

The sedimentary process and distribution of tsunami deposits in coastal lakes: a flume experiment

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A series of flume experiments were performed to examine the sedimentary process and distribution of tsunami deposits in coastal lakes. In the experimental program, a fixed slope of 1/20 and terrestrial area including a pool as a coastal lake were installed, and tsunami-like solitary wave was generated. The tsunami flow transported sediments from a sand bed placed on the slope, and deposited them on the terrestrial area. When the tsunami flow irrupted into the pool, hydraulic jump was occurred. In the area where the hydraulic jump made turbulence, little sediment deposited. Thus, the distribution of the tsunami deposits in the pool did not always show the thinning-landward trend in the present experimental series. The dependence of the amount of sediments on magnitude of tsunami waves was more pronounced in the pool than the land area.

Keywords: tsunami deposit, flume experiment, coastal lake

Variations of terrigenous organic carbon content in flood and slope failure sediments

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In this study, we analyzed the stable organic carbon isotope of sea floor sediments, which were deposited by the modern large floods with typhoon and the slope failure with earthquakes. Stratigraphic variations of terrigenous organic carbon content in the flood sediments were different from those of slope failure sediments.

Sediment cores KH-11-9-FB12 and FB14 were corrected from the deep-sea floor off the Kumano River mouth, which is located on the Kii Peninsula. The sediment cores contain flood-induced sediments by large typhoon in September, 2011, the largest 20th century typhoon, and the large 19th century Totsukawa flood (Ikehara et al., 2012). These flood-induced sediments have high terrigenous organic carbon content. The base of turbidite, which include wood fragments, has highest peak of terrigenous organic carbon content. On the other hand, terrigenous organic carbon content of the lower part of turbidite mud are lower than those of the middle and upper parts of turbidite mud. The stratigraphic variations of terrigenous organic carbon content is not recognized in the middle and upper parts of turbidite mud.

Sediment cores 95A and 104A were corrected from the shallow depression on shelf off the Saru River mouth, Hokkaido, in 2007. These cores contain the sediments by the severe flood with typhoon in August, 2003. The shallow depression on shelf, which is thought to be the old river path during lowstand of the last glacial age, was suitable for preservation of the flood-induced sediments (Katayama et al., 2007). The lower part of the turbidite mud has low terrigenous organic carbon content and the middle and upper parts have high terrigenous organic carbon content. The stratigraphic variations of terrigenous organic carbon content is not recognized in the middle and upper parts of turbidite mud. The turbidite mud off the Saru River mouth have same characteristics as those off the Kumano River mouth. These results suggest that the lower part of flood-induced sediments were formed by erosion and deposition of sea-floor sediments during the early stage of flood. The middle and upper parts were considered to be formed by continuous supply and deposition of terrigenous materials from river mouth during the flood.

The sediment core BP09-6 was corrected from the Beppu Bay. The sediment core contains the slope failure sediments by the large earthquake in 1596 (Keicho-Bungo earthquake; Kuwae et al., 2013). The slope failure sediments are characterized by upward decreasing of terrigenous organic carbon. This result suggests that the turbidity currents were caused by collapse of delta slope sediments, which contain both terrigenous and marine organic materials.

Stratigraphic variations of terrigenous organic carbon content might be important information, when we investigate the records of paleo natural disasters with sea-floor sediments.

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Keywords: turbidite mud, hemipelagites, organic carbon, natural disasters

Quartzose sand and kaolinite-dominated mud derived from felsic plutonic rocks in intense weathering condition

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In the Upper Miocene - Early Pliocene time, Japanese island had a warm and subtropical climate. The mineralogical and chemical compositions of sand and mud of the Upper Miocene Tokiguchi Porcelain Clay and the Early Pliocene in the Kobiwako Group were examined for sedimentary petrography and geochemistry to clarify the influence of the warm climatic condition on sediment composition. Both sediments are considered to have been produced from felsic crystalline basement provenance. These sediments are characterized by the deposition in warm and humid climate on the basis of plant and diatom fossils.

The humid tropical climate produced quartz rich sand and kaolinite rich mud. The Upper Miocene sediments indicate that mafic silicates and feldspars were destroyed so that the sand ranges from arkoses with plagioclase rich sand to subarkoses with dominant of K-feldspar. The Upper Miocene mud show kaolinitic clay mineral composition and aluminous chemical composition. In contrast, the Pliocene sand is arkosic to litharenitic with abundant of feldspars and accessory minerals. In the Pliocene mud, an increase in the relative abundance of smectite accompanies the breakdown of volcanic fragments and volcanic glass is detected.

The intense weathering, rare earth elements (REE) are concentrated in mud. The Miocene sand shows the REE concentration less than one of PAAS level, whereas the Miocene mud display similar level of concentration in PAAS. In many samples, the REE concentration is mostly by biotite and zircon evidenced by HREE concentration.

The intense weathering condition, such as high temperature with humidity, affects the sand and mud compositions with selective destruction of minerals and newly formation of clay minerals. The relative increase of HREE, which is mainly housed in durable minerals, and mineral assemblage of sand and mud probably provide quantitative estimation of weathering degree for the sediments derived from felsic plutonic rocks.

Keywords: Miocene, sand composition, mud composition, REE composition, weathering

Depositional environment of the recent Yangtze Delta sediment deduced from the natural gamma-ray spectroscopy of YD13-G2

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The Yangtze River has transported approximately 500 mt/yr of sediments which formed a well-developed tide-dominated delta on its mouth during the Holocene high-stand. Sediment transport is dominant in rainy summer season or during flooding events, and the 40% is deposited in the estuary and the remaining sediments are transported offshore by tide forming a submerged delta or re-transported southward during stormy winter season. Due to these seasonally contrasted and event driven feature of sedimentation, spatial distribution of the accretion and erosion of the delta body is highly heterogeneous.

The Holocene subaqueous delta sediment has been also used as good sediment archives of the history of the Yangtze discharge and flooding due to its high sedimentation rate and good coverage of the Late Holocene. We also performed drilling of the delta sediment and collected two ~30 m drilling cores and four gravity cores in order to reconstruct the flooding history and the associated change in the detrital provenance. The drilled site (YD-13) is located on clayey bottom with the water depth of 40 m. The top 10 m of the sediment core consists of homogeneous clay with rare sand patches, which could be formed during the Holocene high stand. One of the gravity core (YD13-G2) recovers the 140 cm of surface sediments, and we decided to examine the natural gamma-ray spectrum and stacking pattern of this gravity core at 1 cm resolution in order to stationarity of sedimentation.

Since Cs-137 was not detected from the YD13-G2 sediment, even the surface material was judged to be older than 1950. Pb-210 is detected from the top 50 cm interval, which suggests the near-surface sediments were deposited during these ~100 yrs. However, the vertical profile of Pb-210 shows highly variable from zero to 25 Bq/kg with zigzag shape, which suggests repeated intercalation of old materials. Th-234 / K-40 and Ac-228 / K-40 ratios varies consistently suggesting some varieties in the provenance or grain size. Further examination is necessary to resolve potential event sedimentation and the apparent age of the related sediments.

Keywords: Yangtze Delta, Depositional environment, natural gamma-ray spectroscopy

Provenance changes of Yangtze Delta core sediments and their implications for precipitation changes during the Holocene

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Understanding the complex evolution of the natural environment in response to changes in climatic boundary conditions is a major challenge. Changes in frequency and magnitude of flooding of the Yangtze in association with the variations in East Asian Summer Monsoon (EASM) precipitation during the Holocene is one of such examples. The Yangtze River catchment is particularly sensitive to periodic flooding and droughts caused by temporal and spatial variations in the seasonal precipitation regime.

As a joint research project with Nanjing Normal University, we conducted Yangtze Delta drilling to reconstruct temporal and spatial changes in precipitation within the Yangtze River drainage during the Holocene. Core YD13-1 (31°02' 59.9250" N, 122°50'00.2538" E) was recovered from Yangtze subaqueous delta at a water depth of 37 m, its penetration depth is 39.5 m, and probably covering the entire Holocene. The project focus on decadal/centennial-scale variability of river discharge and its provenance in the lower Yangtze reaches, deltaic system and East China Sea (ECS). It includes the study of the reconstruction of the flood history, the variability of fresh-water input and redistribution of Yangtze-derived sediments and Holocene floodplain development in these areas.

A new tool that use of electron spin resonance (ESR) signal intensity of the E1' center and the crystallinity index (CI) of quartz is introduced to characterize the provenance of the Yangtze River Delta sediments, which were derived from various parts of the Yangtze River drainage, and its temporal changes that should have reflected the spatio-temporal changes in precipitation and flooding. The result will contribute to a more accurate understanding of the changes in spatial precipitation pattern associated with rapid climatic changes, of evolution of the lower Yangtze river-delta-shelf system, and of the environmental and climatic conditions under which the process took place. Our previous research result from the mudbelt core in ECS suggests possible scenarios for the response of the Yangtze catchment to the changes in monsoon intensity and extreme events. New analytical result of the provenance proxy for core sediments from Yangtze River Delta will be presented and possible scenario will be discussed.

Estimating mixing ratio of the sediments from tributaries in the sediments from Yangtze River mouth

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Yangtze river is the largest river in eastern Asia. The rain front is accompanied with the development of summer monsoon, and moves within the Yangtze drainage, bringing heavy rain. Thus, the spatial fluctuation is also important for understanding the behavior of summer monsoon.

A paleoclimate record is needed for reconstructing the distribution of precipitation before metrological record. In Yangtze, over 95% of yielded sediment is suspended particle matter (SPM). The precipitation in drainage is proportional to water discharge, and water discharge is also proportional to suspended sediment concentration.

In this study, as a basis for reconstructing the past distribution of rain in Yangtze drainage, 1) analyze the ESR (Electron Spin Resonance) signal intensity of each tributary, 2) confirm that ESR values can explain the mixture of sediments in the mainstream, 3) discussing how large flood can be detected as a change of ESR values in the river mouth.

The sediments from major tributaries of Yangtze shows different ESR values each other. Using ESR values of each tributary as end members, the modern ESR value at rivermouth is estimated. The estimated value is consistent with the analyzed ESR value of sediments near rivermouth. So, ESR signal intensity can be used for estimating mixture of sediments.

We also calculated how large ESR value at rivermouth can change on the assumption that the flood occurs in specific tributaries. As a result, the flood can be detected as the change of ESR value at rivermouth when the sediment yield increases 5 times than usual.

Evaluation of chemical weathering and sediment flux for several drainages within the Yangtze River basin

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Chemical weathering is closely coupled with erosion and driving landscape evolution. Silicate weathering plays a major role of fixing atmospheric CO₂ in the carbon cycle in time scales longer than 10⁵ years. Therefore, quantitative estimation of chemical weathering rate and evaluation of its controlling factors are critical to understand its role on landscape evolution and controlling the carbon cycle on a long time scale. Researches on evaluating controlling factors of the weathering rates have been conducted using various methods and on various temporal and spatial scales, including theoretical approaches based on mineral dissolution experiments, empirical approaches based on analyses of river water, suspended material and sediments, and numerical modeling approaches to synthesize these data. Although empirical formulations of the chemical weathering and physical erosion rates specific to a certain river have been presented, processes of weathering and erosion should be considered together both from physical and chemical aspects in order to obtain more generalized formulas. Besides, in order to reconstruct the past processes of chemical weathering and erosion from the knowledge of the present processes, it is necessary to establish methods for reconstructing chemical vs physical weathering processes by using sediments which are the end products of weathering and erosion.

Toward the objective above, this study aims to explore the present processes of chemical weathering and erosion in the Yangtze River drainage as an example. Yangtze River is the longest river in Asia with the great water discharge and sediment flux. Hence, the river's role on material cycle on Earth's surface is significant. In addition, water and meteorological data are accumulated for long time period by many gauging stations and meteorological stations in the basin.

Mineral and chemical compositions of suspended particles and sediments as well as chemical composition of dissolved matter are analyzed for water samples and river bank sediments obtained from Yangtze River and its tributaries in the summer of 2011. Using these results, together with river discharge data and dissolved/suspended load concentrations, the fluxes for each element are calculated, and then the inputs from each watershed are obtained. Then, the relative contribution between chemical weathering and physical erosion is estimated. The calculation revealed that chemical weathering rate increases downstream but the relative contribution between chemical weathering and physical erosion in the uppermost part is the maximum in the upper, erosional part. In the lower, depositional part, dissolved carbonate is diluted after the main stream has merged with Poyang Lake, and then increased again toward the river mouth. The processes of chemical weathering and physical erosion in each watershed and their possible controlling factors will be discussed.

Underwater topographic survey for inaccessible water areas, and its applications to submarine and sublake landslides

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Landslides, volcanoes, active faults and other hazard related topographies exist on the sea floor or lake bottoms. It is important to investigate them for assessing future hazard potential. But investigations for these underwater topographies are not so easy because it needs quite high cost, and its heavy weight equipment also requires a ship big enough to hold it. These days, dramatically advanced leisure-use fish finders enable us to investigate underwater topographic survey from shallow to several hundred meters deep. These fish finders are low cost and light weight, so can be equipped on inflatable rafts that is accessible into ultra shallow area of 0.5 - 20 m deep that is usually inaccessible for usual scientific research vessels. Thus the investigating method using the fish finder and an inflatable raft is more versatile than other technical ways. Some advanced fish finders have a side-scan sonar system that obtains 2D image of acoustic reflections, and it can identify bottom materials and underwater structures. Now we are trying to apply for studying submarine and sublake landslides in water areas that have not been surveyed. This presentation shows successful examples of our conducted investigations for the sublake landslides in Lake Kussharo and the 1923 Nebukawa landslide that a part of the landslide dived into the sea. These results have contributed the innovative discussion in generation of tsunamis on the lake, and revealed unknown submarine ruins that landslide devastated.

Keywords: fish finder, submarine landslide, underwater landslide, bathymetric survey, side-scan sonar

Development of a monitoring system of bathymetric change and related sediment transport using optic fiber cables

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A development of monitoring system is important for understanding more detailed process of the bathymetric change and sediment transport. At the nearshore zone, to monitor the nearshore features such as sand ripple migration, and the sediment suspension processes, optical back-scatter sensors (Downing et al., 1981), rotary sidescan sonar system (Traykovski et al., 1999), and sand ripple profiler (Masselink et al., 2007) were developed and used. Those systems can provide the very high-resolution morphological change and transportation, but not suitable for investigation of large-scale sediment erosion and deposition generated by high-energy waves in the surf zone. Where change in water depth is large (e.g. more than 1 m) in short span, the systems will be destroyed, lost, or submerged.

In the present study, we developed a new instrumentation for the monitoring of bathymetric change and related sediment transport in the high-energy shallow marine environment using optic fiber cables. The system consists mainly of four components: (1) an array of optical sediment sensors (OSSs); (2) a support structure (steel pipes); (3) an electronics unit that transmit and receive the LED through the optic fiber cables; and (4) a digital data acquisition system. The OSSs are mounted in a vertical steel pipe, 2 m long; and the spacing between the sensors is 10 cm. The steel pipe with OSSs was embedded to the seafloor at two places beneath a pier (427 m long) of Hazaki Oceanographical Research Station (HORS) owned by the Port and Airport Research Institute (PARI) at Sudahama Coast facing the Pacific Ocean, Japan. Both the electronics unit and the data acquisition system were installed in an observation room on the pier. In addition, those points of measurement are aligned perpendicular to the coastline in water depth approx. 4-5 m. Since active sediment transport that creates and deforms the longshore bar have been observed in this area (e.g., Kuriyama, 2010), detailed process of change in the cross section will be acquired by the present systems. In this presentation, we will show the system and data, and discuss those availability and future plan.

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Keywords: monitoring system, bathymetric change, sediment transport, optic fiber cable

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New insight of tsunami excitation mechanism and its recordable evidence in deep-sea

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Not yet

Keywords: Japan trench, 2011 Tohoku-Oki earthquake, Tsunami, Earthquake, Sediments, Submersible

Deposition and preservation of fine-grained turbidites around the Japanese islands

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We will report the sedimentological characteristics of fine-grained turbidites occurred around the Japanese islands such as off Sanriku, off Kumano, Suruga Bay, Beppu Bay, Japan Trench and off Hidaka. Some of these are thought to be formed in relation to the slope failures by the earthquake-ground shaking. Sometimes, subaqueous debris flow deposits were observed below the fine-grained turbidites. Agitation of the shelf floor by the tsunami waves is another mechanism to create the fine-grained turbidites. Third mechanism is the hyperpycnal flows related to the flood events. Preservation potential of the fine-grained turbidites will be discussed based on the repeated surveys of surface sediments off Sanriku region after the 2011 Tohoku-oki earthquake and its related tsunami. Based on these observation, we will discuss on the depositional processes of the fine-grained turbidites and preferable setting to preserve them as the geological records.

Keywords: turbidite, earthquake, tsunami, preservation potential, sedimentary structure, depositional process