

SIT002-01

会場:301B

時間:5月27日 08:30-09:00

調和性および非調和性ポディフォーム・クロミタイト：その成因の再考 Concordant and discordant podiform chromitites: their origins revisited

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Podiform chromitites, commonly found in harzburgite-dominant peridotite complexes including ophiolites, and have been classified into two types, concordant and discordant chromitites in terms of attitude in the surrounding peridotites (Cassard et al., 1981). Their textural and structural differences are considered to be due to the difference in the degree of deformation: the concordant chromitites are older and more deformed than the discordant ones. As Ahmed and Arai (2002) stated the two types are sometimes different in spinel chemistry, PGE content, and presence/absence of hydrous mineral inclusions in spinel. In addition, the PGE pattern and PGM species are systematically different between the two types of chromitites: IPGE/PPGE ratio is higher in the discordant chromitite than the concordant one, and PGE sulfides are predominant in the former whereas PGE alloys are predominant in the latter. This clearly indicates the two types are completely different in origin: subsolidus deformation cannot produce such differences. There are two possible interpretations; (1) the melt composition involved in chromitite formation was different, e.g., MORB for the concordant chromitite and island-arc magmas such as boninites for the discordant one as Ahmed and Arai (2002) stated; or (2) the concordant chromitite is a deep recycled material (cf. Arai, 2010) whereas the discordant one is a shallow cumulate as Arai and Yurimoto interpreted (1994).

キーワード: ポディフォーム・クロミタイト, オフィオライト

Keywords: podiform chromitite, ophiolite

SIT002-02

会場:301B

時間:5月27日 09:00-09:15

リソスフェアにおける白金族元素の再移動とマントル存在度推定の困難さ Redistribution of platinum-group elements in the lithosphere: hindrance to the estimation of abundances in the mantle

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Platinum-group elements (PGE) in the Earth's mantle are key tracers for understanding the chemical differentiation history of the Earth's interior. In particular, PGE abundances in the primitive mantle are important indices to reveal detailed differentiation processes in the early Earth. The PGE abundances in the primitive mantle are generally estimated from PGE concentrations in natural peridotite samples, most of which derived from oceanic and continental lithosphere. However, it is difficult to estimate the PGE concentrations in a relatively undifferentiated mantle from PGE concentration data of natural peridotites, because PGE concentrations in natural peridotites are quite heterogeneous and don't seem to correlate with other chemical indices. Recent studies on PGE in natural peridotites have revealed that PGE in peridotite are mainly distributed in micrometer-scale platinum-group minerals as well as in 10- to 100-micrometer-scale base metal sulfides (e.g., Lorand et al., 2008, 2010; Kogiso et al., 2008). These studies also demonstrated that PGE in natural peridotites have been remobilized by sulfur-bearing aqueous fluid or silicate melt, although it is not clear where and when such remobilization processes occurred. In any case, it is highly probable that many of the natural peridotites that were used to determine PGE abundances in the mantle had experienced remobilization of PGE. Thus, it is not appropriate to estimate the PGE abundances in the primitive mantle using correlation of PGE with any indices that are thought to reflect "degree of melting" of peridotite. To know the original concentrations of PGE in peridotite samples, it is necessary to reveal the details of the processes that are responsible for redistribution of PGE in the lithosphere.

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キーワード: 白金族元素, マントル不均質, メタソマティズム

Keywords: platinum-group element, mantle heterogeneity, metasomatism

SIT002-03

会場:301B

時間:5月27日 09:15-09:30

Plume-ridge interaction beneath the central Gulf of Aden: Sr, Nd, Pb and Hf isotopic evidence from dredged basalts

Plume-ridge interaction beneath the central Gulf of Aden: Sr, Nd, Pb and Hf isotopic evidence from dredged basalts

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Gulf of Aden is one of the ideal places to investigate processes of continental break-up and the interaction of plume with oceanic spreading ridge system. The Afar plume has strongly been affecting the formation and evolution of the Gulf of Aden and the Red Sea. Indeed, plume material flow could have played a role in the opening of the Gulf of Aden. Therefore, to evaluate the involvement of plume material in the source of basalts we measured Sr-Nd-Pb and Hf isotopic compositions of tholeiitic basalts dredged along the central Gulf of Aden ridge (45.5E-49E). Based on their contrasting spatial geochemical signatures, two groups (Group 1 and 2) of tholeiitic basalts are identified. Group 1 basalts, dredged from east of 46.20E, have relatively wide variations of $^{87}\text{Sr}/^{86}\text{Sr}$ (0.70278-0.70304) and $^{206}\text{Pb}/^{204}\text{Pb}$ (18.21-19.03) and limited range of $^{143}\text{Nd}/^{144}\text{Nd}$ (0.51301-0.51309) and $^{176}\text{Hf}/^{177}\text{Hf}$ (0.283224-0.283276; $e\text{Hf}=15.98-17.83$); analogous to the geochemical signature of enriched (E) to depleted normal-type mid-oceanic ridge basalts (N-MORB). In contrast, Group 2 basalts, dredged between 45.6E and 46.2E, have limited ranges of $^{87}\text{Sr}/^{86}\text{Sr}$ (0.70323-0.70341), $^{206}\text{Pb}/^{204}\text{Pb}$ (19.33-19.49), and $^{143}\text{Nd}/^{144}\text{Nd}$ (0.51285-0.51292) and wide range of $^{176}\text{Hf}/^{177}\text{Hf}$ (0.283020-0.283155; $e\text{Hf}=8.77-13.54$). The geochemical variations reflect the involvement of at least three components in their mantle source; these are (1) depleted MORB-type mantle, (2) plume matrix of the Afar plume, and (3) blobs in the plume matrix. Mixing between the first and second components would have produced Group 1 basalts, while mixing between the second and third components produced Group 2 basalts. The spatial variations in isotopic composition of the basalts suggest that the Afar plume head extends upto 48E along the Aden Ridge.

キーワード: Gulf of Aden, Afar plume, ridge-plume interaction, Sr-Nd-Pb-Hf isotopes

Keywords: Gulf of Aden, Afar plume, ridge-plume interaction, Sr-Nd-Pb-Hf isotopes

SIT002-04

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大町海山蛇紋岩から推定される IBM マントルの発生と進化 Generation and evolution of lithospheric mantle beneath Izu-Bonin-Mariana: Deduced from Ohmachi Seamount serpentinites

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At the base of western slope of the southern half of the Ohmachi Seamount, Izu-Bonin frontal arc, a large exposure of highly metamorphosed serpentinites has been well known (Yuasa et al., 1998; Niida et al., 2001, 2003; Ueda et al., 2004; Hirauchi et al., 2010). The serpentinite basement is divided into massive serpentinites and schistose serpentinites (antigorite schists) in association with a rare occurrence of eclogite (Ueda et al., 2004).

The massive serpentinites, carrying small amounts of primary mantle minerals, can be identified into three different peridotite types as their original lithologies. One is lherzolite, which represents a fertile, residual mantle peridotite (UMP) with primary olivine (Mg#=89~91) and spinel (Cr#=13~18). The second is dunite-chromitite, which represents an island-arc type magma channel sample (MCP), having a distinct mineralogy of olivine (Mg#=91.5~92.5) and spinel (Cr#=65~80) from the residual mantle lherzolite. The third type is cumulates (CUM: wehrlite ~ olivine clinopyroxenite ~ clinopyroxenite) composed of cumulus olivines and clinopyroxenes crystallized within a deep-seated magma chamber and/or magma conduit.

It is deduced from the above lithology and primary mineralogy that the Ohmachi Seamount serpentinite was originated as fertile mantle lherzolite, probably from the upper mantle beneath continental margin (Niida et al., 2001, 2003), before the opening of the West Philippine basin. Prior to the settlement into the active Izu-Bonin arc system, the lithospheric mantle was modified by channeling of island-arc type magmas generated in Paleogene along old island-arc systems of the Ogasawara Ridge and the Kyushu-Palau Ridge. Then, the mantle peridotites were experienced in antigorite metamorphism of serpentine schist (Hirauchi et al., 2010) and in coupling with eclogite and amphibolite (Ueda et al., 2004) generated within a subduction channel.

References:

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Yuasa, M., Nishimura, A., Niida, K. and Ishizuka, O., 1998, *JAMSTEC Deep Sea Res.*, 14, 269-277.

キーワード: 大町海山, 蛇紋岩, レルゾライト, ダナイト, 残存マントルかんらん岩, マグマチャネル
Keywords: Ohmachi Seamount, serpentinite, lherzolite, dunite, residual mantle peridotite, magma channel

SIT002-05

会場:301B

時間:5月27日 09:45-10:00

マリアナトラフの斜長石ハルツバーグサイトに見られる melt impregnation の痕跡 Plagioclase-bearing harzburgite from the Mariana Trough: Evidence for melt impregnation in shallow mantle

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Upper mantle-derived plagioclase peridotite has been explained as a re-equilibrated mineral assemblage at the plagioclase stable P-T condition (Green and Ringwood 1967) and modified mantle peridotite by melt impregnation or melt-rock reaction (e.g. Dick et al., 2010). Here, we examine plagioclase-bearing samples from the Mariana Trough (JAMSTEC KR02-01: Arima et al., 2002) to understand modification through melt impregnation into the residual peridotites.

Chiba et al. (2008) reported that the residual mantle peridotites beneath the Mariana Trough are lherzolite to lherzolititic harzburgite. These rocks attain 71% of 129 samples examined. The major element chemistry of the primary cores of olivine (Mg#=90.0-91.7, NiO=0.31-0.48 wt%), orthopyroxene (Mg#=90.2-91.5, Al₂O₃=2.76-4.58 wt%), clinopyroxene (Mg#=91.0-93.9, Al₂O₃=3.69-5.57 wt%), and spinel (Mg#=67.0-74.6, Cr#=24.0-42.5, TiO₂=0.06-0.22 wt%) indicates a residual mantle peridotite with a small to moderate degree of partial melting.

Interstitial plagioclase, 0.1-0.7 mm in size, have been found in 4 samples of the residual harzburgite, showing trails with small grains of secondary olivine, orthopyroxene, clinopyroxene and spinel among coarse protogranular grains of primary harzburgite minerals. The modal% of plagioclase is 0.3-0.7.

The coarse protogranular grains of primary olivine cores (Mg#=89.5-91.6, NiO=0.31-0.45 wt%), orthopyroxene cores (Mg#=89.2-91.7, Al₂O₃=1.94-5.73 wt%) and clinopyroxene cores (Mg#=90.1-93.8, Al₂O₃=2.27-6.30 wt%) have similar chemical compositions to those of the residual peridotite, whereas the small grains of secondary orthopyroxene (Mg#=90.3-91.6, Al₂O₃=1.30-2.56 wt%) and clinopyroxene (Mg#=91.8-94.0, Al₂O₃=1.79-4.43 wt%) have lower content in Al₂O₃. Characteristically, small grain of spinels have lower Mg# (43.8-64.5), higher Cr# (37.2-54.3), and higher content in TiO₂ (0.07-0.33 wt%).

Concludingly, the plagioclase harzburgite from the Mariana Trough can be explained as a modified residual peridotite by primary melt impregnation, generated in a shallow mantle. These harzburgite resembles 'P-type peridotite' of the Parece Vela (Ohara et al., 2003), 'plagioclase-bearing peridotite' of the southern Mariana Trench (Michibayashi et al., 2009), 'impregnated peridotite' of the Romanche Fracture Zone (Tartarotti et al., 2002) and 'plagioclase peridotite' of the Paleo-MAR (Dick et al., 2010). Such a modification by melt impregnation seems to be frequent in the back-arc lifting and the mid-ocean ridge systems.

References

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キーワード: マリアナトラフ, 斜長石ハルツバーグサイト, 融け残りかんらん岩, 背弧海盆, メルトインプレグネーション
Keywords: Mariana Trough, plagioclase-bearing harzburgite, residual peridotite, back-arc basin, melt impregnation

SIT002-06

会場:301B

時間:5月27日 10:00-10:15

AUV 高精度音響調査が捉えた海底面近傍の活動の様子 = 南部マリアナトラフ熱水噴出孔周辺の調査を一例にして = Volcanic and tectonic activities shown by a high-resolution acoustic survey, the case of the Southern Mariana Trough

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マリアナトラフは太平洋プレートに東側から沈み込まれるフィリピン海プレートの南西縁で現在中速程度の海洋底拡大がある背弧拡大系である。南部マリアナトラフには活発な熱水噴出孔の存在が、拡大軸から火山弧へ至る直線 5 km 程度の間になくとも 3 つ知られている。3 つの熱水噴出孔はそれぞれ、蒲鉾形に盛り上がった拡大軸上の「スネイルサイト」、拡大軸東側麓部「アーキアンサイト」、拡大軸からおよそ 5 km 南西へ離れた位置の火山体頂部「ピカサイト」と呼ばれている。三点は直線上に並んで配置しているように見えて、かつそれぞれの熱水から吹き出す成分は、ピカサイトで拡大軸の特徴が、スネイルサイトで火山弧の特徴が報告されている。これら三点の熱水活動を支配する地質学的背景を探して、AUV うらしまを用いて音響による地形・地質探査、地磁気による地下構造探査、採水や現場水質観測など、多分野にわたる熱水噴出孔周辺の精査が 2009 年夏に行われた。同じ海域内で引き続き 2010 年にしんかい 6500 による潜航調査が持たれ、二年間の調査結果を合わせて以下の結果が得られた。

1. AUV うらしまにより、スネイルサイト・アーキアンサイト・ピカサイト直上および熱水噴出孔は知られていない海域の水中に、音波が異常散乱する様子を捉えた。有人潜水船しんかい 6500 で当該箇所を再訪したところ、AUV の音響観測機器が水中に異常散乱を捉えた一カ所でこれまで知られていなかった熱水噴出孔を発見し、「うらしまサイト」と名付けた。うらしまサイトは熱水性生物の伝播の可能性を考える上で重要な位置を占めるかも知れない。うらしまサイト以外の水中異常散乱箇所には活動的熱水噴出孔を発見できなかったものの、高さ 10 m 程度のデッドチムニーや、水中の濁りがある場所を新たに発見した。これにより高精度の音響探査は活発な熱水そのものを水中に検知できることが分かった。

2. 活動的熱水噴出孔のうち地形的特徴を伴う、アーキアン・ピカ・うらしま各サイトでは、AUV 音響探査による微地形および音圧分布図に基づいて、しんかい 6500 を用いる海底の視認観察を行ったことで、各熱水噴出孔の空間的広がりを議論することが可能になった。アーキアンサイトは拡大軸麓部のマウンド稜線に集中して存在する。ピカサイトはブラックスモーカー活動箇所として知られていた山体頂部中央付近のみならず、山体頂部から西方に延びる尾根線の上全体にデッドチムニーが林立している可能性が高い。うらしまサイトはピカサイトが乗る山体の北側裾野から北方の比較的平らな場所にかけて、150m × 180m の範囲に広がっていると考えられる。

3. スネイルサイトで活動的な熱水噴出孔はアーキアンサイトやピカサイトと異なり地形的特徴に乏しいので、音響画像を緯度経度上に落とした二次元画像から場所を決めることが難しいが、上述水中の音波異常散乱箇所から特定できる。スネイルサイトの周辺には断層や開口割れ目の密度が小さい。一方で衰退した熱水活動があると考えられている同じ拡大軸上の「ヤマナカサイト」は近傍に明らかな亀裂が発達している。スネイルサイトとヤマナカサイトを繋ぐ地質構造は、少なくとも海底面には露出していない。

4. スネイルサイトとヤマナカサイトの間海底面には音波の後方散乱強度が低い場所が複数箇所に現れる。しんかい 6500 で視認したところ、当該箇所には瓦礫様の溶岩が分布していた。海底面における後方散乱強度が低い場所は堆積物など音波を吸収する性質をもつものに覆われているとする解釈が一般的であるところ、今回の海底視認は、新鮮な溶岩でも表面形態によっては後方散乱強度が低い可能性を示した。このことは広域かつ高精度の海底音響探査を行った場合に得る音響画像解釈において、年代が若い溶岩流の分布等を考察し直す必要を迫る。

5. 活動的熱水噴出孔の場所と分布、断層・開口割れ目の大きさと分布、かつ比較的新しい溶岩の流域と分布を検討した結果、拡大軸上およびピカサイトがある火山帯で活動的な場所の絞り込みが可能になった。

キーワード: 高精度音響調査, AUV, 水中の音波異常散乱, 後方散乱強度, 溶岩

Keywords: High-resolution acoustic survey, AUV, water column, ultra-low backscattering intensity, lava flow

SIT002-07

会場:301B

時間:5月27日 10:15-10:30

オマーンオフィオライト海洋地殻の熱水変質に伴う微量元素組成の変化 Trace element distributions of the hydrothermal altered oceanic crust in the Oman ophiolite

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Hydrothermal alteration processes of oceanic crust at mid-ocean ridges cause significant changes in elemental budget and vertical distribution. Although previous studies have been reported chemical compositions of oceanic crustal rocks from dredged and/or drilled modern seafloor and ophiolite, available depth-successive data is still limited. In this study, concentrations of trace elements were determined for a complete section of oceanic crust in the Oman ophiolite in order to investigate elemental mobilization during hydrothermal alteration. Pillow basalts altered at low temperature (<100°C) were highly enriched in B, As, Rb, Cs, Ba, U, and moderately enriched in Pb, suggesting that these elements were adsorbed onto and/or incorporated into secondary minerals, such as smectite and calcite. Mn and Zn were enriched in the transition zone between pillow lava and sheeted dike complex, and depleted in base of sheeted dike complex. On the other hand, Cu and Pb of the sheeted dikes were generally depleted. Dolerite dikes in gabbro altered at high temperature (>300°C) showed enrichment of U, indicating addition of U to rock during high temperature alteration. In contrast to the previous views that both Li and B are leached from rocks during hydrothermal alteration at high temperatures, the lower oceanic crust altered >300°C (even at >450°C) showed B-enrichment relative to fresh rocks. This suggests that the altered oceanic crust is a large sink of B and source of Li.

キーワード: 海洋地殻, 熱水変質, 微量元素

Keywords: oceanic crust, hydrothermal alteration, trace element

SIT002-08

会場:301B

時間:5月27日 10:45-11:00

アウターライズにおける沈み込む海洋プレートの構造変化 Structural changes within the subducting oceanic plate around the outer rise region

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The subducting oceanic plate and the water within it play important roles in seismic and volcanic activities in the island arc. Bending related faulting in the outer rise region is considered to be one of the major mechanisms of the water penetration and hydration of the incoming plate. However, detailed structural changes in the outer rise region have been not well resolved.

In 2009, for revealing seismic structure and its variation around the outer rise, we conducted a reflection and refraction seismic survey along a 500-km long survey line (A2) in the northwestern Pacific region, which is perpendicular to the Kuril trench. The V_p (P-wave velocity) and V_s (S-wave velocity) structure models along line A2 clearly show that the seismic velocities within the oceanic crust gradually decrease toward the trench axis beneath the outer rise and V_p/V_s within the upper crust becomes higher near the trench axis, suggesting high water content within the upper part of oceanic crust. These structural changes begins just at the south end of the outer rise, implying that the bending related faulting at the outer rise is responsible for the variation in the seismic velocity and water content within the incoming plate.

In 2010, for confirming these structural features and revealing the seismic anisotropy, we conducted another reflection and refraction seismic survey along two trench parallel survey lines, R1 and P1. R1 is located at the outer slope of the Kuril trench and P1 is located at the south of the outer rise. Both lines perpendicularly cross the line A2. We deployed 45 OBSs along R1 and P1 at a spacing of 6km, and fired a 7800 cu. in. tuned airgun array of R/V Kairei at a regular spacing of 0.2km. During the airgun shots, we towed a 444-channel, 6km long, hydrophone streamer cable and obtained multi-channel seismic (MCS) reflection data. The quality of the OBS and MCS seismic record section is good. We can observe clear refractions from the oceanic mantle (P_n) with apparent velocity of about 8.0km/sec, which is significantly lower than that of line A2.

We modelled V_p and V_s structure models by using both OBS and MCS traveltimes. Above the oceanic Moho, seismic velocity models of the trench parallel lines R1 and P1 are well consistent with that of A2, supporting the structural features observed along line A2. On the other hand, just below the oceanic Moho, we observed remarkable seismic velocity difference between the trench parallel direction and perpendicular direction, indicating that the significant anisotropy within the oceanic mantle.

キーワード: 海洋地殻, アウターライズ, 異方性, 地震波速度構造, 海底地震計, 構造探査

Keywords: oceanic plate, outer rise, anisotropy, seismic velocity structure, Ocean Bottom Seismometer, wide-angle seismic survey

SIT002-09

会場:301B

時間:5月27日11:00-11:15

北西太平洋海洋リソスフェア構造から推定された高速拡大軸における能動的マントル上昇

Active mantle upwelling at fast-spreading ridge deduced from seismic images of old oceanic lithosphere in the NW Pacific

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One of long-standing questions about the mantle flow, which governs an accretion process of oceanic lithosphere, at the mid-oceanic ridges has been whether the mantle upwelling is active or passive. Although there are lines of geological and geophysical evidences which support dominantly passive upwelling at the mid-oceanic ridges in a sense of the global plate tectonics, it is also possible that, when decompression melting occurs, low density melt is preserved in the mantle to create local buoyancy which forms mantle convection near the spreading axis. A few study about ophiolite and gravity anomalies in the East Pacific Rise demonstrated a possible active upwelling diapirs at the ridges, but yet no seismological evidence which directly indicates the active upwelling has been observed. Here, from seismic data acquired at the old Pacific plate (120 ? 130 Ma) off the Kuril trench, we show very high P-wave velocity ($V_p = 8.6$ km/s) and strong anisotropy (7 %) in the uppermost mantle immediately below the oceanic crust having lower crustal reflectors (LCRs) dipping toward the paleo-ridge with dominantly uniform spacing and dipping. Similar LCRs have been reported by previous seismic studies in the northwestern and eastern Pacific. Based on geometry and distribution of the LCRs, there has been much debate about an origin of the LCR. For example, thermal and chemical modeling predicted that the LCRs were lithological layering formed by downward and outward flow from an axial magma chamber due to passive upwelling of mantle. On the other hand, based on ophiolite studies, it is proposed that ridge-ward lower crustal fabrics may be formed by a basal shear at the crust due to the active mantle upwelling. Our new observations present the first direct seismological evidence indicating strong basal shear of the oceanic crust due to the active upwelling of mantle at the mid-oceanic ridge.

キーワード: 海洋リソスフェア, 地震探査, 地殻, マントル, 異方向性

Keywords: Oceanic lithosphere, Seismic imaging, Crust, Mantle, Anisotropy

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SIT002-10

会場:301B

時間:5月27日 11:15-11:30

Attenuation and anisotropy structure at the lateral edge of the Okinawa trough Attenuation and anisotropy structure at the lateral edge of the Okinawa trough

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The Ryukyu subduction zone and its associated back-arc basin, the Okinawa trough, terminate laterally against the Eurasian lithosphere at northeast Taiwan. The mantle wedge shows a factor of 10 increase in Q values from the segment with significant rifting to NE Taiwan where rifting has just begun. The high Q values beneath central northern Taiwan are probably affiliated to the colder Eurasian lithosphere, but the lithosphere's eastern boundary is unknown. Shear-wave splitting pattern helps to resolve this issue. We found a rotation of the polarization direction of the fast split wave from nearly NS (trench normal) at the southwest OT to roughly EW beneath northern Taiwan in alignment with the orogenic structure. Because the lateral edge of the mantle wedge is blocked by the thick Eurasian lithosphere, trench-parallel flow is suppressed and the trench-normal flow dominates. The western boundary of the trench-normal fast direction is used to mark the western boundary of the mantle wedge, which can be drawn roughly at 121.8E. If this is the boundary, the attenuation pattern suggests that the mantle wedge against the Eurasian lithosphere is cooled by 100-200 degrees.

キーワード: mantle wedge, attenuation, anisotropy, mantle flow

Keywords: mantle wedge, attenuation, anisotropy, mantle flow

SIT002-11

会場:301B

時間:5月27日 11:30-11:45

Anisotropic Mantle Lid in Young Subducted Slab underplating Central Mexico Anisotropic Mantle Lid in Young Subducted Slab underplating Central Mexico

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Modern plate tectonics involves several important ingredients such as seafloor spreading at mid-ocean ridges, generations of island arcs and subductions of plates. Although it is not clear exactly when plate tectonics started, seismic investigations of some of the oldest stable continental crust, the Slave craton and the Superior craton in North America, revealed multiple localized dipping anisotropic layers in the sub-cratonic lithospheric mantle that point towards the possibility of several shallow subduction episodes from late Archean (~2.6 Ga) to early Proterozoic (~1.8 Ga), which may form sub-cratonic lithospheric mantle by successive accretions and stacking. However, such seismic features have never been observed in modern subduction setting and it is extremely difficult to infer the state of plate tectonics such as plate velocities and spreading rates in early Earth. Here we model local converted S-to-P waves and teleseismic P-to-S converted waves to interrogate the interior of the young subducted Cocos plate beneath Central Mexico. We find a strong peak-to-peak P-wave (10 percent) and S-wave anisotropy (10 percent) localized within the topmost 2-6 km of the subducting oceanic mantle, with a fast symmetric axis dipping at about 40 degrees away from the East-Pacific Rise and orienting at about 30 degrees clockwise from the north, which is consistent with local plate motion direction. Such an anisotropic mantle lid is probably composed of dunites and depleted harzburgites assemblages that were originally synthesized and strained at the East Pacific Rise and later subducted. This provides a strong case that processes generating dipping anisotropic layers beneath the Slave craton and other ancient continents can be analogous to modern seafloor spreading at mid-ocean ridges, except they operate under a different thermal state of the mantle in the Earth's history. The analogy established here allows direct inferences of seafloor spreading rates back to the Archean, which has profound implications on the evolution of global heat flux and carbon cycle.

キーワード: Anisotropy, Converted wave, subduction, spreading rate, Craton, Archean

Keywords: Anisotropy, Converted wave, subduction, spreading rate, Craton, Archean

SIT002-12

会場:301B

時間:5月27日 11:45-12:00

Direct evidence for upper mantle structure in the NW Pacific Plate: microstructural analysis of a petit-spot peridotite

Direct evidence for upper mantle structure in the NW Pacific Plate: microstructural analysis of a petit-spot peridotite

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Petit-spots are the late Miocene alkali basaltic volcanoes on the Early Cretaceous NW Pacific Plate, originate at the base of the lithosphere. Petrological studies reveal that the alkali basaltic volcanoes have their roots at the base of the NW Pacific lithosphere (Hirano et al., 2006, 2008), and that essentially unaltered pieces of oceanic lithosphere (tholeiitic basalt, dolerite, gabbro, and mantle peridotite) were caught up in the ascending magma as mafic and ultramafic xenoliths (Abe et al., 2006; Hirano et al., 2004; Yamamoto et al., 2009). Therefore, the petit-spots provide a unique window into the entire section of subducting oceanic lithosphere. We present here the first direct observations on the deep structure of the Pacific lithosphere using microstructural analyses of a petit-spot peridotite xenolith. The petit-spot peridotite xenolith (6K880R2O) which was obtained during the cruise YK05-06, R/V Yokosuka and the submersible Shinkai 6500 from a dive site 6K#880 at the eastern fault escarpment of a petit-spot volcano in the Japan Trench is a lherzolite that consists mainly of coarse- and medium-grained olivine, orthopyroxene, and clinopyroxene, as well as fine-grained aggregates of spinel and orthopyroxene. The bulk trace-element patterns of the aggregates are similar to those of pyrope-rich garnet and the associated clinopyroxene shows a signature typically seen in those equilibrated under conditions of the garnet-lherzolite stability field (Abe et al., 2006). The equilibrium conditions of this sample applied to a two-pyroxene geothermometer (Wells, 1977) and a univariant curve for the garnet-spinel facies transition (O'Neill, 1981; Klemme and O'Neill, 2000), indicating that was determined to be 1100±50 °C at a pressure of 16-20 kbar as reported by Abe et al. (2006) and Yamamoto et al. (2009). This conditions correspond to a depth of ~60 km below the seafloor (Abe et al., 2006; Yamamoto et al., 2009). A strong deformational fabric is marked by a parallel alignment of millimeter-sized elongate minerals and their crystallographic preferred orientation. The olivine displays a [010] fiber pattern with a girdle of [100] axes and a maximum of [010] perpendicular to the foliation, a pattern which is consistent with a transpressional deformation in high temperature conditions at the base of oceanic lithosphere. Our microstructural observations and seismic data indicate that the lower part of the NW Pacific lithosphere possess an early stage structure of mantle flow at the asthenosphere. A discrepancy between the weak anisotropy in the petit-spot peridotite and the strong azimuthal anisotropy from the seismic data in the NW Pacific plate implies the existence of a highly anisotropic component in the deep oceanic lithosphere.

SIT002-13

会場:301B

時間:5月27日 12:00-12:30

アセノスフェアの新しいモデル A new model of the asthenosphere

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アセノスフェアの特徴は、(1)地球化学的に「枯渇」していて、その組成がほぼ均質であること、(2)地球物理学的には地震波の速度が遅く、減衰が大きく、電気伝導度が高いことがあげられる。この古くから知られている観測の他に、最近(1)リソスフェア-アセノスフェア境界での速度変化が大きくかつシャープであること、(2)上部マントル深部にも比較的シャープで速度変化の大きな低速度層がほぼグローバルに存在することが分かって来た。今回は、これらの観察事実を統一的に説明するモデルを提出する。このモデルでは、上部マントルは遷移層直上での部分溶融の溶け残りとして出来たと考える。もし、遷移層直上で部分溶融が起これば、その上の上部マントルの全て(リソスフェアを除き)でも部分溶融が起こればならない。このモデルで上部マントルの水素などの非適合元素の分布やその量(その均一性も含め)が説明できる。ただし、部分溶融の地球物理的観測への効果は上部マントル浅部ではそれほど大きくない。液は少量しかなく、完全には粒界を濡らさないからである。ところが、上部マントル深部では液が完全に粒界を濡らす可能性が高い。上部マントル深部の低速度層は液が完全に粒界を濡らした結果として説明できる。

キーワード: アセノスフェア, 水, 部分融解, 地震波速度, 電気伝導度

Keywords: asthenosphere, water, partial melting, seismic wave velocities, electrical conductivity

SIT002-P01

会場:コンベンションホール

時間:5月27日 14:00-16:30

四国海盆下 10-100km 深における地震波速度の鉛直異方性構造 Seismic radial anisotropy of the lithosphere and asthenosphere beneath the Shikoku Basin from records by OBSs

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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 ($V_{SH} > V_{SV}$), the intensity of radial anisotropy ($(V_{SH} - V_{SV})/V_{mean}$) 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 $V_{SV} > V_{SH}$ 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.

SIT002-P02

会場:コンベンションホール

時間:5月27日 14:00-16:30

アルバニア, ミルディータ・オフィオライト東帯かんらん岩から推測する沈み込み帯初期マグマプロセス

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

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アルバニア, ミルディータ・オフィオライト東帯に分布するかんらん岩について検討した。本オフィオライトの火山岩類は, 島弧的的化学的特徴を示す (Dilek et al., 2008 Lithos)。その結果, 中央海嶺的な単純融解によるメルトの形成と抽出を経たかんらん岩類, インコンパティブル元素に富んだ流体フラックスを伴う開放溶融に形成された高枯渇度かんらん岩と, スピネルのCr#の異なる2種類のダナイトで, 主に構成されていることがわかった。これらの観察事実から, 初期島弧のマグマプロセスについて議論する。

キーワード: オフィオライト, かんらん岩, モホ, 島弧

Keywords: ophiolite, peridotite, MOHO, Island Arc

SIT002-P03

会場:コンベンションホール

時間:5月27日 14:00-16:30

海洋リソスフェアの構造と役割の理解に向けた超深度掘削：モホール計画への取り組み

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

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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).

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キーワード: モホール, 海洋プレート, 超深度掘削

Keywords: MoHole, Oceanic Plate, ultra-deep drilling

SIT002-P04

会場:コンベンションホール

時間:5月27日 14:00-16:30

リザード・オフィオライト (コーンウォール) における 2 種類のダナイト Two types of dunite in the mantle section of the Lizard ophiolite, Cornwall

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リザード・オフィオライトは低速拡大海嶺起源であり (Roberts et al., 1993), その岩石学的特徴は MORB を起源とするマントルに関するマグマプロセスを理解するのに適している。我々は本調査地域にて 2 種類のダナイト (調和性ダナイトと非調和性ダナイト) を発見した。ダナイトは強く蛇紋岩化しているが、非調和性ダナイトには稀にかんらん石が残存する。

レールゾライトとハルツバージャイト中のかんらん石は Fo 値 (Fo_{89-92}), NiO 含有量 (0.35-0.40 wt%) と、一般的な海洋底かんらん岩と類似した組成を示す。しかし、非調和性ダナイト中のかんらん石は Fo 値 (Fo_{83-85}), NiO 含有量 (0.20-0.30 wt%) という低い値を示す。非調和性ダナイト近傍のレールゾライト中のかんらん石も非調和性ダナイトに近い Fo 値 (Fo_{84-87}) と NiO 含有量 (0.20-0.35 wt%) を示す。単斜輝石の TiO_2 含有量 (0.50-1.00 wt%) はマッシュピなレールゾライトの TiO_2 含有量 (<0.25 wt%) よりも高い値を示す。調和性ダナイトは N-MORB 的なメルトとレールゾライトの間で反応することで形成されたと考えられる。これはスピネルの濃集を示すことと整合的である (Arai and Yurimoto, 1994)。一方、非調和性ダナイトは、かんらん岩体の変形後に貫入した Ti と Fe^{3+} に富むメルトとレールゾライトとの間で反応することで形成されたと考えられる。分化によってメルト中の Ti と Fe^{3+} 量が上昇したことで、スピネルは二相に分離したと考えられる。

キーワード: ダナイト, レールゾライト, ハルツバージャイト, リザード・オフィオライト, メルト/壁岩相互反応

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

SIT002-P05

会場:コンベンションホール

時間:5月27日 14:00-16:30

北部オマーンオフィオライト, ワジスクバにおけるサルファイドに富むダナイト Sulfide-rich dunite from Wadi Thuqbah, the northern Oman Ophiolite

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北部オマーンオフィオライト, ワジスクバにおいてサルファイドに富む(2 mode%程度)サルファイドダナイトを見出した。このようなダナイトはオマーンオフィオライトにおいてこれまで報告されていない。サルファイドダナイトはモホ遷移帯のウェールライトとダナイトの境界付近に産している。通常のダナイト中に局所的に不均質な形状で存在すると思われる。ペントランダイト、ピロータイトがマグネタイトと複合粒子を形成している。ペントランダイトとピロータイトは互いに入り組んでおり、マグネタイトはそれらを切る様な組織を示す。

サルファイドダナイト中のかんらん石はその高いFo値(=90.7~91.0)に対しNiO含有量が低い(0.081~0.121 wt%)。このダナイトのかんらん石を周囲に産するウェールライトやサルファイドを含まないダナイト、マントルセクション中のハルツバーバイトのかんらん石と比較すると、かんらん石のNiの含有量は低い。他の親鉄元素や親銅元素(Mn, Co, Cu, Zn, Pb)に大きな違いは見られない。

かんらん石とサルファイド間におけるNiなどの親鉄元素の分配についてはこれまで多くの研究がなされており(Fleet and MacRea, 1988; Naldrett, 1989; Brenan and Caciagli, 2000など)、親鉄元素はサルファイドメルトへより多く分配されることが知られている。サルファイドダナイト中のかんらん石がNiに乏しいことは、Niがかんらん石よりもサルファイドメルトへより多く分配されたためと考えられる。ペントランダイトとピロータイトの複雑な組織は、初生的なサルファイド粒子が温度低下中に2相に分離したものであろう。硫黄の起源については不明であるが、サルファイドの不均質で局所的な分布から、クリスタルマッシュに何らかの形で取り込まれたものと思われる。

キーワード: オマーン・オフィオライト, サルファイドダナイト, 地殻-マントル遷移帯

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

SIT002-P06

会場:コンベンションホール

時間:5月27日 14:00-16:30

北部オマーンオフィオライト、Wadi Hilti における調和性・非調和性クロミタイトのスピネル中の包有物

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

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ポディフォーム・クロミタイト (PCD) はオフィオライトのマントル部～モホ遷移帯にかけて、しばしばダナイトに包まれる様に産する。PCD は、周囲のハルツパーガイトの葉理構造の関係から調和性/非調和性ポディフォーム・クロミタイトの2種類に分類される。調和性/非調和性 PCD の形成場について理解を得るために、クロミタイトのスピネル中の包有物の解析を始めた。オマーンオフィオライト Wadi Hilti の調和性/非調和性 PCD を対象とした。

調和性 PDC (C-PDC) はややレンズ状であり、マントルハルツパーガイト中に厚さ数十 cm～数 m の薄いダナイト層に包まれている。ダナイトとの境界は大部分がシャープであるが、時折ダナイトに漸移する様な構造、ノジュラー組織・アンチノジュラー組織等多様な組織を示す。C-PDC は大部分が massive な構造を示す。一方、非調和性 PDC (D-PDC) は複雑な岩脈状に産し、数 m のダナイト層に包まれて産する。全体的に境界部から中央部にかけて不均質な構造を示す。

薄片観察により両クロミタイトのクロムスピネル中の包有物には2種類があることが判明した。

- (1) スピネルの結晶構造に支配された針状の離溶ラメラ包有物 (径 1 ミクロン未満、長さ数十ミクロン程)
- (2) 不規則に分布する円形～不規則形包有物 (数ミクロン)

これらの包有物について、ラマン分光機 (HORIBA LabRAM HR-800)、及び JEOL の FE-EPMA を用いて分析した。ホスト・クロムスピネルの Cr# は、C-PDC では 0.62 程、D-PDC では 0.72 程である (Ahmed et al., 2002)。分析の結果、C-PDC だけに含まれる (1) 針状包有物は Opx, Cpx, Amphibole、(2) は Cpx, Amphibole, Na-Phlogopite で構成されることが判明した。

両 PDC のインコンパティブル成分に富む包有物の起源は、メルトがマントル中を移動する際に周囲からゾーン・リファイニング的に集めたものであると思われる。また C-PDC の結晶構造に支配された離溶ラメラ包有物は、何らかの冷却・減圧プロセスを示唆している。

キーワード: ポディフォーム・クロミタイト, 包有物, クロムスピネル, オマーン・オフィオライト

Keywords: Podiform Chromitite, Inclusion, Chromite, Oman Ophiolite

SIT002-P07

会場:コンベンションホール

時間:5月27日 14:00-16:30

シート状岩脈群の結晶粒径変化による上部海洋地殻の温度構造の解明 Estimation of the thermal structure in the oceanic upper crust using variation in crystal size of the sheeted dikes

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海洋地殻における熱水循環経路の解明は、地球表層と内部の物質循環や化学的進化、地下生物圏を支えるエネルギー源を理解する上で極めて重要である。そこで、本研究では岩脈貫入時の母岩の温度を与える結晶粒径温度計 (Spohn et al., 1988) を応用して、オマーンオフィオライトのシート状岩脈群の結晶粒径変化から上部海洋地殻中の温度構造の解明を試みた。オマーンオフィオライトでは高速拡大系で生じた海洋リソスフェアの初生的な構造がよく保存されており、高速拡大海嶺系のアナログと考えることができる。

火山岩の結晶粒径を代表する指標に結晶粒径分布図 (Cashman and Marsh, 1988) やバッチメソッド Batch method (Brugger and Hammer, 2010) による特徴的な結晶粒径がある。しかし、精確な結晶粒径分布図を作成するためには、試料中の着目する鉱物種の全ての結晶をトレースし、数 100 ~ 数千の計測が必要となる。また、バッチメソッドでも試料毎に ~ 数千の結晶を数える必要があるが、得られる平均結晶粒径は結晶粒径分布図の結果と本質的に同じである。ところが、特に本研究対象のような海洋底変成作用を被った変質試料では、特に細粒の石基結晶が変質生成物で置換され、SEM・COMPO 像や EPMA の組成マップでは結晶の形状が同定できないことが多い。しかし、そのような試料であっても光学顕微鏡鏡下では形状の輪郭が識別可能なことが多い。そこで本研究では結晶粒径分布図に代えて測定しやすい平均最大粒径を用いる。鏡下で最も大きな石基斜長石の長径・短径を 10 個測定し、その平均を平均最大粒径 (長径及び短径) とする。これを石基斜長石の結晶粒径分布図 (Cashman and Marsh, 1988) の最大粒径と比較したところ、よく一致することを確認した。従って、特徴的な斜長石粒径として平均最大粒径で代表させることが可能である。平均最大粒径は結晶粒径分布図やバッチメソッドに比べ、測定が簡便であり、変質した火成岩にも適用できる点で、実用的な手段と言える。

二次の古拡大軸セグメント中心に位置する Wadi ath Thuqbah のシート状岩脈群から厚さ 1 m 以上の岩脈を 5 枚選び、急冷縁付近から中心までの数カ所から試料を採取した。急冷縁から 20cm より内側では斜長石粒径がほぼ一定である岩脈と、中心に向けて粗粒化する岩脈があった。また、Spohn et al. (1988) の方法で推定した結晶成長速度と核形成率及び母岩温度を Wadi Fizh 沿いのシート状岩脈群の試料と比較した。核形成率は Wadi Fizh 沿いの方が大きい。結晶成長速度、母岩温度は変わらない。この差異を生じた理由として、貫入時のマグマの温度の違いが考えられる。石基斜長石の粒径の違いはマグマが貫入する前に経験した温度履歴の違いを反映している。マグマが高温であるほど、クラスター密度が低くなり、岩脈が貫入した後に発生する結晶核が少なくなるため核形成率が低くなり、より粗粒になる。また、母岩温度は結晶粒径の対数と岩脈のリキダス温度に依存し、リキダス温度が低ければ、算出される母岩温度も低くなる。より低温の母岩中に貫入した岩脈は過冷却度の大きな状態に置かれるため、核形成率が高くなると考えられる。

キーワード: 上部海洋地殻, 温度構造, 結晶粒径変化, シート状岩脈群, オマーンオフィオライト

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

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SIT002-P08

会場:コンベンションホール

時間:5月27日 14:00-16:30

日本海溝に沈み込む海洋プレートの地震学的構造 Seismic image of incoming plate to the Japan Trench

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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 ($V_p = 8.5$ 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-channel 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.

キーワード: 海洋リソスフェア, 地震探査, アウターライズ, 地震波異方性
Keywords: oceanic lithosphere, seismic image, outer rise, seismic anisotropy