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

HDS30-01 Room:511 Time:April 29 16:15-16:30

Submarine mass-transport deposits of the Paleogene Muroto Formation in the Kuromi coastal region, Kochi Prefecture

IKAWA, Yu[1] ; TONAI, Satoshi[1*] ; SHIBATA, Tadahiro[2]

[1]Faculty of Science, Kochi University, [2]Muroto Geopark Promotion Committee

We report stratigraphy and geologic structures of ancient mass-transport deposits exposed as a nearly 2 km continuous outcrop of the Kuromi coastal region, Shikoku Island, Japan to provide detailed information on internal structures of mass-transport deposits and their relationships with encasing sediments. It is allowing important considerations on triggering mechanisms and transport/depositional process of mass-transport deposits.

The mass-transport deposits studied here are in the Upper Eocene to Lower Oligocene Muroto Formation which is a part of the Paleogene Shimanto accretionary complex. The Muroto Formation, about 650 m thick in this area, consists of six lithofacies. These units are thick-bedded mudstone, thin-bedded very fine grained sandstone and mudstone, thin- to medium-bedded fine sandstone and mudstone, thick-bedded sandstone, folded thin-bedded sandstone and mudstone, and chaotic deposits. These sediments are interpreted as a deep-sea channel-levee system with occurrence of submarine landslides.

A field-based study of the Muroto Formation reveals that folded thin-bedded sandstone and mudstone and chaotic deposits are made up of at least two distinct mass-transport deposits, the larger of which reaches thickness of more than 270 m. Fold hinges in these mass-transport deposits are uniformly orientated and parallel to the host bedding. Axial planes in these mass-transport deposits show a girdle-like distribution which are perpendicular to the host bedding. These patterns of fold orientations show that the style of their transport is mainly flow and partly is turbulent flow including broken detrital blocks. These characters show that huge mass-transport deposits may be often formed on plate convergent margins and involved in accretionary prism.

Keywords: submarine mass-transport deposit, accretionary complex, Shimanto belt, Paleogene

HDS30-02 Room:511 Time:April 29 16:30-16:45

Feature of slump and associated structure observed at Daini-Atsumi knoll, the gas production test site from gas-hydrate

SUZUKI, Kiyofumi[1*] ; TAKAYAMA, Tokujiro[1] ; SANADA, Yoshinori[2] ; FUJII, Tetsuya[1]

[1]JOGMEC/TRC, [2]Japan Agency for Marine-Earth Science and Technology

The Daini-Atsumi knoll became famous as the first offshore gas production test site from methane hydrate-bearing marine sediments, is one of outer ridges along northeast Nankai trough, near central Japan. Several slumps were found on seismic sections around Daini-Atsumi knoll. Fortunately, several wells had been penetrating slump deposits and logging data were measured. As a result of seismic profile observations, a strong negative-impedance seismic reflector (NISR) was found in the turbidite sequence beneath the slump deposits. A seismic reflector containing the NISR has good continuity with variable reflectivity from a bottom-simulating reflector (BSR) sequence; that is, the NISR does not indicate a slump basement or the boundary of a chaotic unit. Nevertheless, very normal thin-layer turbidites were found at the depth of NISR from LWD measurement and coring, however, fluid data could indicate difference between upper slump unit and beneath turbidites unit. It implies that NISR does not mean pressured fluid but some fluid stagnation.

Acknowledgement
This research is conducted as a part of MH21 research and the authors would like to express their sincere appreciation to MH21 and the Ministry of Economy, Trade and Industry for disclosure permission for this research.

Keywords: Slump, 3D seismic profile, LWD, Over-consolidate, Gas hydrate, Low impedance

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

HDS30-03 Room:511 Time:April 29 16:45-17:00

Role of slump deposits in a high-methane-flux gentle continental slope

MORITA, Sumito[1*]

[1] AIST-GREEN

A great number of submarine landslide deposits (slump deposits) are known to be buried in Pliocene and the upper formations in northern part of Sanrikuoki Basin (Morita et al., 2011). The slump deposits are mainly made up of imbricated thrust sheets of stacked sedimentary layers which were peeled off from ancient bottom surface. The slump deposits often show dimmed facies as an acoustic characteristic and have dewatering structure from the slip surface, and sometimes have gas chimney at the roof of the slump deposits. These indicate that the slump deposits are strongly related to natural gas in formation water. A key to grasp the nature of the slump deposits is likely in a comparison with a result of previous scientific drilling. Site C9001 is a drill site which was operated by D/V CHIKYU in this survey area (Higuchi et al., 2009). By the result of the expedition, the sedimentary basin is mostly composed of mud and few thin ash and sand layers. The sediments are normal and the parts judged as mass transport deposits (MTD) by visual core description are very limited even in the depth domain interpreted as slump deposits in seismic data. However, methane detected in head space gas and methane hydrate bearing sediments recovery were reported only in the slump deposits domain interpreted in the seismic data. Previous reports with respect to MTD indicate that MTDs generally have the nature as seal where the beds have higher shear strength and density due to compaction. Nevertheless, the nature of the slump deposits in the Sanrikuoki Basin is opposite to those of the other MTDs, and may indicate as if reservoir. The difference of the natures is maybe caused by the environment of very gentle continental slope where the slumping has repeated. There is a hint of it in the fact that slump deposits in the survey area avoided fatal collapse by sliding on the very gentle slope and basically formed the imbrication of block-supported structure.

Keywords: submarine landslide, mass transport deposits, slump, Sanrikuoki Basin, CHIKYU, methane hydrate

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

HDS30-04 Room:511 Time:April 29 17:00-17:15

Liquefaction-induced water-film mechanism in submarine slide

KOKUSHO, Takaji[1*]

[1]Kokusho Takaji

As one of possible mechanisms of seismically triggered submarine slides in cohesionless sandy & gravelly deposits, void redistribution or water film effect seems to be deeply involved (Kokusho, 1999, 2000). In this view, fine soil sublayers sandwiched in coarse grain deposits are considered to play a key role in flow failure. The formation of water films between liquefied sand and overlying lower-permeability seams has been observed under level ground conditions in a number of model tests. Fig. 1 shows a typical example of water film formed beneath a thin silt seam sandwiched in a uniform horizontal sand layer. It has also demonstrated that water film can be generated not only in sands beneath silt seam but also in gravels beneath smaller permeability sands (Kokusho & Kojima 2002). Visit http//:www.civil.chuo-u.ac.jp/lab/doshitu/index.html for video images of the model tests.

For sloping ground conditions it has been demonstrated, based on model shake table tests, that the water film plays an important role in post-earthquake large lateral flow in liquefied ground. Fig.2 shows typical test results where clean fine sand was rained in water to make saturated sand slope shown in (d) in a transparent soil box (Kokusho 2003). Fig.2(a) indicates a case of a uniform sand model where small flow deformation occurs mostly during shaking. The locations of markers in the model are shown in (d) with the same symbols. If a silt seam shown with chain-dotted arc is sandwiched in the uniform sand, a larger flow deformation above the arc occurs not only during but also after shaking as indicated in (b). These results in (a) and (b) are for the input acceleration of 0.31 G. Interestingly, for weaker input acceleration of 0.18G given to the same model in (c), much larger post-shaking flow than (b) occurs, while only minimal deformation takes place during shaking. In these tests, very thin water film can be observed beneath the silt arc.

A basic question may arise that sand which can be so dilative if sheared under a low confining stress may absorb ambient excess pore water and hence block the water film development. It can be pointed out, however, based on the comparative observation of the cases with and without a silt seam that a water film formed beneath the seam serves as a shear stress isolator which prevents deeper soils developing shear strain and positive dilatancy (Kokusho, 2000). Consequently, sand can experience large shear strain beneath the silt seam without suffering from the dilatancy effect, whereas it stops moving after the end of shaking if the sand is uniform.

Another shaking table tests has shown that a soil mass slides even on a very gently inclined water film, which breaks at weak points of the overlying sublayer, triggering the boiling failure in the sand above and a mud avalanche of the upper layer (Kokusho 1999, 2000). For video images of these model tests, visit http//:www.civil.chuo-u.ac.jp/lab/doshitu/index.html.

If water films are formed continuously, they will tremendously reduce the residual strength down to zero if sliding occurs all the way through a continuous water film. Kabasawa and Kokusho (2003) quantified the residual shear resistance exerted during the delayed flow along a water film in the model tests. The result shown in Fig.3 indicates that the residual strength along the water film is almost independent of sand density and other test parameters and remains around 20% that of the uniform sand. Considering that soil deposits are naturally stratified with sandwiched low permeability seams, it seems quite reasonable to identify the water film effect as a major mechanism for seismically induced submarine slides in gently sloped sandy or gravelly sea-bed near coastal areas.

Thus, liquefaction may be highly responsible in earthquake-induced submarine slides, particularly in near-shore sites where the seabed is composed of liquefiable loose sand or gravel.

Keywords: seismic liquefaction, water film, time delay, permeability

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

HDS30-05 Room:511 Time:April 29 17:15-17:30

Factors controlling submarine landslide occurrence: Lessons learned from plate-boundary decollement zones

UJIIE, Kohtaro[1*]

[1]University of Tsukuba

Most submarine slopes are inherently stable. However, once submarine landslide generated, it could induce destruction of seabed infrastructure and tsunamis. The factors controlling submarine landslide occurrence remain poorly understood, mainly because there has been very limited access to slip surface of landslide. Initiation and evolution of plate-boundary decollements in subduction zones may be useful to understand the location of slip surfaces and the slip behavior of submarine landslides. Here, I review decollement processes in subduction zones, which have been revealed from deep ocean drilling in the last 20 years. The decollements develop along (1) weak, smectite-rich layers, (2) the zones of elevated pore pressure, and (3) the mechanical boundary between cemented and non-cemented intervals. These results provide important implications for submarine landslide occurrence. The slip surfaces may localize along an interval of smectite-rich lithology. Such smectite-rich lithology could link to the increased volcanic activity as smectite is commonly derived from alteration of volcanic ash/tuff. The permeability contrast in slope sediments could also play an important role on the development of slip surfaces. The rapid sedimentation of coarse-grained sediments onto fine-grained, argillaceous sediments may cause the generation of elevated pore pressure, which in turn facilitates the onset of submarine landslide. The trap of the hydrate-derived fluid beneath the low permeability sediment may also cause the development of overpressure. The slope sediments may contain the cementation boundary (e.g., opal-A to opal-CT reaction) particularly when geothermal gradient is high. In such case, the submarine landslides may generate along the surface bounding different cementation states.

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

HDS30-06 Room:511 Time:April 29 17:30-17:45

Flow dynamics of Nankai Trough submarine landslide inferred from internal deformation using magnetic fabric

KANAMATSU, Toshiya[1*] ; KAWAMURA, Kiichiro[2] ; KITAMURA, Yujin[3] ; NOVAK, Beth[4] ; STRASSER, Michael[5]

[1]Japan Agency for Marine-Earth Science and Technology, [2]Graduate School of Sciences and Engineers, Yamaguchi University, [3]Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshim, [4]Department of Geology Western Washington University, [5]Geological Institute, Seiss Federal Insitute of Technology ETH Zurich

Submarine landslide deposits in one of the most active subduction zone was investigated by Integrated Ocean Drilling Program (IODP) Expedition 333 as "Nankai Trough Submarine Landslides History" (NanTroSLIDE). The expedition recovered a Pleistocene to Holocene sequence of stacked mass-transport deposits (MTDs) within a slope on the footwall of the megasplay fault at Site C0018, Nankai Trough SW Japan (Strasser et al., 2012). A series of MTDs interbeded with coherent intervals were recovered from the upper 190-meter at C0018 site. We present results of detail fabric analysis using drilled succession of buried mass transport deposits in the slope of Nankai Trough in order to investigate rheology of mass transportation in the subduction zone. Despise very limited lithological information of core research, AMS is proved useful tool to identify MTD deformation and recognize depositional process of MTD (Kitamura et al., 2013, Noback et al., 2013).

Magnetic fabric patterns reveal inhomogeneity within each MTD unit indicating a different compaction and shear occurred during flowing and subsequent deposition (MTD2, MTD3, MTD5). Magnetic fabric in upper interval of each unit generally indicates vertical compression. On the other hand lower interval involve magnetic fabrics showing effect of shear. In the largest MTD (MTD6), a distribution of magnetic foliations images tightly folded strata. Using available paleomagnetic data the shear directions are reoriented, and two different directions are obtained in term of MTD flow directions. It is considered that such variation in flow types and directions derived from the results occurred in responding to a change of slope environment controlled by the tectonic evolution of Nankai accretionary wedge. Through such analysis we can improve our understanding for submarine landslide formation in the active margin.

Keywords: submarine landslide, NanTroSLIDE, IODP, Nankai Trough

HDS30-07 Room:511 Time:April 29 17:45-18:00

Potential tsunamigenic submarine landslides in active margins

KAWAMURA, Kiichiro[1*] ; JAN SVERRE, Laberg[2] ; KANAMATSU, Toshiya[3]

[1]Yamaguchi Univerisity, [2]University of Tromso, [3]JAMSTEC

A review of modern, historical and submarine landslides from the geological record shows that landslides in active continental margins can generate tsunamis. The tsunamis may damage coastal and seabed infrastructure and so represent an important element of marine geohazards research due to their potentially significant impacts on society. The primary trigger mechanism of tsunamis in this type of setting was thought to be earthquake activity; however, there are also a number of alternative hypotheses regarding the likely initiation mechanism including the generation of submarine landslides. In this paper, we briefly review the geological features and trigger mechanisms of tsunamigenic submarine landslides on active margins. Large tsunamigenic submarine landslides appear to occur mostly on margins characterized by non-accretion. These observations has implications for tsunami warning systems as the Japanese system does not consider the scenario of tsunami excitation by submarine landslides

Keywords: tsunamigenic submarine landslide, tsunami earthquake, tectonic erosion, Japan trench, the 2011 Tohoku-Oki earthquake

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

HDS30-P01 Room:Poster Time:April 29 18:15-19:30

Temporal changes of internal stresses and pore pressures of a large-scale submarine debris flow

OTSUBO, Makoto[1*] ; NARUSE, Hajime[2] ; MIYAKAWA, Ayumu[1]

[1]Geological Survey of Japan, AIST, [2]Graduate School of Science, Kyoto University

Mass-transport deposits are major components of depositional systems in the deep sea environments. These deposits usually are composed of muddy chaotic deposits, and are expected to conduct as permeability seals over channel deposits. These mass transport deposits appear as transparent layers on seismic data and chaotic intervals in cores (e.g., Weimer, 1991). Regardless of their common occurrence and distinctive geometry, the dynamics of subaqueous mass transport processes (debris flows) are not well known. It is great difficult to observe directly a subaqueous debris flow.

Naruse and Otsubo (2011) documented quantitatively the internal structures of a mass-transport deposit in the Akkeshi Formation, from the middle part of the Cretaceous-Paleocene Nemuro Group, Japan. The paleostress analysis using meso-scale faults (Yamaji, 2000) of a large-scale mass-transport deposit revealed that the flow experienced two different stress fields: (1) a vertical uni-axial compressional stress field with the sigma1-axes oriented normal to the bedding surface (Phase I) and (2) horizontal tri-axial compressional stress fields with the sigma1-axes oriented parallel to paleocurrent direction (Phase II) (Naruse and Otsubo, 2011).

We examined the temporal changes of internal stresses and pore fluid pressures in a submarine mass transport from the relationships between the principal stresses axes and attitude of fault planes in the mass transports deposits in the Akkeshi Formation. We used 22 fault data and stresses of two Phases in a mass transport deposits. We attribute fault variations to the degree of fault overpressure acting on faults to estimate the pore fluid pressure ratio in the submarine mass-transport deposits. The theory can be explained using the Mohr circles. The inferred internal stresses results imply that the stress fields of Phase I are created by a radial spreading of the flow during its downcurrent movement, while the stress fields of Phase II result from compression during deposition on the basin plain (Naruse and Otsubo, 2011). The increase of pore fluid pressure ratio from Phases I to II represents that the pore fluid pressures have been recognized as playing an important role in the occurrence of the faults in Phase II. On the subdivided Phase II, pore fluid pressure ratio increases until Phase IIa and decreases after Phase IIb while sigma-hmax increases during Phase II.

References:
Naruse, H., and, Otsubo, M. (2011) Heterogeneity of Internal Structures in a Mass-transport Deposit, Upper Cretaceous to Paleocene Akkeshi Formation, Hokkaido Island, Northern Japan. SEPM Special Publication, 96, 279-290.
Weimer, P. (1991) Seismic facies, characteristics and variations in channel evolution, Mississippi Fan (Plio-Pleistocene), Gulf of Mexico, in Weimer, P., and Link, M.H., eds., Seismic Facies and Sedimentary Processes of Submarine Fans and Turbidite Systems, New York, Springer, 323-347.
Yamaji, A. (2000) The multiple inverse method: a new technique to separate stresses from heterogeneous fault-slip data. Journal of Structural Geology, 22, 441-452.

Keywords: stress, pore pressure, meso-scale fault, mass-transport, debris flow, land slide