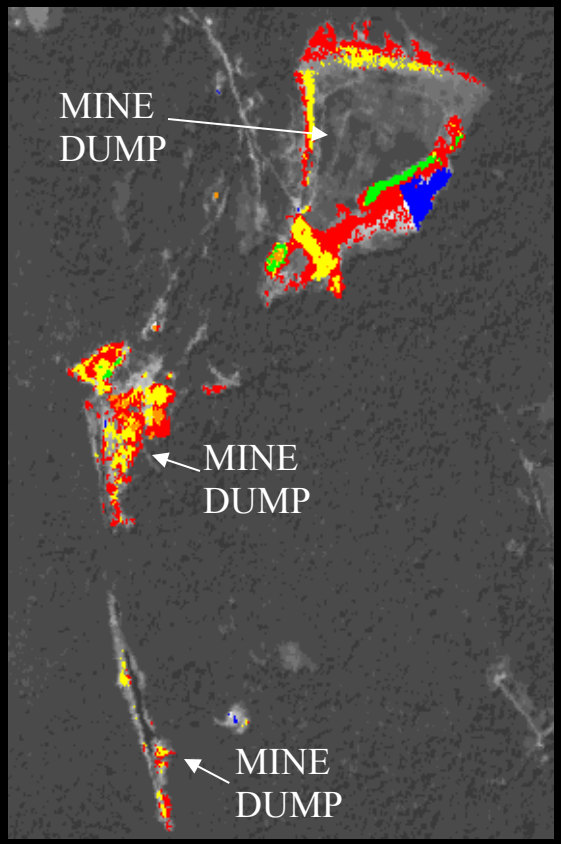
CQ5. Surface Composition and Change

What is the composition of exposed terrestrial surface of the Earth and how does it respond to anthropogenic and non anthropogenic drivers?

CQ5: Overarching Question

What is the composition of exposed terrestrial surface of the Earth and how does it respond to anthropogenic and non anthropogenic drivers?

AVIRIS Minerals Map of Elizabeth Mine, Vermont



EXPLANATION:

- JAROSITE
- MUSCOVITE
- HEMATITE
- GOETHITE
- WATER

Crowley and others, 2001

Science Issue:
Mapping the mineralogical composition of the earth's surface is critical in understanding the distribution and formation economic ore deposits and hydrocarbons, and determining and monitoring processes that impact ecosystems such as acid runoff , desertification, and sediment flux into coastal and marine systems.

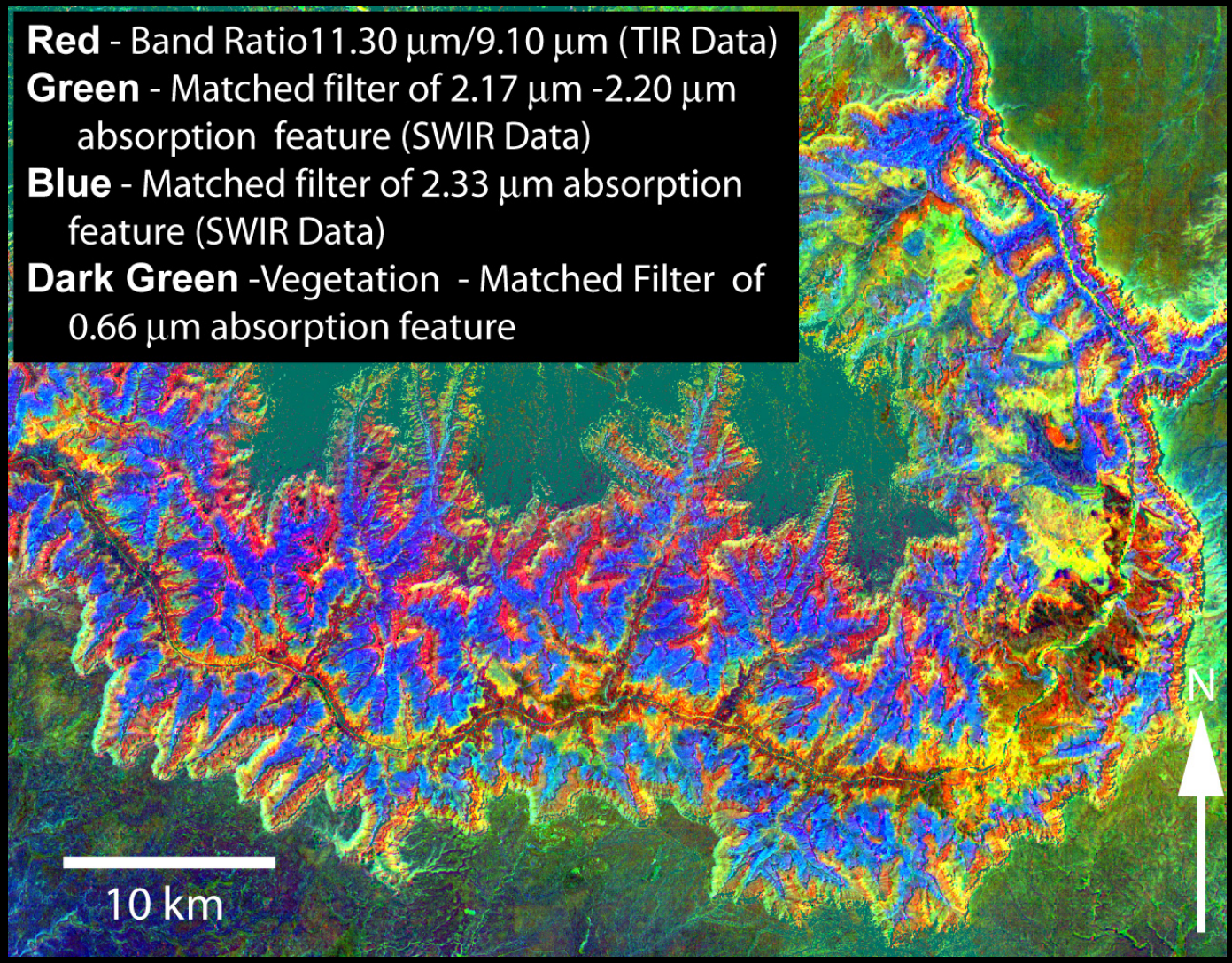
Tools:
VNIR-SWIR-TIR imagery, spectroscopy, mineral maps, false color composite band ratio images,

Approach:
The exposed terrestrial surface of the earth is composed of minerals that exhibit diagnostic spectroscopic absorption features in the 3.25 to 12.0 micrometer region. Mineral maps compiled from VNIR, SWIR and TIR spectroscopic data will be used to monitor desertification processes, determine soil quality, and map acid drainage and increased salinity. Rocks and sediments typically contain mixtures of different minerals and thus exhibit multiple absorption features in the VNIR-SWIR-TIR region. Band ratio false color composite images of VNIR-SWIR and TIR data will be used for rock and sediment type mapping.

Results:
Crowley and others used AVIRIS VNIR and SWIR data to map chemical weathering products of mine waste at the Elizabeth Mine, Vermont. Mineral maps show the distribution of jarosite, hematite and goethite which indicate low ph conditions around mine dumps that produce acid runoff.

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

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) data.



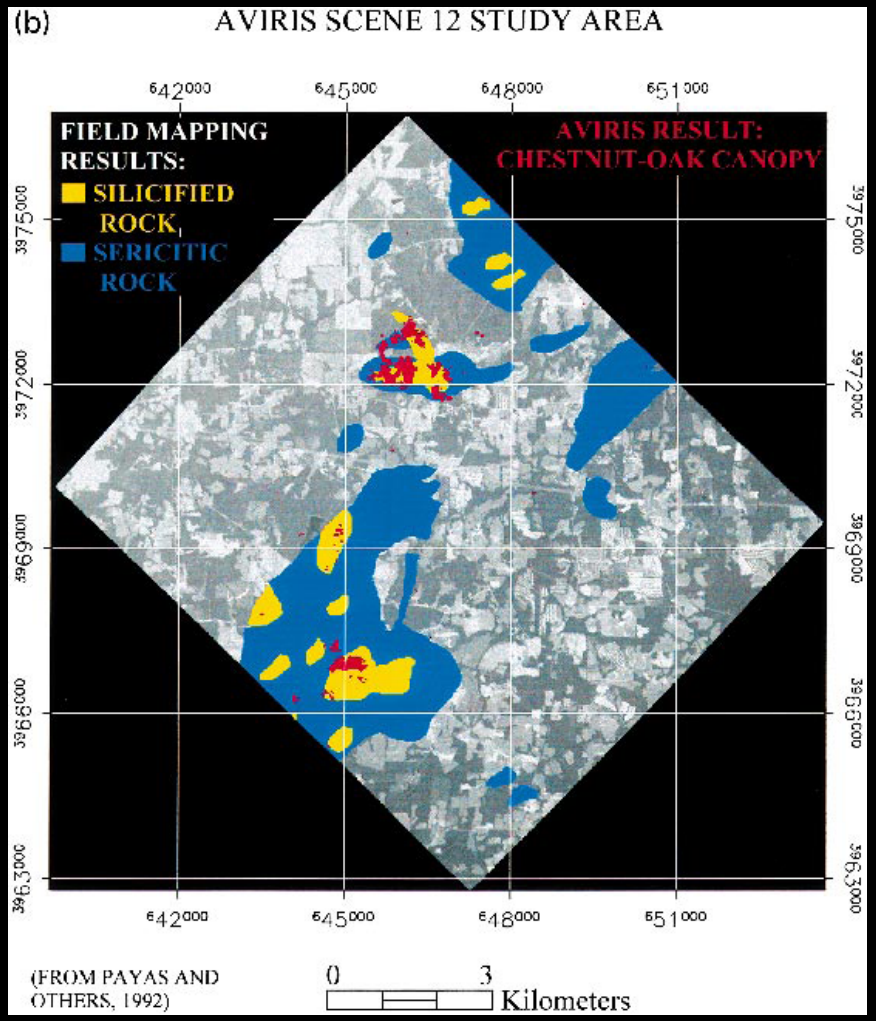
Science Issue:
How to compile more descriptive-detailed lithologic maps?

Tools:
With VINIR-SWIR-TIR capability, HyspIRI will be able to map the most common surficial minerals including quartz (TIR), carbonates (TIR, SWIR), clays (SWIR), oxides (VNIR) and evaporites (VNIR and SWIR).

Approach:
Use false color composite band ratio maps of common mineral groups

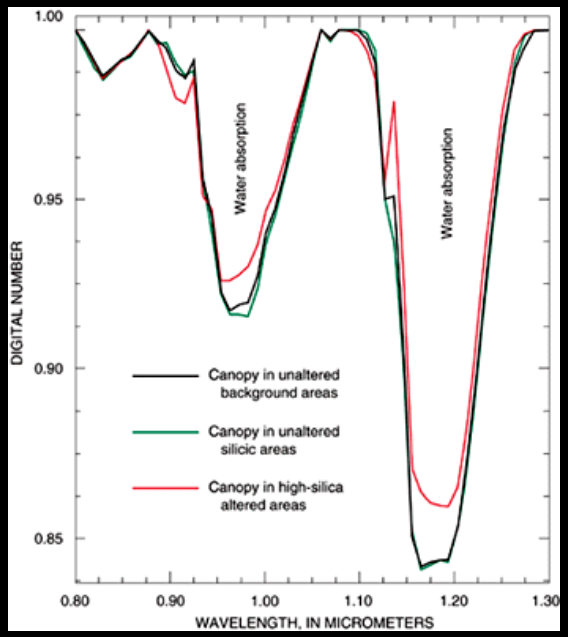
Results:
The Grand Canyon is an example where the quartz-rich sandstones were mapped using TIR data, and the clay-rich shale and carbonate rocks were mapped using SWIR data.

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



Red areas on map indicate stressed Chestnut Oak trees growing on altered rocks

Rowan and others, 1998



AVIRIS spectra illustrate water absorption features in Chestnut Oak leaves are shallower for trees situated on altered rocks

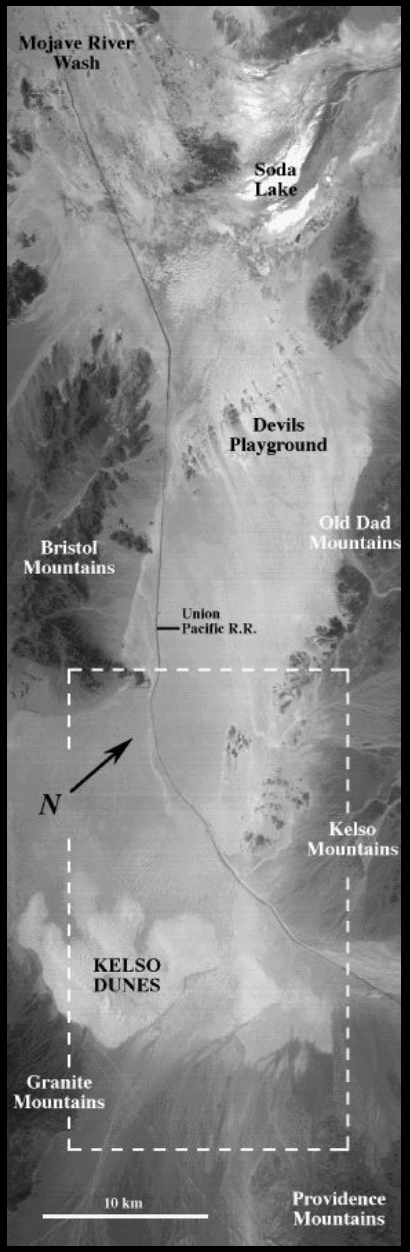
Science Issue:
How do altered rocks affect vegetation?

Tools:
-HyspIRI VNIR SWIR data for vegetation spectral mapping
-HYSPIRI TIR data for lithologic – minerals mapping

Approach:
Study VNIR-SWIR spectral characteristics of trees growing on altered rocks and non-altered rocks.

Results:
Rowan and others 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.

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



Ramsey and Lancaster, 1998

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

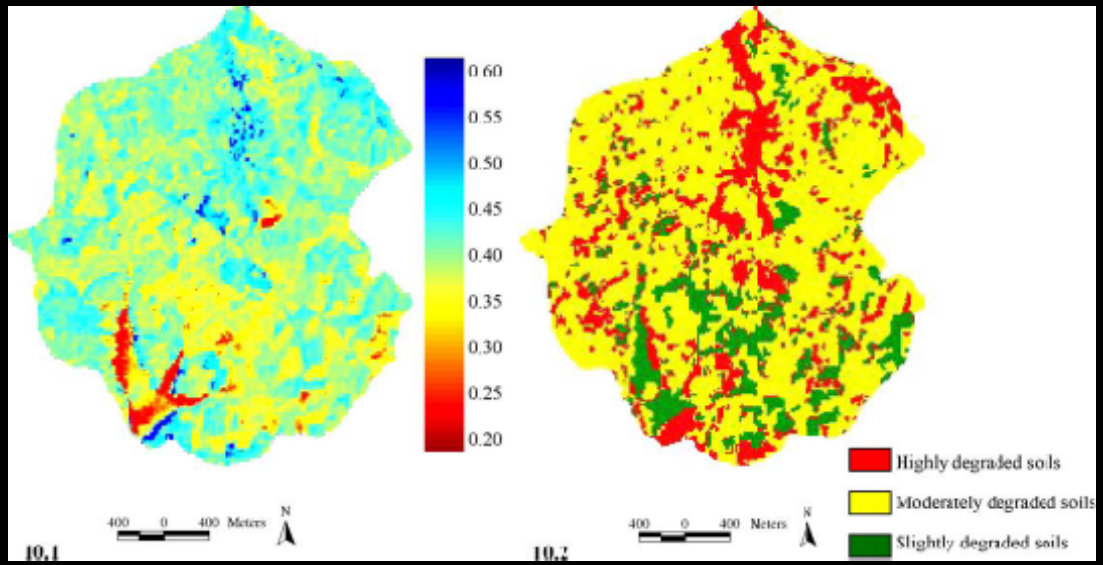
Science Issue:
Monitoring of desertification

Tools:
-Field spectral data
-HyspIRI VNIR, SWIR and TIR 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

Results:
-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



Chikhaoui and others, 2005

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

Tools:

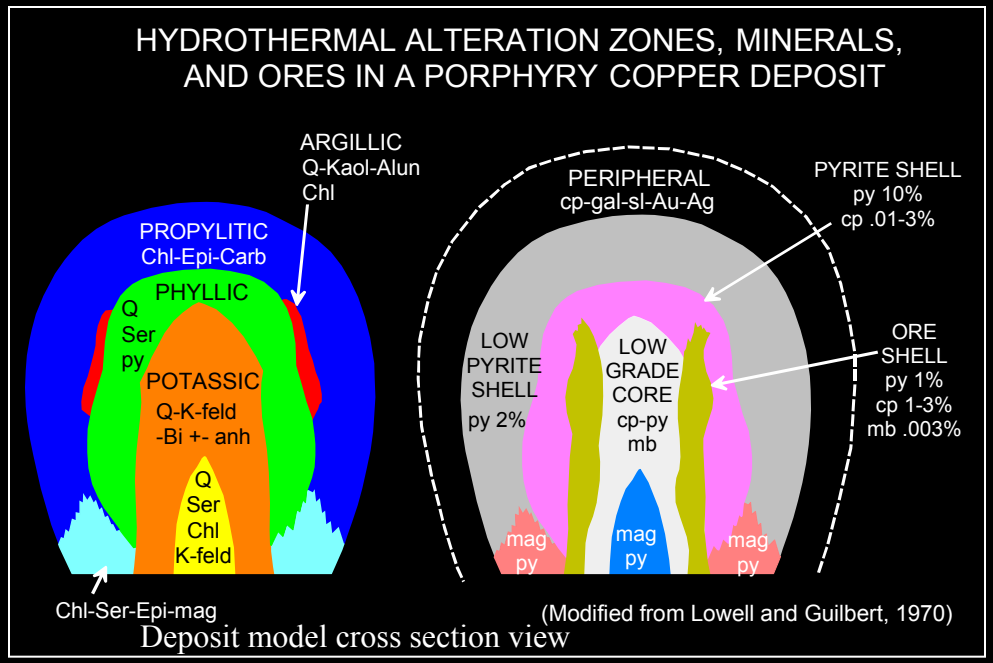
HyspIRI SWIR and TIR data

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 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 potassic-altered and silicified rocks with the TIR detector.

Results:

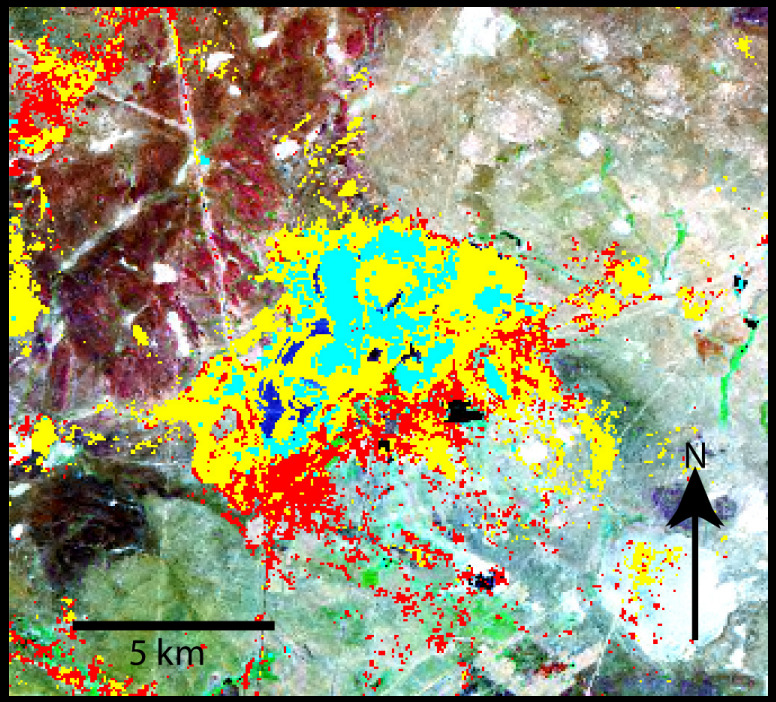
Mars and Rowan (2006), have used ASTER data to regionally map argillic, phyllic, and potassic-altered and silicified rocks along magmatic arcs.



Deposit model cross section view

Results (cont.):

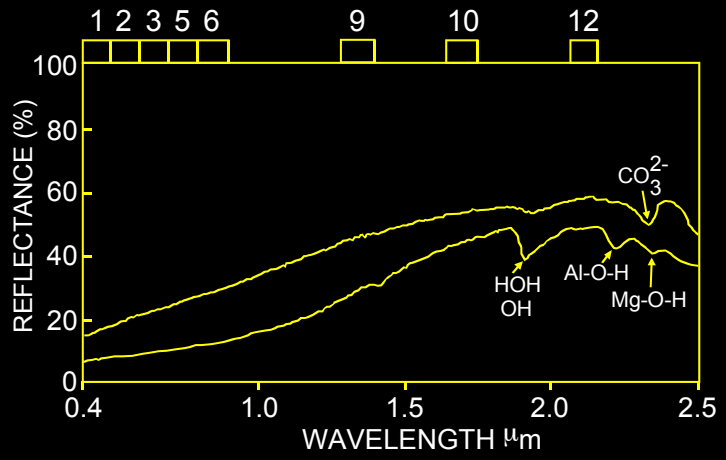
Porphyry copper deposits typically consist of circular to elliptical patterns of potassic, silicified, phyllic and argillic-altered rocks. Linear patterns of alteration have been associated with epithermal systems. Thus, the regional alteration data have been used to identify potential deposits and assess hydrothermal fluid flow.



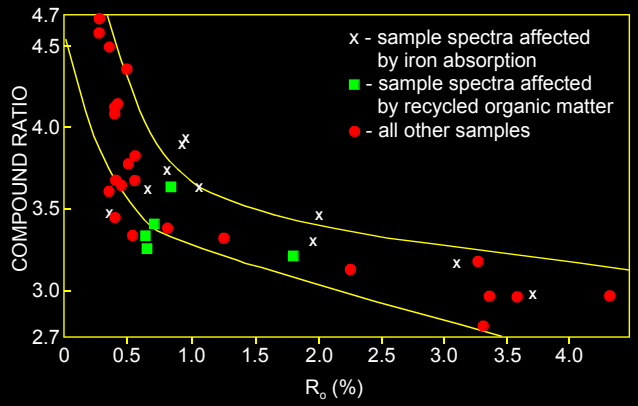
False color composite HyspIRI simulated image of the porphyry copper Konyrat Mine near Balquash, Kazakhstan. Elliptical patterns of altered rocks define the porphyry copper deposit at the surface (Mars and Rowan, 2006)

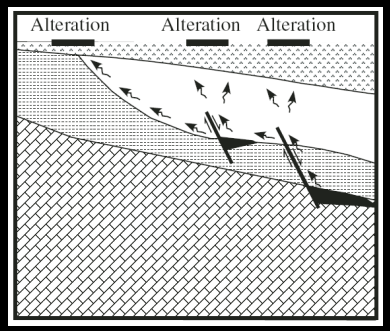
- Potassic-altered - Silicified rocks (TIR data)
- Argillic-altered rocks (SWIR data)
- Phyllic-altered rocks (SWIR data)

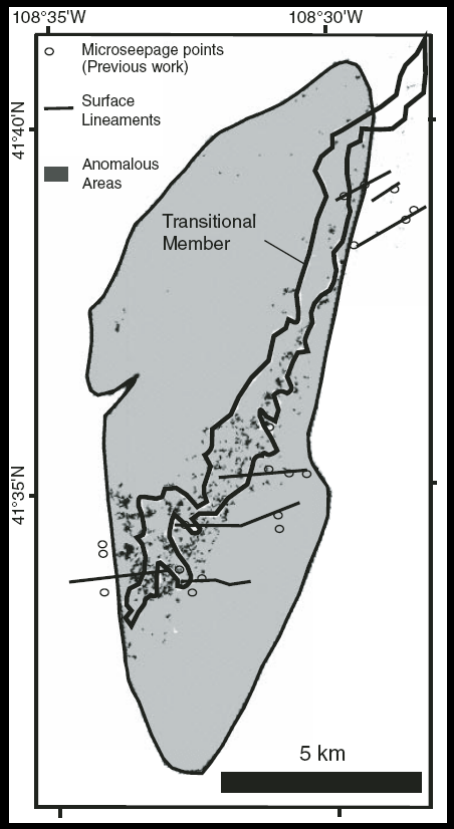
•How do regional trends of minerals and shale thermal maturity within basins better define depositional models and assist in the discovery of new hydrocarbon reserves? (DS 235)



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







Khan and Jacobson, 2008

Science Issue:
How can mineral trends help identify new hydrocarbon reserves?

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

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.

Science Issue:

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

Tools:

HyspIRI VINIR, SWIR and TIR data

Approach:

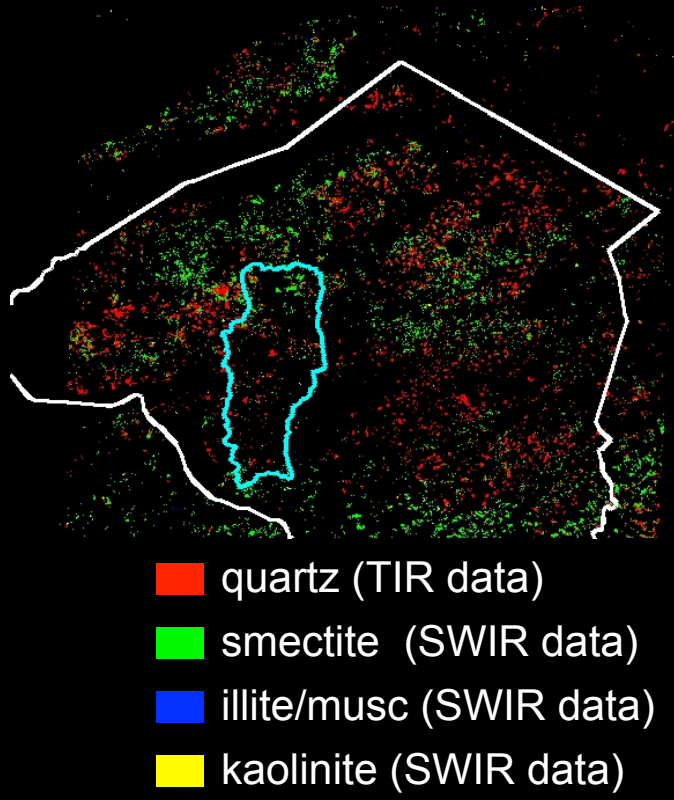
VNIR data - map vegetation density and water turbidity

SWIR and TIR data – soil composition

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 Chesapeake Bay

Results:

Hubbard (2008) used ASTER VNIR, TIR, and ASTER data to map soil and vegetation characteristics 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.



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 runoff, 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).