PETROGRAPHY AND GEOCHEMISTRY OF FERROAN TROCTOLITIC ANORTHOSITE IN LUNAR METEORITE MAC88105. B. L. Jolliff, L. A. Haskin, and R. L. Korotev, Dept. of Earth & Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University, St. Louis, MO, 63130

MAC88105 is a 662.5g meteorite of lunar origin [1,2] collected in the MacAlpine Hills location, Antarctica. It is an anorthositic, glassy matrix breccia that contains numerous lithic clasts, a small number of which are fragments of apparently monomict, igneous lithologies that have mineral compositions in the range expected for the so-called ferroan suite of lunar highland materials. Here, we present detailed petrography and mineral chemistry of one of these clasts, an apparent ferroan troctolitic anorthosite, based upon our examination of thin section MAC88105,97 and our bulk chemical analysis of five separate fragments from MAC88105,51 by INAA.

This clast, designated W2 by the JSC curatorial facility, was originally about 1 cm across, and was exposed on a sawed, interior surface of MAC88105. Thin section MAC88105,97 is small and contains the edge of this clast and some of the adjoining breccia matrix. The area of monomict material comprises a 1 x 3 mm portion of the thin section. The optically determined mode of this portion of the clast is 59 wt.% anorthite (maskelynite), 36% olivine, and 4.5% pyroxene (mostly augite with rare orthopyroxene intergrowths), and trace amounts of ilmenite and chromite. This mode (in vol.%) is that of anorthositic troctolite [3]; however, the material analyzed by INAA consisted of five 1-5 mg chips of the clast that differ substantially from each other in composition. Based on calculated modes, these range from ~90 wt% anorthite plus 10% mafic silicates to 69% anorthite plus 26% olivine; augite ranges from ~4.5 to 9%. Based on a mass balance of elemental concentrations determined for fragments of the clast by INAA and on mineral compositions by EMP, we estimate our sample of the bulk clast, MAC88105,51, to contain ~78 wt% anorthite, ~15% olivine, and ~7% augite plus minor low-Ca pyroxene; i.e., the composition is that of troctolitic anorthosite (Fig. 1). Our thin section is therefore not modally representative of 81005,51, which itself may not be representative of W2 overall, let alone its parent formation. The shapes of the chondrite-normalized REE patterns (Fig.2) mainly reflect the different modal proportions of anorthite and augite; the proportion of olivine has little effect on relative REE abundances but affects the overall concentration.

The clast is strongly shocked, and its original texture is obscured by nearly complete maskelynitization of anorthite and pervasive fracturing of all minerals to a degree exceeding that of the adjoining breccia matrix. Individual olivine grains are anhedral and range in size from ~50 to 500 μm. Pyroxene grains range in size from ~30 to 150 μm. Areas of monomineralic plagioclase span up to 600 μm. Minerals of this clast are unzoned and have uniform compositions. Plagioclase compositions are in the range $An_{96.4-97.4}$. Mafic silicate compositions are olivine, Fo_{55}, clinopyroxene, $Wo_{39}En_{43}Fs_{18}$, and low-Ca pyroxene, $Wo_4En_{60}Fs_{36}$ (Fig. 1 in [2]). The uniform mineral compositions indicate that this clast is monomict and of plutonic origin, probably as a cumulate. Its siderophile element concentrations are very low (Ni:Co < 3 and Au & Ir below our detection limit). Its mineral compositions are similar to those of a troctolitic anorthosite clast found in Y82192 [4,5] and a ferroan igneous lithology in Y791197 [5]. A ferroan troctolitic anorthosite clast has also been described from Apollo 16 breccia 64435 [6], but its mafic minerals have substantially higher Mg/(Mg+Fe). Clast MAC88105 W2 may be placed with the ferroan, mafic subgroup of "FAN-suite" rocks of [6], which includes samples from North Ray Crater, Apollo 16.

Five fragments of clast W2 were analyzed by INAA (samples C2A-C2E of [1]). For most elements analyzed, the compositions of the five fragments can be fit quite well by a model that mixes the three major phases in different proportions. The concentrations of Na and Fe in the phases are those observed in thin section MAC88105,97. Plagioclase contains the bulk of the Na_2O (0.34 %wt), Eu (0.81 μg/g), and La (0.92 μg/g); olivine contains most of the Co (~95 μg/g); and clinopyroxene contains the bulk of the Sc (~135 μg/g), HREE (Yb, 7.8 μg/g, Lu 1.02 μg/g), and some Co (~15 μg/g). This model accounts well for the compositions

of all fragments except for Sm and Tb in A, whose REE pattern lacks the negative slope that those of the other fragments show.

This apparent troctolitic anorthosite is of special interest because its dominant pyroxene is augite. If the clast consists of perfect cumulus minerals, the La concentration of the equilibrium liquid might have been as high as 18 μg/g, some 55 times that of chondrites. The parental magma would have had unusually high Ca/Al, so that olivine and plagioclase crystallization drove the derivative liquid across the cotectic surface to the field of high-Ca pyroxene and led to crystallization of augite before low-Ca pyroxene. If so, such a magma might represent a local anomaly or heterogeneity in the more generally inferred magma-sphere composition, or it might be unrelated to the inferred parent magma(s) of the more commonly observed ferroan suite rocks. Alternatively, this apparent troctolitic anorthosite may have formed initially as part of a cumulus troctolite that contained trapped liquid, then undergone equilibration among plagioclase, olivine, and clinopyroxene. Such was the case for 76535 (plagioclase La concentration 2.5 μg/g, but inferred parent liquid only ~9 μg/g) [7].

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Figure 1.

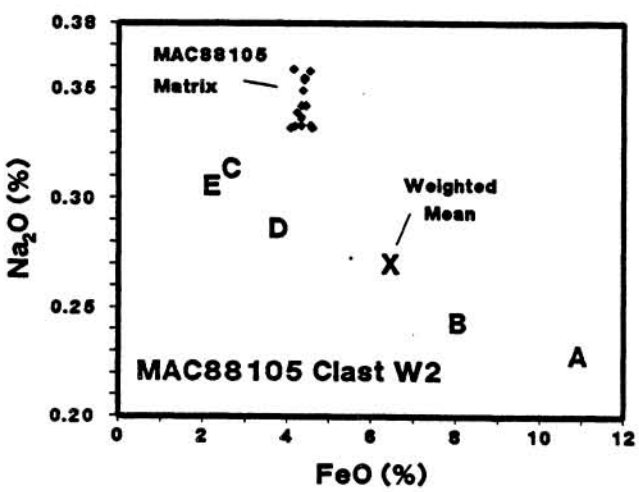

Figure 2