Lunar Meteorites not in conformity with the Lunar Evolution Model based on the Apollo samples.

Hiroshi Takeda[1]; Tomoko Arai[2]; Akira Yamaguchi[3]; Makiko Ohtake[4]

[1] Chia Inst. of Tech.; [2] Lunar Exploration Technology Office, JAXA; [3] NIPR; [4] JAXA

Magma ocean model and the related crustal evolution scenarios of the Moon are mostly based on the Apollo samples collected mainly from the Procellarum KREEP Terrane (PKT). The Ar-Ar ages of most of the crustal rocks in the Apollo samples from the PKT and the surrounding area were reset at around 3.9 b.y. by the basin forming event of Mare Imbrium [1]. We studied two lunar meteorites of highland derivation, Yamato (Y) 86032 and Dhofar (Dho) 489 with the Ar-Ar ages older than 4.3 b.y. and some meteorites from the mare regions, and propose that there are lithologies not in conformity with the Apollo model. We will search for ejection sites of such meteorites in our future lunar missions to establish a global lunar evolution model.

Y86032 is a feldsparthic lunar highland breccia with abundant anorthositic clasts. The absence of KREEP components in the matrix of Y86032 indicates that this meteorite came possibly from the far-side of the Moon. One ferroan anorthosite (FAN) clast has a very old Ar-Ar age of 4.35-4.4 b.y. and epsilon (Nd) of this clast is negative. Eight new polished thin sections (PTS)s made from a large slab [2] contained a large clast of anorthositic breccia (Fig. 1). The range of their An contents of their mineral pairs of anorthite and olivine/pyroxene is slightly more Na-rich than the FAN trend. Discovery of many anorthositic clasts in Y86032 with more Na-rich and Mg-rich than the FAN suggests that there are some lithologies associated with the evolution of the magma ocean, which cannot be explained by the Apollo model.

We found a crystalline clast 4.1x1.3 mm in size in Dho 489 [3]. This clast shows a coarse granulitic texture with elongated oval shaped olivine crystals (up to 0.69 mm). The Fo contents of olivine (Fo84) represent one peak of the bimodal distributions of olivines in the matrix. The Cr/(Cr+Al) atomic ratios of the pleonaste spinel grains in plagioclase (An96) are similar to those found in the Apollo spinel troctolites,which were located at depths greater than or equal to about 12 to 32 km prior to excavation. Bussey and Spudis [4] reported that inner rings of all four largest basins display massifs of nearly pure anorthosite (FeO less than 1 wt %). The Crisium basin displays distinct compositional zoning within exterior sectors of the basin with more mafic silicates. The result in connection with the presence of pure anorthosites excavated from the largest basins as given above will further constrain the origin of Dho 489.

Chemical variations of the Apollo mare basalts were interpreted in terms of TiO2 abundance, such as High-Ti, Low-Ti, and Very-Low-Ti (VLT) basalts. It was known that the mare basalts extruded during 3.8- 3.2 b. y. and basalts with higher Ti contents likely show older crystallization ages, based on the Apollo basalt data. However, some meteorites from the mare regions (Y793169 and Asuka 881757) with Ti content as low as VLT have ages of over 3.9 b. y. [5].

The older Ar-Ar ages of Y86032 [6] and Dho 489 [3] suggest that large basins responsible to the excavation of Y86032 and Dho 489 is not Mare Imbrium. We propose that a large basin formation may mix deep seated crustal rocks such as spinel troctolites with pure anorthosites to produce a magnesian anorthositic breccia. In our future SELENE mission, it is one of crucial science goals to locate the ejection sites for these lithologies which have not been found in the Apollo samples, in order to understand global lunar crustal evolution processes.

References: [1] Nyquist L. et al. (2002) The Century of Space Science, 1325-1376. [2] Yamaguchi A. et al. (2004) LPS XXXV, #1474. [3] Takeda H. et al. (2004) LPS XXXV, #1222. [4] Bussey D. B. and Spudis P. D. (2000) JGR 105, No.E2, 4235-4243. [5] Arai T. et al. (1996) MPS 31, 877-892; Kita et al. (1995) GCA59, 2621-2632. [6] Bogard D. D. et al. (2000) LPS XXXI, #1138.

Figure 1. Photomicrograph of an anorthositic clast in Y86032,45. Width 5 mm.