

SCG060-01

Room:302

Time:May 25 08:30-08:45

Towards mapping of geofluids

Hikaru Iwamori^{1*}, Tohru Watanabe², Michihiko Nakamura³, Masahiro Ichiki³, Junichi Nakajima³

¹Tokyo Institute of Technology, ²Toyama University, ³Tohoku University

There are accumulating evidences indicating that geofluids in subduction zones play important roles in various phenomena, such as seismic and magmatic activities, crustal deformation, metamorphism, evolution of continental crust, and global material differentiation. However, in situ distribution of geofluids within the crust and the mantle, or even their presence, has not been identified with sufficient resolution, hence their roles in the various phenomena mentioned above remain unclear.

Low seismic velocities and/or a high electrical conductivity have conventionally been regarded as diagnostic features for presence of geofluids (e.g., Nakajima and Hasegawa, 2003). Overlapping thermal, compositional and textural variations blur the features specific to geofluids, and the number of unknown parameters apparently exceeds the number of observed variables (e.g., Watanabe, 2005). Therefore, introducing a priori information and models (e.g., thermal and petrological structures) into the analysis (i.e., deducing phase, fraction, geometry [represented by, e.g., aspect ratio] and their spatial distribution of geofluids based on the seismic velocity and electrical conductivity) is necessary. In addition, some key variable or parameter could be sensitive enough to constrain a parameter for geofluids beyond the background variations, eliminating uncertainties introduced by a priori information and models. In this paper, we discuss both aspects, i.e., (i) integration of available information, and (ii) key variables or parameters sensitive to geofluids.

In order to quantitatively identify the spatial distribution of geofluids, we combine (1) observed seismic velocity structure, (2) observed electrical conductivity structure, (3) petrological model, and (4) thermal model, for areas with well-resolved tomography of both seismic velocity and electrical conductivity. The models of (3) and (4) correspond to the point (i) above. Concerning the point (ii), we focus on the contrast between (1) and (2): for a typical case, distribution of low velocity regions coincide well with that of highly conductive regions (e.g., those beneath the northern Miyagi Prefecture area [Mitsuhashi et al., 2001; Nakajima and Hasegawa, 2003]), associated with a few percent decrease in the seismic velocity and two to four orders of magnitude increase in the electrical conductivity. Inspection of all the plausible factors strongly suggests that the huge contrast in amplitude between the seismic velocity and the electrical conductivity may be resolved only when a variation of fluid fraction affects linearly the seismic velocity and nonlinearly the electrical conductivity.

This differential response may arise from the fact that the seismic velocity is approximately a linear function of fluid fraction (Takei, 2002) and is insensitive to the connectivity, whereas the electrical conductivity is sensitive to the connectivity. If the connectivity of fluid increases with its volume fraction, this causes a nonlinear increase of electrical conductivity with the fluid fraction. We thus think that the relationship between connectivity and fluid fraction is a key to interpret the observed seismic velocity and electrical conductivity. Deciphering this relationship, being combined with thermal and petrological models, could be a useful and robust approach to map geofluid distribution.

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SCG060-02

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Pb isotopic compositions of hydrothermal deposits in the Japanese island arc as a tracer of slab-fluids

Koichiro Fujinaga^{1*}, Yasuhiro Kato¹, Yutaro Takaya¹, Masaharu Tanimizu², Hikaru Iwamori³

¹University of Tokyo, ²JAMSTEC, ³Tokyo Institute of Technology

Quite recently, it has been pointed out that "geofluids" released from the subducting plates may be involved in various phenomena in subduction zone, such as young volcanic rocks, deep-seated hot springs and hydrothermal deposits. Systematical investigations of these various materials are needed for identifying the geochemical characteristics of the geofluids. Nakamura et al. (2008) revealed that the slab-fluids derived from two subducted plates (the Pacific plate and the Philippine Sea plate) contribute largely to the genesis of arc magmas in the Central Japan. Here we focus on hydrothermal deposits (vein-type and skarn-type) in the Japanese island arc. Hydrothermal fluids that formed sulphide mineral (galena, pyrite, chalcopyrite, sphalerite etc.) deposits are generally considered to have been derived from magmatic and/or meteoric waters based on H, C, O, and S isotopes in the deposit materials. However, ore fluids may be directly derived from deep fluids. We report Pb isotopic compositions of hydrothermal deposits in the Central Japan and discuss about the origin of ore fluids.

SCG060-03

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Slab-Derived Halogens and Noble Gases Preserved in Peridotite and Eclogite from the Sanbagawa Metamorphic Belt

Hirochika Sumino^{1*}, Shunsuke Endo², Kenta Yoshida³, Tomoyuki Mizukami⁴, Simon Wallis², Takao Hirajima³, Ray Burgess⁵, Chris Ballentine⁵

¹GCRC, University of Tokyo, ²Nagoya University, ³Kyoto University, ⁴Kanazawa University, ⁵SEAES, University of Manchester

Subduction volcanism is generally considered to form a 'subduction barrier' that efficiently recycles volatile components contained in subducted slabs back to the Earth's surface (Staudacher and Allegre, 1988, *Earth Planet. Sci. Lett.* 89, 173-183). Nevertheless, subduction of sediment and seawater-dominated pore fluids to the deep mantle has been proposed to account for heavy noble gas (Ar, Kr and Xe) non-radiogenic elemental abundance and isotopic pattern of the convecting mantle (Holland and Ballentine, 2006, *Nature* 441, 186-191). To verify whether and how subduction fluids preserve a seawater signature, we have determined noble gas and halogen compositions of the Higashi-akaishi peridotite and Western Iratsu and Seba eclogite bodies in the Sanbagawa metamorphic belt, southwest Japan, in which relicts of slab-derived water are contained as hydrous mineral inclusions in wedge mantle rocks exhumed from depths in excess of 100 km (Mizukami et al., 2004, *Nature* 427, 432-436) and aqueous fluid inclusions in associated slab-derived eclogites and quartz veins/lenses (Endo et al., 2009, *J. Metamorphic Geol.* 27, 371-384; Endo, 2010, *Isl. Arc* 19, 313-335; Hirajima et al., 2010, *Geophys. Res. Abst.* 12, EGU2010-6343).

The striking similarities of the observed noble gas and halogen compositions of the Higashi-akaishi peridotite with marine pore fluids (Sumino et al., 2010, *Earth Planet. Sci. Lett.* 294, 163-172) challenge a popular concept, in which the water flux into the mantle wedge is only by hydrous minerals in altered oceanic crust and sediment (e.g., Schmidt and Poli, 1998, *Earth Planet. Sci. Lett.* 163, 361-379). The Western Iratsu eclogite also exhibits non-radiogenic noble gas and halogen elemental ratios well explained by a mixing between seawater-derived and sedimentary components. These results indicate that subduction and closed system retention of marine pore fluid occurs up to depths of at least 100 km. Two mechanisms of subduction of unfractionated pore fluid-derived noble gas and halogens are proposed: one is that a portion of pore-fluid in sediments and/or crust subducts to a depth deeper than the overlying crust and is liberated and incorporated into grain boundaries of the mantle peridotite that is dragged down by flow in the mantle along with the downgoing slab. The other is that hydrated lithospheric mantle, resulting from penetration of pore-fluid along bending-related faulting of the oceanic plate entering subduction zones, preserves unfractionated noble gases and halogens of pore-fluid origin and transports them to the deep mantle.

The subducted halogen and noble gas compositions are clearly distinct from those of arc volcanic gases. This implies that the subduction-related metamorphic rocks of the Sanbagawa belt appear to have frozen-in and preserved a previously unseen part of the deep water recycling process whereby noble gases and halogens (and probably other volatiles) are injected into the wedge mantle just above the subducting slab, requiring a reassessment of the dominant transport mechanism and source of water in subduction zones. A small proportion of marine pore fluid, preserved in the downgoing hydrous peridotite and/or eclogite, can account for the heavy noble gas composition observed in the convecting mantle.

Keywords: noble gas, halogen, fluid inclusion, slab fluid, subduction zone, mantle wedge

SCG060-04

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Metamorphic fluid composition determined by trace element and isotopic composition analysis of metamorphic rocks

Masaaki Uno^{1*}, Hikaru Iwamori¹, Hitomi Nakamura¹, Kenta Ueki¹, Taeho Park¹, Tetsuya Yokoyama¹, Masaharu Tanimizu²

¹Tokyo Institute of Technology, ²JAMSTEC

Regional metamorphic belts provide unique information that is directly relevant to the fluid behavior at plate convergent margin. Petrological and geochemical analyses of the regional metamorphic rocks would resolve not only the composition and amount of geofluids in subduction zones, which can be assessed by those of arc volcanic rocks, but also the transport mechanism of geofluids through quantification of fluid-related textures. However, previous studies on composition, amount, transport-scale of geofluids during metamorphism are inconsistent with each other (e.g. Ferry, 1992; Bebout, 2007). Although the bulk composition of metamorphic rocks represents integration of processes from subduction to exhumation, previous studies did not decode the processes, including sea floor alteration, dehydration and rehydration during subduction, which likely resulted in misinterpretations. Rehydration reaction, in particular, overprints the other two processes (e.g. Okamoto&Toriumi, 2005). In order to understand the fluid processes relevant to metamorphism, it is, therefore, required to identify and separate the processes and the associated material transport.

In this study, we aim to constrain fluid behavior in metamorphism, especially composition, amount, timing of fluid during rehydration reaction in the late stage of metamorphism by comparing geochemical data (bulk trace element and isotopic compositions, bulk water content) with petrogenetic physico-chemical conditions of P-T path, mineralogy and extent of rehydration.

The Sanbagawa metamorphic belt, a subduction-related high P/T-type regional metamorphic belt, was selected for this study, for which extensive petrogenetic information is available. For metabasaltic samples in each metamorphic grade, major and trace elements and Pb isotope analysis were conducted. Mineral composition analysis by EPMA and determination of P-T paths by thermodynamic analysis have been also performed for a part of the samples.

Consequently, we obtained the following results:

- (1) Trace element compositions of metabasites are approximately between the altered oceanic crust and oceanic sediments.
- (2) Analyzed trace elements can be divided into the following 3 groups:
 1. Elements whose concentration differs according to metamorphic grade.
 2. Elements whose concentration is proportional to bulk water (LOI).
 3. Elements which do not have trends above.
- (3) Pb isotopic compositions corrected by rehydration age are not aligned on the mixing line between AOC and sediments, but have higher $^{206}\text{Pb}/^{204}\text{Pb}$ and $^{208}\text{Pb}/^{204}\text{Pb}$ ratio.
- (4) Pb isotopic compositions of metabasites form a trend that corresponds to the IC2 components of global basalt composition proposed by Iwamori et al. (2010), which reflects hydration-dehydration process.

From samples corrected from a single basic block, a linear relationship between elements in (2)-2 and extent of rehydration was found, and fluid composition during rehydration was determined. The concentrations of each element are approximately 650, 480 and 1000 ppm for Rb, Ba and Li, respectively. The concentrations of these elements in the retrograde fluid are of an order comparable to that of fluid from subducting AOC or sediment, but they cannot be explained by linear mixing of AOC fluid and sediment fluid.

The result (4) implies that observed variation in trace element and isotope composition could reflect global differentiation common to the subduction zone fluid processes.

These results suggest that identifying mass transfer associated with rehydration process is possible, by focusing samples collected exclusively from the same basic block, whose samples are likely to have suffered the same P-T path and had a similar initial composition before subduction. A comprehensive study combining metamorphic texture, bulk trace and isotopic composition and thermodynamic analysis at Sanbagawa metamorphic belt has a potential to resolve the fluid processes in the subduction

zone.

Keywords: metamorphism, fluid, trace element, isotope, Sanbagawa metamorphic belt, Geofluid

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Effects of pressure and salinity on partitioning between magma and aqueous fluids at HTHP

Tatsuhiko Kawamoto^{1*}, Kenji Mibe², Ken'iti Kuroiwa¹, Tetsu Kogiso³

¹Inst. Geothermal Sci., Kyoto Univ., ²ERI, Univ. Tokyo, ³Human & Environment Studies, Kyoto Univ.

We will show our new experimental results to understand the effects of pressure and salinity on partitioning between a magma and aqueous fluids at high-temperature and high-pressure conditions using multi anvil apparatus at SPring-8. We will present the followings: (1) we can observe XRF spectra under high-temperature and high-pressure conditions and (2) know the effects of pressure and salinity on trace elemental partitioning between a magma and aqueous fluids, and then conclude (3) that the present data sets are not inconsistent with a previous data set based on quenched experiments by Keppler (1996, Nature). The last point suggests that slab-derived fluids are likely to be saline fluids, which can be able to dissolve significant amounts of trace elements characterizing subduction-zone magmatism.

Keywords: water, magma, high-pressure and high-temperature, elemental partition, synchrotron X-ray, subduction zone

SCG060-06

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Influence of confining and pore fluid pressures on velocity and conductivity of water-saturated rock

Tohru Watanabe^{1*}, Kuno Ayumi¹, Akiyoshi Higuchi¹

¹University of Toyama

Pore fluid pressure in seismogenic zones can play a key role in the occurrence of an earthquake (e.g., Sibson, 2009). Its evaluation via seismic velocities and electrical conductivity can lead to a good understanding of seismic activities. It is essential to understand how seismic velocities and electrical conductivity reflect the pore fluid pressure. We have conducted measurements of elastic wave velocity and electrical conductivity of a water-saturated rock for various confining and pore fluid pressures.

Measurements have been made using a 200 MPa hydrostatic pressure vessel, in which the confining and pore fluid pressures can be separately controlled (Watanabe et al., 2008). Conductivity measurement requires the electrical isolation between water in a rock sample and the metal work of the pressure vessel. A plastic (PEEK) endpiece was specially designed to get electrical isolation between water in a sample and the metal work. The endpiece has a built-in plastic (DURACON) piston, which passes the pressure of oil from an external pump to the pressure of water in a sample. A good linear relationship between the oil and water pressures has been confirmed. The friction of the piston causes only 2-3% difference between oil and water pressures.

Berea sandstone was used for its high porosity (19.1%) and permeability ($3 \times 10^{-13} \text{ m}^2$). Cylindrical samples have dimension of 25 mm in diameter and 30 mm in length. Their axes are perpendicular to the sedimentation bed. The grain size is 100-200 micrometer. A dry sample has $V_p=3.2\text{-}3.3 \text{ km/s}$ and $V_s=1.9\text{-}2.0 \text{ km/s}$ in the direction perpendicular to the axis, and $V_p=3.0\text{-}3.1 \text{ km/s}$ and $V_s=1.9 \text{ km/s}$ in the direction parallel to the axis. Velocities are slightly lower in the direction perpendicular to the sedimentation bed. A water-saturated sample has $V_p=3.5 \text{ km/s}$ and $V_s=2.1 \text{ km/s}$ in the direction perpendicular to the axis. A significant increase in V_p is caused by water saturation. When the pore fluid pressure is kept constant, V_p and V_s increase with increasing confining pressure. When the confining pressure is kept constant V_p and V_s decrease with increasing pore fluid pressure. The effective confining pressure is defined by the difference between the confining and pore fluid pressures. The change in V_p and V_s shows a good correlation with the effective confining pressure. V_p and V_s increases with increasing effective confining pressure. Only a small increase is observed when the effective confining pressure is higher than 60 MPa. Similar results on Berea sandstone have been already reported by Christensen and Wang (1985). We will also report the results of electrical conductivity.

Keywords: elastic wave velocity, electrical conductivity, confining pressure, pore fluid pressure, water-saturated rock

SCG060-07

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A Bayesian approach to spatial estimation of fluid content and geometry in the mantle wedge

Tatsu Kuwatani^{1*}, Kenji Nagata¹, Masato Okada¹, Mitsuhiro Toriumi¹

¹Frontier Sci., Univ. of Tokyo

Recent development of seismic tomography enables us to image the detailed velocity structure in the mantle wedge beneath the Japanese islands (e.g. Nakajima et al., 2001). Nakajima et al. (2005) clarified the variations of porosity and pore geometry from the reduction degree of V_p and V_s data sets in the mantle wedge of the NE Japan by using the unified formulation of the effect of fluid phase on the seismic velocity. However, it is difficult to image the spatial distributions of porosity and pore geometry because seismic velocity data always have error. In this study, we try to image the porosity and pore geometry by using the Markov random field model, which is a type of Bayesian stochastic method that is often applied to image analysis. The spatial continuity of porosity and pore geometry is incorporated by Gaussian Markov Chains as prior probabilities in order to apply the MRF model to our problem. The most probable estimation can be obtained by maximizing the posterior probability of the fluid distribution given the observed velocity structures. In the present study, the steepest descent method was implemented in order to maximize the posterior probability using the Markov chain Monte Carlo (MCMC) algorithm. First, synthetic inversion tests are conducted in order to investigate the effectiveness and validity of the proposed model. Then, we apply the model to the natural data sets of the seismic velocity structures in the mantle wedge (Matsubara et al. 2008), by assuming the physical properties other than porosity and pore geometry (i.e. temperature and type of fluid) are given. Finally, we discuss the validity of the assumption and our model.

Keywords: fluid, mantle wedge, Bayesian estimation

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Spreadsheet mass balance for exploring on element behavior between subducted slab, mantle wedge, and magma

Jun-Ichi Kimura^{1*}, Hiroshi Kawabata¹, Bradley R. Hacke², Peter E. van Keken³, James B. Gill⁴, Robert J. Stern⁵

¹IFREE/JAMSTEC, ²University of California, Santa Barbara, ³University of Michiga, ⁴University of California Santa Cruz, ⁵University of Texas at Dallas

We have developed the Arc Basalt Simulator version 3 (ABS3), a quantitative calculator to examine the mass balance of (1) slab-dehydration and melting, and (2) slab fluid/melt-fluxed mantle melting, and to quantitatively evaluate magma genesis beneath arcs. Calculation results from the ABS3 model suggest that element re-distribution between the subducted slab and slab-derived liquid controls distinctive trace element signatures found in arc magmas and crust. The slab liquid is derived from various mixtures of fluids and melts from sediment and altered oceanic crust, dependent on the thermal structure of the subducted slab. Slab fluids are mostly generated by slab-dehydration to form the volcanic front (VF) magmas with slab P-T conditions around 3 GPa/ 750(C), whereas slab may melt at 3-6 GPa > 830(C) contributing either to the VF or to rear arc (RA) magmas. Compositions of slab fluids and melts are controlled primarily by breakdown of amphibole and lawsonite for VF and phengite for RA slab depths in association with the residual eclogite mineral phases including garnet, clinopyroxenes, and quartz. Temperature dependent partition coefficients and different partition coefficients between melt/fluid and minerals are additional controls. Minor mineral phases such as zircon and titanite also play important roles for certain elements. The slab liquid fluxed melting of depleted mantle wedge peridotite plays additional role to element re-distribution in subduction zone. The degree of partial melting varies between 17-28 % (VF) and 3-22 % (RA), with a slab flux fraction of 2-4.5 % (e.g., VF fluid) to 1-1.5 % (e.g., RA melt), and at melting depths corresponding to 1-2.5 GPa (VF) and 2.4-2.8 GPa (RA). Addition of fluid-immobile elements from the mantle contributes 78-98 % of the magma mass and controls certain isotopes such as Nd and Hf in arc magmas. However, element addition from the slab liquid modifies the liquid mobile elements/isotopes in the arc magmas significantly. The residual peridotite composition is also altered due to modification by the slab flux addition and melt depletion. Modeled peridotite compositions are similar to some peridotites in supra-subduction zone ophiolites, suggesting that element re-distribution beneath arcs is complex.

Keywords: Geochemistry, slab, mantle wedge, magma, mass balance

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A numerical examination of quartz precipitations from ascending fluids and resultant increases in fluid pressures

Kenichi Hoshino^{1*}, Kazuna Fujita¹

¹Grad. Sch. Sci., Hiroshima Univ.

Precipitations of quartz from ascending fluids in fractures and resultant increases in fluid pressures have been numerically simulated to examine the fault-valve model of Sibson et al. (1988) and Sibson (1992). Although a number of detailed analyses have already been made to investigate crack sealing processes around fault zones (e. g., Gratier et al., 2003), essential features of ascending fluids with mineral precipitations resulting in fracture closures have not been analyzed yet. Therefore, two simplified fluid ascending processes have been investigated in the present study: (a) fluids ascend slowly with their temperatures following geothermal gradients and (b) fluids ascend rapidly resulting in isenthalpic or semi-isenthalpic temperature decreases. It can be supposed that the natural fluid ascending systems may take the properties of between (a) and (b).

Decreasing rates of quartz solubility with decreasing temperatures and/or pressures are larger at higher temperatures and pressures. Therefore, when the fluids ascend slowly, the maximum precipitation of quartz may take place at the bottom of the fracture. The precipitation of quartz decreases the fracture width, hence raises the fluid pressure at the bottom. The consequent increase in the fluid pressure gradient may enhance the precipitation, resulting in the most rapid closure of the fracture at the bottom.

When the fluids ascend isenthalpically, boiling conditions may achieve at all depths in the fractures. Therefore, they may boil at the bottom and only steams percolate throughout the fracture, probably resulting in the fracture closure only at the bottom. In cases of semi-isenthalpic ascending with less enthalpy losses, the fluids may also boil at the bottom. Although the fluids may dew at certain depths depending on their degrees of enthalpy loss, the dewed fluids may not precipitate quartz sufficiently for the fracture closure.

On the other hand, the fluids may boil at around the top (probably at several hundred meters below the surface) if the enthalpy losses are adequate. In this case, the largest amount of precipitation may occur at around the top during an early stage. However, an increase in the fluid pressure due to the fracture closure results in a shift of the boiling depth upward. Also, the increase in the fluid pressure decreases the pressure gradient at around the top, resulting in a deceleration of the precipitation. Hence, the amount of the following precipitation at the bottom may exceed those at around the top after a certain duration.

It is quite interesting that the fluids may boil at the bottom or otherwise at around the top depending on their degrees of enthalpy loss. No condition for the fluids to boil at intermediate depths could be found in the present analyses. Those results imply that there may be threshold values of the degrees.

The fluids may not boil when the amounts of enthalpy loss are large, probably resulting in the same properties as the slowly ascending fluids.

The analytical results of the both simplified fluid ascending processes (a) and (b) indicate that the fractures may close mostly at their bottoms.

It should be noted that the above conclusion may be applicable for the fluid ascending systems from any depth. That is, there may be no inevitability for the fracture closure at around the depths of earthquakes.

Keywords: fluid, fracture, quartz, fault, fluid pressure, fault-valve

SCG060-10

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Effects of Al on kinetics of precipitation of silica minerals from aqueous fluids under crustal conditions

Hanae Saishu^{1*}, Atsushi Okamoto¹, Noriyoshi Tsuchiya¹

¹Tohoku university

Silica is a dominant component in the Earth's crust. Because of high solubility of silica in aqueous fluids and its dependency on P-T conditions, dissolution and precipitation processes of silica minerals play significant roles on the spatial and temporal distributions of fluids and rock strength in the crusts. An ubiquitous occurrence of quartz veins in the vicinity of seismogenic zones implies the importance of the sealing of fractures by quartz on the earthquake cycle.

In spite of the importance of the kinetics of silica precipitation, the complete expression of the rate equation has not been determined, except for precipitation rates on surface reactions (Rimstidt & Barnes, 1980). The difficulty in the estimates of the precipitation rate is arisen from the following reasons. First, although quartz is the most stable silica minerals in the crust, cristobalite and amorphous silica occur in the geothermal areas (Alekseyev et al., 2009). Second, precipitation of silica minerals occurs not only on quartz surfaces but also via nucleation processes in fluids. Third, trace elements including Al³⁺, Na⁺ and K⁺ in solutions affect on the species and kinetics during silica precipitation (Okamoto et al., 2010). Feldspars are dominant constituents of the crust, and thus the effects of these minor components are crucial for considering the silica precipitation in the crust.

In this study, we conducted the hydrothermal flow-through experiments to investigate the overall precipitation rate of silica minerals and the effects of Al in the solutions under crustal conditions (430 C and 31 MPa). The experimental apparatus is similar to that in Okamoto et al. (2010). For precipitation of silica minerals, we used a blank vessel that does not include any rock/mineral substrates. The Si-supersaturated solutions (300-350 ppm, C/C_{eq} = 3-3.5) were prepared by dissolution of quartz at 350 °C, and the concentration of Al in the input solution was controlled by dissolution of albite or granite with different temperatures. The Al and Na (and K in the case of granite) included in the input solutions from 0 to 7 ppm, and the atomic ratio of Al and Na were unity, that is same as the stoichiometry of albite.

The experiments in pure Si solution revealed that the precipitation via nucleation in fluids was approximated as the first-order reaction that is the same as the precipitation on the pre-existing quartz surfaces. Activation energy of precipitation of silica minerals from the solution was estimated to be 39 kJ/mol. In solutions in absence of Al, amorphous silica precipitated. With increasing Al and Na contents in the solutions, the dominant silica mineral systematically changes from amorphous silica, cristobalite to quartz. An important observation is that the logarithmic precipitation rate increased linearly with increasing the Al concentration. Combining these results and the surface reaction rate obtained in the previous study, we obtain the empirical full expression of the rate equation on the silica precipitation that is a function of the degree of supersaturation, temperature, pre-existing quartz surface area, water volume, and Al concentration. One of the implications of this rate equation is that dominant precipitation mechanism changes from surface growth on quartz to precipitation via nucleation, with increasing fracture aperture or decreasing quartz mode in the wall rock in the crust. This is consistent with the observations of natural quartz veins. We will discuss the spatial distribution of silica precipitation and its relationship to the fluid flow in the crusts.

References: Rimstidt, J. D. and Barnes, H. D., 1980, *Geochim. Cosmochim. Acta.*, 44, 1683-1699.; Alekseyev, V. A., Medvedeva, L. S. and Starshinova, N. P., 2009, *Geochem. Int.*, 47, 731-735.; Okamoto A., Saishu H., Hirano N. and Tsuchiya N., 2010, *Geochim. Cosmochim. Acta.*, 74, 3692-3706.

Keywords: silica minerals, aluminum, kinetics, precipitation, hydrothermal experiments, vein

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Two primary basalt magmas from NW Rota-1 volcano, Mariana arc, and its heterogeneous mantle diapir

Yoshihiko Tamura^{1*}

¹IFREE, JAMSTEC

Primitive basalts are rarely found in arcs. The active NW Rota-1 volcano in the Mariana arc has erupted near-primitive lavas, which we have sampled with ROV Hyperdolphin (HPD). Samples from the summit (HPD480) and eastern flank (HPD488) include 17 magnesian basalts (51-52 wt % SiO₂) having 7.5-9.5 wt % MgO and Mg# of 61-67, indicating little fractionation. Olivine phenocrysts are as magnesian as Fo₉₃ which contain 0.4 wt % NiO; Cr/(Cr+Al) of spinels are mostly 0.5-0.8, indicating equilibrium with depleted mantle. There are three petrographic groups, based on phenocryst populations: 1) cpx-olivine basalt (COB); 2) plagioclase-olivine basalt (POB); and 3) porphyritic basalt. Geochemical characteristics suggest that POBs formed from lower degrees of mantle melting, or that the COB mantle source was more depleted. On the other hand, they also suggest that COB has a greater subduction component than POB. The calculated primary basaltic magmas of NW Rota-1 volcano (primary POB and COB magmas) indicate segregation pressures of 1.5- 2 GPa (50-65 km deep). These magmas were formed by 15-25 % melting of mantle peridotite having Mg# ~89.5. These two basalt magmatypes are similar to those found for Sumisu and Torishima volcanoes in the Izu-Bonin arc, with COB representing wetter and POB representing drier magmas, where subduction zone-derived melt components are coupled with the water contents. Hydration and partial melting along subducting slabs can trigger Rayleigh-Taylor-like instabilities. Deep subduction components, derived from melting of subducting sediments, play an important role in the generation of NW Rota-1 magmas. Thus, the sediment melting in the underlying slab could have triggered partial melting of hydrous mantle and mantle diapir formation. Moreover, sediment melts may have mixed heterogeneously with hydrous peridotite, which resulted in a mantle diapir consisting of two parts, one poor and another rich in sediment melt.

Keywords: primary magmas, mantle wedge, basalt, arc magmas

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Petrological characteristics of the Finero Phlogopite-Peridotite Massif, Italy

Takahito Suzuki¹, Tomoaki Morishita^{1*}, Akihiro Tamura¹, Masako Yoshikawa², Alberto Zanetti³, Maurizio Mazzucchelli⁴

¹Kanazawa University, ²Kyoto University, ³CNR-Pavia, ⁴Universita di Modena

At subduction zone, hydrous silica-rich fluids/melts derived from subducting lithosphere are expected to be interacting extensively with the overlying mantle, resulting in arc magmatism and/or enrichment of fluid mobile elements (LILE) in the mantle as a source for the following arc magmatism. Details of metasomatic processes in the mantle wedge are crucial to understand the development of subduction zone through the time, and are, however, still not understood yet. The Finero Phlogopite-Peridotite Massif in the Western Italian Alps is well known as a highly metasomatized peridotite massif, which is characterized by abundant metasomatic minerals, such as phlogopite, amphibole and apatite (e.g., Zanetti et al., *Contrib. Mineral. Petrol.*, 134, 107-122; Morishita et al., 2008 *Chem. Geol.* 25, 99-111). Petrological characteristics of the Finero massif have never been well described yet. We present our recent progresses based on field works, especially focusing on metasomatic silica enrichment, the presence of diverse metasomatic agents, antigorite-talc formation and puseodotachylyte-like rocks.

Keywords: fluid, peridotite, metasomatism, Finero massif

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Pressure and temperature dependence of ^{13}C diamond Raman shift determined in-situ to 1.27 GPa and 800 degree C

Shigeru Yamashita^{1*}, Bjorn Mysen²

¹ISEI, Okayama University, ²Geophysical Laboratory, CIW

The pressure- and temperature-dependent Raman shift of synthetic ^{13}C diamond was determined in-situ at temperatures to 800 degree C and at pressures to 1.27 GPa. In-situ experiments were conducted using an Ir-gasketed, externally-heated diamond anvil cell (HDAC) fitted to confocal micro-Raman spectrometer. The pressure dependence of the Raman shift was calibrated to the equation-of-state of pure H_2O (IAPWS-95, Wagner and Pruss, J. Phys. Chem. 31, 2002) with a piece of the ^{13}C diamond aggregate (99% pure) and distilled H_2O loaded in the sample chamber of the HDAC. Temperature was controlled to plus-minus 1 degree C with chromel-alumel thermocouples in contact with the anvils near the sample chamber. To ensure the highest precision of the ^{13}C diamond Raman shift, the emission of the 585 nm Ne line was recorded simultaneously as reference. The in-situ experiments were repeated along four different isochore paths to cover a wide coverage of pressures at high temperatures (0.38 to 1.27 GPa at 800 degree C). No carbon-bearing species were detected in the H_2O fluids, which means that the ^{13}C diamond does not react with H_2O and the diamond anvils as well during these high temperature and pressure measurements.

Multiple regression analysis demonstrated that the pressure and temperature dependence of the ^{13}C diamond Raman shift can be described by a simple quadratic linear form: $\nu(P, T) - \nu(0.1, 25) = -1.065 (\text{plus-minus } 0.044) \times 10^{-2} T - 1.769 (\text{plus-minus } 0.046) \times 10^{-5} T^2 + 2.707 (\text{plus-minus } 0.249) \times 10^{-3} P$, where $\nu(0.1, 25)$ is the Raman shift at ambient condition (1287 cm^{-1}), T is temperature in degree C and P is pressure in MPa. The average error in the pressure determination with this form is estimated to be plus-minus 0.11 GPa. The pressure derivative and the temperature derivative are both consistent with those of Bassett (Mineral Spectroscopy, 1996) and Schiferl et al. (J. Appl. Phys. 82, 1997), within the uncertainties in the regression analysis. In those previous studies, the pressure dependence was measured at ambient temperature, and the temperature dependence was separately measured at ambient pressure. The present result indicates that the pressure and temperature cross derivatives might be present but are negligibly small over the pressure and temperature conditions investigated.

Keywords: diamond, H_2O fluid, Raman shift, in-situ observation

SCG060-14

Room:302

Time:May 25 12:00-12:15

Chemical compositions of hydrothermal fluids derive from a shallow emplacement granite body in Tsushima, Japan.

Masanori Kurosawa^{1*}, Ki-Cheol Shin², satoshi ishii³, Kimikazu Sasa⁴

¹Life Env. Sci., Univ. Tsukuba, ²Res. Inst. Hum. Nat., ³Res. Fac. Center, Univ. Tsukuba, ⁴Puru Appl. Sci., Univ. Tsukuba

Fluid inclusions in quartz from miarolitic cavities, quartz veins, and a Pb-Zn ore deposit at the Miocene granite pluton, Tsushima Islands, Japan, were analyzed by particle-induced X-ray emission (PIXE) to examine chemistries and behaviors of hydrothermal fluids in granite body with shallow emplacement level. The Tsushima granite pluton is mainly composed of biotite-granites and numerous mafic microgranular enclaves. Small miarolitic cavities are relatively common in the granite, and quartz veins are rare. An estimated emplacement level of the granite is 2-6 km deep. Quartz in the miarolitic cavities and the quartz veins contains abundant polyphase inclusions with large halite crystal and vapor-rich inclusion, a small amount of liquid-rich two-phase inclusion, and a few low-salinity liquid-rich inclusion and CO₂ inclusion. Salinities of the polyphase inclusions were of 28-60 wt % NaCl eq., and the homogenizing temperatures (Th) ranged from 460 to 200 C. Two-phase inclusions of the miarolitic cavities showed almost Th of 400-200 C. Quartz in the ore vein contains abundant two-phase inclusion, and a few polyphase inclusion, vapor-rich inclusion, low-salinity liquid inclusion, and CO₂ inclusion. Salinities of the polyphase inclusions were of 28-49 wt % NaCl eq., and the Th ranged from 450 to 250 C.

Element concentrations (average) of polyphase inclusions in the miarolitic cavities, determined by PIXE, were as follows: about 25 wt.% for Cl, 1-5 wt.% for Fe and K, several hundreds to several thousands ppm for Ca, Mn, Ba, Zn, Pb, Br, 200-400 ppm for Cu and Rb, and several tens ppm for Sr and Ge. The compositions are thought to correspond to the original contents of hydrothermal fluid released from the Tsushima granite during solidification. The determined values are several times higher than the values of original hydrothermal fluid estimated from miarolitic quartz from the Miocene Kofu granite (Japan) that has relatively deeper emplacement level (5-8 km deep). The polyphase inclusions of the Tsushima granite were probably formed by decompression boiling of the original hydrothermal fluids during the granite solidification because of the shallow emplacement level. The high contents of transition-metal elements in the polyphase inclusions are also attributable to the element partitioning at the phase separation by boiling. Polyphase inclusions in the quartz veins and the ore vein have compositions similar to those in the miarolitic cavities. Br/Cl ratios (by weight) in the liquid-rich two-phase inclusions are mostly less than 0.0034 of sea values: 0.0014 for the miarolitic cavities, 0.0022 for the quartz veins, and 0.0027 for the ore vein, respectively. On the other hand, the polyphase inclusions have higher values of Br/Cl ratios, and the values are different for each occurrence: 0.0015 to 0.0043 for the miarolitic cavities, 0.0020 to 0.0108 for the quartz veins, and 0.0019 to 0.0124 for the ore vein, respectively.

Keywords: Fluid inclusion, trace element, X-ray analysis, granite, PIXE, ion beam

SCG060-15

Room:302

Time:May 25 12:15-12:30

Progress of hydration in olivine-H₂O and orthopyroxene-H₂O systems at Psat

Yuichi Ogasawara^{1*}, Atsushi Okamoto¹, Noriyoshi Tsuchiya¹

¹Tohoku Univ., Japan

Hydration of ultramafic rocks (serpentinization) commonly occurs in mid-ocean ridges, and the extent and distribution of hydrated mantle plays an important role on the global circulation of H₂O fluids. Although there have been several experimental studies on serpentinization (e.g., Martin and Fyfe, 1970; Seyfried et al., 2003), these studies focused only on the H₂O content in the products or solution chemistries. Therefore, fundamental kinetics and mechanism of serpentinization is still poorly understood. In this study, we conducted hydrothermal experiments on serpentinization to clarify the relationship between the temporal evolution of solution chemistry, progress of hydration reaction and textural developments.

The starting materials were powders of olivine (Fo₉₀, Fa₁₀) or orthopyroxene (En₆₅, Fs₃₅) with size of <0.125mm. The powders and the distilled water were set in the batch type vessel (8.8 cm³) made of the stainless steel with water/rock ratio of 1.0. The temperatures were 250 degreeC at the liq-vap saturation curve. The duration was up to 1008 hours. After the experiments, the solid samples were dried at 90 degreeC for one day, and then were analyzed by X-ray diffractometry and Thermogravimetry. The morphology and cross sections of the products were observed by Scanning electron microscope. The solutions were analyzed by ICP-Mass Spectrometry. The pH values of the solution after the experiments were 7.6-8.5 at room temperature. In both systems, hydration reactions proceeded, but show quite different features in the products and solutions. In the Opx-H₂O experiments, chlorite formed on the surfaces of opx grains. The Si concentration increased with time toward 193.8 ppm, whereas the concentration of Mg was 3.42 ppm. The total H₂O content was less than <0.7 wt.% even at 1008 h. The formation of chlorite is different from the common occurrence of talc after orthopyroxene in natural peridotites. The reason is not clear, but one possibility is that higher Fe content in opx used in this study than that in the oceanic peridotites (En > 80). In the Ol-H₂O experiments, the products were composed of serpentine, magnetite with or without brucite. The H₂O content of the samples increased with time, and reached 3.9 wt.% in 1008h. According to the solution chemistry, the progress of serpentinization is divided into three stages. The concentrations of Si and Mg in solutions increased toward 3.66 and 20.54 ppm, respectively (stage 1), and then decreased drastically toward 0.29 ppm and 0.28 ppm at 504 hours, respectively (stage 2). After 504 h, the solution chemistry was nearly stable (stage 3). Accompanying with the change in the solution chemistry, the products varied as follows: After 336 hours (stage 2 and 3), brucite started to form at the contact with olivine within serpentine rims. Also, only lizardite occurs at stage 1 and 2, whereas chrysotile formed with lizardite. According to activity diagram in Mg-Si-O-H system, the solutions at stage 1 and 2 corresponds to the stability field of serpentine, and a drop in Si concentration indicates the shift from the serpentine stability field to serpentine+brucite stability field, that is consistent with the change of the products. These results suggest that serpentinization after olivine is not always simple as Ol+H₂O=Serp+Br, but the reactions evolve with time. In common peridotites, Ol and Opx coexisted, and hydrothermal alteration occurs heterogeneously. Our experimental results indicate that olivine-H₂O and opx-H₂O system show a quite different fluid compositions (Si and Mg) and different rate of hydration. We will conduct further experiments with Ol+Opx+H₂O systems, and discuss how hydration proceed in the oceanic seafloors.

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Keywords: ultrabasic rock, serpentine, subduction zone

SCG060-16

Room:302

Time:May 25 12:30-12:45

Dehydration kinetics of Antigorite by in situ high-temperature IR microspectroscopy

Michiyo Sawai^{1*}, Arisa Hamada¹, Ikuo Katayama¹, Satoru Nakashima²

¹Hiroshima University, ²Osaka University

Previous studies suggested that the dehydration processes of hydrous minerals such as serpentinite play a key role in a generating mechanism of earthquakes in the subducting slabs. These studies indicate that the reaction of released water from serpentinite with subducting slab is thought to be the cause of intra-slab earthquakes. The volume change caused by reaction and the rate of the reaction products are likely to associate with the earthquake generation mechanism. However, the dehydration process and kinetics of serpentinite are still controversial, thus we here in report the dehydration kinetics of serpentinite.

In previous works, the dehydration kinetics of serpentinite was mainly studied by X-ray diffraction analysis which mainly focused on a change of crystal structure and not for states of water (ex. Inoue et al., 2009). Tokiwai and Nakashima (2010) studied the dehydration kinetics of muscovite by using in situ high-temperature IR microspectroscopy which enables to distinguish the water species. Therefore, we investigated the state of the water in serpentinite and determine the dehydration kinetics by using in situ high-temperature IR microspectroscopy.

Serpentinite samples which consist of antigorite were collected from Nomo peninsula in Nagasaki prefecture. Dehydration experiments of antigorite were conducted by using a fourier transform infrared (FT-IR) microscope in Osaka University, temperature set at 650-750 degrees C and atmospheric pressure under Ar stream which flow rate is 60ml/min.

In the case of antigorite of this study, the spectrum at room temperature shows a relatively sharp band at around 3450-3510 cm^{-1} (peak1), around 3570-3595 cm^{-1} (peak2) and around 3655-3660 cm^{-1} (peak3). Serna et al. (1979) reported that peak1 and peak2 correspond to OH with substitution of Al for Si, and peak3 corresponds to Mg-OH bond, respectively. To describe quantitatively the OH decrease, we measured integral intensity (absorbance) from 3200 to 3900 cm^{-1} . And we also applied a Gaussian function to the absorption band in order to split into the three OH elements and analyze each peak with diffusion equation.

Experimental results show that each peak has different dehydration kinetics and activation energy. The diffusion coefficient approximated by diffusion equation indicates that the peak3 is higher than peak1 and 2. And the activation energy calculated from the temperature show that the peak3 is lower than that of peak1 and peak2. These results suggested that OH associated with Mg tends to dehydrate easily than that associated with Al. In addition we have conducted the heating and cooling experiments of antigorite by the same in situ high-temperature IR microspectroscopy. The results show that the dehydration of Mg-OH (peak3) caused earlier than OH related to Al (peak1 and 2) by about 50 degrees C. These results agree with the data of Bromiley and Pawley (2003) which reports that the presence of even small amount of Al can stabilize antigorite to about some degrees higher temperature.

Keywords: serpentine, dehydration kinetics, diffusion, in situ IR microspectroscopy

SCG060-17

Room:302

Time:May 25 14:15-14:30

Thermal plume in porous media as revealed by streaming potential

Raphael Antoine^{1*}, Kei Kurita¹, Hiroaki Matsuoka¹

¹Earthquake Research Inst., The University

Fluid flow through porous media is a fundamental process to control fluid flow through the crust and the mantle. It has been extensively investigated for long time both in experimental and theoretical approaches but because of experimental limitations fluid dynamical approach has not been conducted enough in laboratory experiments. The main limitation comes from non-transparency of experimental cell, which is composed of solid framework and fluid in the pore space. Non-transparency of solid medium as well as density mismatch make optical investigation through the working cell difficult. Recently nondestructive tomographic methods such as NMR imaging are applied to derive flow field but it requires large experimental facility and lots of cost. In this presentation we report a trial in combining streaming potential and temperatures to estimate flow field in porous media.

Streaming potential, sometimes called as flow potential occurs when fluid flows through porous/granular material which has ion exchanges with flowing fluid. In the experimental cell of the size of 8x8x20 cm glass beads of homogeneous grain size (0.35 to 4 mm in diameter) are packed and NaCl aqueous solution is used as a working fluid. At the base of the cell we put a small heater (5x3x1 mm) as a localized heat source. Pt electrodes are inserted at several vertical positions above the heater along the center line to measure the induced potential by heating. Temperatures are measured by thermocouples along horizontal line 1cm above the heater and along the vertical centerline.

We measured temporal variations of potential and temperature upon heating with constant power supply to the heater. Systematic variations in the potential were obtained: after small decrease at the initiation large positive increase was observed (the potential signal is measured from the lowest electrode closed to the heater). The amplitude of the initial decrease seems not to depend on the applied power while the succeeding large increase is linearly proportional to the power.

We made numerical simulations to compare both potential and temperature in the corresponding geometry and similar situations as the experiment. We obtained similar behavior which can be interpreted as thermal plume rising above the heater in porous media. Different from laminar thermal plume formulated by Batchelor rising velocity of plume seems to depend linearly on the applied power. This confirms average field formulation of Darcy flow is effective in this permeability range.

Keywords: thermal plume, permeable flow, porous media, streaming potential

SCG060-18

Room:302

Time:May 25 14:30-14:45

Structure around Philippine Sea slab beneath Kii Peninsula inferred from receiver function analysis

Takuo Shibutani^{1*}, Taishi Fukui², Yoichiro Nakagawa³, Kazuro Hirahara², Setsuro Nakao¹, Kazuhiro Nishimura¹, Masayo Sawada¹

¹DPRI, Kyoto Univ, ²Science, Kyoto Univ, ³Hitachi Ltd

1. Introduction

Deep low frequency events (DLFEs) are distributed widely from western Shikoku to central Tokai (Obara, 2002). Results from seismic tomographies and receiver function analyses revealed that the oceanic crust of the Philippine Sea plate has a low velocity and a high V_P/V_S ratio (Hirose et al., 2007; Ueno et al., 2008). Hot springs with high $^3\text{He}/^4\text{He}$ ratios are found in an area between central Kinki and Kii Peninsula despite in the forearc region (Sano and Wakita, 1985). These phenomena suggest the process that H_2O subducting with the oceanic crust dehydrates at the depths of 30 - 40 km, causes the DLFEs, and uprises to shallower depths.

We carried out seismic observations in Kii Peninsula since 2004 in order to estimate the structure of the Philippine Sea plate and the surrounding area. We deploy seismometers in linear order with the average spacing of ~ 5 km and record waveforms of teleseismic events. We applied receiver function analyses shown below to the waveform data, and obtained images of S wave velocity discontinuities. In the previous presentation (Shibutani et al., 2009), we reported the results for three profile lines in the NNW-SSE direction along which the Philippine Sea plate is subducting. In this presentation we will report the results for two new profile lines, one in the NNW-SSE direction and the other in the ENE-WSW direction. We will also discuss the structure around Philippine Sea plate subducting beneath Kii Peninsula based on the receiver function images.

2. Receiver function analysis

Receiver functions are calculated by deconvolving the vertical component from the horizontal component of teleseismic P codas. They consist of PS converted waves generated at S wave velocity discontinuities beneath stations. The relative travel times between the PS converted waves and the direct P wave depend on the depths of the discontinuities and the P and S wave velocities above them, and the relative amplitudes depend on the S wave velocity jump at the discontinuities. In this study we converted the time axis of the receiver functions to the depth axis with the velocity model JMA2001 (Ueno et al., 2002), stacked the amplitudes of the receiver functions on the common conversion points, and obtained images of S wave velocity discontinuities.

3. Structure around Philippine Sea slab

A pair of blue and red lines dipping to northwest can be found as a common feature among the four profiles in the subduction direction. These can be interpreted as the upper surface of the Philippine Sea slab and the oceanic Moho, respectively. The oceanic crust sandwiched in between them shows remarkable low velocity (darker blue) up to the depths of 30 - 40 km where the DLFEs occur. The degree of the low velocity in the oceanic crust decreases beyond the depths.

We can find that another blue line branches off near the DLFE area and extends in the mantle wedge in the receiver function images for three profiles in central to western part of the peninsula. This indicates that the mantle wedge is widely low velocity. The red line showing the oceanic Moho becomes unclear beneath 40 km depth, which suggests that the velocity gap between the oceanic crust and the oceanic mantle becomes small. The configuration of the slab seems to be convex upward.

On the other hand, for the profile in the eastern part of the peninsula, we cannot see that low velocity in the oceanic crust extends to the mantle wedge. The oceanic Moho is uniformly clear from 30 km depth at the southeastern edge to 70 km depth at the northwestern edge. The geometry of the slab is linear.

The differences in the structure and geometry of the slab and the mantle wedge between the central to western part and the eastern part of the peninsula can be explained by the amount of H_2O in the oceanic crust beneath 40 km depth after the dehydration.

Keywords: Philippine Sea slab, Mantle wedge, Slab-derived fluid, Receiver function image, Linear array seismic observation, Kii Peninsula

SCG060-19

Room:302

Time:May 25 14:45-15:00

Li isotope map of geofluid in SW Japan: Is deep-crustal fluid in fore-arc region derived from slab?

Yoshiro Nishio^{1*}, Kohei Kazahaya², Yoichi Oyama²

¹Kochi Institute, JAMSTEC, ²Geological Survey of Japan, AIST

It has been proposed that the island arc deep-crustal fluid has played important role in volcanic and seismic activities, although many things, including the relationships between the island arc deep-crustal fluid and slab-derived fluid, have been still unresolved. It has been difficult to identify the nature of deep-crustal fluid based on the geochemical researches using underground water recovered from spring and well, because the deep-crustal fluid is very diluted by surface water during ascending. Lithium (Li), the lightest alkali metal, is a fluid-mobile element having two stable isotopes, ⁷Li/⁶Li, with abundances of 92.5% and 7.5%, respectively. Amount of Li leached from rock to fluid drastically increases with the temperature, and once leached Li is kept in fluid while decreasing temperature (cooling). These features indicate that non-traditional Li isotopic tracer has a great potential to provide new insight on the origin of nature of island arc deep-crustal fluid.

It has been expected that Li isotopic compositions of underground water samples whose Li/Cl ratios are significantly high were not affected by surface water (Nishio et al., 2010). Therefore, to reveal Li isotopic distribution of deep-crustal fluids, we have analyzed Li isotopic compositions of underground water samples whose Li/Cl ratios are significantly high. In this study, the analyzed samples have been recovered from SW Japan (excluding Kyushu area).

The results show that ⁷Li/⁶Li of near-trench samples are significantly higher than those of other samples. This result means that Li in deep-crustal fluids beneath forearc region in SW Japan are derived from subducted Philippine Sea slab. The results, furthermore, reveal that relatively ⁷Li/⁶Li ratios are observed in underground water samples from the western Kii Peninsula where is located in forearc region. Thus, Li isotopic results have presented us new knowledge for island-arc deep-crustal fluid.

Acknowledgements:

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Reference:

Nishio et al., 2010, EPSL 297, 567-576.

Keywords: geofluid, deep-crustal fluid, lithium isotope, SW Japan, slab-derived fluid, Philippine Sea plate

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SCG060-20

Room:302

Time:May 25 15:00-15:15

Characteristics of shallow low-frequency events suggested from numerical simulations

Keisuke Ariyoshi^{1*}, Toru Matsuzawa², Takane Hori¹, Ryoko Nakata¹, Jean-Paul Ampuero³, Ryota Hino², Akira Hasegawa², Yoshiyuki Kaneda¹

¹DONET, JAMSTEC, ²RCPEV, Tohoku University, ³California Institute of Technology

Recently, non-volcanic low-frequency events have been observed along plate boundaries in subduction zones of the world. It is well-known that the low-frequency events occur in the transition zones between the seismogenic zones and the stable-sliding zones, and migrate along strike direction of subduction plate boundaries. On the basis of these characteristics, some numerical simulation studies have tried to estimate the possible ranges of parameters such as frictional stability and pore-pressure, which enables us to know the preseismic change in the activity of the low-frequency events. However, characteristics of the low-frequency events occurring in the shallower part have not been clear. In this study, we perform a numerical simulation with numerous small asperities which generate low-frequency events in the shallower part of a subduction plate boundary, and try to investigate their preseismic change.

Keywords: slow earthquake, migration process, stress perturbation due to great asperity, subduction zone, rate- state dependent friction law, numerical simulation

SCG060-21

Room:302

Time:May 25 15:15-15:30

Spatial distribution of high- and low-frequency earthquakes among the aftershocks of the Iwate-Miyagi Nairiku Earthquake

Masahiro Kosuga^{1*}, The group for the aftershock observations of the Iwate-Miyagi Nairiku Earthquake²

¹Graduate School of Science & Technology, ²GIMNE2008

1. Introduction

Low-frequency earthquakes (LFEQs) have been attracted the interest of seismologists by their waveform characteristics that reflect the unusual source processes. Some LFEQs occur as the aftershocks of large earthquakes. Here we detect LFEQs from the aftershocks of the Iwate-Miyagi Nairiku Earthquake in 2008 and investigate their spatial distribution to get insight to their origin.

2. Data and method

We detect LFEQs by using the predominant frequency of Fourier spectral amplitude for both body wave and coda wave observed at 59 temporal stations operated by the group for the aftershock observations. The predominant frequency depends both hypocentral distance and earthquake magnitude. Thus we first estimate the zero-offset frequency for each earthquake by straight line fitting between the logarithm of predominant frequency and the hypocentral distance. Then we performed a linear regression between the logarithm of zero-offset frequencies and the earthquake magnitudes. We define the frequency deviation for each earthquake by the frequency difference from the regression line. On the scatter plot between the frequency deviation for body wave as the horizontal axis and those for coda wave as the vertical axis, there is a clear positive correlation. We define high-frequency earthquakes (HFEQs) and LFEQs as those in the first quadrant and third quadrant on the scatter plot, respectively, with larger frequency deviation than the standard deviation.

3. Spatial distribution of high- and low-frequency earthquakes

HFEQs are distributed preferentially in the source area of main shock, in particular, in a wide area to the north of mainshock and a linear zone to the SSE of mainshock. On the other hand the LFEQs are distributed complementarily to the HFEQs, in a wide area to the WNW and to the SWS of mainshock, and outside the source area both to the north and to the south. Compared with the geology, the LFEQs are located around the Kurikoma and Yakeishi volcanoes, and in the calderas formed from the Pliocene to the early Pleistocene in age. This suggests that these LFEQs occur in hotter areas where the ductile deformation occurs. Not a few LFEQs occur in a northern extension of seismogenic fault, where postseismic deformation was observed by GPS. This deformation is attributed to the aseismic slip on a fault that did not move coseismically. The LFEQs in the area are located along a deep boundary of aseismic fault. The HFEQs occur on the seismogenic fault that is located to a deeper extension of aseismic fault. This spatial pattern suggests the effect of both the increased pore pressure and the decreased normal stress on the faults as the location moves from the deeper part to the shallower part. Thus the distribution of LFEQs is a key parameter to interpret the role of crustal fluids to the seismogenic processes.

Keywords: low-frequency earthquakes, aftershocks, Iwate-Miyagi Nairiku Earthquake, geofluid

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SCG060-22

Room:302

Time:May 25 15:30-15:45

Electromagnetic measurements to image geofluid in three-dimensions under NE-Japan arc

Yasuo Ogawa^{1*}, Masahiro Ichiki², Takao Koyama³, Hiroaki TOH⁴, Masaki Matsushima⁵, Wataru Kanda¹, Hiromi Fukino⁵, Yoshimori Honkura⁵, Makoto Uyeshima³

¹VFRC, Tokyo Inst. tech, ²Tohoku University, ³University of Tokyo, ⁴Kyoto University, ⁵Tokyo Institute of Technology

Fluids in the crust play an important role in volcanic processes and earthquake generation processes. Electrical resistivity is a geophysical parameter which is sensitive to the existence and connectivity of fluids. Thus, by imaging the resistivity by electrical induction method such as magnetotellurics, we can get important information on the amount, chemical composition and transport properties of fluids.

We have started magnetotelluric measurements in the NE Japan using wideband (0.01s–1000s) and long period (10s?20,000s) measurements. The wideband measurements are focused around the Onikobe caldera and the surrounding regions. In 2009, Thirty magnetotelluric soundings were carried out in and around the Onikobe caldera. We have found the lower crustal conductor with N-S strike directions and its shallower continuation to the Onikobe caldera, which has E-W directions representing the E-W tectonic compression. In 2010, we had 30 more stations to the south of the Naruko volcano, covering 20km x 20km.

In addition to the wideband measurements, we have made long period measurements to image the upper mantle structure. We have 32 long period stations with 20km grid spacing in order to image the upper mantle.

We will show some preliminary results on those on-going measurements.

Keywords: geofluid, magnetotellurics, electromagnetic method, resistivity

SCG060-23

Room:302

Time:May 25 15:45-16:00

Electrical conductivity of fluid-bearing crustal rock under high pressure

Akira Shimojuku^{1*}, Takashi Yoshino¹, Daisuke Yamazaki¹

¹Okayama University, ISEI

It has been reported that the electrical conductivities determined by magnetotelluric methods in the lower crust are much higher than those determined by dry laboratory samples of crustal rocks. The aqueous fluid is the most likely reason for the high-conductivity anomaly regions (e.g., Shankland and Ander, 1982). Since the solubility of silicate component in the aqueous fluid should increase with increasing pressure (Manning, 1994), the electrical conductivity of fluid-bearing rocks can be higher at pressure of the lower crust. To examine the effect of the soluble ionic species in aqueous fluid on the bulk rock conductivity, we measured the electrical conductivity of fluid-bearing quartzite as functions of temperature and fluid content under high pressure.

High-pressure experiments were carried out using a DIA-type high-pressure apparatus. Pyrophyllite was used as a pressure medium, and cylindrical graphite was used as a furnace. We used two kinds of the starting materials. One is the sintered quartz aggregate, which was synthesized from the mixture of quartz reagent and silicic acid using a piston-cylinder high-pressure apparatus. The other is chert generated from Tanba district, Japan. These starting materials initially contain 200-5560 wt. ppm H₂O as a fluid inclusion and OH species. To prevent a loss of water during the electrical conductivity measurements, we used a diamond single crystal capsule. Electrical conductivity was measured using the impedance spectroscopy method. Experiments were conducted at 1 GPa. Temperature range was from 700 to 1450K. The texture of the recovered samples was observed using field-emission scanning electron microscope, and the fluid content was measured using Fourier transformed infrared spectroscopy and calibration proposed by Paterson (1982).

The electrical conductivity increases proportional to (fluid fraction)^{0.86}. Our result suggests that the observational electrical conductivity at Tohoku, Japan (Ogawa et al. 2001) and New Zealand (Wannamaker et al. 2009) in the middle crust is unable to account for quartz plus H₂O. Therefore, plausible explanations of high-conductivity anomaly are presence of saline fluid and/or the other ionic species.

Keywords: electrical conductivity, fluid, crust

SCG060-24

Room:302

Time:May 25 16:00-16:15

Comprehensive geochemical model for the melting of mantle metasomatized by slab-derived fluid

Hitomi Nakamura^{1*}, Hikaru Iwamori¹

¹Tokyo Institute of Technology

The chemical composition of a relatively undifferentiated volcanic rock in arc has the integrated information of the processes occurred beneath a volcano in the mantle wedge, such as material infiltration from the subducting slab and subsequent melting of the mantle. Here, we aim to reveal how the whole rock composition including isotopic ratios and trace element abundances can be quantitatively explained by a series of the relevant processes in the mantle, based on which we constrain the geochemical cycling and thermal structure in subduction zones.

We apply a mass balance model to the Quaternary volcanic rocks of Central Japan where the two oceanic plates obliquely subducts. The compositions of slab-derived fluids can be estimated starting from subduction and dehydration of oceanic crustal materials. Then the composition of fluid-metasomatized mantle, including the amount of slab-derived fluids, is estimated based on isotopic systematics as in Nakamura et al. (2008). The composition of subsequent product (i.e., primary arc magma) is then predicted from that of the estimated metasomatized mantle as a forward model. Finally, by optimizing two important parameters involved in the melting equation (i.e., degree of melting and garnet/spinel lherzolite ratio involved in the melting), we have been successful to inverse these parameters based on the observed compositions of volcanic rocks.

As a result, the condition of magma genesis beneath the Central Japan arc is characterized by relatively high fluid fractions, low melting degrees of melting and high proportions of garnet lherzolite in the melting source region, compared to those of neighboring arcs with single subducting plates. The low melting degree and high garnet contribution may imply a low geothermal gradient and near-solidus melting over the spinel-garnet transition depths, semi-quantitatively constraining the thermal structure beneath Central Japan. The results are consistent with the independent numerical modeling of the region, suggesting a cold environment due to overlapping subduction of the Pacific and Philippine Sea plates.

In spite of the cold environment, adakitic rocks commonly occur in the investigated region. The mass balance model of this study demonstrates that the high fluid fraction, low melting degree of garnet lherzolite (plus subsequent crystal fractionation that shifts the overall abundances without modifying the characteristic patterns such as Sr/Y ratio) may explain the adakite signature in the cold environment. We suggest that the mass balance model is a promising approach to constrain the fluid and melting processes as well as the mantle thermal structure in subduction zones.

Keywords: slab, slab-derived fluid, geofluid, subduction, magma, volcano