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

MIS31-01 Room:106 Time:May 24 09:00-09:15

Relationships of crystal orientation between antigorite and olivine in serpentinite mylonite

SODA, yusuke[1*], MORISHITA, Tomoaki[1], WENK, Hans R.[2]

[1]Frontier Science Organization, Kanazawa University, [2]Department of Earth and Planetary Science, University of California, Berkeley

Serpentinite mylonite is developed penetrative foliation and consists of antigorite. Serpentinite mylonite is described from sheared ultramafic bodies (e.g., Norrell et al., 1989). Foliated antigorite serpentinite with lattice preferred orientation (LPO) causes seismic anisotropy observed in subduction zones (e.g., Katayama et al., 2009, Jung, 2011). However, formation mechanisms and conditions of antigorite LPO are unclear. To clear the formation process of antigorite LPO, we focus on the relationships of crystal orientation between antigorite and host olivine in the serpentinite mylonite.

Studied serpentinite mylonite is from Kurosegawa belt at Toba area, Kii Peninsula. The serpentinite body undergoes multiple stages of deformation and serpentinization. In outcrop, the serpentinite mylonite is cohesive and is surrounded by incohesive serpentinite which has undergone the serpentinization of later stage under lower temperature.

The serpentinite mylonite mainly consists of antigorite and olivine, and developed mylonitic textures such as shear bands and olivine porphyroclast system. The foliation and lineation is defined by array of blade shape antigorite and elongated olivine grains. Antigorite with blade shape are crystallized in the pressure shadows of olivine porphyroclast and pull-apart of olivine grain. Their occurrences indicate syntectonic growth of antigorite.

We measure the crystal orientation of olivine and antigorite by the U-stage and EBSD. In EBSD measurement of antigorite, we try automatic indexing, in addition to manual indexing. Both indexing methods bring the same fabric pattern. Comparing the antigorite patterns from the U-stage measurement and EBSD measurement, both methods also show the same fabric pattern.

The LPOs of olivine show point maximum or partial girdle distributions, and these concentrations deviate from the foliation and lineation of serpentinite mylonite. The LPOs of olivine are formed before the antigorite serpentinization. The LPOs of antigorite, from olivine free domain, show that b axes are parallel to the lineation, c axes are perpendicular to the foliation or make a partial girdle distribution normal to lineation and a axes are a point maximum or form a partial girdle distribution. The orientations of antigorite grains, growing in olivine grains, show topotactic relationship between antigorite and olivine. However, b axes tend to be parallel to the lineation.

Topotactic relationships between olivine and antigorite are attractive mechanisms for the making antigorite LPO (Boudier et al., 2010). Under the shear deformation condition, the other mechanisms, such as rotation of grains, diffusion-precipitate process and anisotropic growth of grains, also would affect the formation of antigorite LPO, in addition to topotaxial growth.

Keywords: antigorite, olivine, LPO, topotactic relationship

MIS31-02 Room:106 Time:May 24 09:15-09:30

Topotaxic replacement of olivine by a lizardite and brucite mixture in the Higashi-akaishi ultramafic body

MIZUKAMI, Tomoyuki[1*], Shintaro Ishigami[1], Shoji Arai[1]

[1]Earth Science, Kanazawa University

Fluid-rock reactions in the ultramafic system cause a wide variety of serpentinite. Analyses of the natural occurrences of serpentinite provide important constraints on contributions of variable factors controlling the development and related fluid chemistry. We present detailed petrological observations of lizardite and brucite (Liz+Brc) serpentinite, that is a retrograde product in a subduction zone environment, in the Higashi-akaishi ultramafic body.

We identified two end members of penetrative structures consisting of a fibrous Liz+Brc mixture: topotaxic vein and non-topotaxic mesh structure. Non-topotaxic vein can be regarded as an intermediate. Topotaxic veins are characteristically developed in a coarse-grained dunite and an optical X axis of a Liz+Brc mixture is sub-parallel to a c-axis of host olivine. Mesh textures overprint porphyroclastic textures of dunite and a Lis+Brc fibers are normal to olivine grain boundaries. The topotaxic veins are localized in the central part of the body whereas non-topotaxic mesh is more dominant in the peripheral part close to the surrounding schists.

Topotaxic veins preserve mineralogical and chemical zonings, indicating a Liz formation at a reaction front and a diffusive extraction of Fe to form magnetite (Mgt) at the center of the vein. Micro-Raman mapping reveals a close relationship between stripes of Brc and Mgt at a vein center. This indicates that Fe ion released at Ol-vein interface has transported through a channel filled by Brc. The Mgt formation was controlled by a reaction: Fe-rich Brc + SiO2 -> Liz +Mgt. A topotaxic relation between Ol and Liz(+Brc) is probably due to a low mobility of Si and high confining pressure. Non-topotaxic meshs show similar mineralogical features but they are rich in Liz and have abundant Mgt at the core. The difference between topotaxic and non-topotaxic replacements can be explained by mobility of elements and a supply of SiO2 depending on activities of aqueous fluids.

A topotaxic replacement of Ol by Liz+Brc possibly take place in shallow mantle where a supply of water-rich fluid is restricted. The case of the Higashi-akaisi body indicates that it can cause a significant amount of Liz+Brc serpentinite with stress-dependent anisotropic structures.

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MIS31-03 Room:106 Time:May 24 09:30-09:45

Mass-transfer and rate-limiting process of serpentinization

OKAMOTO, Atsushi[1*], TSUCHIYA, Noriyoshi[1], OGASAWARA, Yuichi[1]

[1]Graduate School of Environmental Studies, Tohoku University

Serpentine minerals, which are produced by interaction between ultramafic rocks and fluids, contain about 13% water and are the greatest carrier of H2O into the deep interior of Earth. Therefore, the volume and distribution of hydrated oceanic mantle are of special interest for understanding the global water circulation. There are several hydrothermal experiments on serpentinization in ultramafic rocks (Ol, Opx, peridotite)-water (seawater) interaction; however, these previous studies focused only on the extent of hydration of solids (Martin & Fyfe, 1970; Wegner & Ernst, 1983) or on the evolution of solution chemistry (e.g., Seyfried and Dibble, 1980; Allen and Seyfried, 2003). Therefore, the detailed reaction mechanism is still poorly understood, including evolution of the overall reactions, rate-limiting process, and resulting textures.

In this study, we conducted hydrothermal experiments in the olivine (Ol, Fo91) - orthopyroxene (Opx, En92) - H2O system at 250 degreeC and vapor-saturated pressure (Psat) for understanding the mechanism of serpentinization at oceanic lithosphere. At this temperature, high extent of hydration is expected for both Ol-H2O and Opx-H2O systems. The low-pressure condition of this study enables us to analyze both solution chemistry and the extent of hydration of the solid samples in detail. The main cryndorical reaction vessel (inner diameter 10.5 mm, height 100 mm) contains two sub-reaction tubes (inner diameter 4.5 mm, height 100 mm), in which the mineral powders (0.025-0.125 mm in size) are packed by meshes. We conducted three types of experiments in the Ol-H2O, Opx-H2O and Ol-Opx-H2O (Opx layer is sandwiched by Ol layers) systems, respectively.

In the Ol-H2O system, the reaction is divided into three stages. The Mg and Si concentrations increases (stage 1), then decreases (stage 2) and reaches the steady state (stage 1). The mineral assemblage also changes from serpentine (Srp) + magnetite (Mgt) at stages 1 and 2 to Srp + Mgt + brucite (Brc) at stage 3, that is consistent with the solutions, that change from stability field of serpentine to serpentine + brucite by drop of silica activity. The serpentine minerals occur as aggregate of fine-grained crystals (primarily lizardite, but chrysotile appear at stage 3), and discrete brucite crystals occur at the contact with olivine. The olivine commonly contains fractures filled by the products, that is similar to the natural mesh textures. In the Opx-H2O system, the silica activity is 1 to 3 order higher than that in the O-H2O system. The products are composed only of serpentine, and do not contain brucite, talc and magnetite. In contrast to serpentinization after olivine, the reaction occurs by psuedomorphic replacement of Opx. In the Ol-Opx-H2O system, the Mg concentration in the bulk solution is similar to that of the Opx-H2O system, whereas the Si concentration shows the similar behavior to the Ol-H2O experiments. The serpentinization preferentially occurred in the Ol zone at the contact with the Opx zone.

At 250 degreeC, the hydration rate is greater in the Ol-H2O system than in the Opx-H2O system. The contrasting natures of solution chemistry and products suggest that the rate-limiting process during serpentinization in the Ol-H2O, Opx-H2O and Ol-Opx-H2O systems are dissolution of olivine, precipitation of serpentine, and dissolution of orthopyroxene, respectively. Our results also indicate that hydrogen production, that is accompanied by the formation of magnetite, does not occur in the vicinity of Opx.

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Keywords: serpentinization, hydrothermal experiments

MIS31-04 Room:106 Time:May 24 09:45-10:00

Alteration of uppermost oceanic crust and its effect on deformations in subduction zones

YAMAGUCHI, Asuka[1*], KAMEDA, Jun[1], NISHIO, Yoshiro[2], KITAMURA, Yujin[3], SAITO, Saneatsu[3], KIMURA, Gaku[1]

[1]Department of Earth and Planetary Science, the University of Tokyo, [2]Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, [3]Institute for Research on Earth Evolution, Japan Agency for Marine-Earth Science and Technology

Simultaneous deformation and diagenesis characterize shallow parts (depths of $<$10 km) of subduction zones. While the relationships between diagenesis and deformation of hemipelagic and terrigeneous sediment in subduction zones have been discussed for many years, those of basaltic basement have not been evaluated well. To explore the role of diagenesis in subducting basalt, we examined mineralogy and geochemistry of ocean floor basalt at Site C0012, where oceanic crust entering the Nankai Trough, as well as on-land greenstone body within the Mugi melange in Shimanto Accretionary Complex, Japan, which subducted down to 150 - 200 degrees C and 6 - 7 km depth, metamorphosed and then exhumed.

Severe low-temperature alteration is encountered throughout the core samples from Site C0012. Matrix glass is mostly replaced by saponite/celadonite/Fe-hydroxide, olivine is completely replaced by saponite, and plagioclase is partly replaced by saponite and zeolites. Alteration is classified into two stages: broad oxidizing alteration accompanying Fe-hydroxide, and limited reducing alteration accompanying pyrite and intense saponitization, which is concentrated in the topmost ˜20 m-thick part of basaltic rocks. These two alterations would correspond to open- and closed-system hydrothermal circulation (i.e. circulation before and after deposition of overlying sediment), respectively (Lister, 1982). On the other hand, corrensite, saponite-chlorite mixed layer clay is the dominant clay mineral phase of basaltic rocks in the Mugi melange (Kameda et al., 2011). Whole-rock geochemistry data shows smaller LOI and K2O number in the Mugi melange in comparison to Site C0012.

Saponite releases water in response to temperature rise, and is progressively converted to chlorite at temperatures of 150?250 degrees C (Kameda et al., 2011). This diagenetic reaction would build up excess fluid pressure especially within highly saponitized part of ocean floor basalt where off-axis reducing alteration encountered, and enhances underplating of oceanic crust and fluxing of fluid-mobile elements along subductuion thrust. Deformation and mass flux of subducting basalt could be controlled by alteration pattern formed prior to subduction.

MIS31-05 Room:106 Time:May 24 10:00-10:15

”Rock -Fluid-Ecosystem” linkage in oceanic crust

NAKAMURA, Kentaro[1*]

[1]JAMSTEC

In this presentation, I will talk about ”Rock -Fluid-Ecosystem” linkage in oceanic crust and its implication for the exploration of unseen deep biosphere.

Keywords: oceanic crust, Rock -Fluid-Ecosystem linkage, deep-biosphere

MIS31-06 Room:106 Time:May 24 10:45-11:00

Along-axis variations of magmatism: implication from the V1 volcanic rocks in the northern Oman ophiolite

KUSANO, Yuki[1*], MIYASHITA, Sumio[1], UMINO, Susumu[2]

[1]Niigata University, [2]Kanazawa University

Overlapping spreading centers and small offsets, devals, mark the boundaries of the magma supply systems in spreading centers [Langmuir et al., 1986] and it appears as compositional variations between each segment. For example, MORBs recovered from the EPR (11 20 N and 9 30 N) have relatively a small geochemical variation whereas lavas from 10 30 N have a great range in composition, including evolved and less-evolved [Batiza et al., 1996]. On the other hand, digitized profiles of the ridge axis show deeper depth, narrower axial summit and deeper melt lens beneath the ridge axis in the segment margin than shallower and inflated segment center [Scheirer and Macdonald, 1993]. It indicates that magmatisms are changed along a ridge segment. Based on the segment structure proposed by Miyashita et al. [2003], we studied along-axis variations of upper crustal section in the Oman ophiolite and discovered systematic changes of extrusive sequence due to the segment structure.

Comparing eight geologic sections spanning 70 km, the along-axis volcanic system is reconstructed. Representative area of the segment center and margin is Bani Ghayth and Wadi Fizh, respectively. The total thickness of on-axis lava section decreases from the segment center (603 m thick) to the margin (410 m thick). Predominant appearance of pillow lavas around the segment margin indicates more ragged seafloor topography than the center where pahoehoe flows dominate. Their lava compositions are also varied systematically. Homogenized mildly-evolved lavas characterize the segment center. The larger melt lens and the higher ability of melt concentration below the segment center would produce the thick and comparatively homogenized lava sequence. On the other hand, both evolved and less-evolved lavas showing lower degrees of partial melting occur in the segment margin. Smaller melt lenses would promote highly evolved and less-evolved lavas. Although thinner on-axis lava sequences occur at the segment margins, total thickness of lava section is relatively fixed because of off ridge volcanisms. Occurrences of the fissure vent or dikes intruding into the extrusives imply the volcanisms after on-ridge magmatism. Such vigorous off-axis volcanisms are recognized around the second- and third-order segment margins along the EPR. They might be rooted at less-evolved melts from depths avoiding the focus into the melt lens beneath the axis area.

Keywords: MORB, Segment structure, Volcanology, Bulk rock composition, Oman ophiolite

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MIS31-07 Room:106 Time:May 24 11:00-11:15

Occurrence and petrology of the axis stage felsic rocks in the northern Oman ophiolite

TSUCHIYA, Nobutaka[1*], Kazufumi Nakamura[1], UMETSU, Takaaki[1], ADACHI, Yoshiko[2], MIYASHITA, Sumio[3]

[1]Department of Geology, Faculty of Education, Iwate University, [2]Center for Transdisciplinary Research, Niigata University, [3]Department of Geology, Faculty of Science, Niigata University

At mid-ocean ridges, a critical interface for heat and mass exchange between the lithosphere and hydrosphere is the magma–hydrothermal transition (Gillis and Coogan, 2002). A distinctive feature of ophiolitic upper gabbros is the presence of leucocratic rocks in vein networks and/or discrete bodies that commonly contain partially resorbed xenoliths of basaltic material. These presence of felsic rocks in ohiolite suites has been reported by numerous authors, and are called plagiogranite (Coleman and Peterman, 1975). These lithologies are attributed to partial melting of basaltic material, extreme fractional crystallization of basaltic melt, or a combination of these two end-members (Pedersen and Malpas, 1984).

Lippard et al. (1986) classified the felsic rocks in the Oman ophiolite into three stages; high-level intrusives (axis stage), late intrusives, and younger granites associated with emplacement. Rollinson (2009) described similar classification of the felsic rocks in the Oman ophiolite, and discussed petrogenesis of these felsic rocks. This paper describes field occurrences, petrography, and petrochemistry of the felsic rocks in early (axis stage) intrusive rocks.

The early (axis stage) felsic rocks characteristically intrude into the boundary between lowermost sheeted dike complex and upper gabbro. We investigate felsic rocks intrude into the boundary between lowermost sheeted dike complex and upper gabbro, which includes sheeted dikes as large blocks less than 10 m from the main stream of the Wadi Rajimi (Rollinson, 2009). Felsic rocks associated with the sheeted dikes from eastern margin of the Lasail complex and the Wadi Barghah are also investigated, which are intruded by upper gabbroic rocks and quartz diorites. We also investigate felsic rocks intrude into the sheeted dike complex near the quartz dioritic to tonalitic intrusion in the Wadi Khabiyat. These sheeted dikes are infiltrated by quartz dioritic vein networks, which sometimes occurs as pockets and patches. In some places, sheeted dikes are composed of hornblende and pyroxene hornfels cut by quarts dioritic vein networks. These occurrences resemble to the anatectic migmatites of axial magma chamber roof exposed in the Troodos ophiolite, Cyprus, described by Gillis and Coogan (2002).

Gillis and Coogan (2009) describes disequilibrium melting models to explain relatively lower REE concentrations in early felsic rocks. Disequilibrium melting models assume that the concentration of an element in a melt is simply controlled by its concentration in the constituent minerals and the relative proportions in which they dissolve into the melt (e.g., Bea, 1996). Incompatible element concentrations sometimes lower in the quartz dioritic vein compared with the values predicted by equilibrium melting of sheeted dikes, this discrepancy can be explained by disequilibrium melting model. Disequilibrium melting may play a significant role on the petrogenesis of axis stage felsic rocks.

Keywords: Oman ophiolite, plagiogranite, axis stage, oceanic crust, petrochemistry

MIS31-08 Room:106 Time:May 24 11:15-11:30

Petrogenesis of MORB: a implication from concordant dunite bands of the northern Oman ophiolite

AKIZAWA, Norikatsu[1*], ARAI, Shoji[1], TAMURA, Akihiro[2]

[1]Kanazawa Univ. Natural Sci. Earth Sci., [2]Kanazawa Univ. FSO

Dunite bands and veins in the ophiolitic mantle peridotite are interpreted as melt conduits within the suboceanic mantle. In particular, concordant dunite bands are possibly important as melt conduits, through which parental melts of MORB (mid-ocean ridge basalts) were transported to shallower mantle beneath the ridge axis. However, no detailed petrological data of concordant dunite bands and surrounding peridotites have been published. We found concordant dunite bands from various "stratigraphic levels" in the mantle section of the northern Oman ophiolite. They are various in thickness (few millimeters ~ few tens of centimeters) and frequency of appearence. Dunite bands are almost pyroxene-free, and orthopyroxenes, if any, are vermicular in shape. Modal clinopyroxenes in wall peridotites increase toward the dunite band.

Mineral chemistry shows systematic variations in the wall peridotites toward the dunite bands: (1) a decrease in the Fo content (92 to 90.5) of olivines, (2) an increase in the Cr/(Cr + Al) atomic ratio (0.5 to 0.6) and TiO2 content (nil to 0.25 wt %) in spinels, and (3) an increase in the Na2O content (almost nil to 0.2 wt%) of clinopyroxene. In residual peridotites, rare earth element (REE) patterns of clinopyroxene incline from light-REE (LREE) to heavy-REE (HREE) monotonously. REE patterns of clinopyroxene in peridotites near dunite bands are U-shaped or flat. REE characteristics of clinopyroxene in dunite bands within the mantle away from the layered gabbro/peridotite boundary suggest an involvement of "slightly depleted MORB melts", which are slightly more enriched in LREE than the melts in equilibrium with residual peridotites.

We conducted simplified modeling for REE enrichment in clinopyroxenes by using chromatographic approach. The results indicate that MORB melts and "slightly depleted MORB melts" were transported through the present-day concordant dunite bands within the Oman mantle; MORB melts were migrated around the layered gabbro/peridotite boundary. The primitive MORB melts might have changed to MORB through "slightly depleted MORB melts" by interaction with peridotites en route to the uppermost mantle.

Keywords: Oman ophiolite, concordant dunite band, MORB, melt/rock interaction

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MIS31-09 Room:106 Time:May 24 11:30-11:45

Distribution of ultramafic layers in the mantle section of the Oman ophiolite: early magma genesis at spreading centre

Georges Ceuleneer[2], PYTHON, Marie[1*], TAMURA, Akihiro[3], ARAI, Shoji[4]

[1]Hokkaido University, Department of Natural History Sciences, Sappro, Japan, [2]Observatoire Midi-Pyrenees, Laboratoire Geosciences Environnement Toulouse, Toulouse, France, [3]Kanazawa University, Frontier Science Organization, [4]Kanazawa University, Department of Earth Sciences, Kanazawa, Japan

Ultramafic dykes concordant to their host foliation (layerings) are frequently observed at various level of the mantle section of the Oman ophiolite. They generally crop out as series of 3 to about ten parallel veins, a few mm (one crystal) to a ten of cm wide, a few cm spaced out. Their host is usually harzburgite showing, in one third of the cases, increasing Opx content when approaching the layer and, in the two other third of the cases, no variation of the Opx content. Locally concordant dunite may appear in association with pyroxene-rich layerings as thin (a few mm to a few cm) parallel vein in contact with the layer or not. We present here a compilation of the data obtained on about 240 samples taken all over the mantle section of the Oman ophiolite. Their modal composition cover a wide part of the ultramafic domain with rare clinopyroxenite, dunite or wehrlite, abundant orthopyroxenite and websterite, and scarcer clinopyroxene-bearing harzburgite and lherzolite. The distribution map shows that layerings appear at any level in the mantle section, close to the basis as well as a few tens of meters below the Moho. Layerings are abundant only in the northernmost part of the ophiolite, from the Wuqbah to the Fizh blocks with exceptionally low abundance in the Hilti block. They are rare or even non-existent in the south-eastern massifs (Maqsad, Wadi Tayin, etc.) suggesting that condition for their genesis or preservation were reunited only in some specific places in the mantle before obduction. Their major elements chemistry is generally in equilibrium with their host peridotite and their pyroxenes and olivines compositions stay within the peridotite chemical domain with no specific rim-core evolution. However, Cpx trace elements content shows compositions richer in REE than the classical Oman harzburgite with chondrite normalised profiles slightly dipping in the HREE suggesting a magmatic origin with possible magma generation in the garnet peridotites field. Two-pyroxenes geothermometer show equilibrium temperatures between 950 and 1100^{o}C, suggesting high temperature transposition and equilibration. The high abundance of layerings observed close to the Moho transition zone in the Fizh and Wuqbah blocks show that these features and their transposition are not related to the obduction but to early magmatic process below the Omanese spreading centre followed by mantle flow at high temperature.

Keywords: Concordant dykes, Pyroxenites, Oman ophiolite, Mantle, Magatism

MIS31-10 Room:106 Time:May 24 11:45-12:00

Spatial compositional variability and origin of incipient subarc mantle inferred from the northern Oman ophiolite

TAKAZAWA, Eiichi[1*]

[1]Faculty of Science, Niigata University

The Oman ophiolite is a remnant of Neo-Tethyan oceanic lithosphere that has been modified by arc-related magmatism during oceanic thrusting prior to the obduction to the Arabian continent. To understand the formation of oceanic mantle lithosphere at spreading ridge and subsequent modification at incipient subduction zone we conducted a Km-scale mineral chemical mapping of the mantle section in the Fizh and Salahi blocks in the northern Oman ophiolite.

In the Fizh mantle section the range of spinel Cr# (=100xCr/[Cr+Al] molar%) in harzburgites becomes wider from the south (Cr# 43-67) toward the north (Cr# 22-78). In the south, where paleo-ridge segment center has been inferred, relatively homogeneous harzburgites with spinel Cr# around 60 are widely distributed indicating that the degree of melting was equivalent to the upper limit of abyssal peridotites (spinel Cr#~60). On the other hand, in the northern part, where a paleo-ridge segment end was inferred, refractory harzburgites with spinel Cr# greater than 70 are abundant and are linearly distributed from the basal thrust to the Moho. Such highly refractory harzburgites are associated with thick dunite bands in which spinel Cr# is also high (greater than 70). Such region with abundant refractory peridotites is called highly refractory zone (HRZ, hereafter). Away from the HRZ the harzburgites are less refractory and often contain spinels with low Cr# (smaller than 50). Thus, except for the peridotites in the HRZ the harzburgites in the northern Fizh mantle section is less refractory relative to those in the southern Fizh mantle section. Dunites in the Fizh mantle sections have spinel with Cr# ranging from 45 to 80 and tend to have higher spinel Cr# than the harzburgites. Moreover, the dunites with high Cr# spinel (greater than 70) are abundant in the HRZ and in the basal part of the Fizh mantle section.

In the Salahi mantle section the spinel Cr# of harzburgites ranges from 42 to 70 and is most frequent in the range of 55-60. The harzburgites in the southern Fizh mantle section also have similar variation. On the other hand, the Cr# of spinel in dunites in the Salahi mantle section shows a bimodal distribution: frequency peak occurs both at 55-60 and at 68-75. The peak in the 55-60 is also observed in the harzburgites while the peak in the 68-75 occurs only in the dunites. The dunites in the lower level of the Salahi mantle section above the basal thrust often contain high Cr# spinels greater than 70 while the dunites in the upper level of the Salahi mantle section have spinel with Cr# smaller than 65. We consider that the dunites with such low Cr# spinel were formed at MOR stage while those with the high Cr# spinel formed by a reaction with boninitic melt during oceanic thrusting stage.

The distribution of refractory harzburgite and dunite in the northern Oman ophiolite can be modeled as follows. During oceanic thrusting the Oman ophiolite was forced to be located above an incipient subduction zone. The fluid released from metamorphic sole due to thermal metamorphism of altered oceanic crust infiltrated into the mantle section. Dunite channels may have been responsible for fluid infiltration from the base of the ophiolite. The fluid infiltration through dunite channel caused the flux melting of wallrock harzburgite. The presence of the HRZ in the northern Fizh mantle section implies that the infiltration of fluid from the base of ophiolite was abundant in the ridge segment boundary region. The orientation of the HRZ may imply that shear deformation in the segment boundary region enhanced the fluid infiltration. Alternatively, flux melting of less-refractory harzburgites (spinel Cr# smaller than 50) in the ridge segment boundary region produced relatively large amount of boninitic melt. Large porosity may have enhanced further infiltration of fluid from the base resulted in the formation of the HRZ in the segment boundary region.

Keywords: Oman ophiolite, mantle, peridotite, spinel Cr#, flux melting, fluid migration

MIS31-11 Room:106 Time:May 24 13:45-14:00

A study of the structure and evolution of the oceanic lithosphere inferred from mantle xenoliths and drilling samples

ABE, Natsue[1*]

[1]IFREE, JAMSTEC

Deep-seated rock xenoliths often included in oceanic island basalts and abyssal peridotite sampled by oceanic drilling and dredges provide us a lot of information about the deep structure and evolution of the oceanic lithosphere. Here a review of recent studies on such peridotite and the deep crustal materials from the oceanic lithosphere will be presented.

Keywords: oceanic lithosphere, mantle xenoliths, ocean drilling, abyssal peridotite

MIS31-12 Room:106 Time:May 24 14:00-14:15

Fabric and petrological characteristics of mafic and ultramafic rocks in the Tonga Trench

MICHIBAYASHI, Katsuyoshi[1*], Yuri Shinkai[1], Teruaki Ishii[2], Sherman H. Bloomer[3]

[1]Institute of Geosciences, Shizuoka Univeristy, [2]Fukada Geological Institute, [3]Oregon State University

The Tonga trench is one of the deepest oceanic regions in the world (10,866 m), so it may likely to be the closest location to the mantle. In the Tonga trench, various types of rocks have been dredged and drilled at several localities on the landward slopes of the trench. In particular, very pristine peridotites occur at the most deep landward trench slope. 100 samples of mafic and ultramafic rocks collected from several locations were analyzed in order to understand the characteristics and whole picture of the Tonga trench. Mineral composition of olivine and spinel in peridotites suggests that there are two types of regions: central region and northern region. The peridotites in the central regions have high-Cr# (0.46-0.83) which were typical of forearc peridotites. In contrast, the peridotites in the northern region have evidences of the reaction with magma during partial melting. Moreover, on the basis of H2O content (over 100 ppm) of olivine and TiO2 content (from 0.06 to 0.79 at northern region) of spinel, they remarkably reacted with melt and/or fluid. In addition to peridotites composition, mineral composition of plagioclase, clinopyroxene and amphibole in gabbroic rocks also suggest that there have been affected by water infiltration. Olivine fabrics are characterized by E-type and D-type. Although E-type and D-type are no clear relationship of mineral composition, grain size and equilibrium temperature, the only difference between E-type and D-type were fabric intensities. This difference suggests that pristine and serpentinized peridotites in the Tonga trench are deformed in the region where high strain field occurred due to the dragged flow. Eventually, they expose in a very neat condition (i.e. active tectonic erosion and fast ascent rate) resulting from an unique tectonic setting including fast subducting plate (24 cm/yr), fast spreading plate (15 cm/yr) and slab rollback.

Keywords: Tonga trench, mantle wedge, peridotite, serpentinite, gabbro

MIS31-13 Room:106 Time:May 24 14:15-14:30

Reactive Melt Flow as the Origin of Residual Mantle Lithologies and Basalt Chemistries in Mid-Ocean Ridges

KIMURA, Jun-Ichi[1*], Sakae Sano[2]

[1]IFREE / JAMSTEC, [2]Department of Earth Science/ Ehime Unive

A reactive flow geochemical model using pMELTS thermodynamic calculations explains the observed modal, major, and trace element variations in the Red Hills peridotite, New Zealand. The model also reproduces the major and trace element chemical variation in the mid-ocean ridge basalts (MORBs) observed in the present day spreading ridges. The Red Hills peridotite is thought to originate in paleo-MOR magmatic processes in the mantle-MOHO transition zone. The peridotite body consists of a harzburgite matrix and dunite channels. The harzburgite forms the Lower Unit and the harzburgite is intruded by the replacive dunite channels in the Upper Unit. This lithology gradually turns into a massive dunite zone in which disseminated to lenticular clinopyroxene aggregates are present. The rare earth element (REE) compositions of peridotite samples vary greatly depending on their lithologies. In the Lower Unit, REEs are extremely depleted, whereas in the Upper Unit they are relatively fertile, in contradiction to their depleted lithologies. Our model consists of two-stages. The first-stage assumes melting of a depleted MORB source mantle in the garnet stability field, and the second assumes reactions between residual solids and the melts from the first-stage in the spinel stability field in an open system. The model explains the formation of depleted harzburgite and the formation of dunite channels in the harzburgite matrix well. The major and trace element compositions of the melts calculated by the model vary from ultra-depleted MOR melts in harzburgite to normal MORBs in dunite, suggesting that these lithologies are residues of a paleo-MOR. The model also explains the origins of the local and global geochemical trends found in MORBs and the geochemical variation in the abyssal peridotite samples. Our model confirms the important role of reactive flow in the mantle-MOHO transition zone beneath MORs.

Keywords: Ocean ridges, Mantle, MORB, Ophiolite, Melt

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Diversity in PT history of exhumed mantle peridotites and its implication in lithosphere-asthenosphere interaction

OZAWA, Kazuhito[1*], Jena-Louis. Bodinier[2], Carlos J. Garrido[3], NAGAHARA, Hiroko[1]

[1]University of Tokyo, [2]Universite de Montpellier, [3]University of Granada

Pressure and temperature history of exhumed mantle peridotites shows significant diversities, which may be attributed to several factors such as: (1) lithospheric thermal gradient before exhumation, (2) rate of tectonic motion and thermal and mechanical conditions during exhumation, (3) thermal perturbation shortly before or during exhumation of lithosphere such as episodic asthenospheric thermal convection with lithosphere erosion and related magma generation, and transportation, (4) lithosphere formation or growth from asthenosphere through melting and melt separation and subsequent exhumation. These factors may, conversely, be estimated from the mantle peridotites if each effect can be isolated from the others by considering tectonic environment where the mantle peridotite resided and exhumed. The first factor is recorded as the initial condition of exhumation potentially providing information on steady-state mantle heat flow. The second is recorded as compositional zoning of minerals in terms of elements sensitive to PT change. Among these factors, (3) and (4) represent direct thermal and mechanical interactions between lithosphere and asthenosphere and are examined by whole-rock compositions and its heterogeneity constraining thermal condition of melting and melt segregation processes if they were involved (e.g., abyssal peridotite exposed along mid-ocean ridges). The following cooling and thermal relaxation are recorded as compositional zoning in minerals and chemical heterogeneity in a composite lithology over the scale of more than a few centimeters.

These approaches are similarly applicable to any types of mantle peridotites such as orogenic peridotites, mantle section of ophiolites, and mantle xenoliths in alkali basalt and kimberlite. Xenoliths can provide instantaneous thermal states of the mantle up to the depth as deep as a few hundreds km, and is superior in examination of (1) and (3). Contrary to this, intrusive peridotites always underwent slow exhumation process more or less obscuring lithospheric information, and is superior in examination of (2) and (4).

Following the above strategy, thermal histories of three peridotite bodies from world orogenic belts are compared. These are the Horoman peridotite in the Hidaka belt, peridotite bodies in the Pyrenees, and Ronda in the Betic Cordillera. The common feature of these peridotites is that they were initially resided in the garnet stability field before decompression. There are, however, several distinctions: (1) garnet in any rock types is completely transformed into low pressure mineral assemblage (symplectite) in Horoman, garnet in pyroxenites remains but that in peridotites is completely transformed into symplectites in Pyrenees, and garnet remains in peridotites as well as in pyroxenites in Ronda, (2) orthopyroxene in garnet- or symplectite-bearing rocks shows remarkable M-shaped Al zoning in Horoman, weaker but distinct M-shaped in Pyrenees, and very weakly developed in Ronda, (3), orthopyroxene in peridotite and pyroxenites has a Ca-rich margin in Horoman, but such features are not common in Pyrenees and Ronda, and (4) topotaxy is always established in two-pyroxene spinel symplectite in Horoman (Odashima et al., 2008) but not so in Ronda (R. Nagashima, personal communication). These systematic relationships suggest that dP/dT was very small or even negative in Horoman (~adiabatic or heating during exhumation), moderate in Pyrenees (~adiabatic), and large in Ronda (effective cooling with decompression). It is inferred that exhumation accompanying active asthenospheric thermal perturbation took place in Horoman, passive exhumation in Pyrenees, and transportation towards the cooler region probably in a subduction environment in Ronda, in spite of the suggested asthenospheric thermal perturbation in the spinel and plagioclase facies in Ronda (Garrido et al., 2010).

Keywords: lithosphere-asenosphere interaction, mantle pressure temperature history, mantle thermal structure

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Three-dimensional shear wave structures of the upper mantle beneath the Philippine Sea and the French Polynesia region

ISSE, Takehi[1*], SHIOBARA, Hajime[1], SUETSUGU, Daisuke[2], SUGIOKA, Hiroko[2]

[1]OHRC, ERI, Univ. of Tokyo, [2]IFREE, JAMSTEC

We have operated many seafloor observations by using newly developed long-term broadband ocean bottom seismometers (BBOBSs) to reveal the mantle dynamics beneath the oceanic region in the Pacific Ocean. We have conducted array observations by BBOBS in and around the Philippine sea plate to analyze the structure of the subduction zone and in the French Polynesian region characterized by a topographic high of 700 m (called Pacific superswell), a concentration of hotspot chains, and large scale low-velocity anomalies in the lower mantle to analyze the whole mantle structures in this region.

We have analyzed the three-dimensional shear wave structures of the upper mantle beneath these regions by using surface wave tomography technique.

In the Philippine sea region, we analyzed the isotropic and anisotropic shear wave velocity structure by using Rayleigh and Love waves recorded by land and seafloor broadband seismometers. We obtained high spatial resolution (about 300km) shear wave structure model in the Philippine Sea region. Along the Izu-Bonin(Ogasawara)-Mariana arc, we have detected three separate slow anomalies in the mantle wedge at depths shallower than 100 km beneath the rear arc. Each anomaly has a width of about 500 km. We suggest that each of the anomalies is a site of large scale flow of deep mantle into the mantle wedge, and that each already contains a component from the adjacent subducting slab.

Our anisotropic structure model suggests that the fast directions of azimuthal anisotropy are parallel to the directions of ancient seafloor spreading in the lithosphere of the Shikoku and West Philippine Basins and Pacific Ocean, whereas they are parallel to the direction of the present-day absolute plate motion (APM) in the asthenosphere of the Shikoku Basin, and oblique to the direction of the APM in the Pacific Ocean (by about 30 degree) and in the northern part of the West Philippine Basin (by about 55 degree). In the subduction zones around the Philippine Sea plate, the fast direction of azimuthal anisotropy is trench-parallel in the Ryukyu arc, and oriented NW-SE in the Izu-Ogasawara island arc. The Philippine Sea plate, which is a single plate, shows very large lateral variations in azimuthal and radial anisotropies compared with the Pacific plate.

Beneath the superswell in the French Polynesian region, we determined three-dimensional shear wave speed model down to a depth of 200 km by using fundamental mode of Rayleigh waves. The temporary observation by seafloor and islands enables us to study the upper mantle structure beneath the superswell with an unprecedented high resolution. Resolution analyses indicate that these temporary observations locally improve the lateral resolution to about 400 km. We observe superficial slow anomalies associated to the spreading ridges such as the Lau Basin and two kinds of hotspot signatures: We found pronounced and continuous slow anomalies down to at least 200 km depth near the Society, McDonald, Marquesas, and Pitcairn hotspots whereas the slow anomalies beneath the Samoa, Rarotonga and Arago hotspots are only present at depths shallower than 80 km.

Keywords: seafloor observation, upper mantle structure, surface wave analysis