Metal-silicate fractionation in the deep magma ocean and light elements in the core

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It has been believed that a giant impact occurred in the final stage of accretion of the earth. The effect of the impact on fractionation of the Earth has been discussed recently by several authors [1,2], although this process was originally introduced for explaining the origin of the Moon. We may expect a magma ocean extended into the deep lower mantle or even total melting of the early Earth as the results of the giant impact because of the energetic nature of the impact. Since it has been suggested that the reaction and equilibrium were achieved at the bottom of the magma ocean (e.g., [1]), the metallic iron and Mg-perovskite (and/or post-perovskite phase) were in equilibrium in the deep magma ocean.

We have conducted high pressure and temperature experiments on the reactions between iron and Mg-perovskite, and iron and post-perovskite using both the multi-anvil and laser heated diamond anvil cell (LHDAC). Multi-anvil experiments revealed that the solubility of O and Si in molten iron coexisting with Mg-perovskite is 2.23 wt. % and 1.70 wt.%, respectively at 27 GPa and 3040 K and it has a strong positive temperature dependency [3]. Our LHDAC experiments indicate that the solubility of both O and Si in metallic iron increases significantly with increasing pressure, and those coexisting with post-perovskite phase at 135 GPa and 3000K are 6.3 wt. % and 4.0 wt. % respectively, which are consistent with the solubility in metallic iron coexisting with perovskite [4].

These experiments revealed that significant amounts of O and Si, which explain the core density deficit, can be dissolved into metallic iron at the bottom of the magma ocean with the deep lower mantle or CMB depths. A depletion of Si in the mantle can also be produced by dissolution of Si into the metallic core during the core separation stage.

References

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