Using HyspIRI preparatory data for rapid classification of hydrothermal alteration

Betsy Littlefield Wendy Calvin





University of Nevada, Reno

HyspIRI

Hyperspectral Infrared Imager

Made up of two instruments:

- VSWIR imaging spectrometer
 - AVIRIS
 - 0.38-2.5 μm
 - 212 channels
 - 19 day revisit
 - 30 m spatial resolution
- TIR multispectral imager
 - MASTER
 - 4-12 μm
 - 8 channels
 - 5 day revisit; day/night
 - 60 m spatial resolution

Proposed low earth orbit satellite mount but also considering

- Separate spacecraft in sun synchronous orbit
- Deploying both instruments on the ISS

NAS	5
NAS	A 2014 The Hyperspectral Infrare
Imag	ger (HyspIRI) - Science Impact of
Depl	oying Instruments on Separate
Platf	forms
HyspIRI C	Group
Edited b	y Simon J. Hook
Question	n Leads:
CQ1 - Ke CQ2 - Sa	avin Turpie ander Veraverbeke
CQ3 - Re	obert Wright
CQ4 - Ma	artha Anderson
CQ5 - Ar CQ6 - Da	upma Prakash/John "Lyle" Mars ile Quattrochi
Prepared for	
National A	eronautics and
by	
Jet Propu	ilsion Laboratory
Californi	a Institute of Technology
Pasadena	, California
July 201	4

Science questions

- Address a variety of science questions related to:
 - Coastal ocean and inland aquatic environments
 - Wildfire, fuel, and recovery
 - Volcanoes and related signatures
 - Ecosystem function and diversity
 - Human health and urbanization
 - Earth surface composition and change

Science questions

- Address a variety of science questions related to:
 - Coastal ocean and inland aquatic environments
 - Wildfire, fuel, and recovery
 - Volcanoes and related signatures
 - Ecosystem function and diversity
 - Human health and urbanization
 - Earth surface composition and change

- What is the **composition** of the exposed earth surface?
- How do types and
 distributions of altered rocks define regional trends in
 hydrothermal fluid flow?

Sacramento

Bakersfield

Los Angeles

San Francisco

San Jose

- Spring, summer, fall
- 2013-2015
- AVIRIS & MASTER instruments onboard ER-2
- Prototype data collection
- ~18 m resolution
- JPL generates simulated reflectance data at 18, 30, 60 m
- Demonstrate important science applications

Data SIO NOAA U.S. Navy NGA GEBC

LDEO-Columbia, NSF, NOA/

San Diego

Roseville

Sacramento

Elk Grove

Stockton

Placerville

Sonora

Oroville

The Tahoe Box contains:

Leviathan Mine superfund site

Napa

Vallejo

Berkeley

San Rafael

Concord Antioch

- Davies & Calvin, Session No. 298
- Grover Hot Springs

Santa Rosa

Petaluma

Healdsburg

Google earth

Carson City

South Lake Tahoe

Truckee

_ake Taho

Sonora

The Yosemite Box contains:

Mono Lake

Vallejo

- Mono Craters
- Inyo Craters
- Mammoth Mountain
- Long Valley caldera

Salinas

- Casa Diablo geothermal field
- Hot Creek geothermal field



The Bay Area Box contains:

The Geysers geothermal field

Data MBARI Image Landsat Data SIO, NOAA, US, Navy, NGA, GEBCO © 2014 Google Google earth

37 6845389 Jon -123 6112569 elev -3004 m

Sacramento

Stocktor

Modesto

Santa Rosa

San Francisco

Hayward

San Jose



Escondido

San Diego

• Imperial Valley geothermal fields

- Salton Sea
- o Brawley
- o East Mesa
- Hot Mineral Spa
- Mesquite gold mine

Data LDEO-Columbia, NSF, NOAA Image Landsat Data SIO, NOAA, U.S. Navy, NGA, GEBCC Google earth

Mexicali

Project goals

- Identify new systems linked to critical minerals
- Identify high priority sites for geothermal energy development

Project goals

- Identify new systems linked to critical minerals
- Identify high priority sites for geothermal energy development

We need to map the surface mineralogy, specifically:

Hydrothermal alteration minerals Geothermal deposits

- Kaolinite
 Alunite
 Opal
- Muscovite
- Illite
- Chlorite



From Wohletz & Heiken (1992)

Hydrothermal systems

- Modern geothermal systems
- Fossil hydrothermal systems associated with ore bodies

The easiest method

Identification of hydrothermal alteration & geothermal deposits

- Decorrelation stretch of SWIR bands at **2.16**, **2.21**, and **2.24** μ m
- Highlights
 - Kaolinite, alunite as **blue**
 - Muscovite, illite as magenta
 - Chlorite, calcite as yellow
 - Opal as orange
- Keeping it simple promotes use
 - Generate raster images for use in ArcGIS
 - Simple color scheme highlights important areas



Using HyspIRI preparatory data for rapid classification of hydrothermal alteration

Reflectance









- 18 m resolution is better but 60 m resolution is good
 - To increase confidence, threshold images

The blue areas in these images...

Hverir fumarole field, Iceland

Kaolinite

Chemical weathering of feldspar by acidic fluids Argillic and advanced argillic alteration

Alunite

- Sulfate, forms at acidic fumaroles
- Advanced argillic alteration

...indicate hot water has been present

Can you find the Hundley Clay Pit where kaolinite is mined near Mammoth Lakes? 0

2

8

km

Can you find the Hundley Clay Pit where kaolinite is mined near Mammoth Lakes?



Using HyspIRI preparatory data for rapid classification of hydrothermal alteration

0



Travertine, Fish Lake Valley, NV



The yellow areas can indicate hot water

Calcite

- Travertine deposited by subaerial springs
- Tufa deposited by sublacustrine springs
- Occurs in propylitic alteration

Chlorite

- Alteration of mafic minerals
- Chloritic and propylitic alteration

The magenta areas can indicate hot water



Muscovite & illite

- Low temperature alteration minerals
- Argillic and sericitic alteration
- Weathering



Muscovite-rich granite intrusion near the Mesquite gold mine

The orange areas can indicate hot water deposits

Waiotapu geothermal field, New Zealand

6 in

Amorphous silica (opal)

- **Deposited as hot spring sinter**
- **May fill fractures**
- Geothermal deposit, not alteration







Using HyspIRI preparatory data for rapid classification of hydrothermal alteration



Using HyspIRI preparatory data for rapid classification of hydrothermal alteration

Summary

- HyspIRI is a proposed new instrument
- Hyperspectral VSWIR & TIR data
- Useful spatial resolution
- Revisits every 5 or 19 days
- Many science applications
 - Can easily highlight hydrothermal alteration and geothermal deposits
 - With slightly more effort, map specific minerals using more finely tuned DCS combinations
- For more information visit hyspiri.jpl.nasa.gov