DETERMINIG THE MINERALOGY OF LUNAR SAMPLES USING MICRO RAMAN SPECTROSCOPY: COMPARISONS BETWEEN POLISHED AND UNPOLISHED SAMPLES.

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Introduction: Raman spectroscopy is a powerful and versatile non-destructive analytical technique that provides compositional and contextual information on mineral phases for a wide variety of geologic samples including lunar rocks [1,2]. Raman istruments have been developed for upcoming planetary missions, and similar instrumentation could be beneficial for the characterization of lunar materials on future lander or for sample return missions [3]. Portable Raman spectrometers can measure mineralogy in situ in a variety of environments, but topographic inconcistencies in natural, unpolished samples still remain problematic. This can make the absolute identification of specific mineral phases difficult. Lunar rocks are composed of a limited suite of minerals, and being able to detect the subtle differences between mineral phases is essential in understaning their origins.

Samples: We have analyzed a suite of Apollo 16 samples from the double drive tube 68001/68002 using micro Raman spectroscopy. Raman spectra were collected from individual polished and unpolished grains using a WITec α-Scanning Near-Field optical microscope that has been customized to incorporate confocal Raman imaging with a 532 nm frequency-doubled solid state laser operating between 0.3 – 1mW power.
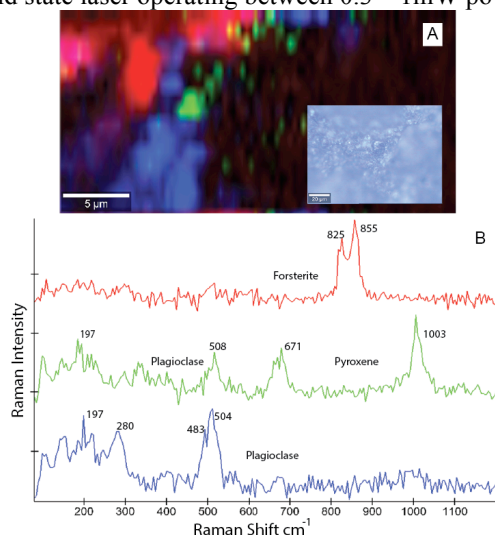

Fig. 1 Raman spectral map and inset image of unpolished grain 68002 1079 (A) and corresponding spectra (B) from unpolished sample grain showing forsterite (red), pyroxene + plagioclase (green), and plagioclase (blue).

Preliminary Results: Comparisons of the scans show we can identify three main phases regardless of polishing: plagioclase (peaks at 197, 283, 483, and 504 cm^{-1}), pyroxene (peaks at 671 and 1003 cm^{-1}), and olivine (forsterite - peaks at 825 and 855 cm^{-1}) (Fig.1). In the polished grains we were able to determine the specific mineral orthopyroxene (peaks at 330, 394, 667, and 1002 cm^{-1}) (Fig.2).

Ongoing Work: As resolution improves, we will be able to extract Fo-Fa compositions and determine specific plagioclase compositions and pyroxene structural types based on subtle shifts in frequencies and the expression of peak doublets. These spectral parameters can be indicators of petrogenic processes and provenance [1, 4, 5]. We are currently adapting a new device to our Raman system that allows us to map the topography of rough surfaces (True Surface ™) and apply the topographic information to the focusing mechanism of the microscope. The system can then adjust the focus the laser on the sample as the topography changes so there is less scatter and a better signal. The goal ultimately is to correlate the compositions and ages of lunar rocks to understand the impact history of the Earth-Moon system.
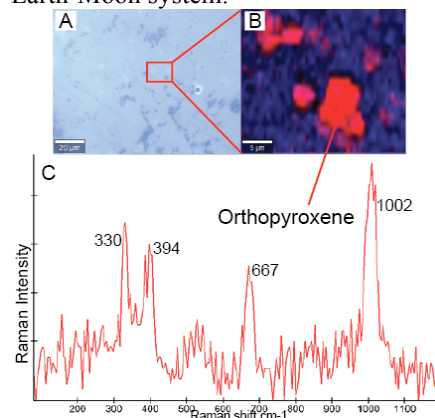

Fig. 2 Example of polished grain with scan area outlined in red box (A), Raman spectral map showing plagioclase (blue) and orthopyroxene (red) (B), and corresponding orthopyroxene spectra including two peaks (330 and 394 cm^{-1}) that were not resolved with the unpolished sample shown in Fig 1.

[1] Wang A. et al (2001) *American Mineralogist, 86,* 790–806. [2] Bower et al. (2015) *Journal of Sedimentary Research, 85,* 1213-1227. [3] Hutchinson I.B. et al. (2014) *Phil. Trans. Of the Royal Society A., 372,* 20140196. [4] Kuebler et al. (2006) *Geochimica et Cosmochimica Acta, 70,* 6201–6222. [5] Freeman et al. (2008) *The Canadian Mineralogist, 46,* 1477-1500.