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外核最上部の密度成層した層に存在する軸対称MAC波の境界モード
The boundary mode of axially symmetric MAC waves can exist in the stratified layer at the top of the Earth's outer core

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外核最上部には、地震学的な観測（例えば、Helffrich & Kaneshima(2010)、Kaneshima & Helffrich(2013)）や理論的な推測により、軽い物質によって密度成層した層がありそうだ、ということが分かってきた。その原因としては、Helffrich(2014) では、初期地球にあった密度成層の名残とする考えが有力だとされている。この密度成層した層には、磁力（Magnetic force）・浮力（Archimedes force）・コリオリ力（Coriolis force）のバランスによって生じる MAC 波が存在する。Braginsky(1993) では、地磁気の 60 年変動を説明するために、その MAC 波を軸対称に限った場合の近似解が理論的に示されている。ここでの層のモデルは、外核内部との境界において密度の不連続があり、層内では浮力振動数が一定であるようなものが用いられている。（しかし、最近の地震学の観測では、このような密度の不連続はなさそうだと言われている。）その解の南北方向の位相速度はアルヴェーン波速度と浮力パラメータの積となり（ c_{lat} = V_A・B_u = V_A・N / f、ここで c_{lat} は南北位相速度、V_A はアルヴェーン波速度、B_u は浮力パラメータ、N は層の浮力振動数、f はコリオリパラメーター)、鉛直構造はサイン波の重ねあわせで表される。また、減衰率は磁気拡散率に比例する。南北位相速度は浮力振動数に比例するので、観測から南北位相速度が分かれば、浮力振動数が推定できる。南北波数 l=2 の基本モード周波数を地磁気の 60 年変動と合わせるようにすると、浮力振動数は地球の自転角速度の 2 倍ほどになる。

私たちは、Braginsky(1993) で想定されたモデルと方程式系に、密度不連続のある層境界に局在した解（ここでは境界モードと呼ぶことにする）も存在することを見出だした。この解は、Braginsky(1993) の解に比べて時間スケールが小さく、もっぱら拡散によって伝播する。また、位相は層境界から離れる方向に進む。周波数は Braginsky(1993) の解のように層内の浮力振動数には依存しない。周波数と鉛直波数は層境界における密度不連続の大きさ、南北波数などに依存している。鉛直構造は境界から離れるにつれて振幅が小さくなるような波形である。密度不連続や南北波数が大きいと、波は時間的にも空間的にも減衰が大きくなる。そのため観測で見つかるには、密度不連続と層の厚さが小さいことが必要であり、南北波数が小さい波が見つかりやすいであろう。仮に、南北波数 l=2 の境界モードの振動数を地磁気の 60 年変動と合わせるようにすると、密度のとびの割合は 10^{-4} 程度になる。なお、この波は、磁気拡散率が小さいほど、時間的にも空間的にも減衰するという層内伝播する波とは逆の性質を持っている。境界モードであるので、境界面を振動させれば、励起されるかもしれない。

キーワード: MAC 波, 外核最上部, H 層
Keywords: MAC waves, the top of the Earth's outer core, H layer

SIT35-P02 会場:コンベンションホール 時間:5 月 26 日 18:15-19:30

高温高圧下における鉄-水反応に対する硫黄の影響
Effect of sulfur on the reaction between iron and water under high pressure and temperature

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形成期の地球内部環境下では Fe と H_2O が反応し、FeH や FeOOH 等の含水素相が出現することが報告されているが（例えば Okuchi ,1997; Ohtani et al.,2005）, 本研究では更に多成分系の反応を調べるために硫黄を加え、Fe-S-H-O 系の高温高圧下における反応関係を調べた。

この系では、反応生成物として想定される金属水素化物中の水素が低圧側で試料から散逸してしまうために、実験は高エネルギー加速器研究機構 (KEK)・放射光実験施設 (PF-AR-NE1A) で行い、その場 X 線回折法によって反応相を観察することにより、試料の相転移の観察や反応生成物の同定を行った。

高温高圧発生装置には AR-NE1 に設置されたレーザー加熱型ダイヤモンドアンビルセルを用いた。出発試料には FeS の粉末を箔状に加工したものと純水を用い、レニウムガスケットに開けた試料室に封入した。圧力測定には H_2O-Ⅶ相の状態方程式を用いた。加熱には Nd:YAG レーザーを用いた両面加熱を行い、試料の高温部からの輻射により反応温度を推定した。

本実験は 24GPa、33GPa の圧力条件、300K-1200K の温度条件で行った。その結果、これらの温度圧力範囲では反応生成物として FeS_2(Pyrite)、dhcp-FeH_X、ε-FeOOH が観察された。ε-FeOOH の安定領域は Fe と H_2O の反応で報告されている圧力よりはるかに高圧側まで存在すること、また ε-FeOOH の高温分解条件が制約できたこと、Fe-S-H 系では水素を含む FeS が報告されているが Fe-S-H-O 系では硫化物相に有意な水素が見られないこと、Fe-S-H 系では見られなかった FeS_2 が新たに出現することなどが分かった。また、発表では回収試料の SEM-EDS 分析の結果についても報告する。

キーワード: 地球核, 軽元素, 水素, 放射光
Keywords: Earth's core, light element, hydrogen, synchrotron

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遷移層から下部マントルに至る圧力でのマントル鉱物の熱伝導測定
Measurement of thermal conductiviy of mantle minarals at pressures of the transition zone 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 we have measured thermal diffusivity and thermal conductivity of upper mantle minerals, i.e. olivine and garnet and hydrous phases, i.e. serpentine and talc. All those data were obtained by the experiments at pressures up to 10 GPa and temperatures to 1100 K. The measurements were conducted by a pulse-heating method of one-dimensional heat flow using the Kawai-type apparatus at the Institute for study of the Earth's interior, Misasa. This current method is a predominant one for study in deep Earth's materials under pressure. It has some advantages as follows:(1) comparatively small amount of samples (2) applicable to materials with anisotropy in thermal conduction (3) simple cell assembly. Moreover, this method enables to obtain specific heat capacity under pressure.

In order to expand pressure range the cell assembly is needed to advance by reducing its dimensions. A new cell-assembly similar to our previous one is designed for a sample of 2.6 mm in diameter and 0.6 mm in thickness. This smaller cell is installed in a 14 mm edged octahedral pressure medium in 7 mm trancated anvils. This cell enables to make measurements of the thermal properties at pressures exceeding 15 GPa, which will covers the condition in the mantle transition zone. The cell will be also applied to pyroxene samples of which sizes are necessarily limited. Test measurements were made using garnet samples. The results agree well with those of the previous experiments using the larger (18-11 and 14-8) cell, and the extrapolations to zero-pressure coincide to values of other methods. Thus, the pulse heating method will be applied for thermal property measurements of wadsleyite, ringwoodite and majorite. Using large anvils ($>$46 mm), the method is probable to measure the thermal conductivity of $MgSiO_3$ perovskite (bridgmanite). However, measurements at high temperature still have somewhat problems in precision. Materials of impulse heater and external furnace should be re-considered. The precision of measurements should be improved by well-controlled machining of the cell assembly and by refining the data acquisition system.

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

SIT35-P04 会場:コンベンションホール 時間:5 月 26 日 18:15-19:30

MgO 格子原子拡散挙動の第一原理シミュレーション
Lattice diffusion in MgO crystal from first principles simulation

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Rheological property is critical to understanding the mantle convection. Diffusion creep might be the dominant deformation mechanism in the Earth's lower mantle and super-Earths' mantle (e.g., Karato, 2011). Thus several experimental and theoretical studies have tried to measure lattice diffusion coefficients under pressure, which are both still technically difficult. There are two theoretical approaches to calculate self-diffusion coefficient in solids. One is based on the static lattice energy calculation and the other is based on the molecular dynamics simulation. In the former case, it is difficult to evaluate attempt frequency and in the latter case, atoms are hardly mobile in actual computation time at the Earth's lower mantle and super-Earths' mantle temperatures. These two approaches were previously applied to MgO, one of major deep mantle constituents (Ita & Cohen, 1997; Ito & Toriumi, 2007). However reported pressure dependences of the self-diffusion coefficients are contradictive with each other particularly at high pressure over 80 GPa.

In this study, we develop a new theoretical method to calculate self-diffusion coefficient in crystals with charged vacancies (Schottky pair) within the first principles framework. This method was then applied to NaCl-type MgO. We found that the calculated pressure dependences of the self-diffusion coefficients in MgO are consistent with those of Ita & Cohen (1997). Diffusion creep viscosity of MgO was then estimated using calculated diffusion coefficients. Our activation volumes are consistent with experimental values at low pressure (Van Orman et al., 2003) and decrease rapidly with increasing pressure. It suggests that super-Earths' mantle would not be quite viscous and the constant activation volume extrapolation leads to overestimation of viscosity in the deep mantle.

This method is widely applicable to other materials including bridgmanite, post-perovskite and CsCl-type MgO, which are important to analyze more realistic planetary interior dynamics.

キーワード: MgO, 格子拡散, 地球下部マントル, スーパーアースマントル, 第一原理計算
Keywords: MgO, lattice diffusion, Earth's lower mantle, super-Earths' mantle, first principles

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海洋性地殻物質の沈み込みとマントル内化学的不均質構造の形成に関する数値シミュレーション
Are LLSVPs formed in the Earth's lowermost mantle by the subduction of oceanic crusts?

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We conducted a series of numerical experiments of thermo-chemical mantle convection where a subduction is preferentially induced at a continental margin, in order to verify a hypothesis that the Large Low-Shear Velocity Provinces (LLSVPs) in the Earth's lowermost mantle are formed by subduction of oceanic crust. In this study, we adopted a model of two-dimensional rectangular box of 2900km height and aspect ratio 6 with reflective boundary condition in the horizontal direction. We placed an immobile lid as a model of surface supercontinent which covers a third of the top surface. We also put a thin layer of chemically dense materials as a model of oceanic crust, which may sink into the deep mantle along with cold descending flows from the top surface.

Our calculations showed that the subducted oceanic crusts are preferentially provided under the continent when the subduction at the margin of continent is stable. However, stable subduction caused strong convection and significantly stirred the mantle under the continent. Therefore, subducted oceanic crusts were distributed almost uniformly under the continent without accumulating on the CMB. On the other hand, the cases with unstable subduction at the margin of continent showed a long-wavelength mantle convection structure which has an ascending plume along the side wall under the continent and a descending plume at the opposite side wall. The large-scale flow gathered subducted oceanic crusts under the continent and formed large piles on the CMB.

Our results suggest that the LLSVPs are hardly formed in the presence of stable plate tectonics like the current one where a stable plate motion including subduction stirs the mantle very effectively. In other words, the formation of large thermochemical piles which are equivalent to the LLSVPs should have been completed before the plate tectonics is well established, assuming that subducted oceanic crusts are the origin of LLSVPs.

キーワード: マントル対流, 数値シミュレーション, LLSVP, プレート沈み込み
Keywords: mantle convection, numerical simulation, LLSVP, plate subduction

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Experimental presentation of plate subduction using paraffin wax
Experimental presentation of plate subduction using paraffin wax

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Experimental approaches using analogue materials have been widely used to understand kinematic behaviors of tectonic plates. Previously molten paraffin in a tank inside a hot water bath has been used. Although tectonic plate-like behaviors, such as inclined subduction and trench migration, have been observed, the “plate” in this case was too thin to reproduce the lithospheric strength and the heat balance through the thermal boundary layer of the Earth. In order to simulate the plate and its motion as a well-developed thermo-mechanical boundary layer on top of vigorously convecting mantle, we have developed a tank apparatus and performed preliminary experiments using paraffin wax.

To control the complex heat and convection processes and for easy observation we constructed a glass tank with an inner size 120x23x4cm. The walls are constructed from double pane glass with panes separated by air gap to reduce heat loss, and reinforced with aluminum plates and bars. The paraffin was melted from bellow by a copper heat-sink containing 24 ceramic heating elements. To reduce heat loss to the back wall, the wall was isolated with 8cm thick foam. At the boundary layer where the paraffin wax was sticking as it cooled down we applied NiCr wire heater to the inner walls. All heating sections were controlled by variable controllers. We cooled the top layer of the wax with a cold air flow carefully controlled with thin foam plates from a vat filed with liquid Nitrogen.

The biggest challenge was the “frosting” effect especially on the front uninsulated wall that prevented the “subduction” of the forming “crust” to deeper levels. External wall temperature was 65 ℃, 70 ℃ was measured at the boundary level by the wire heater, while the wax inside the tank was at 80 ℃. Some external force was necessary to initiate a start of subduction. The maintenance of balance between the various heaters, the wall temperature, the wax temperature and the cooling rate was critical for the successful completion of the experiment.

We observed continuous subduction and clear “crust” forming with subsequent “subduction” . We can say that our experiment properly reproduces the general features of plate motion of the earth. Artificially fracturing or weakening the boundary layer and applying a vertical, downward external force were required to initiate subduction in addition to collision of the plates. The thickness of the plate was the primary parameter controlling subduction behavior and plate motion. The plate showed elastic and plastic behavior depending on its thickness and temperature. A cold and thick “plate” did not subduct even after applying an external force, and formed a stagnant lid. A hot and thinner “plate” did not show continuous subduction behavior, plate motion stopped soon after subduction was initiated, possibly because the slab pull force from the thinner partially subducted slab was too weak. Our experiment results suggest that the driving force of subduction and plate motion is slab pull, not the thermal convection of the molten paraffin or ridge push. We will present photos and videos of the observed processes.

Improvements to the tank and heating elements design are necessary to provide better and easier control over the experiments.

キーワード: analogue experiment, plate subduction, paraffin wax, glass walls tank, slab pull
Keywords: analogue experiment, plate subduction, paraffin wax, glass walls tank, slab pull

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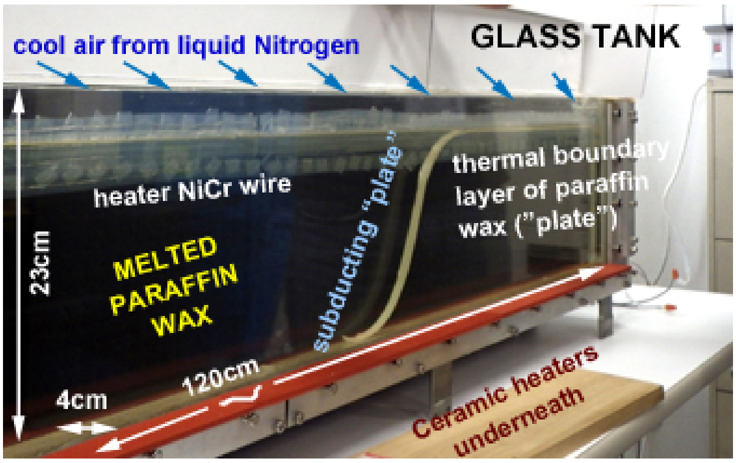

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SIT35-P07 会場:コンベンションホール 時間:5月26日 18:15-19:30

スーパー地球のマントル対流シミュレーション: 熱伝導率の深さ依存性と断熱圧縮の効果
Numerical experiments on mantle convection of super-Earths with variable thermal conductivity and adiabatic compression

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Recently, many extra-solar planets have been discovered by improved observation technologies. Some of these planets, called super-Earths, have small masses (up to 17 times the Earth's) and high mean density (>5000 kg/m3). Numerical modeling of mantle convection of super-Earths plays an important role in studying the occurrence of plate tectonics and the surface environments on these planets. On the other hand, when considering mantle convection of super-Earths, it is also important to take into account the difference in (hydrostatic) pressure in the mantles. Since super-Earths have high inner pressure, there must exist a strong change in physical properties and the effect of adiabatic compression. While the effects of physical properties have been intensively studied so far, those of adiabatic compression have not been well studied in the previous models of mantle convection of super-Earths. Here we conduct numerical experiments of thermal convection of highly compressible fluid in a two-dimensional rectangular box whose thermal expansivity and conductivity are dependent on depth, viscosity is dependent on temperature, in order to elucidate the mantle convection on super-Earths.

Our numerical experiments showed the change in convecting flow patterns depending on the temperature-dependence in viscosity, regardless of the depth-dependence in thermal conductivity. When a viscosity is sufficiently dependent on temperature, horizontal flow becomes dominant in the mantle, with a very weak activity of hot plumes from the base of the mantle. This flow pattern is quite similar to the "stratosphere" in the field of meteorology. In addition, we found that the occurrence of "stratosphere" is enhanced for a strong depth-dependent thermal conductivity. One reason for this is that high conductivity at depth significantly reduces the difference in temperature between the basal thermal boundary layer and isothermal core. Our study therefore suggests that the depth-dependent thermal conductivity is one of the most important agents which control the mantle dynamics of super-Earths.

キーワード: スーパー地球, マントル対流, 断熱圧縮, 熱膨張率, 熱伝導率, 粘性率
Keywords: suoer-Earths, mantle convection, adiabatic compression, thermal expansivity, thermal conductivity, viscosity

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コア形成シミュレーションにおけるストークス流の移流陰解法
Implicit solution of the material transport of the core formation simulation

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In order to investigate the long time-scales of the global core formation process in a growing planet, we are developing the Stokes flow simulation code using MIC based techniques for material transport with a free-surface treatment. We are interested in the dynamical change of the internal structure after solidification of magma ponds/oceans during the core formation under a self-gravitating field, especially because it might lead to an initial heterogeneous structure in the deep mantle.

However current numerical solution method is difficult to solve the system coupled with the energy equation because the numerical system becomes stiff when the dynamical balancing time scale for the increasing/decreasing load by surface deformation is very short compared with the time scale associated with thermal convection. Any explicit time integration scheme will require very small time steps; otherwise, serious numerical oscillation (spurious solutions) will occur.

In this work, we propose to treat the advection as a coordinate nonlinearity, coupled to the momentum equation, thereby defining a fully implicit time integration scheme suitable for stiff problems [Furuichi and May, Compt. Phys. Commum 2015]. We utilize a Jacobian free Newton Krylov (JFNK) based Newton framework to solve the resulting nonlinear equations. We also investigate efficient solution strategies to reduce the computational cost to evaluate the nonlinearity on MIC advection.

These implicit methods are implemented within FD framework [Gerya and Yuen, 2003]. We examine the solution quality and efficiency of these methods by performing numerical experiments we have performed a series of numerical experiments which clarify the accuracy of solutions and trade-off between the computational cost associated with the nonlinear solver and time step size.

キーワード: コア形成, 陰解法, 非線形ソルバ, 自由境界表面
Keywords: core formation, Stokes flow, free surface, implicit time integration, JFNK

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Hi-net で計測される SKS splitting parameter のモデリング
Modeling of SKS splitting parameters measured in Japan with Hi-net

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To systematically investigate the spatial variation of seismic anisotropy around Japanese islands, we measured splitting parameters (fast polarization direction ϕ, delay time δt) of teleseismic SKS phases observed by Hi-net (Ogawa et al., 2014, SSJ). The results indicated regional scale variations of splitting parameters that are apparently related to subduction systems. In order to investigate detailed anisotropic structures (fabric in mantle wedge, subducting slab, and asthenosphere), we conducted forward modeling using synthetic seismograms. We modeled the SKS phases by the ray theory. We assumed that the SKS ray is straight and that each region has homogenous anisotropy. We rigorously calculated the phase velocity in each region by solving the Christoffel matrix. The preliminary analysis indicates that the measured splitting parameters appear to be primarily affected by the A-type fabric in subducting slab (oceanic lithosphere) whose a-axis aligns in the direction of the fast axis observed at the surface by using our OBS data.

キーワード: 地震波異方性, モデリング
Keywords: seismic anisotropy, s-wave splitting, modeling

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マルチモード表面波による上部マントル鉛直異方性の制約
Constraining radial anisotropy in the upper mantle with multi-mode surface waves

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The radial anisotropy of shear waves represents the differences in the propagation speeds between vertically polarized shear waves (SV) and the horizontally polarized ones (SH), and can be a key to the understanding of the dynamic processes in the upper mantle. Seismic surface waves are the most powerful tool to determine the spatial distribution of the radial anisotropy. Some recent studies have revealed the existence of a layer with strong radial anisotropy (with SH >SV) beneath the lithosphere; e.g., under the Pacific plate (Nettles & Dziewonski, 2008, JGR) and the Australian continent (Yoshizawa, 2014, PEPI). This is, however, not always the case and there are also some studies on radial anisotropy that do not show such a clear layer with SH>SV beneath the lithosphere. These differences may be related to the differences in model parameterization.

For the inversions of multi-mode phase speeds of Rayleigh and Love waves for radial anisotropy of shear waves, we can use either set of model parameters for the representation of the anisotropic S velocity; i.e., (A) SV velocity (Vsv) and SH velocity (Vsh), or (B) SV velocity (Vsv) and radial anisotropic parameter ξ =(Vsh/Vsv)^2. The choice of model parameters for inversion is arbitrary, but, through synthetic experiments, we have confirmed that this difference causes non-negligible effects on the reconstruction of radial anisotropic properties of shear waves. This is mainly caused by the differences in the sensitivity kernels of Love-wave phase speeds to Vsv, Vsh and ξ.

For the set of parameters (B) [Vsv, ξ], Love waves always have the largest sensitivity to Vsv with suppressed sensitivity to ξ, and the kernel shapes for both Vsv and ξ are nearly identical. On the other hand, for the parameterization with (A) [Vsv, Vsh], Love wave phase speeds are controlled primarily by the kernels for Vsh, which have the largest sensitivity to Love wave phase speeds with little influence from Vsv, which can be better (and independently) constrained by Rayleigh waves.

Such intrinsic differences in the sensitivities of surface waves can lead to the different results in the estimation of radial anisotropy. Our synthetic experiments suggest that the parameterization with [Vsv, Vsh] would be preferable particularly when the radial anisotropy with SH>SV is caused by anomalously slow SV velocity, which is consistent with the recent anisotropy models reported in the fast moving Pacific and Australian plates. We have also found that the strong dependence of the retrieved anisotropy on the initial model, when we use [Vsv, ξ] as model parameters.
Keywords: radial anisotropy, surface waves, upper mantle, lithosphere, asthenosphere

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日本列島下の遠地地震Ｐ波・Ｓ波トモグラフィー
Teleseismic P- and S-wave tomography beneath Japan Islands

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日本列島は，4 つのプレートが隣接し相互に作用しあう複雑なテクトニクスを有しているため，その地下構造は非常に不均質である．これまでに近地地震データを用いた数多くの地震波トモグラフィー研究により, 詳細な日本列島下の 3 次元速度構造の推定がなされてきた．しかしながら，その研究対象領域は地殻や上部マントルといった浅部に限定されており, 日本列島深部 (深さ 200-700 km) の構造を推定した研究は少なく, その構造はあまり分かっていない. 日本列島深部の構造を調べることは, 沈み込むスラブやマントル上昇流の深部での様子や相互の関連などを理解できると考えられ, マントルダイナミクス解明において非常に重要である.

本研究では, 遠地地震の相対走時残差を使用した遠地地震トモグラフィーにより日本列島深部の P 波, S 波の速度構造を推定した．P 波を用いた同様の研究は過去にも行われてきたが (例えば, Zhao et al., 1994, 2012; Abdelwahed and Zhao, 2007 など), S 波を用いた研究は少ない. P 波と S 波両方のデータを用いることで, 速度構造だけでなくポアソン比の分布も得られ, 日本列島地下深部の構造をより詳細に把握することができる.

本研究で用いた遠地地震の相対走時残差は, P 波においては, 先行研究 (Zhao et al., 1994, 2012; Abdelwahed and Zhao, 2007) により集められた日本からの震央距離 30〜100°　の地震 360 個の中から, 日本全土で観測されており, かつ 100 点以上の観測点で観測された 130 個の遠地地震と, 震源の分布がなるべく均等になるように新たに読み取った 38 個地震の計 168 個の遠地地震より約 6 万個の P 波走時データである. S 波においては, 震源の分布が均等になるように選んだ 56 個の遠地地震より約 4 万個の S 波データを使用した．また, 浅い速度構造を補正するために, 気象庁の一元化カタログから 100 点以上で観測された近地地震約 3 千個を用いた. 解析手法には, 近地地震と遠地地震のデータを同時にインバージョンすることができる Zhao et al. (1994, 2012) のトモグラフィー計算プログラムを用いた.

得られた結果より, P 波, S 波ともに背弧側から続く低速度異常体が見られ, これはマントルウェッジ内のコーナーフローであると考えられる. 関東地方以西においては, 内陸下の稍深発地震の震源に沿った高速度異常を見ることができ, 沈み込むフィリピン海スラブであると考えられる. 特に九州地方になるとこの高速度異常は深さ 400 km 程にまで達する様子が P 波, S 波の両方で見ることができ, フィリピン海スラブは九州下ではマントル遷移層まで沈み込んでいると考えられる. 発表ではこれらに加え, ポアソン比やマントル深部物質の物性に関する R 値 (dlnVs/dlnVp) を求めることで, 日本列島の深部構造をより詳細に議論したい.

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Cape Verde ホットスポットとマントルプルーム
Seismic evidence for a mantle plume beneath the Cape Verde hotspot

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The Cape Verde hotspot is located in the African plate, about 2000 km east of the nearest plate boundary. It is composed of a group of late Cenozoic oceanic islands resting on a broad bathymetric swell on mature (>110 Ma) oceanic lithosphere. This hotspot has a positive surface heat flow, high geoid anomaly, and long-term volcanism. The last known volcanic eruption occurred at Fogo volcano in 1995.

We determined P- and S-wave tomography of the upper mantle beneath the Cape Verde hotspot using arrival-time data measured precisely from three-component seismograms of 106 distant earthquakes recorded by a local seismic network. Our results show a prominent low-velocity anomaly imaged as a continuous column <100 km wide from the uppermost mantle down to about 500 km beneath Cape Verde, especially below the Fogo active volcano, which erupted in 1995. The low-velocity anomaly may reflect a hot mantle plume feeding the Cape Verde hotspot.

キーワード: Cape Verde, ホットスポット, マントルプルーム, 地震波トモグラフィー, マントル遷移層
Keywords: Cape Verde, hotspot, mantle plume, seismic tomography, mantle transition zone