Japan Geoscience Union Meeting 2012
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SCG73-P01 Room:Convention Hall Time:May 21 17:15-18:30

Volume of turbidite body evaluated from 1-D geological information

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To estimate the volume of a sedimentary body composed of turbidite distributing three-dimensionally, using one-dimensional information such as the sedimentary log of outcrops or a borehole, several hypotheses and the experience and knowledge of specialists are required. For determining the sedimentary environments or depositional elements in turbidite successions, we will consider the thickness of individual turbidite beds, the ratio of hemipelagic mudstone to turbidite bed, variability of the turbidite thickness, lateral variation in bed thickness or sedimentary facies, and stratigraphic changes in these characteristics. Because these characteristics are statistical in nature, the consideration of these data of turbidites suggests that one-dimensional information makes it possible to estimate the volume of sedimentary body and lateral variability on the basis of sedimentary environments and depositional elements, even if it is hard to achieve. In this study, we present an evaluating method to estimate the volume of sedimentary body on the basis of bed geometries, bed thickness trends of depositional elements, and statistical data of turbidite successions in several examples.

In turbidite successions, examples of depositional elements that have a good continuity in the lateral direction include deep-sea channel fills, sheet-sand, and lobe deposits. Lobe deposits have a good continuity in the lateral direction and are one of the most important elements of sedimentary body in turbidite successions. Although these data are not independent variables, the following data are necessary for estimating the volume of sedimentary body from a one-dimensional columnar section: (1) lateral continuity and extent of the body, (2) thickness of the body, and (3) observation location of the body. In this study, we focused on lobe deposits, which have a large extent and can satisfy these conditions as compared to other depositional elements. First, we investigated the statistical characters and the method for determining the observation location from the lobe deposits from several turbidite successions, then applied the method, and as a case study, analyzed the turbidite succession of the Awa Group that have detailed three-dimensional information.

Keywords: turbidite, depositional body, volume, bed-thickness distribution, bed-by-bed correlation, depositional element

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Dynamics and sedimentary processes of the turbidity current generated by the 2011 Tohoku Oki Tsunami

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On the basis of the sea-floor sediment cores, records in ocean bottom seismometer and ocean bottom pressure observation, it was suggested that large-scale tsunamis influence deep-sea floor by generating turbidity currents. Tohoku Oki Earthquake (Mw 9.0) and subsequent large tsunami occurred at March 11 2011. Eastern Japan such as Sanriku Coast was severely damaged by the inundation of the tsunami. Coasts and levees were largely eroded by the tsunami waves. On the other hand, we revealed that the broad region of sea-floor from the shelf to the trench slope was covered by the muddy event deposit. OBP and OBS record suggests that the event deposit was transported by a turbidity current generated from the suspended sediment cloud caused by the tsunami wave. The current reached the OBP site that locates 70 km off Sanriku Coast 3 hours after the earthquake, and it was sustained at least 2.5 hours. The head velocity was approximately 5.5 m/s, and the sediment concentration was tentatively estimated as 0.9 ? 2.6 vol.%. The turbidite ranges from 0.3 cm to 15 cm in thickness, and consists of clay to coarse sands. This study reports on the distribution and the detailed characteristics of the turbidite, and estimates the morphodynamics of the tsunanmi-generated turbidity current.

Keywords: tsunami, turbidite, turbidity current, morphodynamics

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Geomorphological and sedimentological dynamic changes at the coast of Tottori Sand Dunes over a last half-century

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Since 1980's, coastal erosion and vegetation growth were key tasks at the Tottori Sand Dunes, south-west Japan. We surveyed these issues from a view point of basin-scale sediment systems. The Sendai River, which is the main river to supply sediments to the coast, has characteristics of intermittent intensive sand transport. As for offshore bars along the coast, we surveyed them by air photos from 1968 to 2008 in every 5 year intervals. The result indicates that offshore bars had declined in the period from 1968 to 1998, but have enlarged since 2003.These changes were caused by large floods at the Sendai River in 1998 and 2004. Grain size analyses of berm-crest sediments along the Tottori Sand Dunes coast were conducted repeatedly since 1955. The result is shown in the figure below. Median diameters of 2004-5 and 2009 beach sediments were coarser than 1.0 mm but ones at 2011 were decreased dramatically: finer than 0.5 mm, which is a similar value to 1955. These changes were perhaps caused by gravel harvesting activities at the Sendai River during 1960's -1970's, which conducted coastal erosion issues later and beach sediments coarsening at that time. The large flood events of 1998 and 2004, however, supplied huge amounts of fine sediment to the coast and enlarger offshore bars and then recovered the beach sediment to be finer since 2011. According to wind duct experiments, sediment transport rates by wind from beach are influenced effectively by their grain sizes. Vegetation growth issues at Tottori Sand Dunes might be related with beach coarsening and decrease in the amount of blown sand. So we are expecting that vegetation growth at Tottori Sand Dunes will attenuate naturally by the increase of blown sand from the beach in near future.

Keywords: offshore bar, beach sediment, grain size changes, the Sendai-river basin, major flood events, particle-size mixture effects on sediment transport

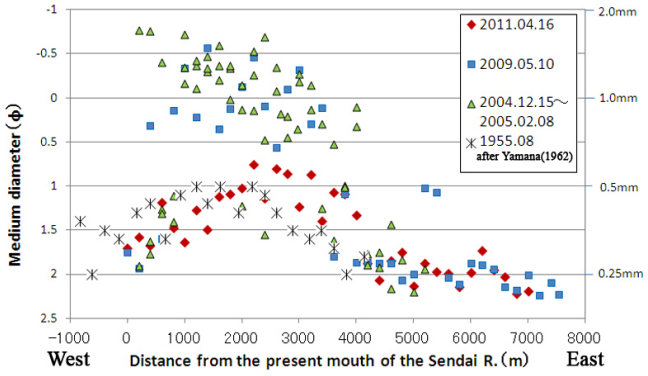

Fig. Medium diameter changes of beach sediments along the Tottori Sand Dunes over 56 years

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Influence of slow bed aggradation/degradation on river meandering

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It is commonly observed that rivers frequently change their courses under bed aggradation, and they do not shift their courses under degradation. In this study, influence of bed aggradation and degradation on river meandering is clarified with the use of linear stability analysis. In the analysis, we introduce the ratio between the time scales of channel shift and bed aggradation/degradation as a small parameter. Applying the multiple scale method and the WKBJ method with the small parameter to the formulation of river flow described by shallow water flow equation and the time variation of bed elevation by Exner equation, the growth rate of perturbation is derived as a function of the aspect ratio and the wavenumber of meandering. It is found that unstable region increases in the aspect ratio-wavenumber plane in the case of bed aggradation while stable region expand in the case of bed degradation. The implication is that river channels have high tendency to meander when bed aggradation takes place while straight channels tend to be maintained when bed degradation takes place.

Keywords: aggradation, degradation, meandering, linear stability analysis

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Re-evaluation of erosion rate in the uppermost reach of Yangtze River based on topographic classification using GIS

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Erosion and deposition in a river system in a tectonically active area plays a role in forming topographic features that keep balance with tectonic activity, and affect atmospheric circulation. Erosion also controls the rate of chemical weathering through interaction with physical weathering by increasing the surface area of rock. Supply of sediments due to erosion also accelerates the burial of organic matters in basins. These processes also affect climate through the changes in atmospheric composition. Therefore, it is important to know how erosion rate changes with changes in relief, uplift rate, bedrock geology, temperature, and precipitation in order to understand tectonics-climate linkage through landform evolution and global geochemical cycles. To discuss this issue, The Tibetan Plateau and surrounding river drainage basins are ideal because of their highly active tectonics.

Measurement of cosmogenic ^{10}Be concentration in quartz grains in river sediments is useful to estimate spatial distribution of relatively long-term erosion rate because river sediment samples are easily obtainable and quartz is common in these sediments. Indeed, there are several studies estimating erosion rates in the Tibetan Plateau and the Jinshajiang River, the uppermost reach of the Yangtze River in south China.

Two common assumptions of this method are 1) erosion rate is uniform within a drainage basin, and 2) eroded sediments do not stay long within a river system but discharge out of the system within a short period. However, such assumptions are not necessarily correct considering topographic variations in a basin and occasional occurrence of depositional landforms that may trap sediments for a long period. We call such landforms 'trapping features'. Previous studies in the Jinshajiang basin using ^{10}Be basically ignored the trapping features although they often occur in the basin. We extracted such features using DEMs(digital elevation models) and GIS and evaluated their depositional effect on erosion rate, re-estimated the sediment flux through the drainage basin, and examined the relationship of erosion rate with local landforms and geology.

Along the lower reaches of the Jinshajiang River, pull-apart-basins and their buried landforms (we call such landforms 're-claimed features') often occurs, whereas there are many small lakes along the uppermost reaches on the Tibetan Plateau. We regarded the reclaimed features and lakes as trapping features. We surveyed some local reclaimed features in the field and described their forms. Then, we used DEMs and ArcGIS to extract the reclaimed features and their source areas. Similarly, we identified the lakes and their source areas. We regarded the rest of the river basin as 'sediment supply area'. Then we re-calculated average erosion rates in the sediment supply areas using 10Be data from previous studies and compared the result with pervious calculations that did not take into account of the effect of trapping features.

The effect of trapping features reduced the estimated sediment flux in the Jinshajiang River basin to about 70% of the previous estimation. We plan to estimate the effect of the trapping features in the drainage area corresponding to each ^{10}Be sample, and discuss the distribution of re-estimated erosion rates in relation to topography, bedrock, geology, and climate.

Keywords: erosion rate, cosmogenic nuclides, GIS, Yangtze River, Tibetan Plateau

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Experimental study of liquefaction and fluid transport: effects of the low-permeability layer

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We report the results of laboratory experiments exploring how the water in a saturated granular medium (glass beads) migrates upwards when it is liquefied by an impulsive vibration. We conduct experiments in a two-layered medium where the upper layer has a lower-permeability and study how it affects the fluid migration. The permeability is controlled by the particle size. In a two-layered medium, we find that the pore water which has originated from the bottom layer temporary accumulates at the interface of the two boundaries, and then ascend through the upper layer in the form of a horizontal sheet or vertical channels. We find that these two different discharge styles are controlled by the permeability ratio of the two layers. We study the temporal change of thickness of the two layers and find that there are three stages; 1: the slope of the upper surface is levelled by the impulse, 2: the pore water is discharged from the bottom layer and accumulates at the interface, after which it migrates upwards, 3: water discharge ends, and the particles settle down. We measured the relaxation time needed for the discharge and compaction to end. Because low-permeability layer inhibits pore water from rising, longer time is needed for a two-layer case compared to the one-layer case. When the particle size of the upper layer is about 1/3 or less of that of the lower layer, relaxation time becomes independent of the bottom particle size. We modelled the relaxation time by introducing the effective permeability of two-layered medium, and find that it explains the measurements well.

Keywords: permeability, Darcy’s law, packing fraction, low-permeability layer

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Slumping of a granular mass on an unconfined slope

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Dense granular flows generated by slumping of granular mass are often encountered in industrial processes where the transport and deposition of granular material such as seeds, cereals, and tablets are involved. They are also observed in geophysical systems, such as pyroclastic flows caused by collapse of a lava dome or volcanic explosions, snow avalanches, and landslides.

Constructing a numerical model to capture the major characteristics of spreading granular materials in the above situations is a significant challenge because the mechanics of the grains and their interactions are incompletely understood at a fundamental level. This study investigated the dynamics of dense granular materials, released from rest and allowed to flow down an unconfined slope, driven by gravitational forces. First laboratory experiments were performed to study granular slumping, in which a measured volume of materials were instantaneously released from a cylindrical tube and spread across an unconfined rigid plane inclined at angles less than the repose angle. On release from the source the particles initially spread radially. However up-slope motion is rapidly arrested and motion down the incline is promoted, leading to an approximately ellipsoidally-shaped deposit once the flow has been fully arrested. Secondly, the flows were modeled under the shallow layer approximation and integrated numerically to capture the motion from initiation to final arrest. In modelling, two types of Coulomb-type friction models were introduced. One has a constant friction coefficient, and another has a friction coefficient that depends upon the dimensionless inertial number of the motion. When the initial aspect ratio of a granular mass and the slope angle is low (< 5 deg), the model with a constant friction coefficient can capture the deposit shape; but when the slope angle is increased, the inertial-number dependent friction model becomes more important. For high aspect ratio granular columns, the shallow water model fails to reproduce some aspects of the experimental observations. Finally an example of model application to geophysical systems is introduced.

Keywords: granular flow, slumping, pyroclastic flow, Coulomb friction law, shallow water theory

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Pore-Scale Simulations of the Diffusion in the Fluid-Saturated Porous Sediments using X-ray Microtomographic Images

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[1]AIST

The material transfer through the microscopic pores in fluid-saturated porous sediments is one of important subjects in sedimentology. We report the results of the application of computer simulations using three-dimensional pore-scale images to the diffusion in porous sediments(Ref.1). Some sets of three-dimensional digital images of sediment samples were obtained by X-ray microtomography. The steady-state diffusion or random-walk simulations were performed on the percolated pores of the images. The results show that (i) it is possible to complete the simulations using a commonplace 64-bit PC in a reasonable time and (ii) the spatial resolution of the CT apparatus is critical. This study was supported by JSPS KAKENHI (No. 23241012).

Ref.1: Nakashima et al. (2011) http://dx.doi.org/10.1007/s11270-010-0473-2

Keywords: sediment, X-ray microtomography, computer simulation, diffusion, porous media

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Cyclic steps formed by a hydrophobic fluid with water dispersed flowing on ice - an analogy with NPLD -

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A variety of characteristic landforms on Mars have been discovered since Mariner 9 spacecraft returned images of Martian surface in 1972 for the first time. Recently, in particular, spiral troughs on Martian north polar ice cap have been focused due to a possibility that characteristic landforms such as spiral troughs can reveal historical variation of climate on Mars. Though they are suspected to have some relation with katabatic wind blowing on the ice cap, it has been unclear how they are formed in detail. It has been observed that spiral troughs are formed perpendicularly to the direction of katabatic wind, so that they should be boundary waves formed between Mars atmosphere and ice rather than troughs excavated by flow. In addition, because internal structures of boundary waves clarified by radar show traces of upstream migration, these steps may possibly be cyclic steps formed by density airflow.

In this study, we have performed a series of analogue model experiments of the formation of cyclic steps on Martian polar ice cap. Experiments were conducted with the use of a low temperature chamber in the Institute of Low Temperature Science (ILTS), Hokkaido University. In order to simulate density airflow including water vapor blowing on Martian polar ice cap, we have used a hydrophobic fluid with water dispersed. We did not include temperature difference among ice, flowing fluid and ambient air, which is important for the formation of cyclic steps on Mars. It is found that cyclic steps were formed on ice even without the influence of temperature. It is suspected that the concentration of water in the hydrophobic fluid changes in space, and non-uniform freezing and melting take place on ice. This causes instability of a flat ice bed. By formulating freezing and melting rates of ice as functions of flow velocity and water concentration respectively, we found that the formation of cyclic steps on ice can be described by the equations similar to that for transportational cyclic steps formed on river beds composed of suspendable fine sand.

Keywords: Cyclic steps, Mars, Polar caps, Ice, Hydrophobic fluid

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An experimental study on cyclic steps formed in bedrock rivers

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A train of steps are often observed to be formed in bedrock rivers. They are thought to be cyclic steps formed due to erosion of bedrock. The erosion of bedrock is assumed to be dominantly driven by abrasion due to bedload sediment transport.

Here we demonstrated a series of flume experiments as an analogue of the formation of cyclic steps on bedrock. The experiments were conducted using the facility of Osaka Institute of Technology. We used a 1.5 m long, 2 cm wide, and 25 cm deep flume made by glass. The flume has 10 cm high weirs at the downstream end and 1.2 m upstream from the downstream end, so that there is an 10 cm deep reservoir. We put sand (0.2 mm in diameter) with cement (150:2) in the reservoir and hardened it so that the flume has an 10 cm 'model bedrock' on its bottom. The flume is tilted by 20 degrees. The water and sand (1.0 mm in diameter) is supplied from a head tank to the upstream end of the flume, flows on 'model bedrock' in the flume, and was dropped from the downstream end into a downstream reservoir, then pumped up to the head tank.

As a result, cyclic steps were formed on the 'model bedrock.' The shapes of the steps were resembled with the shape that predicted by theoretical analysis (Izumi and Yokokawa, 2011).

Keywords: Cyclic steps, Bedrock rivers, Flume experiments