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

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

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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

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

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

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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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