Petrography and Geochemistry of Lunar Meteorite Miller Range 13317. [1]R. A. Zeigler and [2]R. L. Korotev. [1]NASA Johnson Space Center, 2101 NASA Rd 1, Mail Code XI2, Houston, TX 77058. ryan.a.zeigler@nasa.gov. [2]Washington University in St. Louis, 1 Brookings Dr. Campus Box 1169, St. Louis MO, 63130.

Introduction: Miller Range (MIL) 13317 is a 32-g lunar meteorite collected during the 2013-2014 ANSMET (Antarctic Search for Meteorites) field season. It was initially described [1] as having 25% black fusion crust covering a light- to dark-grey matrix, with numerous clasts ranging in size up to 1 cm; it was tentatively classified as a lunar anorthositic breccia. Here we present the petrography and geochemistry of MIL 13317, and examine possible pairing relationships with previously described lunar meteorites.

Methods: The petrography discussed here is based on optical, electron, and x-ray microscopy of two polished thin sections: MIL 13317,6 (1.25 cm^2) and MIL 13317,13 (~0.5 cm^2). We have obtained preliminary bulk-composition data by instrumental neutron activation analysis (INAA) of eight subsamples of MIL 13317,9 (266 mg total).

Petrography: Lunar meteorite MIL 13317 has a fine-grained glassy matrix that contains abundant lithic and mineral clasts (Fig. 1). Basalt clasts (up to ~0.5 cm) are the most common lithic clast type, but several large feldspathic impact-melt clasts (the largest is ~1 cm) are also observed. A variety of smaller granulitic clasts (typically magnesian and feldspathic; up to 0.3 cm) are found, as are abundant small symplectite clasts. Shock-melt veins, typically containing partially resorbed mineral clasts and schlieren are observed within the sample. Much of the plagioclase in the sample has been partially or completely shocked into maskelynite. A vesicular glassy fusion crust is observed: 19 wt% Al_2O_3; 0.8 wt% TiO_2; 0.5 wt% Na_2O; 10.5 wt% FeO; Mg' (Mg/[Mg + Fe]*100) of 52.

Most basalt clasts consist predominantly of large (up to 2-3 mm) zoned pyroxene grains, elongate zoned plagioclase and silica grains (up to ~3 mm), and fine-grained mesostasis areas containing minor amounts of K,Si-rich glass (up to ~75 wt% SiO_2, ~8 wt% K_2O), ilmenite (MgO < 0.5 wt%; Cr_2O_3 < 0.2 wt%), fayalite ($Fo_{<5}$), RE-merrillite, Cl-bearing apatite, and FeS. The pyroxene grains have cores of subcalcic augite and pigeonite (Mg' 40-60), trending toward rims of near endmember pyroxferroite (Fig. 2). Pyroxene grains are rarely exsolved (~1 μm), with both pigeonite hosting augite and vice versa. Large plagioclase grains are typically zoned from cores of $An_{90}Or_{<0.5}$ to rims of $An_{80-75}Or_{<2}$, although mesostasis plagioclase extends the compositional range observed to $An_{65}Or_{<4}$. Medium- and fine-grained basalt clasts and symplectite clasts are also observed (though less common); the observed mineral assemblages and compositions fall within the same ranges observed in the coarse-grained basalt clasts.

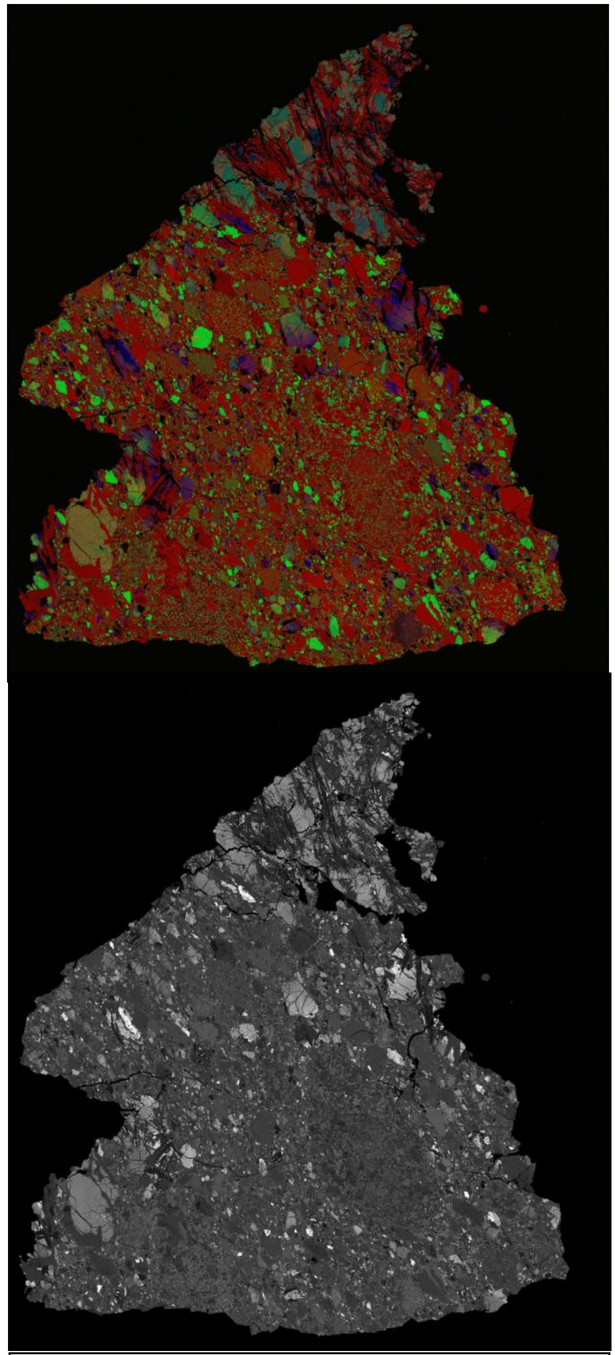

Figure 1: (top) RGB x-ray map (CaMgFe) of MIL 13317,13; (bottom) BSE image of MIL 13317,13. Field of view is 0.5 cm wide.

The feldspathic impact melt clasts have a few large plagioclase clasts set in a fine grained matrix of calcic

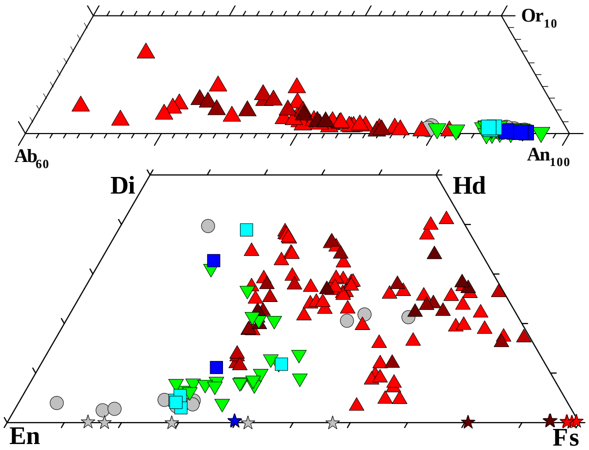

Figure 2: (top) Portion of the plagioclase ternary; (bottom) pyroxene quadrilateral with olivine compositions projected on to the En-Fs join (stars). Points in red are basaltic mineral clasts (different shades are different textures); blue are granulites, green are IMB, and grey are mineral clasts.

plagioclase (An_{98-90}) and low Ca pyroxene ($Fs_{45-25}Wo_{14-4}$) in approximately equal proportions, with minor amounts of more calcic pyroxene ($Fs_{36-29}Wo_{27-21}$), and rare occurrences of FeS and FeNi metal also observed. The granulite clasts are typically small, fine-grained, and magnesian (Fig. 2).

The most common mineral clasts are pyroxene and plagioclase, with less abundant clasts of olivine, ilmenite, silica, and glass also observed. FeNi metal and FeS clasts are rarely observed in the matrix. A single HASP glass clast (~100 µm in diameter; up to 55 wt% Al_2O_3) was found. The composition of the mineral clasts is largely representative of the minerals seen in the major lithic clasts, though a small subset of very magnesian (Mg' > 80) pyroxene and olivine mineral clasts not seen in a lithic clast is observed.

Geochemistry: MIL 13317 is compositionally distinct from any other lunar meteorite (Fig. 3; [2]).

Discussion: The predominance of lithic- and mineral-clasts of an obvious basaltic origin, coupled with the presence of regolith components such as a HASP glass means that MIL 13317 is a basaltic regolith breccia. The basalt is a VLT basalt on the basis of the modal abundance of ilmenite and composition of the fusion crust. While not necessarily a good measure of bulk major-element composition, FeO and Na_2O concentrations in the fusion crust do match the whole-rock INAA data. The paucity of FeNi metal and impact-glass clasts suggests that the regolith from which this meteorite was formed was immature.

References: [1] Satterwhite C. and Righter K. (2015) *Antarctic Meteorite Newsletter, Vol. 38, No. 2*. [2] Korotev R. L. and Irving A. J. (this conf.). [3] Korotev R. L. et al. (2011) *GCA* **75**, 1540–1573.

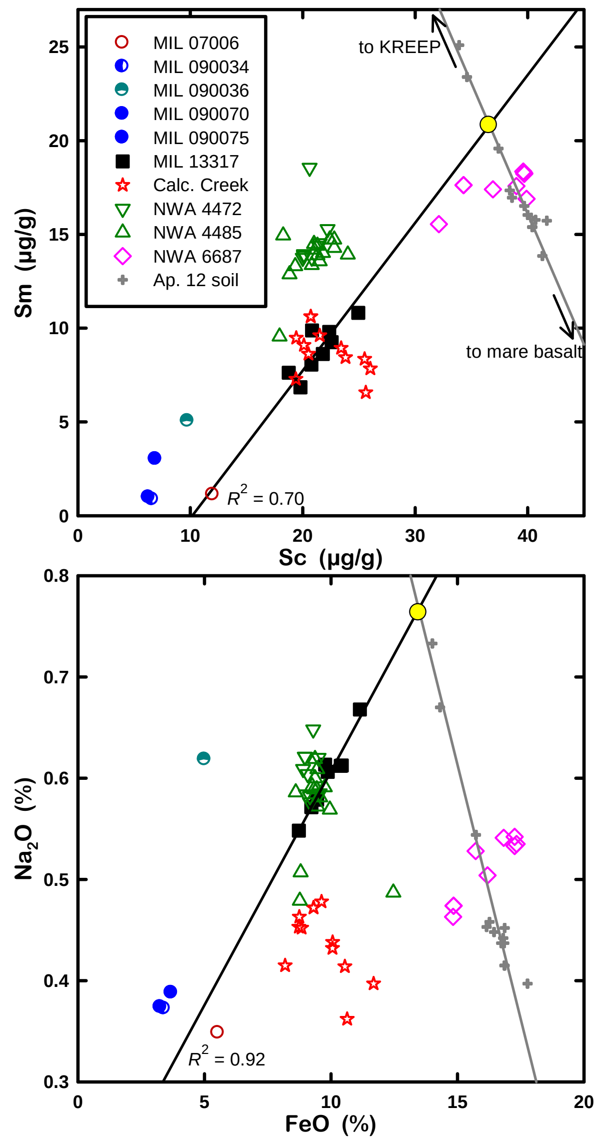

Figure 3. Comparison of MIL 13317 subsamples to subsamples of other meteorites of similar composition and to mean compositions of the other five MIL brecciated lunar meteorite stones, all of which are much more feldspathic. Unlike for Calcalong Creek, NWA 4472/4485, and NWA 6687, subsamples of MIL 13317 increase in Sm and Na concentration with increasing Sc and Fe (diagonal solid line). This trend suggests that the breccia is a mixture of (1) a regolith, represented hypothetically by the yellow circle, which itself is a mixture (as are the Apollo 12 soils [3]) of mare basalt and some KREEPy lithology, and (2) feldspathic material (the melt breccias and granulites) with compositions like MIL 07006 and paired stones MIL 090034/70/75. The mafic component cannot be just mare basalt because extrapolation of the FeO-Na_2O trend to 20% FeO, a typical value for mare basalt, leads to a absurdly high Na_2O concentration, 1.06%.