UNIQUE DUNITE BRECCIA NORTHWEST AFRICA 12217: MINERALOGY, PETROLOGY, AND OXYGEN ISOTOPES. Z. Vaci[1,2], C. B. Agee[1,2], and K. Ziegler[1,2] [1]Institute of Meteoritics, [2]Department of Earth and Planetary Sciences, University of New Mexico, NM, USA.

Introduction: Achondrites are meteorites derived from parent bodies that melted and sometimes differentiated. Many recently discovered achondrites display unique petrology, geochemistry, and isotopic composition such that they do not fit into known achondrite groups. We report here the discovery of a unique ungrouped achondrite that shares petrological affinities with brachinites and brachinite-like achondrites [1,2] and oxygen isotopic affinities with the HED meteorites, angrites, and brachinites. However, its mineralogy sets it apart as a unique dunite breccia unlike any other grouped achondrites.

History and Physical Characteristics: Northwest Africa (NWA) 12217 was purchased by Jay Piatek in 2015 from a Moroccan meteorite dealer. The specimen is a single stone, 148 g, partially covered with black fusion crust. The saw-cut surface (Fig. 1) shows cream-colored and light green angular mineral fragments up to 1 cm in size bounded by dark grey material. A partially oxidized metal grain is also visible. The stone appears brecciated in hand sample.

Fig. 1. Scanned image of cut surface of NWA 12217.

Mineralogy and Petrology: Electron microprobe analyses and SEM BSE mapping of two polished mounts show a dunite with approximately 93% olivine, 4% low and high-Ca pyroxene, and minor chromite, Fe-sulfide, FeNi-metal, andesine plagioclase, alkali feldspar, fluoroapatite, and silica. The minor phases (~0.1 to 1 mm) occupy pockets between much larger olivine grains (~1 mm to cm-sized). Feldspar grains (~200-300 µm) are found in pockets surrounded by radiating fractures and often coincide with high-Si mesostasis or silica. One alkali feldspar grain was found with exsolving silica laminae. A single large metal grain (~1.5 mm) shows a taenite core exsolved from kamacite. Chromite grains are sometimes zoned due to solid solution with magnesiochromite and hercynite. There are also vermicular Cr-bearing symplectites (~50 to 500 µm) found along mineral grain boundaries, often associated with pyroxenes, and sometimes within olivine grains. Lamellar inclusions composed of high-Ca pyroxene, chromite, and Fe-sulfide also cut across olivine grains.

The brecciation visible in the NWA 12217 hand sample is not immediately visible in BSE images, as finer-grained "matrix" material is absent from the dunite. Individual olivine grains appear to be well-compacted and possibly sintered together. Grains are heavily fractured, and fractures appear to displace symplectites and veins. Shock-melt veins are absent, though the heavy fracturing and displaced phases suggest that this meteorite experienced a low degree of shock metamorphism.

Major Element Chemistry: The mineralogy of NWA 12217 seems to be largely equilibrated, as olivines and pyroxenes show uniform, unzoned compositions. This suggests monomict fragmental brecciation. Microprobe analyses: olivine Fa8.6±2.1, Fe/Mn=35±2, n=37; low-Ca pyroxene Fs19.0±1.2 Wo2.7±0.5, Fe/Mn=25±2, n=9; high-Ca pyroxene Fs39.6±3.9 Wo55.7±3.3, Fe/Mn=21±10, n=5; plagioclase Ab62.5±8.8 An35.6±9.2, n=11; alkali feldspar Ab41.6±9.6 Or55.8±10.0, n=8; chromite (in wt%) Al_2O_3=10.1±6.8 Cr_2O_3=59.8±5.1 MgO=10.2±2.9 MnO=0.6±0.1 FeO=17.2±3.1, n=9; kamacite (in mol%) Fe=93.1±0.1 Ni=6.8±0.1, n=8; taenite (in mol%) Fe=82.8±5.1 Ni=17.1±5.1.

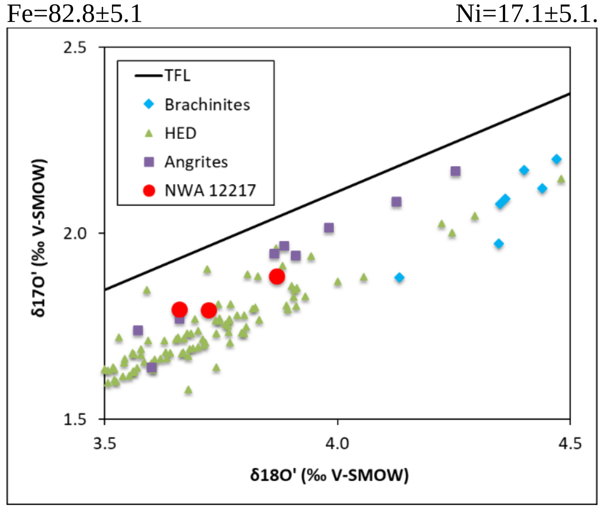

Fig. 2. Triple oxygen plot showing NWA 12217 relative to other grouped achondrites [3,4].

Oxygen Isotopes: Figure 2 shows our results for laser fluorination analyses of three acid-washed fragments with values of $\delta^{18}O$ = 3.723, 3.869, 3.660; $\delta^{17}O$ = 1.793, 1.884, 1.796; $\Delta^{17}O$ = -0.173, -0.159, -0.136 (linearized, all per mil, TFL slope = 0.528); weighted average $\delta^{18}O$ = 1.836; $\delta^{17}O$ = 3.776; $\Delta^{17}O$ = -0.158. These values plot in the vicinity of the HED meteorites, angrites, and brachinites. The $\Delta^{17}O$ of NWA 12217 plots between the eucrite fractionation line (EFL) and the angrite fractionation line (AFL) [3].

Discussion: The origin of NWA 12217 is enigmatic, as its petrologic characteristics preclude its classification as a member of any achondrite group. Its dunitic mineralogy is similar to that of the brachinites, but its olivine composition is more forsteritic than any brachinite (~Fa27-36 [5]). The brachinite-like achondrites are more forsteritic (~Fa20-30 [2]), but their olivines exhibit reverse zoning and are rimmed by orthopyroxene and opaques due to sulfidization [2]. Zoning in NWA 12217 is only observed in increasing Cr content in olivine close to Cr-symplectites. The ureilites span a larger range of forsterite content (~Fa5-25 [2]), but features such as their O isotopes, high CaO and Cr_2O_3 in their olivines, wt% levels of interstitial C, and reduction rims on their olivines [5] preclude classification of NWA 12217 as a ureilite. The O isotopic composition of NWA 12217 could suggest affinity with the HED meteorites, in which case it would be classified as a new dunitic diogenite such as Miller Range (MIL) 03443 or NWA 2968 [6]. The presence of andesine and alkali feldspar in NWA 12217 makes such a classification unlikely, as HED meteorites generally contain more anorthitic plagioclase [7] (Fig. 3). The symplectites and lamellar inclusions in NWA 12217 are similar to those found in the unique achondrite Queen Alexandria Range (QUE) 93148 [8].

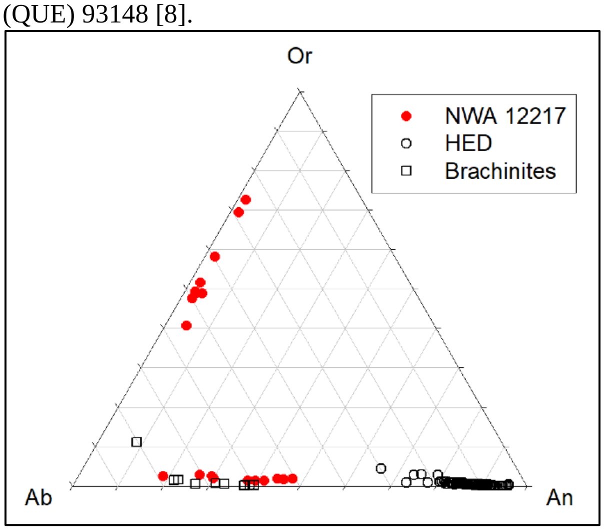

Fig. 3. Feldspar ternary diagram showing compositions of NWA 12217, HED meteorites [7], and brachinites [10].

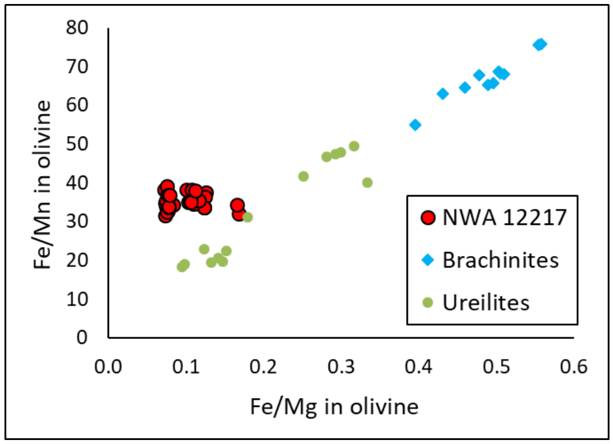

Fig. 4. Fe/Mn vs. Fe/Mg in NWA 12217 compared to brachinites and ureilites. Data are from [2] and references within.

The CaO vs. Cr_2O_3 contents of olivines in NWA 12217 plot in the vicinity of the brachinites, HED meteorites, and QUE 93148, and they overlap slightly with the HED meteorites. Fig. 4 shows Fe/Mn plotted against Fe/Mg for olivines in NWA 12217, brachinites, and ureilites. The brachinites and ureilites show linear trends with near-constant, chondritic Mn/Mg ratios. This type of trend is suggestive of differing redox conditions of common starting material, rather than igneous fractionation which produces a range of Fe/Mg at constant Fe/Mn. Numerous researchers have suggested that these and other primitive achondrites are residues of low degrees of partial melting on the basis of this evidence [1,2,8]. The olivines in NWA 12217, by contrast, display constant Fe/Mn with variable Fe/Mg, suggestive of igneous differentiation and fractional crystallization. Since this meteorite is a breccia, its olivines could be sampling portions of a fractionally crystallized cumulate pile that underwent varying degrees of differentiation. If the olivines of NWA 12217 are cumulates, and not residues, the meteorite is likely sourced from a unique parent body that underwent large degrees of melting and differentiation.

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