Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P01 Room:Convention Hall Time:May 27 14:00-16:30

Seismic radial anisotropy of the lithosphere and asthenosphere beneath the Shikoku Basin from records by OBSs

Akiko Takeo[1*], Kiwamu Nishida[1], Takehi Isse[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Toshihiko Kanazawa[1], Hiroko Sugioka[2]

[1]ERI, the University of Tokyo, [2]IFREE, JAMSTEC

In order to constrain the one-dimensional radially anisotropic structure of the oceanic upper-most mantle, we analyze surface waves in a broadband frequency range, 0.01-0.15 Hz (7-200 sec), using in-situ observed data. Data are those of broadband ocean bottom seismometers (OBSs) operated in the Shikoku Basin, the past (15-30 Ma) back-arc spreading region in the western-most part of the Pacific Ocean. For the first step of analyses, we measure average phase velocities of Love and Rayleigh waves in the Shikoku Basin area using two methods: seismic interferometry at frequencies higher than 0.035 Hz (30 sec), and conventional array analysis of earthquake waveforms at lower frequencies. Obtained phase velocities are consistent between two methods at an intermediate frequency band around 0.035 Hz. We then search for the optimal 1-D radially anisotropic structure that fits observed and theoretical waveforms by simulated annealing.

As a result, there are two types of structures, RAS1 and RAS2, that can similarly explain the observation. For both types of structures, SH-wave is faster (VSH > VSV), the intensity of radial anisotropy (VSH?VSV)/Vmean is 5-10 % at a depth range of 50-80 km, and smaller than 5 % at depth shallower than 30 km. This result is not affected by scaling laws that constrain parameters, such as the intensity of P-wave radial anisotropy. The depth of the largest anisotropy is deeper than the top of low velocity zone for RAS1, and is same as the top of low velocity zone for RAS2. RAS1 implies that the intensity of radial anisotropy is decreased at shallower depth by some mechanism such as canceling with opposite anisotropy VSV > VSH made at the spreading center. RAS2 implies that radial anisotropy is strongest at the top of low velocity zone due to strain accumulation or the melt-layering structure in the asthenosphere.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P02 Room:Convention Hall Time:May 27 14:00-16:30

Magmatic processes constrained from peridotites of the Eastern Mirdita ophiolite (Albania): Implications for subduction

Tomoaki Morishita[1*]

[1]Kanazawa University

Compared with comprehensive studies on arc-related volcanic rocks, there have been few studies of the mantle evolution related to igneous activity in the earliest stages of subduction initiation. Detailed geological and geochemical work on several supra-subduction zone ophiolites has revealed the presence of distinct peridotite units within the mantle section of ophiolites: a MORB-like unit and a highly refractory unit (e.g. Batanova and Sobolev, 2000 Geology; Choi et al., 2008 Contrib Mineral. Petrol). These lithological variations and their relationships have been generally explained by a shift in tectonic setting from MOR to island arc. It should be noted, however, that the tectonic setting of ophiolites is still controversial. The temporal and spatial variation of magmatism in the Izu-Bonin-Mariana (IBM) arc has been well documented by DSDP-ODP drillings, dredges and direct sampling using submersibles and ROVs (e.g. Fryer, 1996 Rev. Geophysics). Reagan et al. (2010 G-cubed) reported that MORB-like basalts were the most prevalent volcanic rocks in the IBM forearc region, followed by boninitic magmatisms. They postulated that the MORB-like tholeiitic basalts were the first lavas to erupt after the oceanic plate began to subduct and termed them forearc basalt (FAB). Peridotites sampled directly from the IBM forearc are crucial to understanding subduction systems. We examined mantle section of a supra-subduction ophiolite, the Eastern Mirdita ophiolite (EMO), Albania (Morishita et al., 2011 Lithos). Structurally, cpx porphyroclast-bearing harzburgite (Cpx-harzburgite) occurs in the lower parts of the peridotite massifs, whereas harzburgite and dunite are more abundant towards the upper parts. The Cpx-harzburgites were formed as the residue of less-flux partial melting, which are similar to those in abyssal peridotites from MOR systems. On the other hand, harzburgites were produced as a result of enhanced partial melting of depleted peridotites due to infiltration of hydrous LREE-enriched fluids/melts. We emphasize here that high-Cr# spinel-bearing dunite and medium-Cr# spinel-bearing dunite occur in refractory harzburgite of the EMO. Lithological variations (dunite and harzburgite) and their geochemical relationships in the EMO are very similar to those in the IBM forearc peridotites (Morishita et al., 2011 Geology). The wide range of variation in dunites from the IBM forearc and the uppermost section of the EMO probably reflects changing melt compositions from MORB-like melts to boninitic melts in the forearc setting due to an increase of slab-derived hydrous fluids/melts during subduction initiation.

Keywords: ophiolite, peridotite, MOHO, Island Arc

SIT002-P03 Room:Convention Hall Time:May 27 14:00-16:30

The MoHole: an ultra-deep drilling into the oceanic mantle

Natsue Abe[1*], Shuichi Kodaira[1]

[1]IFREE, JAMSTEC, [2]Dept, Earth Sciences, Kanazawa Univ.

The MoHole project, which will drills into an intact portion of oceanic lithosphere, is a long-standing ambition of scientific ocean drilling. The 2010 MoHole workshop in Kanazawa followed from several scientific meetings on ocean lithosphere drilling, which reached a consensus that a deep hole through a complete section of fast-spread crust is a renewed priority for the community. New deep drilling technologies now make it possible to fulfill our aspiration to drill completely through intact oceanic crust and into the upper mantle, and address a number of first-order scientific goals: what is the geological nature of the Moho? How is the oceanic crust formed at mid-ocean ridges, and what processes influence its subsequent evolution? What are the geophysical signatures of these processes? What are the interactions with the oceans and biosphere, and their influence on global chemical cycles? What are the limits of life, and the factors controlling these limits? What is the physical and chemical nature of the uppermost mantle, and how does it relate to the overlying magmatic crust?

The selected MoHole target would ideally meet a suite of scientific requirements including fast spreading rate, simple tectonic setting, "normal" crustal seismic structure, and strong reflectivity of Moho. Several technological constraints limit the range or possible sites, including in particular the trade-off between seafloor depth, which should be small enough to allow using mud re-circulating technologies, and temperature at Moho/upper mantle depths, which should be low enough (~?250 degree C) to allow ultra deep drilling (> 6000m) in basement. The workshop participants discussed three areas in the Pacific Basin: 1) the region around Site 1256, 2) the eastern Pacific plate off Mexico, 3) the eastern edge of the north Hawaiian arch.

This is an executive summary of the Kanazawa WS report* (Ildefonse et al., 2010, Scientific Drilling:doi: 10.2204/iodp.sd.10.07.2010).

*Report writing team: Ildefonse, B (Geosciences Montpellier, CNRS, Montpellier, France), Abe, N (JAMSTEC, Yokosuka, Japan), Isozaki, Y (JAMSTEC, Yokosuka, Japan), Blackman, D K (UCSD, La Jolla, CA, USA), Canales, J (WHOI, Woods Hole, MA, USA), Kodaira, S (JAMSTEC, Yokohama, Japan), Myers, G (COL, Washington, DC, USA), Nakamura, K (JAMSTEC, Yokosuka, Japan), Nedimovic, M R (Dalhousie Univ., Halifax, NS, Canada), Seama, N (Kobe Univ., Kobe, Japan), Teagle, D A (NOC, Southampton, United Kingdom), Umino, S (Kanazawa Univ., Kanazawa, Japan), Wilson, D S (UCSB, Santa Barbara, CA, USA), Yamao, M (JAMSTEC, Yokosuka, Japan)

Keywords: MoHole, Oceanic Plate, ultra-deep drilling

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P04 Room:Convention Hall Time:May 27 14:00-16:30

Two types of dunite in the mantle section of the Lizard ophiolite, Cornwall

Shohei Takano[1*], Shoji Arai[2], Akihiro Tamura[3], Satoko Ishimaru[4], Norikatsu Akizawa[1], Hironori Negishi[1]

[1]Dept. Earth Sci., Kanazawa Univ., [2]Nat. Sci. Tech., Kanazawa Univ., [3]FSO, Kanazawa Univ., [4]Dept. Earth Sci., Kanazawa Univ.

The Lizard ophiolite, Cornwall, UK, is of the slow-spreading ridge origin(Roberts et al., 1993), and petrological characteristics of peridotites are useful for our understanding of deep magma processes related with the origin of MORB. We have found two types of dunite(concordant dunite and discordant dunite) in this study area; They were strongly serpentinized and we could find relict olivine only in some discordant dunites.

Fo(Fo_{89-92}) and NiO content(0.35-0.40 wt%) of olivine in lherzolite and harzburgite are similar to those of abyssal peridotite. But, olivine in the discordant dunite is low in Fo(Fo_{83-85}) and NiO content(0.20-0.30 wt%). Fo(Fo_{84-87}) and NiO content(0.20-0.35 wt%) of olivine in lherzolite adjacent to the discordant dunite are close to those of olivine in this dunite. The TiO_2 content(0.50-1.00 wt%) of clinopyroxene in this marginal lherzolite is higher than that of massive lherzolite($<$0.25 wt%) for from the dunite dike. The concordant dunite was formed through interaction between N-MORB-like melt and lherzolite. This is consistent with the presence of spinel concentrations (Arai & Yurimoto, 1994). The discordant dunite is post-deformational, and was formed though interaction between E-MORB-like melt(high-Ti, and high- Fe^{3+}) and lherzolite. Two-phase spinels in this dunite have been crystallized from evolved melt with higher TiO_2 and Fe^{3+} content.

Keywords: dunite, lherzolite, harzburgite, Lizard ophiolite, melt/wall interaction

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P05 Room:Convention Hall Time:May 27 14:00-16:30

Sulfide-rich dunite from Wadi Thuqbah, the northern Oman Ophiolite

Hironori Negishi[1*], Shoji Arai[2], Satoko Ishimaru[2], Akihiro Tamura[3]

[1]Dept. Earth Sci., kanazawa Univ., [2]Nat. Sci. Tech., kanazawa Univ., [3]FSO, Knazawa Univ.

We found a sulfide-rich dunite from Wadi Thuqbah, the northern Oman Ophiolite, which gas never reported elsewhere. The dunite contains about 2 mode% sulfides. The sulfide-rich dunite occurs as heterogeneous patches near the boundary between wehrlite and dunite in the Moho transition zone. Pentlandite and pyrrhotite form composite grains with magnetite. Pentlandite and pyrrhotite show complicated intergrowth, which is cut by magnetite.

The Fo content of olivine is 90.7˜91.0 but the NiO content is 0.1 wt% (0.08˜0.12 wt%) in the sulfide-rich dunite. The high-Mg, low-Ni olivine of the sulfide dunite contains as high contents of olivines in other siderophile elements (Mn, Co, Cu, Zn and Pb) as other sulfide-free dunites, wehrlites and mantle harzburgites.

Localized and heterogeneous distribution of the sulfide-rich dunite suggests incorporation of sulfur into the crystal mash which possibly formed the Moho transition zone dunite and wehrlite.

Keywords: Oman Ophiolite, Sulfide-dunite, crust-mantle transition zone

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P06 Room:Convention Hall Time:May 27 14:00-16:30

Micro-inclusions in spinel in concordant and discordant chromitites from Wadi Hilti, northern Oman ophiolite.

Makoto Miura[1*], Shoji Arai[2], Masayuki Okuno[2], Tomoyuki Mizukami[2], Ahmed Hassan Ahmed[3]

[1]Dept Earth Sci.Kanazawa Univ, [2]Nat. Sci Tech.Kanazawa Univ, [3]Earth. King Abdulaziz

Podiform chromitites (PDC) occur in the Moho transition zone to the mantle section in ophiolites. There are two kinds of podiform chromitites; concordant PDC (C-PDC) is concordant to the foliation of surrounding harzburgites, discordant PDC (D-PDC) is discordant to that. We examined minute inclusions in spinel of chromitites to understand origins of the chromitites from Wadi Hilti, northern Oman ophiolite.

The Hilti C-PDC has a lensoidal shape enveloped by a dunite envelope ($<$ several meters) in thickness mantle harburgite. The boundary with dunite envelope is mostly sharp, and sometimes gradual. Chromitite is overall massive and homogeneous in C-PDC. D-PDC is dike-like in appearance with a dunite envelope (several meters), and chromitite is heterogeneous in D-PDC.

We found 2 types of inclusions in chromian spinel: (1)Needle-like inclusions ($<$1 micron, tens of microns), and (2)globular inclusions (several to tens of microns across). The needle-like inclusions were found only in C-PDC. The Cr# (Cr/(Cr+Al) atomic ratio) of host spinel is different between the two types of chromitites ; 0.62 in C-PDC and 0.70 in D-PDC (Ahmed et al., 2002). Raman spectroscopy and FE-EPMA analysis indicate that the needle-like inclusions are mainly pyroxenes and the globular inclusions are composed of clinopyroxene, pargasite and Na-phlogopite. The former inclusions suggest subsolidus exsolution of silicate components from spinel during cooling and decompression for the C-PDC.

Keywords: Podiform Chromitite, Inclusion, Chromite, Oman Ophiolite

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P07 Room:Convention Hall Time:May 27 14:00-16:30

Estimation of the thermal structure in the oceanic upper crust using variation in crystal size of the sheeted dikes

Ayumi Okugawa[1*], Susumu Umino[1]

[1]Earth Sci., Kanazawa Univ.

It is important to study pathways for hydrothermal circulation in oceanic crust in order to understand material circulation and chemical evolution between surface and interior of the earth that provide energy sources supporting subsurface biosphere. We have restored the thermal structure in the upper oceanic crust based on the variation in crystal size of the sheeted dikes from the Oman Ophiolite by means of the crystal-size thermometer which gives wall-rock temperatures at the time of dike intrusions (Spohn et al., 1988). The Oman Ophiolite provides excellent exposures of well-preserved primary structures of fast spread oceanic lithosphere, which can be regarded as an analog of fast-spreading ridge system.

There are several ways that characterize the crystal size of a volcanic rock such as the crystal size distribution (CSD: Cashman and Marsh, 1988) and characteristic crystal size by the batch method (CCS: Brugger and Hammer, 2010). In order to obtain a precise CSD, we have to trace hundreds to thousands of outlines of crystals of the mineral species in question. Batch method also requires a measurement of thousands of crystals in each sample. The average crystal size obtained by the batch method is essentially identical to the result of CSD. However, crystal shapes and textures in altered samples, which suffered from ocean-floor metamorphism such as those used in the present research, are often unidentifiable or blurred in SEM-COMPO images and chemical maps by an EPMA, but are still identifiable under an optical microscope. Alternatively, we use the average maximum crystal size (Umino, 1995). We measure the major and minor axes of the largest ten groundmass plagioclase under a microscope, which are averaged as the average maximum crystal size (major and minor axes). The average maximum crystal size thus determined gives a similar result obtained by the CSD method. This validates the utility of the average maximum crystal size as a characteristic crystal size. This method is practical because it is easy and quick to be measured than CSD or batch method and is applicable to altered volcanic rocks.

We chose 5 dikes with a thickness >1 m at Wadi ath Thuqbah which is located in the center of a second-order segment of the paleo spreading ridge. Samples were taken every 10 cm from the margin to the center of a dike. The crystal size of the groundmass plagioclase is constant in some dikes and coarsens toward the center in others. We calculated crystal growth rates, nucleation rates and wall-rock temperatures according to Spohn et al. (1988) and compared to the results for the sheeted dikes of Wadi Fizh (Umino and Miyashita, 2008). The nucleation rates of Wadi ath Thuqbah are larger than Wadi Fizh, but the growth rates and the wall-rock temperatures are similar in both locations. This might have risen from the difference in the magmatic temperature upon dike intrusions. The difference in the groundmass plagioclase crystal size inherits from the different thermal history of the dikes prior to the intrusion. If magmatic temperature is well above the liquidus, density of cluster becomes small. This lead to a small number density of crystal nuclei and a low nucleation rate upon dike intrusions, which could grow into large crystals. Furthermore, the wall-rock temperature depends on both the logarithm of crystal size and the plagioclase liquidus temperature of the dike. The lower liquidus temperatures give the lower calculated wall-rock temperatures. The nucleation rate of a dike emplaced into a cooler host becomes large because of a larger degree of undercooling.

Keywords: oceanic upper crust, thermal structure, variation in crystal size, the sheeted dikes, Oman Ophiolite

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SIT002-P08 Room:Convention Hall Time:May 27 14:00-16:30

Seismic image of incoming plate to the Japan Trench

Naoto Noguchi[1*], Shuichi Kodaira[1], Gou Fujie[1], Yuka Kaiho[1]

[1]IFREE,JAMSTEC

Recent geophysical and geochemical studies well demonstrate that the subducting oceanic lithosphere and volatile migration from it are primary factors to control active processes in subduction zones, such as seismic and volcanic activity. But, little is known about structures of oceanic lithosphere and their variation towards trenches. From 2009, IFREE, JAMSTEC has started active source seismic imaging project of the incoming plate to the Kuril, Japan and Izu-Bonin trenches. Our first seismic data, in this project, acquired along a 500-km long north-south aligned profile off the Kuril trench shows striking new views of the oceanic crust and uppermost mantle; i.e., very high velocity in the uppermost mantle immediately below Moho (Vp = 8.5 km/s), lower crustal reflectors dipping to the paleo-ridge with uniform spacing and dip angle and velocity reduction of the crust and the mantle toward the trench from the outer rise region (Fujie et al., 2010). Here, we present results of our second dip-profile perpendicular to the Japan trench in order to compare the seismic image of the off-Kuril profile. Data acquisition parameters are the same in the two profiles. We deployed 75 OBSs with 6-km interval and a 7800-cu. -inches tuned air-gun array of R/V Kairei was shot at every 200 m for acquiring refraction data. Multichannel reflection data are also obtained along the profile using a 444-channle hydrophone streamer cable (6 km long). Data qualities of the OBS-refraction data and the multichannel reflection are generally excellent along the entire profile. The seismic reflection image clearly shows continuous Moho reflection except for the region beneath the horst-graben as well as small seamounts. A notable difference of the reflection image between the off-Kuril-trench profile and the off-Japan-trench profile is reflection character in the lower crust. The lower crustal reflectors in the off-Japan-trench profile generally show lower dip angle. This may indicate the off-Kuril-trench profile is aligned more close to the maximum dip direction of the lower crustal reflectors. Another important difference between the two profiles is observed in the uppermost mantle; i.e., the uppermost mantle velocity along the Japan-trench-profile is around 8.0 km/s which is significantly lower than that along the off-Kuril-profile. This is interpreted to be caused by the seismic anisotropy due to the paleo-mantle flow which provides the fast P-wave direction along the off-Kuril trench. Although we may need further data processing, the current velocity model seems to show the velocity reduction of the uppermost mantle towards the Japan trench.

Keywords: oceanic lithosphere, seismic image, outer rise, seismic anisotropy