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

SSS30-P01 Room:Poster Time:April 29 18:15-19:30

Close examination of universality of matter off Miyagi that earthquakes advanced toward the east

MASE, Hirofumi[1*]

[1]none

I explained how the surrounding of the plate boundary is always compressed(1). I reproduced the Off-Miyagi by the easy experiment(2). I understood earthquakes off Miyagi gradually climbed the slope of the plate boundary. The head within range where small earthquakes occur advanced toward the east gradually and went beyond the hypocenter of 3.11 in November, 2010.(3)

Therefore, the model of off Miyagi is the following. The earthquake of M7 class occurs in several decades by one degree. In every case the hypocenter of it moves east. And, the rear side of it slips to a deep point. The moderate quake guides the earthquake of M7. And, the front of crack is formed. Slip-all-together occurs if the front of crack arrives at a proper place. The feature of this model is to be able to give the answer to the following three large problems at a time. (a)A lot of people think that it is generated repeatedly within the specific range. (b)The cause of the swerve that causes large slip in every case is not discovered. (c)Finally happening is that a shallow part is destroyed at a time.

I want to think about (IC)Off Iwate-Chubu,(IH)Off Iwate-Hokubu,(AT)Off Aomori-Toho,(TK)Off Tokachi referring to (MY)Off Miyagi(Fig.1). The 1968 Tokachi-oki earthquake and the 1994 Sanriku-Haruka-Oki earthquake occurred in (IH)(AT). The coseismic slip distributions on the map of (4) is interesting. Though the rupture starting point and the main rupture zone can be understood of those relation of upper-lower part on slope, both are considerably away. This is a feature and it is necessary to be clarified. I interpret that a main rupture zone is the peak of slip nearest the trench. The 1968 earthquake has two large slip zone. The main rupture zone in the south is located in lower part of the main rupture zone of the 1994 earthquake on slope. I want to pay attention to that. I think the 1968 earthquake went with the earthquake that had to happen ahead of the 1994 earthquake. The earthquakes that occurred in the vicinity in the past(5) have the possibility that there were rupture zones in lower part of the 1968 earthquake or the earthquake that had to happen ahead of the 1994 earthquake on slope. Therefore, I think that (IH)(AT) walks on the road similar to (MY). And, that a shallow part can slips and timing is only waited for. We should think that the earthquake similarly climbs the slope also in region (TK).

Range (39N-40N,143E-144E) in region (IC) is the earthquake-prone zone of small and medium-sized earthquakes after 1923. It is seen that there are a lot of intraplate earthquakes(12). The lower plate always collapses due to the earthquakes and the material overflows up and accretionary wedge will be made. The upper plate relatively becomes long and swells because the lower plate shortens. And, the vicinity of the surface comes into a expansion field. And, steep cliffs are formed and fall because the upper plate surges to the trough. This will explain the geographical features of (IC) shown by (9) and the cause. The expansion field in the vicinity of the surface causes the occurrence of the lateral-fault type(10). The structure of the cliff where the sudden falls easily happen reacts sensitively to peripheral earthquakes. In addition, it has the possibility that is an efficient tsunami generator. This harmonizes with the result of (11).

Reference literature (Details are described to space in the drawing)

(1)MASE(2012) (2)MASE(2012) (3)MASE(2013) (4)NAGAI et al.(2000)/ERI U-Tokyo (5)Wikipedia (9)IZUMI et al.(2012)/JCG (10)NAKAJIMA(1974)/Hokkaido U. (11)ICHIHARA et al.(2013)/JAMSTEC (12)JMA/Monthly Report/June 2004

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参考文献
(1)Hirofumi MASE(2012)/The power to form and maintain oceanic basin and island arc /JpGU2012/SCG67-P06 http://www2.jpgu.org/meeting/2012/html5/session/S-CG67.html
(2)Hirofumi MASE(2012)/Materialization and Experiment of Model of Miyagi Prefecture offing on the 2011 Tohoku-Oki Earthquake/SSJ2012/P2-75
http://jglobal.jst.go.jp/detail.php?JGLOBAL_ID=201202271822634851
(3)Hirofumi MASE(2013)/Model that harmonizes with the rupture process of (Ide et al.2011) ～Relation between 3.11 and off-Miyagi-earthquakes～/JpGU2013/SSS28-P09
http://www2.jpgu.org/meeting/2013/session/S-SS28.html
(4)永井理子・菊地正幸・山中佳子(2000)/三陸における再来大地震の震源過程の比較研究 /東大震研/JpGU2000/Sa-005 Riko NAGAI, et al.(2000)/Comparative study on the asperities of large earthquakes in Sanriku region/ERI Univ. of Tokyo
http://www.eri.u-tokyo.ac.jp/YOTIKYO/11seikahoukoku/koukai/r11.5fig1.JPG
(5)ウィキペディア(Wikipedia)「三陸沖北部地震/繰り返し発生する地震以外の地震」
http://ja.wikipedia.org/wiki/三陸沖北部地震
(6)佐竹健治・平田賢治・谷岡勇市郎・山木　滋(2004)/1952年・2003年十勝沖地震の津波波源の比較－1952年津波の再検討に基づいて－/産総研/SSJ2004年大会
http://unit.aist.go.jp/actfault-eq/seika/meeting/jishin2004/satake.html
(7)八木勇治(2004)/2003年9月26日十勝沖地震(Mjma 8.0)の破壊伝搬の様子EPS分/建築研
http://iisee.kenken.go.jp/staff/yagi/eq/Japan20030926/japan20030926-j.html
(8)山中・菊地(2003)/遠地実体波解析9月26日十勝沖地震(Mj8.0)/東大震研/EIC地震学ノートNo.139
http://www.eri.u-tokyo.ac.jp/sanchu/Seismo_Note/EIC_News/030926.html
(9)泉紀明・堀内大嗣・西澤あずさ・木戸ゆかり・中田高・後藤秀明・渡辺満久・鈴木康弘(2012)/150mグリッドDEMから作成した日本海溝付近の3D海底地形 /海保海洋情報部/研究報告第48号 Noriaki IZUMI, et al.(2012)/3D bathymetric image along the Japan Trench based on 150 meter grid DEM/JHOD,JCG
http://www1.kaiho.mlit.go.jp/GIJUTSUKOKUSAI/KENKYU/report/rhr48/rhr48-tr10.pdf
(10)中島徹(1974)/ 1968年十勝沖地震の前後における発震機構の変化/北大/地球物理学研究報告
Tohoru NAKAJIMA(1974)/Spacial and Sequential Distribution of Focal Mechanisms before and after the Tokachi-Oki Earthquake of May/Hokkaido U.
http://eprints.lib.hokudai.ac.jp/dspace/handle/2115/14044
(11)市原寛・浜野洋三・馬場聖至・笠谷貴史(2013)/東日本大震災で発生した津波が巨大化した原因となった場所を特定/海洋研究開発機構/2013年10月8日
Hiroshi ICHIHARA, et al.(2013)/Tsunami source of the 2011 Tohoku earthquake detected by an ocean-bottom magnetometer/JAMSTEC
http://www.jamstec.go.jp/j/about/press_release/20131008_2/
(12)気象庁/地震・火山月報(防災編)/平成16年6月/6月12日岩手県沖の地震/震央分布図、断面図 JMA/Monthly Report on Earthquakes and Volcanoes in Japan/June 2004/6月12日岩手県沖の地震 http://www.seisvol.kishou.go.jp/eq/gaikyo/index.html#monthly (13)気象庁/地震・火山月報(防災編)/平成15年10月/特集1/図1-4, 平成17年8月/特集1/図8-1,等 http://www.seisvol.kishou.go.jp/eq/gaikyo/index.html#monthly

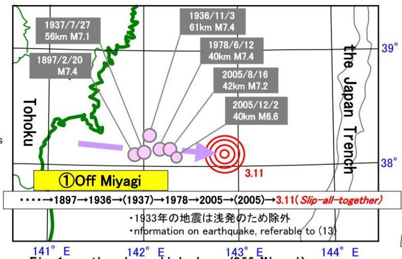


Fig.1 earthquakes climbed up (Off Miyagi)

the Model of Off-Miyagi of 1000 years
(earthquakes climb up)

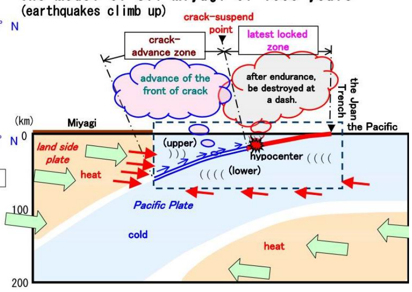
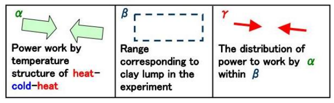


Fig.2 Model cross section intersecting squarely in the Trench and crossing over Miyagi

Explanatory notes



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Diversity of outer-rise earthquakes: As an example of the Off-Fukushima earthquake on 26 October 2013

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Earthquakes occurring in the outer-rise of a subducting plate are associated with the ruptures of the subduing plate itself, that is, intra-plate earthquakes. Such outer-rise earthquakes have been considered to excite much larger high-frequency than earthquakes in the plate boundary of the subducting and overriding plates, because the outer-rise earthquakes should break a lithospheric part where no peculiar weak zones exist.

A M7.1 earthquake occurred off the coast of Fukushima on 26 October 2013, which was probably associated with the 2011 great Tohoku-oki earthquake. We analyzed broadband seismic waveform data of this event recorded by F-net and other seismic networks. Compared with other large outer-rise earthquakes, the high-frequency component (>1Hz) of all the stations along the Pacific coast of eastern Japan is not abundant although slightly larger than plate-boundary earthquakes of low-angle thrust faulting. In contrast, there was the excitation of several impulsive wave packets of several seconds in period. Since only high-frequency waves are abundant at common stations for aftershocks of this outer-rise earthquake, the above features should not be originated by either propagation path or site effect.

Unlike the other outer-rise earthquakes, the rupture process of this earthquake was unique, relatively smooth with several strong patches on a rather homogeneous fault. The breakout of these patches should have been connected without any complex unbroken areas on the fault in the end, in order to explain the observed waveforms. Although we do not deny the break of a virgin (without any peculiar weak planes) lithosphere in this case, several distinguished large strong patches are likely to characterize the heterogeneity in the fault region of this outer-rise earthquake.

Among recent large outer-rise earthquakes along subduction zones near Japan, we have found another example similar to the Fukushima-oki earthquake: for the M7.0 outer-rise event on 14 March 2012 at the junction between Kuril Trench and Japan Trench, several impulsive waveforms with minor high-frequency waves. The state stress of this subducting Pacific plate should be very complex, which might lead to its non-standard rupture process. We shall need to investigate broadband frequency excitation patterns carefully for large outer-rise earthquakes.

In summary, there should be a wide variety of heterogeneities and/or stress state within a subducting lithosphere, which may be important to consider not only the source process of outer-rise earthquakes but also their tsunami generations.

Keywords: outer-rise earthquake, intra-plate earthquake, high frequency seismic waves, fault rupture, heterogeneity of oceanic lithosphere

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High resolution seismic profiling in the northern Japan Trench axis area

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Marine geological and geophysical surveys and analysis of their results have revealed that the ruptured area of the 2011 Tohoku earthquake extended up to the vicinity of the trench axis along the plate boundary fault. To investigate the geological structure, especially the faults and the deformation of the sediments, we have conducted reflection seismic surveys in the trench axis area of the Japan Trench off Miyagi and Iwate prefectures. Three seismic cruises have been carried out in 2011 and 2013 along 81 E-W (dip) lines and 17 N-S (strike) lines. We have used 320 or 380 inch^3 cluster air guns and a 1200 m long streamer cable to obtain high resolution seismic data. Surveyed area covers the trench axis area along the trench strike from seaward of the hypocenter of the Tohoku earthquake around 38 N at south, to ˜40 N at north. Seismic profiles around 38 N show that the trench axis is located on a graben with sediments which have been deformed by reverse faulting. Similar deformation structure is observed around 40 N, but the trench axis is located on a horst not a graben there. The thickness of the incoming sediments on the Pacific plate typically ranges ˜0.3 ? 0.5 s in two way time, however it is reduced down to $<$0.2 s around 39.5 N where the basement of the oceanic crust shows higher relief and trench inner wall is significantly steep. The thickness variation of the incoming sediments can be traced seaward and corresponded with along strike variation of the structure in the outer rise. These high resolutions seismic data served for the site selection of the JFAST drilling project by IODP and also contributes to the JTRACK proposal for future drilling in the Japan Trench following success of the JFAST.

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Seismic surveys in the ruptured area of the 2011 Tohoku earthquake

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We have conducted seismic surveys in the ruptured area of the 2011 Tohoku earthquake off Miyagi prefecture in 2011 and 2013 using JAMSTEC's R/V Kairei. Three multi-channel reflection seismic (MCS) surveys were conducted in 2011 with R/V Kairei's 7800 inch^3 tuned air gun array and ˜6 km long streamer cable. The MCS profiles along 14 E-W (dip) lines and two N-S (strike) lines were acquired during these surveys. Another seismic survey was carried out in 2013 around the JFAST drill site along one dip line and two strike lines. Time migrated sections demonstrated characteristic structure in the Japan Trench subduction zone; the Pacific plate deformed by normal faults (horst and graben structure), frontal prism with seismically transparent or chaotic feature, strong landward dipping reflections corresponding to the backstop interface, "deep sea terrace" in the upper landward trench slope covered with younger sediments mainly deformed with normal faults. Our survey area covers ˜150 km in the trench strike direction around the epicenter area, which is rather small compared with the entire rupture zone (400 ? 500 km in the strike direction) of the Tohoku earthquake, however the structure is considerably variable from south to north. We have selected 6 dip lines, including the JFAST dip line, to apply pre-stack depth migration (PSDM). The PSDM sections provide higher quality profiles and interval velocity models in depth domain which are suitable for understanding the structural framework of the Japan Trench subduction zone. In 2013 survey, we also used four ocean bottom seismographs (OBSs) in addition to the MCS system. The P to S converted wave was clearly observed in the horizontal component seismograms, and the Vp/Vs in the sediment layer around the JFAST drill site was estimated at $>$4.5.

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Determination of Three Thermal Properties in Japan Trench Fast Drilling Project (JFAST)

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The 2011 Mw 9.0 Tohoku-oki earthquake produced a maximum coseismic slip of >50 m near the Japan Trench. Japan Trench Fast Drilling Project (JFAST) as the Integrated Ocean Drilling Program (IODP) Expedition 343 and 343T drilled through the plate boundary fault ruptured during the Tohoku-oki earthquake at site C0019 approximately one year after the earthquake. The most highlighted objective is to detect residual positive temperature anomaly induced by the coseismic frictional heat. To interpret measured temperature anomaly and to calculate coseismic shear stress on the ruptured fault from the temperature anomaly, the full three thermal properties (thermal conductivity, thermal diffusivity and specific heat; only two thermal properties among the three are independent) are necessary. We measured the three thermal properties using four whole round core samples retrieved from borehole C0019E at 177, 697, 802 and 828 mbsf (meter below seafloor), respectively by a transient plane heat source method (also called Hot Disk method). Independently with Hot Disk method, thermal conductivity were also measured by a line heat source method for 45 half core samples using a TEKA half-space probe onboard the D/V Chikyu and by a divided bar technique using 38 crushed core samples (particle samples) in onshore laboratory. The thermal conductivities determined independently by the three methods were consistent each other. Also, the Hot Disk measurements revealed very little anisotropy in thermal conductivity and thermal diffusivity.

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

Keywords: Thermal Prpperty, JFAST, Thermal conductivity, Thermal diffusivity, Specific heat

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Modeling slow and seismic slips off Tohoku considering low to high speed friction behavior of the shallow plate boundary

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Ikari et al. (2013) examined low to high speed frictional properties of fault zone material from the shallow plate boundary in the Tohoku region obtained by the IODP Expedition 343 (JFAST). They found velocity-weakening frictional behavior at slip velocities slower than 10^{-6} m/s and velocity-strengthening at higher slip velocities. This frictional property is considered to be a mechanism that causes slow slip events and stress accumulation during the period between slow slip events. We investigate the effects of this frictional property on generation of slow slip events and megathrust events.

We use a rate- and state-dependent friction law with cut-off velocity to an evolution effect to represent this frictional behavior. Based on the experimental results (Ikari et al., 2013), we set the cut-off velocity at 10^{-6} m/s. We also consider dynamic weakening due to thermal pressurization at high slip velocity. We perform three-dimensional quasi-dynamic modeling of slip processes. Numerical results show the occurrence of slow slip events at intervals of several ten years at the shallow plate boundary. During the period between slow slip events, stress accumulation proceeds. When an earthquake nucleates at the deeper region, coseismic slip propagates into this region, which results in larger slip compared to the case where a simple velocity-strengthening friction law is considered.

Ito et al. (2012) detected slow slip events in the Japan subduction zone before the 2011 Tohoku-Oki earthquake. Shallow very low frequency earthquakes off Tohoku were detected by Matsuzawa et al. (2012). In addition, along the shallow plate boundary off Tokachi, sequential activity of very low frequency earthquakes occurs at intervals of several years (Asano et al., 2008). These observations suggest that the transitional friction behavior investigated by Ikari et al. (2013) occurs along the shallow plate boundary off Tohoku.

Keywords: off Tohoku, shallow plate boundary, low to high speed friction behavior, slow slip, seismic slip

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Friction properties beneath the frontal wedge near the Japan Trench: deduction from topographic variation

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The 2011 Tohoku-oki earthquake (Mw 9.0) produced a fault rupture, extending to the Japan Trench. Deformation and frictional properties beneath the forearc are the keys to elucidate this unusual event.

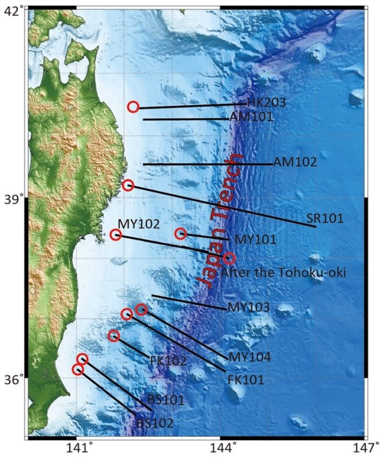
In this study, to obtain frictional properties (μ_b'; the coefficient of effective basal friction), we extracted shape-related parameters from the cross sections of the frontal wedge which are obtained from surveys across the trench that span sporadically along the axis of the Japan Trench. The following two methods were adopted for this study; Critical Taper Theory (CT) and Critical State Theory (CS). Both of the theories are based μ_b' From the Critical Taper Theory. Near latitude 36.1, the taper angles (slope angle + decollement dip angle) has been developed . A possible seamount subduction may differentiate this area. However, near the latitude 38.15 where the largest slip was reported with the 2011 earthquake, the taper angle has also been large without any seamounts. The calculated [or estimated] value of μ_b' in this area is larger than that of the other area, suggesting that the larger strain energy was accumulated in comparison with the other wedges.

From the Critical State Theory, the value of ω (angle between the basal decollement and backstop interface) becomes smaller toward the north. The results of CS show the increase of the ω associate with the increase of the μ_b', suggesting that strain energy is more stored toward the North.

Both results show that the μ_b' has decreased after the earthquake. The change in μ_b' may be due to the earthquake.

It is possible to know friction properties of before the earthquake and that of after the earthquake with bathymetry.

Keywords: Japan Trench, Critical Taper Theory



SSS30-P08 Room:Poster Time:April 29 18:15-19:30

Long-term crustal movement in the Rikuzentakata area, southern Sanriku coast, based on geomorphological/geological featu

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In the northeast Japan forearc, strain rate estimated based on by geological feature is different from that by geodetic feature. Thus, marine terrace suggests that the Sanriku coast has uplifted at the rate of 1 mm/yr since the late Quaternary. On the other hand, this area has subsided at the maximum rate of 10 mm/yr during the past 100 years based on geodetic data. This disaccord indicates the possibility that the giant mega-thrust earthquake causes the Sanriku coast to uplift. However, the 2011 Tohoku-Oki Earthquake (Mw9.0) was accompanied by subsidence along the Sanriku coast. This fact led us to reexamine long-term crustal movement.

We conducted geomorphological/geological analyses in the Sanriku coast, especially the southern part of the coast, where long-term crustal movement is unknown because of lack of widely distributed Pleistocene marine terrace. In this presentation, we will report preliminary results of consideration of long-term crustal movement in the Rikuzentakata area, southern part of Sanriku coast.

Keywords: marine terrace, southern Sanriku coast, long-term crustal movement, alluvial plain

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Large-scale simulation of coseismic and postseismic crustal deformation using a high-fidelity finite element model

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Postseismic crustal deformation of a subduction zone earthquake is an essential factor in such studies as interseismic slip deficit rates and stress-field change of the focal area of inland earthquakes. The viscoelastic behavior of the asthenosphere largely affects postseismic crustal deformation. Several studies have used analytical models or three-dimensional (3D) finite element (FE) method to simulate postseismic crustal deformation, considering the viscoelasticity. Yet because of the large computational cost, simulations using a realistic model of crustal structure have not been carried out, despite that detailed crustal data are available. Based on the technique of high performance computing, we performed large-scale finite element simulations using 3D FE models of higher-fidelity (High-fidelity model: HFM) to available crustal data. We used the data of JTOPO30, which was constructed in a 900 m resolution by MIRC (JTOPO30, 2003), for modeling the ground surface and CAMP standard model (Hashimoto et al. 2004) for the interplate boundaries. By using this data, we constructed a one-kilo-meter-resolution HFM with the size of 1700 x 2600 x 400 km, which includes the whole of the Japanese Islands. The model has 30km thick crust and the underlying viscoelastic mantle wedge, where the Philippine Sea and the Pacific plates are subducting beneath the Eurasian and the North American plates. Because the target area was large, we also took into consideration the curvature of the earth. We expect a large degrees-of-freedom in our HFM. Therefore, to compute the time history of the crustal deformation with such a large-scale model, we used the K computer, the fastest supercomputer in Japan.

In the session, we will show the simulation of the 200-year time history of postseismic crustal deformation using the HFM. In addition, by comparing the results of various sizes of temporal and spatial discretization, we will demonstrate that our method can compute the solution with discretization fine enough for numerical convergence.

Keywords: postseismic crustal deformation, high-fidelity finite element model of crustal structure, large-scale simulation

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Tsunami simulation in the Western Pacific Ocean and East China Sea from the hypothetical M9 Nankai earthquake models

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We computed tsunamis in the Western Pacific Ocean and East China Sea from the hypothetical models of the giant Nankai earthquake proposed by the Cabinet Office of Japanese government (2012). The maximum tsunami heights on the New Guinea coasts, Philippine Islands coasts, and Shanghai coasts in China are about 1.0-5.0 meters, 1.0-7.0 meters, and 0.5-2.0 meters, respectively. They are up to twice large as those computed from the 1707 Hoei earthquake (the largest earthquake along the Nankai trough in Japanese history). The simulation also shows that tsunami heights on the coasts in this area depend on the slip amounts on the Nankai fault.

Responding to the unexpected occurrence of the 2011 Tohoku earthquake, the Cabinet Office of Japanese government (2012) assumed 11 models of the giant Nanakai earthquake (Mw 9.1), computed tsunami heights along the Japanese coasts, and estimated the human and economic disasters. The tsunami heights exceed 10 m on the coasts of 13 prefectures, with a maximum height of 34.4 m.

Tsunamis from such a gigantic earthquake may impact the coasts in the Western Pacific Ocean and East China Sea. Harada and Satake (2012, AOGS; 2013, "Tsunami Events and Lessons Learned", Springer) performed numerical tsunami simulations in these oceans by using various fault models of the past Tokai and Nankai earthquakes.

In this study, we carried out the same simulations from the 11 fault models of the M9 Nankai earthquake. Tsunami propagations were computed by the finite-difference method for the non-linear long-wave equations with Corioli's force (Satake, 1995) in the area of 115-155 deg. E and 8 deg. S to 40 deg. N using the GEBCO 30-second bathymetry data. Initial tsunami heights computed by the Cabinet Office were used. A Manning's roughness coefficient of 0.025 $m^{-1/3}s$ was assumed for the friction and a computation time step of 1 s is used to satisfy the stability condition of the finite-difference method. We simulated tsunamis for 24 hours after the earthquakes.

We thank the Cabinet Office of Japanese government for providing the hypothetical models of the giant Nankai earthquake.

Keywords: sunami numerical simulation, Western Pacific Ocean, East China Sea, maximum tsunami heights, hypothetical M9 Nankai earthquake

SSS30-P11 Room:Poster Time:April 29 18:15-19:30

Stress concentration in the C0002 borehole of the NanTroSEIZE Project, Nankai Trough

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Wellbore instability is a major challenge for the engineer evaluating borehole and formation conditions. Instability is especially important to understand in areas with high stress variations, significant structure anisotropy, or pre-existing fracture systems. Borehole (in)stability is influenced by rock strength, structural properties, and near-field principal stresses. During drilling, the borehole conditions also impact borehole integrity. Factors that we can measure in the borehole during with logging while drilling (LWD) to understand these conditions include Mud Weight, mud loss, ROP (Rate of Penetration), RPM (Rotation Per Minute), WOB (Weight on Bit), and TORQ (Power swivel torque value). By observation the resistivity images, we can utilities the significant features under the interactions of effective stresses and formation.

We conducted stress analysis for Site C0002F of the Nankai Trough transect based on riser and riserless drilling data during IODP Expedition 338. Rock strength and basic physical properties, including velocity, density and porosity are obtained from core samples. The borehole shape, determined from LWD resistivity images, indicates that most of drilling occurred in stable environments, however, in a few instances the bottom hole assembly became stuck. We used our stress profile model to evaluate the mud weight required to drill a stable borehole for the measured rock strength and physical properties. Based on our analysis, we constrained the stress magnitude and possible orientation during IODP Expedition 338 by the drilling parameters. The enlargement and collapse in the borehole indicated that mud weight plays the essential role in the drilling.

Keywords: NanTroSEIZE, LWD, Breakout, Drilling, Borehole Instability

SSS30-P12 Room:Poster Time:April 29 18:15-19:30

Preliminary results of lithology examined during IODP Expedition 348 in the accretionary wedge of the Nankai Trough

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International Ocean Discovery Program (IODP) Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) Expedition 348 took place from 13 September 2013 to 29 January 2014. This expedition was primarily designed to extend riser Hole C0002N to 3600 mbsf (in the event, C0002N sidetrack Hole C0002P was drilled to 3058.5 mbsf). We collected cuttings, core samples, mud gas, and logging data. Here we report the preliminary shipboard lithological results of IODP Expedition 348.

Four lithologic units were identified at Site C0002 based on geological and geochemical characteristics of core and cuttings samples: Unit II (475-512.5 mbsf in Hole C0002M), Unit III (875.5-975.5 mbsf in Hole C0002N), Unit IV (975.5-1665.5 mbsf in Hole C0002N), and Unit V (1665.5-2325.5 mbsf in Hole C0002N, and 1965.5-3058.5 mbsf in Hole C0002P).

Lithologic Unit II is dominated by fine-grained turbiditic deposits. Silty claystone is the main lithology, with subordinate fine-grained sandstone and sandy siltstone. Lithologic Unit III is dominated by silty claystone with trace amounts of very fine loose sand, containing common glauconite grains. Those units are interpreted to be the Kumano forearc basin sediments. Lithologic Unit IV is dominated by silty claystone, with sandstone as a minor lithology. Sandstone cuttings in this unit are generally very weakly consolidated, and occur as disaggregated loose sand. Lithologic Unit IV is divided into five subunits based on sand content and interpreted as the upper accretionary prism sediment. Lithologic Unit V is dominated by silty claystone. Fine-grained and moderately cemented sandstone was a minor component. In Hole C0002P, clay-size content in the silty claystone increases at the depth up to 2625.5 mbsf. The fine silty claystone becomes the dominant lithology from 2625.5 mbsf. This unit is possibly interpreted to be the trench or Shikoku Basin hemipelagic deposits.

Keywords: IODP Expedition 338, NanTroSEIZE, Site C0002

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SSS30-P13 Room:Poster Time:April 29 18:15-19:30

Physical properties of Nankai accretionary prism sediments at Site C0002, IODP Expedition 348

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Integrated Ocean Drilling Program (IODP) Nankai Trough Seismogenic Zone Experiment (NanTroSEIZE) Expedition 348 focused on deepening the existing riser hole at Site C0002 to ~3000 meters below seafloor (mbsf) to access the deep interior of the Miocene inner accretionary prism. This unique tectonic environment, which has never before been sampled in situ by ocean drilling, was characterized through riser drilling, logging while drilling (LWD), mud gas monitoring and sampling, and cuttings and core analysis. Shipboard physical properties measurements including moisture and density (MAD), electrical conductivity, P-wave, natural gamma ray, and magnetic susceptibility measurements were performed mainly on cuttings samples from 870.5 to 3058.5 mbsf, but also on core samples from 2163 and 2204 mbsf.

MAD measurements were conducted on seawater-washed cuttings ("bulk cuttings") in two size fractions of >4 mm and 1-4 mm from 870.5 to 3058.5 mbsf, and hand-picked intact cuttings from the >4 mm size fractions within 1222.5-3058.5 mbsf interval. The bulk cuttings show grain density of 2.68 g/cm3 and 2.72 g/cm3, bulk density of 1.9 g/cm3 to 2.2 g/cm3, and porosity of 50% to 32%. Compared to the values on bulk cuttings, the intact cuttings show almost the same grain density (2.66-2.70 g/cm3), but higher bulk density (2.05-2.41 g/cm3) and lower porosity (37-18%), respectively. The grain density agreement suggests that the measurements on both bulk cuttings and intact cuttings are of good quality, and the differences in porosity and density are real, but the values from the bulk cuttings are affected strongly by artifacts of the drilling process. Thus, the bulk density and porosity data on handpicked cuttings are better representative of formation properties. Combined with the MAD measurements on hand-picked intact cuttings and discrete core samples from previous expeditions, porosity generally decreases from ~60% to ~20% from the seafloor to 3000 mbsf at Site C0002.

Electrical conductivity and P-wave velocity on discrete samples, which were prepared from both cuttings and core samples in the depth interval of 1745.5-3058.5 mbsf, range 0.15-0.9 S/m and 1.7-4.5 km/s, respectively. The electrical resistivity (a reciprocal of conductivity) on discrete samples is generally higher than the LWD resistivity data but the overall depth trends are similar. On the other hand, the P-wave velocity on discrete samples is lower than the LWD P-wave velocity between 2200 mbsf and 2600 mbsf, while the P-wave velocity on discrete samples and LWD P-wave velocity are in a closer agreement below 2600 mbsf. The electrical conductivity and P-wave velocity on discrete samples corrected for in-situ pressure and temperature will be presented.

The shipboard physical properties measurements on cuttings are very limited but can be useful with careful treatment and observation.

Keywords: IODP Expedition 348, NanTroSEIZE, accretionary prism

SSS30-P14 Room:Poster Time:April 29 18:15-19:30

Effects of frictional heating and comminution on coal maturation

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The detection of friction heating on faults is crucial to estimate frictional heat during earthquakes. Recently, vitrinite reflectance (Ro) has been used to detect friction heating along faults. However, the factors controlling increase in Ro on faults remain poorly understood. Moreover, the application of the commonly used kinetic model to the estimation of temperature rise during short-lived thermal events such as frictional heating on faults has not been convinced. Here, we conducted friction experiments on a mixture of 95 wt% clay-rich material from the host rock of the megasplay fault gouge and 5 wt% coal grains from the forearc basin in the Nankai subduction zone at slip rates of 0.15 mm/s-1.3 m/s under dry (room humidity) and wet (water-saturated) conditions. After the experiments, we examined microstructures, Ro and size of coal grains and then compared with those obtained from in and around the megasplay fault gouge. The results show that Ro does not increase by rapid heating alone; grain-size reduction due to comminution is required for increase in Ro. The combination of comminution and heating is the most effective for increase in Ro, possibly due to enhanced mechanochemical reaction associated with an increase in surface area of coal grains. The application of the results to the Nankai megasplay fault gouge is that increased Ro in the fault gouge results from frictional heating and comminution, while that in adjacent to the gouge are mainly derived from comminution. The Ro calculated from the chemical kinetic model is higher than that measured after the experiments. Ro is an useful tool to detect past frictional heating on faults, but the estimation of temperature rise from Ro is problematic; the new kinetics model considering the effects of frictional heating and comminution is necessary to estimate amount of frictional heat.

Keywords: vitrinite reflectance, frictional heating, comminution, Nankai Trough

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SSS30-P15 Room:Poster Time:April 29 18:15-19:30

Receiver function analysis using OBS data: modeling 3-D structure of the Philippine Sea plate off the Kii Peninsula

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Megathrust earthquakes have repeatedly occurred beneath the southwestern Japan, on the subducting Philippine Sea plate, in cycles of 100-150 years [Ando, 1975]. The rupture boundary of the latest two megathrust earthquakes, the 1944 Tonankai and 1946 Nankai earthquakes, is located at the south of the Kii Peninsula. Although some structural heterogeneity was proposed as factors of the rupture boundary [Mochizuki et al., 1998; Kodaira et al., 2006], the question of why rupture propagation stops there is still open in light of our little knowledge about 3-D geometry of the subducting Philippine Sea plate at offshore region.

In this study, we aim to construct 3-D structure model of the subducting Philippine Sea plate by receiver function (RF) analysis, using data of ocean-bottom seismometers (OBSs) deployed from 2003 to 2007 off the Kii Peninsula [Mochizuki et al., 2010; Akuhara et al., 2013]. These OBSs have three-component velocity sensors with natural frequency of 1 Hz, and their orientations were determined in this study from particle motion of regional P-wave. The difficulty of our RF analysis using OBS data is summarized by the following two factors. The first is that noise is dominant within a low-frequency band (1 <Hz), the most stable band for estimating RFs. The second is that the number of teleseismic events is limited because of short observation periods and low S/N ratio.

To overcome these problems, we calculated RFs with the aid of multi-taper correlation (MTC) method [Park and Levin, 2000]. The method is resistant to spectral leakage and able to estimate frequency-dependent uncertainties for RF, which is suitable for noisy OBS data and for high-frequency analysis. We binned resultant RFs by back azimuths, and computed time-domain uncertainties of the RFs from the frequency-dependent uncertainties estimated by the MTC method, using jackknife resampling within each back azimuth bin [Leahy and Collins, 2009]. This uncertainty estimation makes the following phase identification more reliable, even though the number of teleseismic events is limited.

Our preliminary results show some coherent peaks throughout all back azimuth bins, whose amplitude is larger than one-sigma uncertainties. Some of them have moveout, implying existence of dipping layers, and have arrival times roughly corresponding to the depth of the slab mantle. Although more detailed identification process for these peaks is largely left for our future work, these peaks might be converted phases from the slab mantle.

Keywords: ocean-bottom seismometer, receiver function, subduction zone

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Three-dimensional velocity model for the Nankai Trough seismogenic zone based on structural studies

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Coseismic rupture area of the great interplate earthquake concerned about its occurrence along the Nankai Trough presumed by government of Japan is now wider to the west, north and south than the former assumption. Although the new estimation is based on seafloor topography, source area of the past largest megathrust event, present seismic activity and so on, structural information has not always been enough reflected yet. In order to estimate precise coseismic rupture area of the Nankai megathrust earthquake, it is necessary to improve a physical model of the Nankai Trough seismogenic zone based on the geometry of the subducting plate and velocity structure model.

Japan Agency for Marine-Earth Science and Technology had conducted the large-scale high-resolution wide-angle and reflection seismic survey and long-term observation from off Kyushu to Tokai between 2008 and 2012. Layered velocity structure models are now obtained along grid two-dimensional seismic profiles from the Hyuga-nada to the Kii channel area. A three-dimensional seismic tomography using active and passive seismic data observed both land and ocean bottom stations had been also performed for the western Nankai Trough.

In this study, we constructed a three-dimensional velocity model of the Nankai Trough with the procedure as follows;

1) Sampling the velocity structural information along each seismic profile with interval of ˜1km in horizontal, and ˜100m in vertical directions

2) Preparing the geometry model of each interface included in layered models, e.g., basement, plate boundary, Moho, etc.

3) Setting minimum and maximum velocities of each layer based on the velocity models along two-dimensional seismic profiles

4) Interpolating sampled velocity information considering layered structure

(Landmark DecisionSpaceDesktop is used for constructing 3-D modeling)

Previously published layered models are also used to make up for insufficient structural information for the eastern Nankai Trough.

Reliability of the three-dimensional model was confirmed by comparing calculated travel-times with observed travel-times along each seismic profile. We will also try to evaluate the reliability of the model by comparing the hypocenter distribution using three-dimensional velocity model obtained in this study with that determined by three-dimensional seismic tomography using active and passive source data. We will plan to revise our 3D model with additional structural information and construct more precise and detailed model for the entire Nankai Trough area so that the model can be applied to more realistic numerical simulation.

This study is part of 'Research concerning Interaction Between the Tokai, Tonankai and Nankai Earthquakes (FY2008-2012)' funded by Ministry of Education, Culture, Sports, Science and Technology, Japan.

SSS30-P17 Room:Poster Time:April 29 18:15-19:30

Seismic observations off Kii Peninsula

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[1]JAMSTEC

In the Nankai Trough subduction zone, megathrust earthquakes of M 8 class occur repeatedly. There are three main seismogenic segments (Tokai, Tonankai and Nankai earthquake regions), and these segments have ruptured sometimes simultaneously and sometimes individually. To understand the control factor of the seismic linkage among these segments and Hyuga-nada segments, Japan Agency for Marine-Earth Science and Technology has been carried out a series of wide-angle active source surveys and local seismic observations from 2008 to 2012, 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. In this study, we show the results of two local seismic observations off Kii peninsula, the one is in the Kii channel and the other is in the Kumano-nada. The boundary of the Tonankai and Nankai segments is located in this region (Baba and Cummins, 2005), and the existence of the high velocity plutonic rock in the landward plate just beneath Shionomisaki is considered as the control factor of historical rupture variation (Kodaira et al., 2006). Japan Meteorological Agency (JMA) catalogue also indicates the spatial relationship between the seismic activity and seismogenic segments; shallow microseismicity seems to be more active in the Nankai region than in Tonankai region.

The observation in the Kii channel has been performed in FY2010 and was composed of 155 short-tern (about 1.5 months) ocean bottom seismographs (OBSs) and 19 long-term (about 10 months) OBSs. First, we relocated the JMA catalogue earthquakes by using three-dimensional velocity model obtained by active source surveys and adding the first arrival time data at OBSs. As a result, the earthquakes near the trough axis were generally relocated 10-20 km shallower than JMA location. Then, we attempt to detect the earthquakes by using long-term OBS records and found the active intraslab seismicity, especially in the up-dip part of the subducted seamount (Kodaira et al., 2000). The observation in the Kumano-nada has been performed in FY2011 and was composed of 150 short-tern (about 2.5 months) OBSs and 14 long-term (about 8 months) OBSs. Now we perform the first arrival picking of these data with the seismograph data of Dense oceanfloor network system for earthquakes and Tsunamis (DONET), according to the JMA catalogue earthquake list. We will show the preliminary results of hypocenter distribution in the Kumano-nada at the presentation.

Keywords: Nankai Trough, ocean bottom seismographic observation, seismicity

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Seismic observation and active-source seismic surveys on southern Ryukyu arc

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The Ryukyu arc is an island arc located on southeast of the Eurasian plate. The Philippine Sea plate is subducting northwestward at Ryukyu trench. Many large earthquakes (M7~8) occurred on this arc, and some of them generated tsunamis. The 1771 Yaeyama earthquake (M7.4) caused a large tsunami of which a maximal height is 30m. For detailed examinations of fault rupture zones and mechanisms of large earthquakes in this arc, it is important to know the seismicity, lithospheric structures and plate geometry. In 2013, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) launched a series of seismic observations and active-source seismic surveys at the Ryukyu arc as a part of research project funded by Ministry of Education, Culture, Sports, Science and Technology, Japan. In FY2013, we conducted refraction and reflection wide-angle seismic surveys and seismic observation on southern Ryukyu arc.

Active source seismic data were acquired on two survey lines. The one is a 480km-long line across the island arc from the south of Ryukyu trench to Okinawa trough. The other is a 100km-long line in Okinawa trough at northwest of Iriomote island. We conducted a refraction survey on the former survey line with 60 ocean bottom seismographs (OBS), and multichannel seismic reflection (MCS) surveys on both lines. Retrieved data shows clear wave trains propagating in the Philippine Sea plate and island arc. Normal faults in Okinawa trough were clearly observed in MCS data.

For seismic observation, we deployed 36 seismic stations including 30 OBSs and 6 onshore stations. All OBSs are equipped with short period geophones. Onshore stations are deployed at Miyako, Tarama, Ishigaki, Iriomote, Kuroshima and Hateruma islands. They are composed of broadband and/or 2Hz seismometers. We also retrieved seismic data from 60 OBSs that was deployed for the active source refraction survey. Observed seismic waves of small earthquakes show path dependences of waveforms that suggest spatial variations of random inhomogeneities and attenuation. For example, OBSs in Okinawa trough did not record clear S-wave for most of earthquakes. However, they observed clear S-wave and long-lasting coda waves for some shallow earthquakes occurred at north of Iriomote and Yonaguni islands. These waveforms suggest strong random inhomogeneities at the shallow part and high apparent attenuation (due to scattering and intrinsic attenuation) at deeper part underneath the Okinawa trough. In this presentation, we outline our observations and notable features of obtained data.

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A plate boundary earthquake model with consideration on submarine active faults

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Active faults observed on seafloor along Japan Trench are resultants of repeated large earthquakes. We discuss on the relation between large earthquakes and their source faults based on a detailed active fault map along Japan Trench. Judging from the location and continuation of active faults in the earthquake source area, we consider that one of the extensive thrust faults which extends from off-Sanriku to off-Ibaraki for about 500km, is directly related to the source fault of the 2011 off the Pacific coast of Tohoku Earthquake.

The 2011 off the Pacific Coast of Tohoku Earthquake (Mw9.0) generated large tsunami with massive pulsating pattern of waves (Maeda et al. 2011). A leading hypothesis believed among many seismologists is that rupture of two extensive asperity patches surrounded by stable sliding area on the plate boundary generated the earthquake. One of the asperity patches in depth caused the strong motion and the other near the surface caused fault rupture along the axis of Japan Trench and generated gigantic tsunami. Large displacement ˜50m eastward and ˜7 to ˜10m upward was estimated from comparison of data obtained before and after the earthquake in 2004 and 2011 by multi-narrow beam bathymetric surveys across the trench (Fujiwara et al. 2011). Satake et al. (2011) explained the large tsunami height by simultaneous faulting on two different fault planes that fit with the above-mentioned asperities. Since most of the workers hypothesized without any doubt believed that the earthquake was caused by the fault ruptured up to the trench axis, existence of submarine active fault is rather overlooked so far. However, we consider the large displacement is due to landslide and do not find any extensive fault scarp on the trench axis.

We simulated pattern of seafloor deformation associated with the earthquake using a simple dislocation model for a single fault plane with uniform slip that dips 14 degree in depth and 33.6 degree beneath the tectonic bulge related to the extensive active fault. A result shows that an area of large uplift agrees more or less with the location of tectonic bulge with width of about 20km.

The record of tsunami first wave obtained by the GPS wave gage set on about 200m deep seafloor off Kamaishi on southern Sanriku Coast (Port and Airport Research Institute, 2011). The record suggests that after gradual sea-level rise of 2m during 6 minutes, acute sea-level rise of 4m took place within 4 minutes, and then sea-level abruptly dropped by 4m within 2 minutes. The length of pulsating tsunami wave is estimated about 17km from tsunami propagation velocity at 200m deep sea and total duration of pulsating pattern of tsunami, i.e. 7 minutes. This tsunami wave pattern resembles the pattern of seafloor deformation we calculated above.

We also simulate crustal movement and tsunami height along the Tohoku coast by an earthquake source fault model based the location of the submarine fault with fault-slip deduced from tectonic scarp height that is regarded as cumulative fault-slip. Our simulation explains the observed co-seismic subsidence and large tsunami height along the coast better than many other simulations based on various inversion models.

Based on these observations, we propose active fault model for plate boundary earthquake that large earthquakes are characteristically caused from submarine active faults in the island arc crust that overlap each other above the plate boundary in the narrow sense.

Keywords: plate boundary earthquake, asperity model, active fault model

SSS30-P20 Room:Poster Time:April 29 18:15-19:30

The last 6000 years record of tsunami events in the Kaniga-ike pond along the Nankai Trough

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In order to reveal pre-historic record of Nankai Trough earthquakes, we collected 46 vibrocore samples from the Kaniga-ike pond. Stratigraphical study and radiocarbon dating of these samples revealed that sediment of Kaniga-ike pond recorded 17 tsunami events during the last 6000 years. These 17 events repeated almost constant intervals through 300 years. A 2000 years ago event formed remarkable thick tsunami sequence, and also shows an exclusive event in the past 6000 years.

Keywords: Nankai Trough, Tsunami sediment

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Estimate of the contact state of microcrack from the elastic wave velocity measurement

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Birch (1960) studied about the relationship between the confining pressure and the elastic wave velocity. It was indicated that the elastic wave velocity increases with the increasing confining pressure because the microcrack is closed at high pressure. The velocity includes the effect of microcracks at low pressure. We must the elastic wave velocity without the effect of microcrack to know the elastic constants of a rock. To do that, it is necessary to know the process of closing microcracks and the contact state of microcrack.

The power-law relation between the elastic wave velocity and confining pressure is expressed with pressure exponent of μ (Kobayashi and Kozumi, 1976). They assume that the microcrack has single contact in this model. It is necessary to take account in multiple contacts because the microcracks of a rock have multiple contacts. We applied the single contact model to multiple contacts model with the previous study (Archard, 1953). The microcrack has the point contact, ball contact and plane contact when μ is 2/3, 3/5 and 1/2 respectively. The microcrack contacts plastically if μ is $<$1/2. We measured the elastic velocity of rocks with gas medium high pressure apparatus to discuss the effect of the confining pressure.

We measure the velocity with the pulse transmission technique. We set the assembly, composed of a sample between two metal jig pasted piezoelectric transducers, in the pressure vessel. The sample height is about 15-40 mm and diameter is 20 mm. The frequency of transmission wave is 2 MHz. We recorded it 10^{-9}s rate. 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 in the confining pressure up to 100 MPa. When confining pressure is lower than about 100 MPa, μ of the gabbro and granite is about 2/3, indicating that the contact state of microcrack is point contact. However, under pressure higher than 100 MPa, μ becomes under 1/2, indicating that all microcracks are closed plastically in the experiment with gas medium high pressure apparatus. So the velocity at pressure higher than 100 MPa does not include the effect of microcracks. Furthermore, we estimated μ of several rocks from previous studies (Birch, 1960, Zimmer et al., 2002). Although μ depends on rock type at low pressure, it converges to values smaller than 1/2 at high pressure. This indicates that all microcracks are completely closed at high pressure and this result conforms to our experiment. If fluid exists in rocks, the value of μ is less than 1/2 even at low pressure. Therefore the microcrack with fluid acts as having plastic contact. We revealed the process of closing microcracks with the increasing confining pressure from the elastic wave velocity measurement.

SSS30-P22 Room:Poster Time:April 29 18:15-19:30

Frictional properties of the shallow Nankai Trough accretionary sediments

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We have conducted friction experiments on sandstone, tuff, silty mudstone and clayey mudstone samples cored from the shallow Nankai Trough accretionary prism, using a triaxial apparatus recently installed at Chiba University, at a confining pressure of 37 MPa, a pore pressure of 29 MPa, a temperature of 42 degrees C, and an axial displacement rate of 1 micrometer/s. These pressure, pore pressure and temperature correspond to those supposed at the depth of 1 km below seafloor at IODP Site C0002. The results reveal that frictional properties of these samples change systematically according to the content of clay minerals, in particular of smectite. The content of clay minerals is 6.0 wt% in the sandstone sample, 17.2 wt% in the tuff sample, 34.1 wt% in the silty mudstone sample, and 42.0 wt% in the clayey mudstone sample. Except for the sandstone sample in which smectite is absent, smectite is the most abundant clay mineral in all the other samples, occupying 68-76 wt% of total clay minerals.

Steady-state friction coefficient decreases with increasing content of clay minerals, from 0.83 of the sandstone sample, through 0.74 of the tuff sample and 0.34 of the silty mudstone sample, to 0.27 of the clayey mudstone sample. Slip-dependent frictional behavior also changes according to the content of clay minerals; the sandstone sample exhibits slip hardening, while the other samples exhibit slip softening, which becomes more pronounced with increasing amount of clay minerals.

We will also report the velocity dependence of steady-state frictional strength at this condition as well as how frictional properties of these samples change at deeper conditions up to 5 km below seafloor.

Keywords: Nankai Trough, accretionary sediments, frictional properties

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Effects of shear displacement and fault zone structure on the frictional be havior of montmorillonite-quartz gouge

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Recent observation of the low frequency earthquakes in the shallow part of the Nankai subduction zone has demonstrated that faulting there is slow yet seismic; suggesting that frictional velocity dependence along the fault would be negative. However, in a widely accepted model, sediments there is expected to exhibit velocity-strengthening frictional behavior. We have reported that the fault material along the megasplay fault in the Nankai Trough exhibited both velocity-strengthening and velocity-weakening frictional behavior [Tsutsumi et al., 2011]. Fault zone structures may be important to understand why the samples exhibited different velocity dependence. In this study, we have conducted frictional experiments on artificial gouges composed of montmorillonite and quartz mixtures, in order to understand the relationship between the fault zone structures and velocity dependent frictional behavior.

We examined frictional behavior and fault zone structure of the artificial gouge samples composed of montmorillonite/quartz mixtures. All of the experiments were conducted under water-saturated conditions at 1 to 5MPa of normal stress, with shear displacement of 30 mm to 14 m, using a rotary-shear friction testing machine. Velocity step tests were conducted in a range of velocities from 0.003mm/s to 30 mm/s, in order to examine velocity dependent frictional behavior.

Results of these experiments reveal influences of normal stress and displacements on frictional behavior. Velocity weakening behavior was observed for the mixtures of montmorillonite/quartz = 20/80 and 40/60 wt%, respectively, at large displacement. In velocity-weakening samples, montmorillonite becomes to be finer-grained and is well mixed with quartz in the gouge layer after long shear displacements and at high normal stresses. These observation demonstrates that frictional behavior of the montmorillonite/quartz gouge changes with the development of the deformation structures. It is suggested that fault zone structure is one of the important factors of describing the frictional behavior along faults at the Nankai Trough.

Keywords: montmorillonite, frictional experiment, fault zone structure

Friction constitutive properties of shallow subduction zone material as estimated from rotary shear friction experiments

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In order to understand the dependence of constitutive parameters, a, b, and Dc, on slip velocity, V, we conducted experiments by using a rotary shear high velocity friction apparatus. Samples used in this work were collected from the Nankai accretionary prism, offshore from Kii Peninsula, Japan, at Site C0004 during Integrated Ocean Drilling Program (IODP) Expedition 316 [Expedition 316 Scientists, 2009; Tsutsumi *et al*., 2011], and from the Costa Rica subduction zone, Cocos Ridge, at Site U1381 during IODP Expedition 334 [Expedition 334 Scientists, 2012]. All of the samples from the Nankai accretionary prism are clayey silt, whereas those from Costa Rica can be divided into 2 groups with respect to their composition: one is clayey silt (hereinafter referred to as "Costa Rica Unit I"), the other is silicic to calcareous ooze ("Costa Rica Unit II"). All experiments were carried out at 5 MPa normal stress and 0.0028-2.8 mm/sec slip velocity under wet condition (0.5 g samples with 0.5-0.9 ml distilled water). Moreover, we created a simulation program, which can estimate the values of constitutive parameters and system stiffness, k, with Levenberg-Marquardt method, supposing the spring-block model.

The results are summarized as the following: (1) a, b and/or Dc increase with slip velocity; (2) the values are the highest at V = 0.028-0.28 mm/sec; (3) the values are the lowest at V = 0.028-0.28 mm/sec. The reason is not clarified yet, but it is remarkable that, despite the composition, the result of the clayey megasplay fault material from the Nankai accretionary prism resembles the result of Costa Rica Unit II. This implies that, as expected, constitutive parameters depend on not only material but also other conditions. Another remarkable point to be noted is that the values of system stiffness of Costa Rica Unit I decrease by a factor of 10 when compared with the measured apparatus stiffness value. This implies that the mechanical property of the material of Costa Rica Unit I may be more flow-dominated than others. This implies that the mechanical property of the material of Costa Rica Unit I may be more flow-dominated than others. Considering that the samples of the Nankai accretionary prism and Costa Rica contain 20-30 wt%, 60-70 wt% clay, respectively, it is possible that total clay content reflects the gouge behaviour.

Keywords: friction, subduction zone, rate- and state- friction constitutive law, Nankai Trough, Costa Rica

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Physical properties of sediments in reference sites and Frontal prism off Costa Rica: IODP Expedition 344

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Comparing physical properties in reference and frontal prism sites is key to understand dewatering and lithification processes in subduction zone. Furthermore, it can be evidence for identifying the location of decollement and the underthrusting materials into seismogenic depth. In this study, we examined the physical properties of sediments in reference sites and frontal prism site both from on-board data and from laboratory experiments for velocity and porosity measurements with variation of effective pressure. Finally, we converted on-board porosity to fluid pressure using laboratory experimental data for reference sites and frontal prism site.

We focused on reference sites, U1381 and U1414, and frontal prism site, U1412 in the Integrate Ocean Drilling Program Expedition 344 off Costarica. Laboratory experiments for velocity and porosity measurements were conducted with variation of effective pressure. We kept 1MPa of pore pressure and changed confining pressure stepwise to control effective pressure. We calculated in-situ effective pressure using sample depth, bulk density and assumption of hydrostatic pressure of pore pressure. We obtained velocity and porosity data by 5 steps up to the in-situ effective pressure and 5 steps more up to 10 times of the in-situ effective pressure. Porosity change during experiments was calculated using volume change in pore water volume. We assumed on-board porosity under atmospheric pressure condition. 4 samples from sites U1381 and U1414 were measured so far.

Porosity ranges from about 77% to about 53% during experiments. P-wave velocity ranges from about 1.4 to 1.6 km/s. Velocity-porosity relationships from on-board data and from laboratory experiments are comparable nicely and also represents a good agreement with global empirical model. Because both laboratory data and on-board data shows a similar trend in the velocity-porosity relationship except for data from U1381 Unit II, the physical properties of sediment except for sediments from U1381 Unit II is similar in velocity-porosity-effective pressure relationships. Therefore, the porosity-effective pressure can be applied on most of sediments, implying that we can convert the porosity to effective pressure using laboratory results. We estimated fluid pressure from on-board porosity with depth using porosity-effective pressure relationship obtained from laboratory experiments.

For U1381 Unit I, hydrostatic fluid pressure was estimated although the error was large. Because U1381 is located in reference site, the hydrostatic pressure is expected in U1381. On the other hand, for U1414, lower fluid pressure than hydrostatic pressure was estimated in ~10m intervals in the upper part of Unit II. Hydrostatic pressure was estimated in other interval in U1414. Therefore, fluid pressure was recovered to hydrostatic pressure below the over-consolidated layer. In the over-consolidated layer, porosity decreases quickly with constant grain density, which is comparable with the over-consolidation state. Below the over-consolidated layer, porosity increases with decrease of grain density, although the hydrostatic pressure is estimated. In the interval with increase of porosity, because sediments possibly have different physical property, further laboratory experiments on the sediments are needed. Finally, for U1412, over-consolidated sediments were estimated, which may be due to quick dehydration by frontal accretion.

Keywords: IODP, subduction zone, physical property of sediment, elastic wave velocity, pore pressure

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A structural traverse across the Shimanto belt in western Shikoku, Japan

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The Cretaceous and Tertiary Shimanto accretionary complex is largely characterized by imbricated thrust slices of trench-fill and ocean-floor sediments, and is thought as an ancient analog of the Nankai accretionary prism. Recent studies on a thermal structure and fault rock analysis for the Shimanto accretionary complex in the central and eastern Shikoku revealed that it has suffered earthquake faulting along the out-of-sequence thrusts associated with tectonic uplift. However, special distributions of thermal and tectonic structures are remaining unclear since those in the western part of Shikoku are poorly understood. In the presentation, we demonstrate the distributions and details of deformed rocks (e.g. melange and brittle faults), geological structure, and vitrinite reflectance across the Shimanto belt in western Shikoku.

Keywords: Shimanto accretionary complex, Out of sequence thrust, Melange, Vitrinite reflectance, Fault rocks

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Stress estimation of Kure OSTs, Shimanto accretionary complex

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Stress must be concentrated at front of seismogenic fault during rupture propagation. The level of this stress concentration depends on rupture propagation velocity, fault length, thickness of process zone and strength of host rock. However, few quantitative analysis was reported in natural fault due to difficulty of stress estimation. The calcite-twin piezometer, enables stress estimation from elastic rebounded rock, was proposed based on discrete element method simulation and tri-axial rock experiments (Sakaguchi et al., 2011).

The Shimanto accretionary complex is ancient subduction zone and some fossil seismogenic faults were reported.

Among them, pseudotachylyte bearing Kure OSTs cuts Cretaceous Shimotsui, Nonokawa Formation and Kure Melange. This Kure OSTs is composed of echelon formed small faults with thin damaged zone, and burial depth of the host rock is estimated as below 3 km in depth. We obtained three rock samples, applicable for calcite-twin piezometer. The highest value of estimated stress was approximately 420MPa. This is much higher value than the other seismogenic fault in Shimanto accretionary. The Okitsu Fault, formed deeper depth of approximately 4 km, have suffered lower stress of 350 MPa at fault center (Sakaguchi et al., 2011). This indicates that much higher stress was concentrated at shallow Kure OST than deep Okitsu Fault. We propose two models to make high stress at shallow portion. Long crack length from deep to surface causes high stress concentration at shallow portion. Other model causes high stress due to narrower fault zone than the Okitsu Fault. Stress may tend to concentrate at narrower process zone of Kure OSTs than wide process zone of Okitsu Fault.

Keywords: subduction zone, ancient seismogenic, calcite, twin density

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Paleostress analysis of a subduction zone megasplay fault - An example from the Nobeoka Thrust, Japan

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The megasplay faults in subduction zones, branching from plate boundary thrusts, are thought to have a potential to generate earthquakes and accompanying tsunamis. It is therefore important to understand the fault mechanism of megasplay faults for earthquakes and tsunamis occuring in subduction zones. Paleo-splay faults exposed on land often preserve clear deformation features of the seismogenic zone and provide information on the fault mechanisms at depth. One of the important informations that can be obtained from exhumed faults is paleo-stress field. Here we investigated the Nobeoka Thrust, a fossilized megasplay fault in the Shimanto Belt in Kyushu. The hanging wall is Eocene Kitagawa Group, composed of phyllitic shales. The footwall is Eocene to early Oligocene Hyuga Group, composed of foliated cataclasite originated from sandstone-shale melanges. The thrust has been active during the period of 48-40 Ma [Hara and Kimura, 2008]. The hanging- and the footwall have experienced maximum burial temperatures of approximately 320^{o}C and 250^{o}C, respectively [Kondo et al., 2005]. The existence of klippes apart from the Nobeoka Thrust shows that the Nobeoka Thrust is nearly horizontal in regional scale [Murata, 1991, 1995]. Kondo et al. (2005) described two orientations of slickensides from the outcrop, suggesting the existence of flexural gentle fold in kilometer scale. In addition to the previous studies focusing on outcrops, scientific drilling has performed in 2011 penetrated through the Nobeoka Thrust, and core samples and geophysical logging data are obtained. The cores provide important information for investigating geological features under the ground and have an advantage without surface weathering.

In this study, we analyzed paleo-stress from slip vectors on small faults observed in the cores. Small faults are expected to be less-reactivated. The number of small faults is much larger than that of large faults, accordingly, high statistical reliability is expected. Multiple inverse method (MIM; Yamaji, 2000; Otsubo and Yamaji, 2006) was applied to the small faults. K-means clustering (Otsubo et al. , 2006) was applied to stress tensors detected by the MIM for estimating optimal solutions. Preliminary results indicate the presence of solutions with three maximum horizontal stress axes: N85.24^{o}E, N30.07^{o}W and N65.47^{o}E. We examined the formation process of the Nobeoka Thrust based on the results and slickensides on the outcrop. Our results would provide potential insights to the fault evolution of a megasplay fault in subduction zone.

Keywords: Nobeoka Thrust Drilling Project, Subduction zone, Shimanto Belt, paleo-stress, Multiple inverse method

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3D micro structural observation of pseudotachylyte

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Pseudotachylyte, molten fault rock due to dynamic frictional heating, is a strong evidence of seismic fault slip [Sibson 1975]. Recent research reveals pseudotachylytes can be related with dynamic weakening mechanism such as melt lubrication [DiToro et al., 2006]. However, observations of internal structure of pseudotachylyte have been confined to 2D observations with optical-electron microscope. Here we performed X-ray 3D structural observation of natural pseudotachylyte developed close to the Nobeoka thrust which is a major Out of sequence thrust in fossil accretionary prism (Shimanto-belt).

The Nobeoka thrust located in Kyusyu Island, south west Japan, bounding northern and southern Shimanto belt of Cretaceous-Tertiary accretionary complex. The thrust is considered to have been active during 40-48Ma at seismogenic depth of ˜11kmbsf, experienced maximum temperature of which is 320 Cin the hanging wall and 250 C in the footwall. Thus, the Nobeoka thrust is examined that it was major OST in seismogenic zone of accretionary prism (Kondo et al., 2005; Hara and Kimura, 2008; Raimbourg et al., 2009). The pseudotachylyte bearing fault develops in the hanging wall of the Nobeoka thrust with 1 mm of width. Okamoto et al. (2007) reported that carbonate-matrix implosion breccia fill tensile cracks and inner periphery of the fault, interposing pseudotachylyte, based on optical microscopic observation. Though pseudotachylyte cut the implosion breccia, the fault jog consists only of the carbonate-matrix breccia. It may show the fault experienced dynamic pore water pressurizing accompanied by pseudotachylyte generation at its first frictional slip. Therefore, the fault is appropriate to structural investigation of dynamic fault weakening mechanism.

We performed structural observation of this pseudotachylyte with scanning electron-microscope and 3D X-ray microscope. In the electron microscopic observation, we found that fragments of host rock unevenly distributed in the pseudotachylyte. The number of fragments is larger at lower part (footwall-side) than within the center of the pseudotachylyte. We also found open cracks along the fragments arrangement. It is considered to be cooling crack generated due to rapid cooling of molten rock. The 3D x-ray microscopic observation was performed with cylinder sample of 8 mm diameter. The spatial resolution of the x-ray microscope is 1 micro meter, and detailed 3D fault structure was imaged. We focused four planes, A: lower plane of lower fault filling vein, A': lower plane of pseudotachylyte, B: upper plane of upper vein, B': upper plane of pseudotachylyte. The surfaces configurations were extracted and its roughness was evaluated as calculated average roughness, Ra (theta), in each direction. We found that Ra has minimum value in the same direction in each plane, and the lineation strongly develops at the lower planes (A, A').

From the above results, we discussed the faulting process as:

1) Start faulting. strain concentrated in the footwall side and pore pressure was raised at the part.
2) Hydraulic fracturing by high pore pressure, tensile cracks formation and fluid migration.
3) Strength (friction) recovery by draining and formation of pseudotachylyte.

Keywords: pseudotachylyte, 3D micro structure, surface roughness