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

MIS23-01 Room:415 Time:May 2 09:00-09:15

Marine biomarkers deposited on land by the 2011 Tohoku-oki tsunami

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Tsunami deposits, especially sand deposits is generally used for estimating paleotsunami event. Sand deposit is mainly identified as tsunamigenic on the basis of geological, chemical, biological, archaeological, anthropological, geomorphological, and contextual feathers, especially geological and biological features such as lateral changes in thickness and grain size of deposit, presence of marine-origin microfossils and others have been frequently utilized as identifying proxies. However, these characteristics do not always get preserved, in which case it is difficult to identify paleotsunami deposit. If evidence of seawater inundation can be detected, it became a good criterion for marine source of sand deposits. As a proxy of seawater evidence, in this study, we focused on biomarker which is molecular fossils originated from formerly living organisms. Biomarker has two advantages. One is their high preservation potential. It is confirmed to be stable in geological time scale. Another is the obvious difference between terrigenous and marine biomarkers; To take the *n*-alkane, lower *n*-alkane homologs, notably C_{15}, C_{17}, and C_{19} *n*-alkanes, tend to be predominant in many algae whereas higher *n*-alkane homologs, such as C_{27}, C_{29}, and C_{31}, tend to be predominant in leaf waxes of higher plants. To verify whether marine biomarkers are deposit on land by tsunami inundation, samples of the 2011 Tohoku-oki tsunami deposit and underlying soil were collected at Sendai and Odaka, Northeast Japan.

In Sendai, a 3 cm-thick fine sand deposits was formed by the 2011 tsunami at the top of core, and there was paddy soil beneath the sand deposits. Biomarkers were measured at 1 layer in sand deposits and 7 layers in soil deposits. Short-chain *n*-alkanes (C_{16}, C_{17}, C_{18}, and C_{19}) mainly elaborated from algae and fish were occurred only at 5-6 cm depth. It seems that theses short-chain *n*-alkanes were penetrated sandy tsunami deposit and concentrated at 5-6 cm depth. In Odaka, sand deposits were found at 8-15 cm and 18-20 cm depth, and there was paddy soil beneath sand deposits. Organic-rich mud deposits (15-18 cm depth) was intercalated between two sand layers. This mud drape was seems to be formed by first wave together with thin sand layer (18-20 cm depth), and then following waves formed thick sand layer (8-15 cm depth). Biomarkers were measured at 1 layer in surface soil deposits, 8 layers in the 2011 tsunami deposits, and 3 layers in underlying soil deposits. Short-chain *n*-alkanes (C_{16}, C_{17}, C_{18}, and C_{19}), pristane, and phytane were detected only from 20-21 cm deep. Pristane is predominately elaborated from zooplankton, benthos, and fish, while phytane is predominately elaborated from zooplankton or sediment itself by biological activity. Presence of these hydrocarbons suggests a contribution from marine/aquatic, and this characteristic is similar to the results of Sendai.

Marine origin hydrocarbons, such as short-chain *n*-alkanes, pristane, and phytane, were detected at soil layers below sandy tsunami deposits in both sites. Since no marine biomarkers were presented further deep soil layer in both sites and surface soil layer overlying tsunami deposit in Odaka, it is highly possible that these biomarkers were transported by the tsunami. Each sediment samples were collected more than two years after the tsunami, it means marine biomarkers have been preserved at least two years. Our study present the first evidence for the marine biomarkers detected from the modern tsunami event, and we propose possibility of biomarkers as a proxy of paleotsunami identification.

Keywords: biomarker, hydrocarbon, tsunami deposit, 2011 Tohoku-oki tsunami

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MIS23-02 Room:415 Time:May 2 09:15-09:30

Geochemical identification of the tsunami deposit using machine learning machine learning techniques

KUWATANI, Tatsu[1*] ; NAGATA, Kenji[2] ; OKADA, Masato[2] ; WATANABE, Takahiro[1] ; OGAWA, Yasumasa[1] ; KOMAI, Takeshi[1] ; TSUCHIYA, Noriyoshi[1]

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Tsunami deposit is a direct evidence of inundation area of past tsunamis. A large number of publications have been written about the diagnostic signatures and identification criteria for past tsunamis, including sedimentological, micropalaeontological evidences. However their identification is still difficult because all criteria is neither necessary condition nor sufficient condition due to various origin, mechanism and temporal variation of tsunami deposits. Geochemical discrimination is now recognized as other useful proxy which dose not depend on the researcher's subjectivity, especially in the case that other proxies can not be used. Especially, geochemical indicator is suggested to be useful in identification beyond the limit of recognizable sand deposition. In this study, we established the criteria for geochemical discrimination of 2011 Tohoku-oki tsunami deposits and their background marine sediments using machine learning techniques. For 18 analyzed elements, several tens of elemental combinations show the discrimination rates higher than 99%. By applying the criteria to past tsunami deposits in the Sendai Plain, we discuss the validity and effectiveness of the method.

Keywords: tsunami deposit, machine learning, Geochemistry

Japan Geoscience Union Meeting 2014
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MIS23-03 Room:415 Time:May 2 09:30-09:45

Chemical composition of historical tsunami deposits in the Sendai plain and proposal of geochemical discrimination

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A magnitude 9.0 earthquake and huge tsunami occurred off the Pacific coast of Tohoku area in Northeast Japan. After the 2011 Tohoku earthquake and tsunami, disaster science is much focused to reduce the damage around costal area, and it plays an important role as making the set of guidelines in an emergency. Because Japanese islands are located on the plate boundaries among the Pacific, Eurasian, Philippine Sea and North American plates, large earthquakes and tsunamis have repeatedly occurred during historic and prehistoric times. A huge tsunami more than 10m-height is often accompanied with submarine earthquakes around the Pacific Rim. The 2011 Tohoku tsunami was the one of the most destructive natural disasters. By the effect of that, study on earthquakes and tsunami become more and more significant, and it a major issue of social concern in Tohoku and other areas. After the 2011 Tohoku tsunami, these invasion areas were covered by a huge amount of tsunami deposits more than 10 million tons. In addition, we are able to obtain past tsunami deposits with the age of ˜1000-2000 years before present (BP) in the same area using boring corer. In order to make an expecting tsunami invasion map in other areas as soon as possible, we must provide the information about the distribution of past tsunami deposits. However, it is difficult to discriminate the one of tsunami and other events, such as storm and flood. Additionally, we must establish a new technique to detect invisible muddy and thin tsunami deposits. We need historical archives and geological proxy of past tsunami invasion, but it is rare to have both evidences in many cases. Geochemistry is useful techniques to know the source of terrestrial deposits and these weathering processes. Therefore, we tried to apply geochemical techniques in this study.

Keywords: Jogan tsunami sediments, The 2011 Tohoku tsunami, geochemistry

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MIS23-04 Room:415 Time:May 2 09:45-10:00

Scour and deposition by the 2011 Tohoku-oki tsunami at Takata-matsubara in Rikuzentakata City, Japan

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The behavior of the 2011 Tohoku-oki tsunami at the Takata-matsubara in Rikuzentakata city was reconstructed using sedimentary facies analysis, grain size properties and magnetic fabric were summarized as follows;

1) Vertical variations in grain size of the tsunami deposits show ten and several tsunami inflows and outflows of the tsunamis.

2) The deposits were mainly formed by backwash of the tsunami based on the paleocurrent analysis using magnetic fabric measurements.

3) The tsunami flow over the artificial sea wall and destroyed the sea wall with large scours on ground surface. Following ten and several tsunamis with minor wave height can ran-up in order to destroying the sea wall.

Keywords: tsunami deposits, Rikuzentakata City, shooting flow, hydraulic jump, Takata-matsubara, Seawall

Japan Geoscience Union Meeting 2014
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MIS23-05 Room:415 Time:May 2 10:00-10:15

Traces of the 2011 Tohoku-oki tsunami as seen from the topography and geology in rias coast, Iwate Pref.

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[1]TOKAI Univ., [2]FODECO, [3]COR, [4]JAMSTEC

The recent 2011 Tohoku tsunami strongly affected the coastal area of the Pacific coast of Tohoku. Tokai University with JAMSTEC investigated the Tohoku coastal area as a part of Tohoku Ecosystem-Associated Marine Sciences (TEAMS). We have succeeded in capturing traces of tsunami in various sea-bottom.

The trace in the bottom topography:Many uneven terrain has distributed around 15 ˜20m water depth. Many of its terrain is denudation mark, mark denudation of these exhibits an axial direction southeast of Toni-bay case. In the Okirai-bay a distance of approximately 20km from Toni-bay, denudation phenomenon that traces to develop in 15-25m water depth around has been confirmed. This denudation mark is presumed to have been formed by mud flowing toward the sea floor off the coast on the tsunami wave at the time of argument.

The trace in the high-resolution geo-stratigraphic survey: We have defined the A layer between the reflective surface and 1 seafloor. The A layer is located below a few tens of cm seafloor, and is widely distributed. The A layer is equivalent to the unit 1 of core samples described below. Reflecting surface enriched unevenness is also confirmed A layer below, which are estimated to be the traces of past tsunami activity.

The trace in the sea-bottom columnar core section:We estimate that the surface U-1 layer with grading structure (fine sand at the surface and coarse sand with gravel from lower part) of columnar core was the sediment gravity flow caused by the tsunami activity. The U-2 layer with bioturbation structure estimated by the normal bay sediment. There is some sandy layer with 10cm thick in the U-2 layer and also under the U-2 layer. It is estimated that these sandy layer have been formed by the historical tsunami activity.

Keywords: Tsunami deposit, Sanriku coast

Japan Geoscience Union Meeting 2014
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MIS23-06 Room:415 Time:May 2 10:15-10:30

Shallow-marine sedimentary processes of the 2011 Tohoku earthquake tsunami, inferred from sediment c

TAMURA, Toru[1*] ; SAWAI, Yuki[1] ; SAWAI, Yuki[1] ; NAKASHIMA, Rei[1] ; HARA, Junko[1]

[1]Geological Survey of Japan, AIST

While subaerial tsunami deposits have been much explored in recent years, our knowledge of shallow-marine tsunami sedimentation and its resultant deposits is limited. In August and September 2012, we practiced vibrocore drilling at 44 sites in Sendai Bay off the Pacific coast of northeastern Japan to investigate features of the open-sea shallow-marine deposits of the 2011 Tohoku earthquake tsunami and their variations. The tsunami deposit was inferred in the uppermost part of the cores based on the extent of bioturbation and concentrations of short-lived radionuclides. The preserved tsunami deposit, where identifiable, is typically 10-50 cm thick. Its grain size is basically similar to that of the original sediment at each site, which differs from medium to fine sand in the lower shoreface, through very fine sand to clay in the inner shelf, to poorly-sorted gravel, sand and mud offshore. This suggests the limited extent of cross-shelf sediment transport. Several lower shoreface sites show a yellowish coarse sand layer at the top. This yellowish layer is differentiated from the underlying greenish gray sand, and is possibly composed of beach sand transported by the tsunami backwash. In the inner shelf, the tsunami layer tends to show multiple inverse and normal grading of grain size as known in some of subaerial tsunami deposits. These features may help identify older shallow-marine tsunami deposits although more research in different settings is needed for establishing comprehensive criteria.

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MIS23-07 Room:415 Time:May 2 10:30-10:45

Sediment transport induced by the 2011 Tohoku-oki tsunami: A shallow seafloor survey at southern part of the Sendai Bay

YOSHIKAWA, Shuro[1*] ; KANAMATSU, Toshiya[1] ; SAKAMOTO, Izumi[2] ; FUJIMAKI, Mikio[3] ; IMURA, Riichirou[2] ; YAGI, Masatoshi[2] ; NEMOTO, Kenji[2] ; GOTO, Kazuhisa[4] ; SAKAGUCHI, Hide[1]

[1]JAMSTEC, [2]Tokai University, [3]Coastal Ocean Research CO., LTD., [4]Tohoku University

After the 2011 Tohoku-Oki earthquake (Mw 9.0), to examine the tsunami-generated sediment transport and topographic change, and inundation area, a large number of investigations have been conducted on land, particularly at the coastal area of Sendai plain (e.g., Goto et al., 2012, 2014). Understanding the linkage of the transport between land and seafloor is also important. In the present study, to examine the influence of the tsunami and offshore sediment transport, high-resolution shallow seismic survey, sampling of surface sediments, vibracoring, and seafloor observation by underwater video camera were conducted on the shallow seafloor at the southern part of the Sendai Bay, northeastern Japan. The present study will help to understand not only modern sedimentary process induced by tsunami but also identification of paleo-tsunami records, because our knowledge of shallow marine tsunami deposits is limited in contrast to the subaerial tsunami deposits.

One of the principal results is as follows. One or two sharp and continuous reflectors are recognized on the sub-bottom profiles in water depths approx. 6-15 m, excluding the area of outcrops in the southern part of the survey area. With decreasing water depth, depth of the reflectors from the seafloor generally increases (up to approx. 1.5 m). A comparison between the seismic profiles and vibracores infers that the sharp reflectors are erosional surface formed during the 2011 tsunami.

Keywords: shallow marine tsunami deposit, 2011 Tohoku-oki tsunami

Japan Geoscience Union Meeting 2014
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MIS23-08 Room:415 Time:May 2 11:00-11:15

Paleo tsunami events determination using radiogenic nuclides

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Recent advancement of mass spectrometry enables us to determine timing of past events using trace amounts of geological samples. Accelerator Mass Spectrometry (AMS) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) are amongst them and long-lived nuclides can be measured precisely. We have been conducted paleo Tsunami studies applying 14C and U-series dating employing these techniques. Together with geophysical modeling as well as paleo climate proxy data, paleo Tsunami events are clearly reconstructed from these measurements. Also newly developed AMS, single stage AMS, that is dedicated for 14C measurements can produce large number of data to constrain the timing in different manner. In this presentation, several examples of these studies will be introduced along with perspectives of age determinations of paleo Tsunami events.

Keywords: Radiocarbon, Accelerator Mass Spectrometry, Uranium series, Quaternary, Dating

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MIS23-09 Room:415 Time:May 2 11:15-11:30

Marker-tephras for the chronological study of tsunami deposits along the Pacific coast of Eastern Japan

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Tephras are effective markers for chronological studies of tsunami deposits along the Pacific coast of Eastern Japan. Because the information on marker-tephras in the tephra catalog of Japan and its surrounding area (Machida and Arai, 2003) is only basic, this author describes the detailed characteristics of some important tephras for their identifications.

The Kikai-Akahoya ash (K-Ah), one of representative widespread marker-tephras on the Japanese Islands, erupted 7.3 ka from the Kikai Caldera, covering most of the Pacific coastal area of Eastern Japan. Towada-Chuseri tephra (To-Cu, ca.6.0 ka), Towada-a tephra (To-a, 915 A.D.) and Baegdusan-Tomakomai ash (B-Tm, the 10^{th} century A.D.) are markers in the northern Tohoku area. To-Cu and To-a cover the southern Tohoku area, as well. Tephras erupted from Numazawa, Asama and Haruna volcanoes are useful in the southern Tohoku area. They are Numazawa Lake tephra (Nm-N, ca.5.0 k.y.BP), Haruna-Futatsudake-Shibukawa tephra (Hr-FA, the early 6^{th} century A.D.), Haruna-Futatsudake-Ikaho tephra (Hr-FP, the middle of the 6^{th} century A.D.) and Asama-Kasukawa tephra (As-Kk, 1128 A.D.).

Likewise, tephras from Asama and Haruna volcanoes are useful for chronological studies of tsunami deposits in the Kanto area. They are Asama-C tephra (As-C, the latter half of the 3^{rd} century A.D.), Hr-FA, Asama-B tephra (As-B, 1108 A.D.) and Asama-A tephra (As-A, 1783 A.D.). Tephras from Fuji, Amagi, Izu-Oshima, Niijima and Kozushima volcanoes are distributed in the southern Kanto area. As a scoriaceous tephra has difficulty in identification, it is also necessary to check its stratigraphic relationships with silisic marker-tephras, archeological and historical data and radiocarbon ages.

Machida, H. and Arai, F. (2003) Atlas of tephra in and around Japan. Unie. Tokyo Press, 336p.

Keywords: tephra, chronology, tsunami deposit, Eastern Japan, Towada-a tephra, Towada-Chuseri tephra

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MIS23-10 Room:415 Time:May 2 11:30-11:45

Modern and possible paleotsunami deposits in Samenoura, Sanriku Coast, and their relation to tsunami source mechanisms

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[1]Tohoku University, [2]Hokkaido University, [3]University of New South Wales, [4]Australian Nuclear Science and Technology Organisation, [5]U.S. Geological Survey, Pacific Coastal and Marine Science Center, [6]Adam Mickiewicz University in Poznan, [7]Tokyo University

Samenoura is situated in the bay head of a small inlet on the Pacific coast of Oshika Peninsula, one of the nearest places to the epicenter of the 2011 Tohoku-oki Earthquake. According to the Joint Survey Group, wave heights were measured at more than 20 m near the coastline. This area was severely damaged as a result of both co-seismic subsidence and tsunami inundation.

We carried out field surveys of the Tohoku-oki and paleotsunami deposits at Samenoura in March, May and October 2013. Sandy deposits laid down by the Tohoku-oki tsunami were up to 20 cm thick at locations with an elevation greater than 10 m, and were several cm thick within the forest higher up. The tsunami deposit also contained numerous shell fragments and foraminifera. Although some possible sources of the tsunami deposits can be attributed to narrow sandy beaches near the study area, the deposition of such a thick sandy deposit is more or less enigmatic, considering the steep Ria-type coastal topography.

Using a gouge auger and geoslicer, we found at least two sand layers intercalated within muddy sediments. A volcanic ash layer, which corresponds to the AD 915 Towada-a tephra, was also identified from a horizon between these sand layers. The underlying sand layer was most probably laid down by the 869 Jogan earthquake tsunami, one of the large-scale events known to have affected the region. Previous studies of the Jogan tsunami have proposed several possible source models that involve an interplate thrust earthquake. Given that the local bathymetry and topography of Samenoura Bay may be sensitive to the waveform of a large-scale tsunami, paleotsunami deposits found from this area may be the key to determining the source mechanisms of events on the Sanriku Coast.

In this presentation, the possible correlation of the sandy deposits with known paleotsunami events based on detailed radiocarbon dating is discussed. The hydrodynamic character and processes of tsunami sediment erosion and deposition in Samenoura Bay are analyzed using numerical modeling of both interplate and outer-rise earthquake scenarios.

Keywords: tsunami deposit, 2011 Tohoku-oki and 869 Jogan earthquake tsunamis

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MIS23-11 Room:415 Time:May 2 11:45-12:00

Identification and ages of paleotsunami deposits in Sanriku Coast: Trench survey in Koyadori, Iwate Prefecture

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[1]Chiba Univ. Sci., [2]OYO Co., [3]Institute of Accelerator Analysis Ltd.

We show new geological evidence of some historical tsunami deposits based on many radiocarbon dating and tephra analysis. Firstly, we sought study area matching for paleotsunami research based on geomorphological analysis and field survey, and excavated trench in coastal lowlands in Koyadori, Iwate Prefecture, northeast Japan. In trench, eleven event deposits (E1-E11: E1 is the 2011 Tohoku-oki tsunami deposits) interbedded within peat/peaty sediments were discovered. Thus, we revealed roundness of each event deposits and modern beach and river deposits to deduce the origin of event deposits. Consequently, we correlated tsunami deposits to historical tsunami events; E1: the 2011 Tohoku-oki tsunami, E2: 1896 Meiji Sanriku tsunami, E3: 1611 Keicho Sanriku tsunami, E4: 869 Jogan tsunami, and identified total eleven tsunami deposits during the last 3000-4000 years.

Keywords: tsunami deposits, Sanriku Coast, 2011 Tohoku-oki earthquake, historical tsunami, AD869 Jogan tsunami

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MIS23-12 Room:415 Time:May 2 12:00-12:15

Geological survey of paleotsunamis at Noda Village, Iwate Prefecture, Japan

GOTO, Kazuhisa[1*] ; IIJIMA, Yasutaka[1] ; NISHIMURA, Yuichi[2] ; SUGAWARA, Daisuke[1] ; YOKOYAMA, Yusuke[3] ; MIYAIRI, Yosuke[3] ; SAWADA, Chicako[3] ; NAKAMURA, Yugo[2]

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Along the Sanriku coast, pre-historic tsunami record is still poorly understood in contrast to the well-documented historical tsunamis of past 400 years. AD869 Jogan tsunami is one of these cases. The tsunami affected the Sendai Bay area, as tsunami deposits were reported on Sendai and Ishinomaki Plains, but evidence is unsure if the tsunami was also reached along the Sanriku coast. To explore the paleotsunami histories along the Sanriku coast with emphasis on the possible inundation of AD869 event, we conducted field survey along the coast of Noda Village, Iwate Prefecture. Our survey site is now occupied by paddy and the 2011 Tohoku-oki, 1869 Meiji Sanriku and the 1933 Showa Sanriku tsunamis inundated to this site. We took ˜3 m long cores and found several gravel and sand deposits in peat buried by surface paddy soil. Considering the continuous distribution of deposits over 0.7 km from the present shoreline and analytical results of grain size and mineral composition, the deposits are likely formed by the tsunami although further investigation is required. Among these tsunami-like layers, a ˜10 cm thick gravel layer is deposited below tephra layers. One of the tephra layers is identified as Baitoushan-Tomakomai tephra (B-Tm) that was deposited in early to middle 10th Century. Volcanic glasses that can be identified as Towada-a tephra (To-a) of AD915 also is observed in patches at the similar horizon as B-Tm tephra. Radiocarbon dating results above the gravel layer is consistent with the tephra chronology. These analytical results as well as tsunami numerical modeling result suggest the inundation of potentially large tsunami before early to middle 10th Century along the northern Sanriku coast.

Keywords: tsunami, tsunami deposit, Noda village, Jogan tsunami

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MIS23-13 Room:415 Time:May 2 12:15-12:30

Origin of a tsunami-drifted rock in Raga, Tanohata, Iwate Prefecture, transported by the Meiji Sanriku Tsunami in 1896.

OJI, Tatsuo[1*] ; OISHI, Masayuki[2]

[1]Nagoya University Museum, [2]Iwate Prefectural Museum

There are two large boulders on the hill of Raga, Tanohata, Iwate Prefecture. They are located at 24 m above sea level, and approximately 350 m from the coastline. Local villagers have told that these two boulders were derived as tsunami-drifted rocks at the time of Meiji Sanriku Tsunami in 1896. The eastside boulder is approximately 2-3 m in length, 2 m in width and at least 1.5 m in height, and it is estimated to weigh approximately 20 t. This boulder consists of calcarenite, containing numerous individuals of *Orbitolina* sp. that is a common large benthic foraminifera of the Lower Cretaceous. *Orbitolina* is found in '*Orbitolina* Facies' of the Miyako Group, and it is particularly abundant in the upper and uppermost part of the Hiraiga Formation. This *Orbitolina*-abundant horizon is exposed near the mouth of Raga inlet, just southwest of Hiraname coast. Therefore, this boulder is estimated to be located originally near the mouth of Raga inlet, and it should be transported as long as approximately 500 m by (a) tsunami(s). It is not certain whether this boulder was moved by one tsunami, or stepwisely by multiple tunamis. On the other hand, another boulder on the west side of the calcarenite boulder consists of conglomerate with rounded and subrounded pebbles of siliceous shale and chert, and this is considered as derived from the lower part of the Tanohata Formation, which is also exposed just on the southeastern slope of the boulder. This boulder is possibly derived from the southeastern hill, and thus it is not considered as a tsunami-derived rock. In Haipe inlet located about 1.2 km south of Raga, many new tsunami-drifted rocks have arrived onshore particularly on the northwestern side of the bay. The concentrated distribution of these rocks are in concordant with the direction of Tsunami current that came from the southeastern direction toward the erthquake epicenter located off Miyagi Prefecture. On the other hand, the tsunami-drifted rock in Raga is located in the west southwest of Raga inlet. Considering that the epicenter of Meiji Sanriku Earthquake was located off Kamaishi, this location reflects that the Tsunami current came from the east.

Keywords: Miyako Group, Orbitolina, tsunami-drifted rock

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MIS23-14 Room:415 Time:May 2 12:30-12:45

Estimation of the magnitude of tsunami earthquakes along Japan Trench -Re-evaluation of the 1677 Enpo Boso-oki tsunami-

YANAGISAWA, Hideaki[1*] ; GOTO, Kazuhisa[2] ; SUZUKI, Keita[1] ; KANEMARU, Kinuyo[3] ; SUGAWARA, Daisuke[2] ; YANAGISAWA, Hinako[2] ; HASHIMOTO, Kohei[2] ; IWAMOTO, Naoya[4] ; TAKAMORI, Yoshibumi[5]

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Along the Japan Trench, unusual earthquakes sometimes trigger much larger tsunamis than expected from their seismic waves, which were called ”Tsunami earthquake”. The Enpo Boso-oki earthquake tsunami on November 4th of 1677 killed more than 500 persons was a so-called ”Tsunami earthquake”. The magnitude of this earthquake and tsunami has been estimated based on the historical documents which were recorded more than three hundred years ago. However, it is difficult to conduct accurate estimation for the magnitude of the 1677 earthquake and tsunami because the documents include ambiguous and insufficient descriptions. The aim of this study is to determine the magnitude of the 1677 earthquake and tsunami integrating the analysis of historical documents, field survey of tsunami deposit and numerical simulation. From field survey in Choshi city, Chiba prefecture, we found the candidate tsunami deposit in the Kobatke pond. Radiocarbon dating and tephra analysis indicated that the sand deposit was formed between AD1100 and AD1700. Based on these results as well as the interpretation of historical documents, we concluded the sand deposits were formed by the 1677 Enpo boso-oki earthquake tsunami. We further conducted numerical simulation to estimate the magnitude of the earthquake and tsunami and the magnitude of the 1677 earthquake was estimated as Mw=8.34. This magnitude is equivalent to that of the 1896 Meiji Sanriku earthquake tsunami which is well known as ”Tsunami earthquake”. Our results would be very important information to understand the magnitude and nature of ”Tsunami earthquake” along Japan Trench.

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MIS23-15 Room:415 Time:May 2 14:15-14:30

The assemblages of foraminifera in paleo-tsunami sediments on Ishigaki island

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The Ryukyu subduction zone is generally believed to be aseismic because no large thrust earthquake (M>8) has recently occurred; GPS velocity vectors on the islands are parallel but opposite to the relative motion of the oceanic plate. These observations support the idea that the Ryukyu trench is aseismic or unlocked. However, in 1771 a tsunami struck Ishigaki and Miyako islands with the maximum run-up height of 30 m and caused destructive disaster, which implies that a significant earthquake occurred along the Ryukyu subduction zone. According to Nakamura (2009), the source of this event is a tsunami (slow) earthquake near the Ryukyu trench. Moreover, slow-slip events at depths of 30km (Heki and Kataoka, 2009) and very-low frequency earthquakes at shallow depths near the trench axis (Ando et al., 2012) have been identified in the western Ryukyu trench. These findings suggest that the western Ryukyu subduction zone has a potential to generate large thrust earthquakes.

To estimate recurrence intervals and sizes of paleo-tsunamis near the Ryukyu trench, we excavated Holocene deposits at 5 sites on Ishigaki Island during the years of 2011 to 2013. We analyzed the assemblages of foraminifera in the sediments that were transported by tsunamis from the deep seafloor. Most of foraminifera detected from the deposits are benthonic and planktonic foraminifera are rare in all samples at the excavation sites. Species of benthonic foraminifer such as *Calcarina defrancii* (living at 15 to 50 m depths) are dominant in the tsunami deposits compared to the current beach sand. In addition, some mesopelagic species that commonly live at continental shelf depths are also identified from the tsunami sediments. We found that the percentage of mid epipelagic and mesopelagic species in the deposits can provide a significant key to identify paleo-tsunamis. On the western Ishigaki Island, if the population density of these species in a deposit exceeds 10 %, it can be concluded as a tsunami origin, while on the eastern coast if the population density exceeds 20 %, it can be a tsunami deposit because of the bathymetric reasons.

Together with the results of stratigaraphic facies and C14 dating data of the above tsunami sediments, we identified three large tsunamis (similar to the 1771 tsunami) in the past 2000-3000 years: in 1771, between 10-11th C and between 2000 and 2900 cal. B.P. The average recurrence interval of large earthquake was found to be very long, 500 to 1000-2000 years along the western Ryukyu trench.

Keywords: tsunami sediments, foraminifera, Ryukyu dubduction zone, paleo-tsunami, 1771 tsunami

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Tsunami sediment in the Okinawa Island

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The occurrence interval of mega-tsunamis in the south Ryukyu arc was estimated to 200-500 years from the ages of tsunami boulders (Nakata, Kawana 1994, Araoka et al., 2013). The source of 1771 Yaeyama tsunami (Meiwa tsunami), which was the latest mega-tsunami, is interpreted as the M8 class thrust-type earthquake in the Ryukyu trench from the numerical simulation of tsunami. However, past tsunamis have not been found in the central Ryukyu arc because the tsunami boulders were not detected in this area. No tsunami records were documented in the old literatures of central Ryukyu arc. We conducted a tsunami sediment survey in the Okinawa Island to investigate the history of large tsunami on the central Ryukyu Trench. We performed drilling survey from 4 to 15 March 2013 in the Okinawa Island in a collaboration with the coastal disaster prevention section of civil engineering and construction division, the Okinawa Prefectural Office. Survey sites were is Kijoka (Ogimi Village), Teima (Nago), Yaka (Kin Town), Yagi (Nakagusuku Village), Oyama (Ginowan). The sand layers, which have the possibility of tsunami sediments, were found at the cores samples of Teima and Yagi from visual observation. Then, we analyzed the sand layers and their overlying and underlying layers, and compared them with the sand layers. Teima-1 (elevation 4.5m, 0.4km from the coast) is located at the back marshes of the inner part of Oura Bay. We collected five samples at the depth between 1.85m to 1.25m from the surface ground. Yagi1-3 (elevation 2.8-3.1m, 0.1-0.2km from the coast) are located at the coastal lowlands along Nakagusuku. We collected 7 samples at the depths between 0.8m to 4.15m at Yagi-1, 4 samples at the depths between 1.35m to 2.05m at Yagi-2, and 1 sample at the depth of 1.95m at Yagi-3. Furthermore, we sampled modern coastal sands near the survey sites. First, the samples were charged with 10-fold diluted hydrogen peroxide solution after drying completely at the temperature of about 60 degrees. Then samples were washed by the water flow during sieving 63um. After that, the samples were divided to a particle size of five types for using sieve. Foraminifera analysis method was conducted the particle size of 1.00mm ˜0.5mm from sample collection. We picked the samples so as to contain over 150 individuals of foraminifera. Next we classified them to dominant species foraminifera and other species. In addition, we compared their foraminifera composition with those of modern coastal sand, and estimated the origin of the sediment. From the core samples of Teima-1, we detected 3 individuals of *Anomalinella* at the depths of 1.55 m and 1.65 m, and 2 individuals of *Calcarina Mayori* at the depth of 1.65 m. This suggests that the sediments at the depths of 1.55 m and 1.65 m were moved from out of the reef because these species live out of the reef. From the core samples of Yagi-1, we detected 2 individuals of *Anomalinella* at the depths of 3.75 m and 3.85 m, and 4 individuals of *Dendritina* and 3 individuals of *Operculina* at the depth of 3.75 m. Since these species live out of the reef, the sediments at the depths of 3.75 m and 3.85 m were moved from out of the reef. Next we detected 4 individuals of *Dendritina* and 4 individuals of *Operculina* at the depth of 1.85 m in the core sample of Yagi-2. As well, we detected 2 individuals of *Dendritina* at the depth of 2.05 m in the core sample of Yagi-2. These suggest that the sediments at the depth of 1.85 m and 2.05 m were moved from the out of the reef. Thus, we found that the species, which live in the out of reef, were included in the core samples of Teima and Yagi. A possible mechanisms to move the sediment from seafloor to land are ocean waves, storm surges, and tsunamis. However, since ocean waves and storm surge are attenuated by the reef, these could not move the sediments from out of the reef. The sediments which contain the species living out of the reef would have been moved by tsunamis.

Keywords: tsunami, tsunami sediment, foraminifera

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MIS23-17 Room:415 Time:May 2 14:45-15:00

Recognition of washover deposits in the Shizuoka Plain, based on analysis of shape of sand grains

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Three-dimensional morphometric analyses were performed to compare the shape of the sand grains as mentioned below. The surface of the upper part of the sand grain was first scanned to collect the x-, y- and z-coordinates of each point on the grain surface using a Shimadzu OLS4000 confocal laser scanning microscope. The obtained upper surface was connected with its vertically reflected shape to obtain a symmetric closed surface model. The surface model was then converted into a solid model by filling the inside of the surface model with equally spaced points. The axes of sand grains were defined as the principal component axes for the 3D coordinate data of the points consisting of the solid model. The aspect ratios of the sand grain was computed as the square roots of the ratios between eigenvalues of the covariance matrix between the coordinates. The collected coordinate data for the upper surface were normalized for location, orientation, and size so that the centroid of the solid model is placed at the origin, the major axis is placed along the x-axis, and the volume of the solid model is fixed at a constant value. A series of the normalized z-coordinates of individual points was defined as the shape function of the corresponding x- and y-coordinate data and was then decomposed into a 2D domain using a two dimensional Fourier transform. The shape of the sand grain was represented by a set of Fourier amplitudes of each frequency. The angularity was assessed for each grain by the sum of the Fourier amplitudes of the first and higher harmonics divided by the magnitude of the 0th harmonic.

The results of the morphometric analyses clearly indicated that the ratio of the minor axis length to the major axis length well defines the difference in grain shape between beach sands and inferred flood sediments. Most of the flood sediments have smaller aspect ratio (i.e., elongate form) than do most of the beach sands. Scatter plots of the angularity against the aspect ratio for the two sedimentary environments were fairly separated with only slight overlap along the axis of the aspect ratio. Variation in angularity was greater among flood sediments than among beach sands and there was no beach-sand grain with the angularity larger than 7.89. The composition of inferred tsunami deposits seems a mixture of the flood and beach sediments in terms of their grain shape.

Keywords: washover deposits, sedimentary grains, analysis of shape

Japan Geoscience Union Meeting 2014
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MIS23-18 Room:415 Time:May 2 15:00-15:15

Two paleotsunami layers in Kushiro Wetlands and their wide correlation in eastern Hokkaido

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Two paleotsunami sand layers, Ks-TS1 and Ks-TS2, were identified in peatland in Kushiro, eastern Hokkaido. Ks-TS1 occurs several cm beneath Ko-c2 (AD 1694) and Ta-b (AD 1667) tephras, and Ks-TS2 occurs 10 cm above B-Tm tephra (ca. 1000 yBP). Thicknesses of these layers are less than 1-3 mm. Particle size of Ks-TS1 is around 2 phi and Ks-TS2 is around 4 phi. They can be identified by their particle size distribution in the precision of 1/16 phi using Morphologi G3. Ks-TS1 is found at the site located about 2120 m from the modern coastline, 5.9 m above the mean sea level, and Ks-TS2 about 1810 m from the modern coastline, 5.7 m above the mean sea level. The actual run-up limit of paleotsunami may exceed these deposition areas.

At present analytical method is not available to correlate paleotsunami layers across distant regions. However, the tsunami layers in Kushiro are likely correlated with paleotsunami layers in other regions in eastern Hokkaido (Urahoro, Kinashibetsu, Onbetsu, Akkeshi, and Nemuro) on the basis of the stratigraphic relationships between the paleotsunami layers, marker tephras, and peat layers. In Kushiro region, thickness of the peat layer between Ta-b and Ks-TS1 is 16 % of the total peat thickness between Ta-b and B-Tm, and thickness between Ta-b and Ks-TS2 is 81 %. These ratios are similar between Kushiro and other regions, although 10-20 % difference can be seen. According to previous researches, up to eight paleo-tsunami layers in the last 3000 years were identified in eastern Hokkaido. The paleo-tsunami layers in Kushiro are correlated with the last two events and presumed to be the greatest events in the last 3000 years.

Keywords: Paleotsunami deposit, correlation, Precise grain size analysis, Morphologi G3, Hokkaido

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MIS23-19 Room:415 Time:May 2 15:15-15:30

Insight of large tsunami recurrence around the Sea of Japan revealed by surveys of historical and pre-historical tsunami

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[1]Hokkaido University, [2]Far East Branch of Russian Academy of Sciences, Russia

Tsunami deposits provides essential information for assessing tsunami and earthquake hazards in areas where recurrence of tsunamis are not known or poorly recorded. Northern coast of the Sea of Japan is one of these areas. Recent earthquakes such as the 1940 Shakotan-oki, the 1983 Nihonkai-chubu and the 1993 Hokkaido Nansei-oki earthquakes caursed severe damage along the coastal communities in SW Hokkaido, Japan, however, the past tsunami in this region are not known. The historical tsunamis inundated not only in the Japanese coast but also along the Primorye coast, Russia, located at the other side of the Sea of Japan. We repeated reconnaissance along the Primorye coast to find the historical and pre-historical tsunami evidences. In the region, there are natural lowlands facing sandy beach that are suitable for tsunami deposit formation and preservation. The surveys were done from 2010 to 2013 as a joint research project with Hokkaido University and the Russian Academy of Science. We could trace sandy or muddy tsunami deposits buried in the peat associated with the modern tsunamis, and also found candidate of tsunami deposits at multiple sites along the coast. The sandy layers include significant amount of marine diatoms. Based on the C14 dating results of peat sandwiching the sandy layers, age of the events are estimated to be ca. 350 BP, 600 BP, 800 BP and 2100 BP. In Kit Bay, the southernmost site in our survey area, B-Tm tephra (ca. 1000 AD) were deposited patchy between the 800 BP and 2100 BP. Most of the paleo-event deposits are traced inland up to a few hundred meters from the present coast and they are distributed at 4-5 m above the sea level. These might be the first evidence for the recurrence of large tsunamis around the Sea of Japan in the past.

Keywords: tsunami deposit, Primorye, Sea of Japan, paleo-tsunami, historical tsunami

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MIS23-20 Room:415 Time:May 2 15:30-15:45

Preliminary study for evidence of tsunami deposits from Holocene sediments along the coastal area of the Wakasa Bay.

YAMAMOTO, Hirofumi[1*] ; URABE, Atsushi[2] ; SASAKI, Naohiro[1] ; TAKASHIMIZU, Yasuhiro[3] ; KATAOKA, Kyoko S.[2]

[1]Fukui University, [2]NHDR, Niigata University, [3]Niigata University

This study reconstructed the Holocene sedimentary environment and researched the distribution of possible tsunami deposits in the coastal plain along the Wakasa Bay area in Fukui Prefecture.

Around the Wakasa Bay Area, some historical documents suggested the tsunami event of AD 1586 (Tensho Tsunami), but no sedimentary evidence of this event was reported from this area. So, we carried out reconnaissance along the coastal area of the Wakasa Bay to find the natural lowlands facing sandy beach that are suitable for tsunami deposit reservation. For example, at the Sonobe area in Takahama-cho, a low land behind the beach ridges was said to have been a marshes area, and our preliminary study show that this area had shifted from inner bay environments to marshes area about 3000 years ago. At these places, we study the Holocene sediment using the Geoslicer of 5 meters long.

Keywords: Wakasa Bay area, coastal plain, tsunami deposits, Holocene

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MIS23-P01 Room:Poster Time:May 2 16:15-17:30

Bleaching of K-feldspar grains contained in the tsunami deposits of the 2011 off the Pacific coast of Tohoku Tsunami

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[1]Tokyo Metropolitan University

Optically stimulated luminescence (OSL) dating is feasible method to obtain depositional age from sediments and then, it is expected to be useful for tsunami deposits dating. However, it is not clear that the degree of sun bleaching during tsunami transport processes. Firstly, bleaching of K-feldspar grains during tsunami transport processes was investigated with post-IR IRSL (pIRIR) dating using the 2011 off the Pasific coast of Tohoku Tsunami deposits. Then, single-grain OSL dating was attempted to obtain accurate equivalent doses of tsunami deposits. Equivalent doses of K-feldspar grains obtained from various sampling locations and positions.

Comparing IRSL and pIRIR equivalent doses which showed different decreasing rates of OSL intensities with the sunlight exposure time, sandy tsunami deposits were hardly exposed sunlight during tsunami transport processes. However, nearly zero equivalent dose of single-grain OSL measurement was often acquired. Probably, these " zero-dose " K-feldspar grains had been exposed enough to sunlight before the tsunami. Upper position of one run-up tsunami deposits seemed to be rich in K-feldspar grains suggesting the accurate depositional age.

Keywords: tsunami deposits, Optically Stimulated Luminescence, post-IR IRSL, K-feldspar, sedimentary structure, Fukushima

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MIS23-P02 Room:Poster Time:May 2 16:15-17:30

Sedimentological features of tsunami deposit caused by the 2011 Tohoku-oki earthquake tsunami

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In some areas, the inundation distances of the 2011 Tohoku-oki earthquake tsunami was comparable to that of the 869 Jogan tsunami estimated by geological investigations of tsunami deposits. This fact revealed the potential of research of tsunami deposits to speculate the scales of future tsunamis, resulting in strong social demand to detect ancient tsunamis, especially giant tsunamis, using geological studies. Investigation of present tsunami deposits is crucial to understanding sedimentological features of tsunami deposits because the present tsunami deposits can be identified with high reliability and the investigation of the surrounding circumstances is also feasible. In this study, we collected tsunami deposits caused by the 2011 Tohoku-oki earthquake tsunami from 19 areas with different topography. The obtained cores were observed by the unaided eye and by using CT images. In this presentation, we will discuss sedimentological features of these tsunami deposits and relationship with the surrounding circumstances.

Keywords: Tsunami deposit, The 2011 Tohoku-oki earthquake, Tsunami

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MIS23-P03 Room:Poster Time:May 2 16:15-17:30

Characteristic of tsunami deposit left by 2011 Tohoku earthquake, case study of Toni bay

IIJIMA, Satsuki[1*] ; SAKAMOTO, Izumi[1] ; YOKOYAMA, Yuka[1] ; YAGI, Masatoshi[1] ; IMURA, Riichiro[1] ; NEMOTO, Kenji[1] ; FUJIMAKI, Mikio[2] ; FUJIWARA, Yoshihiro[3] ; KASAYA, Takafumi[3]

[1]Tokai University, [2]COR, [3]JAMSTEC

The recent 2011 Tohoku tsunami strongly affected the coastal area of the Pacific coast of Tohoku. The result of onshore features for tsunami impact is well researched, but offshore is only a few researches.

In this presentation, we will show about characteristic of tsunami deposit left by 2011 Tohoku earthquake, case study of Toni bay. We researched about tsunami deposit using acoustic equipments (Multi beam echo sounder ; MBES, Sub bottom profiler ; SBP) and Vibration core sampler (VCS).

The first of all, as the characteristic of submarine topography was sectionalized to 4 areas from topography profile of the valley axis direction.

Second, SBP data was seen signature reflecting surface (40-100cm down from seabed), and it was able to track at the wide area. Thickness of this reflecting surface and seabed were estimate 25-110cm in this bay. This thickness corresponded with the characteristic of the submarine topography.

Moreover, columnar sample of 13T_V_2 (water depth 14 m) could be divided into U1 (sand), U2 (mud), and the U3 (gravel bed). Sand to silt sediments layer with grading (fine sand to gravel) structure observed at the U1.We assume this U1 is 2011 tsunami deposit. The boundary of between U1 and 2 has continuity reflecting surface by SBP data and confirm distribution of this reflecting surface and thickness.

Finally, we were able to estimate tsunami deposit distributed with thickness approximately 25-110cm, and high thickness was distributed to the valley axis.

Keywords: Tsunami deposit, Sanriku Coast

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MIS23-P04 Room:Poster Time:May 2 16:15-17:30

Characteristic of tsunami deposit left by 2011 Tohoku earthquake, case study of Hirota bay

YOKOYAMA, Yuka[1*] ; SAKAMOTO, Izumi[1] ; YAGI, Masatoshi[1] ; IMURA, Riichiro[1] ; IIJIMA, Satsuki[1] ; KANEI, Tatsuki[1] ; NEMOTO, Kenji[1] ; KITO, Takeshi[2] ; FUJIMAKI, Mikio[3] ; FUJIWARA, Yoshihiro[4] ; KASAYA, Takafumi[4]

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The recent 2011Tohoku tsunami strongly affected the coastal area of the Pacific coast of Tohoku. The study of onshore features for tsunami impact is well researched, but offshore is only a few researches. In this presentation, we will show about characteristic of tsunami deposit left by 2011Tohoku earthquake at Hirota bay using by Sub bottom profiler (SBP) and Vibration core sampler (VCS).

We took the total 17sites columnar core (2012:5sites, 2013:12sites) at water depth 8-25 m. The columnar cores were able to sectionalize to 2 units from lithofacies. Unit-1 consists of sand layer and Unit-2 consists of muddy sediment.

Unit-1 was sand to silt sediments layer with grading (fine to very coarse consists gravel and shell fragments) and lamination, and has forms the erosion surface with the lower layer. We assume that denudation is boundary of previous or after tsunami sediment and upper layer (Unit-1) is 2011tsunami deposit. And, Unit-1 was able to sectionalize to some subunits (Unit1a-1e) by grain size analysis and soft X-ray photo.

Unit-2 was massive sediments with fine sand to silt layer characterized by bioturbation. We assume this unit is normal sediment in this bay. And, some columnar cores have Unit-3(underlying layer of Unit-2) that has similar characteristics of Unit-1.

We estimate the 2011tsunami deposit distribution with thickness approximately 20-50 cm, and high thickness area was valley axis and estuarine region, and those area have sedimentation axis each other (NNW-SSE and NW-SE), and join together at offshore area (around 20m). So, tsunami deposits become thicker by overlap with a few tsunami deposits at offshore area.

Keywords: Tsunami deposit, Sanriku coast

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MIS23-P05 Room:Poster Time:May 2 16:15-17:30

Characteristic of tsunami origin submarine topography -Case study of Toni Bay and Okirai Bay

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The recent 2011 Tohoku tsunami strongly affected the coastal area of the Pacfic coast of Tohoku. Toni Bay located south of Kamaishi city and open toward east. Also Okirai bay open toward east. Tokai University started survey there to confirm effect of Tsunami in 2012

Survey of first year, we make extensively submarine topography. As a result, anomaly topography was observed at Toni Bay (depth of 20-25m) and Okirai (depth of 15-20m). Transparent layer with poor internal reflection was observed as the surface layer within the anomaly topography by Sub Bottom Profiler (SBP). Characteristic of columnar core have grading structure (fine to coarse) of sand sediment and erosion structure between sand sediment and clay sediment. It was guessed that erosion structure was made by turbidity current by tsunami activity. For the above reason, estimated anomaly topography is Tsunami origin topography. So we survey around anomaly topography area more closely in 2013. Describe below the character of Toni Bay and Okirai Bay.

[Toni Bay]

In this research area, submarine topography can be divided into three: 1)gentle slope (0.9 degrees) at depth of 15-22m, 2)planation surface at depth of 22-24m, 3)gentle slope at depth of 24m or more. On the 1)-3), these are a lot of protuberance has distributed. Around the protuberance, current marks like a fan or delta shape extend to toward offshore. And groove mark also observed. And we assume this tsunami origin submarine topography have control by protuberance in this way.

[Okirai Bay]

In this research area, topography can be divided into three: 1)gentle slope (1 degrees) at depth of 8.5-17.5m, 2)planation surface at depth of 17.5-19m, 3)gentle slope at depth of 19.5m or more. On the 1), these are a lot of protuberance has distributed. Some tool mark that is cause of protuberance distribute similar to Toni bay, but most of current mark show scour mark.

Tsunami origin submarine topography has almost same character (ex. Water depth) at both bays. But formation factor is different from Toni and OKirai bay.

Keywords: Tsunami orijin submarine topography, Toni Bay, Okirai Bay, Current mark

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MIS23-P06 Room:Poster Time:May 2 16:15-17:30

Relationship between the inundation limit and the maximum extent of the sandy tsunami deposit in Sendai Bay coasts

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Maximum landward extent of the sandy tsunami deposits can be regarded as the minimum inundation limit. Before the 2011 Tohoku-oki tsunami, recent post-tsunami field surveys along low-lying coastlines showed that sandy tsunami deposits commonly extend to approximately over 90% of the actual inundation limit (MacInnes et al., 2009). On the other hand, after the 2011 Tohoku-oki tsunami, some researches of the 2011 tsunami pointed out that the significant gap (0.6-2.0 km) between the inundation limit and the maximum landward extent of the sandy tsunami deposit where the inundation distance was more than 2.5-3.0 km (Goto et al., 2011; Abe et al., 2012; Shishikura et al., 2012). However, it is uncertain why the gap appeared. This study focuses on the relationship between the maximum extent of sandy tsunami deposits and inundation limit of the 2011 Tohoku-oki tsunami.

Inundation limits of the Tohoku-oki tsunami were assessed over 15 shore-normal transects in the Sendai Bay coast. Inundation distances of the 15 transects were found to range from 0.60 to 5.07 km. The maximum limit of the sand layer extended to 2.3-3.0 km (55-74% of the inundation distance) along 6 transects in the wide coastal plain in the northern-middle part of the Sendai Plain. Absence of the sandy tsunami deposits over 3.0 km inland may explained by the limitation of the sand supply from sand beach and sand dune.

Keywords: 2011 Tohoku-oki tsunami, Sendai Bay coast, Inundation limit, Maximum extent of sandy tsunami deposit

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MIS23-P07 Room:Poster Time:May 2 16:15-17:30

Historical tsunami deposits in Numanohama on the Sanriku coast, Japan

GOTO, Tomoko[1*] ; SATAKE, Kenji[2] ; SUGAI, Toshihiko[1] ; ISHIBE, Takeo[2] ; HARADA, Tomoya[3] ; MUROTANI, Satoko[2]

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We conducted tsunami deposit survey in a small valley along the Sanriku coast, Japan, just north of Taro (Miyako city, Iwate prefecture), where the 2011 tsunami heights from the Tohoku earthquake ranged from 17 to 34 m. We identified six tsunami deposits during the recent 500 yrs from the 3-m long Geo-slicer sample. The uppermost one is located on or just below the ground surface and probably from the 2011 Tohoku earthquake. The ^{210}Pb and ^{137}Cs dating analyses indicated that the 2^{nd} to 4^{th} uppermost tsunami deposits can be correlated with historical tsunamis: the 1960 Chilean tsunami, the 1933 and 1896 Sanriku tsunamis. According to Japanese historical documents, other candidate tsunamis since the 15^{th} century are from the 1793 Miyagi-oki earthquake, the 1763 and 1677 Aomori-oki earthquakes, the 1677 Boso-oki earthquake, and the 1611 Sanriku earthquake. Other trans-Pacific tsunamis includes the 1700 Cascadia tsunamis severe damage along the Sanriku coast and these tsunami deposits may be also preserved.

After the 2011 Tohoku earthquake, many surveys for tsunami deposits have been conducted in Sendai plain (Goto *et al*., 2011, Marine Geology; Shishikura *et al*., 2012, Annual Report on Active Fault and Paleoearthquake Researches). There are few reports of tsunami deposit studies along the Sanriku coast. Furthermore, depositional ages of many identified tsunami traces along the Sanriku coast were estimated to be several thousand years before present. The reasons for absence of recent tsunami deposits include that the Sanriku coast is a ria coast characterized by sawtooth-shaped coastline. Because of the steep-sloped valleys, alluvial deposits are very limited and tsunami traces are difficult to be preserved. Around the survey site, however, a marsh is separated from open sea by a beach ridge of $\sim$ 4m high. In this marsh, well-decomposed peat has been developed. The sand deposits were brought by large tsunamis over the beach ridge and preserved in the marsh peat. Our study is the rare case that the geological evidence of recent historical tsunamis was continuously identified.

To identify tsunami deposits, we sketched the sedimentary structure, measured the distribution of grain sizes, and analyzed the microfossils. Depositional ages of tsunami deposits were estimated on the basis of radiocarbon (AMS) dating and ^{210}Pb, ^{137}Cs analysis. The ^{210}Pb dating is useful to determine the depositional rate during the recent 100 years because of its short decay time (the half life time is 22.3 year). The ^{137}Cs dating is useful to judge whether the depositional ages are before or after the start of atmospheric nuclear experiments in AD 1954.

Peat and sand layers are alternated with their thickness of several centimeters to several tens centimeters. Each sand layer consists of beach pebble and sand or rock pieces from host rock in this area. The sand layers have structure characteristic to tsunami deposit: erosional contact, alternation of normal- and inverse-grading, lamination and thin mud layer sandwiched between two sand layers. The sand layer can be traced continuously along the landward transect. Abundant marine microfossils in the sand layers indicate that the sea water flow into the marsh with the tsunami sand.

The ^{14}C result shows that peat at around 3 m depth deposited after the 15^{th} century. The ^{210}Pb decay curve indicates that the deposition ages of the upper four tsunami deposit layers are during recent 100 yrs. The 2^{nd} uppermost tsunami deposit can be correlated with the 1960 Chilean tsunami because ^{137}Cs was detected down to this layer.

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Keywords: Tsunami deposit, Sanriku coast

Japan Geoscience Union Meeting 2014
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MIS23-P08 Room:Poster Time:May 2 16:15-17:30

A Study of Paleo-Tsunami along the Coastal Area of Akita Prefecture, the eastern margin of Japan Sea

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Tsunami is the most destructive natural disaster on the coastal area. North-eastern Japan along the Japan Sea has been suffered by tsunamis, such as the 1833, 1983, and 1993 tsunamis. Recently, tsunami deposits have been reported from various areas and environments in Japan. However, paleo-seismological study based on the tsunami deposits has not been reported from along the coastal area of Akita Prefecture. We report a study of paleo-tsunami along the coastal area of Akita Prefecture. These results will be presented in this session.

Keywords: tsunami deposit, paleo-tsunami, eastern margin of Japan Sea, Akita Prefecture

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Paleoenvironmental changes and tectonic movements reconstructed from diatoms in Tokushima, during the last 4000 years

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The average recurrence interval of the interplate earthquakes along the Nankai Trough is estimated from many histrical records and archaeological data (Sangawa 2008). However, the studeis of tectonic movement related to Nankai earthquakes is still limited (Maemoku 1989, Shishikura et al. 2008).

Yuki city, Tokushima prefecture, which located in north part of the Nankai Trough, has been subsided and many tsunamis attacked along the coast of the Shikoku islands accompanied by the previous Nankai earthquakes. Therefore, some historical documents and memorial monuments written about the past Nankai earthquakes and tsunamis remain in this city.

In order to obtain the geological evidences of tectonic movements and tsunami depsosits, we conducted a 7m long core drilling at a small marsh behind a barrier spit in Tainohama of Minami city nearly Yuki city. The core includes more than 12 sand layers in organic-rich muddy sedimentary succession up to 5 m depth in this core. And we analyzed fossil diatoms from the core.

The diatom assemblages included in the peat and peaty mud deposits were predominated by fresh and brackish water species, especially *Pseudostaurosira brevistriata*, *Pseudostaurosira subsalina*, *Staurosirella pinnata*, *Tabellaria fenestrate*. *Pinnularia* spp. and *Eunotia* spp. are also dominated. In contrast to the above mentioned sand layers, brackish water and marine species, especially *Diploneis smithii*, *Mastogloia recta* were increased. The diatom assemblages from the organic rich muddy sediments and radiocarbon ages indicates that freshwater marsh or saltmarsh formed in this region during at least the past 4000 years. On the other hand, the diatoms from the sandy layers indicates that salinity of environments when the layers were formed was higher than freshwater or salt marsh. The diatom assemblage suggest that the sand layers were transported from seaside by past tsunamis. On the other hand, changes of diatom assemblages in the muddy sediments show increase or a decrease of freshwater species, suggesting a paleo coastal environment changes due to past earthquakes along the Nankai Trough.

Keywords: Nankai trough, Tsunami deposit, Tectonic movement, Pleo coastal environment, Diatom

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Study of tsunami deposits along west coastal area of Kagoshima Prefecture, Japan

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In the west coast of the Kyushu district, there is no plate boundary in the front, and there is few record of an earthquake and tsunami. There are little investigations and researches of tsunami deposits in this area compared with East Coast facing the Pacific Ocean. However, reexamination of the disaster prevention planning in a coastal area is advanced by the occurrence of the 2011 off the Pacific coast of Tohoku Earthquake, and it is necessary to expand the data about the past tsunami history.

We have investigated the literature about records of the disasters of tsunami, and observed drilling core. We read aerial photos and topographical maps, and classified topography such as beach ridge, sand dune, backswamp. Based on the geographical classifications, we confirmed geographical features and existence of reclaimed land, and determined the survey sites. Drilling cores were taken in ten sites along the west coastal areas of Kagoshima Prefecture. In order to clarify lateral continuity of sediments, several cores were taken at each site. In consideration of sea level change, we collected sediments after about 6,000-7,000 years ago.

We acquired X-rays CT images to visualize internal structure of sediment three-dimensionally without destroying core. After having photographed X-rays CT image, we divided the core into half in lengthwise direction and observed the surface. Sediments are dated using radiocarbon dating and tephrochronology.

Some event deposits are identified in the drilling core taken from Gumizaki site, Nakayama site and Hashima site. Ages of these event deposits are around 7,000 cal BP and 9,500 cal BP (Gumizaki site), 3,500-2,500 cal BP (Nakayama site). However, these event deposits are not defined in other sites. These event deposits were possibly made by local event.

We found the layer including volcanic glass derived from the Kikai-Akahoya tephra in drilling core which were taken from Gumizaki site. The layer was possibly carried by the event accompanied with explosion of Kikai caldera.

In this presentation, we discuss the depositional environmental changes and the origin of event deposits by analysis of microfossil and detail observation of cores.

Keywords: tsunami deposits, event deposits, Kagoshima Prefecture

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Tsunami deposits in eastern coast area of Ishigaki Island, Japan.

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We found two tsunami deposits in eastern coast area of Ishigaki Island, Japan. The tsunami deposits contain many pebble-sized bioclasts such as coral fragments and mollusks, and clay rip-up clasts comprising material from the underlying soil. These deposits have erosive basement and fine upward. These layers thin abruptly at the landward margins, and fine inland. The altitude of the landward end of the lower and upper tsunami deposits attain up to 6 and 8 m, respectively. We referred to as deposits T-II and T-I in order of ascending stratigraphic position. Radiocarbon ages of excellent preserved and articulated marine bivalves mean that T-I and T-II were caused by the AD 1771 Meiwa tsunami and by tsunami at 740-500 cal. yrs BP (AD 1210-1450), respectively. It is noteworthy that abundant fragments of coral and molluscs remains are found from the debris flow deposit below T-II. Radiocarbon ages suggest these fragments were transported up to 8 m elevation by tsunami between 2490-2240 and 930-620 cal. yrs BP.

Keywords: tsunami deposits, Ishigaki Island

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The use of benthic foraminifera within tsunami sediments

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Tsunami hazard assessment begins with a compilation of past events that have affected a specific location. Given the inherent limitations of historical archives, the geological record has the potential to provide an independent dataset useful for establishing a richer, chronologically deeper time series of past events. Recent geological studies of tsunami are helping to improve our understanding of the nature and character of tsunami sediments. Wherever possible, researchers should be increasingly working to improve the research ' tool kit ' available to identify past and analyse modern tsunami events. Marine, benthic foraminifera (single celled heterotrophic protists) have often been reported as present within tsunami-deposited sediments but in reality, little information about environmental conditions, and by analogy, the tsunami that deposited them, has been reported even though foraminifera have an enormous capacity to provide meaningful palaeo-environmental data. In light of more recent tsunami events, the use of foraminifera has increased yet their full potential in this capacity is still often not frequently utilised. We discuss the potential use of foraminifera within tsunami research using results from specific case studies from Japan, south Asia, North America, Europe, the UK and New Zealand. We present an updated review in the gaps in our understanding on this topic area and reassert models for ' better ' practice where possible, to assist researchers who examine foraminiferal assemblages within tsunami geology.

Keywords: Tsunami, Foraminifera, Benthic, Tsunami deposit