PETROGENESIS OF IGNEOUS-TEXTURED CLASTS IN MARTIAN METEORITE NORTHWEST AFRICA 7034. A. R. Santos[1], C. B. Agee[1], M. Humayun[2], F. M. McCubbin[3], C. K. Shearer[1], [1]Institute of Meteoritics, 1 University of New Mexico, MSC03-2050, Albuquerque, NM 87131, [2]National High Magnetic Field Laboratory, Tallahassee, FL 32310, [3]NASA Johnson Space Center, Mail Code XI2, 2101 NASA Parkway, Houston TX 77058, (asantos5@unm.edu).

Introduction: The martian meteorite Northwest Africa 7034 (and pairings) is a breccia that samples a variety of materials from the martian crust. Several previous studies have identified multiple types of igneous-textured clasts within the breccia [1-3], and these clasts have the potential to provide insight into the igneous evolution of Mars. One challenge presented by studying these small rock fragments is the lack of field context for this breccia (i.e., where on Mars it formed), so we do not know how many sources these small rock fragments are derived from or the exact formation history of these sources (i.e., are the sources mantle derived melt or melts contaminated by a meteorite impactor on Mars). Our goal in this study is to examine specific igneous-textured clast groups to determine if they are petrogenetically related (i.e., from the same igneous source) and determine more information about their formation history, then use them to derive new insights about the igneous history of Mars. We will focus on the basalt clasts, FTP clasts (named due to their high concentration of iron, titanium, and phosphorous), and mineral fragments described by [1] (Fig. 1). We will examine these materials for evidence of impactor contamination (as proposed for some materials by [2]) or mantle melt derivation. We will also test the petrogenetic models proposed in [1], which are igneous processes that could have occurred regardless of where the melt parental to the clasts was formed. These models include 1) derivation of the FTP clasts from a basalt clast melt through silicate liquid immiscibility (SLI), 2) derivation of the FTP clasts from a basalt clast melt through fractional crystallization, and 3) a lack of petrogenetic relationship between these clast groups. The relationship between the clast groups and the mineral fragments will also be explored.

Methods: Thirty-six clasts from 12 thin sections and probe mounts from the UNM Meteorite Museum collection were analyzed for this study. Clasts were first imaged using the electron microprobe and FEG SEM at the University of New Mexico to determine textures and mineral modes. Individual mineral grains within clasts were then analyzed for major and minor element composition using WDS with the electron microprobe. Mineral compositions were combined with mineral modes and calculated densities to determine bulk clast composition. A subset of clasts was measured for a suite of 70 elements using LA-ICP-MS at the National High Magnetic Field Laboratory (as in [2]). Average compositions for each clast group were determined using a weighted average based on clast area.

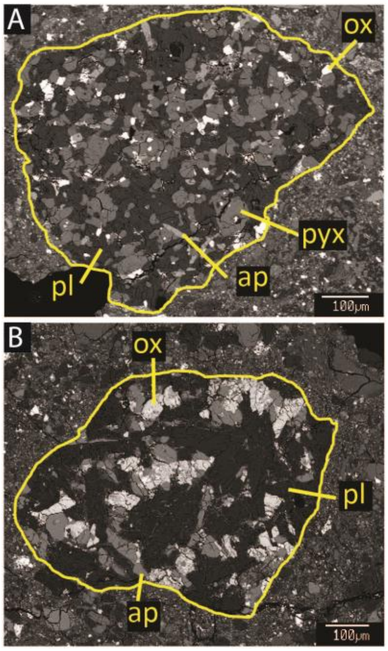

Figure 1: A: BSE image of a basalt clast. B: BSE image of an FTP clast. Pyx-pyroxene, pl-plagioclase, ox-Fe-Ti oxide, ap-apatite.

Impactor Contamination: Plots of Ge vs. SiO_2 and Ni vs. MgO (Fig. 2A) in the FTP and basalt clasts indicate they have higher than expected amounts of Ge and Ni relative to previously measured SNC meteorites. The basalt clasts appear to contain closer to chondritic ratios of other siderophile elements (e.g., Os/Ir, Pt/Ir), while the FTP clasts only seem to contain chondritic Os/Ir. Both clast types contain higher abundances of these HSEs than SNCs measured by [4-5]. These results suggest the NWA 7034 clasts were influenced by different sources or processes than the SNC meteorites during their formation.

Are the basalt and FTP clasts genetically related?: The models of igneous petrogenesis we are testing in this portion of the study (i.e., petrogenetic links through fractional crystallization or liquid immiscibility) would result in predictable geochemical characteristics for each clast type due to known elemental partitioning behavior. Our major, minor, and trace element analyses of the clasts allow us to investigate each scenario. As in [1], both of these scenarios assume the FTP clasts are derived from a melt that has the same composition as the weighted average of the basalt clasts.

First we will examine the model of silicate liquid immiscibility. Two immiscible silicate liquids in equilibrium with each other must also be in equilibrium with the same mineral assemblage. Based on the major element compositions of pyroxene (Fig. 2B) and feldspars [1] in the two clasts, there is substantial overlap in bulk composition of the major mineralogy. However, the SLI model does not hold when the distributions of incompatible trace elements are considered. The plot in Fig. 2C shows incompatible lithophile elements from the average FTP clast composition normalized to the average basalt clast composition. The FTP clasts are enriched in all elements shown, which is inconsistent with SLI since certain elements should prefer to enter the Si-rich liquid during liquid immiscibility, and thus should be more enriched in the basalt clasts [6].

We now consider whether or not the basalt and FTP clasts in NWA 7034 can be genetically linked by fractional crystallization. Incompatible lithophile trace elements are enriched in the FTP clasts relative to the basalt clasts. Assuming the average basalt clast composition represents a liquid, simple Rayleigh fractionation models predict ~60% crystallization of this liquid would be required to achieve the incompatible element concentrations in the FTP clasts. The fractional crystallization model does not hold when the major element compositions of the major mineralogy are considered. Fig. 2B shows pyroxene chemistry of the two clast groups; although each group individually shows the expected compositional trends for fractional crystallization, there is no distinct shift in mineral composition from the basalt to FTP clasts.

Interpretations: As indicated by trace element characteristics and mineral chemistries, it is unlikely the FTP clasts were derived from a melt with the composition of the basalt clasts through liquid immiscibility or fractional crystallization. Therefore, it is likely that these two clast groups are not genetically related, but have similar geochemical enrichments. Each clast group appears to have independently undergone fractional crystallization.

The chemistry of the FTP and basalt clasts is more similar to the average martian crust than the SNCs. The trace element patterns from the weighted averages for both clast groups are also similar to the predicted patterns and concentrations of the trapped liquid remaining after 98% and 99.5% crystallization of a martian magma ocean from [8] (Fig. 2D). These geochemical similarities to the proposed sources of enrichment in the shergottites suggest that these clasts might represent the enriched source itself (e.g., the crust), or that they sampled the enriched source (e.g., the end stage liquids from magma ocean crystallization), possibly through a mechanism similar to that of lunar KREEP-basalts.

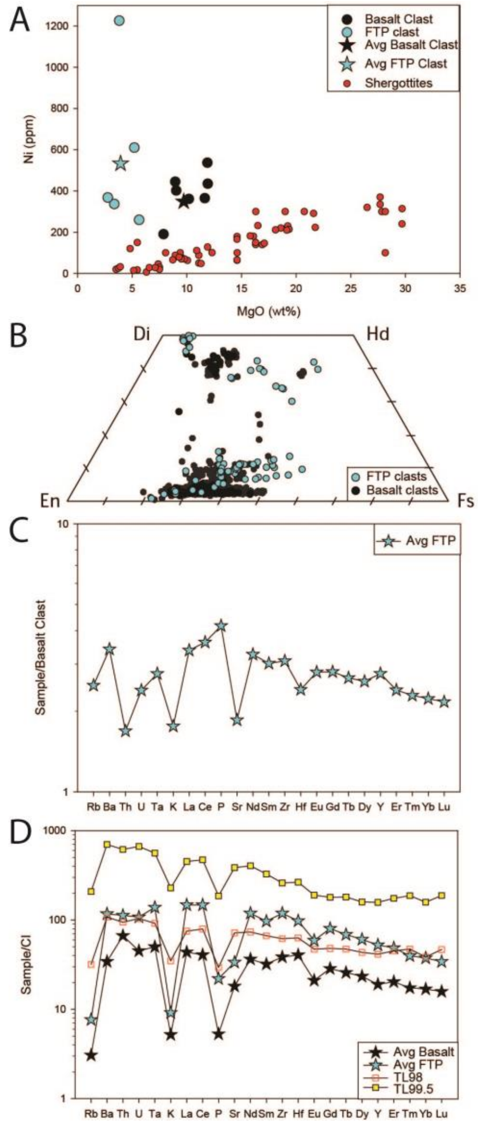

Figure 2: A: Ni vs. MgO in shergottites (red dots, [9]), FTP (blue dots) and basalt clasts (black dots), weighted average compositions are designated by stars. B: Pyroxene quadrilateral for both clast types. C: Trace element content of the FTP clast average normalized to the basalt clast average. D: CI normalized [7] trace element compositions for each clast type, as well as those calculated by [8] for liquids remaining after 98% (TL98) and 99.5% (TL99.5) crystallization of a martian magma ocean.

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