Future Hyperspectral VSWIR and Multispectral TIR Spaceborne Instruments

Michael Abrams
NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena USA

(c) 2016 California Institute of Technology. Government sponsorship acknowledged.

fppt.com

Why Hyperspectral VSWIR for Geology?

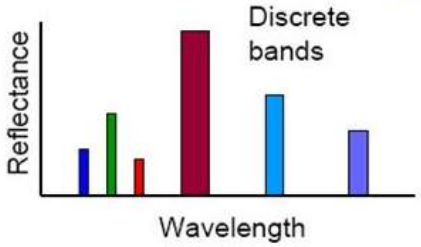
Multispectral vs Hyperspectral

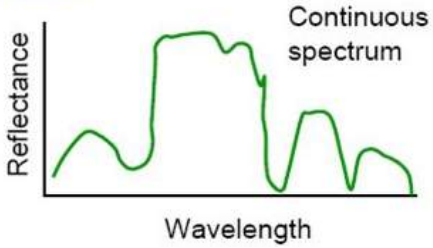
10

Multispectral

Hyperspectral

Each pixel





Few fixed bands

- minimum identification
- low confidence
- field knowledge and lab-analysis required

Contiguous bands

- maximum identification
- high confidence
- data base usable
- spectral unmixing

fppt.com

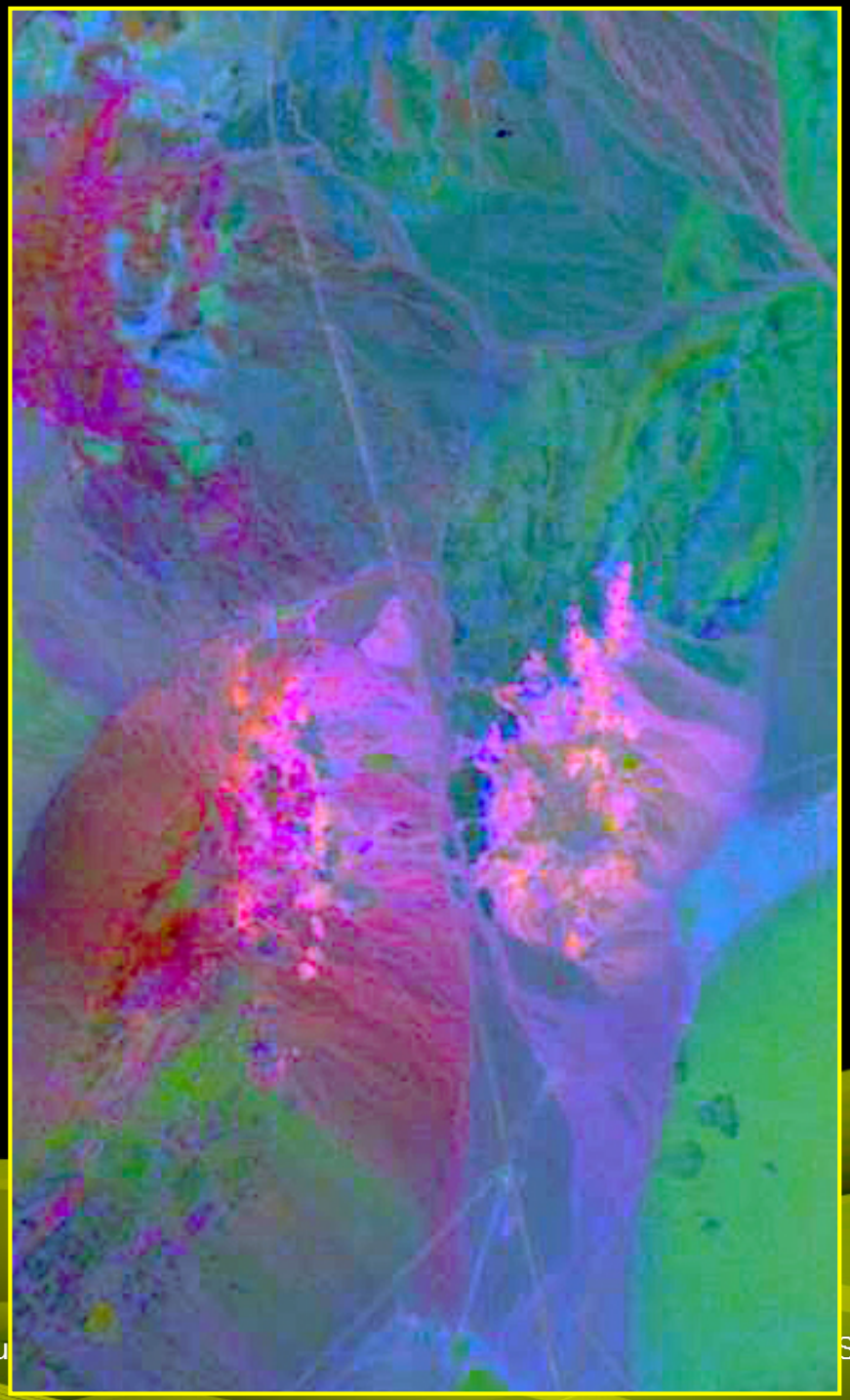
Cuprite Mining District, Nevada, USA

Gold-silver deposits

Alteration: silicified, opalized, argillized

fppt.com

Landsat multispectral data, 7 bands; band ratios. Alteration assemblage in pink/magenta: hydrous minerals (kaolinite, alunite, etc.)

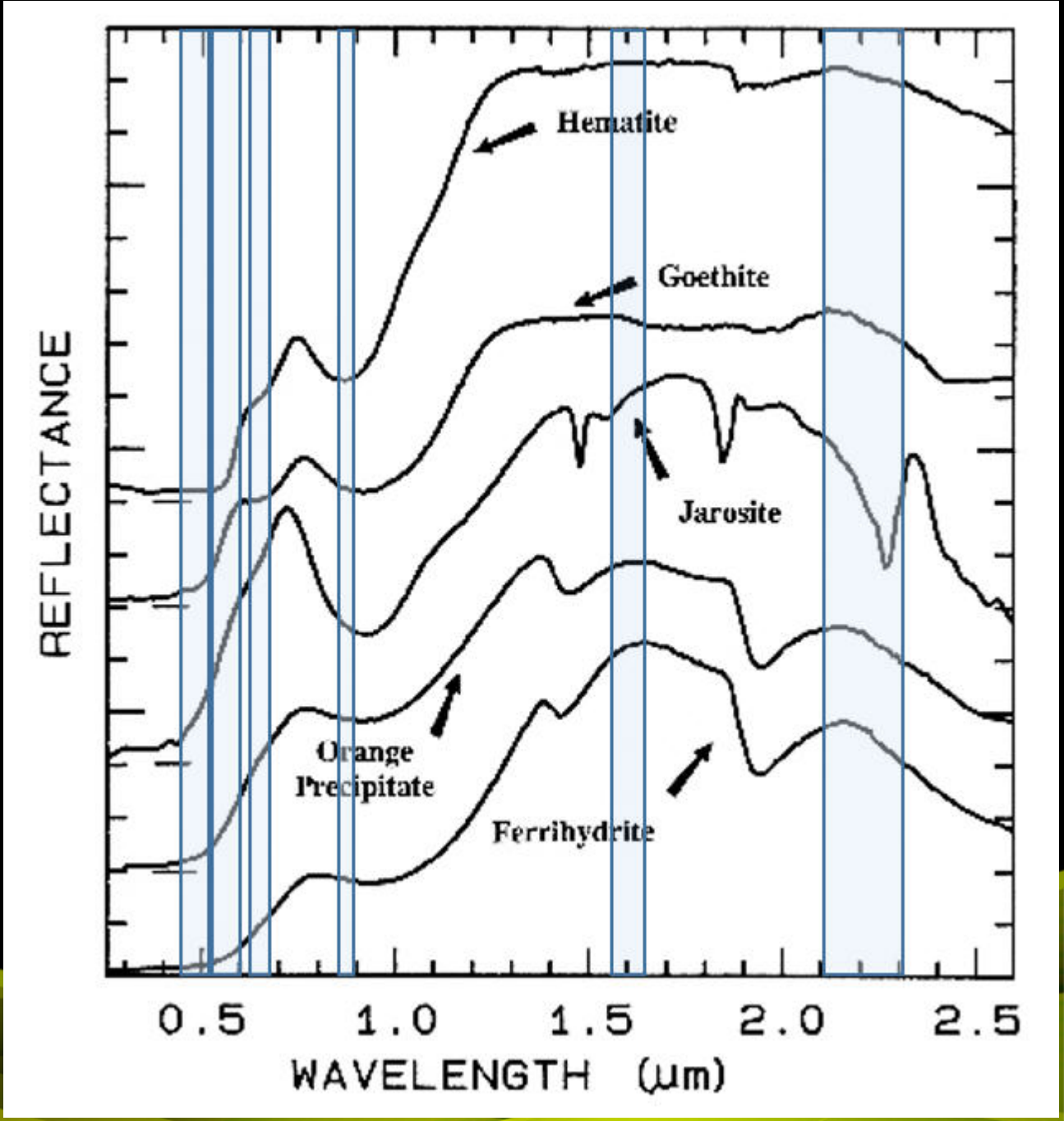


fppt.com

Spectra of Iron minerals

0.4-1.3 um data for iron species; Landsat bands are blue bars

Jarosite, goethite, hematite, ferrihydrite

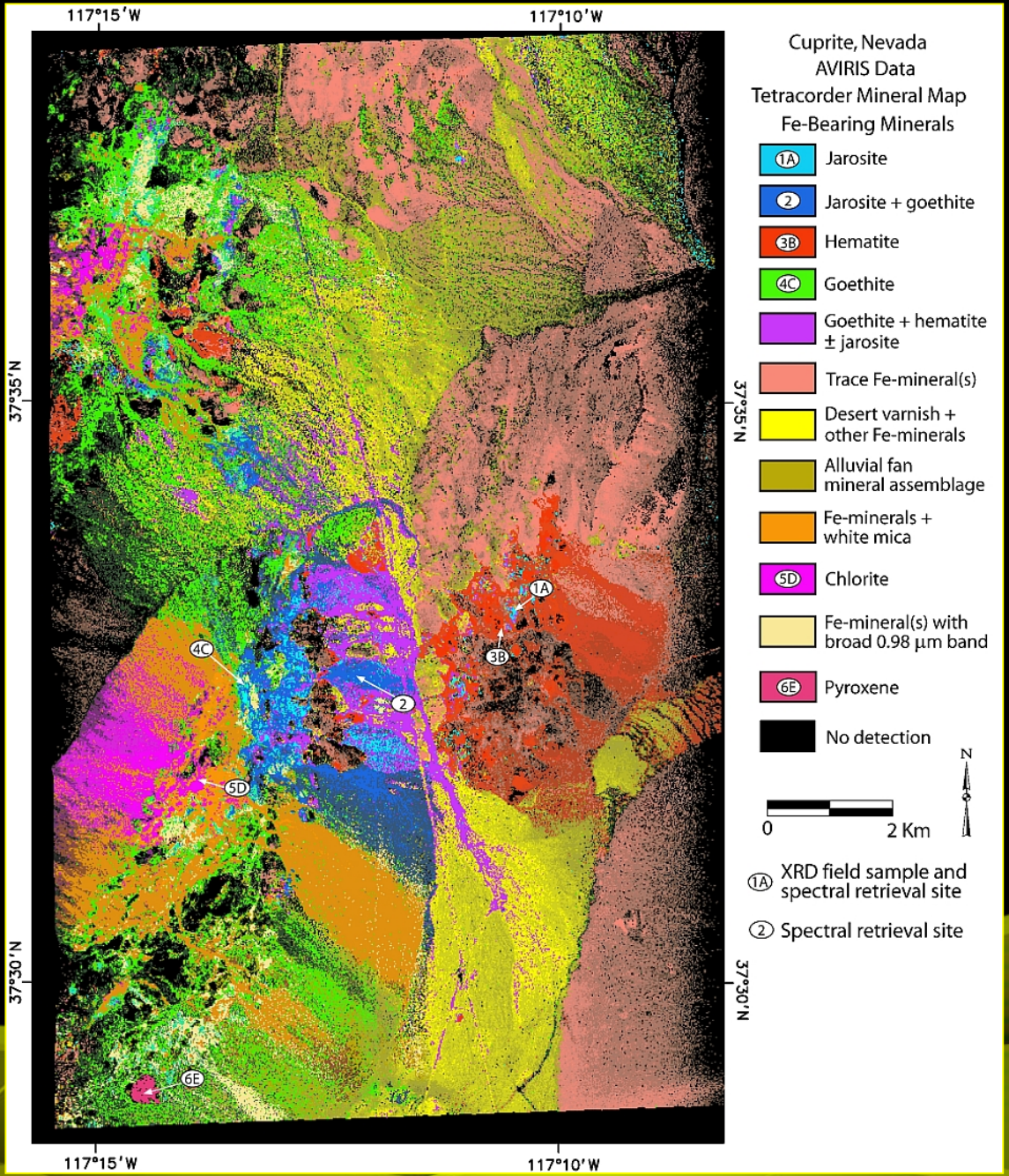


fppt.com

Airborne hyperspectral VNIR data; ~100 bands

0.4-1.3 um data for iron species

Jarosite, goethite, hematite, chlorite

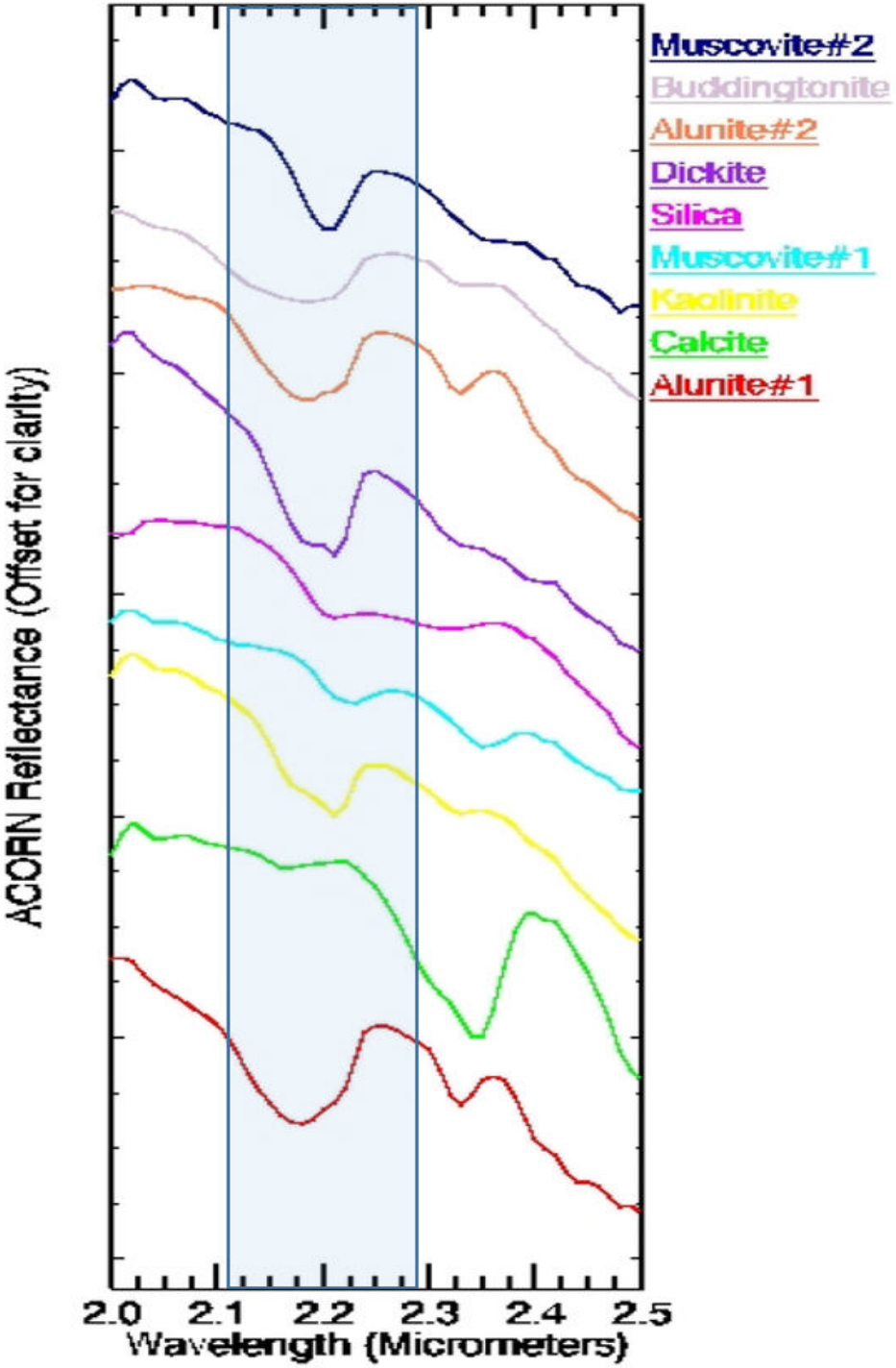


fppt.com

Spectra of hydrous minerals in short-wave infrared (SWIR)

2.0-2.4 um data for clays, carbonates species

Alunite, kaolinite, dickite, montmorillonite, muscovite, carbonate, chlorite, chalcedony, halloysite

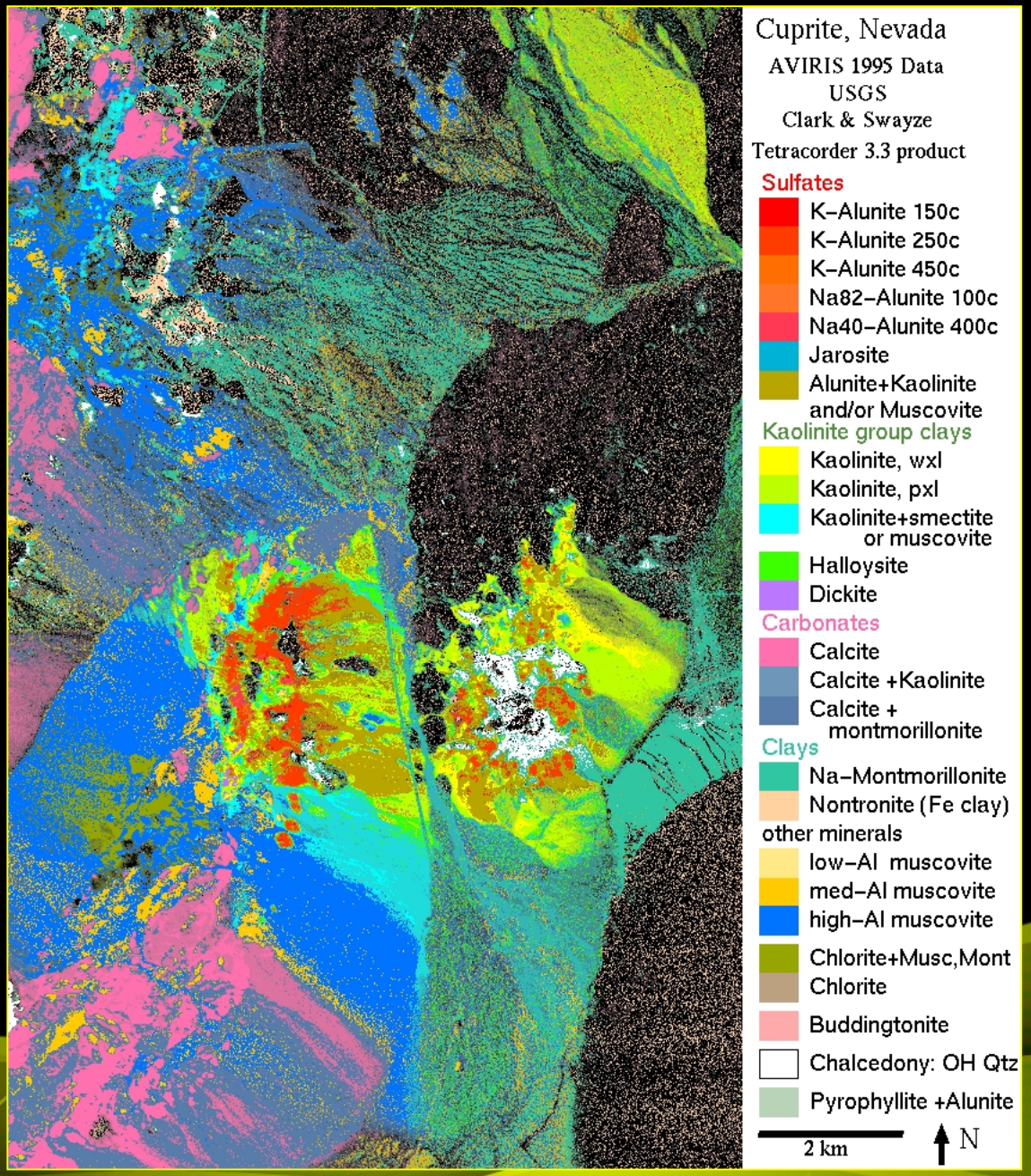


fppt.com

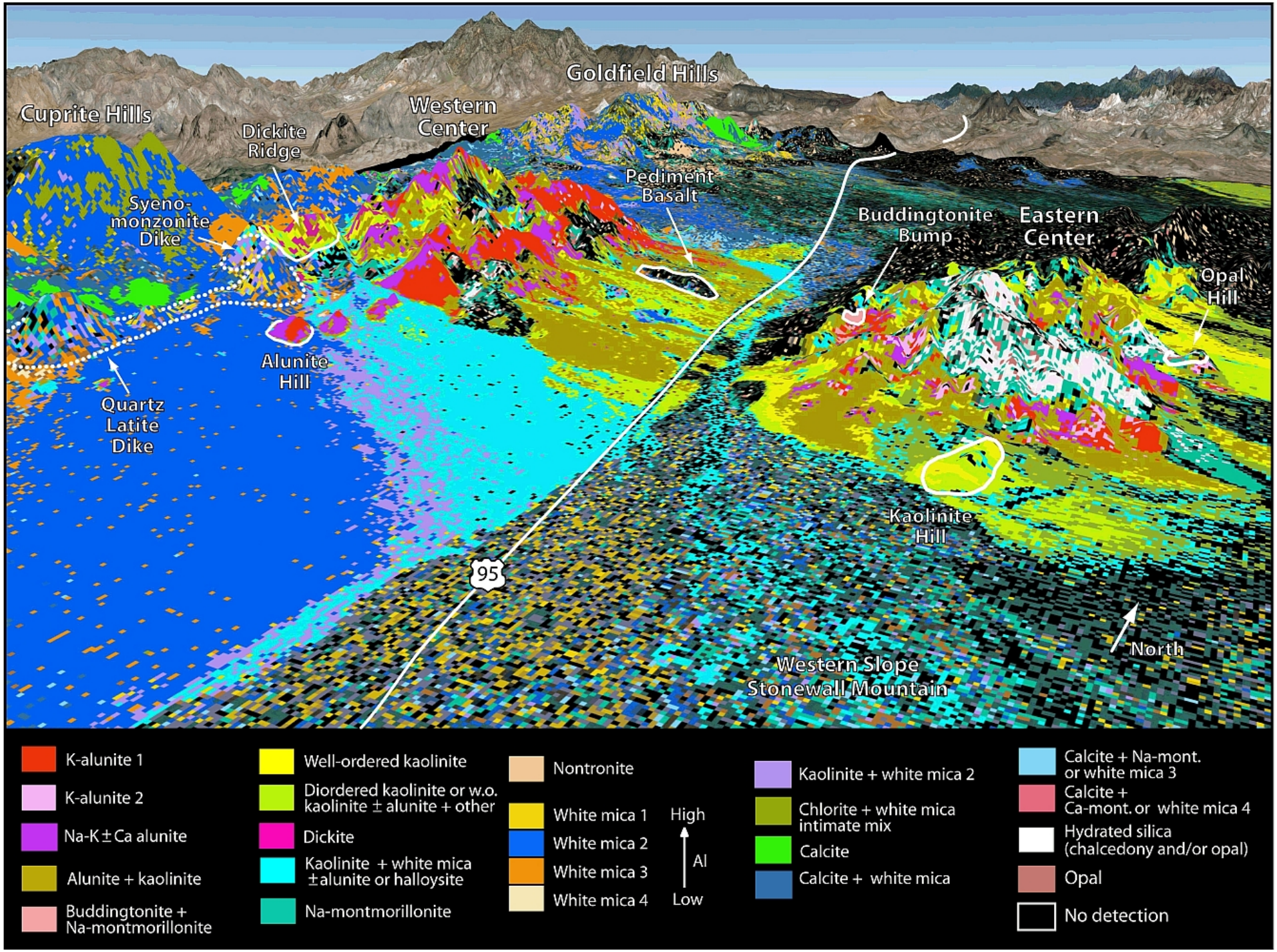
Airborne hyperspectral SWIR data; ~100 bands

1.3-2.4 um data for clays, carbonates

Alunite, kaolinite, dickite, montmorillonite, muscovite, carbonate, chlorite, chalcedony, halloysite



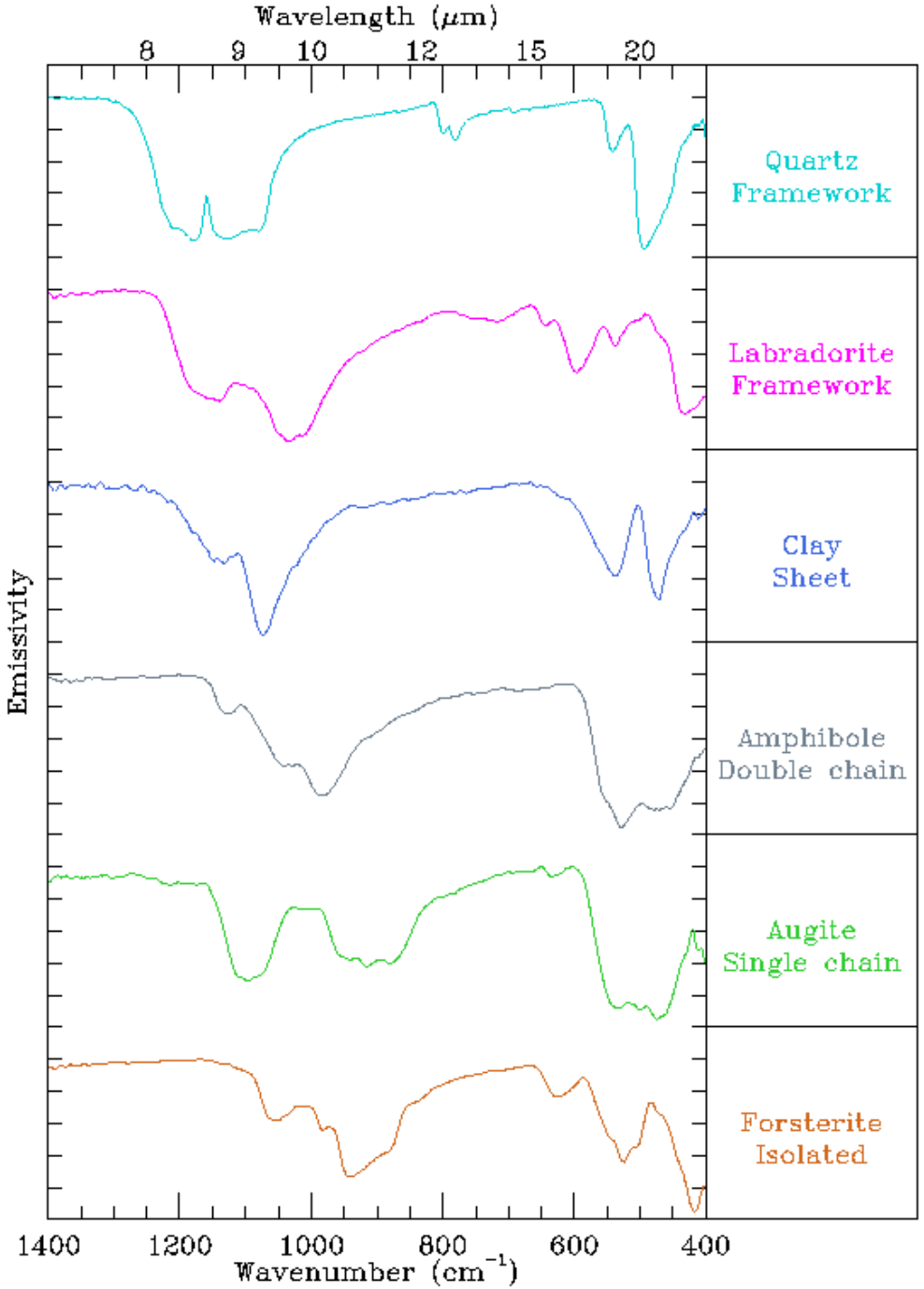
fppt.com


Goldfield Hills
Cuprite Hills
Western Center
Dickite Ridge
Pediment Basalt
Syeno-monzonite Dike
Buddingtonite Bump
Eastern Center
Opal Hill
Alunite Hill
Quartz Latite Dike
Kaolinite Hill
95
North
Western Slope Stonewall Mountain
K-alunite 1
K-alunite 2
Na-K ± Ca alunite
Alunite + kaolinite
Buddingtonite + Na-montmorillonite
Well-ordered kaolinite
Diordered kaolinite or w.o. kaolinite ± alunite + other
Dickite
Kaolinite + white mica ±alunite or halloysite
Na-montmorillonite
Nontronite
White mica 1
White mica 2
White mica 3
White mica 4
High
Al
Low
Kaolinite + white mica 2
Chlorite + white mica intimate mix
Calcite
Calcite + white mica
Calcite + Na-mont. or white mica 3
Calcite + Ca-mont. or white mica 4
Hydrated silica (chalcedony and/or opal)
Opal
No detection

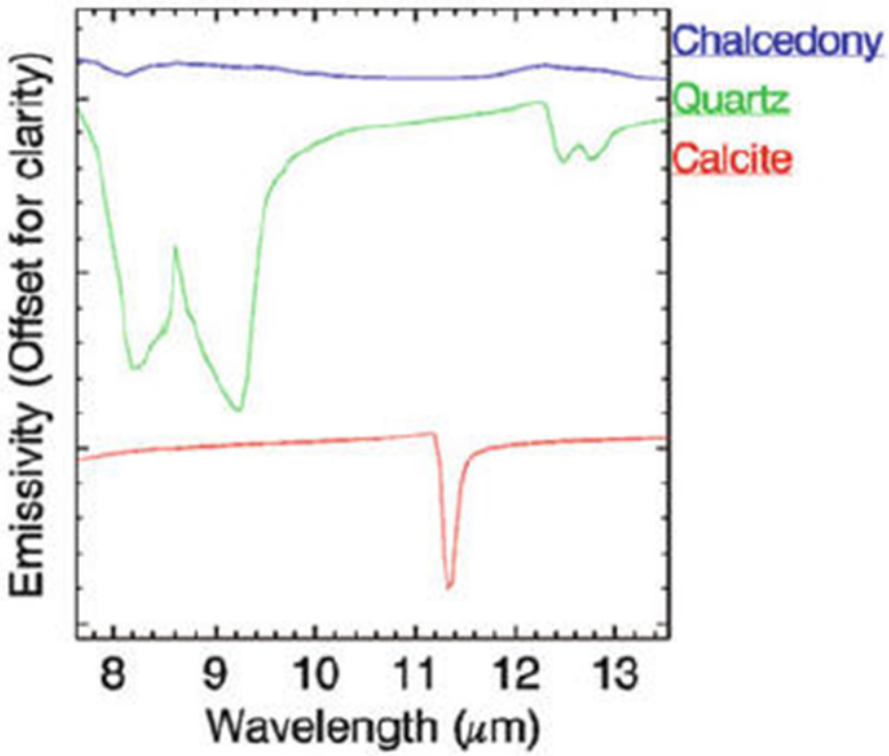
Thermal infrared (TIR) spectra of silicates

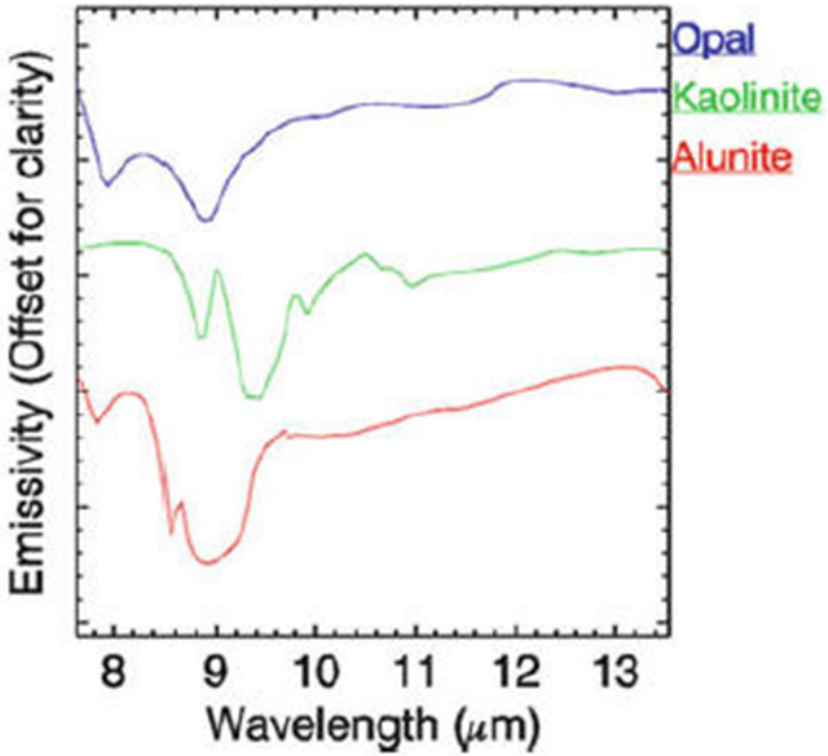
8-12 um laboratory data for Silicates

Silicic to mafic, shift of primary absorption bands to longer wavelength



Why Multispectral TIR for Geology?



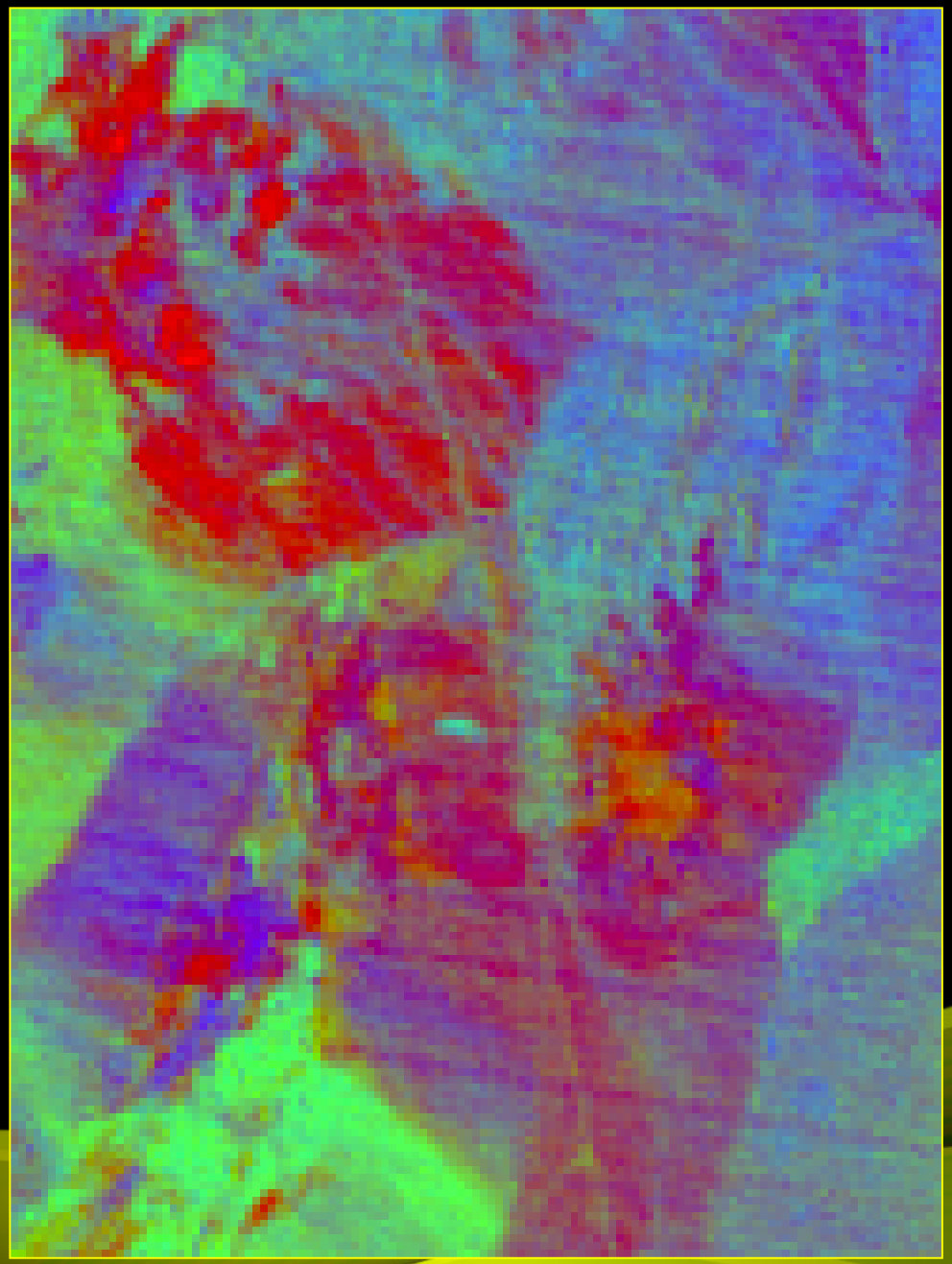


fppt.com

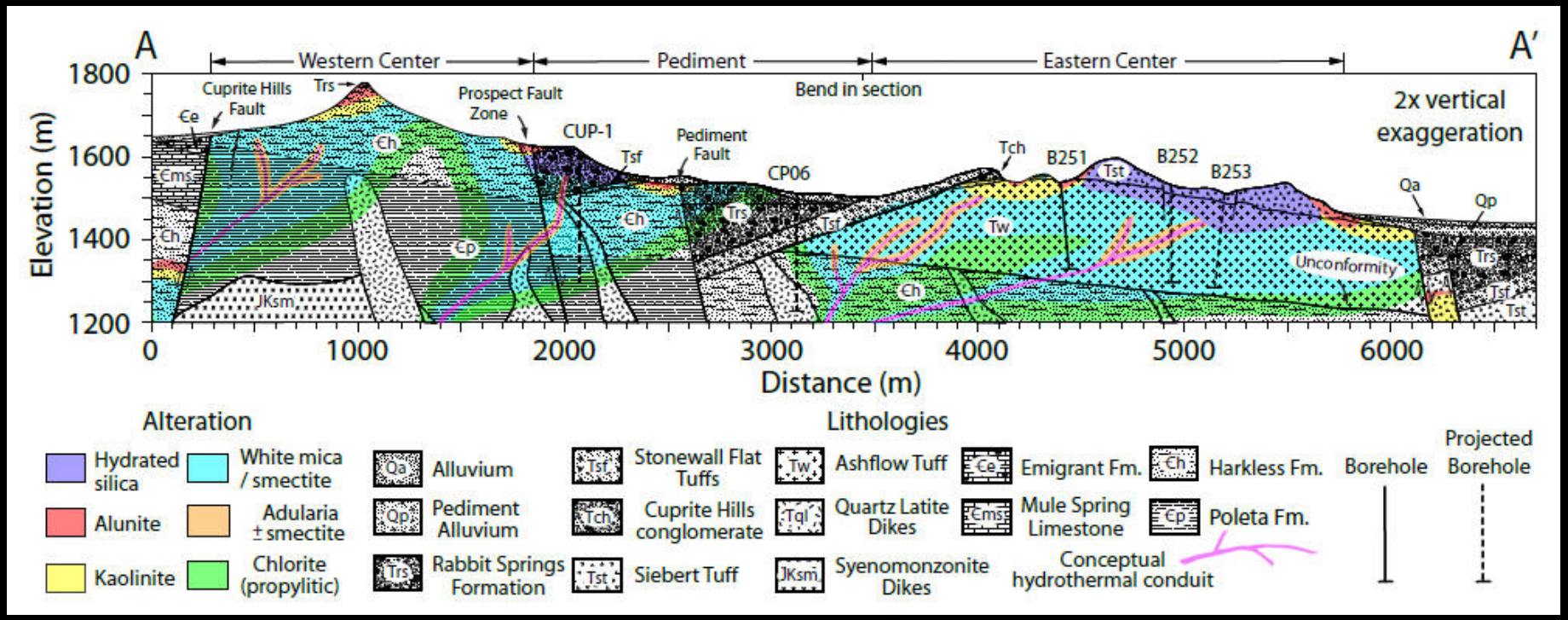
ASTER TIR data; 5 bands in TIR with 90m pixels

8-12 um data for SiO_2, CO_3

Opal, chalcedony, carbonate, volcanics



fppt.com



Evidence suggests that Cuprite is a late Miocene low-sulfidation adularia – sericite type hot spring deposit overprinted by late-stage steam-heated advanced argillic alteration.

fppt.com

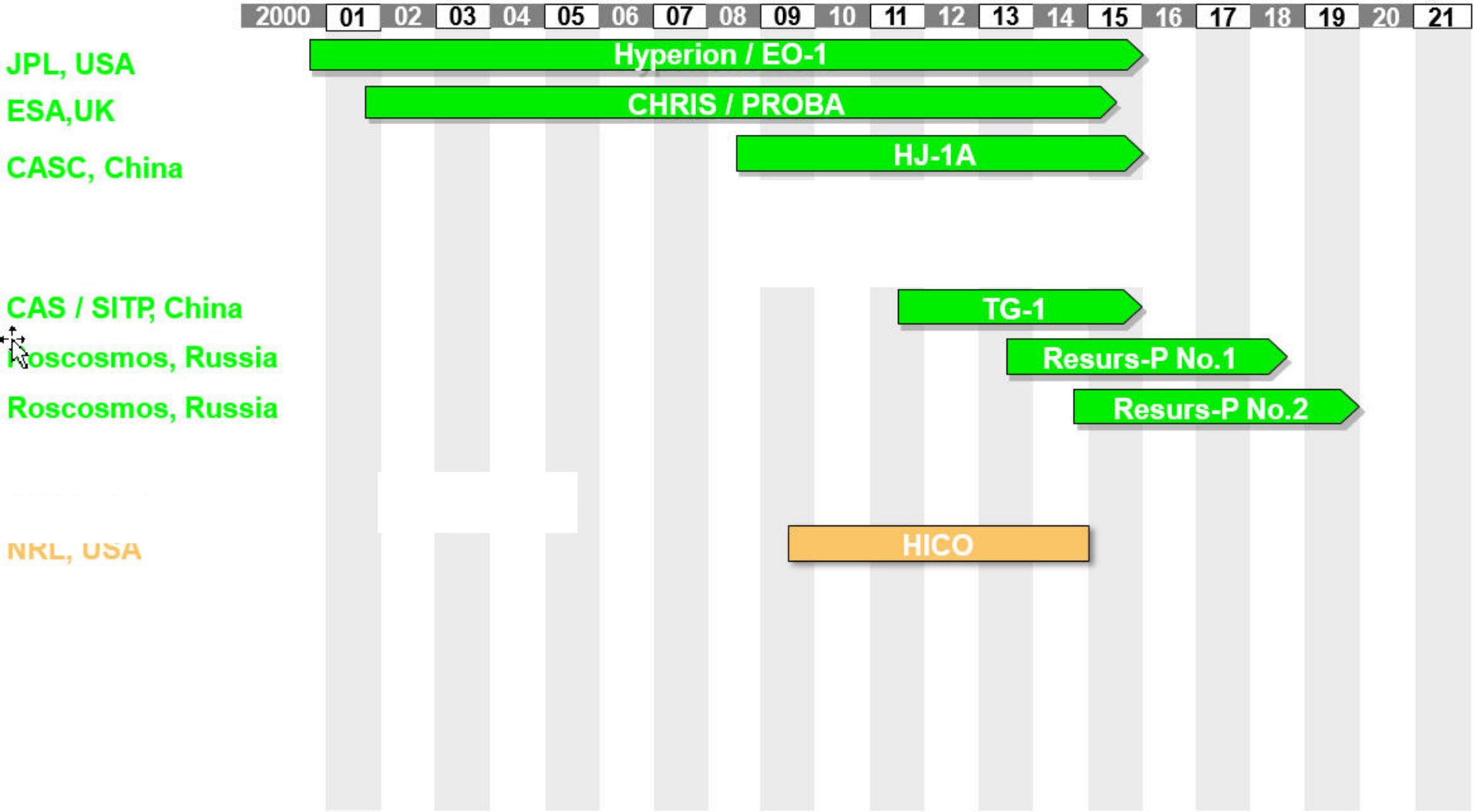
Hyperspectral VSWIR Spaceborne Instruments

Michael Abrams, Jet Propulsion Laboratory, California Institute of Technology

fppt.com

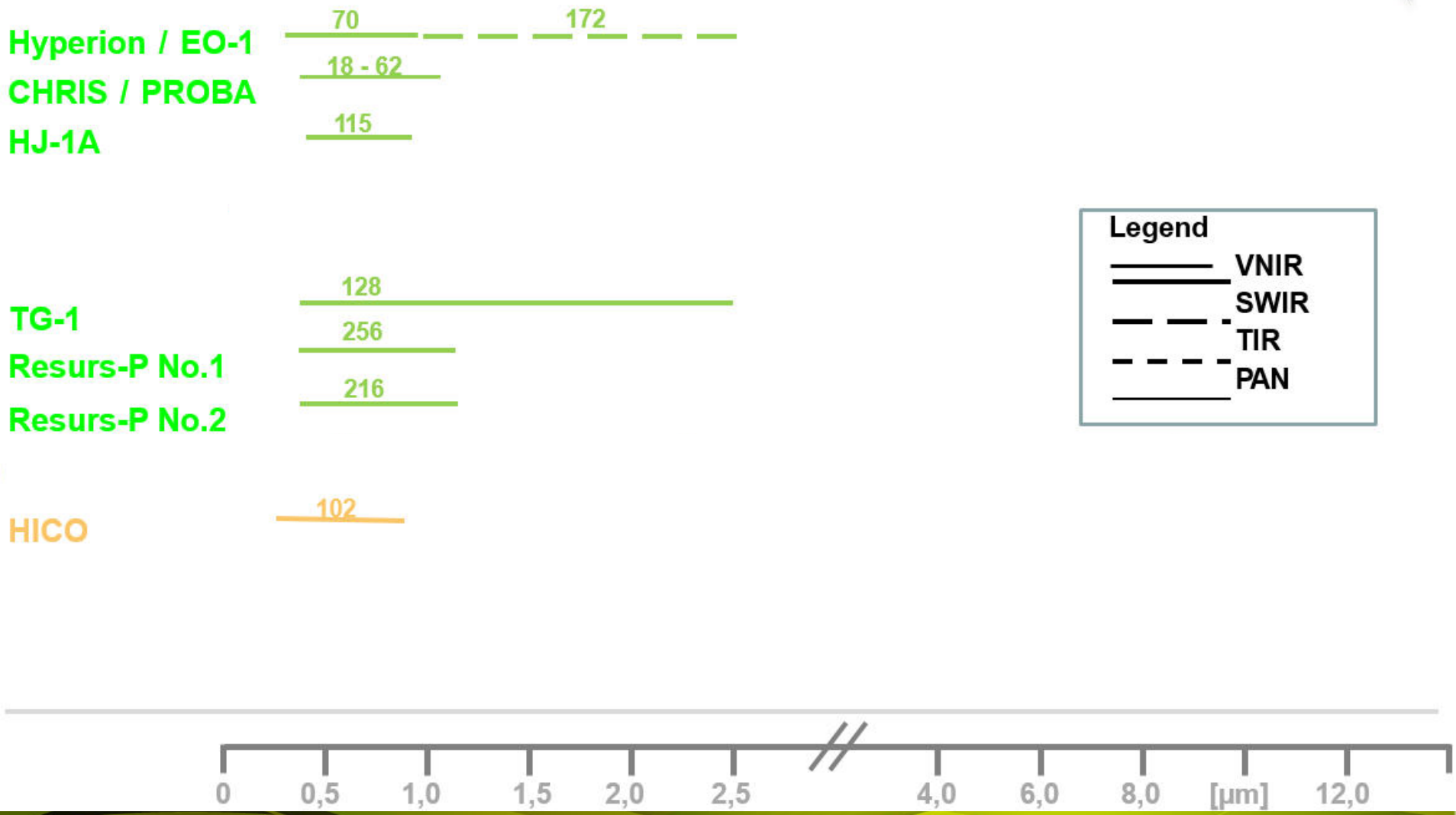
Running and terminated IS EO missions

Launch and life time



Running and terminated IS EO missions

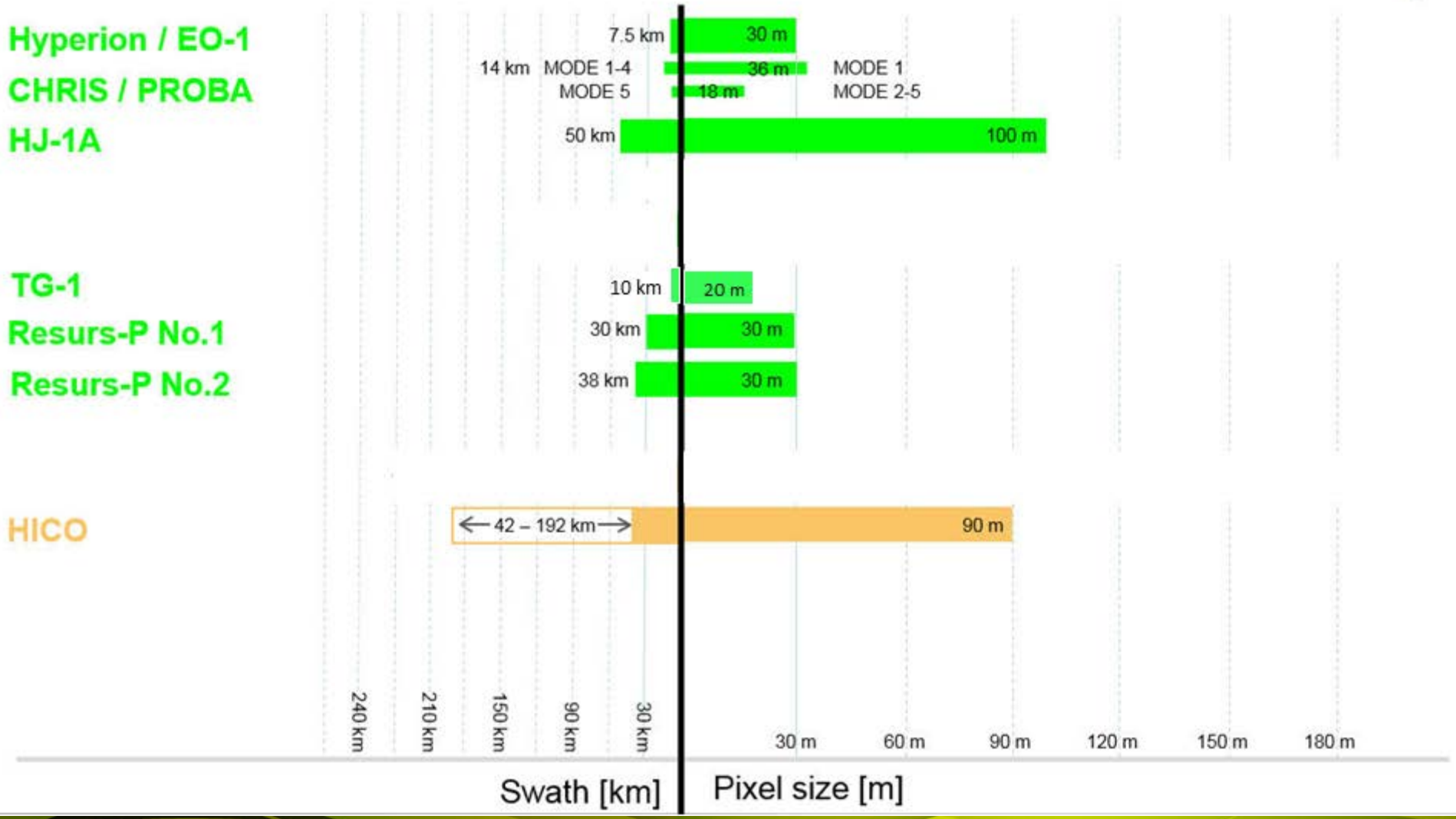
Spectral characteristics



fppt.com

Running and terminated IS EO missions

Spatial characteristics



fppt.com

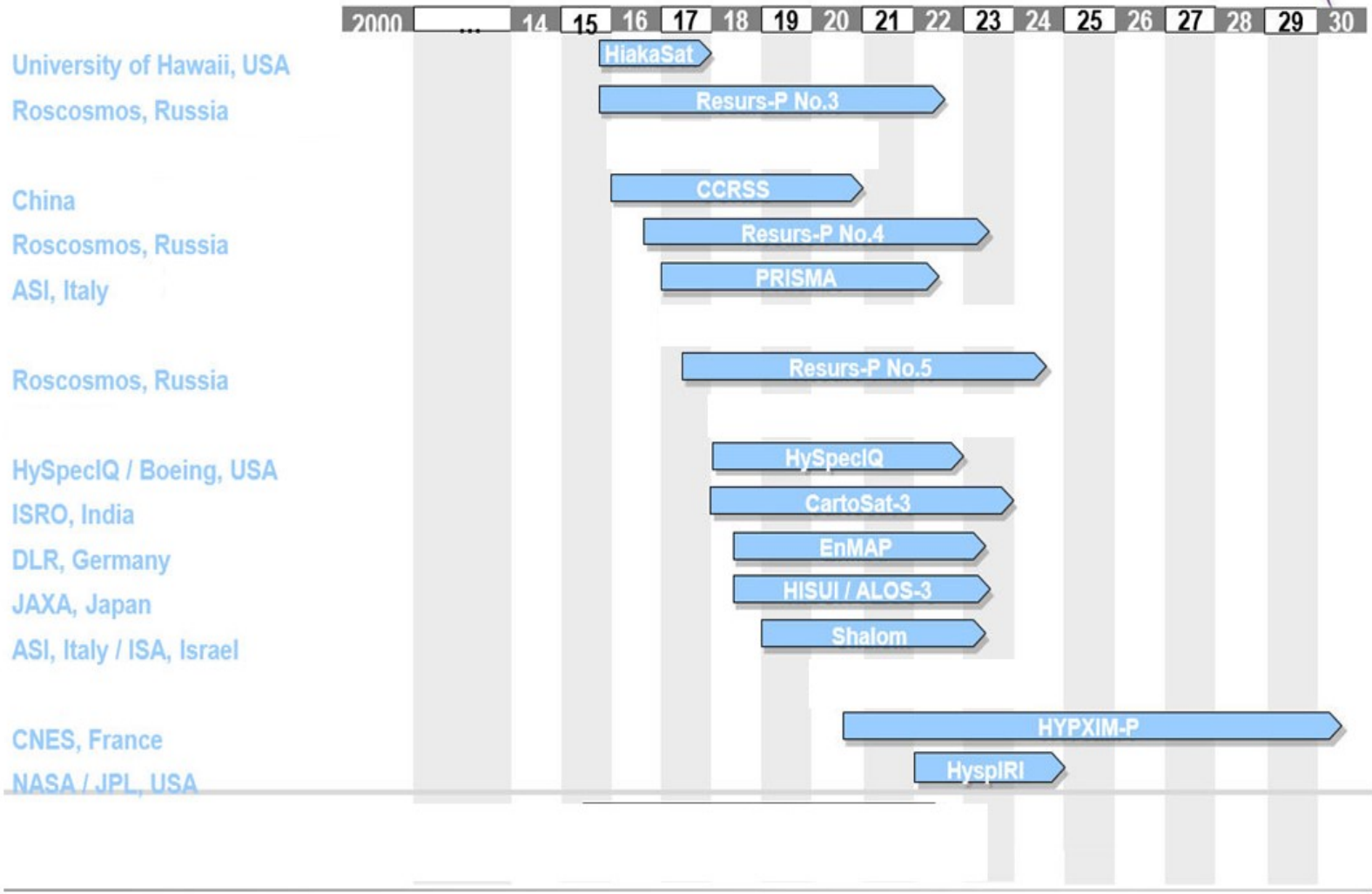
Future Hyperspectral VSWIR Missions

Michael Abrams, Jet Propulsion Laboratory, California Institute of Technology

fppt.com

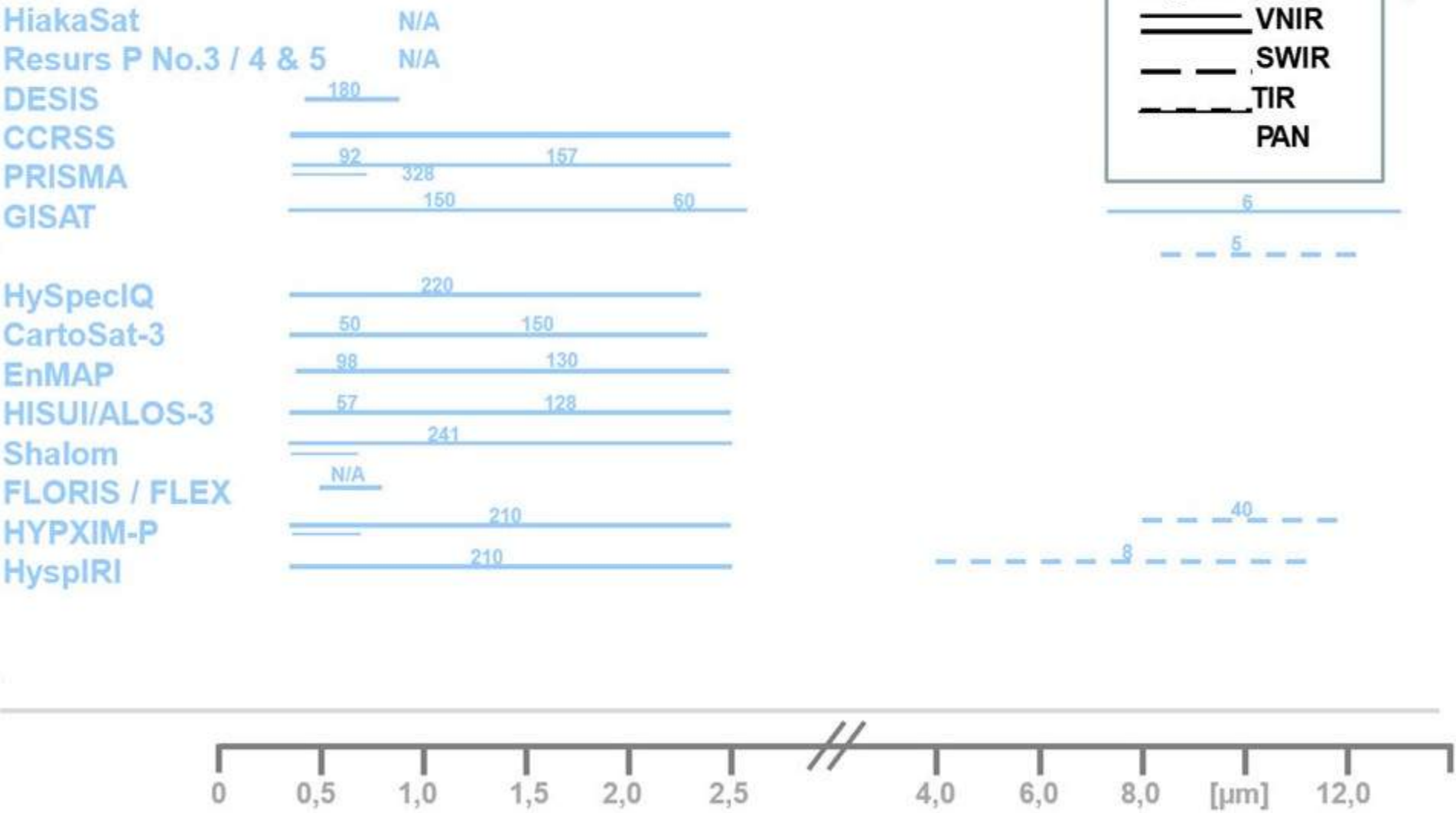
Future IS EO missions

Launch and life time



Future IS EO missions

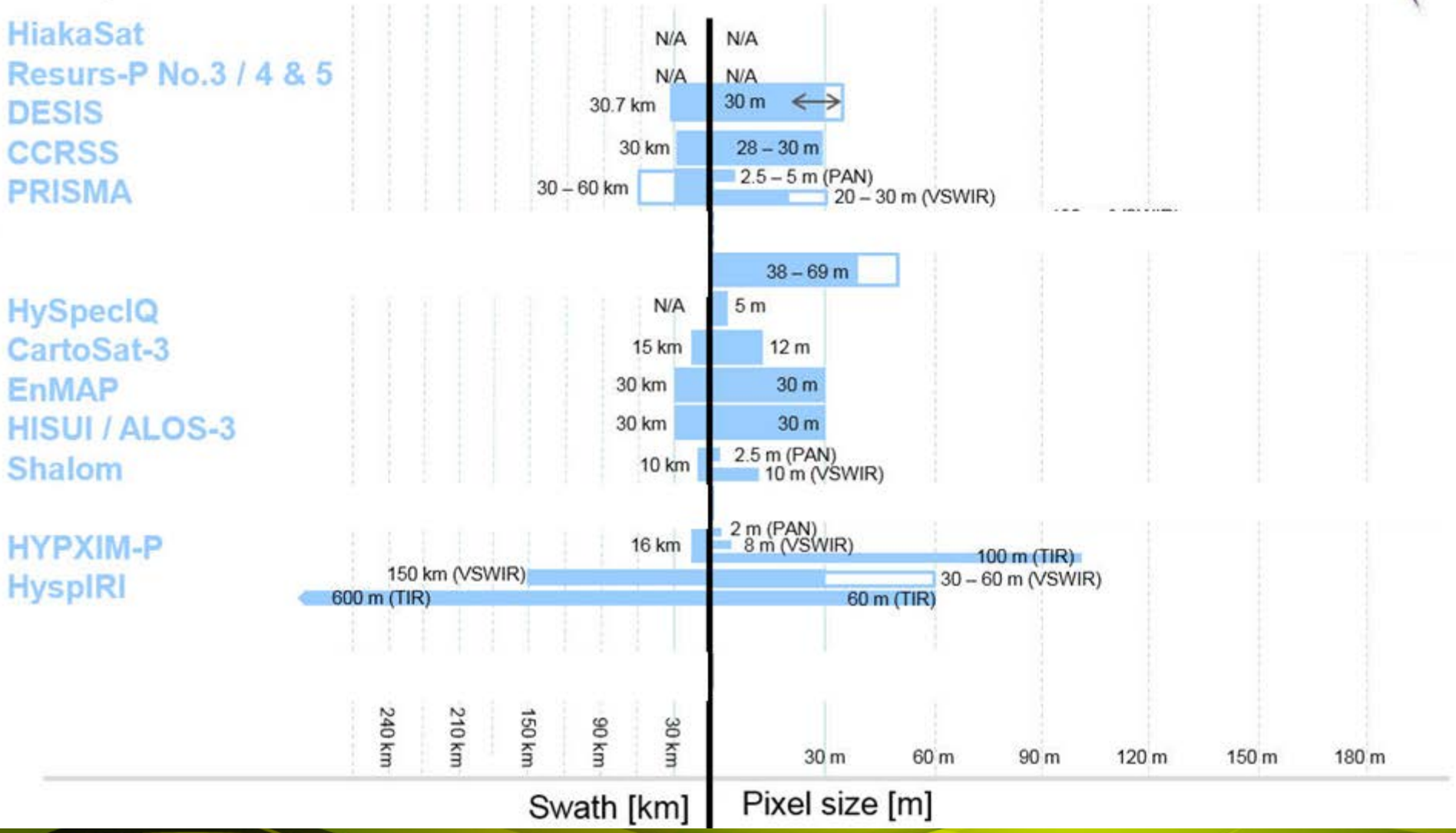
Spectral characteristics



fppt.com

Future IS EO missions

Spatial characteristics



fppt.com

HyspIRI Objectives and Approach

Key Science and Science Applications

Climate: Ecosystem biochemistry, condition & feedback; spectral albedo; carbon/dust on snow/ice; biomass burning; evapotranspiration

Ecosystems: *Global* biodiversity, plant functional types, physiological condition, and biochemistry including agricultural lands

Fires: Fuel status; fire frequency, severity, emissions, and patterns of recovery *globally*

Coral reef and coastal habitats: *Global* composition and status

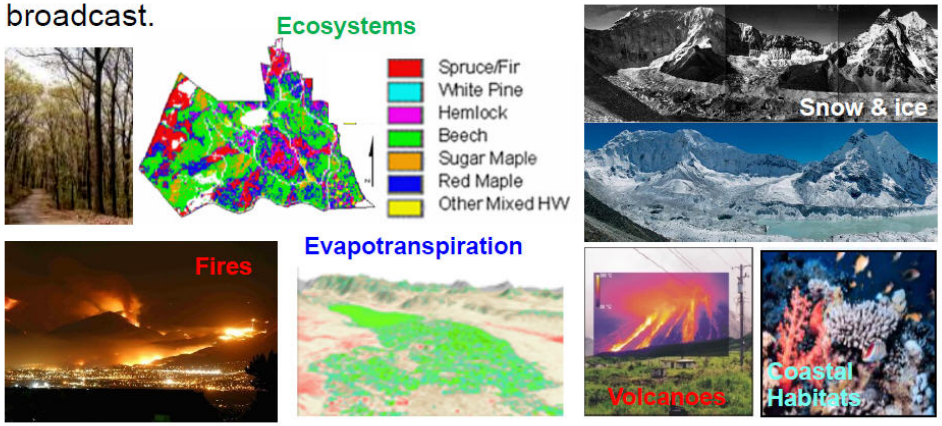
Volcanoes: Eruptions, emissions, regional and *global* impact

Geology and resources: *Global* distributions of surface mineral resources and improved understanding of geology and related hazards

Applications: Disasters, EcoForecasting, Water, Health/AQ

Mission Urgency

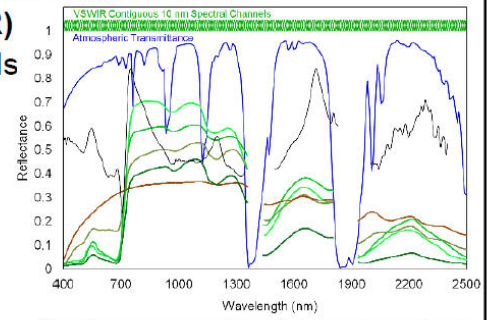
The HyspIRI science and applications objectives are critical today and uniquely addressed by the combined imaging spectroscopy, thermal infrared measurements, and IPM direct broadcast.



Measurement

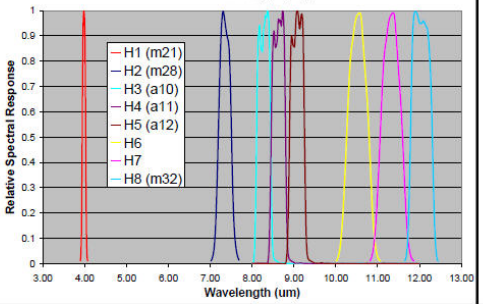
Imaging Spectrometer (VSWIR)

- 380 to 2500nm in ≤10nm bands
- 60 m spatial sampling*
- 19 days revisit*
- Global land and shallow water

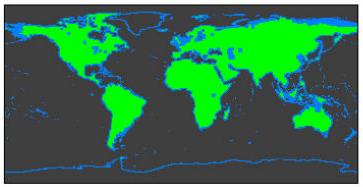


Thermal Infrared (TIR):

- 8 bands between 4-12 µm
- 60 m spatial sampling
- 5 days revisit; day/night
- Global land and shallow water



IPM-Low Latency data subsets



Mission Concept Status

Level 1 Measurement Requirements: Vetted by community and stable

Payload: VSWIR Imaging Spectrometer, **TIR** Multi-spectral Radiometer, and **Intelligent Payload Module (IPM)**

Full Mission original option: Mature

Separate Small Mission option: Pegasus-based solutions identified and studied

***SLI Support:** HyspIRI VSWIR evolving to 30m at 185km swath

ECOSTRESS TIR: Selected EVI for ISS

VSWIR Dyson Option: Technology/Science ISS Demonstration

Summary: The HyspIRI mission measurement requirements and baseline instruments approach are mature and stable with good heritage, low risk and modest cost. Now exploring a range of instrument and data options to save cost, per guidance letter.

Multispectral TIR Spaceborne Instruments

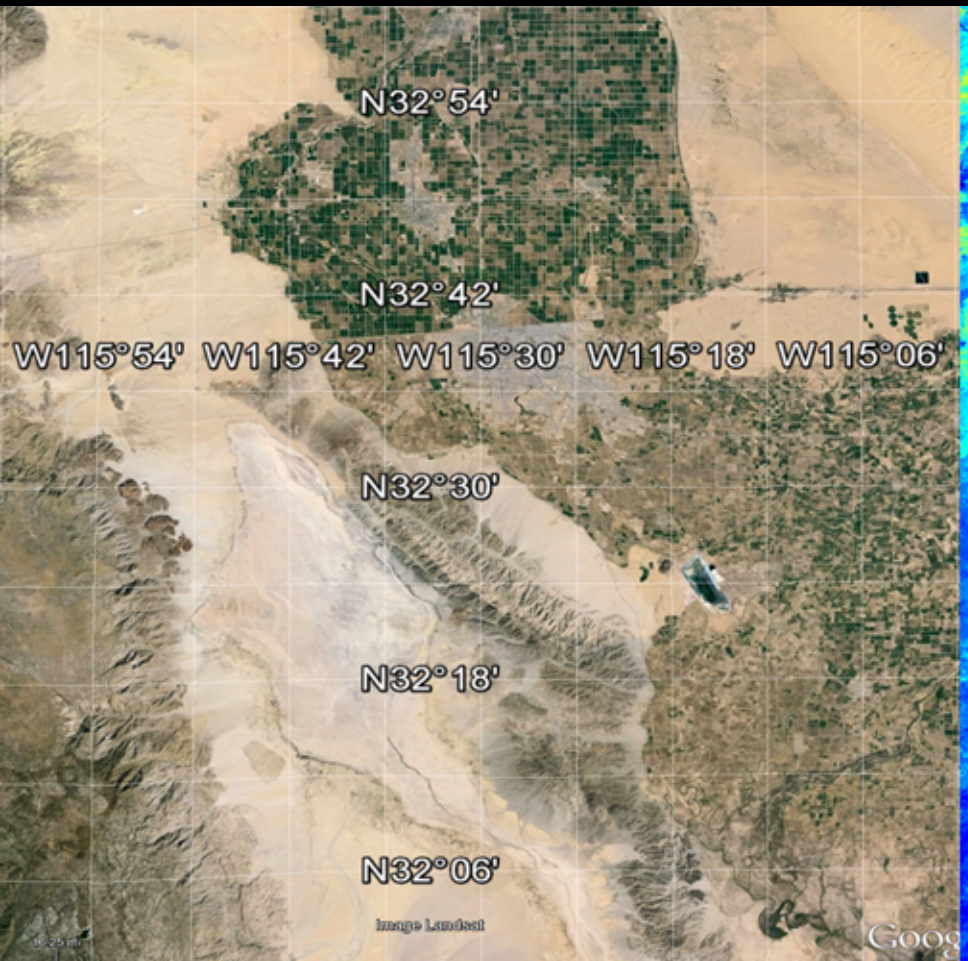
Michael Abrams, Jet Propulsion Laboratory, California Institute of Technology

fppt.com

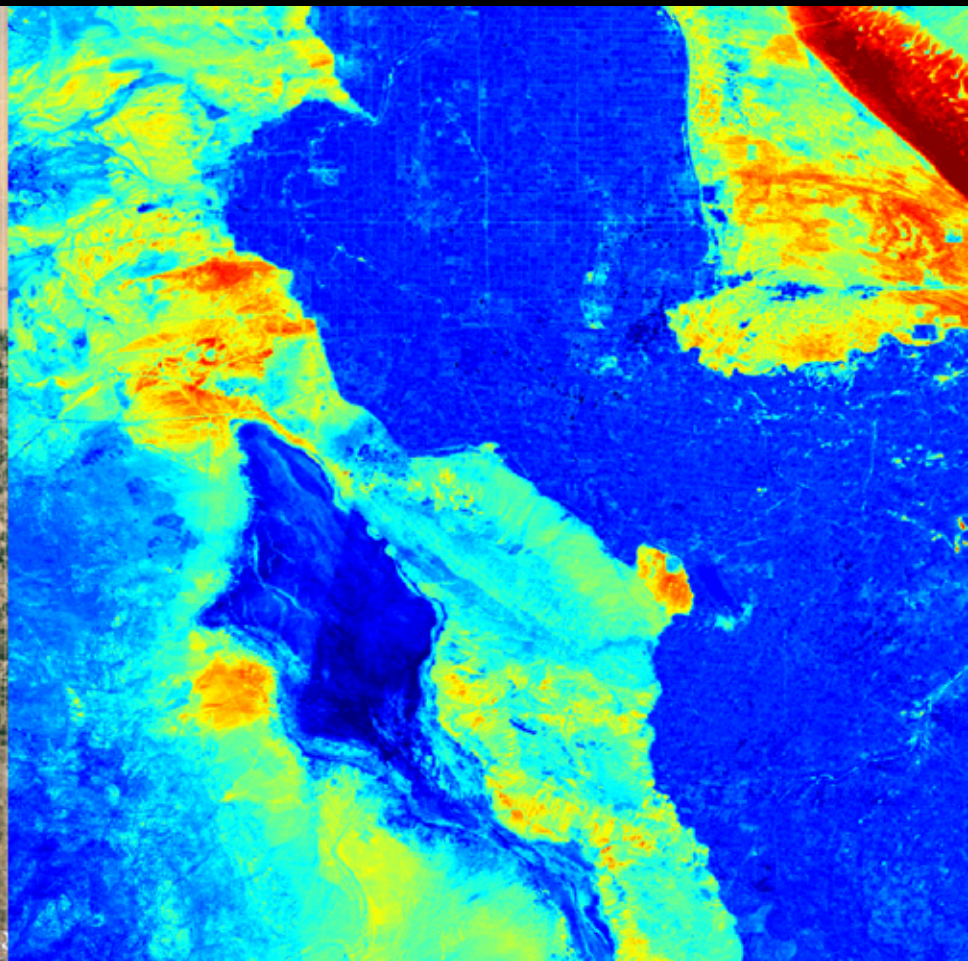
Operational TIR Missions

ASTER on Terra: 2000-present
90 m pixels, 5 bands, 60 km swath

Google Earth

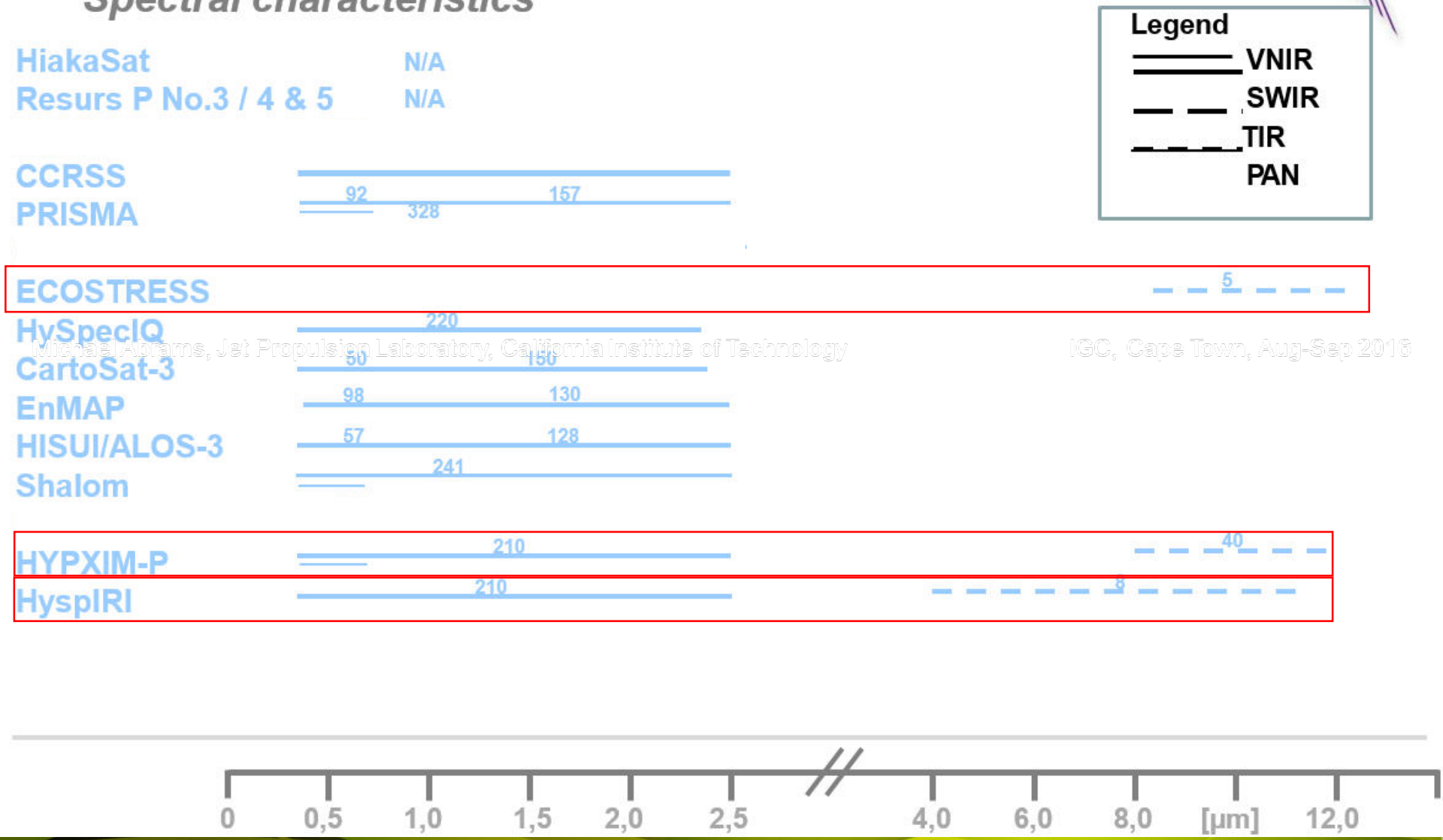


Quartz Index

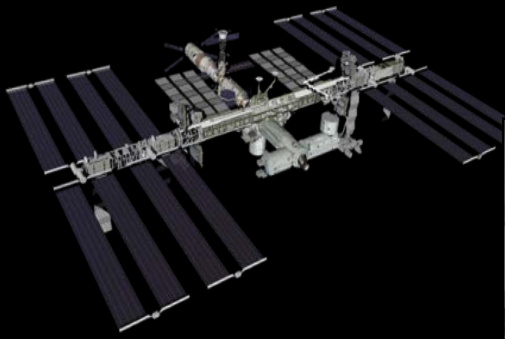


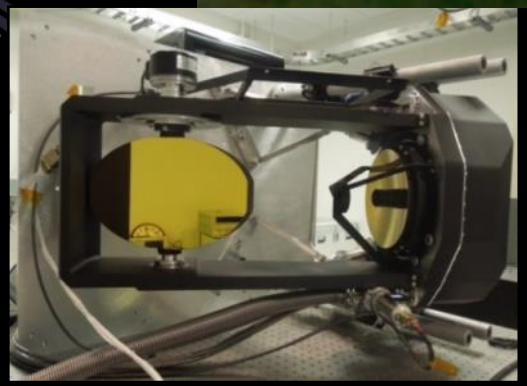
Future Multispectral TIR Missions

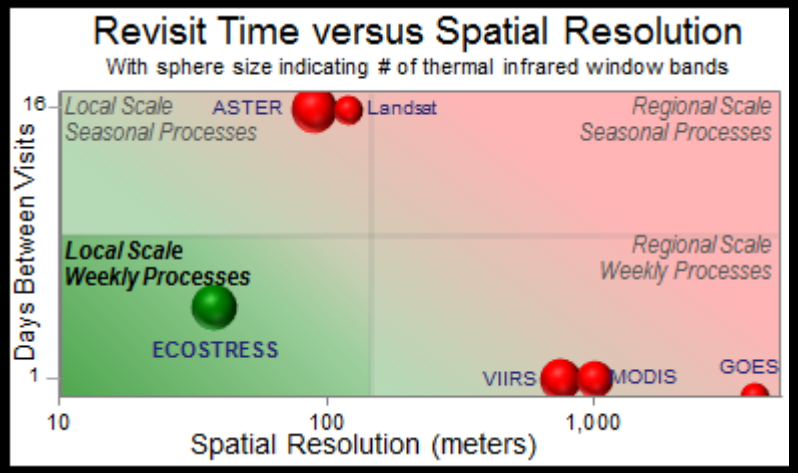
Spectral characteristics



ECOSTRESS

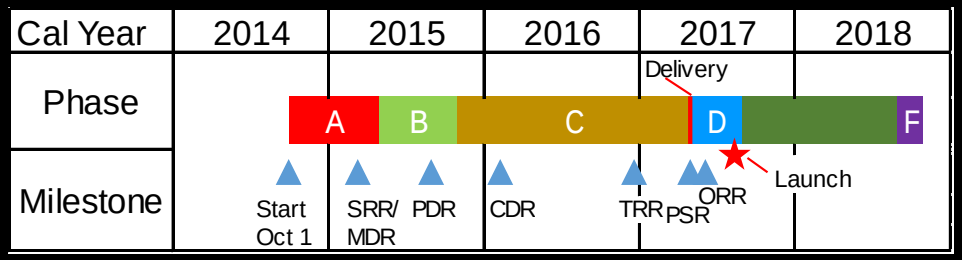






Mission

- Class D $30M cost cap
- 31-months from project start to delivery
- JPL implementation and management
- 69-month project duration (Phase A-F)
- On ISS-JEMS Module
- 12-month Science Operations (Phase E)



The inclined, precessing ISS orbit enables ECOSTRESS to sample the diurnal cycle in critical regions across the globe at spatiotemporal scales missed by current instruments in Sun-synchronous polar and high-altitude geostationary orbits.

Instrument

•Leverages functionally-tested PHyTIR space-ready hardware developed under the NASA Instrument Incubator Program:

- Spectral resolution: 5 bands in the thermal infrared window (8-12.5 μm) part of the electromagnetic spectrum
- Noise equivalent delta temperature: ≤ 0.3 K
- Spatial resolution: 38 m x 69 m
- Swath width: 400 km @ 400 km altitude (51°)

•*Well understood measurement and algorithms based on prior missions, such as ASTER, MODIS, and Landsat*

fppt.com

SUMMARY

- Future looks promising for hyperspectral VSWIR sampling missions:
  EnMAP (Germany), Resurs-P No. 3 (Russia), HISUI (Japan), Cartosat-3 (India), CCRSS (China)

- Lack of funded, manifested global mapping VSWIR missions

- Very few multispectral TIR missions funded beyond ASTER:
  ECOSTRESS (USA)

fppt.com