Japan Geoscience Union Meeting 2013
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MIS23-01 Room:103 Time:May 24 09:00-09:15

Preliminary results of IODP Expedition 338: Operational aspects

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The Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) is a multi-disciplinary scientific project designed to investigate fault mechanics and seismogenesis along subduction megathrusts through reflection and refraction seismic imaging, direct sampling, in situ measurements, and long-term monitoring in conjunction with laboratory and numerical modeling studies. As part of the NanTroSEIZE program, operations during Integrated Ocean Drilling Program (IODP) Expedition 338 were planned to extend and case riser Hole C0002F located at the southeastern margin of the Kumano forearc basin, begun on Expedition 326 in 2010, from 856 meters below the sea floor (mbsf) to 3600 mbsf.

Riser operations extended the hole to 2005.5 mbsf, collecting a full suite of logging- and measurement-while-drilling (LWD/MWD), mud gas and cutting data. However, due to damage to the riser during unfavorable winds and strong current conditions, riser operations were cancelled. Hole C0002F was suspended at 2005.5 mbsf, but left for re-entry during future riser drilling operations, which will deepen the hole to penetrate the megasplay fault at about 5000 mbsf. Contingency riserless operations included coring at Site C0002 (200-505, 902-940 and 1100.5-1120 mbsf), LWD at Sites C0012 (0-709 mbsf) and C0018 (0-350 mbsf), and LWD and coring at Sites C0021 (0-294 mbsf) and C0022 (0-420 mbsf).

Combined primary riser operations and contingency riserless operations at Site C0002 allowed to sample the upper part of the forearc basin sediments and gas hydrate zone, the basal Kumano Basin-to-accretionary prism unconformity, and the upper portion of the inner wedge with cores, drill cuttings, mud gas sampling, and an extensive suite of LWD logs.

Site C0018 is located within a depocenter for downslope mass transport in a slope basin seaward of the megasplay fault, and was drilled and sampled during Expedition 333 targeting mass-transport deposits (MTDs). Site C0021 is located ˜2 km NW of Site C0018 and at a more proximal site for MTDs observed at Site C0018. LWD at Site C0018 provided logging data to characterize the sedimentary section and MTDs, which are correlatable with the previous core and seismic data. LWD and coring at Site C0021 provided data for correlation to Site C0018. Together the sites provided constraints on the lateral variability of MTDs within the basin, which relates to the nature, provenance, and kinematics of the submarine landslides.

Site C0022 is located in the slope basin between previously drilled Sites C0004 and C0008. LWD and coring at this site penetrated through the tip of the megasplay fault, and provided constraints on the activity of this megasplay fault.

Site C0012 is located in the Shikoku Basin on the crest of a prominent basement high (Kashinosaki Knoll) on the subducting Philippine Sea plate, where coring down to 630.5 mbsf had been conducted during Expeditions 322 and 333. LWD operations at this site provided logging data to characterize the sedimentary section and the upper portion of the oceanic crust, which are correlatable with the previous core and seismic data.

Keywords: IODP Expedition 338, C0002, C0012, C0018, C0021, C0022

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MIS23-02 Room:103 Time:May 24 09:15-09:30

Porewater chemistry of seafloor sediments based on the onboard analyses Expedition 338 at Nankai Trough

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During IODP Expedition 338, sediments were sampled from Site C0002 at Kumano Basin and Site C0022 on the frontal arc slope of Nankai Trough. At Site C0002, the sediments were obtained from the depths between 200 - 500 mbsf (meters below seafloor), 900 - 940 mbsf, and 1100 ? 1120 mbsf. Porewater was analyzed after squeezing using the standard onboard analytical procedures. Porewater from the sediments at 1111 mbsf was extracted using GRIND method after testing the appropriateness of this method. Here, the tested results of GRIND method and porewater chemistry of the Site C0002 are described.

GRIND method was originally developed for the sediments and rocks, for which standard squeezing (standard method, hereafter) did not provide adequate volumes of pore?fluid. However, it would also be applicable to extract the porewater from small volume of the sediment samples. 40 g sediment was ground with 5 mL ultrapure water in a ball mill, and the water was squeezed using the standard method. As results, chlorinity was comparable (RD <2%) with that obtained using the standard method, and major ions, Br, sulfate, Na, Mg and Ca, and minor ions, B, Li and Sr are useful if 5-10 % difference of concentration from that obtained using the standard method can be acceptable. Among the major ions, K concentration was always ca. 20 % higher and phosphate ca. 15 % lower than those obtained using the standard method. Most of the minor and trace metal concentrations (Fe, Mn, Si, Ba, V, Cu, Zn, Rb, Mo, Cs, Pb, U) obtained using the GRIND method were much larger than those obtained using the standard squeezing method, probably due to extraction of adsorbed elements onto the sediment particles via desorption in addition to the dissolved components. Thus, the GRIND method cannot be applicable for the minor and trace metals except Li and Sr, of which RD are <10%.

At Site C0002, continuous profiles of porewater chemistry are obtained down to 1050 mbsf combining the results of previous and present expeditions. 10 samples from the above former two intervals were analyzed using both standard squeezing and GRIND methods, and the deepest porewater chemistry was obtained for the sediment at 1111 mbsf only using the GRIND method.

Chlorinity decreased from 550 mM of the porewater from the seafloor sediment to 350 mM down to 400 mbsf, increased to 480 mM down to 800 mbsf, then decreased to 450 mM at 1111 mbsf. The boundary between Units I (upper forearc basin sediment) - II (lower forearc sediment) and II-III (basal (starved) sediment) are 140 and 830 mbsf respectively. The depletion of chloriniy occurs in Unit II due to the contribution of freshwater from gas hydrates. Similar depletion of the concentration in the Unit II are observed for Na, K, Mg, B, Sr, Ba and Rb. Alkalinity, phosphate and ammonium increase in Unit I and decrease in Unit II, suggesting that those are released via decomposition of organic matters and then removed by precipitation (P) and decomposition (ammonium). Br increases in Unit I due to decomposition of biogenic material (probably algae), similar to P and ammonium, while in and below Unit II, it changes in accordance with Cl. Ca and Li increase in Unit II probably due to dissolution of biogenic and/or detrital minerals. In Unit IV (upper accretionary prism), chlorinity alkalinity and Na decreased, while Ca increased with depth in Unit IV. Variations of each element correspond to the lithological units, suggesting that the porewater chemistry is partly controlled by the interaction between porewater and sediments including mircrobiology of each sediments, which comprise different mineralogy and chemistry.

Keywords: porewater, gas hydrate, Kumano Basin, GRIND method

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MIS23-03 Room:103 Time:May 24 09:30-09:50

JFAST: Drilling to the Plate Boundary to Investigate the Large Slip of the 2011 Tohoku-oki Earthquake

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The 2011 Tohoku-Oki earthquake produced the largest fault slip ever recorded for an earthquake, up to 50 meters on the shallow portion of the subduction megathrust. This region of the plate boundary was not expected to have large slip during earthquakes, so the huge co-seismic displacements and resultant devastating tsunami were a shocking surprise to the seismological community. In response to the earthquake, the Integrated Ocean Drilling Program (IODP) rapidly planned and carried out Expedition 343 (JFAST) to investigate the rupture mechanisms and physical conditions that produced the large slip. During April/May and July 2012, three boreholes located at a site close to the Japan Trench about 90 km east of earthquake epicenter, successfully reached the plate boundary fault at depths of about 820 meters below seafloor. These boreholes enabled geophysical logging, core sampling and installation of a temperature observatory in the vicinity of the fault zone.

Analyses of core samples obtained from the plate boundary decollement show a narrow zone (less than 5 meters) of highly deformed fabric in a clay layer. The pronounced localization of deformation within this material suggests coseismic weakening during past earthquakes. Estimates of the level of dynamic friction during the recent earthquake are expected from the temperature monitoring that was installed during the expedition. Also, laboratory experiments on the retrieved core samples will give estimates of the frictional properties of the fault rocks. Combining investigations of the physical, chemical, and mechanical properties of the fault zone along with determinations of the local stress state from borehole breakouts, will provide information to help explain the very large slip that occurred during the earthquake.

Keywords: JFAST, Tohoku-oki earthquake, IODP, Sea-floor Drilling, Fault Friction, Japan Trench

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MIS23-04 Room:103 Time:May 24 09:50-10:05

Subseafloor biosphere in plate boundary of Japan Trench forearc

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The 11 March 2011 (Mw 9.0) Tohoku-oki earthquake source exhibited a compound rupture. The amount of slip increased up dip from the hypocenter to where the maximum slip of more than 50 m occurred near the trench. Large slip near the trench caused the strong impulsive peak of the tsunami. The Japan Trench Fast Drilling Project (JFAST) sailed April 1 to May 24 and was a rapid-response IODP expedition (IODP Exp 343) with a primary scientific objective to identify slipping fault(s) by LWD and retrieving core samples from across the plate boundary. The IODP Exp 343 had another objective as well. It was to justify the possible existence of earthquake-sustained subseafloor biosphere in the seismogenic subduction systems that had been hypothesized based on previous observations and laboratory experiments of abundant mechanochemical hydrogenogenesis by fault activities.

Since many geophysical observations predicted that the 3.11 Tohoku-oki earthquake provided the large seafloor displacement probably induced by large fault slip(s) along certain fault(s) in somewhere of the deep subseafloor environment at the Site C0019, we predicted that the possible earthquake-induced H2 concentration anomaly occurred at the time of slipping and was still preserved in the core sample of the Site C0019 even 14 months after the Tohoku-oki earthquake. A great spike in H2 concentration at around 700 m below seafloor (mbsf) may represent the earthquake-induced H2 concentration anomaly followed by the fault slipping caused by the Tohoku-oki earthquake. The LWD measurement and other pore-water chemistry data also suggested the existence of fault.

Not only H2 but also CH4 and other pore-water chemical characteristics in the core samples were of great geochemical and biogeochemical interest because the core samples that covered the whole sequence of plate boundary zones in the forearc regions of the subduction systems. There have been known only 3 forearc regions in the history where the ODP-IODP operation recovered the whole sequence of core samples penetrating the inter-plates boundary. Our pore-water chemistry demonstrated very unique profiles of abundance and isotopic composition of CH4, other hydrocarbons and sulfur compounds. These chemical profiles predicted the possible incidence and functions of novel subseafloor biosphere associated with spatially extended faulting structures and hydrothermal circulation of fluids in the deep inter-plates boundary.

Keywords: subseafloor biosphere, plate boundary, forearc, fault slipping, methane, molecular hydrogen

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MIS23-05 Room:103 Time:May 24 10:05-10:20

Biogeochemical dynamics of amino acids in deep-subsurface marine sediments

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Amino acids in sediment pore waters are key compounds in metabolic activities of sedimentary microbes and in remineralization of carbon and nitrogen. However little is known about their biogeochemical dynamics (e.g., sources and transformation processes) in deep-subsurface sediments.

As a new approach to constrain the sources of dissolved amino acids in sediment pore waters, this study reports and compares compound-specific d15N and enantiomer ratio (%D) of total hydrolysable amino acids (THAA) in solid phase and dissolved hydrolysable amino acids (DHAA) in pore waters from the same sediment samples. Samples were collected from deep-subsurface sediments (down to 172.9 m below seafloor) at the Sagami Trough (NW Pacific) during D/V Chikyu cruise CK09-03 (Expedition 905: December 2009).

In the sediments deeper than 9 mbsf, average %D values of DHAA were 25.9% in alanine, 24.8% in aspartic acid, 11.3% in serine, and 16.3% in glutamic acid, and average %D changes from THAA were +15.3% in alanine, -0.4% in aspartic acid, -8.1% in serine, and 4.6% in glutamic acid. Compound-specific d15N analysis showed that d15N values of alanine are higher in the DHAA than the THAA and that d15N values of glycine and glutamic acid are similar between the two fractions (d15N-DHAA - d15N-THAA = +5.8 permil, +1.9 permil, -0.3 permil, respectively). These results suggest that the DHAA fractions have different d15N and %D signatures from the THAA fractions, and that hydrolysis of the THAA could not be the sole source of the DHAA. Alternatively, the d15N and %D signatures of DHAA are consistent with the idea that in situ release of proteinaceous materials from sedimentary microbial biomass (such as peptidoglycan of Gram-positive bacteria) is an important source of DHAA. This suggests that recycle of dissolved amino acids by microbes would be an important process during amino-acid degradation and microbial metabolism in the deep-subsurface sediments.

Keywords: Deep biosphere, Organic matter, Nitrogen isotope, Amino acids, Bacteria

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MIS23-06 Room:103 Time:May 24 10:20-10:40

Exploration of the Deep Coalbed Biosphere off Shimokita (IODP Expedition 337): Overview and Perspectives

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Among the least characterized Earth systems that can be addressed by scientific ocean drilling are deeply buried hydrocarbon reservoirs in sediments along continental margins. In particular, the role of subseafloor microbial ecosystems for the formation and fate of these reservoirs remains poorly understood. The IODP Expedition 337 was the first expedition dedicated to subseafloor microbiology that used riser-drilling technology on the drilling research vessel CHIKYU. The drilling site C0020 is located in a forearc basin formed by the subduction of the Pacific Plate off the Shimokita Peninsula at a water depth of 1,180 meters. During Expedition 337, we penetrated a 2.466 meters-deep sedimentary sequence with a series of coal (i.e., lignite) layers at around 2 km below the seafloor. Hole C0020A is currently the deepest hole in the history of scientific ocean drilling. Riser drilling at Site C0020 provided an unprecedented record of dynamically changing depositional environments in the former forearc basin off the Shimokita Peninsula during the late Oligocene and Miocene. This record is comprised of a rich diversity of lithological facies reflecting environments ranging from warm-temperature coastal back-swamps to cool water continental shelf. The use of riser-drilling technology in very deep sediments created both unique opportunities and new challenges the study of subseafloor life. Downhole logging operations yielded data of unprecedented quality that provide a comprehensive view of sediment properties and water mobility at Site C0020. Onboard analysis of gas chemistry and isotopic compositions provided the first indication of the existence of a subseafloor biosphere in deep coalbed horizons. Expedition 337 also provided a test ground for the use of riser drilling technology to address geobiological and biogeochemical objectives and was therefore a crucial step toward the next phase of deep scientific ocean drilling.

Keywords: IODP Expedition 337, Deep Biosphere, Deep Carbon Cycle

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MIS23-07 Room:103 Time:May 24 11:00-11:15

Physical properties of sediment cores and cuttings in Sanrikuoki Basin at Site C0020, IODP Expedition 337

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Physical properties which should be affected by local diagenesis process are very important to evaluate sedimentary formations below the seafloor. A series of physical properties measurements were carried out in laboratory on D/V Chikyu, using core samples and cuttings from a riser drill hole at Site C0020 in northern Sanrikuoki Basin off Shimokita Peninsula. As routine, measurements with multi-sensor core logger were performed, moisture and density (MAD), P-wave velocity and electric resistivity were measured using discrete core samples, and thermal conductivity was measured on half cores. Cuttings recovered by the riser drilling system were also applied to MAD analysis, being separated into four categories: original bulk and sieved size categories of >4.0, 1.0?4.0, and 0.25?1.0 mm. Cubic samples cut off from the cuttings were applied to the P-wave velocity analysis and the electrical impedance analysis. In addition, anelastic strain recovery analysis was made on the vessel using some whole-round cores and vitrinite reflectance analysis was also performed on some coaly samples. As a result of the MAD analysis, porosity of siltstone, sandstone, and shale gradually decreased to the greater depth. Porosity corresponds to lithologic variation. For example, porosity of carbonate-cemented sandstone and siltstone has much lower values than non-cemented sandstone and siltstone. The carbonate-cemented rocks have also higher thermal conductivity than the others, and indicate specific CT values on X-ray computed tomography analysis. The cuttings also show a gradual decrease in porosity but have generally higher values than the core samples. Discrete core samples are likely more representative of in-situ porosity than cuttings. Vitrinite reflectance indicates basically low maturity.

Keywords: physical properties, core, cuttings, coal, IODP, Expedition 337

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MIS23-08 Room:103 Time:May 24 11:15-11:30

Coordination of NanoSIMS and cell sorting to reveal microbial metabolic activity in sediment of the South Pacific Gyre

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The South Pacific Gyre (SPG) is characterized as the most oligotrophic open ocean environment. The sediment is rich in oxygen but poor in energy-sources such as reduced organic matter, and hence harbors very low numbers of microbial cells in relatively shallow (˜20 meters below the seafloor) subseafloor sediment (D'Hondt et al., 2009; Kallmeyer et al., 2012). In such an energy-limited sedimentary habitat, only a small size of microbial community persists living functions with extraordinary low oxygen-consumption rate (Roy et al., 2012). However, because of the current technological limitation, deeper habitats of the SPG remain largely unknown.

During IODP Expedition 329, sediment samples recovered from whole sedimentary column down to the sediment-basement interface were successfully recovered, providing an unprecedented opportunity to tackle some technological challenges to clarify if indigenous life is present, and if any, what is the microbiological and biogeochemical characteristics in such extreme environments.

To evaluate small biomass in the SPG sedimentary habitat accurately, we made modification on a cell separation technique. Cell recovery ratio was monitored with an image-based cell enumeration technique (Morono et al., 2009). The control samples were prepared by mixing E. coli cells in sterilized sediment. Increasing sediment volume resulted in lower recovery of microbial cells. Cell recovery rates in the SPG sediment samples, which contain small zeolitic mineral grains, were generally lower than those in other oceanographic settings (i.e., organic-rich continental margin sediments). To gain cell recovery rate, we examined multiple density gradient layers. After multiple modifications, we cold increase cell recovery rate up to 80-95%. In addition, cell enumeration using flow cytometry showed consistent numbers with microscopy-based cell count.

We then used the above-mentioned technique for deciphering eco-physiology of microbial life in the SPG sediments. During Expedition 329, we have initiated incubation with stable isotope-labeled substrates such as bicarbonate, glucose, amino acids, acetate, and ammonium (Morono et al., 2011) under the (micro-)aerobic condition. One of the critical technological challenges in this project is to harvest low concentrations of sedimentary microbial cells for the single-cell-based microbiological analysis. Using a new cell separation technique and sorting, we successfully sorted enough number of microbial cells in small spots on the membranes (i.e., 10^3 to 10^5 cells per spot). Preliminary results from NanoSIMS analysis showed incorporation of substrates after 1.5-years incubation of microbial cells in subseafloor sediments of the SPG.

Keywords: NanoSIMS, Subseafloor biosphere, South Pacific Gyre, Stable Isotope Probing

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MIS23-09 Room:103 Time:May 24 11:45-12:00

Plio-Pleistocene sea-level changes in Canterbury Basin, off New Zealand based on fossil ostracode assemblages

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High-resolution analysis of fossil ostracode assemblages was examined to clarify detailed sea-level change during the late Pliocene and early Pleistocene in IODP (Integrated Ocean Drilling Program) sites U1353 (85 m water depth), U1354 (113 m) and U1351 (122 m), which are located on the continental shelf of Canterbury Basin, off New Zealand. Forty, eighty and nineteen samples from Plio-Pleistocene strata of U1353, U1354 and U1351 were chosen respectively. In addition, the samples from core top in each shelf site and a slope site (344 m water depth) were also used to reveal recent ostracode assemblages in the study area. At least, 178 ostracode species belonging to 70 genera were identified, and many of them inhabit in the recent continental shelf around New Zealand (e.g. Swanson, 1979). We examined 103 samples containing more than 40 ostracode specimens and 78 taxa which occupied more than 3.5% of total relative abundance in any samples for Q-mode factor analysis. As a result, first six varimax factors explained 69.3% of total variance and their factors were interpreted as follows: Factor 1, inner-middle shelf (40-80 m); Factor 2, middle-outer shelf (80-200 m); Factor 3, middle-outer shelf (50-180 m); Factor 4, middle-outer shelf (75-125 m); Factor 5, lagoon/estuary and inner shelf(0-50 m); and Factor 6, outer shelf (ca. 200 m). Vertical paleobathymetric shifts were reconstructed based on Q-mode factor analysis and lithofacies. At least, seven, fourteen and three transgressive-regressive cycles with the amplitude of ca. 25-115 m water depth were recognized in U1353, U1354 and U1351, respectively. These paleobathymetric changes can be correlated with the LR04 stack curve (Lisiecki & Raymo, 2005) based on the frequency of cycles, the datum of trustworthy microfossil bioevents and unconformities. Thus, some high-stand and low-stand periods might coincide with MIS M2, G10, G10-7, G6-4, G3, G2, G1, 104, 103, 102, 101, 100, 99, 63, 62, 61, 60, 59, 43, 42, 41 and 40. In this study area, these paleobathymetric changes were strongly influenced by sea-level fluctuations because the rates of sediment accumulation and basin subsidence were nearly equal and they canceled each other.

Keywords: IODP Exp.317, Ostracode assemblage, Plio-Pleistocene, New Zealand, Sea-level change

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MIS23-10 Room:103 Time:May 24 12:00-12:15

Application of compound-specific radiocarbon dating to IODP Exp.318 U1357A core

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Radiocarbon (^{14}C) dating of Antarctic margin sediments is difficult, because these sediments generally lack calcareous foraminifera. Moreover, the sediments are subjected to contamination of relict organic matter eroded from the Antarctic continent (*e.g.* Ohkouchi *et al*., 2003), leading to older radiocarbon ages of bulk sedimentary organic matter. Compound-specific (CS) ^{14}C dating targets short-chain (C_{14}, C_{16} and C_{18}) fatty acids isolated from sediments. These compounds are derived from various organisms, but they are little contained in relict organic matter because the decomposition rate is relatively fast (Ohkouchi *et al*., 2003). Therefore, CS ^{14}C dating is unaffected by relict organic matter from Antarctic continent (Ohkouchi and Eglinton, 2008) and can provide accurate age. The aim of this study is establishment of accurate age model of U1357A core using CS ^{14}C dating. U1357A core (66o24.7991'S, 140o25.5008'E; 1014.9 m water depth; 186.6 m core length) was drilled at Adelie Basin located on the continental shelf off Wilkes Land, Antarctica during Integrated Ocean Drilling Program (IODP) Expedition 318 by D/V JOIDES Resolution (Expedition 318 Scientists, 2011). Lithology of this core is diatom ooze with lamination. We measured CS ^{14}C ages from 13 samples. Target compound is mainly $C_{16:0}$ fatty acid. In some samples, $C_{16:1}$ fatty acid and cyclopheophorbide a were used for CS ^{14}C dating. Samples were processed chemically using the protocol of Ohkouchi *et al*. (in review). Purification of target fatty acids uses high performance liquid chromatography - evaporative light scattering detector (HPLC-ELSD) system in JAMSTEC. Purification of CO_2 and graphitization were undertaken by dedicated high vacuum line of University of Tokyo (Yokoyama *et al*., 2010), and the measurement of ^{14}C was conducted by Accelerator Mass Spectrometry (AMS) at University of Tokyo (Matsuzaki *et al*., 2007). ^{14}C ages were calibrated using CALIB 6.02 and the Marine09 calibration curve (Reimer *et al*., 2009) with a reservoir age of 1144 +/- 120 years (Hall *et al*., 2010). We successfully obtained 13 CS ^{14}C ages. CS ^{14}C ages showed the deepest samples is last glacial period (21,957 +/- 260 cal. BP) and other samples are Holocene (9,663 +/- 190 cal. BP to modern). This suggests that; i) there is hiatus between 176.65 meters below seafloor (mbsf) and 181.66 mbsf of this core, ii) this core has a continuous record of the past ˜10,000 years.

Keywords: compound-specific radiocarbon dating, Southern Ocean, Adelie Basin, Holocene, IODP

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MIS23-11 Room:103 Time:May 24 12:15-12:30

The preliminary results on drilling Paleogene drift sediments off Newfoundland, IODP Expedition 342

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In June and July 2012, the R/V JOIDES Resolution for IODP Expedition 342 drilled the seafloor off Newfoundland. This cruise successfully recovered high quality cores from nine sites (U1403 to U1411) across a depth transect ranging from 3022 to 4944 m water depth. The recovered sedimentary sequence consists of carbonate clay to oozes, recording Cretaceous to Miocene climatic and oceanographic events, including the K/Pg boundary, the Paleocene/Eocene thermal maximum, Middle Eocene climatic optimum, and the Eocene-Oligocene transition.

The shipboard biostratigraphy and magnetostratigraphy provide high-quality age models of the sediments. The models are consistent and correlative between the cores. In all the sites, Pleistocene foraminifer ooze caps the Miocene clay and Eocene calcareous ooze. The pre-Pliocene sediments are dated to 102 to 15 Ma. Sedimentation rates indicate rapid accumulation in middle Eocene (47-40 Ma; $>$ 3 cm/k.y.) and in the Oligocene-Miocene sediments (26-22 Ma; $>$10 cm/k.y.).

The Expedition aims to evaluate changes in the carbonate compensation depth (CCD) through the Eocene hyperthermal events. Shipboard analytical results of the recovered sediments allow us to reconstruct the history of the CCD in the North Atlantic. Carbonate contents in the sediments suggest the CCD was deeper than ˜4.5 km depth through the late Cretaceous to the early Eocene and as deep as ˜4.5-3.5 km after the early Eocene.

Another main objective of the expedition was to obtain high deposition rate records of the transition form the early Eocene climatic optimum ˜50 Ma, though the development of northern hemisphere ice sheets in the Oligocene and Miocene. We recovered expanded records of the middle Eocene that include numerous carbonate accumulation events that are possibly correlative with those in the equatorial Pacific. In the early Oligocene sediments, we found sand-sized lithics, possibly correlating with expansion of ice sheets around Greenland. We also recovered an exceptionally expanded record of the Oligocene/Miocene boundary. Many of the mid-depth sites display well developed lithologic cycles that likely reflect astronomical forcing. Other objectives were to understand overturning of deep-water masses in the North Atlantic and to tune bio- and magneto-stratigraphic events astronomically. We found exceptionally well-preserved calcareous and siliceous microfossils in the sedimentary succession of the cores. The biostratigraphy, magnetostratigraphy, cyclostratigraphy, and geochemistry of the microfossils will provide high-quality data for understanding North Atlantic paleoceanography and calibrating geochronology of the Eocene and Oligocene.

Keywords: IODP Exp 342, Paleogene, paleoceanography, North Atlantic

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MIS23-12 Room:103 Time:May 24 12:30-12:45

Early and Middle Eocene radiolarian assemblages in the eastern equatorial Pacific Ocean (IODP Leg 320 Site U1331)

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Quantitative faunal analyses of radiolarians were used to reconstruct paleoceanographic conditions spanning the interval from Zones RP8 (early Eocene) to RP16 (middle Eocene) in pelagic sequences recovered at Integrated Ocean Drilling Program (IODP) Site U1331 in the eastern equatorial Pacific Ocean. On the basis of relative abundance data from the low to high latitudes reported in the previous literature, paleoceanographic indices were identified: (1) species indicative of warmer conditions include Stylosphaera coronata coronata, Phormocyrtis embolum, Dendrospyris didiceros, Phormocyrtis cf. proxima, and Thyrsocyrtis triacantha; (2) species indicative of cooler conditions include: the Lophocyrtis aspera group, the Lithocyclia ocellus group, Hexacontium sp. A, Hexacontium sp. B, Thecosphaerella glebulenta, and Lithelius sp. A.

Two warming and at least six cooling events in the early to middle Eocene were identified from radiolarian assemblage variations. The paleoclimatic trends can be summarized as follows: warming in C23n.2n to C21r (˜51.5-49.0 Ma), and C18n (40.2-39.0 Ma); cooling in C21r (48.5-47.8 Ma), lower C20r (46.2-45.2 Ma), top C20r to C20n (44.0-43.0 Ma), top C20n to C19r (43.0-41.7 Ma), C19n to C18r (41.7-40.2 Ma), C18n.1n (39.0-38.5 Ma). These cooling events corresponded to the ELi and BLi events, which were identified in benthic foraminiferal d18O of the Southern Ocean.

In general, radiolarian and opal mass accumulation rates (MARs) in the eastern equatorial Pacific had higher values in cooling conditions during the middle Eocene. The changes in biological productivity in the eastern equatorial Pacific were associated with cooling of tropical surface water.

The change in relative abundance of radiolarians and CaCO3 content at Site U1331 indicated that middle Eocene carbonate events (Carbonate Accumulation Events [CAEs]; Lyle et al, 2005) coincided with the cooling events of tropical surface water. At least CAE-2 and CAE-3 were associated with high biological productivity as well as cooling.

Keywords: Equatorial Pacific Ocean, Middle Eocene, Radiolaria, IODP

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MIS23-13 Room:103 Time:May 24 14:15-14:30

Taxonomic study of the Miocene species Paragloborotalia siakensis at IODP Site U1338 in the Eastern Equatorial Pacific

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Paragloborotalia siakensis (LeRoy) is an important index species of the middle Miocene. The top occurrence of this species defines the upper boundary of Zone N.14 (Blow, 1969). However, many workers have regarded this species as a junior synonym of *Globorotalia mayeri* (Cushman and Ellisor) (e.g. Bolli and Saunders, 1982). Recently, Zachariasse and Sudijono (2012) examined many specimens from the type area of *P. siakensis* and re-examined both holotypes of *P. siakensis* and *G. mayeri* using SEM microphotography. They concluded that these two species should be distinguished from each other. Further re-examinations have been required to identify the biostratigraphic and paleoceanographic significance of each species.

The species identified as *P. siakensis* and *G. mayeri* occurs dominantly in Miocene sequences around the Eastern Equatorial Pacific (e.g. Kennett et al., 1985). In this study, we conducted a taxonomic study of *P. siakensis* obtained from IODP Site U1338 in the Eastern Equatorial Pacific by means of morphometric methods. According to our results, the population from Site U1338 should be compared with the holotype of *P. siakensis*. In contrast, no specimen similar to the holotype of *G. mayeri* was detected.

We also investigated temporal size changes of *P. siakensis* from the middle Miocene interval of Site U1338. The maximum diameter of *P. siakensis* shows significant reducing (”dwarfing” of Witting, 1997) at cooling intervals inferred by alkenone and isotope data (Rousselle et al., 2013). Several planktonic foraminiferal species show such dwarfing patterns (Wade and Olsson, 2009) induced by environmental stress. It is possible to say that dwarfing of *P. siakensis* at Site U1338 might be induced by a shallowing of the thermocline in the Eastern Equatorial Pacific toward La Nina-like conditions.

Keywords: planktonic foraminifera, Integrated Ocean Drilling Program, Eastern Equatorial Pacific, biostratigraphy, taxonomy

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MIS23-14 Room:103 Time:May 24 14:30-14:45

Changes in coral assemblages in the Great Barrier Reef since the last glaciation

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Drilling into submerged reef structures along the shelf edge of the Great Barrier Reef was carried out during IODP Expedition 325 with the purpose of reconstructing sea level and environmental changes since the Last Glacial Maximum (LGM) and analyzing their impact on reef communities and reef growth. A total of 34 boreholes were drilled between 42 and 167 mbsl at 17 sites along four transects at three geographic locations (Hydrographers Passage, Noggin Pass, and Ribbon Reef). Two basic chronostratigraphic units can be recognized: a last glacial to deglacial reef sequence overlying older Pleistocene reefal and non-reefal deposits. The former varies in thickness from ˜5.5 m to ˜34 m and consists primarily of coralgal boundstone with various proportions of microbialite. In this study we analyze the variations in coral assemblages since the last glaciation. Exp. 325 cores show that diverse corals, including Faviids, *Acropora*, *Montipora*, and *Porites*, were growing during the last glacial period on the shelf edge. Their distribution was limited to the most distal boreholes during the LGM lowstand. The subsequent deglaciation saw the development of a shallow-water coral assemblage dominated by encrusting to massive *Isopora* and branching *Acropora* and *Seriatopora* as sea level rose. The tops of distal boreholes are marked by a shift to deeper assemblages dominated by encrusting *Porites* and *Montipora* reflecting reef drowning and the formation of submerged reef terraces. As sea level kept rising, a shallow-water *Isopora*-dominated assemblage re-established further upslope and formed a barrier reef before drowning in turn.

Keywords: IODP Expedition 325 GBREC, Great Barrier Reef, Corals, Last Glacial Maximum, Reef initiation, Reef demise

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MIS23-15 Room:103 Time:May 24 14:45-15:00

Late Cenozoic paleoceanography in the northwestern Pacific and eastern Indian oceans based on calcareous nannofossils

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We report Miocene to Pleistocene paleoceanography in the northwestern Pacific and eastern Indian oceans based on calcareous nannofossil assemblages from the ODP holes 1210A and 762B. The coccolith productivity, relative abundance of *Discoaster* (a lower photic taxon) and coccolith size distribution of *Reticulofenestra* show good relationship and allow us to reconstruct a sea-surface stratification or mixing condition that associates a change in nutrient level. The low coccolith productivity, abundant *Discoaster* and large *Reticulofenestra* suggests relatively deep thermocline and nutricline (i.e., oligotrophic condition). In contrast, the high coccolith productivity, rare *Discoaster* and abundant small *Reticulofenestra* indicates relatively shallow thermocline and nutricline (i.e., eutrophic condition). The thermocline was deep and warm, oligotrophic water widespread during 13 to 9 Ma in both areas, which was followed by eutrophication from 9 Ma onward. The coccolith size distribution of *Reticulofenestra* suggests the stepwise eutrophication along with collapse of sea-surface stratification at 8.1, 6.5 and 5.0 Ma in the northwestern Pacific Ocean. Whereas abrupt eutrophication occurred at 8.9 Ma in the eastern Indian Ocean. The nannofossil assemblages indicate that the process and timing of eutrophication are different between the two areas during that period.

Keywords: Calcareous nannofossil, Cenozoic, Eutrophication, Coccolith size

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MIS23-16 Room:103 Time:May 24 15:15-15:30

Paleoinclinations of post-cruise samples from Canopus Guyot of the Louisville seamount trail (IODP Expedition 330)

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IODP Expedition 330 sampled volcanic basement rocks at five sites on four guyots along the northwestern part (late Cretaceous to early Eocene age) of the 4300-km-long Louisville seamount trail. Shipboard paleomagnetic data were used for the calculation of paleolatitudes of each guyot, and we (Exp. 330 shipboard scientists) concluded that the Louisville hotspot has remained within 3-5^o of its present-day latitude of about 51^{o}S between 70 and 50 Ma (Koppers *et al*., 2012, *Nature Geoscience*, **5**, 911-917). In order to determine more reliable paleolatitude estimates, a number of discrete rock samples were collected for a post-cruise research. In this presentation, we will present the paleolatitude of Canopus Guyot (ca. 74 Ma) that was determined from analysis of post-cruise paleomagnetic data of Site U1372. In our post-cruise study, paleomagnetic measurements and stepwise demagnetizations (alternating-field and thermal methods) were conducted in magnetically shielded rooms, and characteristic remanent magnetization components were used to calculate lava unit-mean paleoinclinations. On the basis of inclination-only statistics of 20 lava unit-means, we obtained a paleolatitude of ca. 45^{o}S for Canopus Guyot, which is statistically indistinguishable from the paleolatitude estimate (ca. 43^{o}S) for this guyot determined from shipboard discrete sample data. The paleolatitude for Canopus is low compared to the present latitude of the hotspot, implying possible southward motion of the Louisville hotspot before 70 Ma.

Keywords: Louisville seamount trail, Louisville hotspot, Canopus Guyot, IODP Expedition 330, paleolatitude, paleomagnetic inclination

Japan Geoscience Union Meeting 2013
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MIS23-17 Room:103 Time:May 24 15:30-15:45

Preliminary report for IODP Expedition 345 Hess Deep Plutonic Crust

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IODP Exp. 345, Hess Deep Plutonic Crust was conducted drilling into the oceanic lower crust from December 13, 2012 to February 12, 2013. The principal objective for drilling at the Hess Deep Rift located in the equatorial Pacific was, to test competing hypotheses of magmatic accretion (gabbro glacia vs. sheet sill models) and hydrothermal processes in the lower ocean crust formed at the fast-spreading East Pacific Rise (EPR). These hypotheses make predictions that can only be tested by drilling, i.e., the presence or absence of systematic variations with depth in mineral and bulk rock compositions, presence or absence of modally layered gabbro, and the extent and nature of hydrothermal alteration and deformation.

The drilling was carried out in ~4850 m water depth under quite challenging borehole conditions. We recovered primitive plutonic lithologies; olivine gabbro, troctolite, gabbro, orthopyroxene-bearing gabbroic rocks. The recovered rocks exhibit cumulate textures similar to those found in layered mafic intrusions and some ophiolite complexes. Details of their mineralogical and petrologic evolution, however, are novel on the ocean floor.

Keywords: IODP Exp. 345, Hess Deep, Oceanic lower crust, Gabbro

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MIS23-P01 Room:Convention Hall Time:May 24 16:15-17:30

NanoSIMS ion imaging analyses for biological samples: Applications to sebseafloor life.

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The CAMECA NanoSIMS 50L ion microprobe represents the *in-situ* microanalysis by secondary ion mass spectrometry, combining unprecedented spatial resolution (minimum spot size of ˜50 nm for Cs^+ or ˜150 nm for O^-) with ultra-high sensitivity. Up to 7 elemental and/or isotopic images can be acquired simultaneously by 7 electron multipliers with sensitivity in the ppm. The capability for maps of multiple elements and isotopes within a sample with permil precision and accuracy and nm scale spatial resolution is unique to the NanoSIMS and provides a new approach to study of the isotope and trace element distributions within the sample, i.e., extraterrestrial, terrestrial and biology samples, including meteorites, Earth rocks and microbial cells in deep and ancient subseafloor sediments by the Integrated Ocean Drilling Program (IODP).

In last decade conventional SIMS technique has been used to microbiology to match chemotaxonomic and phylogenetic signature of microbes. Recently NanoSIMS ion imaging introduced to a stable isotope probing study (i.e., ^{13}C, ^{15}N labeling) for a single cell to understand microbial metabolic activities, and metal-probed *in-situ* hybridization for phylogenetic identification.

Subseafloor sediments of the South Pacific Gyre (SPG) obtained by IODP Expedition 329 represent a large proportion of organic-poor, oxidized sediments in the open sea. The sediment is characterized as rich in oxygen but poor in energy sources. In an energy-limited sedimentary environment, a small size of microbial community perseveres functions for life with extraordinary low oxygen-consumption rate. However, the nature of deep sedimentary microbial life in the SPG remains still unknown. In this study, we will investigate metabolic activity of the SPG sedimentary cells with a NanoSIMS ion imaging.

Isotope labeled SPG sedimentary cells (incorporation of substrates after 1.5- years incubation) were analyzed by a raster ion imaging in a NanoSIMS 50L ion microprobe at the JAMSTEC Kochi Institute for Core Sample Research. A focused primary Cs^+ beam of ˜0.8 pA was rastered over 20 x 20 to 28 x 28 micrometer areas on samples. Negative secondary ions of ^{12}C, ^{13}C, $^{12}C^{14}N$, $^{12}C^{15}N$ and ^{32}S were measured using 5 electron multipliers in multidetection mode at a high mass resolution of about 9,000 that is sufficient to separate all relevant isobaric interferences (i.e., ^{13}C on $^{12}C^{1}H$). Each run was started after stabilization of the secondary ion beam intensity following presputtering of approximately 5 to 10 min with strong primary ion beam current. Each image run repeatedly scanned (30 to 40 times) the same area, with individual images consisting of 256 x 256 or 512 x 512 pixels, depending on the region-of-interest, having a dwell time of 2,000 to 3,000 microsecond. We prepared E.coli cells as the standard samples, which have different carbon isotopic rations of 0, 5, 10, 15 and 20 % enriched in ^{13}C (relative to the ^{12}C) or ^{15}N (elative to the ^{14}N) to evaluate an instrumental mass fractionation for C and N isotopes as well as to find target mass peaks (^{12}C, ^{13}C, $^{12}C^{14}N$, $^{12}C^{15}N$ and ^{32}S). This presentation will highlight results to illustrate critical analytical issues affecting precision and accuracy including sample preparation and data processing.

Keywords: NanoSIMS, sebseafloor microbes, isotope imaging, stable isotope labeling

Japan Geoscience Union Meeting 2013
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MIS23-P02 Room:Convention Hall Time:May 24 16:15-17:30

Development of Gold-ISH for sensitive detection of microbial phylogeny with a NanoSIMS ion microprobe

Kengo Kubota[1*], Yuki Morono[2], Motoo Ito[2], Takeshi Terada[3], Shogo Itezono[1], Hideki Harada[1], Fumio Inagaki[2]

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As yet most of prokaryotes in subseafloor are not culturable, linking prokaryotic phylogeny and metabolic activities at single cell resolution by culture-independent techniques is one of big concerns to understand biogeochemical nutrient cycles. Isotopic or radioisotopic labeling of microorganisms and subsequent phylogenetic identification by in situ hybridization of rRNA-targeted probes can directly link metabolic activity and phylogeny at single cell resolution. After the recent development of a NanoSIMS ion microprobe with high spatial resolution of ˜50 nm, isotope probing studies at single cell resolution are nowadays more popular to understand microbial metabolic activities related to carbon, nitrogen and sulfur metabolisms. Methods for simultaneous isotopic measurements and phylogenetic identification of single microbial cells were reported in 2008 from three different laboratories, and they all used halogen elements due to their high ionization yields and relatively low abundances in biomass. However, halogen-based these techniques still have drawbacks when apply to subseafloor samples, especially with halogen rich samples.

Gold is the one without exception for a SIMS analysis and it shows comparable ionization yield to halogen elements. In addition, gold is also relatively low natural abundance in biomass: it can make lower background signals. Furthermore, gold signals can be enhanced by gold enhancement to achieve high sensitivity. In this study, we focused on undecagold, which is consisted of 11 Au atoms with the diameter of only 0.8 nm. Here we present applicability of undecagold-labeled probes for the identification of single cells by an ion imaging analysis using the JAMSTEC NanoSIMS 50L.

For probe generation, mono-maleimide functionalized undecagold was successfully conjugated with thiol-linked oligonucleotide. After PAGE, more than two bands were observed. The band expected to be undecagolds labeled with single oligonucleotides was cut, purified, and used for in situ hybridization. Oligonucleotide probes were also labeled with Cy3, allowing verification of specific hybridization signals by epifluorescent microscopy before NanoSIMS analysis.

For the proof-of-concept, purely cultivated and 13C enriched E. coli cells and non-enriched M. maripaludis cells were mixed and used for FISH experiment with the EUB338 probe. Specific fluorescent signals were obtained only from E. coli cells and the undecagold-derived Au signals detected by nanoSIMS were identical to 13C signals, indicating only E. coli cells were successfully detected by the undecagold-labeled probe and the method has sufficient sensitivity for NanoSIMS analysis.

Further experiment was conducted using a granular sludge sample. The granular sludge was incubated with 13C-labeled lactate and sulfate to label lactate-utilizer under a sulfate-reducing environment. After hybridizing with the Desulfovibrionales-targeting SRB385 probe, specific FISH signals were obtained from rod-shaped cells. Undecagold-derived Au signals were identical to 13C signals by NanoSIMS analysis, indicating Desulfovibrionales is the main lactate-utilizer in the environment. The signals obtained from undecagod-labeled probes had high signal-to-noise ratio (approximately 10), enabling clear discrimination from background signals. These results indicated that undecagold is stable under the parameters used in this study and can be used for in situ hybridization study with NanoSIMS for ecological understanding in microbial ecology. Gold-ISH may open the door to decipher biogeochemical processes by linking uncultured microbial metabolisms with microbial phylogeny in complex microbial communities.

Keywords: Gold-ISH, NanoSIMS ion microprobe, Undecagold

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MIS23-P03 Room:Convention Hall Time:May 24 16:15-17:30

Detection of coenzyme F430 in deep sea sediments: A key molecule for biological methanogenesis

Yoshinori Takano[1*], Masanori Kaneko[1], Naohiko Ohkouchi[1]

[1]JAMSTEC

We report the presence of coenzyme factor 430 (F430), a prosthetic group of methyl coenzyme M reductase for archaeal methanogenesis, in the deep sub-seafloor biosphere. At 106.7 m depth in sediment collected off Shimokita Peninsula, northwestern Pacific, its concentration was estimated to be at least 40 fmol g sediment-1 (i.e. 36 pg g-1 wet sediment). This is about three orders of magnitude lower than typical concentrations of archaeal intact polar lipids in similar sub-seafloor sediments. On the basis of the concentration of F430 in methanogens and conversion to biomass composed of typical sub-seafloor microbial cells, we estimated that ca. 2 x 106 cells g-1 could be methanogens in the deeply buried marine sediment.

To our knowledge, this is the first study reporting F430 in a methanogenic environment of deep sub-seafloor biosphere. Further studies on the spatial and vertical distributions of F430 in the sedimentary column could potentially provide crucial information on sub-seafloor biological methanogenic processes.

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Reference:
Takano, Y., Kaneko, M., Kahnt, J., Imachi, H., Shima, S., Ohkouchi, N. (2013) Detection of coenzyme factor 430 in deep-sea sediments: A key molecule for biological methanogenesis. Organic Geochemistry, DOI: 10.1016/j.orggeochem.2013.01.012

Japan Geoscience Union Meeting 2013
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MIS23-P04 Room:Convention Hall Time:May 24 16:15-17:30

Genetic Signatures from the Aging Oceanic Crust: Evidence for Ancient Subvent Biosphere?

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Several lines of evidence strongly suggest that microbial communities exist within young ocean crust on the flank of mid-ocean ridge systems where fluid circulation is vigorous. Aging of ocean crust is accompanied with significant decreases in porosity due to secondary mineral formation and oxidative alteration within the first 10-15 million years. After thermally driven fluid circulation ceases at ˜65 Ma, basalt weathering appears to be a sole energy source in the aging ocean crust, the habitability of which remains to be largely unknown. Basaltic cores obtained during Expedition 329 (U1365: >100 Ma; U1367: ˜33.5 Ma; U1368: ˜13.5 Ma) provide a systematic opportunity to determine age variations in habitability and microbial community within the basalt basement thinly covered with oxic and organic-poor sediment. In this study, flame sterilization of the core exterior (Lever et al., 2006) and a newly developed technique for DNA extraction (Kouduka et al. 2012) were applied to minimize contamination and to maximize DNA recovery from low biomass habitat, respectively.

Although the numbers of microbial cells were below a minimum detection limit of ˜105 cells/cm3, 16S rRNA gene sequences were successfully obtained from all core samples associated with fracture-filling assemblages of oxidized or reduced secondary minerals. Contamination sources including drilling mud and surface and bottom seawater were thoroughly inspected, and it was found microbial communities in the basalt cores were clearly distinct from those from contaminant ones (<97% similarity). Phylum- or class-level distributions of microbial communities also suggested that neither formation age, depth nor chemical alteration is clearly correlated with the community structure. Many phylotypes belonging to Deltaproteobacteria and Fimicutes were closely related to strictly anaerobic metal and/or sulfate reducers (>95% similarity), despite the oxygenated bottom sediment. As overall community structures resemble previously reported ones from seafloor and subseafloor basalt with young age (< 1Ma) (Lysnes et al., 2004; Santelli et al., 2008) and low-temperature vent fluids (Huber et al., 2009), there is the possibility that genetic material originated from the subvent biosphere has been preserved owing to extremely low habitability and/or irreversible biding of DNA to rock matrix in the aged oceanic crust.

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MIS23-P05 Room:Convention Hall Time:May 24 16:15-17:30

Radon measurement during IODP Exp.337

Hidenori Kumagai[1*], Akira Ijiri[2], Fumio Inagaki[2], Kai-Uwe Hinrichs[3], Yusuke Kubo[4], IODP Expedition 337 Science Party[5]

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D/V Chikyu is capable of riser-drilling using circulation mud. The circulation mud repeatedly comes back on the deck of D/V Chikyu from the deep bottom of the borehole. Thus, it is regarded to be a carrier of formation gases and other information, which could be utilized for real-time monitoring on formation gases and fluids. On D/V Chikyu, a degasser is placed on its mud circulation line, we could retrieve the dissolved gases and supply into various monitoring and sampling apparatus. As such monitoring apparatus, Radon (Rn) monitor is also available as a third party tool connecting to one of the auxiliary ports of scientific gas line on D/V Chikyu through fine-mesh dust filter.

Radon (Rn) is an inert radioactive gas of the daughter nuclei of Uranium and Thorium with rather short half-lives. Among Rn isotopes we focus 222Rn having longest half-life of 3.82dy. Although 220Rn shows second longest half-life of 55.3s, most of 220Rn decayed during transportation to the surface. Due to such short half lives and volatility, Rn has widely been monitored to detect micro-cracking prior to the seismic activities (e.g. Igarashi et al., 1995). The concentration of Rn dissolved into the circulation mud is anticipated to reflect the lithological units of the formation; its parental elements, Uranium and Thorium, are generally rich in the terrigenous sediments and felsic rocks. In addition, some coal bed contain abundant Uranium up to 200 ppm (Takeda, 1981), which may enables sensitive detection of coal bed or lithological change during the drilling with continuous profile.

The measurement was performed by an AlphaGUARD PQ2000 Pro apparatus (Saphymo GmbH, Germany) based on an ionization chamber method. The extracted gases dissolving in circulation mud certainly contained formation gases from deep borehole although careful calibrations are required. The newly obtained time sequential Rn data will be presented. The parameter of the measurement are as follows; effective chamber volume is 650mL with 10 min integration, the flow-rate was controlled as 65ml/min.

References:
Igarashi G. et al. (1995) Science, 269, 60-70.
Takeda E. (1981) Bull. Geol. Surv. Japan, 31(11), 583-682 (in Japanese).

Keywords: IODP Exp.337, Gas monitoring, Radon measurement

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MIS23-P06 Room:Convention Hall Time:May 24 16:15-17:30

Thermal properties of the sedimentary rocks at Site C0020, IODP Expedition 337 in Sanriku-oki basin

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Thermal properties of thick sedimentary basins are important parameters to evaluate the thermal structure at depth and the maturation process for organic materials. Therefore, thermal conductivity measurement is listed as routine measurements for IODP program on board. However, to understand non-steady state processes for heat flow and diffusion, thermal diffusivity and specific heat are necessary to be evaluated as well. Therefore, in this study, a series of thermal property measurements were conducted on the sediment cores at site C0020 from IODP expedition 337 in Sanriku-oki basin. Thermal conductivity and thermal diffusivity were measured by Hot Disk method (Hot Disk AB Ltd., TPS 1500). Hot disk method (or the transient plane source technique) enables us to measure both thermal conductivity and thermal diffusivity at the same time within few minutes. We used half round core samples with 4 cm length in all measurements. The flat sensor was placed between the surfaces of a half round core sample and a heat insulating material (expanded polyethylene, thermal conductivity = 0.034W/mK) during measurements. Before measurements, half round core samples were saturated by NaCl solutions with 35 per mil, and we loaded 4.9 N during measurement at room temperature.

Thermal conductivity of sample ranged from 0.4 to 2.9 W/mK. Thermal conductivity of sandstone and siltstone increased with depth from 1.4 (1,278 mbsf) to 1.9 W/mK (2,466 mbsf). Lignite showed very low thermal conductivity and the largest thermal conductivity values were observed in carbonate cemented sedimentary rocks. A half-space line source method using TK04 (TeKa Ltd.) was applied to measure the half round core samples on D/V CHIKYU during IODP expedition 337, and the thermal conductivity and the lithological variation of the thermal conductivity measured on board were similar with our data. Thermal diffusivity was decreased with depth from 0.5 mm^2/s to 0.9 mm^2/s as well. Thermal conductivity was scattered at depth from 1,900 to 2,000 mbsf, and this scattering reflects the lithological variation of core samples. Thermal diffusivity of lignite (or coal) was 0.16 mm^2/s, and the largest value of 1.9 mm^2/s was observed on unconsolidated coarse sand. The increase in the thermal conductivity and thermal diffusivity is consistent with reduction in porosity with depth. On the other hand, thermal conductivities of lignite and cemented rocks will depend more on the pore structure and chemical compositions. Thermal diffusivities for most samples are exponentially increased with increasing thermal conductivity, though, the thermal conductivity of unconsolidated coarse sand is deviated from the exponential curve. We measured thermal properties under atmospheric condition; therefore, our data might underestimate in-situ values. Therefore, to investigate the relationship between thermal property, porosity, and pore structure at depth, we can estimate the in-situ thermal property indirectly.

Keywords: IODP expedition 337, thermal conductivity, thermal diffusivity, Sanriku-oki basin

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Compaction and dewatering process in New Jersey Shallow Shelf inferred from IODP Exp.313 core samples

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IODP Exp.313 was conducted on the New Jersey shallow shelf in May to July 2009. The L/B Kayd chartered for a mission-specific platform recovered 612 cores at three sites. This study focuses on compaction and dewatering processes associated with the architecture of the sedimentary sequences under frequent sea-level changes (based on core-log integration). Particularly, a high sedimentation rate often induces underconsolidation of sediments with overpressured pore fluids which complicates consolidation behavior. Understanding the compaction process and its effect on architecture of the sedimentary sequences reveals probable geometry of sedimentary structure before deformation, and provides important information to estimate frequency and amplitude of eustatic changes. In this study, we aim to discuss initial in situ diagenesis and dewatering processes based on physical properties measured or estimated from down-hole logging, the Multi Sensor Core Logger System (MSCL), and discrete core samples. Correlation of the three Expedition 313 sites and the seismic profile will provide better estimation of the spatial distribution of dewatering paths.

Onboard and offshore MSCL measurements provided physical properties of whole-round cores including porosity, density, electric resistivity, P-wave velocity, magnetic susceptibility and natural gamma ray. Bulk density derived from individual core samples show good correlation with gamma-ray density from MSCL, and the other physical properties from discrete core samples also correspond to WL-logging and core logging data. Porosity-depth curve measured on MSCL exhibits slightly lower porosity than discrete samples in the glauconitic-sand interval which shows relatively higher density. In M0027A, comprehensive trend of porosity-depth curve in each lithology parallels standard curve in North Sea (e.g. Sondergeld et al., 2005). Therefore these data indicates normal compaction process in the study area. On the other hand, on-board geochemical analysis indicates distribution of abnormal fresh water at M0027A (Mountain et al., 2010). Though estimated pore pressure using density profiles do not show confining layers, porosity fluctuations mesured by MSCL and discrete samples suggest that those water lenses are possibly sealed by impermeable layers. This presentation will discuss estimated pore pressure and permeability from discrete core samples.

This research used data provided by the Integrated Ocean Drilling Program and is supported by Japan Drilling Earth Science Consortium (J-DESC).

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Lithology and paleoenvironments at drilled Site C0020 off the Shimokita Peninsula, IODP Exp. 337

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Marine subsurface hydrocarbon reservoirs and the associated microbial life in continental margin sediments are among the least characterized Earth systems that can be accessed by scientific ocean drilling. We penetrated a 2,466 m-deep sediment sequence with a series of coal layers around 2 km below the seafloor. Here, we report the lithology of sediments and paleoenvironments from drilling Site C0020, IODP Expedition 337. Based on macroscopic and microscopic description of cutting and core samples during this expedition, which was supported by XRD and XRF data as well as all available data (e.g. logging, micropaleontology and physical properties data) we defined four different lithologic units present in Site C0020. The succession of lithofacies at Hole C0020A also provides insight into the evolution of depositional environments in the site region.

Keywords: IODP Exp.337, Marine subsurface hydrocarbon reservoirs, microbial life, depositional environments

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X-ray CT images of drilled cores and CT value data from IODP Expedition 337; Deep coalbed biosphere off Shimokita

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X-ray computed tomography (CT) on board 'Chikyu' is a revolutionary analysis suited to scientific ocean drilling. It is a quick and nondestructive method to produce geological image of cores and to quantify the porosity and permeability in sediment and rock of cores using CT value.

Here, we will introduce some examples of CT image of cores and CT value data from IODP Expedition 337; Deep coalbed biosphere off Shimokita, Japan, northwestern Pacific Ocean.

Keywords: X-ray CT, Ocean drilling, IODP Expedition 337

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Mud logging: its importance and potential for IODP future riser expeditions

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[1]CDEX/JAMSTEC

New IODP structure will start from October 2013 and D/V Chikyu operated by CDEX/JAMSTEC will continue to act important role as a riser drilling vessel for deeper scientific drilling (to ˜6500+ mbsf) in IODP.

Mud logging is a conventional technique in petroleum industry to investigate well site geology, to search for oil/gas reservoirs and to carry out safety control. Three IODP riser expeditions werecarried out with the Chikyu in 2009 and 2012, and mud logging operations were also included in the expeditions. Meanwhile mud logging as a new scientific measurement technique has been attempted on the Chikyu, continuous coring has also been a basic approach in shallower riserless scientific drilling (˜2000 mbsf) by not only D/V JOIDES Resolution (JR) but also the Chikyu in IODP. However, since continuous coring generally takes great amount of operation time with high risks of hole instability; the deeper a hole becomes, the more it will be difficult to accomplish. Therefore, mud logging has been recognized as one of important scientific measurement techniques to investigate lithological, petrophysical and geochemical features of deep crust and upper mantle.

The Chikyu conducted two riser operations in JFY 2012 (Exps 337 and 338). Mud logging in these expeditions was carried out both for operational safety control (operation mud logging) and scientific cuttings/mud gas monitoring. Operation mud logging is mainly composed of lithological description of cuttings and real-time mud gas monitoring. Cuttings for lithological description are ordinarily sampled at every 5 m in depth. In mud gas monitoring, concentrations of hydrocarbons (C1 to C5), CO2 and H2S gases are monitored in real-time.

In this presentation, results of operation mud logging in Exps 337 and 338 will be shown. In addition, potential of mud logging as a method of scientific measurement and issues for future expeditions will be discussed.

Keywords: Scientific drilling, IODP, Riser drilling, Mud logging, Core, Real-time gas monitoring

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Diatom and nannofossil biostratigraphy of DSDP Holes 366 and 369A, offshore northwest African margin

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We re-investigated the standard coccolith and diatom biostratigraphy zonations from Deep Sea Drilling Project (DSDP) Holes 366 and 369A in the eastern equatorial Atlantic Ocean in order to determine the relative ages for the low-latitude diatom zonation. Applying the ages of nannofossil zonations to diatom ones, the ages of several diatom bioevents (first common occurrence, FCO and first occurrence, FO) which determined biozones of DSDP Holes 366 and 369A are evaluated as followed:

FCO of *Baxteriopsis brunii* (ca. 38.4 Ma)
FO of *Coscinodiscus excavatus* (ca. 33.4 Ma)
FO of *Cestodiscus reticulatus* (ca. 32.8 Ma)
FO of *Rocella vigilans* (ca. 30.5 Ma)
FO of *Rossiella symmetrica* (ca. 29.5 Ma)
FO of *Bogorovia veniamini* (ca. 25.2 Ma).

These ages may applicable for not only these holes but also others and more biostratigraphical studies in other holes which contain Paleogene diatoms are needed in order to compare with each other.

Keywords: diatoms, nannofossils, biostratigraphy, Paleogene, DSDP 366, DSDP 369A

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Refined diatom biostratigraphy of the IODP Expedition 320/321 Sites U1334 and U1338

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Two hundred sixty slides from IODP Expedition 320/321 Holes U1334A, U1338A and U1338B were investigated to define the diatom biostratigraphic datums and acquire the paleoceanographic changes in the eastern equatorial Pacific Ocean from the middle Eocene to middle Pleistocene. As a result, the datums of twenty-four diatom zones were defined as follows:
Fragilariopsis doliolus (NTD 17; 0-0.69 Ma), *Nitzschia reinholdii* (NTD 16; 0.69-1.05 Ma),
Rhizosolenia praebergonii (NTD 15; 1.05-3.06 Ma), *Nitzschia jouseae* (NTD 14; 3.06-4.57 Ma),
Thalassiosira convexa (NTD 13; 4.57-5.40 Ma), *Nitzschia miocenica* (NTD 12; 5.40-7.36 Ma),
Nitzschia porteri (NTD 11; 7.36-8.23 Ma), *Thalassiosira yabei* (NTD 10; 8.23-8.88 Ma),
Actinocyclus moronensis (NTD 9; 8.88-10.18 Ma), *Craspedodiscus coscinodiscus* (NTD 8; 10.18-11.09 Ma),
Coscinodiscus gigas var. *diorama* (NTD 7; 11.09-11.70 Ma), *Araniscus lewisianus* (NTD 6; 11.70-12.41 Ma),
Cestodiscus peplum (NTD 5; 12.41-14.36 Ma), *Crucidenticula nicobarica* (NTD 4; 14.36-15.58? Ma),
Triceratium pileus (NTD 3; 15.58?-20.00 Ma), *Craspedodiscus elegans* (NTD 2; 20.00-22.18 Ma),
Rossiella fennerae (22.18-23.37 Ma), *Rocella gelida* (23.37-25.96 Ma),
Bogorovia veniamini (25.96-27.56 Ma), *Rocella vigilans* (27.56-29.98 Ma),
Cestodiscus trochus (29.98-30.95 Ma), *Coscinodiscus excavatus* (30.95-33.71 Ma),
Baxteriopsis brunii (33.71- ? Ma), *Asterolampra marylandica* (?- ? Ma) Zones.

Keywords: IODP Expedition 320/321, diatoms, biostratigraphy, Site U1334, Site U1338

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The Neogene records of the fossil diatoms from the core ODP Leg 145 Site 887, Northeastern Pacific

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Gulf of Alaska located in high latitude region of Subpolar Gyre in the northeastern Pacific. In this region, Alaskan Gyre is formed in eastern part of Subpolar Gyre as the subarctic current goes north and flows as Alaskan stream. Additionally, ice sheet expansion in Pleistocene contributed the drop of the global mean surface temperature with the large-scale cooling in the Northern Hemisphere (Broccoli, 2000). However, detail process of the cooling from the middle Miocene to present has been under discussion.

Moreover, the North Pacific Diatom (NPD) Zones established by Yanagisawa & Akiba (1998) have been used to define the geological/sedimentary ages in this region. However, there have been little discussions on the age gaps of diatom bioevents, including the first/last appearances of each taxon which define the NPD zones, between northwestern and northeastern Pacific because of little analyses using the same core to compare the diatom biostratigraphy with paleomagnetism around these regions.

There is two previous works for establish of northeastern Pacific diatom biostratigraphy with paleomagnetism data acquired from single core such as Barron & Gladenkov (1995) and Watanabe & Yanagisawa (2005). The former showed important result for the establishment of the Neogene diatom biostratigraphy in northeastern Pacific using with several Ocean Drilling Program (ODP) cores including Site 887, however the sampling intervals were lower to decide the detail ages of diatom bioevents because they mostly used only core catcher samples. Moreover, the ages of each diatom event used diatom biostratigraphy have been settled based on the magnetostratigraphic ages, but the paleomagnetic time scale has renewed by Gradstein et al. (2012). Therefore, each paleomagnetic event corresponding to biostratigraphy must be needed to recalculate. On the other hand, Watanabe & Akiba (2005) achieved higher-resolution analysis, but they focused on short interval from the early to middle Miocene.

Accordingly, to establish the detail northwestern diatom biostratigraphy with recalculate ages with Gradstein et al. (2012), this study used the core samples of ODP Leg 145 Site 887 drilled in Patton-Murray Seamounts, southern Gulf of Alaska, as well as Integrated Ocean Drilling Program (IODP) Expedition 341 planned to drill on May to July, 2013 in northern part of Gulf of Alaska. The objectives of this study are 1) to establish high-resolution diatom biostratigraphy from the Miocene to Present in Northeastern Pacific with comparing to paleomagnetism of Gradstein et al. (2012) and 2) to reveal paleoenvironmental changes in this region.

Reference: Barron, J.A. & Gladenkov, A.Y. 1995. Proc. ODP. Sci. Rslt , 145 , 3-19; Broccoli, A.J. 2000. Journal of Climate , 13 , 951-976; Gradstein, F.M., et al. 2012. A Geologic Time Scale 2012. Cambridge (Cambridge Univ. Press); Yanagisawa, Y. & Akiba, F. 1998. Jour. Geol. Soc. Japan. 104(6). 395-414; Watanabe, M. & Yanagisawa, Y. 2005. The Island Arc , 14, 91-101.

Keywords: Gulf of Alaska, Northeastern Pacific, IODP, diatoms, biostratigraphy, paloenvironment

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Refined diatom biostratigraphy and paleoceanography in the ODP Leg 145 Hole 884B

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In this study, fossil diatom assemblages from the Ocean Drilling Program (ODP) Leg 145 Hole 884B were investigated to refine the diatom biostratigraphy in the northwestern Pacific Ocean. As the results, twenty-one diatom zones with the Neogene North Pacific Diatom zone codes (NPD) were defined and their high resolution datum ages (~10 kyr on average) were recalculated based on the geomagnetic polarity time scale in Hilgen et al. (2012) from the early Miocene to the Pleistocene. The refined diatom biostratigraphy is intended for practical use to determine the precise datums and correlation with other regions in the north Pacific. The analysis of paleoenvironmental indicators for an interval of 0-5 Ma was also carried out in this study. The cold-water indicators, which showed high abundances throughout the interval, suggest the cold environmental conditions throughout from the Pliocene to the Pleistocene. Relatively higher abundance of temperate-water species at ca. 2.8 Ma, appearance of sea-ice related species at ca. 2.7 Ma and a slight increase of neritic species observed at ca. 1.9 Ma may reflect a series of Northern Hemisphere Glaciation (NHG) events. The peak of cold-water species, like *Neodenticula seminae*, at ca. 0.9 Ma might be affected by the global cooling of the Middle Pleistocene Transition (MPT), which is characterized by a severe increase of glaciations which started at 1.25 Ma and completed at 0.7 Ma. The first occurrence of *N. seminae* (ca. 2.6 Ma) and the last ones of *N. kamtschatica* (ca. 2.6 Ma) and *N. koizumii* (ca. 0.9 Ma) also seem to correspond to the NHG or MPT events.

Keywords: diatom, biostratigraphy, North Pacific, Neogene, paleoceanography

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Exp 906: The Kumano Mud-Volcano Drilling II and Hybrid Pressure Coring System

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D/V Chikyu implemented pressure coring by using the newly developed Hybrid Pressure Coring System (Hybrid PCS) for the first time in Expedition 906 in June 25-28, 2012. The expedition was carried out at the Kumano Mud Volcano #5 (1900 m water depth), and penetrated to 203 mbsf by riserless drilling. Pressure coring of 3 m advance was attempted five times at selected horizons. Pressure core was analyzed onboard by using Pressure Core Analysis and Transfer System (PCATS) of Geotek Limited. In addition normal HPCS/ESCS coring was also carried out by turns.

Drilling Site: Mud volcano, typically formed at convergent margin, works as a natural pipeline that conveys material from deep source to the surface. In the Nankai Trough area, tectonic activity of subducting plate created mud volcanoes, among which Kumano Mud Volcano #5 is one of the most active site in terms of fluid and gas seepage. Surface cores to 20 mbsf were collected in previous Chikyu Exp 903 in 2009.

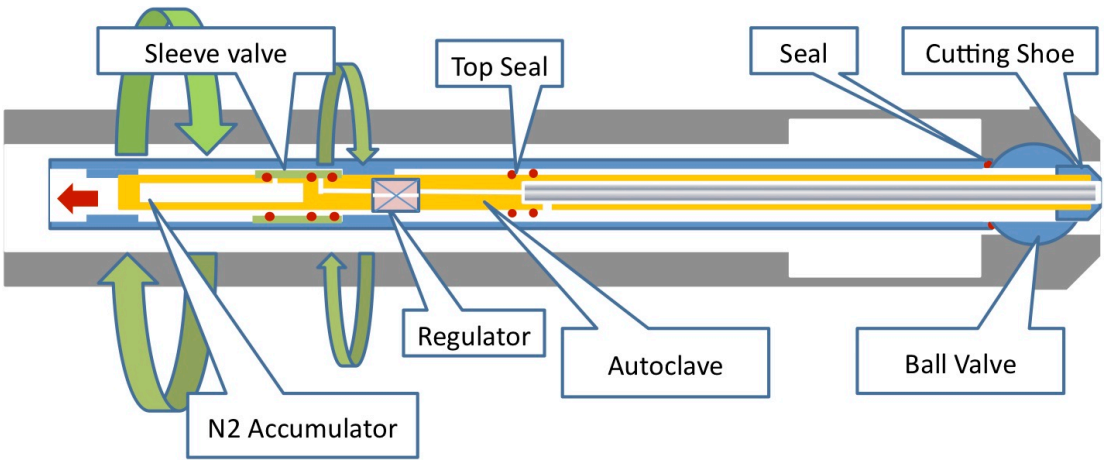
Scientific Purpose: Pressurized core samples will provide methane hydrates and in-situ volatile gas components such as H2 and CO. With accurate evaluation of geochemical, geophysical and microbiological characteristics of deep material in mud volcano, we can infer that the mud-volcano in the Nankai Trough forearc basin is the window to the deep seismogenic zone, in which geochemical and biological characteristics and behaviors may be highly sensitive to the seismogenic fault activity.

Hybrid PCS: Hybrid PCS was designed to capture a pressurized core sample with 51 mm in diameter, 3 m in length, and up to 5,000 psi in pressure. The system is compatible with Chikyu's ESCS wireline coring system, which runs through 5 and 5-1/2 inch drill pipes. The core liner closure mechanism includes three valves; lower ball valve, top seal for mud return port, and pressure control valve connected to the accumulator. These valves works by running / retrieving core wire line.

PCATS: PCATS provides non-destructive analysis of X-ray CT, P-wave velocity and gamma density of core samples in pressure chamber. Sampling and analysis of gas derived through controlled depressurization process can also be carried out. Core samples are transferred to storage chamber for transportation for further analysis in an onshore laboratory.

In Exp 906, core recovery was limited due to sticky formation in mud volcano, but 0.9 m of pressurized core material was recovered at the last attempt. This presentation, an introduction to the newly developed Hybrid PCS and a summary of Exp 906 will be presented.

Keywords: Pressure coring, Chikyu, Mud volcano, Hybrid PCS, PCATS



Japan Geoscience Union Meeting 2013
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MIS23-P16 Room:Convention Hall Time:May 24 16:15-17:30

Sea-level changes around the Last Glacial Maximum based on large benthic foraminiferal assemblages: IODP Exp.325

Choko Nakada[1*], Noriko Yagioka[1], Kazuhiko Fujita[2], Hironobu Kan[3], Yusuke Yokoyama[4]

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The shelf edge of the Great Barrier Reef was cored during the Integrated Ocean Drilling Program (IODP) Expedition 325 Great Barrier Reef Environmental Changes. Lower parts of cores drilled on deeper shelf slopes, consisting mainly of unconsolidated carbonate sediments, may record sea-level changes around the Last Glacial Maximum (LGM). The purpose of this study was to reconstruct sea-level changes around the LGM, based on large benthic foraminiferal (LBF) assemblages.

Grain-size and foraminiferal analyses were conducted for 64 unconsolidated sediment samples from the lower parts of cores drilled at HoleM0040 and M0041 on the HYD_02A transect. Paleo-water depths were estimated by comparisons of fossil LBF assemblages with modern LBF assemblages. LBF assemblages in these two cores were dominated by Operculina sp. and Amphistegina spp. Relative sea-level changes based on the paleodepth estimations were generally consistent with reported sea-level changes around the LGM.

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Geology of the subduction boundaries and suggestion for the future work - How to avoid ultra-mega-earthquakes -

Teruaki Ishii[1*]

[1]Fukada Geological Institute

The Philippine Sea plate is surrounded by several subduction boundaries, which are subducted and subducting boundaries in the southern & eastern margins and northern & western margins, respectively. I have been working to establish the geological cross section of the Southern Mariana trench inner wall area, and mentioned that mantle peridotites exposed along the trench inner wall. I hope that those basic data from the southern end can contribute to consider the physical plate model in the northern end of the plate at Nankai trough. If subducting slave contacts with the mantle peridotite of the subducted slave like in the Southern Mariana, slippery serpentine mud layer can be deposited easily under hydrous environment at subduction boundaries. On the other hand, those geological evidences give us some ideas about how to avoid ultra-mega-earthquakes in the Japanese Islands.Injection of serpentine mud into the asperity zone may be a possible answer.

Keywords: Philippine Sea plate, subduction boundary, ultra-mega-earthquake, serpentine mud, scientific ocean drilling, mantle peridotite

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MIS23-P18 Room:Convention Hall Time:May 24 16:15-17:30

Partial melting and assimilation at the basal part of sheeted dike complex in Hole 1256D, ultra-fast spread oceanic crus

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Hole 1256D is located on 15 Ma oceanic crust formed at the superfast spreading East Pacific Rise (220 mm/yr full spreading rate). This hole is the first successful drilling that penetrated the entire upper oceanic crust from 250 m thick sediments, 811 m thick extrusives (including the Transition Zone) and a thin (346 m) sheeted dike complex and drilled 105 m into the upper gabbro (Teagle et al., 2006) and important as the reference of oceanic crust from fast spreading ridges. The gabbro appears as two distinct units between the metamorphosed dike complexes. These were defined as gabbro 1 (52 m thick) and gabbro 2 (12 m thick) from above (Teagle et al., 2006). The sheeted dike complex just above the gabbro 1 is highly metamorphosed and called as granoblastic dikes. The Similar metamorphosed dike complex appears between the gabbro 1 and 2, and also the deepest part of the hole below the gabbro 2, and is called as dike screen 1 and 2, respectively.

Exp. 335 was operated as the fourth expedition at the hole 1256D. This expedition drilled 14.5 m of metamorphosed dike complex. Because of numerous fractures and very hard lithofacies, recovery was very low. Instead, a large amount of rock samples were collected from junk baskets. Some of the samples from the junk baskets were larger then core samples and showed the lithofacies that have not reported before at this hole.

The samples collected from Exp. 335 are mainly composed granoblastic dikes that are characterized by granular clinopyroxene and orthopyroxene with minor dioritic to tonalitic veins and patches. These granoblastic dikes correspond to the lithofacies of the dike screen 2 in the hole 1256D. We report petrological and geochemical features of granoblastic dikes from Exp. 335. On the basis of petrographic and petrological facts, we present evidence suggesting partial melting in the deepest part of the granoblastic dikes, which may be responsible to the generation of silicic melts.

Keywords: oceanic crust, magma, partial melting, IODP, superfast spreading ridge, Hole 1256D

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Emplacement and solidification of a large off-ridge lava flow from ODP-Hole 1256C, Guatemala Basin

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Site 1256 is located at 91deg56.1' W in the 3650-m deep Guatemala Basin on Cocos plate formed at ˜15 Ma on the eastern flank of the East Pacific Rise. A large off-ridge lava flow 75-100 m in thickness and ca. 10 cubic kilometers in volume drilled at site 1256 provides an unprecedented opportunity to understand the internal structures and solidification and emplacement processes of large lava flows. Hole C penetrated a 35-m thick lava from 280 mbsf to 315 mbsf. We present mineral compositions and grain size analyses of the core samples from Hole 1256C, and discuss the crystallization and emplacement processes of the large off-ridge lava flow. Phenocrysts are olivine, clinopyroxene and plagioclase, and the groundmass minerals are clinopyroxene, plagioclase and magnetite with mesostatic quartz and biotite. The core samples show variolitic, subophitic and poikilitic textures and mesostatic intergrowth of plagioclase and quartz. The lava flow consists mostly of NMORB with high-K^2O EMORB intervened at a depth interval of 290-300 mbsf (Wilson et al.,2003). High-K^2O EMORB has high-Mg# (60˜70) clinopyroxenes and is interpreted to have intruded into the solidifying lava body at the final stage of the lava emplacement. Given the interval of EMORB was intruded after the upper and lower lavas solidified, olivine phenocryst size and number density distributions prior to the intrusion of EMORB are similar to those formed by crystal precipitation by Rowland and Walker (1988). Mapping analyses of augite and pigeonite demonstrated domains different in Al^2O^3, CaO and MgO concentrations within a single grain. Three types of augite (Augite-N1, Augite-N2 and Augite-N3) and two types of pigeonite (Pigeonite-N1 and Pigeonite-N2) are identified for the domains in pyroxene crystals from NMORB lava intervals. The EMORB lava interval has three type augite (Augite-E1, Augite-E2 and Augite-E3) and two types of pigeonite domains. Two pairs of Pigeonite-N1 & Augite-N3 and Pigeonite-E1 & Augite-E1 are in equilibrium with each other in terms of Fe-Mg partitioning. The crystallization order is Augite-N3 & Pigeonite-N1, Pigeonite-N2, Augite-N1, Augite-N2(rim), followed by the intrusion of EMORB, and then Augite-E1 and Pigeonite-E1, Pigeonite-E2, Augite-E2 and Augite-E3 (rim).

Keywords: Ocean Drilling, Hole 1256C, Off-ridge volcano, Mid-ocean ridge, Large lava flow, Oceanic crust

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Southern Ocean drilling proposal: Outline and future plan of Antarctic Cryosphere evolution project (AnCEP)

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The Southern Ocean has played a very important role in the global climate system through geologic history to the present day. To understand the processes that change atmospheric CO2 concentrations, it is important to understand the sub-systems and processes of the Antarctic cryosphere, such as changes to the Antarctic Circumpolar Current (ACC), the Weddell Gyre, the biological pump, sea surface temperature, the polar front location, the distribution of sea-ice, and the Antarctic ice sheet on modern and geologic time scales. The evolution of the Antarctic cryosphere for major climate shifts during the Cenozoic is still poorly understood. The key motivation for the IODP scientific drilling in the Southern Ocean stems from a lack of knowledge of the complex role the Antarctic cryosphere plays in the global climate system and water circulation. Understanding the history of variations of ice volume and associated cryospheric changes during the Cenozoic is of great importance because changes of ice volume and distribution change global sea levels, affect albedo, control the latitudinal temperature gradient of the Southern Hemisphere and thus heat transport via atmospheric and oceanic circulation, and in?uence the distribution of ice shelves and seasonal sea ice, which are commonly considered to cause the cold bottom waters that drive global ocean circulation.

We will propose the drill sites along a north to south transect in the Indian sector of the Southern Ocean. The proposed sites are on sediment drift deposits on the Conrad Rise, and on the Del Cano Rise. The arrangement of those sites is crossing the oceanic fronts, the subtropical front, subantarctic front, Antarctic polar front, and winter sea ice limit. These sites contain continuous sedimentary sequences exhibiting moderate to high sedimentation rates. Age control will be provided by oxygen isotope stratigraphy, relative geomagnetic paleointensity with conventional geomagnetic polarity stratigraphy, and high-resolution biostratigraphy. The data from this drilling will greatly advance our understanding of the relationship between Antarctic climate change and Southern Ocean paleoceanographic variability.

The proposed sites are strategically located to reveal the evolution of the Antarctic cryosphere and to investigate the role of the ACC and Weddell Gyre system in that evolution. The Indian sector of the Southern Ocean is a most suitable high-latitude ocean to elucidate the evolution of the Antarctic cryosphere. Our main objectives are:

1. Evolution of the ACC and Weddell Gyre system: To test the hypothesis that considerable expansion of the ACC and Weddell Gyre system caused global cooling and a large decrease in the thickness of the EAIS during the mid-Pleistocene transition (MPT).

2. Variability of the Antarctic climate and sea-ice distribution during the Quaternary: To reconstruct high-resolution records of ACC migration, sea ice coverage, surface-water stratification, the biological pump, acidification of ocean waters, and eolian dust inputs in the Southern Ocean.

Keywords: Southern Ocean, Antarctic Circumpolar Current, Antarctic ice sheet, IODP, sea ice, paleoceanography

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Neogene history of Mediterranean hydrology based on sedimentary osmium isotopic records

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The Mediterranean Sea has experienced an extreme event called Messinian Salinity Crisis (MSC) that represents a formation of gigantic evaporite deposits in deep basins. In this study we report an osmium (Os) isotopic record of marine sediment cores from four deep-sea drilling (DSDP) sites in the Mediterranean; DSDP Site 372 in the western Mediterranean, DSDP Site 374 in the central Mediterranean, and DSDP Sites 375 and 376 in the eastern Mediterranean. The Os isotopic ratios of the pre-MSC sediments (Burdigalian to Serravallian) in the western Mediterranean are identical to that of the coeval global seawater. In contrast, the pre-MSC sediments (Langhian to early Messinian) in the eastern Mediterranean have significantly low $^{187}Os/^{188}Os$ values than those of the global Middle-Late Miocene seawater. Our data suggest that Os in the eastern Mediterranean was not fully mixed with that of other seas such as western Mediterranean and North Atlantic, and that the basin isolation has already started before the MSC, probably as early as Middle Miocene. The unradiogenic Os would have been supplied to the eastern Mediterranean by selective weathering of ultramafic rocks in the surrounding ophiolite bodies, which contains high amount of non-radiogenic Os. The isotopic compositions of Os in gypsum samples from all sites are significantly lower than the end-Miocene ocean water values, suggesting isolation of all Messinian basins. Sediments from the Pliocene show Os isotopic ratios more radiogenic, and close to the global seawater values of the Pliocene, indicating that Os started mixing with global seawater again.

Keywords: osmium isotopes, Messinian, Mediterranean, evaporite