Japan Geoscience Union Meeting 2014
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7 years of NanTroSEIZE: Achievements and Lessons Learned

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The objectives of Integrated Ocean Drilling Program (IODP) Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) include characterizing the nature of fault slip and strain accumulation, fault and wall rock composition, fault architecture, and state variables throughout an active plate boundary system. A deep riser drilling into the locked portion of the Tonankai asperity at IODP Hole C0002F began during IODP Expedition 326 in 2010. After one-year delay due to 3.11 Tohoku event (which gave severe damage to D/V Chikyu), the hole was deepened to 2005 m below seafloor during Expedition 338 in 2012, then deepened to ˜3000 m during Expedition 348 in 2013. In addition to the intermittent coring, continuous information was acquired through logging-while-drilling, mud-gas monitoring and cutting analyses. NanTrosEIZE also targets understanding shallow characteristics of subducting Shikoku Basin, forearc slope and Kumano forearc basin.

Through LWD and core analyses, shallow stress state along NanTroSEIZE transect has been revealed. Fault regime changes from normal/strike-slip at <˜500m to strike-slip in the deeper part (>˜500 m). Maximum compressional stress is vertical throughout the transect, indicating that the gravitational effect is dominant. Maximum horizontal stress is parallel to the subduction direction, with secondary contribution by the plate convergence. It is consistent with the result from circular air-gun shooting around the vertical seismic array in the central Kumano Basin, which revealed a Vp anisotropy (˜5%) in the Kumano Basin that suggests subduction-parallel compression.

Through drilling at two subduction input sites in the Shikoku Basin, we identified a significant Source of fluid in seismogenic zone; ˜30 vol% saponite in the basalt sample. This suggests that in the deeper portion of plate boundary, fluid production from basaltic rock (saponite-chlorite) can be greater than from smectite-illite conversion and sediment compaction.

Lab. friction studies in the shallow megasplay fault zone confirmed that shallow faults are velocity-strengthening at slow slip rates. On the other hand, the frictional coefficient during high-velocity (˜1 m/s) slips is very low under the undrained condition, suggesting that earthquake rupture propagates easily through clay-rich fault gouge by high-velocity weakening.

Lines of evidence strongly support the activity of shallow portion of megasplay and decollement. Mud breccia in the surface of splay footwall side indicates the earthquake-induced collapse and reworking. Vitrinite reflectance anomaly localized at the fault reveals past thermal anomaly >380degC, indicative of coseismic slip near the deafloor that should have generated a huge tsunami. XRF scanner analysis of microbreccia fault zone in the shallow megasplay indicates an increased illitization relative to surrounding host rock, representing an additional evidence of possible frictional heating and mechano-chemical clay mineral alteration.

Borehole observatories are essential in order to detect and monitor a small and low-frequency deformation that is continuing around the plate boundary. First complex borehole observatory, including geodetic, seismic and hydrological sensors, was successfully installed in the southern Kumano Basin and connected to cable network for realtime monitoring.

So far we drilled at 13 sites, participated by >170 scientists from 15 countries, and published more than 60 scientific papers. Such achievements were made possible by tremendous efforts by CDEX, who tackled with numerous technical challenges such as mechanical setbacks of riser and vessel, concern about the expedition time available (cost and budget), typhoon/low pressure evacuation, and riser drilling in the 5-knot Kuroshio current.

Keywords: IODP, Chikyu, seismogenic zone, Nankai Trough

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Ultra-deep riser drilling into the Nankai accretionary prism: Preliminary results of IODP Expedition 348

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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 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, International Ocean Discovery Program (IODP) Expedition 348 started on 13 September 2013 and was completed on 29 January 2014. During Expedition 348, the drilling vessel *Chikyu* advanced the ultra-deep riser hole at Site C0002, located 80 km offshore from the Kii Peninsula, from a depth of 860 meters below sea floor (mbsf) to 3058.5 mbsf, the world record for the deepest scientific ocean drilling, and cased it for future access. The drilling operation successfully obtained data on formation physical properties from logging while drilling (LWD) tools, as well as from lithological analyses of cuttings and core from the interior of the active accretionary prism at the Nankai Trough. IODP Site C0002 is the currently only borehole to access the deep interior of an active convergent margin. We will present preliminary scientific results as well as key aspects of riser-drilling operations, including two sidetrack borehole drilling operations conducted in this never-before accessed tectonic environment.

Keywords: IODP, NanTroSEIZE, Nankai Trough, accretionary prism

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MIS32-03 Room:416 Time:April 30 09:30-09:45

Costa-Rica Seismogenesis Program (CRISP) to understand characteristic magnitude of subduction earthquake

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Variations in earthquake magnitude and recurrence intervals of fault behavior are best understood in the context of regional tectonics. Convergent margins may be divided into two end-member types termed erosive and accretionary plate boundaries (e.g. von Huene and Scholl, 1991; Clift and Vannucchi, 2004). These margins may differ greatly in lithology, physical properties and hydrology. The Nankai accretionary margin has a 1300-year historical earthquake record with a recurrence interval of 100-150 years (Ando, 1975). Great earthquakes at Nankai are typically tsunamigenic and include the 1944 Tonankai (Mw=8.1) and 1946 Nankaido (Mw=8.1) earthquakes (Kanamori, 1977). In contrast, the Middle America trench offshore Costa Rica events of M=7.6 reoccur on average of every 40 years. The CRISP drilling area is offshore Costa Rica just northwest of the Osa Peninsula. Comparisons between these margins may produce insights into mechanisms that influence characteristic magnitudes and recurrence intervals of subduction earthquakes.

The IODP Costa-Rica Seismogenesis Program (CRISP) has carried out the first step toward the deep riser drilling by characterizing the shallow lithologic, hydrologic, stress, and thermal state at offshore Osa Peninsula (Vannucchi et al., 2011; Harris et al., 2013). CRISP drilling reveals that the shallow basement of upper plate crust is forearc basin material consisting of lithic sedimentary units with terrigenous sediment accumulated at a high rate. A large sediment flux to the forearc may have originated from the uplifted back-arc Talamanca Cordillera due to Cocos-Ridge subduction (Lonsdale and Klitgord, 1978; van Andel et al., 1971). Both the Nankai and the CRISP drilling areas are characterized by the subduction of young oceanic crust with high heat flow and active fluid flow (Spinelli and Wang, 2008; Spinelli and Harris, 2011; Harris et al., 2010). The Nankai and Costa Rica margins are ideal ares to better understand the relation between the earthquake magnitudes and other subduction zone factors.

Keywords: Large subduction earthquake, seismogenic fault, accretion and erosive margin

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Estimation of the past bottom-ocean environment of 2Ma based on the benthic foraminifera stratigraphy: IODP Exp. 344

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IODP Exp.344 (Costa Rica Seismogenesis Project: CRISP 2) is designed to understand the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones and drilled five sites off the western coast of Costa Rica around the southern end of the Middle America Trench, where the oceanic Cocos Plate is subsiding beneath the Carrbbean Plate.

Site U1414 is the reference site and its 2Ma is characterized by lower slope assemblages and also there is not any big change of assemblages. However, a lot of Chilostomella oolina are in the upper samples. This means sea bottom environment is a little change from at least 0.12Ma to recent.

The assemblages of Site U1412 are very similar to U1414. The differences are two biozones; one has a lot of Cibicidoides mackkannai, and the other has Brizalina bicostata. These species are originally on upper shelf, and that means these zones are allocated layers.

Main objective of this study in the Site U1413 is to understand the tectonic-induced submergence/ uplifting history or paleoslope instabilities in the upper slope area. Benthic foraminifera (BF) are a useful tool to estimate the past bottom-ocean environment. Based on benthic foraminiferal biostratigraphy of U1413, we have recognized the following four biozones for the sequence of past 2 million years and identified plausible slump mass came from the shallower-water environment

The BF divided into Group A (Zone I) is distributed on the lower continental slope in the modern equatorial Pacific. (Smith, 1963, 1964). Group B in Zone II is reported mainly from the lower to middle slope environment of the Pacific. Group C in Zone III is estimated to be distributed in the upper slope. Group D in Zone IV lives in the upper to middle slope as well as the drill site.

On the other hand, some shelf species such as Brizalina bicostata, Cibicorbis inflatus and Uvigerina incilis (Group E) occur throughout the sequence of the hole. Those species are, however, considered to be reworked specimens from shallower environment, because they co-occurred with deeper water species as Groups A to D, and because a similar occurrence has been reported in the Peru-Chile Trench area by Ingle and Kolpack (1980).

In Zone III, another species group composed of Brizalina spp., (Group C), which is distributed mainly in the upper slope areas in the modern oceans. Because Group C is not accompanied by Group D or other deeper-water species, the interval of Cores 17H-11H in Hole A apparently correspond to the upper continental slope, at least shallower than the depth of Group D. Also, the tests of Brizalina spp. are well-preserved in contrast to the co-occurred Group E. These results imply that Zone III is allocated Mass transported sediments, like a slump. This interpretation has been also supported by geochemical and logging data. The slump mass has been inferred at the interval between 45-150 mbsf based on the irregular profiles for organic matters and a fold structure plausibly formed by slumping. The slump mass might reflects the active subsidence due to tectonic erosion or passage of subducting seamount at the plate interface.

Keywords: benthic foraminifera, paleobathymetry, Subduction zone

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Limits and Habitability of the Deep Subseafloor Biosphere: New Insights from IODP Expeditions 329 and 337

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In the past decade, the Integrated Ocean Drilling Program (IODP) has offered unique opportunities to explore how life persists and evolves in ecosystems of the Earth interior. There are very few natural environments on surface of the Earth where life is absent; however, the limits to life are expected in the subsurface world. Processes that mediate genetic and functional evolutions of the deep subseafloor life may be very different to those in the Earth surface ecosystems. Previous studies of subseafloor sedimentary habitats demonstrated that activity of microbial communities is generally extremely low, mainly because of the limit of nutrient and energy supply. Nevertheless, microbial activity plays important ecological roles in biogeochemical element cycles over geological timescale.

In 2010, during Expedition 329, we explored limits and habitability of life in deep-sea sediments and basalts in the South Pacific Gyre, the largest oceanic province where surface chlorophyll concentrations and primary productivity in the gyre are lower than any other regions of the world ocean. In 2012, during Expedition 337, we also explored the deep subseafloor coalbed biosphere off the Shimokita Peninsula of Japan. Using riser system of the *Chikyu*, we successfully drilled, cored and logged down to the depth of 2,466 meters below the seafloor.

The IODP Expeditions 329 and 337 represent aerobic and anaerobic subseafloor microbial ecosystems on our planet, respectively, both of which realms have never been explored by previous scientific drilling; therefore, these provide unprecedented opportunities to address the issue of limits and habitability in the deep subseafloor biosphere. A variety of geophysical and geochemical properties, such as temperature, pH, pressure, salinity, porosity, and availability of nutrient and energy are conceivable to constrain biomass and activity of deep life and extent of the subseafloor biosphere. These are systematically investigated by international and multidisciplinary teams of the Expedition 329 and 337 scientists.

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Geophysical logging at the Shimokita IODP Expedition 337

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Research achievements using the geophysical logging data obtained at the Shimokita IODP expedition 337 would be presented.

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History of the Mediterranean Sea based on drilled core samples

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Mediterranean Sea has experienced an extreme event called Messinian Salinity Crisis (MSC) that represents a formation of gigantic evaporite deposits in deep basins. Although theis event has long been studied, a fundamental question whether the Mediterranean Sea was desiccated or not, still remains unsolved. In this presentation we review the recent achievements of the MSC. To understand hydrological conditions of the Mediterranean Sea during the Miocene-Pliocene, we report a series of Os isotopic record of marine sediment cores from four deep-sea drilling sites in the Balearic Basin, the Tyrrhenian Sea, the Ionian Basin and the Florence Rise, in comparison with the coeval sediments in North Atlantic. Osmium isotopic ratios of the pre-Messinian sediments in the western Mediterranean basin are almost identical to that of the coeval ocean water. In contrast, the pre-Messinian sediments in the eastern Mediterranean basin have significantly low $^{187}Os/^{188}Os$ values. This suggests that Os in the eastern Mediterranean was not fully mixed with western Mediterranean and North Atlantic, and that the basin isolation has already started much earlier than the MSC. The less radiogenic Os would have been supplied to the eastern Mediterranean by selective weathering of ultramafic rocks cropping out in the drainage areas, which contains high amount of non-radiogenic Os. The isotopic compositions of Os in gypsum and halite samples are significantly lower in eastern Mediterranean basins, compared with those of gypsum samples from the western Mediterranean basin, supporting the idea that limited exchange of seawater between eastern and western basins sustained also during the MSC. In all sites Pliocene sediments show more radiogenic Os isotopic ratios, which are close to the coeval oceanic values, indicating that Os started mixing with global seawater again.

Keywords: Mediterranean Sea, Messinian Salinity Crisis, osmium isotope

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Exp. 325 Great Barrier Reef Environmental Changes

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[1]Yusuke YOKOYAMA

The Great Barrier Reef is the largest coral reef in the world and a world heritage site. Integrated Ocean Drilling Program (IODP) Expedition 325 drilled fossil corals and obtained 225m of core materials from 42 to 167 m below sea-level. The site is suited for reconstructing paleo climate data because: 1) reconstructed sea-level data is relatively immune from isostatic effect since it is located at site far from former ice covered regions (far-field), 2) it locates in or near the Indo Pacific Warm Pool (IPWP) where paleo sea surface temperature (SST) data will constrain climate model strongly, and 3) the growth history of the reef since the LGM is to unlock a key factors for reef system response against environmental changes. Both sea level and climate data have been reconstructed by the science party and they provides new insights of the climate system. In this presentation, I will overview and introduce some key findings of IODP 325 GBR environmental changes (Yokoyama et al., 2011)

Reference: Yokoyama, Y. et al. (2011) ”IODP Expedition 325: Great Barrier Reefs Reveals Past Sea-Level, Climate and Environmental Changes Since the Last Ice Age” Scientific Drilling, 12, 32-45.

Keywords: Sea level change, Glacier, Last Glacial Maximum, Sea Surface Temperature, Coral, The Great Barrier Reef

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Determination of hydrocarbon gas in drilling mud and cores during Expedition 348 at the Nankai Trough, Japan

FUCHIDA, Shigeshi[1*] ; HAMMERSCHMIDT, Sebastian[2] ; EXPIDITION 348, Shipboard scientists[3]

[1]Osaka City University, [2]University of Bremen, [3]University of Wisconsin and others

The recent International Ocean Discovery Program (IODP) Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) Expedition 348 at Site C0002 drilled and cored successfully up to 3058.5 mbsf. During drilling and coring, hydrocarbon and other inorganic gas concentrations were monitored on board. Here, we will report the distribution and origin of the hydrocarbon gas in Holes C0002N (838 to 2330 mbsf) and C0002P (1954 to 3058 mbsf).

Methane, ethane, and propane concentrations in the headspace gas were measured by Geoservices and by using the scientific drilling mud gas monitoring system onboard D/V Chikyu. Total gas concentrations were dominated by methane, with the highest concentrations of up to 8% at around 1305 mbsf. Downhole gas concentrations steadily decreased to values <0.2 %. Ethane and propane were only present in minor concentrations, and higher homologues (i.e. n-butane, i-butane, n-pentane, i-pentane) stayed typically below 0.01 %. Below 2200 mbsf, ethane and propane increase steadily with depth. Bernard diagram (i.e. Bernard parameter vs. $d^{13}C_{CH4}$, Bernard et al., 1978) indicates that the gas in Hole C0002NP was gradually changed from biogenic to thermogenic with increasing depth.

Headspace gas samples from cores in Hole C0002P (2160-2220 mbsf) were all dominated by methane, with up to 23455 ppm. Methane concentration in the headspace gas samples was higher than the drilling mud gas samples at the same interval. This underestimation of methane in the drilling mud is due to the influence of drilling parameter (e.g. rate of penetration), mud properties (e.g. mud weight) and degassing efficiency.

Keywords: IODP, Expedition 348, Nantrosize, hydrocarbon

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MIS32-10 Room:416 Time:April 30 11:30-11:45

New approach for subsurface methanogenesis

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[1]JAMSTEC

Quantitative understanding of microbially mediated methanogenesis is important in biogeochemistry for many reasons; Firstly, methanogenesis plays an important role in the carbon cycle on the Earth mediating a terminal process of organic matter degradation and a major metabolic process in anoxic sediments. Secondly, methane produced by methanogens results in methane hydrate formation which is a potential energy resource, while methane released to the atmosphere acts as a greenhouse gas. Thirdly, since methanogens are primitive organisms, clarification of their distribution and environmental factors controlling their activity provides better understanding of subsurface biosphere and environmental constraints for early life.

Although quantitative understanding of distribution and activity of methanogens is requisite for better understanding of methane biogeochemistry, available techniques are restricted to address this issue. Particularly, it is difficult to quantitatively detect a signal of modern methanogenesis from deep marine sediment cores where methanogenic activity is low and complex mixture of organic matter is accumulated during a geologic time scale. However, if function-specific compound directly involved in the methanogenic reaction can be quantified, we would be able to extract information about distribution and activities of methanogens in the marine sediments.

Recently we developed analysis of coenzyme F430. Since F430 catalyzes a terminal step of methanogenesis and possessed by all methanogens, it should be a good biomarker for methanogenesis. High sensitive detection of F430 by LC-MS/MS (sub-femto mol level) allows to detect F430 in marine sediment. We will present the developed methodology and application to sediment core samples.

Keywords: coenzyme F430, methanogenesis, LC-MS/MS, marine sediment

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Lake drilling in Japan: Biwa and Suigetsu

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Lake drilling is an important subject of the International Continental Scientific Drilling Program (ICDP), where several projects were implemented in ancient-type lakes utilizing the GRAD200 and GRA800 systems. However, proposals for attempting lake drilling in Japan have not been submitted to ICDP so far. In 2002, an ICDP workshop, entitled ”Lake Biwa and Lake Suigetsu: Recorders of Global Paleoenvironments and Island Arc Tectonics” was held in order to assemble an international team and prepare a full proposal. Subsequently, piston coring and deep drillings were made in Lake Biwa supported by the grant-in-aid from Monbusho. Studies of these core samples are now ongoing in various disciplines including sedimentlogy, paleomagnetism, organic and inorganic chemistry, and radiocarbon dating. In Lake Suigetsu, an international collaborative research has been carried out aiming to provide a high-resolution paleoenvironmental record of the East Asian monsoon. It also contributed toward establishing a purely terrestrial radiocarbon calibration model, based on analysis of the annually laminated sediment. As the next step of the current researches in Lake Biwa and Lake Suigetsu, we expect a new drilling project targeting a 250-m thick continuous clay member of the Lake Biwa sediments.

Keywords: ICDP, Lake drilling, Lake Biwa, Lake Suigetsu

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How the stress state changes with time in and aroud faults

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[1]NIED

It is an important factor for forecast a future earthquake how the strength of a fault plane is recovered and how the stress in and around the fault plane accumulate during an earthquake cycle. However, it is difficult to inspect the time variation of stress state in and around a faults in the field because the period of an earthquake cycle is very long. I introduce examples to be concerned with time variations of stress states by downhole in-situ stress measurement (Ikeda et al., 1996a; Ikeda et al., 1996b; Ikeda et al., 2001; Tsukahara et. al., 2001; Omura et al., 2004; Yamashita et al., 2004; Hickman and Zoback, 2004; Lin et al., 2007; Yabe et al., 2010; Yamashita et al., 2010; Yabe and Omura, 2011; Kuwahara et al., 2012; Ito et al., 2013; Lin et al., 2013). Those examples indicade that stress increases since after an earthquake toward the next earthquake. However, it is not clear whether the stress increase linearly with time, or change largely just after an earthquake, or increase rapidly just before the next earthquake. We need repeated measurements of in-situ stress to detect directly a time variation of stress state in and around a fault after an earthquake.

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Keywords: stress, fault, in-situ measurement, hydraulic fracture, borehole breakout, downhole measurement

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Physicochemical process during earthquake slip: An example from the TCDP

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Several fault-drilling projects have been conducted with the common aim of seeking direct access to zones of active faulting and understanding the fundamental processes governing earthquakes and fault behavior, as well as the factors that control their natural variability. Here, we review recent scientific drilling project on the the Chelungpu Fault which slipped during the 1999 Taiwan Chi-Chi earthquake. One of the main findings of fault-drilling research is a better understanding of the physicochemical processes of the primary slip zone during an earthquake, which is closely related to the mechanism of dynamic fault weakening. In the case of the Chelungpu fault, integrated research with borehole experiments, core sample analyses, and numerical simulations were performed, and the results indicate that thermal pressurization occurred during the 1999 earthquake, explain ing the peculiar seismic behavior during the earthquake. Such fault-drilling project related to active fault certainly improve our knowledge and understanding of earthquakes.

Keywords: Onland fault drilling, Active fault

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Deep Fault Drilling Project, Alpine Fault, New Zealand

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The Alpine Fault is mature (>460 km offset), active (25 mm/yr), and late in its seismic cycle. It ruptured in AD 1717, has a 330 yr return time, and M8 earthquake probability is c. 30% in the next 50 yrs (Berryman et al. 2013). The objective of the Deep Fault Drilling Project (DFDP) is to collect materials, measure ambient conditions, and monitor at depth on the Alpine Fault, to understand earthquake processes and the formation of a continental orogen.

Pilot drilling (DFDP-1) was completed in 2011. Two boreholes were drilled, wireline geophysical loggings collected, and observatory installed. The followings were revealed as Initial results. A low-permeability alteration zone overprints the boundary between fault core and damage zone. The alteration zone significantly affects physical properties and likely evolves during the seismic cycle. There is a fluid pressure step of 0.53 MPa across the fault at 128 m depth, and probable greater difference at greater depth. Geothermal gradient is 63 +/- 2 C/km. Physical properties are highly asymmetric, suggesting a possible (northeastward) preferred rupture direction.

Planning is now underway for the next phase of drilling (”DFDP-2”), which is scheduled to start in 2014. The target total depth (TD) is 1.3 km, with contingency to reach 1.5 km. We drill, sample, and monitor the Alpine Fault to address fault zone evolution via brittle and ductile processes operating in the upper and mid-crust in this novel experiment.

Keywords: Fault zone drilling, the Alpine Fault, Earthquake processes, Brittle and ductile processes

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An Overview of IODP Expedition 346: Asian Monsoon

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In IODP Expedition 346, Joides Resolution (JR) started her cruise from Valdez,Alaska on August 2nd, sailed all the way to the Japan Sea/East Sea (JS/ES), drilled 7 sites in the JS/ES and 2 sites in the northern East China Sea (ECS), and ended her cruise at Pusan, Korea on September 28th. During six weeks of drilling, we recovered 6135.3 m of core, with an average recovery of 101%, which is a record of IODP. The expedition was originally aimed to test the hypothesis that Plio-Pleistocene uplift of Himalaya and Tibetan Plateau (HTP) and/or emergence and growth of the northern hemisphere ice sheets and consequent establishment of the two discrete modes of westerly jet (WJ) circulation is the cause of the millennial-scale variability of the East Asian summer monsoon (EASM) and amplification of the Dansgaard-Oeschger cycles (DOC). The expedition is also aimed to test the hypothesis that surface and deep water conditions of the JS/ES has been controlled by the nature and strength of the water influx through the Tsushima Strait which are strongly influenced by EASM precipitation, eustatic sea level changes, and EAWM cooling.

In order to explore the linkage between WJ circulation and EASM precipitation, it is critical to obtain high-resolution, continuous sedimentary records that preserve proxies of both WJ and EASM. In this respect, the JS/ES is ideal because its hemipelagic sediments contain significant amount of the eolian dust transported from East Asia by the WJ, and alternations of dark and light layers that characterize Quaternary sediments of the sea record variations of EASM precipitation over South China (Tada et al., 1999). Sites are also arranged along the north-south transect to monitor the behavior of the WJ. The sites are arranged to make the depth transect to monitor the behavior of deep water through changes in calcium carbonate compensation depth and bottom water oxygenation level. Northern East China Sea is ideal to monitor changes in EASM precipitation because its surface water salinity and temperature during summer is significantly influenced by the discharge of the Yangtze River whose drainage area covers the majority of the South China where EASM precipitation is most intense (Kubota et al., 2010).

Because of recent advances in drilling technology and newly developed analytical tools, we were able to collect and examine sediment records that were impossible to acquire even a few years ago. The newly engineered half piston core system (called the half APC) enabled us to recover the deepest piston core in DSDP/ODP/IODP history (490.4 m in Hole U1427A). That achievement was also the deepest continuously recovered piston cored sequence, initiated at the mudline and penetrating to the ˜500 m depth solely by piston coring. These technological advances delivered a series of new surprises. Examples are pristine dark?light laminae from ˜12 Ma sediment recovered by piston core from 410 m core depth below seafloor, Method A [CSF-A] at Site U1425 and from 210 m CSF-A at Site U1430.

Through this expedition, we collected the geological evidence necessary to test the hypotheses described above through drilling in the JS/ES and northern part of the ECS, and are trying to 1) specify the onset timing of orbital and millennial-scale variability of EASM, EAWM and WJ and reconstruct their evolution process and spatial variation patterns, and 2) reconstruct orbital and millennial-scale paleoceanographic changes in the JS/ES to clarify the linkage between the paleoceanography of the JS/ES and EASM, EAWM and/or sea level. Comparison of the obtained results with the uplift history of HTP and/or ice volume changes will enable us to test the hypotheses.

Keywords: IODP, Expedition 346, Japan Sea/East Sea, East China Sea, Dansgaard-Oeschger Cycle, East Asian Monsoon

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MIS32-16 Room:416 Time:April 30 14:30-14:45

Sediment cores recovered from the Sea of Japan/East Sea during IODP Expedition 346 and preliminary result of foraminifer

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Integrated Ocean Drilling Program (IODP) Expedition 346 (29 July?27 September 2013) recovered 6135.3 m of core from seven sites in the Sea of Japan/East Sea and two adjacent sites in the East China Sea. One of the objectives of this expedition is to explore the orbital- and millennial-scale variation and evolution of the East Asian monsoon and its impact on the paleoceanography in the Sea of Japan/East Sea. We recovered centimeter- to meter-scale alternation of dark and light layers in the Pleistocene sediments that could be correlated across the six sites in latitudinal and depth transects of the Sea of Japan/East Sea (U1422?U1426 and U1430), suggesting that the Sea of Japan/East Sea responded as a single system to climatic and/or oceanographic perturbations. Sediments of shallower sites (U1426: 903 mbsl and U1427: 330 mbsl) contain well preserved calcareous fossils and are expected to provide high-quality oxygen isotope stratigraphy that will be a key age controls for the entire region. In particular, high sedimentation rate (˜36 cm/kyr) and a complete splice down to ˜400 m at Site U1427 make it possible to produce centennial-scale continuous records in shallow water environments for the last ˜1.2 Ma. We conducted preliminary oxygen and carbon isotope analyses of benthic and planktonic foraminifera for core catchers from Site U1427A (87 samples). The oxygen isotope variations correspond to lithological change alternating low isotope values in darker clay-rich and high values in light biogenic component-rich sediment and therefore show similar variation to physical properties of the sediment, such as bulk density, magnetic susceptibility, natural gamma ray, and color reflectance. These results confirm high potential of this site for paleoceanographic investigation in orbital, millennial, and centennial timescales.

Expedition 346 Scientists:
Anderson, W., Bassetti, M-A., Brace, B., Clemens, S., Dickens, G., Dunlea, A., Gallagher, S., Giosan, L., Gurgel, M., Henderson, A., Holbourn A., Ikehara, K., Irino, T., Itaki, T., Karasuda, A., Kinsley, C., Kubota, Y., Lee, G-S., Lee, K-E., Lofi, J., Lopes, C., Peterson, L., Saavedra-Pellitero, M., Singh, R., Sugisaki, S., Toucanne, S., Wan, S., Xuan, C., Zheng, H., and Ziegler, M.

Keywords: IODP, Expedition 346, Asian Monsoon, Sea of Japan/East Sea

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Preliminary results from shipboard research during IODP Expedition 341 (Alaska Tectonics, Climate and Sedimentation)

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The North American Cordillera is an active orogen, which in the Pleistocene is, at times, covered by the Cordilleran Ice Sheet. Ice sheet dynamics are likely impacted by global climate and likely enhanced the erosion in the Cordillera. The melt water discharge to the ocean may play an important role in the rich ecosystem in the Gulf of Alaska by delivering nutrients. In the modern Gulf of Alaska, a rich diversity of marine microorganisms is associated with the seasonal nutrient supply derived from glacial melt water. Continuous paleoceanographic reconstruction by marine microfossils (radiolarians, diatoms, foraminifers etc.) can provide the history of the nutrient supply that may be associated with ice sheet dynamics and glacial runoff into the Gulf of Alaska.

Since the late Miocene, ice sheets formed on the North American continent and intensified around 2.5 Ma during Northern Hemisphere glaciation, which had a strong impact on global and regional environments. On the other hand, the large ice sheet may also have enhanced the erosion process in the higher latitudes and supplied terrigenous inputs such as glacial sediments to the coastal zone. Therefore, it is expected that the sediments in the Gulf of Alaska have recorded directly the history of the Cordillera ice sheet formation and erosion process since the Neogene. In this background, the Integrated Ocean Drilling Program (IODP) Expedition 341 held between May to July 2013, targeted this high-resolution sediment record from late Cenozoic in order to investigate the relevance of climate change in the North Pacific Ocean and the erosion process of Cordilleran glaciers. The drilling was conducted from deep-sea fan to continental shelf occupied by glaciers during glacial expanses.

According to preliminary ship-board results, the sediments recovered during this expedition record paleoceanographic changes in the Gulf of Alaska since the late Miocene and extremely high sedimentation rates which could be one of the greatest achievements in this expedition. In addition, microscopic observation, organic and inorganic chemical analysis and measurement of the physical properties suggest that a large amount of the terrestrial sediments have been transported. A large amount of glacial sediments (ice-rafted debris) have been also recorded. Although it was expected that calcareous microfossils are poorly preserved in this area, the sediment samples obtained in this cruise contained a continuous and rich foraminifera record which will allow the establishment of a long continuous oxygen isotopic curve. Siliceous microfossil and p-mag analyses enable the building of firm chronostratigraphy when combined with the oxygen isotopic curve. Under this well-constrained age determination, other chemical/physical/biological investigations will be done and then we will clarify the paleoenvironmental fluctuation that is unprecedented in the North Pacific.

Keywords: IODP Exp. 341, Gulf of Alaska, land/ocean paleoenvironment, Glacier

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MIS32-18 Room:416 Time:April 30 15:00-15:15

IODP Exp. 345: The first sample of primitive layered gabbros from fast-spreading lower oceanic crust

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Three-quarters of the ocean crust formed at fast-spreading ridges is composed of plutonic rocks whose mineral assemblages, textures and compositions record the history of melt transport and crystallization between the mantle and the seafloor. However, owing to the nearly continuous overlying extrusive upper crust, sampling in situ the lower crust is challenging. Hence, models for understanding the formation of the lower crust are based essentially on geophysical studies and ophiolites. Integrated Ocean Drilling Program (IODP) Expedition 345 recovered the first significant sections of primitive, modally layered gabbroic rocks from the lowermost plutonic crust formed at a fast-spreading ridge, and exposed at the Hess Deep Rift (Gillis et al., Nature, 2014, doi:10.1038/nature12778).

Keywords: layered gabbro, oceanic lower crust, Hess Deep, fast-spreading ridge, East Pacific Rise, primitive gabbro

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Results of Previous Drilling on Cretaceous Oceanic Plateaus and Future Outlook

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Oceanic plateaus, reach volumes of several 10^6 to several 10^7 km^3, are characterized by anomalously high rates of mantle melting that represent the largest volcanic events in the Earth's history. There is currently a lively debate about the oceanic plateau volcanism: whether they are built by plume heads from the lower mantle, changes in plate stress, or even meteor impacts. One difficulty with their research is that several of oceanic plateaus (e.g., Kerguelen Plateau) were erupted on remnants of continents where assimilation of continental lithosphere can obscure the primary mantle signature of the lavas. In contrast, Cretaceous oceanic plateaus in the western Pacific (Ontong Java Plateau, Shatsky Rise, and so on) have no effect of the crustal assimilation, permitting its primary origin in mantle to be resolved. The time of productions of the western Pacific plateaus coincides with increases in climate warming, resulting oceanic anoxic event, and eustatic sea level change; and therefore, its origin receives attention from paleo-environment aspects, too. It is proposed that the western Pacific plateaus were formed by the upwelling of very large plume head of mantle material, superplume, that erupted beneath the Pacific basin (Larson, 1991, *Geology*, 19, 547-550). The present-day South Pacific superswell is probably the nearly exhausted remnant of the original upwelling. Moreover, the remnant of the superplume is likely detected by seismic data (e.g., Suetsugu *et al*., 2009, *Geochem Geophys Geosyst* 10, Q11014).

The plume head phenomenon occurs naturally in numerical and laboratory experiments, but there is currently no unequivocal geological evidence proving that a starting plume head in convecting mantle has operated with Earth. Thus several alternative explanations (described above) or more complex plume head models are proposed to explain origin of the oceanic plateaus.

To test the plume head model, petrological and geochemical data from igneous rocks are important. Although a small number of dredges have recovered basalts from the western Pacific plateaus, almost of all such samples were highly altered. The best way to obtain fresh samples is by drilling of holes. Thus, operations during Ocean Drilling Program (ODP) Leg 192 and Integrated Ocean Drilling Program (IODP) Expedition 324 drilled Ontong Java Plateau and Shatsky Rise, respectively, seeking evidence that would test the plume head hypothesis (Mahoney *et al*., 2001, *Init Rep ODP*, 192; Sager *et al*., 2010, *Proc IODP*, 324). Based on drilling of several holes in the oceanic plateaus, both expeditions have extended our knowledge of the compositions and origin of the plateaus magmas considerably. However, both expeditions uncovered complications that do not fit the simple model, so debate over plume head hypothesis continued.

One of the main reasons for the previous failure to test the plume head model is that the previous drilling holes in the oceanic plateaus were too thin; only $<$300 m basement lavas were recovered among the thick oceanic plateaus ($>$30 km). The information of such thin drilling holes is difficult to evaluate the plume head model that is proposed by numerical and laboratory experiments. The laboratory experiments of "thermo-chemical" plumes containing both thermal and chemical density anomalies are characterized by a strong time-dependence and could develop for mantle density anomalies lower than 2% (e.g., Kumagai *et al*., 2008, *Geophys Res Lett*, 35, L16301). Such thermal or chemical density anomalies would be detected by geological researches of long drilling cores (e.g., ˜3000 m basement lavas which construct ˜10% of total thickness of the oceanic plateaus). To date, such long cores were difficult to recover, but a riser drilling vessel Chikyu has made drilling $>$3000 m basement lavas technically feasible.

Keywords: oceanic plateau, large igneous province, plume, magma genesis

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MIS32-20 Room:416 Time:April 30 15:30-15:45

Recent progress in paleo- and rock magnetism and its applications produced by IODP

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Paleomagnetists have sailed most of the IODP expeditions, and greatly contributed to the achievement of the aims of individual expeditions. At the beggining of the new phase of IODP, I will review progress in paleomagnetism and rock magnetism and their applications produced by IODP for the last about 10 years.

Results of the two IODP coring programs, one in the North Atlantic (Exp. 303/306) and the other in the east equatorial Pacific (Exp. 320/321), greatly improved our understanding of the past geomagnetic field variations. High-resolution paleointensity records during the Pleistocene with precise age control were obtained from North Atlantic drift sediments. These records led the establishment of the PISO-1500 paleointensity stack, which is now used as the standard curve for paleointensity-assisted chronostratigraphy. Detailed records of polarity reversals and excursions were also obtained. From the equatorial Pacific sediment cores, continuous Miocene to Eocene relative paleointensity records were obtained for the first time, although resolution is not high. Previously, continuous paleointensity records were available only for the last ca. 3 m.y. No discernible relation between paleointensity and polarity length was recognized, despite that a weak positive correlation was suggested previously. On the other hand, volcanic rocks from seamounts (Exp. 330) and oceanic plateau (Exp. 324) were utilized for obtaining absolute paleointensity in the Mesozoic.

Rock- and paleomagnetism was applied to resolve various geological and geophysical problems in IODP. First of all, paleomagnetism contributed progress in the mantle dynamics; paleomagnetic inclinations revealed that the Louisville hotspot did not move in concert with the Hawaiian hotspot (Exp. 330), which is known to have shifted southward about 15 degrees between about 80 and 50 Ma. Magnetic techniques such as the anisotropy of magnetic susceptibility were successfully utilized for studying subduction zone dynamics (NanTroSEIZE, CRIPS). Rock magnetic techniques become widely used in paleoceanographic and paleoenvironmental applications. It was recently revealed using IODP cores that biogenic magnetite prevails in marine sediments (e.g., Exp. 320/321 and 329). Its role to remanent magnetization acquisition processes and potential applications to paleoceanography are attracted attention.

Keywords: paleomagnetism, rock magnetism, IODP, paleointensity

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MIS32-21 Room:416 Time:April 30 16:15-16:30

Chikyu logging review in IODP and future of well logging in scientific drilling

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[1]JAMSTEC

It has passed seven years since Chikyu joined the IODP expeditions. There were many expeditions where well logging were conducted: NanTroSEIZE exp314 in 2007, expeditions 319 and322 in 2009, exp332 in 2010, exp338 in 2012-2013, exp348 in 2013-2014; Japan trench fast drilling project (J-FAST) exp343 in 2012; Deep coalbed biosphere off Shimokita exp337 in 2012. The total logged length on Chikyu during IODP Expeditions are 26.2 km in the seven years period. Well logging has increased its importance in science and operations. The reasons are 1) sensor and technological innovation brings more geological and geophysical information, 2) spot or partial interval coring in combination of logging-while-drilling and mudlogging is best option in deepwater expeditions, and 3) need of LWD real time data in decision making for precise location of observatory installation and spot coring. Riser drilling by Chikyu improves hole condition by means of drilling fluid control, which improves logging data quality, and its large hole diameter bring us more selections of tools, measurements, and downhole experiments.

The logging companies have been developing new measurement, higher accuracy and resolution tools. For example, resisitivity image tools have wider azimuthal coverage and higher resolution, which helpto deeper geological interpretations and breakout analysis. The new sonic tool improves accuracy of velocity in soft sediment and more availability of measurement in shear velocity.

With accessing deeper, more challenging management of time (coring is a time consuming operation),combination of spot coring in the most interesting interval and continuous logging may be one of solutions under limited cruise schedule.

Realtime LWD data acquisition and interpretation were required to install observatory at proper depth. Current LWD technology sends more data to surface, which helps to understand the lithology in real time.

To use large diameter of riser pipes brings us a lot of advantages against lowering logging tools through small drill pipes. Proper tool size and sensor position in the borehole improve data quality. Increasing of tool selection brings more variety of measurement and experiment. FMI resistivity borehole imager covers more image area of borehole wall. Pressure test by dual packer and fluid sampling were available with large diameter tools.

Logging activities and results by Chikyu as part of IODP (2003-2013) will be reviewed and discuss its potential, role, and challengs in the future scientific drilling.

Keywords: logging, Chikyu, IODP

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Mud logging for scientific drilling on D/V Chikyu: results of the past riser operations in the 1st phase IODP

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[1]CDEX/JAMSTEC

Mud logging has been a key technology for scientific drilling operation by D/V Chikyu. In order to penetrate into deeper formation by riser drilling, full-coring operation to targeted total depth is difficult due to taking much operation time. Therefore mud logging obviously contributes to acquiring continuous geological and geochemical data from formation and circulating fluid in formation to targeted total depth. In the IODP 1st phase, riser drilling operations with mud logging were conducted 4 times by the Chikyu (Expeditions 319, 337, 338, and 348). In this paper, we highlight some results of mud logging operated in the past operation and discuss on technical challenging for future riser operations by the Chikyu.

Mud logging is roughly composed of three components, lithological logging on cuttings, mud gas monitoring, and mud circulation/drilling parameters monitoring. As well known, cuttings lithology logging and mud gas monitoring are important tool to understand geological characteristics beneath drilling site based on results of not only the IODP riser operations by the Chikyu but also ICDP onshore drilling projects (e.g., Unzen and SAFOD). However, potential of mud circulation and drilling parameters monitoring associated with cuttings and mud gas analyses has not been discussed in detail in scientific drilling community. d-exponent is an indicator to detect zone of high pore pressure during drilling and it is well developed in the petroleum industry. d-exponent is defined as normalized rate of penetration (ROP) with rotation speed (RPM) and weight on bit (WOB), and in general case, d-exponent gradually decreases as entering into high pore pressure zone increasing ROP. During Expedition 348, we often faced formation with difficulty of drilling, and supposed there was relatively higher pore pressure zone based on the d-exponent analysis. In this presentation, we will discuss on comprehensive mud logging data analysis including data of d-exponent acquired in the past riser drilling operation and assess its potential for future expeditions.

Keywords: D/V Chikyu, IODP, Mud logging, Cuttings, Mud gas monitoring, Scientific drilling

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Downhole Logging Data Acquisition and Integration: Changing Tactics in the IODP and Its Future Direction

MOE, Kyaw[1] ; KIDO, Yukari[1*] ; SANADA, Yoshinori[1]

[1]CDEX-JAMSTEC

Since the initiation of IODP in 2003, three drilling platforms, Chikyu, JOIDES Resolution (JR) and Mission Specific Platform (MSP), operated at various environments of global locations using varieties of new techniques. Overcoming many difficulties, longest serving ship JR reached the maximum time in operations with 32 expeditions even ship was modified in dock for 38 months, new riser ship Chikyu with 13 expeditions, and MSP with 5 expeditions. Varying in their capabilities, JR expeditions covered most global areas and research themes where MSP and Chikyu expeditions were targeted to the most challenging and extreme environments. Further addition of riser technology and very shallow locations for MSP brought wider choice of new logging and coring tools, rigfloor parameter, and very high-resolution slim-hole logging tools.

In the downhole logging data acquisition, JR continued her standard set of basic wireline logging with best cost and performance factor but MSP and Chikyu were used expedition/project specific measurements with higher cost and better technology. For the new challenges in the various IODP expeditions, things changed from the previous program were new tools and better measurements, data integration applications and facilities, increased staffing for science support.

Those new techniques covering laboratory and downhole measurements, extended widely in measurement types and improved their capability and efficiency in data integration and onsite decision making. All these large volume of data with wider choice of software further enhanced the integrated studies like cuttings/core-log-seismic integration for the very deep-riser holes.

In this talk, dowhhole measurements data acquisition and wider data integration in the IODP will be summarized, operational-technical-scientific highlights and lessons will be reviewed, and future direction will be discussed.

Keywords: IODP, Logging, Data Integration, Chikyu, JOIDES Resolution, MSP

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MIS32-24 Room:416 Time:April 30 17:00-17:15

Overview of IODP drilling in Izu-Bonin-Mariana arc

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What is raw and juvenile continental crust? Furthermore, how does it form and evolve into mature continental crust? The continental crust we observe on the surface of the earth has been deformed, metamorphosed, and otherwise processed perhaps several times from its creation in subduction zones to the present.

Although there are many examples of accreted arc crust on the margins of continents, during- and/or post-collision geochemical changes are widespread, and we do not have the ability to observe active crust-forming processes in modern arcs except by what we can infer from eruptions at the surface, and by remote sensing of arc interiors. ULTRA-DEEP DRILLING INTO ARC CRUST is the best way to sample unprocessed juvenile continental-type crust, to observe these active processes that produce the nuclei of new continental crust, and to examine the nature of juvenile continental crust as first generated at intra-oceanic arcs.

Key questions for comprehending arc crust formation are: (1) What is the nature of the crust and mantle in the region prior to the beginning of subduction? (2) How does subduction initiate and initial arc crust form? (3) What are the spatial changes of arc magma and crust composition of the entire arc? (4) How do the middle arc crust evolve? Possible strategies for answering these questions include drilling by IODP at the Izu-Bonin-Mariana (IBM) arc system. IODP has proposals to drill at the IBM, including three non-riser holes (IBM-1, IBM-2 and IBM-3) and one riser, ultra-deep hole (IBM-4), which answer these questions, respectively, and the four drillings result in comprehensive understanding of the arc evolution and continental crust formation. Drillings by Joides Resolution at three sites (IBM-1, IBM-2 and IBM-3) are scheduled in 2014. This presentation will give an overview of these 3 cruises and their perspectives.

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Tsunami deposits sciences as geohazard research program of ICDP

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Tsunamis initiated by the 2004 Indian Ocean earthquake (Mw 9.1?9.3) and the 2011 Tohoku-oki earthquake (Mw 9.0) have provided recent demonstrations of the widespread catastrophic damage and loss of life that can be caused by mega tsunamis. Mega tsunamis have dramatic impacts on geological processes as well as on human societies. Large-scale erosion and the mass transport of sediments by tsunamis cause rapid environmental change and biological turnover in coastal areas. Mega tsunamis leave evidence of their passage in the geological record on a time scale far beyond human memory.

Over geological time, mega tsunamis have been caused by events such as subduction-zone earthquakes, volcanic eruptions, landslides (on land and submarine), and meteorite impacts. Large submarine collapses of gas-hydrate-bearing sediments may also have caused mega tsunamis. These facts demonstrate that the risk of catastrophic tsunamis is not limited to active tectonic margins. Although the frequency of these catastrophic events is low compared to a human lifetime, there is no telling when and where the next events will occur.

The 2004 and 2011 events, and the recognition that mega tsunamis have occurred many times on both historical and geological time scales, have prompted international efforts to better understand the hazards associated with tsunamis and to design disaster control strategies at regional and global levels. The foundation on which mega-tsunami risk management is built is hazard assessment, including knowledge of the location, frequency, and magnitude of past events. This basic research leads to a better understanding of the dynamics of geological and biological evolution in coastal regions. Historical documents provide important information for regional analysis of past tsunamis, but their value is limited by the short length of the historical record. Studies of tsunami deposits provide a useful means of extending the length of those records onto a geological time scale.

To solve the above mentioned problems and aim at further development in these study field, following research programs are prospected.

Understanding past mega tsunamis from geological records.

+ Mega tsunami events during earth history.

+ Mega tsunami impacts through human history.

Global coordination of research to develop an inventory of tsunami deposits

+ Catalogue of mega tsunamis (size, source, age) at plate subduction zones.

+Catalogue of mega tsunamis (size, source, age) for island countries that have suffered far-field effects of mega tsunamis.

Outreach to and nurturing of young scientists in the field of tsunami geology

Keywords: Tsunami deposit, Geohazard, Continental drillig

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Japan Beyond-Brittle Project

ASANUMA, Hiroshi[1*] ; TSUCHIYA, Noriyoshi[2] ; ITO, Hisao[3] ; MURAOKA, Hirofumi[4]

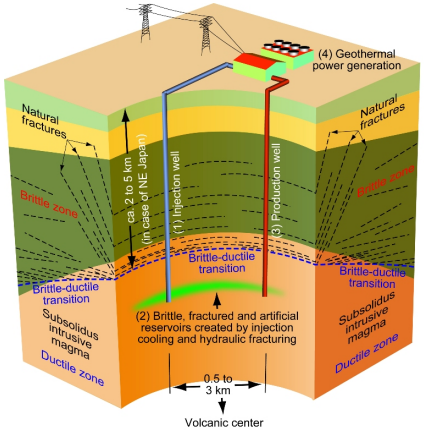
[1]AIST, [2]Tohoku University, [3]Independent Scientist, [4]Hirosaki University

New conventional geothermal energy projects have not been actively promoted in Japan for the last decade because of perceptions of high relative cost, limited electricity generating potential and the high degrees of uncertainties and associated risks of subsurface development. More recently however, EGS (Enhanced Geothermal System) geothermal has been identified as a most promising method of geothermal development because of its potential applicability to a much wider range of sites, many of which have previously been considered to be unsuitable for geothermal development. Meanwhile, some critical problems with EGS technologies have been experimentally identified, such as low recovery of injected water, difficulties in establishing universal design/development methodologies, and the occurrence of induced seismicity, suggesting that there may be limitations in realizing EGS in earthquake-prone compression tectonic zones.

We propose a new concept of engineered geothermal development where reservoirs are created in ductile basement. This potentially has a number of advantages including: (a) simpler design and control of the reservoir, (b) nearly full recovery of injected water, (c) sustainable production, (d) lower cost when developed in relatively shallower ductile zones in compression tectonic settings, (e) large potential quantities of energy extraction from widely distributed ductile zones, (f) the establishment of a universal design/development methodology, and (g) suppression of felt earthquakes from/around the reservoirs.

To further assess the potential of EGS reservoir development in ductile zones we have initiated the ”Japan Beyond-Brittle Project (JBBP)”. It is intended that the first few years of the JBBP will be spent in basic scientific investigation and necessary technology development, including studies on rock mechanics in the brittle/ductile regime, characterization of ductile rock masses, development of modeling methodologies/technologies, and investigations of induced/triggered earthquakes. We expect to drill a deep experimental borehole that will penetrate the ductile zone in northeast Japan after basic studies are completed. The feasibility of EGS reservoir development in the ductile zone will then be assessed through observations and experimental results in the borehole. An ICDP supported workshop on JBBP has been held March 12-16 in Sendai, Japan, where feasibility, necessary breakthroughs, and roadmap has been discussed from scientific and technological points of view.

Keywords: Geothermal, Brittle-ductile transition, EGS



Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

MIS32-27 Room:416 Time:April 30 17:45-18:00

Expectations for the new decade of drilling science

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What kind of roles the 'drilling science' should undertake? This presentation proposes directions of 'drilling science' in the coming decades, to bridge the three methods to explore subsurface; exploration geophysics, drilling technology and usage of boreholes, and geology as material science.

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MIS32-P01 Room:Poster Time:April 30 18:15-19:30

Hydraulic properties and pore structure of the sedimentary rocks at Site C0020, IODP Expedition 337 in Sanriku-oki basin

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Microbial biomass in the ocean sediments is controlled by physical, chemical and biological factor and conditions. The biomass in sediments reduces with increasing depth, and the limit of life and the reduction rate of biomass is partly controlled by physical conditions because lithification and diagenesis of oceanic sediments induce reduction of porosity, permeability and pore size. However the relationship between biomass and physical property for deep oceanic sediments is not well known. Therefore, in this study, a series of physical property measurements (Water potential, permeability and porosity) were conducted on the sediment cores at site C0020 from IODP expedition 337 and at site 902 from the Chikyu shakedown cruise (CY06-06) in Sanriku-oki basin. We measured water potential under atmospheric condition and permeability under confining pressure up to 40 MPa. Then we estimated the correlation between water potential and microbial biomass in the sediments.

Keywords: permeability, water potential, water activity, off-Sanriku basin, IODP expedition 337, biomass

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MIS32-P02 Room:Poster Time:April 30 18:15-19:30

Coring disturbances with the riser drilling system of the D/V Chikyu during IODP Exp. 337 off Shimokita, Japan

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Coring disturbances were observed using the riser drilling system of the D/V Chikyu during IODP Exp. 337 off Shimokita, Japan. Injections of drilling mud and fluid with high density and pressure used in riser drilling during Expedition 337 caused complications to visual core observations. Semiconsolidated materials were commonly observed in this Hole, and drilling mud often easily penetrated the semiconsolidated sandstones and siltstones, causing possible false lamination structure in the cores, which might be misinterpreted as natural sedimentary structure preserved in the cores. Here, we report various kind of coring disturbances which were observed on board with riser drilling system.

Keywords: Coring disturbance, riser drilling, IODP, Exp. 337

Japan Geoscience Union Meeting 2014
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MIS32-P03 Room:Poster Time:April 30 18:15-19:30

Lithology and XRF analysis data 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 present the 160 XRF data and lithology of sediments and paleoenvironments from drilling Site C0020, IODP Expedition 337. 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 this region.

Keywords: Lithology, XRF, IODP, Exp.337

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MIS32-P04 Room:Poster Time:April 30 18:15-19:30

Structural characteristics of Nankai accretionary prism at C0002: Preliminary results from IODP Expedition 348

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[1]JAMSTEC, [2]AIST, [3]SCRIPS, [4]University of Granada, [5]IODP Expedition 348

Integrated Ocean Discovery Program (IODP) Expedition 348 has deepened hole down to 3058.5 mbsf at Site C0002, and collected cutting and core samples of Upper Miocene Nankai accretionary prism. The structural key observation made on cuttings in Holes C0002N and C0002P, and cores retrieved in Hole C0002P are:

a) The structures observed in intact cuttings include slickenlined surfaces, scaly fabric, deformation bands, minor faults and mineral veins. Slickenlines are observed throughout the whole interval, but scaly fabric is increasingly observed below ˜2200 mbsf. The other types of structures are scattered throughout the whole section.

b) The cored interval is characterized by steep bedding planes (more than 75?). A fault zone, 90 cm in thickness, with a few mm-size angular clasts is present in one of the cores (2204.9?2205.8 mbsf). In its present position, the brittle fault zone is associated with a normal faulting sense. It is unclear if this represents an early thrust rotated after its development or late normal fault.

c) SEM images in the upper part of Hole C0002N show little evidence for opal diagenesis, implying T<60?80 ℃ at 1225.5 mbsf. In Hole C0002N, the fabric lacks a strongly preferred orientation in clay-rich materials, except along striated micro-faults formed by clays. These zones are extremely localized with a thickness of a few microns or less. In Hole C0002P, below 2200 msbf, SEM images show the development of a regularly spaced fabric in sandstones, constituted by thin (<0.1?1 um), clay-dominated shear planes. Towards the base of the hole, below 2625 mbsf, compaction fabrics in clay?rich materials can be observed. Very thin shear zones with almost no wall damage zone have cut this fabric.

The overall character of the deformation (independent particulate flow with limited evidence for cataclastic deformation) is suggestive of that deformations occurred in a relatively shallow environment (approximately 0?4 km in burial depth).

Keywords: Expedition 348, C0002, Fault zone, Core, Cuttings

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MIS32-P05 Room:Poster Time:April 30 18:15-19:30

Seismic reflection survey investigating subduction inputs at the Sagami Trough

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The Sagami Trough is a plate convergent zone of the Philippine Sea Plate underneath the NE Japan including the Kanto area. Varied seismic events occurred associated with the plate convergence. Maginitude (M) 8-class earthquakes, for example 1703 Genroku and 1923 Taisho-Kanto events, damaged the Kanto area seriously. On the other hand, slow-slip events have been observed in the Boso area with 5-7 year interval, whose released energies were comparable to Mw 6. Source depths of the M8-class earthquakes and slow-slip events are almost same. One possible reason of the varied seismogenesis is different subduction inputs at the Sagami Trough. To understand the varied seismogenesis, structural and material information are important. A drilling proposal for subduction input at the Sagami Trough is planned to be submitted. Japan Agency for Marine-Earth Science and Technology was conducted a seismic reflection survey in April, 2013 at the southward of the Sagami Trough on the Philippine Sea Plate. Although a planned seismic line had been 270-km length at the 50-km southward of the trough in WNW-ESE direction, acquired data is limited in half of the planned line for rough weather from volcanic front to landward slope of the trench axis, showing sediment distribution and basement morphology. Sediments can be divided in three units. Basement morphology is rugged as basement highs reaching seafloor at the volcanic front and rising at the Frontal Arc and Outer Arc High of the former arc in the Izu-Ogasawara area, and as depressions as 4-km from seafloor filled by thick sediments. The sediments and basement are comparable to those in the vicinity of the Sagami Trough using conducted seismic profiles at the cross points. In this presentation, we will show the seismic profiles around the Sagami Trough, deduce the ages and materials of sediments and basements comparing previous results, infer the subduction inputs of the Sagami Trough, and discuss the seismogenesis around the Sagami Trough.

Keywords: MCS survey, Sagami Trough, subduction input

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MIS32-P06 Room:Poster Time:April 30 18:15-19:30

Core quality evaluation with X-CT data

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Xray Computed Tomography (X-CT) is a powerful tool for an observation of internal structures and conditions of core samples. In the laboratory of D/V Chikyu, X-CT data has been used in initial evaluations of sample lithology, structure and physical properties such as density, before splitting the sample. In addition, the non-destructive measurement is particularly useful to evaluate the sample quality, based on which we can optimize the sampling and sample distribution plan. For example, intact pieces are passed to high-priority and contamination-sensitive analyses after observation of X-CT image. However, the evaluation of core quality has been mostly based on visual observation. While visual observation is good for quick evaluation, it sometimes lacked consistency and detailed survey.

In this study we propose a quantitative way to evaluate the core quality from X-CT data. The core quality index (CQI) is calculated as the ratio of area with CT value higher than a threshold value in a sliced image of core sample. The threshold value is determined from the representative CT value in the core section and varies depending on lithology. The data in the region of interest, which is 15 cm^2 of central part of core sample, is binarized with the threshold value to provide normalized index through all sections. The plot of CQI reveals the position and degree of damages inside a core sample.

The method is applied to X-CT data of a total of 176 sections from IODP Exp 337. The results show that CQI profile clearly differentiates intact part and disturbed part of core section. Comparison with other core quality indicators in pore water chemistry and chemical tracer experiments suggests that CQI can be used to identify intervals suitable for contamination-free sampling.

The figure shows an example of binarized X-CT slice of a core sample. Red in the central part (purple) shows porous part in the core sample.

Keywords: Chikyu, IODP, X-CT, core sample