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LUNAR CRUSTAL HISTORY FROM ISOTOPIC STUDIES OF LUNAR ANORTHOSITES

Abstract

Anorthosites occur ubiquitously within the lunar crust at depths of 3-30 km in apparent confirmation of the Lunar Magma Ocean (LMO) hypothesis [1,5]. We will present recent chronological studies of anorthosites [2] that are relevant both to the LMO hypothesis and also to the lunar cataclysm hypothesis. Old (ca. 4.4 Ga) Sm-Nd ages have been determined for some Apollo 16 anorthosites, and primitive initial $^{87}\text{Sr}/^{86}\text{Sr}$ ratios have been measured for several, but well-defined Rb-Sr ages concordant with the Sm-Nd ages have not been determined until now. Lunar anorthosite 67075, a Feldspathic Fragmental Breccia (FFB) collected near the rim of North Ray Crater, has concordant Sm-Nd and Rb-Sr ages of 4.47 ± 0.07 Ga and 4.49 ± 0.07 Ga, respectively. Initial $^{143}\text{Nd}/^{144}\text{Nd}$ determined from the Sm-Nd isochron corresponds to $\epsilon_{\text{Nd,CHUR}} = 0.3\pm 0.5$ compared to a Chondritic Uniform Reservoir, or $\epsilon_{\text{Nd,HEDPB}} = -0.6\pm 0.5$ compared to the initial $^{143}\text{Nd}/^{144}\text{Nd}$ of the HED Parent Body [3]. Lunar anorthosites tend to have positive ϵ_{Nd} when compared to CHUR, apparently inconsistent with derivation from a single lunar magma ocean. Although ϵ_{Nd} is negative for some anorthosites if lunar initial $^{143}\text{Nd}/^{144}\text{Nd}$ is taken equal to HEDR for the HED parent body [3], 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. An anorthositic clast from desert meteorite Dhofar 908 has an ^{39}Ar - ^{40}Ar age of 4.42 ± 0.04 Ga, the same as the 4.36 - 4.41 ± 0.035 Ga ^{39}Ar - ^{40}Ar age of anorthositic clast Y-86032,116 in Antarctic meteorite Yamato-86032 [3,4]. Conclusions: (i) Lunar anorthosites come from diverse sources. Orbital geochemical studies confirm variability in lunar crustal composition [1, 5]. We suggest that the variability extends to anorthosites alone as shown by the Sm-Nd data (Fig. 2) and the existence of magnesian anorthosites (MAN, [6]) and “An93 anorthosites” [3,4]. (ii) Anorthositic clasts in lunar meteorites retain “high” Ar-Ar ages compared to Apollo anorthosites. This is perhaps a hint that “cataclysmic” impacts were on average less energetic in the mostly farside source regions of these meteorites than on the lunar nearside. References: [1] Ohtake M. et al. (2009) *Nature* 461, 236-241. [2] Nyquist L. et al. (2009) LPSC41, submitted. [3] Nyquist L. et al. (2006) *GCA* 70, 5990-6015. [4] Yamaguchi A. et al (2010), *GCA*, submitted. [5] Cahill J. T. S. et al. (2009) *JGR* 114, E09001. [6] Takeda H. et al. (2006) *Earth Planet. Sci. Let.* 247, 171-184.