PETROLOGY AND COMPOSITION OF LUNAR FELSIC GRANULITIC BRECCIA NORTHWEST AFRICA 8022 AND OCCURRENCE OF FORSTERITE IN LUNAR BRECCIA NWA 8001. S. M. Kuehner[1], A. J. Irving[1] and R. L. Korotev[2] [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195 (kuehner@ess.washington.edu), [2]Dept. of Earth & Planetary Sciences, Washington University, St. Louis, MO.

Introduction: The continued discovery of further lunar meteorites (now totaling at least 95 unpaired specimens), especially from sites in Oman and Northwest Africa, has considerably expanded our knowledge of the lithologic variety in parts of the Moon not represented by returned samples. NWA 8022 is a relatively felsic example among distinctive granulitic specimens representing a rare type of highlands lithology (in addition to NWA 3163 and paired stones, and NWA 5744 and paired stone). Here we also report on the discovery of the most magnesian olivine yet known from the Moon in non-granulitic feldspathic breccia NWA 8001.

Northwest Africa 8022: This partially fusion-crusted specimen (see Figure 1) is a highly recrystallized felsic olivine-gabbroic breccia containing some larger (to 2 mm) clasts rich in anorthite ($An_{95.9}Or_{0.3}$).

Figure 1. ***a. (above)*** *Whole NWA 8022 stone showing brown fusion crust (width 13 cm). Photo A. Aaronson.* ***b. (below)*** *Cut interior surface (width 3.7 cm) showing feldspathic clasts and shock veins. Photo A. Giesy.*

The matrix consists of extremely small grains (2-10 microns) of pigeonite ($Fs_{20.6-22.2}Wo_{21.5-10.0}$; FeO/MnO = 50-58), olivine ($Fa_{31.5-31.7}$; FeO/MnO = 93-101), ilmenite, Cr-ulvöspinel, fayalite, kamacite, pentlandite and rare awaruite enclosed in anorthite (see Figure 2).

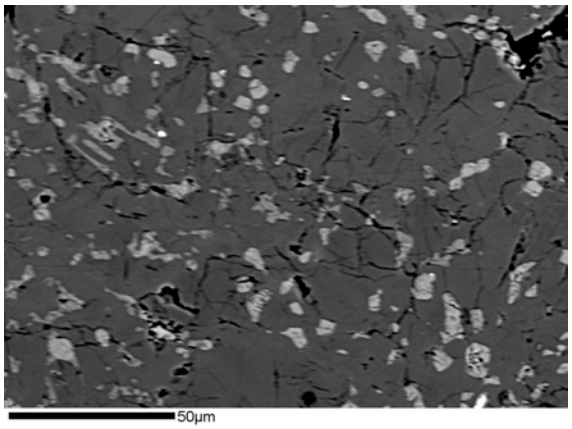

Figure 2. *BSE image of NWA 8022 matrix highlighting the extremely fine-grained olivine and pyroxene grains (light gray) within plagioclase (darker gray).*

Magnesian Olivine in Lunar Highlands Rocks: The most Mg-rich olivine previously found on the Moon (in several Apollo spinel troctolites) has a composition of Fa_8 [3]. Other troctolites and rare ultramafic rocks contain olivine in the range Fa_{10-17} [3].

Feldspathic breccia Northwest Africa 8001 is unique among lunar highlands rocks in containing sparse grains of even more Mg-rich forsterite ($Fa_{5.7-9.0}$; FeO/MnO = 91-104 – see Figure 3). Otherwise NWA 8001 is a complex polymict breccia composed of angular mineral clasts, some mare basalt clasts and glass spheres in a fine grained matrix. The major minerals are anorthite ($An_{96.8-97.3}Or_{0.1-0.2}$), more ferroan olivine ($Fa_{39.7-47.7}$; FeO/MnO = 89-95), low-Ca pyroxene ($Fs_{31.2-33.5}Wo_{5.6-3.9}$; FeO/MnO = 56-63) and subcalcic augite ($Fs_{17.2-44.4}Wo_{36.5-26.6}$; FeO/MnO = 49-62), along with minor subcalcic ferroaugite ($Fs_{58.8}Wo_{33.4}$; FeO/MnO = 72), ilmenite and troilite.

Rare grains of Cr-Mg-rich pleonaste spinel also are present, and potentially derive from a spinel troctolite lithology. This phase (presumably pink in color) invites comparison with the Apollo 17 pink spinel troctolites [4] and a small clast present in ALHA 81005 [5], although those parageneses include more ferroan olivine than the forsterite described above.

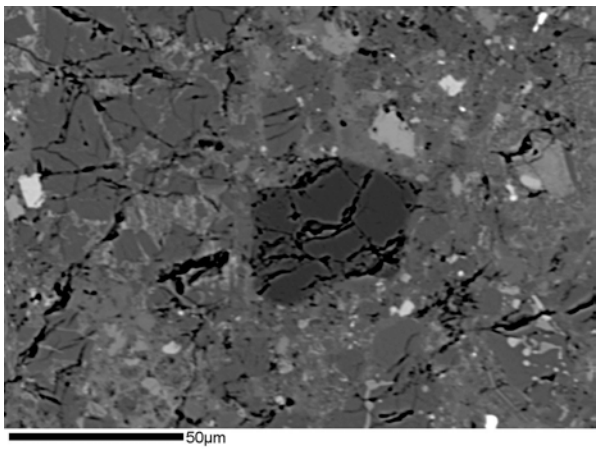

Figure 3. *BSE image of NWA 8001 showing angular forsterite grain (dark) associated with fragments of anorthitic plagioclase (medium gray), pyroxenes, olivine, ilmenite and troilite.*

Bulk Rock Compositions: The results of instrumental neutron activation analyses of bulk subsamples of NWA 8001 and NWA 8022 are given in a separate abstract [6], and selected abundances for lunar granulitic breccia specimens are plotted in Figure 4.

Among the granulitic specimens, NWA 8022 is more felsic (less mafic) than the NWA 3163 and NWA 5744 specimens (except for NWA 6475), and also is considerably more thorium-rich and REE-rich. We suggest that all these very fine grained specimens represent materials excavated from the deep lunar crust following burial and thermal metamorphism of impact-comminuted, more ancient highlands rocks of gabbroic-troctolitic-anorthositic compositions.

Most feldspathic lunar meteorites that are highly polymict (that is, the regolith and fragmental breccias), have Th/Sm = 0.3±0.1 (Figure 4), close to the KREEP ratio of ~0.35 depite the low concentrations of Sm and Th. NWA 8022 follows the trend noted by [7] that magnesian granulitic breccias have high Th/Sm (Figure 4). This disparity argues that the protoliths of magnesian granulitic breccias were largely uncontaminated by KREEP [7].

References: [1] Irving A. et al. 2006 *Lunar Planet. Sci.* **XXXVII**, #1365; Hudgins J. et al. 2011 *Geochim. Cosmochim. Acta* **75**, 2865-2881; McLeod C. et al. 2013 *AGU Fall Mtg.*, #V33D-2795 [2] Kuehner S. et al. 2010 *Lunar Planet. Sci.* **XLI**, #1552; Kent J. et al. 2012 *Lunar Planet. Sci.* **XLIII**, #2559 [3] Papike J. et al. 1998 *In* Planetary Materials, *Rev. Mineral.* **36** [4] James O. and Hedenquist J. 1978 *Lunar Planet. Sci.* **IX**, 588-590 [5] Gross J. et al. 2011 *Lunar Planet. Sci.* **XLII**, #2620 [6] Korotev R. and Irving A. 2014 *Lunar Planet. Sci.* **XLV**, this conference [7] Korotev R. et al. 2003 *Geochim. Cosmochim. Acta* **67**, 4895-4923.

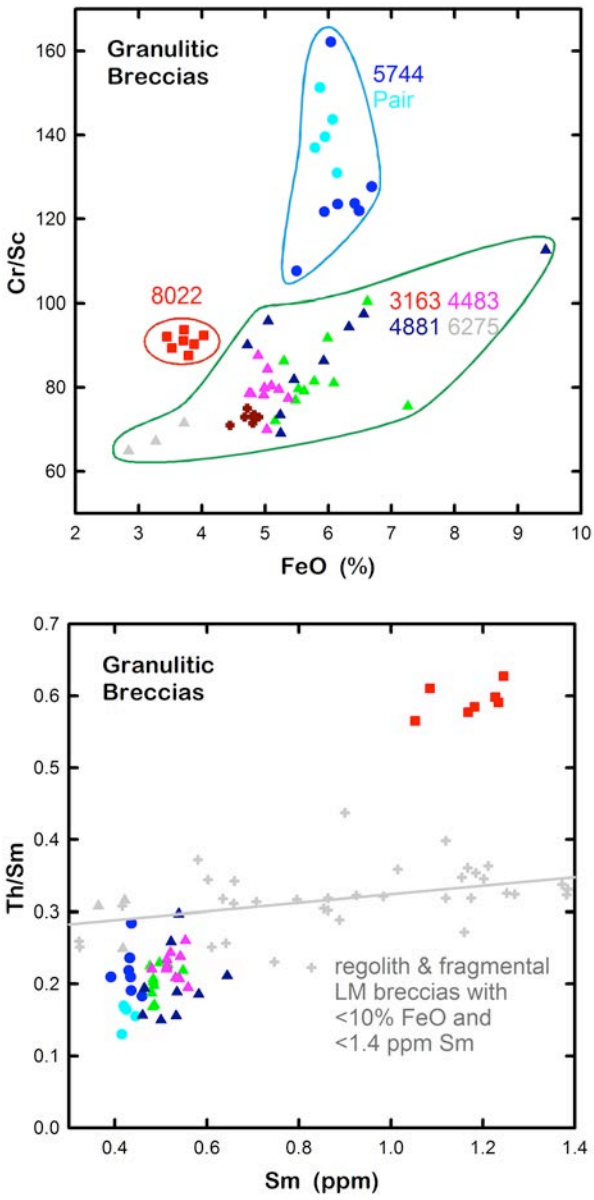

Figure 4. *Compositional plots for NWA 8022 and more mafic lunar granulitic breccias NWA 3163 and NWA 5744 (plus paired stones).*