LUNAR CRUSTAL HISTORY RECORDED IN LUNAR ANORTHOSITES. L. E. Nyquist 1, C.-Y. Shih 2, Y. D. Reese 3, J. Park 4,5, D. Bogard 1, D. Garrison 2, A. Yamaguchi 6. 1KR/NASA Johnson Space Center, Houston, TX 77058. E-mail: laurence.e.nyquist@nasa.gov. 2ESCG Jacobs-Sverdrup, Houston, TX 77058. 3Mail Code JE-23, ESGC/Muniz Engineering, Houston, TX 77058. 4Lunar and Planetary Institute, 3600 Bay Area Blvd. Houston, TX 77058, 5NASA-MSFC, Huntsville, AL 35812 & Univ. Alabama @ Huntsville, 35805, 6National Institute of Polar Research, Tachikawa, Tokyo, 190-8518, Japan.

Introduction: Anorthosites occur ubiquitously within the lunar crust at depths of ~3-30 km in apparent confirmation of the Lunar Magma Ocean (LMO) hypothesis. [1]. We have dated lunar anorthosite 67075, a Feldspathic Fragmental Breccia (FFB) collected near the rim of North Ray Crater by the Sm-Nd and Rb-Sr techniques. We also have dated an anorthositic white clast (WC) in lunar meteorite Dhofar 908 by the 39Ar-40Ar technique and measured whole rock (WR) Sm-Nd data for a companion sample. We discuss the significance of the ages determined for these and other anorthosites for the early magmatic and bombardment history of the moon.

Concordant Sm-Nd and Rb-Sr Ages for 67075: Although 39Ar-40Ar ages of ~3.95-4.04 Ga have been reported for 67075 [2,3], our Sm-Nd and Rb-Sr ages for this anorthosite are 4.47±0.07 Ga and 4.49±0.07 Ga, respectively. Figure 1 shows the Sm-Nd isochron; the Rb-Sr isochron is not shown here.

Similarly old Sm-Nd ages have been determined for Apollo 16 anorthosites 60025 [4] and 67215 [5], and other anorthosites for the early magmatic and sialic white clast (WC) in lunar meteorite Dhofar 908 [6].

Anorthositic Clasts of Lunar Meteorites Y86032 and Dho 908

Figure 1. Sm-Nd data for Dho 908 WC compared to bulk, plagioclase and pyroxene-enriched samples of Y-86032 [8].

Figure 2. Sm-Nd isochron for 67075.
the clast. (A higher age for the last 3% of the Ar is discounted.)

Discussion: Two other measured Ar-Ar ages for FANs are 3.93±0.08 Ga for 67215 [5], and 4.15±0.12 Ga for 60025 [9, Bogard,unpublished]. These ages are reset and show that these anorthosites were exposed to secondary heating that also could have perturbed the other chronometers. In contrast, anorthositic clasts in two lunar meteorites, Yamato 86032 and Dhoar 908, retain older Ar-Ar ages up to ~4.35 Ga [7, this investigation], consistent with Sm-Nd ages of the clasts.

Lunar Meteorites Retain “High” Ar-Ar Ages. On the basis of the few currently available analyses, it appears that the anorthositic clasts in lunar highland meteorites are less likely to have been reset by secondary heating events than anorthosites returned during the Apollo program. The upper portion of Fig. 4 shows Ar-Ar ages measured in the JSC lab for anorthositic clasts from Y-86032 [7], the magnesian anorthosite (MAN) clast from Dhofar 489 [10], as well as Dho 908WC. Also shown are the ages of an impact melt vein in Y-86032 [7] and the matrix of Dho 908 [11]. Only the impact melt (Y-86032,30) has an Ar-Ar age consistent with the nominal ~3.8-4.0 Ga period of the putative lunar impact cataclysm, a hint that “cataclysmic” impacts were on average less energetic in the source regions of these meteorites than on the lunar nearside.

Lunar Anorthosites: From Diverse Sources. Fig. 5 summarizes (T, Nd) values for highland rocks analyzed in the JSC lab. Lunar anorthosites tend to have \( ^{143}Nd/^{144}Nd > 0 \) when compared to a chondritic reference value, i.e., CHUR [6], apparently inconsistent with derivation from a single lunar magma ocean. This problem is partially resolved if lunar initial \( ^{143}Nd/^{144}Nd \) is taken equal to HEDR for the HED parent body [7], but enough variability remains among the anorthosite data alone to suggest that lunar anorthosites do not derive from a single source, i.e., they are not all products of the LMO. Orbital geochemical studies confirm variability in lunar crustal composition [1, 13].