ESTIMATION OF THE COMPOSITION OF HOST MAGMAS FROM PLAGIOCLASE IN LUNAR HIGHLAND ROCKS IN ANALOGY WITH THE TERRESTRIAL ADCUMULATES.

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Introduction: Trace element abundance in zoned plagioclase is a record of the physical and chemical evolution of magmas [1, 2]. The careful treatment of the compositional dependence of partition coefficients [3, 4] and post-cumulus processes will allow us to estimate the composition of host magmas of lunar highland rocks. In this study, we examine the behavior of both the incompatible and mafic elements in terrestrial plagioclases of adcumulates, specifically on the effect of interstitial melts in cumulates. Then, we discuss post-cumulus processes of plagioclases of FAN (ferroan anorthosite) of lunar highland rocks and their host magmas from sub-chondritic Ti/Ba Bulk Silicate Moon proposed in [4].

Plagioclase Samples:

Terrestrial Basaltic Samples. We analyzed plagioclases from terrestrial island arc basalts (Hachijo Basalt "Ishizumi" and Fuji Basalt "E7") and a basalt-related adcumulate ejecta (Fuji Cumulate "92-14" [5]).

Lunar Highland Samples. We studied plagioclases from FAN which are representatives consisting of lunar highland [3, 4]. We selected well-studied 5 representative thin sections of FAN from Apollo lunar sample collections, 61015.173, 65315.91, 60015.120, 15415.29 and 67075.46.

SIMS Analysis of Plagioclase Samples: Trace-element analyses were performed using CAMECA ims1270 instrument operated by the Geological Survey of Japan [6-9]. The plagioclase grains were analyzed for thirteen elements (Na, Mg, Al, Si, K, Ca, Sc, Ti, Mn, Fe, Co, Sr, Ba) on high mass resolution mode without energy filtering [6].

Table 1. SIMS analyses of trace elements in plagioclases from lunar FAN (61015.173, An 96) and terrestrial Hachijo volcano (Ishizumi, An 96).

	Sr ppm	Na_2O%	Ba ppm	K_2O%	FeO%
61015.173	243	0.48	15.5	0.012	0.22
Hachijo	258	0.44	3.75	0.0028	0.49
	MnO%	**TiO_2%**	**MgO%**	**Co ppm**	**Sc ppm**
61015.173	0.0054	0.0131	0.07	0.12	0.16
Hachijo	0.004	0.006	0.077	0.40	0.16

Lessons from terrestrial plagioclases:

The compositional dependence of partition coefficients. While the partition coefficient of Sr between plagioclases and basaltic magmas is estimated to be constantly 1.6, that of Ba are estimated to increase from 0.13 to 0.24 with decreasing An of plagioclases from 96 to 80. The partition coefficients of Ti are estimated between plagioclases and basaltic magmas to be 0.015 and 0.036 for plagioclases (An96) and (An80) respectively [3, 4]. The partition coefficient of K drops for high An content with dropping Na concentration[3]

The effect of interstitial melts and post-cumulus process. Treiman [10] pointed that that subsolidus equilibration is a reasonable cause for incompatible element-enriched minerals in some plutonic meteorites. This is true for solidification in a closed system, but not for an open system. The interstitial melts was lost in an open system from some cumulates by compaction (e.g. the Stillwater complex [11]). Both the bulk rocks and plagioclases are depleted in incompatible elements in cumulates of rhythmic layers of the North Arm Mountain complex [12] showing an efficient loss of melt. Furthermore, the core composition of the plagioclases and clinopyroxenes are constant and less fractionated [12]. For these adcumulates in an open system, enrichment of incompatible elements in plagioclases is negligible during post-cumulus processes. Even in such conditions, depletion of Fe, Mg and other mafic elements in plagioclase is possible because of diffusion under slow post-cumulus processes [13] where enough coexisting mafic minerals reequilibrate to plagioclases.

Terrestrial basalts and related cumulates. When we compared the Fuji and Hachijo volcanoes (Fig. 1), the bulk basalt of Fuji is enriched in Sr, Na, Ba, K and Ti relative to Hachijo (Line A). The adcumulates of

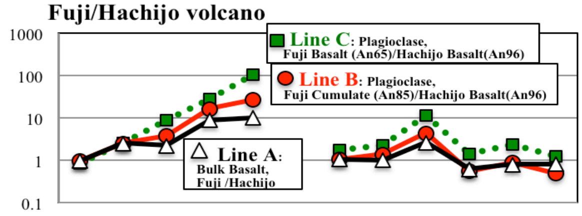

Fig. 1. Comparison of plagioclases and bulk basalts from the Fuji to Hachijo Volcano, ordered decreasing partition coefficients of plagioclase.

Fuji are thought to be comagmatic to basalts from Fuji [5]. Both the plagioclase from Fuji Cumulate (An85, Line B) and that from Fuji Basalt (An65, Line C) are normalized to the plagioclase (An96) from Hachijo Basalt. The enrichment of Sr is the same as any lines. For other elements, all lines show similar patterns. The mutual ratios including the Ti/Ba ratio can be basically caused by the An-dependence of the partition coefficients of plagioclase from a common parental magma, although the possibilities of loss of some mafic elements in Fuji Cumulate remain under post-cumulus processes. Finally, the plagioclase of Fuji Cumulate inherits the concentrations of Sr, Ba and Ti in Fuji Basalt, and is clearly distinguishable from those of Hachijo Basalt.

Lunar FAN Plagioclases:

The effects of recrystallization. Some FAN (e.g., 15415) show recrystallization texture, which might have resulted in modification of trace element abundance in plagioclase. Only 1% recrystallization of clinopyroxene can drastically deplete Sc and Mg in plagioclase shown in Fig. 2. By selecting homogeneously high Sc samples, such as 60015 grain A, 61015 and 65315, the effect of recrystallization of clinopyroxenes on trace element abundance is negligible.

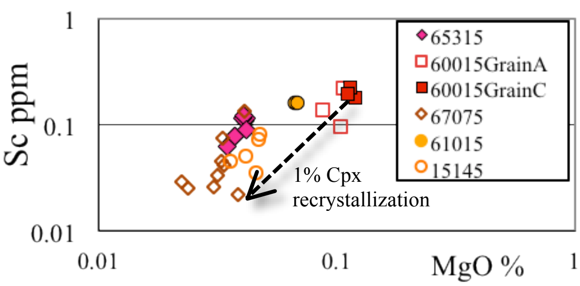

Fig. 2. The variation of concentrations of Sc (ppm) against MgO (%) of the plagioclase of FAN.

Ti/Ba ratio of the host magmas and bulk silicate moon. Concentrations of Ba and TiO_2 in plagioclase from lunar samples 60015, 61015 and 65315 plot near a line with a constrant Ti/Ba ratio (Fig. 3). By applying the partition coefficients of these elements, these data infer sub-chondritic Ti/Ba ratios in their parent-magmas which are prior to fractional crystallization and equilibrate with their source mantle [4]. If the trace element abundance in these FAN samples were affected by the interstitial melts, primary Ti/Ba ratios in these plagioclase samples would have been even higher because the particient coefficient of Ti is smaller than that of Ba. The obserbed low Ti/Ba ratio indicates that the effects of interstitial melts to lunar cumulus anorthosite would be limited, analogous to the adcumulates of some terrestrial igneous complexes and Fuji Cumulate. The low Ti/Ba ratios in the source magma of FAN proposed here are consistent with our previous model for FAN magma evolution, which further speculate Bulk Silicate Moon (BSM) with high Al2O3 (6.1%), sub-chondritic Sr/Al and Ti/Ba ratios and chondritic Sr/Ba ratios [4].

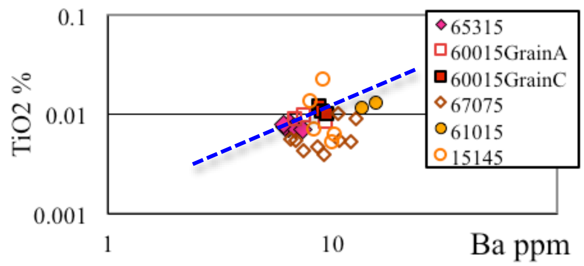

Fig. 3. The variation of concentrations of TiO2 (%) against Ba (ppm) of the plagioclase of FAN.

Conclusions: 1) The effects of interstitial melts in some terrestrial adcumulates are limited by compaction in an open system. The homogeneous core of these plagioclase crystals could preserve the signature of the concentrations of Sr, Ba and Ti in the host magma. 2) When we select the homogeneously high Sc lunar plagioclases from FAN, we can avoid the effect of recrystallization of clinopyroxenes. 3) The homogeneously high Sc lunar plagioclases from FAN show the constant Ti/Ba ratio. This is the base of the sub-chondritic Ti/Ba Bulk Silicate Moon [4].

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