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PETROLOGY AND COMPOSITION OF LUNAR FELDSPATHIC BRECCIAS NWA 2995, DHOFAR 1180 AND DHOFAR 1428

T. E. Bunch[1], J. H. Wittke[1], and R. L. Korotev[2]. [1]Department of Geology, Northern Arizona University, Flagstaff, Arizona. E-mail: tbear1@cableone.net. [2]Earth and Planetary Sciences, Washington University, St. Louis, Missouri

A feldspathic breccia from Algeria and two mingled highlands + mare lunar breccias found recently in Oman bring the total number of unpaired lunar meteorites to more than 40.

Northwest Africa 2995 is a very fresh feldspathic fragmental breccia that contains many highlands fine-grained lithologies: norite (orthopyroxene $Fs_{26.4}Wo_4$, FeO/MnO = 66), olivine basalt (olivine $Fa_{87.2}$, FeO/MnO = 95; plagioclase $An_{84.7}$), subophitic basalt (augite $Fs_{25-48}Wo_{37.1-25.9}$; pigeonite $Fs_{27.8-31.7}Wo_{15.4-9.3}$, FeO/MnO = 53; olivine $Fa_{36.3}$, FeO/MnO = 90; plagioclase An_{97}), gabbro (olivine $Fa_{34.7}$, FeO/MnO = 95; pigeonite $Fs_{28.2}Wo_{8.9}$, FeO/MnO = 67; plagioclase An_{94}), KREEP-like basalt (plagioclase $Ab_{50}Or_{17.4}$; K-feldspar $Ab_{14.3}Or_{83.6}$; silica, phosphate and Fe-rich pyroxenes), troctolite (olivine $Fa_{30.8}$, FeO/MnO = 94; plagioclase $An_{94.7}$), granulitic impact melts (olivine Fa_{31}; orthopyroxene $Fs_{25.2}Wo_{3.4}$; plagioclase An_{95}); anorthosite ($An_{92.7-96.8}$), glassy impact melts, coarse-grained mineral fragments, and a 0.35 mm-size grain of meteoritic NiFe metal (Ni = 6.3 wt%, Co = 1.0 wt%).

Dhofar 1180 and Dhofar 1428 are clast-rich, crystalline melt breccias that do not appear to be paired stones. Dhofar 1180 is largely populated with anorthositic lithologies, including ferroan anorthosite (plagioclase An_{95} with up to 1.1 wt% FeO), anorthositic gabbro (olivine Fa_{39}, FeO/MnO = 96–101), norite (olivine Fa_{18}), troctolite, minor amounts of ophitic to subophitic basalts (evidently with mare affinities) and impact melt breccias. Dhofar 1428 is dominated by plagioclase and xenolithic breccia clasts with subordinate amounts of norite (olivine Fa_{36}, FeO/MnO = 104; plagioclase $An_{96.4}$; orthopyroxene $Fs_{28.4}Wo_{4.1}$, FeO/MnO = 51), troctolite (plagioclase $An_{95.5}$; olivine $Fa_{25.8}$, FeO/MnO = 89), and subophitic basalts that contain highly zoned pyroxenes ($Fs_{14.9}$ $Wo_{5.1}$ to $Fs_{41.2}$ $Wo_{15.2}$).

Bulk Compositions: Dhofar 1180 contains 22.6 wt% Al_2O_3, 9.3 wt% FeO and 0.9 ppm Th, and plots at the feldspathic end of the field for mingled highlands + mare lunar breccias [1]. It does not appear to be paired with any other of the known Omani lunar meteorites, and shows compositional similarities to Calcalong Creek and Yamato-983885, but with a lower bulk Mg/Fe ratio and lower concentrations of incompatible elements. Analyses of NWA 2995 and Dhofar 1428 are in progress.

References: [1] Korotev R. L. 2005. *Chemie der Erde* 65:297–346.

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NORTHWEST AFRICA 2968: A DUNITE FROM 4 VESTA

T. E. Bunch[1], J. H. Wittke[1], D. Rumble III[2], A. J. Irving[3], and B. Reed. [1]Department of Geology, Northern Arizona University, Flagstaff, Arizona, USA. E-mail: tbear1@cableone.net. [2]Geophysical Laboratory, Carnegie Institution, Washington, D.C. [3]Department of Earth and Space Sciences, University of Washington, Seattle, Washington, USA

Discovery: A total of 268 grams of blocky, dark brown fragments (17–25 mm across) collected by nomads in Algeria in 2004 appear to be from the first recognized coarse-grained olivine-rich rock with affinities to the HEDO meteorites.

Petrography: The original grain size is unknown because of a tendency to fracture on curved to linear compression and shear fractures subparallel to one of the extinction directions in olivine, but it must have been in excess of 20 mm. Olivine ($Fa_{7.5\pm0.2}$; FeO/MnO = 48; both Cr_2O_3 and NiO < 0.03 wt%) is predominant (>95 vol%), and exhibits large domain offset, isolated mosaicness and undulatory extinction. Tiny grains (<0.03 mm) of orthopyroxene ($Fs_{6.7}Wo_{1.5}$, FeO/MnO = 26), metal (kamacite, Ni = 4.7–6.8; taenite, Ni = 39.1–50.7 wt%), troilite (Ni = 0.36 wt%) and pyrrhotite (Ni = 1.7–4.7 wt%) occur commonly within fractures (see BSE image below) and as rare inclusions.

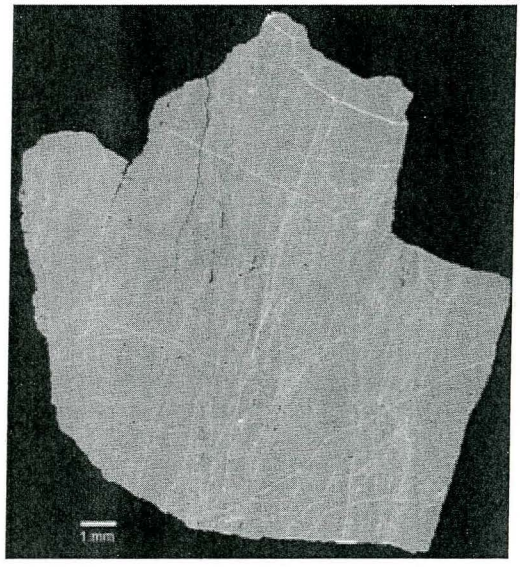

Fig. 1.

Oxygen Isotopic Composition: Replicate analyses of an acid-washed and metal-free sample by laser fluorination gave, respectively: $\delta^{17}O$ = +1.44, +1.48, $\delta^{18}O$ = +3.08, +3.22, $\Delta^{17}O$ = –0.178, –0.212 per mil (for m_{TFL} = 0.526).

Conclusions: On the basis of FeO/MnO ratios [1] and oxygen isotopic compositions [2], NWA 2968 has affinities with the HEDO meteorites and by inference 4 Vesta. Olivine is much more magnesian than in the six known olivine diogenites (Fa_{28-36} [3]), and thus NWA 2968 may represent a cumulate from a very primitive Vestan magma.

References: [1] Papike J. et al. 2003. *American Mineralogist* 88:469–472. [2] Wiechert U. et al. 2004. *Earth and Planetary Science Letters* 221: 373–382; Greenwood R. et al. 2005. *Nature* 435:916–918. [3] Irving A. et al. 2003. Abstract #1502. 36th Lunar and Planetary Science Conference. Irving A. et al. 2005. Abstract #2188. 36th Lunar and Planetary Science Conference.