IMAGING SPECTROSCOPY IN THE 5-7 MICROMETER WAVELENGTH REGION FOR QUANTITATIVE ANALYSIS OF FE^{2+} IN OLIVINE AND HYDRATION.

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Introduction: The 5-7 micron wavelength region has been largely unexploited for science and exploration applications of reflected or emitted radiation. Recent laboratory work, however, has shown enormous potential for this wavelength region in compositional analyses for science and exploration [1] and telescopic observations show exciting potential for exploiting this region as well for the detection and characterization of water in lunar soils [2]. We report here on the science potential and an instrument concept for implementing the science we call Hyperspectral Imaging Spectrometer 57: HIS-57.

For implementation of this new science potential from the 5-7 µm wavelength region, capable instrumentation will be required. The constraints on instrument design will be mass, volume, cooling requirements. Thus it will need to be small, lightweight and not require extensive cooling, while having the imaging and spectral capabilities for robust science applications. Here we envision an implementation of this hypothetical instrument on the Moon for the determination of mineralogy and hydration.

Example Science in the 5-7 µm region: Mg/Fe ratios in Olivine

Reflectance spectra measurements of a suite of olivine minerals with Mg/(Fe+Mg) ratios that range from 0-100 are shown in Figure 1. The wavelength position of the absorptions near 5.5 and 6.0 microns systematically move to longer wavelengths with increasing Mg/(Fe+Mg) ratio. This is shown in Figure 2. This is the type or property to be measured by the HIS-57.

5-7 µm Imaging Spectrometer Science Goals and Characteristics

- Understand Igneous Process on the Moon
- Understand Lunar Stratigraphy
- Understand Volatiles on the Moon

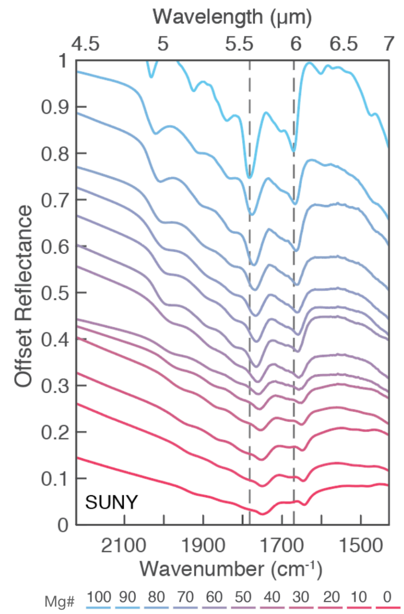

Figure 1. Reflectance spectra of pure synthetic olivine samples (measured [5]) with Mg/(Mg+Fe) ratio that spans the full solid solution. (After Kremer et al. 2020 [1].)

These goals will be accomplished by an imaging spectrometer covering 5000-7000 nm using a single detector and a linear dispersive element. The end result is a simple, well-calibrated spectrometer with a high signal-to-noise ratio (SNR) and excellent spectra/ spatial uniformity. From a rover or landed platform, the instrument will be able to map the distribution of and spatial relationship between major rock and soils types in situ on the Moon.

There are challenges to making measurements in the 5-7 µm wavelength region. One key challenge is this wavelength region makes the switch from primarily reflected electromagnetic radiation to primarily emitted radiation. For a planetary body like the Moon, emitted radiation would be the dominant source. With the temperatures expected on the surface of the Moon the performance of the HOT-BIRD would satisfy the signal to noise requirements.

Another key challenge is the availability of technology to make high quality measurements. Detector technology continues to evolve and develop. New capabilities are emerging. One such detector is the T2SL HOT-BIRD. The HOT-BIRD detector has a 640x512 pixel detector. This has a spectral range of 5000-7000 nm with a 20 nm spectral resolution.

The Jet Propulsion Laboratory has extensive experience in developing imaging spectrometers for space flight [e.g. 3, 4]. Building off this extensive experience, we envision the development of a high-quality imaging spectrometer that. We will report on the instrument concepts we are working on for this wavelength region.

References: [1] Kremer, C. H., J. F. Mustard and C. M. Pieters, GRL47, e2020GL089151. https://doi.org/10.1029/2020GL089151 [2] Honniball, C. et al., 2020, Nature Astronomy. [3] Pieters, C. M., et al. "The Moon Mineralogy Mapper (M³) on Chandrayaan-1." Current Science (2009): 500-505. [4] Blaney, D. L., et al. EPSC Abstracts. Vol. 10, EPSC2015-319, European Planetary Science Congress 2015.

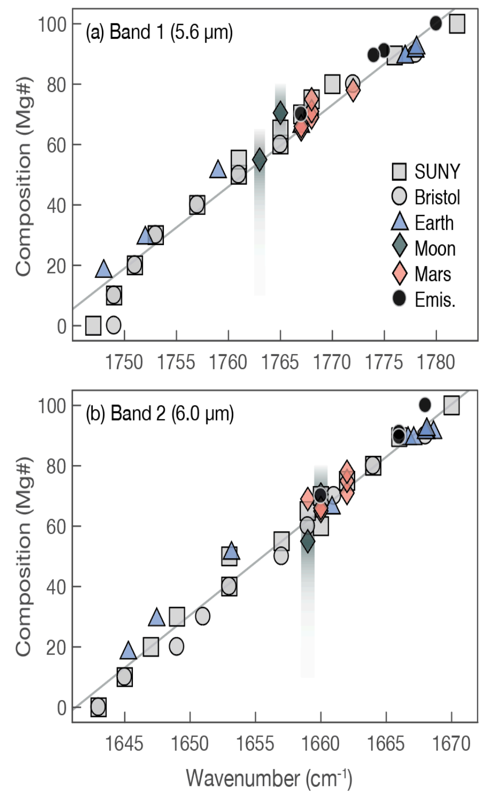

Figure 2. Plot of band position vs. Mg# composition of a suite of >50 synthetic (see Fig. 1) and natural olivine samples. (After Kremer et al., 2020 [1])