Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)
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SGC54-14 Room:201A Time:May 20 12:30-12:45

Chemical evolution of basal magma ocean and mantle structure of the early Earth

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Our recent study showed the experimental evidence on the gravitational stability of basal magma ocean against crystallized solid silicate at >76 GPa conditions (Nomura et al., 2011 Nature). This dense, incompatible element-rich reservoir should be crystallized to form the stable layered structure at the base of the mantle in the early Earth.

To elucidate the chemical structure of the crystallized basal magma ocean, we performed silicate melting (crystallizing) experiments at ~70 GPa and ~135 GPa (correspond to core-mantle boundary condition) as follows. (1) Melting experiments of pyrolitic silicate at high PT, (2) The identification of the liquidus phases and partition coefficients between silicate melt and liquidus phases using field emission-type electron microprobe. (3) Calculation of the composition of fractionally crystallized basal magma ocean (4) Sysnthesis of the starting material with calculated (3) compositon, and back to (1).

In this presentation, we will show the results of (1) pressure and compositional dependence of the partition coefficients (Fe, Al, Ca, K, Na) between silicate melt and solid, (2) liquidus phase relations at ~70 GPa and ~135 GPa in evolving basal magma ocean, and we will propose (3) the chemical layering structure of the early Earth.

Keywords: basal magma ocean, early Earth, high pressure experiments, laser-heated diamond anvil cell, silicate solid-liquid partitioning