Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

MIS25-01 Room:201B Time:May 24 09:00-09:15

The foraminifera assemblages in tsunami sediments on Ishigaki Island, southwestern Japan

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Foraminifera, single celled protists, are widely applied to paleoenvironmental, paleooceanic, stratigraphic and sedimentological investigations due to their abundant populations. Moreover, they are sensitive to living environment and have high preservation potential within the sediments (Mamo et. al, 2009). Although foraminifera assemblage analysis is remarkable tools for geoscience researchers to understand the variation of paleoenvironment, however, the use of foraminifera assemblage has not been developed well in palotsunami research. Up to the present, not only investigation methods but also analytic procedures have not been established.

In 1771, a destructive tsunami struck Ishigaki Island, southwestern Japan, with the maximum run-up height of 30 meters to cause about 9000 fatalities (half populations of Ishigaki Island), and the mortality rates of 25 villages on the eastern and southern coasts reached 10- 90%. For the mechanism of this tsunami, Nakamura (2009) proposed the source should be a large subduction thrust earthquake that occurred near Ryukyu trench axis, while Goto et al. (2010) suggested a model of extensive submarine landslides triggered by an intra-plate earthquake. Furthermore, Ando et al. (2015) identified four tsunami evens from tsunami sediments for the last 2000-2500 years.

In this study, we tried to identify tsunami events based on foraminifera assemblage in soil deposits. In order to approach this aim, we analyzed forty-seven soil samples obtained from five excavation sites on both eastern and western coasts in this island. A total of 117 foraminifera species from 36 genus were recognized through our analysis. Subsequently, we classified all foraminifera tests into three clusters based on the result of Hatta and Ujiie (1992): shallow-water foraminifera ($<$15m), inter-mediate depth foraminifera (15m to 50m) and deep-water foraminifera ($>$50m). After this procedure, we took the ratio of individual numbers in deep-water + inter mediate-depth to total amount for each soil sample. This analysis yields that samples with high ratios ($>$0.2) were identified as tsunami deposits, conversely those with low ratios ($<$0.15) as beach sand or terrigenous sediments. This suggests that foraminifera assemblage analysis can provide significant tool to identify paleotsunami deposits from other sedimentary processes. Our analysis of foraminifera assemblages provides at least three tsunami events in 1771, AD 1000 to 1300, and BC 300 to 600 that struck Ishigaki Island.

Keywords: foraminifera assemblages, tsunami sediments, Ishigaki Island, 1771 tsunami, Ryukyu subduction zone

Japan Geoscience Union Meeting 2015
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MIS25-02 Room:201B Time:May 24 09:15-09:30

Evaluating the magnitude of late Holocene mega-tsunamis on Ishigaki Island based on an analysis of molluscan assemblages

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Four ancient tsunami deposits have been identified on Ishigaki Island, Okinawa, Japan. Three tsunami deposits (T-I, T-II, and T-IV) are calcareous sand beds which have sharp erosional bases and normal graded structure, while one tsunami deposit (T-III) is buried tsunami boulders between tsunami deposits T-II and T-IV. The youngest tsunami deposit T-I, was caused by the AD 1771 Meiwa tsunami, which had a wave height of at least 10 m in the study area. The depositional ages of the three older tsunami deposits (T-II, T-III, and T-IV) are 790-610 cal. yrs BP, 1494-1258 cal. yrs BP and 2502-2287 to 1494-1258 cal. yrs BP, respectively. The elevations of the landward margins of sandy tsunami deposits T-I, T-II, and T-IV are up to 9, 6, and 8 m, respectively. This study examines the influence of the local topography, such as beach ridge and reef system, on the runup of these ancient tsunamis based on a comparison of molluscan assemblages in the tsunami deposits T-I, T-II, and T-IV and those found in recent beach deposits. The results show that the conditions in the reef system off the study area have remained largely unchanged since the occurrence of tsunami T-IV. Beach ridge during the occurrence of tsunami T-IV did not become well developed relative to those during the occurrence of tsunami T-I and T-II. These findings suggest that the magnitude of tsunami T-II were smaller than those of tsunamis T-I and T-IV, while the magnitude of tsunami T-IV did not reach that of tsunami T-I (AD 1771 Meiwa tsunami).

Keywords: large tsunami, Ishigaki Island, late Holocene, analysis of molluscan assemblages

Japan Geoscience Union Meeting 2015
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MIS25-03 Room:201B Time:May 24 09:30-09:45

Paleo environment changes and tsunami deposits in Susami city, Wakayama prefecture during the Holocene

CHIBA, Takashi[1*] ; GOTO, Kazuhisa[2] ; FUJINO, Shigehiro[1] ; YOKOYAMA, Yusuke[3] ; MIYAIRI, Yosuke[4] ; SAWADA, Chikako[4] ; ISHIZAWA, Takashi[5] ; NISHIMURA, Yuichi[6] ; SUGAWARA, Daisuke[2] ; GOFF, James[7]

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Kii peninsula was attacked by many tsunamis accompanied by the previous Nankai earthquakes. There is little geological evidence supporting past tsunamis in western coast of Kii peninsula (Komatsubara et al. 2007, Fujino et al. 2008), although there are some geological evidences recognized as tsunami deposits in eastern coast. On the other hand, it is suggested that some great earthquakes brought about co-seismic uplift larger than the usual great earthquake such as Showa Nankai earthquake in southern part of Kii peninsula generated (Shishikura et al. 2008). However, information of tectonic movements by past earthquakes is limited. Therefore, we need to obtain the geological evidence of the past tsunamis and tectonic movements due to Nankai earthquakes in western part of Kii peninsula to reveal the recurrence intervals and co-seismic or inter-seismic crustal movements. Against this background, we conducted drilling survey in lowland probably be not affected directly from sea waves at Susami city, Wakayama Prefecture, central Japan and obtained about 800cm long core sample, and also analyzed fossil diatoms.

The core is composed of organic rich mud from 150cm to 300cm, organic-organic poor mud from 300cm to 680cm and gravel deposit of basement rock fragments from 680cm to 760cm depth mainly. Basement rock sedimented in Miocene is recognized below 760cm depth. Also, at least 7 sand or gravel layers are included in organic-rich muddy sediment from 150cm to 300cm depth in the core. Meanwhile, K-Ah volcanic ash (erupted in 7200 cal. BP) layer is recognized at 560cm to 630cm depth. And also we obtained accelerator mass spectrometry (AMS) radiocarbon dates covering during 2000BC-6000BC.

The diatom assemblages included in the mud deposits to 300cm from 760cm depth were dominated by marine and marine-brackish species such as Planothidium delicatulum and Cocconeis scutellu. These species decreased and freshwater diatom such as Eunotia and Pinnlaria increased gradually from lower to upper of the core. Especially, the organic rich mud above 300cm depth contained no marine species. The changes of diatom assemblages in the muddy sediments from 300cm to 760cm depth show the tendency of increase of freshwater diatoms and decrease of marine diatoms, suggesting effects of paleo-sea level changes so called Jomon transgression and its regression. These diatom assemblage changes also suggest that tidal flat was formed in this area during 3500BC-6000BC, and changed to salt marsh after that. On the other hand, the sand and gravel layers from 150cm to 300cm depth contained very small amounts of marine diatoms. It is suggests that these sand and gravel layers were transported by strong current from seaside such as tsunami during 2000BC-3500BC.

Keywords: Nankain trough, Kii peninsula, Tsunami deposit, Fossil diatom assemblage, Holocene

Japan Geoscience Union Meeting 2015
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MIS25-04 Room:201B Time:May 24 09:45-10:00

Trench and coring survey of the tsunami deposits in the coastal area along the Wakasa Bay, Takahama, Fukui Prefecture.

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Some sand layers which might be formed by the tsunami event were found in the peaty deposits under the coastal lowland in Sonobe area, Takahama-cho, Fukui Prefecture. This time, we mainly investigate the shallow sand layers than 1m.

The coring and trench survey in this area shows that the sand layers are distributed more than 500m to the inland form the shore. The sand include grains of the well-rounded rock fragments and organic remains such as shell, foraminifera and spine of the sea urchin, which are a lot included in the coastal sand of this area. In addition, the sand layers eroded the peaty sediments at the base, and include the rip-up clast of them. The radiocarbon dates of the peaty sediments below and above the sand layer show that the layers deposited between the 14th and the 16th century.

These data shows that the sand layers might be formed by ancient tsunami event of 16th century recorded in the historical documents in this area.

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

Japan Geoscience Union Meeting 2015
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MIS25-05 Room:201B Time:May 24 10:00-10:15

Event deposits discovered on the mouth area of Arakawa River, Niigata, Japan

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A characteristic sandy layer probably resulting from past tsunami event was discovered on the mouth area of Arakawa River, Niigata, Japan. The event layer shows following features. The deposit is 1) distributed at least approximately 1 km from the coast; 2) shows a fining- and thinning- landward trend, 3) indicates increasingly poor sorting landward, and 4) includes mud clasts eroded from the muddy layer below the event deposits.

Keywords: Tsunami deposits

Japan Geoscience Union Meeting 2015
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MIS25-06 Room:201B Time:May 24 10:15-10:30

Geologic evidence of tsunamis in Kujukuri

PILARCZYK, Jessica[1*] ; SAWAI, Yuki[2] ; HORTON, Benjamin[1] ; NAMEGAYA, Yuichi[2] ; SHINOZAKI, Tetsuya[2] ; TANIGAWA, Koichiro[2] ; FUJIWARA, Osamu[2] ; SHISHIKURA, Masanobu[2] ; MATSUMOTO, Dan[2] ; DURA, Tina[1]

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Along the northern part of the Japan Trench, the subduction of the Pacific plate under the North American plate has frequently generated tsunamigenic-earthquakes up to ˜M 8.0. In contrast, the middle and southern parts of the Japan Trench were considered relatively inactive until the 2011 Tohoku-oki (M 9.0) event generated one of the largest tsunamis in recorded history. Geologic evidence from the Sendai plain revealed an event in A.D. 869 that could have forecast the severity of the Tohoku-oki tsunami in 2011. Seismic models indicate that the Tohoku-oki earthquake may have transferred stress southwards down the fault to the potentially locked southern segment of the Japan Trench (Simons et al., 2011 Nature). This scenario could produce an earthquake in the near future that would be comparable in magnitude to the Tohoku-oki event. Reconstructing the history of individual great earthquakes and accompanying tsunamis from the coastal zone adjacent to the southern trench provides an assessment of the seismic hazard for several metropolitan areas.

We have found two anomalous marine sand layers preserved in low-energy freshwater environments where they would not normally occur (i.e., present day rice paddies). The medium to coarse sand layers range in thickness from 3-10 cm, are intercalated with muddy peat, and the two upper layers can be traced 3.8 km inland and ˜5 km along the present Kujukuri coastline near Sanmu City. The sand layers have features consistent with tsunami deposits found elsewhere, such as a distinct erosional base, marine geochemical signature, offshore foraminifera, rip-up clasts, normal grading, and a mud drape. Preliminary radiocarbon dating of seeds, charcoal and insect cuticles constrain the age of the upper sand to A.D. 1613 ? 1651. Possible candidates for the upper sand are the Genroku tsunami of A.D. 1703 and the Empo tsunami of A.D. 1677. The age of the bottom sand is A.D. 971 ? 1047, an age that coincides with an 11th century gap in the historical record.

Keywords: Japan Trench, Tsunami deposit, Kujukuri

Japan Geoscience Union Meeting 2015
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MIS25-07 Room:201B Time:May 24 10:30-10:45

Was the 2011 Tohoku tsunami once-a-millennium disaster in the Sendai Plain?

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Geological evidences show that recurrence intervals of outsize tsunamis along the Japan Trench may be shorter than previously thought. In the Sendai Plain, A sand layer was found in peat above a historical volcanic ash (AD 915), and is dominated by brackish-marine diatoms. Radiocarbon dating obtained from plant macrofossils permits correlation of the sand layer for the 1454 Kyotoku tsunami. The distribution of the layer shows that the run-up distance of the 1454 tsunami was at least 1 km, longer than any tsunamis that occurred during the last 200 years except for the 2011 Tohoku tsunami. Numerical simulation for tsunami inundation suggests that such an inundation distance is accounted for a rupture similar to that of the Jogan earthquake. The 1454 Kyotoku tsunami is thus considered as an unusually large tsunami comparable with the AD 869 Jogan and 2014 Tohoku tsunamis, indicating that such tsunami inundated on the Sendai Plain more often than previously thought.

Keywords: Japan Trench, Tsunami deposit, Recurrence interval

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MIS25-08 Room:201B Time:May 24 11:00-11:15

Quartz optically-stimulated luminescence dating of AD 869 Jogan tsunami deposit

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Optically-stimulated luminescence (OSL) dating, as applicable to the sediment grain directly, has a potential to provide an effective way to establish the chronology of tsunami deposits. AD 869 Jogan tsunami is one of the oldest tsunamis recorded in a historical document in Japan. Deposit of the Jogan tsunami thus offers an opportunity to check the reliability of OSL dating to a deposit older than 1,000 years, which may be prehistoric elsewhere. We applied the quartz OSL dating to a sand layer formed by the Jogan tsunami found in a geoslice sample obtained from the Sendai plain, Japan, to compare resultant OSL ages with the depositional age. The sediment succession consists of beach-dune sand, lower peat, the Jogan tsunami deposit, upper peat, pre-2011 paddy soil, and the 2011 tsunami deposit, in ascending order. A standard Single Aliquot Regenerative (SAR) protocol was applied to large aliquots of 180-250 μm fraction of two samples from the beach-dune sand, and four samples from differing levels of the Jogan tsunami deposit to obtain equivalent dose ($D_{e,bulk}$). OSL decay curves are dominated by the medium component, and thus for two samples from the Jogan deposit the fast OSL component was isolated to be used for determining the equivalent dose ($D_{e,fast}$). All samples show unimodal distribution of De,bulk with relatively low overdispersion 11-22 %, suggesting that sediment grains were well bleached before burial. Using $D_{e,bulk}$, OSL ages of the tsunami deposit was underestimated by 30-40 %, and even the beach-dune sand was dated younger than AD 869. $D_{e,fast}$ in contrast resulted in a robust age estimate with a slight underestimation. Pulsed annealing test shows that the bulk OSL signal is thermally unstable. The medium component OSL, isolated from the bulk signal, is clearly truncated in the natural OSL decay curve compared to regenerated ones, which is considered as the main source of the underestimation. Such unfavourable influence of the medium OSL component has been commonly reported in tectonically active regions, which are also prone to tsunami, and thus should be considered with caution in dating tsunami deposits.

Keywords: tsunami, luminescence dating, Jogan earthquake, tsunami deposit, Sendai Plain, chronology

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MIS25-09 Room:201B Time:May 24 11:15-11:30

Highly precise radiocarbon dating of tsunami deposits

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Highly precise dating of tsunami deposit will be a useful tool for elucidation the frequencies of occurrence of the paleotsunami. Radiocarbon dating is used as dating tool of tsunami deposit. However, conventional radiocarbon dating does not have the enough precision to distinguish historical tsunami deposits.We have developed a highly precise radiocarbon dating method using a high-density sampling method.We will present about a high precision radiocarbon dating method of tsunami deposit using data from Iwanuma investigation site.

Keywords: radiocarbon dating, tsunami deposit, peat, wiggle matching, 14C, AMS

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MIS25-10 Room:201B Time:May 24 11:30-11:45

Spatial variation of sediment observed by reflecting surface and columnar core at Hirota bay

YOKOYAMA, Yuka[1*] ; SAKAMOTO, Izumi[1] ; YAGI, Masatoshi[1] ; INOUE, Tomohito[1] ; IIJIMA, Satsuki[1] ; NEMOTO, Kenji[1] ; FUJIMAKI, Mikio[2]

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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 and spatial change of sediment in Hirota bay using by Sub Bottom Profiler (SBP) and Vibration Core Sampler (VCS).

We took the columnar core at water depth from 8 to 30 m. The columnar cores were able to sectionalize into mainly two units by lithofacies, Unit-1(sand layer) and Unit-2(muddy layer) from the top. And, we sectionalize U2 into six more subunits, called U2-I to U2-Ⅵ from the top.

Therefore, layer of U2 is U2-I: sandy silt with shell piece, U2-Ⅱ: silt with bioturbtaion, U2-Ⅲ: sandy silt with wood chip, U2-Ⅳ: sandy silt with sand at the base, U2-Ⅴ: silty sand with granule and very coarse sand at the base and U2-Ⅵ: silt layer. Sagayama et al. (2014) assume that U2-I have a possibility of paleo event unit by diatom analysis.

SBP data were able to sectionalize to some reflection surfaces (R1-R7). R1 and R6 distribute widely, but other reflection surfaces clear away toward offshore.

We estimate distribute of each unit using by comparison of lithofacies and reflection surface. Reflection surface accord with sedimentary units. Then, U1 distribute widely and number of U2 combination were decrease toward offshore from coastal area.

These data shows paleo event sediment mechanism and it also show spatial changes of sub bottom environment.

Keywords: Tsunami deposit, Sanriku coast

Japan Geoscience Union Meeting 2015
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MIS25-11 Room:201B Time:May 24 11:45-12:00

Hydraulic experiment and numerical modeling on tsunami deposit aiming tsunami source estimation

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Tsunamis generate large amounts of bed load and suspended load because of strong tractive force and turbulence in shallow seas. The sediment transport due to tsunamis have caused various damages such as collapsing coastal structures, shoaling navigation channels in ports and blocking water intakes in power plants. A risk assessment of the sediment transport is important for tsunami disaster mitigation, and a numerical model to analyze the phenomena has been required. Many hydraulic experiments and field investigations on the sediment transport and the bathymetry change caused by tsunamis have been carried out, and the measured data have contributed to constructing the numerical model. However, because such damages occur in the water, almost all of the researches on the tsunami sediment transport have assumed an inundated condition. They focused on the sediment transport and the bathymetry change when tsunamis arrive in the shallow seas. On the other hand, the sediment transport can make tsunami deposit on land, lakes and marshes. Some analysis of the tsunami deposit have obtained invaluable knowledge of historical and paleo-tsunamis. Therefore, the hydraulic experiments on the tsunami sediment transport on land are also carried out and the numerical model is attempted to extend to tsunami run-ups recently.

The present numerical model can cover tsunami source, propagation and sediment transport in the sea. The model can predict bathymetry changes due to tsunamis in coastal areas if fault models of earthquakes are given. A small fishing port, for example, has complicated coastal structures like breakwaters, and generates numerical instability easily. However, the practical and detailed simulation on tsunami sediment transport using a two meters grid was conducted stably. Therefore, if the numerical model is upgraded to simulate the sediment transport and the tsunami deposit by tsunami run-up, the model is expected to enable to analyze tsunami sources using the tsunami deposit distribution on land, lakes and marshes.

Based on the background described above, the hydraulic experiments and the numerical modeling on sediment transport under the inundated condition are explained firstly. Besides, the hydraulic experiments on land aiming to extend the numerical model to tsunami run-up are introduced. From simulation on the tsunami sediment transport in actual sea areas, present state and issues of the numerical model are organized. Finally, a method to estimate tsunami sources using tsunami deposit distribution is investigated.

Keywords: tsunami run-up, sediment transport, bed load, suspended load, topography change, inverse analysis

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MIS25-P01 Room:Convention Hall Time:May 24 18:15-19:30

Field evidence of tsunami sediments along the east coast of Taiwan

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Study on paleo tsunami deposits in geologic stratum is one of valuable tools for identification of paleo earthquake in the tectonically active coast, in Taiwan. After the 2011 Tohoku tsunami, demand increased greatly for geologists with expertise in the geology of tsunami deposits, who could study prehistoric tsunami deposits.In Taiwan, east coast is very close to the Pacific Ocean and the Ryukyu Trench. In order to confirm the tsunami attacked the east coast of Taiwan, we are investigate the East Coast from Hualien to Taitung coast.

Keywords: the east coast of Taiwan, tsunami sediment

Japan Geoscience Union Meeting 2015
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MIS25-P02 Room:Convention Hall Time:May 24 18:15-19:30

Source of tsunami sediments estimated using foraminifera in the east coast of Ishigaki Island

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Investigations of old literatures and tsunami boulders revealed that large historical and paleo tsunamis had been attacked the Sakishima Islands for several thousands years. The 1771 Yaeyama tsunami (Meiwa tsunami) was the biggest tsunami in the historically recorded ones in the Yaeyama Islands. The 14C dating of the coral fossils over the tsunami boulders also showed the repeating large paleo tsunamis in the Sakishima Islands.

The sand layers were frequently observed at the excavation sites of the archeological surveys. However, the source of such sands using the foraminifera had not been surveyed in the Sakishima Islands.

We investigated the source of the sands of the tsunami sediments using the analysis of the foraminifera. We performed the trench-survey at Tanaka cattle farm, Ibaruma, the east coast of the Ishigaki Islands on November 5-8, 2013. Five trench, whose elevations were from 2.65 m to 8.13 m, had been excavated along the survey line from the shore to inland. We sampled the sediments at the interval of 20 cm to downward direction. The mud contents, particle-size analysis, and the foraminiferal analysis of the sediments were done. We picked the foraminifera whose number is over 150 from the sample of the grain size of 2-0.5 mm and analyzed them. The sampled was decimated when the quantity of the sample was large. Then we sampled the beach sands and analyzed them to investigate the source of the tsunami sediments. We performed the community analysis using cluster analysis and multidimensional scaling method. For the community analysis, we used the recent foraminifera group data sampled at beach, sea grass beds, reef crest, and moat in the north of Ishigaki Island (Fujita, 2006), and compared them with those of tsunami sediments.

Almost trench sites consists of first (cultivated soil), second (sand layer including rip-up crusts), third (silt layer), and fourth (sand layer with grading and coral fossils) layers. The most inland trench consists of first (cultivated soil), second (grading sand layer with rip-up crusts), third (mud layer including many gravel), and fourth (Shimajiri mud stone) layers.

The age of second and fourth layers, which were possibly the tsunami sediments, were estimated as 200-300 years and 500-800 years from the dating the C14 age of the in-situ bivalves.

The community analysis of the foraminifera showed that the compositions of the foraminifera at the seaward and landward sites had changed gradually through the same layers. The group which lived near the reef crest was dominant in the seaward site, whereas the group near the shore was dominant near the inland site.

This suggests that the sediment of the reef crest and shelf was deposited near the shore, although the sand near the shore was deposited in the inland by the tsunami of 200-300 years ago. Moreover, the foraminifera (Amphistrgina spp. and Elphidium spp.), which could dissolve at fresh water condition, was concentrated at fourth layer. The ground water had leaked near the bottom of the trench sites. The above-mentioned foraminifera would have remained selectively whereas others solved in the fresh-water condition. This suggests that the effect of the dissolution would be important factor for the preservation of foraminifera in the tsunami sediments.

Keywords: tsunami sediments, foraminifera, Ishigaki Island

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MIS25-P03 Room:Convention Hall Time:May 24 18:15-19:30

Four Holocene uplifted benches and two historical tsunami gravels around Koseda coast, Yakushima Island

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Many researchers have noted that Yakushima may have been struck by a huge earthquake and tsunami along Ryukyu subduction zone during historical age, but there is currently no clear evidence of this. We described four Holocene wave-cut benches uplifted by subduction earthquakes and two historical tsunami gravel beds around Koseda coast in northeastern Yakushima Island.

Keywords: Holocene wave-cut bench, huge tsunami trace, huge earthquake, Ryukyu subduction zone, Koseda coast, Yakushima Island

Japan Geoscience Union Meeting 2015
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MIS25-P04 Room:Convention Hall Time:May 24 18:15-19:30

Tsunami deposit survey on the Chichi Is. and Haha Is. in the Bonin Islands (Preliminary report)

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The Izu-Bonin subduction zone has been regarded as so-called ”Mariana-type subduction zone” where M>7 interplate earthquakes do not occur. Ishibashi and Harada (2013) proposed a working hypothesis that the 1605 Keicho earthquake which has been considered a great tsunami earthquake along the Nankai trough was a giant/great earthquake along the Izu-Bonin trench based on the similarity of the distributions of ground shaking and tsunami of this event and the 2010 Bonin earthquake. Harada et al. (2013) carried out the tsunami numerical simulations from the fault models along the Izu-Bonin trench and their results support the Ishibashi and Harada’s hypothesis. However, it has not discovered that the evidences of the giant/great earthquake along the Izu-Bonin trench yet. Therefore, in order to discover the tsunami traces of the earthquake such as tsunami deposit or tsunami boulders, we started to tsunami deposit survey on the Chichi Is. and Haha Is. in the Bonin Islands last year.

We have conducted two tsunami deposit surveys on the Chichi Is., Haha Is. and some territorial islands around the two islands. Total number of survey points is 23. We found tsunami deposits at three survey areas in the Chichi Is. (Sakai-ura beach, Yatsuse-gawa valley and Minami-fukurozawa valley).

Some preliminary results are as follows. We found at least three event layers on the outcrops in the Sakai-ura beach in Chichi Is. Upper two layers were possibly deposited by the tsunamis or storms because of their typical features of tsunami deposit. The third layer (thickness is 50˜100 cm) has the sharp basal contact with under soil and consists of large amount of corals which suggest an unidirectional flow. At the two survey points in Yatsuse-gawa valley, some event layers were identified. In the Minami-fukurozawa valley, two thick layers include large gravels and four or five thin layers on the outcrops. However, origin of the thick layers has not been revealed yet. More tsunami deposit surveys are necessary in the islands to confirm these layers were tsunami deposits or not.

We thank Mr. Ichiro Hosoda, other teachers, and students of the Ogasawara high school for supporting our survey. This study was supported by JSPS KAKENHI Grant-in-Aid for Young Scientists (B) (Grant Number 26750129).

Keywords: tsunami deposit, Chichi Is. and Haha Is., Izu-Bonin subduction zone, 1605 Keicho earthquake

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Tsunami sediment immediately after K-Ah ash fall in Miyazaki Plain

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Miyazaki Prefectural Museum of Nature and History, along with the Ishizaki river renovation of Miyazaki Sadowara Kuroda in 1996, have created peeling specimen of outcrops.The peeling specimens contains Akahoya volcanic ash of mollusk shells and Jomon transgression period.It is possible to observe the formation of up to 7.5 m depth from the surface. Result of study in sedimentological deposition environments of the stripping specimen, it was possible to find a tsunami deposits.

The peeling specimens include Crassostrea gigas, Tegillarca granosa, Thalassinoides isp..From these, Akahoya volcanic ash was deposited under inner bay environment close to the tidal flats or tidal flats.

Akahoya ash, exhibited a white tinged with pale yellow to pale pink in the specimen, the layer thickness is about 1.5m.The boundary between the lower strata exhibits a clear erosion.Bottom is a massive volcanic ash containing a large amount of wood.The top, HCS-mimics, parallel lamina, is observed climbing ripple laminae.The upper is covered with a non-structure of volcanic ash.Paleocurrent which is determined from the form of climbing ripple is a west direction from the east.Akahoya ash facies, such as erosion surface can not be seen until the climbing ripple from the bottom, i is judged to be continuously deposited.HCS-mimics are formed in the inner bay, we observed flow to the landward, there is a possibility of tsunami deposits.

Fujiwara et al. (2010) reported the tsunami deposits with characteristics similar in Oita, and the like be covered with ash fall of Akahoya, and are to be tsunami deposits caused by eruption.On the other hand, the tsunami deposits reported this time, not that it can be determined that volcanic ash.Also, the thickness of the secondary sediment is developed thick and 1.5m, while climbing ripple formed in sediment supply is often on even the naked eye observation, and the like to become only Akahoya ash, at least drop Akahoya ash is considered to be those that occurred after sufficiently deposited.In view of the above, this time the observed tsunami deposits, I believed to be due to the tsunami that occurred immediately after ash. Because it is information from a single stripping specimen, it is enough assurance not be obtained, it is necessary to consider the tsunami occurrence factors other than the Akahoya eruption, information of tsunami research is scarce Miyazaki coast of tsunami than other regions in performing the studies, it is very valuable sample.

Keywords: tsunami deposits, Kikai-Akahoya-ash (K-Ah), Miyazaki Prefecture, Peels of Outcrops

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Preliminary report on paleotsunami study in Nankoku City, Kochi Prefecture, western Japan

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Kochi Prefecture has been struck repeatedly by large tsunamis generated by subduction zone earthquakes along the Nankai Trough. Historical records through approximately 1,300 years indicate great earthquakes (M ˜8) basically occurred at intervals of 100-200 years along the Nankai Trough. However, because historical documents are relatively sparse before the 16th century, it is difficult to evaluate magnitudes and rupture areas of earthquakes during this period. Tsunami deposits provide basic data for reconstructing not only the long-term earthquake history but also the magnitudes and the rupture areas. Therefore we studied tsunami deposits in Kochi Prefecture.

We drilled in coastal lowlands of Toyo Town, Nankoku City, Shimanto Town and Kuroshio Town. We obtained cores and geoslices at 9 sites in a coastal lowland up to 3 m in elevation in Nankoku City. Deposits above the Kikai-Akahoya tephra (erupted ca. 7,200 cal BP) consist mainly of mud, peat and include event sand sheets. We present initial findings following the preliminary results of radiocarbon dating and fossil diatom analysis for some cores.

Keywords: tsunami deposit, fossil diatom analysis, Nankai Trough, Nankoku City, Kochi Prefecture

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Nankai Earthquake events recorded in lacustrine sediment along the eastern coast of the Kii Peninsula, southwest Japan.

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We research on tsunami sediment from lacustrine deposits along the Nankai Trough for prehistoric earthquake reconstruction. Total 21 cores are collected from the two lakes named Zasa-ike and Ashihama-ike, which locate behind coastal ridge along the southeastern coast off Kii Peninsula. Eighty C14 radioactive carbon dating are carried on plant remains containing the cores deposited under non-marine condition.

As a result, Ashihama-ike records two major events, 2000yBP to 2300yBP and 1000yBP to 1100yBP through 4500 years interval. The other Zasa-ike has six events are detected, which are 7000yBP, 6500yBP, 3500yBP, 2000-2300yBP, 1300yBP, and 1100yBP through the interval of 7500 years. The oldest event in these cores is conglomeratic coarse sediment covered by K-Ah tephra obtained from the lowermost part of cores. Both two events, 2000yBP to 2300yBP and 1000yBP to 1100yBP can be correlated among the ponds Ashihama-ike and Zasa-ike which has two kilometers in distance each other.

Keywords: Nankai Earthquakes, tsunami sediment

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Assessing modern sediment distributions as tsunami indicators for coastlines facing the Japan Trench

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Geologic studies conducted in coastal areas of Japan have revealed evidence of earthquakes and tsunamis that predate the historical record. These studies assess the long-term seismic trends along subduction zones, and provide improved hazard assessment by constraining the possible magnitudes of future events. However, one of the obstacles facing the proper identification of paleo-tsunami deposits is the lack of a modern analogue.

In 2013 we collected modern surface samples along two coastal transects located on Hasunuma Beach (Kujukuri), a region with a history of tsunamis, and documented their foraminiferal (taxonomy and taphonomy) and grain size distributions. Highest concentrations of foraminifera were found in swash and foreshore zones and markedly decreased landward towards the backshore and dune. Swash and foreshore assemblages were dominated by Pararotalia nipponica, Quinqueloculina sp., and planktics, whereas the backshore and dune contained only species with robust tests (e.g., Pararotalia nipponica, Ammonia parkinsoniana, and Lenticulina sp.).

Taphonomic analysis (surface condition of individual tests) revealed that swash and foreshore samples contained higher abundances of unaltered and fragmented foraminifera, whereas the majority of foraminifera in dry beach samples were corroded due to subaerial exposure. Results of particle size analysis show a marked decrease in size from the swash zone (coarse sand) to the dunes (fine to very fine sand).

Partitioning Around Medoid (PAM) cluster analysis of the modern surface data indicated that foraminiferal taphonomy, a proxy that is not commonly applied to overwash deposits, discriminated coastal zones more effectively than taxonomy or grain size. Although a multi-proxy approach is necessary to properly assess overwash deposits, foraminiferal taphonomy will be most useful in determining sediment provenance and aiding in the interpretation of anomalous sand layers previously identified at this location.

Keywords: Tsunami deposit, Foraminifera, Kujukuri

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Field Survey of Tsunami Deposits in a Reclaimed Lagoon in Minami-Soma City, Fukushima Prefecture

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For the purpose of reconstructing paleo-tsunami histories, we conducted field survey of tsunami deposits at the Idagawa drained land in Odaka district, Minami-Soma City, Fukushima Prefecture in June and November 2014. We set a survey line perpendicular to the coast and obtained 11 core samples of 1.4-2.7 m length at distance ranging 0.6-2.7 km by using handy geo-slicer. We sketched the facies, analyzed grain sizes, and measured the ^{14}C ages. Tsunami trace of the 2011 Tohoku-oki earthquake covers the rice paddy soil in the drained land with the thickness of 3-30 cm, and it can be observed at the all sampling sites. Six sandy layers including the 2011 tsunami trace were identified in the 2.7 m long core sample obtained at the central part of the drained land. The ^{14}C age at the lowermost part of the sample was 2,310±20 yr BP, indicating that there are possibly six or more tsunamis attacked the survey area.

Tsunami deposit survey on the Fukushima coast is important to constrain the southern limits of the 869 Jogan and 1611 Keicho tsunami deposits, and northern limit of the 1677 Enpo tsunami deposit. Along the coasts of Sendai plain to Fukushima, paleo-tsunami deposits were reported by previous studies (Sawai *et al.*, 2012, GRL). At the present survey site, three event layers which deposited after 2,820 yrBP were identified in 1.1-1.6 m long core samples by a previous survey (Goto and Aoyama, 2005, Abstracts for the JpGU). The sedimentary features of the 2011 Tohoku-oki tsunami deposit were reported by Oota and Hoyanagi (Proceedings of the 2014 annual meeting of the Geological Society of Japan). The survey site is a former lagoon where a reclamation project started in 1919, and has been utilized for rice paddies until the 2011 Tohoku-oki earthquake. Old maps published in 1910, 1888 and 1821 indicate a lagoon or inner bay facing a coast, which is affected by the tide. It is expected that the paleo-tsunamis transported sandy deposit from coast to the inner part of the bay, which can be distinguished with inner-bay muddy deposit.

The facies of the core sample obtained at the central part of drained land (1.8 km from the coast) can be divided into 11 units from the top to the bottom as follows: 1. Very fine to coarse sand including mud drape and normal grading (thickness ~ 30 cm); 2. Soil for rice paddies including undecomposed plants; 3. Alternative layers of medium sand with lamination and mud clasts; 4. Muddy layer including shell fragment; 5. Fine to medium sand with normal grading and lamination; 6. Muddy layer; 7. Medium sand with normal grading and lamination; 8. Reductive muddy layer with olive yellowish color; 9. Medium sandy layer with normal grading and rich mud clasts; 10. Reductive muddy layer; and 11. Medium to coarse sand layer with normal grading, lamination, and mud clasts. Six sandy layers (1, 3, 5, 7, 9, 11) have sharp basal contacts with the lower units, and can be widely identified at the survey area: hence, they are considered to be event deposits. To estimate the depositional ages, we obtained ^{14}C ages for wood/shell fragments and charred materials as follows: 1000±20 yrBP (calendar year 2σ: AD1310-1420) from a shell fragment below unit 3, 1660±30 yrBP (AD270-430) from a charred material above unit 5, 1960±20 yrBP (40BC-AD90) from a charred material above unit 9, and 2310±20 yrBP (410BC-260BC) from wood fragment at the lower part of unit 11. Inner-bay muddy deposits below unit 8 contain rich oyster assemblage and shell fragments of Trapezium clam in core samples with the distance <1.2 km from the coast, while their productivity abruptly decreased above unit 5. This indicates that the sedimentary environment changed at the border of unit 5. In future, we plan to reveal the characteristics of deposit and reconstruct the sedimentary environment through the microfossil and elementary analyses as well as careful investigation of samples by increasing the number of samples.

Keywords: Tsunami deposit, Fukushima, Paleo-tsunami, Historical earthquakes

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Sedimentary features of the 2011 Tohoku-Oki tsunami deposit and paleo-tsunami history in Numanohama, Sanriku Coast

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We have conducted tsunami deposit surveys in Numanohama marsh in Miyako City, Iwate Prefecture since the summer of 2012. Tsunami deposit from the 2011 Tohoku-Oki earthquake at this site has characteristic facies that contain both marine- and land-origin particles. This facies represents a sequence of tsunami inflow transporting marine sand/pebble and return flow transporting land soil, riverbed pebble and talus deposits. We identified at least 10 event layers from the 5.8 m long column sample; we named these layers as S1 to S10 from the top to the bottom. S10 has a characteristic facies with mixed marine and land particles, similar to the 2011 deposit. Radiocarbon dating (^{14}C) result shows that S10 deposited from 1800±20 yrBP (calendar year within 2σ range: AD130-320) to 340±30 yrBP (AD1470-1640).

V-shaped valleys are distributed along the Sanriku coast from Miyako to Kuji City. At the survey site, the tsunami height from the 2011 Tohoku-Oki earthquake was 34.1 m (Tsuji *et al.*, 2011). Oguchi *et al.* (2013, Abstracts for the fall meeting of the Association of Japanese Geographers) made detailed geomorphological survey using a laser scanner in Aneyoshi, Miyako City, and showed that tsunami wave eroded land soil and vegetation in valley plain, and lead collapse of rock wall or slope. Sediments eroded by tsunami re-deposit in a valley plain as 'tsunami deposit'. Understanding the characteristic features of tsunami deposit from the 2011 Tohoku-Oki earthquake in a V-shaped valley is useful for identifying paleo-tsunami deposits along the Sanriku coast.

The characteristic feature of the 2011 Tohoku-Oki tsunami deposit could be identified up to 300 m inland from the shoreline. The content ratio of marine pebbles gradually decreases toward inland. On the contrary, riverbed pebbles become rich at upstream sites with a distance of >560 m from the coast. The event layers could be divided into five kinds of particles; A (marine sands/pebbles), B (rock clast from the rock wall), C (riverbed pebbles), D (talus deposits), and E (land soil). Particles A-E are considered to be transported toward inland by tsunami inflow, while a part of these particles were re-transported by return flow. Particles classified into B and D are strongly influenced by return flow and transported by mud or debris flow from the top of small valley. After such a flow joins the main river stream, riverbed pebble were transported further seaward.

We conducted a drilling survey by using handy geo-slicer, observed outcrops and pit at the valley plain to investigate the distribution of each paleo-event layer. In addition to the six layers in our previous study, we identified four additional event layers S7-S10. The ^{14}C dating revealed that those events occurred during the period from 1950±20yrBP (AD0-AD120) to 410±20yrBP (AD1440-1610). We plan to estimate the depositional ages from more dating samples and to reconstruct paleo environment in this marsh.

Keywords: Tsunami deposit, Sanriku coast, Paleo-tsunami, Historical earthquakes

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MIS25-P11 Room:Convention Hall Time:May 24 18:15-19:30

Tsunami deposits observed with rice paddy development at Noda village, Iwate Prefecture

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Tsunami-like layers were appeared on drainage channel wall that excavated for rice paddy development at Noda village, Iwate Prefecture. This site located behind the tide embankment (elevation of the embankment top is TP+12m) along the northern part of Sanriku coast. The 2011 Tohoku-oki tsunami was inundated to about 1km inland going over the embankment.

We identified four sand and gravel layers that were distributed continuously in peat buried by surface paddy soil (Event I to Event IV from the top). These layers show a tendency becoming thin and shallow toward inland. Therefore upper layers were mixed in surface soil and disappear. Each layer has an erosional base and consist of one massive unit, however it has no distinct laminae, rip-up mud clasts and grain size grading. We consider each event layer was probably formed by tsunamis because of the distribution and sedimentary structures are similar to tsunami deposits that have been reported in previous studies.

Event II sand is deposited below tephra layers. The distinct tephra layer is identified as Baitoushan-Tomakomai tephra (B-Tm) that was deposited in early to middle 10th Century. Other one can be identified as Towada-a tephra (To-a) of AD915 is observed only in a few points just below the B-Tm tephra layer. Radiocarbon dating results just above and below Event II sand layer is consistent with the tephra chronology. These analytical results suggest Event II sand deposited early to middle 10th Century, therefore Event II is potentially corresponding to 869 Jogan tsunami. Radiocarbon dating results just above and below Event I gravel layer shows 14th Century to early 17th Century. 1611 Keicho Oushu (Sanriku) tsunami is known as one of the historical large tsunamis which recorded damage along the Sanriku coast at this time. It is pointed out that tsunami might have also occurred in 1454 along the Pacific coast of Tohoku district, although there is no definite record.

Radiocarbon dates of lower event layers suggest that each layer deposited 5th Century to 6th Century (EventIII) and 1st Century to 3rd Century (Event IV). Our survey result mean four (five including 2011 Tohoku-oki) inundation of potentially large tsunamis occurred past 2000 years in this site.

Keywords: tsunami deposit, historical tsunami, Jogan tsunami, Keicho Oushu (Sanriku) tsunami, Noda village Iwate Prefecture

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Estimation of formative mechanism and classification of surface facies of tsunami origin sediment at Hirota bay

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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 classification of surface facies, and estimate the formative mechanism of tsunami origin sediment.

We took the columnar core at water depth 8-30 m. The columnar cores were able to sectionalize to mainly two units from lithofacies. Unit-1(U1) consists of sand layer and Unit-2(U2) consists of muddy layer. Yokoyama et al. (2014) assume that U1 were 2011 tsunami origin sediment, and U2 were normal sediment in this bay. We estimate U1 distribution with thickness approximately 7-80 cm. U1 thickness have lateral change around coastal area (water depth about 8 m), but homogenize a thickness around water depth about 13-16 m. Therefore, we estimate some sediment lobe were unified toward offshore.

U1 were able to sectionalize to some sub units from grading. Sub unit number was decrease from coastal area to offshore. Sub unit-1a (bottom layer of U1) have granule to fine pebble at base, and grain size gradually become finer from coastal area to offshore.

13HV8 (water depth about 13 m) was able to sectionalize to sub unit-1a and 1b, sub unit-1a consists of grading section (medium-very coarse sand), parallel lamina section (medium sand) and fine sand section (very fine sand-fine sand) from the bottom, it is similar to the character of Bouma sequence -a, -b, -d or -e, and sub unit-1b have same characteristics, too.

Keywords: Tsunami deposit, Sanriku coast

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Tsunami origin sediments observed from the Ohtsuchi bay, Iwate Pref., Japan.

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The recent 2011 Tohoku tsunami strongly affected the coastal area of the Pacific coast of Tohoku. Tokai University and JAMSTEC team investigated the Tohoku coastal area as a part of Tohoku Ecosystem-Associated Marine Sciences (TEAMS).

We researched using acoustic equipments (Multi narrow echo sounder : MNB and Sub bottom profiler : SBP), and bottom sampler.

SBP data was seen signature reflecting (20-50cm down from seabed), and able to estimate the reflecting surface to depth of approximately 20 m at Ohtsuchi bay. The most strong reflector (R1) near the sea-bottom (20-70cm in depth) have rich in unevenness characters and have large lateral change around the shallow area (5-15m). However, R1 changes flat and smooth reflector to the offing (over -30m in depth).

Characteristic of columnar core sample at Ohtsuchi bay consists by 2 (shallow area) to 3 (deep area) sedimentogical units, such as upper sandy unit (30-110cm), middle reddish brown silt unit (60-130) and lower sandy unit. This coarse sand and gravel layer from Unit-1 eroded out the underlying reddish brown silt (Unit-2) zone. Geological facies (Unit-1) of the cores from the Ohtsuchi correspond with reflector from SBP such as R-1. It is estimated that the upper sandy sediment unit with grading structure above the erosion layer, which observed Ohtsuchi bay, is assumed to be a layer of sediment gravity flow caused by the tsunami activity.

Keywords: tsunami sediment, Ohtsuchi bay

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Effectiveness of luminescence dating of tsunami deposits examined from the March 2011 Tohoku-oki Tsunami deposits

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Optically Stimulated Luminescence (OSL), which determines depositional age of sediments using minerals such as quartz and feldspar, may be useful for dating tsunami deposits. Furthermore, OSL dating is occasionally used for transport-depositional processes of sediments in terms of bleaching achievements, which might be able to apply tsunami deposits. In spite of these potentials, OSL dating studies on tsunami deposits have been hardly conducted. The current study was undertaken in order to confirm these effectiveness of OSL dating on tsunami deposits using the 2011 Tohoku-oki tsunami deposits at Soma city and Minamisoma city, Fukushima Prefecture, northeastern Japan.

Single grain OSL dating was able to extract the grains indicating true depositional age of the 2011 Tohoku-oki tsunami deposits at 11 locations (26 samples), which shows nearly zero OSL intensities. It is interpreted from the results that single grain OSL dating is a feasible method to estimate appreciate depositional age of tsunami deposits. Meanwhile, some grains were overestimated depositional age remarkably. Therefore general OSL dating, which measures a number of grains on one aliquot, is probably difficult to estimate accurate depositional age of tsunami deposits. The results of OSL dating indicated most of sand grains in tsunami deposits had not been exposed to daylight during tsunami transport processes. This means that sand grains in tsunami deposits preserving bleaching achievements of sediment sources. OSL dating is able to calculate bleaching achievements of minerals, therefore, it might be able to estimate sediment sources of tsunami deposits.

Keywords: OSL dating, transport and depositional processes, tsunami deposits, the 2011 off the Pacific coast of Tohoku Earthquake, feldspar

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Correlations of tsunami deposits based on high-dense array drilling survey at Koyadori, Iwate Prefecture

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Tsunami deposits study greatly increased after The 2011 off the Pacific coast of Tohoku earthquake tsunami. However, tsunami deposits are covered and sometimes disturbed, and thus we generally conducted coring survey and correlate tsunami deposits between each core based on lithology and age. Especially, the correlation of tsunami deposits is very significant for assessment of tsunami and earthquake risk. In this study, we carried out high-density array drilling survey to confirm continuity of tsunami deposits. Additionally, we tried to compare the correlation of each tsunami deposits when we change the interval of coring sites. Consequently, we correlated each tsunami deposits confidently in 2.5 m, 5 m, and 10 m interval. In 20 m and 50 m interval, we can correlate some tsunami deposits, however accuracy of the correlation is much lower than that of 2.5 m and 5 m interval. Although this study is one case, we need to confirm the accuracy of correlation in the future.

Keywords: tsunami deposits, high-dense array drilling survey, Sanriku Coast, correlation of tsunami deposits

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Local correlation of sandy paleo-tsunami layers and estimation of inundation distance in eastern Hokkaido

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We found multiple paleo-tsunami sand layers of the last 3000 years in seven marshes (Urahoro, Kinashibetsu, Onbetsu, Kushiro, Akkeshi, Nemuro, and Betsukai) on a 200-km-long coastline of eastern Hokkaido, Japan. In the previous studies, up to six paleo-tsunami layers were described in these regions, but inundation area of only few events were discussed. The purpose of the present study is to evaluate the inundation area of every paleo-tsunami events along each transect based on the local correlation of paleo-tsunami layers. Along the Urahoro transect (370 to 625 m from the sea), at most ten sand layers were observed and five layers of them were successfully correlated along the whole transect by comparing their particle sizes and mineral compositions. For the uppermost layer we correlated, the mean grain size smoothly decreases landward from 0.24 to 0.74 phi, and its heavy mineral ratio decreases from 40 to 34 %. The other four layers also show individual decreasing trends both in particle size and heavy mineral ratio. In other regions, there are two sand layers in Kinashibetsu, six in Onbetsu, two in Kushiro, two in Akkeshi, eight in Nemuro, and two in Betsukai. Four layers in Onbetsu can be correlated and traced to 590-670 m from sea, and four in Nemuro are traced to 260-300 m. These layers are presumed to be formed by relatively large events. Along the Betsukai transect, the far side of Nemuro peninsula, two fine-sand layers were observed and presumed to be evidences of large paleo-tsunami events which formed sand layers along the Pacific coast. Methods for wide correlation of paleo-tsunami layers, however, have not been developed and should be discussed by future works.

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

MIS25-P17 Room:Convention Hall Time:May 24 18:15-19:30

Sedimentary process and distribution of terrestrial tsunami deposit: a flume experiment

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Flume experiments were conducted to examine the effects of the magnitude of tsunami and existence of a lake in coastal lowland on sedimentary process and resulting sediment distribution regarding the setting that run-up tsunami transports sediments in coastal zone (e.g. sandy beach or dune) to coastal lowland. We prepared three topographical models of the terrestrial area: flat models with a shallow or deep pool filled with water (9 mm and 45 mm depth, respectively, and 1.0 m long) at their center, and an entirely flat topographical model without a pool. In each run, only one run-up tsunami flow passed through the terrestrial area without generating strong backwash. The tsunami flow was supercritical throughout the terrestrial area in the experimental series without a pool, while it transformed from supercritical into subcritical generating a hydraulic jump in the pool for the runs with a pool. The tsunami magnitude, terrestrial tsunami deposit, and terrestrial topography setting showed the following relationships:

(i) The total amount of tsunami sediment depended on the magnitude of tsunami.

(ii) In the experimental series with a pool, most of sediments deposited in the pool, but little sediment was in the area where the hydraulic jump occurred.

(iii) The amount of the deposit at a given site did not always depend on the magnitude of the tsunami even in the same topography setting.

Although further investigation is needed, the present experiments showed some possible clues for future field surveys to understand tsunami deposits.

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Keywords: terrestrial tsunami deposit, coastal lake

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An attempt to estimate high-precision 14C dating of tsunami deposits based on the Bayes theorem

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One of the most important issues to estimate recurrence interval of subduction zone earthquakes and tsunamis is precise determination of depositional ages of tsunami deposits (Komatsubara et al., 2006). However, a common technique, which is usually dating organic materials from above and below the candidate deposits, often has large statistical errors ranging from few tens to few hundreds of years. Furthermore, erosion of bottom soil during the tsunami inundation may lead large bracketing age of the event (Goto et al., 2014).

These statistical errors arise during calibration of ^{14}C date. Because of the fluctuations in the calibration curve, calibration will often result in widened and multi-peaked calendar age uncertainties (Blaauw, 2010). To solve this problem, the Bayes theorem is useful to constrain the calibration results. The purpose of this study is to conduct millimeter-scale high resolution radiocarbon dating and to estimate precise determination of the depositional age of tsunami deposits based on the Bayes theorem. In this study, we use deposition model of Oxcal ver. 4.2.4 (Ramsey, 2009). An age-depth model can be made using this model based on the information of the stratigraphic order of deposition and depth information (Ramsey, 2008).

As examples, here we show results of high-resolution radiocarbon dating of soil samples below the paleo tsunami deposits at Urahoro, Hokkaido (Nanayama et al., 2002) and those at Noda Village, Iwate. For example, tsunami deposit at Urahoro is considered to have been formed in the 17th century (Nishimura and Nakamura, 2010), because it lies just below the Ta-b tephra that erupted A.D. 1677. However, it is difficult to estimate the age using ^{14}C dating method, because this age has wiggles in calibration curve. In spite of these wiggles, high resolution measurement allows us to make age-depth model using Bayes theorem and to estimate the precise age of this deposit as early to middle 17th century.

Keywords: tsunami deposits, 14C dating, Bayes theorem

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Laboratory experiment of tsunami deposit using a large wave flume

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The laboratory experiment was conducted to study the relationship between the hydraulic condition and sedimentological features of tsunami deposit. The large wave flume in CRIEPI which can generate incoming wave with up to 3.0 m/s on the shoreline was used in this study. This large scale experiment allows us to use the actual sand and the reproducibility of sedimentological features of tsunami deposit is expected. In the presentation, we will show the preliminary results of this laboratory experiments.

Keywords: tsunami deposit, laboratory experiment

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Identification criteria of the tsunami deposits based on the Japanese paleotsunami researches

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Identification criteria of the tsunami deposits have frequently been discussed by many researchers (e.g., Morton et al., 2007; Goff et al., 2012). As Goto et al. (2014) noted, it is generally agreed that there is no single criterion that can be used to identify a tsunami deposit but rather that multi-proxy analyses of criteria, such as sedimentology, micropaleontology and geochemistry are required.

Identification criteria may be different in countries and local regions because of the difference of geological, historical, and cultural backgrounds. For example, Japan has ˜1,300 years historical records of earthquake and tsunami. Therefore, many tsunami deposits up to 1,300 years can be correlated to the historically described tsunami events and this is used as one of the most important identification criteria in Japan (e.g., Komatsubara et al., 2006).

This study investigated previously published research papers that discussed about candidate tsunami deposits along the Japanese coast to explore the identification criteria of the tsunami deposits specifically for Japan. We found that the identification criteria that were used in the previous papers can be classified into 40 to 50 categories. Some of them are used to specify whether the candidate deposit is the event deposit and thus those are not straightforward ones to identify tsunami deposit. On the other hand, there are some categories that would be useful to identify the tsunami deposit. These information would be valuable to assign the validity to the tsunami deposit identification for the future researches.

Keywords: tsunami, tsunami deposit