NORTHWEST AFRICA 5721: A VESICULAR, EUCRITE-LIKE, UNGROUPED MAFIC ACHONDRITE FROM AN UNRECOGNIZED PARENT BODY.
T. E. Bunch[1], J.-A. Barrat[2], J. H. Wittke[1], D. Rumble, III[3] and A. J. Irving[4] [1]Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011 (tbear1@cableone.net), [2]Institut Universitaire Européen de la Mer, Université de Bretagne Occidentale, Brest, France, [3]Geophysical Laboratory, Carnegie Institution, Washington, DC, [4]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA.

A very fresh 67.5 gram dark stone with a dark gray, partly translucent fusion crust found in southwestern Morocco in 2007 is a unique mafic achondrite containing prominent vesicles. Although this specimen is broadly similar to some eucrites, there are significant differences, implying that it is related to a differentiated parent body distinct from that yielding eucrites.

Figure 1. *Exterior of a 5 cm piece of NWA 5721 showing elongate pyroxene blades and vesicle pits.*

Figure 2. *Cut interior surface (width 35 mm) showing elongate pyroxene blades and vesicles.*

Petrography: The texture of NWA 5721 is dominated by long (up to 12 mm), bladed dark pyroxene grains – mostly pigeonite ($Fs_{53.2-68.1}Wo_{13.5-8}$, FeO/ MnO = 35) but also augite ($Fs_{39.4-44.4}Wo_{32.2-36.7}$, FeO/ MnO = 27). Some swallow-tailed pyroxene grains form lamellar intergrowths with plagioclase ($An_{82.3-88.0}$), and in places there are ophitic to subophitic textures. Other regions with variolitic and plumose textures have interstitial poikilitic residuum containing tiny pyroxenes set in masses of a low birefringent silica phase (possibly cristobalite or tridymite), iron sulfide, fayalite ($Fa_{85.7}$, FeO/MnO = 48), metal, ilmenite and felsic glasses. Pigeonite and augite grains exhibit large changes in grainsize over short distances (see Figure 3). Numerous smooth-walled but empty vesicles range in size from 0.2-2.5 mm (see Figures 2 and 3).

Figure 3a (above). *Plane-polarized light thin section image (24 mm) showing grainsize variation and irregularly-shaped vesicles.*
Figure 3b (below). *Cross-polarized light thin section image of a coarser, ophitic region (13 mm).*

Oxygen Isotopes: Analyses of two acid-washed whole rock subsamples by laser fluorination gave, respectively: $\delta^{18}O$ = 2.93, 2.99; $\delta^{17}O$ = 1.26, 1.32; $\Delta^{17}O$ = -0.281, -0.254 per mil. These values fall at the lower bound of the broad range for eucrites, mesosiderites and diogenitic ultramafic rocks [1] – see Figure 4. We also report here CIW results for vesicular diogenite Dhofar 700, respectively: $\delta^{18}O$ = 3.12, 3.87, 3.31, 3.51;

$\delta^{17}O$ = 1.44, 1.82, 1.55, 1.62; $\Delta^{17}O$ = -0.205, -0.231, -0.191, -0.222 per mil, which differ slightly from those determined at OU (see also Figure 5).

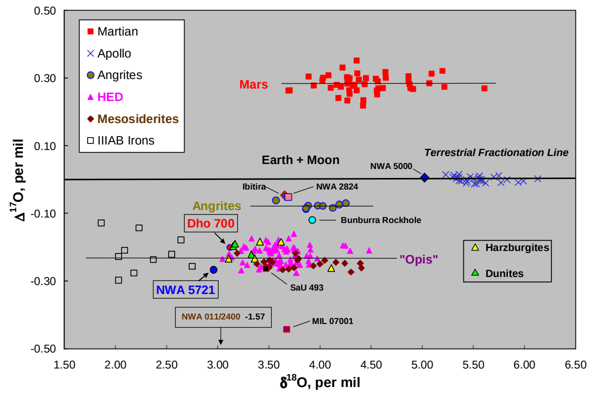

Figure 4. *Oxygen isotopic compositions of NWA 5721 and other "planetary" achondrites. All data by laser fluorination [1, 2], except for IIIAB irons [3].*

Figure 5. *Prominent vesicles in anomalous diogenite Dhofar 700. Photo © A. Hupé.*

Bulk Elemental Composition: Representative whole rock powder from a ~1 gram interior slice of NWA 5721 was analyzed by ICP-AES and ICP-MS.

	NWA 5721	*Juvinas [4]*		*NWA 5721**	*Juvinas [4]*
SiO_2	nd	nd	La	1.64	2.72
TiO_2	0.58	0.63	Ce	4.24	7.08
Al_2O_3	12.49	12.93	Pr	0.63	1.07
Cr_2O_3	0.30	0.35	Nd	3.21	5.37
FeO_T	19.62	18.71	Sm	1.05	1.72
MnO	0.55	0.53	Eu	0.47	0.635
MgO	4.07	7.18	Gd	1.47	2.24
CaO	10.46	10.39	Tb	0.27	0.417
Na_2O	0.43	0.42	Dy	1.85	2.83
K_2O	nd	0.05	Ho	0.42	0.629
P_2O_5	0.21	0.08	Er	1.25	1.83
			Yb	1.30	1.78
Mg/(Mg+Fe)	0.270	0.406	Lu	0.20	0.266

*****Also Ni 1.2, Ga 2.8, Zn 6.6, Rb 0.7, Sr 68, Ba 20 ppm

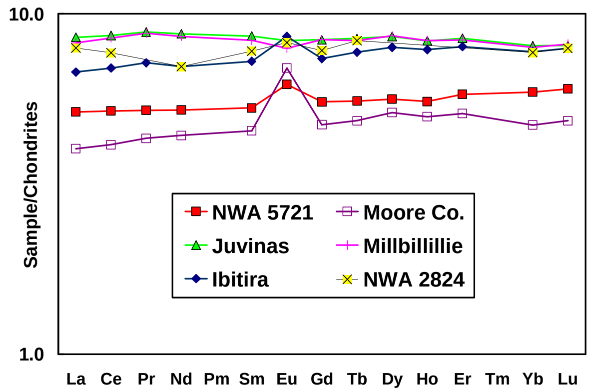

Figure 6. *Chondrite-normalized bulk REE abundances for NWA 5721, typical basaltic and cumulate eucrites [4], Ibitira [4] and NWA 2824 [5].*

The chondrite-normalized REE pattern is essentially flat at ~5.4×chondrites with a small positive Eu anomaly (Figure 6). This pattern is parallel to those for typical eucrites and vesicular eucrite-like achondrites (Ibitira, NWA 2824), but at lower overall abundances.

Discussion: Although NWA 5721 has mineral compositions and perhaps a $\Delta^{17}O$ value similar to those in typical eucrites, it differs from them in the following significant ways: presence of abundant vesicles, very low bulk MgO content and very high FeO/MgO ratio (both beyond values for basaltic eucrites), high Ga/Al ratio (~1.8 times higher than in eucrites), much higher abundances of P and Rb, REE abundances and a $\delta^{18}O$ value lower than those of typical basaltic eucrites.

Among HED meteorites with broadly similar oxygen isotopic compositions, the only obviously vesicular specimen is diogenite Dhofar 700. The parent body for NWA 5721 surely cannot be the same as for vesicular, eucrite-like achondrites Ibitira and NWA 2824, because of the significant oxygen isotope differences [5]. The distinctive features of NWA 5721 also make derivation from the same body as typical eucrites (purportedly 4Vesta) unlikely, and in fact there may be at least six different sources for such mafic achondrites [see 2].

References: [1] Wiechert U. et al. (2004) *EPSL* **221**, 373-382; Greenwood R. et al. (2005) *Nature* **435**, 916-918; Greenwood R. et al. (2006) *Science* **313**, 1763-1765; *Antarctic Met. Newsletter* (2008) **31**, p. 15; Barrat J.-A. et al. (2008) *MAPS* **43**, 1759-1775; Rumble D. and Irving A. (2009) *Lunar Planet. Sci.* **XL**, #2293; Bland P. et al. (2009) *Science* **325**, 1525; Bunch T. et al. (2010) *73rd Meteorit. Soc. Mtg.*, #5315 [2] Irving A. et al. (2011) *Lunar Planet Sci.* **XLII**, this conference [3] Clayton R. and Mayeda T. (1996) *GCA* **60**, 1999-2017 [4] Barrat J.-A. et al. (2000) *MAPS* **35**, 1087-1100; Barrat J.-A. et al. (2007) *GCA* **71**, 4108-4124 [5] Bunch T. et al. (2009) *72nd Meteorit. Soc. Mtg.*, #5367.