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

MIS25-01 Room:101B Time:May 20 09:00-09:15

Aspects of, and approaches to, tsunami-genetic sediments

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It is well-known that the nature of tsunami changes markedly from long wave, step-wave or breaker, to some flow or cuurent form. And from deep-sea, off-shore,and coastal to landarea. Ways, causes, and places of these change are quite variable. The destruction of structures,including houses, buildings,sea-walls and so on, depend on the nature of tsunami or tsunami-generated flow which attack those structures. More precise knowledge about the 2011 giant tsunami is required. It should provide information for the future tsunami disaster prevation for that local area also.

Tunamiites,including run-up tsunami deposits, in general, are still difficult deposits to identify. Theoretical understanding of the local change of a tsunami's nature and better knowledge about the characteristic features of tsunami-induced deposits is needed for the comprehensive grasp of the mechanism leading up to tsunami disasters.

Keywords: tasunami deposits, recognition of tsunami deposits, seismic tsunami, seismic tsunami deposits, prevention of tsunami disaster, tsunamiites

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MIS25-02 Room:101B Time:May 20 09:15-09:30

Inundation and sedimentary features of the 2011 Tohoku-oki tsunami along a 20-km-stretch of coastal lowland

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The 2011 Tohoku-oki tsunami caused severe damage to the coastal regions of eastern Japan and left tsunami sediments on the affected area. We discuss differences in depositional features of the 2011 Tohoku-oki tsunami from the viewpoints of the sediment source and coastal topography as well as tsunami flow height. The study area on the Misawa coast, northern Tohoku, includes a 20-km-long coastline with sandy beaches, coastal dunes and gently sloping lowland and provides an opportunity to examine effects of topography and land use on the features of tsunami deposits. During field surveys conducted from April 10 to May 2, 2011, we described the thickness, facies, and structures of the tsunami deposit. We also collected sand samples at approximately 20-m intervals along thirteen shore-perpendicular transects, which extended up to 420 m inland.

The extent of the coastal lowland affected the flow height and inundation distance. The run-up height was 10 m on a terrace slope in the southern part of the study area, where the lowland is only 100 m wide. On the other hand, the maximum inundation was 550 m and run-up height was 3.2 m on a flat topography in the northern area. The average flow height was 4-5 m on the Misawa coast. The run-up height and slope gradient show a strong positive correlation whereas the run-up height and distance are negatively correlated.

The tsunami eroded coastal dunes and small scarps along the coast. Right behind the eroded dune, the tsunami deposit is more than 20 cm thick and then decreases rapidly landward. In other words, the deposit layer is thick only behind the deposit source. The deposit thickness seems unrelated to flow height or flow depth.

Grain size distribution and mineral assemblage of the 2011 tsunami deposits, beach sand, and dune sand were measured. The 2011 deposit represents a trend of landward fining. The heavy mineral content tends to decrease inland.

This thick deposit is composed largely of medium sand (1-2 phi), which has planar and parallel bedding but does not show apparent upward fining or coarsening. The particle size of the sand is similar to that of the coastal dune sand, suggesting it was the source material of the tsunami sediment. On the other hand, the inland thin tsunami deposit consists mainly of fine sand (2.275 phi), which sometimes shows upward fining. This well-sorted fine sediment suggests deposition from suspension, whereas the relatively coarse sand implies deposition from traction flows. The depositional features of the 2011 Tohoku-oki tsunami deposit are affected mainly by coastal topography and extent of eroded areas and seem unrelated to flow height.

Keywords: 2011 Tohoku-oki tsunami, tsunami deposit, grain size, run-up height, topography, Misawa Coast

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MIS25-03 Room:101B Time:May 20 09:30-09:45

Mega-dunes formed by the 2011 Tohoku-Oki tsunami at the Kesennuma Bay, Japan

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The 2011 off the Pacific coast of Tohoku Earthquake was one of the largest events in the history of Japan. The huge tsunami (the 2011 Tohoku-Oki tsunami) inundated a large coastal area of northeastern Japan, causing widespread devastation. Twenty days after the tsunami, we analyzed the impact of the tsunami on the sea bottom of the Kesennuma inner bay using side-scan sonar and a depth sounder to explore the damage and bathymetric change in the harbor. Herein we present the first direct evidence that the sea bottom sediments of around 10?15 m were reworked by the tsunami to thickness of a few meters, and that large dunes were formed by the tsunami. Considering that the sea wave influence is as weak as it is inside the inner bay, the potential exists that even meter-thick sandy or silty paleo-tsunami deposits are preserved in shallow sea bottoms with large bedforms. This finding will be a steppingstone to future geological studies of tsunami effects in shallow sea regions.

Keywords: 2011 Tohoku-Oki tsunami, Kesennuma Bay, Mega-dune

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MIS25-04 Room:101B Time:May 20 09:45-10:00

Impact of the 20110311 tsunami on the geography and sediment distribution in Kesennuma Bay, Miyagi, Japan.

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MMany tsunami deposits on land have been studied in order to evaluate the height and landward penetration of a tsunami and the age of the occurrence of the associated earthquake. However, the construction of disaster measures requires the age and scale for each earthquake using all tsunami deposits, including those traveling long distances such as the 2010 Chilean Tsunami, in the marine sediments in a coastal area. Currently, few data regarding the change in the geography and sediment distribution after a recent tsunami are available to assist in analyzing ancient tsunami deposits in marine sediments.

In Kesennuma Bay, the study area, the sea bottom was scoured, the geography and sediments were altered, and much debris, oil, and chemical materials flowed into the sea from land as a result of the 2011 tsunami. The change of geography and sediment distribution by this tsunami are the modern analog for analysis of the tsunami record in strata. Thus, highly precise information applicable to the restoration of historical tsunami deposits can be obtained by this investigation. We collected data on water depth, refraction intensity by acoustic systems, and four sediment samples, interpreted the intensity related to the physical properties (density, particle form and grain size) of the sediment, made a three-dimensional topographical map and distribution map of the sediment and debris, and evaluated the marine environmental change based on a comparison with a chart published before 11 March 2001.

The altitude at three bench marks around the bay decreased about 0.7 m after the earthquake. This value compares favorably with our map, which suggested a drop of 1 m in water depth after the earthquake, with geographical changes restricted to the inner and near mouth of the bay.

A north-south geographical rise ($<$ 8 m water depth) on the east side and a depression ($>$ 16 m water depth) on the west side excavated by the tsunami are present in the inner area of the bay off Kesennuma Port. No excavations are present in the shallower bottom from the central to south area of the bay. Thus, the excavation resulting from the tsunami is restricted to the inner bay.

Acoustic reaction is strong in the uneven geography present in the dune field which intersects perpendicularly with the bay axis in the joint area between the inner and central area of the bay. Coarse sediment and woody material are present in the area. The tsunami deposit of the Chilean earthquake is distributed here as well (Shiomi, et al., 2011).

Three clusters composed of many dunes are also distributed in the southeast area of the bay. The reflective intensity is strong at the top of the dune and is weak at its bottom. Fishermen stated that muddy sediment was widely distributed in the bay before this earthquake and that the sea bottom in the southwest area of the bay was exposed at the time that the water surface reached its lowest point during the tsunami. Thus, the evidence suggests that much debris and clastic particles were transported and the dune was formed by the backwash of the tsunami.

The unique distribution of the excavation and inflow materials is an important phenomenon in the recognition of tsunami deposits in ancient marine strata.

This investigation is one theme of the support program (Recovery of Great East Japan Earthquake Disaster and Reconstruction of Japan) of the Association of National Universities (JANU).

Keywords: Tsunami, acoustic systems, geography, sediment, debris, Japan

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MIS25-05 Room:101B Time:May 20 10:00-10:15

Total volume of sand and mud deposited by the 2011 Tohoku-oki tsunami at Sendai Plain

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A relationship among the volumes of the sediments, landform, and magnitude of the tsunami were pointed out based on the field surveys after recent tsunamis (e.g. Matsumoto et al. 2010). Moreover, the hydraulic experiment further showed that 80 % of the volume of the sand can be accounted by sediment transported from the land near the shoreline (Harada et al. 2011). Nevertheless, the relationship between the volume of sediment and its source is still uncertain. In fact, total volume of sediments (sand plus mud) was estimated in the previous studies. However, because there is a potential that the sources of sand and mud are different, the volumes of sand and mud should be estimated separately.

In this study, we report the relationship among the volume of sand and mud, landforms, sediment sources, and magnitude of the 2011 Tohoku-oki tsunami at Sendai Plain based on field survey on April, June, and August 2011.

We set 6 transects with about 0.6-4.0 km inundation distance in and around Sendai Plain. We observed thickness of the tsunami deposits at totally 166 pits every 10-340 m along each transect. Volumes of sand and mud deposited per unit width and area of the coastal zone are calculated based on the cumulative thickness of the deposits along each transect. We also conducted kinematic GPS measurement of the topographies. Land condition is classified based on field observation and analysis of satellite images and aerial photographs.

Beach distributes 0-150 m from the shoreline along transect. Coastal forest (sand dune) distributes 60-880 m from the coastline. Rice paddy field extends between 180-280 m and 330-4030 m from the shoreline, and occupies a great part of most transects.

Volume of sand deposited per unit width along each transect is estimated approx. 30-180 m^2/m and the volume is in proportion to the inundation distance. Volume of mud deposited per unit width is calculated approx. 1-60 m^3/m and, as like sand volume, the mud volume is also in proportion to the inundation distance. Moreover, mud volume relates to the width of rice paddy field, suggesting the source of mud is mainly the rice paddy. In fact, mud volume is very minor component if the transect is covered with narrow rice paddy field. On the other hand, it is interesting to note that the volume of sand per unit area (m^2) along each transect is remarkably similar in range (approx. 0.037-0.054 m^3/m^2), which is probably controlled by the duration of the sand suspension by the bore front at the shallow sea and the beach. In contrast, mud volume deposited per unit area is calculated about 0.002-0.018 m^3/m^2, the volume is in proportion to the width of rice paddy field.

The volume of sand per unit width (approx. 30-180 m^3/m) is approximately 1-5 times that reported for the 1998 Papua New Guinea tsunami (approx. 36 m^3/m, Gelfenbaum and Jaffe, 2003) , where the run up height was 10-15 m and the inundation distance was 0.75 km along the transect, and the 2004 Indian Ocean tsunami (approx. 78-83 m^3/m, Fujino et al. 2006; Matsumoto et al. 2010), whose run up heights were 4-10 m and the inundation distances were 1-2 km along the transects. Our survey transects in Sendai Plain, the run up heights were 10-20 m (Mori et al. 2011) and the inundation distances were 0.6-4.0 km, respectively. The landform condition of Sendai Plain is suitable for the transportation and the deposition of tsunami sand because the area is characterized by the remarkably flat and low rice paddy fields. As the results, these conditions promote the transportation and deposition of significantly large volume of sand by the tsunami on land at Sendai Plain. Moreover, if we consider the volume of mud, the total volumes of sediments (sand plus mud) per unit width are about 30-230 m^3/m, resulted in remarkably larger volume of sediments deposited on land than those by the recent tsunamis.

Keywords: 2011 Tohoku-oki tsunami, tsunami deposit, volume of sediment, Sendai Plain

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MIS25-06 Room:101B Time:May 20 10:15-10:30

Probable submarine ”tsunami” deposits by the 2011 off the Pacific Coast of Tohoku earthquake

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Large sediment transport was occurred by the 2011 off the Pacific Coast of Tohoku earthquake. At the shelf edge of the Sendai Bay, a turbidite bed with thick turbidite mud and deformed sediment was observed above normal hemipelagic sandy mud. 134Cs and 137Cs occurred not only the sediment surface but also in the turbidite mud. These facts indicate the following processes to make the sediment sequence; 1) sediment deformation by the strong ground motion by the earthquake, 2) resuspension of shelf sediments by the tsunami and formation of turbidity currents, 3) turbidite sand deposition from the turbidity currents and formation of small mud pond using a small submarine relief, 4) fall of radioactive elements from air through water column and piling up of the elements at the surface of highly turbid bottom water in the small relief, and 5) deposition of turbidite mud from the highly turbid bottom water.

Keywords: marine sediments, turbidite, tsunami, deformation

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MIS25-07 Room:101B Time:May 20 10:45-11:00

Coastal lowland deposition by tsunami over a coastal sand dune: Examples from historical and present tsunami deposits on

TAKASHIMIZU, Yasuhiro[1*], NAGAI, Jun[2], URABE, Atsushi[1], SATO, Yoshiki[3], OKAMURA, Satoshi[4], NISHIMURA, Yuichi[2], SUZUKI, Koji[1]

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Coastal lowland deposition by tsunami over a coastal sand dune: Examples from historical and present tsunami deposits on coastal lowland

Takashimizu, Y., Nagai, J., Urabe, A., Sato, Y., Okamura, S., Nishimura, Y. and Suzuki, K.

Characteristics of the deposits from a tsunami over a coastal sand dune with several kilo-meters inundation were discussed from two tsunami deposits. First one is the seventeenth century tsunami deposit in the eastern Iburi Coast, Hokkaido, northern Japan, and another one is the 2011 T?hoku tsunami deposit in the central Sendai Coast, Miyagi, north eastern Japan. Base on the sedimentological analysis, it is clarified that both deposits shows same characteristics as follows;

1. Deposits caused from tsunami inundated to two to three kilo-meters inland
2. Distance of the distribution limit of the sands is around two kilometers from the coastal line.
3. Massive or faint parallel lamination
4. Decreasing bed thickness toward inland
5. Fining grain size toward inland
6. Including marine diatom species
7. Erosional contact at base and including rip up clasts
8. Paleo-current direction estimated from grain fabric shows the beds were deposited from inflow only

It is considered that these may show the generic characteristics of the tsunami deposits on coastal lowland caused by a tsunami over a coastal sand dune. In contrast, the different features between the both tsunami deposits are also recognized as follows;

1. The seventeenth century tsunami deposit simply fines toward inland, and on the other hand, the 2011 Tohoku tsunami deposit shows fining inland with two sudden coarsening
2. The seventeenth century tsunami deposit doesn't include mud layer, and on the other hand, the 2011 Tohoku tsunami deposit is covered by thick mud
3. The frequency of marine water diatom species in the 2011 Tohoku tsunami sand is quite low, compared to the seventeenth century tsunami deposits

We interpreted that these are the results from the differences of the geomorphological features between the both coastal lowlands and the influence rate of the artificial changes of the lands. These results contribute to the progress of paleo-tsunami science and give good evidences to indentify the tsunami deposits from coastal lowland in future studies.

Keywords: tsunami deposit, coastal lowland, Tohoku, Hokkaido, Fabric, Diatom

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MIS25-08 Room:101B Time:May 20 11:00-11:15

Holocene alternated auto-allochthonous oyster beds in Pashukuru-numa Lake, Hokkaido: tsunami deposits during 8-6.6ka ?

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Pashukuru-numa Lake located in Shiranuka Town, about 30km west of Kushiro City, east Hokkaido, is a small lagoon closed by sand bar from the Pacific southward, which was a small inner bayment during the Holocene transgression. The Holocene oyster shell beds along the inner side of east coast nearby a tidal inlet of the lake are known to be exposed during ebb of spring tide, as reported by Matsushima (1982). During the trench survey last summer of the Holocene deposits about 3.5 meter thick along east lake coast, we found the four alternating beds of allochthonous and autochthonous oyster shell concentrations with a total thickness of 2 meters in the lower half of the Holocene. We briefly describe the taphonomic characteristics of oyster shell beds such as lithostratigraphy, mode of shell occurrence and species composition of molluscs. We also performed radiocarbon dating for shell and wood materials from seven horizons. Four carbon-14 ages of an intertidal species (*Trapezium liratum*) from four horizons of two-meter thick shell beds ranges about 8,000 to 6,600 cal. BP. These lines of evidence suggest their formative processes possibly as a few times repetitions of tsunami events for allochthonous layers and inter-tsunami intervals for allochthonous layers forming small oyster colonies or reef. Taking three thin sand layers intercalated within modern peat sediments overlying the oyster bearing mud, which were inferred to be tsunami up-flow deposits during 13th century to 1843 by Nanayama et al. (2001), into account, their oyster shell beds seem to have been formed during 1,400 years from 8,000 to 6,600 cal. BP. under the influence of a few times tsunami events occurred at intervals of a few hundreds years.

Besides the Holocene oyster beds in Pashukuru-numa Lake, several oyster shell beds with alternating allochthonous and autochthonous characteristics are recognized from the Cretaceous to Recent in many places in Japan, we will be able to detect the records of tsunami-related sedimentary events during geologic time.

Keywords: Holocene, Crassostrea, shell beds, tsunami deposits, Pashukuru-numa Lake, Hokkaido

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MIS25-09 Room:101B Time:May 20 11:15-11:30

Two historical tsunami deposits from the Otagawa-lowland, western Shizuoka Prefecture, Pacific coast of central Japan

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Introduction

Two tsunami deposits formed in the last ~1500 years were found from the excavation sites of the Motojima ruins and river conservation work in the Ota-gawa lowland, on the Enshu-nada coast, near the Nankai trough. These excavation sites are located in the flood plain of the Ota-gawa river ~2.5-3.5km inland from the present coastline, and correspond to the former bay head which expanded along the Ota-gawa river. These tsunami deposits are attributed to the 1096 Eicho earthquake and an earthquake of the fourth to seventh century, respectively.

Eicho tsunami deposit in the Motojima ruins

The tsunami deposit is intercalated in the silt beds covering the ruins ranging the first to fourth century in age. It is 20-30 cm in thickness and continuously traced along the artificial slope ~120 m in coast-normal direction and ~70 m in coast-parallel direction. The tsunami deposit consists of a fine alternation of ripple laminated fine to medium sand beds. Each of the sand bed shows a normal grading and is covered by a mud drape and shows the deposition from one sequence of tsunami run-up or backwash. We then inferred that the tsunami deposit recoded the repeated occurrence of the tsunami waves. Radiocarbon ages suggest that the tsunami occurred around the boundary of the 11th and 12th century.

Tsunami deposit of the fourth to seventh century

The tsunami deposit was observed along the outcrop made by the river conservation work and continuously traced over 150 m in the coast-normal direction. It consists of stratified sand beds with ~70 cm thickness and shows a fining landward trend. It covers the tidal flat mud with an erosion surface, showing a fining upward sequence, and gradually covered by blackish silt beds (Sato et al., this meeting). Fine alternation of ripple laminated sand beds and mud drapes characterizes the tsunami deposit. Rock type and mineral composition of the tsunami deposit is similar to that of the beach sediments on the Enshu-nada coast and suggests that the deposit was mainly transported from the beach by tsunami run-up (Aoshima et al. this meeting).

Radiocarbon ages and fragments of the potteries included in the tsunami deposit suggest that the tsunami occurred at a period between the late of fourth century and end of the seventh century.

Keywords: Otagwa lowland, Tsunami deposit, Tokai earthquake, Paleoearthquake, Shizuoka

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MIS25-10 Room:101B Time:May 20 11:30-11:45

Researches of tsunami deposits from Holocene sediments in the southeast Shizuoka Plain, Shizuoka Prefecture

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Two possible tsunami deposits were reported from the Holocene in the southeast area of the Shizuoka Plain, Shizuoka Prefecture. In order to clarify the depositional ages and distribution of these deposits, this study will present their stratigraphic distribution from five sediment cores and 25 pits.

Keywords: Shizuoka Plain, Holocene, tsunami deposits

Japan Geoscience Union Meeting 2012
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MIS25-11 Room:101B Time:May 20 11:45-12:00

Paleo-tsunami records at the Ryukyu Islands based on the distribution of boulders

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The Ryukyu Islands, Japan extend approximately 1000 km northeast to southwest along the Ryukyu Trench between Taiwan and Kyushu, Japan. Most of the islands and islets of the Ryukyu Islands are rimmed by fringing reefs. It is well known that the 1771 Meiwa Tsunami devastated at the Sakishima Islands, southwestern end of the Ryukyu Islands. The tsunami run-up height is estimated up to 30 m and it caused approx. 12,000 deaths. On the other hand, there are no historical records of huge tsunamis in the Okinawa and Amami Islands, north from the Sakishima Islands. One of the issues to study the geological record of paleo-tsunamis at the Ryukyu Islands is the preservation of the sandy tsunami deposits since the islands are located in the subtropical area. Moreover, terrestrial sedimentary layer is thin and not allow us to know the long record of the paleo-tsunamis. On the other hand, there are numerous boulders that are composed of corals and carbonate rocks at the coasts of the Ryukyu Islands. Based on the geological study and hydrodynamic analyses, boulders at the coastal zone of the Sakishima Islands are interpreted as the tsunami origin, while only boulders deposited by the storm waves are observed in the Okinawa and Amami Islands (Goto et al., 2010). According to the 14C dating, some of the tsunami boulders at the Sakishima Islands were deposited by the 1771 Meiwa Tsunami, while the others were deposited prior to this event (e.g. Araoka et al., 2010). This in turn suggests that such coralline boulder deposits are useful to investigate the tsunami recurrence interval at the subtropical area instead of the sandy tsunami deposits. Moreover, absence of the tsunami boulders at Okinawa and Amami Islands shows striking contrast to the Sakishima Islands. The results may imply that large tsunamigenic earthquakes were heterogeneously occurred among the Ryukyu Islands.

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MIS25-12 Room:101B Time:May 20 12:00-12:15

History of past tsunami events at Southern Ryukyus: Estimation from radiocarbon dating of Porites coral boulders

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An enormous tsunami were caused by huge earthquake happened off eastern Japan on last March, which devastated wide coastal areas in Japan. It is noted that giant tsunamis have been repeatedly striking all over Japan. For example, one of the largest tsunami disasters in Japanese history was ”the Meiwa tsunami”, happened in 1771. This tsunami struck southern part of Ryukyu Islands, and killed more than 12,000 people. The maximum wave height and casualty of the tsunami were similar to 2011 Tohoku tsunami. However, the origin of the Meiwa tsunami is still controversial. Moreover, information about past tsunamis before 1771 Meiwa tsunami was limited in this region. Therefore, not only local historical documents but also geological evidences should be needed for collecting information on past tsunamis such as recurrence period, frequency and scale as well as the damage caused by these tsunamis and for future disaster mitigation in this region.

A large number of massive coral head boulders, locally called ”Tsunami-ishi”, are widely scattered both along the shore and on the reef at Southern Ryukyu Islands. These coralline boulders were likely transported by past tsunamis struck in this area. The coralline tsunami boulders were previously reported, which were deposited by the 2004 Indian Ocean tsunami. We focus on these coral boulders, especially genus of *Porites* spp., which could be used as records of past tsunami disasters. When corals were cast ashore by large tsunamis, their growth stopped at that time and the date of the tsunami event could be determined by radiometric dating of well-preserved surface parts of these boulders.

We performed a large number of radiocarbon dating analyses on 92 massive *Porites* spp. coral boulders collected from several islands in Southern Ryukyus. These results show that past tsunami disasters were likely happened repeatedly in this region from more than 2,500 years ago, including the 1771 Meiwa tsunami. The recurrence period of tsunamis struck in this region were estimated about 150 to 400 years.

The timing and frequency of the past tsunamis could be validated due to a lot dating results of *Porites* coral boulders. Combining this study with tsunami engineering and geophysics could also lead to further contributions to reveal past tsunamis. When we want to know about past tsunami disasters, we have been typically focused on tsunami deposits remained in ground. This newly study by using coastal boulders would offer numerous suggestions for a lot of studies of coastal boulders and historical tsunami researches.

Keywords: Tsunami boulders, Porites spp. coral, Radiocarbon dating, Histrocal tsunamis, Southern Ryukyu Islands, Tsunami deposits

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MIS25-13 Room:101B Time:May 20 13:45-14:00

Hydraulics of sediment erosion and reworking by surging currents

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Bottom irregularities and undulations affect the hydraulic behavior of currents, and a friction force working on bottom surface, as well as physical properties such as depth and velocity, is a significant factor responsible for flow conditions. Fluid pressure acting on the boundary between bottom currents and bed surface is a major cause of erosion and reworking of materials. Hydrological effects depending on ground-surface conditions were appreciated in the interpretation of sedimentary processes caused by the 1923 Kamchatka earthquake tsunami (Minoura et al., 1996). The tsunami deposit was very thin (˜2 cm), however it was traceable for more than 6 km inland from the coast. Historical materials reveal that on 14 April rushing waves surged over the frozen snowfields of the Kamchatka plain. Through smoothing the snow surface by freezing, the critical tractive force finally exceeded the tractive force of flowing water, and thus rushing currents penetrated a depth of the plain, forming a landward tapering sand layer covering a wide range of the plain. In proportion to the increase in tractive force, the surface takes the force by shear stress. With increase in current speed, cohesive soft-sediment surfaces undergo shearing deformation depending on the scale of tractive force, and finally stress intensity escalates to a critical point of detachment threshold.

From late autumn to early spring, the rice fields in Tohoku are uncultivated, and paddy soils are exposed without vegetational cover. The 2011 Tohoku-Oki earthquake tsunami took place in early spring (11 March 20111), and it was five months after the final harvesting. The coastal zones of rice fields were subjected to torrential flooding. The sediment detachment threshold from the bed is defined as the force equilibrium between the tractive and resistant forces. The critical tractive force of cohesive soft surface is expressed as a function of yield stress (Ty1). Otsubo and Muraoka (1988) presented a mathematical model explaining the relation between tractive and resistant forces. When tractive shear stress reaches to yield stress, the threshold condition (Tc1) in mud transport is expressed in the following.

Tc1 = 0.27T0.6y1 (1)

The tractive force at the threshold of bed destruction (Tc2) is given as follows.

Tc2 = 0.79T0.94y1 (2)

The yield stress of paddy surface in the Sendai plain ranges from 1.27 to 2.35 N/m2 (Geospatial Information Authority of Japan, 1984). Thus, the tractive force of the threshold conditions of grain motion and initial surface erosion are calculated to be Tc1 = 0.31˜0.44 N/m2 and Tc2 = 0.99˜1.77 N/m2, respectively. The results indicate that the erosion of bed surface does not occur in case of the tractive force to be less than 0.31 N/m2. If the tractive force exceeds 1.77 N/m2, mass erosion of cohesive bed takes place. When the tractive force of currents exceeds the critical friction force of bottom surface, shearing stress starts to act on the surface. After passing the threshold of resistance, mud surface is deformed in response to increasing stress, and finally mass erosion of mud surfaces occurs.

Supercritical flows were generated where surging currents by the Tohoku-Oki tsunami crossed levees and roads to paddy surfaces, causing mass erosion of surfaces. In the paddy fields of Sendai mud chips and blocks were formed. The concentrated occurrence of cobble to pebble-sized balls of mud was frequently recognized on the downstream side of levees after the retreat of the 3.11 tsunami. Thin veneers of sand and mud covered the mud balls. Marks of migration on paddies indicated that rushing water moved them by rolling or slipping. Rice straw is chaffed by machine after harvesting, and small pieces of straw are scatted on rice fields. These pieces were included in mad balls, and it is interpreted that mud chips adhered paddy soils mixed with straw fragments during rolling on bottom surface and finally attained to forming cohesive mud balls.

Keywords: Tsunami, Surging current, Erosion, tractive force, yield value

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

MIS25-14 Room:101B Time:May 20 14:00-14:15

Applicability of sediment transport model to paleotsunami deposit: preliminary examination for the 869 Jogan tsunami

SUGAWARA, Daisuke[1*], Fumihiko Imamura[1], TAKAHASHI, Tomoyuki[2]

[1]Tohoku University, [2]Kansai University

In general, inundation area and wave source of a paleotsunami are estimated numerically based on the maximum inland extend of the tsunami deposit[1][2], although the field observation of the 2011 Tohoku-oki tsunami reported a significant gap between the maximum inland extent of the deposit and inundation limit of the tsunami[3]. The inundation area and fault parameters of the paleotsunami can be estimated more adequately if sediment transport modeling can explain the field data of the tsunami deposit. In this study, the sediment transport model by Takahasi et al.[4] is applied to the 869 Jogan tsunami in the Sendai Plain. The modeling requires careful consideration of sand and hydraulic parameters, such as grain size and roughness coefficient. In this presentation, the sensitivity of these parameters against the modeling result is examined, and the applicability of the modeling to the Jogan tsunami is discussed through a comparison of the field data and modeling results.

The tsunami propagation in the open sea and inundation on land were calculated using the Mw 8.4 Jogan earthquake model, which was proposed previously[1][2]. The numerical result showed that most of the deposition on land is accounted by the erosion of the coastal dune. The deposition depends on the topographic undulations; it is thicker within the topographic depression. Total amount of erosion and deposition varies 2-3 times depending on in particular the grain size and roughness coefficient. The comparison of the modeling result and the field data[5] showed that the general trend of landward thinning of the Jogan tsunami deposit was well reproduced by the modeling, although the deposition near the coast was overestimated. Direct comparison of the field data and the modeling results showed both considerable underestimate (1%) and overestimate over the land. This may be accounted by the sensitivity of the modeling parameters, as well as the precision of the reconstructed paleo-topography used for the calculation. Field observation of modern tsunami deposits reported significant the local variation of the thickness of the tsunami deposit. Direct comparison of the field data and the modeling results may be inadequate unless the field data is obtained densely. Further consideration is needed for the survey method and data analysis of the pleotsunami deposit.

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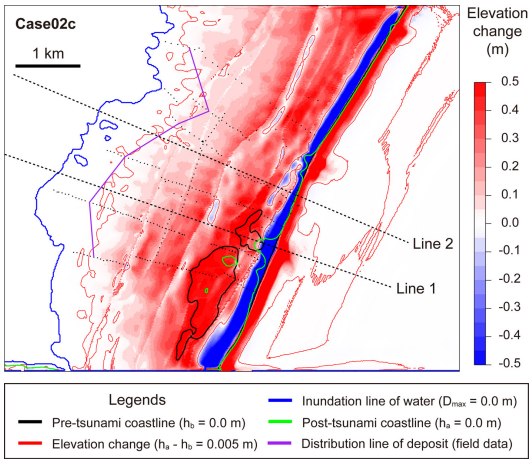
Keywords: tsunami deposit, numerical simulation, sediment transport modeling, Jogan earthquake tsunami



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

MIS25-P01 Room:Convention Hall Time:May 20 15:30-17:00

Beach deposits inferred as being formed by the 2011 Tohoku Tsunami at the Sendai Coast

SHIRAI, Masaaki[1*], HAYASHIZAKI, Ryo[1], UTSUGAWA, Takako[1], Yasutoki Mukaiyama[1], MURAGISHI, Jun[1]

[1]Tokyo Metropolitan University

Tsunami deposits are important evidence for analysis of paleo-earthquake and paleo-tsunami. Generally tsunami deposits are recognized as sand layers intercalated in muddy sediments in estuary, coastal swamp, and so on. Whereas, it is difficult to distinguish sandy tsunami deposit from sandy beach deposit. We carried out field survey of tsunami deposit on beach formed by the 2011 off the Pacific Coast of Tohoku Earthquake tsunami (2011 Tohoku Tsunami) on 3 May, 2011 nearby the Sendai Airport.

On the foreshore environment, 10 cm thick mafic minerals concentrated layer and water escape structures (pipes) above the layer were observed. Because these structures means continuous erosion and subsequent rapid accumulation of sand grains and water, which is not common on beach environment, the deposit may have been formed by 2011 Tohoku Tsunami. Water escape structures were formed also in surface sand on coastal dune. Because coastal dune sand is transported and deposited by wind, water escape structure exist in unusual conditions. These sand layers should have been formed by2011 Tohoku Tsunami. Further analyses are planned for elucidate origin of these deposits.

Keywords: 2011 Tohoku Tsunami, tsunami deposit, beach, water-escape structure

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

MIS25-P02 Room:Convention Hall Time:May 20 15:30-17:00

Backshore deposits inferred as being formed by the 2011 off the Pacific Coast of Tohoku Earthquake Tsunami at the Tsuris

HAYASHIZAKI, Ryo[1*], SHIRAI, Masaaki[1], MURAGISHI, Jun[1]

[1]Tokyo Metropolitan University

Tsunami deposits are important evidences of paleo-tsunami and paleo-earthquake. However, studied on tsunami deposits around the shoreline have not been reported frequently, because it is believed that tsunamis generally erode coastal topographies. We investigated beach deposits at the Turishihama Beach, Shinchi Town, Fukushima Prefecture on July 17, 2011. We found the deposits, which are inferred as being formed by the 2011 off the Pacific Coast of Tohoku Earthquake Tsunami (2011 Tohoku Tsunami).

Survey at the Turishihama Beach had been carried out before the 2011 Tohoku tsunami on October 17, 2010. Comparing to before the 2011 Tohoku tsunami, backshore was thicker and flatter; the gradient of foreshore was higher. On the backshore, a 50 cm pit was excavated and backshore deposits were observed. The deposits composed granule to medium sand. A wedge shaped granule layer between 33 to 40 cm depths from the surface showed landward dipping (N45W, S12) on its top. The granule layer was overlain high-angle landward dipping sand-granule cross laminae layer. Although land shape of berm dips landward, its gradient is shallow than 10 degrees. Therefore, observed granule wedge and overlying sand-granule layers may have been formed unusual backshore environment, that is the 2011 Tohoku tsunami run-up. Further analyses are planned for elucidate depositional process and origin of these deposits.

Keywords: The 2011 off the Pacific Coast of Tohoku Earthquake, tsunami deposits, backshore

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

MIS25-P03 Room:Convention Hall Time:May 20 15:30-17:00

Possible onshore-dominated source of tsunami deposits of the 2011 Tohoku tsunami: a case study from northern Fukushima

SULASTYA PUTRA, Purna[1*], Yuichi Nishimura[1], Yugo Nakamura[1], Eko Yulianto[2]

[1]Institute of Seismology and Volcanology, Hokkaido University, [2]Research Center for Geotechnology, Indonesian Institute of Sciences

We surveyed the tsunami deposits of 2011 Tohoku tsunami at Matsukawaura and Yunuki, two lowlands in northern Fukushima. The presence of a lagoon at Matsukawaura and river at Yunuki makes these locations are the best location to study the source of tsunami deposits. Matsukawaura is a flat area, and it was a paddy field before inundated by tsunami. At Matsukawaura we surveyed and sampled every 200 m along 2 km transect. Our first point is just behind the lagoon. The inundation distance was around 3.8 km, and our last point was about 300 m before inundation limit. The tsunami height was around 9 m. The tsunami deposits here composed of sand and mud layers. The mud is black and along the transect the mud is distributed in the upper part of the tsunami deposits; however it is sometimes intercalated between the sand. The thickness of the mud is from 1 to 10 cm, and the thickness of the sand is from 3 to 10 cm. Sometimes, within the sand, rip-up clasts are present.

Yunuki is a flat (1.5 x 5 km2) valley located around 7 km south of Matsukawaura. The inundation distance was about 4.5 km, with tsunami height about 10 m. At Yunuki, we surveyed the tsunami deposits along 4.1 km transect (longitudinal transect). We also surveyed the tsunami deposits crossing the river (transversal transect). Total 26 points for longitudinal transect and 11 points for transversal points were observed and sampled. In general the tsunami deposits are composed of sand layer covered by mud. The sand sometimes laminated. This laminated sand deposited above the massive or graded bedding sand.

To understand the main source of these tsunami deposits, we perform foraminifera and mineral composition analysis of beach, dune, lagoon, and tsunami deposits. Examples of foraminifera found within the tsunami deposits are genus of Elphidium, Haynesina, Rotalia. Some species of Elphidium, Haynesina are typical of lagoon spesies.

Based on the percentages of foraminifera, shell fragments and mineral composition, the possible main source for tsunami deposits at Matsukawaura were dune (30%) and lagoon (35%), meanwhile at Yunuki the possible main source was the dune (70%). This novelty result is very important because we always thinking that tsunami deposits mostly sourced from offshore area, and now we understand that tsunami deposits can also mostly sourced from onshore area.

Keywords: tsunami deposits, onshore source, Yunuki and Matsukawaura, foraminifera, tsunami Tohoku 2011

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

MIS25-P04 Room:Convention Hall Time:May 20 15:30-17:00

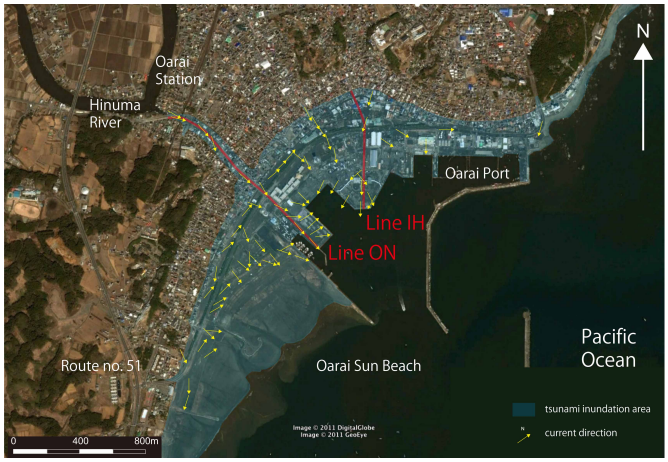
Relationship between tsunami inundation and sand distribution due to the 2011 Tohoku Earthquake tsunami

SHIGENO, Kiyoyuki[1*], Shota Arai[1], NANAYAMA, Futoshi[2], ITO, Takashi[1]

[1]Ibaraki University, [2]AIST

The great earthquake off the Pacific coast of Tohoku was a magnitude Mw 9.0 undersea megathrust earthquake off the coast of Japan that occurred on 11 March 2011. The earthquake triggered powerful tsunami waves that reached heights of up to 40.5 m in Miyako, and which, in the Sendai area, travelled up to 10 km inland. There were three invasions and maximum height was 4.2m at Oarai, Ibaraki Prefecture, and then tsunami came out serious damage for Oarai port and downtown areas. Just after the tsunami, we went there and described tsunami inundation and tsunami sedimentation. In our presentation, we report the relationship between tsunami inundation area and sand distribution due to the 2011 tsunami in this area.

Keywords: 2011 Tohoku Earthquake, tsunami inundation area, sand distribution, Oarai, Ibaraki Prefecture, Oarai Port, Tsunami deposit



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

MIS25-P05 Room:Convention Hall Time:May 20 15:30-17:00

Tsunami sandy sediments of the coastal forest reserve in Asahi city, Chiba Prefecture, central Japan

KODAMA, Satoko[1*], HISADA, Ken-ichiro[2]

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3.11 gigantic tsunami hit Pacific coast of NE Japan and human damage was extended to Chiba Prefecture. Sandy tsunami sediments were distributed in the forest reserve at Yasashigaura coast 3 km west of Asahi city downtown, Chiba Prefecture. The mud drape covering current ripple was discovered there. This mud drape covering current ripple indicates that the stagnant water situation occurred when the gigantic tsunami hit and when tsunami water overflowed artificial bank 5.4 m high into the forest reserve.

The grain size analysis of rippled sandy tsunami sediments collected from the forest reserve indicates that grains less than 0.25 mm occupy 93%, and the threshold velocity attains 25.2 to 29.9 cm/s. The current producing current ripple was concluded to be due to outflow of tsunami, because the direction suggested by all fallen pine trees was different from that of rippled sediments; all pine trees were fell down by hitting of inflow.

In this paper, inflow and outflow of tsunami water flow in the forest reserve will be discussed based on the rippled sediments and fallen trees and grasses. In conclusion, referring to DVD recorded at the near-by light house, it proves that sandy tsunami sediments were produced by 1st and 4th hits of tsunami.

Keywords: inflow, outflow, sandy tsunami sediment, ripple, mud drape, land form

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

MIS25-P06 Room:Convention Hall Time:May 20 15:30-17:00

Behavior of the 2011 Tohoku Tsunami inundated in Taro area (Miyako City) inferred from the distribution of flow traces

TACHIBANA, Toru[1*]

[1]Soil Engineering Corporation

An outsized tsunami generated by the 2011 off the Pacific coast of Tohoku Earthquake swept the wide area along the Pacific coast of the Japan Islands. Taro area in Miyako city (Iwate prefecture) is one of severely damaged cities. This area is located near the rupture zone of this earthquake and situated in the inner part of a narrow bay along the Sanriku Coast. The area has been repeatedly destroyed by tsunamis such as the 1986 Meiji Sanriku Tsunami and the 1933 Showa Sanriku Tsunami. Hence, various mitigation measures against tsunamis were taken in the area. For example, roads in Taro area were planned to be easy to escape from tsunamis; the large embankments of 10 m high and 2.4 km long were built, surrounding the central part of the area. Nevertheless, the 2011 tsunami completely destroyed the area again.

Based on huge damages of the 2011 tsunami, disaster prevention plan against tsunamis are reconsidered in Miyako city. The field survey along the Sanriku Coast, which was immediately conducted after the tsunami, shows basic information on the 2011 tsunami in Taro area: run-up height and inundated area. However, behavior of the tsunamis inundated into the area, however, is still unclear. Therefore, we report the tsunami behavior based on tsunami traces collected by a field survey in Taro area.

We take notice tsunami traces left on artificial objects. In urbanized area, tsunami traces such as tsunami deposits are rare, whereas those left on artificial objects such as concrete structures or asphalt-paved roads are abundant. Some of these traces record directions or orientations of tsunami flows and become clues to clarify behavior of the tsunami.

Our field survey was conducted in November, 2011 (about 8 months after the 2011 tsunami). In this survey, about 300 points of tsunami traces were observed and flow directions or orientations left in them were measured mainly on the embankments and the roads. These traces are categorized into two types of flow traces. One type of traces is linear scrape on flat surfaces of concrete structures or asphalt-paved roads. This type is left by some objects dragged by the tsunami such as ships, building materials, or gravels. Directions of the scrapes indicate those of tsunami flows. Another type is bending of poles such as street lights or utility poles. This type is formed by some objects that are moved by tsunami flows, and hit and bend poles. Bending directions of the poles reflect those of tsunami flows.

Distribution of flow traces of the 2011 tsunami in Taro area are interpreted assuming that these traces were left by the strongest rup-up and backwash currents in the tsunami. Representation of behavior of the tsunami is summarized as multi-directional run-up currents shifted by landform and the embankments and backwash currents showing nearly direct routes to the sea.

Keywords: tsunami, 2011 Tohoku Earthquake, flow trace, Taro, Miyako

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

MIS25-P07 Room:Convention Hall Time:May 20 15:30-17:00

Transportation and deposition of tsunami boulders and an onshore gravelly tsunami deposit

YAMADA, Masaki[1*], FUJINO, Shigehiro[2], GOTO, Kazuhisa[3]

[1]University of Tsukuba, [2]University of Tsukuba, [3]Chiba Institute of Technology

Tsunami deposits in stratum give helpful information for disaster prevention such as inundation area of paleotsunamis and recurrence intervals. To identify tsunami deposits in strata, it is necessary to show as many criteria as possible. Whereas most of the recent tsunami deposits that have been reported so far are composed of sand, gravelly tsunami deposits are rarely reported. While, gravely paleotsunami deposits are often identified in the stratum. Description of the various grain sizes will clarify the diversity of tsunami deposits, and provide criteria to identify tsunami deposits in strata.

This paper reports relationship between tsunami behaviors and characteristics of onshore gravelly tsunami deposits at Settai, Taro-cho, Miyako City, Iwate prefecture, Japan that were inundated by the 2011 Tohoku-oki tsunami. In this region, the highest point of inundation height was 28.1 m and the inundation distance reached to 1.8 km from shore. As a result, lowlands that had been used to paddy fields were covered by tsunami deposits. Moreover, many boulders such as bits of concrete, tetrapod and rock were transported from shore. The deposition of the boulders and tsunami deposits in Settai is one of the rare cases in the sense that wide range of sedimentary grains are left concurrently by a tsunami. Because the methods to estimate the current velocity from transported boulders have already been established, the boulders and tsunami deposits can be a research object to examine relationship tsunami behaviors and characteristics of the deposits.

Boulders are concentrated in some areas rather than scattered in the lowland. Changes in current velocity and current direction due to geographical factors probably affect the characteristic distribution of the boulders. The obtained data show a sharp decline in thickness and gravel size of the gravelly tsunami deposits where many of the boulders are stopped. This indicates that many of the sand and gravel were deposited as the current velocity diminished and the boulders were stopped. The current velocity estimated from larger boulders is 8.0 m/s or more. In the future, the more studies that weigh the boulder and tsunami deposit can be expected to estimate the current velocity of past tsunami from paleotsunami deposits.

Keywords: 2011 Tohoku-oki tsunami, gravelly tsunami deposit, boulder, current velocity

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

MIS25-P08 Room:Convention Hall Time:May 20 15:30-17:00

Tsunami deposits by the 2011 Tohoku Earthquake -observation from the estuary of kuji, natsui river and fudai beach-

SEO, Nanami[1*]

[1]Division of Human Environmental Science | Faculty of Human Development, Kobe University

I Study of tsunami deposits in Kuji, Iwate Prefecture and Fudai beach.
The estuary in Kuji,I observed tsunami deposits,and got the sample.
Layer thickness was about 30cm,the bottom had various size Gravel and sand substrate,poor selection.13-24cm layer had fine grained upqaward,0-13cm layer had massive sand layer and observed a lot of piece of mica.
Results of observation of benthic foraminifera,live in shallower than 20-33m
were rich.
Sandbar at the estuary was eroded,and lagoon had been reduced.
Also in Fudai,sandbar was eroded and lost.

Keywords: Tsunami deposit, The 2011 Tohoku Earthquake, Tsunami, Kuji river, Natsui river, Fudai beach

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

MIS25-P09 Room:Convention Hall Time:May 20 15:30-17:00

Facies and chemical analysis of the 2011 Tohoku earthquake tsunami deposit for identification of paleotsunami deposit

SASAKI, Toshinori[1*], YOSHII, Takumi[1], ITO, Yuki[1], UETA, Keiichi[1], AOYAGI, Yasuhira[1], MATSUYAMA, Masafumi[1], Satoshi Kanaguri[2], Makoto Yanagida[2], OKUZAWA, Koichi[3], Masakazu Watanabe[3], Takahiro Iida[3]

[1]CRIEPI, [2]Hanshin Consultants, [3]Ceres

The 2011 Tohoku earthquake accompanied gigantic tsunami that caused severe damage along the Pacific coast of Hokkaido, Tohoku and Kanto districts.

We have conducted facies and chemical analysis of the tsunami deposit for identifying paleotsunami deposits at the Sanriku-cho, Ofunato city. We carried out the observation of these deposits by pit and boring survey in the field, and grain size analysis, EC, ion analysis, stable isotope analysis in the laboratory.

We will present a detailed result and conclusion at the poster.

Keywords: The 2011 Tohoku earthquake, Tsunami, Tsumani deposit, Facies, Chemical analysis, Paleotsunami deposit

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

MIS25-P10 Room:Convention Hall Time:May 20 15:30-17:00

Microtopography formed by the 2011 Tohoku earthquake tsunami and facies of tsunami deposit at Yoshihama, Iwate

SASAKI, Toshinori[1*], Makoto Yanagida[2], UETA, Keiichi[1]

[1]CRIEPI, [2]Hanshin Consultants

The 2011 Tohoku earthquake accompanied gigantic tsunami that caused severe damage along the Pacific coast of Hokkaido, Tohoku and Kanto districts.

We have conducted microtopography and facies analysis of the 2011 Tohoku earthquake tsunami deposit at the Sanriku-cho, Ofunato city. We carried out the observation of topography using detailed DEM after the earthquake, and facies analysis in the field. Distribution of tsunami deposit have crevasse splay like topography. There are a lot of dunes in this distribution area.

We will present a detailed result and conclusion at the poster.

Keywords: The 2011 Tohoku earthquake, Tsunami, Tsumani deposit, Microtopography, Facies analysis

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

MIS25-P11 Room:Convention Hall Time:May 20 15:30-17:00

Two types of Tsunami deposits in Kujukuri Coast at the 2011 Tohoku Earthquake

OKAZAKI, Hiroko[1*], OHKI Jun'ichi[1]

[1]Natural History Museum and Institute, Chiba

Tsunami caused by the 2011 Tohoku Earthquake brought terrible damage to Pacific Ocean side of Boso Peninsula, eastern part of Japan. This report described Tsunami deposits in Kujukuri Coast at the earthquake. Kujukuri Coast is sand beach, 60km long, along the northeastern part of Boso Peninsula. Recently, a supply of sand decreases and a man-made change is remarkable in the coast. The height of tsunami was approximately 2.5m (at Choshi) and raised northeastward remarkably. A coastal Tsunami deposits varied depending on the height of the tsunami and the existence of the artificial component and the width of sand beach.

Keywords: Tsunami deposits, Kujukuri Coast, 2011 Tohoku Earthquake

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

MIS25-P12 Room:Convention Hall Time:May 20 15:30-17:00

An application of facies analysis and tsunami deposit investigation using X-ray CT images of the boring cores

TATEISHI, Ryo[1*], SASAKI Toshinori[2], SHIMADA Koji[1], IWAMORI Akiyuki[3], HARADA Hiroaki[3], MORI Toshio[4], UETA Keiichi[2], SUGIMORI Tatsuji[5], YAMANE Hiroshi[5], KITADA Naoko[6], ECHIGO Tomoo[6]

[1]JAEA, Monju, [2]CRIEPI, [3]The Kansai Electric Power Co. Inc, [4]The Japan Atomic Power Co., [5]Dia Consultants, [6]GRI

Introduction: As a part of tsunami deposit investigation (Shimada *et al.*, 2012, this session), the boring survey was carried out in the lake Kugushi, central Japan. Four boring points (KG11-1 to KG11-4, from north to south) were set along N-S direction and another one (KG11-5) was placed in SW part of the lake. We discuss the transition of sedimental environment after the Heian Period within 1m thicknesses of the cores and the existence of the evidence for the large tsunami generated by the Tensho earthquake, occurred at AD 1586.

Regional settings and methods: The Mikata-goko area is located in subsidence side of the Mikata fault (N-S strike, E dip). The blackish lake Kugushi has N-S major axis and connects to Wakasa bay by the river cutting beach ridge in northern part of the lake. Main source of sediment supply into the lake was the old-Kiyama river along the Mikata fault before the Kanbun earthquake, occurred at AD 1662. The old-Kiyama river was closed due to uplift by the earthquake, and the main source was altered to an artificial canal through another lake. The old-Kiyama river delta remains in southern part of the lake Kugushi.

Facies analysis based on observation of the cores by eyes and X-ray CT images, and 14C dating was operated.

Results: As a result of the facies analysis, the bed is classified into three groups, III, II and I from lower to upper. The bed III, which mainly consists of organic fine silt, shows uniform grain size distribution in macro scale, but contains thin units typically composed of a pair of an erosion surface with clastic mud overlied by graded silt. The bed II mainly consists of highly bioturbated organic coarse silt and contains granule-sized clast. The bed I mainly consists of organic-rich fine silt and contains shell fragments.

Mean sedimentation rate are 0.5m/ka (KG11-1 and KG11-5) and 0.8m/ka (KG11-2, KG11-3 and KG11-4), based on the obtained 14C ages.

Sedimental environment: The bed III is interpreted to represent the deposits of quiet lake. The coarse-grained units are interpreted as the deposits of minor river flood. The bed II is interpreted to represent the deposits of prodelta. Upward coarsening from the bed III to the bed II and high sedimentation rate (see below) suggest progradation of the old-Kiyama river delta. Dominance of bioturbation suggests activation of the bioactivity as a result of shallowing of the lake. The bed I is interpreted to represent the deposits of quiet lake.

The sedimentation rate of the bed II are about 0.4m/ka (KG11-1), 1.6m/ka (KG11-2 and KG11-3) and 0.8m/ka (KG11-4 and KG11-5). These differences probably depend on influence range of the old-Kiyama river flow. The assumed sedimentation rate of the bed I is low in each core (about 0.1m/ka to 0.4m/ka).

The acceleration of the sedimentation rate through the bed III and the bed II, is thought to be artificial effects in the Heian Period. The 14C ages around the boundary are Cal AD 540-620 (KG11-1), Cal AD 780-980 (KG11-2), Cal AD 890-1020 (KG11-3) and Cal AD 890-990 (KG11-5). The deceleration of the sedimentation rate through the bed II and the bed I, is thought to be decrease of the sediment supply by the uplift of the old-Kiyama river. The 14C ages around the boundary are Cal AD 1150-1260 (KG11-1), Cal AD 900-1030 (KG11-2), Cal AD 1290-1410 (KG11-4) and Cal AD 1700-1920 (KG11-5).

The Tensho earthquake: Some historical records mentioned the large tsunami attacked the Wakasa Bay area at the Tensho earthquake. If it was true, the evidence should remain beneath the boundary of the bed II and the bed I. But, no clear erosion surface or coarse-grained deposits can be detected by analysis of high-resolution X-ray CT images (0.5mm pitch: correspond to 0.5~1.0yr) at the horizon. Thus, the evidence of large tsunami as mentioned in the historical records is not recognized.

Keywords: lake deposit, boring core, X-ray CT image, tsunami deposit, infrequent gigantic tsunami

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

MIS25-P13 Room:Convention Hall Time:May 20 15:30-17:00

An evaluation flowchart for detection of infrequent gigantic tsunami and the case study in the Wakasa Bay area

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Introduction : We propose an evaluation flowchart for detection of infrequent gigantic tsunami, which rapidly provides accurate and practical solutions applicable to the coastal important installations. We have investigated the tsunami deposit at the coast of the Wakasa Bay in the Sea of Japan, after the 2011 Off the Pacific Coast of Tohoku earthquake. The X-ray CT images of unconsolidated lagoon sediments captured during our case study is effective in facies analysis and enabled us to develop the evaluation flowchart. The objective of the flowchart is gigantic tsunami because tiny ones affect no damage on the coastal important installations. ***Philosophy of detection of infrequent gigantic tsunami*** : No tsunami deposit has been reported in the Wakasa Bay area. A lack of subduction zone along the coast of the Sea of Japan seems to result in the infrequency of gigantic tsunami generated by mega-earthquakes. Thus, investigation method for tsunami deposits supported by a comparison with descriptions in historical materials such as the way along the Pacific coast may overlook indications of infrequent gigantic tsunami in the study area. The purpose of our investigation is accumulation of information regarding traces of infrequent gigantic tsunami. Objective strata are Holocene and partly Upper Pleistcene. We aim to detect sand layers contained within fine-grained sediments. Sand layers showing synchronous and regional characteristics (Umitsu, 1999) can be used as a common marker (hereafter, a marker sand layer) to be examined whether it is a tsunami deposit which makes a subject of us in view of a possibility of infrequent gigantic tsunami. ***Selection of the boring point*** : We selected 9 points composed of 5 points in the lake Kugushi and 2 points on neighboring land, each 1 point in the lake Suga and the Nakayama marsh in consideration of continuous sedimentation of fine-grained materials, distribution of beach sand, distance from shoreline, elevation, and path of tsunami. Representativeness of the area in the Wakasa Bay was checked by the commonness of the recent tsunami height and propagation of simulated tsunami. ***Sampling*** : Soft sediments of bottom of lakes and the marsh were successively sampled using boring machine with advanced thin-wall sampler. ***Analyses*** : Observation of half-cut cores, and measurements of magnetic susceptibility (using U-channel), wet and dry weight, and color were carried out. Dating (14C) by AMS method and tephra analysis were also carried out. These systematic analyses assist objective judgment on the absence or existence of the marker sand layer. ***The judgment*** : Sediments are composed of silt in the lake Kugushi and the lake Suga, or organic materials in the Nakayama marsh (upper 2 m portion of each core). There is no marker sand layer at least after Cal AD 240-400 (2 sigma) based on the analyses. We judged that gigantic tsunami accompanied by deposition of marker sand layers did not occur during the period of sedimentation. The result is concordant with the result of interview survey regarding historical tsunami record to priests of Shinto-shrines in the coast of the Wakasa Bay area, who said there had been no record of tsunami since the Heian-period. ***Additional examinations*** : The X-ray CT analysis of the upper most sections (ca. 1 m depth) of lake sediments clearly shows weak sedimentary structures or trace fossils that are mostly undetectable by naked eye. Despite such capability, no marker sand layer was detected. Detailed discussion can be seen in Tateishi et al. (2012, this session). Although there are no marker sand layers, we further examined nanofossils and diatoms for detection the inflow of seawater into these lakes. Predominance marine nanofossils in specific horizon have not been observed. Much inflow of seawater during short term by gigantic tsunami did not happen. Nanofossil analysis should be indispensable in our flowchart if the marker sand layer was detected.

Keywords: infrequent gigantic tsunami, tsunami deposit, evaluation flowchart, boring core

Japan Geoscience Union Meeting 2012
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MIS25-P14 Room:Convention Hall Time:May 20 15:30-17:00

Classification of the survey contents in the syudy of tsunami deposits in Japan

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Japanese text only

Keywords: tsunami deposits, Japan

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MIS25-P15 Room:Convention Hall Time:May 20 15:30-17:00

The 2000 years ago tsunami event in the Kamoda-oike pond, eastern end of Shikoku Island

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Nankai earthquakes are plate boundary earthquake associated with the Nankai Subduction Zone that have been recorded in historical documents a total of nine times since the Tenmu Nankai earthquake in A.D. 684. In order to reveal pre-historical evidence of Nankai earthquakes, we investigated core sediments from ponds and lakes on the coast of southwestern Japanese Islands along the Nankai Trough.

We collected eight vibrocore samples from the Kamoda-oike pond which located in eastern end of Shikoku Island. Stratigraphical study and radiocarbon dating of these samples revealed that Kamoda-oike pond recorded only one tsunami event in 2000-2300 years ago during last 3500 yeares.

Keywords: Nankai earthquake, tsunami sediment

Keywords: tsunami sediment, Nankai earthquake

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MIS25-P16 Room:Convention Hall Time:May 20 15:30-17:00

The 17th century tsunami age in Hokkaido estimated from the core bored at Lake Harutori-ko, eastern Hokkaido

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Eastern Hokkaido is a severe Earthquakes and Tsunamis district occurred at Kuril trench in Pacific Ocean. The intervals of the huge earthquakes are estimated about 300˜500 years and the last event occurred in 17th century. But there is no precise tsunami age because the documents of them are only after 19th centuries. At the same time, Tohoku area had hit the huge earthquake named *Keicho Sanriku* Earthquake (1611). Some hypothesis says the 17th century tsunami in Hokkaido corresponds to *Keicho Sanriku* Earthquake. So it is important to estimate the tsunami age.

We analyzed the core sample and thin section from Lake Harutori-ko located in southeast of Kushiro city, eastern Hokkaido. There are 17th century tsunami deposits, lamina and tephra (Ta-b: 1667) in order into 16.5 cm long thin section. We observed thin section in microscope of 1000 magnifications to identify diatoms, which is important component of limnological lamina.

On the microscopic observation of the sedimentary and microfossil assemblages, about 30 laminae with light and dark layers were observed. 75 species belonging to 40 genera are identified in this sediment. In addition to them, plant opal, silicoflagellate and chrysophycean cysts are observed. Diatom assemblages are cyclically changed in related to the laminated structures. Those changes presumed that laminated structures might be formed by seasonal lake environmental changes. Therefore we could decide the detail dating of the 17th century tsunami by counting of the laminae.

Keywords: Tsunami deposit, Diatom, Lamina, Eastern Hokkaido

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

MIS25-P17 Room:Convention Hall Time:May 20 15:30-17:00

Correlation of paleo-tsunami layers based on grain size and sediment composition, eastern Hokkaido

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Geological study of tsunami deposits is the most reliable method to reconstruct properties of paleo-tsunamis along the Kuril trench because there are no historical records on earthquakes before the 19th century in eastern Hokkaido. Correlation of event layers is needed to discuss the scale and behavior of paleo-tsunami. In general, the correlation of a tsunami layer is based on its thickness, depositional structures, marker tephras, and radiometric ages. Thickness and depositional structures are, however, affected by micro-topography. Thus, the tsunami deposits extend over a distance of hundreds meters are difficult to correlate. On the Pacific coast of eastern Hokkaido, only few marker tephras are available and are insufficient for chronology before the 17th century. In spite of recent developments of radiocarbon dating, the error of measurement often exceeds several centuries. In many cases, no dating samples are available. The present study attempts to correlate tsunami layers on the basis of the particle size distribution with a precision of 1/16 phi, component materials, diatom assemblage, and chemical composition of volcanic glass and orthopyroxene. Particle size distribution was measured with Camsizer (Retsch Inc.).

Field surveys were done on five peat lands in eastern Hokkaido; Urahoro, Kinashibetsu, Onbetsu, Akkeshi, and Nemuro. Deposits were excavated using the Geoslicer (100 and 150 cm length). The tsunami sand samples were taken from every two cm and from every sub-unit.

Between Tarumae-c tephra (Ta-c, ca. 2700 yBP) and Komagatake-c2 tephra (Ko-c2, AD 1694), eight sandy layers were identified at Urahoro (U1 - U8), two layers at Kinashibetsu (K1 and K2), four layers at Onbetsu (O1 - O4), two layers at Akkeshi (A1 and A2), and seven layers at Nemuro (N1 - N7). These layers were recognized as paleo-tsunami deposits, because they contained marine and blackish diatoms and well-rounded sand grains. Their grain size distribution and mineral composition are similar to those of recent beach and coastal dune sediments. Most tsunami layers can be correlated along one transect on the basis of precise grain size distribution and mineral composition. Their variation between layers is greater than that between sites. However, sand samples collected from inland sites contain more fine grains and light minerals than samples from coastal sites. Additionally, the U1 layer in Urahoro is distinguished from others by the appearance of much orthopyroxene. The variation of mineral composition implies difference of the coastal environment, likely difference of season.

Correlation of tsunami layers suggests that U1, U2, U5, and U8 are distributed more widely than other tsunami layers in Urahoro. Likewise, widely distributed layers are O3, O1, and O2 in Onbetsu, and N2, N1, N4, and N7 in Nemuro, in that order.

At present we cannot correlate tsunami layers across five regions. However, the tsunami layers in Kinashibetsu, Onbetsu, and Akkeshi are likely correlated with thick tsunami deposits in Urahoro and Nemuro on the basis of the stratigraphic relationships between the sand layers and marker tephras.

In Nemuro area, upper sand layers contain more marine and brackish diatoms. In Kinashibetsu, Onbetsu, and Akkeshi, thickness of upper sand layers are greater than those of lower layers. These areas likely show decreasing resistance to tsunami attack.

Keywords: Tsunami deposit, Correlation, Grain size, Mineral composition, Pacific coast of Hokkaido

Japan Geoscience Union Meeting 2012
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MIS25-P18 Room:Convention Hall Time:May 20 15:30-17:00

Daitom fossil assemblages of a Tsunami deposit found at the Ota-gawa lowland, western Shizuoka Pref., central Japan

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Holocene outcrop including a tsunami deposit was found at the Ota-gwa lowland ˜3.5 km inland from the present coastline (Fujiwara *et al.*, this meeting). We performed fossil diatom analyses on a part of deposits including the sand layer and discuss environmental changes around the study area. Fossil diatom assemblages are different between the above and beneath the tsunami deposit and indicate that environmental changes occurred associated with the earthquake.

Goelogy of this outcrop consist of peat layer, mud layer, sand layer (Tsunami deposit) and silt layer in ascending order. Their thicknesses are approximately 10 cm, 10 cm, 70 cm and more than 60 cm resepectively. The sand layer was recognized over 150 m in N-S direction horizontally. The sand layer includes several sandy layers showing fining upward. It indicates that tsunami waves attacked this area repeatedly. Aoshima *et al.* (this meeting) reports that gravel components, roundness and mineral composition of this layer are resemble those of sediments around the Tenryu river and the Enshu-nada coast. Radiocarbon ages from this layer suggest that this layer was formed at 4^{th} to 7^{th} century (Fujiwara *et al.*, this meeting).

As the results of the analyses, fossil diatom assemblages show harmonic changes with the core stratigraphy. The peat layer shows dominance of fresh water species, for example *Pinnularia spp.*, *Eunotia* spp. and *Cymbella* spp. making up 10-30 % respectively. They indicates that the peat layer was formed at the fresh water marsh. In contrast, main component species of the mud layer are brackish to marine species such as *Cocconeis scutellum*, *Tryblionella granulate* and *Tryblionella lanceolata*. This feature indicates that mud layer deposited at a tidal flat. The sand layer is characterized by the mixture of fresh, fresh-brackish and brackish-marine species. Especially, *Achnanthes hauckiana*, *Rhopalodia gibberula*, and *Cocconeis placentula* increased than the underlying sediments. The silt layer coved the tsunami deposit shows the abundance of fresh and fresh-brackish species such as *Rhoicosphenia abbreviata* indicating the middle to lower part of river. The upper of the silt layer is characterized by the dominance of *Pseudopodosira kosugii* indicating the marine limit during the Holocene (Sato *et al.*, 1996).

The environmental change from fresh marsh to tidal flat between the peat layer and the mud layer indicates a relative sea-level rising. After deposition of the tsunami deposit, an environmental change from the tidal flat to the riverine estuary occurred rapidly. Radiocarbon ages suggest that this environmental change was triggered by geomorphological change due to the tsunami flows, for example mass transportation. The characteristics of the fossil diatom assemblages of the tsunami deposit indicate exotic water and sediments were transported from inland by tsunami currents flowing seaward.

Reference

Aoshima *et al.*, this meeting, Rock type and mineral compositions of the tsunami deposit from the Otagawa lowland, western Shisuoka Prefecture

Fujiwara *et al.*, this meeting, Two historical tsunami deposits from the Ota-gawa lowland, western Shizuoka Prefecture, Pacific coast of central Japan

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Keywords: Tsunami deposit, Ota-gawa lowland, diatom fossil assemblages, Holocene

Japan Geoscience Union Meeting 2012
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MIS25-P19 Room:Convention Hall Time:May 20 15:30-17:00

Researches of tsunami deposits from Holocene bay deposits in the Shimizu Plain, Shizuoka Prefecture

KOBAYASHI, Konatsu[1*], KITAMURA, Akihisa[1], TAMAKI, Chikako[1]

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In order to clarify the frequency of tsunami during the last few millennia, this study researches stratigraphic distribution of tsunami deposits from four sediment cores from Holocene bay deposits in the Shimizu Plain, Shizuoka Prefecture. As a result, three graded sand beds are detected from mud layers between -5 m and 0 m altitude. These beds contain molluscan shells which are not found from the underlying and overlying deposits. These indicate that these sand beds may be tsunami deposits.

Keywords: tsunami deposits, bay deposits, Holocene, Shimizu Plain

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MIS25-P20 Room:Convention Hall Time:May 20 15:30-17:00

Rock type and mineral compositions of the tsunami deposit from the Otagawa lowland, western Shizuoka Prefecture

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Introduction:

Composition of mineral and rock type in the sand beds is an important criteria to identify the source area of the sediments. Roundness of grains reflects the transport and depositional process and is a useful indicator to distinguish the river and marine sediments. Here we adapt these criteria to the tsunami deposit reported by Fujiwara et al. (this meeting) from the Ota-gawa lowland, on the Enshu-nada coast, near the Nankai trough and discuss the source of the deposit.

The tsunami deposit:

The tsunami deposit, ˜70 cm in thickness, was found at the excavation site of river improvements ˜3.5 km inland from the present coastline. It consists of stratified and laminated sand beds with some sub-rounded pebbles and granules and can be traced over 200 m in the coast-normal direction. The tsunami deposit covers tidal flat mud with an erosion surface and is gradually overlain by brackish silt beds (Sato et al., this meeting). Fossil shells of brackish-marine species such as (Cyclina sinensis, Corbicula japonica) are also included in the tsunami deposit. Estimated age of the tsunami deposit ranges from the late of forth century to the end of seventh century (Fujiwara et al., this meeting).

Composition and roundness of gravel:

The composition of gravel was examined using 149 pieces of gravel. Accompanied with abundant gravels of sandstone and mudstone (˜90%), granite and crystalline schist (˜3%) characterize the tsunami deposit. Granite and crystalline schist are not distributed in the drainage of the Ota river (Shimanto belt), but in the drainage of the Tenryu river (Sanbagawa belt or the Ryoke belt). Beach deposits of the Enshu-nada coast are mainly supplied from the Tenryu river and then include ˜ 9% of granite and crystalline schist grains.

We calculated the values of roundness using Krumbein (1941)'s method for the gravels from the tsunami deposit, beach deposits on the Enshu-nada coast and river floor deposits of the Ota river near the study site. The values in the tsunami deposit are 0.72 for sandstone gravels (N=46) and 0.66 for mudstone gravels (N=45). Diameter of gravels ranges from 9.5 to 26.5mm. Values in the beach deposits are 0.70 for sandstone gravels and 0.62 for the mudstone gravels and similar to the values from the tsunami deposit. On the contrary, values of river floor deposits are 0.49 for the sandstone gravels and 0.44 for the mudstone and are clearly different from that of the tsunami deposit. According to the observation in the field, gravel content in the tsunami deposit (numbers of the gravels in the deposits of 1 kg) shows a landward decreasing trend.

Mineral composition of sand bed:

Mineral composition of the sand bed was examined using 266 sand grains (0.18mm-0.71mm in diameter) obtained from the lower part of the tsunami deposit (within 40 cm from the bottom surface). Component of sand grains is lithic fragment (38%), quartz (28%), feldspar (25%), and mica (4%). Occurrence of garnet (1%) characterizes the sand beds. This mineral composition in the sand beds is similar to that of dunes on the Enshu-nada coast and the river floor deposits of Tenryu river (Yosii and Sato, 2010). Garnet is an index mineral of the sediments derived from the Tenryu river, which has the outcrops of granitic rocks in its drainage (Aoshima, 2011).

Our data strongly suggest that the tsunami deposit was mainly transported from the Enshu-nada coast by tsunami run up.

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Keywords: Ota-gawa lowland, the tsunami deposit, the Tenryu river, the Enshunada coast, roundness, garnet

Japan Geoscience Union Meeting 2012
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MIS25-P21 Room:Convention Hall Time:May 20 15:30-17:00

Geomorphic Changes due to 2004 tsunami-Kirinda Fishery Harbor, Sri Lanka

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Tsunami can erode and bring in large volume of sand and other sea bed material into the land area behind the beach. The seabed became shallower near the coast at most locations, suggesting deposition of inner shelf or deep-sea sediments in the shallow areas. A variable amount offshore material was incorporated into the deposit even though the amount and depth of erosion offshore were not quantified. Relative to the onshore study of tsunami deposition, the impact of the tsunami on the offshore bathymetry is poorly understood, due to the scarcity of pre- and post-tsunami bathymetric data, which are useful for analysing tsunami erosion and deposition offshore. Numerical sediment transport model is a better approach for understanding the offshore process of the bathymetric change by the tsunami. Even though, various models have been proposed to understand the sedimentary process of the onshore and offshore sediment transport, most of the model yet to be validated using bathymetric data immediately before and after the tsunami. The bathymetric data at nearshore zone measured by JICA on November 2004 and February 2005 at Kirinda harbor (81.3375E, 6.2181N), Sri Lanka, was recoded the bathymetric change by the 2004 Indian Ocean Tsunami. This study is assessing the onshore and offshore geomorphic changes due to tsunami in Kirinda, while testing the validity of the sediment transport model using recorded bathymetry data. Nested grid system which includes six domains with different resolution is used to simulate the tsunami propagation and inundation as well as the bed level change. First of all, bed level change in smallest domain is obtained and compare with the measured data in order to validate the sediment transport model. The model calculated erosion and deposition ratio for the Kirinda harbor after the tsunami wave is 0.61, whereas the ratio was given as 0.52 for the measured data. Furthermore, high sedimentation occurred in the bay areas because of the diffracted tsunami inflow into the bays and erosion had been noted at the headlands, as well as at the artificial coastal structures such as breakwaters. The model predicted results overall are compatible with the measured data, although the model could not perfectly demonstrated the local effects. By applying the sediment transport model for the larger domains, it is found out that about 1 m layer of sediment is eroded at 50-100 m depth by tsunami flow and deposited on the nearshore area.

Keywords: sediment transport model, geomorphic changes, tsunami