

Pairing of basalt clasts in breccias and basalts of lunar meteorites based on pyroxene REE abundances

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Lunar meteorites are important sources of information of the Moon as well as Apollo and Luna returned samples. Over the sixty lunar meteorites collected from Antarctica and hot deserts represent around thirty different locations on the Moon [e.g., 1], because of pairing. Yamato (Y) 793169 and Asuka (A) 881757 (YA basalts, hereafter) are probably the most significant lunar meteorites in the point that they are low-Ti unbrecciated mare basalts crystallized about 3.9 Ga [2, 3]. The discovery of the YA basalts gave us the clue to reconsider the empirical composition-age correlation in mare basalts volcanism that higher-Ti basalts erupted at older ages and lower-Ti at younger age. Y981031 is a regolith breccia consisting of mare basalt clasts and highland rocks. The basalt clasts show remarkable similarities of YA basalts especially A881757, such as constituent minerals, mineral compositions, coarse grain size, relatively coarsely-exsolved pyroxene lamellae by typical mare basalt standard, and the presence of fayalite-silica symplectite [4]. Here, we present pyroxene REE abundances measured by ion microprobe in order to verify the possible petrogenetic connection of the basalt clasts in Y981031 and YA basalts. We analyzed three cores and rims in three pyroxene grains from Y981031 basalt clasts: core 1 (Fe# 0.35, Wo33En44), rim1 (Fe# 0.65, Wo15En29), core 2 (Fe# 0.3, Wo40En42), rim 2 (Fe# 0.54, Wo19En38), core 3 (Fe# 0.39, Wo11En54), rim 3 (Fe# 0.69, Wo17En26). Also analyzed are a core, a rim and an intermediated point in A881757: core (Fe# 0.47, Wo31En37), mid (Fe# 0.65, Wo22En27), rim (Fe# 0.87, Wo41En7), and two cores, rims and one intermediate point in Y793169: core 1 (Fe# 0.44, Wo21En45), rim 1 (Fe# 0.97, Wo19En2), core 2 (Fe# 0.39, Wo24En46), mid 2 (Fe# 0.56, Wo25En33), rim 2 (Fe# 0.75, Wo24En19). Analyses were done by Cameca imf-1270 ion microprobe at the Geological Survey of Japan.

Both REE concentrations and chondrite-normalized patterns are similar in measured pyroxenes of the three meteorites. The REE concentrations become enriched from cores to rims for all the pyroxenes, correlating with Fe #, rather than with Wo content. The REE patterns do not much change between cores and rim. In all the three meteorites pyroxenes, positive slopes are found from La to Sm and slightly positive or flat slopes from Gd to Yb, but the degree of LREE slopes are varies: Sm/La = 1.8 - 4.9 in Y981031, 1.3 - 3.7 and 14 (core 2) in Y793169, and 6.1 - 9.8 in A881757. All cores and rims have negative Eu anomaly and the extents of Eu anomaly are almost identical. In Y793169, the positive LREE slopes is extremely steep in one core, but others are similar to those of Y981031, while the slopes are generally steeper in A881757 than Y793169 and Y981031. REE abundances for pyroxene rims are about 4 - 8 times higher than those for cores in the three meteorites: LREE: 8.3 (Sm) x chondrite and HREE: 6.2 (Dy) x chondrite in Y981031; LREE: 5.3 (Sm) x chondrite and HREE: 6.5 (Dy) x chondrite in A881757 and LREE: 6.9 (Sm) x chondrite and HREE: 3.9 (Dy) x chondrite in Y793169. The core-rim variation of REE abundances in the three samples are not unusual for typical, rapidly cooled mare basalts and the REE patterns are analogous to those of Apollo low-Ti mare basalts [5]. REE abundance and pattern in YA basalts are remarkably similar to each other, supporting the derivation from the common parent magma. The similarity of REE abundances and patterns of pyroxene core and rims in YA basalts and basalt clasts in Y981031 indicates that those pyroxenes are probably generated from a parent magma with similar REE compositions and fractional crystallization, and thus strongly supports the common genetic relationship.

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