Title of Project : Experimental study on deep mantle by Kawai-type multianvil press

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【Purpose and Background of the Research】

High pressure experiments in Earth and planetary science are critically important research methods for understanding the inaccessible deep interiors of the Earth and planets. The high-pressure group of the Institute for Planetary Materials, Okayama University (IPM) leads the world in pressure and temperature generation using the large-volume Kawai-type multi-anvil apparatus (KMA), which enables us to constrain phase equilibria, element partitioning and many physical properties at a pressure equivalent to the deep interior of the Earth. With our technological innovations, it is time to comprehensively develop research on lower mantle pressure, which requires the generation of ultra-high pressure using KMA.

In the research on the Earth's deep interior so far, we have succeeded in identifying the structure and constituent materials of the Earth's interior by combining seismological observations and mineral physics. Now we have a better understanding of the complex structure at the bottom of the mantle. However, these studies are just snapshots of the current Earth's interior. Interpretation of geochemical information as a tracer is essential for understanding the formation and evolution of the solid Earth. It is believed that the Earth grew due to the accumulation of meteorites in the early stages of the birth of the solar system and formed the current chemical layered structure. The causes of many geochemical anomalies observed in the mantle and the existence of primitive reservoirs that survived the birth of the Earth without degassing remain unresolved. The key to the solution is an integrated understanding of the fragmentarily known geochemical anomalies and the heterogeneous structure of the mantle. In this research, we will develop multifaceted research such as melting experiments under high pressure and high temperature, viscoelastic properties, heat conduction, transport of materials by diffusion, infiltration, and determination of thermoelectric effect by utilizing the characteristics of KMA. We will tackle the unsolved mantle problem and challenge to create an integrated model of the Earth's mantle evolution.

【Research Methods】

Melting experiments at pressures corresponding to the bottom of the magma ocean will be performed to determine the partition coefficient of highly siderophile elements between silicates and metals. The origin of the primitive reservoir chemically isolated in the deep mantle after core formation will be elucidated by a two-phase system deformation experiment using a D111-type deformation device that can perform deformation experiments under lower mantle conditions. The cooling process inside the earth will be investigated by measuring the thermal conductivity using the pulse heating method at the core mantle boundary (CMB). We will also investigate whether elemental diffusion and redox processes at the CMB can produce the observed chemical anomalies in the mantle.

【Expected Research Achievements and Scientific Significance】

By making full use of the Kawai-type multi-anvil press technology that originated in Japan, it is expected that problems that were difficult to solve by other experimental methods will be solved.

1. Melting experiments in the pressure region that could not be achieved until now, can put an end to the controversy over the late veneer hypothesis by determining the parent iron element distribution between silicate and iron melt.
2. The rheology of the lower mantle from ultra-high pressure multi-anvil deformation experiments can constrain the formation of primordial reservoirs in the deep mantle.
3. Thermoelectric measurements under high pressure provide new insights into the origin of heat transport, redox states, and mantle isotopic anomalies at the CMB.

It is expected that the execution of this research will enable the construction of an integrated mantle evolution model for the first time, and will be a breakthrough for understanding the evolution of the solid earth.

【Publications Relevant to the Project】

· T. Yoshino, Y. Makino, T. Suzuki, T. Hirata, Grain boundary diffusion of W in lower mantle phase with implications for isotopic heterogeneity in oceanic island basalts by core-mantle interactions. *Earth and Planetary Science Letters*, **530,** 115887, 2020.
· N. Tsujino, Y. Nishihara, D. Yamazaki, Y. Seto, Y. Higo, E. Takahashi, Mantle dynamics inferred from the crystallographic preferred orientation of bridgmanite. *Nature*, **539,** 831–834, 2016.

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