NORTHWEST AFRICA 14340: PETROLOGICAL CHARACTERIZATION AND SHOCK METAMORPHISM OF A LUNAR REGOLITH BRECCIA.

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Introduction: Lunar meteorite Northwest Africa (NWA) 14340 was found in Algeria in 2017 as a single 8.26 gram stone that has been classified as a clast-rich, matrix-supported feldspathic breccia. A partially glassy spherule indicates that this meteorite was part of the lunar regolith. Recently, high-pressure minerals have been documented from the matrix of ten lunar meteorite breccias, which constrain the temperature-pressure conditions of the shock-lithification process [1, 2]. In this study, we characterize the mineralogy and petrology of NWA 14340, with a focus on shock effects in lithic clasts, and the nature of the matrix between these macroscopic components, using electron microscopy and Raman spectroscopy. These results help to unravel the impact history of lunar regolith components and how they evolve to become coherent rocks.

Results: NWA 14340 contains various types of lithic clasts including norite, olivine-gabbro, basalt, and devitrified glass, listed in descending order of abundance, and mineral fragments, that are set in a fine-grained to glassy matrix. The major minerals are plagioclase ($An_{92.0}$-$An_{98.1}$), olivine ($Fa_{17.4}$-$Fa_{35.4}$, FeO/MnO = 88.2 ± 5, N = 21), and pyroxene ($En_{13.0-36.7}Wo_{2.5-41.2}$, FeO/MnO = 52.3 ± 4, N = 26). Some pyroxene contains augite exsolution lamellae ($En_{15.6-16.2}Wo_{40.3-40.9}$, FeO/MnO = 46.5 ± 4, N = 8). Minor phases include silica, ilmenite, troilite, and FeNi metal and accessory zircon. Lithic fragments are highly shocked. Pyroxene exhibits mechanical twinning, mosaicism and planar fractures. The majority of plagioclase in lithic clasts is amorphous, found either as diaplectic glass or glass containing flow lines and vesicles. The most highly shocked clasts exhibit pyroxene / plagioclase grain boundary melting. Olivine exhibits planar fractures and mosaicism. The matrix interstitial to these clasts comprises flow-textured, vesiculated glass. Small, rounded blebs of troilite in surrounding glass are consistent with partial melting. Within the glass, 1-10 μm size crystals are heterogeneously distributed. The occurrence, grain size and grain shape of these crystals are similar to that reported by [1, 2] for other lunar regolith breccias. Some of these crystals are identified as tissintite II [3]–a high-pressure, vacancy-rich pyroxene-structured mineral enriched in Mg, Fe and Cr–compared with tissintite, which has a plagioclase composition (An_{58-69}) [4]. Other, as yet unidentified, silicate minerals have crystallized from the melt, which will be constrained using Raman spectroscopy.

Discussion: The structural state and composition of feldspar, coupled with deformation in olivine and pyroxene, constrain the conditions of shock metamorphism [5]. The shock pressures experienced by clasts in NWA 14340 range from ~25-27 GPa and <30 GPa to >45 GPa. Experimentally-formed tissintite is stable at pressures of 4.5-10 GPa and a temperature of >1273 K [6]. Other minerals, in addition to tissintite-II, that have crystallized in the NWA 14340 matrix will need to be identified in order to unravel the history of the shock-lithification process recorded in this meteorite.

References: [1] Zhang A. C. et al. 2021. *Geophysical Research Letters* 48. [2] Kroemer C. R. et al. (2021) *LPSC LIII*, Abstract # 1316. [3] Ma abstract from LPSC. [4] Ma C. et al. 2015. *Earth and Planetary Science Letters* 422. [5] Fritz J. et al. (2019) *Meteoritics & Planetary Science 54:* 1533-1547. [6] Rucks et al. American Mineralogist 103: 1516-1519.