A High Resolution Microprobe Study of EETA79001 Lithology C

C.M. Schrader1, B.A. Cohen2, J.J. Donovan3, and E.P. Vicenzì4. NASA Postdoctoral Program-MSFC (Christian.M.Schrader@nasa.gov), NASA-MSFC, University of Oregon Department of Chemistry, Smithsonian Institution, Museum Conservation Institute

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

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 component and to examine Martian surface processes using elemental ratios and correlations.

Sample description
This thin section EETA79001,16 L contains pools of non-crystalline impact melt glass up to several hundred microns across and mixed domains of dendritic crystals, mostly olivine, with interstitial glass. These texture features are interpreted to have formed by in situ crystallization of the impact melt. This section also contains sub-rounded olivine and sparse S- and P-rich grains that may represent partially fused relict grains.

Analysis and approach
We conducted a 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 keV/0.1% EDS and WDS elemental datasets were generated with a focused beam (-1µm) 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 bedrock), excess plagioclase from the impact melt front, and the Martian soil. This Martian soil contains excess Ni from olivine weathering [3.4] and sulfide species from hydrothermal fluids, volcanic aerosols, or evaporitic processes [3.4,7].

For example, if excess sulfur is contributed by mixed soil, S might be expected to correlate positively with other elements such as Cr and Ni. Conversely, if it is correlated with elements like Fe, this may point to a host-rock source for the S, such as Lithology A sulfides.

WDS results
Figure 1 shows element maps and a backscatter electron (BSE) images 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 occurs in the lower left hand corner of the sample, while the highest Fe content is in the middle of the thin section. Impact melts from meteorites represent our most direct samples of Martian regolith.

Figure 2 contains EDS-derived element maps for a region dominated by olivine quench crystals in impact melt. There are larger olivine grains on which quench crystals are nucleating and several small grains of S- and P-bearing minerals.

Magnesium is concentrated in olivine. Calcium is concentrated around olivine crystals, where it is preferentially enriched by the removal of Mg. Fe, and Si from the melt. This maps distinctly shows the largest non-silicate grains – both of which have high relative concentrations of Fe (not shown), Si, and Ca, and moderately high concentrations of P. Phosphorus occurs in Fe-S-P-CI glass but is present in almost equal proportions as streaks in the impact melt. These high-phosphorus melt zones are also slightly elevated in Ca and depleted in Si. One zone runs along the crystallization front and the other is in the center of the melt pool. Sulfur occurs with Fe in grains circled in Figure 2. This includes both the above-mentioned grains and other apparent Fe-sulfides or Fe-S alloys. Additionally, S is concentrated in a number of smaller areas or regions of olivine without any other determined elements. These may be sulfides or sulfates with undetermined carbonation or S-rich portions of interstitial glasses. Sulfur occurs in detectable amounts at a low background level and in the Fe-S-P-CI glasses.

Data analysis
We exported EDS data for the area shown in Figure 2 into spreadsheet for statistical analysis in Excel and Statistix, including correlation and principal component analysis (PCA). Figure 3 contains a gray scale image of this region and of the subregion of pure melt for which data was extracted for a second experiment.

PCA results
We show components with eigenvalues > 1.0. The total variance explained by these components is 53% and 46%, respectively. See Figure 4 for experimental display of these components.

Preliminary conclusions
These PCA results cannot be uniquely interpreted, but they support the presence of excess plagioclase and a mobile (sulfate) addition to the pre-impact material. In both experiments, the first component 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 Fe is in the pure melt and the C1 component corresponds to the zonation in the melt visible in Figure 2. The PCA suggests that there is an accompanying Si 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 Fe and Ca and vice versa for Mg and Ni. The assignment of K with C1 is apparent from WDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2).

In both experiments, the second component has 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 that there is an accompanying Si 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 strongly negative eigenvectors for Ti and Ni. The assignment of K with C1 is apparent from WDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2). Rearrangement of K with C1 is proposed to be from EDS maps (Figure 2).

Figure 1. BSE image and WDS-derived element maps for section EETA79001A, area A. Coordinates are in microns, note that the scale for Si and Al is from the other image.

Figure 2. EDS element maps for area B. Cr is shown as blue whereas other elements are shown as red.

Figure 3. BSE element maps for area B. Cr is shown as blue whereas other elements are shown as red.