Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-01 Room:302 Time:May 21 14:15-14:30

Tsunami generation near Japan by earthquakes in along-strike single segmentation and along-dip double segmentation

Junji Koyama[1*], Motohiro Tsuzuki[1]

[1]Div. Natural History Sciences, Hokkaido Uni.

After the 2011 Tohoku-oki megathrust earthquake of Mw9.0, we have proposed a hypothesis that megathrust earthquakes worldwide occur Along-dip Double Segmentation (ADDS) or Along-strike Single Segmentation (ASSS). The former is characterized by the apparent absence of earthquakes in the aligned seismic segments along the Japan trench as opposed to those along the Japan Islands that generate repeated smaller earthquakes (ADDS), where the 2011 Tohoku-oki megathrust occurred. Meanwhile, the latter is by a weak seismic activity before the main event all over the subduction zone, where we find aligned seismic segments along the subduction zone from the trench to the island-arc (ASSS). A typical example of ASSS is the Nankai trough, Japan, where future great earthquakes are expected. The 1960 and 2010 Chile megathrusts occurred in ASSS. In and near Japan, ADDS earthquake activity is restrictively found along the Pacific side of Hokkaido and Tohoku regions and the Hyuganada, Kyushu. The rest of seismic activity near Japan is classified into ASSS. Comparing tsunami magnitude m from local tsunami-wave heights and seismic moment Mo from long-period surface-waves of 61 earthquakes from 1923 in and near Japan, we found that tsunami-wave heights of ASSS earthquakes are almost two times larger than those of ADDS's. This is also confirmed by studying tsunami magnitude Mt evaluated from teleseismic tsunami-wave heights. The reason of this different excitation between ADDS and ASSS is considered to be due to either (1) shallower focal depths for ASSS give rise to larger ocean bottom deformation, resulting in larger tsunami excitation, (2) larger dip-angles of fault planes for ASSS, (3) three dimensional ocean-bottom structures, such as troughs, trenches and continental shelves, or (4) ocean bottom topography nearby causes the focusing of tsunami waves. (1) is the conclusion that we would like to derive. (2) Speaking about the effect of dip angles to the maximum ocean bottom deformations, the difference is about 30% in cases of reverse faults with dip angles of 30 and 60 degrees. (3) Both of earthquakes along the passive margin of the back-arc basin of the Japan sea and along the Nankai trough are classified into ASSS. (4) Both of local and teleseismic tsunami-wave heights do suggest the similar result, rejecting the local tsunami focusing. Therefore, we conclude that the larger tsunami excitation for ASSS earthquakes is due to larger amount of ocean bottom deformations than those for ADDS earthquakes or by the reason of (1) or by both the effects. Asperity for ADDS locates in the shallow part of the subduction zone along the trench, and it ruptures only in the case of megathrust events like as the 2011 Tohoku-oki earthquake. In estimating tsunami wave heights for future earthquakes, we have to take into account of this difference in tsunami excitations in the ADDS or ASSS zone.

Keywords: Along-strike Single Segmentation, Along-dip Double Segmentation, Megathrust Earthquakes, Tsunami Generation, Tsunami Magnitude

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-02 Room:302 Time:May 21 14:30-14:45

The 2011 Tohoku-oki megathrust earthquake (Mw 9.0) and slip deficit of the past tsunami earthquakes in the region

Motohiro Tsuzuki[1*], Junji Koyama[1]

[1]Department of Natural History Sciences, Graduate School of Science, Hokkaido University

The 2011 Tohoku-oki megathrust earthquake of Mw 9.0 generated a devastating tsunami. Gusman et al. (2011) estimated the slip distribution of the earthquake, analyzing tsunami waveforms, GPS data, and ocean bottom deformation, and they indicated that the largest slip was located shallower part of the fault near the trench. That place is the same source areas of tsunamis by significant earthquakes of 869, 1611, 1793 and 1896 (Hatori,1975). This means a slip deficit existed in the region of the 2011 because there was little strain accumulation there if the region released the strain perfectly every time. We aware some of these earthquakes were tsunami earthquakes and there must have been the slip deficit. Seismic moment of an earthquake with some slip deficit is smaller than that of an earthquake without deficit, when the areal sizes of two earthquakes the same. Now the comparison is made to check the above hypothesis that the seismic moment of tsunami earthquakes is smaller than that of ordinary inter-plate earthquakes with a same size of rupture areas.

This is done by studying the scaling relation between seismic moment and rupture area of tsunami and ordinary earthquakes. Standard scaling law for ordinary earthquakes is adopted from Koyama (1977); $\log M_o = 1.5 \log S + 15.12$, where M_o is seismic moment [Nm] and S is rupture area [km^2]. Compared to the relation, we obtained smaller seismic moment for some tsunami earthquakes such as 1992 Nicaragua, 2006 Java, and 2010 Sumatra. Some other tsunami earthquakes such as 1994 Java, 1996 Peru, and 1998 Papua New Guinea are almost the same as the relation. The former are those characterised by low rupture velocity, and the latter are by land-slides or slump of ocean bottoms and may be by a smooth faulting with weak fault heterogeneities.

The 1896 tsunami earthquake occurred in the region of horst and graben structure similar to the 1992 Nicaragua earthquake. This indicates tsunami earthquakes off the Pacific coast of Tohoku are also characterized by low rupture velocity, and there must have been slip deficits.

We conclude that before the 2011 earthquake, the trench side of the rupture zone had a large amount of slip deficit due to repeated ruptures by tsunami earthquakes. Since the 2011 megathrust occurred in Along-dip Double Segmentation, the trench-ward seismic segment has had the potential to generate large moment release due to the slip deficit and the large slip in the trench-ward segment had accompanied with the rupture in the land-ward segment.

Keywords: tsunami earthquake, slip deficit

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-03 Room:302 Time:May 21 14:45-15:00

Slip deficit distribution using earthquake catalogs

IWATSUKI, Maho[1], Ryoya Ikuta[1*]

[1]Faculty of Science, Shizuoka university

We tried to make a spatial distribution of the slip deficit beneath subduction trench. Slip deficit is defined by ratio of deficit of seismic or aseismic slip to cumulative plate convergence. Yamanaka & Kikuchi, 2003 showed a spatio-temporal distribution map of seismic slip (nominally asperity map)in the Tohoku district using historical strong motion records. If we assume that asperities slip only by seismic slip, shortness of seismic slip on an asperity relative to plate convergence is defined as slip deficit. To make slip deficit map using their method, we need to define spatial distribution of asperitiesand amount of seismic slip for all historical earthquakes in addition to. subduction velocity.However, strong motion seismogram is not always available for historical earthquakes in the world. Therefore, we tried to make the space-time slip distribution map using Earthquake Catalogs which only equips the hypocenter and magnitude informations instead of record of strong-motion seismogram. Before making the space-time distribution map beneath global subduction trenches, we made the space-time slip distribution map in the Tohoku district and assessed whether this method would be appropriate replacement of strict asperity map. In order to assess the validity of this method, we compared the spatio-temporal distribution map of co-seismic slip beneath the Tohoku district made in the previous studies with that made by our easy method. As a result, although there are some differences in the results between the previous study and our method, they are generally similar. Although there is a room for improving in our method, it can be applied to other subduction zonesin the world.

Keywords: asperity, subduction, the 2011 Tohoku-Oki earthquake, earthquake catalog, slip history

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-04 Room:302 Time:May 21 15:00-15:15

Estimation of the lower limit of the coseismic slip and the strength in the deeper part near the 2011 mainshock

Keita Chiba[1*], Yoshihisa Iio[1], Yukitoshi Fukahata[1]

[1] Disaster Prevention Research Institute, Kyoto University

Numerous studies have estimated the slip distributions of the 2011 off the Pacific coast of Tohoku Earthquake. However, the reliable slip distribution has not been necessarily clarified. We estimated the lower limit of the coseismic slip region in the deeper part of the fault near the mainshock, using the F-net focal mechanism data and stress changes by the various fault models and then discussed the relation the initial stresses and the slip distributions. Two characteristic focal mechanism distributions after the mainshock were found at the deeper part of the fault off the Miyagi ˜ Iwate Prefecture, where are located in the vicinity of the mainshock hypocenter. The first case is the distribution composed of P-axis with vertical dip angle above the plate boundary and with dip angle parallel in the direction of the plate subduction below the plate boundary in depth of about 40km. The second is located deeper than the first case, which is located about 40-50km at the plate boundary, and is characterized by thrust type events near the plate boundary. We calculated the stress changes by the coseismic slip model that we made artificially, referring to Chiba et al., (2012) using Okada(1992), and then found that above-mentioned features about the focal mechanism distributions appeared equally in the case of the stress changes. The first and second case in the stress change correspond to the parts that the slip gradient is steep and lower limit of the slip, respectively. However, it may be practically expected that focal mechanism distributions after the mainshock are also affected by postseismic slip and initial stresses. We thus examined the dip angle distributions of the P-axis and .axis, which calculated the stress changes with the slip model including the afterslip and initial stress, above the plate boundary. As a result, it was implied that the shear strength in the region deeper than the lower limit of the coseismic slip distribution was high to some extent(> 5˜10MPa), whereas the shear strength in the region with large coseismic slip was weak(< 5MPa).

Keywords: focal mechanism, fault model, stress change, initial stress

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-05 Room:302 Time:May 21 15:15-15:30

Determination of Stress State in Japan Trench Fast Drilling Project (JFAST)

Weiren Lin[1*], Marianne Conin[2], J. Casey Moore[3], Frederick M. Chester[4], Yasuyuki Nakamura[5], James J. Mori[6], Louise Anderson[7], Emily E. Brodsky[3], Nobuhisa Eguchi[8], Sean TOCZKO[8], Expedition 343 scientists[9]

[1]Kochi/JAMSTEC, [2]Universite des Antilles et de la Guyane, [3]University of California, Santa Cruz, [4]Texas A&M University, [5]IFREE/JAMSTEC, [6]Kyoto University, [7]University of Leicester, [8]CDEX / JAMSTEC, [9]IODP

The 2011 Mw 9.0 Tohoku-oki earthquake produced a maximum coseismic slip of >50 m near the Japan Trench, which could result in a completely reduced stress state in the region. We tested this hypothesis by determining the in-situ stress state of the frontal prism from boreholes of Japan Trench Fast Drilling Project (JFAST) drilled by the Integrated Ocean Drilling Program approximately one year after the earthquake, and by inferring the pre-earthquake stress state. On the basis of the horizontal stress orientations and magnitudes estimated from borehole breakouts, and the increase in coseismic displacement during propagation of the rupture to the trench axis, we concluded that in-situ horizontal stress decreased during the earthquake. The stress change suggests an active slip of the frontal plate-interface consistent with coseismic fault weakening and a nearly total stress drop.

Acknowledgments: This research used data provided by IODP. We thank all drilling and logging operation staff on board the D/V Chikyu during expedition 343.

Keywords: JFAST, Stress, Breakout

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-06 Room:302 Time:May 21 15:30-15:45

Anelastic deformation during the 2011 Tohoku earthquake: The role of extensional faulting in the generation of a tsunami

Takeshi Tsuji[1*], Kiichiro Kawamura[2], Toshiya Kanamatsu[3], Takafumi Kasaya[3], Katsunori FUJIKURA[3], Yoshihiro Ito[4], Tetsuro Tsuru[5], Masataka Kinoshita[3]

[1]WPI-I2CNER, Kyushu University, [2]Yamaguchi University, [3]JAMSTEC, [4]Tohoku University, [5]COSMO Oil Co. Ltd.

The 2011 Tohoku-oki earthquake (Mw 9.0) ruptured a wide area along the plate interface (˜450 km in the trench-parallel direction) and generated a particularly large tsunami. On the basis of geodetic and geophysical data as well as tsunami records, large slip along the plate interface (˜60 m) was estimated to have occurred near the trench off Miyagi. However, the mechanisms of large displacement along the plate interface near the trench are not well understood. Prior to the 2011 Tohoku-oki earthquake, the plate interface near the Japan Trench was thought to be too weak to accumulate strain and, because of this presumed weak lithology, the frontal prism was expected to deform aseismically. Here we identify a series of faults in seismic reflection profiles acquired within and outside of the tsunami source area and examine dynamic changes of the fault traces on the seafloor by comparing observations made during submersible dives before and after the 2011 earthquake, in order to identify characteristic geological structures and dynamic fault activity within the overriding plate in the tsunami source area. During the seafloor observations, we also repeatedly measured heat flow to evaluate the activity of the fault system.

Observations of seafloor morphologies and environments made before and after the 2011 Tohoku-oki earthquake reveal open fissures, generated during the earthquake, where the fault trace is interpreted on seismic profiles to intersect the seafloor. Anomalously high heat flow was observed at a landward-dipping normal fault in August 2011, five months after the earthquake, but by August 2012 heat flow measured at the same station had decreased to close to the background value, which suggests that the normal fault ruptured during the 2011 earthquake. These seafloor observations and measurements demonstrate deformation that was both extensional and anelastic within the overriding continental plate during the 2011 earthquake. Seismic profiles as well as seafloor bathymetry data in the tsunami source area further demonstrate that landward-dipping normal faults (extensional faults) collapse the continental framework and detach the seaward frontal crust from the landward crust at far landward from the trench. The extensional and anelastic deformation (i.e., normal faulting) observed in both seafloor observations and seismic profiles allows the smooth seaward movement of the continental crust. Seaward extension of the continental crust close to the trench axis in response to normal faulting is a characteristic structure of tsunami source areas, as similar landward-dipping normal faults have been observed at other convergent plate margins where tsunamigenic earthquakes have occurred. We propose that the existence of a normal fault that moves the continental crust close to the trench can be considered one indicator of a source area for a huge tsunami.

Keywords: 2011 Tohoku-oki earthquake, Tsunami mechanisms, seafloor observations, normal fault, anelastic deformation, heat flow

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-07 Room:302 Time:May 21 15:45-16:00

Vertical seafloor deformation associated with the 2011 Tohoku-Oki earthquake

Ryota Hino[1*], Daisuke Inazu[2], Takeshi Iinuma[1], Yusaku Ohta[1], Yoshihiro Ito[1], Yukihito Osada[1], Motoyuki Kido[1], Hiromi Fujimoto[1], Yoshiyuki Kaneda[3]

[1]Tohoku Univerisity, [2]National research institute for earth science and disaster prevention, [3]JAMSTEC

The 2011 Tohoku-Oki earthquake was preceded by a large (Mw7.3) interplate earthquake which gave rise to evident afterslip and intensive aftershock activity. Although the studies on the afterslip and aftershocks suggested that the slow slip propagated towards the hypocenter of the mainshock of the Tohoku-oki earthquake, no clear evidences of the acceleration of fault slip related to the nucleation of the mainshock have been presented. In this report, we will present the results of reanalysis of the eight ocean bottom pressure records obtained around the hypocenter to inspect if there were any fluctuations of fault slip prior to the occurrence of the mainshock, other than the afterslip of the M7.3 earthquake. By removing short-term variation common to all of the records, assuming that the common component is caused by non-tidal physical oceanographic pressure variation, noise level of the pressure records was considerably reduced. The processed pressure records show that rates of seafloor deformation decayed gradually or were almost constant until the mainshock occurrence, but no remarkable accelerations exceeding noise level, ~ 2 cm. The noise level of the pressure data corresponds to vertical displacement caused by slip along the plate boundary with amount of ~ 20 cm and we conclude that the Tohoku-oki mainshock was not associated with a preslip larger than this amount within a couple of hours prior to the initial break of the mainshock. In the presentation we will report on the postseismic deformation following the M-9 mainshock.

Keywords: seafloor geodesy, Tohoku-oki earthquake

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-08 Room:302 Time:May 21 16:15-16:30

Seismic reflection character and spatial distribution of the Nankai shallow decollement with tsunami potential

Jin-Oh Park[1*], Hajime Naruse[2]

[1]Atmosphere and Ocean Research Institute, University of Tokyo, [2]Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

One of the biggest features of the subduction-zone processes is tsunami earthquake that generate tsunamis disproportionately large for their seismic energy. Tsunami earthquakes have been reported in the subduction zones worldwide: for example, 1896 Sanriku, 1946 Aleutian, 1992 Nicaragua, and 1994 Java. Most of the tsunami earthquakes appear to propagate along shallow decollement up to near trench. However, the tsunamigenic decollement is not clearly identified and its nature is largely unknown. Here we report seismic reflection character and spatial distribution of the tsunamigenic, shallow decollement along the Nankai subduction zone, southwest Japan. Seismic reflection profiles along and across the Nankai Trough reveal clear shallow plate-boundary fault (i.e., decollement) with variation of negative and positive polarity reflections. Very-low-frequency earthquakes suggesting slow seismic slip and shear failure occur around the decollements with tsunami potential. Although fluid-poor decollement with positive polarity reflection too may have tsunami potential, fluid-rich decollement with negative polarity reflection could be much easier to slip due to elevated fluid pressure leading to low effective normal stress so that it is conditionally stable. On the whole, the fluid-rich decollement is identified off Shikoku Island and Cape Shiono. The fluid-poor decollement is recognized off Kii Channel. Alteration of the fluid-rich and fluid-poor decollements is observed off Kumano Basin. The huge, fluid-rich decollement zone off Shikoku Island is almost consistent with tsunami source area of the 1605 Keicho event. On seismic reflection profiles, we also identify three distinct turbidites underthrusting along the shallow decollement immediately beneath the Nankai accretionary wedge. Deep sea turbidite subduction may affect formation of the fluid-rich decollement with much more tsunami potential.

Keywords: Nankai Trough, decollement, seismic reflection, spatial distribution, tsunami

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-09 Room:302 Time:May 21 16:30-16:45

Estimation of effective pressure in Nankai accretionary margin using physical properties of sediments

Yoshitaka Hashimoto[1*], Mika Yamaguchi[1], Shougo Abe[1], Hiroki Tano[1]

[1]Kochi University

Effective pressure within accretionary wedge and along decollement in subduction zone affects both on strength of sediments in wedges and friction strength along decollement or mega-splay faults. Those strengths control widely wedge architecture, stress state, and seismic behavior. Therefore, estimation of effective pressure is critical to understand wedge state and seismicity in subduction zone.

In this study, we estimate effective pressure along decollement from shallow to deep up to shallow seismogenic zone, and also along mega-splay fault in Nankai trough combining physical properties of sediments with information from seismic profiles in Nankai Troguh.

For shallow decollement, from deformation front to ~25 km landward, we followed Tobin and Saffer (2009) to estimate effective pressure. They used velocity-porosity relationship obtained from sediments only in the toe and reference sites. Porosity was converted from velocity along decollement obtained by seismic data in Nankai Trough. The porosity was converted to effective pressure based on porosity-effective pressure relationship at reference site. We have newly made porosity-velocity relationship with additional data from rocks in Shiamnto Belt to cover wider range of porosity. The estimated effective pressure based on the newly modified porosity-velocity relationship represents less than 10 MPa, which is very consistent with the result of Tobin and Saffer (2009).

For deeper decollement, about 5 km depth, effective pressure was estimated using elastic properties of hanging-wall and footwall bounded by fossil seismogenic fault in Mugi melange, Shimanto Belt. The elastic properties were measured in laboratory under controlled effective pressure. Amplitude variations with offset (AVO) analysis were taken for the estimation. By comparison between AVO parameters from seismic data and the elastic properties, appropriate effective pressure was estimated as about 15MPa in hanging-wall and about 10 MPa in footwall.

Finally, for deep mega-splay fault, ~8-10km deeper portion, effective pressure is also estimated by elastic properties of hanging-wall and footwall bounded by Nobeoka thrust, Shimanto Belt. AVO analysis was also conducted to compare AVO parameters from seismic data and the elastic properties. The estimated effective pressure is about 50 MPa in hanging-wall and 5MPa in footwall although the coincidence between AVO parameters was not so good. The bad coincidence is probably due to anisotropy of elastic property especially in hanging-wall. At least, the difference in effective pressure between hanging-wall and footwall is larger than other portions.

Distribution of effective pressure in subduction zone from shallow to deep was examined in this study. About 5-15 MPa of effective pressure are distributed along shallow to deep decollement up to shallower portion of seismogenic zone. 5MPa in footwall and about 50MPa in hanging-wall of effective pressure are obtained along deep mega-splay fault. This low effective pressure in footwall both in decollement and mega-splay fault lead to low friction along those faults. This estimation is for the modern state based on the seismic data.

Keywords: Nankai Trough, effective pressure, physical properties, velocity, porosity

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-10 Room:302 Time:May 21 16:45-17:00

Accumulation process of earthquake-induced turbid layer in the Nankai Trough accretionary prism

Ritsuko Sawada[1], Juichiro Ashi[1*], Akiko Omura[1], Ken Ikehara[2]

[1]The University of Tokyo, [2]National Institute of Advanced Industrial Science and Technology

While massive seafloor turbid layers were observed at slope basin of Nankai Trough off Kumano in the proximity of an epicenter of the 2004 Earthquake (Mw 7.4) during submersible observation immediately after the earthquake, they were not recognized at the same observation site after 6 years of the event. This phenomenon is considered to have been resulted from rapid deposition of large amounts of sediments within a relatively short time. We can investigate paleoearthquakes based on estimations of sedimentation age after careful assessment of whether the depositions are caused by earthquakes or not. It is inferred that these deep-sea turbid phenomena are accompanied by relatively high sedimentation rate and characterized by a typical accumulation processes, but the picture remains unsolved. We aim to investigate the possible mechanism of suspended layers generated just after an earthquake and their accumulation and sedimentation processes, which also contribute to evaluation of samples studied for paleoenvironment and paleooceanography.

We used the data derived during KY04-11, KH-10-3 and KH-11-9, and the data on ROV NSS (Navigable Sampling System). We also used high-resolution images obtained from a chirp subbottom profiler (SBP) surveys, and interpreted geological structure of the basin in detail.

Based on the result of the SBP profiles acquired at the slope basin, we classified the deposition structure into acoustic transparent layers and the acoustical high amplitude layer. The thickness of upper transparent layer is 2 m. The layer is considered to have been originated from earthquake-induced turbid layer. A ripple-like structure was observed on the seafloor of the slope basin from the NSS deep sea video footage. The crest of the ripple-like structure is considered to have been developed parallel to the bathymetry, which suggests that it seems to be an evidence of traveling down of sediment gravity flows along the slope. In addition, since the ripple-like crest structure originates from two directions in NE-SW and NW-SE, several basin-wards incoming sediment flows from surrounding slope basin areas are presumed. Moreover considering the slope basin, the sediment source region that could supply sediments based on the bathymetrical map, deposition rate and seismogenic interval, the acoustic transparent layer observed in this basin is considered to have been deposited during single earthquake event. In addition, clay fabrics of the sediment samples obtained during KT-06-7 Cruise observed by a scanning electron microscope (SEM) were characterized by a ”granular structure” formed by high-concentrated mud fluids, which suggests that the occurred suspended layer is composed of high-concentrated state substances. Thus, thick sediment layer is eventually expected after completed settling of suspended layer. The comparison of the measured water depth in 2004 and 2010/2011 resulted that the suspended layer was estimated to be at least 2.5 m. Since no significant differences exist between the thickness of the acoustic transparent layer recognized in SBP profile and the one of coseismic turbid deposit layer derived from the results of particle settling experiments and seafloor observations, the transparent layer is considered to have been originated from turbid layer.

From these results, the upper acoustic transparent layer in the slope basin is considered to have been formed by the 2004 event, which suggests that sediment layer with the thickness of 2 m can be deposited after M7 class earthquake. Moreover, this study proposes the possibility for determining the presence and absence of turbid sediment in the sedimentary basin based on high-resolution SBP data, which contribute to reconstruct the histories of paleoearthquakes.

Keywords: earthquake-induced sediment, gravity flow, slope basin, turbid layer

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-11 Room:302 Time:May 21 17:00-17:15

ACORK off Muroto: Tidal response and overpressure observed from borehole pore pressure monitoring in the Nankai Trough

Masataka Kinoshita[3*], Hidenori Kumagai[3], BECKER, Keir[1], DAVIS, Earl[2]

[1]Univ. Miami, [2]Geological Survey of canada, [3]JAMSTEC

Pore pressure and hydrological properties play key roles in governing coupling and slip behavior along the subducting plate interface. During the KR12-17 cruise, five dives were completed using ROV KAIKO onboard R/V KAIREI during Nov. 4-8, 2012, to retrieve pore pressure data and interstitial fluid samples from ACORKs at ODP Holes 808I and 1173B situated landward and seaward of the deformation front in the Nankai Trough off Cape Muroto. Since their deployment during ODP Leg196 in 2001, we now have over 11-year-long continuous pressure records. Data from most monitoring depths show systematic variations in average pressure, and in formation pressure response to seafloor tidal loading.

In 2005 and 2009, we observed significant decrease in the amplitudes of pressure response to semi-diurnal tidal loading at Hole 808I. We suggest that this is due to the reduction of hydraulic diffusivity around ACORK casing.

Venting of fluid from ACORK mouth at Hole 808I (up to 1 L/min.), coming from the decollement, has been continuing for long, but was terminated by closing the valve in 2011. As opposed to our expextation the pressure decreased instantaneously by a few kPa, followed by a slow pressure recovery. Termination of the flow could also have terminated the supply of advective heat, resulting in the thermal contraction of the casing and thus in the pressure decrease. This inference is supported by the 2-D cylindrical numerical simulation.

Keywords: Nankai Trough, ODP, Borehole monitoring, decollement, seismogenic zone, pore pressure

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-12 Room:302 Time:May 21 17:15-17:30

Development of seafloor and seafloor borehole observatory network in the Nankai Trough for monitoring earthquake and slo

Eiichiro Araki[1*], Kazuya Kitada[1], Toshinori Kimura[1], Takashi Yokobiki[1], Hiroyuki Matsumoto[1], Katsuyoshi Kawaguchi[1], Yoshiyuki Kaneda[1]

[1]Japan Agency for Marine-Earth Science and Technology

A seafloor seismo-geodetic observation network using a submarine cable called ”DONET” (Dense Ocean-floor Network for Earthquake and Tsunamis) is currently under development in and around the epicenter of the Tonankai earthquake in the Nankai Trough. The purpose of the observation system development is to study mechanism of seismogenesis of large earthquakes in subducting oceanic plate.

Observation of ground deformation and earthquake above the seismogenic plate interface in the Nankai Trough seafloor should give a very important data to model the system of the coupling at the plate interface in the seismogenic cycles. In the development of the DONET, observation of seafloor ground deformation is important target. We planned ground deformation observation in the DONET in two methods, one using a seafloor height measurement based on the seafloor pressure data, and the other using geodetic sensors installed in a seafloor borehole where the surrounding media is more consistent and stable with less effect from oceanographic disturbances.

Our installation of the DONET seafloor observation network started in March 2010 with seafloor seismometer and seafloor pressure gauges, completing in July 2011 with 20 seafloor observatory in the seafloor. In the installation of the seafloor seismometers, we took care to bury the seismometer in the seabed using a caisson penetrated into the sediment to minimize effect from current flow in the seafloor for broadband wide-dynamic range seismic observation. In February 2013, we further improved the installation by filling the gap between the seismometer and the caisson with sand. After filling sand, we confirmed improvement in the seismic background noise level in many of the observatories.

In observing long-term ground deformation with seafloor pressure measurement, instrumental drift of the pressure gauge can be larger than the pressure change expected from seafloor deformation. Our measure on the instrument drift is to implement repeated calibration of the pressure gauges in the seafloor. We had an experimental calibration of the seafloor pressure gauge in January 2013 by JAMSTEC R/V Kaiyo.

Development of seafloor borehole observation network was planned as a part of IODP scientific drilling in the Nankai Trough. We successfully constructed the first long-term seafloor borehole seismogeodetic observatory in IODP C0002G hole in December, 2010. After confirming the proper function of the borehole instruments in 2011-2012 periods, we finally connected DONET cable to the borehole observatory in January 24, 2013. Currently we perform continuous real-time observation with the borehole observatory in IODP C0002G hole connected to the DONET. Observed records of the borehole strainmeter, tiltmeter, pore-fluid pressure gauges, and broadband seismometer showed clear signature of ground deformation from oceanic tide, tsunami, and long-period ocean gravity waves. We continues observation with the combined seafloor and seafloor borehole observation systems to analyze earthquakes and slow slip phenomena in the seismogenic plate boundary in the Nankai Trough.

Keywords: the Nankai Trough, seismic observation, ground deformation monitoring, borehole, seafloor pressure, seafloor cable

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-13 Room:302 Time:May 22 09:00-09:15

Analyses of mineral composition and carbonaceous material in the megasplay fault of the Nankai Trough

Hirokazu Masumoto[1], Tetsuro Hirono[1*], Hikaru Yabuta[1], Tsuyoshi Ishikawa[2], Wataru Tanikawa[2]

[1]Graduate School of Science, Osaka University, [2]JAMSTEC-Kochi

We analysed the mineral composition by XRD and carbonaceous material by vitrinite reflectance measurement, micro FTIR and micro Raman spectroscopies.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-14 Room:302 Time:May 22 09:15-09:30

Segmentation of hypocenters and 3-D velocity structure around the Kii Peninsula

Takeshi Akuhara[1*], Kimihiro Mochizuki[1], Kazuo Nakahigashi[1], Tomoaki Yamada[1], Masanao Shinohara[1], Shin'ichi Sakai[1], Toshihiko Kanazawa[2], Kenji Uehira[2], Hiroshi Shimizu[3]

[1]Earthquake Research Institute, University of Tokyo, [2]National Reasearch Institute for Earth Science and Disaster Prevention, [3]Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University

Around the Kii Peninsula, the rupture boundary of the Tonankai and Nankai earthqueks is located. In addition, there can be seen along-strike segmentations in hypocenters, P-wave anisotropy, low frequency earthquake (LFE) distribution and subduction depth of the Philippine Sea (PHP) Plate. To investigate these segmentations, 3-D velocity structure and hypocenters were determined by using ocean bottom seismometers (OBSs) deployed from 2003 to 2007 and on-land stations.

To begin with, we determined station corrections which compensate travel time delays due to the sediment layers based on traveltime misfits. A double-difference tomography method was adapted to obtain 3-D velocity structures and a grid search method was used to increase the number of determined hypocenters. In addition, we performed calculations of waveform cross-correlation coefficients (CC) in order to improve relative hypocenters and to detect similar event clusters. Waveforms recorded by OBSs are problematic in that their frequencies tend to be monotonic due to the sediment layers. To overcome this problem, a new method was developed which determines thresholds of CC at every station statistically.

As a result, geometry of the PHS Plate was estimated. It has been discovered that Vp/Vs ratio is segmented within the oceanic crust and at the bottom of the overriding plate, which coincides with the LFE distribution. In the western Kii segment, Vp/Vs ratio is low within the oceanic crust and LFE cluster with small amount of cumulative slip is located. It is considered that the pore fluid pressure is relatively low in this segment. In the eastern Kii segment, because no LFEs occur and Vp/Vs ratio is high, the pore fluid pressure must be comparable to the lithostatic pressure, so the plate interface may be at the state of stable slip.

Similar segmentation has also been seen in hypocenters. In the western Kii segment and its west side segment, most earthquakes occur in the oceanic crust and mantle, respectively. In the western Kii segment, fewer earthquakes occur. Moreover, variation of the depth can also be seen where earthquakes do not occur within the oceanic crust, which can be considered to reflect difference of the thermal structure.

As a result of cluster analysis based on waveform similarity, we found a fault sequence in the oceanic mantle and an inter-plate earthquake cluster at the southern tip of the Kii Peninsula. The inter-plate earthquakes occur at the landward edge of the strong plate coupling zone. Long term observations of these inter-plate earthquakes might provide insight into the state of plate coupling during inter-seismic periods.

Keywords: subduction zone, Kii Peninsula, ocean bottom seismometer, hypocenters, 3-D seismic velocity structure, similar event cluster

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-15 Room:302 Time:May 22 09:30-09:45

Spatial distribution of random velocity inhomogeneities at western Nankai trough

Tsutomu Takahashi[1*], Koichiro Obana[1], Yojiro Yamamoto[1], Yuka Kaiho[1], Ayako Nakanishi[1], Shuichi Kodaira[1], Yoshiyuki Kaneda[1]

[1]JAMSTEC

Major interplate earthquakes at Nankai trough show various rupture patterns, for example, the individual rupture of one segment or nearly simultaneous or successive ruptures of contiguous segments. Lithosphere structures around the Nankai trough are intensively studied by using active and passive seismic sources to elucidate their relation with seismicity and segment distribution. From 2008, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) conducted seismic surveys at Nankai trough as a part of ”Research concerning Interaction Between the Tokai, Tonankai and Nankai Earthquakes” funded by Ministry of Education, Culture, Sports, Science and Technology, Japan. This study applied the peak delay time analysis [e.g., Takahashi et al. 2009] to estimate the spatial distribution of random inhomogeneities in the crust and uppermost mantle. Peak delay time is defined as the time lag from S-wave onset to the maximal amplitude arrival. This measurement mainly reflects the accumulated effect of multiple forward scattering, and is insensitive to the medium inelasticity. We measured peak delay times from the RMS envelopes of horizontal components at 4-8Hz, 8-16Hz and 16-32Hz. This study used the velocity seismograms that are recorded by 665 ocean bottom seismographs, 20 DONET stations, and 532 onshore seismic stations. Onshore stations are composed of the F-net and Hi-net stations that are maintained by National Research Institute for Earth Science and Disaster Prevention (NIED) of Japan. It is assumed that the random inhomogeneities are represented by the von Karman type power spectral density function (PSDF). Inversion analysis shows that medium at the Nankai trough is characterized by weak inhomogeneities with steep spectral gradient. That means inhomogeneities at smaller wavelength (˜ a few hundred meters) are significantly weak. Long wavelength component of inhomogeneities, meanwhile, shows some anomalies along the Nankai trough. Strong inhomogeneities at large wavelength are imaged at Hyuga-nada and Kii-channel. Similar strong random inhomogeneities are found beneath west Shikoku at 20-60km depth and around the Cape Shionomisaki at 20-60km depth. Strong inhomogeneities at west Shikoku and Cape Sionomisaki are located in non-volcanic tremor zones. Similar random inhomogeneities were found in high-microseismicity area in Hokkaido, and existence fluid was pointed out by velocity structure analysis [Kita et al. 2010]. These results suggest that random inhomogeneity is an important medium property related with seismicity and geofluid distribution.

Keywords: Nankai Trough, random media, scattering

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-16 Room:302 Time:May 22 09:45-10:00

On the anomalies of distribution of Green's function amplitudes for M9 source in Nankai trough

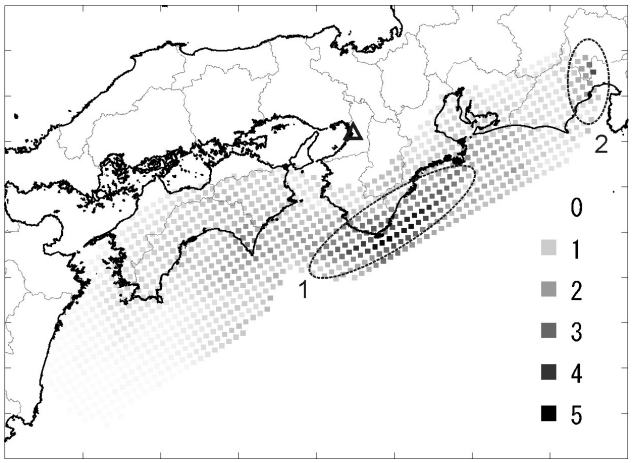
Anatoly Petukhin[1*], Ken Miyakoshi[1], Masato Tsurugi[1], Kawase Hiroshi[2], Katuhiro Kamae[3]

[1]Geo-Research Institute, [2]DPRI, Kyoto University, [3]Research Reactor Institute, Kyoto University

Effect of various areas (asperities or SMGA) in source of a megathrust subduction zone earthqauke on the simulated long-period ground motions is studied. For this case study we employed source fault model proposed by HERP (2012), for future M9-class event in Nankai trough. Velocity structure is 3-D JIVSM model developed for long-period ground motion simulations (Koketsu et al., 2012). Target site is located in center of Osaka basin. Green's functions for large number of subsources (>1000) were calculated by the finite-difference method using reciprocity approach. Depths, strike angles and dip angles of subsources are adjusted to the shape of upper boundary of the Philippine sea plate in the JIVSM model.

Results for period range 4-20sec are shown in the Figure below. Figure shows distribution of peak amplitudes of Green's functions, calculated at the target site in Osaka basin (marked by triangle). Darker colors indicate subsources producing larger amplitudes in Osaka, while lighter colors indicate smaller amplitudes. Strongly nonuniform distribution is observed, with two areas of anormal large amplitudes: (1) large elongated area just south of Kii peninsula and (2) a smaller area north of Suruga bay. Elongation of both areas fit well 10-15km isolines of depth distribution of the Philippine sea plate, while target site is located on a perpendicular to these isolines. For this reason, preliminarily we suppouse that plate shape may have critical effect on the simulated ground motions, through a cumulative effect of subsource radiation patterns and specific strike and dip angle distributions.

Keywords: Megathrust earthquake, Source modeling, Green's function, Long-period ground motions, Reciprocity method, Nankai trough



Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-17 Room:302 Time:May 22 10:00-10:15

Spatiotemporal relation of inland earthquakes in southwest Japan to interplate earthquakes along the Nankai trough

Yosuke Shikakura[1*], Yukitoshi Fukahata[2], Kazuro Hirahara[3]

[1]Grad. Sch. Environ. Stud., Nagoya Univ., [2]DPRI, Kyoto Univ., [3]Grad. Sch. Science, Kyoto Univ.

There are many inland active faults in and around the Kinki region. The earthquakes on the faults are mainly generated by the E-W compression caused by the relative motion between North American and Eurasian plates (Sagiya, 2004). However, because inland earthquakes increases in the period from 50 years before to 10 years after the occurrence of great interplate earthquakes along the Nankai trough (Utsu, 1974; Hori & Oike, 1996), earthquake generations on inland faults are affected by the interplate earthquakes. We have evaluated stress change on many inland faults in this region. Our result predicts reverse faulting increases before interplate earthquakes along the trough, and strike-slip faulting increases after the interplate earthquakes. In this presentation we examine the validity of the prediction by spatiotemporal pattern of historical earthquakes.

In the computation we obtained quasi-static viscoelastic slip response functions in an elastic-viscoelastic stratified medium by Fukahata & Matsu'ura (2006). We employed plate interface of Philippine Sea plate subduction by Hashimoto et al. (2004). Amount of slip is set by Time or Slip Predictable models (Shimazaki & Nakata, 1980). The relative motion is after Heki & Miyazaki (2001). The compressive strain rate due to EW compression is 0.3×10^{-7} (yr^{-1}) with the direction of N100E. The geometries of inland faults are after HERP.

The results already presented are summarized as follows. The E-W compression is the primary cause of the long-term stress changes in this region, and forms general trend of strike of inland faults. The elastic changes in Coulomb Failure Function (dCFF) due to interplate earthquakes are mostly negative on reverse faults and mostly positive on strike-slip faults. This is because this region dragged to the SSE direction due to interplate earthquakes. As a result, dCFF are negative on N-S trending reverse faults and positive on NW-SE trending left-lateral and NE-SW trending right-lateral strike-slip faults. The calculated dCFF on source faults of 9 historical inland earthquakes at last 500 years are consistent with the historical records, because dCFF are the highest-ever at the occurrence in most cases. The computed dCFF on 73 inland faults are consistent with the historical earthquake pattern, presented in the first paragraph. These results suggest the inland reverse faulting increases before interplate earthquakes, whereas strike-slip faulting increases after interplate earthquakes. Recently, this relation is obtained in the seismic observation in the northern Tohoku region before and after the 2011 great Tohoku-oki earthquake (Asano et al., 2011).

Focal mechanism of inland earthquakes corresponds to the fault mechanism in and around the Kinki region, as a reflection of the local stress fields (Townend & Zoback, 2006; Terakawa & Matsu'ura, 2010). That is, there occur reverse earthquakes in the SW Chubu and central Kinki regions, and strike-slip earthquakes in the western Chubu and NW Kinki regions, corresponding to the fault mechanism. Conversely, mechanisms of inland earthquakes in a certain region can be roughly assumed by fault mechanisms. With our prediction, we can expect the inland earthquakes increases in the reverse fault region before interplate earthquakes, whereas the inland earthquakes increase in the strike-slip fault region after interplate earthquakes.

Based on the concept, we examined the spatiotemporal pattern of inland earthquakes. The expectation is notably consistent with the earthquake occurrence in the reverse fault region. On the other hand, in the strike-slip fault region, consistency of expectation is good in the western Chubu region (occurrence rate increases after interplate earthquakes) and not good in the NW Kinki region (occurrence rate increases before interplate earthquakes). As a whole, our result for inland earthquake occurrence is supported by the spatiotemporal pattern of historical inland earthquakes.

Keywords: subduction zone, the Kinki region, interplate earthquake along the Nankai trough, Coulomb failure function, historical earthquake, inland earthquake

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-18 Room:302 Time:May 22 10:15-10:30

The results of researches on the seismic linkage among mega thrust earthquake seismogenic zones around the Nankai trough

Yoshiyuki Kaneda[1*], Kazuro Hirahara[2], Takashi Furumura[3]

[1]JAMSTEC, [2]Kyoto University, [3]University of Tokyo

The recurrence of Nankai trough mega thrust earthquakes is the very severe problem
to Japan. Therefore, MEXT of Japanese government has started to the research project on the estimation of seismic linkage around the Nanakai trough mega thrust earthquake seismogenic zones. This project is composed of three research subjects as the observational research, simulation research and disaster mitigation research.

In results of observational research subject, the precise structures and seismicity around the western part of the Nankai trough are obtained. Especially, precise structures and characteristics of off Hyuga seismogenic zone including Kyushu-Palau
Ridge are obtained from refraction seismic surveys. Around off Hyuga, low frequency detected by the new analytical method. Furthermore, we have carried out observations of earthquakes and crustal deformations around off East Japan seismogenic zone from before 2011 East Japan earthquake, so, results of off East Japan observations indicated crustal activities among the pre shock, the main shock and aftershocks at 2011 East Japan. As results of simulation research subject, the crustal deformation database has been constructed and tsunami sediments were sampled and analyzed for the estimation of historical large tsunami recurrences. And some simulation technologies have been developed for advanced simulation researches including recurrence cycle simulations and data assimilations. .

Finally, in disaster mitigation research subject, precise seismic wave and tsunami propagations have simulated for the reliable hazard estimation. Furthermore, for the disaster mitigations and improvements of regional disaster measures, we have discussed with local governmental people and lifeline industrial people at some regional disaster prevention research societies. Results from this project contributed to the new estimation of maximum Nankai tough seismogenic zones, tsunamigenic zones and damages by Japanese Cabinet office.

Keywords: Nankai trough, Mega thrust earthquake, Seismic linkage

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-19 Room:302 Time:May 22 11:00-11:15

Preliminary results of IODP Expedition 338: Scientific aspects

Kyuichi Kanagawa[1*], Brandon Dugan[2], Gregory Moore[3], Michael Strasser[4], Lena Maeda[5], Sean Toczko[5], IODP Expedition 338 Scientists[6]

[1]Chiba University, [2]Rice University, [3]University of Hawaii, [4]ETH, [5]JAMSTEC, [6]IODP Expedition 338

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, 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). These sites and drilling intervals represent key targets not sampled during previous NanTroSEIZE expeditions, but relevant to comprehensively characterize the alteration stage of the oceanic basement input to the subduction zone, the early stage of Kumano Basin evolution, gas hydrates in the forearc basin, and the recent activity of the shallow megasplay fault zone system and submarine landslides.

Preliminary scientific results of Expedition 338 include:

1. LWD, mud gas monitoring and analyses of cuttings from the deep riser hole characterize two lithological units within the inner wedge of the accretionary prism at Site C0002, separated by a prominent fault zone at ~1640 mbsf. Internal style of deformation, downhole increase of thermogenically formed gas, and evidence for mechanical compaction and cementation document a complex structural evolution and provide unprecedented insights into the mechanical state and behavior of the wedge at depth.

2. Multiple samples of the boundary between the Kumano Basin section and the underlying accretionary prism at Site C0002 shed new light on this unconformity, the interpretation of which was debatable from previous samples and data. New samples suggest that variable erosional processes were active on small spatial scales.

3. Geochemical data characterize the gas-hydrate bearing zone (200-400 mbsf) in the Kumano Basin at Site C0002 as a zone of disseminated methane-dominated hydrate of microbial origin.

4. Operations at Site C0012 included 178.7 m of detailed LWD characterization of the oceanic basement, indicating an upper ~100 m zone of altered pillow basalts and sheet flow deposits, and a lower, presumably less altered basement unit.

5. Cores recovered at Site C0021 improve our understanding of submarine landslides in the slope basins seaward of the splay fault. LWD data acquired at Sites C0018 and C0021 characterize in situ internal structures and properties of mass-transport deposits (MTDs) which relate to the dynamics and kinematics of submarine landslides.

6. LWD resistivity images from Hole C0022A, located in the slope basin immediately seaward of the megasplay fault, show a conductive horizon where the tip of the megasplay fault is inferred from the 3D seismic data. Although the fault itself was not sampled at Hole C0022B, structural and porosity data from cores as well as interstitial water data suggest that the conductive horizon is possibly the splay fault tip.

Keywords: NanTroSEIZE, accretionary prism, forearc basin, megasplay fault, submarine landslide, subduction input

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-20 Room:302 Time:May 22 11:15-11:30

Preliminary structural geology results of IODP Expedition 338

Asuka Yamaguchi[1*], Toru Takeshita[2], Jacob Geersen[3], Olivier Fabbri[4], Kiyokazu Oohashi[5], Yehua Shan[6], Kyuichi Kanagawa[5], Expedition 338 Scientists[7]

[1]AORI, Univ. Tokyo, [2]Hokkaido Univ., [3]Univ. Southampton, [4]Univ. Franche-Comte, [5]Chiba Univ., [6]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, [7]IODP Expedition 338

Integrated Ocean Drilling Program (IODP) Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) Expedition 338 took place from October 1, 2012 to January 13, 2013. This expedition was originally planned to extend riser Hole C0002F from 856 to ~3600 mbsf. However, riser operations at Hole C0002F were suspended at 2005.5 mbsf because the riser pipe was damaged by unfavorable wind/current conditions. Contingency riserless operations including 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) have been performed instead of deepen Hole C0002F. Here we report the preliminary results of Expedition 338 shipboard structural studies.

During Expedition 338, two types of sample material were used for structural geology analyses: (1) cuttings (1-4 mm and >4 mm size fractions) sampled at 5-10 m intervals between 865.5 and 2004.5 mbsf during riser drilling of Hole C0002F, and (2) cores recovered from intervals of 200.0-1112.84 mbsf at Holes C0002H, C0002J, C0002K, and from intervals of 0-419.5 mbsf at Hole C0022B. For the cuttings from Hole C0002F, deformation structures such as vein structures, carbonate veins, slick-enlined surfaces, and minor faults, were observed as well as high number of drilling-induced deformation structures. Between 1550.5-1675.5 mbsf, up to 10% of investigated cuttings show slickenlined surfaces. This is correlatable with the high fracture concentration interval identified by LWD resistivity images. Abundant bedding, faults and deformation bands are observed in the cores retrieved from Holes H, J, K and L at Site C0002. Deformation structures are rarely observed in cores from the upper part of the Kumano Basin deposits (Unit II), while they are numerous in cores from the lowermost part of the Kumano Basin sediments (Unit III) and from the accretionary prism sediments (Unit IV). At Site C0022, orientations of bedding dip and minor faults appear to change across the possible splay fault. The existence of highly fractured or disturbed material and claystone with planar fabrics suggest that the interval of 100-101 mbsf is a plausible candidate for the location of the splay fault at Site C0022.

Keywords: IODP Expedition 338, NanTroSEIZE, Site C0002, Site C00021, Site C00022

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-21 Room:302 Time:May 22 11:30-11:45

What determines Mw7 or Mw8?

Arito Sakaguchi[1*], Yuzuru Yamamoto[1], Yoshitaka Hashimoto[2], Robert Harris[3], Expedition 344 Scientists[4]

[1]IFREE/JAMSTEC, [2]Kochi univ., [3]Oregon State University, [4]IODP

Variations in earthquake magnitude and recurrence intervals of fault behavior need to be understood in the context of regional tectonics. Convergent margins may be divided into two end-member types that are termed erosive and accretionary plate boundaries (e.g. von Huene and Scholl, 1991; Clift and Vannucchi, 2004). The Nankai accretionary margin has a 1300-year historical earthquake record with a recurrence interval of 100-150 years (Ando, 1975). In contrast, the Middle America trench offshore Costa Rica represents an erosive margin characterized by magnitudes as high as 7.6Mw, with a recurrence interval of several decades.

CRISP (Costa-Rica Seismogenesis Project) Program-A has carried out the first step toward deep riser drilling by characterizing the shallow lithologic, hydrologic, stress, and thermal state of this area (Vannucchi et al., 2011; Harris et al., 2013). CRISP drilling of Exp. 344 reveals that the shallow upper plate crust is composed of terrigenous sediment accumulated at a high rate. The Costa Rica seismogenic zone is 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). These characteristics are similar to the Nankai seismogenic zone (Kinoshita et al., 2008). Some differences exist between both margins including the convergence rates, the thickness and composition of incoming sediments, and physical properties of the crust. Among them, P-wave velocity within the upper plate of the Costa Rica margin (Stavenhagen et al., 1998) is much higher than at the Nankai margin (Nakanishi et al., 2002). In frictional stick-slip systems, the recurrence interval and event displacement varies with the stiffness of the system. We propose that the characteristic magnitude of large subduction earthquakes and recurrence intervals are influenced by the stiffness of the upper plate. This hypothesis may be best tested at the Nankai and Costa Rica margins.

Keywords: Large subduction earthquake, seismogenic zone drilling, accretion and erosive margin

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-22 Room:302 Time:May 22 11:45-12:00

Preliminary results of stress and strain analyses, IODP Expeditions 334 and 344, Costa Rica Seismogenesis Project (CRISP

Yuzuru Yamamoto[1*], Weiren Lin[1], Yoichi Usui[1], Xixi Zhao[2], Saneatsu Saito[1], Michael Stipp[3], Paola Vannucchi[5], Walter Kurz[6], Arito Sakaguchi[1], Robert Harris[7], Expeditions 334 and 344 Scientists[4]

[1]IFREE, JAMSTEC, [2]UCSC, [3]GEOMAR, [4]University of London, [5]University of Graz, [6]Oregon State University, [7]USIO

The Costa Rica Seismogenesis Project (CRISP) is designed to understand the processes that control nucleation and seismic rupture of large earthquakes at erosional subduction zones. Integrated Ocean Drilling Program (IODP) Expeditions 334 and 344 penetrated the middle slope at Sites U1378 and 1380, the upper slope at Sites U1379 and U1413, the frontal prism at Site U1412, and input sites at Sites U1381 and U1414.

Stress and strain analyses using anelastic strain recovery (ASR), fault kinematics, and anisotropy of magnetic susceptibility (AMS) have been conducted in the middle and the upper slope. Based on ASR analyses during Expedition 334, a clear difference in present-days stress state between the slope sediments and the basement were identified at Site U1379: A normal-fault stress regime characterizes the slope sediments, whereas a strike-slip regime corresponds to the basement. On the other hand, the stress-states in the slope sediments at Sites U1378 and U1380 are characterized by a strike-slip regime that has Sigma 2 oriented vertically. The Sigma 1 direction is oriented NNW-SSE, which corresponds to the SHmax direction identified in the logging while drilling (LWD), parallel to the present GPS direction. In contrast to the present-day stress state, the ancient stress and strain based on onboard fault kinematics during both expeditions and AMS were controlled by direction of plate subduction (Sigma 1 oriented to the vertical, whereas Sigma 2 oriented NW-SE). The spatial and time variations in stress state along the CRISP transect plausibly correspond to the stress variations during earthquake cycles. Preliminary ASR and AMS results will be incorporated into this study.

Keywords: Stress, Costa Rica, CRISP, Earthquake cycle

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-23 Room:302 Time:May 22 12:00-12:15

Fluid-rock interaction and resultant rupture of great earthquake -An exercise from fossilized seismogenic plate boundary

Gaku Kimura[1*], Saneatsu Saito[2], Asuka Yamaguchi[3], Jun Kameda[1], Mari Hamahashi[1], Rina Fukuchi[4], Mio Eida[5], Yohei Hamada[1], Yoshitaka Hashimoto[5], Koichiro Fujimoto[4], Shoko Hina[6], Yujin Kitamura[2]

[1]Dept. Earth and Planetary Science, The University of Tokyo, [2]IFREE, JAMSTEC, [3]Atmosphere and Ocean Research Institute, The University of Tokyo, [4]Tokyo Gakugei University, [5]Kochi University, [6]The Asahi Shimbun Company

Recent investigations of exhumed and fossilized plate boundary thrusts and megasplay faults strongly suggest that unraveling the physico-chemical dynamics of fluid-rock interaction and resultant rupture of great earthquake and tsunami is the scientific target of the seimogenic plate boundary processes, which is accessible only by Chikyu-deep riser drilling. The expected result of drilling into the active and living fault in depth will be a great step of science.

Technological advantage of the Chikyu Riser drilling is no doubt for its ability of deep hole with coring, logging and observatory installation. A main target of IODP was direct drilling into the sesimogenic plate boundary thrust in the Nankai Trough of subduction zone. After the first proposal for the NantroSEIZE many new discoveries have been reported from subduction zones, e.g. deep low frequency earthquakes, shallow low frequency earthquakes, high velocity slip even along the plate boundary decollement and on-going stress build-up within the hanging wall accretionary prism. However, unfortunately the deep target of IODP has not been reached yet.

Before drilling into the seismogenic deep splay fault and plate boundary thrust, we have conducted investigation of exhumed and fossilized splay fault of the Nobeoka thrust and plate boundary fault rocks recorded as melange in the Shimanto belt, Japan.
The Nobeoka thrust was once buried at the depth more than 10 km in subduction zone. Combining with inspection of surface exposure, drilling with logging for physical properties and borehole imaging was operated to compare the one dimension data set with the three dimensional occurrences of the fault zone.

Even though surface weathering and cracking with exhumation, the results of coring, logging, and borehole imaging present the condition of the fault in the depth of plate boundary. They show porosity less than several percentages with contrast between the hanging wall and footwall, which are well correlated with electric resistivity, and elastic wave velocities of Vp and Vs. They are systematically changes with the development of discrete slip zones in the shear zone and define a quantitative damage zone. Abundant mineral precipitation is characteristic in the fault and presents a catalog of fault rocks from friction melt of pseudotachylyte to fluidized fault rock suggesting various fault mechanisms of dynamic weakening.

REE pattern of carbonate vein precipitated along the slip surfaces and extensional cracks suggests that fluid flow along the fault, which might be co-seismic, would be under reductive condition but inter-seismic fluid appear to be oxidized condition. The change in chemical property appear be from rupture-related fluid-rock interaction along the plate boundary.

Exploration of the fossilized plate boundary to deep living ones is the revolving jump like autopsy to modern open-heart surgery in medical science. The drilling into various plate boundaries with different subduction parameters is quite essential.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-24 Room:302 Time:May 22 12:15-12:30

Changes in illite crystallinity in the Nobeoka thrust fault zone SW Japan, ancient megaspray fault in a subduction zone

Rina Fukuchi[1*], Koichiro Fujimoto[1], Mari Hamahashi[2], Asuka Yamaguchi[2], Gaku Kimura[2], Jun Kameda[2], Yohei Hamada[4], Shoko Hina[2], Yoshitaka Hashimoto[3], Mio Eida[3], Yujin Kitamura[4], Saneatsu Saito[4], Yukihiro Mizuochi[5], Kazunori Hase[5], Takayuki Akashi[5]

[1]Tokyo Gakugei University, [2]The University of Tokyo, [3]Kochi University, [4]Japan Agency for Marine-Earth Science and Tecnology, [5]Sumiko Resources Exploration & Development, Co.,Ltd.

The Nobeka thrust is a fossilized OOST in the Shimanto belts, Cretaceous and Paleogene accretionary complex in SW Japan. A bore hole penetrating the Nobeoka thrust was drilled at Nobeoka city, SW Japan as analogue of NanTroSEIZE project. Total drilling length was 255 m and continuous core samples were recovered. The borehole runs through the Nobeoka thrust at the depth of 41.3m. The hangingwall is mainly phyllite of Kitagawa group and the footwall is cataclacite of Hyuga group (Kondo et al., 2005).

The depth interval between 29m and 78.4m is suffered intense cataclasis due to Nobeoka thrust. Quartz and carbonate veins are enriched in this interval except 41.3-52 m depth interval. We identified from 41.3m to 41.8 m to be a main thrust zone. We also recognize fault breccia at 114m depth.

We collected fragmented core samples from every three meters and analyzed constituent minerals by powder X-ray diffraction. Quartz, plagioclase, illite, chlorite, calcite are main constituent minerals from the top to the bottom. Ankerite sometimes occurs as a vein mineral. Here, we focus on the illite with special reference to fault activity.

We measured IC values (FWHM of illite 001 peak) of 65 samples from the top to the bottom. They show remarkable change between hanging-wall and footwall.

IC values range from 0.14^o to 0.22^o above 38m depth they increase from 0.18^o to 0.30^o in the damaged zone between 38m and 41.0m depth. They range from 0.43^o to 0.58^o just above the Nobeoka thrust between 41.0 to 41.3 m depth. They range from 0.49^o to 0.59^o in the fault core between 41.3m and 41.8m depth, They range from 0.38^o to 0.62^o in the footwall. Here, we focus on the changes in IC values in the hanging-wall.

IC values increase near the Nobeoka thrust. In the damaged zone, the samples are divided into two groups, A and B. In the group A, IC value and peak intensity show negative correlation, whereas, IC values are low and peak intensity is high in the group B. In the fault core, carbonate and clay minerals are enriched and plagioclase content is decreased by intense hydrothermal alteration. The alteration temperature may be lower than the maximum plaetoemperature of Kitagawa group (320 degrees centigrade). This alteration may affect the high IC values in the fault core and the zone just above the fault.

Cray minerals are easily amorphitized by pulverization. IC values should increase during pulverization. We conducted pulverization experiment of illite rich core samples by planetary ball mill. The IC values increased with decresing peak intensity, in a similar relations as that of group A.

Therefore, the increase in IC values in the damaged zone of the Nobeoka thrust result from two processes, which are pulverization (group A) and hydrothermal alteration(group B).

Keywords: cray mineral, megaspray fault, illite

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-25 Room:302 Time:May 22 14:15-14:30

Frictional behavior of incoming pelagic sediments to the Tohoku subduction zone

Michiyo Sawai[1*], Takehiro Hirose[2]

[1]Hiroshima University, [2]Kochi/JAMSTEC

The 2011 Tohoku earthquake (Mw 9.0) off the Pacific coast of Japan produced huge slip (˜50 m) on the shallow part of the megathrust fault (e.g., Fujiwara *et al*., 2011), resulting in destructive tsunamis. Although the multiple causes of such large slip at shallow depths is expected, the frictional property of sediments around the megathrust, especially at coseismic slip velocities, may significantly contribute to large slip along the fault. We thus investigate the frictional properties of pelagic sediments to be subducting beneath the Tohoku region at seismic velocities and large displacement toward understanding the rupture processes to cause large slip at the shallow portion of the subduction plate boundary.

We have conducted friction experiments on incoming pelagic sediments on the Pacific plate (DSDP, Leg56, Site 436, Core 38 (358 mbsf) and Core 40 (378 mbsf)). The site locates about 100 km northeast from the Hole C0019E drilled during the IODP Expedition 343 (J-FAST). Core 38 is diatom-rich clayey sediment, while Core 40 contains mainly smectite which could correspond to black-colored sheared clay in the plate boundary fault zone recovered during Expedition 343. Experiments are performed at slip velocities of 2.5 x 10^{-4} to 1.3 m/s, normal stresses of 0.8 to 2.0 MPa and slip displacement of ˜16 m under brine saturated conditions, using a rotary-shear friction apparatus. One gram of gouge was placed between rock cylinders of sandstone or gabbro of 25 mm diameter with Teflon sleeve outside to contain gouge. Both gouge sample and host rock were saturated with brine before the experiments.

In both Cores 38 and 40, a typical slip weakening behavior appears at slip velocity of 1.3 m/s; friction coefficient of the sediments rapidly increases at the onset of sliding (initial peak friction) and then progressively decreases to $<$0.1 with displacement. However, at low velocities there is significant difference in friction level between two. Steady-state friction coefficient of Core 40 is remarkably low ($<$ 0.2) over a wide range of slip rate (2.5 x 10^{-4} to 1.3 m/s). In contrast, steady-state friction of Core 38 is high values of ˜0.6 at low velocities, but decreases to $<$0.1 toward seismic slip velocity of 1.3 m/s. This marked difference in frictional strength between two sediments could be attributed to smectite content and initial grain size: clay minerals align preferentially along most shear planes in Core 40, whereas fracturing and subsequent shear enhanced compaction seems dominant deformation processes in Core 38. In addition, peak friction of Core40 is far smaller than that of Core38 and steady-state friction of Core 40 is smaller than that of similar studies conducted on other fault gouge (e.g., Mizoguchi *et al*., 2007; Ujiie and Tsutsumi, 2010). These results suggest that the incoming pelagic zone in Core 40, possibly source material of the current plate boundary fault zone, is energetically very easy for earthquake ruptures to propagate at shallow portion of the Tohoku subduction zone, leading to large slip near the trench.

Keywords: Tohoku earthquake, High-velocity friction, Pelagic sediments

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-26 Room:302 Time:May 22 14:30-14:45

Mechanical properties of the shallow Nankai Trough accretionary sediments

Miki Takahashi[1*], Hidenori Ito[2], Shuhei Azuma[2], Kiyokazu Oohashi[2], Kyuichi Kanagawa[2], Atsuyuki Inoue[2]

[1]AFERC, AIST, [2]Graduate School of Sicence, Chiba Univ.

We report the results of triaxial compression and friction experiments of mudstone, sandstone and tuff samples, which are cored from the shallow (1000-1500 mbsf) Nankai Trough accretionary prism at Sites C0002 and C0009 of IODP Expeditions 315 and 319, at confining pressures, pore water pressures and temperatures close to their in situ conditions.

Triaxial compression experiments at these conditions and an axial displacement rate of 10 micron/s reveal that failure strength is 300 MPa for a sandstone sample, 48 MPa for a tuff sample, 20 MPa for a silty mud sample, and 14 MPa for a clayey mud sample. Another silty mud sample did not fail, and deformed ductilely at strength of ˜15 MPa. The sandstone sample is strongly lithified by being cemented by calcite and dolomite, which makes this sample's failure strength very high. The ductilely deformed silty mud sample seems not lithified enough to fail. Failure strength of the other three samples shows a negative correlation with the content of clay minerals, i.e. it increases with decreasing content of clay minerals.

Friction experiments at these conditions and axial displacement rates changed stepwise among 0.1, 1 and 10 micron/s reveal that frictional strength, too, has a negative correlation with the content of clay minerals; steady-state friction coefficient is $>$0.8 for the sandstone sample with ˜5 wt% clays, ˜0.7 for the tuff sample with ˜15 wt% clays, ˜0.55 for the silty mud samples with ˜30 wt% clays, and ˜0.25 for the clayey mud sample with ˜40 wt% clays. Slip-dependent frictional behavior also shows a correlation with the content of clay minerals; sandstone sample, tuff and silty mud samples, and clayey mud sample exhibit slip-hardening, quasi steady-state slip, and slip-softening, respectively. All samples showed an increase in friction when sliding velocity was increased or vice versa, i.e., velocity strengthening. We also found that the velocity dependence of friction has a correlation with the content of clay minerals, suggesting an increasing contribution of flow with increasing amount of clay minerals.

Thus the mechanical properties of shallow accretionary sediments differ basically according to the content of clay minerals, which would have important implications for deformation and faulting in the shallow Nankai Trough accretionary prism.

Keywords: fracture experiment, permeability, velocity dependent of friction

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-27 Room:302 Time:May 22 14:45-15:00

Dynamic weakening of smectite-rich faults at intermediate velocities and its importance for rupture propagation

Kiyokazu Oohashi[1*], Takehiro Hirose[2]

[1]Graduate School of Science, Chiba University, [2]Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology

Shallow portion of the subduction interface had long been assumed to be aseismic and releasing stress by creep. However, the 2011 Tohoku-oki earthquake clearly demonstrated that the subduction zone earthquakes can propagate to the surface and causes devastating tsunamis resulted from large seafloor displacements. Recent high velocity friction experiments and dynamic modeling are revealing dynamic weakening processes and rupture propagation to the shallow aseismic regions (Faulkner et al., 2011, GRL; Noda and Lapusta, 2013, Nature). Here we provide frictional properties of smectite-rich, synthetic fault gouges (bentonite-quartz mixtures) under the various slip velocities to understand the processes of interseismic loading and coseismic weakening. Experiments were conducted under the normal stress of 2 MPa and slip rates of 30 um/s to 1.3 m/s, using rotary-shear, low- to high-velocity friction testing apparatus. Synthetic fault gouges were saturated with deionized water and placed between gabbro host rock (slider). At the low slip rates of 30 to 150 um/s, friction coefficient remains constant values without visible slip weakening or hardening for any fraction of mixtures. On the other hand, friction becomes unstable at the slip rates of few mm/s, and exhibits noticeable slip weakening at the slip rates faster than 22 mm/s. Intense slip weakening can be observed from 20 to 35 % bentonite mixtures in particular. The velocity, which starts to appear dynamic weakening, comes from 1-2 order of magnitude lower than previous study (Di Toro et al., 2011, Science). According to the slide-hold-slide test, specimens after the slip weakening recover its strength logarithmically with time, but not correspond with temperature decay. Additionally, slip weakening can not be observed from the experiments with highly permeable host rock. These results suggest that the dynamic weakening at the velocity range of mm/s can be attributed to mechanically and/or thermally activated pressurization of pore fluids. These experimental results can explain high friction at interseismic loading and dynamic weakening associated with coseismic rupture. Dynamic weakening at intermediate velocity may assist rupture propagation to the shallow portion of the subduction interface.

Keywords: Smectite, Fault gouge, Friction experiment, Dynamic weakening, Thermal pressurization, Tsunamigenic earthquake

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-28 Room:302 Time:May 22 15:00-15:15

Megathrust-zone heterogeneity and megathrust earthquakes

Dapeng Zhao[1*]

[1]Tohoku University

We investigated the detailed 3-D seismic structure of the crust and upper mantle under the NE Japan and SW Japan arcs and its implications for the generation of large megathrust earthquakes. We used P and S wave arrival times from earthquakes under the forearc region under the Pacific Ocean and back-arc region under the Japan Sea which are relocated precisely using sP depth phases. P and S wave arrival-time data from many relocated aftershocks of the 2011 Tohoku-oki earthquake (Mw 9.0) are added to determine the updated 3-D Vp and Vs models of the Tohoku forearc region.

Significant structural heterogeneities are revealed in the interplate megathrust zone under the Tohoku forearc. Three low-velocity (low-V) anomalies exist off Sanriku, off Fukushima and off Ibaraki. There is a correlation between the velocity variation and the distribution of large thrust-type earthquakes ($M > 6.0$) that occurred from 1900 to 2011, including the foreshock, mainshock and aftershocks of the 2011 Tohoku-oki earthquake. The low-V patches in the megathrust zone may contain subducted sediments and fluids associated with slab dehydration, thus the subducting Pacific plate and the overriding continental plate may become weakly coupled or even decoupled in the low-V areas. In contrast, the high-velocity (high-V) patches in the megathrust zone may result from subducted oceanic ridges, seamounts and other topographic highs on the Pacific seafloor that become asperities where the subducting Pacific plate and the overriding continental plate are strongly coupled. Thus tectonic stress tends to accumulate in these high-V areas for a relatively long time during subduction, leading to the nucleation of large and great earthquakes in those areas. The off-Miyagi high-V zone, where the Tohoku-oki mainshock and its largest foreshock occurred, corresponds to the area with large coseismic slip (> 25 m) during the Tohoku-oki mainshock. This indicates that the off-Miyagi high-V zone is a large asperity in the megathrust zone that ruptured during the Tohoku-oki mainshock. These results indicate that the rupture nucleations of the large events in the 2011 Tohoku-oki earthquake sequence, including the mainshock and major foreshocks and aftershocks, were controlled by the structural heterogeneities in the interplate megathrust zone and the over-riding continental plate.

Detailed 3-D Vp and Vs models of the entire Southwest Japan arc from the Nankai trough to the Japan Sea are determined for the first time using a large number of high-quality arrival-time data from local earthquakes. Our results show that strong lateral heterogeneities exist in the interplate megathrust zone under the Nankai forearc. Large interplate earthquakes mainly occurred in or around high-V patches in the megathrust zone. These high-V patches may represent asperities formed by the subducted oceanic ridges and seamounts. Low-V zones in the megathrust zone may contain sediments and fluids associated with slab dehydration and so become weakly coupled areas. Our results also show that the coseismic slip distributions of some megathrust earthquakes are not limited in the high-V patches (asperities) where the ruptures initiated. Because of the weak interplate coupling in the low-V areas, the rupture of an interplate earthquake could unimpededly pass through the low-V anomalies and so result in a great megathrust earthquake.

References

Huang, Z., D. Zhao (2013) Relocating the 2011 Tohoku-oki earthquakes (M 6.0-9.0). Tectonophysics 586, 35-45.

Liu, X., D. Zhao, S. Li (2013) Seismic imaging of the Southwest Japan arc from the Nankai trough to the Japan Sea. Phys. Earth Planet. Inter. 216, 59-73.

Tong, P., D. Zhao, D. Yang (2012) Tomography of the 2011 Iwaki earthquake (M 7.0) and Fukushima nuclear power plant area. Solid Earth 3, 43-51.

Zhao, D. et al. (2011) Structural heterogeneity in the megathrust zone and mechanism of the 2011 Tohoku-oki earthquake (Mw 9.0). Geophys. Res. Lett. 38, L17308.

Keywords: subduction zone, great earthquakes, structural heterogeneity, seismic tomography, forearc, fluids

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-29 Room:302 Time:May 22 15:15-15:30

3D modeling of the cycle of megathrust earthquakes in the southern Kuril subduction zone considering high speed friction

Bunichiro Shibazaki[1*], Hiroyuki Noda[2]

[1]International Institute of Seismology and Earthquake Engineering, Building Research Institute, [2]Japan Agency for Marine-Earth Science and Technology

Studies on deposits of prehistoric tsunamis indicate the occurrence of destructive earthquakes (Mw 8.4) along the southern Kuril trench subduction zone (Nanayama et al., 2003). Intervals between inferred outsized tsunami events average nearly 400 years, but range widely from about 100 to 800 years (Sawai et al. 2009).

Recent studies on fault zones show that considerable weakening can occur at a high slip velocity because of pore-fluid pressurization via frictional heating or thermal weakening processes (Noda and Lapusta, 2010; Di Toro et al., 2011, Tsutsumi et al., 2011). Shibazaki et al. (2011) performed 3D quasi-dynamic modeling of the great Tohoku-oki earthquake cycle by considering high-speed friction. The present study models the megathrust earthquake cycle along the southern Kuril trench subduction zone, considering weakening of friction by thermal pressurization at high slip velocity.

We investigate the model considering a rate- and state-dependent friction law and thermal pressurization by using a spectral solver (Noda and Lapusta, 2010) to calculate the temperature and pore pressure evolution on a fault plane. Asperities for the 1952 Tokachi-oki earthquake (Mw 8.1) and the 1973 Nemuro-oki earthquake (Mw 7.8) are considered. The Geospatial Information Authority of Japan (2012) suggests that there is a slip deficit region at the shallower subduction interface between the two source regions, and in this respect, we set a larger asperity near the trench. We set the frictional properties of velocity weakening within the asperities and that of velocity strengthening outside of the asperities. Results show that when a rupture occurs around the large asperity near the trench, significant thermal pressurization occurs, resulting in large and fast slips. This rupture propagates to the stable creeping region and to the asperities of Mw 8 earthquakes. We examine conditions where observed recurrence intervals are reproduced. In cases where the recurrence interval of megathrust earthquakes is around 400 years, the size of the megathrust earthquakes reaches Mw 8.8.

Keywords: the southern Kuril subduction zone, megathrust earthquakes, earthquake cycle, high-speed friction

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-30 Room:302 Time:May 22 15:30-15:45

Strength drop as a detectable short-term precursor: feasibility of acoustic monitoring at a natural scale

Nobuki Kame[1*], Satoshi Fujita[1], Masao Nakatani[1], Tetsuya Kusakabe[1]

[1]Earthquake Res. Inst., Univ. of Tokyo

On the basis of the revised RSF proposed by Nagata et al. (2012), we reinvestigated frictional stick-slip cycles of earthquake faults. Simulation results showed a fairly large strength drop in the preslip period, which is localized within a few years preceding the earthquake. This suggests a possibility of earthquake forecast by monitoring the strength drop of a natural fault by acoustic methodology. In laboratory, Nagata et al. (2008, 2012) conducted rock friction experiments in a double-direct-shear apparatus, where they simultaneously measured P-wave transmissivity across the frictional interface to monitor the state of contact (= strength). The acoustic transmissivity |T| was found to reflect changes in the contact state very well. However, a critical problem is that how the acoustic monitoring can be realized at a natural scale. The present paper discusses its feasibility based on the earlier studies on the acoustic method for monitoring mechanical properties of imperfectly welded interfaces (Kendall and Tabor, 1971; Schoenberg, 1980).

We started from the laboratory experiment of Nagata et al. (2008) of the order of strength 10MPa, fc_lab = 1MHz and L_lab = 1micron, where fc is a cutoff frequency and L is a characteristic slip distance of the interface. We theoretically derived that I times greater strength and J times greater L lead to fc = (I/J)fc_lab. For our simulation values of I=10 (100MPa strength) and J=10^5 (L=10cm), fc can be estimated as 100 Hz. Recently reported large L=1m (J=10^6) (Hori and Miyazaki, 2011; Kato and Yoshida, 2011) and weak strength of 10MPa (I=1) (Hasegawa et al., 2011) for the 2012 Mw9.0 Tohoku earthquake, fc could be as low as 1 Hz. We think that the frequency range between 1 to 100 Hz is seismically observable. In fact, the explosion reflection surveys conducted over the plate boundary on the forearc slope of the Japan Trench successfully revealed the intensity distribution of plate boundary PP reflection around 5 - 20 Hz (Fujie et al., 2002; Mochizuki et al., 2005). Because acoustic reflection |R| is theoretically related to |T| (Schoenberg, 1980), acoustic monitoring of strength via |R| looks feasible at a natural scale. Note that though expected change of |T| in the preslip period would depend on the ratio of the change to the absolute value (Nagata et al., 2012), and the ratio is arbitrary in the simulations (only the change from an arbitrarily chosen reference value is necessary). The ratio could be more than 50% if a weak fault is considered in our simulation, and it would be easily detected by seismic reflection surveys.

Reference

Kame, N., Fujita, S., Nakatani, M. and Kusakabe, T., Earthquake cycle simulation with a revised rate- and state-dependent friction law, Tectonophysics (2012), http://dx.doi.org/10.1016/j.tecto.2012.11.029

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-31 Room:302 Time:May 22 16:15-16:30

Paradox of seismicity in subduction zones: Background seismicity and mega-earthquakes

Satoshi Ide[1*]

[1]Dept. EPS, Univ of Tokyo

Since earthquakes release elastic strain accumulated by long-term plate motion, we expect that fast plate subduction yields frequent occurrence of earthquakes. This intuitive expectation is supported by observation. A background seismicity rate estimated by applying the ETAS model in a finite area of subduction zone correlates with the velocity of relative plate motion. Especially a strong correlation exists for subduction zones in the south western Pacific including the Mariana and Tonga-Kermadec subduction zones. Despite high seismicity, no earthquake larger than M9 has been known in these regions and the Mariana subduction zone was considered as a representative region where no mega-earthquake occur in early comparative subductology. In total, these regions have a potential to yield one M9 earthquake every decade, if we assume the complete coupling and the independent occurrence of large earthquakes. On the other hand, there are many regions where seismicity is extraordinary lower than the expectation by the above proportionality. These include the Nankai, Ryukyu, Cascadia, and southern Chile subduction zones, all of which are also known as the area of ”slow earthquake”, i.e., tectonic tremor and slow slip events, and as the high-risk area of mega-earthquakes. Therefore, apparently high seismicity implies low risk of mega-earthquakes, and vice versa. Slow aseismic process seems to be a key to reconcile this paradox. Actually, the above fact is not new, and vaguely and regionally recognized by many researchers. However, I emphasis that it is an important paradox in earthquake science, that should be considered globally and quantitatively.

Keywords: subduction zone, seismicity, ETAS, slow earthquake

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-32 Room:302 Time:May 22 16:30-16:45

Similarity and variability of great earthquakes in world's subduction zones

Kenji Satake[1*]

[1]Earthquake Research Institute, University of Tokyo

Because recurrence interval of giant (M˜9) earthquake is typically several hundred years, data of past earthquakes are limited from a particular subduction zone. However, we can increase our knowledge by studying the subduction zones in the world. For five giant earthquakes with M=9 or larger occurred in the world since the 20th century, instrumental data such as seismic waves, tsunamis, or geodetic data were used to estimate the slip distribution and similarities. For older earthquakes, historical documents or paleoseismological data such as coastal movement (subsidence or uplift), tsunami deposit, or turbidite can help to estimate size and recurrence of past earthquakes. They show the variability of past earthquakes: giant (M˜9) earthquakes occurred in the source regions of recurrent M˜8 earthquakes, hence it is dangerous to assume characteristic earthquake model (Satake and Atwater, 2007).

For the post 20th century earthquakes, i.e., the 1952 Kamchatka (Mw 9.0), 1960 Chile (Mw 9.5), 1964 Alaska (Mw 9.2), 2004 Sumatra-Andaman (Mw 9.1) and 2011 Tohoku (Mw 9.0) earthquakes, the slip distributions have been estimated from inversion of tsunami and geodetic data. The results show that the largest slip is twice to four times larger than the average slip, and the asperity (defined as the area with more than 1.5 times the average slip) consists 16-32 % of the total fault area. The scaling relations among seismic moment, fault area, asperity area, average slip obtained for M˜8 earthquakes can be applied for the M˜9 earthquakes (Murotani et al., 2013).

Paleoseismological studies around the Pacific ocean have revealed the recurrence interval of giant earthquakes. In southern Chile where the 1960 earthquake occurred, historical records indicated that the recurrence interval was ˜ 100 years, but recent studies of tsunami deposit (Cisternas et al., 2005) show that the penultimate event occurred in 1575 and the recurrence interval is ˜ 300 years. In north America, along the Cascadia subduction zone, no great earthquakes have been recorded in historical records. Numerious paleosesimological stuides on coastal subsidence, tsunami deposit or offshore turbidite have shown that more than 40 great earthquakes occurred in the Holocene, but the number of giant earthquakes (M˜9) is about a half, or the average recuccence interval is ˜ 500 years (Goldfinger et al., 2012). Along the Kuril trench, the great earthquakes that left tsunami deposits occurred with ˜ 500 year interval, and the most recent one occured in the 17th century (Nanayama et al., 2003). Tsunami deposit studies in Sendai plain showed that the recurrence interval of giant earthquake similar to the 869 Jogan and 2011 Tohoku earthquakes is 500 to 800 years (Sawai et al., 2012). Similar paleoseismological studies have been made in countries around the Indian Ocean such as Thiland, Indonesia, or India, and they show that tsunamis similar to the 2004 Indian Ocean tsunami occurred several hundread ago. The tsunami deposits in Thailand show that the average recurrence interval is ˜ 500 years (Prendergast et al., 2012.)

Keywords: great earthquakes, tsunami, paleoseismology, subduction zone

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-33 Room:302 Time:May 22 16:45-17:00

Tsunami source models of the 2011 Tohoku and 1896 Sanriku earthquakes

Yushiro Fujii[1*], Tomoya Harada[2], Kenji Satake[2]

[1]IISEE, Building Research Institute, [2]ERI, University of Tokyo

We estimated the tsunami sources of the 2011 Tohoku earthquake and 1896 Meiji Sanriku tsunami earthquake by modeling the tsunami waveform data and tsunami height data along the coasts.

The spatial and temporal slip distribution of the 2011 Tohoku tsunami source was inverted from 53 tsunami waveforms recorded at ocean bottom pressure gauges, GPS wave gauges, and coastal wave and tide gauges (Satake et al., 2013, BSSA). The result shows that fault slip started near the hypocenter and very large (> 25 m) slip occurred on the deep plate interface near the hypocenter within ~ 2.5 min, then huge (up to 69 m) slip occurred at the shallow part near the trench axis and propagated to the north. The final slip distribution shows that the slip increases toward the trench axis. The average slip on a 550 km long and 200 km wide fault is 9.5 m, and the total seismic moment is 4.2 x 10^{22} Nm (Mw = 9.0). The slip distribution can be decomposed into a shallow slip near the trench axis (Mw = 8.8) and a deeper slip on the plate interface (Mw = 8.8).

The shallow slip near the trench axis is similar to the proposed model of the 1896 Sanriku tsunami earthquake (Tanioka and Satake, 1996, GRL), which is inferred from the tsunami records at three tide gauges (Hanasaki, Ayukawa and Choshi). The maximum tsunami height observed at tide gauges was 1.2 m at Ayukawa, which is much smaller than the observed one for the 2011 tsunami (> 8 m), while the maximum tsunami height (~ 40 m) along the Sanriku coast was similar to the 2011 tsunami. The tide gauge records and the coastal tsunami heights from the 1896 Sanriku earthquake can be explained by halving the slip of the 2011 source model on the northern subfaults along the trench axis (200 km x 50 km). The seismic moment is ~ 3 x 10^{21} Nm (Mw = 8.2). While the average slip of ~ 9 m is similar to the previous estimates (Tanioka and Seno, 2001, GRL), the slip increases toward south. This indicates that both the 1896 and 2011 earthquakes had similar slip distribution along the trench axis.

Keywords: 2011 Tohoku earthquake, 1896 Sanriku earthquake, Slip distribution, Tsunami waveform data, Tsunami height along coast

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-34 Room:302 Time:May 22 17:00-17:15

The feature of the Tsunami height according to type of the coastal landforms - in the case of the 2011 Tohoku Earthquake

Nobuhisa Matsuta[1*], Yasuhiro Suzuki[1], Nobuhiko Sugito[1], Yoshimichi Senda[2], Satoshi Ishiguro[3], Chikara Uchida[4]

[1]Nagoya University, [2]Nakanihon Air Service CO., [3]National Institute for Environmental Studies, [4]Tamano Consultants Co.

Along the Sanriku shoreline, a lot of the Thsunami height dates have been measured by the 2011 Tohoku Earthquake Tsunami Joint Survey Group (2012) in the field survey and Tsunami damage area maps were made by interpretation of the aerial photographs taken just after the earthquake (Tsunami Damage Mapping Team, Association of Japanese Geographers, 2011). Also, we can access historical Tsunamis dates (1896, 1933, 1960).

We classified according to the type of coastal landforms and then compared the 2011 Tohoku Earthquake Tsunami to historical tsunamis. In the result, in short wavelength Tsunami case, a tsunami height in bordering open ocean areas is higher than in bordering inner bay. On the other hand, in long wavelength Tsunami case, a tsunami height in bordering open ocean areas is similar as bordering inner bay. In the 2011 Tohoku Earthquake Tsunami case, we can show the tsunami height with features of both the short wave and the long wave in the northern and the southern area, and the middle area has only the long wave feature. The areal distribution correlates with the tectonic geomorphology in sea bed.

This study leads us in understanding of the detail subduction earthquakes in poor observation equipment area and geological period.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, coastal landform, Meiji Tsunami, Wavelength of Tsunami, Ocean-Trench Earthquake

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-35 Room:302 Time:May 22 17:15-17:30

Holocene event deposits detected from Kushimoto, Wakayama prefecture, along the Nankai Trough

Masanobu Shishikura[1*], Hideaki Maemoku[2], Tomoo Echigo[3], Masashi Omata[4], Yorihide Kouriya[4], Shibuya Noriyuki[4]

[1]Active Fault and Earthquake Research Center, AIST, [2]Geography, Edu., Hiroshima Univ., [3]GRI, [4]Crearia Inc.

We found several Holocene event deposits in Kushimoto where tsunami has been repeatedly attacked due to mega-thrust earthquakes along the Nankai Trough. Analyzing the drilling cores up to 9 m in depth, mean recurrence interval of event is estimated to 400-600 years. This result is consistent with our previous studies of tsunami boulders and uplifted sessile assemblages in outskirts area.

Drilling survey site is in the campus of Kushimoto-Koza high school located in tombolo of 500 m in width and 5.8 m in altitude. Obtained core samples show that at least 7 layers of fine-coarse sand are intercalated into humic silt-clay. Based on the lithofacies, it is inferred that sand has been intermittently transported into marsh or lagoon.

In the depth of 7.4 m, we found volcanic ash layer which is probably K-Ah tephra (ca 7300 yr BP). Radiocarbon samples in the depth of 4.1 m and 3.2 m were dated to 5570-5320 yrs BP and 4150-3980 yrs BP respectively. Archeological layer of late Yayoi period (1800 years ago) was also found in the depth of 1.8 m. Because seven sand layers were deposited between 5400 yrs BP and 1800 yrs BP, mean recurrence interval of event can be estimated to 400-600 years.

Cause of event deposits found in this survey is tsunami or storm, but its distinction is difficult. To identify tsunami deposit, it is necessary to consider synchronism with crustal movement reconstructed by microfossil analysis.

Keywords: Nankai Trough, Kushimoto, Holocene, tsunami, deposit

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-36 Room:302 Time:May 22 17:30-17:45

Revisiting the unusual uplift of the Kikai Island at northern Ryukyu Islands, Japan

Kazuhisa Goto[1*], Yosuke Suda[1], Fumihiko Imamura[1], Chuki Hongo[2], Yuji Yagi[3]

[1]Tohoku University, [2]University of the Ryukyus, [3]University of Tsukuba

After the 2011 Tohoku-oki tsunami, reevaluation of the maximum earthquake and tsunami along the coastal area of Japan is the important issue for the future disaster prevention. In this sense, understanding the historical and pre-historic earthquake and tsunami events is the straightforward way to prepare the future disaster countermeasures. In this study, we evaluated the possible maximum earthquake event at the northern Ryukyu Islands (Amami-Oshima and Kikai Islands), Japan based on the geological and geomorphological evidence and then conducted the numerical modeling of the seismotectonic uplift and tsunami. Kikai Island marks one of the highest uplift rates in the world. Namely, the island was intermittently uplifted about 1-4 m of 1,500-2,000 years interval during the Holocene by the seismic event and the latest one was occurred at about 1,550 years ago (e.g., Webster et al., 1998). On the other hand, there is no evidence of such remarkable uplift at the east coast of the Amami-Oshima Island (approx. 30 km away from the Kikai Island). Moreover, coastal boulders deposited on these islands' reefs were of storm wave origin without any tsunami origin, suggesting no remarkable tsunami was affected to these coasts during past 2,300 years. These evidences can be used as the geological and geomorphological constraints of the seismic event at 1,550 years ago. Our preliminary numerical modeling of the seismotectonic uplift revealed that the above-mentioned constraints were explained reasonably by the high-angle reverse faults rather than the row-angle thrust type fault at the plate boundary.

Keywords: earthquake, uplift, tsunami, Kikai Island

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P01 Room:Convention Hall Time:May 21 18:15-19:30

Initial data evaluation of seismometer and tiltmeter installed in the C0002G borehole observatory in the Nankai Trough

Toshinori Kimura[1*], Eiichiro Araki[1], Kazuya Kitada[1]

[1]JAMSTEC

Cable connection between DONET (Dense Oceanfloor Network system for Earthquake and Tsunamis) and C0002G observatory was successfully completed on Jan. 24, 2013. The C0002G observatory has a sensor suite comprising a volumetric strainmeter, tiltmeter, seismometers, pressure gauge, and thermometer, which was installed during IODP Exp.332 on Dec. 2010. After the cable connection, it has become possible to obtain realtime observed borehole data through DONET seafloor cable. In this presentation, we report results of initial data processing especially for seismometers and tiltmeter for future advanced analysis.

We conducted initial data processing including: 1) Power spectral density analysis calculated from 1 hour continuous noise record and comparison results of each sensor. 2) Running spectrum analysis using continuous long-term data and comparison results of each sensor. 3) Estimation of sensor orientation. Details of each processing are described as follows.

1) Power spectral density analysis

We calculate Power spectral density (PSD) using background noise record with length of 1 hour. We obtain PSD plots calculated from each seismic sensor including a broadband seismometer (CMG3TBD, Guralp systems), geophone (GS-11D, Geospace), accelerometer (JA-5H200, JAE) and tiltmeter (LILY, Applied geomechanics). In the obtained PSD, microseisms peaks around 0.3 Hz are clearly visible for all sensors. We then compared obtained results of borehole sensors and DONET seafloor seismometer. Results show that the microseisms peaks of boreholes sensors are smaller than those of DONET seismometers. The difference is 10 dB for horizontal component, and is 3-5 dB for vertical component. For high frequency region, 1-50 Hz, noise-levels of borehole sensors are much smaller than those of DONET seafloor seismometer with the difference of around 20dB. These results imply borehole sensors can capture very small seismic events which cannot be captured by DONET seismometers. We also confirmed that obtained noise-levels are consistent with the results of land experiments which were conducted before installation. For geophone, we conducted the signal coil calibration method, and obtained response parameters which are not changed with those obtained during the land experiments. We then concluded that the borehole seismic sensors were not damaged during the installation.

2) Running spectrum analysis

We calculate running spectrum using long-term data acquired since Jan. 25 2013. We checked long-term stability of each borehole seismic sensor from the results. Results shows common characteristic as the results of 1 hour data. The daily changes of microseisms peaks are clearly visible in the results. Performance degradations of borehole sensors are not found in the results.

3) Estimation of sensor orientation

We applied a cross-correlation method based on Nakano et al. (2012) to teleseismic records to estimate orientation of borehole sensors. We calculate cross-correlation between rotated horizontal waveforms of borehole seismometer and reference horizontal waveforms of DONET seismometer. We calculated cross-correlations for each rotated angle from 0 to 360 degree with a rotation rate of 1 degree. We then obtained the orientation angle of 46 degree from North with clockwise rotation, which has a maximum amplitude of calculated cross-correlation.

The above mentioned results show that seismometer package and tiltmeter installed in C0002G observatory are functional with expected performance which was revealed by the land experiments. Now auto evaluation processes are running to monitor sensor functions on data server. We plan to carry out an advanced check for sensor response using earthquake records. We also plan to analyze very small seismic events which are captured only by the borehole observatory. Furthermore, we plan to perform seismic interferometry analysis applied to continuous noise records and earthquake records for structural monitoring.

Keywords: borehole observatory, seismometer, Nankai trough, data evaluation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P02 Room:Convention Hall Time:May 21 18:15-19:30

Precision observation of seafloor pressure change on the platform of C0002 borehole observatory in Nankai Trough

Kazuya Kitada[1*], Eiichiro Araki[1], Hiroyuki Matsumoto[1], Toshinori Kimura[1]

[1]Japan Agency for Marine-Earth Science and Technology

Long-term observation of seafloor and pore pressures off Kii Peninsula is important for the detection of the crustal movement, the monitoring of fluid migration around splay faults and also understanding the pre and post earthquake events in the focal region of the Tonankai earthquake. Pressure measurement contains the instrumental drift in pressure sensors in addition to the pressure changes associated with the crustal movement, fluid migration and etc. In order to remove the drift, the drift rate is estimated by the laboratory experiment. However, for the long-term observation over one year, it is difficult to quantify the behavior of the drift. In this study, we have conducted the precision observation of seafloor pressure change on the platform of C0002 borehole observatory for the development of the in-situ calibration method.

During the IODP Expedition 332 in December 2010, we deployed a long-term borehole monitoring system (LTBMS) with pressure gauges (Paroscientific Inc. 8B7000-2 and 8B7000-1) into C0002 riserless borehole in Nankai Trough to monitor the seismogenic behavior of subduction zone plate boundaries. Seafloor pressure and pore pressure measurements are continuously conducted since the deployment. In this January 2013, the C0002 long-term borehole observatory was connected to the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET) for real-time monitoring during the KY13-02 cruise by the R/V Kaiyo. Therefore, the platform of C0002 borehole observatory is good target for the in-situ calibration study.

During the KY13-02 cruise, pressure gauge (Paroscientific Inc. 8B7000-2-005) was deployed on the platform of C0002 observatory by ROV Hyper-Dolphin and precise observation of seafloor pressure change were conducted for one hour. Prior to the cruise, the pressure gauge were precisely calibrated by the laboratory experiment. To reduce the effect of the pressure change, the gauge was pressurized at the target pressure under the seafoor temperature condition and the valve was closed in the laboratory. On the platform after the deployment, the valve was opened for the pressure measurement. Tilt sensor was also attached to the pressure sensor for the tilt calibration. We conducted the measurement twice on January 20 and February 1 for the repeatability evaluation.

The offset of the borehole pressure gauge from the absolute pressure value was 240 hPa. The repeatability of the measurement was 14 hPa within the specification of the pressure sensor(0.005%FS=34.5hPa), which is larger than the laboratory experiment. We found from the in-situ calibration that keeping the pressure condition is important for the precise pressure measurement. We will quantify the effects of the temperature change, tilt of the pressure gauge and the density change of the oil inside the gauge for the precise evaluation. Further, we plan to conduct the in-situ calibration at C0002 borehole observatory to estimate the long-term instrument drift and apply the calibration method to the DONET pressure gauges in Nankai Trough.

Keywords: Seafloor pressure observation, In-situ calibration, Nankai Trough, Borehole observatory, Crustal movement, Pore pressure

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P03 Room:Convention Hall Time:May 21 18:15-19:30

The stress variation along the Nankai Trough observed in the scientific drillings Borehole C0010A and C0004B, NanTroSEIZ

HungYu Wu[1*], Sanada Yoshinori[1], Kinoshita Masataka[1]

[1]Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

In NanTroSEZIE Exp. 319, well C0010A was drilled to compare with well C0004B in physical properties, fault zone architecture, and the variations along-strike of Nankai Trough. Based on the seismic reflection data, the character of the mega-spray fault diverges remarkably between C0010A and C0004B. The well conditions of LWD images are collected to 550 meter below sea floor (mbsf). In this paper, we used the stress polygon to analyze the reprocessing LWD images for picking the breakout and tensile fracture azimuth and width in well C0010A and C0004B. The stress state in site C0010A can be modified by the borehole conditions, logging data and the physical properties. The same methods run on the site C0004B and the stable, consistent stress profiles are shown. Several faults were identified by the rotated borehole breakout orientation. The fractures distributions also supported the stress anomaly in the vicinity of the faults. The magnitudes of the horizontal stresses in C0010A vary in the different units comparing to the C0004B. The difference of two sites indicated that the local structure near the Nankai Trough would be the factor to influence the stress state in the boreholes. However, the normal fault stress regime was designed in both boreholes. The low stress level in the shallow portion near the Nakai Trough was obtained in this scientific drilling project.

Keywords: NanTroSEIZE, LWD, Breakout, Tensile fractures, Stress polygon

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P04 Room:Convention Hall Time:May 21 18:15-19:30

Analysis of Fracture Characteristic against Shape of Borehole Breakout

Jun Shibanuma[1*], Yasuhiro Yamada[1], Matsuoka Toshifumi[1]

[1]kyoto University

In general, when fault is formed, the damage zone where includes many fractures will also be formed. Therefore, in previous research, it is known that stress field is disturbed by soft layer which is in fault zone. Thus, we consider that we can identify fractures derived from fault and its scale, shape, and other characteristics with comparing stress state and fracture distribution. Further, I think we can reveal which fracture affects the stress state. Then, I analyze the relationship between dip direction and strike azimuth of fractures and borehole breakout (BO). BO is the failure of borehole caused by stress concentration and it occur two positions separated 180 degree.

I classified the fractures into three patterns by near BOs shape. 1 BO direction is rotating. 2 BOs interval is not 180 degree. 3 No influence against BO shape.

Finally, I found the dip angle of fracture of pattern 2 is little higher than others. But, both dip angle and strike azimuth fractures of 3 distribute all around. So there are other factors affect BO shape. And around damage zone, I estimated from well data, amount of fractures of pattern 2 is much more other areas. I predict that is because the stress is released along fracture, especially near the fault from previous research result.

Keywords: Fracture, Borehole Breakout, Stress state, logging, Nankai Trough, Accretionary Prism

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P05 Room:Convention Hall Time:May 21 18:15-19:30

Unsolving the fault activity off Tokai through 14C dating fossilised Calyptogena .spp shells.

Kazuhiro Yagasaki[1*], Shin'ichi Kuramoto[2], Juichiro Ashi[1]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, [2]JAMSTEC

The Nankai and the Tokai Trough regions are common areas for cold seeps, an area of the ocean floor where Hydrogen Sulphide (H2S), Methane (CH4) and often hydro-carbon rich fluid seepage occurs. These various substances encourage the growth of Calyptogena .spp colonies to flourish at these sites. Naturally, cold seeps occur at tectonically active continental margins and are mostly ephemeral. This suggests that the activities of cold seeps are possibly influenced by the tectonic activity of the diverging plates. Previously attempts were made to reconstruct the cold seep activity history through amino acid racemisation dating. Yet further data is required to show any significant relationship. In order to further study the possible relationship between the cold seep activity and past major fault activity, radioactive 14C dating method will be used to attempt and accurately measure the age of the Calyptogena. spp shells.

Keywords: Tokai Trough, Cold Seeps, Calyptogena .spp, 14C dating, Fault activity

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P06 Room:Convention Hall Time:May 21 18:15-19:30

High resolution shallow structures of the northern marginal fault of the forearc basin off Kumano

Juichiro Ashi[1*], Ken Ikehara[2], Takanori Ojima[1], KH-11-9 Shipboard Scientists[1]

[1]The University of Tokyo, [2]National Institute of Advanced Industrial Science and Technology

Investigation of shallow deformation structures is significant for understanding of recent tectonic activity. We carried out deep towed subbottom profiling survey by ROV NSS (Navigable Sampling System) during Hakuho-maru KH-11-9 cruise. High resolution mapping of shallow structures was successfully conducted by a chirp subbottom profiling system. ROV NSS also has a capability to take a piston core with a pinpoint accuracy. The studied area is the northern margin of the Kumao Trough. The Kumano Trough is a well developed forearc basin associated with the growth of the accretionary prism that has been examined by IODP drillings. The basin is characterized by pervasive large-scale folds trending ENE-WSW. The northern basin margin is divided into two domains, with water depth differences of 14 m: northern margin at a water depth of 2028 m and southern main basin floor at a water depth of 2042 m, by ENE-WSW trending step. An asymmetric anticlinal fold suggesting activity of a blind fault is recognized beneath this step on multichannel seismic reflection profiles. Subbottom profiles show that reflectors of both fold limbs bend up and thin out toward the fold axis. The northern limb is completely filled by sediments and the southern limb corresponds to the gentle slope between the northern margin and the main basin floor. Acoustically transparent layers are dominant at upper 5 m sequences of the both limbs. These layers seem to correspond to Holocene sediments after approximately 10,000 years ago by adjacent core sample ages. Because bend structures of shallow strata near the fold axis attribute to relative uplift of the fold axis region, vertical displacement for the past 10,000 years is estimated to be 2.5 m. Further deep structures revealed by SBPs show accumulation of displacement with depth. Moreover, MCS profiles suggest strike slip deformation around this anticline based on existence of flower structures. Therefore, it is inferred that the northern marginal fault located below this fold is active for more than 10,000 years at least.

Keywords: monoclinal fold, flexure, active fault, forearc basin

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P07 Room:Convention Hall Time:May 21 18:15-19:30

Studies of the source depth and the depositional environment of the mud volcano by using of drilling cores in the Kumano

Satoru Muraoka[1*], Juichiro Ashi[1], Arito Sakaguchi[2], Toshiya Kanamatsu[2], Kan Aoike[2], Fumio Inagaki[2]

[1]Atomosphere and Ocean Research Institute, The University of Tokyo, [2]Japan Agency for Marine-Earth Science and Technology

Submarine mud volcanoes are formed as conical mounds composed of erupted unconsolidated or partially consolidated sediments from mud diapirs. Hence submarine mud volcanoes have been attracting attention as a tool that can get substance beneath the seafloor without super deep drilling. It is expected to contribute in order to understand the formation of accretionary prisms and the mechanism of large earthquakes. On this view, researchers of mud volcanoes all over the world tried to measure the physical properties of mud volcano's sediments and estimate source depth of mud volcanoes. However, in the Nankai Trough known as a seismogenic zone, the source depth of mud volcanoes developed in Kumano basin have been unsolved.

The purpose of this study is to estimate the source depth and to discuss the formation process by using of shallow drilling cores from two sites (C9004, C9005) at the summit of the mud volcano in the Kumano basin, during CK09-01 using Deep-Sea Drilling Vessel CHIKYU, in March, 2009. We conducted mainly measurements of vitrinite reflectance, porosity, density, nannofossil age dating and anisotropy of magnetic susceptibility.

We estimated the depositional depths of various clasts in the mud volcano from the vitrinite reflectance, the nannofossil age and the geothermal gradient near this study area.

In the result, the source depth was estimated to be approximately 1900 mbsf by maximum burial depth of clasts. Focus of the discussion is about whether the materials of the source depth are derived from the accretionary prism or the forearc basin. It is inferred that the environment of the source was the forearc basin in view of the following two points. 1) Clast densities versus estimated burial are inconsistent with the logging results of the accretionary prism off Kumano. However a density decreases at the boundary between the forearc basin and the accretionary prism, the decay has not appeared in clast densities of the mud volcano. 2) Clay mineral composition of the mud volcano differs from one of the upper accretionary prism indicated from an examination of IODP Expedition 314 by Deep-Sea Drilling Vessel CHIKYU. The abundance ratio of smectite is large in the upper accretionary prism, whereas it is low in the deepest estimated clasts of the mud volcano. These results show that the source of the mud volacano is the forearc basin. Besides, the depth is the deeper, clast ages of the mud volcano are the older by the nannofossil age, but at 1700 mbsf, the age versus the depth indicates the gap of the age. If the source is not the accretionary prism, it would considered that the gap shows the old forearc basin sediments. Therefore, it would appear that the unconformity is developed in the boundary between the present and the old forearc basin near 1700 mbsf. This study suggests that the thickness of the Kumano basin is more than about 2000 m.

We will also discuss particle arrangements within erupted materials to understand grain fabric and its deformation by anisotropy of magnetic susceptibility.

Keywords: mud volcano, mud diapir, vitrinite reflectance, forearc basin, Nankai Trough

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P08 Room:Convention Hall Time:May 21 18:15-19:30

A seismic inversion study for incoming sedimentary sequence in the Nankai Trough, southwest Japan

Kazuya Naito[1*], Jin-Oh Park[1]

[1]Atmosphere and Ocean Research Institute, the University of Tokyo

The Nankai Trough, off southwest Japan, is a well known convergent margin on where huge earthquakes have been repeated in the cycle of 100–200 years. The next emergence of the disaster is concerned and many scientist have been studying to unveil and assess the dimension and mechanism of earthquakes and tsunamis. Here we show the physical properties distribution in incoming sedimentary sequence in the Nankai Trough. The seismic inversion technique is a method to estimate acoustic impedance of layers on seismic profiles with some drilling well data. We use 3D and 2D MCS profiles which acquired with KR06–02 and KR05–12 cruises and well data which drilled on the cruises of IODP Expedition 322 and 338.

Keywords: Nankai Trough, sediments, inversion, acoustic impedance, seismic reflection, Core-Logging-Seismic Integration

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P09 Room:Convention Hall Time:May 21 18:15-19:30

Influence of Diatomaceous Structure on the Physical Properties - An Example of off San-riku, North Japan -

Takanori Ojima[1*], Saneatsu Saito[2]

[1]AORI, The University of Tokyo, [2]JAMSTEC

During Ocean Drilling Program (ODP) Leg. 186, two sites (Site 1150 and Site 1151) were drilled on the continental slope of the deep-sea forearc basin of northern Japan. Diatomaceous sediments were recovered Site 1150 (39o 10.9'N, 143o 19.9'E) and Site 1151 (38o 45.1'N, 143o20.0'E), and the depth of each site is 1181.60 mbsf and 1113.60 mbsf, respectively. This area is under the influence of the Oyashio current and is one of the highly bio-productive regions of the North Pacific Ocean (Motoyama et al., 2004). The combination of high productivity and active tectonic deformation that often caused high rate accumulating of fossil and organic rich sediments.

The onboard results of porosity measurements show high value (50-70 %) down to 1000 mbsf, and obviously higher than nearby subduction trench, Nankai Trough (Taylor and Fisher, 1993). There is a possibility that diatomaceous shell keep a frame structure from effective stress and load pressure. On another drilling site result, DSDP (Deep Sea Drilling Project) Leg. 19 located 60 km to the north of ODP sites, was reported high value of porosity, but recognized only shallow range (>500 mbsf) (Shephard and Bryant, 1980).

We focused on the relationships between physical property, microstructure, and logging data at deep range(-1000 mbsf). We picked 14 samples to observe microstructure using SEM and measure permeability using flow-pump approach (1.5-4.5 MPa). Logging data were collected using wireline logging (Sacks and Suyehiro, 2003). Based on these results, it is expected that microstructure and logging can be integrated into a general model of core-log correlation.

We observed many pore in and around diatom fossils using SEM even in the sample from deeper than 1000 mbsf, and measured pore size and permeability at each depth. As depth deepen, porosity generally decreased by effective stress and load pressure, and permeability is also decreased. In this site, we recognized diminish as wavy curve in correlation between depth and permeability. Furthermore, wavelength cycle nearly matched resistivity alternation, and promised to have a correlation with lithofacies change.

In this presentation, We show results of microstructure using SEM, measured physical properties, and wireline logging data, respectively.

Keywords: diatom, high porosity, pore size analysis, permeability, logging

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P10 Room:Convention Hall Time:May 21 18:15-19:30

Dehydration of amorphous silica in subduction seismogenic zone

Mayuko Shimizu[1*], Jun Kameda[1], Yohei Hamada[2], Gaku Kimura[1]

[1]The University of Tokyo, [2]Japan Agency for Marine-Earth Science and Technology

Generally, a shallow part of a plate boundary megathrust has been considered as aseismic. However, in the 2011 Tohoku-oki earthquake, the seismic fault slip propagated close to the axis of the Japan Trench and caused an extremely large tsunami. It is considered that ductile deformation of unconsolidated sediments is common deformation mechanism prominent in this aseismic region of the shallow part of the subduction zone. Accordingly, it is still unknown how the seismic rupture reached to nearby the trench axis.

The megathrust is characterized by a prominent reflector. Therefore it has been pointed out that the megathrust may host highly pressurized fluids (Kimura et al., 2012). Moreover, based on the result of mineral analysis by Deep Sea Drilling Project (DSDP) in 1977, it is supposed that the subducting sediments mainly consist of vitric diatomaceous and radiolarian silt with pelagic clay intervals.

Opal-A in the vitric diatomaceous silt transform to quartz, and smectite in the pelagic clay to illite. These diagenetic reactions accompany dehydration reactions. The dehydration rates become maximum at 50-60 km horizontally from the deformation front, where the temperature along the megathrust is 100-120?C. This region coincides with the locus with a prominent reflector, and this suggests that the main source of highly pressured fluids is dehydration of sediments (Kimura et al., 2012).

However, few studies have conducted mineral analysis of sediments along the Japan Trench, and detailed dehydration process of hydrous minerals and the reality of fluid pressure have been poorly constrained. Therefore, in this study, we examined by X-ray diffraction whole rock composition of sediments including opal-A, which was recovered from outer rise of the Japan Trench during DSDP Leg56. In this talk, we present calculations of the diageneses of opal-A and smectite, and discuss development mechanism of fluid pressure in the shallow portion of the megathrust in the Japan Trench.

References

Kimura et al. (2012) Runaway slip to the trench due to rupture of highly pressurized megathrust beneath the middle trench slope: The tsunamigenesis of the 2011 Tohoku earthquake off the east coast of northern Japan. Earth and Planetary Science Letters, 339-340, 32-45

Keywords: Subduction zone, Silica, Dehydration, XRD

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P11 Room:Convention Hall Time:May 21 18:15-19:30

Core-log integration of a subduction zone megasplay fault -Example from the Nobeoka Thrust Drilling-

Mari Hamahashi[1*], Saneatsu Saito[2], Gaku Kimura[1], Asuka Yamaguchi[3], Rina Fukuchi[4], Jun Kameda[1], Yohei Hamada[2], Koichiro Fujimoto[4], Yoshitaka Hashimoto[6], Shoko Hina[5], Mio Eida[6], Yujin Kitamura[2]

[1]The University of Tokyo, [2]Japan Agency for Marine-Earth Science and Technology, [3]Atomosphere and Ocean Research Institute, The University of Tokyo, [4]Tokyo Gakugei University, [5]The Asahi Shimbunsha, [6]Kochi University

Subduction zone megasplays are known to act as tsunami-seismogenic faults and have been the focus of numerous geological and geophysical research. Reflectance surveys and wave tomography reveal clear outlines of the megasplay in the Nankai Trough, indicating low velocity zone along the thrust and the contrast in physical property and structure between the hanging wall and footwall. Megasplay has been the target of Integrated Ocean Drilling Program (NanTroSEIZE), but the deep portion of the megasplay has not been reached yet. Thus the nature and evolution of megasplay remain to be poorly constrained. On the other hand, however, the fossilized megasplay fault now exhumed on-land, enables to directly observe and study the lithology and structures from the outcrop. The Nobeoka Thrust in Shimanto belt, Kyushu Island, has been studied to be a fossilized megasplay fault, and present well preserved structures of fault zones from the seismogenic regime. To obtain geologic and geophysical datasets to correlate with ocean drilling program, the Nobeoka Thrust Drilling Project was conducted in 2011. 255m of continuous coring and geophysical logging was held, and the main fault core between the hanging wall and footwall was found at 41m depth.

The purpose of this study is to present the results of core-log integration, focusing on the relation among lithology, structure, and physical property along the Nobeoka Thrust, emphasizing the clear contrast between the hanging wall and footwall.

Hanging wall (0-41.3m) is composed of the Kitagawa Group of phyllite of alternating beds of sandstone and shale, while the footwall (41.3˜255m) is composed of the Hyuga Group of foliated cataclasite consisted with scaly shale, tuffacious shale, sandstone, and acidic tuff. The main fault core between the hanging wall and footwall is random fabric cataclasite of ˜50cm thickness, and above and below, the damage zone close to the fault core is characteristic in the hanging wall and footwall. The hanging wall damage zone (32.4-41.3m) is sandstone-rich, with boudinaged and fragmented structures, while the footwall damage zone (41.3-53m) is clay-rich cataclasite with abundant fragments and less mineral veins. 5 lithologic units are classified in the footwall, mainly by the variety of sandstone, silt, and tuff and its structures. Other than the main fault core, several macroscopic fault zones are seen throughout depth in the hanging wall and footwall, which are included in each unit and partly influence the change in lithology and structure there. Tuffacious silt becomes abundant especially from Unit 3, across the fault zone at 112-118m.

Geophysical logging data correlates well with the lithology and structure observed above, and the contrast between the hanging wall and footwall is particularly clear around the main fault core. Footwall presents higher values of neutron porosity (˜7.6%) compared to hanging wall (˜4.8%), while porosity is lowest (˜3.6%) towards/just above fault core. Resistivity is higher at hanging wall (LN˜507, SN˜453, GD˜400 ohm-m), followed by drop near fault core (329,268,315) and stably lower footwall (308,232,310). P-wave velocity is slightly higher at hanging wall and fault core(˜4.3km/sec) compared to footwall (˜4.2km/sec). Temporary drop in natural gamma ray (˜108API) and spontaneous potential (˜39mV) are characteristic towards and just above fault core, while values are nearly constant at hanging wall (˜123API, ˜55mV) and footwall (˜122API, ˜57mV). Density does not vary much throughout depth (˜2.7g/cc).

Curve fitting of number distribution of logging data for each unit, and statistically significant values are obtained from normalized distribution. To understand and estimate the physical property of megasplay fault from logging data, I recalculate values using elastic theory of open cracks assuming the effective pressure to be 55 MPa representing those at in situ values of the Nobeoka Thrust when it was active at depth.

Keywords: Megasplay fault, accretionary prism, Nankai Trough, Physical property

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P12 Room:Convention Hall Time:May 21 18:15-19:30

Physical properties at out of sequence thrust: Nobeoka thrust, Shimanto Belt, Southwest Japan

Yoshitaka Hashimoto[1*], Shogo Abe[1], Hiroki Tano[1], Saneatsu Saito[2], Asuka Yamaguchi[3], Jun Kameda[4], Mari Hamahashi[4], Rina Fukuchi[5], Yohei Hamada[2], Mio Eida[1], Koichiro Fujimoto[5], Yujin Kitamura[2], Gaku Kimura[4]

[1]Kochi University, [2]JAMSTEC, [3]AORI, [4]University of Tokyo, [5]Tokyo Gakugei University

To understand information from geophysical survey combining with natural rocks, direct measurement of physical properties on natural rocks is essential. Mega-splay faults cutting whole accretionary wedges in the latest stage of deformation history in subduction zone are commonly observed in seismic profiles. The mega-splay faults are developing around the shallower portion of seismogenic zone along subduction plate interface, and penetrating to ocean floor in transition zone with higher angle of slope topography between outer and inner wedges. Therefore, the mega-splay fault can be a boundary of physical properties of sediments. The on-land analogue of the mega-splay faults is considered to be an out-of-sequence thrust, which cuts paleo-thermal structures. In this study, we measured physical properties of hanging-wall and footwall of the Nobeoka thrust, which is an on-land out-of-sequence thrust. The samples were cored by Nobeoka thrust drilling project (NOBELL).

Nobeoka Thrust is a major geologic boundary between the Northern and the Southern Belts of the Shimanto accretionary complex in Kyushu, Southwest Japan. The paleo-maximum temperature of hanging-wall and footwall is about 320?C and 250?C, respectively. About 70?C difference in temperature is observed at the thrust. The hanging-wall is composed of phyllite. Major component of footwall is tectonic melange of terrigenious sediments and tuff. Damage zone related to Nobeoka thrust is developed in the footwall. Minor faults with carbonate and quartz veins are densely observed in the damage zone. Cataclasite is also identified in the damage zone in some part. Core was drilled about 250m long and Nobeoka thrust is located about 40m of depth in the core. The damage zone is ranging in the depth from about 40m to 110m. We classified samples into three, phyllite in hanging-wall, cataclasite and melange in footwall. 5 samples for each were tested to get physical properties.

We have conducted P-wave and S-wave velocity measurement under controlled effective pressure. Effective pressure ranges from 5MPa to 65 MPa with 5MPa interval. In the laboratory test, change in pore water volume and axial displacement were recorded. Porosity and density were also measured.

Obtained P-wave and S-wave velocities for phyllite, cataclasite, and melange are 4.71-5.01 km/s and 2.78-2.57 km/s, 4.42-4.76km/s and 2.38-2.48 km/s, and 4.48-4.76 km/s and 2.34-2.44 km/s, respectively. Vp/Vs for cataclasite is relatively low (1.85-1.91) than that for others (1.90-1.95). Porosities for phyllite, cataclasite and melange are 1-5%, 2-10%, and 2-8%, respectively. Density is almost constant for all lithologies.

Amplitude variations with offset (AVO) analysis were taken for the estimation of effective pressure. By comparison between AVO parameters from seismic data and the elastic properties, appropriate effective pressure was estimated as about 50 MPa in hanging-wall and about 5 MPa in footwall. Although the coincidence between AVO parameters was not so good, at least, the difference in effective pressure between hanging-wall and footwall is relatively larger. The bad coincidence is probably due to anisotropy of elastic property especially in hanging-wall.

Keywords: out of sequence thrust, Shimanto Belt, velocity

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P13 Room:Convention Hall Time:May 21 18:15-19:30

Detecting time-dependent fluid discharge at the toe of the Nankai Trough accretionary prism

Yoshifumi Kawada[1*], Shusaku Goto[2], Makoto Yamano[1], Juichiro Ashi[3]

[1]ERI, Univ of Tokyo, [2]GSJ/AIST, [3]AORI, Univ of Tokyo

To detect time-dependent fluid discharge from the toe of the Nankai Trough accretionary prism, the Omine Ridge, we have deployed heat-flow probes since 2010. Observing fluid discharge is a first step to understand seismic activity of subduction zones, because fluid discharge is not only related to fluid drainage from accretionary prisms but also to building-up mechanism of pore fluid pressure at the seismogenic zone of accretionary prisms.

We have deployed two stand-alone heat-flow meters (SAHF) on one of the bacterial mats where fluid discharge is expected and on a normal seafloor near the bacterial mat where no fluid discharge is expected. The 60 cm long heat probe contains five preciously calibrated thermistors at an interval of 11 cm. We have also deployed a temperature meter near one of the SAHFs, which records the temperature slightly above the seafloor. The deployment periods are during Mar 15 and Aug 6 2010, Aug 6 2010 and Sep 11 2012, and Sep 11 2012 and the present. A remotely controlled vehicle, Hyper-dolphin (controlled by R/V Natsushima) and a submersible, Shinkai-6500 (R/V Yokosuka) were used during the deployments and the recovery of the instruments (NT10-05Leg1, YK10-09, NT12-18).

Because the location of deployment is as shallow as 2500 m and is suffered from temperature fluctuations of bottom water due to tides as well as the Kuroshio Current, we deliberately use these fluctuations to obtain fluid flow velocity (Goto et al., 2006). The temperature time series is analyzed using the short-time Fourier transform (STFT) with a given time window (typically, 4 to 5 months). The amplitude ratio (of the deep sensor to the shallow sensor) and phase difference between two thermistors of different depth as functions of frequency simultaneously give Darcy velocity and thermal diffusivity. The phase difference is mainly related to thermal diffusivity; it is small for large diffusivities. Given the phase difference, the amplitude ratio is related to Darcy velocity. For example, the ratio is small for upward flows and large for downward flows with reference to the zero velocity.

We have obtained meaningful difference between the temperature records taken from the two sites: a bacterial mat and a normal seafloor around the bacterial mat. On a normal seafloor, almost zero velocity is obtained with a typical thermal diffusivity observed at this area, 3x10?7 m^2/s. In contrast, on a bacterial mat, upward Darcy velocity of 2?3x10?7 m/s is detected. Preliminary analysis shows that the estimated Darcy velocity is $1x10^{?7}$ m/s in early 2011, smaller than that before and after this period. Anomalous high thermal diffusivity up to twice as a typical value (e.g., $5x10^{?7}$ m^2/s) is obtained at the shallowest 20 cm below the seafloor, although a typical value is obtained at deeper locations than that. This large diffusivity is probably resulted from the formation of the bacterial mat.

Keywords: fluid seepage, accretionary prism, heat flow, subduction zone, long-term monitoring

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P14 Room:Convention Hall Time:May 21 18:15-19:30

Micro-seismicity in incoming Philippine Sea Plate off Kii Peninsula based on ocean-bottom seismographic observation

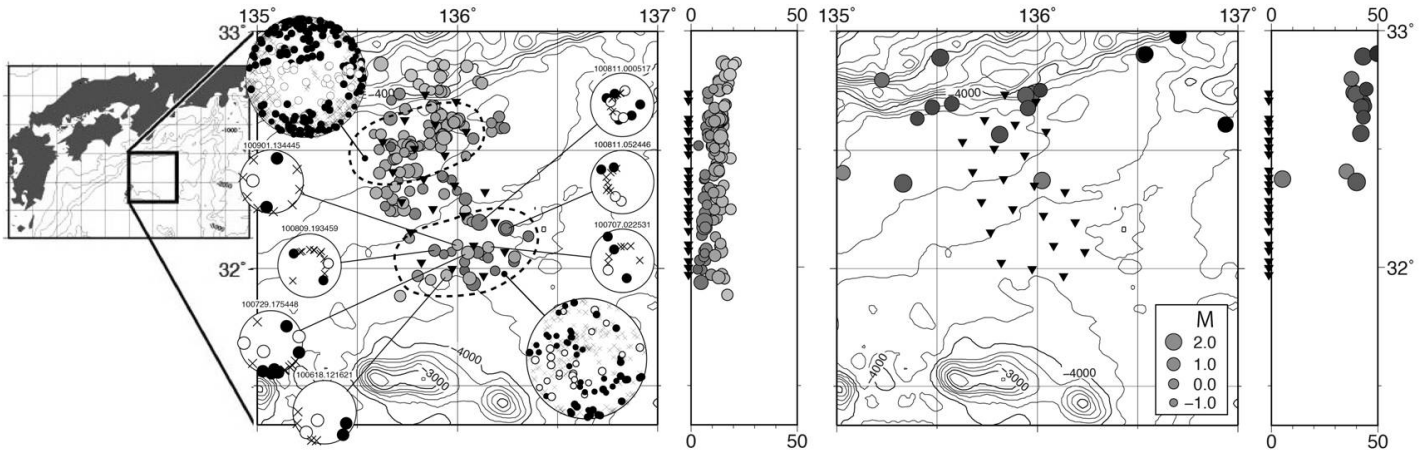
Kenji Hirata[1*], Hiroaki Tsushima[2], Akio Kobayashi[2], Akira Yamazaki[3], Hisatoshi Baba[4], Akio Katsumata[2], Hiroshi UENO[2], Shigeki Aoki[2], Naoki Hayashimoto[2], Daisuke MUTO[2], Yasuhiro Yoshida[5], Kenji Maeda[2], Takashi Yokota[2]

[1]National Rsearch Institute for Earth Science and Disaster Prevention, [2]Meteorological Research Institute, JMA, [3]Japan Meteorological Agency, [4]Tokai University, [5]Ministry of Education,Culture,Sports,Science & Technology in Japan

From 2005 to 2008, we repeated ocean-bottom seismograph (OBS) observation to investigate micro-seismicity around the axis of the Nankai Trough off Kii Peninsula, southwest Japan (Yamazaki et al., 2011, Tech.Rep.MRI). This micro-seismicity is not recorded well with land seismic networks. Obana et al.(2005, JGR) distinguished them into two groups; shallow microearthquakes occurring within the oceanic crust of the incoming Philippine Sea Plate (PSP) (around 10 km in depth) and deep ones occurring in the uppermost mantle of PSP (about 15 km to 25 km in depth). Obana et al. also reported that composite focal mechanisms of the shallower microearthquakes showed extensional stress in the direction nearly normal to the trough axis and those of the deeper ones showed compressional stress in the direction normal to the trough axis, indicating ”bending” of the incoming PHP. If so, how far south from the Nankai Trough axis the plate bending stress starts to build up and how it develops?

To investigate this problem, we deployed 24 OBSs, with 8 n.m. (˜15 km) of the spatial interval between every OBS, to the south from the trough axis in 2009. Following the previous two reports last year (Hirata et al., 2012a, JpGU meeting; 2012b, SSJ meeting), we discuss the depth range and focal mechanism of these microearthquakes.

Figure shows hypocenters, located in this study, for the observation period of about three months (left panel of figure). We chose only hypocenters within and nearby the OBS network to plot those in the figure. Shaded circles and closed inversed triangles indicate hypocenters and OBSs, respectively. The events are smaller than M2, and most of them are limited less than M1.5. Almost all of those occur less than 20 km in depth, and thus are confirmed to occur within the oceanic crust and the uppermost mantle. In the southern region of the OBS network, half of the events seems to occur within the oceanic crust and the other half in the uppermost mantle. This feature in the southern region is robust in the examination of various hypocenter determination using six different 1D velocity structures. These events are not recorded on JMA land-based seismic network (right panel). It is difficult to consider the events occur only within this temporary OBS network that was arbitrarily positioned by us. So we guess that similar microearthquakes perhaps occur in wider area outside of the OBS network. Figure also shows composite plots of the P-wave first motion polarity (lower hemisphere projections) for microearthquakes occurring in the northern and southern regions of the OBS network. Open and closed circles indicate downward and upward P-wave first motion, respectively. The composite plots suggest that trough-normal extensional stress is predominant in both the northern and southern regions; in the northern region (near the trough axis), the microearthquakes can be explained by normal faults having trough-normal extensional stress. In the southern region, however, those are seemed to be strike-slip faults. The trough-normal extensional stress is perhaps produced by bending of the incoming Philippine Sea Plate.



Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P15 Room:Convention Hall Time:May 21 18:15-19:30

Three-dimensional plate geometry and velocity models for the western Nankai Trough based on structural studies

Ayako Nakanishi[1*], Norio Shimomura[1], Shuichi Kodaira[1], Koichiro Obana[1], Tsutomu Takahashi[1], Yojiro Yamamoto[1], Mikiya Yamashita[1], Narumi Takahashi[1], Yoshiyuki Kaneda[1], Tetsuya Takeda[2], Tomotake Ueno[2], Katsuhiko Shiomi[2]

[1]JAMSTEC, [2]NIED

Great interplate earthquakes have repeatedly occurred in pairs along the Nankai Trough. In order to reduce a great deal of damage to coastal area from both strong ground motion and tsunami generation, it is necessary to understand rupture synchronization and segmentation of the Nankai megathrust earthquake. For a precise estimate of the rupture zone of the Nankai megathrust event based on the knowledge of realistic earthquake cycles and variations of magnitude, it is important to know the geometry and property of the plate boundary of the subduction seismogenic zone. To improve a physical model of the Nankai Trough seismogenic zone, the large-scale high-resolution wide-angle and reflection (MCS) seismic studies, and long-term observation have been conducted since 2008. Marine active source seismic data have been acquired along grid two-dimensional profiles having the total length of ˜800km per year. A three-dimensional seismic tomography using active and passive seismic data observed both land and ocean bottom stations have been also performed. This study is part of 'Research concerning Interaction Between the Tokai, Tonankai and Nankai Earthquakes' funded by Ministry of Education, Culture, Sports, Science and Technology, Japan. The seismic survey was conducted off the Tokai area including the onshore survey across the eastern Kii Peninsula in 2012, the final year of this project.

Compiling those studies provides a three-dimensional plate geometry and velocity structure models of the western Nankai Trough at the moment. Although their reliability and resolution should be evaluated, these models can be applied to a numerical simulation to examine if the observed rupture zone of the historical event can be reproduced. We will also try to construct more fine-scale model for the entire Nankai Trough area.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P16 Room:Convention Hall Time:May 21 18:15-19:30

Subducting structure in the northern end of the Nansei-Shoto Trench deduced from MCS profile and topography

Daishi Horiuchi[1*], Azusa Nishizawa[1], Kentaro Kaneda[1], Mitsuhiro Oikawa[1], Yukari Fujioka[1]

[1]JHOD, Japan Coast Guard

A large number of earthquakes occur at subduction zones and their vicinity, and sometimes a large earthquake with a severe damage occurs there (e.g. 2011 Tohoku-Oki earthquake in the Japan Trench region, Tokai-Tonankai-Nankai earthquake in the Nankai Trough region). The Nansei-Shoto Trench is the subduction zone where the Philippine Sea plate subducting below the Eurasia plate.

Japan Coast Guard carried out the refraction and the multi-channel reflection seismic survey in the northern end of the Nansei-Shoto Trench. The Survey line named ECr11 is perpendicular to the trench-arc-backarc system and traverses the Nansei-Shoto arc between the Yaku-Shima Island and Tokara Islands. ECr11 roughly overlaps the refraction seismic survey profile of Iwasaki et al.(1990) in the area from the forearc to trench. Iwasaki et al.(1990) used explosives and an air-gun array as seismic sources. They deduced ”a huge sedimentary wedge, whose thickness exceeds 12km, overlying the subducted oceanic lithosphere” and the structure of the subducted oceanic plate. To obtain the structure from the shallower part to the deeper part of the subduction zone, we deployed ocean bottom seismographs more closely than Iwasaki et al.(1990), and carried out the refraction and multi-channel reflection seismic surveys along same survey line.

We report the shallower part of the subduction zone in the northern end of the Nansei-Shoto Trench and spatial distribution of active faults deduced from the multi-channel reflection seismic profile (MCS profile) and topography.

Specifications of multi-channel reflection seismic surveys are as follows.

Source: 5.7l (350 inch^3)x3 tuned air-gun array (air-gun cluster)
Shot interval: 50 m
Record device: streamer cable (3,000m length and 240 channel hydrophone (12.5m interval))
Record length: 12 sec

Many lineations that parallel to the Nansei-Shoto Trench locate on the Philippine Sea plate before subducting beneath the Nansei-Shoto Trench confirmed from the MCS profile and the topography. These lineations are deduced the normal faults formed by bending of the Philippine Sea plate that accompanies with subduction.

In the MCS profile, clear reflectors are detected at the top of the subducting oceanic plate. We can trace these reflectors about 80km landward from the trench axis.

Keywords: Nansei-Shoto Trench, Philippine Sea Plate, subduction zone, reflection seismic survey, seafloor topography

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P17 Room:Convention Hall Time:May 21 18:15-19:30

Crustal Deformation Analysis Method with High-fidelity 3D Model and Application to Estimation of Coseismic Slip

Ryoichiro Agata[1*], Tsuyoshi Ichimura[2], Mamoru Hyodo[3], Takane Hori[3], Kazuro Hirahara[4], Muneo Hori[2]

[1]School of Engineering, The University of Tokyo, [2]Earthquake Research Institute, The University of Tokyo, [3]JAMSTEC, [4]Graduate School of Science, Kyoto University

Coseismic slip distribution is estimated by combining crustal deformation analysis in a large scale with the detailed data of the crust and the observation data of crustal deformation. Observation data with high accuracy have been accumulated, not only on the ground (e.g. GEONET: operated by GSI) but also on the seafloor (e.g. DONET: operated by JAMSTEC). In addition, geometry and material data in 1km grid of the crustal structure of the Japanese islands have been developed. However, in spite of the detailed crustal data, crustal deformation analyses have been performed by using simplified crustal structure model like homogeneous half-space. Therefore in this research, by using accumulated data and the technique of high performance computing, we developed a method for generating a high-fidelity 3D finite element (FE) model of crustal structure. A method for crustal deformation analyses with the generated model is also proposed. Then an application of the proposed method to estimation of coseismic slip distribution is shown.

We use FE analysis because it has an advantage in analyzing complex geometry of crustal structure. Assuming crustal structure to be a linear elastic body, we perform static analysis of coseismic crustal deformation due to fault dislocation. For high-fidelity 3D FE model generation, we developed an automatic FE model generation method using background grids by extending the method of (Ichimura et al. 2009). Tetrahedral elements are used near the surfaces to represent the geometries of the crust well, while voxel elements are used in the homogeneous areas, in order to achieve a good balance between reduction of the number of elements and reproduction of the geometry. Our method is verified by comparing the results with the analytical solution in a half-space (Okada, 1985).

To perform this computation fast using an FE model with large degree-of-freedom (DOF), firstly we solved the problem by CG method with a simple preconditioning, parallelizing it by OpenMP. However, this computation took a long time, so we improved the method by introducing adaptive preconditioner and single precision arithmetic. As a result, the computation time is significantly reduced.

As an application example, we estimated coseismic slip distribution in the 2011 Tohoku earthquake using Northeast Japan models. The models are generated by the proposed method, and their DOF are more than 150 million. We applied the estimation method used in (Sato et al. 2010). In comparison of estimation results using our high-fidelity model and conventional homogeneous half-space, significant difference could be seen in the estimation results.

As future work, ambiguity of the geometry and material properties of the crust should be taken into consideration.

Keywords: Inversion analysis of coseismic slip, High-fidelity 3D Crustal Structure Model, Crustal Deformation Analysis

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P18 Room:Convention Hall Time:May 21 18:15-19:30

Application of back-projection method to OBS data for understanding rupture propagation of the 2011 Tohoku earthquake

Yukihiro Nakatani[1*], Kimihiro Mochizuki[1], Masanao Shinohara[1], Tomoaki Yamada[1], Ryota Hino[2], Yoshihiro Ito[2], Yoshio Murai[3], Toshinori Sato[4]

[1]Earthquake Research Institute, The University of Tokyo, [2]Graduate School of Science, Tohoku University, [3]Graduate School of Science, Hokkaido University, [4]Graduate School of Science, Chiba University

The rupture process of the 2011 Tohoku earthquake was remarkably complicated. To discuss what constrains the rupture propagation, it is important to clarify the space and time variation of seismicity before and after the Mw 9.0 event. High-resolution seismicity around the rupture region of the main shock is required for such discussion. We used data from a dense array of 31 ocean bottom seismometers (OBSs) that were deployed before and recovered after the main shock off Ibaraki. The station interval of the array was about 6km. Accurate OBS positions were determined by applying the LSQR algorithm to the acoustic measurements between the vessel and OBS.

In this study, we tried to estimate the initial rupture area by applying back-projection method to these OBS array data.

First of all, we constructed a 3-D velocity structure model off Tohoku by compiling the results of marine seismic surveys (e.g., Mochizuki et al., 2008; Miura et al., 2005) and the tomography under the Japanese islands (Matsubara and Obara, 2011). In this case, P-wave velocities are given to grid points at a horizontal grid spacing of 10km and a vertical grid spacing of 5km. Then, we constructed a travel time field bounded by 35.5N - 40.5N and 141E - 144.5E (about 300km X 540km) with the same grid interval. To refine the theoretical travel time field, we referred to precise hypocenters of aftershocks determined with OBS data from aftershock observations (Shinohara et al., 2012).

After constructing the theoretical travel time field, we measured the array response function to confirm the resolution of the apparent slowness vector arriving at the array, applied a proper frequency filter selected with consideration of the sediment under each OBS, and estimated the initial rupture area of the main shock by projecting semblance values.

Keywords: the 2011 Tohoku earthquake, ocean bottom seismometer, back-projection

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P19 Room:Convention Hall Time:May 21 18:15-19:30

Progress of bending process of Pacific Plate and flattening process of bent slab detected with CMT solusion of JMA

Nobuaki Niitsuma[1*]

[1]Institute of Geoscience,Shizuoka University, Sendai

The hypocenters and forcal mechanisms distribute symmetrically with an axis crossing through the bending head of trench axis toward ocean side. The hypocenter of the East Japan Super Earthquake M9.0 of 2011 March 11 locates on the axis. The seismic free area appeared on the cross point of Japan Trench and the axis after the East Japan Super Earthquake.

The seismic free area surrounded by hypocenters with normal fault type forcal mechanism mainly and lateral fault type in island arc side. The forcal mechanisms are determined with orientations of principal stress axes.

The strengths of 3 principal stress can be calculated with moment tensor and nonDC (double couple) component ratio in CMT(centroid, moment tensor) forcal mechanism solution from Japan Meterological Agency. Normal fault type forcal mechanism can be defined using the strengths into push apart normal fault type of excess compressional stress with negative nonDC component, pull away normal fault type of exess tentional stress with positive nonDC component, and double couple normal fault type without nonDC component.

The normal fault type forcal mechanisms around the seismic free area are refined into push apart type for deeper earthquakes with deeper intial shoch hypocenter (e.g. 2011 March 11 M7.5), and pull away type for shallower hypocenter (e.g. 2012 December 7 M7.3). The depth dependence of excess compressional stress and excess tentional stress is consistent with bending process of oceanic plate along trench. Bending process should induce compressional stress for deeper layer and extensional stress for shallower layer of oceanic Plate. When the compressional principal stress with vertical orientation decreases with shallowing and reachs comparable to intermediate principal stress with horizontal orientation by the bending process, the stress axes exchange and the forcal mechanism changes from normal fault type with horizontal intermediate principal axis to lateral fault type with vertical intermediate principal stress axis. The lateral fault type hypocenters around the seismic free area (e.g. 2011 July 10 M7.3) consisitent with the stress axes exchange.

Oceanic Plate bends along trench and subducts as bent slab. The bent slab flattens under the East Japan coast area and subduct under the west coast of Japan Sea as a flat plane. Reverse fault type earthquakes dominate in the decending slab under the East Japan coast area. The forcal mechanisms with compressional principal axis parallel to the slab surface are classified into collisional reverse fault type of excess compressional stress with negative nonDC component (e.g. 2003 May 26 M7.2) and suctional reverse fault type of execess tentional stress with positive nonDC component (e.g. 2011 April 7 M7.2), which consistent with flattening process of bent slab. Flattening process of descending bent slab should induce compressional stress for extended shallower layer and tention to rip off bent slab.

CMT forcal mechanism solutions reporting by Japan Meteological Agency are usefull for monitoring the progress of bending process of oceanic plate and flattening process of bent slab.

Keywords: CMT solution, bending process, flattening process, Japan Trench, nonDCcomponent, seismic free area

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P20 Room:Convention Hall Time:May 21 18:15-19:30

Ahead of the 3.11, has the greatly east offing pushed the subducting plate really?

Hirofumi Mase[1*]

[1]none

If the temperature of a subducting plate is low, high temperature areas are generated on and under it and they tighten it from both sides by pulling against mutually(1). The stress keeps accumulating because it is not off Miyagi though there is the temperature structure that strain is liberated easily usually off Iwate and Fukushima(2). I presented the model concerning the cutting plane that expresses the range from coast to trench off Miyagi and passes the epicenter of the 3.11(3). I value (4) for the slip distribution and the rupture process of 3.11. I expect that the model will harmonize with (4) and past observation facts. The grounds material used as follows is (5).

We can understand well the features of earthquakes before and after 3.11 by the spatial distribution of focal mechanisms(P6, 1994/01/01-2012/12/31). a)(before 3.11) There are many reverse fault type earthquakes(reverse-type) at the west of the trench axis(Axis) from off Iwate to off Fukushima. At the east, one normal-type off Miyagi stands out. b)(after 3.11, off Miyagi) At the area that centers on the point(Q) of 38deg.N-144deg.E, normal-type overflow around and strike-slip-type of ”Pull” stand out at the west. c)(after 3.11, off Iwate and Fukushima) Reverse-type are generated chiefly at the west of Axis, normal-type chiefly at the east, and they are faced on the boundary of Axis.

A reverse-type(y) and a normal-type(x) occurred about Q recently. The difference at the time of occurrence was a few seconds(2012/12/7M7.3 Sanriku-Oki). The appearance of (y) looks mysterious in the situation that it is located on the LINE that connects remarkable epicenters[(3.11)-(2011/7/10M7.3 strike-slip-type(X))-(x)-Axis,Q-(y)-(2011/3/11M7.5 normal-type(Y))].

Two years ago 3.11 was generated and (Y) followed 39 minutes later. It shows that the east of (Y) did not move though the LINE became ”Pull” by the rapid subduction. The density in the direction of east and west has decreased about (Y). (X) was generated four months later. It was a strike-slip-type pushed from the south north both. It suggests that the amount of subduction about (X) was larger than it in the south and north of (X). Because the density amends from the south north can be expected, the density reduction in the direction of east and west about (X) is less than it about (Y). At this time, the east of (Y) did not move. Up to the present time, normal-type and strike-slip-type overflow from (X) to Q, normal-type overflow from Q to (Y). Though off Miyagi is the field of ”Pull” from east to west, I guess that the density is high in the west of the boundary of Axis and low in the east. Receiving pressure from the west, reverse-type(y) was generated because the above plate slipped up and east.

Thinking the east of (Y) to be just like an anchor still now might be appropriate. The fact of a) shows the doubt in which pressure from the open sea didn’t exist even just before 3.11. The fact of b)c) shows that the east of Axis is a field of ”Pull” and that the action of force has changed on the boundary of Axis. Because the amount of subduction of the lower plate off Iwate and Fukushima is small by circumstances(2), the east is ”Pull” though the west of Axis is reverse-type and ”Push” already. This harmonizes with the explanations(1) that among powers to act on the subducting plate, one acts from not the east but the lower.

(1)[Mase]http://www2.jpgu.org/meeting/2007/program/pdf/S149/S149-005
(2)[Mase]SSJ/ABSTRACTS/2011MEETING/P3-40
(3)[Mase]SSJ/ABSTRACTS/2012MEETING/P2-75
(4)[Ide]http://www.s.u-tokyo.ac.jp/ja/press/2011/12.html
(5)[JMA]http://www.jma.go.jp/jma/press/1301/10a/1212tohoku.pdf

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P21 Room:Convention Hall Time:May 21 18:15-19:30

A possible M10 event deduced from the lessons of the 2011 Tohoku-Oki earthquake

Kiyoshi Yomogida[1*]

[1]Earth & Planet. Dynamics, Hokkaido University

After the 2011 Tohoku-Oki earthquake, the immediate threat of megathrust earthquakes in and around Japan has been suddenly advocated by some researchers. One even points out the possibility of a larger event than ever, an event of Magnitude 10. In this study, we discuss whether an event of M10 is realistic or not, from not only statistical aspects of earthquake occurrence or macroscopic scaling laws of seismic sources in a conventional manner (e.g., fault size, the amount of slips) but also the diversity of megathrust earthquakes that was revealed after the occurrence of the 2011 Tohoku-Oki earthquake. From a simple extrapolation of seismicity and macroscopic scaling laws, one event of M10 occurs every 500 years all over the world, with its fault length, width and average slip to be 1,200 km, 600 km and 50 m, respectively. The width may not exceed 200 km very much because of the limitation of an elastic region of a plate boundary in a subduction zone. We therefore need either of (1) average slip as large as 100 m or (2) fault length of more than 1,500 km for a possible M10 event. The average slip may be able to exceed 100 m, considering an area of very large shallow slips associated with the 2011 Tohoku-Oki earthquake, but we must take care that this is possible only for an event of the along-dip double segmentation. This type of events is, however, generally adjacent to segments of weak plate coupling with small coseismic slips. In contrast, an event of the conventional along-dip single segmentation may extend its fault into many adjacent segments. A drawback in this case is that the average slip may not exceed 50 m unless there are several segments of very strong plate coupling, resulting in co-seismic slips lager than those for usual events repeating in each segment. Although a very large strong shallow segment of the double segmentation is a candidate of an M10 event, we cannot find any clear evidence of such a region from the present seismic pattern in the world. The subduction zone in south Chile is the best candidate from its apparent strong plate coupling although it may not occur for a while due to the nearly complete strain release associated with the 1960 earthquake. We consider a very large event will be impossible even if a large portion of subduction zones breaks in the Aleutian trench because of the existence of several segments of weak plate coupling with slow events or aseismic slips in this subduction zone.

Keywords: megathrust earthquake, 2011 Tohoku-Oki earthquake, double segmentation, strong coupling, fault width, average slip

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P22 Room:Convention Hall Time:May 21 18:15-19:30

Investigation of slip parameters and fault slip behavior in the shallow part of subduction zone on the basis of vitrinit

Yohei Hamada[1*], Arito Sakaguchi[1], Wataru Tanikawa[1], Yuzuru Yamamoto[1], Asuka Yamaguchi[2], Jun Kameda[2], Gaku Kimura[2]

[1]JAMSTEC, [2]The University of Tokyo

Enormous earthquakes repeatedly occur in subduction zones, and the slips along megathrusts, in particular those propagating to the toe of the forearc wedge, generate ruinous tsunamis. Quantitative evaluation of slip parameters (i.e., slip velocity, rise time and slip distance) of past slip events at shallow, tsunamigenic part of the fault is critical to characterize such earthquakes. Here we attempt to quantify these parameters of slips that may have occurred along the shallow megasplay fault and the plate boundary decollement in the Nankai Trough, off southwest Japan. We apply a kinetic modeling to vitrinite reflectance profiles on the two fault rock samples obtained from Integrated Ocean Drilling Program (IODP). This approach constitutes two calculation procedures: heat generation and numerical profile fitting of vitrinite reflectance data. For the purpose of obtaining optimal slip parameters, residue calculation is implemented to estimate fitting accuracy. As the result, the measured distribution of vitrinite reflectance is reasonably fitted with heat generation rate (Q) and slip duration (tr) of 16,600 J/s/m2 and 6,250 s, respectively, for the megasplay, and 23,200 J/s/m2 and 2,350 s, respectively, for the frontal decollement, implying slow and long-term slips. To compare these slip behaviors with those in other settings of shallow part of subduction zone, we measured vitrinite reflectance on fossilized analogue faults, exposed in the Miura-Boso accretionary complex (the Shirako fault and the Emi fault), and examined their slip parameters by the above method. The measurement is conducted by using a newly-developed optical microscopy which allows us to 2-dimensional reflectance measurement on polished slab samples. The obtained vitrinite reflectance profiles both show strong anomaly at the slip zones. The reflectance anomaly in the Shirako fault is also recognized at the outside of the slip zone as is the case for the megathrusts in the Nankai trough. The numerical analysis yields slip velocity and slip distance of 0.14 cm/s and 5.17 m, respectively, under the optimal parameters set of = 14,500 J/s/m2 and tr = 3,600 s. On the other hand, the reflectance anomaly at the Emi fault is limited only inside of the slip zone. This condition (i.e. the absence of reflectance anomaly in the host rock) is taken as a constraint to determine and tr for the Emi fault. The estimated slip parameters are then compared with previous reports. The maximum temperature, Tmax, for the Nankai megasplay fault is consistent with the temperature constraint suggested by Hirono et al. [2009]. On the other hand, the calculated temperature contradicts the estimation deduced from clay mineral analysis [Kameda et al., submitted]. This discrepancy might indicate that the Shirako fault has experienced two types of slips; faster slip which caused temperature increase only inside the fault and acceleration of illitization, and slower slip which keep a high temperature state for a while enough to heat up the host rock by thermal conduction. Two constraints are combined to estimate slip parameters for the Emi fault. One is that Tmax is 350-1100 C [Hamada et al., 2011], and another is the absence of vitrinite reflectance anomaly in the host rock. Slip parameter ranges defined by these constraints are relatively faster slip velocity (˜ 1m/s) and shorter displacement (˜ 1m) than those for other faults. These results show large variation of slip parameters in shallow part of subduction zone. Especially, slow slip velocity, long-term rise time and large displacement are recognized in the three fault zones (the megasplay, the frontal decollement and the Shirako fault). These parameters are longer and slower than typical coseismic slip, but are rather consistent with rapid afterslip.

Keywords: slip parameters, vitrinite reflectance, frictional heat

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P23 Room:Convention Hall Time:May 21 18:15-19:30

Frictional heating recoded in virtinite reflectance within coal material concentrated layer: The Cretaceous Shimanto Bel

Kiyohiko Morita[1*], HASHIMOTO, Yoshitaka[1], HIROSE, Takehiro[2], KITAMURA, Manami[3]

[1]Kochi University, [2]Japan Agency for Marine-Earth Science and Technology, [3]Hiroshima University

Frictional heating recoded in virtinite reflectance within coal material concentrated layer: The Cretaceous Shimanto Belt

Kiyohiko Morita, Yoshitaka Hashimoto, Manami Kitamura, Takehiro Hirose

A degree of frictional heating by fault activity is related to effective friction coefficient, normal stress, displacement, slip rate and thickness of fault. So if we can detect the frictional heating along fault, the strength of friction of the fault can be constrained even from natural materials. In this study, we tried to detect the evidence of frictional heating along minor faults developed in on-land accretionary complex using vitrinite reflectance. The frictional heating was also identified along shallow deocollement and mega-spaly fault in Nankai trough by detailed examination of distribution of vitrinite reflectance (Sakaguchi et al. 2011). The similar evidence can be observed in the on-land accretionary complex anywhere.

We have found a coal concentrated layer in the coherent unit, Shimanto Belt, Shikoku, SW Japan. The coal concentrated layer is located in a central part of Nonokawa formation. Thickness of the coal concentrated layer is about 80 cm. Some faults are developed within the coal concentrated layer. Thickness of the faults is about a few mm to 1 cm. The fault branches and undulates at some parts. The coal concentrated layer is appropriate to examine the distribution of vitrinite reflectance. The background value of virtinite reflectance in this area is about 1.1% reported by a previous study (Sakaguchi, 1996).

4 samples from host rocks as background and 6 samples from the coal concentrated layer were collected. Samples from the coal concentrated layer distribute 0 cm, 3 cm, 8 cm, 9 cm, 20 cm, 35 cm from a major fault.

Random oriented vitirinite reflectance (Ro) was measured on polished thin sections. The modal value of Ro in host rocks is about 0.98%, which nicely coincides with the values from the previous study. Variations in Ro in host rocks represent relatively larger than that in the coal concentrated layer, which might be due to rework of the virtinite grains. The modal value of Ro in coal concentrated layer is about 0.92 %, which represent a normal distribution in each histogram except for the samples at 0 cm and 3 cm from the fault. In the samples at 0 cm and 3 cm from the fault, another peak and a weak bulge were observed at 0.2-0.3% higher Ro value. Double peak distribution is clear especially in the sample at 0 cm. Those higher peak and bulge possibly indicate the frictional heating along the fault. Spatial distribution of Ro in the thin sections also shows that vitrinite grains with higher Ro concentrate along the fault zone with thickness of 1cm.

We followed the method by O'Hara (2004), a simple method to estimate temperature by frictional heating from vitrinite reflectance. He used a model to convert temperature from Ro, proposed by Sweeny and Burnmum (1990) with high cooling rate as 0.035 degree C/s and 1.0 degree C/s for heated Ro. On the basis of the model, the higher Ro value corresponds about 460 - 540 degree C. Background value of Ro indicate about 146 degree C. We estimated friction coefficient also following O'Hara (2004)'s method using those obtained temperatures (460-540 degree C in fault zone and 146 in background), fault thickness (1cm, 4cm), displacement (1-5m), normal stress (126.2 MPa assuming 30 degree C/km of thermal gradient, 2650 kg/cm3 of density). The estimated frictional coefficient is about 0.14 in the maximum and about 0.01 in the minimum if the thickness is small and displacement is large. This result indicate very small friction coefficient in the coal concentrated layer. The small friction coefficient can be due to fluidization of nature of coal itself.

Keywords: vitrinite

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P24 Room:Convention Hall Time:May 21 18:15-19:30

Two types of asperities on the Tohoku-oki interplate megathrust

Ichiko Shimizu[1*]

[1]Department of Earth and Planetary Science, Facluty of Science, University of Tokyo

The 2011 off the Pacific coast of Tohoku Earthquake with a magnitude (M) of 9.0 (the M9 Tohoku-oki earthquake) occurred at an intermediate depth (approximately 17-18 km below the sea level) on the subducting plate interface, whereas the M7-class Miyagi-oki earthquake had been occurred at the down-dip side (35-45 km below the sea level). To clarify the difference in frictional properties between the deep and intermediate-depth seismogenic zones, a strength profile of the NE Japan interplate megathrust was constructed across the source region of the M9 earthquake.

In the model, rheological properties of siliceous sedimentary rocks and subducting seamounts at the top of the oceanic plate were represented by those of wet quartz (+ clay minerals) and gabbro, respectively. Depth-dependent changes of pressure, temperature, and pore pressure ratio were taken into account. At the deep (>35 km) part of the thrust fault, siliceous rocks become ductile due to increasing temperature ($> 250^{o}$), whereas gabbroic rocks are brittle and strong. Thus, the asperity of the M7-class earthquakes is considered as a broken seamount, which is surrounded by siliceous sedimentary rocks. A conditionally stable nature of the surrounding region is explained by frictional behaviors of quartz in the brittle?ductile transition zone. In contrast to the deep M7-class asperity, the M9 asperity (i.e., a region that was strongly coupled before the M9 Tohoku-oki earthquake) occupies a large part of the plate interface because shear strength is relatively insensitive to rock types at the intermediate depth. Depth-varying characteristics of seismic radiation patterns found by Lay et al. (2012) reflect these two kinds of asperities. The along-arc extension of the M9 asperity is constrained by fluid distributions on the plate interface.

References

Lay, T., H. Kanamori, C. J. Ammon, K. D. Koper, A. R. Hutko, L. Ye, H. Yue, and T. M. Rushing (2012), Depth-varying rupture properties of subduction zone megathrust faults, J. Geophys. Res., 117, B04311, doi:10.1029/2011JB009133.

Keywords: The 2011 off the Pacific coast of Tohoku Earthquake, asperity, rheology, subduction zone, friction, brittle-ductile transition

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P25 Room:Convention Hall Time:May 21 18:15-19:30

Regulation of maximum earthquake sizes by the lithospheric rheology

Atsuko Namiki[1*], Tetsuo Yamaguchi[2], Ikuro Sumita[3], Takehito Suzuki[1], Satoshi Ide[1]

[1]EPS, Univ. of Tokyo, [2]Kyushu University, [3]Kanazawa University

Shallow part of the Earth can be considered to behave as an elastic material such that earthquakes occur, whereas the deeper part deforms viscously. However, it still remains unclear how the seismicity changes with this viscous/elastic transition. On the other hand, the rock consisting the Earth is frequently modeled by a Maxwell fluid which behaves as an elastic material when it deforms at a time scale which is sufficiently shorter than the relaxation time scale. Here we perform shear deformation experiments of quasi Maxwell fluid under different strain rates, and show that the same material can cause earthquakes associated with elastic rebound as well as viscous flow. Around the threshold to cause earthquakes, both earthquakes in which ruptures propagate at a shear wave velocity and viscous relaxation occur simultaneously. The threshold is determined by the strain rate, relaxation time, shear modulus, and the adhesive stress. We construct a scaling applicable to a real faulting system by taking account of the fact that strain rates depend inversely on the faulting length scales. Our scaling predicts that a larger fault can relax the accumulated stress more and the maximum sizes of earthquakes which can occur on Earth becomes around Mw 9. The 2011 Tohoku-Oki Earthquake (Mw 9.0) resulted in a huge coseismic slip, but was insufficient to reconcile all the inter-seismic deformation since the previous earthquake. Our scaling suggests that this earthquake must be around the threshold and some part of the accumulated stress has relaxed viscously prior to the earthquake. Our scaling also explains the fact that only small earthquakes show repeatability and magnitudes of the slow earthquakes are small. Another important feature of our scaling is that the accumulated strain is not proportional to the accumulated stress. For an accurate risk assessment, accumulated stress should be evaluated rather than strain.

Keywords: Viscosity of the shallow Earth, Stress relaxation, Rupture velocity, Tohoku-Oki earthquake

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P26 Room:Convention Hall Time:May 21 18:15-19:30

Frictional properties of sediments on the Cocos Plate collected during the IODP Exp334, CRISP

Yuka Namiki[1*], Akito Tsutsumi[1], Kohtaro Ujiie[2], Jun Kameda[3]

[1]Graduate School of Science, Kyoto University, [2]University of Tsukuba, [3]University of Tokyo

Knowledge of the frictional properties of input sediments to subduction zones is fundamental in modeling of the subduction-related faulting processes. However, experimental studies on frictional properties of diverse composition of the input sediments are still limited. On the Cocos plate, which subducts at Middle America Trench offshore Costa Rica, clay, silty clay, and biogenic sediments such as silicic to calcareous ooze are deposited on basalt. They have some tephra layers. In this study, frictional properties of the sediments collected at a reference site of offshore Costa Rica (Site U1381) during the IODP expedition 334 were examined.

The sediments were observed under the microscope and analyzed with X-ray diffraction. The tested samples can be divided into three groups: clastic material, volcanic glasses and biogenic sediments. Frictional experiments were performed at steady slip velocity (v = 0.28 mm/s) to study the shear strength of them, and under a velocity-stepping condition to study the friction velocity dependence of the samples. Experimental results reveal that the shear strength is similar for all the samples at the initiation of the slip. However, the friction values of the silty clastic material reduce to ˜0.2 at the steady state, while those of the volcanic glasses and the biogenic sediments are high at 0.6˜0.8. These results suggest that shear zones are likely to be formed in the uppermost silty clay sediments. The silty clay material shows velocity-strengthening at $0.0028 < v < 2.8$ mm/s. In contrast, the volcanic glasses and the biogenic sediments show velocity-weakening at $0.0028 < v < 0.28$ mm/s and velocity-strengthening at $0.28 < v < 2.8$ mm/s. Stable slip would occur in the silty clay unit. On the contrary, the velocity weakening behavior at slow velocities could provide a condition to initiate unstable fault motion at shallow depths along the fault channel.

Keywords: subdaction zone, frictional experiment, CRISP

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P27 Room:Convention Hall Time:May 21 18:15-19:30

Time-dependent consolidation and reduction in permeability of quartz aggregate due to pressure solution precipitation

Hiroyuki Noda[1*], Keishi Okazaki[2], Ikuo Katayama[2]

[1]IFREE, JAMSTEC, [2]Graduate School of Science, Hiroshima University

During diagenesis process, incohesive sediments are compacted, lose porosity and permeability, and gain resistance against deformation. Understanding of evolution in the hydrological and mechanical properties during diagenesis is of essential importance in considering deformation of a shallow part of the crust including accretionary prism. Pressure solution precipitation creep is one of the important mechanisms in diagenesis of sediments, and thus has been intensively studied. Previous studies have established microphysical models and the constitutive law during compaction creep [e.g., Shimizu, 1995; Niemeijer et al., 2002]. In the present study, we put our focus on the evolution in the permeability and storage capacity during consolidation due to pressure solution precipitation creep of quartz aggregate.

Recent studies [e.g., Noda and Lapusta, 2013] have pointed out the importance of hydraulic properties on the earthquake generation mechanisms. In particular, permeability plays a cardinal role in thermal pressurization of pore fluid due to frictional heating during high velocity fault slip. An important unknown is whether the host rock (or sediments) fractures with significant increase in the porosity and the permeability or not. Such a property would depend on the degree of consolidation or diagenesis, as well as confining pressure, temperature, and loading condition. In the present study, the focus is put on the effect of time-dependent consolidation or diagenesis on the mechanical and hydraulic properties.

The starting material is commercially available quartzite power the mean grain size of which is about 6 microns. We have prepared the specimens from slurry by sedimentation inside silver tubes which are used as jackets during compaction experiments with gas apparatus at Hiroshima University. The initial specimens have good repeatability in terms of permeability. Compaction experiments are performed with distilled water as pore fluid and at 200 MPa confining pressure, 100 MPa pore pressure, and temperature at most 550 degree C. Permeability and storage capacity are monitored continuously during compaction experiment by pore pressure oscillation technique [e.g., Fischer and Paterson, 1992]. The shortening of the specimen is measured by the hit-point method from time to time.

After the consolidation test, we performed triaxial deformation test at constant load point velocity at room temperature. It turns out that solution-precipitation process extend the elastic limit of the sediment pretty quickly. When the specimen is heated up to 500 degree C by about 100 degree C/ 10 min and cooled down by a similar rate as soon as the temperature reaches 500 degree C, the specimen shows peak strength about 300 MPa in terms of axial compressional stress applied in addition to the 100 MPa effective isotropic pressure. Note that an uncooked sample yields as soon as the axial compressional stress is added. In the present poster, the relations between the shortening and hydraulic properties will be discussed.

Keywords: Diagenesis, Deformation experiment, Fluid-flow experiment

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P28 Room:Convention Hall Time:May 21 18:15-19:30

Measurement of the elastic wave velocity of rocks in subduction zones with the gas medium high pressure apparatus

Hayata Tamai[1*], Jun Muto[1], Hiroyuki Nagahama[1], Masahiro Ishikawa[2]

[1]Depertment of Geology , Graduate School of Science, Tohoku Univ., [2]Graduate School of Environment and Information Science, Yokohama National University

The velocity structure of the Earth has been illuminated from the seismological observation (Nakajima et al., 2001) in various places and the quantitative measurement of the seismic wave velocity in laboratory (Nishimoto et al., 2005). The seismic wave velocity is higher at the large coseismic slip area of the Mw 9.0 Tohoku-Oki Earthquake in 2011 than surrounding region (Zhao et al., 2011). This indicates that the rupture of the Tohoku-Oki Earthquake was controlled by structural heterogeneities in the megathrust zone. In order to know the relationship between the velocity anomaly and frictional properties of rocks, we need to measure the elastic velocity of various rocks composing of subduction zones.

In this study, we developed a system of elastic (ultrasonic) wave velocity measurement with the gas medium apparatus which has accurate hydrostatic pressure and can control the temperature and the pore pressure. We can also measure elastic properties such as elastic constants and poisson's ratio in the system by the usage of internal strain gages.

The electric wave velocity was measured by pulse transmission technique employing ultrasonic wave (2 MHz frequency). The wave was recorded by oscilloscope which sampling rate is 10^9 sampling/s. The rock sample and two metal jig pasted piezoelectric transducers of 6 mm diameter were placed in the pressure vessel. The height and diameter of rock samples are about 15-40 mm and 20 mm respectively. We calibrated the system with the metal jig and glass samples whose velocity is known. We measured Vp and Vs of the gabbro and granite during pressurization and depressurization to a maximum confining pressure of 200 MPa. The velocity increased drastically with the increase of the confining pressure up to 100 MPa. After the confining pressure exceeded 100 MPa, the velocity showed gradual increase with pressure. Vp and Vs of the rocks were higher during pressurization than those during depressurization at the same confining pressure, because microcracks that closed at high pressure do not completely reopen during depressurization (Birch 1960). We compared the velocity obtained in this study with the theoretical velocity predicted at a given pressure, temperature and rock composition (Hacker and Abers, 2004). At the confining pressure less than 100 MPa, the measured velocities were significantly lower than theoretical velocities. At pressure higher than 100 MPa, they are consistent with the theoretical velocities. Because the theoretical velocities did not include the effect of microcracks, this indicates that the microcracks closed completely at the pressure higher than 100 MPa. In contrast, the velocity measured with the Piston cylinder-type apparatus in previous studies increased by pressurization until about 400 MPa, and this indicates that the microcracks don't close until higher pressure. Thus the measurement with the gas medium apparatus is suited to measure elastic properties of rocks at shallow part of subduction zones. The elastic wave velocity of rocks increases steadily after microcracks close completely with the increasing pressure. So we can estimate the elastic wave velocity at even more than 200 MPa. In the presentation we will introduce measurement of elastic properties of rocks in subduction zones.

Keywords: elastic wave velocity, gas medium high pressure apparatus, microcrack, rocks in subduction zones, seismic tomography, reflection survey

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P29 Room:Convention Hall Time:May 21 18:15-19:30

Revisit of dynamic critical taper theory for the Japan trench from the topographic point of view

Hiroaki Koge[1*], Shuichi Kodaira[2], Toshiya Fujiwara[2], Tomoyuki Sasaki[3], Yohei Hamada[4], Mari Hamahashi[1], Jun Kameda[1], Gaku Kimura[1]

[1]Department of Earth and Planetary Science of the Graduate School of Science, The University of Tokyo, [2]Institute for Research on Earth Evolution Japan Agency for Marine-Earth Science and Technology, [3]Ocean Engineering & Development Corporation, [4]Japan Agency for Marine-Earth Science and Technology, [5]Atomosphere and Ocean Research Institute, The University of Tokyo

The March 11, 2011 Tohoku-oki earthquake (Mw9.0) is supposed to have fault rupture extending to the shallow part of subduction zone at the Japan Trench. Various inversion analyses by using, for example, geodetic, teleseismic body waves, strong ground motion or tsunami waveform, show large displacement near the trench axis.Moreover, bathymetric comparison between before and after the earthquake clearly demonstrated that the seafloor on outermost landward slope moved ˜50 m east-southeastward to the trench and uplifted ˜7 to 10 m. Although the mechanism of such fault rupture is not clear, revisiting the structure, deformation and friction properties at the base of the forearc will be key to elucidate this important issue.

Based on bathymetric and seismic reflection data (e.g., angle of slope, dip angle of the subducting plate) and physical states of the wedge and plate boundary (e.g., normal stress, fluid pressure, shear stress and coefficient of friction), Kimura et al. (2012) suggested that middle slope and lower slope of the Japan Trench is in a critical state. Dynamic Critical taper theory proposed by Wang and Hu (2006) improved the Mohr?Coulomb theory to show how stress state changes in terms of seismic cycle. Although the shape of the wedge in the Japan trench is consistent with this theory, stress transition in the shallow region of the trench should be reconsidered.

Because of along-trench variability in the bathymetry and the direction of plate convergence, it is very useful to reconsider relation of taper angle and the friction of the plate boundary at several profiles along the Japan Trench.

In this study, based on Kimura et al. (2012), we used a bathymetric data taken before the Tohoku-oki earthquake and re-examined the relationship between the taper angle and friction of plate boundary in shallow part of the Japan Trench. First, we divided the trench into three segments from south to north, and chose five seismic survey lines from each area, focusing on a specific range from the trench to the splay fault (˜ 20km). By applying the Critical taper theory to the individual cross-section, and based on the assumption that splay fault behaves as a backstop, we discuss stress balance between the interior and base of the wedge, fluid pressure ratio, and effective friction coefficient of the plate boundary.Dip angle of the subducting plate is obtained from images by seismic reflectance surveys, and by studying a broad range in the Japan Trench, we determine the deformation process in the shallow part of the trench.

References

Fujiwara, T. et al. The 2011 Tohoku-Oki earthquake: Displacement reaching the trench axis. Science Vol. 334,1240(2011)

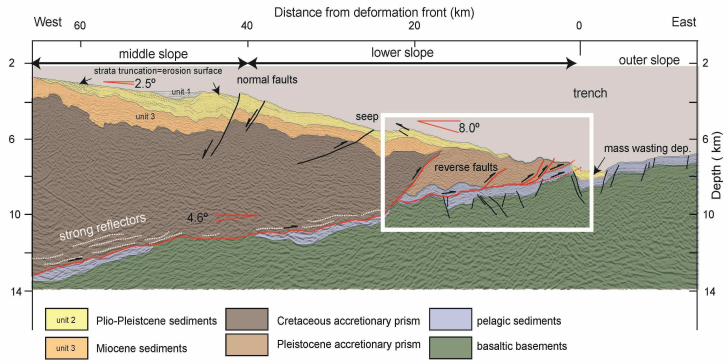
Kodaira, S et al. Coseismic fault rupture at the trench axis during the 2011 Tohoku-oki earthquake. Nature Geoscience 5, 646?650 (2012)

Kimura, G et al. Runaway slip to the trench due to rupture of highly pressurized megathrust beneath the middle trench slope: The tsunamigenesis of the 2011 Tohoku earthquake off the east coast of northern Japan, Earth and Planetary Science Letters, 339-340, 32-45. (2012)

Ito, Y et al. Frontal wedge deformation near the source region of the 2011 Tohoku-Oki earthquake, Geophysical Research Letters 38(15): L00G05.(2011)

Keywords: critical taper, slope, the Japan trench

SSS31-P29 Room:Convention Hall Time:May 21 18:15-19:30



Sesimic profile along MY 102 modified from Tsuji et al. (2011).

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P30 Room:Convention Hall Time:May 21 18:15-19:30

Relation between Stress Perturbation of the Virtual Fault Models of Intra-plate Eq. and the 1605 Keicho Eq.

Fuyuki Hirose[1*], Kenji Maeda[1]

[1]Meteorological Research Institute

1.Introduction

We have developed and improved a three-dimensional earthquake cycle model on the basis of the rate- and state-dependent friction law. Hirose and Maeda (2011, JpGU, SSJ; 2012, JpGU) numerically simulated great earthquakes along the Nankai trough and produced some occurrence patterns applying heterogeneous frictional parameters and effective normal stress.

However, we could not simulate a pattern that a rupture occurred on only a shallow portion of the plate boundary like the 1605 Keicho earthquake (Furumura et al., 2010, SSJ) even after taking into consideration stress perturbations of inland earthquakes (Hirose & Maeda, 2012, SSJ).

2.Virtual fault models of intra-plate earthquakes

There is the Zenisu ridge with a strike of NE-SW south off Tokai district. We can observe background seismicity and some M6-class earthquakes around the area. In the same area, Kaizuka (1972, Kagaku) pointed out existence of the Nishi-shichitou fault with left-lateral and a strike of N-S. In addition, M7.1 and M7.4 intra-plate earthquakes occurred southeast off Kii peninsula in 2004. Such intra-plate earthquakes may become a trigger of the Keicho type earthquake.

In this study, we try to simulate the Keicho type earthquake taking into consideration stress perturbations of intra-plate earthquakes around the trough, using the method same as Hirose & Maeda (2012, SSJ). We will report our result in the session.

Keywords: Nankai trough, Keicho earthquake, Simulation, stress perturbation, intra-plate earthquakes

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P31 Room:Convention Hall Time:May 21 18:15-19:30

Numerical simulation of Nankai Earthquake, Hyuga-nada Earthquakes, and slow slip events in Bungo Channel

Ryoko Nakata[1*], Mamoru Hyodo[1], Takane Hori[1]

[1]JAMSTEC

We numerically simulated cycles for occurrences of seismic and aseismic events in the region from Hyuga-nada to off Shikoku of southwest Japan with the 3D geometry of the Philippine Sea plate. In this study, we model Nankai Earthquake, three large earthquakes in Hyuga-nada, and slow slip events (SSEs) in the Bungo channel using the composite law, which is a type of rate- and state-dependent friction law. We put the seismogenic zone for the Nankai Earthquake from off Kii peninsula to cape Ashizuri. And we set frictional properties at source area of SSE and the Hyuga-nada earthquakes to satisfy a condition of slow slip and unstable slip, respectively.

As a result, these earthquakes and SSEs occur, whose recurrence intervals roughly correspond to observation data. In our simulation, the Nankai Earthquake and the northern Hyuga-nada earthquake mostly occur independently. And once or twice for a thousand years, rupture of the Nankai Earthquake extends to the Hyuga-nada region. When shallow area at off cape Ashizuri is locked, rupture of the Nankai Earthquake does not extend to the westward. Coseismic slip or afterslip frequently occurs after the Nankai Earthquake in the source area of SSE in the Bungo channel. Then, SSEs in the Bungo channel do not occur after the Nankai Earthquakes for a while, and it repeatedly occurs before the next Nankai Earthquake.

By using these results, it is possible to describe the correlation among occurrences of Nankai Earthquake, Hyuga-nada Earthquake, and Bungo channel SSEs. But these phenomena have not been observed in the past. Therefore, it is required to include a discussion of modeling hypothesis and uncertainty of frictional properties.

Acknowledgments

This work was partly supported by the project ”Evaluation and disaster prevention research for the coming Tokai, Tonankai and Nankai earthquakes” of the Ministry of Education, Culture, Sports, Science and Technology of Japan. The Earth Simulator was used for all simulations.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P32 Room:Convention Hall Time:May 21 18:15-19:30

Two alternative regimes in Nankai seismic cycles caused by depth dependent distribution of fracture energy

Mamoru Hyodo[1*], Takane Hori[1]

[1]JAMSTEC SeismoLP

Great earthquakes have occurred repeatedly along the Nankai Trough in southwestern Japan with recurrence intervals of 100?200 y. The magnitudes of Nankai earthquakes have varied throughout this recurrence history, with many studies to date asserting that an event's magnitude is controlled only by the number of broken segments arranged along the Nankai Trough. However, evidence for seismic slip on the shallowest part of the decollement has been found in cores from boreholes drilled along the trough. In fact, slip on the shallowest part of the plate interface became larger during the 2011 Tohoku earthquake, causing a devastating tsunami. Moreover, recent evidence suggests that large tsunami with recurrence intervals of several hundred years have occurred along the Nankai Trough. Therefore, it is now essential to reconsider the scenario of Nankai Trough earthquakes, including the possibility of seismic slip on the shallow subduction interface. Recently, model calculations of the interplate seismic cycle have been conducted using rate- and state-dependent friction laws. In these calculations, assuming heterogeneous distribution of fracture energy in the seismogenic zone and its shallower extension, both massive earthquakes with slips up to the trough axis and ordinary earthquakes in the seismogenic zone can occur in different seismic cycles. Here, we apply a similar heterogeneous distribution of fracture energy in the shallower plate interface of the Nankai Trough. In the model, we represent the difference in fracture energy by the difference in the characteristic slip distance L. To model the conventional seismogenic zone as a zone of low fracture energy, we set L to be 0.05 m at depths of 10?20 km. Conversely, the shallow plate boundary near the trough is modeled as a zone of high fracture energy. By applying various values of L (0.05m<L<10m) in the shallower region, we explain the effect of gaps in fracture energies on resultant seismic cycles. For small gaps in fracture energies (0.05m<L<2.25m), the rupture in the every earthquake propagates up to the top of plate interface. In cases of relatively high fracture energies on the shallow interface (i.e. L >= 2.25 m), however, two types of earthquake with different moment magnitude occur alternately. The recurrence interval of the larger type (i.e., that with the greater slip distance) is about 370 y, which is comparable to the recurrence interval of larger tsunami deduced from recent geological findings. Large coseismic slip (i.e., more than 10 m) extends to the trough axis during the larger types. In contrast, the smaller one, whose seismic slip is distributed only along the seismogenic zone, occurs after ~200 y of the larger one. These results indicate the depth dependent distribution of fracture energy could be a factor which controls the large variation of seismic cycles along the Nankai Trough.

Keywords: numerical simulation, earthquake generation cycle, subduction zone, fracture energy heterogeneity, rate- and state-dependent friction laws

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P33 Room:Convention Hall Time:May 21 18:15-19:30

Dynamics of decollement formation during accretion and mechanism of great earthquake generation in subduction zones

Takane Hori[1*], Hide Sakaguchi[1]

[1]Japan Agency for Marine-Earth Science and Technology

In the previous studies, necessary conditions for decollement formation have been considered as the existence of weak layers due to material heterogeneities, fluid pressure anomaly, etc. Further, in the multiple decollement formation, as called decollement step-down, the newer decollement would be formed deeper than the older one. However, our numerical experiments of accretionary prism formation demonstrate that decollement can be formed without material heterogeneity, and the newer decollement is formed above the older one. We will explain the mechanism of the above processes, and propose new paradigm for the dynamics in accretion and decollement formation. Furthermore, we will discuss earthquake generation mechanism based on our dynamical model for accretion formation.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P34 Room:Convention Hall Time:May 21 18:15-19:30

Dynamic Simulation of the Seismic Behavior on the Shallow Part of the Fault during Mega-Thrust Earthquakes Part.3

Kenichi Tsuda[1*], DORJPALAM, Saruul[1], DAN, Kazuo[1], OGAWA, Sachio[1], WATANABE, Takahide[1], IRIE, Kiyoshi[1], URATANI, Hiroaki[2], IWASE, Satoshi[2]

[1]Ohsaki Research Institute Inc., [2]Chubu Electric Power Co., Inc.

The recent mega-thrust earthquakes, such as the 2011 Tohoku-Oki earthquake (M9.0), the 2004 Sumatra earthquake (M9.2) and the 2010 Chile earthquake (M8.8) showed some distinct features. For example, huge slips on the order of several ten meters on the shallow part of the fault without radiating short-period seismic waves (strong ground motions) are detected. Another is that the deep part of the fault radiates strong ground motions (e.g. Lay et al., 2012). The feature of seismic behavior especially shown on the shallow part of the fault has been highlighted if the rupture of the mega-thrust earthquakes reaches to the shallow part. Although various kinds of observations for the seismic behavior (rupture process and ground motion characteristics etc.) on the shallow part of the fault plane during the mega-trust earthquakes have been reported, the number of analytical or numerical studies based on dynamic simulation is still limited.

In this study, we carried out the dynamic simulations in order to get better understandings about the seismic behavior on the shallow part of the fault during mega-thrust earthquakes. We used the two-dimensional spectral element method (Ampuero, 2009) that can incorporate the complex fault geometry into simulation as well as to save computational resources. The simulation utilizes the slip-weakening law (Ida, 1972). In the simulation, we investigated the seismic behavior with changing some parameters such as the critical slip distance (Dc), the material parameters, and the rupture directivity in addition to the stress drop whose results are shown in Tsuda et al. (2012). The results of simulations are useful to get better understandings about the seismic behavior on the shallow part of the fault during the future mega-thrust earthquakes along the Nankai Trough, Japan.

Keywords: mega-thrust earthquake, shallow part of fault plane, seismic behavior, dynamic simulation, spectral element method

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P35 Room:Convention Hall Time:May 21 18:15-19:30

3-D numerical modeling of temperature, fluid flow and heat flow associated with subduction of the PHS plate in SW Japan

Yingfeng Ji[1*], Shoichi Yoshioka[2], Takumi Matsumoto[3]

[1]Department of Earth and Planetary Science, Graduate School of Science, Kobe University, [2]Research Center for Urban Safety and Security, Kobe University, [3]National Research Institute for Earth Science and Disaster Prevention (NIED)

Constructing a three-dimensional numerical model, we investigated temperature, fluid flow and heat flow distributions associated with subduction of the Philippine Sea plate subducting beneath the Amuran plate, southwest Japan. We modeled realistic three-dimensional shape of the Philippine Sea slab by an inversion analysis using ABIC, using the geometry datum obtained by high resolution of P-wave tomography and seismic reflection study. Subducion velocity was set to be 4 cm/yr during a period from 7 to 3 Ma in the direction parallel to the strike of the Kinan Seamount Chain, and 6.32 cm/yr for the last 3 Myr obliquely in the current convergent direction. The results showed the patterns of temperature distribution, fluid flow and surface heat flow distributions in southwest Japan after 7 Myr of subduction. We found that the cooling effect brought by the Philippine slab is remarkable in the portion on descent slope of the slab with a larger composite subduction angle. The distribution of interplate temperature on the slab upper surface appears similar to the geometry of slab upper surface, indicating a corresponding relation between them.. Flow velocity of the mantle substance near the upper surface of the Philippine Sea slab is lower than that of the slab, and oblique subduction resulted in convection in oblique direction beneath the Osaka Bay where a dip angle of the slab is much larger than that beneath Shikoku. Subduction velocities on ascent and descent slope gradients are different, for they have a different composite subduction angle. Surface heat flow distribution is also affected by the slab shape. The cooling effect became large with increasing subduction time and slab length. To fit the observed surface heat flow distribution better in the model domain, we changed thickness of the continental plate and pore pressure ratio related to frictional heating on the plate interface, and evaluated the simulated results using the least square method. As a result, we suggest that thickness of the continental plate larger than 30 Myr. Pore pressure ratio larger than 0.95 is better for fitting the observation data. High heat flow anomalies in Shikoku and the Kii Peninsula and the low anomaly along the Seto inland sea exist according to the comparison to the results of simulation.

Keywords: numerical simulation, temperature, fluid flow, heat flow, Philippine Sea plate, Southwest Japan

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P36 Room:Convention Hall Time:May 21 18:15-19:30

Rock magnetism of Tsunami boulders and its implication to emplacement history.

Tetsuro Sato[1*], Norihiro Nakamura[1], Kazuhisa Goto[2], Hiroyuki Nagahama[1], Koji Minoura[1]

[1]Graduate School of Earth Science, Tohoku Univ., [2]International Research Institute of Disaster Science (IRIDeS),Tohoku University

In Ishigaki Island of Japan, there are several tens of erratic boulders, consisted of hermatypic coral. They had been emplaced due to the 1771 Meiwa Tsunami and/or prehistorical Tsunamis, called Tsunami boulder. These boulders that originally had attached to the reef edge emplaced to the shoreline or reef flat. To reveal the age of ancient Tsunami attacks, recent studies have conducted radiocarbon dating to Tsunami boulders and the result showed the population of five tsunamis since about 2000 years ago. Therefore, each Tsunami event might have transported or rotated Tsunami boulders more than once. However, radiocarbon dating cannot discriminate subsequent rotations. To solve this problem, we propose the paleomagnetic strategy. When coral grows, the coral magnetized parallel to the Earth's magnetic field due to the presence of magnetosome or detrital magnetite. If boulder have fine-grained magnetite, it is easy to acquire the secondly magnetization. Thus, the boulder obtains the new magnetization as it moves and rotates. This new magnetization is called viscous remanent magnetization (VRM) and increases progressively with age like vector composition. Using progressive thermal demagnetization (PTD), these vector components are erased young to old. Therefore, PTD can visualize the point of magnetic vector component changed and this point indicates the presence of Tsunami event. Furthermore, Neel's theory gives the formula that natural VRM acquired at low temperature over a long time disappears at a high temperature in a short time. This formula predicts multiple Tsunami age is determined from rotation record of each boulder. Our result showed multiple points of vector component changed during 383K to 413K. This result consist with emplacement mode of "Bari-ishi" which have been emplaced by 1771 Meiwa Tsunami. Our paleomagnetically-dated ages agree well with the population of radiocarbon dating. Furthermore, the ages calculated by the demagnetization temperature of VRM are close to ages of radiocarbon dating, although remanence-carrying mineral should be a single domain magnetite. To reveal the magnetic mineralogy, we conducted Lowrie-Fuller test, X-ray diffraction, high-temperature hysteresis to determine the Curie point. These allow us that the magnetic mineral of Tsunami boulder is of single domain magnetite. Therefore, our paleomagnetic strategy is valid for revealing the multiple transportation history of Tsunami boulder at Ishigaki Island.

Keywords: Tsunami boulder, paleomagnetism, viscous remanent magnetization, Neel's theory, single domain

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P37 Room:Convention Hall Time:May 21 18:15-19:30

Hearing survey of the tsunami generated by the 1911 great earthquake(M8.0) occurred around Kikai-jima, Japan

IWAMOTO, Kengo[1], Kazuhiko Goto[1*]

[1]NOEV, Kagoshima Univ.

The great earthquake(M8.0) occurred around Kikai-jima, Japan in 1911 and the weak tsunami was known to attack Amami-oshima (Imamura, 1913). However, it is recently revealed that there are some traditions of tsunami height more than 5m in Kikai-jima and Amami-oshima. Then, we conducted hearing survey at Kikai-jima, Amami-oshima, Kakeroma-jima, Uke-shima, Yoro-shima and Takara-jima in 2011-2012 for understanding the actual conditions of tsunami.

Number of collected information on tsunami is 34 at Kikai-jima, 19 at Amami-oshima and 2 at Kakeroma-jima, many of which are oral traditions from parents or grandparents. Characteristics of tsunami are summarized as follows :

1. Height of tsunami was more than 5m at the west coast of Kikai-jima. On the other hand, it was low at the east coast.
2. Height of tsunami was more than 5m at Amami-oshima, which was larger at the east coast generally in comparison with that at the west coast.
3. There was no severe tsunami damage at Kakeroma-jima, Uke-shima and Yoro-shima.
4. Ebbing tide was observed at Kikai-jima, the middle and the northern part of Amami-oshima. (There is no information on the first motion of tsunami at the southern part of Amami-oshima.)

The present hearing survey reveals that the 1911 tsunami is reasonable size for earthquake magnitude of 8.0. The tsunami simulation shows the collected information on tsunami is explained well by the model that the tsunami is generated by the thrust fault located at the north-northeast off Kikai-jima.

Keywords: great earthquake, tsunami, plate boundary, Nansei-shoto, Kikai-jima

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P38 Room:Convention Hall Time:May 21 18:15-19:30

Nankai Earthquake recurrences recorded in lacustrine sediment from eastern Shikoku

Takahiro Fukumoto[1*], Hiromi Matsuoka[2], Makoto Okamura[2]

[1]Graduate School of Science, Kochi Univ., [2]Kochi Univ.

We collect total nine cores from Kamoda-oike , western Shikoku. These core samples cover 0-6,500 years in Late Holocene time. Only one thick tsunami sediment obtains in the interval which composed of brown colored plant material-rich mud. This tsunami sand layer which shows 2000yBP to 2300yBP in age, yield light gray colored, well sorted and well rounded sand.

Historical records among 1,000 years interval are not written in any archives around this pond even 1707 Hoei Nankai Earthquake. This pond may have sedimentary potential in which tsunami sediment records huge tsunami only.

Keywords: tsunami sediment, Nankai earthquake, Nankai Trough, tsunami record

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P39 Room:Convention Hall Time:May 21 18:15-19:30

Nankai Earthquake recurrences recorded in lacustrine sediment

Makoto Okamura[1*], Hiromi Matsuoka[2]

[1]Kochi University, [2]Kochi University

We collected total nine cores from Sugari-oike facing the Kumano-nada Sea. The cores cover 0-3500 years in interval through the latest Holocene time. Total eighteen tsunami sand layers found in light-brown colored plant-rich material. Several tsunami sediments can be correlated to the historical records such as the Ninna Tonankai (AD 887 year) and Tenmu Tonankai (AD 684 year). Among 1000 years interval, we can recognize five-layers
in top 200 cm cores. The other hand, three tsunami layers yield in these cores which correspond 2000, 2300 and 2500 years respectively.

Relative intensity of tsunami is difficult to know because of paleoenvironmental condition are not stable because of having several tsunami-pass inlet.

Keywords: Nankai Earthquakes, Tsunami sediments, Sukari O-ike

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P40 Room:Convention Hall Time:May 21 18:15-19:30

Re-examination of large 20th century earthquakes along the southern Japan trench -The 1927 and 1953 off Boso earthquakes

Satoko Murotani[1*], Kenji Satake[1]

[1]Earthquake Research Institute, the University of Tokyo

We re-examine hypocenters, focal mechanisms and fault models for large earthquakes off Boso region along the southern Japan Trench. The relocated epicenter of the 1927 Boso earthquake, from newly collected S and S-P times, is about 100 km to the west of that of Japan Meteorological Agency (JMA).

Off Boso, several large earthquakes (e.g., the 1953 Boso earthquake) and tsunami earthquakes (e.g., the 1677 Empo earthquake) have occurred, but their recurrence periods are not well known. Two earthquakes, one on August 18, 1927 with Mjma 6.4 and Mt 7.4, and the other on November 25, 1953 with Mjma 7.4 and Mt 7.8, have different epicenters and tsunami source areas. While the 1927 epicenter was located southeast of the 1953 epicenter, the 1927 tsunami source was estimated northwest of the 1953 tsunami source (Hatori,1975). We identified the locations of tide gauge stations in 1920's, and recalculated the tsunami travel time. The tsunami source area was located a little southwest of that of Hatori (1975). To relocate epicenter, we collected seismic waveforms and original arrival time reports from the local meteorological observatories of the 1927 earthquake, and re-examined those S-P times. At some observatories, the value reported as a preliminary tremor in 1927 was not S-P but L-P time. Even if there were no report from a local meteorological observatory, there were some observatories where seismic waveform records remain, and P and S wave arrival times were written on them. Re-examined S-P time distribution of the 1927 earthquake looks similar to that of the 1953 earthquake. The 1927 epicenter is estimated at 141.2-141.7E and 34.1-34.2N, while that of JMA (2004) is 142.4E and 33.8N. The 1953 epicenter by JMA is 141.4E, 34.2N.

Keywords: Off Boso earthquake, Hypocenter location, Tsunami simulation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P41 Room:Convention Hall Time:May 21 18:15-19:30

Fault model of the 17th century great earthquake off Hokkaido estimated from tsunami deposit data

Kei Ioki[1*], Yuichiro Tanioka[1]

[1]Institute of Seismology and Volcanology, Hokkaido University

Historically great underthrust earthquakes occurred off east Hokkaido. On the other hand, tsunami deposits by prehistoric tsunami have been found on the coast of east Hokkaido, Japan. These tsunami deposits were found at far inland away from tsunami inundation area by historic great earthquakes. The elevations of the location where tsunami deposits were found are also much higher than estimated heights of historic tsunamis. The recurrence interval of events is about 400 ~ 600 years. The latest event occurred early 17th century because that the latest tsunami deposits can be seen just under the volcanic ash caused by the 1667 Tarumae eruption. Large tsunami of the 17th century was generated by the earthquake that ruptured the area of Tokachi-Oki and Nemuro-Oki regions.

We estimated fault model of the 17th century earthquake by using both lowland tsunami deposit data and elevations of the location where tsunami deposits were found near the coast at highland. A finite-difference scheme was used to solve the non-linear long-wave equations with a moving boundary condition. The computed tsunami inundation and heights were compared to tsunami deposit data at 11 locations on the coast of east Hokkaido. Satake et al. (2008) estimated the fault model of the 17th century earthquake. This fault model was estimated to compare lowland tsunami deposit data and computed tsunami inundation area. This fault model of large rupture area of the plate interface was needed to explain the large tsunami inundation. Additionally, the fault model of very large slip amount at shallow part of the plate interface near the trench is needed to explain the high tsunami height near the coast. Therefore, fault model was added at the plate interface near the trench.

The result shows that lowland tsunami deposit data were explained by a tsunami inundation caused by a large rupture area at deep part of the plate interface. Elevations of the location where tsunami deposits were found near the coast were explained by very large slip amount at shallow part of the plate interface near the trench. The total seismic moment of the 17th century earthquake was calculated to be $1.7*10^{22}$ Nm (Mw 8.8) by assuming that the rigidity is $4*10^{10}$ N/m^2. The 2011 Tohoku earthquake also ruptured the large area off Tohoku and very large slip amount was fond at shallow part of the plate interface near the trench. It is possible that the 17th century great earthquake was the same type of the 2011 Tohoku earthquake.

Keywords: great earthquake, tsunami, Hokkaido

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P42 Room:Convention Hall Time:May 21 18:15-19:30

Preliminary report on submarine active-fault landforms in the Sagami Trough, revealed by 0.5-arcsecond-mesh DEM

Nobuhiko Sugito[1*], Takashi Nakata[2], Mitsuhisa Watanabe[3], Hideaki Goto[2], Yasuhiro Suzuki[1]

[1]Nagoya Univ., [2]Hiroshima Univ., [3]Toyo Univ.

We have conducted submarine-topographic surveys using multi-beam echo sounder in the Sagami Trough, in order to produce 0.5-arcsecond-mesh DEM, which is necessary for detailed analysis of submarine active-fault landforms.

This study was supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Observation and Research Program for Prediction of Earthquakes and Volcanic Eruptions.

Keywords: Submarine active fault, Fault-related landform, Historical earthquake, Multi-beam echo sounder, Sagami Trough

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P43 Room:Convention Hall Time:May 21 18:15-19:30

3D bathymetric image of the Sagami Trough and the Boso Triple Junction area

Noriaki Izumi[1*], Azusa Nishizawa[1], Daishi Horiuchi[1], Yukari Kido[2], Takashi Nakata[3], Hideaki Goto[3], Mitsuhisa Watanabe[4], Yasuhiro Suzuki[5]

[1]Hydrographic and Oceanographic Department, Japan Coast Guard, [2]Japan Agency for Marine-Earth Science And Technology, [3]Hiroshima University, [4]Toyo University, [5]Nagoya University

A triple junction is a place where complex interactions of plates occur. The Pacific plate, the North American plate and the Philippine Sea plate collide at the junction of the Japan Trench and the Izu-Bonin Trench, and the Sagami Trough. At these trenches and their vicinity, a collision of plates builds up strain and causes intraplate and interplate earthquakes. Those imprints may have been preserved in the topography.

To understand the seafloor topography of the triple junction and its vicinity, especially spatial distribution of active submarine faults, we made detailed seafloor topographic images based on 150m DEM processed from the original data obtained by Japan Coast Guard and JAMSTEC.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SSS31-P44 Room:Convention Hall Time:May 21 18:15-19:30

Reexamination of the late Quaternary crustal movements in the Sanriku Coast, Northeast Japan, based on geomorphological

Daisuke Ishimura[1*], Takahiro Miyauchi[1]

[1]Graduate School of Sciences, Chiba University

The 2011 off the Pacific coast of Tohoku Earthquake (Mw 9.0) was accompanied by wide crustal subsidence (max. 1.2 m) along the Saniku coast on the Northeast Japan forearc, about 150 km distant from the axis of Japan Trench. This fact led us to qualitatively and quantitatively reexamine the component of coseismic, post-seismic and inter-seismic crustal movements in cumulative long-term uplift of the coast on the forearc. In order to achieve this aim, we conducted geomorphic analysis, drilling survey, and analysis of boring cores along the Sanriku Coast.

Keywords: Pleistocene, Holocene, crustal movement, marine terrace, Sanriku Coast