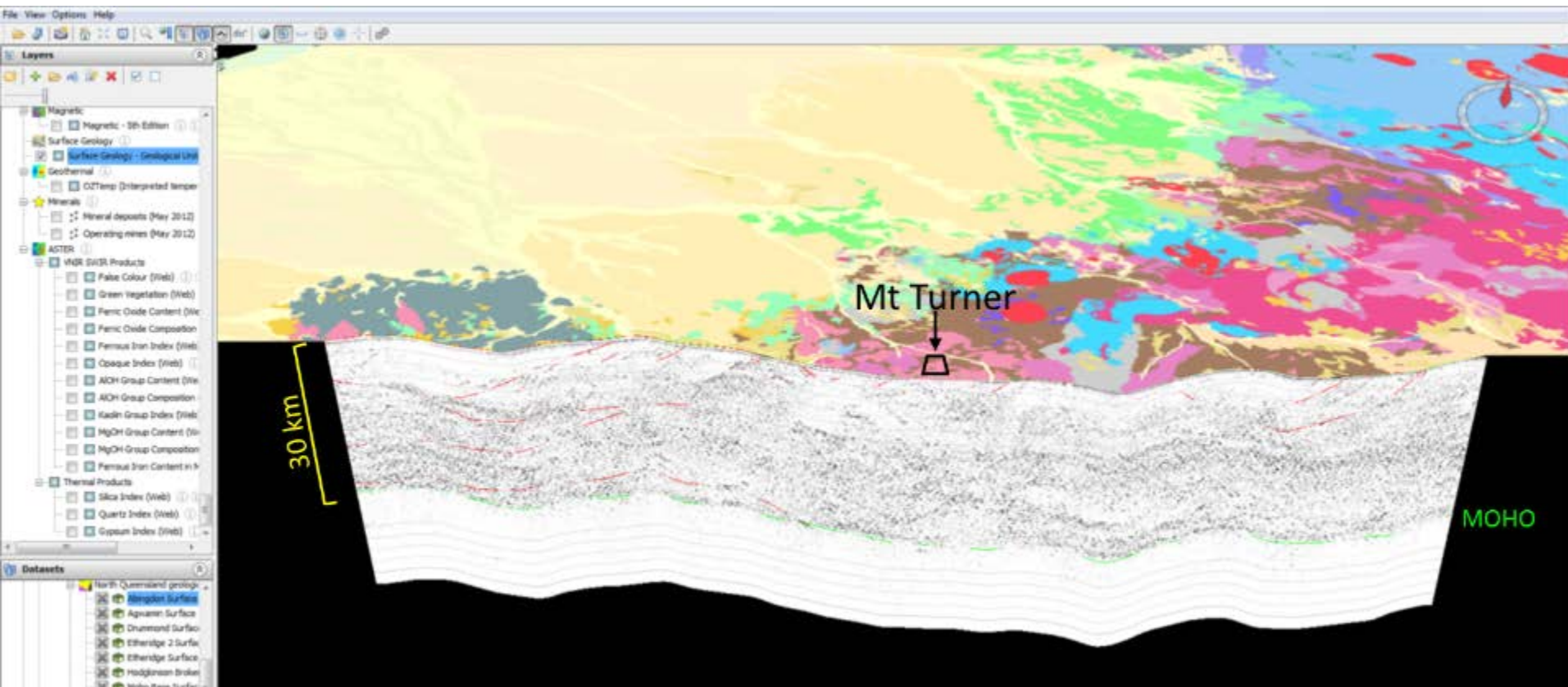


- Regolith mapping
- Exposed clay-rich soils – dust generation risk
- Metasomatic phyllic alteration

# Mt Turner, Qld - 3D Mineral Mapping @ASTER spectral resolution

NVCL drillcore, airborne HyMap and satellite ASTER  
+ seismics + interpreted geology

<http://www.ga.gov.au/data-pubs/interactive-3d-models/world-wind-3d-data-viewer>

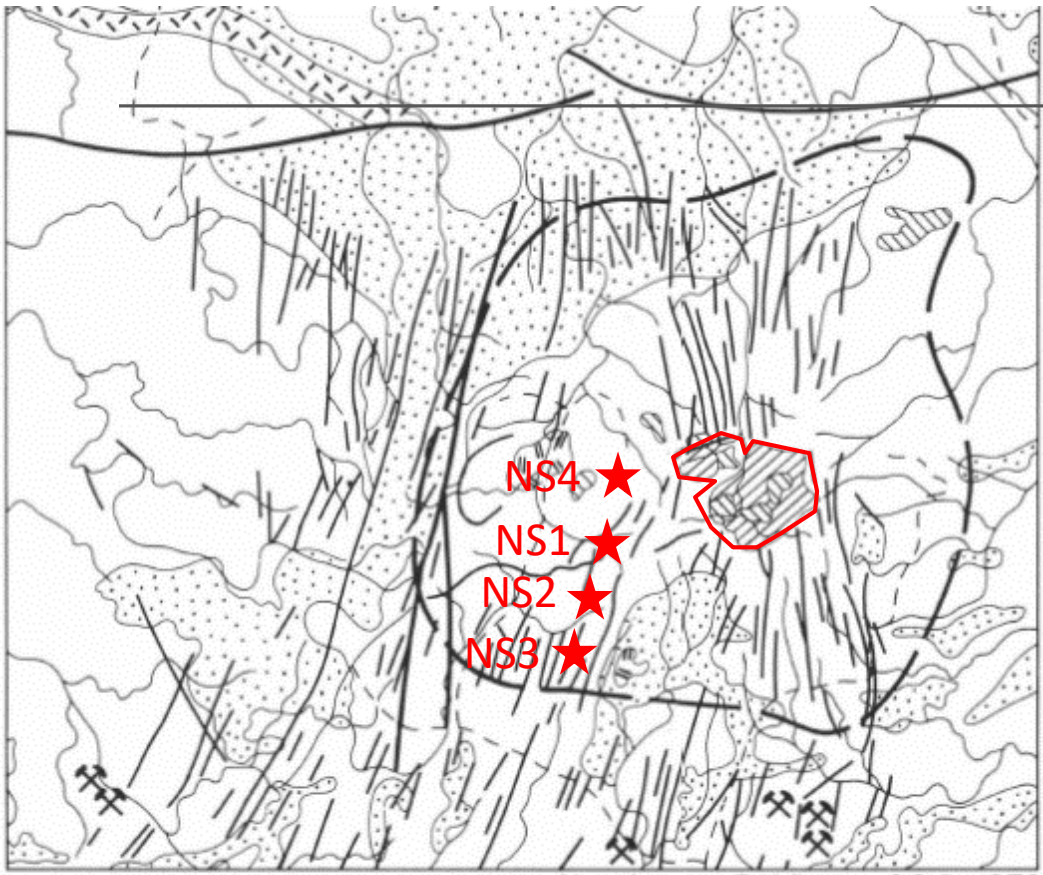




# Mt Turner - Published alteration

Rossiter 1979, BMR Journal

- 12 km<sup>2</sup> of silicic, potassic, **phyllitic**, **argillic** and propylitic alteration

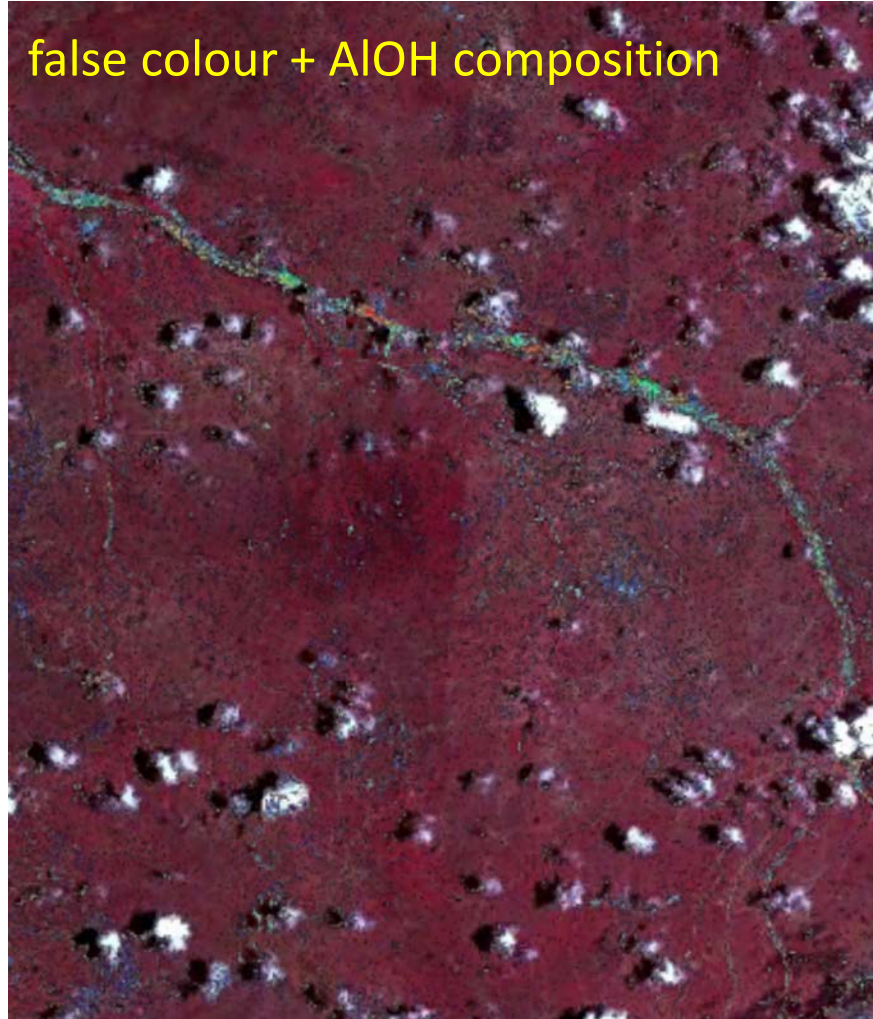


	CARBONIFEROUS ?
	'DISMAL CREEK VOLCANICS' Ignimbritic dacite
	'MT DARCY MICROGRANODIORITE' Porphyritic microgranodiorite
	Breccia
	Intrusive rhyolite
	PROTEROZOIC
	'FORSAYTH', 'AURORA' AND 'DELANEY' GRANITES Biotite granite

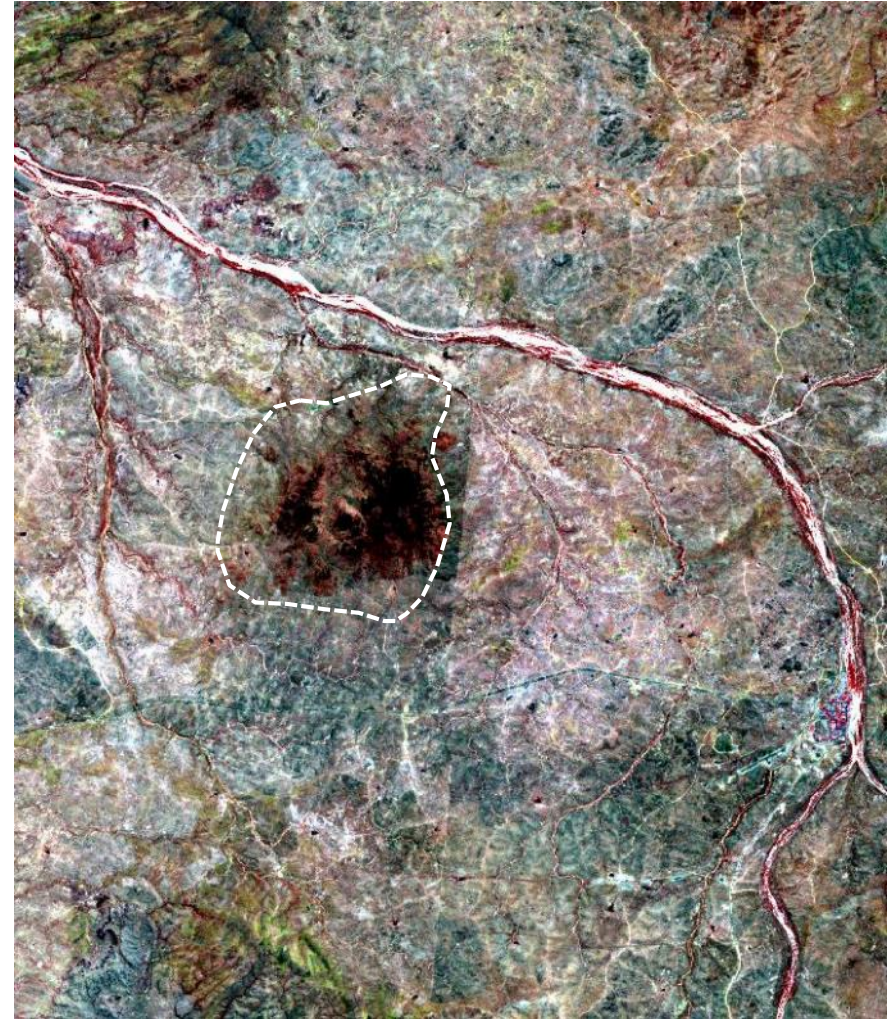


# Mt Turner, Qld - 3D Mineral Mapping @ASTER spectral resolution

V1 ASTER false colour +  
AlOH group composition



Updated ASTER scene  
false colour image

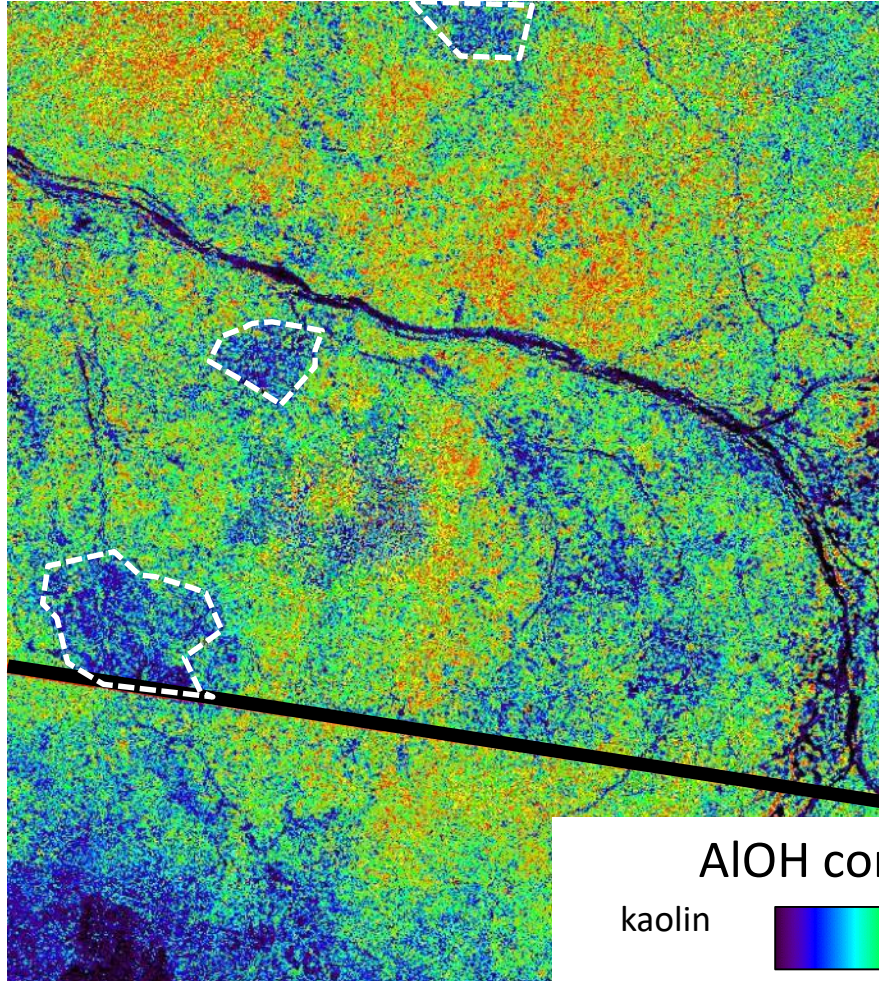




# Mt Turner, Qld - 3D Mineral Mapping @ASTER spectral resolution

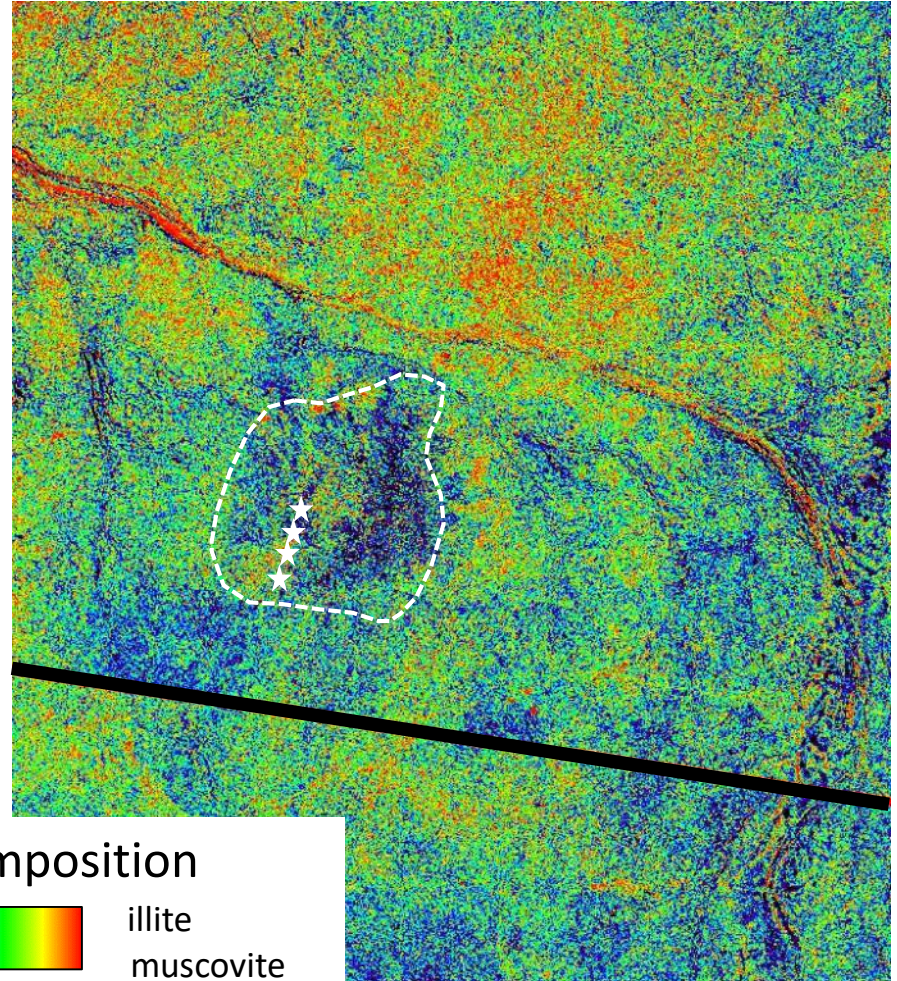
Updated ASTER scene

AIOH group composition – no vege unmix



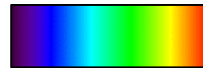
Updated ASTER scene

V2 AIOH group composition



AIOH composition

kaolin



illite

muscovite

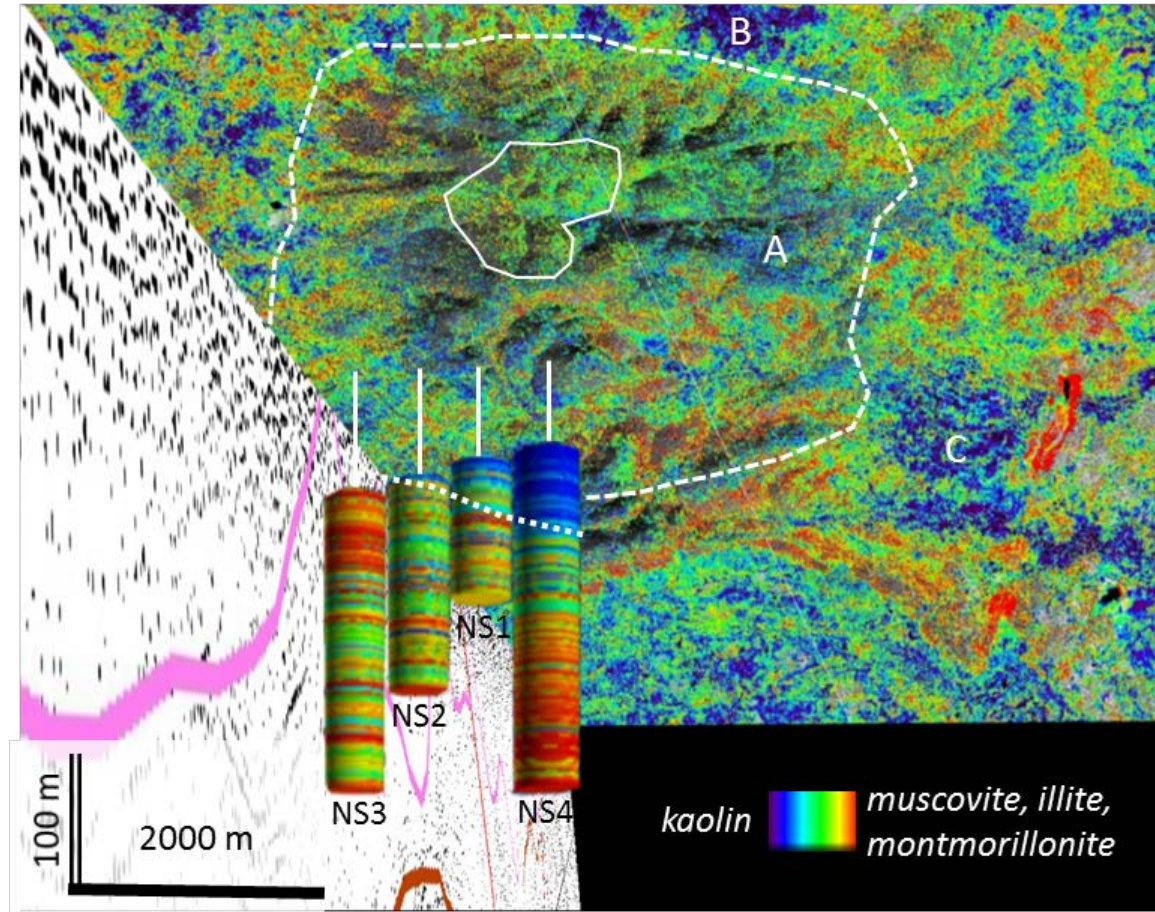
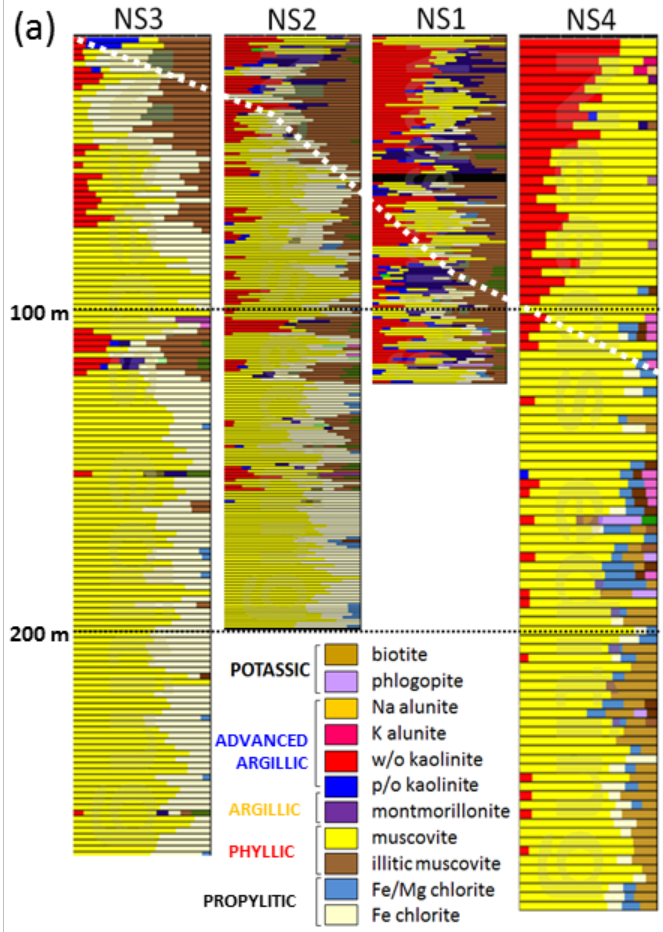
*advanced argillic?*

*phyllic?*



# Mt Turner, Qld - 3D Mineral Mapping @ASTER spectral resolution

NVCL drillcore, airborne HyMap + seismics + published geology



MIRA's Geoscience Analyst 3D software



# How to get the Queensland 3D mineral mapping data?

Geological Survey of Queensland's QDEX Data portal: <http://qdexdata.dnrm.qld.gov.au/flamingo/>

CSIRO's Data Access Portal (DAP) <https://data.csiro.au/dap>

- 3D mineral mapping of Queensland product summary @ ASTER resolution (pdf)
- 3D mineral mapping data & products
  - BSQ reflectance data @ASTER spectral resolution
    - ASTER
    - HyMap
    - Hyperion
  - BSQ mineral products @ASTER spectral resolution<sup>+</sup>
    - ASTER
    - HyMap
  - Final products in TIF format<sup>+</sup>
    - ASTER
    - HyMap
- Supporting documents (csv files)
  - NGSa @ASTER spectral resolution
  - NVCL @ASTER spectral resolution

<http://qdexdata.dnrm.qld.gov.au/flamingo>

<https://data.csiro.au/dap/landingpage?pid=csiro:20912>

<http://doi.org/10.4225/08/58a3aefb62e56>

The screenshot displays the CSIRO Data Access Portal interface. At the top, there are navigation tabs for 'SEARCH', 'BROWSE', and 'DOMAIN SEARCH'. The main content area is titled '3D Mineral mapping of Queensland - Version 2 ASTER and related geoscience products'. Below the title, there are tabs for 'Description' and 'Files'. The 'Description' tab is active, showing the following information:

- Copy this persistent link to share this collection:** <https://data.csiro.au/dap/landingpage?pid=csiro:20912>
- About this Collection**
  - Collection Title:** 3D Mineral mapping of Queensland - Version 2 ASTER and related geoscience products
  - Collection Description:** The digital 3-dimensional (3D) mineral mapping suite of Queensland comprises ~20 "standardized" products at the spectral resolution of the ASTER (Advanced Space-borne Thermal Emission and Reflection Radiometer) sensor and generated from publicly-available satellite, airborne, field and drill core spectral data spanning the visible near ... [more](#)
  - Field of Research:** Earth Sciences not elsewhere classified, Environmental Sciences not elsewhere classified, Exploration Geochemistry, Geology not elsewhere classified, Geomorphology and Regolith and Landscape Evolution, Geophysics not elsewhere classified, Mineralogy and Crystallography, Photogrammetry and Remote Sensing, Soil Sciences not elsewhere classified
  - Start Date:** Dec 2014
  - End Date:** Dec 2016
  - Contact:** Cindy Ong  
Cindy.Ong@csiro.au
  - Keywords:** Mineral mapping; 3D; ASTER; HyMap; NVCL; NGSa; vegetation unmixing; Geology; Alteration; Regolith; Queensland; Australia; Version 2
  - Lineage:** The ASTER data used in this project are freely available from the United States Geological Survey (USGS) Land Processes Distributed Active Archive Centre (LPDAAC) ([https://lpdaac.usgs.gov/dataset\\_discovery/aster/aster\\_products\\_table/ast\\_11t](https://lpdaac.usgs.gov/dataset_discovery/aster/aster_products_table/ast_11t)) as well as NASA's REVERB (<http://reverb.echo.nasa.gov>) and Japan's Advanced Institute for Science Technology (AIST) <https://gbank.gsi.jp/mades/map>. The Australian ASTER Geoscience (V1) Maps can be downloaded from CSIRO's Data Access Portal (DAP) (<https://data.csiro.au/dap/landingpage?pid=csiro%3A6182>) and Geoscience Australia's Australian Geoscience Information Network, Geoscience Australia (AUSGIN) (<http://portal.geoscience.gov.au/gmap.html>). The NVCL data can be downloaded from <http://www.auscope.org.au/nvcl> or <http://portal.geoscience.gov.au/gmap.html>. The National Geochemical Survey of Australia (NGSA) spectral data is accessible via CSIRO's Data Access Portal <http://www.ga.gov.au/about/projects/minerals-archive/concluded/national-geochemical-survey>.
  - Credit:** All the derived geoscience products were developed as part of a

± **Table 1. Geoscience product descriptions @ ASTER spectral resolution**

<b>ASTER Version 2 product name</b>	<b>information</b>	<b>algorithm<sup>*</sup></b>	<b>vegetation unmixing<sup>**</sup></b>	<b>masking<sup>***</sup></b>	<b>issues<sup>****</sup></b>
# false colour <sup>5</sup>	Landforms, geological textures, drainage, land use, cloud and vegetation cover (green vegetation = red)	Red: B <sub>3</sub> Green: B <sub>2</sub> Blue: B <sub>1</sub>	no	no	Cloud, green vegetation
# <u>VNIR_SWIR_albedo</u>	Base-map for mineral products in GIS.	$(B_1+B_2+B_3+B_4+B_5+B_6+B_7+B_8+B_9)/9$	+ green vegetation <sup>*</sup>	none	Scan-angle dependent BRDF (bi-directional reflectance distribution function) particularly in airborne scanner imagery like <u>HyMap</u> .
# <u>green_vegetation</u>	photosynthetic green vegetation	$(B_3/B_2)^{1/3}$ #	none	none	
# <u>dry_vegetation</u> @	non-photosynthetic vegetation with cellulose and lignin	Weighted linear combination of NIR and SWIR bands	none	none	ASTER spectral bands were not designed specifically for accurate measurement cellulose or lignin – index is thus an approximation
# <u>ferric_oxide_content</u>	hematite ± goethite ± jarosite = high values	$B_4/B_3$ ;	+ green vegetation - dry vegetation	<i>ASTER: green vegetation, shadow/water</i> <i>HyMap: green vegetation</i>	ASTER spectral bands were not designed specifically for accurate measurement of ferric oxide content, i.e. lacks key bands at 0.76 and 0.9 µm.
# <u>ferric_oxide_composition</u>	hematite = high values; goethite and no iron oxide = lower values	$B_2/B_1$	+ green vegetation	<i>ASTER: green vegetation, shadow/water.</i> <i>HyMap: green vegetation</i>	Low values can be associated with any non-hematite-rich surface.
# <u>ferrous_index_2</u>	ferrous-bearing silicates & carbonates such as <u>actinolite</u> , chlorite, pyroxene, olivine, <u>ferroan dolomite</u> , <u>ankerite</u> , siderite	$(B_5+B_6)/(B_3+B_4)$	+ green vegetation	<i>ASTER: green vegetation, shadow/water.</i> <i>HyMap: green vegetation</i>	Complicated by the presence of carbon black (ash) after recent fire.
# <u>opaque_index_2</u>	carbon black (e.g. graphite) ± Mn-bearing oxides ± ferrous oxides (e.g. magnetite) ± iron-sulphides (e.g. pyrite) = high values	$(B_1/B_4) + (1-VNIR\_SWIR\_albedo)$	+ green vegetation + dry vegetation	<i>ASTER: green vegetation, shadow/water.</i> <i>HyMap: green vegetation</i>	topographic shading and BRDF

CSIRO Mineral Resources report EP1767 <https://data.csiro.au/dap/landingpage?pid=csiro:20912>



# Summary

- Complicating effects of green and dry vegetation isolated and removed from the remote sensing data
- All spectral data resampled to @ASTER resolution which enables integration in 3D of derived mineral information products
- ASTER V2 mineral information >90% coverage - previously <10% for many V1 products/areas
- Geology revealed including alteration footprints – helping to deliver on the National UNCOVER challenge
- Opportunity to extend nationally and internationally

# SE Qld surface PIMA sampling

Kaylene Camuti

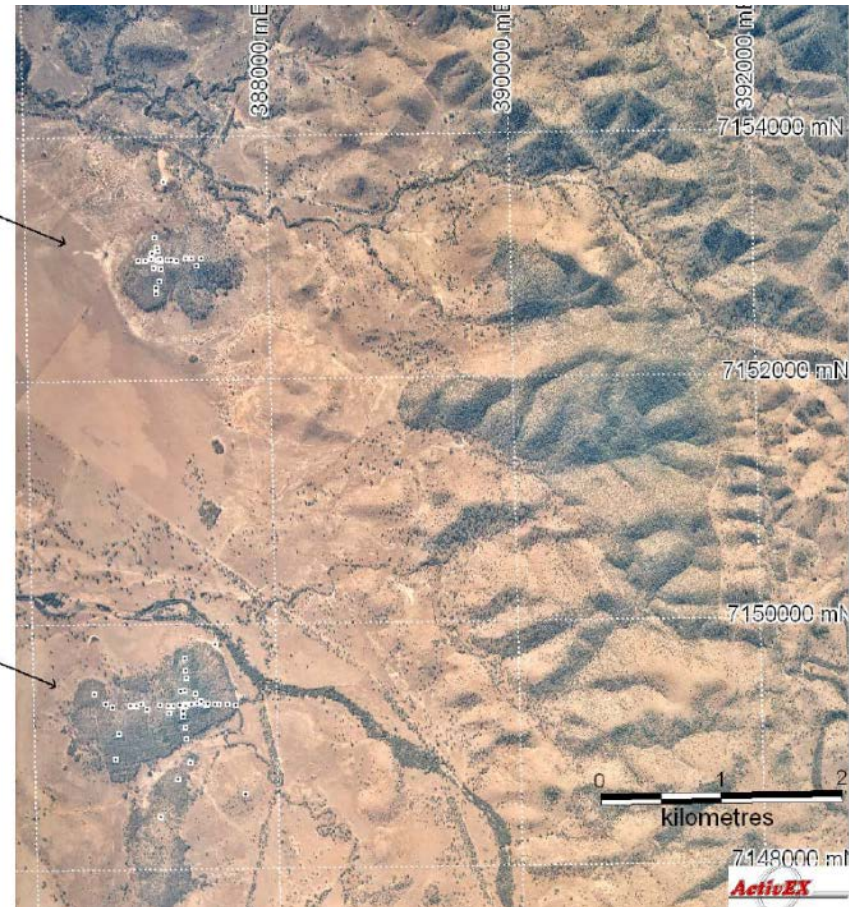
2008 SMEDG meeting

<https://smedg.org.au/TLS%20Kaylene%20Camuti.pdf>



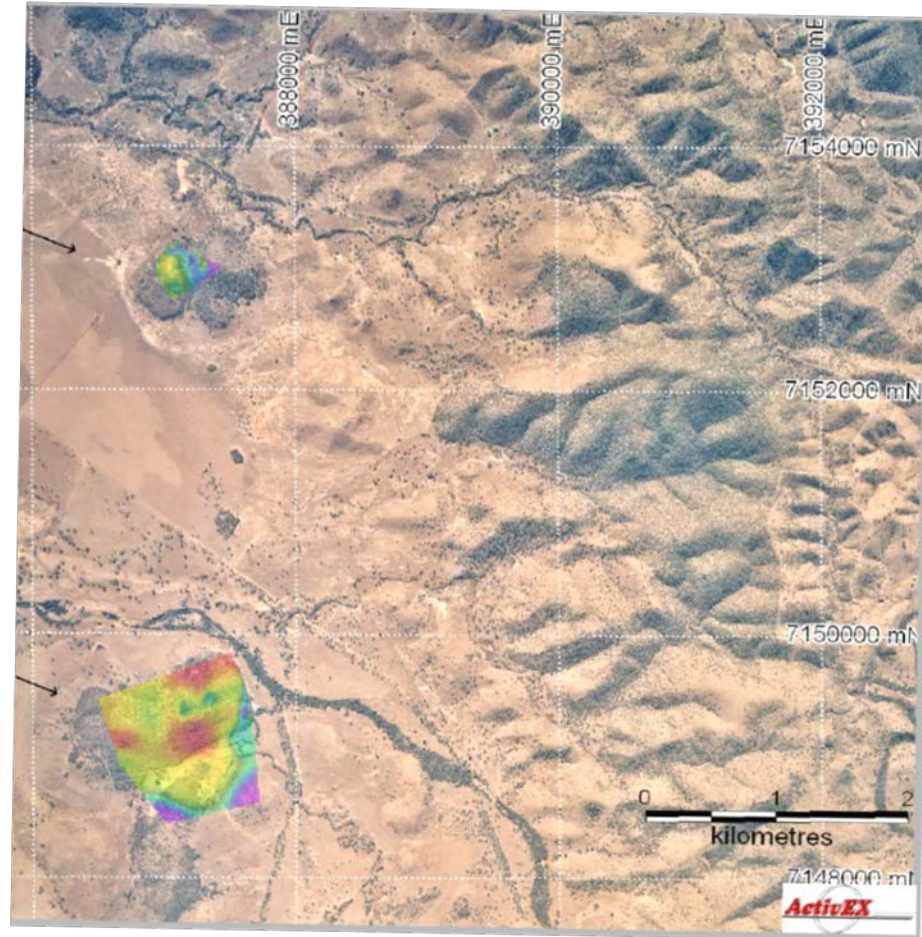
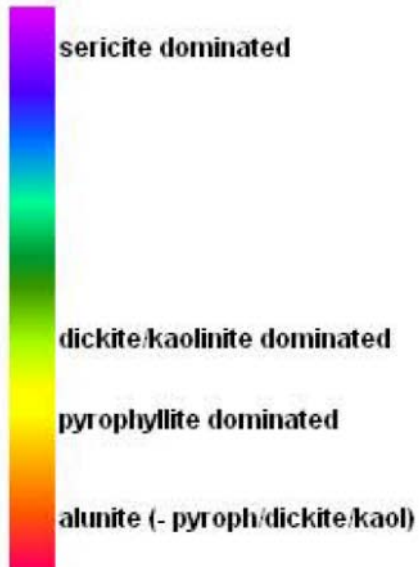
Demonbanga

Blairmore

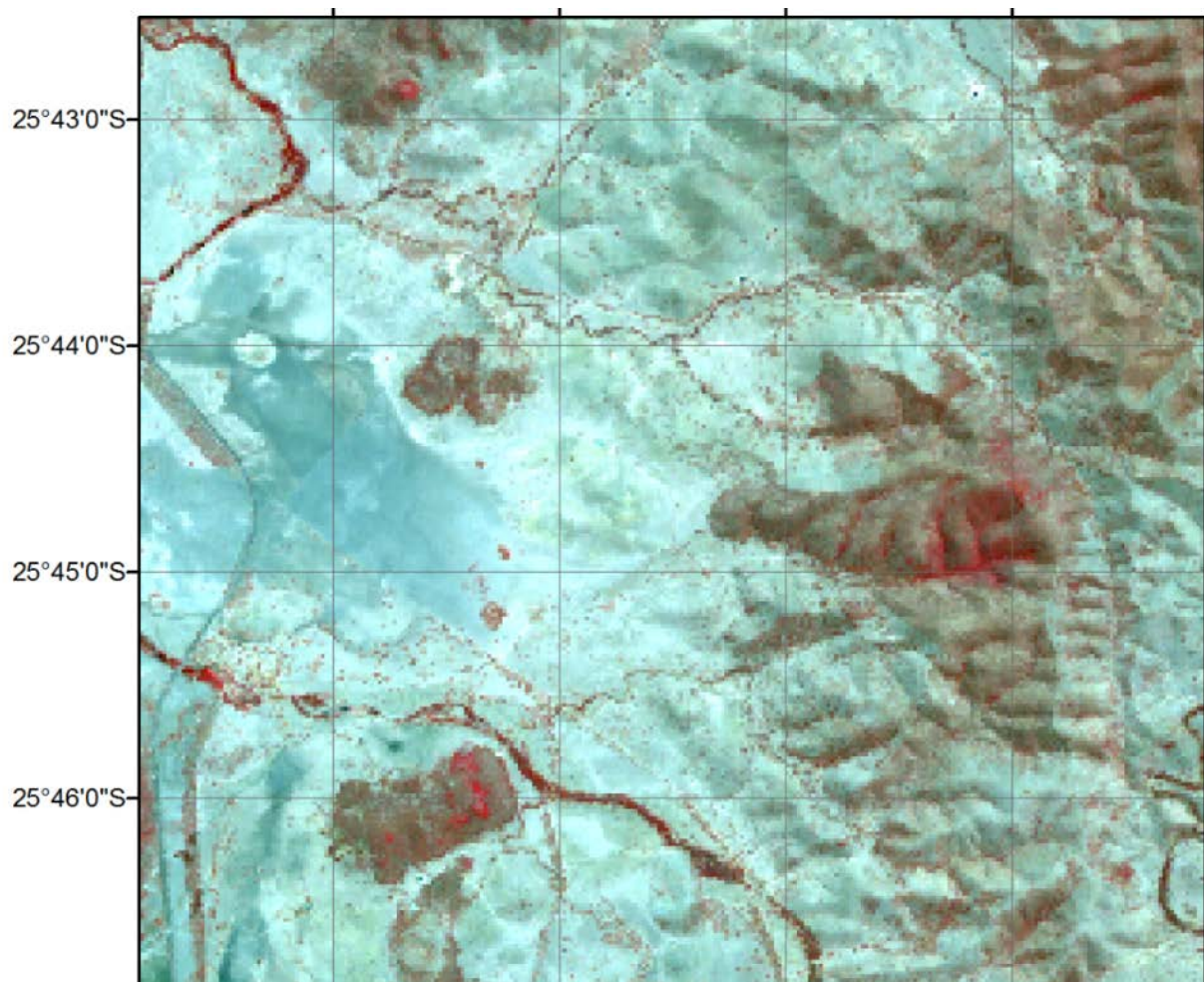




# PIMA Mineralogy Rock Chip Samples

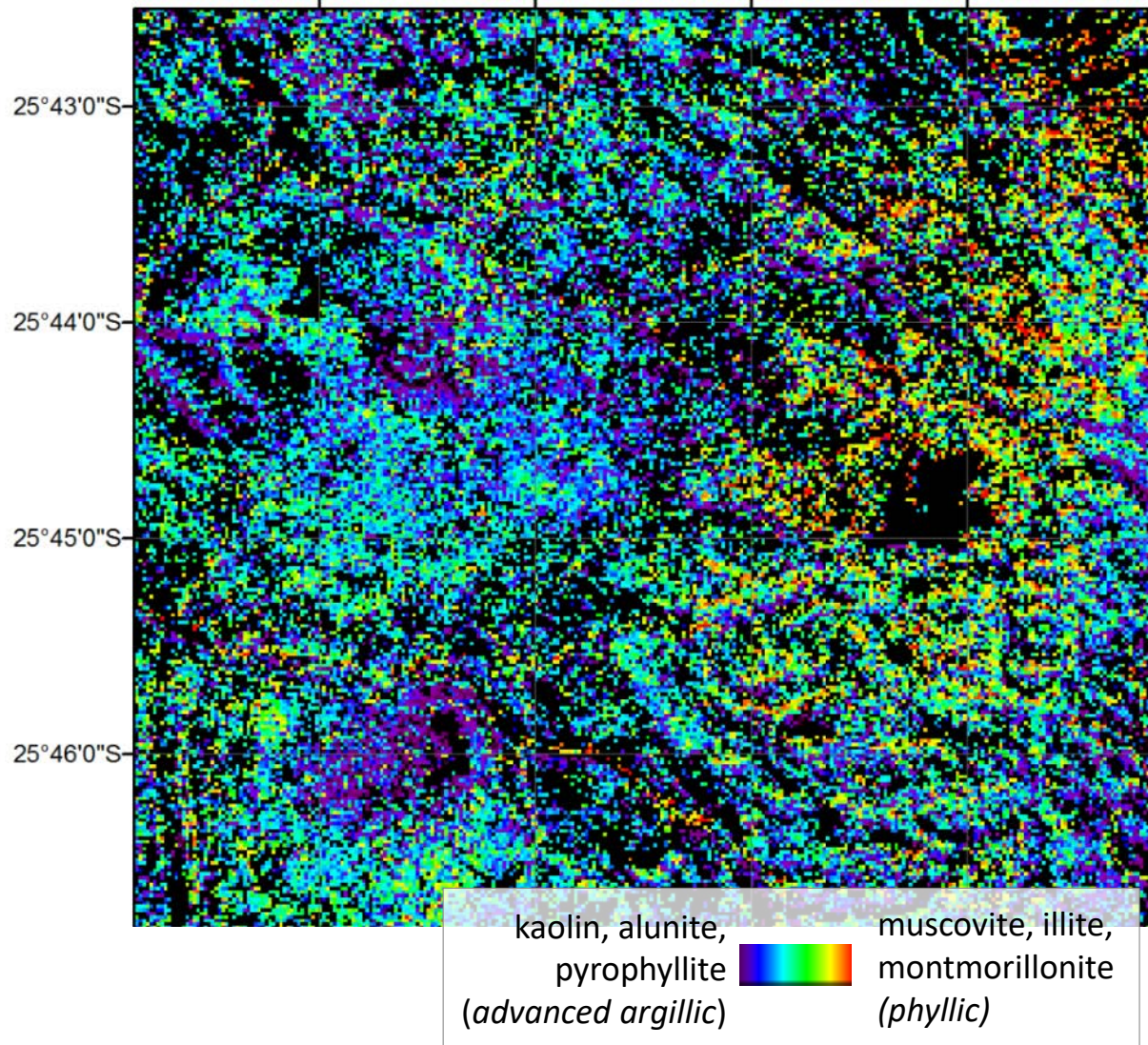


# *ASTER false colour image*



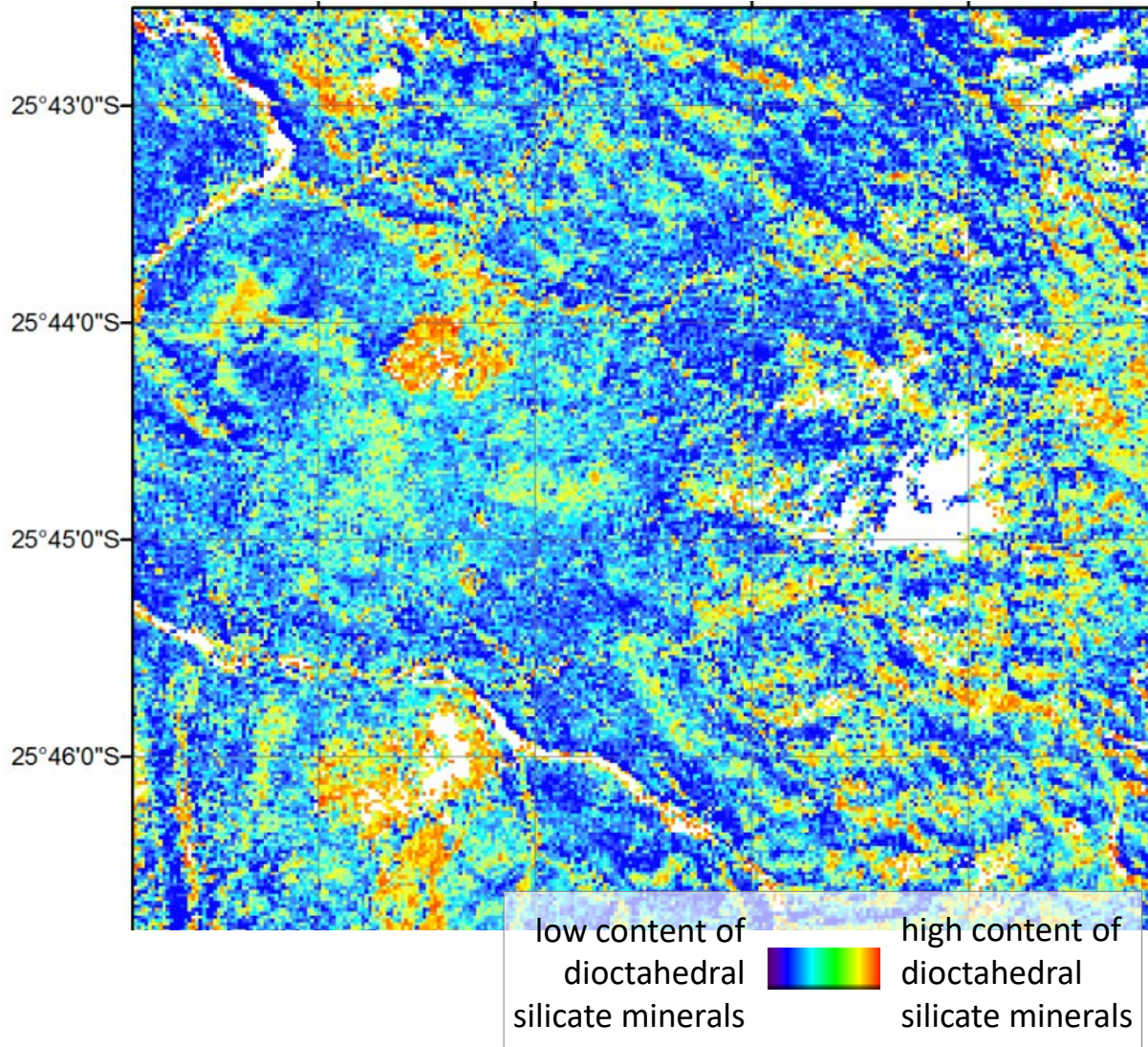


# ASTER V2 AIOH\_group\_composition\_mask





# ASTER V2 AlOH\_group\_content





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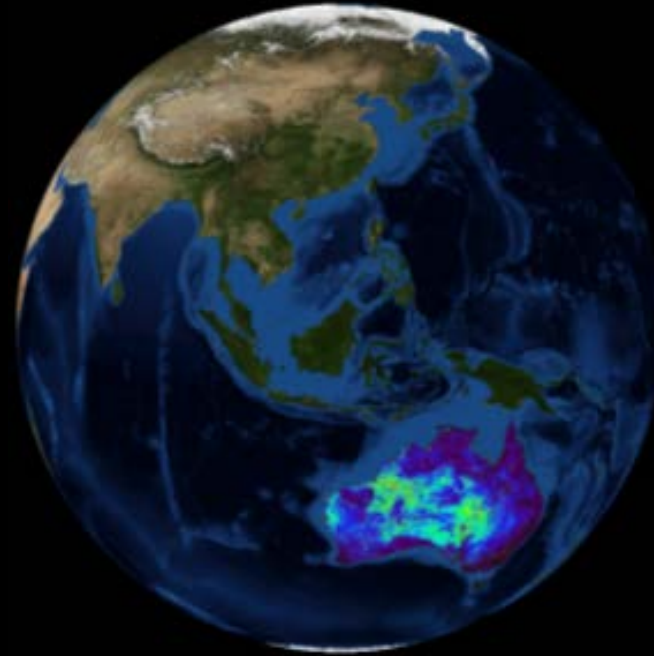


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