CORRELATED RAMAN AND REFLECTANCE SPECTROSCOPY FOR *in situ* LUNAR RESOURCE EXPLORATION. D. M. Bower[1,4], T. Hewagama[1,4], N. Gorius[2,4], F. Jin[3], S. Trivedi[3], S. Li[4], S. Aslam[4], P. Misra[5], T. A. Livengood[1,4] and J. R. Kolasinski[4], [1]University of Maryland College Park, College Park, MD 20742, dina.m.bower@nasa.gov, [2]Catholic University of America, Washington, DC 20064, [3]Brimrose Corporation, Hunt Valley, MD, 21152, [4]NASA Goddard Space Flight Center, Greenbelt, MD, 20771, [5]Howard University, Washington, DC, 20059.

Introduction: A composite instrument combining Raman spectroscopy and reflectance spectroscopy will enable rapid, nondestructive, passive characterization of lunar surface materials to identify trace compounds without sample preparation. The **R**apid **O**ptical **C**haracterization **S**uite for in situ **T**arget **A**nalysis of Lunar **R**ocks (**ROCSTAR**) is designed to search for minerals and volatiles in lunar materials using a combined package of time-resolved visible (VIS) 532 nm and near-infrared (NIR) 785 nm Raman, supported by near-Infrared/mid-Infrared (NIR-MIR) reflectance spectroscopy. ROCSTAR implements mature vibrational spectroscopy techniques to probe for chemical species of significance in lunar prospecting. As asserted in recent reports on lunar surface exploration, resource identification is critical to develop a viable long-term lunar exploration program enabling a continued human presence [1]. ROCSTAR capabilities will enable rapid quantitative measurements on lunar surface materials while reducing the need for mechanical or thermal processing to evaluate water and metal contents. Water is a priority resource essential to life support, facility operations, and synthesizing fuels. Mineral-bound metals are also important resource targets in regolith and mare basalts [2]. Lunar minerals ilmenite and pyroxene are known hosts of metals like Cr, Ni, Co, and Mn, and ilmenite in particular has been considered for Fe and O_2 extraction [3][4].

Raman spectroscopy provides structural information to identify volatiles and minerals in a matter of seconds. It has been used for decades to measure the composition of returned lunar samples and analog materials ([5][6][7] [8] and references therein). Reflectance spectroscopy has a strong lunar mission heritage to build on, having been used for decades to evaluate the mineralogy of the lunar surface via remote measurements from orbital platforms like Galileo, Clementine, Lunar Prospector, and the Moon Mineralogy Mapper (M^3) on Chandrayaan 1, as well as multiple Earth-based telescope measurements [9][10][11]. The two complementary techniques, used together, ensure near-comprehensive identification and accurate characterization of lunar materials suitable for resource extraction.

Science and Technology Goals: Our main goal is to provide the means for *in situ* standalone identification of priority resource materials on the lunar surface with minimal power needs in a compact package, mass ~3 kg, ~(36 x 22 x 17) cm^3 in volume. The architecture of ROCSTAR ensures adaptability to any surface mission platform, whether that be inside a lander/rover or extended on a robotic arm, or as a handheld device carried by astronauts. This is enabled by the careful choice and integration of spectrometer and optics technologies that have been proven in previous flight scenarios. Figure 1 shows one possible option in which the instrument is employed by an astronaut for close-up measurements of lunar regolith.

ROCSTAR can determine the composition, variety, and distribution of minerals, metals, and water with correlated spectroscopic measurements (Fig. 1). These measurements have been achieved in the lab by pointing ROCSTAR's probe at a target at a distance of a few mm with sequential activation of high resolution NIR-MIR reflectance context imaging and acquisitions, followed by NIR-VIS Raman acquisitions, each for ~0.5 – 40 s integration time (depending on the target material). Our next step is to test ROCSTAR in the field to fine-tune our current measurement parameters and to test the capabilities of the instrument.

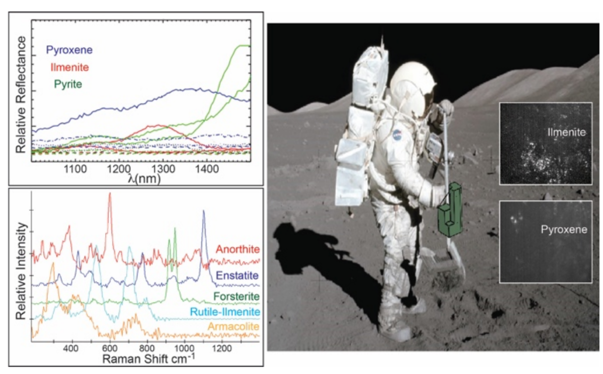

Figure 1 Preliminary Reflectance and Raman spectra (left) and context reflectance imaging (right) of representative analog lunar minerals supporting the design of the ROCSTAR handheld system that can be used by an astronaut to characterize the lunar surface and identify materials targeted for resource prospecting.

Acknowledgments: We acknowledge Goddard Space Flight Center internal R&D funds that enabled past and current work.

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