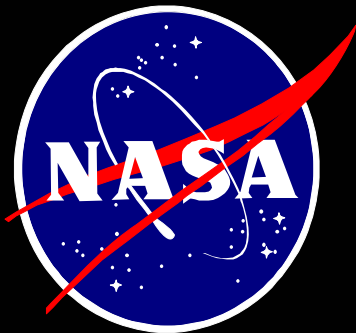


HyspIRI Workshop  
Combined VNIR-SWIR and TIR  
Combined Question 5  
**Surface Composition and Change**

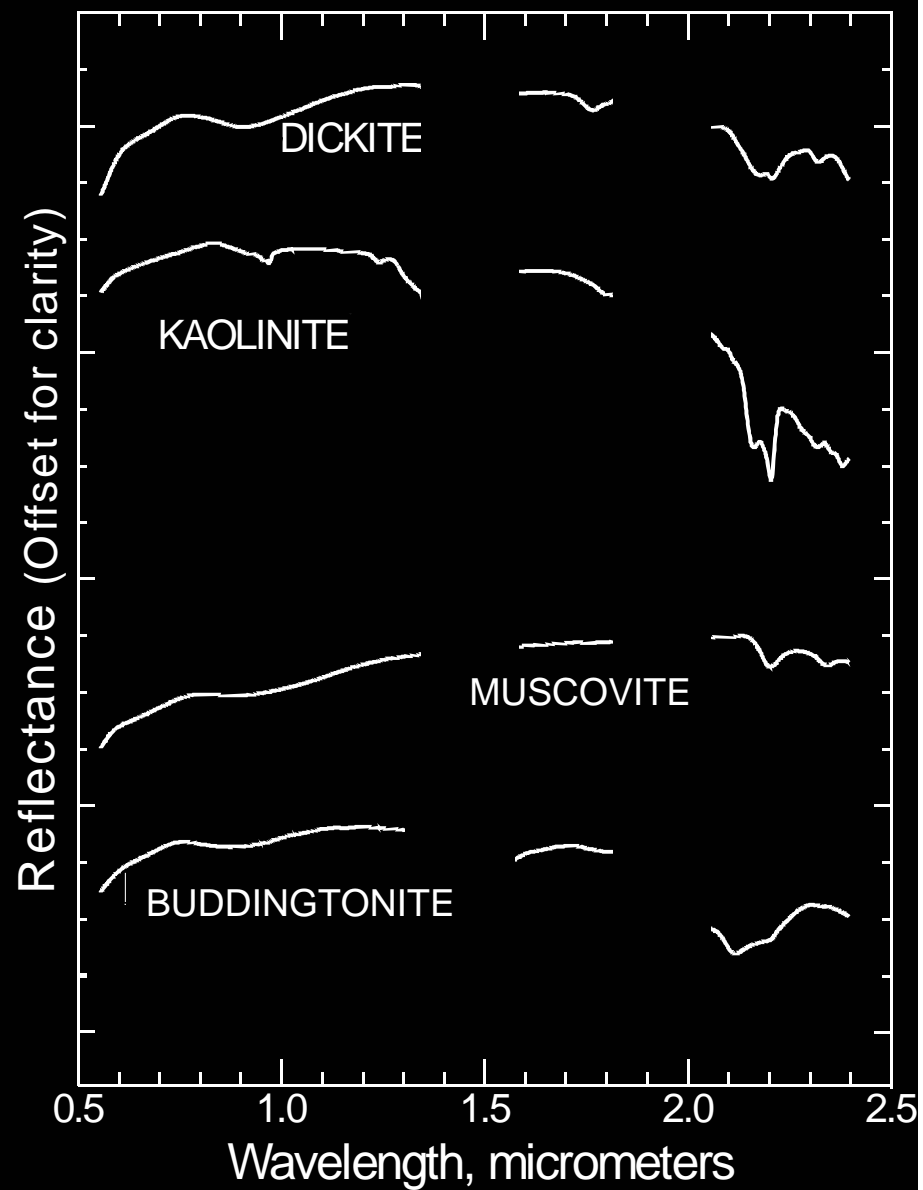
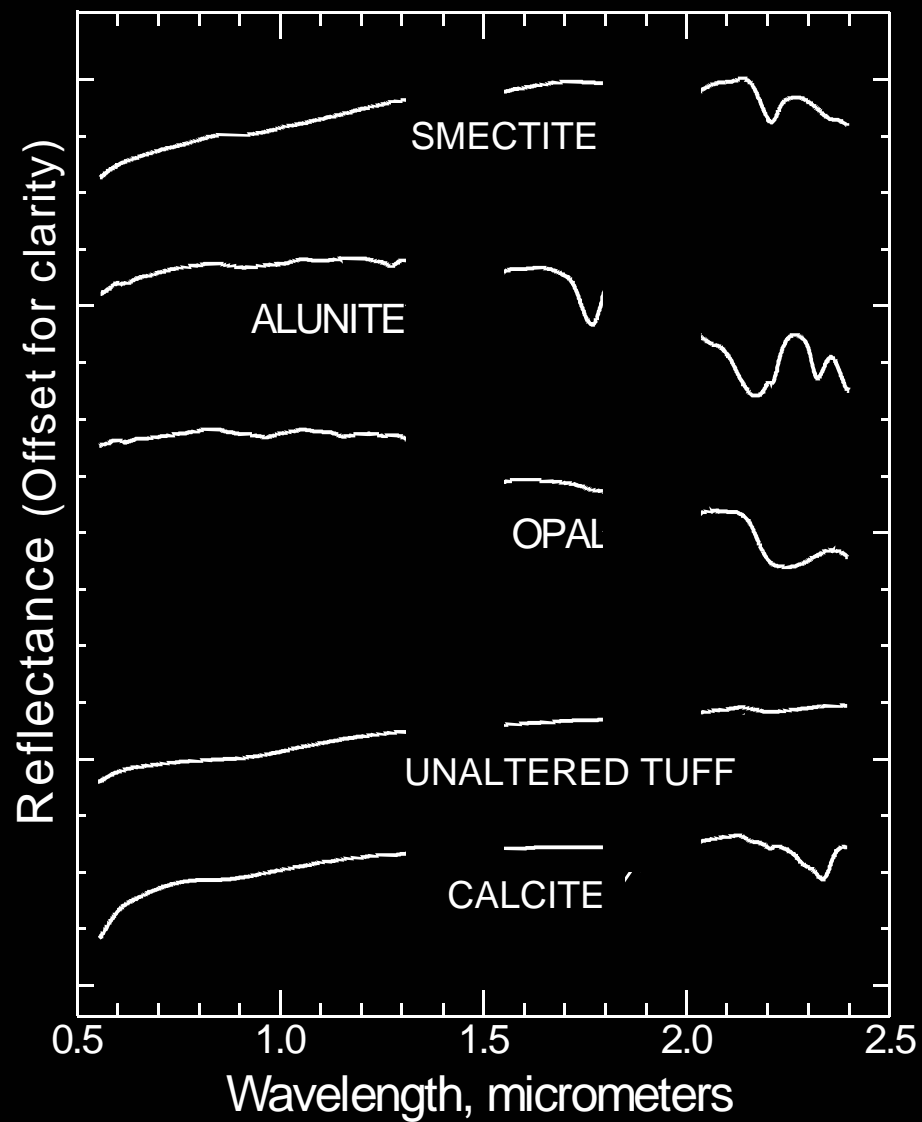
John Carr "Lyle" Mars  
and  
Anupma Prakash



• What is the composition of the exposed terrestrial surface of the Earth? (DS 220)

SPECTRAL REGION/ SPATIAL RESOLUTION	BANDS - WAVELENGTH REGION, MICROMETERS	COMPOSITIONAL INFORMATION
VNIR /  SWIR / 60 m	~ 95 BANDS* 0.380 - 1.40 $\mu\text{m}$  ~ 80 BANDS* 1.40 - 2.50 $\mu\text{m}$	<ul style="list-style-type: none"> <li>- FERRIC-FERROUS IRON ABSORPTION</li> <li>- REE</li> </ul> <hr/> <ul style="list-style-type: none"> <li>- AL-O-H IN CLAYS, MICAS, SULFATE MINERALS</li> <li>- CO<sub>3</sub> IN CARBONATES</li> <li>- Mg-O-H IN AMPHIBOLES, MICAS</li> <li>- H-O-H IN EVAPORITES, CLAYS</li> </ul>
TIR / 60 m	B1 - 3.98 $\mu\text{m}$ B2 - 7.35 $\mu\text{m}$ B3 - 8.28 $\mu\text{m}$ B4 - 8.63 $\mu\text{m}$ B5 - 9.07 $\mu\text{m}$ B6 -10.53 $\mu\text{m}$ B7 -11.33 $\mu\text{m}$ B8 -12.05 $\mu\text{m}$	<ul style="list-style-type: none"> <li>- SILICATE MINERALS, ESPECIALLY SHIFT TO SHORTER WAVELENGTHS</li> <li>- SULFATE MINERALS</li> <li>- CARBONATE MINERALS</li> </ul>

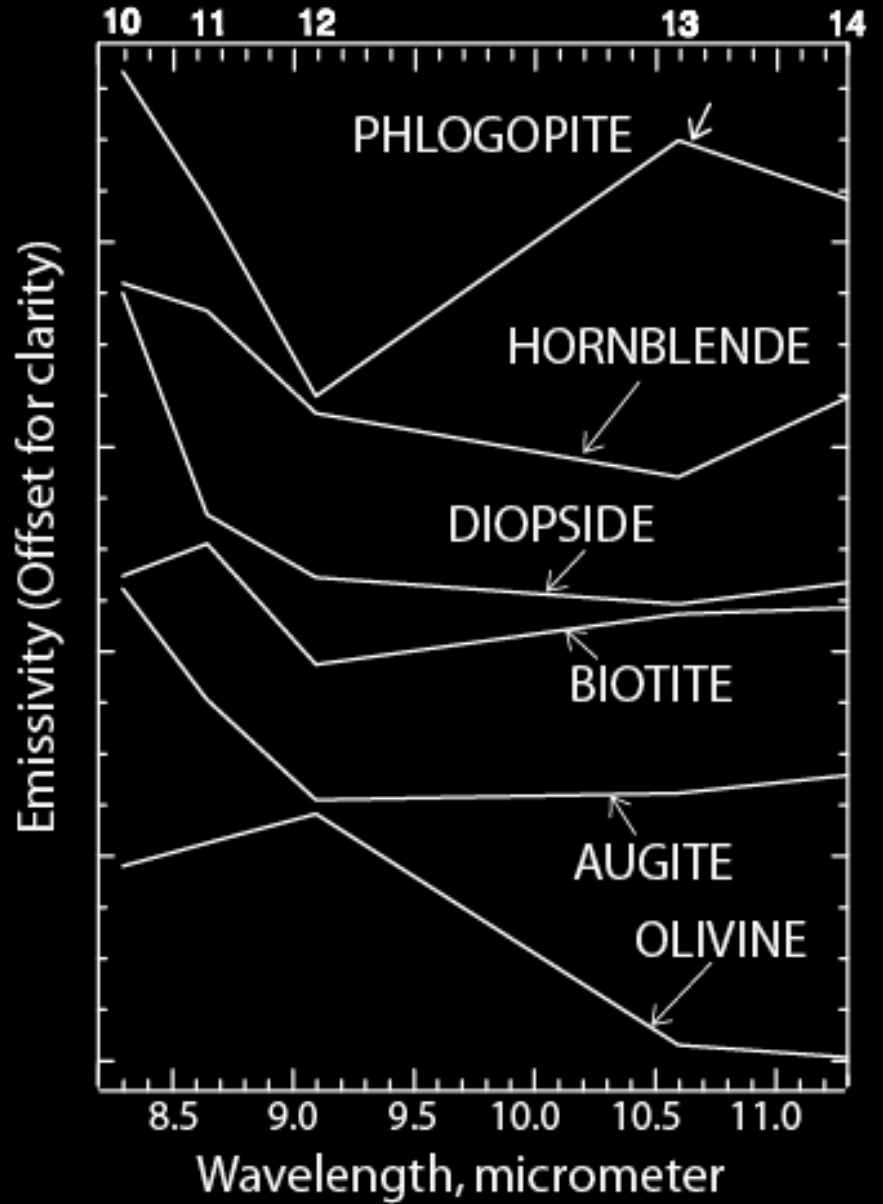
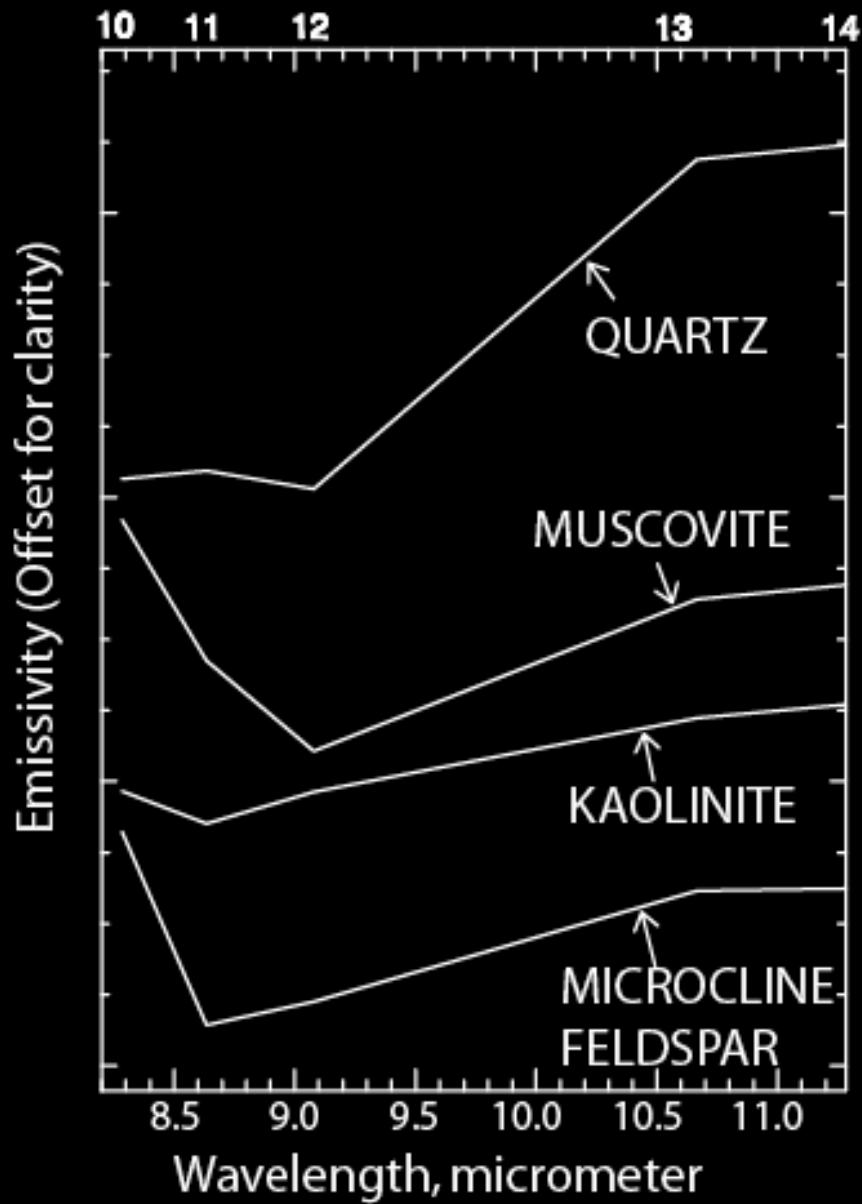
\* After removal of atmospheric absorption bands



• What is the composition of the exposed terrestrial surface of the Earth? (DS 220)

SPECTRAL REGION/ SPATIAL RESOLUTION	BANDS - WAVELENGTH REGION, MICROMETERS	COMPOSITIONAL INFORMATION
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\* After removal of atmospheric absorption bands



- What is the composition of the exposed terrestrial surface of the Earth? (DS 220)

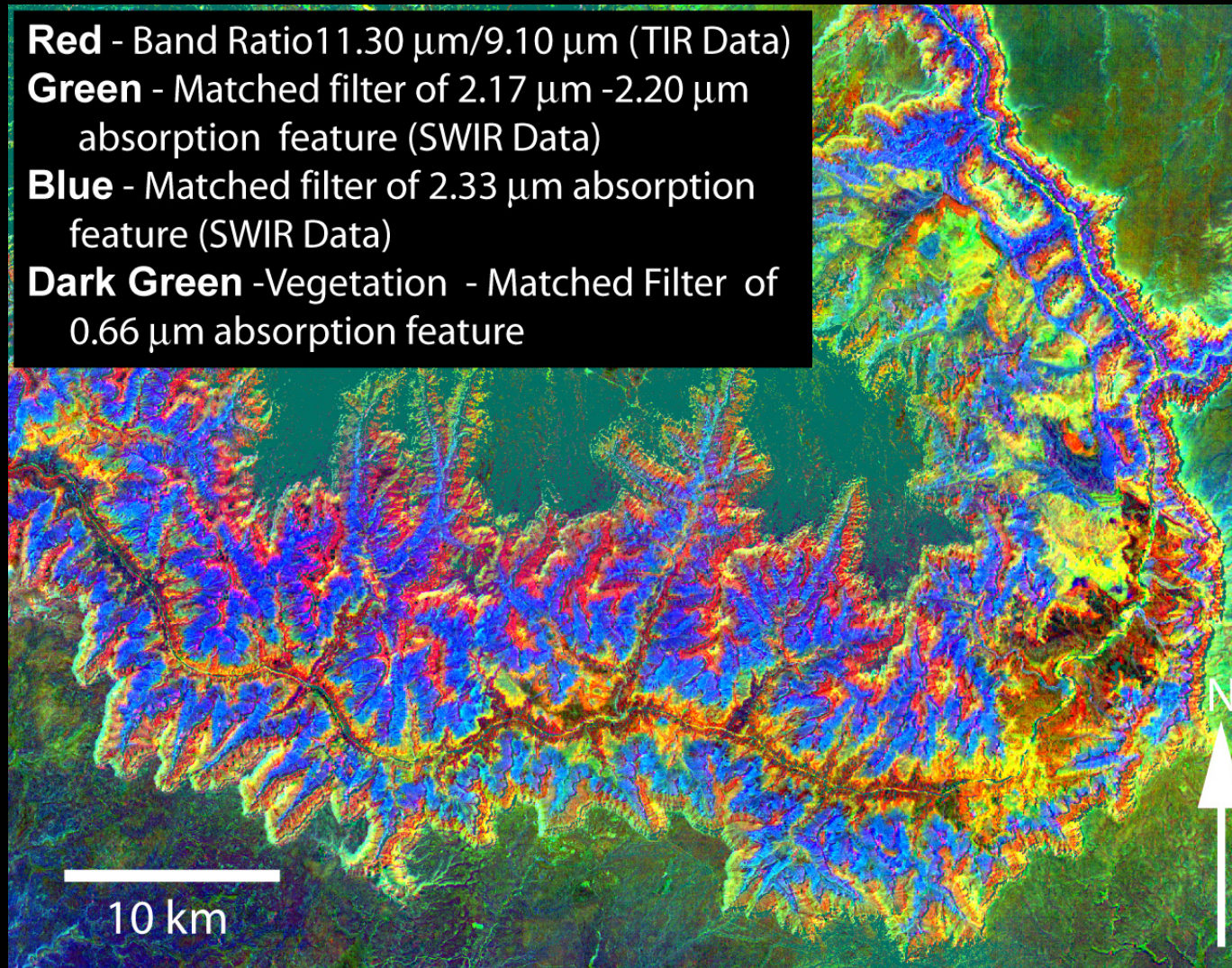
**False color composite HypsIRI simulated image of Grand Canyon, Arizona derived from TIR (red band - quartz-rich rocks), SWIR (green band - clay and muscovite-rich rocks; blue band - carbonate-rich rocks), and VNIR (dark green - green vegetation) data.**

**Red** - Band Ratio  $11.30 \mu\text{m}/9.10 \mu\text{m}$  (TIR Data)

**Green** - Matched filter of  $2.17 \mu\text{m} - 2.20 \mu\text{m}$  absorption feature (SWIR Data)

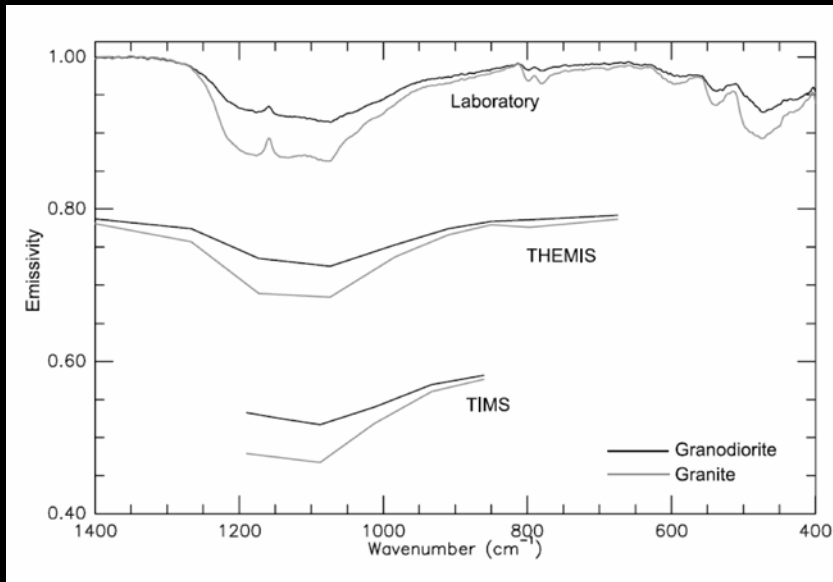
**Blue** - Matched filter of  $2.33 \mu\text{m}$  absorption feature (SWIR Data)

**Dark Green** -Vegetation - Matched Filter of  $0.66 \mu\text{m}$  absorption feature

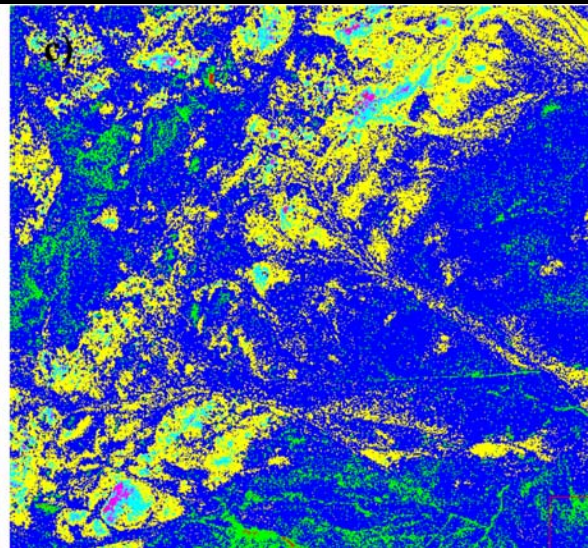
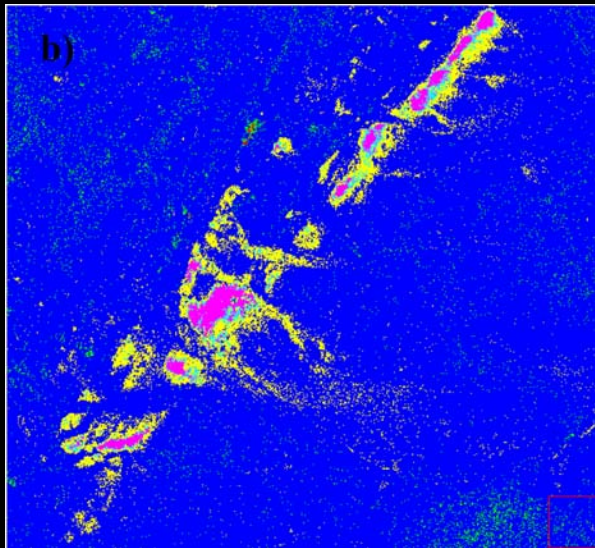
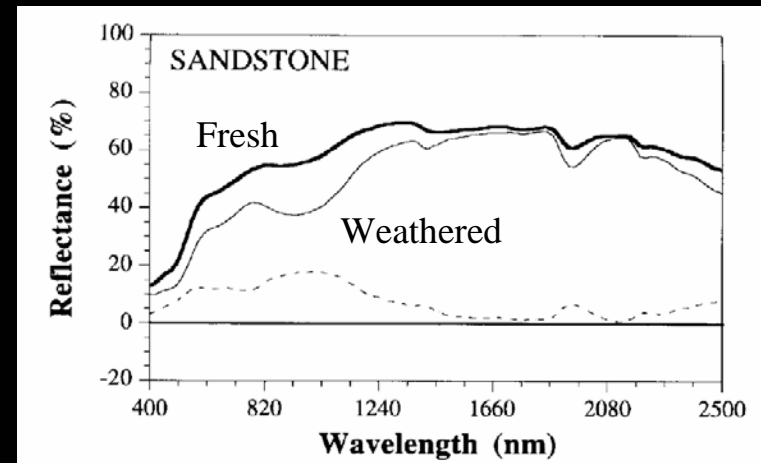


•How is the distribution of the primary minerals and mineral groups on the exposed terrestrial surface changing over time? (DS 218)

Michalski and others, 2004



Younis and others, 1997

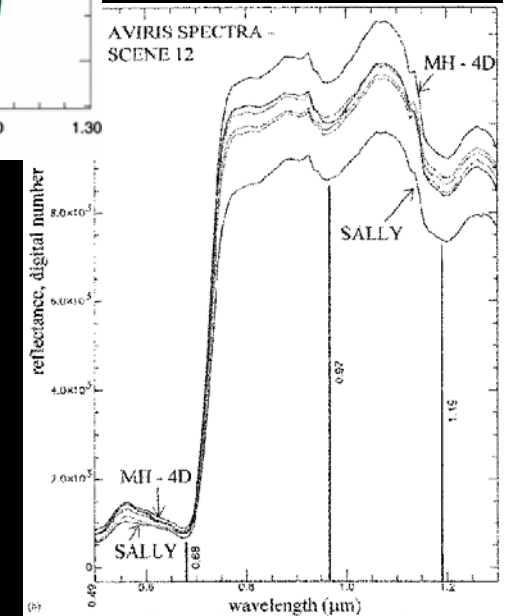
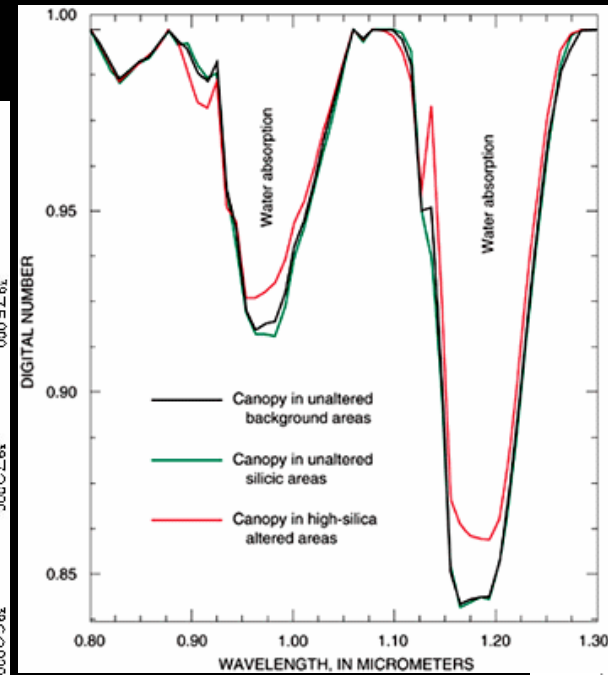
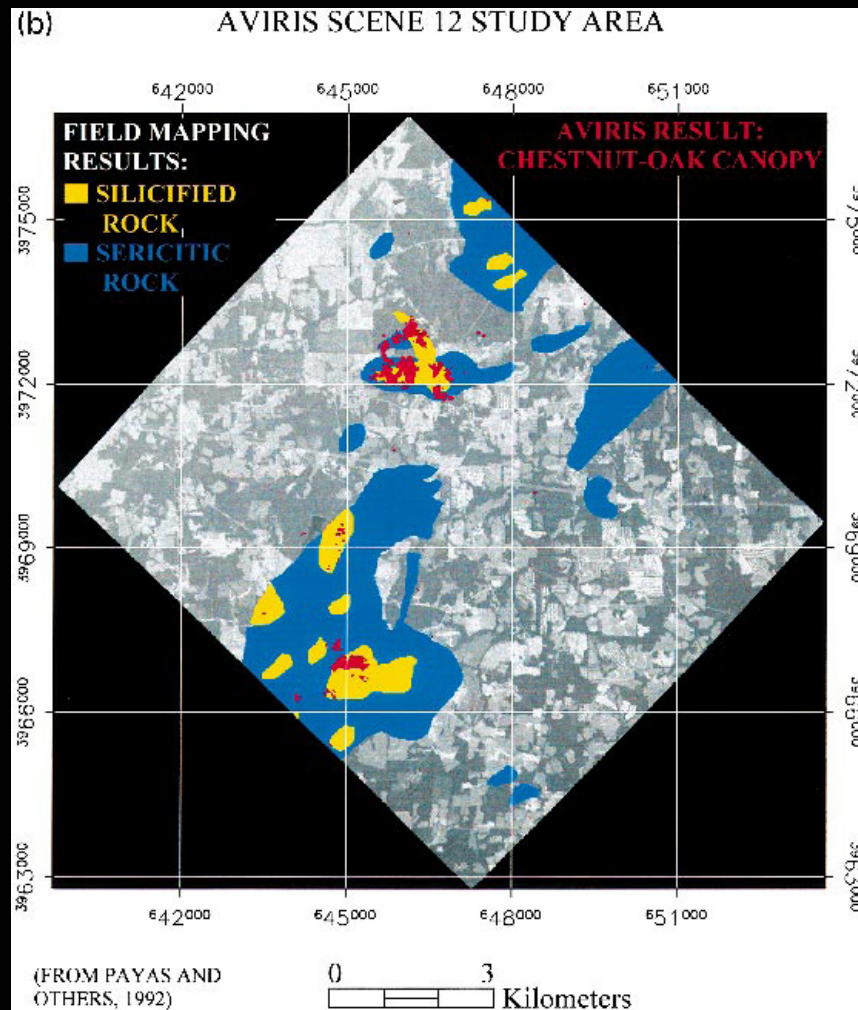


- Amphibolite
- Goethite
- Illite

Papp and Cudahy, 2002

- How does the surface mineralogy relate to the plant physiology and function on the terrestrial surface of the Earth? (DS 114)

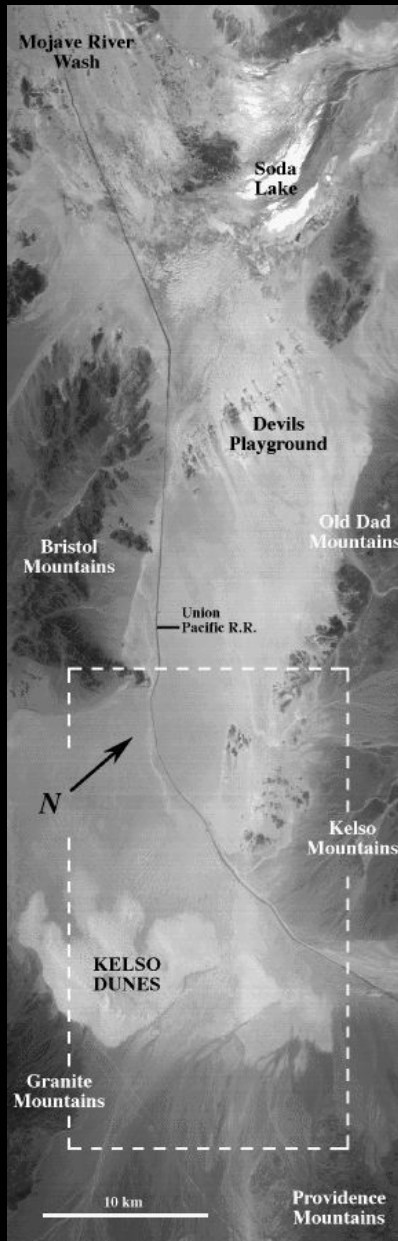
Rowan and others, 1998





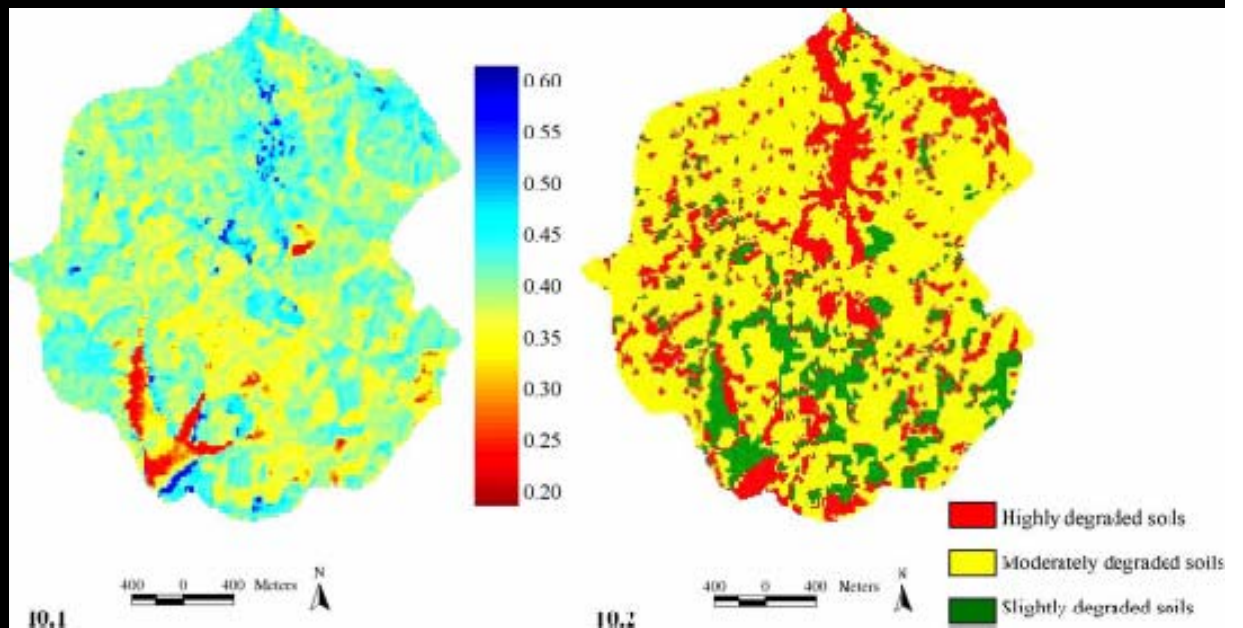
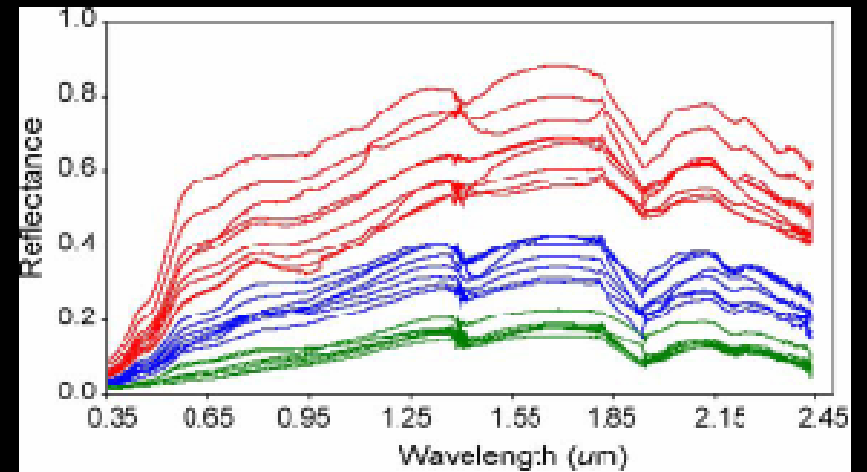
- How is the composition of exposed terrestrial surface responding to anthropogenic and non anthropogenic drivers (desertification, disturbance e.g. logging, mining)? (DS 114)

## Ramsey and Lancaster, 1998



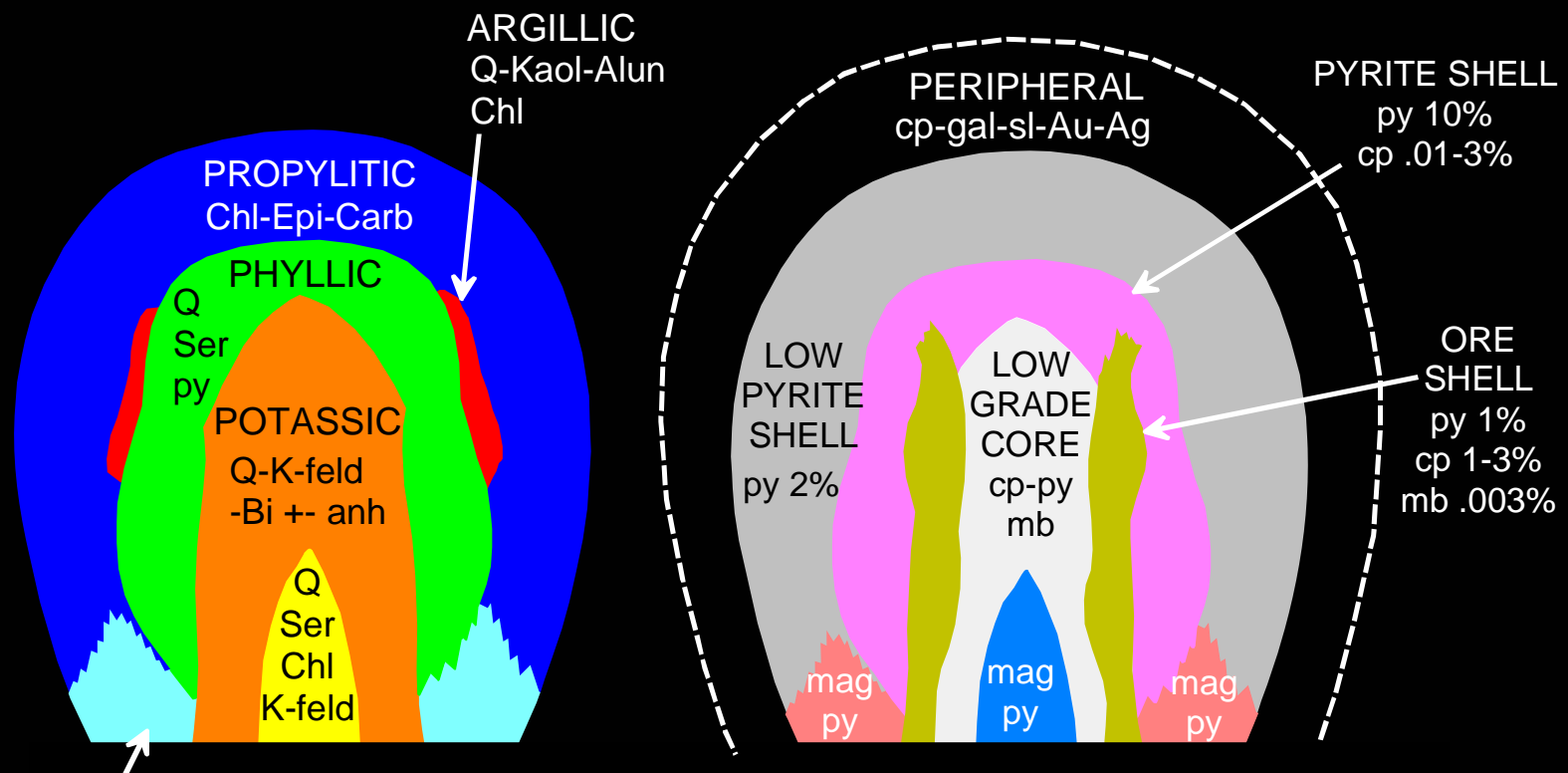
Dune migration in the Mojave Desert, California using TIMS data

## Chikhaoui and others, 2005 Land Degradation Index Study, Northern Morocco



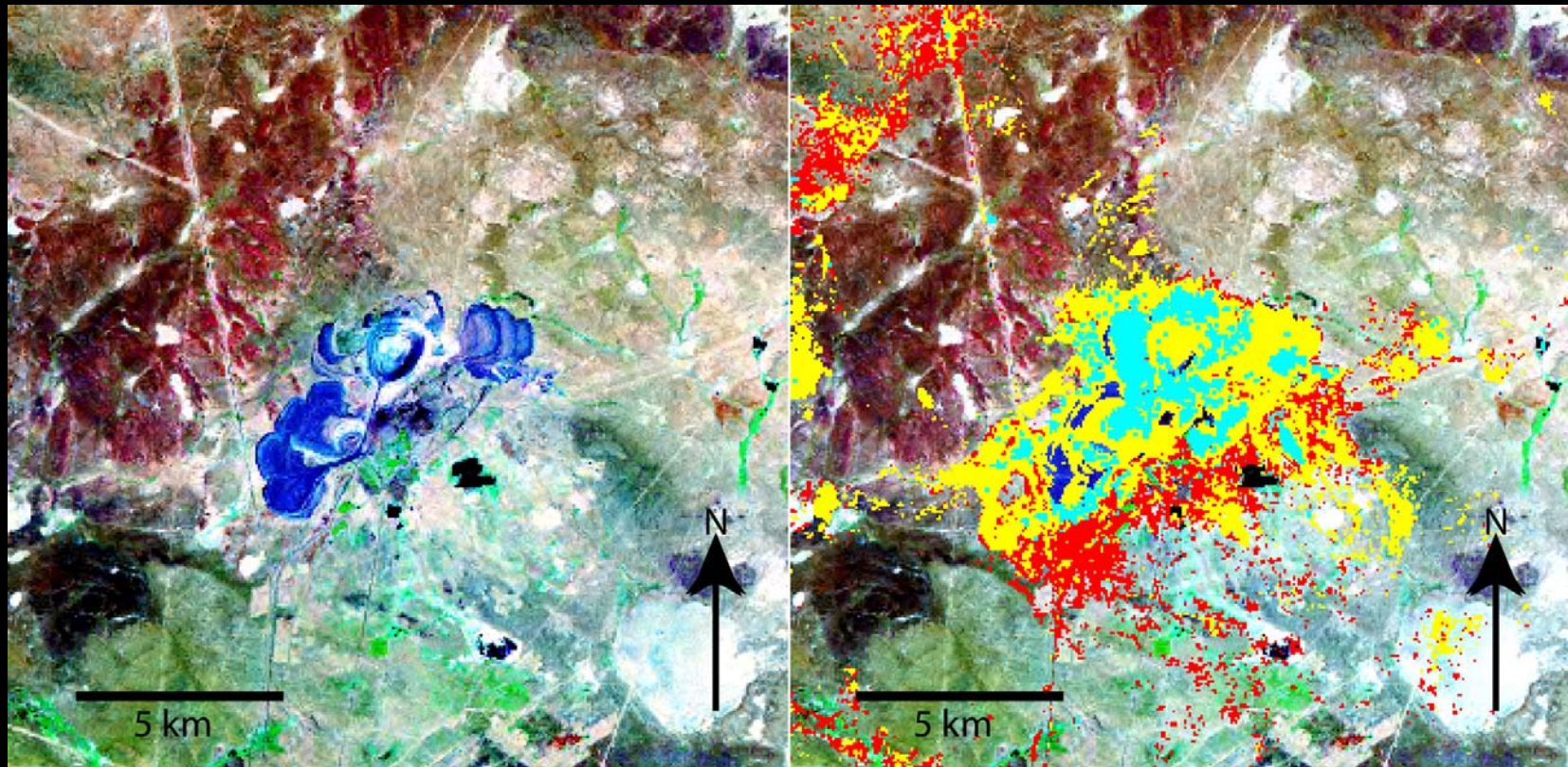
•Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

## HYDROTHERMAL ALTERATION ZONES, MINERALS, AND ORES IN A PORPHYRY COPPER DEPOSIT



(Modified from Lowell and Guilbert, 1970)

•Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)



**A. False color composite  
HypsIRI simulated image of  
the porphyry copper Konyrat  
Mine near Balaquash,  
Kazakstan.**

- Silicified rocks (TIR data)**
- Argillic-altered rocks (SWIR data)**
- Phyllic-altered rocks (SWIR data)**

- Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

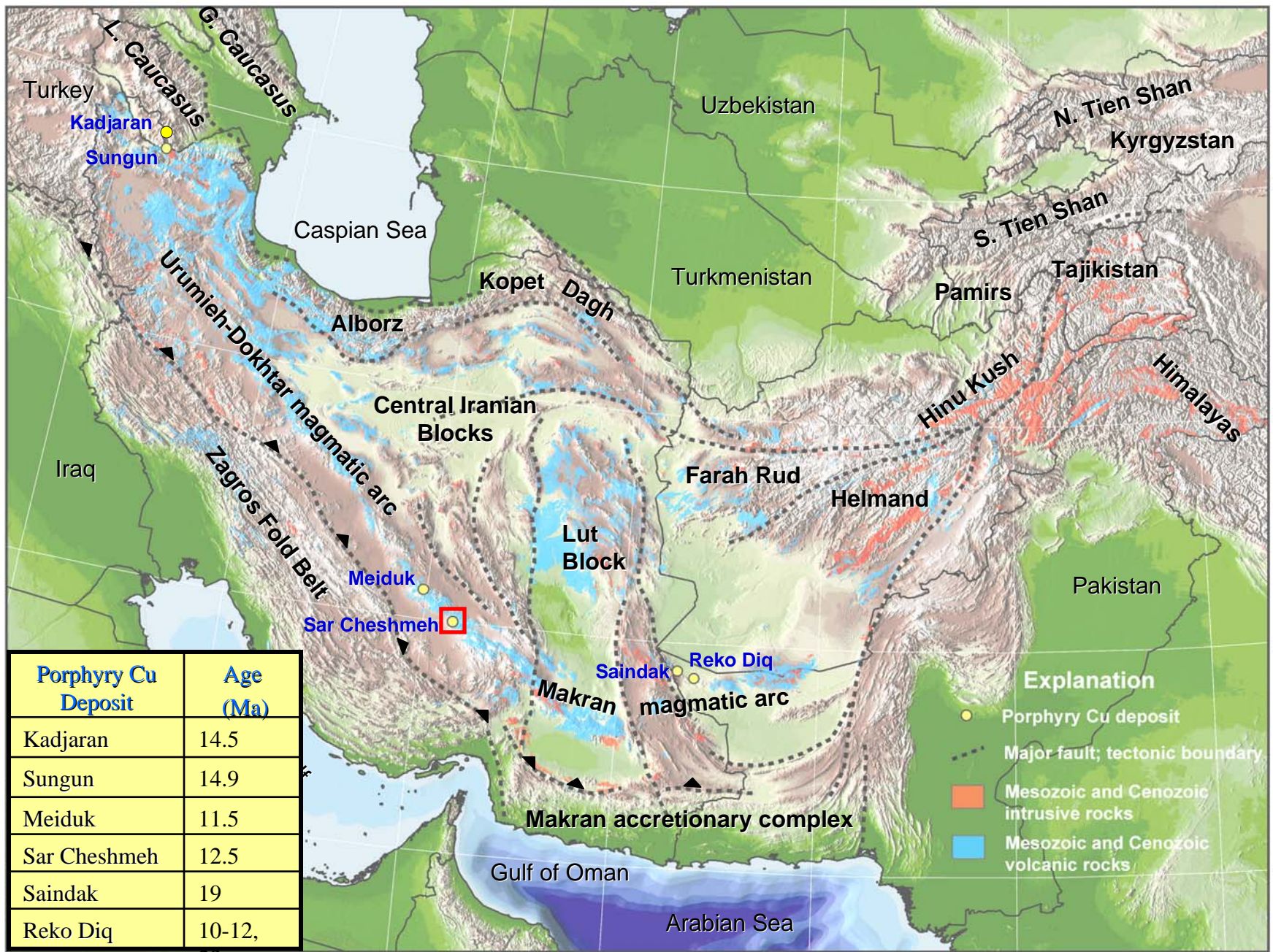
ASTER COVERAGE FOR IRAN, PAKISTAN AND AFGHANISTAN



OUTLINE OF ASTER COVERAGE

SCALE 500 km





50° 23'

55°

60°

65°

70°

75°

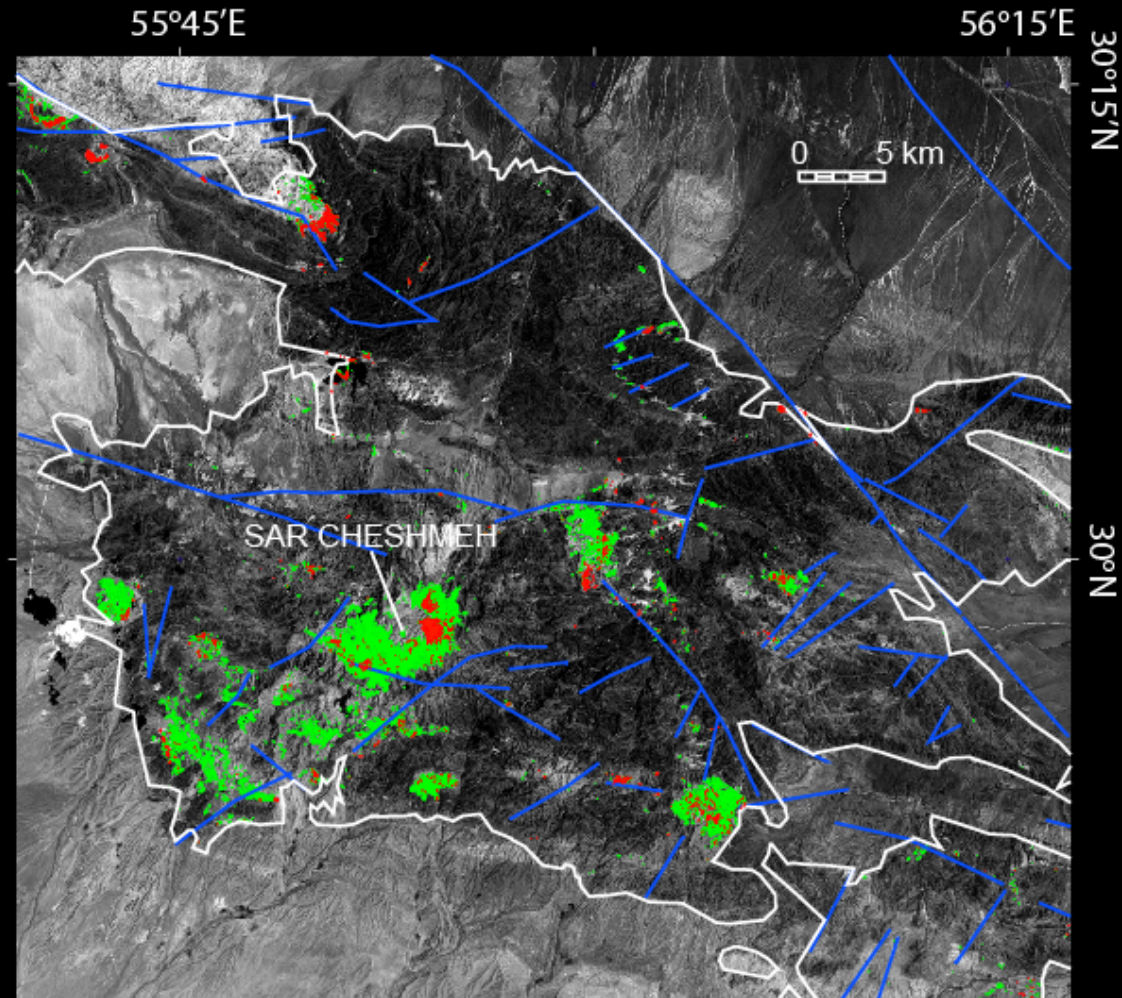
40°

35°

30°

25°

•Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

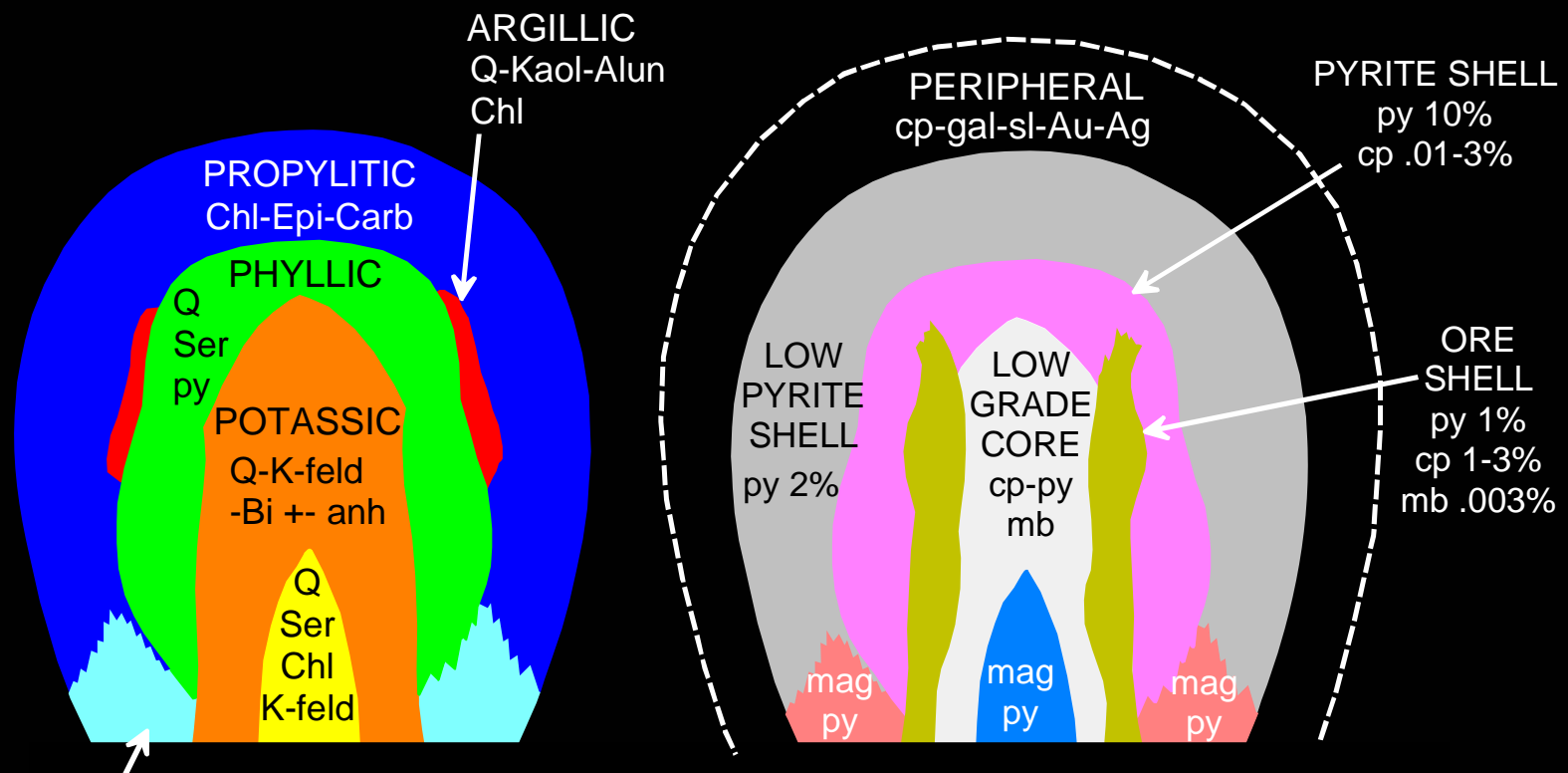


EXPLANATION - TM BAND 7 IMAGE AND ALTERATION

- ARGILLIC ALTERATION
- PHYLIC ALTERATION
- OUTLINE OF VOLCANIC UNITS
- FAULT FROM GEOLOGIC MAP

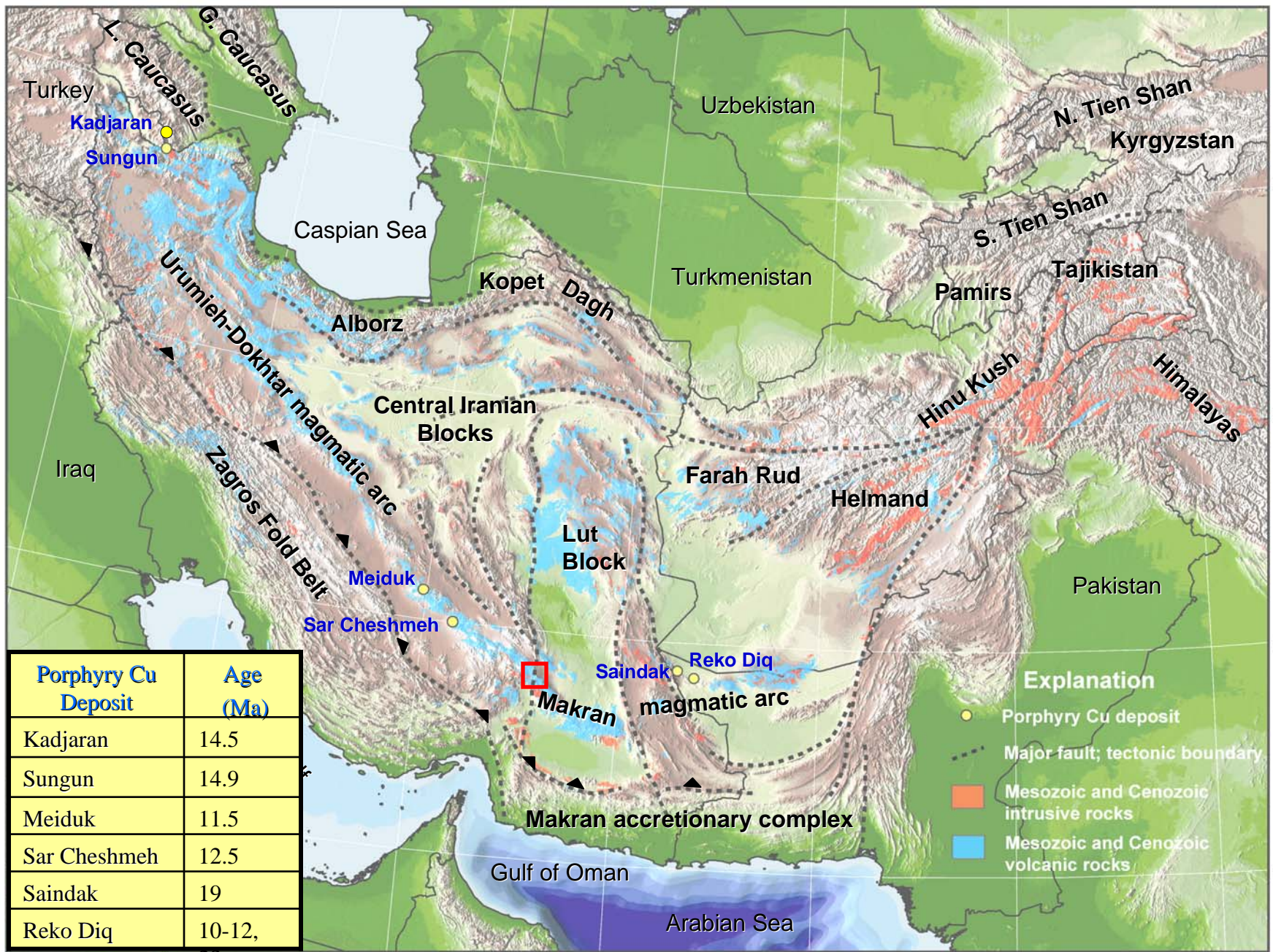
•Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

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(Modified from Lowell and Guilbert, 1970)





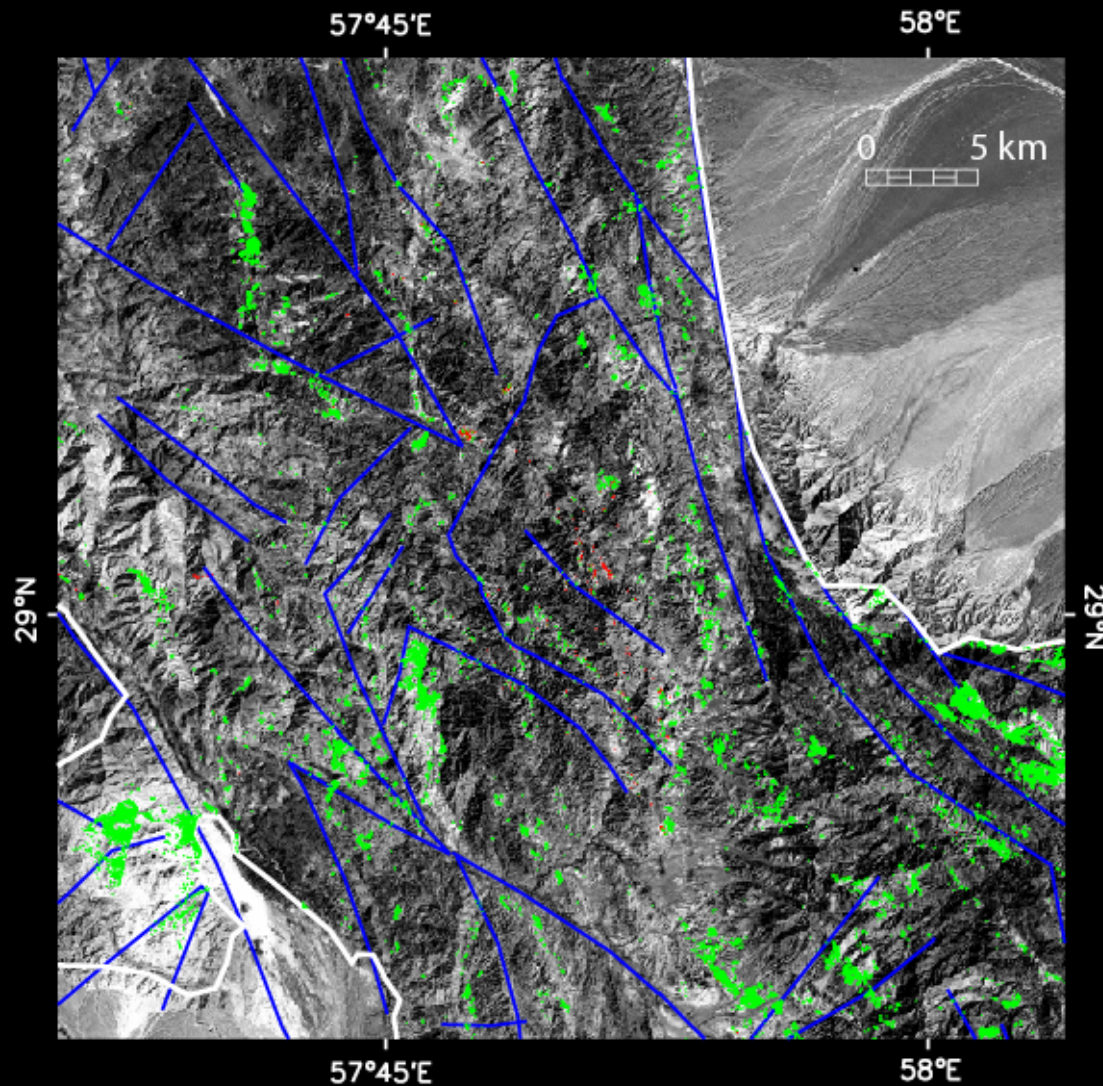
Porphyry Cu Deposit	Age (Ma)
Kadjaran	14.5
Sungun	14.9
Meiduk	11.5
Sar Cheshmeh	12.5
Saindak	19
Reko Diq	10-12,

**Explanation**

- Porphyry Cu deposit
- Major fault; tectonic boundary
- Mesozoic and Cenozoic intrusive rocks
- Mesozoic and Cenozoic volcanic rocks

50° 23      55°      60°      65°      70°      75°

•Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

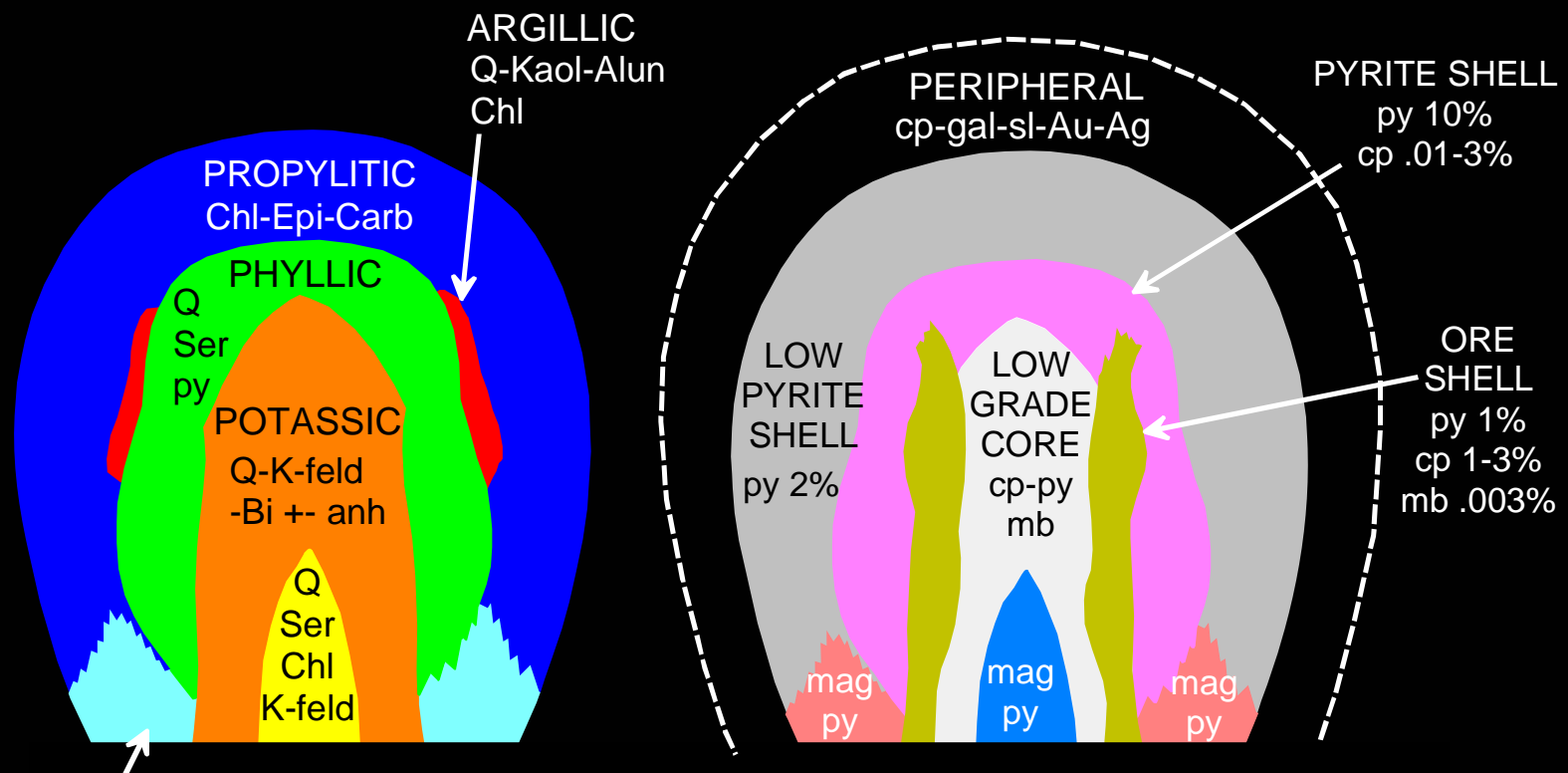


EXPLANATION - TM BAND 7 IMAGE AND ALTERATION

- ARGILLIC ALTERATION
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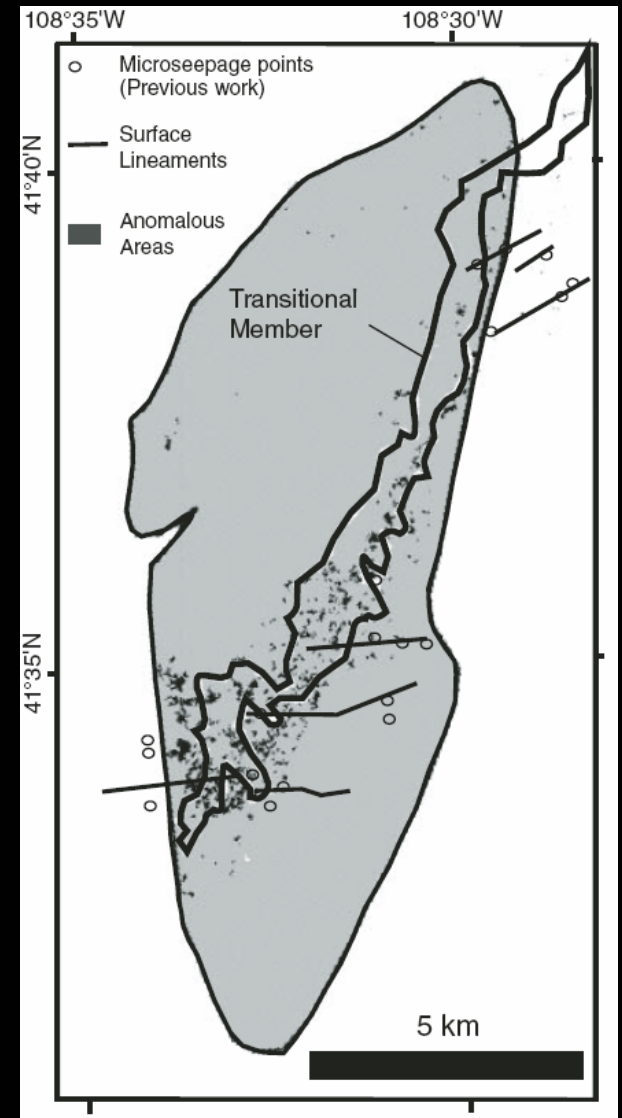
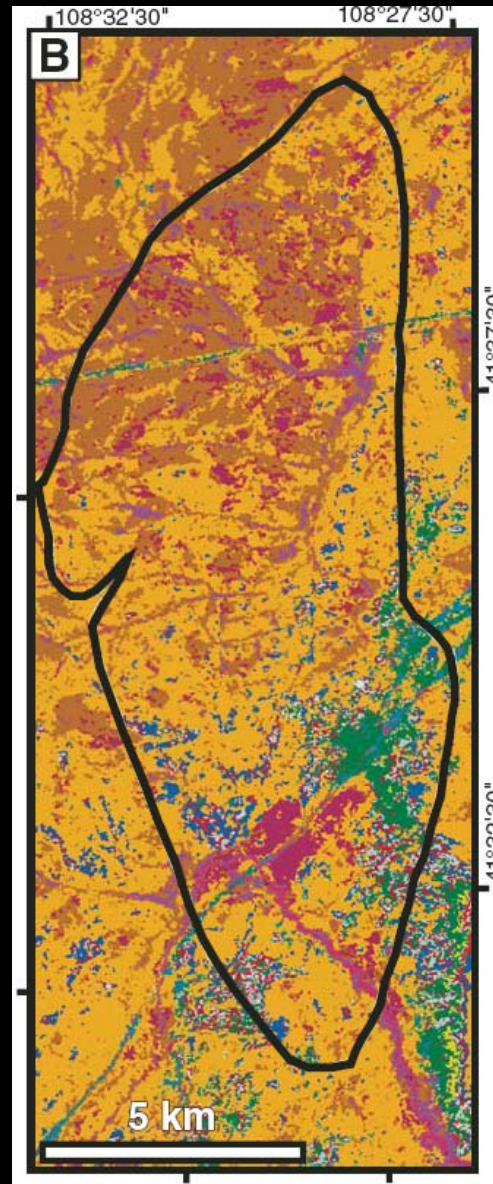
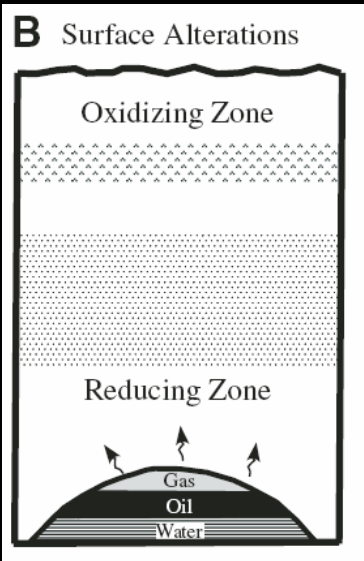
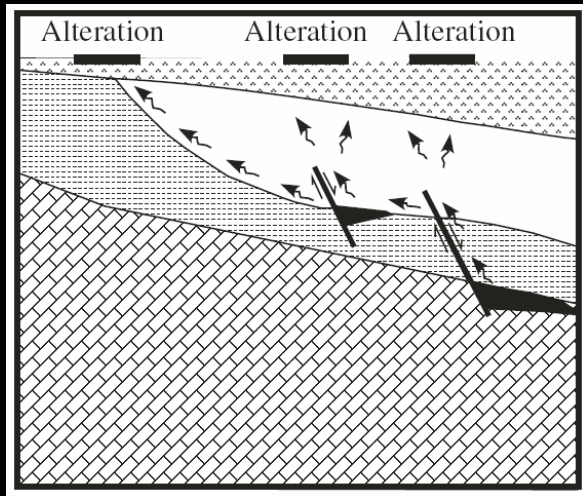
•Can high-resolution alteration maps define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

## HYDROTHERMAL ALTERATION ZONES, MINERALS, AND ORES IN A PORPHYRY COPPER DEPOSIT



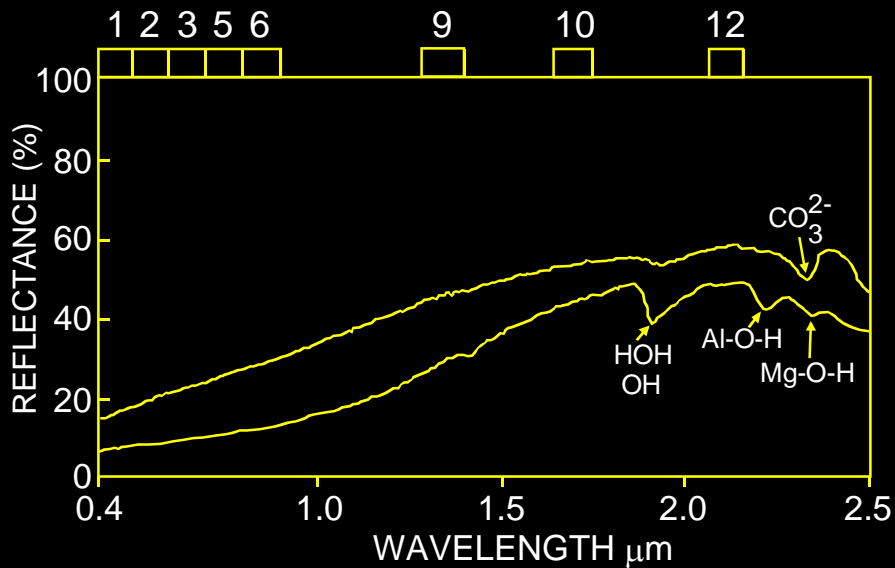
(Modified from Lowell and Guilbert, 1970)

- Can regional high-resolution lithologic and thermal maturity maps of basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)



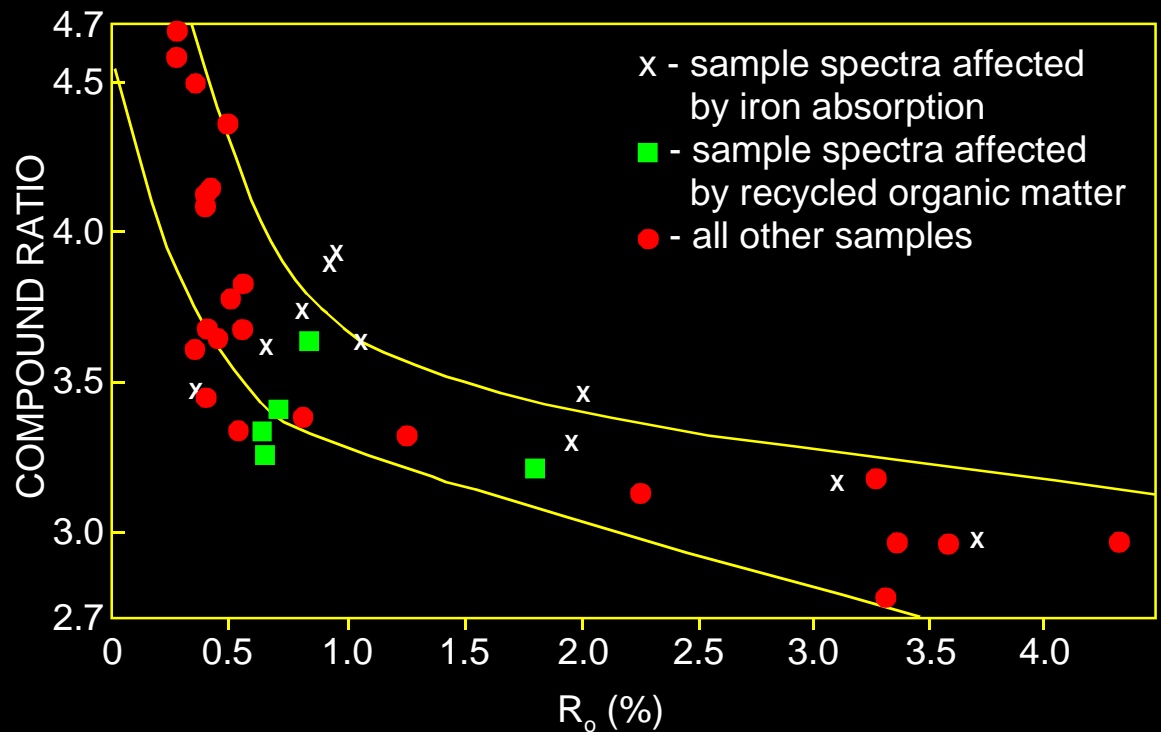
Khan and Jacobson, 2008

• Can regional high-resolution lithologic and thermal maturity maps of basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)



Compound Ratio:  
 $(\text{Ch3}/\text{Ch1} + (\text{Ch5}/\text{Ch3})$   
 $+ (\text{Ch6}/\text{Ch5}) + (\text{Ch10}/\text{Ch9})$   
 $- (\text{Ch12}/\text{Ch10})$

Rowan and others, 1995



- What habitat changes occur in shallow coastal and inland aquatic environments affected by changes in nearby land composition? (DS25 ?)

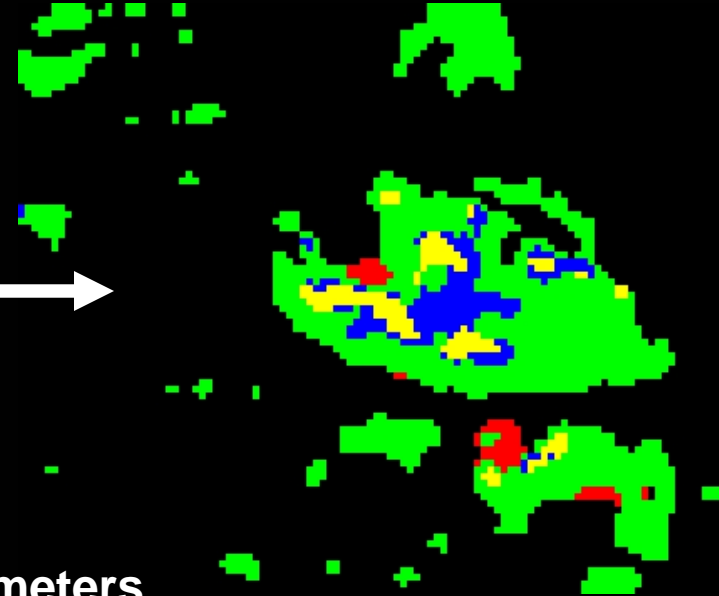


**Chesapeake water shed during heavy rainfall**

Hubbard, 2008

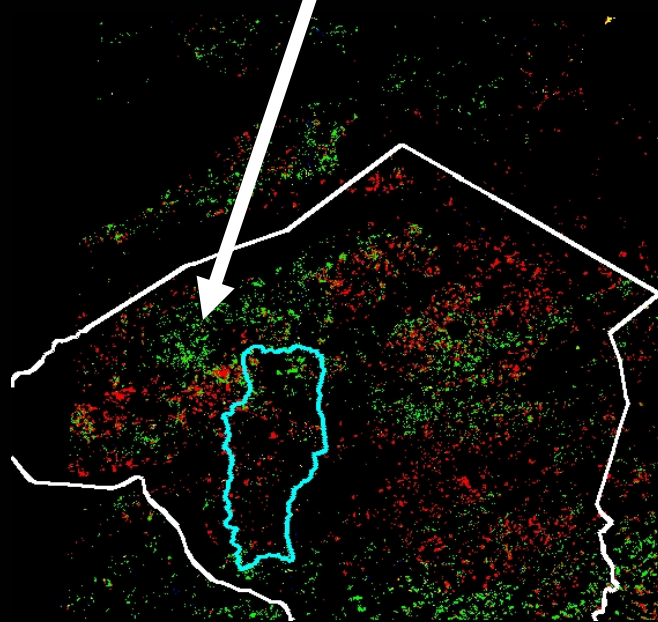
04/09/00  
MODIS

# Quartz and clay mineral types mapped using ASTER spectral endmembers



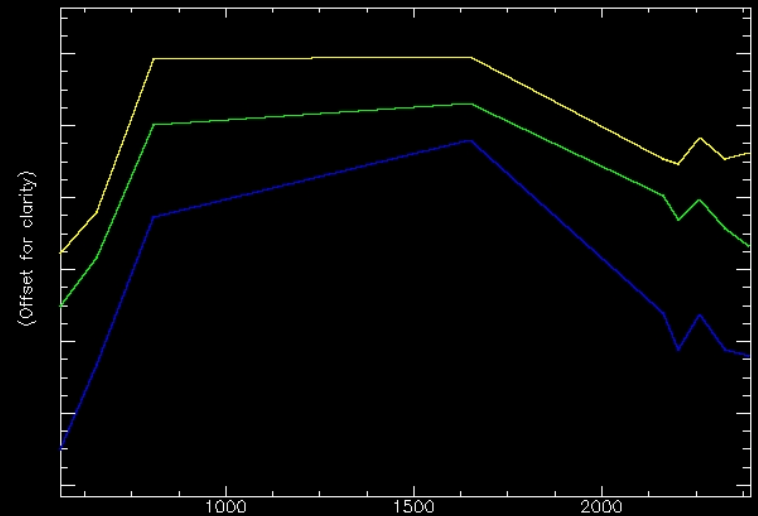
800 meters

Hubbard, 2008



intimate mixture classes:

- quartz
- smectite
- illite/musc
- kaolinite



## clay mineralogy part 2: what's so important about smectite-bearing soils anyway?



- expandable clay with high dispersive forces
- forms a water impermeable seal or barrier
- prevents water infiltration
- increases runoff, especially on higher slopes
- leads to rilling and gullying on higher slopes
- seals become cracked, crusts when dry
- see papers by I. Shainberg, M. J. Singer, M. Ben-Hur, R. Karen, E. Ben-Dor M. Agassi and others

Hubbard, 2008



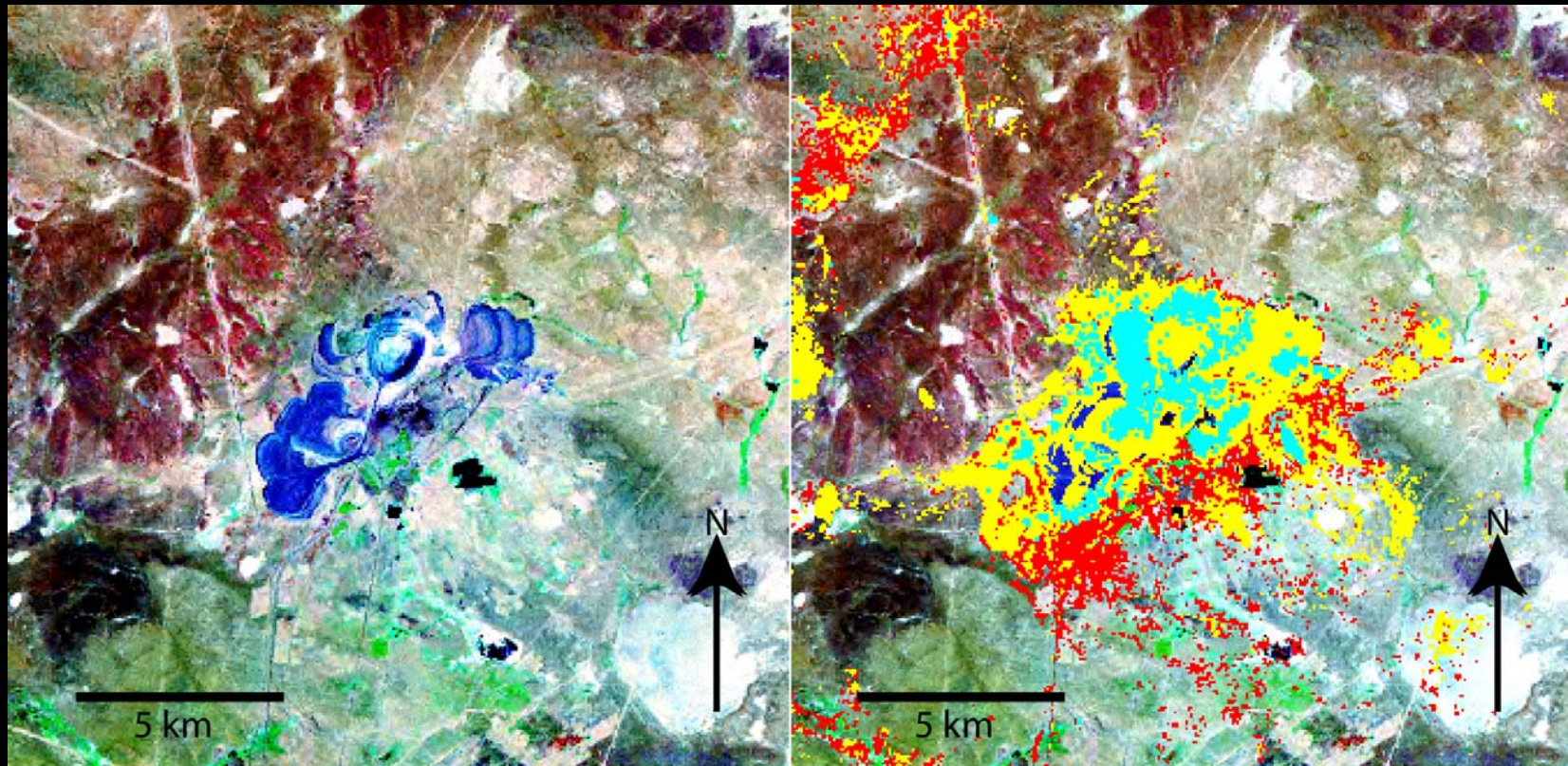


## CONCLUSIONS:

HYSPIRI WILL BE ABLE TO REGIONALLY  
MAP THE GREATEST VARIETY OF  
MINERALOGY OF ANY SPACEBORNE  
SENSOR IN EARTH ORBIT

HYSPIRI WILL PROVIDE TEMPORAL DATA  
SETS TO MONITOR EARTH PROCESSES

- How is the composition of exposed terrestrial surface responding to anthropogenic and non anthropogenic drivers (desertification, disturbance e.g. logging, mining)? (DS 114)



**False color composite  
HispIRI simulated image of  
the porphyry copper Konyrat  
Mine near Balaquash,  
Kazakstan.**

- Cyan** Silicified rocks (TIR data)
- Red** Alunite and kaolinite-rich rocks (SWIR data)
- Yellow** Sericite-rich rocks (SWIR data)

# • What is the composition of the exposed terrestrial surface of the Earth? (DS 220)



U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY

GEOLOGIC INVESTIGATIONS SERIES LETTER, Number 131

## The North America Tapestry of Time and Terrain

Cobertura de Tiempo y Terrenos de Norte América  
L'Amérique du Nord : un collage de terrains d'âges différents

Tapestry Compiled by  
Kate E. Barton<sup>1</sup>, David G. Howell<sup>1</sup>, and José F. Vigil<sup>1</sup>

Geology Compiled by  
John C. Reed, Jr.<sup>2</sup> and John O. Wheeler<sup>2</sup>

<sup>1</sup>U.S. Geological Survey, <sup>2</sup>Geological Survey of Canada  
2003

This map illustrates the geologic time scale of the exposed terrestrial surface of the Earth. It is based on the geologic time scale of the International Union of Geological Sciences (IUGS) and the geologic time scale of the Geological Society of America (GSA). The map shows the distribution of geologic units across North America, with colors representing different geologic eras and periods. The map is a mosaic of different geologic units, showing the complex history of the continent.

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### Geologic Time Scale

Millions of Years Ago (Ma)

Millions of Years Ago (Ma)

Millions of Years Ago (Ma)

Millions of Years Ago (Ma)

Millions of Years Ago (Ma)

Millions of Years Ago (Ma)

Millions of Years Ago (Ma)

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Millions of Years Ago (Ma)

Millions of Years Ago (Ma)



U.S. Geological Survey, Map Distribution Center, Box 2008  
Foster Building, Reston, Virginia, 20192-2008 • 1-800-243-5300  
Available on the Web at <http://pubs.usgs.gov/of/2003/of131/>  
Revised and updated by publication on December 8, 2003



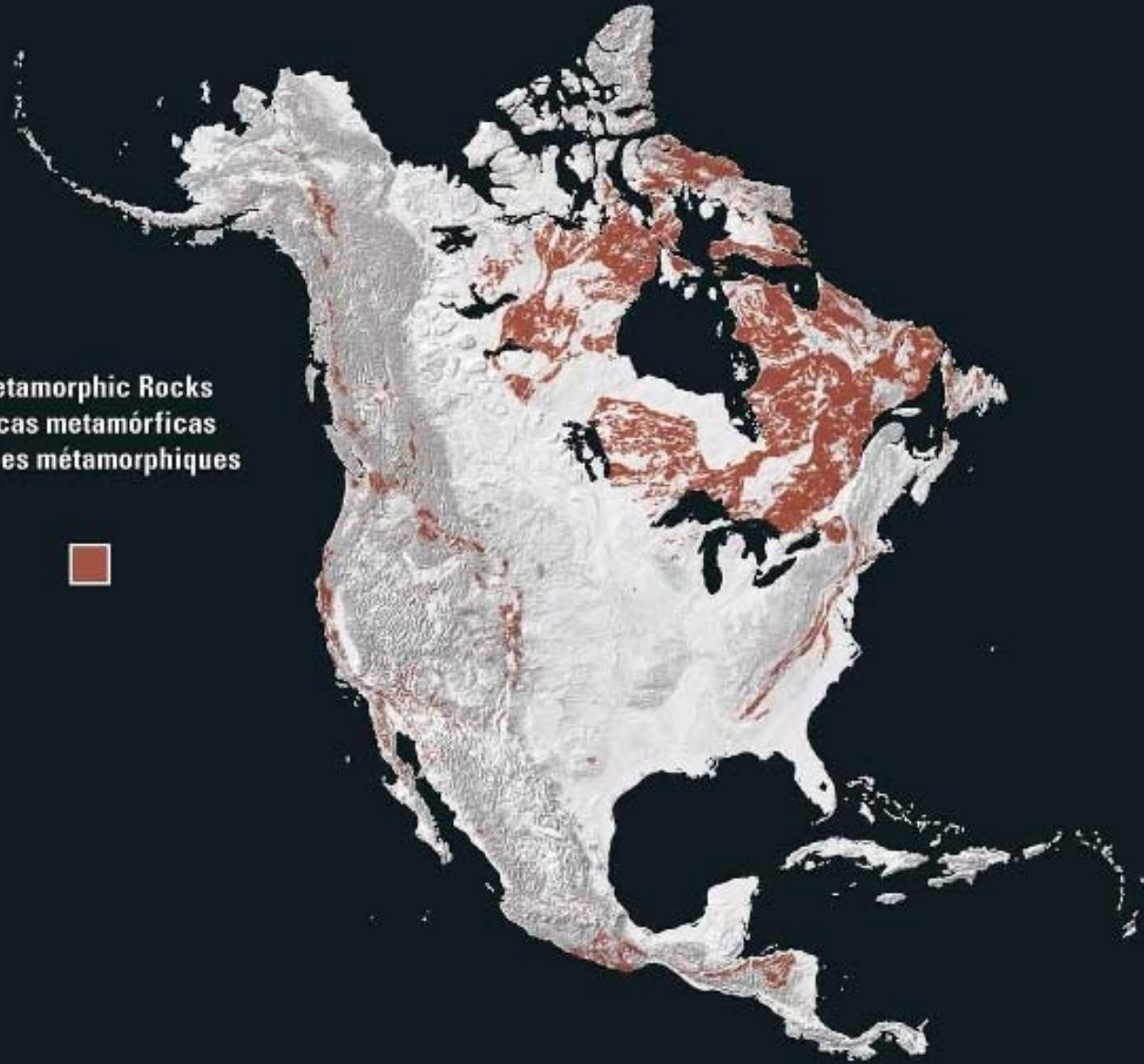
Plutonic Rocks  
Rocas plutónicas  
Roches plutoniques



Volcanic Rocks  
Rocas volcánicas  
Roches volcaniques



Metamorphic Rocks  
Rocas metamórficas  
Roches métamorphiques



Sedimentary Rocks  
Rocas sedimentarias  
Roches sédimentaires

