A High Resolution Microprobe Study of EETA79001 Lithology C

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Background
Antarctic meteorite EETA79001 has received substantial attention for possibly containing a component of Martian soil in its impact glass (Lithology C) [2]. The composition of Martian soil can illuminate near-surface processes such as impact gardening [2] and hydrothermal and volcanic activity [3,4]. Impact melts in meteorites represent our most direct samples of Martian rock.

We present the initial findings from a high-resolution electron microprobe study of Lithology C from Martian meteorite EETA79001. As this study develops, we aim to extract details of a potential soil composition and to examine Martian surface processes using elemental ratios and correlations.

Sample description
This thin section EETA79001L08 contains pools of non-crystalline impact melt glass up to several hundred microns across and mixed domains of dentritic clasts, mostly olivine, with interstitial glass. These clasts are interpreted to have formed by incipient crystallization of the impact melt. This section also contains sub-rounded olivine and sparse S- and P-bearing grains that may represent partially fused relict grains.

Analysis and approach
We conducted semi-quantitative EDS and quantitative WDS elemental mapping on the Cameca SX-100 electron microprobe at the CAMCOR facility in Eugene, Oregon. EDS datasets were generated for two areas of 1024 by 768 pixels at ~0.3-μm/pixel. WDS elemental datasets were generated with a focused beam (~1-μm) operating at 12 keV and 50 nA. EDS data were processed using Thermo NSS software and WDS data were processed using the Probe for EPMA software package.

We are working to assess pre-impact compositions in the melt. Possible sources are: Lithology A (the host basalt), excess plagioclase from bedrock, and the Martian soil [1]. Martian soil contains excess Ni from olivine weathering [3,4] and salts and sulfate-species from hydrothermal fluids, volcanic aerosols, or evaporitic processes [3,4,7].

For example, if excess sulfur is contributed by melted soil, Si might be expected to correlate positively with other elements rich in soil but poor in Lithology A, such as Ca and Ni. Conversely, if S is correlated with elements like Fe, this may point to a host-rock source for the S, such as Lithology A sulfide.

WDS results

Figure 1 shows element maps and a backscatter electron (BSE) image for one area of the thin section. Magnesium and Fe are concentrated in areas of crystallization. Chlorine is relatively low throughout except for one area that corresponds to high K values. Most of the highest K occurring Fe/Mg separate for impact melts in meteorites represent our most direct samples of Martian rock.

Figure 1. BSE image and WDS-derived element maps for section EETA79001A, area 2. Coordinates are in microns. Note that the scale for S is 1/9 of the other maps.

Figure 2. EDS element maps for area S, based on 30-μm pixels. Color bars for the map have high Fe, while other grains do not.

Figure 3. grayscale image of the entire section and the center of the pure melt designated by the red square.

Figure 4. Map of the impact melt (left) and the surrounding Martian soil (right). The black line shows the boundary between the two areas.

Preliminary conclusions

These PCA results cannot be uniquely interpreted, but they support the presence of excess plagioclase and a mobile (soluble) addition to the pre-impact material.

In both experiments, the first components have positive eigenvectors for Al and Ca and negative eigenvectors for Fe and Mg. This suggests that the majority of the variance is controlled by an exchange of plagioclase composition for a mafic composition. Because Lithology A is in the pure melt and in the partially crystallized soil, this component may represent excess plagioclase in the pre-impact material, supporting Rao et al. [1].

In both experiments, the second components have negative eigenvectors for Si and positive for Ca, P, S, and Cl. This component corresponds to the zonation in the melt visible in Figure 2. The PCA suggests there is an accompanying S and possibly Cl enrichment not apparent by visible inspection.

Component IV in experiment 1 and Component III in experiment 2 have strong positive eigenvectors for K and Ca and variable negative eigenvectors for Ti and Ni. The association of K with Cl is apparent from WDS maps (Figure 1) but not from EDS maps (Figure 2). Ni, K, and Cl are all enriched in Martian soil [3-7], but while K and Cl are soluble and mobile, Ni is residual from weathered olivine.

This suggests a separate input into the pre-impact material for mobile elements than for elements from in situ weathering. This indicates a likely soil component in the precursor to Lithology C as suggested by Rao et al. [1].