Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

HCG31-01 Room:105 Time:May 20 09:00-09:15

Boso triple junction: large-scale instability and landsliding for potential tsunami genesis

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Boso triple junction is defined as a PAC-EUR (later NAM)-PHS subduction boundary, known as the only TTT-type. The NW side (hanging wall) is largely collapsed to SW-ward beyond the NE-SW trending thrust belt onshore and offshore of Boso. In much more trench side is developed the NE-SW trending normal fault system which is further collapsed to the junction-ward just north of the Katsuura deepsea basin and triple junction area (Iwabuchi et al., 1990; Ogawa et al., 1989; Seno et al., 1989; Soh et al., 1988). Iwabuchi also showed that the PHS relics are underlying between the NAM and PAC, suggesting that just before PHS was subducted to N, before changing into NW as of the present PHS motion. Seno and Ogawa et al. indicated that the present PHS NW motion is quite recent ($<$ 0.5 Ma), bringing the hanging wall side to be unstable and collapsed, due to E-W horizontal stretching. Because of such horizontal stretching, both of the slope with large-scale submarine sliding and of phacoidal-shaped Katsuura deepsea basin with two-level deepsea terraces occurred by gravitational instability. NAM NW-ward dragging made the previous WNW-ESE trending submarine lineaments dragged to N-S, and even to SWS. ROV KAIKO10K (KR99-10) showed a large-scale submarine collapse and sliding just landward slope toe of the triple junction area (Ogawa & Yanagisawa, 2011 Springer Book). Historic tsunami earthquakes (1677 Enpo M8.0, 1953 Showa M7.4) which occurred off-Boso might be due to such large-scale submarine sliding, if not by much more landward NE thrusting.

Keywords: Boso triple junction, submarine landsliding, large collapse, submarine canyon, tsunami

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HCG31-02 Room:105 Time:May 20 09:15-09:30

Scientific drilling for elucidation of submarine landslide mechanism

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Submarine landslide is known to sometimes threaten our life by cutting off submarine cables, causing tsunami, eroding coastlines, and it is also said that submarine landslides may enhance dissociation of natural methane hydrate below the seafloor. However, the causes of submarine landslides have not been understood very much at this moment. So, the current IODP (Integrated Ocean Drilling Program) raised Mechanism of submarine landslides as one of the high-priority scientific targets in the science plan for the next IODP (International Ocean Discovery Program), which will begin in 2013. A landslide type, Circular Slip, has been often taken as general landslide model, however, lots of issues remain in lithology and in rock properties due to their heterogeneity. On the other hand, Layer-parallel Slip, a simple model of landslide, is going to be an appropriate target for scientific drilling. So as to explain the strategy of the scientific drilling, this presentation introduces submarine landslides in Sanrikuoki Basin as an instance of the layer-parallel slip.

In high resolution 3D seismic data, the submarine landslide deposits in the Sanrikuoki Basin are characterized by a number of typical deformations due to slumping and the related dewatering structure (Morita et al., 2011a). The structure tells that the dewatering structure occurred on the slip plane of landslide at the same time as slumping. It implies that excess fluid in the slip plane caused a lubrication to enhance mass movement of the surface ground. The seismic phases within the landslide deposits imply there is natural gas component in the formation water, which can absolutely affect stability of the ground. Slip plane at the bottom of each landslide deposit is traceable to a layer corresponding to the slip plane in the lateral normal formation, in which the layer is generally characterized by low amplitude of some thickness (Morita et al., 2011b). Thus, the structure related to the submarine landslides in this area is very clear to understand.

A scientific drilling in such location of the layer-parallel slip will enable us to trace the elementary step of the slip plane formation. This will be achieved by comparison of detailed structures and the physical properties between in the slip plane and in the layer corresponding to the slip plane. Also, the natural gas contribution to the elementary step will be examined. The data to be collected by the drilling in the simple structure of the layer-parallel slip will be very practical for landslide modeling to approach the true mechanism of submarine landslides.

This study uses three dimensional seismic data from METI fundamental seismic survey 2008, Sanrikuoki 3D.

Keywords: Submarine landslide, IODP, scientific drilling, layer-parallel slip, slip plane, 3D seismic survey

HCG31-03 Room:105 Time:May 20 09:30-09:45

Trapped sediment in Ocean Bottom Seismometers - The 2011 Tohoku-Oki Earthquake and earthquake-induced turbidite

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We recovered 17 ocean bottom seismometers (OBSs) after the 2011 Tohoku-Oki Earthquake (Mw=9.0), and collected sediment samples from the OBSs, off Miyagi region. All these OBSs had deployed before the earthquake in order to observe seismic activities, and recovered during five cruises conducted from March to December, 2011. Particularly, three OBSs have recovered just after the occurrence of the earthquake, during R/V Kairei (JAMSTEC) KR11-05 Leg2 cruise, (14 - 31 Mar., 2011). All 17 OBSs were filled with greenish dark-gray soft sediments. We analyzed grain-size and benthic foraminifers of 14 OBS-fill sediment samples, and also analyzed multi-narrow beam echo sounder (SeaBeam 2112) data collected during KR11-05 Leg2, KR11-E03, and KR11-E05 cruises of R/V Kairei, to delineate bathymetry in detail. These sediment samples are composed of clay to coarse-sand, and the grain-size of the sediment decreases from the continental shelf to trench (Arai et al., 2011). Miura et al. (2011) interpreted these sediments were derived as turbidite induced by submarine landslide; however, our analyses of SeaBeam bathymetric data do not show distinct scars of landslides on the continental shelf to mid-slope terrace, off Miyagi. Moreover, the shallowest OBS (depth=299m) on the gentle slope (less than 2-degree) was filled with sediments. Arai et al. (2011) proposed that large tsunamis eroded continental shelf and induced the turbidity currents, on the basis of grain-size analysis of the OBS-fill sediments and sediment samples by Shinkai 6500 and Deep-Tow of R/V Yokosuka. Such OBS-fill sediments have not recovered previous long-term (several months ? one year) observations by same type of OBSs, for example, around the Nankai Trough. Additionally, OBSs on the landward slope of Japan Trench deployed after the 2011 Tohoku-Oki Earthquake were not filled with sediments. On the basis of these observations and analyses, we infer these OBS-fill sediments are derived by large scale turbidity currents, from the shallow part of continental shelf, off Miyagi. Probably these OBSs trapped these wide-spread turbidites induced by 2011 Tohoku-Oki Earthquake and tsunamis.

<References>
Arai et al. (2011) 2011 Annual Meeting of the Sedimentological Society of Japan, Abstract, P34.
Miura et al. (2011) 118th Annual Meeting of the Geological Society of Japan, Abstract, R12-P4.

Keywords: Ocean Bottom Seismometer, 2011 Tohoku-Oki Earthquake, turbidite, tsunami, bathymetry

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HCG31-04 Room:105 Time:May 20 09:45-10:00

Submarine Liquefied Sediment Flows: Characteristics and Their Potential Impacts on Societies

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Subaqueous sediment gravity flows (SSGF) have become an increasingly important subject for research in relation to geomorphodynamics of sediment routing systems connecting river basins, estuaries and coastal oceans. Also, submarine landslides and flow slides have received considerable attention in view of their destructive power and associated consequences in nearshore and offshore facilities. Fluid-sediment interaction is a key process that features any SSGF. Here, I summarize some recent research advances on the characteristics and dynamics of submarine liquefied sediment flows and discuss their potential impacts on societies involving Tsunami.

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HCG31-05 Room:105 Time:May 20 10:00-10:15

A slope stability study for marine gas hydrate resource development

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There are lots of studies and hypotheses with regard to relationship between gas hydrates below sea floor and marine landslides. Most of them deal with large-scale phenomena related to global climate change in geological time frame. On the other hand, investigations to develop marine gas hydrates resource have started in countries such as Japan, US, Korea, India, etc.

The Japanese national program includes an offshore production test of gas from hydrates deposit in marine sediments in early 2013 at a location off Atsumi Peninsula, Pacific coast of the central Japan. The planned test is relatively small scale; production from a single well, duration is one to several weeks, and expected dissociated area is 10 to 100 meter radius from the well, that is completely different scale in area and involved energy from climate related events. However, possibility to influence the sea floor stability by the test cannot be denied. Meanwhile, small scale events in shallow depth, or natural events that are not caused by gas hydrate dissociation can damage production facilities such as pipelines. Therefore, more quantitative risk analysis than geological scale problem is necessary.

From those view points, as one subject of the Research Consortium for Methane Hydrate Resources in Japan (MH21), the authors have started a seafloor stability study to use the Eastern Nankai Trough as a model area. The area has complicated geology with knolls and anticlines in the active margin. Gas hydrate concentrated zones have been found in sandy layers of turbidite sediments. In early 2013, the first offshore production test by depressurization technique will be conducted at a location in the north slope of the Daini Atsumi Knoll in the area.

Near the location, we have found relatively large kilo-meter scale slide scars that might be created by uplift of the knoll and erosion to a seafloor valley. The base of the slide deposit is shallower than gas hydrate rich zone, gas hydrates in the area have played limited role in the occurrence of slides. Because the area is close to epi-centers of Tonankai Earthquakes that have happened every hundreds of years, the earthquakes might trigger the slides.

Therefore, we started a quantitative risk analysis of slope instability in the Atsumi Daini Knoll area. Firstly, bathymetry and structural geology information from seismic survey, and geotechnical information from core samples and geophysical logging data were analyzed. Moreover, micro-bathymetry and precise geology data were taken by side-scan sonar and sub-bottom profiler of AUV Urashima. Core samples and cone penetration test data from shallower formations than the gas hydrate concentrated zone in the area taken using DV Chikyu were utilized to obtain geotechnical information.

Using those information, the factor of safety (FoS) under static load was calculated using bathymetry data, and FoS under seismic load that was assumed from predicted Nankai metathrust earthquake (combination of Tokai, Tonankai, and Nankai quakes) was computed using 1D dynamic analysis. Also some numerical models are employed to evaluate effects of gas hydrate dissociation by production test and subsequent reduction of formation strength, mass movement by a possible expansion of slide area, and occurrence and propagation of Tsunami.

New data obtained are under tests and analyses, and their results will be used to update the model and results. A hazard map of slope instability in the Eastern Nankai Trough area will be made for the planning of future resource development.

Not only for gas hydrates but also other marine resources, public acceptance requires correct risk analysis, communication, and building of understanding. This slope stability study is one of those processes. There are still many uncertainties in the relationship between submarine slope instability and gas hydrate, so both viewpoints of basic science and practical risk analysis are necessary.

Keywords: methane hydrate, submarine landslide, geotechnical, tsunami

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HCG31-P01 Room:Convention Hall Time:May 20 10:30-12:00

Benthic foraminiferal faunas in the sediment into OBSs off Miyagi after 2011 earthquake of the Pacific coast of Tohoku

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After the earthquake of the Pacific coast of Tohoku with mega-tsunami on March 11, 2011, the ocean bottom seismographs (OBS) installed on the Pacific Ocean bottom off Miyagi Prefecture were recovered urgently to analyze the record (Miura et al, 2011). Unconsolidated sediment was found inside the hard hat to protect OBS, and we have analyzed the depth distribution of benthic foraminiferal assemblages.

Several OBSs were installed on the land side of Japan Trench for the natural long-term seismometry. As far as an OBS is placed in right position at sea-bottom, sediment is not easily to be injected inside the hard hat. Therefore, sediment in the hard hat was possibly brought by water flow with sediment, which was raised up in bottom-water in the OBS-arranged area (Miura, 2011). After the earthquake, it has reported that muddy sediment covers in the large area from shelf-edge to trench slope (300-5940 m in water depth) off Sanriku region (Ikehara et al., 2011) , and this sediment is assumes to be transported by low density turbidity current (Arai et al., 2011).

Foraminifera are a kind of Protista with shell, and inhabit in every sea-bottom, from brackish coastal waters to ocean floor and trenches. A lot of species live every favorite environment. Many of species are generally good depth-indicators, and, an assemblage in association with some species is recognized in a certain depth range (depth zone) to some extent. Therefore, displacement of sediment by turbidity current, for example, should be detected as an abnormal distribution of foraminiferal assemblage. On the abnormality in the OBS-installed area off Miyagi Prefecture, foraminiferal distribution reported by Matoba (1976) provides a suitable reference for the present comparative study.

The 14 samples are obtained from the OBS stations of 299-2773 m in depth range. Among six assemblages recognized in this study, five are comparable with five ones of Matoba (1976) from 220-1980 m in depth range, and another one is deeper than the Matoba's deepest station. Compared with Matoba's assemblages, those of shallower depth than ca.1500 m are almost coincident, except for a boundary of deeper assemblages at ca.2000 m of this study. Its comparable boundary of Matoba's assemblages is drawn at ca.1800 m, 200 m deeper.

This difference of faunal boundary at deeper sites suggests more large dislocation of sediment at deeper part of trench slope. We will discuss the mechanism of sediment intrusion into hard hat, origin of suspended sediment, and trigger of turbidity current, as well as magnitude of turbidity current.

Keywords: earthquake, tsunami, OBS, benthic foraminifera, turbidity current

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HCG31-P02 Room:Convention Hall Time:May 20 10:30-12:00

Large submarine landslides in the Japan Trench: An old but new scenario for tsunami generation

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We describe in detail possible large submarine landslides, several tens of kilometers in length and width, on the trench landward slope of the Japan Trench on the basis of high-resolution topographic surveys and detailed seafloor observations. These slides stopped at the toe of the trench slope. After initial movement of the toe along a basal decollement or thrust of the trench landward slope wedge during an earthquake, the basal frictional condition(s) might change drastically from static to dynamic, thus reducing the frictional strength. As a result, rapid submarine landsliding push downward on the toe, generating large vertical and horizontal displacements for tsunamis. The thrust movement at the toe of the trench slope was probably resulting from submarine landsliding with rupture propagation. This thrust movement might be with big slips without strong seismic waves. This hypothesis could explain suitably the relation between large displacement of the thrust fault and tsunami generation by the 2011 Tohoku earthquake as well as tsunami generation by the 1896 Tohoku earthquake.

It has been believed that tsunamis are generated only by seafloor topographic change caused only by active faulting, excepting for local effects by volcanic and/or small landsliding. However, the Japanese tsunami warning system does not include the tsunami excitation scenario by submarine landsliding. In fact, in 1979, a tsunami 2?3 m in height struck Nice, France, unaccompanied by any seismic signals. This silent tsunami was considered to be generated by submarine landsliding near the Nice harbor (Dan et al., 2007). Tsunami-generating submarine landslides have been known to occur from various areas in the world (Yamada et al., 2012). Thus, all data pertaining to tsunami generation mechanisms as well as topographic changes in survey data from before to after the 2011 Tohoku earthquake should be carefully examined to improve our understanding of tsunami generation.

Some of the Tohoku people have called the silent tsunami as Yoda, which is different meaning from Tsunami. In spite of the previous people experience we forget totally the Yoda, because we believe that tsunamis should be excited only by seafloor deformation of rupture propagation. According to Yamada et al. (2011), there are many giant submarine landslides, not only in active margins as the Japan Trench, Nankai Trough, Kuril Trench, but also in passive margins as continental slope of the Atlantic Ocean, and also in volcanic islands and deep-sea fan. We must consider the basic mechanism of tsunami excitation immediately. Our tsunami early warning systems following the ever-believed tsunami excitation mechanism may be wrong.

Keywords: Submarine landslide, Tsunami, Tohoku-oki earthquake, Meiji-Sanriku earthquake tsunami

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HCG31-P03 Room:Convention Hall Time:May 20 10:30-12:00

Mass Transfer deposits along the splay fault Nankai Trough, Kumanonada: Deformation structure and transfer direction of

KANAMATSU, Toshiya[1*], ASHI, Juichiro[2], KAWAMURA, Kiichiro[3], KITAMURA, Yujin[1], IKEHARA, Ken[4], MURAYAMA, Masafumi[5]

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Integrated Ocean Drilling Program Expedition 333 was conducted to core a slope site (C0018) for NanTroSLIDE (Nankai Trough Submarine Landslide History) project. A stacked mass transport deposits (MTDs) recognized in 3-D seismic data in the slope basin of the megasplay fault, offshore Kii Peninsula was cored in order to establish a mass-movement event stratigraphy and analyze its rheological property to constrain sliding. Several slid sediments forming MTDs were recovered. Various types of deformation structures, which were formed during sliding were found in the MTDs intervals. The depositional timing of the MTDs sequence was constrained by biostratigraphy, paleomagnetostratography, and tephrostratigraphy. It indicates that all MTDs were formed within 1Ma.

In the area of upper slope of C0018 prominent arcuate scarps caused by submarine landslide are identified. It is supposed that those collapsed materials were sources for MTDs. To document characteristics of the scarps and MTDs of the area, detail surface and subbottom observations were conducted using Navigable Sampling System (NSS) of Atmosphere and Ocean Research Institute, Univ. Tokyo. The youngest MTD layer (MTD1) is interbeded 1.3 m bellow sea floor with 3-m thickness at C0018. In order to understand a transport direction of MTD1, 1) tracking the layer using a subbottom profiler equipped with NSS, and 2) sediment sampling for structural reconstruction of deformed layer to infer a slope sliding direction were conducted. The subbotom images acquired by NSS represent that MTD1 reveals a channeling structure extending to NW. Reoriented folding axes of deformation layers show NW-SE trending. A sliding direction of MTD1 was inferred as a perpendicular direction to the folding axes, which coincident with the channeling structure in the subbotom images. The method described above may elucidate a rheology of MTDs, and can be applied to the analysis of the other MTDs. Because the scarps distribution is along around a surface location of the splay fault, it is supposed that the surface collapses were induced by the fault activations. Thus establishing a stratigraphy of MTDs is important to understand hazardous events occurred near the surface in the great earthquake rupture zone off Kumano.

Keywords: Submarine landslide, splay fault, Nankai Trough

HCG31-P04 Room:Convention Hall Time:May 20 10:30-12:00

Submarine landslide structure in the lower Pleistocene slope deposits, exposed at the Miura Peninsula, central Japan.

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The Nojima Formation, a lower Pleistocene slope deposit, of the middle Kazusa Group is exposed at the northern Miura Peninsula, central Japan. In the study area, the submarine landslide deposits are observed at the horizon between 2-65 m below the YH02 tuff bed correlated with the Kd39 tuff bed (1.76 Ma: Nagahashi et al., 2000) of the Kiwada Formation of the Kazusa Group in the Boso Peninsula. We investigated the internal structure of submarine landslide deposits of the Nojima Formation based on the field observation and bored core analysis.

The Nojima Formation of the study area is divided into three units, lower, middle and upper units. The lower unit, about 50 m thick, is composed of muddy sandstones lower and alternation of sandy mudstones and mudstones upper, the middle unit, about 20 m thick, is mainly composed of muddy sandstones, and the upper unit, about 5-40 m thick, is of conglomerate lower to muddy sandstones upper, representing fining upward. The sandy mudstones of the middle unit are sharply contact with the uppermost mudstones of the lower unit. At the boundary, the mudstone is partly injected into the sandy mudstones. The injection has width's up to 40 cm and lengths up to 3 m. Strikes and dips in the middle unit represent various values, which are not in accord with those of the lower and upper units representing constant values. Total five tuff beds are correlated between the lower unit and middle unit, which indicates all horizon of the middle unit is duplicated with the lower horizon. The conglomerate of the lowermost of upper unit, eroding and covering the middle unit, is composed of mudstone, muddy sandstone and sandstone boulders.

The duplication of the middle and lower units indicate that the middle is a slide block and run onto the lower unit by submarine landslide. The middle unit is coarser than the same horizon of the lower unit, which indicates the middle unit is originated from more proximal environment than the lower. Then the upper unit is interpreted as gravity flow deposits filling the slide scar. Considering the stratigraphic relationship based on key tuffs, the heights of the landslide are estimated as up to 110 m+ thick.

Keywords: submarine landslide, lower Pleistocene, Kazusa Group, Nojima Formation, Miura Peninsula, slope deposits

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Characteristic of submarine landslide deposit,observed and the Nebukawa coustal area

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There is Nebukawa district at the foot of a mountain of Hakone volcano somma in Kanagawa prefecture which have steep slopes near the coast. Just after the Great Kanto Earthquake of 1923, the Ohbora district was collapsed which composed Hakone volcano somma and landslide fall down around the Shiraito river. Then landslide happened same time at right behind Nebukawa station and the landslide roll up railroad station, nearby houses and train. And then the landslide reached to submarine.

At the area, Ohne lava layer distribution at nearby sea shore and Nebukawaishi lava layer distribute at over 60m above sea level. In addition volcaniclastic material layer which composed lower layer (solid lapilli tuff) and upper layer (pumice, loam) between Ohne lava and Nebukawaishi lava.

In this study, we used ultra high resolution multibeam echosounder SeaBat 7125 to high precision survey seafloor terrain. We have also dived for take rocks from seafloor.

There two-type of topographical structure, Zone-1 characterized by coarse reflection distributed parallel to the coastal topography. Zone-2 Spread of lobe structure off the coast from the coast opposite, then Zone-2 cut on Zone-1.

There rock from the lobe is a Nebukawa, which locate more than 60m above sea level. There rock derives by the landslide which occurred in big earthquake.

Keywords: Nebukawa, landslide, lobe structure

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HCG31-P06 Room:Convention Hall Time:May 20 10:30-12:00

Experimental Study on Motion Mechanism of Submarine Landslides

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Submarine landslides are characterized by large scale and long run out distance. Besides causing tsunami, it can also cause major disasters on communication when a submarine landslide damages submarine communication cables. At present, the study on occurrence and motion mechanisms of submarine landslides is not enough. In this study, we tried to clarify the reason that submarine landslide has larger scale and longer moving distance than those occurred in continent. An apparatus to simulate submarine landslide was developed for this purpose. For each test, normal stress, shear stress and pore-water pressure of submarine landslide model acting on the apparatus bottom are measured, and friction coefficient for each test can be obtained. The paper examines the influences by landslide scale and motion velocity on the shear resistance. The result shows friction coefficient increasing when the mass of sliding body increased. Friction changed irregularly when the velocity of the sliding mass became higher, but density coefficient decreased when the velocity of the sliding mass became higher.

Keywords: motion mechanism, submarine landslide, experiment study