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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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

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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

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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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