Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SIT41-01 Room:302 Time:May 20 09:00-09:15

Toward modeling the anisotropic velocity structure beneath the Japanese subduction zone (1)

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Study of seismic anisotropy is one of the key problems in seismology because seismic anisotropy has close relationship with mantle dynamics and process of the earth evolution. However, it remains to be fully elucidated. Especially, the spatial distribution is poorly understood. Therefore, we launched modeling of seismic anisotropy structure.

Assuming that the modeling space is composed of weakly anisotropic medium, where hexagonal symmetry axis is in vertical, we estimate three-dimensional (3-D) P-wave isotropic velocity and radial anisotropy structures beneath the Japan subduction zone by P-wave travel-time inversion. In this presentation, we show the 3-D distributions of P-wave isotropic velocity and radial anisotropy beneath the Tohoku district. On the other hand, there are a lot of observations explained by the existence of horizontal azimuthal anisotropy. Therefore the immediate problem is the validity of the anisotropy assumed in the calculation.

Our ultimate purpose is to propose a comprehensive seismic velocity model including anisotropy beneath the Japan subduction zone and to explain various phenomena generated by anisotropy. Furthermore, based on the anisotropy model, we try to improve the understanding about the dynamics of the subduction zone.

Keywords: seismic anisotropy

SIT41-02 Room:302 Time:May 20 09:15-09:30

Viscosity structure model around 410-km discontinuity: mineralogical approach

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The 410-km seismic discontinuity has been attributed to the pressure-induced phase transformation from olivine to wadsleyite in an olivine component of mantle peridotite. The phase transformation may induce abrupt change in viscosity at 410 km depth, and the viscosity discontinuity may play an important role in the dynamics of the upper mantle and the mantle transition zone. Attempts have been made to determine viscosity structure of deep mantle by geophysical observations (e.g., aisostasy data of post-glacial rebound and gravity anomaly observations), however, the obtained viscosity-depth profile has been controversial. On the other hand, the viscosity-depth profile of deep mantle can be determined based on experimental data of a deformation experiment at high pressure and temperature. Recently, we made technical developments in the deformation experiment adopting new technique for high-pressure generation, and achieved viscosity measurement at pressure-temperature conditions of the upper part of the mantle transition zone. In order to determine the viscosity at the upper part of the mantle transition zone, we conducted in situ stress-strain measurement of wadsleyite at 13-14 GPa, 1400-1700 K and strain rates of 3.1-15 x 10^{-5} s^{-1} using a deformation-DIA apparatus at BL04B1 beamline of SPring-8. We found that water enhanced plastic deformation of wadsleyite and water dependence of wadsleyite creep strength was larger than that of olivine. Based on the experimental result, viscosity decreases at the 410 km boundary at moderate water content while little viscosity contrast exists at dry condition. Moreover, these experimental results suggest that heterogeneity in water at the mantle transition zone leads large viscosity heterogeneity at the upper part of the mantle transition zone.

Keywords: 410-km discontinuity, wadsleyite, viscosity, creep strength, water, deformation experiment

SIT41-03 Room:302 Time:May 20 09:30-09:45

Crystal structure of low-pressure $Ca_2AlSiO_{5.5}$ defect perovskite

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$CaSiO_3$ perovskite could dissolve Al_2O_3 component by forming oxygen vacancies. $Ca_2Al_2O_5$ brownmillerite structure can be regarded as an endmember for this dissolution mechanism, as all Si are replaced with Al. As a result, 1/6 of the oxygens are removed, and half of the Al are in tetrahedral coordination. If this is the dominant mechanism for Al dissolution into $CaSiO_3$ perovskite, the perovskite should contain oxygen vacancies, and physical properties such as elastic properties and transport properties would be significantly affected. For the intermediate composition of the $CaSiO_3$-$Ca_2Al_2O_5$ join, $Ca_2AlSiO_{5.5}$ with a rhombohedral perovskite structure was reported (Fitz Gerald & Ringwood, 1991). Later, a lower-pressure form of this phase was also found (Blab et al., 2007). Both phases were regarded to have oxygen-deficient perovskite-related structures, and structural models were proposed (Blab et al., 2007). However, the crystal structures have not been determined to date. Recently, we have demonstrated that a combination of NMR and SDPD (structure determination from powder data) is very powerful technique to solve unknown crystal structures (Kanzaki et al., 2011). In this study, we have applied this technique to the low-pressure $Ca_2AlSiO_{5.5}$ phase.

THe low-pressure phase of $Ca_2AlSiO_{5.5}$ was synthesized at 7 GPa and 1500 ^oC for 2H using a multi-anvil high-pressure device. Powder X-ray diffraction pattern for structural analysis was measured at BL19B2 of SPring-8 (for details, see Kanzaki et al., 2011). Local structures around Si and Al were studied by ^{29}Si MAS NMR and ^{27}Al 3Q MAS NMR. The crystal structure was solved using real-space searching program FOX (Favre-Nicolin & Cerny, 2002). The number and coordination of sites for Al and Si obtained by NMR were utilized for FOX calculation. After the initial structure was obtained, the structure was refined using Rietveld method (RIETAN-FP; Izumi & Momma, 2007).

Powder X-ray diffraction pattern of the phase is essentially identical to those reported by previous studies, and the obtained lattice parameters are consistent with those of Blab et al. (2007) with 8-fold superstructure. The space group was found to be C2/c. ^{29}Si MAS NMR spectrum revealed a single peak for tetrahedral Si. ^{27}Al 3Q MAS NMR spectrum revealed a single peak for octahedral Al. These results are in contrast to structure model proposed by Blab et al. (2007), in which both tetrahedral and octahedral Al and Si sites were assumed based on EELS spectra. Using NMR information as constraints, the crystal structure was successfully solved. The crystal structure of the phase is made of perovskite-like double-layer of AlO_6 octahedra and double-layer of tetrahedral SiO_4, stacked alternatively in the [111] direction of cubic perovskite, forming 8-fold superstructure. Oxygen is deficient at the middle of the double-layer of SiO_4, and 1/3 of the oxygens are missing from this oxygen close packing layer. The remaining oxygens are moved to form tetrahedral sites. One notable feature of the structure is that each SiO_4 tetrahedron has one non-bridging oxygen. This is in contrast to brownmillerite or perovskite structures, in which all oxygen are shared by two Al(Si). This new structure reveals another type of oxygen vacancy formation mode other than that of brownmillerite. Based on this structure, this phase is expected to have large anisotropic properties, such as higher compressibility in the c-direction.

This study was partly conducted during Misasa International Student Intern Program 2011 (Y.W.).

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Keywords: Ca2AlSiO5.5, high pressure phase, crystal structure, powder X-ray diffraction, defect perovskite, nuclear magnetic resonance

SIT41-04 Room:302 Time:May 20 09:45-10:00

P-wave tomography of Northeastern China observed with NECESSArray

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A passive broadband seismic experiment, NorthEast China Extended SeiSmic Array (NECESSArray) has been deployed since 2009 for two years. Northeastern China is a very interesting region because slabs subducting from the south Kuril and Japan trenches are stagnant in the mantle transition zone and extends to northeastern China, and above the stagnant slabs, Sino-Korea craton and unusual volcanism in the continent exist. The relationships between the deep slabs and shallow structures are important clues to understand the tectonic features.

P-wave travel-time picks of the NECESSArray stations were made interactively, while the teleseismic arrival time residuals were extracted using the adaptive stacking method. We picked more than 13,000 event-station pairs. Relative travel-times of P-wave between different stations were measured as a function of frequency using deep events of which P-waves separate in time from depth phases and very shallow events of which P-waves and depth phases are completely coincide. We found strong dispersive effect that is not predicted by our previous three dimensional (3D) P-wave model. We will combine the picked travel times and the frequency depended relative travel times to image a 3D P-wave heterogeneities of the northeastern China. We will present our first model at the meeting. The result shows fin structures of the stagnant Pacific slab. It is It is particularly worth noting that the northern part of the stagnant Japan slab seems to be buckling.

Keywords: Mantle, Mantle transition zone

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SIT41-05 Room:302 Time:May 20 10:00-10:15

Thermal equation of state of CaSiO3 perovskite

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CaSiO3 perovskite (Ca-perovskite) is one of the major constituent minerals in the deep mantle. In the lower mantle conditions, peridotitic mantle and subducted mid-oceanic ridge basalt (MORB) contain ˜5 wt% and ˜23 wt% Ca-Perovskite, respectively (Hirose et al., 1999, Wood, 2000, Hirose et al., 2005). In addition to MORB, recently, subduction of continental crusts is discussed in relation to the continental growth history. Experimental studies demonstrated that subducted continental crust may also contain Ca-perovskite at the pressure-temperature conditions near the 660-km discontinuity (Wu et al., 2009). Therefore, the density and elastic behavior of Ca-perovskite may be a key to understand the distribution of the subducted materials in the deep Earth. In the present study, we constructed a thermal equation of state of Ca-perovskite based on high-temperature diamond anvil cell (DAC) experiments.

The pressure-volume-temperature (P-V-T) relation of Ca-Perovskite was studied in a DAC with in situ X-ray diffraction method. For high-P-T generation, an externally-heated DAC and laser-heated DAC were used. A membrane gas regulating system was attached to both types of the DAC. Diamond anvils with 150 micron

beveled were used. A starting material was pure CaSiO3 glass mixed with platinum powder which served as a laser absorber and pressure standard. The sample mixture was sandwiched by NaCl pressure medium and was loaded into 50 micron sample chamber in a rhenium gasket. Angle-dispersive X-ray diffraction spectra were collected on a charge-coupled device (CCD) at the BL10XU beamline, SPring-8. Exposure times were 10 seconds. A monochromatized X-ray with a wavelength of about 0.41 A was collimated to 20 micron in diameter. Pressure was calculated from the unit-cell volume of Pt, using the thermal equation of state of Pt (Fei et al., 2004).

We conducted three separate compression runs at BL10XU of SPring-8.The sample was compressed to a certain pressure at 300 K and then the temperature was increased by the laser heating to synthesize Ca-perovskite. After the temperature was reached to a desired temperature, we started compression by increasing the gas pressure in the membrane system. During compression, we kept constant temperature so as to make isothermal compression experiments. We collected the XRD pattern at every 3-4 GPa. The maximum pressure we reached was 127 GPa. In one run, we conducted simultaneous heating of laser and external heating systems. First we increased the temperature by the external heating system to 700 K. Then, the laser was turned on to further increase temperature. This technique allowed us to reduce the temperature gradient in the sample and to attain much more stable heating compared to the laser heating alone.

We fitted thus obtained data to a thermal equation of state. We will present new P-V-T data of Ca-perovskite and discuss its density and elastic behavior at the deep lower mantle conditions.

Keywords: CaSiO3 perovskite, thermal equation state, X-ray diffraction, diamond anvil cell

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SIT41-06 Room:302 Time:May 20 10:15-10:30

Geophysical and mineralogical constraints on the post-spinel transformation: A case study for the Tonga slab

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We investigate the precise depth of the 660 km discontinuity for the Tonga slab, with the aim of determining the Clapeylon slope of the post-spinel transformation. We analyze waveform data from short period seismic networks at western United States and Japan for about 100 deep (h> 500 km) and intermediate-depth (h>200km) earthquakes within a small (nearly 200 km by 200 km) area near 20S. We investigate later phases in a time window from 3 s to 20 s after direct P waves and search for S-to-P converted waves at the 660 km discontinuity, which would represent the post-spinel transformation. We find that immediately below the foci of the deepest earthquakes the discontinuity is depressed down to the depths of 685+-5 km on average. We also observe that the discontinuity dips toward WNW by 10+-3 km within about 70 km laterally. We attempt to constrain the thermal structure near the S to P conversion points based on an assumption that the deepest earthquakes occur around the coldest core of the Tonga slab. The distribution of the hypocenters relocated in this study and previously published tomographic images of the same region indicate that the Tonga slab bends upward when it approaches the 660 km discontinuity and transiently stagnates around the discontinuity, before it ultimately impinges on the lower mantle. By using these observations as the constraints, we numerically model the thermal structure of the Tonga slab. We find that the S-to-P conversion points are located inside and near the bottom of the Tonga slab. We also estimate the temperature around the conversion points as 1200 +- 100 degrees C, which is 300+-100 K colder than the surrounding mantle. As the average depression of the discontinuity (down to 685+-5 km) corresponds to an pressure excess over the global average (660 km) by 1.0+-0.2 GPa, the assumption of equilibrium post-spinel transformation gives an estimate of the Clapeyron slope (C1) of -3.3(+1.3 -2.7) MPa/K. On the other hand the observation of the dip of the discontinuity and the computed temperature variation (by about 200 K) leads to another independent estimate of the Clapeyron slope (C2) of -2.0(+-1.0) MPa/K. The discrepancy between C1 and C2 is marginally significant and can be diminished by considering that the slab materials at the conversion points are currently descending across the phase boundary fast enough and thus the depth of the post-spinel transformation is controlled by nucleation kinetics as well as by the temperature. The nucleation overpressure may be on the order of 0.5 GPa for the post-spinel transformation.

Keywords: post-spinel transformation, 660km discontinuity, Tonga slab, Clapeylon slope, kinetics, seismic array

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SIT41-07 Room:302 Time:May 20 10:45-11:00

Efficient and accurate ab initio calculations on the lattice thermal conductivity: Applications to $MgSiO_3$ Pv and PPv

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Although thermal transport property of materials under pressure and temperature is of importance for understanding thermal structure and its thermal history of the Earth, both experimental and theoretical determinations of the thermal conductivity still remain technically challenging particularly at the deep mantle and core conditions. However, ab initio computational method has been recently extended to transport phenomena due to some technical advances. The intrinsic bulk thermal conduction of insulator is caused by lattice anharmonicty owing to phonon-phonon interactions. The key parameter to predict the lattice thermal conductivity, k, is thus the anharmonic coupling strength. Earlier theoretical works calculated k of MgO with various approaches such as molecular dynamics simulation and finite difference method. In those approaches, the sufficient simulation cell size should be taken account for accurate description of the long wavelength phonon scattering, and therefore the computational cost to calculate k tends to be expensive particularly for more complex minerals such as $MgSiO_3$. Actually, to the best of our knowledge, the k of $MgSiO_3$ perovskite (Mg-Pv) or post-perovskite (Mg-PPv) at high-pressure and high- temperature still not established by ab initio calculation. In contrast to those approaches, we evaluate the anharmonic coupling strength based on the density-functional perturbation theory. In this approach, the higher-order force tensors are calculated through a number of phonon decay channels obtained within the perturbative scheme taking care only of the primitive cell. We have been developing a technique for the calculation of the phonon damping function necessary to obtain the phonon relaxation time. Then k is calculated with additional harmonic-level of calculations.

In this presentation, we show that the k of Mg-Pv and Mg-PPv as a function of pressure and temperature. The k of Mg-Pv calculated at ambient condition is found to be in excellent agreement with the experiment (M. Osako and E. Ito, Geophys. Res. Lett. 18, 239, 1991). The current results are applied to evaluate the effective k and the total heat flow at the core-mantle boundary (CMB) with a composite averaging between MgO and $MgSiO_3$. This provides better constraints for the thermal evolution of the Earth.

Research supported by Senior Research Fellow Center, Ehime University.

Keywords: ab initio calculations, lattice thermal conductivity, phonon-phonon interaction, deep mantle minerals

SIT41-08 Room:302 Time:May 20 11:00-11:15

Hemispheric variation of the depth dependent attenuation structures of the top half of the inner core

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Previous studies suggested the existence of the hemispheric heterogeneities in the top 100 km of the inner core (ex. Wen and Niu, 2002). However, the depth dependent profiles of the attenuation have not been well constrained because of the poor resolution due to difficulties in analyzing contaminated core phase data. Iritani et al. [2010, GRL, 2011, SSJ] employed a waveform inversion method based on simulated annealing (SA) that enables to analyze complicated waveforms with phase overlapping and applied it to Hi-net and NECESSArray data. The obtained models show similar features that we have definite high attenuation zone around 200 km depth from ICB.

In this study, we collect high-quality core phase data from large number of broadband arrays to obtain the depth dependent profiles of the top half of the inner core in various regions. The resultant data set consists of about 8,500 waveform traces from PASSCAL arrays deployed in a number of places in the world, permanent European stations and USArray. Sampling regions are beneath northeastern Pacific, American and African continent for the western hemisphere of the inner core, and eastern and central Asia for the eastern hemisphere. We apply the same method as Iritani et al. [2010] to these data. In general, the obtained attenuation models for the western hemisphere show the gradually increase from ICB and have a peak around 200 km depth and those for the eastern hemisphere have a high attenuation zone at the top 150 km layer. However, almost all models show common features below 250 km depth and attenuation gradually decreases with depth. We also obtain the averaged structure models for each hemisphere, and similar features are observed. It appears that hemispheric heterogeneities of the inner core are confined in the top 150 - 250 km of the inner core.

Keywords: inner core, attenuation, hemispheric structure

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Sound velocities of laser-shocked iron alloys under Earth's core condition

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When we consider the structure of the Earth's interior, the sound velocity is one of the important physical properties of the interior materials because it can be directly compared with the seismological data which can yield the physical properties of the Earth's interior. Although it needs to measure the sound velocity of the interior material under high pressure and temperature, the sound velocity measurement of the materials on the condition over 200 GPa and 4000 K, such as the Earth's core condition, is technically difficult in static compression technique (e.g. diamond anvil cell: DAC) (1-4). Therefore, in such higher pressure and temperature, dynamic compression technique, such as gas gun, is used. Although some works about the sound velocity of pure iron have been done by gas gun (5-7), it is not enough to discuss about the Earth's core which consists of iron alloy. Although Badro et al. (8) and Fiquet et al. (9) measured compressional sound velocity for some iron alloys (FeO, FeSi, FeS, FeS2, and Fe3C) at room temperature by inelastic x-ray scattering (IXS) at the DAC, the sound velocity data of liquid iron alloy is very few (10, 11).

We performed laser-shock experiments of liquid iron alloys at HIPER system of GXII laser in Institute of Laser Engineering, Osaka University (ILE) (12). We measured the sound velocities of iron alloys (Fe-Si, Fe-Ni-Si) under the Earth's core condition. The sound velocities were measured by side-on radiography (7). We will report the results of the sound velocity measurement for the laser-shocked iron alloys.

Part of this work was performed under the Joint Research of Institute of Laser Engineering, Osaka University.

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Keywords: Sound velocity, Laser, Shock wave, FeSi, Earth's core, Experiment

SIT41-P01 Room:Convention Hall Time:May 20 17:15-18:30

Dynamics of plate spin motion through plate boundary

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Compared with other planets, the Earth has a variety of special features. One of them is plate tectonics. Because of the feature, the Earth's surface has unique motions such as strike-slip motion along plate boundary and spin motion of a plate. Regarding strike-slip motions, they lead to vorticity along the plate boundary and we can consider the vorticity as an infinitesimal spin motion. Therefore, both strike-slip motion and spin motion of a plate are spin motions and consequently we would state that it is spin motions that characterize plate tectonics and the Earth. However, the dynamics of spin motion is not well understood, thought the plate spin motion must include vital information about plate tectonics, especially the dynamics of plate boundary which is the most intricate problems in this field. Hence, we here focus on the dynamics of plate spin motion.

To begin with, we analyzed the basic equation of mantle convection since plate tectonics is a part of mantle convection as the thermal boundary layer and we will grasp the dynamics of plate tectonics from that of mantle convection. The analysis shows that the effect associated with the horizontal viscosity variation of the surface is indispensable to generate vorticity or plate spin motion. As a parameter of the horizontal viscosity variation, we make use of individual plate size since a plate size expresses the distance between hard plate center and soft plate boundary and is therefore one of simple parameters to consider the influence of the horizontal viscosity variation. Dividing observed Euler poles into two components: spin Euler pole associated with spin motion of a plate and straight Euler pole associated with straight motion of a plate, we revealed that the potential energy generated by subduction excites the plate motion, particularly the straight motion, in a large scale motion and the straight motion transmits into the spin motion through the plate boundary, especially in a small scale motion, mainly less than 1000 km of the radius of plate. In addition to the individual plate analysis for plate spin motion, the global plate motion analysis called spherical harmonic expansion also demonstrates the transmission from the straight motions into the spin motions in a small scale motion.

These results suggest that while small plates have high spin motions since they receive the force to spin through the plate boundary without large deformation, i.e., low strain rate, large plates do not have high spin motion since the force to spin does not well transmit because of the large deformation, i.e., high strain rate, along the plate boundary which we call a "strike-slip" boundary. This difference of force transmission, or strain rate, along plate boundary in plate size might be associated with the difference of the stress along the plate boundary; for example, we need larger stress along plate boundary in order to spin larger plates. In other words, this difference might be attributed to the rheology of plate tectonics, especially along plate boundary. Estimating the stress to spin, we will obtain the rheology of plate boundary from observation, that is, plate motion, which advances the theory of plate tectonics substantially.

Keywords: plate tectonics, plate boundary, dynamics, plate spin motion, toroidal-poloidal motion, vorticity of plate tectonics

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SIT41-P02 Room:Convention Hall Time:May 20 17:15-18:30

3-D Imaging of Continental Lithosphere with Multi-mode Surface Waves

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Developments of high-density seismic arrays and techniques of seismic tomography in the last a few decades have enhanced the horizontal resolution of seismic images of the Earth's interior. Seismic surface waves are one of the most powerful tools to map 3-D images of the uppermost mantle, although its depth resolution is limited to the top 200 km as long as we use readily measurable fundamental-mode surface waves that are normally sufficient to map oceanic lithosphere with the thickness of about 100 km or less. On the other hand, high-resolution imaging of continental lithosphere, whose thickness tends to exceed 200 km beneath major cratonic areas, requires higher-mode data with greater sensitivities to the deeper structure. The use of higher-mode surface waves is, however, not straightforward, since several modes overlap in time and cannot be separated in a seismogram, particularly at short distances commonly used in regional-scale tomographic studies.

We present recent progress on the high-resolution regional-scale mapping of the continental upper mantle using multi-mode surface waves, with a particular focus on the 3-D imaging of radial anisotropy of shear wave speed as well as the lithosphere-asthenosphere boundary (LAB) beneath continental areas. Surface waves are inherently not very sensitive to the sharpness of boundaries due their long wavelength. The depth of LAB, however, can be estimated from the peak of negative gradient of a velocity model, while the thickness of LAB can be deduced from the sharpness of the velocity gradient. Using the recent continental tomography models of Australia and North America, we investigate the relationship between the distribution of LAB beneath the continents and the strength of radial anisotropy, which implies a significant correlation between the present-day plate motion and faster SH wave speed anomaly in the asthenosphere beneath the estimated LAB.

Keywords: surface waves, lithosphere, asthenosphere, continent, anisotropy

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HYDROUS MELTING OF LHERZOLITE AND CRATONIC MANTLE

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Mantle peridotite xenoliths from kimberlite pipes at craton sometimes have unusual chemical, modal, and textual compositions [1, 2]. The cratonic mantle, which consist mainly of olivine, orthopyroxene, garnet and clinopyroxene, are characterized the high amount of orthopyroxene (=high-Si) with high Mg# (= Mg/(Mg + Fe) atomic ratio) [1]. Here, based on melting experiments of hydrous pyrolitic lherzolite at upper mantle conditions, we suggest possibilities of the Si- and Mg-rich cratonic peridotites as residues by partial melting of lherzolite at hydrous condition at depth of more than ~140 km. Starting materials are pyrolitic lherzolite + H2O. The powder of SiO2, TiO2, Al2O3, Cr2O3, Fe2O3, CaCO3, Na2CO3, K2CO3, and NiO was mixed, and degas at T = 1273 K and ambient pressure in atmosphere. Then it was melted at 1773 K and quenched to form glass in a 1-atm furnace (Prof. Kawasaki's laboratory in Ehime University) with oxygen fugacity controlled at the QFM buffer using CO2/H2 gas mixture. Finally, powders of MgO and Mg(OH)2 are added to be the water contents of starting material as 2 wt% and 8 wt%. Experiments were performed by using multi anvil type high-pressure apparatus (ORENGE 1000) of the GRC in Ehime University at the temperature of 1273-1873 K at the pressure of 3-8 GPa. In our experimental conditions, all products contains liquid phase. The residual mineral assemblage is olivine + opx + cpx + garnet at lower temperature. At the experiments with 2 wt% H2O, the solid phases resolved to liquid as a next order, clinopyroxene, garnet, orthopyroxene and olivine. In the experiments of 8 wt% H2O, stability field of olivine shrinks and that of orthopyroxene expands with increasing pressure. It is noted that the liquidus phase is not olivine but orthopyroxene at pressure higher than 6 GPa. Actually, the opx/ol ratio of cratonic mantle xenoliths is known to be higher than that of mantle xenolith in other regions [e.g., 1, 8], and our results imply that water greatly influenced for generation of cratonic mantle at the early earth. If our conclusion is correct, the Earth's mantle is very heterogeneous in water content, and water was one of the important components for formation of continent(s) at early Earth.

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Keywords: hydrous lherzolite, high pressure and temperature experiments, craton, partial melting, enstatite

SIT41-P04 Room:Convention Hall Time:May 20 17:15-18:30

Thermodynamic Calculation of polybaric Melting of Mantle Peridotite

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Partial melting is an essential process for both material differentiation and heat transportation of the Earth. Numerical forward calculation is useful approach to predict melting in the dynamic system such as the magma ocean that may have developed from surface to lower mantle depth, and the present day subduction zone where fluid addition, mantle convection and melting are tightly coupled. Thermodynamic calculation by system energy minimization is a general approach to describe dynamic melting of such multi component and multi phase system, because that can provide an internally consistent relation of phase relation and mass and energy balance during melting.

We have developed a straightforward algorithm for calculating phase equilibria of multicomponent system by energy minimization of the system, together with thermodynamic configuration to describe a molar Gibbs free energy of silicate melt. The thermodynamic model constructed with the algorithm and melt thermodynamic configuration successfully reproduced melting phase relation of mantle peridotite at 1 GPa. We have expanded a calibration database of the thermodynamic model up to 3 GPa to conduct a polybaric melting calculation, which is dominant in natural tectonic settings (e.g., mid-ocean ridges and hotspots).

Construction of equation of state of silicate melt is an essential factor to evaluate multi pressure melting. We employ two different configurations for volumetric parameters of silicate melt to investigate better approach to predict melting relation at high pressure. In the first configuration, molar volume of silicate melt end-component is represented by the difference from the volume of corresponding solid end-component (dV), and the dV is calibrated with the results of previously reported melting experiments. We also employed a set of 1 bar experimental volumetric parameters (Lange and Carmichael, 1990) for the equation of state of silicate melt, which is commonly used to calculate melt volumetric property. In this case, standard state molar volume of melt end-component is calibrated with the calibration data set. In both configurations, dCp, which is the difference in molar specific heat between the corresponding melt and solid end-components, are also calibrated and ideal solution are assumed for silicate melt. The tested system consists of SiO2-Al2O3-FeO-Fe3O4-MgO-CaO and includes olivine, clinopyroxene, orthopyroxene, and spinel with silicate melt. Thermodynamic parameters and enthalpy, entropy and temperature of fusion at 1 bar for solid end-components are taken from previous studies.

Our thermodynamic calculation with calibration of dV successfully reproduced experimentally determined multi pressure melting reaction of mantle spinel lherzolite at 1-3 GPa (Hirose and Kushiro, 1993), including systematics between pressure-temperature-composition of the system and melt composition and melting degree. On the other hand, calculation result with parameter of derive larger misfit with experimental result. Our model with calibration of dV makes better prediction than pMELTS (thermodynamic model to calculate phase relation of melt present system), in terms of temperature-phase proportion including melt fraction. pMELTS did not calibrate melt volumetric parameters and utilized volumetric parameters. It is deduced that our configuration, in which thermodynamic parameters for melt is calibrated based on the difference from the corresponding solid end-component at melting P-T conditions, is useful approach, rather than extrapolation from standard state properties of simple systems as have been often employed in the previous studies.

Keywords: Thermodynamics, melting, mantle, phase equilibra

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High pressure phase relations of hydrous MORB and hydrous Harzburgite in the mantle transition zone

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Oceanic plate (slab) is subducting into Earth's deep interior and it is stagnant around the mantle transition zone, which is confirmed by seismic tomographic image. Slab is believed to consist of three different compositional layers by MORB, harzburgite and lherzolite. So the phase relations of these compositional rocks have been clarified so far together with the determination of the physical property and so on at high pressure and temperature. On the other hand, subducting slab can transport water in to the Earth's deep interior because of the pressure of hydrous minerals. Therefore it is important to study the effect of water for the subducting slab materials. In this study the phase relations for hydrous MORB and hydrous harzburgite have been studied in the condition corresponding to the mantle transition zone.

The high pressure experiments were conducted at pressure of 15 to 23 GPa and temperature of 1400 and 1600 deg C using MA8-type (Kawai-type) multi-anvil apparatus. Garnet and stishovite were stable at 15 to 22 GPa in MORB composition. However, over 23GPa, garnet transformed to Ca-perovskite, Mg-perovskite and calcium-ferrite. On the other hand in harzburgite composiotion, wadsleyite transformed to ringwoodite at around 18 GPa, and the post spinel transformation was observed at around 23 GPa. Moreover akimotoite was stable at 15 to 21 GPa.

On the dry MORB, garnet transformed gradually 25 to 30GPa. But in the hydrous MORB, garnet transformed sharply at around 22 to 23 GPa. On the harzburgite composition, garnet is stable at the mantle transition zone in dry condition. However in hydrous condition, akimotoite was stable. Thus water affects the phase transformation boundaries and the phase assemblies remarkably. As the results, the density profiles of the subducting slab should change in dry and hydrous cases, and should be important for mantle dynamics.

Keywords: high pressure phase relation, hydrous MORB, hydrous Harzburgite, the mantle transition zone

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A miniature cubic anvil apparatus for optical measurement on deep earth minerals under high pressure

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A miniature cubic anvil apparatus was developed for optical measurement on deep earth minerals with relatively large volume under high pressure, and preliminary experiments were conducted to 3.6 GPa at room temperature with optical visual observation and ruby fluorescence measurement. In the apparatus, a cubic pressure medium was squeezed with six tungsten carbide anvils, which are driven with a pair of guide blocks by tightening four sets of screws. Optical access on the sample was made through holes in axial anvils and the guide blocks as well as optical windows made of Al_2O_3 single crystals embedded in the pressure medium. The apparatus is compact and light, ˜53 mm in diameter and height and ˜530 g in weight, and the features of the apparatus benefits easy application of the apparatus to various types of standard optical measurement systems. The optical measurement on the sample with relatively large volume should greatly contribute to advancements of studies relevant to high-pressure behaviors of deep earth minerals.

Keywords: cubic anvil apparatus, optical measurement, deep earth mineral, high pressure, optical visual observation, ruby fluorescence measurement

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SIT41-P07 Room:Convention Hall Time:May 20 17:15-18:30

SS-precursors observed by NECESSArray: Lehman discontinuity beneath the northeastern Pacific ?

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We analyze SS-precursors from aftershocks of the 2010 Chilean (Mw 8.8) earthquake recorded by NECESSArray. Slant-stacked seismograms of 13 shallow events recorded by ~120 stations of NECESSArray show a strong signal above the 4-sigma noise level about 85 sec before the arrival of the parent SS-phase. This may be originated from the Lehman discontinuity located at a depth of ~200km, but the polarity may be reversed. While signals from 410km- and 660km-discontinuity are well resolved, no signal for the G-discontinuity deeper than 60km is observed. The G-discontinuity (or seismic LAB) beneath the bounce point of the SS-phase (northeastern Pacific) may be shallower than 60km or absent.

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Sound velocity measurements of SiO_2 - Al_2O_3 glass under high-pressure

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Determination of the structure and physical properties of silicate melt under high pressure and high temperature is an important key to understand the Earth's evolution and the gravitational stability of melts in Earth's deep interior. Natural silicate melts mainly consist of SiO_2 with various chemical components. Aluminum is one of the most abundant elements in the natural silicate melts, and the Al_2O_3 contents can be as high as 12 mol.% in magmas. To understand the effect of Al_2O_3 on the compression behavior of silicate melts is therefore essentially important. There have so far been a number of experimental studies of glasses, as the analogue of melts, in the binary system of SiO_2-Al_2O_3 with various experimental techniques. Previous experimental results obtained by NMR, IR, Raman and X-ray diffraction spectroscopies showed that SiO_2-Al_2O_3 glasses with 0.4 to up to 12.0 wt.% Al_2O_3 contain high coordinated (5-, and 6-fold coordinated) Al sites (e.g., Sen and Yaungman, 2004, Okuno et al., 2005), which significantly affects the density of SiO_2-Al_2O_3 glasses (Okuno et al., 2005; Linh and Hoaug, 2007). However, there are few experimental studies about the structures and physical properties of SiO_2 - Al_2O_3 glasses under high pressure toward an implication for the Earth's evolution and geophysical phenomenon in Earth's deep interior due to experimental difficulties.

To understand the effect of Al_2O_3 on the compression behavior of SiO_2-Al_2O_3 glasses under high pressure, *in-situ* high pressure Brillouin scattering measurements of acoustic wave velocities were carried out at room temperature in a symmetric diamond anvil cell. Brillouin scattering is highly sensitive to the structural change regardless of the state of the sample (glass, liquid and crystal) and its result of silicate glasses can provide us with the information leading to the changes of structure and density in silicate melts in the temperature and pressure range corresponding to the Earth's mantle. We synthesized SiO_2 - Al_2O_3 glasses with several compositions by levitation method using CO_2 laser and performed structure analysis of them by X-ray diffraction at BL04B2, SPring-8. Brillouin scattering measurements of acoustic wave velocity were carried out up to 60 GPa.

Our results showed that the velocity-pressure curve of the sample with lower alumina contents has very similar trend to that of SiO_2 glass. In contrast, we observed the anomalous sound velocity evolution for the samples with higher alumina contents, which strongly suggests the drastic change of compression behavior of SiO_2-Al_2O_3 glass.

In this presentation, we will present those new experimental results on the compressional behavior of SiO_2-Al_2O_3 glasses including the results obtained by synchrotron X-ray diffraction measurements, and discuss about the possible implications for the magmas in deep Earth's interior.

Keywords: Structure of silicate glass and melt, Brillouin scattering, Acoustic wave velocity measurement

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SIT41-P09 Room:Convention Hall Time:May 20 17:15-18:30

The method for joint tomography using both NECESSArray and global bulletin data

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In the last SSJ, we presented the results of our delay time tomography using the triplicated data observed by NECESSArray. Our tomography used the array analysis method by Iritani et al. (2010, GRL) in measuring traveltimes, which enables accurate phase identification and retrieval of the information of secondary phases. However, because the method can be applied only to the array data, its application was so far restricted to regional tomography, and corrections of the effects of structures outside the studied region were not straightforward.

In this study, we propose a new tomography method to apply our method to global tomography. The basic idea is to use both array waveform data (e.g., NECESSArray data) and global bulletin data (e.g., EHB data). The measurements of traveltimes for the former dataset are identical to what we have done in our previous tomography. The traveltime data in the latter dataset are used with modified phase associations. We assume that the phase type of the first arrivals of the bulletin data should be identical to that for the nearby event used in the analyses of the array waveform data. Such modifications can be applied only to the regions where we have dense arrays, however, because the phase misidentification can be greatly suppressed, the accuracy of the obtained model should be improved in these regions. If we focus only on the structures in these regions, they are assumed to be the results of the regional tomography with accurate corrections of the outside effects.

We applied this method to the NECESSArray data and the EHB bulletin data. At the time of the presentation, we plan to show how much improvements we can achieve by modified phase associations. We also plan to compare the models with and without NECESSArray data and discuss the plausibility of the features which are pointed out in our previous study.

Keywords: tomography, Earth's internal structures

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Sound velocity measurements of CaSiO3 perovskite to 133 GPa and implications for lowermost mantle seismic anomalies

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We report the measurements of aggregate shear velocity (VS) of CaSiO3 perovskite (CaPv) at high pressure (P) between 33 and 133 GPa and room temperature (T) on the basis of Brillouin spectroscopy. The sample had a tetragonal perovskite structure throughout the experiments. The measured P?VS data show the shear modulus and its pressure derivative at ambient condition to be G0 = 115.8 GPa and G' = 1.20, respectively. The zero-pressure shear velocity is determined to be VS0 = 5.23 km/sec, in good agreement with the previous estimate inferred from ultrasonic measurements on Ca(Si,Ti)O3 perovskite at 1 bar. Our experimental results are also generally consistent with earlier calculations on tetragonal CaPv. According to the very recent predictions, such tetragonal CaPv has similar velocities to the cubic phase. These indicate that shear and longitudinal velocities of CaPv are much lower than those of the other lower mantle minerals such as MgSiO3-rich perovskite and ferropericlase. While primitive mantle includes certain amount of CaPv, a depleted peridotite (former harzburgite) layer in subducted oceanic lithosphere is deficient in CaPv and enriched in ferropericlase in the lower mantle. Such harzburgite exhibits 1.2% faster VS and 0.8% slower bulk sound velocity (VB) than the primitive mantle at lowermost mantle P-T conditions. The observed fast VS and slow VB anomalies in the D" layer underneath the circum-Pacific region may be attributed in large part to the presence of subducted harzburgitic materials.

Keywords: CaSiO3 perovskite, lower mantle, shear velocity,, Brillouin spectroscopy, harzburgite

SIT41-P11 Room:Convention Hall Time:May 20 17:15-18:30

Imaging the subducting slabs and mantle plumes with high-resolution global tomography

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Global seismic tomography has been used to determine the 3-D whole-mantle structure, which has provided important information on the deep structures of the subducting slabs and mantle plumes as well as deep Earth dynamics. Tomographic images under the hotspot volcanoes such as Hawaii, Iceland and Tahiti exhibit low-velocity anomalies, which may reflect hot mantle plumes (e.g., Zhao, 2004, 2009). Zhao et al. (2009) investigated the upper-mantle structures under the intraplate volcanoes in China (Mt. Changbai and Mt. Wudalianchi). Their results suggest that these intraplate volcanoes are related to the big mantle wedge above the stagnant Pacific slab under East Asia. In this work, we have tried to determine a more detailed 3-D mantle structure by using global tomography. In Zhao (2004, 2009), the thickness of the subducting Pacific slab was imaged to be 200-250 km due to the lower resolution. While high-resolution local and regional tomography under the Japan Islands shows the slab thickness to be 85-90 km (Zhao et al., 2009, 2011; Huang et al., 2011). To obtain a high-resolution whole-mantle tomography, we have tried to adopt a much denser flexible-grid with a grid interval of 50 km in depth and 100-200 km in lateral direction. We used five kinds of ISC P-wave data (P, pP, PP, PcP and P-diff phases), and adopted a flexible-grid model parameterization (Zhao, 2009; Yamamoto and Zhao, 2010). The 1-D iasp91 Earth model was adopted to be the starting model for the tomographic inversion. In this work we have used about 1.7 million P-wave arrival times from about 13000 earthquakes. By using many kinds of seismic phases, the spatial resolution of the tomographic images has been much improved for the upper mantle under the oceanic regions. The preliminary results show a similar pattern of whole-mantle tomography as the previous models, but both the subducting slabs and mantle plumes exhibit sharper images than those revealed by the previous studies.

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D” discontinuity in the northwestern edge of the Pacific Large Low-Velocity Province detected by NECESSArray and F-net

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Broadband seismic recordings from the stations of NECESSArray and F-net are analyzed to investigate the shear-wave velocity discontinuity at the top of D” layer across the northwestern edge of the Pacific Large Low-Shear-Velocity Province (LLSVP). In this study, we focus on the nature of the D” discontinuity across the edge of the LLSVP by detecting a precursor to ScS phase at epicentral distances of 65o to 85o. Transverse component seismograms from earthquakes occurred in the Kermadec, Fiji, and Vanuatu regions are assembled and analyzed. Employing linear and phase-weighted vespagram (Schimmel and Paulssen, 1997), we identified a clear arrival with an arrival time and slowness between the S and ScS waves, indicating a reflected S wave from the D” discontinuity.

Keywords: D” discontinuity, LLSVP, lowermost mantle, ScS-wave, array analysis, Northwest Pacific

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Seismic Evidence for Existence of an Ultra-low Velocity Zone in the Lowermost Mantle Beneath the Central Pacific

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We consider waveform data for nine events in Papua New Guinea recorded at stations in North America that sample the lowermost mantle beneath the central Pacific. Two of these events have high-quality waveforms. We interpret the waveforms for these two events using forward full-waveform modeling and derive 1-D models appropriate for the study region. We show that a strong later phase (also noted by previous workers) about 25 s after the S arrival at epicentral distances from about 90 to 110 degrees and azimuths from about 50 to 65 degrees can be explained as an ScS phase (or diffracted ScS phase) produced by a low velocity zone (LVZ) with a thickness of about 120 km and a velocity decrease of about 5% underlain by an ultra-low velocity zone (ULVZ) with a thickness of about 50 km and a velocity decrease of about 30%. These low velocities imply the presence of a significant amount of iron.

SIT41-P14 Room:Convention Hall Time:May 20 17:15-18:30

The high conductivity of iron and thermal evolution of the Earth's core

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Earth's magnetic field is re-generated by dynamo action via convection currents in the liquid metal outer core, which are in turn driven by a combination of thermal buoyancy associated with secular cooling (along with possible radioactive heating) and buoyant release of incompatible light alloying components upon inner core solidification. Prior to the crystallization of an inner core, the energy for maintaining a geodynamo must be supplied in excess of the heat conducted down the isentropic gradient that develops in the presence of convection, placing tight constraints upon the core's thermal evolution. Here we present new measurements and calculations of the electrical resistivity of iron to 1 Mbar pressure, combined with a model accounting for saturation resistivity of core metal, to show that the thermal conductivity of the uppermost core is greater than 90 W/m/K. These values are significantly higher than previous estimates, implying rapid secular core cooling, an inner core younger than 1 Ga, and ubiquitous melting of the lowermost mantle during early Earth. An enhanced conductivity with depth suppresses convection in the deep core, such that its center was stably stratified prior to the onset of inner core crystallization.

Keywords: high pressure experiments, first-principles calculations, resistivity saturation, core conductivity, thermal evolution

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Consideration about generation of the Earth's magnetic field - Based on the model experiment of three fold water tank -

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1 Purpose The Earth's magnetic field can be viewed as a dipole in the first approximation. This means that an electric circular current along the equator must exist. So, we set the hypothesis and we try to inspect that one, by using the experiment named of "three-fold water tank"which is well known in the field of Meteorology as a hint.

2 Method (1) Used by rotating three fold water tank, which is consisted of three tanks ,that is ,first a center tank with hot water as inner core, next a intermediary tank with usual water as outer core, and the last is a most outer side tank with icy water as mantle and crust, we did experiments repeatedly.Then, we observed the movement of the second main tank's water-surface, which is covered with aluminum powder faintly by changing same experiments conditions. (2)Next, we really charged the water tank with minus electricity (corresponding to plus charged outer core, but here for experimental convenient, minus charge adopted) by using a high-voltage static-electricity generation device which is known as Vandegraph one, and executed above experiment (1) again. On this occasion, we measured the magnetic field's intensity and the polarity of the space surrounding three fold water tank by Tesra meter (accuracy 0.01mT). And also we measured the value at a fixed point with time passage in order to inspect our hypothesis.

3 Result <Experiment 1> Experiment for finding generation-mechanism of the Earth's magnetic field by taking advantage of model experiment which is well known as one of three fold water tanks in Meteorology. Then, astonishingly, on the surface of the water covered with aluminum-powder as a tracer of that flow-direction, a reversal flow like a snake dance against the turn table's rotation (clockwise direction), appeared from the high temperature's side, namely, hot center-tank. Our hypothesis has been verified to be right. The same magnetic field as present Earth's polarity has appeared really. By the way, outer core is thought to be made of iron (Fe) which is fluid and is charged with plus electricity. So, we can think that in the outer core, there are electric current in the clockwise direction as along equator. As a result, the magnetic field like a dipole could be understood to appear. Thus, we could succeed in and reconstruct the occurrence of reversal flow against the turn-table's rotation (the Earth's rotation of North hemisphere) by this our original way of experiment. <Experiment 2> Experiment for exploring the new knowledge and clue on the mechanism of occurrence the N-S pole's reversal of the Earth's magnetic field. We noticed important factors concerning with N-S pole reversal phenomenon. Namely, when the difference of the temperature T between inside and outside of outer core comes to diminishing, the time point of H=0 (magnetic force disappears) arrives and after that, the N-S pole reversal begins. As reversal flow like a snake dance, occurred from high temperature's side (center tank's side) get weaken and become small sized one, we can observe that the difference of temperature T between inside and outside of outer core also get becoming to diminish. From this fact, we can understand that the Earth's magnetic field is generated by a tug of war of two opposite flows, namely a flow for the direction of the Earth's direction and the reversal flow against it. And eventually, the magnetic field of the Earth is thought to disappear when these two flows come to a certain power balance point. If T becomes under some one value, namely the certain power balance point, the flow of the Earth's rotation-direction overcome eventually. This means that the Earth's magnetic field turns to to be a reversal one.

4 Summary N-S pole reversal of the Earth's magnetic field does not occur when a drastic or dramatic change of somewhat happen to begin instantly. But, unexpectedly, we noticed it occurs during the process of diminishing the value of temperature difference T.

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P-V-T equation of state of hcp-Fe

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It is essential to realize high pressure and high temperature conditions in the laboratory by means of high pres-sure experiments to measure the physical properties of high pressure minerals for understanding the structure and dynamics in the earth's interior. In this study, we tried to expand the pressure range in a Kawai-type mul-tianvil apparatus equipped with sintered diamond anvil by optimization of assembly size and materials for cell assembly, and then measured P-V-T relationship of hcp-iron to discuss the dynamics of the inner core because. the hcp-iron is though to be dominant phase in the inner core based on recent diamond anvil experiments (Tateno et al., 2010).

We used synchrotron radiation facility, SPring-8, to conduct in situ X-ray observation at high pressure and temperature to determine P-V-T relation. Kawai-type cell assemblies were squeezed by high pressure press (SPEED-mk.II Madonna at BL04B1) using sintered diamond cubes with 14 mm edge length and 1.0 mm trun-cation edge length. Cr-doped MgO was used as pressure medium and TiB2+hBN was used as heating material. Preheated pyrophyllite was used as preformed gasket.

In the present study, pressure and temperature range were up to ˜83 GPa and 1300K. In the experiments, X-ray diffraction data were collected at every 200 K step during cooling cycle with pressure interval of 5-10 GPa. Pressure was estimated from the volume of gold by using equation of state of gold proposed by Tsuchiya (2003).

We fitted our data to third-order Birch-Murnaghan equation of state and Mie-Gruneisen thermal equation of state. As a result, thermoelastic parameters of the isothermal bulk modulus, its pressure derivative, Debye temperature, Gruneisen parameter at ambient pressure and volume dependence of the Gruneisen parameter were determined to be 151.1 (4.8) GPa, 5.6 (0.2), 1110 (87) K, 2.92 (0.24) and 0.99 (0.42), respectively. In addition to present analysis, we need to re-analyze by taking into account the electric pressure term in equation of state.

Our thermoelastic data indicate that the density of the inner core is 4-5 % heavier than observations by seis-mology (e.g., PREM). This result is consistent with previous study (Dubrovinsky et al., 2000) and indicates the existence of light elements in the inner core.

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Seismic structure near the inner core boundary in the south polar region

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Good spatial coverage of seismic data points is important for better understanding physical processes occurring in the Earth's core. Although fine seismic structure near the inner core boundary (ICB) has been examined using body waves by many researchers, the core structure of the polar region, especially the south polar region, still has been poorly resolved. Investigating the seismic structure in the polar region has a geophysical importance associated with the tangent cylinder in the outer core. The tangent cylinder acts as a barrier to the convective mixing and can create a reservoir of compositional anomalies. The polar region of the Earth's outer core can then be characterized by low density and high temperature. Investigating the polar regions is also important for increasing constrains on the nature of hemispherical variation in properties of the inner core observed in seismological studies. Based on such seismic models anisotropic growth possibly associated with the outer core convection has been suggested. It however remains under discussion whether lower velocities would reflect either a low growth rate or a fast growth rate. The preferential equatorial solidification in the Earth's core leads to slower inner-core growth in the polar region. Thus the comparison of the structure near the ICB between in the polar region and in the rest can provide a test for solidification scenarios.

Seismic rays from South America to Indonesia pass beneath Antarctica. These rays are invaluable because they sample the region near the ICB beneath the south polar region. We analyzed core phases on vertical-component broadband seismograms of JISNET, OHP and IRIS stations in and near Indonesia for earthquakes in South America from January 1998 to September 2002. We selected waveforms including PKIKP whose turning point or one of its intersections at the ICB is located south of 60 S. The total number of selected waveforms is 118 for the 37 earthquakes. The observed waveforms were band-pass filtered between 1 and 20 s. Synthetic seismograms are computed up to the frequency of 2 Hz using the Direct Solution Method (DSM). The PREM model is used as the reference. We analyzed differential traveltimes and amplitude ratios between core phases (PKIKP, PKiKP, PKPbc, and PKPc-diff). The model we obtained (SPR) is described relative to PREM as follows: a 0.05 km/s lower Vp value at the top of the inner core, a 1.5 times steeper Vp gradient in the upper 300 km of the inner core, a smaller Qp (300) in the upper 300 km of the inner core, and a 0.04 km/s lower Vp at the bottom of the outer core.

Our velocity structure in the lowermost outer core lies in between the two global reference models PREM and AK135. Previous models for the western hemisphere are close to SPR for the base of the outer core. The Vp value of SPR at the base of the outer core is larger than that of AK135 by 0.2%, suggesting that the outer core inside the tangent cylinder is not distinctive from the rest of the outer core. As regards the Vp structure in the upper inner core, SPR has smaller Vp values compared to PREM and AK135, and is close to that of previous models for the western hemisphere, although most of our data sample the eastern hemisphere of the inner core. Our results thus indicate that the inner core does not have a simple hemispherical variation as usually supposed. An eyeball-shaped high-Vp anomaly, such that higher Vp than the global reference models is rather concentrated to smaller region beneath eastern Asia, could be consistent with our results. If the same relationship between slow inner core growth and low inner core Vp applies to near the equatorial region, the western-hemisphere would also have a low growth rate of the inner core.

Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SIT41-P18 Room:Convention Hall Time:May 20 17:15-18:30

Melting relationships of the Fe-Ni-S system at 15GPa

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The planetary core consists of iron-nickel alloy and lightening elements, such as sulfur and silicon. Study of melting relations of iron alloys is of important to understand formation, evolution, and the present state of the planetary core. An addition of nickel to iron affects significantly the phase relations of iron alloys. Here, we report the results of quenching experiments on the Fe-Ni-S system at 15GPa.

Phase relations of the Fe-Ni-S system at 15 GPa were studied by using a KAWAI type high pressure apparatus at Okayama University. Recovered samples were examined by the electron microprobe JXA-8230.

At 15GPa, $(Fe,Ni)_3S_2$ and $(Fe,Ni)_3S$ are stable as intermediate compounds at subsolidus conditions. Iron solubility of $(Fe,Ni)_3S_2$ is limited to Fe/(Fe+Ni)=0.76 at 1000K, although Fei et al.(1997) reported that Fe_3S_2 is stable at 14GPa and 1125K. $(Fe,Ni)_3S$ is stable at only the Ni-rich portion. Addition of nickel depresses significantly the melting temperature of the Fe-FeS system. Ternary eutectic point locates around $Fe_{12}Ni_{55}S_{33}$ and its melting temperature is lower than 900K.

Keywords: core, Fe-Ni-S system, phase relations

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Density measurement of liquid Fe-O at high pressure and high temperature using an X-ray absorption method

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The Earth's outer core is thought to be composed of liquid iron alloys with a small amount of light elements, such as sulfur, oxygen and silicon. Existence of a liquid core is also suggested to other terrestrial planets (Mars and Mercury).Thus the effect of light elements on the density of liquid iron is fundamental to understand the composition and structure of the planetary cores.

The densities of liquid Fe-S, Fe-Si, and Fe-C have been reported using X-ray absorption method (Nishida et al., 2011; Sanloup et al., 2004; Terasaki et al., 2010). As a result, it was revealed that the rate of density decrease is quite different depending on the dissolving light element. Hence, it is important to figure out the effects on liquid iron by individual light elements. Although oxygen is one of the most popular candidates of the light elements in the Earth's outer core, the effect of oxygen on the density of liquid iron has never been reported to date. In this study, we have measured the density of liquid Fe-O (O = 0.5 wt%) up to 3 GPa and 2250 K using X-ray absorption method at BL22XU, SPring-8 synchrotron facility. The obtained density of this study is 6.65(3) g/cm^3 at 3 GPa and 2005 K. Compared to the density of pure liquid iron at the present experimental condition, the density of liquid Fe-O is about 7% smaller than that of liquid iron and thermal expansion coefficient of liquid Fe-O is similar to that of liquid iron.

Keywords: core, oxygen, density, high pressure and high temperature, synchrotron

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Sound velocity measurements of liquid Fe-S at high pressure: Implications for the Earth's and lunar cores

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The sound velocity of liquid Fe-S is an important physical property to understand the Earth's and lunar outer cores. We measured P-wave velocity (V_P) of liquid $Fe_{84}S_{16}$, $Fe_{60}S_{40}$, and $Fe_{50}S_{50}$ up to 5.4 GPa and 1550 ^oC using ultrasonic method combined with synchrotron X-ray technique. The derived VP of liquid Fe-S shows very little change with temperature. The V_P of liquid Fe-S decreases linearly with increasing S content at 2.5 GPa and 1300 ^oC. The V_P of liquid $Fe_{60}S_{40}$ increases almost linearly. The expected V_P of the lunar outer core range 3840-4250 m/s assuming the lunar core consists of liquid Fe-FeS outer core and solid Fe inner core. Although the V_P of liquid $Fe_{60}S_{40}$ is slower than that of pure liquid Fe up to 5.4 GPa, the V_P of liquid $Fe_{60}S_{40}$ should be exceed that of liquid Fe over 7 GPa because the pressure derivative of V_P of liquid $Fe_{60}S_{40}$ is larger than that of liquid Fe. This result suggests S is effective in increasing the V_P of liquid Fe over 7 GPa. Therefore, S is considered to be a possible light element of the Earth's outer core.

Keywords: high pressure, sound velocity, core, liquid, Fe-S