TREX MEASUREMENTS OF MINERALOGICAL SAMPLES IN THE PSI LAB FROM THE VACUUM-UV TO THERMAL INFRARED WAVELENGTHS N.C. Pearson[1] R.N. Clark[1], A.R. Hendrix[1] and the TREX team. [1]Planetary Science Institute, Tucson, AZ, 85719 USA , npearson@psi.edu

Introduction: The Toolbox for Research and Exploration (TREX) is a NASA SSERVI (Solar System Exploration Research Virtual Institute) node. TREX (trex.psi.edu) aims to decrease risk to future missions, specifically to the Moon, the Martian moons, and near-Earth asteroids, by improving mission success and assuring the safety of astronauts, their instruments, and spacecraft. TREX studies will focus on characteristics of the fine grains that cover the surfaces of these target bodies – their spectral characteristics and the potential resources (such as H_2O) they may harbor. TREX studies are organized into four Themes: lab studies [1], Moon studies [2], small-bodies studies [3], and field work [4]). Here we describe one of several laboratory facilities to measure the spectral reflectance of fine-grained geologic materials.

Background: Environment chambers have long been used to simulate outer space environments for comparison of analog material samples and returned samples to spacecraft data. To this end the Planetary Science Institute (PSI) Spectroscopy Lab has environment chambers to measure the diffuse reflectance of rock and mineral samples from ~0.12-20.0µm. The large chamber in its current configuration and attached spectrometers enable measurements from only 0.12-2.5µm, with plans to extend this to the full 20.0µm range in the near future. The chamber has been designed to reach a high vacuum of $1X10^{-6}$ Torr, heat samples 500K and cool them to 77K. Additional chambers include small chambers which can be cooled or heated, enable measurements over many phase angles and with sapphire windows can be used to measure spectra from 0.2 to 5µm. Another chamber has fixed 12 degree incident and emission angles and can cool samples to the triple point of nitrogen (46 Kelvins). The Chambers were originally built/refurbished for the Cassini Visual and Infrared Mapping Spectrometer, VIMS (R. Clark Team Member) [5, 6, 7, 8, 9, 10] and are now a facility at PSI.

Methods and Instrumentation: The main environment chamber (Figure 1) has been designed to relatively quickly measure mineral samples and other solid materials. To this end it has been equipped with a high vacuum pumping system, and two quick release swing doors sealed with a rubber viton gaskets. For sample observation while measurements are being made, multiple ports have been equipped with either sapphire or quartz glass windows, with a macro camera being used to record visible images and video of the sample while under vacuum. A single axis movable stage has been installed that can be cooled using circulated liquid nitrogen, or heated with resistor. Two temperature probes have been installed so that both ambient temperature of the chamber, and the temperature of the sample can be recorded, which when combined with pressure sensor readings can used to estimate relative humidity inside the chamber. Illumination of the sample comes from a vacuum-UV-visible spectrum deuterium lamp, and a tungsten halogen lamp for the visible and near infrared. The deuterium lamp also acts to simulate the harsh UV exposure airless surfaces are exposed to in space.

To achieve a broad spectral range, multiple spectrometers, detectors, and window materials are used for view ports into the chamber. For the ~0.12-0.22um range, an Andor Solis cooled silicon detector array [11] with a McPherson Inc. Model 234/302 Monochrometer [12] and 1200 line/mm grating is used. This spectral range can be increased to 0.6um if a 300 line/mm grating is used instead. Additionally, a filter wheel has several bandpass filters for wavelength calibration and order sorting filters. Wavelength calibration can also be done using the emission line spectra of the deuterium lamp. The grating, detector, filter wheel, and slit are separated from the main vacuum environment using a magnesium fluoride window to prevent contaminants from samples settling or condensing on the detector and grating. To illuminate samples in the vacuum UV to near UV portion of the spectrum a deuterium lamp with magnesium fluoride housing window is used within the chamber. In the 0.2-0.88µm region, spectra are collected using an Ocean Optics Flame spectrometer [13] which is external to the chamber using a sapphire view port and a 90° off axis parabolic mirror to focus reflected light from the mineral sample to a fiber optic cable that is connected to the spectrometer. For the 0.35-2.5µm region an Analytical Spectral Devices (ASD inc.) Field Spectrometer 3 [14] is used in a similar fashion to the Ocean Optics spectrometer and uses the tungsten halogen lamp as a light source.

Future Instrumentation: PSI has recently acquired a Nicolet Nexus 870 FTIR [15] with mercury cadmium telluride (MCTa), deuterated triglycine sulfate (DTGS), and indium antimide (InSb) detectors. This instrument will interface with the chamber through a zinc selenide window already installed on the chamber and illuminate the sample with silicon nitride globar source.

Conclusion: The environment chambers at the PSI spectroscopy lab have been to designed to measure samples over a wide spectral range of ~0.12-20.0μm, and with the intent to simulate the wide array of surface conditions that are encountered throughout the solar system, with a temperature range of 47-500K, pressures down to $1X10^{-6}$Torr and the harsh UV radiation environment on airless bodies. This chamber is currently being used to measure fine grained minerals, meteorites, and Apollo lunar samples [1] for the TREX SSERVI project, and will continue to support projects and scientists at the Planetary Science Institute.

References: [1] Lane, M. D. et al. (2018) LPSC 49, Abstract #1098. [2] Banks, M. E. et al. (2018) LPSC 49, Abstract #2653. [3] Domingue, D. L. et al. (2018) LPSC 49, Abstract #1141. [4] Noe Dobrea, E. Z. et al. (2018) LPSC 49, Abstract #1618. [5] Clark, R. N. et al. (2008) *Icarus, 193 372-386. [6]* Clark, R. N. (2009) *Science, 326(5952), 562–564. [7]* Clark, R. N. *et al.* (2009) *JGR* 114 E03001. [8] Takir et al. (2013) *Meteoritics & Planet. Sci., 48(9):1618-1637. [9]* Clark, R. N. *et al.* (2010) *JGR 115 E10005. [10]* Clark, R. N. *et al.* (2012) *Icarus 218, 831-860.* [11]Andor Technology, iDus user Guide [12] McPherson Inc 234/302 Manual [13] Ocean Optics Document: 225-00000-000-11-201604 [14] ASD Document 600540 Rev. J [15] Thermofisher Nicolet, Nexus 870 Manual and Guide

Acknowledgements: Funding for this project has come from NASA Cassini VIMS R. Clark team member funding, Solar System Exploration Research Virtual Institute 2016 (SSERVI16) Cooperative Agreement (NNH16ZDA001N), and the Planetary Science Institute.

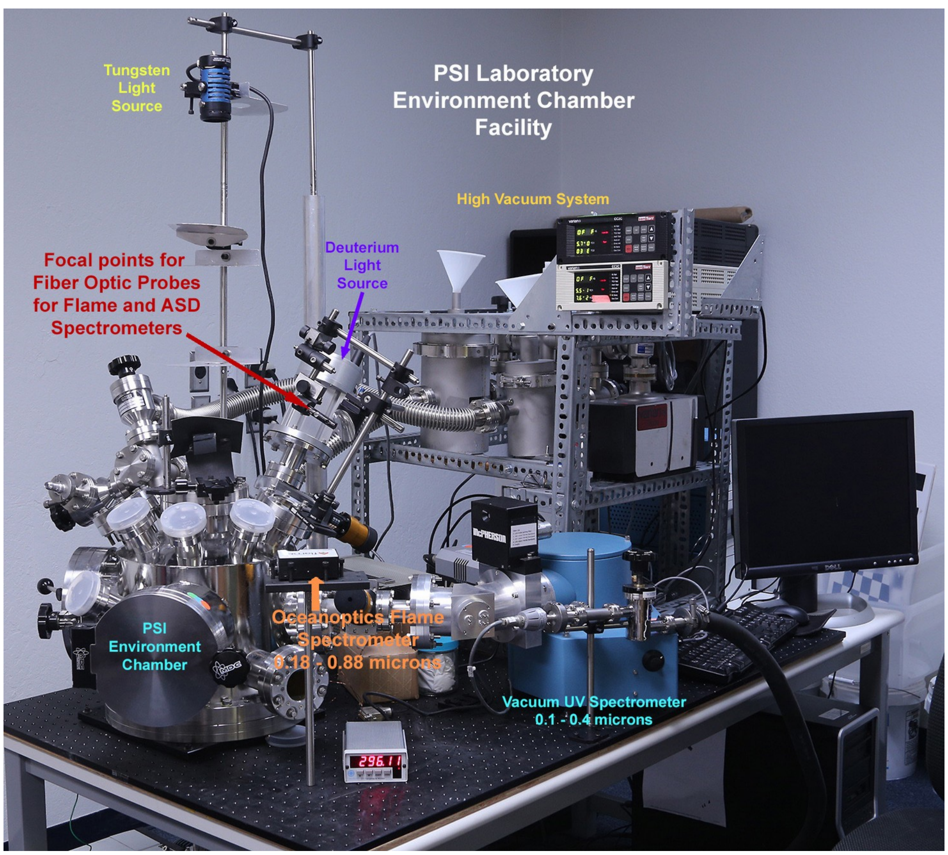

Figure 1: The Planetary Science Institute main environment chamber with primary external equipment labeled.