THE VOLATILE CONTENT OF ANCIENT LUNAR BASALTS AS INFERRED FROM TRACE ABUNDANCES IN SILICATE PHASES.

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Introduction: The study of indigenous lunar volatiles has undergone a renaissance over the last decade, following the discovery of water in lunar pyroclastic glasses, melt inclusions, and apatite [1-3]. Pyroclastic glasses and melt inclusions are particularly valuable, because they can be used to calculate the volatile content of their parental melts [1,2], but samples are few, tap only a few lunar interior locations, and may not reveal the scope of heterogeneities. While apatite is a common accessory phase, it is not found in every lunar sample and the complexities of F, Cl, and OH partitioning make it unreliable for determining melt volatile compositions [4]. To help overcome those shortcomings, we developed a new technique using secondary ion mass spectrometry (SIMS) to measure volatile abundances in common nominally anhydrous minerals (NAMs) such as plagioclase, pyroxene, and olivine. This will allow the evaluation of volatile behavior in lunar samples previously unmeasurable and produce a more comprehensive view of lunar interior volatiles.

Sample and Methods: Lunar meteorite Miller Range (MIL) 13317 is a breccia containing numerous low-KREEP, low-Ti basaltic fragments [5-7]. Recent work showed MIL 13317's basalts formed at 4.332 Ga [6,7], making them some of the oldest samples from the Moon and, therefore, ideal for assessing volatiles associated with the Moon's earliest volcanic processes.

Two thin sections of MIL 13317 (,5 and ,23 were analyzed with the University of Hawai'i Cameca ims 1280 SIMS. The primary Cs^+ beam at ~5 nA was defocused to ~20 μm. Data collection was restricted with a field aperture to the inner ~4 μm of the spot. We measured ^{12}C, $^{16}O^1H$, ^{19}F, ^{31}P, ^{32}S, and ^{35}Cl using an electron multiplier. Mass resolving power was sufficient to resolve all species from interfering ions. We captured ^{16}OH images in prior to data collection. Abundances were calculated with (species)/^{30}Si versus wt.% (species) calibration curves constructed for each ion of interest using terrestrial glass and pyroxene standards with known CO_2, H_2O, F, P, S, and/or Cl content. The OH detection limit was ~5 ppm, based on the measurements of Suprasil 3002 quartz (<1 ppm H_2O).

Preliminary Results: Like many lunar meteorites, MIL 13317 is shock metamorphosed. Undulose extinction and mosaicism are common in plagioclase, and the mafic minerals are so cracked as to be unusable for volatile analysis. We focused our analyses on the structurally modified, but uncracked plagioclase. Initial analyses show OH is heterogeneously distributed in the plagioclase (Fig. 1), ranging from ~0 ppm to ~55 ppm. This is quite high compared with previous measurements of lunar plagioclase [8,9]. We do not think that these high values are analytical artifacts, as cracks would have been readily apparent in the OH image during analysis and ^{12}C counts (from epoxy) remain low. We are still evaluating potential causes of the high variability of H_2O in plagioclase from ancient MIL 13317, but suspect it may be related to shock. Plagioclase with such high H_2O content in these ancient basalts would indicate a very high H_2O source very early in the Moon's history, which would need to be taken into account by future modeling of lunar differentiation.
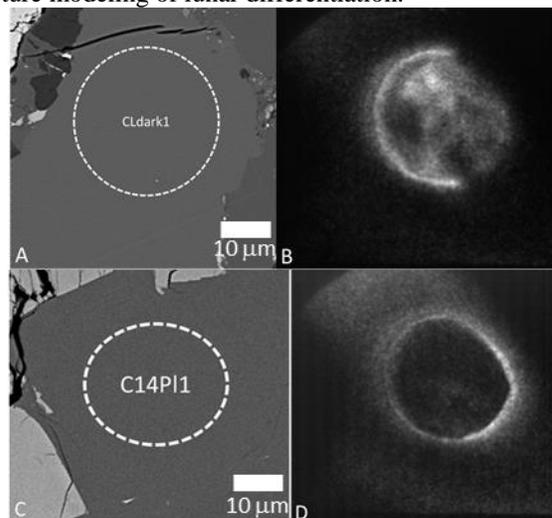

Fig. 1. Corresponding BSE (A & C) and ^{16}OH ion (B & D) images of SIMS analyses in MIL13317. Image (B) has high OH, while (D) has ^{16}OH~0.

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