A NEW BULK SILICATE MOON MODEL: GIANT IMPACT-FISSIONS ENRICHED IN CRUSTAL COMPONENTS OF PROTO-EARTH AND MOON BODIES. S. Togashi[1], [1]Geological Survey of Japan, AIST, (Central 7, Tsukuba, 305-8567, Japan, s-togashi@aist.go.jp)

Introduction: A new bulk silicate Moon (BSM), which is enriched in crustal components, is proposed. The BSM has high concentrations of Al2O3 (~6%), and low Sr/Ba, Sr/Al, Ti/Th, Ti/Ba, and Yb/La ratios relative to chondrites. This is in contrast to the previous BSM models that keep chondritic ratios for refractory elements [e.g. 1, 2] or that are depleted in incompatible elements [e.g. 3].

The enriched BSM can be generated by accretion of fissions enriched in crustal component of the proto-Earth and Moon bodies by the last giant impact.

The BSM can produce the FAN-host magma based on plagioclase element abundances [4-6]. Furthermore, the estimated upper feldspathic crust derived from the BSM is comparable with the model based on lunar meteorites proposed by Korotev et al. [7].

Bulk Silicate Proto-Earth and Moon Bodies (BSP): An assumed BSP has the same composition as the bulk silicate Earth (BSE) except for volatile elements. The BSP was recalculated with 5 times enrichment of alkaline elements and water relative to BSE to be 100 total% to have nearly chondritic alkaline/refractory element ratios (Fig. 1). The BSP still has chondritic ratios for refractory elements and Mg# as same as BSE.

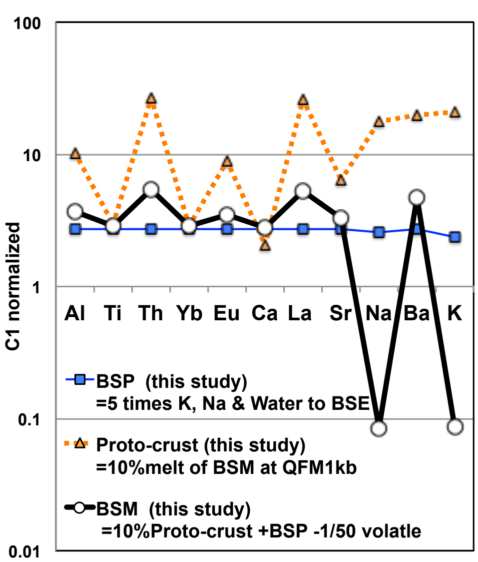

Fig. 1. C1 normalized composition of a bulk silicate Moon (BSM) enriched in crustal components, a bulk silicate proto-Earth and Moon bodies (BSP) and a proto-crust on the proto-bodies. Elements were ordered with increasing ionic radii in plagioclase structure [8].

Proto-crust Formation on the Proto-Earth and Moon Bodies: Proto-crusts were formed by direct partial melting of the BSP (Fig. 2). The concentrations of major elements in the melts were calculated by using phase relations based on Rhyolite-MELTS program [9], and those of trace elements were calculated by using the mineral/melts partition coefficients. Low partial melts (~10%) have sub-chondritic Sr/Ba and Sr/Al ratios under low pressure where plagioclases are stable in the mantle (Fig. 1). That is because Sr is strongly partitioned in the albite-rich plagioclases in the alkali-enriched BSM. The low partial melts also have sub-chondritic Ti/Th, Ti/Ba and Yb/La ratios because of the common presence of high Ca-pyroxenes in the BSM (Fig. 1).

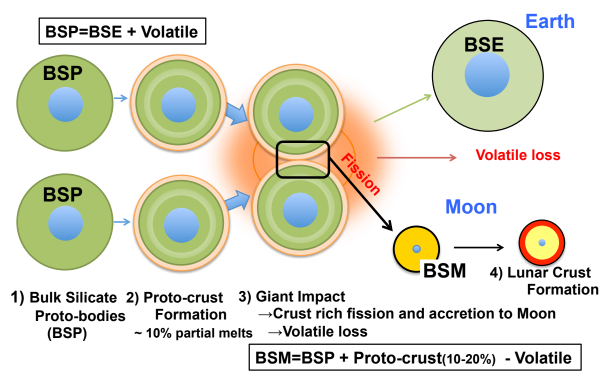

Fig. 2. A bulk silicate Moon (BSM) formed from a giant impact-fissions enriched in crustal components of the fractionated proto-Earth and Moon bodies.

Giant Impact-fissions enriched in Crustal Components for a Bulk Silicate Moon (BSM): During the last giant impact, some parts of the proto-crusts were mixed with the primitive BSP (Fig. 2). The mixed fissions were separated, volatized and accreted to a bulk silicate Moon (BSM) enriched in crustal components. This might correspond to a lost part of collisional erosion process [10].

In Fig, 3, 10% partial melting of the BSP generated the proto-crust, and the 10% of the proto-crust mixed with the primitive BSP. The mixture lost volatiles (~1/50 times) and accreted to the BSM. The concentration of Al2O3 in the BSM was calculated to be 5.9% in this case. The BSM basically inherited the signature of the composition of the proto-crusts with sub-chondritic Sr/Ba, Sr/Al, Ti/Th, Ti/Ba and Yb/La (Fig. 3).

Lunar Early Crust Formation: A simple two-step model was applied to the evolution of magmas to form the lunar early crust by using Rhyolite-MELTS [9]. The conditions of the evolution of the magmas were restricted by the potential to crystallize and float plagioclases and by the expected abundances of Sr and Ba in FAN-host magmas.

An estimated FAN-host magma was shown in Fig. 3. In this case, the initial magma was generated by 40% equilibrium melting of the BSM at 0.8 GPa and the magma subsequently crystallized at 0.2GPa. After 39% crystallization, the magma started to crystalize and float plagioclases as a FAN-host magma. The initial FAN-host magma basically inherited the signature of composition of the BSM (Fig. 3), because the main minerals prior to plagioclase crystallization were olivine and low Ca-pyroxene.

The floated plagioclases mixed with the FAN-host magmas or rocks, and formed the feldspathic lunar crust.

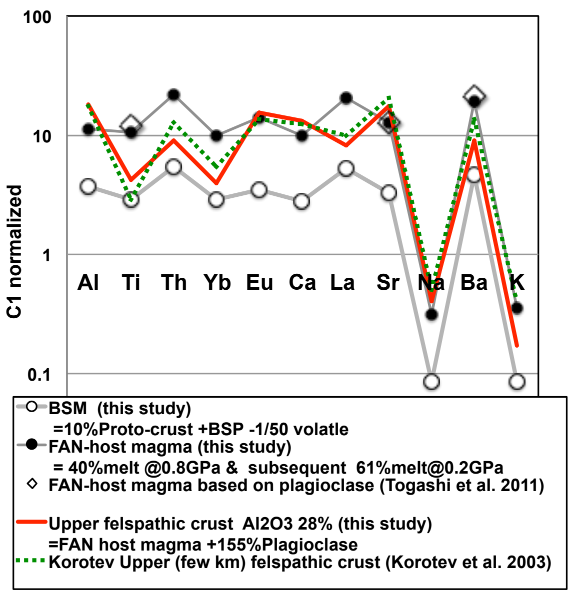

Fig. 3. C1 normalized composition of FAN-host magmas and upper feldspathic crusts.

Discussion: As shown in Fig. 3, the estimated FAN-host magma derived from the new BSM model has sub-chondritic Sr/Ba, Sr/Al and Ti/Ba ratios. It is consistent with the FAN-host magma based on the observed elemental abundances in plagioclases [4-6].

Korotev et al. [7] estimated the composition of the upper few kilometers of typical feldspathic crust based on feldspathic meteorites (Fig. 3). The feldspathic upper crust has an average Al2O3 concentrations of 28.5% and an average Mg# of 70.

For comparison to the Korotev feldspathic upper crust, 155% of plagioclase (An 97 from FAN) was added to the initial FAN-host magma in this study up to Al2O3 concentrations of 28%. As shown in Fig. 3, the estimated compositions of the upper feldspathic crust are comparable with those of the Korotev feldspathic upper crust. Moreover, the estimated Mg# of the upper feldspathic crust is 69 which agrees with the Korotev feldspathic upper crust.

Several percent additions of KREEP or Mg-suite rocks to the crusts could explain the enrichment of Th, La and Ba, but could not explain enough the observed depletion in Ti and Yb in the crusts. Both of the mafic component in the Korotev feldspathic upper crust and the FAN-host magma in this study are required to have low Ti/Th, Ti/Ba and Yb/La ratios.

Conclusions: A new model of the bulk silicate Moon (BSM), which is enriched in crustal components during the last giant impact, is proposed.

An assumed bulk silicate proto-Earth and Moon bodies (BSP) was enriched in alkaline elements with the nearly chondritic alkaline/refractory element ratios, while it kept chondritic ratios for refractory elements and Mg# as same as bulk silicate earth (BSE).

Proto-crusts on the proto-bodies were formed by direct partial melting of the BSP. During the last giant impact, some parts of the crusts were mixed with the BSP. The mixed fissions were separated, volatized and accreted to the BSM enriched in crustal components.

The proposed BSM has high concentrations of Al2O3 (~6%) and sub-chondritic Sr/Ba, Sr/Al, Ti/Th, Ti/Ba and Yb/La ratios inheriting the composition of the proto-crusts.

The lunar initial magma was produced by equilibrium melting of the BSM at deeper places. After certain degrees of crystallization at shallower places, the magma started to crystalize and float plagioclases as a FAN-host magma.

The FAN-host magma inherits the composition of the BSM, and is consistent with the FAN-host magma based on plagioclase elemental abundances [4-6].

Furthermore, the BSM model enables us to understand depletion in Ti and Yb relative to incompatible elements (Th, Ba and La) in the upper feldspathic crust based on meteorites proposed by Korotev et al. [7].

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