PRELIMINARY RESULTS OF A NEW LUNAR IMPACT-MELT BRECCIA METEORITE NORTHWESTERN (NWA) 13638.

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Introduction: Any new addition to the lunar meteorite database can potentially expand our knowledge of the petrological diversity of the lunar crust and mantle. A new lunar meteorite was recently found in Algeria as a single large stone of ~512 grams. Based on the texture and mineral chemistry, we classified this new meteorite to be clast-rich, polymict impact-melt breccia with a provisional name of NWA 13638, using the classification scheme by Stöffler et al. (1980). Here, we present the initial petrography and mineralogy description of NWA 13638.

Methods: Two cut pieces of NWA 13638 were polished and studied with a Zeiss 1550 VP field emission scanning electron microscope (FE-SEM) and a JEOL JXA-8200 electron probe microanalyzer (EPMA). Natural and synthetic standards were used as standards for EPMA. Elemental concentrations were analyzed using an electron beam accelerated at 15 kV with a 25 nA current. Counting times are 20 s for all elements except for Mn (40 s).

Results:

Confirmation of lunar origin. Lunar origin was established based on mineral chemistry. The range of molar Fe/Mn ratios of olivine (94 ± 16, n = 9) encompasses the value (105) in Papike et al. [2]. Pyroxenes contain molar Fe/Mn ratios of 62.5 ± 5.5 (n = 16) for pigeonite and 65.6 ± 8.6 (n = 37) for augite. The Fe-Mn plot of all analyses in pyroxenes contains a slope similar to that in Papike et al. [2] (Fig. 1).

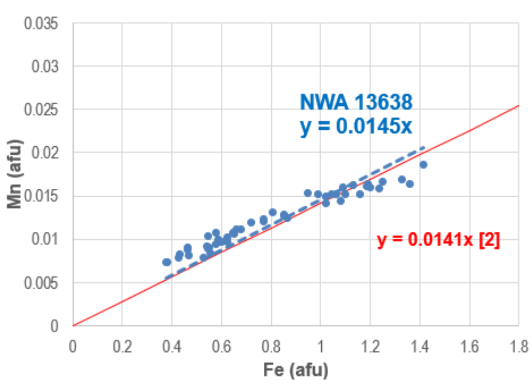

Fig. 1. Mn and Fe in NWA 13638 pyroxenes with a fitted trend line of a slope of 0.0145. The red line is the trend for lunar pyroxenes in [2].

Petrography. Rock and mineral clasts in NWA 13638 consist of >25 vol% of the whole sample. Gray and white rock fragments in NWA 13638 display subangular to angular shapes with sizes ranging up to ~4 cm in the longest dimension (Fig. 2). The gray clasts are breccias containing both rock and mineral fragments. The white clasts are also brecciated and feldspathic. Mineral fragments appear inside the breccia fragments or in direct contact with the matrix. The matrix of NWA 13638 is black and glassy with occasional vesicles. Terrestrial weathering appears to be moderate since metal grains display no alteration rims. Ca-carbonate and barite were observed in a few cracks and pore space.

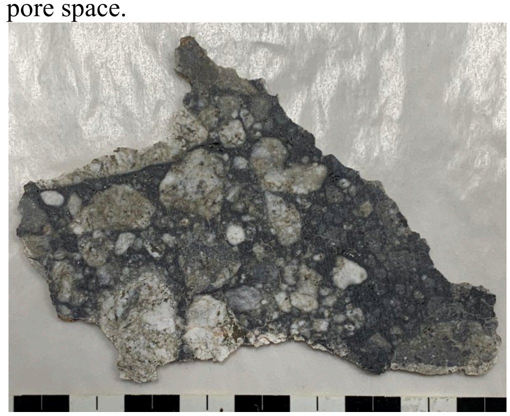

Fig. 2. A cut slice of NWA 13638. The black scale bar at the bottom is 1 cm (tick marks are 5 mm).

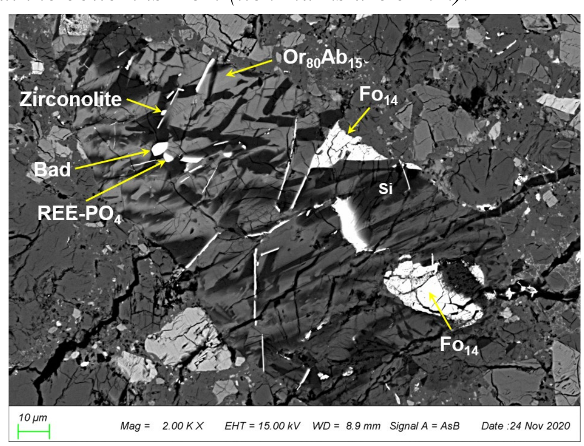

Fig. 3. A felsite fragment in NWA 13638 showing graphic intergrowth of a silica phase (Si) and K-Ba-rich feldspars. Other phases present are zirconolite, baddeleyite (Bad), REE-phosphate (REE-PO4), fayalite (Fo_{14}). Scale bar: 10 µm.

Rock fragments. Large clasts consist of breccias and anorthosite fragments. For ease of discussion, we refer to breccia fragments in NWA 13638 as proto-breccias. Within these proto-breccias, we observed both rock (basalt, felsite, symplectite, and impact melt) fragments and mineral fragments (e.g., feldspar, pyroxenes, fayalite, a silica phase). The felsic fragments show graphic intergrowth of a silica phase and K-rich feldspar with Ti- and Zr-rich phases (Fig. 3). The symplectite is similar to those observed in crystalline meteorite MIL 05035 [3].

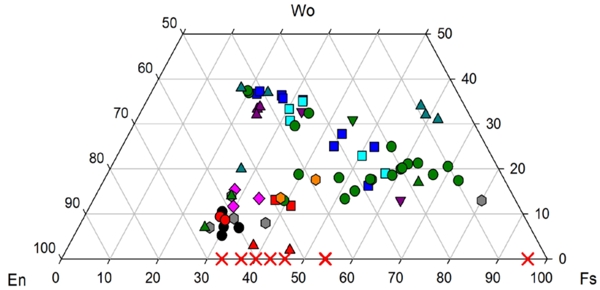

Fig. 4. Compositions of pyroxenes in NWA 13638. Different symbols show different grains. Olivine compositions (Fo#, crosses) are plotted on the En-Fs binary.

Mineral fragments. Pyroxenes and felspars are the most common mineral fragments, although minor amounts of olivine and silica phases are present. Individual fayalite grains of 150 µm in the largest dimension were observed in the proto-breccia clasts. Pyroxene fragments often contain exsolution lamellae, but a few zoned, euhedral pyroxene fragments are also present. Both olivine and pyroxene show a wide range of compositions (Fig. 4). Some pyroxene fragments display compositional zoning from ~$En_{45}Wo_{37}$ to $En_{14}Wo_{19}$ (Fig. 4). Feldspars in NWA 13638 contain both Ca-rich plagioclase and K-rich feldspars (Fig. 5). Plagioclase ranges from nearly pure anorthite in individual fragments to ~An_{87} in basaltic fragments. K-rich feldspars were mainly observed in felsic fragments (Fig. 3), which contains Ba up to ~8 wt%. An interesting occurrence is the direct contact of K-rich feldspars ($An_{4\text{-}2}Ab_{16\text{-}15}$) with plagioclase ($An_{94}Ab_5$) in a basaltic clast (Fig. 6).

Matrix. The matrix of NWA 13638 is devitrified, containing microlites of feldspars and pyroxenes (Fig. 7). The bulk chemistry of the matrix is feldspathic.

Discussion:

This newly confirmed lunar meteorite adds to the current collection of lunar meteorites (n = 433, the Meteorite Bulletin database). The proto-breccia in NWA 13638 with basalts, evolved lithologies (e.g., symplectites, felsites, silica fragments), and pyroxene of exsolution lamellae is possibly sourced from a mare terrane. The anorthositic fragments in NWA 13638 are consistent with a highland origin. The presence of both basaltic proto-breccias and highland rocks in NWA 13638 implies that NWA 13638 likely originated a terrane that received both inputs from mare and highland. Given the diverse lithologies in NWA 13638, our initial study only scratched the surface. Additional studies will be available at the time of the conference.

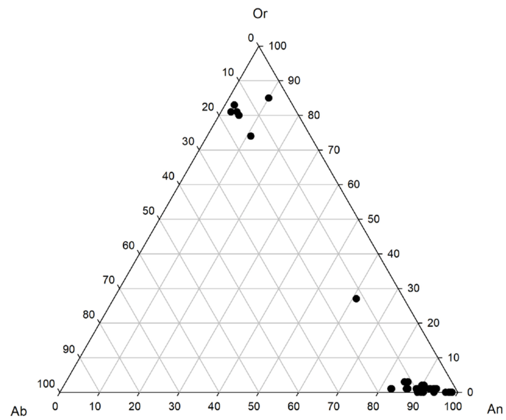

Fig. 5. Compositions of feldspars in NWA 13638.

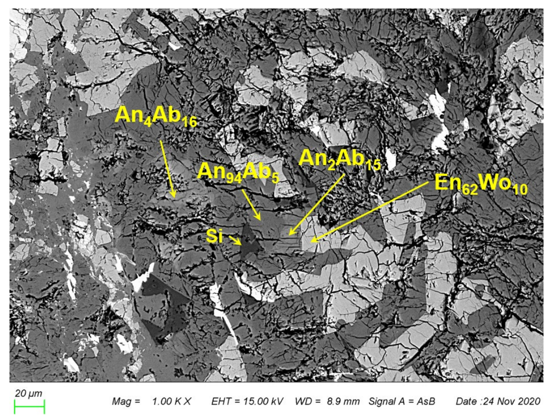

Fig. 6. K-rich feldspars in contact with plagioclase in a basaltic clast. Scale bar: 20 µm.

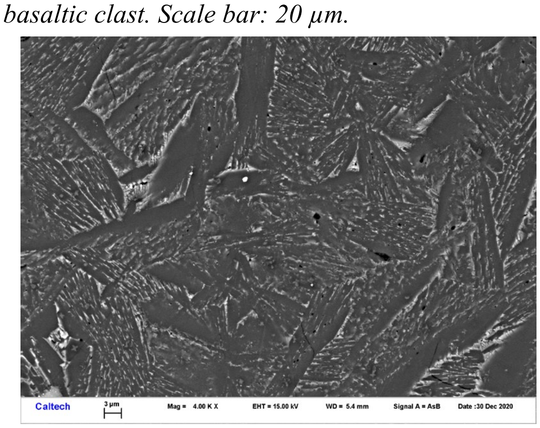

Fig. 7. Matrix of NWA 13638. Scale bar: 1 µm.

References: [1] Stoeffler, D. et al. in *Conference on the Lunar Highlands Crust.* 51-70 (New York and Oxford, Pergamon Press). [2] Papike, J. J. et al. (2003) *Am. Min.*, *88*, 469-472. Liu, Y. et al., 2009. *Meteo. Planet. Sci.*, *44*, 261-284.