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SIT03-P01 会場:3 階ポスター会場 時間:4 月 29 日 18:15-19:30

GHz 音速法とブリリュアン散乱法の併用による マントル鉱物のその場弾性測定 II
Single crystal elasticity by means of GHz ultrasonics and Brillouin scattering in DAC II

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マントル鉱物の弾性はブリリュアン（BS）散乱法により測定されてきたが、ダイヤモンドアンビルセル（DAC）で測定する場合、約 100GPa の高圧下になると試料鉱物の P 波速度がダイヤモンドの S 波速度と同程度になり測定できなくなるという問題があった（試料の S 波速度は測定可能）。 この問題を解決するための方法として、P 波速度は GHz 音速法で測定し S 波速度はブリリュアン散乱法で測定するという単純なアイデアを着想し開発を行ってきた。昨年度の連合大会では、GH ｚ音速法の基本的技術開発の状況を発表した。今年度は、その後の進歩を発表する。発表までに、実際に DAC 中で加圧した試料からの GH ｚシグナルを取得を目指している段階である。

キーワード: マントル, DAC, 結晶弾性, GH ｚ音速法
Keywords: mantle, DAC, single crystal elasticity, GHz ultrasonics

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ケイ酸塩ペロブスカイトの単結晶弾性
Single-crystal elastic property of silicate perovskites

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Information of single-crystal elasticity of silicate perovskite is essential for comprehensive understanding of the lower mantle. We have measured single-crystal elastic property of $Mg_{1-x}Fe_xSiO_3$ perovskite (x = 0 or 0.035) by means of inelastic x-ray scattering at the ambient condition. The present results show relatively low values compared to previous reports for the iron free sample. The effect of iron increases both adiabatic bulk modulus and shear modulus. Combining the present results with pressure and temperature derivatives reported in literature, the chemical composition of the lower mantle will be discussed.
Keywords: silicate perovskite, single-crystal elasticity, the lower mantle, inelastic x-ray scattering

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遷移層から下部マントルに至る圧力での高圧鉱物の熱伝導測定
Measurement of thermal conduction of high-pressure minerals at pressures of the transition zone and to the lower mantle

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Knowledge of thermal diffusivity or thermal conductivity of the mantle is vital for study of the dynamics of the Earth. So far thermal diffusivity and thermal conductivity of mantle minerals were measured under high pressure using a pulse-heating method of one-dimensional heat flow. This method is a predominant one for study in deep Earth's materials under pressure because it requires comparatively small amount of samples. It is also applicable to materials with anisotropy in thermal conduction. In addition its measurement yields heat capacity data under pressure.

Thermal conductivity or thermal diffusivity of olivine and garnet increases 3-4 % per 1 GPa, and olivine still reveals anisotropy in thermal conduction under the conditions of the upper mantle. Antigorite, a high-temperature form of serpentine, has low thermal diffusivity and low thermal conductivity which are much lower than those of olivine, whereas talc has high thermal diffusivity and thermal conductivity comparable to those of olivine. All those data were obtained from the measurements at pressures up to 10 GPa and temperatures to 1100 K. An advanced cell assembly was needed to expand the pressure range of measurement.

A new pressure-cell assembly similar to our previous one is designed for a sample of 3 mm in diameter and 0.7 mm in thickness. This smaller cell was applied to pyroxene samples of which sizes were necessarily limited. The measurements were conducted using the Kawai-type apparatus at the Institute for study of the Earth's interior, Misasa. This cell enabled to make measurements of thermal properties at pressures exceeding 15 GPa, which will covers the condition in the mantle transition zone.

We made preliminary measurements by this cell for the garnet sample as a test material. The thermal diffusivity showed slightly lower value (5˜10 %) and the thermal conductivity was slightly high (0˜10 %) value compared with the previous results by the large cell. The precision of measurements should be improved by well-controlled machining of the cell assembly and by refining the data acquisition system. After that this cell will be used for measurements of wadsleyite, ringwoodite and majorite. A cell assembly of more reduced in size is planned. This cell will be used for measurements of MgSiO3 perovskite.

キーワード: マントル鉱物, 熱拡散率, 熱伝導率, 高圧力
Keywords: mantle minerals, thermal diffusivity, thermal conductivity, high-pressure

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高温高圧下における Fe-S-Si 系の元素分配：地球核への応用
Elemental partitioning in the Fe-S-Si system at high pressure and temperature: Implications for the Earth's core

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It is widely accepted that the Earth's core is mainly composed of iron and contains light elements to account for the core's density deficit. Alloying with light elements significantly affects the physical properties of iron and the arguments on the chemical structure of the Earth's core. Therefore, the melting relation of the Fe-light elements system is the key to clarifying the chemical structure of the core because the inner core has formed by crystallization of the molten outer core. Although there are many candidates for light elements in the core, based on geochemical modeling and high-pressure partitioning experiments, sulfur and silicon are considered to be the major light elements. Despite the importance of the effect of sulfur and silicon on the physical properties of iron, previous studies, including high-pressure melting experiments in the Fe-S-Si system, did not cover the pressure conditions of the core. To better understand the properties of the core, we investigated the melting relations of the Fe-S-Si system under high-pressure conditions corresponding to the Earth's core.

We report on the melting relations in the Fe-S-Si system up to 135 GPa. Melting experiments were performed in the pressure range of 37-135 GPa and the temperature range of 1800?4100 K using a double-sided laser-heated diamond anvil cell. The composition of the starting material was $Fe_{80.1}S_{12.7}Si_{7.2}$ (Fe-8 wt.% S-4 wt.% Si). Melting relations were examined on the basis of quenched textures of the recovered samples and chemical analysis of observed phases. The chemical composition of the coexisting phases in the samples was obtained with an energy-dispersive X-ray spectroscopy (EDS) system attached to the FEG-SEM. We determined the compositions of the coexisting phases and investigated the partitioning behavior of sulfur and silicon between the metallic melt and the coexisting iron alloy.

We consistently found that a quenched melt with a dendritic texture coexists with a solid Fe alloy in the recovered samples, implying that the samples were partially melted under the experimental pressure and temperature conditions. Based on the present results, the partition coefficients of sulfur and silicon between the liquid and solid Fe alloy were determined in the pressure range from 37 to 135 GPa. The value obtained for D_{sulfur} at 37 GPa was 0.032(28), whereas $D_{silicon}$ was 4.53(73), which is significantly higher than D_{sulfur}. The obtained values of Dsulfur were between 0.032(28) and 0.135(35) and those of $D_{silicon}$ were between 2.63(12) and 5.58(56) in this study. The present results indicate that the solid Fe alloy is silicon rich whereas the metallic melt is enriched in sulfur. We can find that this trend continues up to the core-mantle boundary (CMB) pressure.

The information on partitioning of light elements between the metallic melt and hcp-Fe is the key for clarifying the chemical structure of the Earth's core because the inner core is considered to have crystallized from the liquid outer core during cooling of the Earth. Moreover, previous studies strongly implied that both sulfur and silicon were the plausible candidates for the light elements in the core. Therefore, our experimental results in the Fe-S-Si system offer important clues for understanding the composition of the Earth's core. Based on the present results, if the Earth's core cools down below the melting temperature of the core material, silicon could be preferentially partitioned into hcp-Fe from the Fe-S-Si liquid during crystallization of the inner core. The present data demonstrated that if the Earth's core contains both sulfur and silicon as light elements, the present-day Earth has a sulfur-rich outer core and a silicon-rich inner core.

キーワード: 地球核, 軽元素, 元素分配, 結晶化
Keywords: Earth's core, light element, elemental partitioning, crystallization

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CMB 電気伝導度不均質と非双極子磁場
Influence of the electrical conductivity heterogeneity at the CMB on the flow and magnetic field in the core

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The effects of electromagnetic induction in the heterogeneous mantle on the observed electromagnetic fields have been studied numerically to investigate possible causes of short time-scale variation known as the geomagnetic jerk. We found previously that the jerk-like magnetic and electric field variations observed at the surface of Earth can be explained by an input of a sudden variation of the toroidal field at the top of the core and large-scale conductivity heterogeneity of which conductivity is about 100 times higher than the background electrical conductivity. In this study, the effect of the heterogeneity on the flow in the core and magnetic field is evaluated by using a simple plane model of a heterogeneous mantle. Preliminary results suggest that the signature of the magnetic field may be detected as a stationary field at the Earth's surface if the heterogeneity is planetary scale, but the penetration length of its effect in the core is much shorter than the length scale of the heterogeneity.

キーワード: 地磁気, CMB
Keywords: geomagnetic field, CMB

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マグマオーシャン最深部における地球核へのカリウム分配量　－地球核の熱源への応用
Potassium solubility into the Earth's core at the base of the magma ocean -Implication for the heat source of the core

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Since the densities of the Earth's inner/outer cores are smaller than pure iron at the core conditions, the core has been thought to include light elements, such as H, C, S, O, Si (e.g., Poirier, 1994). Although the light element(s) in the core has not been decided yet, high-pressure experiments and cosmochemical estimations suggested that Si and O are plausible light elements. The energy causing the geodynamo is derived from the accretion energy at the early stage of the Earth, the latent heat of crystallization of the inner core, the gravitation energy associated with the exclusion of light materials from the inner core, and the radioactive decay of radioactive elements which are potentially present in the core. The Earth's core might contain long-lived radioactive elements such as U, Th, and K. In particular, potassium (K) is more depleted in the mantle than other volatile elements. Thus, potassium may be included in the core. In order to verify the amount of potassium in the core, we have performed potassium partitioning experiments under high pressure and temperature.

We studied partitioning of potassium between aluminosilicate (adularia, $KAlSi_3O_8$) and metal containing oxygen and silicon, and partitioning of potassium without light elements (Fe-O, Fe-Si, pure Fe) at pressures up to 50 GPa and 3500 K using a double-sided laser-heated diamond anvil cell. Our results for the pressure, temperature, and compositional effects on the partitioning coefficient of potassium, D_K (i.e., the content of potassium in metal [wt%] divided by the content of potassium in silicate [wt%]), reveal that the temperature effect is slightly positive but weaker than that reported previously, whereas the pressure effect is negative and oxygen in metal increases the potassium content in metal, although silicon in metal has the opposite effect. According to the effects on potassium partitioning, we estimated that the amount of potassium in the core is less than 32 ppm and that it generates less than 0.14 TW heat in the core. This amount of heat is small compared with the heat flux at the core-mantle boundary (5-15 TW).

Keywords: Potassium, magma ocean, high pressure, high temperature, Earth's core