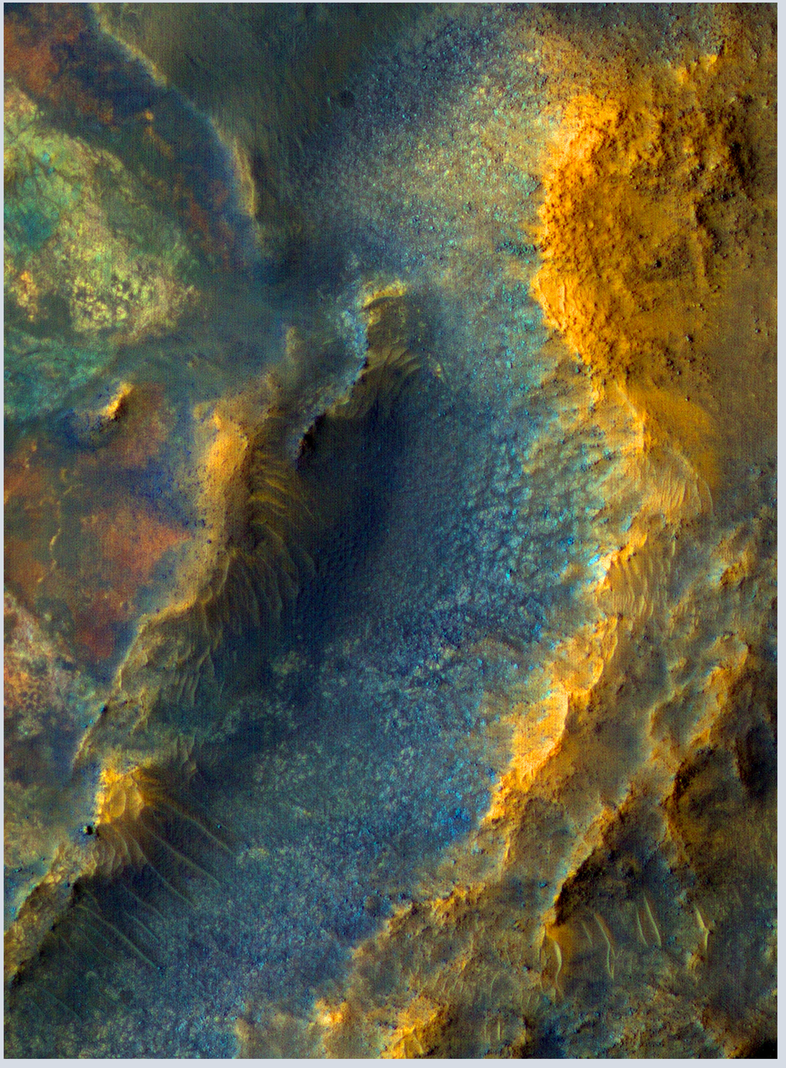

Imaging Spectrometers on SmallSats to Mars: Science Drivers and Needed Technologies

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Scientific Motivation: Ancient Environments

Key community documents have recommended exploration of ancient Martian environmental transitions and better understanding of aqueous environments linked to habitability [e.g. 1-3].

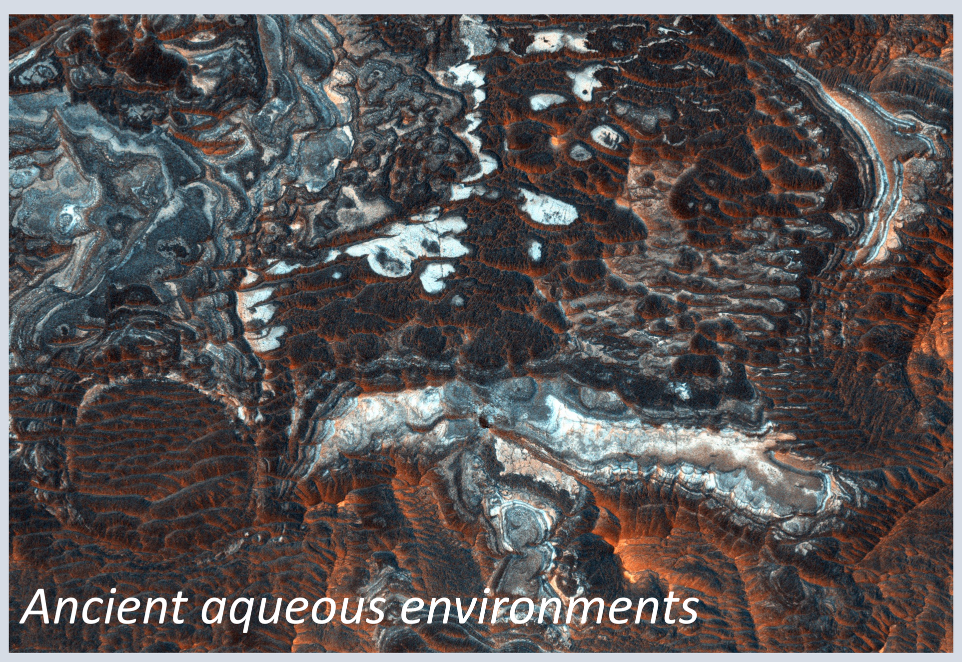
– MASWG included a small spacecraft to map mineralogy from orbit as an example first step in Mission Arc #1: Diverse ancient environments and habitability

Scientific Motivation: Polar and Near Surface Ice

Composition is a key clue to formation processes and preservation of surface observable ice reservoirs.

– MASWG Mission Arc #3 focusses on ice and geologically recent climate change. Orbital imaging (spectral + texture) is an important precursor to landed geophysics and deep drilling into ice reservoirs

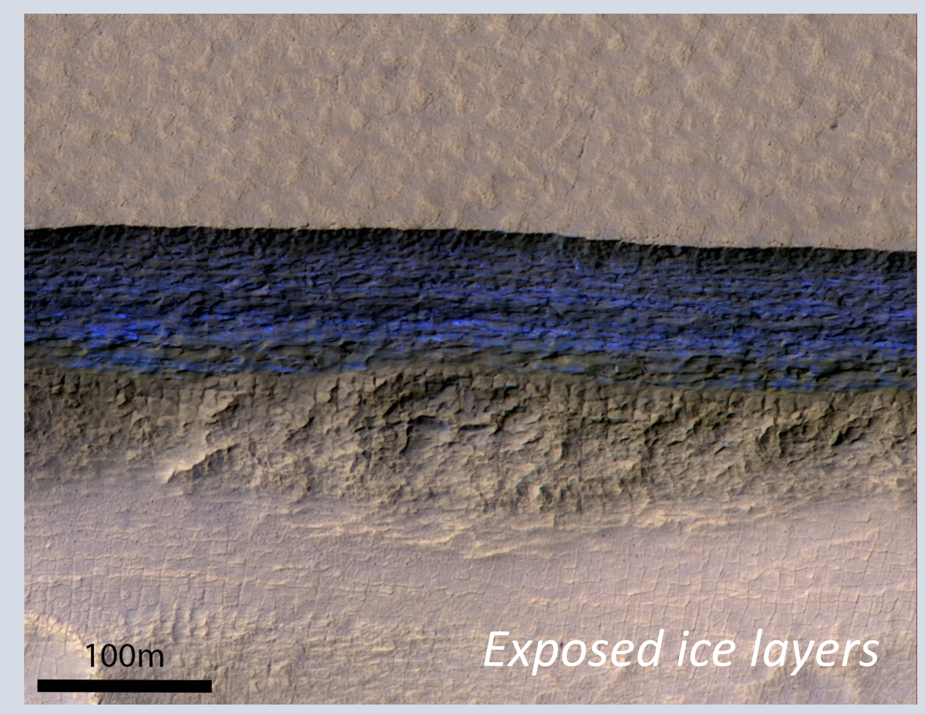
Both could be addressed by orbital visible short-wave infrared (VSWIR) and thermal (IR) imaging spectrometers.



Ancient aqueous environments

Major Imaging Spectrometer Requirements:

- 6-7 m/pixel (2.5x to 3x better than CRISM)
- Wavelength range at least 1000 to 3000nm, but preferably both shorter and longer
- Spectral resolution and SNR similar to or better than CRISM.
- Targeted observations of 1000s of known locations
- Image swath of ~3.5 km or wider

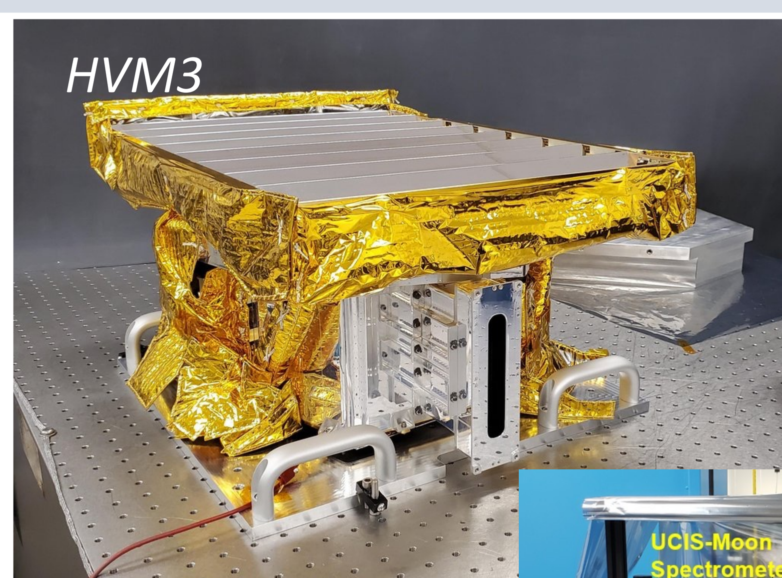


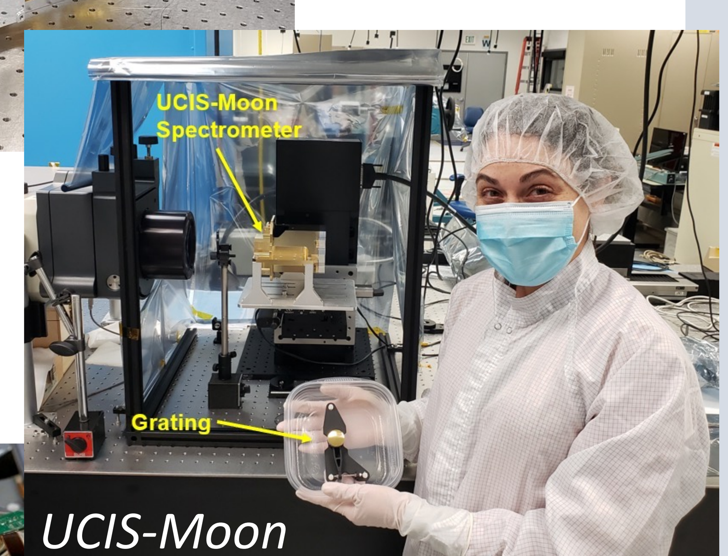
Exposed ice layers

JPL Spectrometer Development:

- Technology advances have enabled imaging spectrometers that fulfill above requirements at that are low enough mass and power that they could be compatible with smallsat missions to Mars [4].
- Both Offner and Dyson designs developed by JPL in low volume, mass and power prototypes and flight instruments:
  - High-resolution Volatiles and Minerals Moon Mapper (HVM3) on Lunar Trailblazer [5]
  - Ultra-Compact Imaging Spectrometer (UCIS) Moon [6]
  - Mapping Imaging Spectrometer for Europa (MISE) [7]
  - Earth Surface Mineral Dust Source Investigation (EMIT) [8]
  - VSWIR+MWIR (600 to 3600 nm) Dyson Imaging Spectrometer (VMDIS) for Cubesat [9]
  - Reduced size microVMIDS
  - Instrument Testbed (ITB) telescope.

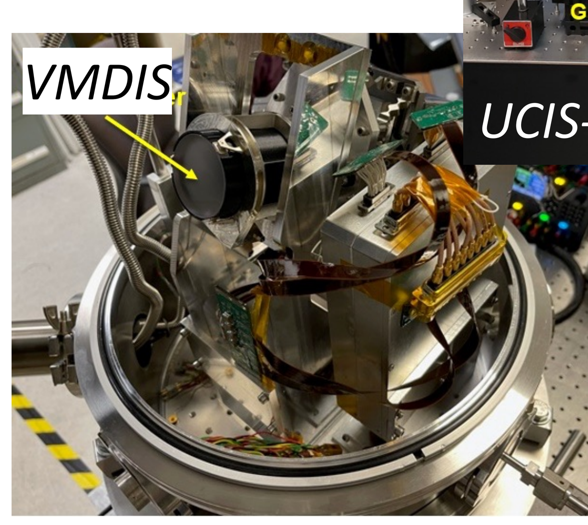
HVM3



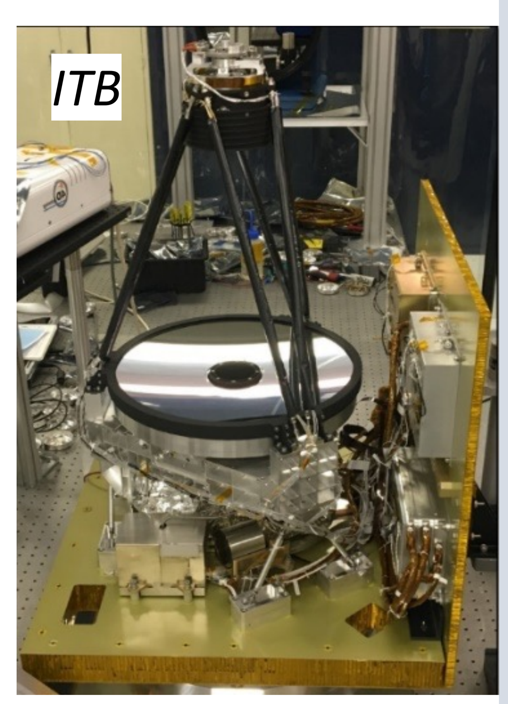


UCIS-Moon

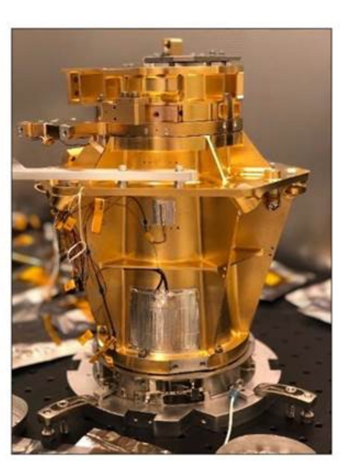
VMDIS



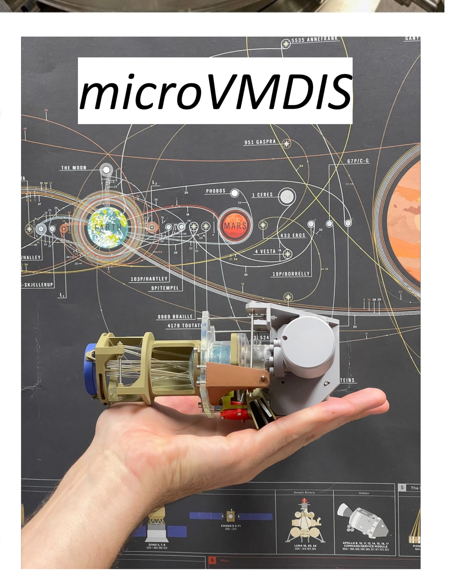
ITB



EMIT



microVMDIS



Needed SmallSat Technologies:

- Capable SmallSat bus (~15-20kg, 80W science payload, inserted into Mars orbit)
- Pointing requirements
  - Control: ~0.05 – 0.01˚ (10% swatch width at 300 km)
  - Knowledge: 0.001˚ (1 pixel at 300 km)
  - Stability: ~0.01˚/sec
- Data / Communication throughput (few 100 Gbits / day), ~5,000 – 10,000 targeted observations
- ConOps

Lunar Trailblazer: SmallSat with Imaging Spectrometers headed to the Moon

References: **[1]** Jakoksky et al., Report by the Mars Architecture Strategy Working Group (MASWG) report, 2020 **[2]** National Academy of Sciences, Origins of Worlds and Life, 2022 Planetary Science Decadal Survey, **[3]** Mars Exploration Program Analysis Group (MEPAG) Science Goals, Objectives, and Priorities, 2020, **[4]** Green et al., "Low-Cost Imaging Spectrometer for Mars," Low Cost Mars Mission Conference 2022. **[5]** Bender et al., SPIE, 2022 **[6]** Haag et al., SPIE, 2019 **[7]** Blaney et al., LPSC, 2019 **[8]** Green et al., IEEE Aerospace, 2020, **[9]** Vinckier et al., SPIE, 2022

Pre-decisional, for planning purposes only