2D AND 3D IDENTIFICATION AND CHARACTERIZATION OF MELT INCLUSIONS IN BASALTIC LUNAR METEORITES

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Introduction: The detection of water ice on the Moon's surface and water in lunar samples revolutionized views of the abundance, distribution, and potential sources of H_2O and other lunar volatiles [1–3]. Volatiles affect the rheological properties of minerals and melts (e.g., density and viscosity) and influence magma eruption processes (magma ascent, effervescence, expansion, and fragmentation) [4]. They thus represent an important facet of the Moon's magmatic history, but magmatic, volcanic, and secondary processes work to alter the original volatile inventory of the primary melt to the one recorded in the rocks we study. Under the right conditions, silicate melt may become trapped in early-formed minerals as melt inclusions (MI), preventing or minimizing the degassing of these volatiles. As a result, melt inclusions (MI) present the opportunity to learn more about the volatile inventory of the lunar magmas pre-eruption [5–6]. Volatiles in melt inclusions have been studied in some Apollo samples [e.g., 7–9], but they have yet to be interrogated in lunar meteorites.

Sample: We investigate one unbrecciated lunar basaltic meteorite, Northwest Africa (NWA) 479, recovered in Morocco in 2000 [10]. The NWA 479 meteorite contains phenocrysts of olivine, pyroxene, and chromite suspended in a fine-grained groundmass of pyroxene and anorthitic plagioclase crystals [11]. The texture and bulk composition of NWA 479 indicate that it is paired with NWA 032, found one year prior [10–13].

Methods: We use a combination of 2D and 3D methods to determine modal mineralogy, mineral composition, and textures, and to locate and characterize melt inclusions in NWA 479. X-ray computed tomography (XCT) scans of a chip of NWA 479 were performed at the University of Texas at the High-Resolution X-ray CT Facility. The 3D modal mineralogy of the major mineral phases present within the samples was determined using the XCT data. Visualizations and modal abundance calculations were performed in Dragonfly™ software. After scanning, NWA 479 was cut. A subsplit of NWA 479 was dry polished by hand using isopropanol alcohol (IPA) and diamond powder. After cleaning in IPA the sample was pressed into an Al-disk filled with indium. Backscattered-electron (BSE) maps were acquired of the whole sample using the University of Arizona's Hitachi TM4000Plus Scanning Electron Microscope (SEM). Energy-dispersive X-ray Spectroscopy (EDS) spot analyses and BSE imaging were used to characterize the chemistry and texture of the melt inclusions, respectively.

Results and Ongoing Work: Based on the XCT data, the 3D modal mineralogy of NWA 479 is as follows: 58.8 vol.% pyroxene, 23.6 vol.% plagioclase, 17.4 vol.% olivine, and 0.2 vol.% high-z phases (e.g., ilmenite, troilite). So far, we have identified 10 melt inclusions in the polished section. They range from 12.4–190 µm in length. Analysis of these melt inclusions show that most contain microlites and are partially crystalline.

We plan to continue our work by determining the mineral chemistry of melt inclusion hosts and the chemistry of the melt inclusions themselves using the Cameca SX100 electron microprobe at the University of Arizona. At the meeting, we will present the full 2D and 3D characterization of the melt inclusions. This characterization work forms the basis upon which future isotopic measurements of volatiles will be conducted.

References: [1] Clark R.N. (2009) Science 326:562–564. [2] Pieters C.M. et al. (2009) Science 326:568–572. [3] Sunshine J.M. et al. (2009) Science 326:565–568. [4] Lowenstern J.B. (2003) Developments in Volcanology 5:1–21. [5] Roedder, E. and Weiblen, P.W. (1970) Geochimica et Cosmochimica Acta 1:801. [6] Roedder, E. and Weiblen, P.W. (1971) Geochimica et Cosmochimica Acta 1:207. [7] Hauri E.H. et al. (2011) Science 333:213–215. [8] Ni, P. et al. (2019) Geochimica et Cosmochimica Acta 249:17–41. [9] Stephant, A. (2020) Geochimica et Cosmochimica Acta 284:196–221. [10] Barrat J.A. et al. (2001) LPS XXXII, Abstract #1317. [11] Grossman J.N. (2000) Meteoritics & Planetary Science 35:A199–A225. [12] Barrat J.A. et al. (2005) Geochimica et Cosmochimica Acta 69:5597–5609. [13] Fagan T.J. et al. (2002) Meteoritics & Planetary Science 37:371–394.

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