A 2U SWIR-MIR POINT SPECTROMETER FOR SMALLSAT AND LANDED MISSIONS: ENABLING CHARACTERIZATION OF SOLAR SYSTEM VOLATILES. B. L. Ehlmann[1,2], J. Blacksberg[2], X. Chen[2], W. Johnson[2], M. Kenyon[2], C. Raymond[2] [1]Division of Geological and Planetary Sciences, California Institute of Technology [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California, 91109 (ehlmann@caltech.edu)

We are building a compact (2U), low-cost, and uniquely capable infrared point spectrometer covering both the shortwave-IR (2-4 μm) and mid-IR (6-12 μm) wavelength regions. While many spaceborne point spectrometers have been built with a diversity of performance characteristics, no flight spectrometer currently exists that will cover the broad solar reflectance plus thermal emission spectral range that we are targeting within a compact form-factor and low-cost instrument (e.g., compatible with CubeSats). Our instrument is suitable for small spacecraft reconnaissance of asteroids, the Moon, and planetary satellites as well as use on mass-constrained landed missions and built around three unique JPL Microdevices Laboratory technologies: curved gratings, thermopile detectors, and barrier infrared detectors (BIRD). We have customized and extended these technologies specifically for this instrument to make it possible to measure the shortwave- and mid-IR simultaneously in a payload that fits in 2U.

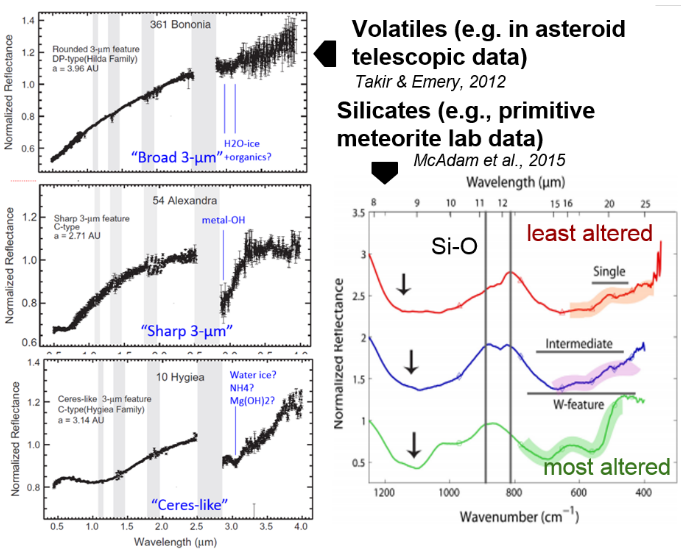

Figure 1. Our 2U SWIR+MIR point spectrometer will determine the type and quantity of volatiles on planetary surfaces, motivated by the desire to discriminate hydrated minerals, carbonates, sulfates ices, organics, and ammoniated species as well as discriminate amorphous and crystalline silicates.

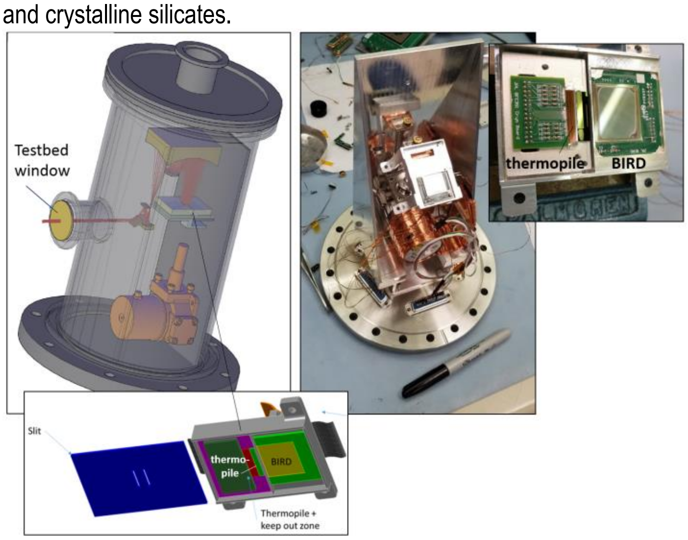

Figure 2. Compact 2U SWIR-MIR point spectrometer as designed with prototype in build.

The combination of the two wavelength ranges allows us to simultaneously collect information about volatiles (e.g., water, hydrated minerals, organics) and silicate minerals. Absorptions due to metal-OH, H_2O, N-H, C-H, C-O, S-O, and Si-O are interrogated. Analysis of telescopic data [e.g., 1], asteroid mission data from Ceres, Ryugu, Bennu, and the Moon [e.g., 2-7], and laboratory data of meteorites [e.g., 8] demonstrate the importance of the 2-4 μm SWIR wavelength region for volatiles, including the ability to distinguish the carrier of hydration (mineral phase vs. ice) and recognize ammonia, organic, and carbonate phases, performing quantitative modeling of abundances. The 7-12 μm MIR also provides a crucial means of distinguishing meteorite family and degree of aqueous alteration [e.g. 9], providing information on silicate mineralogy, the presence of amorphous vs. glassy materials, and the presence of sulfates and organics (Fig. 1). Thus, this dual wavelength spectroscopic capability is desirable for solar system exploration, particularly for small satellites and mass-constrained landers.

Design Reference Case: The target performance requirements are

1) measure wavelength ranges including 2.0-4.0 μm and 8-12 μm reflectance and emission
2) with at least 0.02 μm and 10 cm^{-1} wavenumber spectral resolution, sufficient to identify key absorption

phases [1-9]

3) with an IFOV of ≤5 mrad
4) with SNR sufficient to detect 1% band depths due to OH/H_2O and Si-O on a 0.05 albedo asteroid. The 1% band depth threshold is set to be significantly lower than that measured for hydrated meteorites in lab and for asteroids in telescopic data [1, 9].
5) Resource utilization of mass <1.5 kg, power <5 W, volume <2U.

Status: A breadboard is currently under development at JPL. A microcryocooler maintains two temperature zones for the BIRD and thermopile detectors, which share an optical assembly comprised of telescopic optics, relays, and a curved grating spectrometer (Fig. 2). The optical assembly performs as expected. We are presently testing detector performance, mounted on the FPA assembly, under vacuum as a function of temperature, as controlled by the microcryocooler. Integrated system tests with calibration targets and meteoritic materials are expected for mid-2019. Anticipated TRL is ~5, suitable for incorporation in upcoming SIMPLEx, Lunar, Discovery, and New Frontiers missions.

Acknowledgements: This work has been conducted at the Jet Propulsion Laboratory, Caltech, under a contract with the National Aeronautics and Space Administration (NASA) and represents follow-on from a workshop on Assaying the Near Earth Object population, conducted at the Keck Institute for Space Studies.

References: [1] Takir & Emery, 2012, *Icarus* [2] De Sanctis et al., 2015, *Nature* [3] De Sanctis et al., 2016, *Nature* [4] De Sanctis et al., 2017, *Science*, [5] Iwata, T. et al. (2017) *SSR* [6] Lauretta et al., *this conf*, [7] Pieters et al., 2009, *Science* [8] Takir et al., 2013, *MAPS* [9] McAdam et al., 2015, *Icarus*