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Core Formation Process and Composition of the Core

OHTANI, Eiji[1*]

[1]Graduate School of Science, Tohoku University

Geochemical and cosmochemical arguments imply that major candidates of the light elements in the core are Si, O, S, and H with small amount of hydrogen. In the early stage of the planetary formation, the core formation process started by percolation of the metallic liquid though silicate matrix (1). The planetesimals which built the Earth could have a composition similar to enstatite chondrite, which contains some amount of sulfur as sulfide such as troilite, CaS, and metallic iron under reducing conditions. Therefore, the in the early stage of the accretion of the planetesimals, the Fe-FeS eutectic liquid could be formed and separated to the core by the percolation process. The major light elements of the core at this stage will be sulfur.

The internal pressure and temperature increased with the growth of the earth, and metallic iron depleted in sulfur was molten. The molten metallic iron can dissolve both Si and O as was experimentally shown by several authors (2). The core forming metallic liquid sunk into the bottom of the magma ocean and was in equilibrium with the magma ocean at high pressure around 40-60 GPa (3). The core separation occurred by the Rayleigh-Taylor instability. The core contains S, Si, and O by this process. If small amount of water was trapped in the magma ocean, most of H can be absorbed by the metallic core by strong partitioning of H into the metallic iron (4), and the magma ocean would have become dry.

The partitioning experiments between solid and liquid iron alloys indicate that S is strongly partitioned into the liquid outer core, whereas O is weakly into the liquid outer core, and Si into the solid inner core. H contents in the outer and inner cores are nearly the same due to similar H contents in solid and liquid iron (4). Based on the partitioning behavior between the outer and inner cores, the equation of state, and sound velocity of iron-light element alloys, the plausible distributions of the light elements in the outer and inner cores are examined.

References: (1) Terasaki, H. et al., Phys. Earth Planet. Inter., 202-1-6, 2012. (2) Kawazoe, T. and Ohtani, E., Phys. Chem. Minerals, 33, 227-234, 2006. (3) Siebert, J. et. al., Science, 339, 1194-1197, 2013. (4) Okuchi, T., Science, 278, 1781-1784, 1998.

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