
Rb-Sr AND Sm-Nd ISOTOPIC STUDIES OF LUNAR HIGHLAND METEORITE Y86032 AND LUNAR FERROAN ANORTHOSITES 60025 AND 67075. C.-Y. Shih1, L. E. Nyquist2, Y. Reese1 and A. Yamaguchi3, and H. Takeda4, 1Mail Code C23, Lockheed-Martin Space Operations, 2400 NASA Parkway, P.O. Box 58561, Houston, TX 77258-8561, chi-yu.shih1@jsc.nasa.gov; 2Mail Code KR, NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058, l.nyquist@jsc.nasa.gov; 3NIPR, Tokyo 173-8515, Japan, yamaguch@nipr.ac.jp; 4Research Institute, Chiba Institute of Technology, Narashino, Japan, takeda@pf.it-chiba.ac.jp

Introduction: Lunar meteorite Yamato (Y) 86032 is a feldspathic breccia containing anorthositic fragments similar to ferroan anorthosite (FAN) clasts commonly found in Apollo 16 highland rocks [1-3]. Previous 39Ar-40Ar analyses of a grey anorthositic clast (116 GC) in Y86032 revealed an old degassing age of 4.39±0.06 Ga [4], which is as old as crystallization ages of some FANs e.g. 60025, 67016 and 67215, as determined by the more robust Sm-Nd radiometric crystallization ages of some FANs e.g. 60025, 67016 and 67075. Previous Rb-Sr AND Sm-Nd ISOTOPIC STUDIES OF LUNAR HIGHLAND METEORITE Y86032 AND LUNAR FERROAN ANORTHOSITES 60025 AND 67075. C.-Y. Shih 1, L. E. Nyquist 2, Y. Reese 1 and A. Yamaguchi 3, and H. Takeda 4, 1Mail Code C23, Lockheed-Martin Space Operations, 2400 NASA Parkway, P.O. Box 58561, Houston, TX 77258-8561, chi-yu.shih1@jsc.nasa.gov; 2Mail Code KR, NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058, l.nyquist@jsc.nasa.gov; 3NIPR, Tokyo 173-8515, Japan, yamaguch@nipr.ac.jp; 4Research Institute, Chiba Institute of Technology, Narashino, Japan, takeda@pf.it-chiba.ac.jp

Isotopic data clearly indicate that Y86032 is closely related to FANs and contains materials formed during early differentiation of the LMO. The impact melt sample,33 lying to the far right of the isochron may have gained Rb during its formation. Including the four Y86032 data, the FAN isochron age and I(Sr) becomes 4.7±0.4 Ga and I(Sr)=0.699060±23, respectively. This isochron probably represents the time of the LMO formation and can be used to estimate the lunar initial 87Sr/86Sr ratios. These lunar FAN samples are consistently more evolved than their eucrite counterparts represented by the reference isochron of T=4.44±0.17 Ga and I(Sr)=0.699004±9 (dotted line), defined by eleven plagioclase data from ten eucrites (triangles) studied in this lab [13]. The dashed line shows our reference isochron for CAI E38 of Efremovka using its Sm-Nd age [13]. Efremovka, a CV-type C-chondrite similar to Allende. Its CAI E-38 gives an I(Sr) of 0.69834±15, which is within errors of I(Sr), 0.69892±2, reported for Allende CAI’s in [14].

Figure 1. Rb-Sr data for Y86032 samples and FAN and eucritic plagioclases.

Sr isotopic evolution and timescale of lunar formation: Fig. 2 shows the correlation of 87Sr/86Sr and formation time interval ΔT as functions of parent reservoirs with various 87Rb/86Sr ratios. Thick dotted lines represent Sr-isotopic growth curves corresponding to 87Rb/86Sr ratios of ~1.04 (EH, enstatite chondrites), ~0.26 (C-chondrite, CV-type) and ~0.084 (Earth) from the solar system initial 87Sr/86Sr ratio of 0.69934 resembling CAI E-38 from Efremovka (CV). The intersections (circles) of the estimated lunar initial 87Sr/86Sr ratio of 0.699069 (at 4.56 Ga) with these growth curves yield the possible formation time intervals for the Moon. In the context of lunar origin by the giant impact hypothesis, a
single-stage evolution of the Sr isotopic composition is most consistent with a CV-type reservoir, for which ~35 Ma of evolution is required. A similarly rapid timescale (20-40 Ma) for lunar formation was proposed recently using the short-lived Hf-W system [15,16]. A longer time of ~105 Ma is needed if the lunar Sr originated from an Earth-like $^{87}$Rb/$^{86}$Sr reservoir prior to the giant impact. However, a more complex multi-stage Sr isotopic evolution is also permissible. Fig. 2 shows a first stage of proto-lunar evolution in a high $^{87}$Rb/$^{86}$Sr EH-like reservoir for ~6 Ma (open diamond), and follows by a second stage of evolution in an Earth-like reservoir for ~30 Ma (thin dotted line).

Petrogenetic implications: The $\varepsilon_{Nd}$-values and age data for Y86032 and Apollo 16 FANs and KREEP basalts are summarized in Fig. 4. The 67075 bulk sample has a highly positive $\varepsilon_{Nd}$ value of ~8 for its $^{39}$Ar/$^{40}$Ar age of 3.98±0.05 Ga [17]. It and 62236 [12] were probably derived from comparatively young LREE-depleted sources, not related to the LMO. Our 60025 bulk sample, and Y86032,44DG and ,28LG data plot near the KREEP evolution line of $^{147}$Sm/$^{144}$Nd = ~0.17. A REE model calculation shows that the ,28 LG sample can be a plagioclase cumulate, with ~5% trapped liquid, crystallized from an LMO having $^{147}$Sm/$^{144}$Nd = ~0.18 after ~94% differentiation. However, high $^{147}$Sm/$^{144}$Nd of ,116GC and ,33IM, can not be produced from a melt with $^{147}$Sm/$^{144}$Nd = ~0.12, as indicated by its negative $\varepsilon_{Nd}$ value at ~4.39 Ga by a similar plagioclase accumulation process, suggesting an older primary crystallization age.