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

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NRC DECADAL SURVEY

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A mission that addresses how and why Earth’s surface composition and thermal properties vary with location and time and has implications for resources, susceptibility to natural hazards, and ecosystem health.

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Mission to observe surface composition and thermal properties.

Combined VNIR-SWIR and TIR Combined Question 5

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

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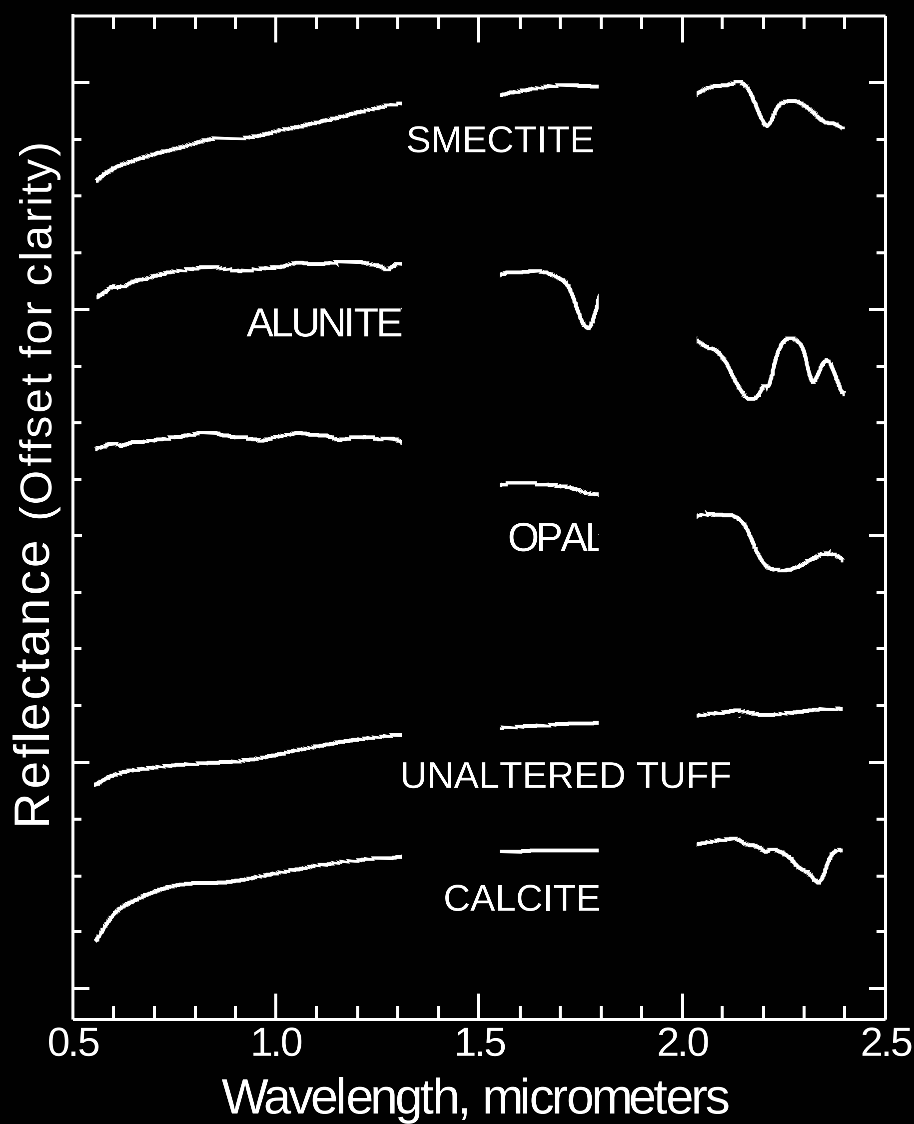
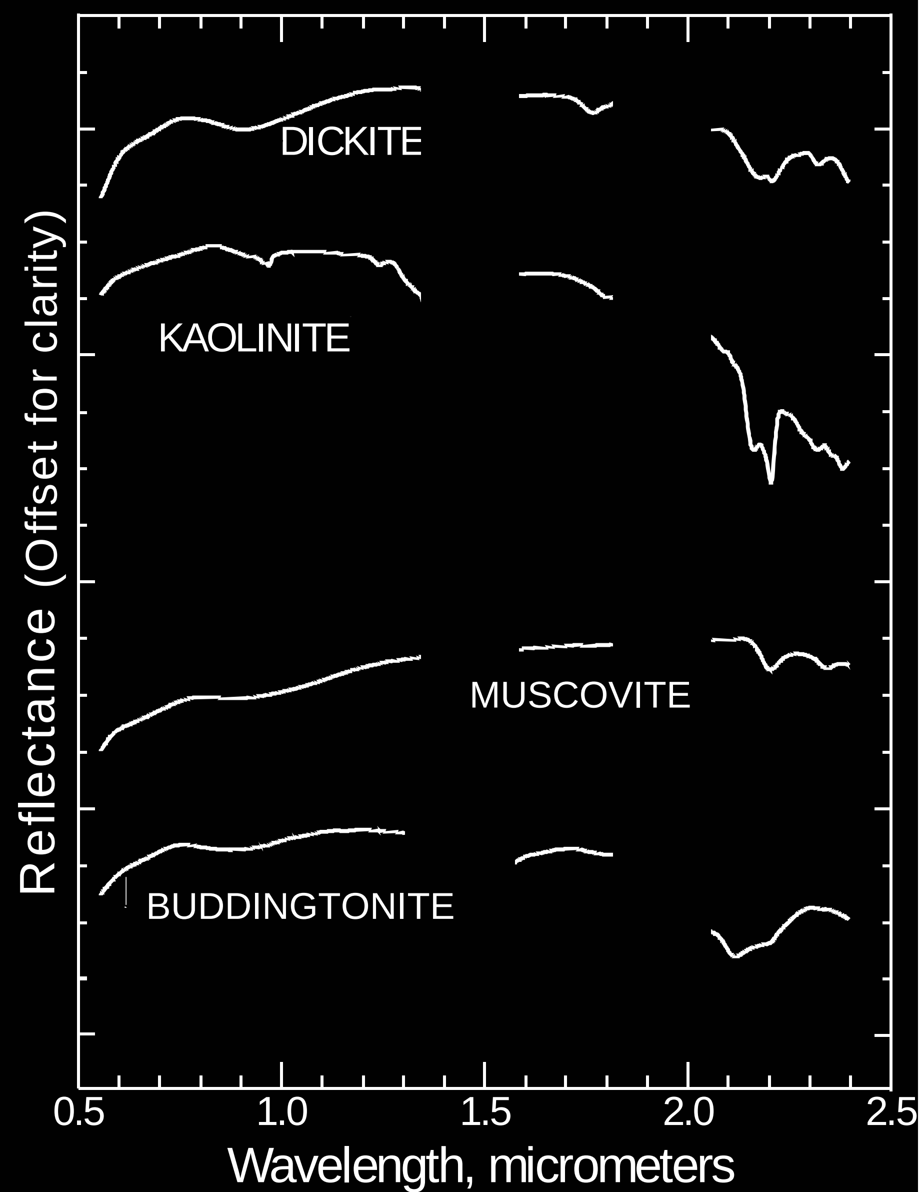
SPECTRAL REGION/ SPATIAL RESOLUTION	BANDS - WAVE-LENGTH REGION, MICROMETERS	COMPOSITIONAL INFORMATION
VNIR /	~ 95 BANDS* 0.350 - 1.40 μm	- FERRIC-FERROUS IRON ABSORPTION - REE
SWIR / 60 m	~ 80 BANDS* 1.40 - 2.50 μm	- AL-O-H IN CLAYS, MICAS, SULFATE MINERALS - CO_3 IN CARBONATES - Mg-O-H IN AMPHIBOLES, MICAS - H-O-H IN EVAPORITES, CLAYS
TIR / 60 m	B1 - 3.98 μm B2 - 7.35 μm B3 - 8.28 μm B4 - 8.63 μm B5 - 9.07 μm B6 -10.53 μm B7 -11.33 μm B8 -12.05 μm	- SILICATE MINERALS, ESPECIALLY SHIFT TO SHORTER WAVELENGTHS - SULFATE MINERALS - CARBONATE MINERALS

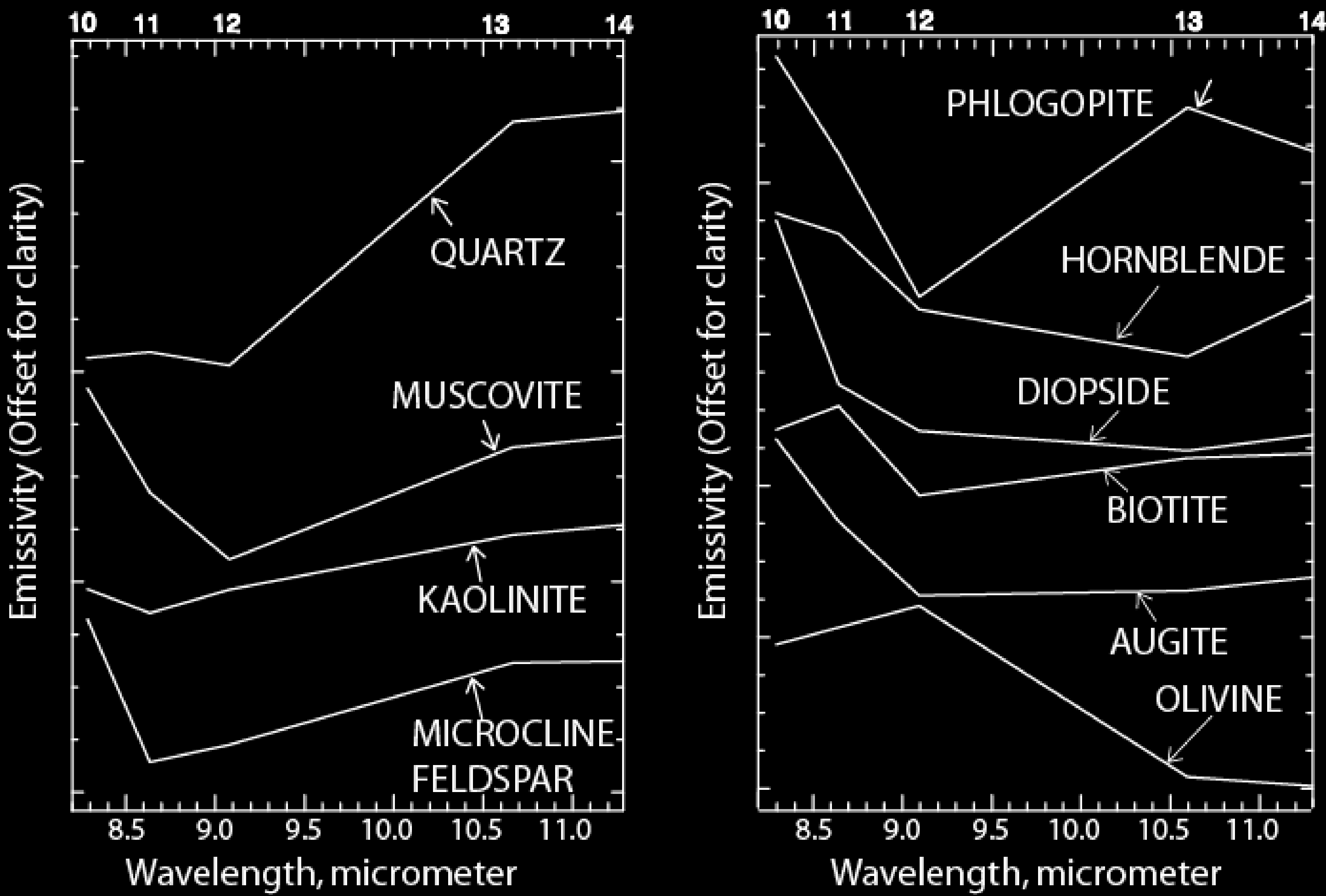
* After removal of atmospheric absorption bands

VNIR- SWIR LABORATORY SPECTRA RESAMPLED TO 10 NANOMETER SPACING





LABORATORY SPECTRA RESAMPLED TO ASTER BANDPASSES



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

Science Issue:
How to compile more descriptive-detailed mineral and lithologic maps?

Tools:
VINIR-SWIR-TIR surface reflectance and emissivity data
Spectral field data (calibration – validation)

Approach:

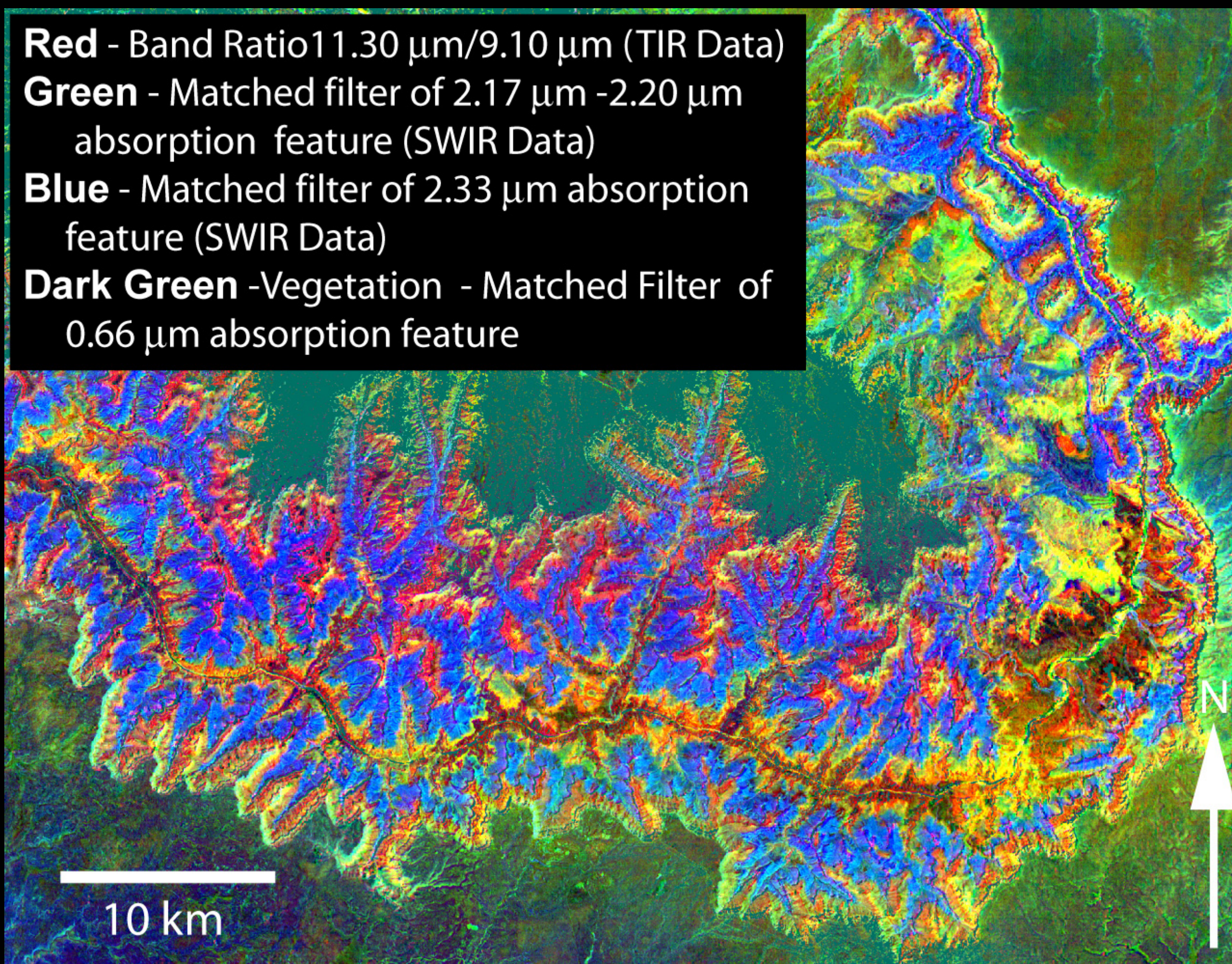
HyspIRI will be able to map the most common surfical minerals including quartz (TIR), carbonates (TIR, SWIR), clays (SWIR), oxides (VNIR) and evaporites (VNIR and SWIR

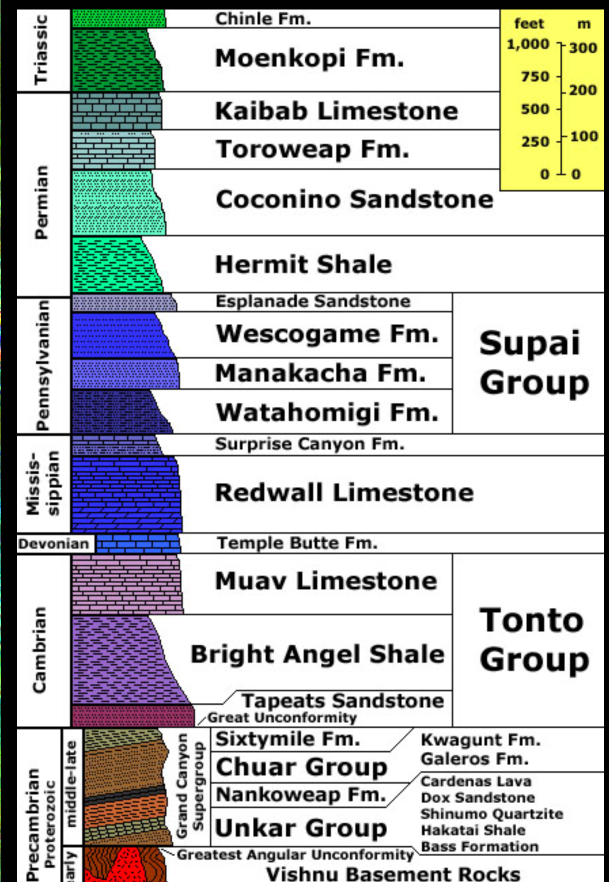
Spectroscopic mapping of diagnostic absorption features – SAM, Mathched Filtering, band ratios, band ratio logical operators…

Use false color composite combinations of ratio and abundance maps that highlight common mineral groups – rock and sediment types

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

False color composite HyspIRI 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) ASTER data.





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

Level Three Products:

Mineral maps

Regional false color composite images of mineral groups

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

Science Issue:

How do altered rocks affect vegetation?

Tools:

-HyspIRI VNIR SWIR reflectance data for vegetation spectral mapping

-HYSPIRI VNIR-SWIR, TIR reflectance and emissivity data for lithologic – minerals mapping

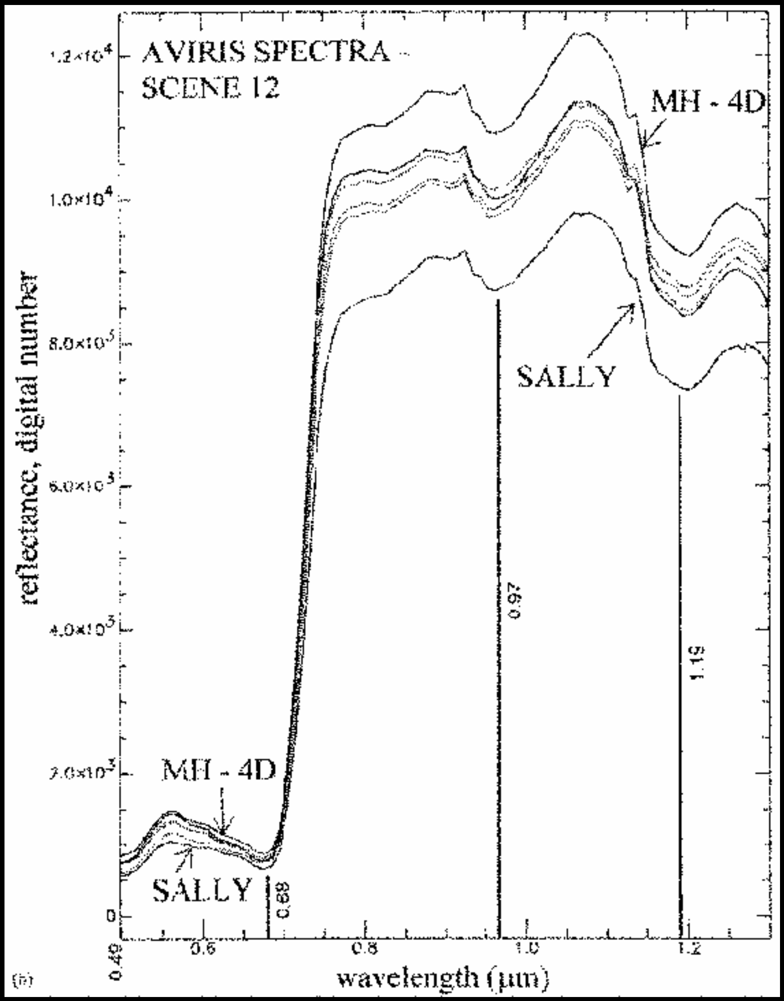
Approach:

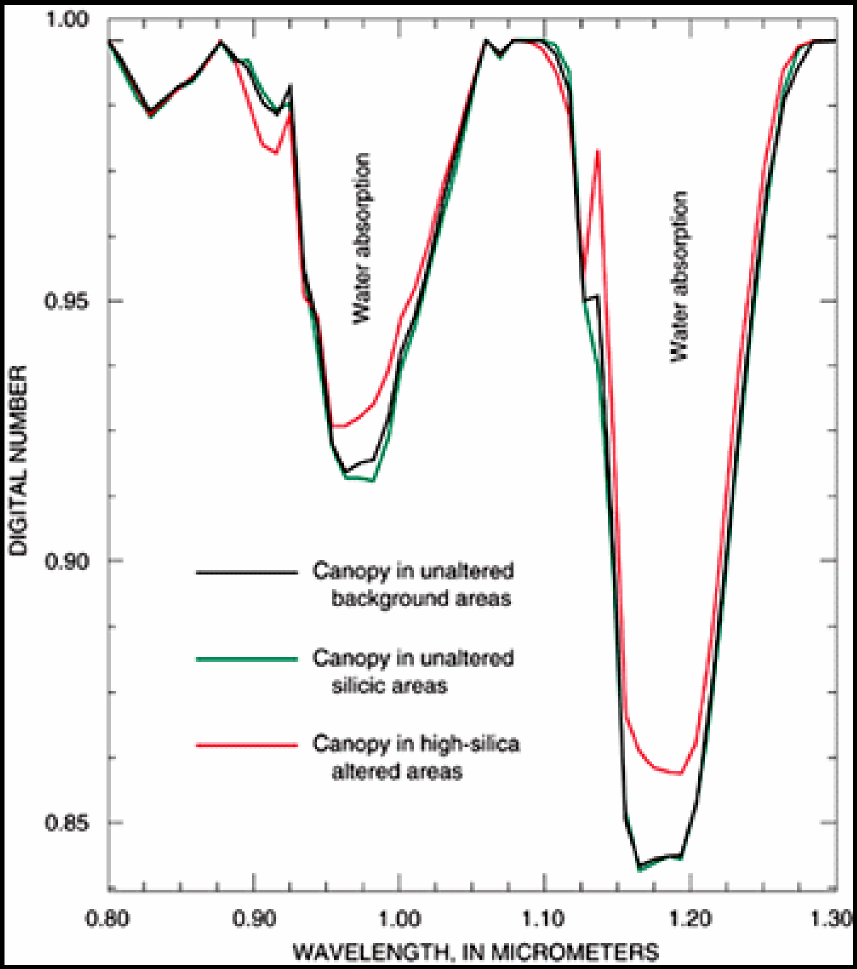
Study VNIR-SWIR spectral characteristics of vegetation

Mapping rocks beneath vegetation cover.

Results:

Rowan and others (1998) illustrated that AVIRIS spectra water absorption features in Chestnut Oak leaves were shallower for trees situated on altered rocks vs. non-altered rocks. Band ratio and match filtering mapping of the water vapor features delineated stressed Chestnut Oak trees growing on altered rocks.





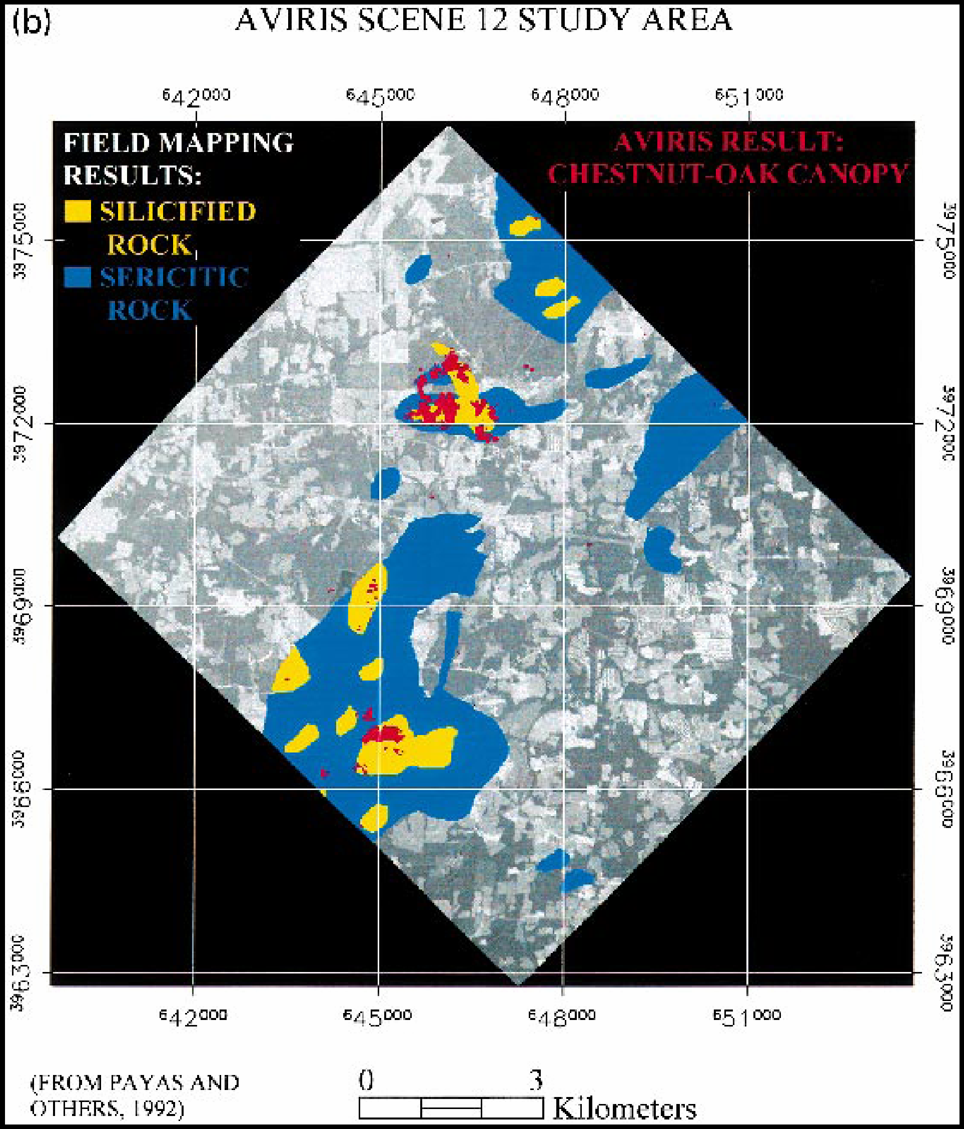
AVIRIS spectra illustrate water absorption features (0.97 µm and 1.19 µm) in Chestnut Oak leaves are shallower for trees situated on altered rocks

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

Level Three Products:

Mineral maps compiled from VNIR-SWIR-TIR data

Water absorption maps of the 0.965 and 1.18 micrometer region of green vegetation



Red areas on map indicate stressed Chestnut Oak trees growing on altered rocks (Rowan and others, 1998)

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

Science Issue:

Monitoring of desertification

Tools:

-Field spectral data

-HyspIRI VNIR, SWIR and TIR reflectance and emissivity data, multiple temporal datasets

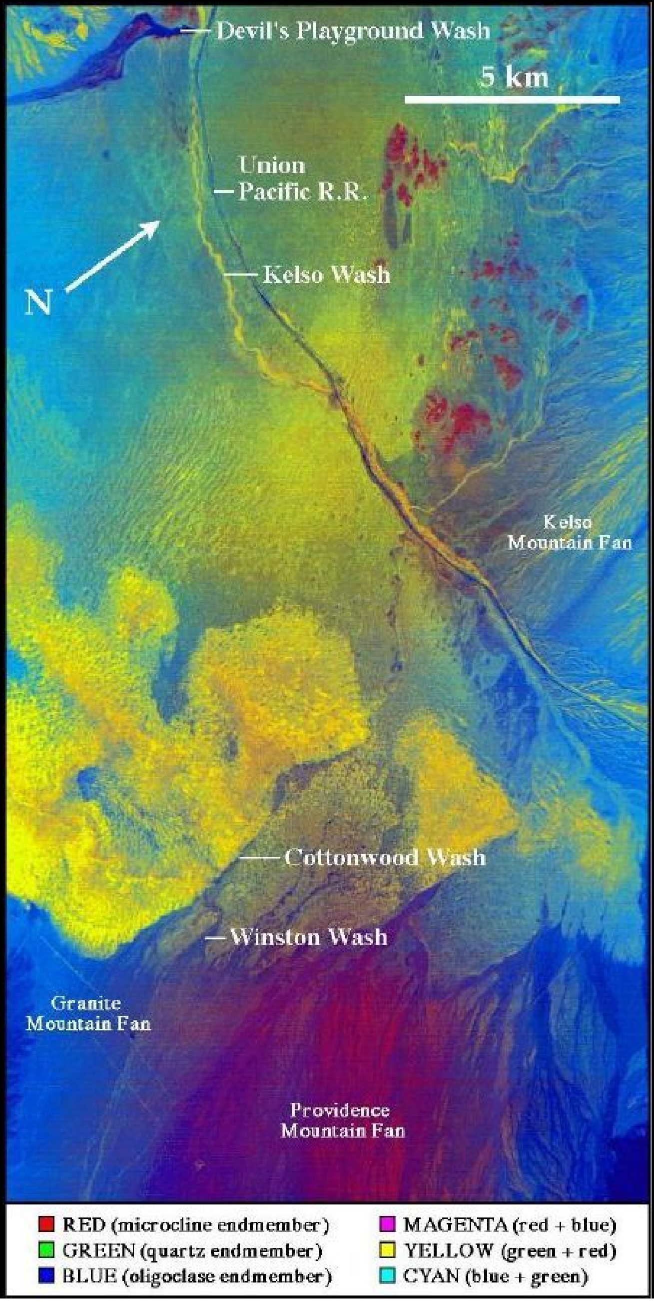
Approach:

-HyspIRI VNIR-SWIR data can be used to map vegetation, and clay, carbonate, and evaporite compositions of soils.

-HyspIRI TIR data can be used to map soil quartz content and quartz sand movement.

-Multiple HyspIRI data sets can be used to monitor landscape changes

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

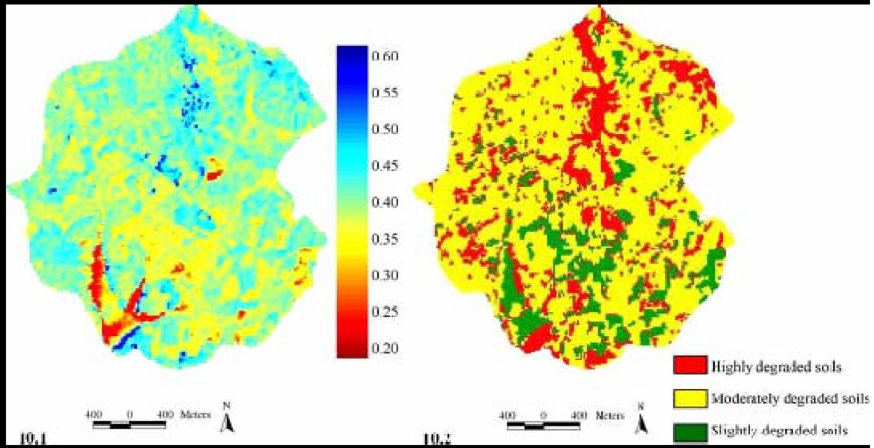


EXAMPLE:

-Chikhaoui and others used ASTER VNIR-SWIR field spectra and VNIR SWIR ASTER data to compile a land degradation index map.

-Ramsey and Lancaster used TIMS TIR data to monitor dune migration of quartz-rich sands.

Land Degradation Index Northern Morocco-Index compiled from ASTER VNIR-SWIR data and ASD field data



Chikhaoui and others, 2005

Monitoring dune migration in the Mojave Desert, California using TIMS (TIR) data

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

Level three products?

New LDI maps using VNIR-SWIR-TIR data

LDI Change maps???

•How do types and distributions of altered rocks 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)

Science Issue:

How can hydrothermal alteration be used to identify new economic deposits and better define hydrothermal fluid flow in hydrothermal systems?

Tools:

HyspIRI SWIR and TIR reflectance and emissivity data

Field spectral data

Approach:

- Deposit models such as Lowell and Guilbert (1970) suggest that most hydrothermal systems produce zones of different altered rocks based on geochemical conditions and alteration intensity.

- Propylitic, argillic, and phyillic-altered rocks have SWIR absorption features and potassic- and silicic-altered rocks have TIR absorption features. Thus, HyspIRI SWIR data could be used to map the propylitic, argillic and phyllic-altered rocks, and HyspIRI TIR data could be used to map hydrothermally altered silica-rich rocks with the TIR detector.

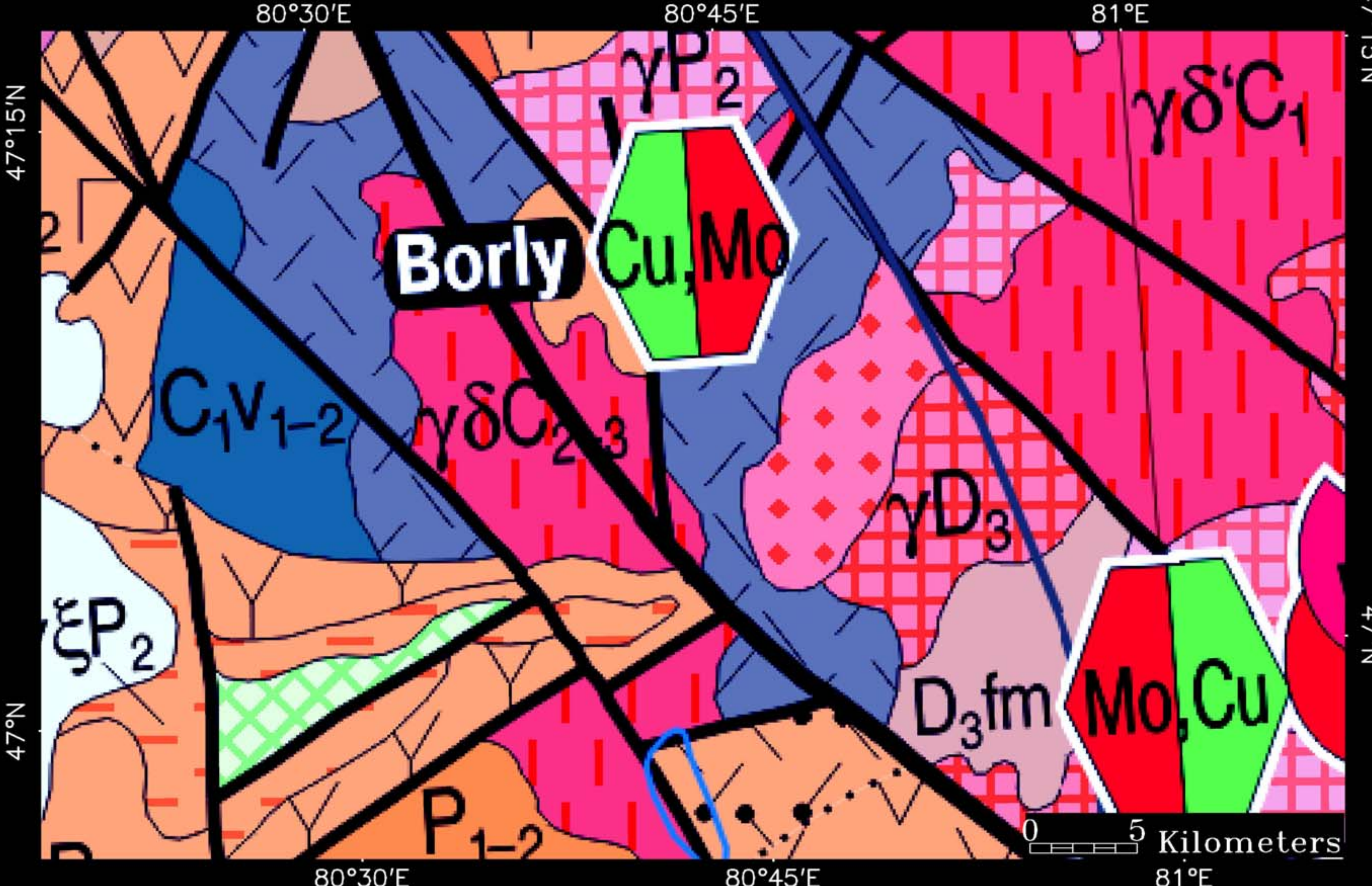
•How do types and distributions of altered rocks define regional trends in hydrothermal fluid flow for magmatic arcs and tectonic basins, better define hydrothermal deposit models, and assist in the discovery of new economic deposits? (DS 227)

Results:
ASTER data has been used to regionally map argillic, phyllic, and silicic rocks along magmatic arcs (Mars and Rowan, 2006; Mars 2009.

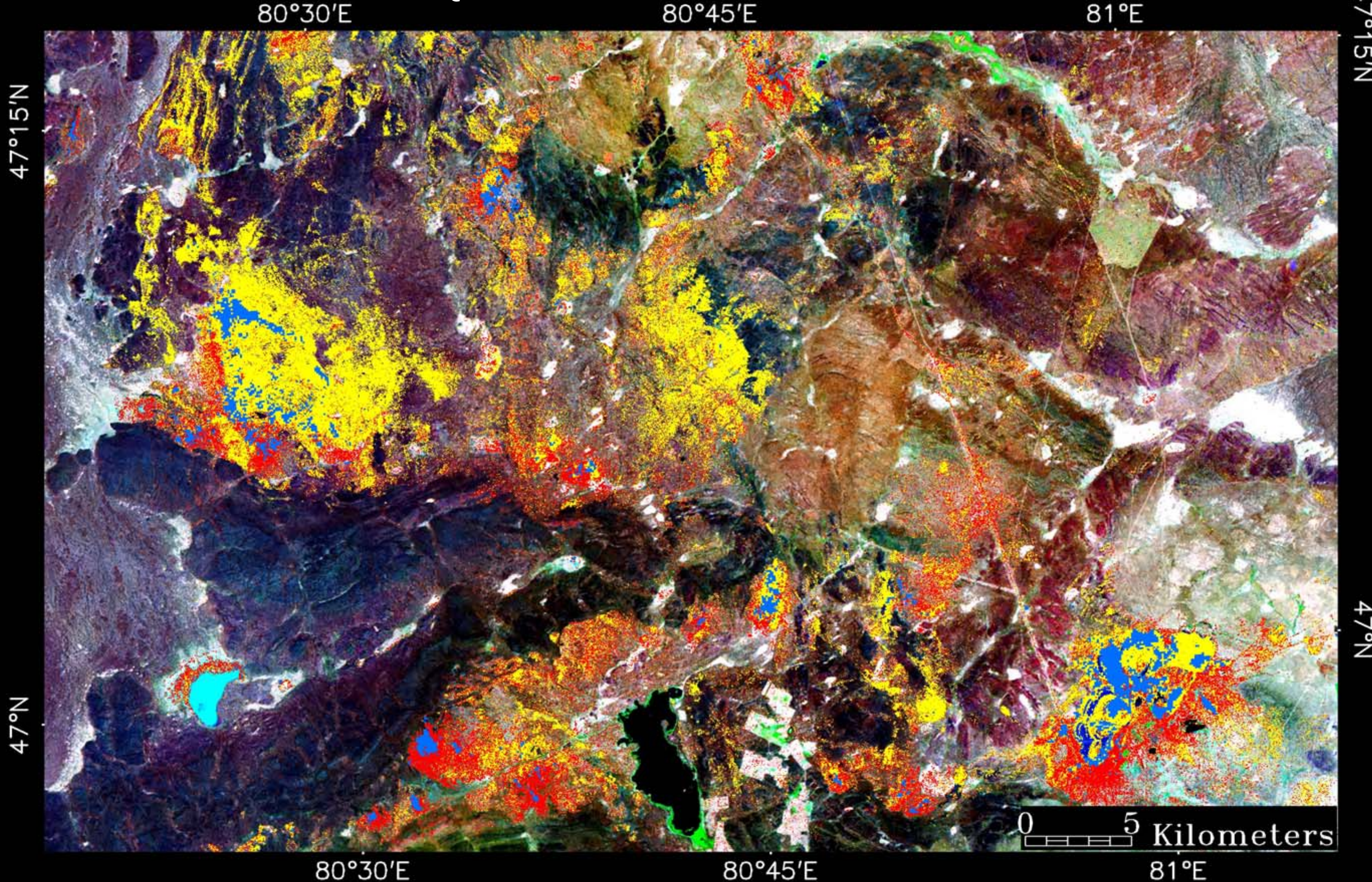
Porphyry copper deposits typically consist of circular to elliptical patterns of phyllic and argillic-altered rocks. Linear patterns of alteration have been associated with epithermal systems.

The regional alteration data have been used to identify potential deposits and assess hydrothermal fluid flow.

GEOLOGIC MAP OF NORTH WESTERN BALQASH, KAZAKHSTAN



LANDSAT 5 FALSE COLOR COMPOSITE IMAGE (R=7, G=4, B=4) OF NORTH WESTERN BALQASH, KAZAKHSTAN



YELLOW - PHILLIC-ALTERED ROCKS

RED – ARGILLIC-ALTERED ROCKS

BLUE – HYDROTHERMALLY ALTERED SILICA RICH ROCKS

•How do regional trends of minerals and shale thermal maturity within basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)

Science Issue:

How can mineral trends help identify new hydrocarbon reserves?

Tools:

HyspIRI VNIR, SWIR, and TIR reflectance and emissivity data.

Sample spectral data

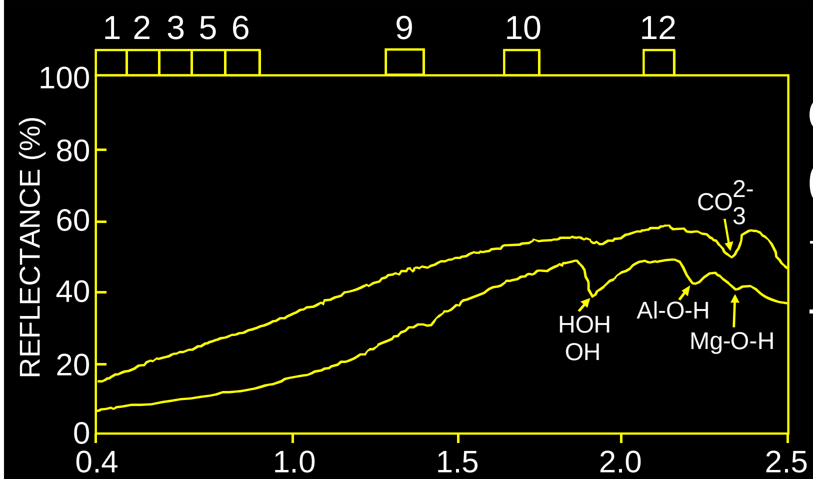
Approach:

-As hydrocarbons migrate, they alter rocks in the form of oxidation. Hyperspectral VNIR data could be used to identify bleached zones which may represent hydrocarbon seeps

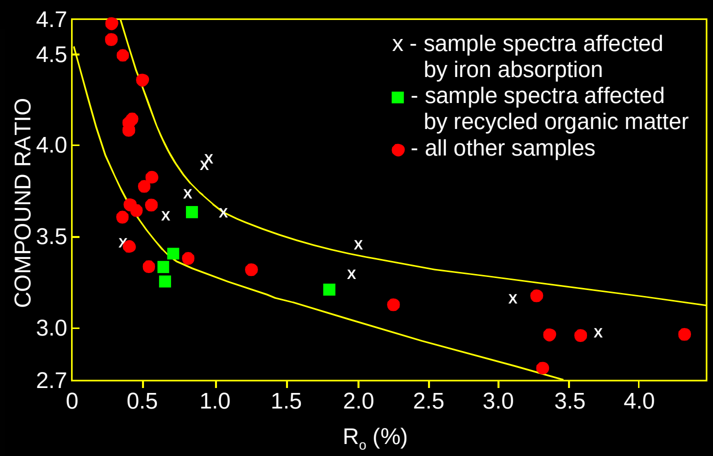
- Mineral maps compiled from VNIR-SWIR-TIR data assist in detailed surface geologic mapping

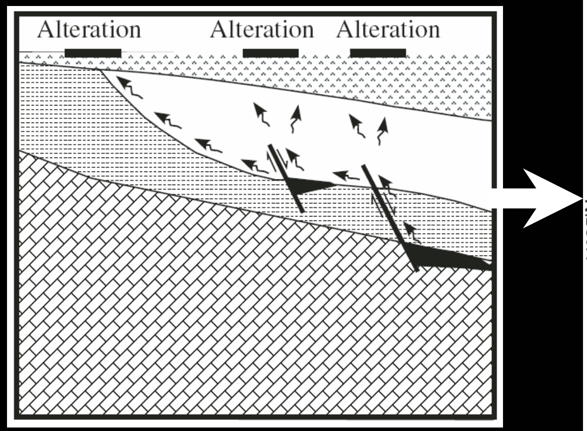
-Determine thermal maturity of source rocks using VNIR, SWIR and TIR data by compiling vitrinite reflectance maps

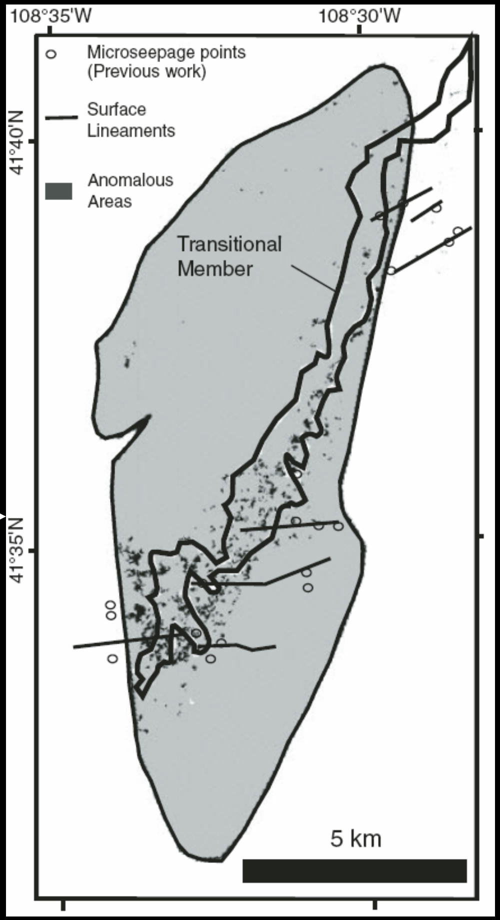
•How do regional trends of minerals and shale thermal maturity within basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)



Compound Ratio:
(Ch3/Ch1+(Ch5/Ch3)
+(Ch6/Ch5)+(Ch10/Ch9)
-(Ch12/Ch10)







Khan and Jacobson, 2008

Results:

- Khan and Jacobson (2008) have mapped bleached hydrocarbon seeps using VNIR-SWIR Hyperion (hyperspectral data.
- Rowan and others (1995) showed a relationship between vitrinite reflectance and reflectance. Using compound ratios they mapped thermal maturity using Landsat TM data in the Pieri Shale, Wyoming.

•How do regional trends of minerals and shale thermal maturity within basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)

LEVEL THREE PRODUCTS

Vitrinite reflectance - thermal maturity maps
Oxidation Maps
Mineral Maps

How do changes in land composition affect coastal and inland aquatic ecosystems? [DS 25]

Science Issue:

How do changes in land composition affect coastal and inland aquatic ecosystems? [DS 25]

Tools:

HyspIRI VINIR, SWIR and TIR reflectance and emissivity data, TIR Temp. data

Approach:

VNIR data - map vegetation density and water turbidity

SWIR and TIR data – soil composition

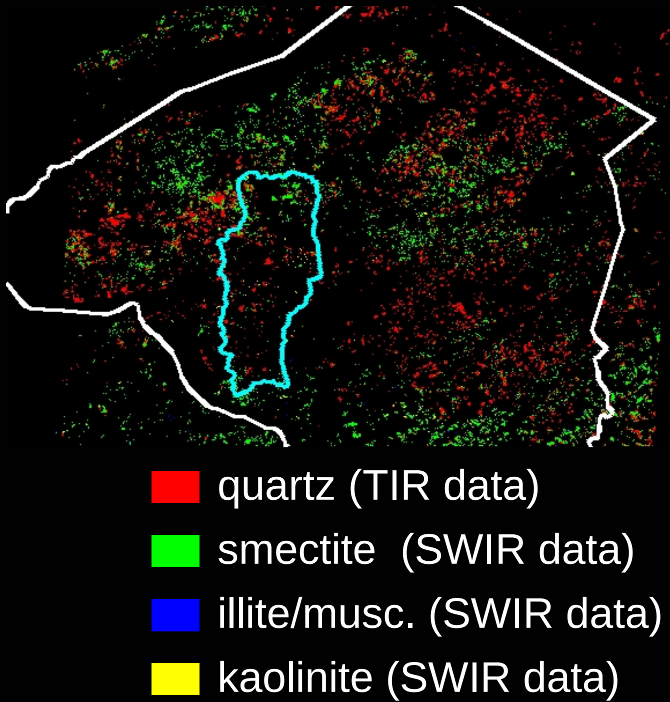
TIR Surface Temp. data – Marine and riverine water circulation

Example:

Hubbard (2008) used ASTER VNIR, TIR, and ASTER data to map soil and vegetation charateristics of the Little Conestoga water shed.

Farming practices expose large areas of smectite-rich soils venerable to erosion during periods of large storms and runoff.

MODIS image (04/09/00) of Chesapeake water shed during heavy rainfall. Yellow arrow illustrates location of increased sediment loading at the Little Conestoga water shed into the Susquehanna River and resulting sediment plume in the upper part of the Chesapeak Bay



Endmember mapping of the Little Conestoga water shed area illustrates a large amount of smectite. Swelling clays tend to produce water impermeable crusts that increase runnoff, rilling and gully development. The TIR and SWIR data allow for a more complete mineralogical analysis of the the soil including quartz, clays, carbonates and evaporites (Hubbard, 2008).

How do changes in land composition affect coastal and inland aquatic ecosystems? [DS 25]

LEVEL THREE PRODUCTS

Turbidity Maps

CONCLUSIONS:

LEGACY - TIMS, ASTER, AVIRIS, HYPERION - OTHERS – MASTER, HYMAP

SUPPORTING SCIENTIFIC RESEARCH:

LDI INDEX USING VNIR SWIR TIR

TIR MEASUREMENTS OF ORGANIC RICH ROCKS TO DETERMINE RELATIONSHIPS TO VITRINITE REFLECTANCE

TURBIDITY STUDIES

VALIDATION OF HYDROTHERMALLY ALTERED SILICA-RICH ROCKS

VEGETATION STUDIES OF WATER ABSORPTION FEATURES

VALIDATION:

SPATIALLY RESAMPLED DATASETS – HYPERION, AVIRIS, ASTER

FIELD DATA

PRODUCTS:

LEVEL 2 – SURFACE REFLECTANCE, EMISSIVITY, SURFACE TEMPERATURE

LEVEL 3 – MINERAL AND LITHOLOGIC MAPS, LDI MAPS, VEG.-WATER ABSORPTION MAPS, TURBIDITY MAPS

Thank you!

QUESTIONS?