

## Limit of mountain growth in the development of experimental landforms

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A series of experiments with rainfall-erosion and uplift of various rates, in which a square (60×60 cm) mound of a mixture of fine sand and kaolinite is uplifted at a constant rate under the artificial mist-type rainfall, suggests the existence of threshold uplift rates. In the run with the uplift rate below the lower threshold, drainage networks develop as the surface is slowly uplifted. The erosion is exclusively fluvial and no high slope develops. When the uplift rate becomes higher than this lower threshold, uplift exceeds erosion on the divides of drainage basins, which developed with fluvial erosion, and hills grow and slope processes start working. The divides grow into low mountain ridges with the uplift and slope failures become dominant. When the relief grows high enough, large landslides occur concentratedly. The average height and relief lower with the landslides, but the ridges soon grow again with the uplift till the next concentration of large landslides, and this process proceeds repeatedly. Uplift and erosion seems to become balanced to keep average height and relief roughly constant and landscapes similar. Assuming the existence of the critical slope controlled by the strength of mound-forming material and the rainfall intensity, the experimental landform is considered to reach a dynamic equilibrium condition at a certain relief regardless of the uplift rate. However, when the uplift rate is in the range between the lower and the upper thresholds, both relief and average height become higher with the uplift at higher rate. A simple equilibrium or steady state seems difficult to be expected with the critical slope. Although the maximum slope in a 1 cm grid becomes higher than 80 degree in all runs, considering that the angle of repose of dried mound-forming material is about 34 degree, it is rather difficult to take this maximum slope as the critical slope. The observation of the experiment suggests that large landslides require triggering events to occur, and without triggering events slopes can grow higher. Large landslides often occur when the rainfall is resumed after halting the rainfall for the measurement. This resumption of rainfall can be the major triggering event in the experiment. The interval of measurement is not exactly constant but does not vary so much among runs. As far as the resumption of rainfall after the measurement is the major triggering event, hills can grow higher with the uplift at higher rate. Moreover, fluvial processes can work more with the uplift at lower rate to widen valleys and therefore increase the area of lower slope. Average slope, relief, maximum height, and average height all become lower. In this way experimental landforms can have average height and relief corresponding to the uplift rate. This condition may be called quasi steady state. When the uplift rate is higher than the upper threshold, on the other hand, relief grows to the limit determined by the width of deposition area. In this case further increase in uplift rate cannot increase the height or relief any more, and this condition apparently does not agree with the condition of equilibrium.

Erosion rate is considered to increase with average slope, and some people pointed out that the relation is nonlinear. In the experiments the average value of the highest slope in a 1 cm grid shows similar linear increase with relief regardless of the uplift rate, but they become to show no clear relationship after relief reaches about 60 mm when landslides become dominated in the landform change process. Erosion rate also increase linearly with average slope first, but it becomes almost constant after the dominance of large landslides in the process of landform development. The relation between erosion rate and average slope seems necessary to be reconsidered with taking uplift rate into account.

Keywords: rainfall-erosion experiment, limit of mountain growth, threshold uplift rate, critical slope, landslides

## Evolution of river profile of experimental mountain building

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River profiles and their evolution during mountain building are investigated and the characteristics of river profile under mountain steady-states are examined by rainfall-erosion experiments under various uplift rate. Miniature landforms are developed with constant uplifting of sand-block (mixture of fine sand and kaolinite) and artificial rainfall. Four experiments are operated under the uplift rate of 0.2 mm/h, 0.5mm/h, 1.2 mm/h and 5.0 mm/h. Based on landform measurement, 1 cm grid elevation models are constructed. Streams are generated by basin analysis with the elevation models.

Relationship between the slope of channel ( $S$ ) and the catchment area ( $A$ ) are examined. Plots of  $\log S$  and  $\log A$  ( $S$ - $A$  plots) show convex, linear and slightly concave forms as mountain building progress. In the mountain steady-states, the  $S$ - $A$  plots show slightly concave forms, and the forms are stable until end of uplifting. It is deduced that  $S$ - $A$  plots become linear forms if they are at steady-state by stream-power incision model. But our result shows that  $S$ - $A$  plots under steady-state shows slightly concave forms, expressing that channel slopes at downstream becomes relatively steep than those deduced by the model. This situation should be result of downstream increasing sediment flux, which is important factor of graded river but neglected by the traditional stream-power incision models.

Keywords: rainfall-erosion experiment, uplift, river profile, equilibrium, sediment flux

## Experimental study of the effect of partial uplift on river channels

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Flume experiments were conducted to examine the effects of uplift on river channels in which the uplift area was restricted to the middle reaches. Experimental landform was evolved by exerting fine water mist on the slope consisting of a mixture of fine sand and clay, and the uplift was realized by jacking up the partial area of the flume bottom. The conventional idea that the occurrence of water gaps was determined by the balance between rates of uplift and downward erosion is true locally. The rate of down erosion is, however, variable due to the change of channel paths in the meso-scale. The avoidance of flowing in the uplift area tends to cause a new confluence and higher stream power producing larger erosion rate. A confluence makes the possibility of forming water gap high. The avoidance of the uplift area, however, does not always induce a confluence, in which the water gap is not generated.

Keywords: river channel, uplift, laboratory experiments

## Current status and issues of grain-size analysis using a digital image method and a laser diffraction method for sedimen

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Grain size measurement is the most fundamental physical information in evaluating the characteristics of various materials, the analytical technology. These are JIS standardized clearly by the association of powder process industry and engineering, Japan. In geomorphological field, we are carried out the grain size analysis of volcanic ash, mud, sand, and gravel using in combination of settling tube method, laser diffraction scattering method (LD), sieve classification method and the precipitation method in generally. According to currently technology, it is possible that the LD of each company to measure the particles of a wide range of 10nm to 3mm in a short period. However, we believe that a technical problem for analyzing nature sediments still now because these are not a powder of industrial products with same physical properties.

For example, we know a large scattered light intensity can be achieved in the shorter wavelength of the incident light because it is confirmed by measurement of the fine particles of submicron order, strength is not enough laser light. Moreover backscatter increases depending on the shape of non-spherical particles, tend to shift the fine particle side is confirmed grain size. Further, when using an algorithm for determining the particle size by inverse calculation using the Mie theory, it is necessary to set the user side of the value of the absorption coefficient and the particle refractive index.

This assumption is a very annoying problem for the user.

Recently, the particle size measurement in the field of powder technology, the development of new analytical instruments using digital image analysis method has been increasing. In this method, it is acquired the two-dimensional image of the particle is first digitally imaged by pixel division using the CCD camera and divided into two sub-methods, static (JIS Z 8827-1:2008; ISO 13322-1) and dynamic (JIS Z 8827-2:2010; ISO 13322-2). The methods may be used either, a process that takes as a digital image the particles, the statistical processing on a personal computer is the same.

Analysis method using a digital image of a single particle is clear, it is easy to be trusted from the user side. In addition, the use of the digital image, various particle shape parameter as well as information about the particle size distribution and the particle size of each definition different, for example, can be analyzed at the same time the value aspect ratio, elongation, circularity, HS circularity, convexity, solidity, etc.. Further, it is possible to obtain also the physical properties such as transmittance and intensity. We believe that it is analyzed in conjunction with the particle size measurement result data on physical properties and particle shape these, and becoming a new standard for particle size analysis in the future.

The present study includes the result of "Research and Development of Margin Assessment Methodology of Decay Heat Removal Function against External Hazards" entrusted to Japan Atomic Energy Agency by the Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT).

Keywords: laser diffraction method, digital image method, sediment, grain-size analysis, current status, issues

## Causes of gravel-sand distribution in upstream part of the river revealed from changes in lithology and form of detritus

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Downstream fining of fluvial clastic sediments has been generally attributed to two processes, "hydraulic sorting" and "sand grains production", the former is that finer grains are transported farther than coarser grains, while the latter implies crushing and abrasion of gravels. In this study, we investigated that how the two processes operate on this tendency along the tributary of Watarase River, the major branch of the Tone River on the basis of field survey and measurement of finer grains (4 to 0.5 mm in diameter). Lithological composition of each grain size fraction from cobble to coarse-grained sand (128-0.5 mm in diameter) with 1  $\phi$  (phi scale) intervals and roundness were obtained with digital microscope.

Changes in lithological composition of cobble – pebble, granule and very coarse sand fractions are not explained only with "hydraulic sorting" of clastic grains. It implies that crushing and abrasion of gravel – very coarse sand fractions and consequent "sand grains production" occur at the studied area.

Whereas, coarse sand fraction (1-0.5 mm) shows remarkable features that (i) change in lithological composition along the tributary was not recognized and (ii) grains become rounded in downstream direction. These facts suggest that abrasion of the grains occur dominantly than crushing in coarse sand fraction and "sand grain production" may not be efficient to grains smaller than coarse sand. Therefore, it will be important to research the distribution of coarse sand and finer grains in bed material along the river in order to reveal the transition from "producing process" to "sorting process", erosion – transport processes of clastic sediments and a development of sedimentological geomorphology along the river.

### References

- Frings, R. 2011. *Journal of Sedimentary Research* 81 : 52-63.  
Kodama, Y. 1994. *Journal of Sedimentary Research* A64(1) : 68-75.

Keywords: gravel, sand, crush-abrasion, lithological component, roundness, tributary of Watarase River

## Earth-surface processes on the basis of instrumental observations in Takidani-ike lake-catchment system, central Japan

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Lacustrine sediments contain both high-resolution regional environmental records and global information in lake-catchment systems. They are also of great use for reconstructing short-term environmental changes (precipitation, water discharge, etc.) and understanding earth-surface processes (erosion, transportation, sedimentation) in the lake-catchment system.

Process understanding is essential for clarifying causal relations in earth surface phenomena and proper interpretation of sediment information. Instrumental observation (monitoring) is of great use for the process understanding. This study deals with the instrumental observation for a small pond-catchment system (Takidani-ike) near Kanazawa University. The pond is storage reservoir. It is used for agricultural irrigation in summer. Therefore the water level shows highly fluctuation. Our observation consists of sediment sampling with trap, water level measurement, temperature measurement, and precipitation measurement. Observation in Takidani-ike using sediment trap has continued since June 2000.

Observational and analytical results for Takidani-ike show that; the sedimentation rate (both monthly and seasonal sedimentation) is expressed as a function of two factors; precipitation intensity (external factor) and water level change (system factor, closely related to size of erodible area). The correlation for the seasonal relationship is better than one for the monthly relationship, suggesting that reservoir effect in the catchment should be considered. The results also show that mineral grain size may be used as proxies for sedimentation rate.

Keywords: lake-catchment system, earth-surface process, pond sediment, sedimentation rate

## Characteristics and production processes of coastal huge blocks in the Miyako Island

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There are many coastal huge blocks in the Miyako Island. Some were brought from the sea bottom by tsunamis. Most of others were made by landslides of the coastal cliffs. Previous studies showed the dynamics of the production of such huge blocks from the coastal cliffs of Ryukyu limestone. Development of notches formed near the sea level and vertical cracks on the surface of the marine terraces near the cliffs caused the instability of the rock mass and finally it were torn into coastal huge blocks. This process indicates that the height of the cliff relates the block form and size. However there are large variety of form and size of coastal blocks in Miyako Island. Although smaller blocks are distributed in front of the higher cliff in the Boraga beach, huge blocks with vegetated top are distributed in front of the 20 meters high cliff in Higashi-hennazaki. This Study aims to describe the characteristics and distribution of coastal blocs and discuss production processes of the blocks.

In the Miyako Island the Ryukyu limestone covers the semi-consolidated sandstone or mudstone called the Shimajiri formations. These are unconformable. The Ryukyu limestone is hard and permeable rock and the Shimajiri formations are soft and impermeable rocks. These two layers outcrop on the cliffs and their boundary usually occurs high above the sea level. Groundwater springs or seeps from the boundary on the cliff. The water erodes the Shimajiri formations along the boundary. This process causes the notch-like form at the boundary. At the Braga beach the height of the cliff is more than 40 meters and the boundary of the layers, where groundwater springs, locates 14-20 meters high above the sea level. Development of the notch-like form caused instability of the limestone layer. And then the layer collapsed and produced limestone blocks. They rolled down to the beach breaking into smaller blocks. At the Aragusuku and Urasoko fishing port coasts the blocks were produced by same process. At the Higashi-hennazaki the boundary locates several meters above the sea level. Groundwater sapping forms notch-like form at the boundary. At the Shimajiri coast the Ryukyu limestone appears on all the cliff. A notch was formed at the sea level by the wave process. On these type of coasts the limestone cliffs were torn into huge blocks. The blocks with vegetation on the top of them were deposited along the coast.

Keywords: huge block, geomorphic process, coastal cliff, spring, Ryukyu limestone, Miyako Island

## Late Quarternary tectonic development at the northeastern margin of Tibet revealed by $^{10}\text{Be}$ and $^{26}\text{Al}$

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Tibetan Plateau has been growing up due to collision between the Indian and Eurasian plates and expanding its area laterally by invading marginal forelands and making them involved into deformation. The mechanism of expansion at the northeastern margin of the plateau is still a subject of much debate due to the scarcity of tectonic researches. In the Kumkol Basin at the northeastern margin of the plateau we made detailed geomorphological mapping using satellite images, and revealed that there is a huge anticlinorium that consists of many thrusts and folds covered with significantly deformed fluvial or fluvio-glacial fans or terraces along the Pitileke River. The development and deformation rate of the anticlinorium would give an important clue to understanding the growth mechanism of the plateau. In order to estimate the deformation rate, we dated depositional surfaces by surface exposure dating by using cosmogenic radionuclides (CRNs), such as  $^{10}\text{Be}$  or  $^{26}\text{Al}$ . Field investigations were conducted in 2011 and 2013, and mainly pebbles of vein quartz were collected at 22 points on the surface of fans and terraces. Depth-profile samples were collected also from 3-m deep sections at two points; each depth profile of  $^{10}\text{Be}$  and  $^{26}\text{Al}$  concentrations were analyzed for the exposure age, erosion rate, and inheritance by the Monte Carlo simulation. In addition, grain-by-grain CRN concentrations were measured for surface samples from two points to estimate the origin of sediments. Following three inferences were obtained: (1) the sediments of the lower part of terraces and the present river contain reworked sediments; (2) depositional processes and erosion processes are strengthened in the glacial and interglacial period, respectively; (3) the uppermost two steps of terraces were formed before the MIS6 and in the transition period from MIS6 to MIS5, respectively.

Keywords: Tibetan Plateau, Qaidam Basin, tectonic landform, surface exposure dating

## Longitudinal distribution of incision rates in the Oshika Gorge, Tottori prefecture using terrestrial cosmogenic $^{10}\text{Be}$ :

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We determined longitudinal changes of incision rates in the 3 km long Oshika Gorge, Tottori prefecture, Western Japan, by exposure dating of a series of granitic strath terraces using terrestrial cosmogenic  $^{10}\text{Be}$ . Thereby we discuss development of a waterfall sequence zone and an incised meander zone. The bedrock of the gorge consists of granite. We collected 24 granite samples from surface of erosional terraces. The oldest exposure age of a strath terrace was 50.2 kyr (relative height from river-bed is 11.0 m) and the youngest exposure age was 1.2 kyr (relative height is 1.2 m). Incision rates in the Oshika Gorge varied from 0.24 mm/yr to 1.40 mm/yr. Those of step-pool sequence zones and large boulder scatter zones were about 0.64~1.40 mm/yr, which showed increasing tendency toward downstream. Those of the waterfall-pool sequence zone were 0.24~0.57 mm/yr, which showed rapid increase toward downstream. This means that gradient of the waterfall-pool sequence zone has been under increasing conditions in these c.a.50 kyr, resulting from river-bed roughness increase according to waterfall-pool growth. The incised meander zone is located just upstream adjacent to the waterfall-pool sequence zone. Incision rate of the incised meander zone was 0.36 mm/yr, which was slower than that of step-pool sequence zones and faster than that of the waterfall-pool sequence zone. In this reach, alternate gravel bars were developed because of lower gradient and as a result, lateral migration of the river occurred and the incised meander zone was developed.

Keywords: bedrock river, incision rate, cosmogenic nuclide  $^{10}\text{Be}$ , waterfall-pool sequence, incised meander zone

## Basin-averaged erosion rates of Yakushima using cosmogenic $^{10}\text{Be}$ in river sediments

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Quantitative understanding of erosion rates under several geomorphic and geological settings is important to discuss the process of erosion. We investigated basin-averaged erosion rates from cosmogenic  $^{10}\text{Be}$  in quartz grains from river sediments in Yakushima. Erosion rates in Yakushima are relatively low within a similar range to those in regions of several times lower rainfall than Yakushima. This finding suggests that rainfall is not necessarily a causal factor of landform evolution. In this presentation, we focus on a pattern of hillslope erosion and a process of landform evolution in Yakushima.

This research project has been conducted as the regulatory supporting research funded by the Secretariat of Nuclear Regulation Authority (Secretariat of NRA), Japan.

Keywords: Yakushima, Basin-averaged erosion rate, precipitation, cosmogenic Be-10

## Temporal variation of Kurobe River Sediments revealed by TL and ESR signals in quartz

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While the ESR signals of the E1' center in quartz was used to investigate the origin of the loess in MIS 1 and 2 (Toyoda and Naruse, 2002) and of the sediments in the Sea of Japan (Nagashima et al., 2007). Shimada (2008) showed that TLCI (thermoluminescence color image) may be useful for similar qualitative study on river sediments. In the present study, the wavelength-temperature two dimensional thermoluminescence measurement was employed, together with the ESR measurements, to investigate the temporal change of these characteristics observed in fluvial sediments of the Kurobe river.

Eight sediment samples were collected from the present river bed along the Kurobe River in 2012 and 14 samples in 2013. They were sieved into two grain size fractions of 500-250 $\mu$ m, 250-75 $\mu$ m. Quartz grains were extracted using chemicals, heavy liquid, and an isodynamic magnetic separator. The obtained quartz grains were heated at 300 degree Celsius for 1 hour to erase the inherited signals. Each sample was then separated into 9 subsample aliquots for gamma ray irradiation up to 2640 Gy, which are for ESR measurements. Other aliquots for TL measurement were given a dose of 809 or 857 Gy with wrapping the tubes with Al foil in order to keep the samples in the dark.

TL measurements were performed by using the two dimensional TL apparatus. We measure the TL emission spectra during heating up to 450 degree Celsius. Red emission (538 to 658 nm) was observed between 140 and 250 degree Celsius (Low Red) and 290 and 370 degree Celsius (High Red) and Blue emission (379 to 538 nm) was between 103 and 211 degree Celsius (Blue). The integrated counts were taken as the intensities of the red and blue emissions. The results of ESR measurements will be given in the presentation together with the TL results.

Keywords: ESR, TL(thermiluminescence)

## Distribution pattern and formation processes of potholes in Oshika, Tottori: role of pothole on river incision processes

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Potholes on the Oshika River bed near Takaganma, Misasa-Town, Tottori, Western Japan were surveyed. Surrounding terrace development revealed that there potholes were formed within 3,600 years. Plan view survey illustrated a line distribution pattern of potholes, resulting from longitudinal vortices generated in flood flows. Longitudinal profiles (Fig.) showed that bottom levels of potholes were close to or towards to those of the present river bed. In general, potholes have a role of effective drilling erosion on a hard bedrock elimination with few sediment loads in the river incision processes.

Keywords: potholes, pothole developing processes, line distribution, river incision processes, balloon photos, The Oshika River, Tottori, Japan

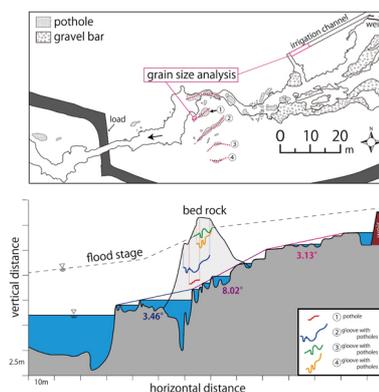


Fig. Plan view and long profiles of Takaganma-Potholes, Misasa Town, Tottori Pref., Japan