【Grant-in-Aid for Scientific Research(S)】

Science and Engineering (Mathematical and physical sciences)

Title of Project：High-pressure Experimental Geochemistry：Elemental Distribution of Trace-siderophile Elements within the Earth's Core

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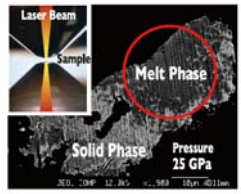
Research Area：Geo- and Cosmo-chemistry

Keyword：Isotope Geosciences

【Purpose and Background of the Research】

Formation sequence of the Earth's central core is one of the most basic and principal "enigma" in the evolutional history of the Earth and the Solar system. The Earth's core constitutes of two components, namely, the inner core (solidified Fe-Ni alloy) and the outer core (molten Fe-Ni alloy). The inner core grew up with the continuous cooling of the Earth, and this resulted in the continuous or episodic changes in the chemical composition of inner- and outer-core, and probably the lower-most mantle. To understand the elemental distribution under the global scale, chemical composition of the core should be defined. However, the discussion is still based on the "extrapolation" of the data obtained with the medium or lower pressure and temperatures. To overcome this, we will combine the high-pressure experimental technique and the state-of-the-art new analytical technique. The main goal of this study is to investigate the elemental distribution or circulation of trace-elements among the inner- and outer-core, and the data obtained here can provide key information about the formation sequence of the Earth's core and mantle.

【Research Methods】



Distribution of trace siderophile elements under the high pressure and high temperature conditions can be experimentally investigated by the coupling of the laser heating-diamond anvil cell (Laser-DAC) and the laser ablation-ICP-mass spectrometer. The resulting data provides picercing information about the origin and the evolutional sequence of the Earth' s core.

Direct experimental approaches for the geochemical feature of the Earth's core have been retarded mainly due to two reasons; (a) difficulty in production of high-pressure, and (b) analytical difficulty in the determination of trace-elements from small volume samples (<40 μm). Concerning the high-pressure experiments, Dr. K. Hirose (principal researcher of this group) succeeded in producing the high pressure (>100 GPa) by means of a modified shape-diamond anvil cell (DAC). After the optimization and geometry and laser heating protocols, both the high-pressure and high-temperature, demonstrating the Earth's core, can be achieved. Recently, we have developed a new analytical technique using a femtosecond-laser ablation-ICP-mass spectrometer technique, which enabled us to determine the trace-element abundances directly from metallic samples with the spatial resolution of better than 5-10 μm. This is very important to obtain a reliable elemental data from DAC run samples, because the typical size of the DAC run products could be much smaller than 20 μm across. With the modified-DAC system and the newly developed high-sensitivity analytical technique, the detailed and reliable discussion for the geochemical evolution of the Earth's core can be made based on the data for the elemental distribution obtained with series of different pressure and temperature conditions.

【Expected Research Achievements and Scientific Significance】

The main goal of this study is to understand the evolutional sequences of the Earth's core through the Earth and the solar system evolution, and this is highly-academic research objectives. Combination of the high-pressure experiments with the newly developed high-sensitivity elemental analysis techniques provides direct and piercing data for the geochemical discussions. This indicates that the geochemical discussion based on the indirect or "extrapolated" data for elemental distribution was no longer forceful. Moreover, analytical technique developed in this study would be applied to the many industrial or engineering applications, such as semiconductor, nuclear or material sciences. In fact, the preliminary results demonstrate clearly that the newly developed femtosecond laser ablation-ICP-mass spectrometry has a potential to become a significant and the most sensitive tool for the elemental determination from solid materials.

【Publications Relevant to the Project】

T. Hirata, Y. Kon (2008) Evaluation of analytical capability of NIR femtosecond laser ablation-inductively coupled plasma mass spectrometry. Anal. Sci., 24, 345-353.

K. Hirose (2006) Post-perovskite phase transition and the nature of D" layer, **Superplumes: Beyond Plate Tectonics**, edited by D. A. Yuen, S. Maruyama, S. Karato, and B. F. Windley, Springer, pp. 69-82.

【Term of Project】 FY2009-2013

【Budget Allocation】 144,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.kueps.kyoto-u.ac.jp/