Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SIT05-01 会場:303 時間:5 月 26 日 16:15-16:30

ハードロックを対象とした最新ロギング技術の活用
Applications of state of the art downhole logging for hard-rock

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Downhole logging has been one of standard measurements in scientific drilling. Its basic data are gamma-ray, spectral gamma-ray, electrical resistivity, density, porosity, sonic velocity, seismic velocity, and borehole image. These data has being applied to physical properties, lithology, sedimentology, structural geology, rock mechanics, hydrogeology, mineralogy, geochemistry etc. State of the art downhole logging leads us higher resolution, more data variation and volume, and then to new scientific results. We here discuss basics of wireline logging and LWD (Logging Whole Drilling), their standard/extensive applications, drilling strategy, potential applications for hard rocks with new technology with some case studies.

One of the advantages of downhole logging over coring is continuous data. Poor core recovery is one of the major issues in hard rock drilling. Continuous logging data covers the missing core intervals. Another advantage is in-situ measurement in downhole. It is important to measurements physical properties like electrical resistivity, sonic velocity, density, porosity, before physical changing and developing contamination of cores with drilling fluid. New geochemical fluid analyzer allows us to measure fluid compositions, for example optical spectrometer (20ch), C1, C2-C5, C6+, CO2, pH, fluorescence, density, viscosity, flowline pressure, temperature, electrical resistivity, gas-oil ratio. Downhole fluid sampler allows us to sample formation fluid with less contamination. In addition, large diameter side-wall coring tool allows us to take 3.8 cm diameter and 6.3 cm length cores from borehole wall.

New sensor technology brings us higher accuracy/resolution and more data volume. Latest borehole image tools give us much higher resolution than previous generations. It helps to descript small structure and fractures. New gamma-ray spectral tools allows us to identify minerals: Al, Ba, C, Ca, Cl, Fe, Gd, K, Mg, Mn, Na, S, Si, Ti, Cu, Ni. Some of these new tools require larger guide pipes to low the tools into borehole. Chikyu's riser drilling gives more chances to use new tools with large diameter riser pipes.

Chikyu's riser drilling allows us to approach deeper in safer approach. While it expands our leading edge of science, it requires longer days and huge cost. It drives us to consider spot coring (at selected intervals) from coring of the whole interval. Under this situation, it is more important for downhole logging to compensates the missing coring intervals. While wireline logging is carried out after coring, LWD before coring suggests us best spot coring intervals or best position for observatory installation. New LWD technology provides various high resolution data same as those of wireline logging. These above change paradigm of drilling strategies.

Riser drilling circulates cuttings (small pieces of formation rocks during drilling) and formation gas to surface with drilling fluid. They are valuable samples and information from subsurface, too, and utilized oil and gas industries long time, but we just have started our studies for science researches. Integration analysis with core, logging, seismic, and cuttings must maximize our science products.

キーワード: ロギング, ハードロック, ちきゅう, IODP
Keywords: logging, hard rock, Chikyu, riser drilling, IODP

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チャレンジャー海淵前弧における蛇紋岩湧水系の理解のカギは若い玄武岩の活動にある
Young basaltic volcanism as a key for understanding serpentinite-hosted vents in the Challenger Deep Forearc

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The Izu-Bonin-Mariana forearc is a typical nonaccretionary convergent plate margin; the inner trench slope exposes lithologies found in many ophiolites. In particular, serpentinized peridotite crops out and has been sampled from the inner trench wall along the southernmost Mariana forearc facing the Challenger Deep. Our studies there indicate that this is a region of forearc rifting unusually close to the trench axis, as manifested by the Southeast Mariana Forearc Rift [SEMFR; Ribeiro et al., 2013, G3]. Convergent margin igneous activity is generally limited to beyond 100-200 km from the trench, so the presence of SEMFR is an unusual characteristic of the southernmost Mariana forearc. We have also discovered more evidence of young basaltic volcanism from ~100 km west of SEMFR. DSV Shinkai 6500 dives during YK13-08 cruise recovered volcaniclastics from 5.5 to 6 km deep in the inner wall of the Mariana Trench, ~50 km northeast of the Challenger Deep [Stern et al., 2014, Island Arc]. The volcaniclastics include fresh basaltic glasses that are similar to basalts from SEMFR as well as to Mariana Trough backarc basin basalts and we conclude that they formed by recent eruptions on the inner trench wall. Earthquake foci also indicate that the Challenger Deep forearc is a region of strong extension, and bathymetric data indicate that multiple tectonic rifts dissect it, indicating that diffuse extension occurs in the forearc.

We have discovered and have been studying a serpentinite-hosted ecosystem, the Shinkai Seep Field [SSF; Ohara et al., 2012, PNAS] in the inner wall of the Mariana Trench, ~80 km northeast of the Challenger Deep. SSF is a diffuse cold seep, serpentinite-hosted system that hosts ecosystem mainly consisted of vesicomyid clams. We have tried to find more SSF-type seeps along the southernmost Mariana forearc during YK13-08 and YK14-13 cruises, but no such seeps were found so far. The origin of the fluid of SSF may originate in the shallow subducting slab, unrelated to igneous activity. Another possibility, based on the fact that YK13-08 volcaniclastics are found ~5 km west of SSF, is that SSF vent fluid originated from seawater circulated within the shallow crust driven by the heat of young magmatic intrusion, as is proposed for the Lost City hydrothermal field in the Mid-Atlantic Ridge. Our results suggest that identifying sites of recent forearc igneous activity may help locate other sites of seafloor venting on the inner trench wall of the Challenger Deep Forearc.

Keywords: Challenger Deep, forearc, serpentinite, young basalt

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巨大海台とホットスポット海山の海洋掘削；揮発性成分研究への展開
Volatile studies through drilling of oceanic plateaus and hotspot seamounts

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Oceanic plateaus and hotspot seamounts are the manifestation of magmatism unrelated to plate boundary processes. Such oceanic volcanism is a key issue in mantle geochemistry as it is a probe of the source mantle in depth. Collecting submarine volcanic rocks is essential to geochemical and petrological studies because most part of volcanic bodies exist under water. Moreover, mantle volatiles can be only studied with submarine glasses quenched under high water pressure. A problem for studying submarine rocks would be that they are easily altered by hydrothermal and low-temperature fluids, but here I would show some examples in which noble gas compositions were successfully determined using fresh core samples from aged oceaic plateau and hotspot seamounts. This is probably the first study to determine noble gas compositions of oceanic plateau basalts.

Louisville seamount chain was formed by a long-lived hotspot in the southern Pacific. Moderately to highly altered rocks have been collected by previous dredge hauls. The IODP Expedition 330 drilled and cored seamounts at the age between 50 and 74 Ma. Although the cored rocks were variously altered, we occasionally found fresh basalts in which olivine phenocrysts were well preserved. Such olivines are good container of mantle volatiles including noble gases. The $^{3}He/^{4}He$ ratios of the studied olivines range from a value similar to those of MORB (~8 Ra) to slightly elevated ratios up to 10.6 Ra (Hanyu, 2014). Moreover, some olivines exhibit a primordial Ne isotopic signature that can be discriminated from MORB Ne ratios. These noble gas compositions document a deep origin of the Louisville mantle plume from less-depleted mantle.

Shatsky Rise in the northern Pacific is an oceanic plateau constructed by intense volcanism around 140 Ma. This plateau was recently revisited by IODP Expedition 324, in which amazingly fresh glasses were cored in two of the drill holes at such aged oceanic plateau. Well-preserved quenched glasses on pillow basalts and massive flows allowed us to determine reliable major and trace elements (Sano et al., 2012), volatile compositions (Shimizu et al., 2013), and noble gases (Hanyu et al., in press). Fortunately, the effect of radiogenic ingrowth was minimal for He isotopes because of high He abundance and low U and Th concentrations in tholeiitic basalts. Glasses from a drill core at Ori Massif show a narrow range in $^{3}He/^{4}He$ between 5.5 and 5.9 Ra, which is lower than the MORB value. Such low and uniform $^{3}He/^{4}He$ is assigned as a feature for their mantle source, suggesting the involvement of recycled slab material in the source of Shatsky Rise.

Our understanding of the time of volcanism, crustal structure, magma sources, and melting processes could be deepened through drilling of oceanic plateaus and hotspot seamounts. Emission of volatiles from oceanic plateaus might have caused drastic change of Earth's surface environment, such as mass extinction, a hypothesis of which must be proved by ocean drilling. Ontong Java Plateau could be one of potential targets of future drilling, as its crustal structure is partly getting uncovered by on-going geophysical surveys.

キーワード: 巨大海台, ホットスポット, 海洋掘削, 揮発性成分, マントル物質循環
Keywords: oceanic plateaus, hotspots, ocean drilling, volatiles, mantle recycling

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高温沈み込み帯における初期島弧火成活動の進化過程
Evolutionary processes of initial arc magma yield from hot subduction zone reference from the Oman Ophiolite

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東ヨーロッパから中央アジアにかけて断続的に分布するテーティスオフィオライト帯は、いずれも基底部に沈み込んだスラブ起源と考えられている変成岩を伴い、マントル—斑レイ岩—岩脈群—溶岩層からなるオフィオライトナップで構成されることが知られている。溶岩類には共通して無人岩が含まれることや、層序が伊豆小笠原マリアナ弧と類似することから、オフィオライトの起源として前弧域が提案されている（e.g. Dilek and Furnes, 2009）。しかし、中東のオマーンオフィオライトでは、100 Ma 頃に高速拡大海嶺から沈み込み帯への転換によって、無人岩を含む島弧火成活動が起こった（Ishikawa et al., 2002）。放散虫化石年代から、この島弧火成活動は拡大軸火成活動後 200 万年以内に終息し（Agui et al., 2014）、その後 1000 万年以上かかってアラビア半島に衝上した。本講演では、オマーンの無人岩の産状、岩石学的・地球化学的特徴から、短命に終わったオマーンの沈み込み帯モデルを考察する。

層厚約 1100 m の島弧火山噴出物（V2 火山岩類）は下位の海嶺溶岩層（V1 層）を覆い，斜長石，斜方輝石，単斜輝石とかんらん石を含む島弧ソレアイト質溶岩（LV2）を主体とし（Kusano et al., 2014），局所的に降下火砕物を産する．島弧火山噴出物層の上部にはかんらん石，斜方輝石と単斜輝石斑晶を含む無人岩（UV2）を伴う．無人岩は海嶺系および島弧ソレアイト溶岩に貫入する複数の岩脈群から供給され，枕状溶岩，シート溶岩や降下火砕物をなす．火山岩組成は海嶺期から島弧火成活動期を通じて次第に枯渇していくが，新鮮な火山ガラス中の LIL 元素などの沈み込み由来成分は次第に富む傾向を示す．また，これらの Hf・Nd 同位体組成は，無人岩マグマ生成には遠洋性堆積物メルトが関与している可能性を示唆する．島弧火山岩類を生成したソースマントルの部分溶融度を重希土類元素と HFS 元素組成を用いたマスバランス計算から求めたところ，島弧ソレアイト・無人岩とも海嶺下の溶け残りマントルの再溶融で説明可能であることがわかった。これは、島弧ソレアイトと無人岩は古島弧のウェッジマントル内でほぼ同時期に生成され、付加したスラブ成分組成の違いにより異なるマグマを生じた可能性を示唆する。一方、Cr スピネル中のガラス包有物から最も初生的と考えられるメルト組成（MgO 16 wt%; H_2O 2.0 wt%）を見出し，マントルかんらん岩と共存可能な温度圧力を Putirka（2008）の地質温度圧力計で推定したところ，1320 ℃，0.5 GPa であった．これは海嶺下マントルと同程度のマントルポテンシャル温度であり，上述した無人岩マグマが拡大軸下の高温の解け残りマントルのフラックス融解で生じたという検討と調和的である．また，基底変成岩が記録する沈み込んだスラブの最高変成温度圧力は>800 ℃，～1 GPa であり，島弧火山岩類の生成に関与した流体と平衡であったことから（Ishikawa et al., 2005, Searle and Cox, 2002），火山フロント直下のスラブ深度は 50-70 km であったと推定される．島弧活動期を通じてマグマが枯渇していき，火成活動が短期間で終息することは，ウェッジマントルが発達せず上盤側が冷却してしまったことを示唆する．島弧火成活動終息後の 90 Ma 頃活動したプレート内玄武岩（V3）マグマは，沈み込んだ低角スラブのデラミネーションが誘発したことで説明される．

キーワード: 初期島弧火成活動, 高温沈み込み帯, 無人岩, オマーンオフィオライト
Keywords: Initial arc, Hot subduction zone, Boninite, Oman Ophiolite

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IODP Exp. 351 Izu-Bonin-Mariana Arc Origins 速報
IODP Exp. 351 Izu-Bonin-Mariana Arc Origins

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Understanding how subduction zones are initiated and continental crust forms in intraoceanic arcs requires knowledge of the inception and evolution of a representative intraoceanic arc, such as the Izu-Bonin-Mariana (IBM) arc system. This can be obtained by identification and exploration of regions adjacent to an arc, where unequivocally pre-arc crust (basement) overlain by undisturbed arc-derived materials exists. IODP Exp.351 targeted, in particular, evidence for the earliest evolution of the IBM system following inception.

The Exp. 351 drill site (U1438) is located in Amami Sankaku Basin (ASB), west of the Kyushu-Palau Ridge (KPR), i.e., paleo-IBM arc. Seismic reflection profiles suggest that sediment thickness of the Basin is about 1.3 km thick, and igneous crust, presumed to be oceanic, is about 5.5 km thick. This igneous crust seemed likely to be the basement of the IBM arc.

Primary objectives of this Expedition were: 1) determine the nature of the crust and mantle preexisting the IBM arc; 2) identify and model the process of subduction initiation and initial arc crust formation; 3) determine the compositional evolution during the Paleogene of the IBM arc; 4) establish geophysical properties of the ASB.

Exp. 351 lasted 2 months from May 30, 2014 aboard the JOIDES Resolution. Site U1438 (in 4700m water depth) consisted of 4 cored holes with overlapping recoveries; igneous basement was reached after coring the entire sediment section. The cored interval comprises 5 units: uppermost Unit I is hemipelagic sediment with intercalated ash layers, presumably recording explosive volcanism mainly from the Ryukyu and Kyushu arcs; Units II and III host a series of volcaniclastic gravity-flow deposits, likely recording the magmatic history of the IBM Arc from arc initiation until 25 Ma; Siliceous pelagic sediment (Unit IV) underlies these deposits with minimal coarse-grained sediment input, and could pre-date arc initiation. Sediment-basement contact occurs at 1461 mbsf. A basalt to dolerite section dominantly composed of plagioclase and clinopyroxene with rare chilled margins continues to the bottom of the Hole at 1611 mbsf. Preliminary assessment of the results suggests that basaltic basement is early-middle Eocene (or older) and geochemically similar to forearc basalts from IBM forearc.

Exp.351 is regarded as successful because :1)Sedimentary record preserving subduction initiation, arc maturation to shutdown was recovered: 2)Igneous basement of Amami Sankaku Basin, i.e., basement of IBM arc was recovered. The outcome of this expedition permits hypothesis testing for subduction initiation and subsequent Arc evolution.

キーワード: 伊豆小笠原マリアナ弧, IODP, Exp.351, 沈み込み開始, 海洋性島弧
Keywords: Izu-Bonin-Mariana arc, IODP, Exp.351, subduction initiation, oceanic island arc

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IODP-EXP352：IBM前弧掘削による沈み込み初期過程とオフィオライトモデルの検証
Overview of IODP Expedition 352 - Testing subduction initiation and ophiolite models by drilling the outer IBM fore-arcs

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The Izu-Bonin-Mariana (IBM) arc is the ideal locality for studying subduction initiation, arc magmatism and the earliest stages of continental crust formation. To gain a better understanding of the evolution of subduction zones, three IODP expeditions (Expedition 350, 351 and 352) were conducted at the IBM arc system (rare-arc, proto-arc and fore-arc) between March and September 2014 by the JOIDES Resolution drilling vessel. Expedition 352 was targeted to drill the entire magmatic sequence comprising the outer Bonin fore-arc to elucidate early subduction dynamics and test ophiolite formation models posit formation upon subduction initiation. During the expedition, a total of 1.22 km of igneous basement related to subduction initiation and 0.46 km of overlying sedimentary rocks were cored from four sites (U1439, U1440, U1441, U1442).

Two sites (U1440 and U1441) located nearer to the trench, recovered igneous rocks at the basement that are mostly fore-arc basalts (FABs) manifest as pillow lavas, sheet flows and hyaloclastites. At the lowermost part of Hole U1440B, FABs are overlain by dolerites, which are interpreted as feeder dikes for the upper FAB lava units. Compositions of FABs are similar to those of mid oceanic ridge basalts, and exhibit little evidence of subduction influence.

From the two sites (U1439 and U1442) located ~15 km west from U1440 and U1441, pillow lavas, massive lavas, hyaloclastites and pyroclastic flow deposits of boninite were recovered. Boninites with doleritic texture were also recovered from the lowermost part of Hole U1439C, which may represent a dike complex. No FAB was found beneath boninite in these sites. Boninites are chemically distinct from FAB by virtue of higher SiO_2, MgO and K_2O and lower TiO_2. These chemical criteria dictate that boninites formed by partial melting of a more depleted mantle source enriched in slab-derived subduction components.

The presence of feeder dikes at the bases of FAB and boninite holes (U1440B and U1439C, respectively) indicates that the occurrence of boninitic and FAB lavas was offset horizontally as opposed to vertically. At a relatively early stage of subduction formation, conditions of magma genesis changed drastically from predominantly decompression melting (formation of FAB) to flux melting (formation of boninite).

キーワード: IODP, 前弧玄武岩, ボニナイト, 沈み込み帯, オフィオライト
Keywords: IODP, Fore-arc basalt, boninite, subduction zone, ophiolite

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Water in glassy volcaniclastics recovered during IBM IODP Exp. 350: can it help fingerprint eruption sites?

Water in glassy volcaniclastics recovered during IBM IODP Exp. 350: can it help fingerprint eruption sites?

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NICHOLS, Alexander[1*] ; TAMURA, Yoshihiko[1] ; BUSBY, Cathy[2] ; BLUM, Peter[3] ; JUTZELER, Martin[4] ; SCHINDLBECK, Julie[5] ; MCINTOSH, Iona[1] ; IODP, Expedition 350 scientists[6]

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The Izu-Bonin-Mariana arc system (IBM) extends over 2800 km south from the Izu Peninsula (Japan) to beyond Guam (USA). During 2014 the Izu segment was the focus of three IODP drilling expeditions (350, 351 and 352) that investigated different aspects of this intra-oceanic arc system. This work focuses on material recovered in the first of these expeditions that took place from March 30 to May 30 2014.

IODP Expedition 350 drilled at two sites (Tamura et al., In Press). Site U1436 in the fore-arc at 1776 meters below sea level (mbsl), ~60 km east of the arc-front volcano Aogashima, is a geotechnical hole drilled in preparation for proposed deep drilling at site IBM-4. This was followed by Site U1437 at 2117 mbsl in the rear-arc, the main focus of the expedition, located in a volcano-bounded basin between the Manji and Enpo rear-arc seamount chains, ~90 km west of the arc-front volcanoes Myojinsho and Myojin Knoll. Hole U1436A reached 150 meters below seafloor (mbsf), recovering 71.6 m of Pleistocene to Pliocene sediments consisting of a single lithostratigraphic unit of tuffaceous mud (~60%) intercalated with ~150 volcaniclastic layers. Volcaniclastics range from ash to lapilli-ash size, and record mafic (~80 layers, ~60% of the recovered volcaniclastics) to more evolved volcanism. A distinctive glassy mafic ash layer that may record a large-volume eruption was recovered at ~50 mbsf; in order to recover the layer less disturbed by coring, three additional holes (U1436B, C, and D) were drilled at the site to better constrain its thickness and thus its origin. Drilling at Site U1437 across Holes U1437B, D and E, reached 1806.5 mbsf and recovered 1120.76 m of Pleistocene to Miocene tuffaceous mud and mudstone (~60%) intercalated with volcaniclastic layers (~2500 layers) that were divided into seven lithostratigraphic units. The proportion of the volcaniclastics and their dominantly fine grain size (ash/tuff) is surprisingly low for an intra-volcano basin and suggest distal sources. In Units VI and VII, below 1320 mbsf, the volcaniclastics included a greater proportion of coarser material (lapilli-tuff to tuff-breccia) that may originate more proximally. Within Unit I a record of mafic and more evolved volcanism could be identified, but this became more difficult with depth.

Water is being measured in glassy material from the volcaniclastic layers. As water solubility increases with increasing pressure, if water is saturated in the melt on eruption, the water left in the glass provides a means to estimate the pressure at the time of quenching. This can then be used to infer whether or not the eruption that generated the volcaniclastics was submarine, and if so at what water depth it occurred. We will examine whether water can be used to constrain eruption depths and help to locate possible sources of the volcaniclastics recovered in IODP Expedition 350. One possible issue that may overprint the water signal even in fresh-looking glass is post-eruption hydration of the glass by seawater at ambient temperature at their site of deposition. Water added in this way enters the glass as molecular water because at sub-magmatic temperatures the species interconversion reaction between molecular water and hydroxyl species is negligible. This results in anomalously high concentrations of molecular water compared to the speciation expected at eruption temperature. If this is recognized in the glassy volcaniclastics from IODP Expedition 350, we will examine whether it is possible to restore eruption water contents using their measured hydroxyl content and water speciation models. If successful, we will then infer from the restored water contents whether the eruptions that generated the glasses were submarine, and if so the depth of eruption required for the melts to be saturated at the time of quenching.

Tamura, Y. et al., In Press. Proceedings of the International Ocean Discovery Program, Expedition 350. doi:10.14379/iodp.proc.350.2015

キーワード: Izu-Bonin-Mariana drilling, volcaniclastics, glass, water content, water speciation, vent conditions
Keywords: Izu-Bonin-Mariana drilling, volcaniclastics, glass, water content, water speciation, vent conditions

SIT05-08 会場:303 時間:5 月 27 日 09:45-10:00

安山岩マグマと大陸生成に関する新仮説
Andesite Magmas are Produced Along Oceanic Arcs Where the Crust is Thin: A New Hypothesis

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The straightforward but unexpected relationship presented here relates crustal thickness and magma type in the Izu-Ogasawara (Bonin) Oceanic arc. Volcanoes along the Ogasawara segment of the arc are underlain by thin crust (16-21 km)?in contrast to those along the Izu segment, where the crust is ~35 km thick. Interestingly, andesite magmas are dominant products from the former volcanoes and mostly basaltic lavas erupt from the latter. Moreover, andesite magmas have been similarly dominant in the Oligocene Izu-Ogasawara-Mariana arc, when the arc was immature and their crust must have been thin. Why and how do volcanoes on the thin crust erupt andesite magmas? An introductory petrology textbook might answer this question by suggesting that, under decreasing pressure and hydrous conditions, the liquidus field of forsterite expands relative to that of enstatite, with the result that, at some point, enstatite melts incongruently to produce primary andesite melt. According to the hypothesis presented here, however, rising mantle diapirs stall near the base of the oceanic crust at depths controlled by the thickness of the overlying crust. Where the crust is thin, as along the Ogasawara segment of the arc, pressures are relatively low, and magmas produced in the mantle wedge tend to be andesitic. Where the crust is thick, as along the Izu segment, pressures are greater, and only basaltic magmas tend to be produced. Implications of this hypothesis include the following: (1) A 'stockpile' of continental crust (andesitic magma) was produced during the Archean and Proterozoic, when most crust was thin. (2) Most andesite magmas erupted on continental crust could be recycled from 'primary' andesite originally produced in oceanic arcs. The rate of continental crust accumulation would therefore have been greatest early in Earth's history, soon after subduction was initiated.

キーワード: 大陸地殻, 安山岩, 海洋島弧, 地殻, マントル, 初生マグマ
Keywords: continental crust, andesite, oceanic arc, crust, mantle, primary magma

Japan Geoscience Union Meeting 2015
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SIT05-09 会場:303 時間:5 月 27 日 10:00-10:15

高 Si 無人岩はリサイクルしたスラブ起源か？
Is high-silica boninite of recycled slab origin?

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Primitive melt inclusions in chrome spinel from the Ogasawara Archipelago comprise two discrete groups of high-SiO_2, MgO (high-Si) and low-SiO_2, MgO (low-Si) boninitic suites with ultra-depleted dish- and V-shaped, and less depleted flat rare earth element (REE) patterns. The most magnesian melt inclusions of each geochemical type were used to estimate the genetic T-P conditions for primary boninites by using [1], which range from 1345 degC-0.56 GPa to 1421 degC-0.85 GPa for the 48-46 Ma high-Si and low-Si boninites, and 1381 degC-0.85 GPa for the 45 Ma low-Si boninite. These T-P conditions for the low-Si boninites lie on an adiabatic melting path of depleted mid-ocean ridge basalt mantle (DMM) with a mantle potential T (MPT) of 1420 degC, which is in agreement with that of the primary proto-arc basalt (PAB) magma preceding boninites estimated by PRIMELT2 [2]. This is consistent with the previous model of the subduction initiation in which the onset of the Pacific Slab subduction at 52 Ma forced upwelling of DMM from the depth of ca. 100 km to yield PAB. The residue of PAB was subsequently fluxed by slab fluids to yield the low-Si boninite at 48-46 Ma [3]. On the contrary, the higher temperatures for the high-Si boninite magma generation cannot be explained by this scheme, but has been ascribed to the involvement of a mantle plume with a MPT $>$1500 degC [4]. However, the ascent of such high-T peridotite to $<$1 GPa should cause extensive decompression melting to produce picritic magmas, which have never been found among the pre-boninite PAB. This discrepancy can be reconciled if the depleted proto-boninite source already existed below the DMM-like PAB source before the subduction began. With the rise of DMM, refractory harzburgite ascended without melting, and hence retained its high temperature. At 48-46 Ma, introduction of slab fluids caused remelting of the PAB residue and high-T harzburgite, resulted in the low-Si and high-Si boninites, respectively. Meanwhile, convection within the mantle wedge brought the less depleted residue of PAB and DMM into the region fluxed by slab fluids, which melted to yield the less depleted low-Si boninite at 45 Ma, and fertile arc basalts, respectively.

The presence of refractory high-Si boninite source is supported by the unradiogenic Os isotopic compositions of chrome spinel derived from high-Si boninite in Ogasawara [5] and harzburgite drilled in the Izu Forearc [6], which experienced melt extraction in Proterozoic age and became the source for the boninite magmas. Such Proterozoic depleted harzburgites are also known to exist below the lithosphere of the Ontong Java [7] and Kerguelen Plateau [8], and are considered to be remnants of recycled slab subducted below the Rodinia supercontinent [7]. The residual mantle experienced up to 25% melting below the Proterozoic mid-ocean ridges descended and stagnated in the transition zone below Rodinia. The refractory harzburgite slab was then brought up to the base of the continental lithosphere at a depth of around 100 km with the ascent of the super plume either during the rifting of Rodinia, or later Gondwana, and was drifted away with the continental fragments and is now spread sporadically below the Pacific and Indian plates. The globally limited occurrence of high-Si boninite is only possible when the remnants of harzburgitic slabs are tapped by a descending slab after subduction initiation and brought upward to the region of flux melting.

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キーワード: 伊豆─小笠原─マリアナ弧, 無人岩, 沈み込み帯発生, メルト包有物, クロムスピネル, スラブリサイクル
Keywords: Izu-Ogasawara-Mariana Arc, boninite, subduction initiation, melt inclusions, Cr spinel, recycled slab

SIT05-10 会場:303 時間:5 月 27 日 10:15-10:30

オマーンオフィオライトにおけるマントルかんらん岩と火山岩の成因関係の再検討
Reexamination of genetic relationship between mantle peridotite and volcanic rocks in the Oman ophiolite

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The volcanic sequence in the Oman ophiolite consists of MORB, island arc tholeiite and boninite from the bottom to the top (Ishikawa et al., 2002; Yamazaki, 2012, Kusano et al., 2012, 2014). These evidences support the change in tectonic setting for the Oman ophiolite from spreading ridge to incipient subduction zone (Umino et al., 1990; Arai et al., 2006). The boninitic dikes and lavas in the Oman ophiolite are high-Ca boninite and require melting of cpx-bearing peridotite such as lherzolite (Kusano et al, 2014). However, boninite occupies only about 13 % of the lavas in the V2 unit (Kusano et al, 2014). It's left as an unsolved problem what and where the residue after extraction of island arc tholeiite is. Harzburgite with spinel Cr# (=Cr/(Cr+Al) atomic ratio) lower than 0.65 is widely distributed inside of the mantle section. We speculate that these harzburgites may be the residues after extraction of arc tholeiitic melt produced by flux melting of lherzolite during intra-oceanic thrusting. Clinopyroxenes in such harzburgite are highly depleted in LREE relative to HREE in the C1 chondrite-normalized REE patterns. Before flux melting the mantle section may have consisted of moderately depleted lherzolite which composition is similar to the basal lherzolites in the northern Oman ophiolite (Takazawa et al., 2003; Khedr et al., 2013, 2014). Highly refractory harzburgites and dunites locally occur in the lower part of the mantle section above basal thrust and have spinel Cr# greater than 0.7. Emplacement of hot young oceanic lithospheric mantle caused thermal metamorphism and dehydration of subducting oceanic crust (Hacker and Mosenfelder, 1996; Ishikawa et al., 2005). Both fluid and sediment-derived melt may have infiltrated into the mantle section caused flux melting of harzburgite and produced boninitic melt together with highly refractory dunite (Arai et al., 2006; Nomoto and Takazawa, 2013; Kanke and Takazawa, 2014).

キーワード: オマーンオフィオライト, マントルセクション, かんらん岩, 島弧ソレアイト, ボニナイト, フラックス溶融
Keywords: Oman ophiolite, mantle section, peridotite, island arc tholeiite, boninite, flux melting

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SIT05-11 会場:303 時間:5 月 27 日 10:30-10:45

高速拡大海嶺下の下部地殻の進化過程：Hess Deep Rift で採取されたトロクトライトの例
Evolutional process of fast-spreading lower oceanic crust: an example of troctolites at the Hess Deep Rift

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Troctolites were recovered during IODP Expedition 345 at Hess Deep Rift (Dec 2012 - Feb 2013), which targeted plutonic rocks from fast-spread lower ocean crust. The troctolites are divided into two groups based on textural differences; fine-grained troctolite (including a skeletal olivine-bearing troctolite sample),and coarse-grained troctolite.

The major-element compositions of olivine, plagioclase and clinopyroxene in coarse-grained troctolites are intermediate between those in olivine gabbros/olivine-bearing gabbros and peridotites recovered from the Hess Deep Rift. Fo content and NiO of olivine range from 87 to 89, and 0.2 to 0.3 wt.%, respectively. An content of plagioclase ranges from 85 to 90. Mg# and Cr_2O_3 of clinopyroxene range from 0.88 to 0.91, and 0.5 to 1.2 wt.%, respectively. In contrast, fine-grained troctolites partly overlap with olivine gabbros/olivine-bearing gabbros in mineral chemistry. Fo content and NiO of olivine range from 83 to 86, and 0.08 to 0.2 wt.%, respectively. An content of plagioclase ranges from 77 to 84. Mg# and Cr_2O_3 of clinopyroxene range from 0.82 to 0.89, and nearly nil to 1.0 wt.%, respectively. Trace-element analyses of olivine and plagioclase show progressive enrichment in REE from coarse-grained to fine-grained troctolites. In contrast, clinopyroxenes show scattered trace-element compositions in the fine-grained troctolites, even in a single thin section.

The changes in chemical composition of olivine and plagioclase from coarse-grained to fine-grained (and skeletal olivine-bearing) troctolites may be ascribed to variable degrees of reequilibration with crystallizing melts during cooling. Fine-grained troctolites possibly record melt/rock interactions that would be responsible for the variable chemical compositions of clinopyroxenes. At Hess Deep, lower crustal troctolites possibly underwent several stages of evolution, combining fractional crystallization of MORB (mid-ocean ridge basalt) melts, combined with melt/troctolite interaction during migration. Melt migration processes in the lower oceanic crust would result in enhanced regional diversity of MORB chemistry.

キーワード: トロクトライト, 高速拡大海嶺, メルト/トロクトライト相互反応, Hess Deep, 微量元素組成
Keywords: Troctolite, Fast-spreading ridge, Melt/troctolite interaction, Hess Deep, Trace-element composition

SIT05-12 会場:303 時間:5 月 27 日 11:00-11:15

Earthquake activity in the Pacific plate near the Japan Trench axis after the 2011 Tohoku-Oki Earthquake

Earthquake activity in the Pacific plate near the Japan Trench axis after the 2011 Tohoku-Oki Earthquake

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Intra-plate normal-faulting earthquakes near oceanic trenches likely associate with bending of the incoming/subducting plates. Focal mechanisms of the intra-plate normal-faulting earthquakes in trench-outer slope area suggest tensional stress at shallow depths, which may promote infiltration of seawater several tens of kilometers into the oceanic lithosphere. Recent seismic structural studies in the trench-outer slope area present seismic velocity changes in the oceanic plate approaching the trench accompanied by the development of bending-related faults cutting the oceanic crust (e.g., Fujie et al., 2013, Grevemeyer et al., 2007). However, details on hypocenter locations, especially in depths, of outer-trench normal-faulting earthquakes and relation to the crustal structures have not been well understood due to less frequent activity than inter-plate earthquakes and lack of near-field observations. After the 2011 Tohoku-Oki Earthquake (Mw 9.0), shallow normal-faulting seismicity has been active in the incoming/subducting Pacific plate near the Japan Trench (e.g., Asano et al., 2011). To investigate the stress state in the incoming/subducting Pacific plate near the trench axis and relations between earthquakes and crustal structures, we have conducted a series of ocean bottom seismograph (OBS) observations near the trench axis since the occurrence of the 2011 Tohoku-Oki earthquake. These OBS observations provide accurate hypocenter locations and focal mechanisms of earthquakes occurred in the Pacific plate. Earthquakes with a normal-faulting focal mechanism occurred at depths of shallower than 40 km beneath the outer slope of the Japan Trench. The normal-faulting earthquakes in the oceanic crust coincide with normal-faults cutting the oceanic crust and forming horst and graben structures. The hypocenter distributions and T-axes directions suggest earthquakes activity along pre-existing structures in the oceanic crust in addition to the trench-parallel normal faults. Both the pre-existing structures, such as fracture zones, and trench-parallel normal faults formed in the trench outer slope area could act as faults of the shallow normal-faulting earthquakes. Furthermore, the normal-faulting earthquakes occurred at deeper depths compared with the OBS observations before the 2011 earthquake by Hino et al. (2009). The 2011 Tohoku-Oki Earthquake likely changed the stress state in the Pacific plate. These observations suggest that stress regime in the oceanic lithosphere, which could change in temporal and spatial, and both pre-existing and newly created faults in the oceanic crust are important factor to understand the hydration of the oceanic plate prior to the subduction.

キーワード: Intra-plate earthquake, horst and graben, normal faulting, OBS
Keywords: Intra-plate earthquake, horst and graben, normal faulting, OBS

SIT05-13　会場:303　時間:5 月 27 日 11:15-11:30

マリアナ海溝チャレンジャー海淵の超枯渇したオリビンスピネルサンド
Ultradepleted olivine and spinel sands in Challenger Deep, Mariana Trench

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Peridotite has been studied extensively as a clue to understand the uppermost mantle structure. Abysal peridotite is known to be exposed to the plate spreading axes such as mid-ocean ridges and the plate convergence margin such as trenches. Many studies have had interested in peridotites outcropped at the landside slope in the southern Mariana Trench. Challenger Deep (10,911 m depth) of Mariana Trench is the deepest in the Earth. However, it is difficult even today to sample rocks exposed at deeper slopes than 7,000 m depth due to technical problem. In 2008, JAMSTEC (Japan Agency for Marine-Earth Science and Technology) sampled a sediment core at 10,350 m in Challenger Deep by ABISMO (Automatic Bottom Inspection and Sediment Mobile). Mafic minerals such as olivine and spinel have been identified in this core. They may be derived from peridotites that could be exposed at deeper slopes than 7,000 m below the sea surface. Therefore, these mafic minerals may give us an opportunity to explore mantle peridotite at the bottom of Challenger Deep. We have chosen relatively coarse mineral grains from this core. These grains were analysed their chemical compositions by EPMA (Electron Probe Micro Analyzer). As a result, olivine, spinel, pyroxene, plagioclase, quartz and magnetite were identified. The olivine CaO are less than 0.07 wt%. Moreover, assuming that both spinel and olivine grains were derived from the same peridotites, spinel Cr# and olivine Mg# indicated that the peridotite could be in the mantle origin. The spinel Cr# are highly depleted up to 0.8, suggesting their origin from the forearc mantle. Olivine Mg# in the sediment core have been compared with those in peridotites occurred at the landside slope. It shows that olivine Mg# increase toward deeper slopes from 3,500 m depth. As a result, it suggests that these olivine and spinel grains could be derived from peridotites exposed at the deeper slopes than 7,000 m depth, possibly at very bottom of Challenger Deep, where unknown peridotites could have been highly depleted.
Keywords: Challenger Deep, olivine sand, spinel sand, forearc, boninite

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SIT05-14 会場:303 時間:5 月 27 日 11:30-11:45

オマーンオフィオライト、北部フィズ岩体の基底部かんらん岩に記録されたスラブ由来流体による交代作用
Metasomatism during subduction initiation recorded in basal peridotites of the northern Fizh massif, Oman ophiolite

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The Oman ophiolite is one of the best preserved sections of oceanic lithosphere worldwide. It lies on more than 400 km along the north eastern coast of the Arabian Peninsula. The Oman ophiolite and its underling metamorphic sole are regarded as being direct analogues of obducted oceanic lithosphere and subducted oceanic crust that formed by overthrusting (e.g. Boudier et al., 1989, Ishikawa et al., 2002). This idea is supported by the presence of granitic rocks and boninite dykes in the northern part of the ophiolite, which were generated by the partial melting of the subducting plate sediment cover during metamorphic sole formation (Cox et al., 1999) or by mantle metasomatism by fluid dehydrated from metamorphic sole during subduction initiation (Ishikawa et al., 2002).

We focus on the basal clinopyroxene (Cpx)-rich peridotites in the northernmost Fizh massif in order to discuss the origin of the metasomatic agent and the degree of metasomatism, and to estimate the Cpx trace element and Nd-Sr isotopic compsositions.

The chondrite-normalised multi-element patterns for Cpxs in these rocks are significantly depleted in incompatible elements. The multi-element Cpx patterns were basically reproduced by 4-12% of melt extraction from a spinel peridotite source. However, the highly incompatible element (e.g., Ba, Nb, La, Ce, and Pb) characteristics of the basal Cpx-rich peridotites could not be reproduced by simple melting modelling. Ishikawa et al. (2005) proposed a trace element compositions for fluids released from the metamorphic sole beneath the Oman ophiolite. The enrichment of highly incompatible elements is generally reproduced by the addition of very small amounts of these fluids ($\leq$ 0.3 %) to the residual peridotites.

The Sm-Nd isotopic data plotted on the gabbro isochron (100 Ma) of the Fizh block (as given by McCulloch et al., 1980, 1981) suggests that the basal Cpx-rich peridotites were formed by partial melting contemporaneously with the generation of oceanic crust. Initial Sr isotopic compositions of the Cpxs within the basal Cpx-rich peridotites cover a wide range ($^{87}Sr/^{86}Sr$ = 0.7030-0.7074), in contrast to the rather constant initial Nd isotopic compositions. The initial Sr-Nd isotopic compositions consistently plot on the mixing line between Cretaceous seawater and MORB-type oceanic crust (presented by McCulloch et al., 1980), suggesting a contribution of seawater from the metamorphic sole.

Based on these observations, we propose that small amounts of fluids derived from the metamorphic sole (amphibolites and quartzose rocks) were added to the overlying residual peridotites during the initial stages of subduction.

キーワード: マントル交代作用, オマーンオフィオライト, 基底部かんらん岩, スラブ由来流体, 微量元素組成, Nd-Sr 同位体組成
Keywords: mantle metasomatism, Oman ophiolite, basal peridotite, slab-derived fluid, trace element compositions, Nd-Sr isotopic compositions

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SIT05-15 会場:303 時間:5 月 27 日 11:45-12:00

プレート沈み込み直前の海洋プレート屈曲に伴う断層による含水プロセスの解明に向けた東北沖海洋掘削計画
Investigation into hydrology along Bending-induced faults by off-Tohoku Incoming Plate Sampling

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MORISHITA, Tomoaki[1*] ; MORGAN, Jason[2] ; FUJIE, Gou[3] ; ABE, Natsue[3] ; ONO, Shigeaki[3] ;
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プレート沈み込みに伴う海洋プレートの屈曲により断層が形成され，この断層にそってプレート深部まで海水が供給されるという概念（Peacock, 2001 Geology) は広く認識されている。実際に，地球物理観測により，この事実を支持するデータも報告されている（例えば，Ranero et al., 2003 Nature; Worzewski et al., 2010 Nature Geosci.)。しかし，どのように，どの深さまで，どの範囲で海洋プレートがプレート沈み込み直前の屈曲に伴う断層で含水するかという実体は不明である。東北沖は，古く冷たい海洋プレートの代表である。また，地球物理観測によって，深部までの断層形成が示唆されており (Nakanishi, 2011 in Accretionary Prisms and Convergent Margin Tectonics; Nakamura et al., 2013 Geophys. Res. Lett.), 海洋プレート深部のマントルまで水が供給され蛇紋岩化を引き起こしている可能性が高い（Obana et al., 2012 Geophys. Res. Lett.)。本発表では，沈み込む海洋プレートの屈曲に伴う断層による含水プロセスを解明すべく国際海洋掘削申請として提案予定の東北沖掘削計画の概要について述べる。

キーワード: プレート沈み込み, アウターライズ, 含水, 地震, 海洋掘削, 蛇紋岩化
Keywords: Subducting Plate, Outerrise, Hydrology, Earthquake, Oceanic Drilling, Serpentinization

SIT05-16 会場:303 時間:5 月 27 日 12:00-12:15

北西太平洋シャツキー海台南東方における海洋モホ面の構造的特徴
Structural variation of oceanic Moho at southeast of the Shatsky Rise in the Northwestern Pacific

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OHIRA, Akane[1*] ; KODAIRA, Shuichi[2] ; NAKAMURA, Yasuyuki[2] ; FUJIE, Gou[2] ; ARAI, Ryuta[2] ; MIURA, Seiichi[2]

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In the northwestern Pacific magnetic anomaly lineations are identified by many studies. It is revealed that the oceanic crust in southeast of Shatsky Rise was formed on a paleo-ridge between the Pacific Plate and Farallon Plate from Late Jurassic to the Early Cretaceous (e.g. Nakanishi et al., 1989), and considered to consist of the typical oceanic crust and mantle. In such area, understanding of crustal and mantle seismic structure and nature of the Moho is an important clue to reveal structures and formation/alternation process of the typical oceanic lithosphere. However, there are few studies which covered wide range of ages of the oceanic plate continuously by using latest seismic techniques.

In 2014 we conducted an active-source refraction/reflection survey along 1130km-long line in southeast of Shatsky Rise. Five ocean bottom seismometers (OBSs) were deployed and recovered by R/V Kairei of Japan Agency for Marine-Earth Science and Technology (JAMSTEC). We used an airgun array with a total volume of 7,800 cubic inches with firing at intervals of 200m as controlled sources. Multi-channel seismic reflection (MCS) data were also collected with a 444-channel, 6,000-m-long streamer cable.

On MCS sections strong variation of the Moho were imaged. The clear and sharp Moho was imaged up to about 50km from southwest end, then the Moho was changed to be ambiguous from this point. In some areas, the Moho was not identified. The thickness of the sedimentary layer was about $\leq$0.3km except area around northeast end of survey line in which sediments from the Emperor seamounts may be supplied. The apparent velocity of uppermost mantle refractions (Pn) observed on the OBS record was about $\leq$8.6km/sec. We also identified reflected waves from the upper mantle at large offsets in records (170-440km offsets), which are similar to mantle reflection phases observed in northwest Pacific Basin (Kaneda et al., 2010). As a result of forward modeling (Fujie et al., 2008) of the mantle reflection phases, depths of these reflectors were about 40km-65km, some of which may correspond to the lithosphere-asthenosphere boundary.

Japan Geoscience Union Meeting 2015
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SIT05-17 会場:303 時間:5 月 27 日 12:15-12:30

Petrological characteristics of Opx-bearing primitive gabbros from the East Pacific Rise and the Oman ophiolite

Petrological characteristics of Opx-bearing primitive gabbros from the East Pacific Rise and the Oman ophiolite

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The Mid Oceanic Ridge Basalt is the tectonic window, which provides the geochemical and petrological character of the lower oceanic crust and the process associated with the melt-rock interaction and crystallization. The Hess Deep rift is located in the vicinity of the Galapagos triple junction between the fast spreading East Pacific Rise and the Cocos-Nazca Ridge. Lower crust of Hess Deep is exposed along the southern slope of the intrarift ridge between 4675 and 4800 m depth and was sampled during IODP Expedition 345. Primitive troctolites and olivine-rich gabbros are the dominant recovered lithologies and shipboard data showed a high Mg# whole rock chemistry in concordance with their primitive nature. In a MOR system, olivine is a typical primitive mineral and orthoyroxene (Opx) usually appear late in the crystallisation sequence, when the magma already reached a significant degree of differentiation. In spite Opx is not expected in any primitive lithology, this mineral is commonly present in Hess Deep gabbros and may be associated with olivine. This curious association of cumulate Opx with olivine and other primitive minerals was also observed at a lower extent in some gabbros from ODP/IODP Hole 1256D, in the upper Hess Deep crustal section (ODP Hole 894G), and in the crustal section of the Oman ophiolite (Kahwad and Maqsad massifs) where, in particular, Opx-bearing troctolites coexist with clinopyroxene oikocrysts and Opx-bearing troctolites and amphibole-bearing primitive olivine gabbros.

Three types of Opx textures may be distinguished in Opx-bearing olivine gabbros and troctolites: (1) recrystallised corona around olivine, (2) exsolution within clinopyroxene and (3) large prismatic or poikilitic grains. Prismatic or poikilitic Opx are present at all level of the gabbroic crust, while exsolutions and corona were observed only in the lower crust. The mineral chemical compositions vary more with the structural level than with the lithological type and (Opx-bearing) olivine gabbros from Holes 894G, 1256D and from the upper crust of the Oman ophiolite show more differentiated characteristics than the same lithology in the Site 1415 and in the Oman lower crust. Pyroxenes in all samples from the lower crust show a relatively narrow range of Mg# (from 84 to 86% for Opx and 86 to 89% for Cpx) with large variation of minor elements (Ti, Al, Cr) suggesting a strong influence of melt-rock reaction during their formation. On the other hand, the upper crust samples show a large variation in their ferro-magnesian Mg# (72-87% for Cpx and 70-85% for Opx) together with a relatively weak scatter in minor elements. Poikilitic Opx are more differentiated and associated with lower Fo-olivine. Magmatic crystallisation were then the dominant event in the upper crust, so that Opx is likely to be directly crystallised from magma. In contrast, in the lower crust, magmatic processes were dominated by melt-rock reaction, and the chemical composition and habitus of Opx show that they have been probably formed by reaction between previously abundant olivine and melt.

キーワード: Hess Deep, IODP exp. 345, Primitive gabbro, Orthopyroxene, Ocean lower crust, Oman ophiolite
Keywords: Hess Deep, IODP exp. 345, Primitive gabbro, Orthopyroxene, Ocean lower crust, Oman ophiolite

SIT05-18 会場:303 時間:5 月 27 日 12:30-12:45

Petrological and chemical evolution of oceanic crust above a spreading axis: an example from Wadi Mahram, Oman Ophiolite

Petrological and chemical evolution of oceanic crust above a spreading axis: an example from Wadi Mahram, Oman Ophiolite

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The Maqsad (or Sumail) massif composes the largest block of the Oman ophiolite. It is characterised by a structural mantle diapir elongating along an axis orientated 120^o to the North. This mantle diapir represents the axis of the former Oman spreading centre. Previous geological mapping revealed right above the diapir and from the mantle up to the sheeted dyke, a gabbroic crustal section mainly composed of olivine-rich, probably primitive, lithologies. Troctolites are particularly abundant in this section, and crop out at any level of the lower and the upper crustal section. We sampled in Wadi Mahram a transect of this troctolite-rich oceanic crust right above the diapir, thus of the last crust that was formed precisely above the spreading axis.

The lower most section, below 800 m above the mantle-crust transition zone (MCTZ), is mainly composed of a layered dunite-troctolites series characterized by strong variation in their modal composition. In spite of the local presence of olivine-poor gabbroic to anorthositic layers, the section remains dominated rich in olivine-rich facies. Locally, the layered section is cross-cut by discordant olivine gabbro dykes and veins.

From 800 to 2000 m above MCTZ, a stronger diversity is observed in the lithological facies, which varies in the range of plagioclase-free dunite-wehrlite to troctolite and olivine-free isotropic gabbro. Dolerite dykes are observed in the uppermost lithologies whatever their nature (troctolitic, wehrlitic or gabbroic) showing that the sheeted dyke complex roots equally in primitive and differentiated formations. Orthopyroxene is almost absent from the lower most section but appears and becomes abundant above 800 m above MCTZ, its coronitic to poikilitic texture suggest that it comes partly as the reaction product between melt and olivine and as the crystallisation product of late stagnant melts.

The mineral chemistry show that the lower section exhibit on average more primitive characteristics than the upper section. However, the most differentiated lithologies are found below 500 m above the mantle-crust transition zone where they crop out as dykes cross cutting troctolite layered blocks, showing that differentiated melt may be injected directly from the mantle in the lower crust. The upper half section is characterized by a great chemical scatter also reflected by the lithological variability that may be compatible with magma mixing and differentiation. Olivine gabbros are sometimes more primitive than troctolites, which may overlie them, showing that these two lithologies are not strictly linked by a same parental magma. The variation of the mineral chemical composition with depth shows that injection of primitive or differentiated magmas occurred at various level in the crust. The genesis of the crust directly above the spreading axis was driven by complex processes involving successive injections of primitive and differentiated magmas within a crystallising mush, magma mixing and more or less strong melt-rock reaction.

キーワード: Oman Ophiolite, Gabbro, Oceanic crust genesis, Spreading axis, Ocean ridge, Troctolite
Keywords: Oman Ophiolite, Gabbro, Oceanic crust genesis, Spreading axis, Ocean ridge, Troctolite

SIT05-P01　会場:コンベンションホール　時間:5 月 26 日 18:15-19:30

スピネルメルト包有物から得られた初生的無人岩マグマの成因
Origin of geochemical variations of primary boninite magmas of the Ogasawara (Bonin) Archipelago

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小笠原群島の火山岩年代・層序は，約 50Ma の伊豆―小笠原―マリアナ沈み込み帯の形成直後に発生したマグマ組成がプレート沈み込みの進行に伴って徐々に変化したことを示している。ここでは，48Ma から 46Ma にかけて希土類元素などに著しく乏しい無人岩（ボニナイト）（高枯渇無人岩）が活動し，その後低枯渇な無人岩（~45Ma）にとってかわった。その後 40Ma には無人岩活動は終息し，島弧ソレアイトおよびカルクアルカリ岩マグマを噴出する通常の島弧火山活動に移行した（Ishizuka et al., 2006, 2011; 海野・中野, 2007; Kanayama et al., 2012）。マントルと平衡であった初生マグマ組成の時空間分布とその成因を明らかにすることで，沈み込み開始から定常的な島弧―海溝系として確立するまでに島弧下マントルウエッジが辿った温度組成構造の進化，すなわちマントル流動履歴を解明することができる。Umino et al. (2015, Geology) は，無人岩のクロムスピネルから初生的なメルトを捕獲・凍結したメルト包有物を見出し，小笠原群島の初生無人岩マグマ組成を報告した。本公演では，それらの初生マグマの成因を検討する。

高枯渇無人岩メルト包有物（48-46Ma）には，高 SiO_2（SiO_2 >54.7 wt%, MgO <23.3 wt%）および低 SiO_2（SiO_2 >54.6 wt%, MgO <17.7 wt%）タイプが存在する。これらは皿型から V 字型の希土類元素 (REE) パターンを示し，V 字型の方が LILE/La 比が高い傾向にある。V 字型 REE パターンを示す無人岩は小笠原群島から報告されておらず，メルト包有物に特有である。低枯渇無人岩メルト包有物（~45Ma）は，低 SiO_2 含有量（SiO_2 >53.5 wt%, MgO <18.9 wt%）で，フラットな REE パターンを示す。

各タイプの最も初生的（高 MgO 含有量）な無人岩メルト包有物について，その起源物質を微量元素を用いたモデリング (Kimura et al., 2010) によって検討した。高枯渇無人岩メルトは，10~20%程度のメルトを分別した MORB 起源かんらん岩 (DMM, Workman and Hart, 2005) が，エクロジャイトと平衡なスラブ流体の付加により部分溶融することにより生じた。LILE/La のバリエーションはスラブ流体成分組成の違いに依存すると考えられるが，これはスラブ直上かんらん岩の脱水の寄与程度，すなわちマントルウェッジの温度の違いを反映している可能性がある。低枯渇無人岩は起源マントルの枯渇度が小さく（DMM ? 4~8%程度），堆積物の寄与が大きい。

各タイプ内のメルト包有物の主要・微量元素組成バリエーションは，高 MgO メルト包有物と珪長質（SiO_2=65-70 程度）メルトの混合によって説明できる。マントル中を上昇する無人岩マグマと珪長質メルトの混合によりスピネルの安定領域にマグマがおかれた結果 (Arai and Yurimoto, 1994)，高い過冷却度で核形成・成長したスピネルに幅広い組成のメルトが包有されたと考えられる。

無人岩の全岩組成は，メルト包有物とは異なる組成バリエーションを示す。これらは，マントルで生成された未分化無人岩マグマが浅部での脱ガスを経て，スピネルやカンラン石，斜方輝石の結晶分別，分化マグマや異なるタイプの無人岩マグマとの混合の結果，形成された。

キーワード: 無人岩, メルト包有物, 微量元素組成, 沈み込み帯, 島弧, 初生マグマ
Keywords: boninite, melt inclusion, trace element composition, subduction zone, island arc, primary magma

SIT05-P02 会場:コンベンションホール 時間:5 月 26 日 18:15-19:30

国際深海科学掘削計画第 351 次研究航海で得られたコア試料の岩石記載と地球物理学データのまとめ
IODP Expedition 351 Izu-Bonin-Mariana Arc Origins: Summary of lithostratigraphy and geophysical data

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はじめに：
国際深海掘削科学計画第 351 次研究航海（2014 年 6〜7 月に実施）では，伊豆―小笠原―マリアナ（IBM）弧の古島弧である九州パラオ海嶺の西側に位置する奄美三角海盆海域の U1438 地点の掘削が行われた．回収された 1611 mのコアのうち，上位 1461 mは堆積物であり，残り 150 mは基盤の海洋地殻である．本講演では，回収されたコアの岩石学的記載と岩石物性測定結果のまとめを報告する．これらのデータより，IBM 弧における沈み込みの開始過程と，それに続く IBM 弧の発達史に関して，解像度の高い情報が得られると期待される．

U1438 地点のコアの岩石学的記載：
U1438 地点から回収されたコアは，半遠洋性の堆積物, タービダイトおよび火成岩の基盤岩から構成されている．岩石学的記載に基づき，回収されたコアは 5 つのユニットに区分された．最上位のユニット I（厚さ 160.3 m）は, おそらく琉球弧や九州弧の爆発的火山活動に由来すると考えられる火山灰の層を幾重にも挟む半遠洋性堆積物から成る．ユニット II（厚さ 139.4 m）とユニット III（厚さ 1046.4 m）はタービダイトから成り，IBM 弧のマグマ活動史を記録している．微化石を用いた生層序や古地磁気を用いた年代モデルに基づくと，ユニット II の堆積した地質年代は漸新世，ユニット III が堆積した地質年代は漸新世から始新世に至ると推定される．ユニット III はユニット II よりも粗粒であり，粗粒な砕屑物のユニットが 5 つ認められる．ユニット IV（厚さ 99.7 m）は，凝灰岩質の砂岩に挟まれた珪長質な遠洋性堆積物から成り，始新世の早期（約 5000 万年前）に堆積したと推定される．火成岩の基盤岩（ユニット 1，長さ 150 m）は海底下 1461 mに出現する．基盤岩の放射年代は決定されていないが，微化石を用いた生層序から約 5000 万年かそれよりも古いと推定される．ユニット 1 は玄武岩の溶岩流から成っており，溶岩流の大部分は高 MgO（$\geq$8 wt.%），低 TiO_2（0.6-1.1 wt.%）のソレアイト質玄武岩である．溶岩流の大部分は無斑晶質であるが，いくつかの溶岩流にはクロムスピネル，カンラン石，斜長石，単斜輝石の斑晶が含まれる．石基組織は完晶質から隠微晶質，ガラス質まで多様である．

U1438 地点のコア及び孔内の岩石物性：
本研究航海では，コアの *P* 波速度，密度，空隙率，熱伝導率，磁化率といった岩石物性の測定も行われた．その目的は，コアを岩石学的に記載しユニット区分するための判断材料とするためである．また，地震学的研究によって事前に得られている海底下の地震波速度構造から岩相を解釈するするために，岩石物性データを活用するためである．堆積物層であるユニット I（最上位）からユニット IV（下位）にかけては，全体として，堆積物の圧密に伴う空隙率の減少と *P* 波速度の増加が認められる．ユニット III 上部の P 波速度や磁化率の変動は，泥岩に対する砂岩・礫岩の比と相関している．すなわち，比較的速い *P* 波速度は高密度の火山砕屑物が入った泥岩層に対応し，比較的遅い P 波速度は火山砕屑物が入っていない泥岩層に対応する．ユニット IV の自然ガンマ線量に顕著なスパイクが認められるが，これはおそらく，コア試料中の U，Th，K の濃度が高いためである．
ピストン式採泥器（APCT-3）を用いて，海底面から海底下 83.2 m までの深度の間で孔内温度を 7 点測定し, 77.6 K/km という線形の地温勾配が得られた．孔壁の熱伝導率がほぼ一定の値（0.952 W/mK）を示すことも考慮すると，地温勾配は堆積物の圧密や熱水循環といった局所的なプロセスによって乱されていないと考えられる．これらの観察事実と測定によって得られた物性値から，U1438 地点における地殻熱流量は 73.7 mW/m^2 と求まり，リソスフェアの年代が 4000-6000 万年程度であることが示唆される．この年代は，上述した生層序や古地磁気を用いた年代モデルに基づき推定された基盤岩の年代（約 5000 万年かそれよりも古い）と矛盾しない．

キーワード: 国際深海科学掘削計画, 伊豆―小笠原―マリアナ弧, 九州パラオ海嶺, 奄美三角海盆, 島弧の発達
Keywords: IODP, IBM arc, Kyushu-Palau ridge, Amami Sankaku Basin, evolution of island arc

SIT05-P03 会場:コンベンションホール 時間:5 月 26 日 18:15-19:30

アウターライズ断層での海洋リソスフェアの蛇紋岩化作用
Serpentinization in the oceanic lithosphere along the outer-rise faults

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Hydration of oceanic lithosphere can occur along outer-rise faults that relate to the plate bending at close to the trench (Faccenda et al. 2009). This contributes an additional source of water into the Earth interior, which might have larger water flux than that transported by hydrated oceanic crust. Recent seismic reflection survey has shown that seismic velocity in the oceanic lithosphere decreases at where bending-related faults are observed (e.g., Ranero et al. 2003; Fujie et al. 2013). Although these seismic data is not enough to image what extent of hydration occurs along the outer-rise faults, we modeled the thickness of serpentinization based on fluid percolation. When the reaction kinetics is much faster than the fluid access to the reaction front, the reaction rate is controlled by permeability through the hydrated layer (Macdonald and Fyfe 1985). Using laboratory measured permeability, the reaction thickness of serpentinization is estimated as thick as 10 km for a period from the initiation of outer-rise fault to the trench axis assuming a plate velocity of 10 cm/year. If outer-rise faults occur 100 km interval, subduction water flux is estimated to be 4.8 x 10^{12} kg/year by hydrated oceanic lithosphere, which is approximately 4 times larger than that carried by oceanic crust. More detail discussion and implication will be prepared for the meeting.

キーワード: アウターライズ断層, 海洋リソスフェア, 蛇紋岩
Keywords: outer-rise fault, oceanic lithosphere, serpentinite

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南部マリアナ海溝最西端のかんらん岩はパレスベラリフト起源？
Origin of peridotites outcroppted in the westernmost margin of the southern Mariana Trench

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The Izu-Bonin-Marina (IBM) arc is a typical intra-oceanic arc system. The forearc is non-accretionary convergent margin, where Mafic crustal rocks occurred along the inner trench slope with mantle peridotites. Mariana arc system is the southern part of the IBM arc system and forms arcuately. The trench axis of the southern Mariana trench runs across Mariana volcanic arc and backarc basin (Mariana trough) and is connected to Parece Vela Basin at the westernmost area. There have been no geological studies on the westernmost Marianas trench since Hawkins and Batiza(1977). Recently, investigations for the junction area between Mariana trench and Parece Vela Basin have been conducted using the submersible Shinkai6500 (Dive 6K1397 and 6K1398) as a part of YK14-13 cruise by the R/V Yokosuka in 2014. Shinkai6500 recovered plagioclase-bearing lherzolites and harzbergites from the tectonic ridge along the inner trench slope of the westernmost Mariana Trench. The samples show coarse grained textures (>1mm), heterogeneous intermediate textures, and fine grained textures (<0.6mm). The peridotites with the coarse grained texture were sampled from the shallowest part (3705-4042m) in the dive area, whereas the peridotites with the fine grained textures were sampled from the deepest part (5996m). Olivine fabrics vary associate with texture. : (010)[100]pattern for the coarse grained textures, {0kl}[100]pattern for the fine grained textures, and various indistinct patterns for the heterogeneous textures. The variations of both olivine textures and crystallographic fabrics with depth suggest variations of deformation processes with depth. Olivine-Spinel compositions are in a range of the Olivine-Spinel Mantle Array, indicating that the peridotites are depleted residues after partial melting of the upper mantle. Spinel compositions is bimodal between moderately high Cr# spinels (up to 0.54 in 6K1398R16) and relatively low Cr# spinels (as low as 0.30 in 6K1397R18). The increase of Cr# appears to be correlated with Ti contents (0.03-0.49), indicating that melt-rock interaction under shallow lithospheric mantle conditions. Furthermore, chemical compositions of Spinel Mg# and Cr# are almost identical to those of Parece Vela Basin peridotites, suggesting that Parece Vela Basin Mantle may be exposed on the inner trench slope in the westernmost Mariana trench.
Keywords: peridotite, Mariana Trench, Parece Vela Basin, olivine, CPO

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Preliminary isotope results from the deeper part of Hole U1437, IODP Exp. 350: rear-arc or volcanic-front sources?

Preliminary isotope results from the deeper part of Hole U1437, IODP Exp. 350: rear-arc or volcanic-front sources?

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The Izu-Bonin-Mariana arc (IBM) is an intra-oceanic arc that formed ˜50 million years ago (Ma). Understanding the magmatic evolution of this arc is fundamental in understanding the initiation and evolution of other intra-oceanic arcs and the genesis of continental crust. Previous drilling and dredging at the volcanic front and dredging in the rear-arc of the IBM has provided a record of the magmatic evolution of the volcanic front since the arc’s formation, and revealed a geochemical asymmetry between the volcanic front and rear-arc. Determining the causes of this geochemical asymmetry and when it became established is important to understand the magmatic process of the entire IBM arc.

One of the scientific objectives of IODP Exp. 350 is to clarify the geochemical characteristics of the Paleogene basement underlying the Izu rear-arc region, which has not be accessed by dredging (Tamura et al., 2013). Site U1437 is located in the Izu rear-arc, ˜330 km west of the axis of the Izu-Bonin Trench and ˜90 km of the arc-front volcanoes Myojinsho and Myojin Knoll, at 2117 mbsl. Site U1437 consists of three coherent holes (U1437B, D, and E), reaches 1806.5 mbsf, and is divided into seven lithostratigraphic units (Unit I-VII). Units VI and VII, below 1320 mbsf, are volcaniclastics with coarser material, while Units I to V are tuffaceous mud and mudstone with intercalated volcaniclastic layers. It is worth noting that Unit VI is intruded at ˜1390 mbsl by a single rhyolitic intrusion (igneous Unit 1) (Tamura et al., 2015).

Although the available age constraints are 10.97-11.85 Ma, inferred from a nanofossil assemblage at ˜1403 mbsf and a preliminary U-Pb zircon concordia intercept age of 13.6 +1.6/-1.7 Ma on the rhyolite at ˜1390 mbsl (Tamura et al., 2015), the geochemical characteristics of units VI and VII are expected to approach the geochemical characteristics of the older basement. Moreover, the volcaniclastics of units VI and VII include a greater proportion of coarser material, indicating they are more proximal to their sources.

Therefore, initially we have focused on Hole U1437E (Units V to VII) in order to obtain as much information on the older basement as possible. The shipboard geochemical analyses, using Zr and Y elements that are resistant to alteration, showed that the proximal volcaniclastics of units VI and VII have a wide signature, including arc-front and rear-arc sources, and the geochemical variation in Units I-V generally reflect relative proportions of distal arc-front and proximal rear-arc volcanic sources (Tamura et al., 2015). Our onshore major and trace elements analyses also show arc-front and rear-arc signatures in units VI and VII (Sato et al., 2015).

The rear-arc volcanos in the Izu-Bonin arc are known to have lower $^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$, and $^{206}Pb/^{204}Pb$ ratios than arc-front volcanos (Tamura et al., 2007). Therefore, in addition to the major and trace element compositions, isotope ratios such as Sr, Nd, Pb, and Hf also provide important constraints to identify the source characteristics of the volcaniclastics. We are now analyzing the Sr, Nd, Pb, and Hf isotope ratios of selected samples from Hole U1437E. Although acid leaching is necessary to eliminate the alteration effect, it is expected that the Nd and Hf isotopes will preserve their original characteristics because of their high resistance to alteration, even though the samples are severely altered. We will present the preliminary isotope results, with constraints, to elucidate the source characteristics of the volcaniclastics and intrusion of site U1437.

Keywords: Sr-Nd-Pb-Hf isotopes, Volcanic front, Rear arc, Izu-Bonin-Mariana (IBM), Exp 350, U1437