HYDROUS GLASSES OF LUNAR SAMPLE 75055: A MICRO-RAMAN SPECTROSCOPY INVESTIGATION.

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Introduction: The lunar surface, once thought to be bone dry [1] is turning up with new evidence showing a more hydrous content of the early lunar crust [2-4]. A Micro-Raman spectroscopic analysis of Apollo sample 75055 can display additional signatures of OH^- and H_2O within the melt inclusions present within ilmenite and apatite grains.

Samples and Methodology: Apollo sample 75055 [5] (ilmenite basalt) was chosen due to abundant melt inclusions in large apatite and ilmenite, late-stage glass and trapped glasses. Apollo thin-section 75055,50 and thick-section 75055,123b were selected due to previous studies, which showed volatile spikes in these samples. The melt inclusions present within ilmenite grains in these sections, as well as glasses in the skeletal matrix surrounding the grains were targeted.

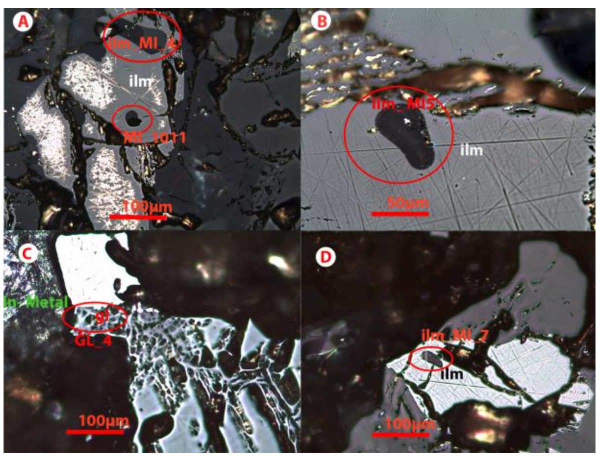

Figure 1: Reflected light images of 775055,123b ilmenite melt inclusion. Circled regions were analyzed in Raman. gl = glasses and melts,ilm = ilmenite, pyx = pyroxene, In-Metal = Indium mount

75055,50 is an epoxy-mounted thin-section prepared by Johnson Space Center in the 1970's. **75055,123b** was mounted in the Lunar Laboratory at Wesleyan University, wherein a lunar sample chip was mounted in a molten indium (~150˚C), and then cooled under vacuum. The sample was then cut with a low-speed diamond saw in a pure ethanol and dry ice slurry. Polishing and grinding of the sample was done with 100% ethanol, except for the final polishing step, which utilized 98% ethanol (following the JSC protocol). A preliminary observation under reflected light was used in order to determine locations of glasses and melt inclusions, which were verified via SEM analyses and to determine the locations and composition of microcrystalline grains within these inclusions. Raman spectroscopy was taken using a Wi-TEC alpha300R confocal Raman microscope system equipped with a 50 mW frequency doubled 532 nm Nd:YAG excitation laser at the Stony Brook University Vibrational Spectroscopy Laboratory. Point spectra were collected using a 100x objective, which allowed spatial resolution on a submicron scale, to detect the presence of broad peaks around 3300 cm^{-1} to determine the presence of OH^- and H_2O [6-9].

Results and Discussion: In our preliminary analyses of these samples, we found 7 melt inclusions and 4 glasses in 75055,123b, yielding observations of peaks in the OH/H_2O range in 2 melt inclusion as well as 1 glass. We also observed two hydrous melt inclusions within 75055,50.

75055,123b**:** Of the glass observed in 75055,123b, two melt inclusions and one glass displayed a feature at ~ 3300 cm^{-1}. In melt inclusion 1011 (Figure 3A), we obtained 2 analyses at 1800s and 60s to verify that the peak was still present after extended laser heating. Within the same ilmenite grain, melt inclusion ilm_MI4 (Figure 1A) did not exhibit this feature in the Raman analysis. We

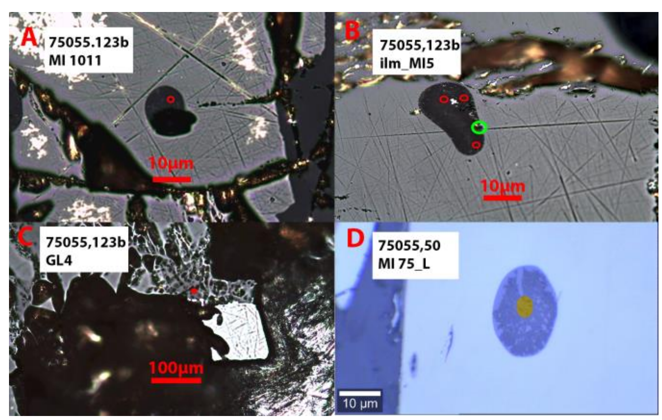

Figure 2. Raman Analysis locations in 75055,123b (A-C) and 75055,50 (D)

also observed a faint $OH^-\backslash H_2O$ peak in GL_4 (Figure 3C). Ilmenite melt inclusion ilm_MI_5 (Figure 3B) analyses had a Raman peak which closely resembled those as evidenced in the analyses of the others melts 1011 and GL_4.

75055,50: In 75055,50 we observed four additional ilmenite melt inclusions, two of which displayed a similar character to those in 75055,123b within the OH/H_2O range (Figure 3D).

Discussion: 75055,50 and 75055,123b exhibited melt inclusions with Raman peaks in the H_2O/OH^- range. Given the long history of thin section 75055,50, which has a history away from JSC since the mid-1970s, and more recent thick section 75055,123b [2], each provides a similar feature in the OH/H_2O range in Raman, it could suggest the features present are from the same source. However, it is still necessary to determine whether these features can be attributed to terrestrial contamination.

Summary and Future Work: Utilizing Raman spectroscopy we are able to detect the presence of volatiles such as H_2O and OH^- as a wide peak around 3300 cm^{-1} [6-9] before conducting a more detailed analysis utilizing secondary ion mass spectroscopy[2] (SIMS) to quantify the content. This will allow us to further understand the nature of these water-rich glasses, and will provide valuable information to the composition of the early lunar crust and mantle.

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References: [1] Elkins-Tanton, L. (2008), EPSL, 271, 181-191, [2] Greenwood, J. P. et al. (2011) Nature Geosci., 4, 79-82, [3] Barnes et al. (2015) LPSC XLVI, abstract # 1352 . [4] Robert, F. (2011) Nature Geosci. , 4, 2, 74-75. [5] Meyer, C. (2008) Lunar Sample Compendium. [6] deChou (1980), Clays Clay Min, 28, 2,111-118. [7] Dubessy, J. (1992) EJM , 4, 5, 885-894. [8]Thomas. S. et al. (2008), Amer. Min., 93, 1550-1557 [9] Le Losq, C et al. (2012), Amer. Min., 97, 779-790.

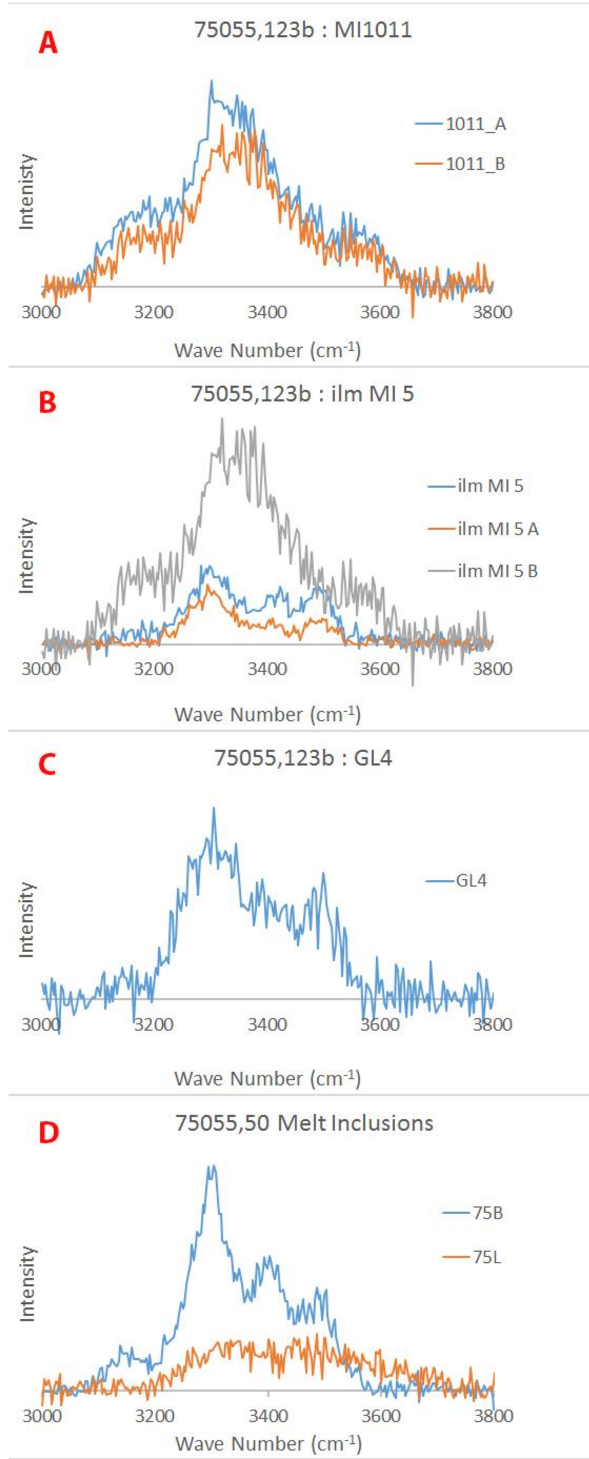

Figure 3: Raman spectra of 75055,123b (A-C) and 75055,50 (D) exhibiting OH/H_2O peaks