VQ6. Earth Surface Rock/Soil and Shallow Aquatic Bottom Composition (RG, HD)

• What is the composition of the exposed terrestrial rock/soil and shallow aquatic bottom surface and how does compositional understanding this relate to hazards, resources and understanding of change?
VQ6. Earth Surface and Shallow Water Bottom Composition (RG, HD)

• What is the distribution of the primary minerals and mineral groups on the exposed terrestrial surface? [DS 218]
• What is the bottom composition (sand, rock, mud, coral, algae, SAV, etc) of the shallow water regions of the Earth?
• What fundamentally new concepts for mineral and hydrocarbon research will arise from uniform and detailed global geochemistry of the exposed rock/soil surface [DS227]
• What changes occur in shallow coastal and inland aquatic environments? [DS 25]
• Can measurements of rock and soil composition be used to understand and mitigate hazards? [DS227]
Mineral Spectral Signatures in the Solar Reflected Spectrum

- Muscovite $K_2Al_4[Si_6Al_2O_{20}](OH)_4$
- Montmorillonite $(Na, Ca)_{0.33}(Al, Mg)_2Si_4O_{10}(OH)_2*nH_2O$
- Alunite $KAl_3(SO_4)_2(OH)_6$
- Kaolinite $Al_4[Si_4O_{10}](OH)_8$
- Gypsum $CaSO_4\cdot2H_2O$
- Goethite $FeO\cdotOH$
- Jarosite $NaFe_3(SO_4)_2(OH)_6$
- Calcite $CaCO_3$
- Dolomite $CaMg(CO_3)_2$
- Hematite $Fe_2O_3$
Geochemistry link to spectral signatures
Spectral Imaging Cube of Cuprite, NV measured by NASA’s Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

A complete solar spectrum is measured for each spatial point.
1 micron region mineral map from AVIRIS

Roger Clark and Dr. Gregg Swayze, USGS

Cuprite, Nevada
AVIRIS 1995 Data
USGS
Clark & Swayze
Tetraorder 3.3 product

Iron Oxides
- nanocrystalline
- Hematite
- Fine-grained to medium-grained
- Hematite
- Large-grained hematite

Iron Hydroxide
- Goethite
- amorphous and other iron oxides, hydroxides

Iron Sulfate
- Jarosite

Fe$^{2+}$-minerals
- Fe$^{2+}$-bearing minerals +
- Hematite

Fe$^{2+}$-bearing minerals
- Fe$^{2+}$-bearing minerals: broad absorptions

Note Fe$^{2+}$-bearing minerals are mainly muscovites and chlorites

2 km
2 micron region mineral map from AVIRIS

Cuprite, Nevada
AVIRIS 1995 Data
USGS
Clark & Swayze
Tetracorder 3.3 product

Sulfates
- K-Alunite 150c
- K-Alunite 250c
- K-Alunite 450c
- Na82–Alunite 100c
- Na40–Alunite 400c
- Jarosite
- Alunite + Kaolinite and/or Muscovite

Kaolinite group clays
- Kaolinite, wkl
- Kaolinite, pkl
- Kaolinite + smectite or muscovite
- Halloysite
- Dickite

Carbonates
- Calcite
- Calcite + Kaolinite
- Calcite + montmorillonite

Clays
- Na–Montmorillonite
- Nontronite (Fe clay)

Other minerals
- low-Al muscovite
- med-Al muscovite
- high-Al muscovite
- Chlorite + Musc, Mont
- Chlorite
- Buddingtonite
- Chalcedony, OH Qtz
- Pyrophyllite + Alunite

Scale: 2 km
Orientation: N
In Situ Spectral Measurements of Shallow Water Bottom Composition (E. Hochberg, Nova Southeastern University, FL)
LDF analysis of AVIRIS measurements for shallow water bottom composition, Kaneohe Bay, HI (E. Hochberg, Nova Southeastern University, FL)
WTC Hazards from AVIRIS 010916

Debris composition and dispersal

Asbestos

Reference spectrum: Chrysotile coating on Girder WTC01-08 (multiplied by 0.341)

AVIRIS: wtc_r9w_10b_11ws.rtgc
9 pixel average near L2309S923

Fire location and temperature

AVIRIS
Estimate
Residual

Test fit for spectrum G
Temperature Estimate=984K
1.48% of the area
Mapping Superfund Hazards at Leadville, CO

Surface mineral/geochemistry related to acid generations

Comment from EPA regarding use of imaging spectroscopy measurement for acid mine hazard remediation

I am writing to convey the support of my office and staff for the AVIRIS program. Remote sensing data collected by NASA/JPL with the Airborne Visible-Infrared Imaging Spectrometer (AVIRIS) instrument of the California Gulch NPL Site near Leadville, Colorado has provided information aiding in the remediation of heavy metal contamination at this site. AVIRIS data was collected in July of 1995 and was calibrated and mapped using the Tricorder algorithm at the USGS. Similar work was done at the Summitville NPL site and is beginning in the Upper Animas Basin. This work has resulted in, and will continue to produce significant cost savings in site investigations and cleanup activities.

Use of the AVIRIS data and technology has provided an estimated $2 million dollar saving in site investigation study expenditures. The AVIRIS technology has also resulted in shortening of the site investigation process by an estimated 2½ years.
Mt Shasta, CA: AVIRIS used to assess volcano debris flow hazard (J. Crowley, USGS)

Explanation for Mount Shasta AVIRIS image and minerals map

- **Strong Oxide**
- **Kaolinite**
- **Alunite ± Kaolinite ± Gypsum**
- **Red Banks Oxide**

Kaolinite and Alunite > 35°
Kaolinite and Alunite 30° to 35° slope
Kaolinite and Alunite <= 30° slope

Red
Green
Cyan

Lakes and Streams
Glaciers
Contours

Border between dominantly older Pleistocene (southern part) glacially incised terrain and younger Holocene (northern part) less glacially incised terrain

Water sheds

Highest Frequency of Debris Flows (20th century)

Contour interval 50 m

Scale 1 km
Key Thoughts

The temporal repeat for the VSWIR at the equator is 19 days

The baseline requirements are closely tied to the Decadal Survey and vetted with two years of science study groups.
   - Requirement growth is to be avoided.
   - Requirement clarification is good.

Objectives of the VSWIR breakout sessions:
   - Refine, strengthen and prioritize the science questions.
   - Assure the science questions are clearly answerable with the VSWIR science measurements.
   - Bring the Science Traceability Matrices forward from current 1\textsuperscript{st} draft

Specify specific products, algorithms, portions of the spectrum used
HyspIRI Imaging Spectroscopy (VSWIR) Science Measurements

Science Questions:
- What is the composition, function, and health of land and water ecosystems?
- How are these ecosystems being altered by human activities and natural causes?
- How do these changes affect fundamental ecosystem processes upon which life on Earth depends?

Measurement:
- 380 to 2500 nm in 10nm bands
- Accurate location 60m spatial
- 19 days revisit
- Global land and shallow water

Map of dominant tree species, Bartlett Forest, NH

Red tide algal bloom in Monterey Bay, CA
Back Up
Mount Shasta AVIRIS image and minerals map

Explanation for Mount Shasta AVIRIS image and minerals map

- **Strong Oxide**
- **Kaolinite**
- **Cristobalite**
- **Amphibole-rich Flows**
- **Alunite + Kaolinite + Gypsum**
- **Red Banks Oxide**

**Scale:** 1 km

- **Kaolinite and Alunite > 35° slope**
- **Kaolinite and Alunite 30° to 35° slope**
- **Kaolinite and Alunite <= 30° slope**
- **Lakes and Streams**
- **Glaciers**
- **Contours**

Border between dominantly older Pleistocene (southern part) glacially incised terrain and younger Holocene (northern part) less glacially incised terrain

**Scale:** 1 km

- **Mud Creek**
- **Water sheds**
- **Ash Creek**
- **Bolam Creek**
- **Highest Frequency of Debris Flows (20th century)**
- **Whitney Creek**
- **Diller Canyon**
- **Cascade Gulch**
- **Panther Creek**
- **Gravel Creek**
- **Inconstance Creek**
- **Avalanche Gulch**