Grain abrasion of gravel–sand in fluvial–beach systems: the case study of Tenryu River to Enshu Coast, central Japan

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Clastic sediment grains are “abraded (rounded)” as a result of alternating succession of angulation and rounding during transport process from river to beach. It is general that as the fluvial gravel is finer, the roundness which represents the smoothness of particle outline becomes lower (more angular) (Sneed and Folk 1958). Utsugawa (2017MS) confirmed the tendency with an analysis of the roundness of gravel–sand (0.5–128 mm in diameter) obtained from the Japanese river (the watershed of Watarase River). Difficulty of rounding accompanying with the grain size reduction may have been caused mainly by (i) the finer grain tends to be irrefrangible; i.e., high durability (Kodama1994) and/or inactive collision among grains, and by (ii) the input of pristine and angular grains produced from coarser grains as a result of breaking and abrasion (Utsugawa and Shirai 2016). We examined the changes in roundness of sand grains, which had not shown distinct rounding in fluvial environment, around river to beach.

“Fragile” shale and “hard” chert which are composed by very fine grains and rarely include “recycled grains” were selected, and the changes in roundness of grains (0.5–2 mm in diameter) obtained from 6 sites in ca. 62 km from the downstream reaches of Tenryu River to the Enshu Coast were investigated in this study. Approximately 110–130 grains of each rock type and size fraction were randomly extracted using a VHX-1000 digital microscope (KEYENCE Co., Ltd.). Using the image analyzing software PIA-Pro installed in FF-30micro (Jasco International Co., Ltd.), a roundness parameter “O. Bluntness” (Pirard1993MS) was obtained. O.Bluntness was converted to “Krumbein roundness” based on roundness chart of Krumbein (1941).

At the furthest site along the Enshu Coast, the most irrefrangible coarse-grained chert sand achieved its highest roundness. It is generally accepted that quartz sand grain is significantly rounded in coastal environment than in fluvial environment due to rolling on the beach by swash. As a whole, fragile shale and hard chert grains showed similar tendency of quartz grains. Note that, shale grains between river mouth to proximal beach sites on both grain size fraction did not become rounded even though the grains were transported on beach. Gravels (mainly 2–64 mm in diameter) supplied from Tenryu River are broadly distributed on beach surface near the river mouth, and are usually saltated and rolled by swash. Since gravels frequently collide each other due mainly to the swash, the gravels would be broken and/or abraded, and active production of pristine angular sand grains would cause decrease in roundness around river mouth.

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Keywords: sand, roundness, grain abrasion, Tenryu River, Enshu Coast

Age and depositional process of beach sediments around Sesoko Island (Okinawa, Japan), based on abrasion grades and radiocarbon ages of *Baculogypsina* (Foraminifera)

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Topographic changes of coral-reef beaches are predicted to occur due to sea-level rise associated with global warming. Beach sediments are mainly composed of skeletal fragments and shells produced by calcifying organisms, which are sensitive to environment changes. However, the production age, transport time and depositional age of beach sediments have not yet been fully understood. Here we show the age and depositional process of beach sediments around Sesoko Island (Okinawa, Japan), based on the abrasion grades and radiocarbon (^{14}C) ages of *Baculogypsina* (star sand; Foraminifera). Results of abrasion-grade analysis showed that well-preserved tests of *Baculogypsina* (a pristine test with most spines remained) became fewer from the reef flat toward the beach, where abraded tests with no spines were found abundantly. Results of ^{14}C dating showed that all *Baculogypsina* ages were after ca. 1300 cal AD, while most of coral fragment ages were younger (ca. 1700 cal AD-Modern) than *Baculogypsina* ages. *Baculogypsina* ages generally became older from the reef flat toward the beach. *Baculogypsina* ages in beach sediments were younger in the north side than the south side. These results suggest that the production of *Baculogypsina* tests increased after 1300 cal AD. This is likely caused by the formation of a reef flat (i.e. the increase of foraminiferal habitats) related to a relative sea-level fall at late Holocene. After transported from a reef flat, *Baculogypsina* tests were deposited into a beach mainly from the north to the south by nearshore currents. The presence of modern coral fragments brought by tidal waves and typhoons suggest that beach formation continues until present.

Keywords: foraminifera, coral reef, beach sediments, radiocarbon age, abrasion grade

Probabilistic Evaluation of Coastal Aggradation Models of Kamakura and Zushi areas, Japan

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In coastal lowlands of Kamakura and Zushi areas, a pebbly tidal flat deposit is widely recognized near the present sea level. The 14C datings of the pebbly tidal flat deposit form 3 cohorts. Since each cohort forms near the ages in which major historical earthquakes appears in historical documents, these pebbly tidal flat could be generated by tectonic uplifts of these earthquakes. However, it is hard to deny other aggradation process such as gradual or not tectonic but intermittent. Here I attempted statistical approach to evaluate models that assume intermittent and gradual and obtain optimum solution to explain observed dating dataset. In these models, parameters such as life span of the pebbly tidal flat or uplift ages are varied to obtain optimum solution.
First, 14C age distributions of samples in the pebbly tidal flat are calculated for the gradual (Model 1) and intermittent (Model 2) aggradation models. For each basin models, dating samples are randomly picked up to form a virtual dataset and its age distribution is compared with the dataset obtained in the field. We define similarity of the virtual dataset to the observed one based on Kormogolov-Smirnov Test and probability to obtain “similar” dataset from the virtual basin is calculated. The probability denoted by p* is compared among the models and scenarios from various life span of the basins or timings of uplifts.
The optimum solution for Model 1 assumes life span of the tidal flat from AD500 to 1800 (p* = 0.0600).
The optimum solution for Model 2 assumes aggradation events in AD1680, 1180 and 780 (p* = 0.2150).
The scenario that assumes the aggradation event were coeval to the historical major earthquakes (AD1703, 1257 and 878) marks p* = 0.0942. Comparison between observed dataset and age distribution in the virtual basin implies that the 1703 and 1257 or 1293 earthquakes were responsible for the aggradations; however, the AD 878 major earthquake seems to have less responsibility for the aggradation event.
In summary, the tidal flat deposit found in the lowlands of Kamakura and Zushi areas 1) seem to be formed by intermittent aggradation rather than gradual aggradation, and 2) the intermittent aggradations could be coeval to the historical major earthquakes. However, 3) other possibilities such as human activity should be considered before we conclude the historical major earthquakes are responsible for the aggradations.

Keywords: tidal flat, aggradation, historical earthquake, dating, Sagami Bay, probabilistic evaluation

Investigation of preservation potential of sedimentary structures by ruled-lattice model for bioturbation

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Bioturbation is a mixing process of sediment and soils by activities of benthic animals, such as their nest building or foraging. In many places, bioturbation causes the time-averaging effect on fossil records, and it disturbs preservation of primary sedimentary structures. Therefore, in order to reconstruct paleo-ecosystem or paleo-environmental information from geologic records, it is necessary to quantify the degree of loss of the initial information by bioturbation . Here, we examined preservation potential of sedimentary structures by using a lattice model of bioturbation based on simple rules. The model implied that (1) a threshold of the sediment mobility parameter to make sedimentary structures massive exists and that (2) bioturbation may work as a band-pass filter against preservation of sedimentary structures, by which lamination showing the high-frequency oscillation in grain-size distribution becomes obscured whereas the low-frequency fluctuation is preserved.

In order to conduct numerical experiments of sediment-diffusion processes by activities of benthic animals, we developed the lattice model based on the simple rules. The probabilistic lattice model of bioturbation has advantages that it can easily incorporate the observations of both the behavior of benthic animals and the morphology of ichnofossils as the model parameters. In this model, sedimentary successions are discretized vertically to the lattice cells containing multiple sediment particles. Sediment particles in each lattice cell are assumed to move upward or downward following the prescribed probabilistic model at each time step. Lengths of particle migration are decided by the normal probability distribution. Thus, governing parameters of this lattice model are: the active-range of bioturbation, the probability of occurrence of particle migration, the average length of particle migration, and the probability of downward (upward) migration of particles. In addition to these rules employed in the lattice model of Schiffers et al. (2011), we added the effects of bed aggradation to the model, which are represented by the sedimentation rate and the primary sedimentary structures. Schiffers et al. (2011) suggested that the bioturbated structures observed in their experiments were well approximated by this lattice model.

Using our lattice model, we conducted the numerical experiments of bioturbation of parallel-laminated sediment, in which the initial concentration of tracer particles varies vertically following (1) single- or (2) multi-spectral curves. The degree of conservation of the primary sedimentary structures was quantified by the Fourier-analysis of the resultant concentrations of tracer particles preserved in the intervals deeper than the active-range of bioturbation.

Keywords: Bioturbation, Sedimentary structure, ruled-lattice model

Relationship between bedrock strength and change in shape of bedrock channel due to base level lowing: Laboratory experiments

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Developments of bedrock rivers are controlled by climate, uplift and bedrock strength, etc. Among these, it is suggested that bedrock strength may be an important parameter influencing the local aspect of river topography development, because some field studies reported that there often are knickzones in areas with high bedrock strength. However, the exact relationship is little understood, because topographic change takes a long time and many other parameters are widely different in fields. In this study, we conduct model experiments under simple setting where we simulate bedrock using homogenous mixtures of sand and kaolinite. We explore the dependence of developmental processes of channel shape on the bedrock strength.
Each run starts with an initial topography where a single straight channel is set in the center of the flume. The mixture consists of well-sorted sand (f=0.2mm) and kaolinite. By changing the ratio between sand and kaolinite, different rock strength can be realized. Water was flowed from the upstream end constantly using a discharge controller. The weir, a pile of blocks (1 cm in height), is installed at the downstream end. Base level drop is actualized by removing the block(s). At intervals of 20 minutes, one block is removed (i.e., 1 cm base level drop), which is repeated about 7 times during each run. The topography is measured three-dimensionally by photogrammetry. The experiment was finished when the channel profile remains almost unchanged for about 30 minutes or more after the last block was removed. We regarded the profile at the end of experiments as a final stable state.
Comparing the channel profiles at the end of experiment between runs, it was confirmed that final stable channel profiles is almost the same even if we change rock strength. This means that bedrock strength is not a factor that determines the final channel profile and has influence only while the river changes from the initial shape to the final shape.
During each run, the gradient of channel increases to the maximum value, and then declined to some constant value (stable state). The maximum value is higher with increase in rock strength, although final states are similar between different rock strengths. Sinuousity of channel tended to increase when the river has higher gradient than that in the stable state, although sinuousity at the final state also showed no difference between different bedrock strengths. This facts suggests the possibility that the strong meandering seen in the area of hard bedrock in nature is only a transitional phenomenon in the geographic timescale. Because it is considered that not only rock strength itself but also spatial variation in strength can affect the sinuousity, more experiment and discussion is necessary.

Keywords: river topography, bedrock strength, meandering

Temporal change of incision rate in relation to river terraces: model experiment

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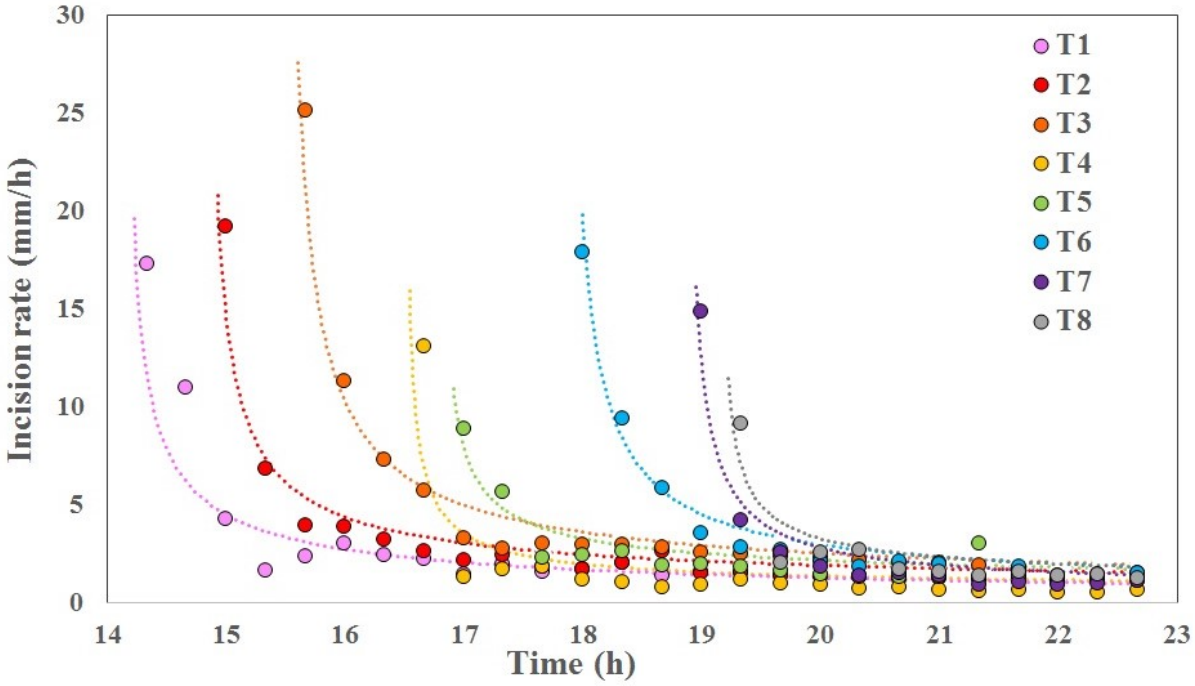
It is a common method to estimate incision rate using river terrace to know uplift rate, under assumption of long-term steady-state in equilibrium between uplift and incision (e.g., Burbank et al. 1996; Pazzaglia & Brandon 2001). It seems that river terraces provide a straightforward way to quantify the incision rate, by calculating the height of a terrace (from the nearby modern river bed) divided by the age of the terrace. However, previous studies show that the incision rate calculated from a younger terrace results in a larger value, which is called "Sadler effect" and holds over the order of 10^7 years (Finnegan et al., 2014). Sadler effect suggests that incision rate estimated from a terrace is apparent speed. In this research, we aim to explore the factors that induce the Sadler effect by conducting model experiments that allow observation of temporal change of landforms.
A sand mixed with s kaolinite (volume ratio is 10.5 to 1) was employed as a model material for bedrocks. We settled the material in the experimental flume to form a 1 degree-dip flat slope as an initial landform. Rainfall was simulated by fine mist supplied from sprinklers. In this study, we realized uplift by tilting the flume. Landform was measured at interval of 20 minutes, by photogrammetry. After the preliminary stage for landform development, we set the uplift rate at 0.5 degree/ h.
We analyzed eight terraces (T1 –T8) along the identical channel. Identifying the time of formation of each terrace and measuring the temporal change of the terrace height from the nearby river beds, we calculate the incision rate in the same manner used in field researches. The incision rate calculated as such was higher if the terrace was younger, so the Sadler effect appeared also in the experiment. It was also confirmed that the Sadler effect of the identical terrace decreases as the elapsed time after terrace formation increases.
We also measured the "actual vertical erosion rate" from the difference of the altitudes of river beds at different time. The results showed fluctuation of river bed elevation, suggesting that Sadler effect can be attributed to temporal deviation from the long-term average, as mentioned by Gallen et al. (2015). If we can know the property of the deviation, it may be possible to estimate long-term-average incision rate only from young terraces.

Keywords: terrace, incision rate

Temporal change of averaged incision rate estimated from identical terraces



Paleoweathering environments recorded in the Pliocene-Pleistocene Kobiwako Group, southwest Japan

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The Kobiwako Group, which is distributed around southern part of Lake Biwa and northern part of Mie prefecture, provides important paleoweathering records during Pliocene and Pleistocene periods.
This research aims to clarify the relationship between paleoweathering and source rocks in the Kobiwako Group, using sedimentary facies analysis, major and trace elemental geochemistry. The Iga and Kitamata formations, in the lower part of the Kobiwako Group, are examined in this research.
The Iga formation, in northern part of Mie prefecture mainly consists of mudstone and claystone with thin sand layers, suggests the deposition in the floodplain and short-lived lake environments with meander river system. The Kitamata Formation is composed from sand and boulder bearing conglomerate beds, indicating the deposition in coarse grained braided river environment.
The chemical analysis of the mudstones in the Iga and Kitamata formations represents variated weathering intensity. The discrimination using REE composition, the sediments in the Iga Formation were supplied from wide variety of igneous rock types between differentiated to not-differentiated. The sediments derived from differentiated rock type display high weathering index showing the intense chemical weathering environments in hinterland. Meanwhile, the sediments supplied from not-differentiated rock type, prevailing in the Kitamata Formation and the upper part of the Iga Formation, indicate the derivation under weak chemical weathering environments.
The paleoweathering degree estimated with provenance analysis represents the reality of paleoweathering environments even in the sediments derived from mixed source rocks.
This study could be utilized as a basis for understanding of past change of geological environment, because weathering zone is located at the top of the environment.
This study was carried out under a contract with METI (Ministry of Economy, Trade and Industry) as part of its R&D supporting program for developing geological disposal technology.

Keywords: paleoweathering, hinterland, provenance

Development of vertisol in the Middle Miocene Porcelain Clay Formation in the Setouchi Geologic Province; its paleoclimatic and paleoweathering significances

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The description of paleosols, chemical and mineralogical analysis and sedimentary facies analysis were carried out for the Middle Miocene Seto Porcelain Clay Formation distributed in the Toyota City, Aichi Prefecture. The main paleosol characterized by hummock-and-swale structure showing gilgai microrelief and mukkara subsurface horizon is equivalent to Vertisol (Soil Survey Staff, 1999). This result indicates that climatic conditions in this period were subhumid to semiarid climates with a pronounced dry season.

The Seto Porcelain Clay Formation, the lower member of the Seto Group, distributed in the Aichi Prefecture, is considered to be deposited in the middle Miocene period (6-9 Ma) dated by the paleomagnetic data (Nakayama and Yoshikawa, 1990; Nakayama et al., 1995).
The Sedimentary facies analysis suggests that deposition occurred mainly in a lacustrine, backswamp and floodplain with meandering river channel.
Three paleosol horizons were developed in the stagnant water sediments and have been described and compared to modern soils; versitol-like (swelling clay soils), histosol-like (peaty soils) and inceptisol-like (young soils). Histosol-like paleosol and inceptisol-like paleosol were developed on lowland topography. Histosol-like paleosol, characterized by thick peaty horizon and reddish mottling showing subsurface-water gleization, ascribes to poor-drainage condition on the lower topography and high vegetation cover. Inceptisol-like paleosol, characterized by thin soil horizon and poor illuviated clay, ascribes to lower topography and rapid sedimentation with short exposure duration. These paleosols, therefore, reflect on the local topographic and/or sedimentary features, for example drainage condition, vegetation cover and sedimentation rate. On the other hand, the vertisol-like paleosol was developed on the flat terrace with gentle slope. The paleosol is characterized by illuviated clay-rich B horizon (Bt horizon, argillic horizon), hummock-and-swale structure showing gilgai microrelief and mukkara subsurface horizon (Paton, 1974). The strongly differentiated soil horizons of versisol-like paleosol reflect on the X-ray bulk and clay-fraction mineralogy and bulk chemistry of soil profiles. The paleosol shows vertical fluctuating of chemical weathering ratio (Al_2O_3 wt. % /Na_2O wt. % and CIA value; Nesbitt and Young, 1982), mineral weathering ratio (kaolinite/feldspar ratio by intensity of XRD) and proportion of clay fraction in the soil horizons. Higher chemical and mineral weathering ratio and finer grain size in the Bt horizons than those in the Bw and C horizons suggest pronounced leaching of cation from surface soil horizons (O and A horizons) and their accumulation in sub-surface soil horizons (B and C horizons). Besides, the effects of parent material and grain size have been checked by using REE composition (especially by Eu anomaly) and clay minerals/quartz ratio by intensity of XRD and Al_2O_3 wt. % /SiO_2 wt. %. Above described vertisol-like paleosol, accordingly, indicates the typical soil type that represents the climatic division (zonal soil) in the period. The results are suggestion that the climatic conditions in this period were subhumid to semiarid climates with a pronounced dry season.

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Keywords: paleosolol, vertisol, chemical weathering, microtopography, geochemistry, Middle Miocene

Seismic reflection profiling of lacustrine deposits and discovery of an extremely large sublacustrine landslide in Lake Inawashiro, Fukushima, Japan

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Large landslides (larger than several hundred square meters) have been occurred in coastal and shallow water (shallower than about 100 meters) environments by historical big earthquakes. Possible mechanisms for landslides are related with liquefaction and destruction of water saturated materials induced by earthquakes. Although liquefactions have been frequently and widely observed as sand boils and ground failure by modern earthquakes in Japan, landslides in coastal and shallow water environments have been less recognized. Thus generation of large landslides should be related to a specific condition other than the sensitivity for liquefaction. In Lake Inawashiro in Fukushima, Japan, there are a number of topographic remnants of landslide along coastal areas. This suggests that the lake has been under the specific condition to generate landslides. To clarify the condition, the authors investigated the lake area geologically and geotechnically.

In 2015 and 2016, the authors carried out seismic reflection profiling by using 3.5 kHz Sub-bottom Profiler, scanned about 120 km in total distance of transects covering the entire Lake Inawashiro area. Comparison of seismic profile data with the sedimentary core (INW2012) sampled by Fukushima University in 2012 at the center of lake revealed the following results regarding to landslides and slope stabilities.

1) Seismic profiles shows the entire lacustrine sequences deposited after the lake formation in the southern half of the lake. Most of the profiles suggest simple layered structures. Some of the strong reflection layers within the structures correspond to known wide-spread tephra horizons observed in INW2012 core. A strong reflection layer of the bottom of the lacustrine deposit corresponds to the horizon of sand and gravels. Thus lacustrine deposit consistently has been deposited in the southern half of the lake. Whereas, sedimentary structures in profiles are not well recognized in the northern half of the lake. This is because that coarser (deltaic) sediment supply from Bandai volcano via the Nagase River probably affected the bottom of northern part of the lake and resulted in the acoustic waves reflected strongly and attenuated rapidly at the surface. The large landslides inferred from the present topography could be recognized underneath the coarse sediments.

2) Acoustically transparent facies, that indicates structureless sediments, is often observed across the lake. It suggests that soft sediment deformation by fluid or gas ejections have occurred in the lacustrine deposits, and also the lacustrine deposit has been affected by earthquakes repeatedly. In particular, the density of the facies is high in > 13 m below the lake bottom at the center of the lake. This horizon is about 1 m below the As-K tephra horizon (18,100 yrs. BP from Asama Volcano; Hirose et al, 2014). The age can be estimated as 20,000 years ago and infers an occurrence of a probable large earthquake affected this area at the time.

3) An extremely large subaqueous landslide structure was discovered. The length is 2.8 km and the

maximum thickness is about 25 m. The landslide structure is present beneath the horizon of about 20,000 years ago, and shows a massive body slid on a slope of 0.8 degrees. The distal end of the landslide consists of a number of thrusts and folds by compression. This study of landslide structure is important that clarified a whole process of sliding and a rupture surface. Further direct sampling from the rupture surface is necessary to understand the factors and condition of generation of landslides in coastal and shallow water environments.

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Keywords: submarine landslide, subaquatic landslide, seismic profiling, Lake Inawashiro, earthquake, tsunami

A study of relationship between stratigraphic patterns and paleo-climatic changes in Rathnapura basin, Sri Lanka

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Quaternary sediments of Sri Lanka is distributed in river valleys as valley-fill deposits and floodplain deposits. Sri Lanka, as a tropical country is prominent of depositing sediments because of high rate of erosion, transportation and deposition in river flows. There is an evidence of stratigraphical patterns and paleo-climatic changes from the Quaternary period. The dominant mode of sediment transport and deposition as well as the composition and stratigraphy reflect the prevailing environmental conditions. Stratification of many sediment types in the Kalu Ganga river basin in Rathnapura is conspicuous in terms of depth of sediments and number of sediment layers. This research aims to study the sediment types and stratigraphy in Rathnapura basin. Sediment samples were taken from the gem mines representing the middle and lower catchment of the Kalu Ganga river basin. Gem mines provide a valuable opportunity to examine the stratigraphy and other physical characteristics of the fluvial sediments in this area. Sediment types identified mainly by sieve analysis and pipette analysis. There is a spatial variation in the number and the depth of gem bearing sediment layers. Evidence of a lake has come from the lower catchment area of the river. Stratigraphy of the area has rich of evidences to study of paleo-climate of the region.

Keywords: stratigraphy, sediments, Kalu Ganga, deposition, paleo-climate

Occurrence of Huge Mountain Collapse and its Sediments Developing in Niigata - Nagano Prefecture border, Central Japan ; Pleistocene Epoch Events

*Toshihiro Asahina[1]

1. PASCO CORPORATION

1.Introduction
I review the huge collapse in non-volcano regions similar to "mountain collapse - rockslide avalanche occurrence" occurred in many volcanoes. The survey area is the northeastern part of the Sekita Mountains located in the Niigata - Nagano prefecture border, and the northern side of the ridgeline has a maximum height of 400 m and a steep cliff extending over about 6 km extension. The huge collapse formed the small undulation flat surface such as the Shoubu Plateau, the upper stream area of the Shibumi River, the Daigonji Plateau, and so on. At present, traces of huge collapse are confirmed in 5 places. According to Takeuchi et al.(2000), the Uonuma Formation of the late Pliocene to Late Pleistocene is distributed around these areas.
2.Huge collapsed terrain
In this paper, I call the huge collapse that formed the Shoubu Plateau and so on as Nonomi collapse, call the collapse that formed a small undulation flat surface in the upper stream area of the Shibumi River as Tensui collapse, and call the huge collapse that formed the Daigonji Plateau as Daigonji collapse, and discuss these collapse cases. The Nonomi collapse has a sliding cliff of 150 m in height and a sliding width of 950 m in width as a cliff top. The horizontal flow distance of sediment is estimated to be 2,700 m and the layer thickness is estimated to be 50 m at the maximum and 15 to 20 m on average. The Tensui collapse has a sliding cliff with a maximum relative height of 400 m and a sliding width reaching 3,000 m. The horizontal flow distance of the sediment is estimated to be 4,500 m, the layer thickness is estimated to be 15 to 30 m on average, and 3 sites of hummocky mass can be confirmed. The Daigonji collapse is estimated as the top of the cliff in the vicinity of Tensuiyama Mountain. The horizontal flow distance of the sediment is estimated to be 3,300 m and the layer thickness is estimated to be 10 to 35 m on average.
3.Properties and composition of collapsed deposits
Collapsed sediments consist of sedimentary layer(sis) consisting of siltstones and sedimentary layer(tfb) mainly composed of andesitic volcanic rocks. Both strata are consolidated to such a degree that they can’ t easily penetrate with a hammer. The sedimentary layer composed of siltstone is densely packed in angular clast with a diameter of about several cm, and it may include andesite angular clast. Features of the sedimentary layer composed mainly of andesitic volcanic rocks are 1)clast-supported ~ matrix-supported sediment containing a large number of angular to subangular clast (ϕ - 3 m, mostly ϕ 10 - 50 cm) of andesite, 2)sedimentary structure with water during deposition can’ t be seen, 3)besides andesite, siltstone, sandstone, tuff, etc. are present in the clast, and it contains Kusare clast, 4)matrix part is tuffaceous sand mixed silty and fresh part is blueish gray to blue-greenish gray. The sedimentary layer due to Nonomi and Tensui collapse was formed from basement strata, tfb-1(maximum layer thickness 20 m), sis-1(same 5 m), sis-2(15 m), tfb-2(10 m), tfb-3(20 m), topsoil. Paleosol ·organic matter of several cm thickness is sandwiched between sis-1 - sis-2 and sis-2 - tfb-2. On the other hand, the sedimentary layer due to the Daigonji collapse is layered from the base to the upper tfb (maximum layer thickness 20 m), sis(15 m), tfb(10 m), topsoil.
4.Origin of collapse and collapse sediment
Sediments generated by the huge collapse originate from the Uonuma Formation. With reference to

Takeuchi et al. (2000), the collapsed strata are mainly of the Uonuma Formation, andesite tuff breccia, volcanic tuff and marine silt sand phase. Stratigraphically, the former is higher and the latter is lower. This huge collapse shows a cycle in which the lower stratum is repeatedly collapsed while the gap is sandwiched by the extent of formation of old soil after stratigraphically upper strata collapse and then the upper strata collapse again. A relatively large time gap occurred at least twice.

5.Discussion

The huge collapse is presumed to have at least 5 events from the sedimentary layer distribution. However, from the Lidar data, the occurrence of more events is estimated, and correspondence with the sedimentary layer, the identification of the time and the contrast of the collapsed sedimentary layer are future tasks.

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Keywords: huge collapse, rockslide avalanche, Pleistocene Epoch, Uomuma Group, Sekita Mountains

Three-dimensional analysis with high-frequency ground penetrating radar of tsunami experiment deposits

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A tsunami experiment was conducted in a wave flume (205m in length, 60cm in width, 95cm in depth) in CRIEPI (March 1, 2016). GPR (Ground Penetrating Radar) scanning with a high frequency antenna (1.6GHz) was performed for the experiment deposits. The used material was sand (median, 0.2mm) and dune (20cm in height) was formed in the center of flume. A tsunami (wave height, 80cm) went over the dune, and run up to the landside, and deposited sand layer, 1-3cm in thickness. The GPR measurement was carried out for 10 m long around the dune. GPR profiles show three-dimensional low basin-shaped reflection around the dune, and parallel reflection consisting of two levels that was a gently convex upward in the landside. This result matches the CT result (Yoshii et al., 2016). The trench of the deposits confirmed that the low basin-shaped reflection was caused by the hydraulic jump at dune. As for the tsunami deposit, it was revealed that the boundary surfaces between different two layers (the lower coarse-grained sand layer and the upper fine-grained sand layer) became the gently convex upward reflection.

Yoshii T., M. Matsuyama and S. Tanaka (2016) Sedimentary characteristics of tsunami deposits made in wave flume. JpGU2016. MIS11-P18.

Keywords: tsunami deposits, GPR, experiment

Distribution pattern of surface sediments around Okinoerabu-jima and Tokuno-shima Islands

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The distribution pattern of surface sediment around Okinoerabu-jima and Tokuno-shima was compiled based on 155 surface sediment samples and sub-bottom profiler (SBP) records. Surface sediments around islands above water depth 600 m show gravel and very coarser sand and are characterized by high contents of calcium carbonate deposition mainly originated from coral, shells and briozoans. These results indicate that depositional environment in this area is affected by strong hydrodynamics effects. Spatial variation in grain size of surface sediments west off the Okinoerabu-jima and Tokuno-shima (eastern edge of Okinawa Trough) shows to become a finer toward increasing in water depth, and silt sediments including planktonic foraminifera are deposited in the Yoron and Okinoerabu basins below the water depth of 800 m. Stratified reflectors with the penetration depth of 60-80 m in the SBP profile are observed in these basins. These results indicate that hydrodynamics effects to sedimentary process decrease toward the increasing water depth and hemipelagic sediments are deposited in the basin. On the other hand, sand sediments are distributed at the seafloor to water depth of 1200 m in the eastern area of the Okinoerabu-jima and Tokuno-shima. Discontinuous stratified reflectors of the SBP profile are widely observed in this area. Compering with grain size and SBP records in the western area of the Okinoerabu-jima and Tokuno-shima, sedimentary process in the eastern area of these islands is affected by strongly hydrodynamics effect caused by open topographic.

Keywords: sediment, grain size, Okinoerabu-jima, Tokuno-shima

Environmental history of Lake Kasumigaura during the last 600 years

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Environmental history of Lake Kasumigaura during the last 500 years is clarified based on the result of grain size analysis and total organic carbon, total nitrogen and total sulfur contents of cored sediment taken at the central part of Lake Kasumigaura. Age controls used are Asama-A tephra of 1783 AD, Fuji-Hoei tephra of AD 1707 and carbon-14 date of Corbicula japonica fossils. Profiles of grain size and element contents versus age show that the closed lake condition developed gradually until the eruption of Mt. Fuji in 1707 and further developed after the eruption of Mt. Asama in 1783. Former studies showed that the closing of the lake condition developed gradually owing to the wide interval of sampling, however, the result of this study shows that the change of lake environment was very short period. The reason for abrupt environmental change was caused by the rapid burial of the inlet of lake with volcanic materials which flew from river Tone. This caused decrease in changing waters of the lake and that from the Pacific Ocean.

Keywords: Lake Kasumigaura, Environmental history, sediment

Evaluation of ichnodiversity by image-resampling method to correct outcrop exposure bias

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This study proposes a new method to evaluate the diversity of ichnofossils from the outcrop records. Ichnofossils are records of responses of benthic animals to marine environmental conditions. Therefore, detailed analyses of ichnoassemblages provide information of the paleoenvironmental conditions on ancient seafloor. Activities of benthic animals affect superficial to subsurface sediment on seafloor. For instance, burrowing or grazing by infauna may rework sediment and destroy sedimentary structures. These behaviors may raise pore water oxygenation level, and may result in accelerated decomposition of the organic matter in sediment (Aller, 1994). Thus, it is important to evaluate ichnoassemblage in quantitative way from various aspects (e.g. diversity, abundance, disparity, and bioturbation intensity) to reveal the paleoenvironmental conditions from geologic records. Particularly, ichnodiversity (defined here as number of ichnogenera in an ichnoassemblage) is regarded as an important parameter that characterizes sedimentary environments (e.g. Cummnings and Hodgson, 2011). However, numbers of ichnogenera observed in outcrops reflect not only actual diversity in activities of benthic animals but also exposed area of observed outcrops. Even though there are several established methods for correcting such sample size biases in studies of paleobiodiversity, such as rarefaction (Sanders, 1968) or shareholder quorum subsampling (SQS; Alroy, 2010), these methods cannot be applied to analyses of ichnodiversity because number of individuals of ichnofossils is difficult to identify due to their morphological characteristics. For instance, an individual specimen of planar-formed regular network graphoglyptids that may be preserved in fragments cannot be defined in observation on outcrops.

To this end, this study proposes a new method to evaluate the ichnodiversity independent of exposed area of outcrops by using of image-resampling technique with application of the SQS method. The procedures of our method are following. First, the line-of-interest for data resampling is randomly set in the acquired outcrop image. The number of ichnogenera on the line is then counted. As the length of the line-of-interest increases, the number of counted ichnogenera increases. Repetition of this resampling process derives the relationship between the observed length and number of ichnogenera, which can be approximated by the non-linear function fitted to the resampled data. The obtained curve can be regarded as the equivalent of “rarefaction curves” of the biodiversity. Next, the ichnodiversity (the expected number of ichnogenera) of the examined outcrop image is calculated at a given value of the “coverage” of the actual diversity, which is estimated from the slopes of the tangential lines of “rarefaction curves” (Chao and Jost, 2012). Consequently, fluctuation of the ichnodiversity in the outcrop image data at any given “coverage” is obtained independent of differences in the exposed area of outcrops. This method was applied to artificial data of ichnoassemblages to verify the methodology particularly on effects of distribution patterns of ichnofossils on bedding planes. Ten kinds of artificial ichnofossil images were allocated on the virtual bedding planes to generate artificial outcrop images showing ichnoassemblages. In these series of experiments, two types of spatial distribution pattern of ichnofossils were examined: uniform and patchy distributions. Our method indicated that the distribution patterns did not affect ichnodiversity at sufficiently high “coverage.”

This method was also applied to the field data of deposits of the submarine channel-levee complex in the Izaki olistolith of the Nichinan Group distributed on the southeastern part of Kyushu, southwestern Japan (Sakai, 1987). Our method revealed that the ichnodiversity of the successions in the Izaki olistolith is relatively high in channel deposits and is low in levee deposits.

Keywords: Ichnofossil, Ichnodiversity, Outcrop exposure bias, submarine channel-levee deposits

The comparison of heavy mineral assemblage and chemical composition of detrital garnets between Bengal Fan and Himalayan foreland basin sediments

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The submarine Bengal Fan is the largest submarine fan system on Earth. The changes in the mineral assemblages of fan sediments record the uplift history of the Himalayan orogenic system.
IODP Expedition 354 drilled seven sites in an E–W transect along the 8˚N latitude in the Bengal Fan (France-Lanord et al., 2015). The deepest site U1451 A and B recovered a complete sequence of fan deposits. The sediments drilled at this site consisted of mica and quartz-rich sand, silt, and clay, with the exception of the lower Oligocene-Eocene section. In this study, we examined the chemistry of detrital garnets in the sediments in Bengal Fan and Siwalik Group in Nepal in order to compare both provenance characteristics. The garnet compositions plotted are shown on the Py-Sp+Alm-Gro-And triangular diagram with discriminant fields by Mange and Morton (2007). The data of mineral assemblage in the Siwalik Group is after Yoshida et al. (2016).
It is already reported that the heavy mineral assemblage of the Late Oligocene silt-sands mainly consists of tourmaline and rutile assemblage with rare garnet and amphibole by Yoshida et al. (2016). At the early part of the Middle Miocene sequence, amphibole and garnets increase rapidly, and there are frequent occurrences of aluminosilicate and staurolite. In the Middle Miocene sediments, the assemblage of heavy minerals becomes diverse, and metamorphic minerals, such as staurolite, chloritoid, aluminosilicate, amphibole, and garnet, are normally included in the sediments. The detrital garnets show the derivation from crystalline schist and amphibolite facies metamorphic rocks in the Early Miocene period and granulite facies metamorphic rocks in the Middle Miocene period.
In the lower Siwalik Group, foreland basin deposits, the mineral assemblage is characterized by the predominance of zircon and tourmaline. The heavy mineral assemblage was changed in the middle part of the lower Siwalik Group. The sediments include a large amount of blue-green amphibole and aluminosilicates (kyanite and sillimanite) with staurolite and chloritoid. In the end of Early Miocene, the detrital garnets were shed mainly from amphibolite facies metamorphic rocks. The detrital garnets were derived from granulate and amphibolite facies metamorphic rocks in the Middle Miocene time. These changes seem to have been occurred around 13-10 Ma in western Nepal and 9-7 Ma in central Nepal (Yoshida et al., 2016).
These measurements of heavy minerals demonstrate wide exposure and sediment production from a metamorphic terrane in the Himalayas during the Middle Miocene period, though these high-grade metamorphic minerals are occasionally included in Early Miocene sands. Also the above mentioned metamorphic mineral grains of Early Miocene and Late Oligocene sands may record exposure history of a metamorphic terrane, consists of amphibolite facies, prior to the period of high sediment production during the Middle Miocene. The chemistry of detrital garnet, records the gradual change of source terranes, from low-grade metamorphic facies and amphibolite facies to high-grade metamorphic facies. This change is similar to the provenance transition recorded in foreland basin deposits.

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Keywords: Himalaya, sediment composition

Lithological properties on diagenesis process of Miocene carbonate rocks in northeast Java basin, Indonesia

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Currently Northeast Java Basin contains the sixth largest oil reserve in Indonesia, but the complexity and heterogeneity of carbonate reservoir increasing the exploration risk. Sedimentology and diagenesis process are the most fundamental aspects for appropriate exploration. Accurate knowledge of these parameters for hydrocarbon reservoir is required for increasing performance of the oil and gas field. Thus, sedimentology as well as diagenesis aspect must be studied as detail as possible. This should be done along with microfacies analyses and stable isotope analyses.
The Miocene carbonate rocks of 283m thick were deposited in a high energy shallow marine settings in a rifting basin. The carbonate succession can be divided into 3 main units from base to top: fine grain limestone, dolostone, and coarse grain limestone. Fine grain limestone, wackestone and mudstone, was interpreted as fore-mound carbonate likely derived from pre-existing limestone, characterized by the abundances of intraclasts. Dolostone unit was a diagenetic product from marine dolomitization process. The planar structure with polymodal fabric of dolostone suggest that dolomitization process was worked on single nucleation from homogenous parental rocks under uniform growth at low temperature (Sibley and Greg, 1987). While coarse grain limestone, packestone and grainstone, is interpreted as terrigenous carbonate in which its fossil components show different responses to fluctuation of silisiclastic influx. Negative values both of $\delta^{13}C$ and $\delta^{18}O$ on limestone and dolostone unit suggest a marine diagenesis process followed by an intensive meteoric diagenesis that was likely related with tectonic uplift activity. In detail, the dolostone unit showed higher $\delta^{18}O$ value than limestone unit, most likely associated with different fractionation factors between dolomite and calcite. Between two limestone units also showed different values both $\delta^{13}C$ and $\delta^{18}O$. The coarse grain limestone unit showed lower both $\delta^{13}C$ and $\delta^{18}O$ values than fine grain limestone. This suggests that meteoric diagenesis works very effectively on coarse-grained and permeable limestone in which meteoric water easily go through into the rocks, then change its constituents.

Keywords: Limestone, Dolostone, Miocene, Indonesia

