

## 合成カンラン岩の漸次的温度変化時の電気伝導度連続測定：部分融解の影響 Continuous measurements of electrical conductivity of synthetic peridotite under changing temperature: Melting effect

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Transport properties of the mantle (ex. electrical conductivity, viscosity, and seismic attenuation) sharply changes during ascent of the mantle especially at around mantle solidus. Electrical conductivity is considered to be the most sensitive property to the presence of partial melt. To understand how partial melting changes the conductivity of ascending mantle (ex. mid-ocean ridge), we measured the electrical conductivity of synthesized peridotite samples, which have different manners of melting with temperature, during slow increases and decreases in temperature under atmospheric pressure.

Three types of samples, forsterite (80%) + diopside (20%), forsterite (95%) + diopside (5%) and forsterite (50%) + enstatite (40%) + diopside (10%) with addition of 0.5% spinel, were synthesized from Mg(OH)<sub>2</sub>, SiO<sub>2</sub>, CaCO<sub>3</sub> and MgAl<sub>2</sub>O<sub>4</sub> powders with particle size of <50 nm. We continuously measured the electrical conductivity of these samples at temperature range from 1100 °C to 1400 °C. Microstructures of the samples quenched from above solidus were observed by scanning electron microscopy (SEM) in order to measure the melt fraction.

The electrical conductivity at well below (>50 °C) solidus of the forsterite + diopside samples exhibited a linear distribution in their Arrhenius plots indicating that a single mechanism controls. Such linear relationship was no longer observed at higher temperature regime exhibiting its exponential increase until the temperature reached to produce a phase assembly of forsterite + melt. In addition, the grain size dependence on electrical conductivity disappeared at temperature between 1350 °C and 1360 °C, indicating that the effective conductive path changed from grain boundary to other path. The result indicates that there is a phase assembly of forsterite + diopside + melt phase at around 1360 °C which has not been appeared in the previously reported phase diagram (Kushiro and Schairer, 1963).

Monotonic increase of electrical conductivity was observed above solidus of the forsterite + enstatite + diopside + spinel sample, and such increment is considered to be strongly related melt fraction changing with temperature, which is supported from SEM observation.

キーワード: 電気伝導度, カンラン岩, 部分融解, メルト分率

Keywords: electrical conductivity, peridotite, partial melting, melt fraction

## 高温高圧下における金の単結晶弾性の測定 Measurement of single crystal elasticity of Gold (Au) under high temperature and high pressure

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Single crystal elasticity of gold (Au) has been measured by inelastic X ray scattering method under high pressure. A few tens micrometer Au single crystal was prepared from a large commercial crystal by using FIB technique. The small crystal was placed inside a gasket hole of DAC apparatus. We succeeded to measure single crystal elasticity at 0.8 GPa and 3.2 GPa; the pressures were determined by the Ruby scale. ~100 peaks were observed at each pressure, and used to constrain the three independent constants of  $C_{11}$ ,  $C_{12}$ , and  $C_{44}$ . The resulted elastic constants are consistent with the previous data at ambient pressure.

We observed that  $C_{11}$  and  $C_{44}$  increase with increasing pressure, and  $C_{12}$  decreases with increasing pressure. We will expand the pressure range and temperature range of the measurement to establish the equation of state of gold with unprecedented accuracy.

キーワード: 金, 単結晶, 弾性, 高圧

Keywords: Gold, single crystal, elasticity, high pressure

## 半導体ダイヤモンドヒーターによる高圧力下での高温発生 High temperature generation using semiconductor diamond heater at high pressure

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Melting relations of the Earth materials are information essentially important to clarify the early differentiation and evolution of the Earth. Nevertheless melting experiments using the Kawai-type apparatus under mid mantle conditions are impossible because of limited temperature generation. Following Shatsky et al. (2009), we have tried to generate temperatures higher than 3500 K adopting B-doped semiconductor diamond heater. In order to carry out melting experiments at higher than 50 GPa, we adopt sintered diamond anvils. Temperature (T) is estimated by extrapolating a T-W (power) curve constructed up to 2600 C based on the W/re thermocouple measurement. Our T-generation reached ca. 4700 C at 55GPa.

キーワード: 高温発生, 半導体ダイヤモンドヒーター, 川井式 装置, 焼結ダイヤモンド

Keywords: High temperature generation, Semiconductor diamond heater, Kawai-type apparatus, sintered diamond

## Numerical Simulation on Subduction of the Pacific Plate into Northeast China and the Seismogenic Mechanism of Earthquake

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The Pacific Plate is subducted into Northeast China up to 660km deep, leading to a series of deep earthquakes in Hunchun zones of Jilin province, which was noticed by seismologists in the past. As the only deep-earthquake belt in China, its occurrence-time, locations and magnitudes are closely associated with Japan trench earthquakes and shallow earthquakes in Northeast China. Until now, seismologists attached great importance to this phenomenon and researched it in various aspects. On the one hand, research results confirmed the above phenomenon. On the other hand, masses of important results were obtained including the structure of the Pacific subducting plate, lithosphere structure in Northeast China, the earthquake focal mechanism and the seismic dynamic mechanism about the deep and shallow earthquakes. But until now, there is seldom systematic research about the relationship among the Pacific plate, deep and shallow earthquakes using numerical simulation method. Therefore, this paper will study their relationships and furtherly explore the tectonic stress field and dynamics environment in Northeast China.

Based on the geology data and the seismic velocity structure in Northeast China, we built the 2D vertical model along the 45 degree latitude ranging from 104 to 144 degree longitude with 0-660km deep to simulate the Pacific plate subducting to Northeast China using finite element numerical simulation method. According to motion rate of the Pacific plate to the Eurasian plate, the boundary conditions are given. The model with the typical tectonic belts, such as Tanlu fault, can explain the earthquake mechanism and study the stress fields and displacement fields. Besides the relationship between fault belts and shallow earthquakes is discussed. Through numerical simulation and comprehensive analysis, some conclusions are obtained as follows:

(1) The Pacific plate subduction into Northeastern China is the main dynamic resource causing a series of deep-focal and shallow-focal earthquakes. The stress field shows that there are two main areas of stress concentration under the subduction of the Pacific plate. It can help us to explain the relationship about the seismogenic mechanism between deep and shallow earthquakes.

(2) The displacement field and deformation field are given. The results show the displacement field and deformation field are controlled by the Pacific plate subduction rates. Exist of low velocity medium in the middle crust layer is in favor of the occurrence of the shallow earthquakes.

キーワード: numerical simulation, subduction of the Pacific plate, deep and shallow earthquakes, Northeast China

Keywords: numerical simulation, subduction of the Pacific plate, deep and shallow earthquakes, Northeast China

S-velocity structure of the crust and uppermost mantle of East Asia from ambient seismic noise  
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We have collected continuous vertical-component broadband data from 1109 seismic stations in regional networks across China, Korea, and Japan for the year 2011, and we have measured over half a million Rayleigh wave group velocity dispersion curves from one-year stacks of station-pair ambient seismic noise cross-correlations. The Rayleigh wave group velocity dispersion curves are regionalized on a tessellated spherical shell grid in the period range 10 to 50 s to produce maps of Rayleigh wave group velocity distributions. Maps at 10 seconds period match well with geologic features at the surface. In particular, we observe low group velocities in the Songliao, Bohai Bay, Sichuan, Ordos, Tarim, and Junggar Basins in China, and the Ulleung and Yamato Basins in the East Sea (Sea of Japan). Higher group velocities are observed in regions with less sediment cover. At periods around 30 s, we observe group velocity decreases going from east to west in China, representing an overall trend of crustal thickening due to the collision between the Indian and Eurasian plates. The Ordos and Sichuan blocks show higher group velocities relative to the eastern margin of the Tibetan Plateau, possibly reflecting low temperatures in these cratons. Using the Rayleigh wave group velocity distributions, we have performed 1D linear inversions at each node on the spherical shell grid to retrieve S-velocity perturbations with respect to the reference model LITHO1.0 of Pasyanos *et al.* (2014). This has allowed us to construct a 3D model of the crust and uppermost mantle for East Asia. We observe large-scale lateral variation in the crust compared to the LITHO1.0 model. From 50 to 100 km depth, we observe a low-velocity mantle wedge underneath Japan and the Strait of Korea, and at 100 km depth we see a general trend of increasing S-velocities from east to west, possibly reflecting temperature/water content variations in the mantle.

キーワード: East Asia, tomography, ambient noise  
Keywords: East Asia, tomography, ambient noise

## 表面波位相速度から推定される沖縄トラフにおける1次元S波速度構造 One-dimensional shear velocity structure beneath Okinawa trough inferred from surface wave phase velocity

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沈み込み帯の構造は、観測点のある島弧直下の構造は盛んに研究が進められているが、背弧側の構造はその地域に地震計がほとんどないために、あまり進んでいないのが現状である。しかし、沈み込み帯全体のダイナミクスを明らかにする上で、島弧直下の構造だけではなく、背弧側の構造も知ることは重要である。

本研究では沖縄トラフに焦点を当てている。琉球弧はフィリピン海プレートが沈み込んでできている島弧である。その背弧には沖縄トラフがあり、ここは背弧拡大域と考えられている。沖縄トラフにおける地殻構造に関しては、海上保安庁が地震探査を行っており（例えば、堀内他, 2011）、モホ面の深さが求められている。上部マントルの構造に関しては Nakamura et al. (2003) が沖縄トラフを含む琉球弧でのトモグラフィを行い、P波、S波速度構造を求めている。他に中国の大陸構造の研究でその範囲の端として構造が求められているものもある（例えば、Huang and Zhao, 2006）が、背弧拡大の構造が分かるほどには解像度は高くない。したがって、まだダイナミクスの全体像はまだ良く分かっていない。

そこを背弧域を含む南西諸島周辺の構造を解明することを最終的な目標とし、本研究ではまず沖縄トラフの平均的な1次元S波速度構造を求めることを目的とする。比較のために、拡大する前の構造と考えられる東シナ海大陸棚の1次元S波速度構造も求める。

まず、2点法によりレイリー波、ラブ波の位相速度を測定し、分散曲線を得た。F-net、China Digital Seismograph Network (CDSN)、Global Seismograph Network (GSN) の観測点を使用した。

得られた位相速度の分散曲線から、2観測点間の平均的な1次元S波速度構造を遺伝的アルゴリズムを使って推定した。最上部マントル（モホ面から220 km）は radial anisotropy、それ以外の層は等方性を仮定した。

沖縄トラフのモホ面直下のS波速度は大陸棚に比べてかなり低く、これはマントルの上昇による部分溶融を示しているのかもしれない。しかし、220 km 付近では沖縄トラフの方が高くなっており、マントルの上昇の源が深くないことを示唆している。このマントルの上昇は、中央海嶺で解釈されているような受動的な流れかもしれない。沖縄トラフの西側ではSV波がSH波に比べて低速度になっている。しかし、東側ではほぼ同じである。この radial anisotropy は部分溶融の割れ目の形状またはマントル鉱物の選択配向によるものかもしれない。

キーワード: 沖縄トラフ, 背弧拡大, 地震波速度構造, 表面波

Keywords: Okinawa trough, backarc spreading, seismic structure, surface wave

## フレンチポリネシア下のP波速度異常 P-wave velocity anomalies of the plume beneath the French Polynesia

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The French Polynesian region is characterized by positive topographic anomalies of 700 m, a concentration of hotspot chains. Many seismic tomography results show a broad low-velocity anomaly in the lower mantle continued from the base of the mantle. These observations suggest that a large-scale mantle flow rises from the bottom of the mantle beneath the region. Joint Japanese-French broadband seismological observations were performed from 2001 to 2005 with 10 island stations from the Polynesian PLUME project (Barruol et al. 2002) and 10 broadband ocean bottom seismometers (BBOBSs) from the Polynesian BBOBS project (Suetsugu et al. 2005). A P-wave

tomography using the data from these projects revealed that large-scale low-velocity anomalies (on the order of 1000 km in diameter) from the bottom of the mantle become smaller-scale low-velocity anomalies (on the order of 100 km in diameter) at the depth of about 1000 km. However the connection of the small-scale low-velocity anomalies to the surface hotspots was not revealed because of the poor resolution in the upper mantle.

A new P-wave tomography with better resolution in the upper mantle was obtained by adding data from BBOBSs around Society Islands deployed along the TIARES project during 2009 - 2010 (Suetsugu et al. 2012) and by taking the finite frequency effect into account for the frequency-depended differential travel times. The frequency-depended differential travel times were measured by multi-band cross correlating P waveforms. The new P-wave tomography shows strong low-velocity anomalies beneath the Society Islands and Pitcairn in the upper mantle although they do not extend to the 660-km discontinuity. This model also shows that small-scale low-velocity anomalies in the uppermost lower mantle. The low-velocity anomalies in the depth range about 550 - 900 km are smaller both in lateral area and amplitude than those in most of the upper mantle and the lower mantle. The velocity patterns are well correlated each other in the depth range but are not correlated with the patterns above and below, indicating the mantle beneath the French polynesia can be divided into 3 layers in terms of radial correlation.

キーワード: トモグラフィ, プルーム, マントル, フレンチポリネシア

Keywords: Tomography, Plume, Mantle, French Polynesia