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Rb-Sr isotopic systematics of alkali-rich fragments in Bhola and Yamato-74442

YOKOYAMA, Tatsunori[1]*, MISAWA, Keiji[2], Osamu Okano[3]

[1]SOKENDAI, [2]AMRC, NIPR, [3]Faculty of Sci., Okayama Univ.

Introduction: Alkaline elements (potassium, rubidium, and cesium) are classified as large ion lithophiles and are enriched in residual liquid phase during crystallization. Sodium, potassium, rubidium, and cesium are also classified as moderately volatile elements and large fractionations are expected as a result of evaporation/condensation.

Alkali-rich igneous fragments were identified in the brecciated LL-chonderites, Krahenberg (LL5) [1], Bhola (LL3-6) [2], and Yamato (Y)-74442 (LL4) [3-5], and show characteristic fractionation patterns of alkaline elements (e.g., Na~0.5xCI, K~12xCI, Rb~45xCI, and Cs~70xCI [6]). The alkali-rich fragments in Krahenberg, Bhola, and Y-74442 are very similar in mineralogy, petrography, and mineral chemistry, implying that they could have formed from related precursor materials [5]. In order to understand origin of these alkali-rich fragments as well as to constrain timing of their formation and elemental fractionation, we have undertaken Rb-Sr isotopic studies on alkali-rich fragments in Bhola and Y-74442.

Results and Discussion: Abundances of rubidium in the whole-rock samples of Bhola and Y-74442 are 2-10 times of those of ordinary chondrites, indicating a contribution of alkali-rich fragments. Rubidium in four fragments from Y-74442 are highly enriched; 20-180 times of those of ordinary chondrites. Two fragments (87-94 and 87-99) show an enrichment of rubidium (~80-180xOC) and a depletion of strontium (~0.2-0.3 x OC).

Alkali-rich fragments (Y-74442,87-101 and 87-114) yield a two-point isochron age of 4441+/-30 Ma (2 sigma) with an initial ^{87}Sr/^{86}Sr ratio of 0.7082+/-0.0085, indicating a young age with a slightly high initial ^{87}Sr/^{86}Sr ratio compared with those of Krahenberg (T=4656+/-33 Ma, (^{87}Sr/^{86}Sr)$_I$=0.6994+/-0.0011; recalculated by (^{87}Rb decay constant)=1.402 x $10^{-11}a^{-1}$)[1]. Relatively young ^{39}Ar-^{40}Ar ages of ~4200 Ma were reported for alkali-rich fragments in Bhola [7] and a whole-rock sample of Y-74442 [8], which suggests that they suffered impact event(s) with the partial degassing of argon, and that their alkaline fractionation might have occurred prior to the impact event(s).

An alkali-rich fragment in Y-74442,101-2 shows porphyritic texture: subhedral olivines are (~50 um in size) embedded in microcrystalline pyroxene (~5 um in size) and alkali-rich glass groundmass, suggesting that the temperature did not exceed liquidus, and that the fragment was cooled more slowly. The difference in thermal history among alkali-rich fragments will provide a clue of their "formation" processes. We suggest one of the possible formation processes of alkali-rich fragments is impact heating.

The alkali-rich fragments in Krahenberg and Bhola possess flat REE patterns [6]. Geochemistry (i.e., solid/liquid fractionation process) could not be responsible for the enrichments of heavier alkalis in the Krahenberg, Bhola, and Y-74442 fragments. Taking into account for the lack of detectable potassium isotopic fractionation in the Krahenberg fragment [9] along with the old formation ages of ~4.56 Ga for the Krahenberg [1], the alkaline elemental fractionation of the precursor materials could have occurred during an early stage of solar system evolution. After the elemental fractionation events, the fragments might be partly melted by impact(s).

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