

DISSOLVED CARBON CONTENT OF THE LUNAR VOLCANIC GLASS BEADS AND MELT INCLUSIONS: CARBON FROM THE LUNAR INTERIOR. D. T. Wetzel¹, E. H. Hauri², A. E. Saal¹, and M. J. Rutherford¹, ¹Dept. of Geological Sciences, Brown University, Providence RI 02912 (Diane_Wetzel@brown.edu), ²DTM Carnegie Institute of Washington, DC 20015 (ehauri@ciw.edu).

Introduction: The lunar volcanic glass beads are thought to have formed during fire-fountain eruptions. Since the Moon was previously thought to be dry, carbon was proposed to be the main volatile element dissolved. The oxidation of graphite can produce the CO-rich gas phase needed to drive these fire-fountain eruptions that produced the glass beads [1]. Recently, indigenous water was measured in both the lunar volcanic glass beads and olivine-hosted melt inclusions along with S, F, and Cl, providing evidence for the involvement of other volatiles contributing to lunar fire fountain eruptions [2-4]. Although carbon concentrations are well below the detection limits of FTIR and Raman spectroscopy, recent advances in analytical techniques have lowered the detection limits for carbon using the SIMS and NanoSIMS. Carbon can now be measured down to 0.14 ppm C [2]. We present the NanoSIMS data for the carbon concentrations dissolved in the picritic glass beads and melt inclusions and interpret the data in terms of volcanic degassing processes in ascending lunar magmas.

Samples and Analytical Techniques: We examined the Apollo 15 very-low Ti and low Ti glasses (15426/27) and the Apollo 17 high Ti glasses (74220) as well as the olivine-hosted melt inclusions and the host glass beads from the Apollo 17 samples. The major element and partial volatile (H, F, S, and Cl) contents for all samples have been reported previously [2-4]. The carbon and hydrogen data presented were measured using a Cameca NanoSIMS 50L multicollector ion microprobe at DTM, CIW, using the methods recently developed by Hauri et al. [5]. The major element compositions were obtained using a Cameca SX-100 electron microprobe at the American Museum of Natural History for the lunar glass beads and a JEOL Superprobe at the Geophysical Lab, CIW for the melt inclusions and host glass beads.

Results: We determined the C concentrations dissolved in 85 very-low Ti (green), 15 low Ti (yellow), and 83 high Ti (orange) glass beads. The green glasses contained up to 1.6 ppm C while the yellow and orange glasses only contained up to 0.23 ppm C and 0.67 ppm C, respectively. We also measured carbon dissolved in the melt inclusions from Hauri et al. [3], which contained between 0.47 and 5.65 ppm C. The host matrix orange glasses also contained up to 2.77 ppm C dissolved. The melt inclusions have up to one hundred times higher water concentrations than the host orange

glass beads but only 2-3 times higher carbon contents than the host glasses, indicating that most of the carbon degassed and relatively lower fractions of water contributed to the gas phase during the time of melt inclusion entrapment. Among the glass bead data, the yellow glasses have variable H₂O contents but a fairly uniform C content. The orange glasses display a relatively constant H₂O for a range in C. The green glasses have a trend similar to the yellow glasses, but also have more variability and some overlap with the orange glasses. As observed with the other volatile elements measured in the lunar glass beads and melt inclusions [2,3], the measured C correlates with other volatiles and major elements, indicating these volatiles are indigenous.

In general, more H₂O is dissolved in these glasses than C, which is consistent with current C-O-H solubility and degassing models [e.g., 6,7] that show ascending basaltic magmas produce a CO-rich gas phase during the early degassing stage. This observation is especially apparent for the melt inclusion data. We interpret the melt inclusions to have been entrapped by olivine during ascent-induced degassing. In contrast, the variations in the different bead groups are likely to represent kinetic-controlled degassing from beads after near-surface fragmentation.

Conclusions: We report the indigenous dissolved carbon measured in the lunar picritic glass beads and melt inclusions, which confirms carbon was present in the source regions of the lunar picritic glasses. During the ascent of the lunar magmas, the dissolved carbon would have eventually exsolved to form an initially CO-rich gas phase that propelled the picritic magmas to the lunar surface. This result is an important constraint to consider for lunar formation and evolution models.

References: [1] Sato M. (1976) *PLSC 7th*, p.1323-25. [2] Saal A.E. et al. (2008) *Nature*, 454, p.192-195. [3] Hauri E.H. et al. (2011) *Science*, 333, p.213-215. [4] Saal A.E. et al. (2013) *Science*, 340, p.1317-1320. [5] Hauri E.H. et al. (2006) *EPSL*, 248, p.715. [6] Dixon J.E. and Stolper E. (1995) *J. Petrol*, 36, p.1633-1646. [7] Wetzel D.T. et al. (2013) *PNAS*, 110, 8010-8013.