Effects of Atmospheric Processing on Minerals Relevant to Small Bodies. C. Jaramillo-Correa[1*], J. P. Allain[1], R. Clark[2], E. Cloutis[3], D. L. Domingue[2], A. Hendrix[2], N. Pearson[2], D. W. Savin[4], F. Vilas[2]. [1]Ken and Mary Alice Lindquist Department of Nuclear Engineering, Pennsylvania State University, University Park, PA, U.S.A. (*camilo@psu.edu), [2]Planetary Science Institute, Tucson, AZ, U.S.A., [3]University of Winnipeg, Department of Geography, Winnipeg, MB, Canada, [4]Columbia Astrophysics Laboratory, Columbia University, New York, NY, U.S.A.

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 develop tools and research methods for the exploration of airless bodies, specifically the Moon, the Martian moons, and near-Earth asteroids. TREX studies are organized into four Themes: (1) laboratory studies, (2) lunar studies, (3) small bodies studies, and (4) field work. The work presented here is part of Theme 3: investigations of fine-grained materials on the surface of small bodies.

Background: Reflectance spectroscopy is a powerful technique for the compositional analysis of planetary bodies in our Solar System. Characteristics such as mineralogy and chemical and physical state of the surface of airless bodies can be obtained from their reflectance spectra [1]. In a laboratory setting, this technique has been used to study terrestrial minerals, serving as extra-terrestrial analogs; helping establish a reference set of data to interpret remote observations.

Existing in Earth's atmosphere, terrestrial analogs have been exposed to reactive species that are not present on airless bodies. Exposure to the Earth environments may lead to changes in the spectral properties of the minerals (due to hydration, oxidation, etc.). Thus, minerals observed in airless bodies exhibit different characteristics than their terrestrial counterparts.

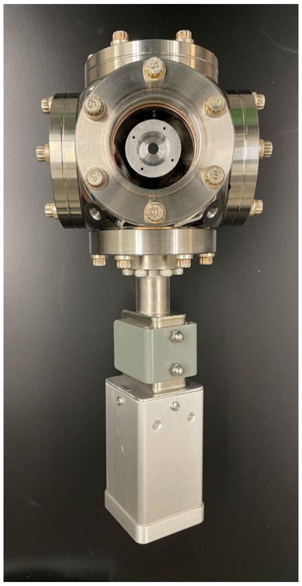

Figure 1: Portable sample capsule used to transport samples between the glovebox and the characterization setups, under a protected environment

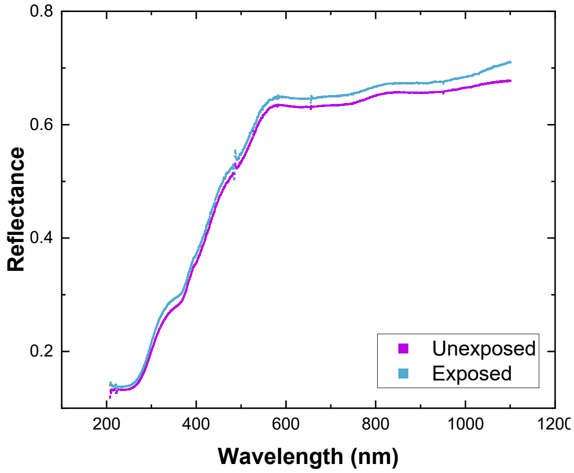

Figure 2: Reflectance spectroscopy of serpentine powder (grain size <25 μm) prepared in a glovebox under an inert environment, unexposed to air (purple) and prepared in air (blue).

Experiment: Here, we show how exposing minerals to air can produce changes in their reflectance spectra. To do this, we developed a protocol to generate minerals that have never been exposed to air starting from terrestrial minerals [2]. Briefly, we break down grains into loose powders inside a glovebox with an inert environment to generate grains with fresh faces that have never been in contact with air. Then we load the powders into a portable sample capsule that can keep the samples protected from air. The capsule, shown in figure 1, can be transported to our reflectance spectroscopy setup, where spectra from the minerals can be collected. The handling, transport and characterization of the unexposed minerals was always performed under a controlled environment using sealed sample capsules to avoid contamination of the sample.

For this work, we collected UV-Vis-NIR reflectance spectra (210–1100 nm) of the unexposed minerals, as well as spectra from their air-exposed counterparts. The spectra were collected under a 30°-0°-30° incidence-emission-phase-angle geometry. We observed differences in the spectra of 9 different minerals,

Table 1: List of minerals characterized in this work with a few examples of ateroids/meteorite class they are common to

Mineral	Asteroid class	Meteorite class
Olivine	S-type	Ordinary, CC, CO, CV, CK, R Chondrites
Dolomite	C-type	CM & CI Chondrites
Serpentine (1)	C-type	CM2 Chondrites
Serpentine (2)	C-type	CM2 Chondrites
Hematite		CK Chondrites
Pyrrhotite (1)	S-type	CI Chondrites
Pyrrhotite (2)	S-type	CI Chondrites
Ilmenite	S-type	L Chondrite

summarized in table 1. An example of one of the studied minerals, serpentine, is show in Figure 2.

We also performed X-Ray Photoelectron Spectroscopy (XPS) and X-Ray Diffraction (XRD) studies on the unexposed and exposed minerals, to identify any differences in the sample chemistry, that can be associated with the changes observed in the reflectance spectra of the minerals.

For the XRD measurements, the powders were placed on a silicon disc inside the glovebox. The silicon holder was then sealed with a polymer cap, and transported to the XRD instrument (Bruker D8) to obtain the diffraction patterns. For the XPS, the powders were loaded and sealed inside the portable sample capsule, which was then integrated into the IGNIS facility (briefly described in [3]. There, the powders were transferred to the IGNIS chamber under vacuum to collect the XPS spectra.

Acknowledgments: This work is funded by the National Aeronautics and Space Administration through the Solar System Exploration Research Virtual Institute 2016 (SSERVI16) Cooperative Agreement TREX (NNH16ZDA001N).

This work has been performed at the Materials Research Laboratory at the University of Illinois at Urbana-Champaign. Special thanks to Prof. Mohan Sankaran and Prof. Qing Cao for providing the laboratory facilities to perform this work.

References: [1] Cloutis, E.A., et al. (2018) *Primitive Meteorites and Asteroids: Physical, Chemical, and Spectroscopic Observations Paving the Way to Exploration*, Elsevier, 273–343. [2] Jaramillo-Correa, C. et al. (2022) *AGU Fall meeting*, P36B-04 [3] Lang, E. et al. (2017) *Nucl. Mater. Energy*, vol. 12, 1352–1357.