A COMPARISON OF ANORTHOSITIC LUNAR LITHOLOGIES: VARIATIONS ON THE FAN THEME.

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Introduction: Certain anorthositic rocks that are rare in the returned lunar samples have been identified among lunar meteorites (*e.g.* [1-4]). The variety of anorthosites in the Apollo collection also is more varied than is widely recognized. James et al. [5] identified three lithologies in a composite clast of FAN-suite rocks in lunar breccia 64435. They further divided all FANs into four subgroups: anorthositic ferroan (AF), mafic magnesian (MM), mafic ferroan (MF), and anorthositic sodic (AS, absent in the 64435 clast). Here we report Sm-Nd isotopic studies of the lithologies present in the 64435 composite clast and compare the new data to our previous data for lunar anorthosites incuding lunar anorthositic meteorites [1-4]. Mineralogy-petrography, *in situ* trace element studies, Sr-isotope studies, and Ar-Ar chronology are included, but only the Nd-isotopic studies are currently complete.

Mineralogy-petrography: We present Mg' and An contents of lithic fragments in the same thin sections (PTSs) studied by [5,6] as well as in new thick sections prepared for *in situ* trace element analyses by LA-ICPMS. Fig. 1 compares Mg' in olivine and low- and high-Ca pyroxene in the 64435 Coarse Troctolitic Anorthosite (CTA) to values in the Dhofar 489 and 908 Magnesian Anorthosites (MgAN [1]). Mg' values for these anorthosites are intermediate to values found more commonly for FANs and Mg-suite rocks. Data for the other 64435 lithologies plot at lower Mg' values more typical of FANs. Primary augite is present in CTA. Sodic anorthosites (SAN) [3,7] and the hypothesized "An93 anorthosite" [2,3] have slightly lower An contents than An~95 for the AS suite of [3]. The isotopic data presented here are for anorthosites of more typical An~97-98, the AF, MF, and MM rocks of [5,6].

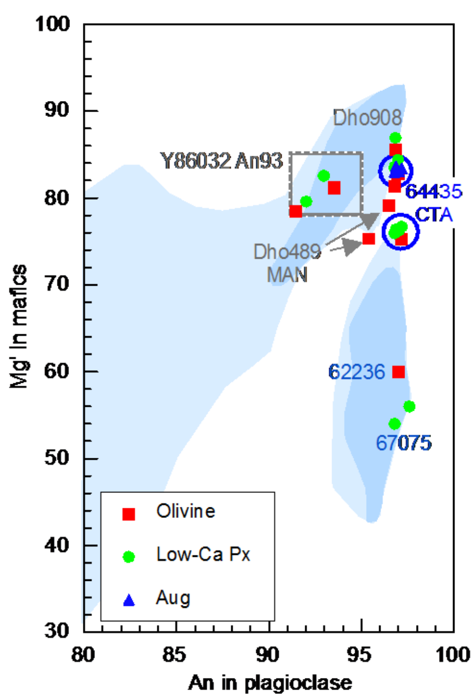

Figure 2. Mg' vs. An for selected anorthosites compared to these parameters for pristine rocks (blue shaded background [3]).

Trace Element Geochemistry: Trace element data for individual 64435 clasts were reported by [5], and *in situ* SIMS analyses by [6]. New solution ICPMS analyses of bulk samples of CTA, CA, and two bulk samples of FTA are shown in Fig. 2. (See [5] for clast nomenclature). REE abundances in CA are slightly lower than those in bulk samples of better known large anorthosites like 60025 and 15415. REE abundances in bulk CTA and ,325 FTA are similar even though Mg' is higher than for typical FANs. Also shown in Fig. 2 are REE abundances in fragmental breccias MIL 090034 (MIL34) and MIL 090070 (MIL70) [4]. These two highland breccias are among the most plagioclase-rich of lunar highland meteorites, and plot in the "troctolite" field on a diagram of FeO vs. Al_2O_3 [4]. Typical highlands meteorites have Al_2O_3 ~26% (*cf.* [4]) compared to ~30% for MIL34 and MIL70, and ~36% for

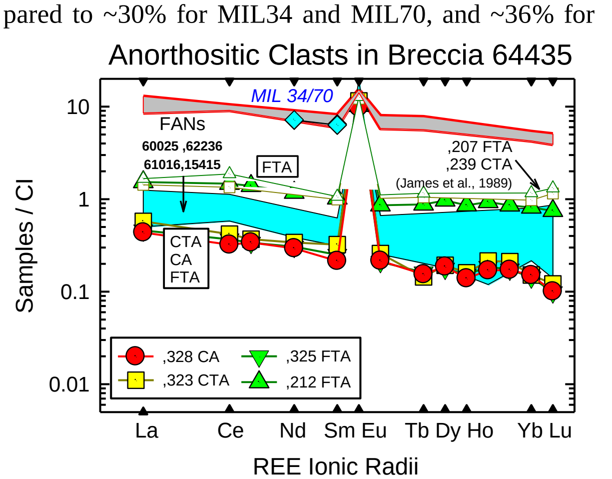

Figure 1. REE abundances in 64435 lithologies. Abundances in ,325 FTA are nearly identical to those in ,328 CA, and are not clearly visible in the figure.

“pure anorthosites like 15415 and 60025.

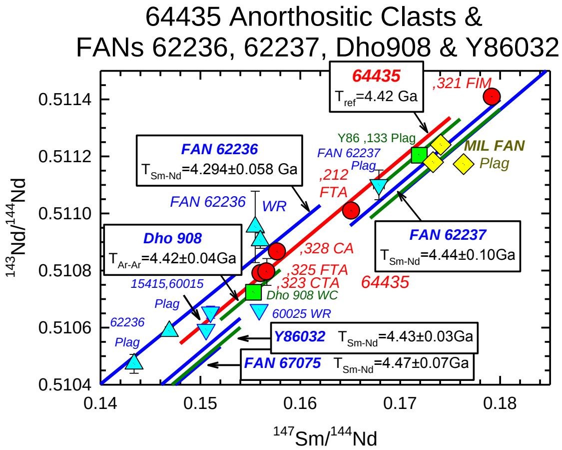

Figure 3. ^{147}Sm-^{144}Nd data for 64435 clasts (red circles) compared to data for ~4.3-4.5 Ga anorthosites.

^{147}Sm-^{143}Nd data: Fig. 3 shows new data for the 64435 clasts compared to data for some larger anorthosites analysed at JSC. Internal Sm-Nd isochrons in the range ~4.3-4.5 Ga as shown in the figure were determined for several of those anorthosites. No isochron is confidently determined for the 64435 lithologies alone. However, if the fine-grained impact melt (FIM) is included, the data define a regression line (not shown in Fig. 3) corresponding to an apparent age of 4.0±0.5 Ga and initial ε_{Nd} (CHUR) = 0.2±2.0 (CHUR = Chondritic Unifrom Reservoir [8]). There are only minor differences in the Nd-isotopic systematics of CA, CTA, and ,328 FTA suggesting similar source materials for anorthositic and troctolitic samples. The Nd isotopic data of the 64435 lithologies are nearly coincident with those of the “white clast” in the Dho 908 lunar highland meteorite at comparatively low ^{147}Sm^{144}Nd and at higher ^{147}Sm/^{144}Nd with plagioclase in the “white clast” Y86032,133 in Yamato 86032 [3], as well as with the data for the MIL 34/70 lunar meteorites suggesting that the petrogenetic processes are not site-specific. We note that impact resetting of the Ar-Ar ages of the MIL34/70 anorthositic breccias [4] is not apparent in their Sm-Nd data.

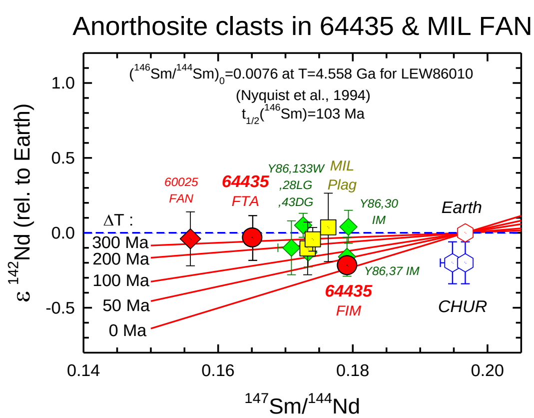

Figure 4. ^{142}Nd-^{144}Nd data for 64435 and Y86032 clasts and MIL 34/70 lunar highlands meteorites.

^{146}Sm-^{142}Nd data: New ^{146}Sm-^{142}Nd data for the 64435 clasts and the MIL34/70 meteorites are consistent with their formation within the first ~200 Ma of solar system history from an Earth-like isotopic reservoir characterized by the present day ^{142}Nd /^{144}Nd of the terrestrial laboratory standard, or with later formation from a CHUR reservoir (Fig. 4). More complex models do not seem justified by the data.

(T, ε_{Nd}) of lunar anorthosites: Fig. 5 shows (T, ε_{Nd} values of the 64435 lithologies plotted at the average internal isochron age of troctolitic anorthosites 62236 [9] and 62237, i.e., 4.37±0.07 Ga. Also shown are data for other anorthosites and two KREEP balsalts. JSC internal isochron data for 67075 and Y86032 clasts [2], and 60025 plagioclase plotted at the 4360±3 Ma age of [10] are consistent with the CHUR [8] value for an undifferentiated LMO, or one in which plagioclase dominates the REE budget. Other anorthosites contain more radiogenic Nd produced in an environment in which mafic phases dominated the REE budget, perhaps in rockbergs with variable proportions of mafic minerals forming and remelting during a protracted LMO phase. (*cf*. [11], Fig. 4 of [12]).

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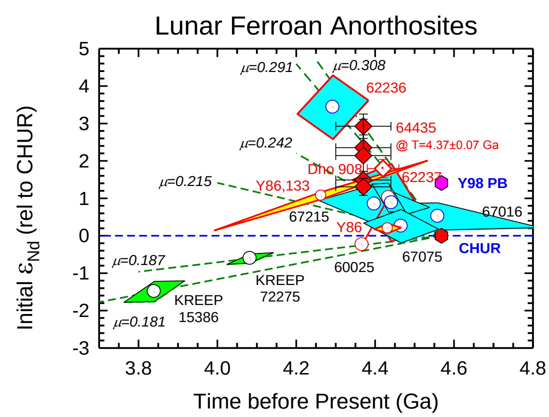

Figure 5. (T, ε_{Nd}) diagram for lunar anorthosites.