THE CLASSIFICATION OF LUNAR METEORITE NORTH WEST AFRICA 11223

K. Hewson[1], K. Tait[1], V. Di Cecco[1], I. Nicklin[1, 1]Department of Natural History, Royal Ontario Museum, 100 Queens Park, Toronto, Ontario M5S 2C6, Canada

Introduction: Lunar breccias from the highlands of the moon comprise approximately half of the known lunar meteorites to date [2]. Meteorite North West Africa (NWA) 11223 (ROM accession number M57543) is a feldspathic lunar breccia found in southern Morocco in 2016. The entire meteorite has been estimated to have been approximately 10 kilograms in weight prior to fragmentation into several smaller pieces, with the largest fragment being approximately 2 kilograms. The piece we analysed is 28 grams and, along with the other pieces, lacks fusion crust and has a white caliche coating from burial. There is no evidence of this weathering surface penetrating deeper into the rocks.

Methods: A petrographic thin section was analysed under a polarized light microscope and points were chosen in feldspar, olivine and pyroxene grains for chemical analysis. Major and minor elemental abundances were gathered using a JEOL JXA8230 5-WDS Electron Microprobe (EMPA) at the University of Toronto. A total of 125 points were analysed across the sample. Petrographic observations were made in transmitted and reflected light to determine mineralogy and textures.

Figure 1: A thin section map of NWA 11223 taken under polarised light microscope. Scale bar = 2 mm.

Petrography: The sample has a brecciated appearance consisting of clasts and individual mineral grains of variable sizes in a dark grey, glassy matrix. Two types of clasts were observed: pale anorthite clasts; and murky mixed clasts containing olivine (predominantly forsterite), pyroxene (predominantly enstatite) and anorthite (Figure 1). A large anorthite grain (1 cm by 0.5 cm) is present in the sample and displays granular textures. The smaller anorthite clasts range in size from 50 µm to 2 mm long. The mixed, darker clasts range in size from 50 µm to 2.5 mm long. The anorthite clasts are predominantly elongate and the darker clasts are blocky and irregular in shape. Minor barite and calcite veins are visible in thin section throughout the sample.

Geochemistry: Feldspar composition was measured in 86 points. Data indicates a highly anorthitic composition with averages of $An_{96.84}$, $Ab_{4.05}$ and $Or_{0.27}$ with minimal chemical variation. This is consistent both in the clasts and the matrix. Olivine and pyroxene compositions were measured in 39 points (17 olivine and 22 pyroxene). The average composition of olivine is forsteritic ($Fa_{37.48}$) with a compositional range of $Fa_{28\text{-}43.7}$. Pyroxene is enstatitic on average ($En_{49.11}$, $Fs_{37.36}$, $Wo_{13.52}$) with some grains bearing evidence of exsolution. Si-rich areas (10 µm in length) were found within a mottled region in association with anorthite grains. These areas contain an average SiO_2 abundance of 95.28 %. The mean FeO/MnO ratio for olivine is 96.7 and 57.5 for pyroxene. The combined mean FeO/MnO ratio for both minerals is 74.6. The Mg# for olivines in the sample is 0.49 and 0.43 for the pyroxenes. The matrix has an anorthitic composition with minor variability across the sample ($An_{92.3\text{-}97.4}$, $Al_{3\text{-}7.4}$, $Or_{0.1\text{-}0.4}$).

Discussion: NWA 11223 is classified as a feldspathic lunar breccia supported by the mineralogy and petrology. The sample is classified as polymict, due to the occurrence of two clast types throughout the sample. The presence of pyroxene and olivine in clasts indicate mare origin for a portion of the sample. High anorthite abundances with minor albite content ($Al_{1.7\text{-}7.4}$) are consistent with an origin from the lunar highlands. Evidence of shock events are present in the clasts as well as individual grains, for example the granular textures in the large anorthite grain as well as mosaicism in smaller anorthite grains. Shock exsolution is evident in the Si-rich area, likely indicating silica was exsolved outwards as a result of these shock events. Fe/Mn ratios in olivine and pyroxene grains indicate that the sample is a lunar meteorite [1].Other classification parameters suggested by Korotev (2005) such as relative abundance of KREEP, ilmenite abundance and siderophile abundances based on trace element concentrations are pending at this time. Weathering is indicated by the presence of aluminum silicate in veins.

Acknowledgements: The authors acknowledge Dr. David Gregory for access to the sample, and a NSERC DG grant to K.T.T. to fund analyses.

References: [1] Korotev R. L. (2005) *Chemie der Erde* 65:297-346. [2] Korotev R. L., Zeigler, R. A., Joliff, B. L., Irving, A. J., Bunch, T. E. 2009. *Meteoritics & Planetary Science* 44: 1287-1322.