PETROGRAPHY AND COMPOSITION OF LUNAR BASALTIC METEORITE NWA 3160. R.A. Zeigler[1], R. L. Korotev[1], A. J. Irving[2], B. L. Jolliff[1], S. M. Kuehner[2], and A. C. Hupé. [1]Dept. Earth & Planetary Sciences, Washington University, Campus Box 1169, St. Louis, MO 63130 zeigler@levee.wustl.edu [2]Dept. Earth & Space Sciences, University of Washington, Seattle, WA 98195.

Introduction: NWA 3160 is a new basaltic lunar meteorite collected in the North Africa desert. It consists of 3 stones totaling 34g. The main stone (28g) is a basalt clast with a minor amount of attached breccia. The two smaller stones (totaling 6 grams) are breccia fragments. NWA 3160 is paired with several other recently recovered basaltic/gabbroic meteorites from North Africa, collectively known as NWA 2727 [1]. The bulk composition o f the NWA 3160 basalt is similar to Apollo 12 [2] and Apollo 15 [3] olivine basalts in some respects, although there are also significant differences. The breccia portion of NWA 3160 has a similar mineralogy and broadly similar composition as the basalt portion, but differs in important ways. There may be a petrogenetic relationship between NWA 3160 and NWA 773.

Methods: We determined mineral compositions by electron microprobe analysis. Bulk chemistry was determined by INAA on 7 basalt (146 mg total) and 3 breccia (61 mg) subsamples of NWA 3160 [see 4 for more analytical details].

Petrography: The main mass of NWA 3160 is a porphyritic basalt (Fig. 1), with euhedral to subhedral olivine (~0.1-09 mm) and minor chromite (<0.1 mm)

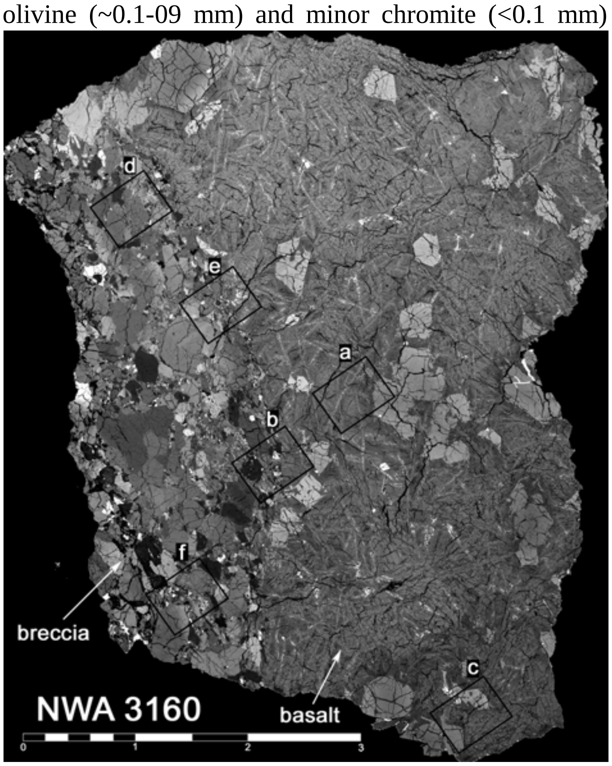

Figure1: Back-scattered electron (BSE) mosaic of NWA 3160 showing both the basalt (right) and the breccia (left lithologies. Black boxes are enlarged in Fig. 3. Scale bar is in mm.

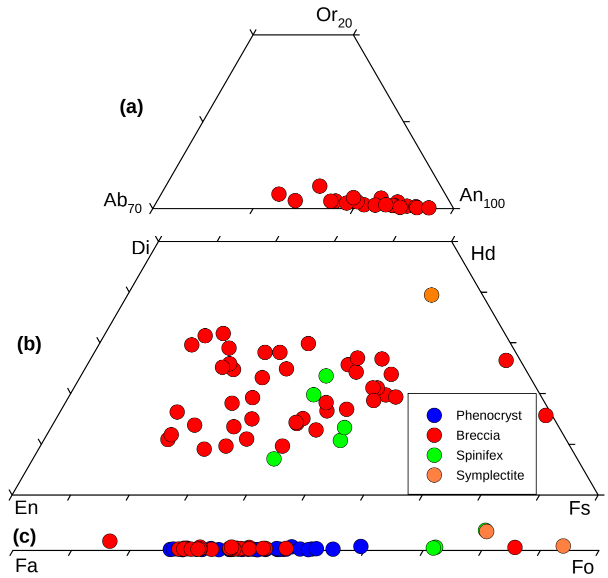

Figure 2: Mineral compositions in NWA 3160 in both the basalt lithology (blue and green) and the breccia lithology (red and orange). **(a)** portion of the An-Or-Ab feldspar ternary. **(b)** Pyroxene quadrilateral. **(c)** Olivine line.

phenocrysts. Olivine phenocrysts are zoned, with cores typically Fo_{55-70} and rims extending to ~Fo_{40} (Fig. 2). The basalt groundmass (Fig. 3) has spinifex olivine (Fo_{29}) and skeletal pyroxene ($En_{37-39}Wo_{11-13}$) set in a fine grained matrix of pyroxene ($En_{35-39}Wo_{20-23}$), glass, and olivine (~Fo_{22}). The breccia lithology of NWA 3160 is a fragmental breccia consisting primarily of olivine (Fo_{6-82}) and pyroxene ($En_{1-68}Wo_{9-39}Fs_{16-83}$), with minor amounts of plagioclase (An_{82-97}), and trace silica, symplectite, and Fe-Ti-Cr oxides.

Bulk Composition: Although we have not yet determined the major-element composition of the NWA 3160 basalt, the lack of ilmenite in the groundmass indicates that it is a low or very-low Ti basalt. The concentrations of FeO (21.6 wt%) and the ferromagnesian trace-elements Sc, Cr, and Co (41, 3570, and 66 ppm) in the basalt are consistent with those observed in Apollo 12 and Apollo 15 olivine basalts [2,3]. Concentrations of Na_2O and Eu (0.14 wt% and 0.55 ppm) are low by a factor of 1.5-2 relative to Apollo olivine basalts (and lower than any reported lunar basalt [5]), although some of the VLT picritic glasses have similar concentrations [5]. REE concentrations are slightly elevated relative to Apollo olivine basalts (~5 ppm Sm) and the REE pattern of NWA 3160 has an enrichment in light REE (Fig. 4), something uncommon in any lunar low-Ti basalt [2-4]. The Th:Sm ratio of the basalt is

0.33, higher than any previously analyzed group of lunar basalts [4]. The bulk composition of the breccia lithology of NWA 3160 is similar to the basalt lithology for many elements, e.g. FeO, Sc, Cr, Co (20.1 wt%, 40.3 ppm, 3080 ppm, 58 ppm), with the most notable differences being moderately higher Na_2O concentrations (0.19 wt% vs. 0.14 wt%), elevated ITE concentrations (by a factor of 2-3, e.g., ~15 pm Sm) and a REE pattern that is considerably more light REE enriched than the basalt.

Discussion: NWA 3160 is a new type of lunar olivine basalt. Although it shares some characteristics with other lunar olivine basalts (e.g., FeO, Sc, Cr, Co concentrations), there are significant differences, including a light-REE enriched REE pattern, higher Th/REE ratios, and exceptionally low Na_2O and Eu concentrations. These features make the NWA 3160 basalt nearly unique among lunar basaltic samples, with only lunar meteorite NWA 773 [6] sharing all of these compositional traits, although lunar meteorites LAP 02205 and NWA 032 have similar REE and Th concentrations [4]. Dhofar 287, a lunar meteorite olivine basalt also has a light REE enriched REE pattern, however, it does not have a high Th:Sm ratio (0.14) or depletions in Na_2O (0.53 wt%) and Eu (1.2 ppm) [7]. The exceptionally low concentrations of Na_2O and Eu in NWA 3160 indicate a source region that is depleted in plagioclase. The differences in composition between the breccia and basalt portions of NWA 3160 are minor for many elements, and are consistent with a higher proportion of normative plagioclase and lower proportion of normative olivine in the breccia than the basalt. The lithology responsible for the elevated ITE concentrations in the breccia is unknown at this time. The preliminary results suggest a possible relationship between NWA 3160 and NWA 773.

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References: [1] Bunch T. E. et al. (2006) *LPS XXXVII*, this volume. [2] Neal C. R. et al. (1994) *Meteoritics, 29*, 334-48. [3] Ryder G. and Shuraytz B. C. (2001) *JGR, 106*, 1435-51. [4] Zeigler R. A. et al. (2005) *MAPS, 40*, 1073-1101. [5] Papike J. J. et al. (1998) Planet. Mat., *Rev. Mineral. 36*. [6] Jolliff B. L. et al. (2003) *GCA, 67*, 4857-79. [7] Anand et al. (2003) *MAPS, 38*, 485-99.

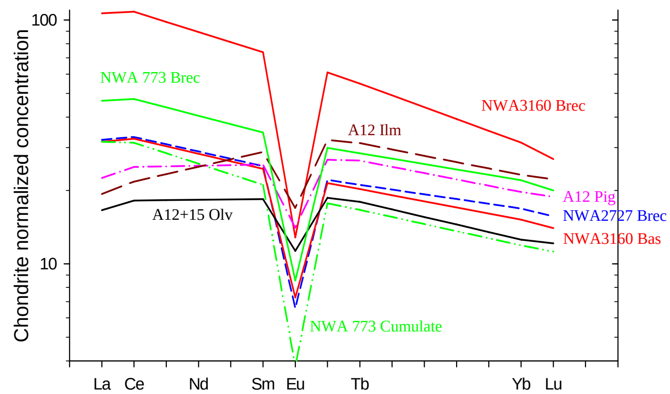

Figure 4: Chondrite-normalized REE plot showing NWA 3160 compared to other basaltic lunar meteorites and several low-Ti basalt suites. NWA 773 data from [6]. Apollo low-Ti basalt data from Fig. 13 in [4] and the references therein.

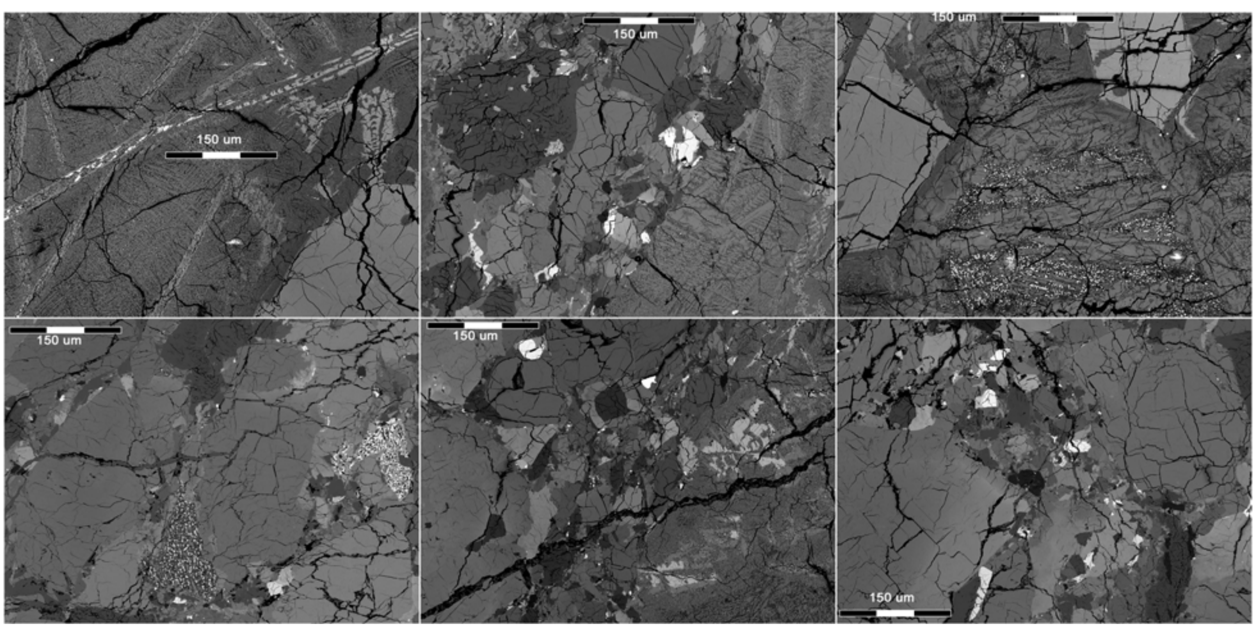

Figure 3: BSE images of NWA 3160. **(a)** Close-up of the basalt lithology showing a portion of an olivine phenocryst (olv) and the spinifex olivine (black arrows) and skeletal pyroxene (white arrows) grains of the matrix. **(b)** Contact between the basalt (right) and breccia (left) lithologies. **(c)** Close-up of the basalt lithology showing portions of two olivine phenocrysts and the fine grained matrix of pyx (medium grey), glass (dark areas), and olivine (tiny bright grains). **(d)** Close-up of the breccia lithology containing two different symplectite grains. **(e)** Contact between the basalt (right) and breccia (left) lithologies. **(f)** Close-up of the breccia lithology showing fine-grained clastic material separating two larger mafic mineral clasts.