CONSTRAINING THE PETROGENESIS OF MONOMINERALIC CLASTS WITHIN THE MARTIAN POLYMICT BRECCIA NORTHWEST AFRICA 7034. G. Motta1*, S. Ramsey1, A. Udry1, T. K. Traylor1, J. Davidson2, J. Gross3,4, C. T. Adcock1, 1Department of Geoscience, University of Nevada, Las Vegas, Las Vegas NV, USA; *mottag1@unlv.nevada.edu, 2School of Earth and Space Exploration, Arizona State University, Tempe AZ, USA; 3Astromaterials Research and Exploration Science division, NASA JSC, Houston, TX, USA; 4Rutgers, The State University of New Jersey, Piscataway, NJ, USA.

Introduction: The only direct evidence we have of magmatic processes, formation, and evolution on Mars have come from terrestrially discovered meteorite samples, making their study crucial to understand the geologic history of the Red Planet. Northwest Africa (NWA) 7034 and its 17 pairs are the only polymict breccia in the martian meteorite collection, and represent the lithification of igneous, sedimentary, and impact lithologies within a single cohesive stone [1–2]. Igneous zircons within the breccia have ages as old as ~4.47 Ga and indicate that NWA 7034 contains a primordial, enriched crustal component that was established ~20 Ma after planetary accretion, making its study crucial to understand martian magmatic processes during early stages of crustal building [3–4]. Monomineralic clasts within NWA 7034 and their formation and emplacement are still poorly understood. Although they are mineralogically, geochemically, and texturally diverse, a petrogenetic relationship between monomineralic clasts has not yet been defined. As these minerals lack lithologic context on Mars, melt inclusions (Fig. 1), or pockets of magma entrapped within crystallized minerals, have provided us the opportunity to investigate their potential magmatic source(s). Here we present the first comprehensive investigation of melt inclusions and the petrogenetic implications of monomineralic clasts within NWA 7034.

Methods: Two polished sections of NWA 7034 were analyzed for textural, mineralogical, and geochemical composition and were lent by the ASU Buseck Center for Meteorite Studies (BCMS). The identification of melt inclusions within monomineralic clasts was conducted at the University of Nevada, Las Vegas (UNLV) using a TESCAN VEGA Scanning electron microscope (SEM). We acquired backscattered electron (BSE) images and qualitative energy dispersive spectroscopy (EDS) X-ray maps of monomineralic clasts and hosted melt inclusions. Mineral major and minor elemental analyses were conducted on pyroxene hosts using a JEOL JXA-8900 Electron Probe Microanalyzer (EPMA) at UNLV using a 15 kV accelerating voltage, 10 nA beam current, 2 µm spot size, and 30 s count times, following the methods described in [5].

Results: Monomineralic clasts are located within a microcrystalline (~0.5 µm) groundmass and are typically subhedral to anhedral with some of the largest clasts being >1 mm. Feldspar, pyroxene, and phosphate phases are typically the largest (100–500 µm) and the most abundant single mineral clasts, followed by Fe-oxides. Monomineralic clasts are often crosscut by Ca-bearing fractures with Fe-oxide deposits. Pyroxene and feldspar clasts commonly display varying widths and directions of exsolution, along with patchy Mg/Fe or Na/K zoning.

Pyroxene Hosts: Pyroxene hosts are texturally and geochemically diverse. Monomineralic pyroxene range in composition from En15-60Fs18-56Wo3-48 and are sometimes irregularly heterogeneous within a single mineral grain (Fig. 2). Exsolution lamellae within monomineralic pyroxene varies in width, direction, and Ca-enrichment depending on the clast. Pyroxene hosts have an average Mg# (100 × molar MgO /[molar MgO + molar FeO*]) of ~63.

Figure 1. Backscattered electron (BSE) image of a melt inclusion within monomineralic pyroxene. Mineral abbreviations are as follows: Px = pyroxene, Ox = oxides, MI = melt inclusion

Melt Inclusions: Around ~17 melt inclusions of >15 µm and ~28 melt inclusions of <15 µm have been found within monomineralic pyroxene and have subrounded or irregular textures (see Fig. 1) Melt inclusions were not found in other clasts or other monomineralic phases. Nearly all 45 melt inclusions are adjacent to iron oxides, and some show a distinct compositional halo in contrast to the host pyroxene phase. Qualitative imaging shows melt inclusions may contain microlytic phases and Fe-oxide inclusions (Fig. 1), however from our preliminary analyses, we cannot identify specific mineral...
compositions. Low-Ca and high-Ca exsolution lamellae within the host pyroxene appear to crosscut melt inclusions (Fig. 3c), while other melt inclusions have formed between two stoichiometrically distinct pyroxene compositions (Fig. 3b). Preliminary compositions collected using EDS suggest melt inclusions are also variably enriched in K$_2$O, Na$_2$O, Al$_2$O$_3$, and CaO compared to the host pyroxenes.

Discussion: Host pyroxenes show similar major element compositions to those in previous studies [6,7], (Fig. 2). The trends of pyroxene compositions for the monomineralic clasts from [6] overlap those of this study, as well as the compositions from pyroxenes from polyphase clasts [7].

Figure 2. Pyroxene quadrilateral with analyses of monomineralic clasts compared to previous studies [6,7].

The textures of monomineralic clasts within NWA 7034 may be indicative of a range of formation and emplacement processes. For example, exsolution lamellae that have differing widths, directions, and crystallographic appearances suggest variability in thermal annealing and temperature (900–1050°C), as already suggested by [6]. Heterogeneous geochemical composition within single mineral clasts (Fig. 3b) could be a result of differentiation processes, such as fractional crystallization, which resulted in two different compositions. Melt inclusions are rare in NWA 7034, and those that have been found are sometimes within these variable compositions and textures (Fig. 3 a–c).

Continuing further mineral major, minor, and trace elemental analyses on monomineralic clasts and melt inclusions will help constrain potential differentiation processes and parental melt composition(s), which could provide insight for their textural, geochemical, and mineralogical heterogeneity, as we ultimately aim to establish the petrogenetic relationship between monomineralic clasts. Completion of our work will help constrain the heterogeneity of the early martian interior and establish a relationship, not only to other igneous lithologies within NWA 7034, but also to other martian meteorites in the current collection.


Figure 3. BSE and X-ray maps of melt inclusions within monomineralic pyroxene of varying composition. a) Two melt inclusions hosted by a pyroxene grain adjacent to plagioclase. b) X-ray map of the area in (a) showing two distinct low-Ca (En$_{33}$Fs$_{38}$Wo$_{29}$) and high-Ca (En$_{29}$Fs$_{30}$Wo$_{41}$) compositions, with variable exsolution. c) Melt inclusions hosted within low-Ca exsolution in a high-Ca pyroxene grain. d) X-ray map of the area in (c). MI = melt inclusion, Px = pyroxene, Plag = plagioclase, Cpx = clinopyroxene, Opx = orthopyroxene