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斜長岩質地殻形成過程の再評価に基づく月バルク組成への制約
Lunar Bulk Composition Constrained by Reevaluation for Formation Mechanism of Anorthosite Crust

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Recent observations by lunar explorations have shown that the lunar highland crust is highly anorthositic in composition and is ˜45-60 km thick. The Moon has been thought to have undergone a global magma ocean stage very early in its history and the anorthositic crust was formed by accumulation of anorthite crystallized in the lunar magma ocean (LMO).

The bulk composition of the Moon has been estimated by previous studies from geochemical and geophysical data. There are, however, large disparities among the estimates, because of the lack of direct chemical and structural information on the lunar interior right after the solidification of the magma ocean. The initial composition of the LMO, particularly FeO and refractory elements (Al2O3 and CaO), largely affects physical properties of melts as well as the phase relation of anorthite crystallization, and thus the dynamics of the cooling LMO.

Tonks & Melosh (1990) suggested that crystals could be separated from the magma when a settling/floating velocity for crystals calculated from Stokes' law are much larger than a convective velocity in magma ocean. The laboratory experiments intended for a terrestrial magma chamber, however, have revealed that the crystal separation does not take place at the convective region, but at the boundary layer of fluid, where the effects of viscosity are significant (Martin and Nokes, 1989, Solomatov et al. 1993).

We have developed a fractional crystallization model of LMO and investigated the conditions for the effective floatation of anorthite in the LMO to reproduce the observed critical features of the lunar crust to constrain the FeO and refractory element contents (Sakai et al., 2010, 2011). In this study, we refined our model by considering crystal separation in the boundary layer (Solomatov et al., 2003) and tried to constrain the contents of FeO and refractory elements in the initial LMO more rigorously.

The results showed that the initial FeO content should be more abundant than that of BSE, and the degree of enrichment of refractory elements should be $<$ less than 2.3 times of the BSE. These values satisfy the conditions for floatation of anorthtie found in the Apollo sample (James, 1972; Wilshire et al., 1972). The new model with boundary layer fractionation supports our previous conclusion that the FeO content of the LMO is larger than that of the BSE.

The higher FeO content estimated for the LMO than the BSE implies that the impactor that hit the proto-Earth was enriched in FeO than the BSE or that the oxygen fugacity of the LMO was higher than the BSE.

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