NORTHWEST AFRICA 10986: A COMPLEX LUNAR HIGHLANDS BRECCIA

S. E. Roberts[1], M. C. McCanta[1], M. M. Jean[1], and L. A. Taylor[1] [1]Planetary Geosciences Institute, Department of Earth and Planetary Sciences, University of Tennessee, Knoxville TN 37996. srober76@vols.utk.edu

Introduction: NWA 10986 is a new impact-melt breccia from the lunar highlands, found on November 15, 2015 in Grarat Zawi, Mahbed, Western Sahara [1]. Lunar meteorites such as NWA 10986 have the potential to offer new information about the Moon supplementing that from the Apollo and Luna sample return missions [2]. Unlike the sample return missions of the last century, the source locations for lunar meteorites are not known. This allows the possibility of lunar meteorites being sourced from areas away from the Procellarum KREEP Terrain (PKT). The Lunar Magma Ocean (LMO) theory for the petrogenesis of lunar lithologies was constructed based on Apollo samples that were all collected within the PKT. The Mg-suite rocks found in the highlands along with subsequent mare basalt magmatism are all influenced by KREEP magmatism according to the LMO theory. The ability to sample areas of the lunar highlands away from the influence of the PKT is crucial in refining our understanding of the evolution of the Moon and the LMO. Lunar meteorite finds have increased the diversity of highlands material beyond that of Apollo and present challenges to the LMO theory, e.g. [3]. The lithologies represented in NWA 10986 offer new evidence for the evolution of the lunar highlands and the influence of KREEP magmatism.

Petrography: In total, two thick and two thin sections have been investigated. NWA 10986 experienced multiple generations of brecciation and melting and includes a large amount of impact-generated glass. A complex matrix bound by glass encompasses fragmented and brecciated lithic clasts and fragments. Clasts have experienced partial to complete consumption and melting during impact events. Plagioclase-rich clasts show a variety of textures and mineral compositions representing a complete sampling of the diverse lunar highlands lithologies. Shock effects are variable throughout the sample yet the plagioclase have not been converted to maskelynite. This meteorite has experienced terrestrial weathering with large veins of barite crosscutting the samples.

Results: Mineral and whole-rock, major- and minor-element analyses were collected with a Cameca SX-100 electron microprobe. Fused-bead, whole-rock EMP analyses of Al_2O_3 (26.6 wt %) and FeO + MgO (11.8 wt %) confirm the highlands-component contribution to this meteorite [2]. Large areas of glass within the meteorite are approximately the same composition as the whole rock composition. Some areas of glass preserve elongated vesicles. The An content of plagioclase along with the Mg# in pyroxene and olivine were used to determine the highland lithologic affinity for the clasts [4]. Lithologies represented by the clasts include Mg-suite, ferroan anorthosites, gabbronorites, basalts, impact melts, and granulites. Pyroxene compositions are extremely diverse ranging from pigeonite to pyroxferroite. Large individual grains (up to 0.6 mm) of exsolved pyroxenes are found randomly throughout the sections. Pyroxferroite is found both as whole grains and attached to associated pyroxferroite breakdown material assemblages of ferroaugite, fayalite, and Si-rich glass [5]. The Ti# (Ti/[Ti+Cr]) and Fe# (Fe/[Fe+Mg]) of pyroxenes in the basaltic clasts were used to estimate the bulk rock TiO_2 of the clasts [6]. Pyroxenes in basaltic clasts represent very-low Ti and low Ti basalts.

Discussion: The clasts of NWA 10986 offer a unique sampling of the diversity of lithologies found within the lunar highlands. Clasts represent highland felsic and mafic lithologies, including Mg-suite clasts which are unusual among lunar meteorites [2]. These highland lithologies are consistent with and expand the Apollo classification system of ferroan anorthosite, hi-Mg, and alkali suites [4]. Whole pyroxferroite grains and pyroxferroite breakdown material in the basalt clasts suggest a complex cooling history along with possible shock modification. Presence of pyroxferroite breakdown material is unusual in mare basalts as it suggests extensive fractional crystallization coupled with slow cooling [6]. We suspect that the basalts found within this clast represent cryptomare. Trace-element data will reveal the relationships between the clasts and the influence of KREEP on petrogenesis.

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