

## Investigation of tsunami disasters using lake Kitagata sediment

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Tsunami disaster after the Tohoku Earthquake that occurred in 2011 increased our concern tsunami in the Japan Sea side of the coastal region as well as the Pacific side. We can find the description of large scale tsunami disaster occurred in the Sea of Japan side in historical documents. In this study, we investigated the tsunami disaster along the Japan side coast using the sediment core from the lake Kitagata, Fukui prefecture. Lake Kitagata is a brackish lake connected to the Sea of Japan. One of the tsunami records occurred in this region is the Tensho tsunami in 1586. This tsunami was described in two literatures, mentioning that the huge waves overwashed the land. However, no sedimentological traces of this tsunami have been reported. Possible tsunami sediment layer was found from the depth 170-203cm of the core (KT14-5), which is collected from the point about 2 km inland from the sea. The layer shows coarse mineral particle size, increase in the amount of calcium carbonate, decrease in the amount of organic matter and moisture content. A corresponding layer in another core includes the shell of sea origin. In addition, diatom assemblage shows that marine and brackish species were about 70% of the total diatom, while that of a sample 30 cm beneath this layer exhibits freshwater species with about 60 percent of the total diatom species. These lines of observation indicate that this layer is tsunami deposit. <sup>14</sup>C dating results in 1404-1474 cal AD for a shell from this layer (196cm) slightly older than, but more or less equivalent to the age of Tensho tsunami. This finding is one of the evidences for a large scale tsunami disaster in the past in Hokuriku region.

Keywords: tsunami, lake sediment, diatom

## An experimental study on salt weathering in cold and dry climate

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To examine the effects of salt weathering on tafoni growth in cold and dry climate like Antarctica and Mars, a laboratory experiment was carried out using two types of rocks (Oya tuff and Aoshima sandstone) and three types of salt solutions (NaCl, Na<sub>2</sub>SO<sub>4</sub> and MgSO<sub>4</sub>). Cubic specimens with a side of 5 cm in length were immersed in each saturated salt solution for 10°C for 72 h. After immersion, specimens were oven-dried at 110°C for 48 h and stored in a desiccator for a month. Then, specimens were subjected to wetting/drying cycles in a cold chamber with humidity change, which ranges from 20 to 100%RH within every 6 hours. Air temperature was kept to 10°C in the cold chamber. Fine materials with the size of < 2 mm were splitted off from the surface of specimens with salts. The weight reduction of the specimen was largest for the case using NaCl. The decrease in Equo-tip hardness value of specimens with NaCl indicated the reduction of the surface strength. The longitudinal wave velocity of all specimens did not change. Therefore, salt weathering only occurred on the rock surface. The temperature on all specimens increased immediately after humidity increased, and the degree of temperature change was larger for the specimens with NaCl which deliquesces in air with high humidity. These temperature changes might be induced by salt dissolution and deliquescence with water condensation.

Keywords: salt weathering, humidity change, tafoni, Antarctica, Mars

## Biological weathering on the first gallery wall of Angkor Wat temple, Cambodia

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The Angkor complex is mainly constructed in the 9-13<sup>th</sup> century by Khmer dynasty and was designated as a world cultural heritage by UNESCO in 1992. The Angkor complex represents the entire range of Khmer art and is also famous for large trees growing on the temple wall (Ta Prohm) and various lichens on the stone surfaces. Angkor Wat temple, constructed of sandstone and laterite, is one of the most popular temples in the complex. The French School of Asian Studies (Ecole française d'Extrême-Orient, EFEO) had performed conservation work in early 20<sup>th</sup> century. However, it was in poor condition after the Cambodian civil war. During the period of 1986 to 1993, Archaeological Survey of India (ASI) contributed to the Angkor Wat's conservation including reconstruction of the building itself, replacement of blocks, and removal of vegetation. After completion of the cleaning procedures (nearly 200,000 m<sup>2</sup>) by ASI, the original color, gray to yellowish brown, of the Angkor Wat sandstone was restored. However, after two years, cyanobacteria have colonized large portions of the surface of Angkor Wat temple. We categorized surface of the first gallery wall into four types: 1) area covered by cyanobacteria; 2) un-covered area; 3) exfoliated area; and 4) re-covered area after peeling off. We measure the hardness of the first gallery wall by Schmidt rock hammer. Average rebound value of exfoliated area is 3.7 times higher than cyanobacteria covered area. In Un-covered area, it is 3.6 times higher than cyanobacteria covered area. Cyanobacteria are not protecting the wall surface but are accelerating its weathering by reducing surface hardness. However, it is hard to remove clearly and will be easily covered again.

Keywords: Angkor Wat temple, Biological weathering, Cyanobacteria, Cultural heritage

## Burial history of the Gonghe Basin, northeastern Tibet, constrained by in situ cosmogenic radionuclides

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Tibetan plateau has been growing up and expanding its area laterally due to the collision between Indian and Eurasian Plates. The marginal deformation of the plateau related to the lateral growth formed many mountain ranges and inter-mountain basins surrounding the plateau. Understanding development and sedimentation histories of them is an important key for revealing the growing process of the northeastern plateau. Gonghe Basin, one of the inter-mountain basins at the northeastern margin of the plateau, is located about 3200 m above the sea level and bordered by Qinghai Nan Shan and Heka Shan on the north and south, respectively. Previous researches reported that after the Yellow River filled the basin with over 500 m thick clastic sediments, the river has been cutting down through the sediments and formed many fluvial terraces. In order to reveal the process, we applied detailed geomorphological mapping, and surface exposure and burial dating by using in situ cosmogenic radionuclides (CRNs). In this presentation, we will mainly introduce burial ages of the basin sediment and their implications for early stage of development of the basin.

For cosmogenic burial dating, quartz pebbles in the basin fill were collected from the nine sampling sites locating every 50 m depth in the valley. As  $^{10}\text{Be}$  and  $^{26}\text{Al}$  have different decay constant,  $^{26}\text{Al}/^{10}\text{Be}$ -ratio yield the time elapsed since shielded from cosmic rays. Calculated burial ages are in remarkable stratigraphic order from top to bottom of the fill. Each of the deposition rates determined from the burial ages are almost the same deposition rate of about 70 mm/kyr. This indicates that the basin had been constantly filled since the late Miocene. In the presentation we will also discuss an effect of constant deposition on burial ages and rejuvenation resulted from down cutting of the Yellow River.

Keywords: Tibetan Plateau, Gonghe Basin, cosmogenic radionuclide, burial age

## Detection of landslide surface deformation around Dhunche, Trishuli River watershed in Nepal using time-series InSAR images

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Dhunche in Trishuli River watershed, Nepal is the town (ca. 3,000m in elevation) that is located 46km north from Kathumandu, where is in the transition area from lesser Himalaya to High Himalaya. The Gorkha earthquake-induced landslides were concentrated around the town, there is the risk that heavy rains in monsoon seasons will reactivate such the landslides. Therefore, continuous monitoring of slight deformation by landslides is important to prevent disasters. In this study I used Advanced Land Observing Satellite-2 (ALOS-2)/Phased Array L-band Synthetic Aperture Radar-2 (PALSAR-2) observed before and after the earthquake, 21 Feb 2015 and 2 May, in the monsoon season of 25 Jul and 22 Aug, and in the late monsoon season of 22 Aug and 3 Oct, and produced SAR interferograms using RINC 0.47 software (Ozawa 2014). By interpreting these InSAR images, I found that there are (1) landslides slightly deformed by the earthquake and continuously and slightly deformed, (2) landslides which was not deformed by the earthquake but continuously and slightly deformed. These knowledges are thought to be basic materials to map hazard of future landslides. PALSAR-2 data used in this study were provided by JAXA in the framework of special collaborative research (B) "Surface deformation study using a new generation SAR" by Earthquake Research Institute, the University of Tokyo. This study was also supported by "the Nepal Earthquake and Hazard Mapping of Future Landslides for Making the Plan of Better Reconstruction" (Principal investigator, Prof. Chigira) related to the April 2015 Nepal earthquake in the J-RAPID Program by Japan Science and Technology Agency (JST).

\* Reference

Ozawa T (2014) Development of InSAR processing tools in NIED -Part 3-. Proceedings of Japan Geoscience Union Meeting 2014 STT59-P12. <http://www2.jpgu.org/meeting/2014/session/S-TT59.html>

Keywords: SAR, Landslide, Nepal, Earthquake, Monsoon

## Orogens and global landform, revisited through an analysis of digital elevation model

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This presentation shows statistical relationship between the ages of continental crust and two topographical parameters: elevation and relief both of which derived from a global DEM (Figures 1 and 2). Although the term "orogeny" is tricky because different meanings are put on by different researchers, if we accept the definition that the orogeny is processes growing upper continental crusts along the convergent boundaries of plates, megascale landform is primarily explained by isostatic uplift and following erosion. From this point of view, reeducation is required for geography teachers in Japanese high schools, because they are largely confused about orogeny and orogens.

Keywords: Orogen, Megascale landform, Digital elevation model (DEM), Geographic education

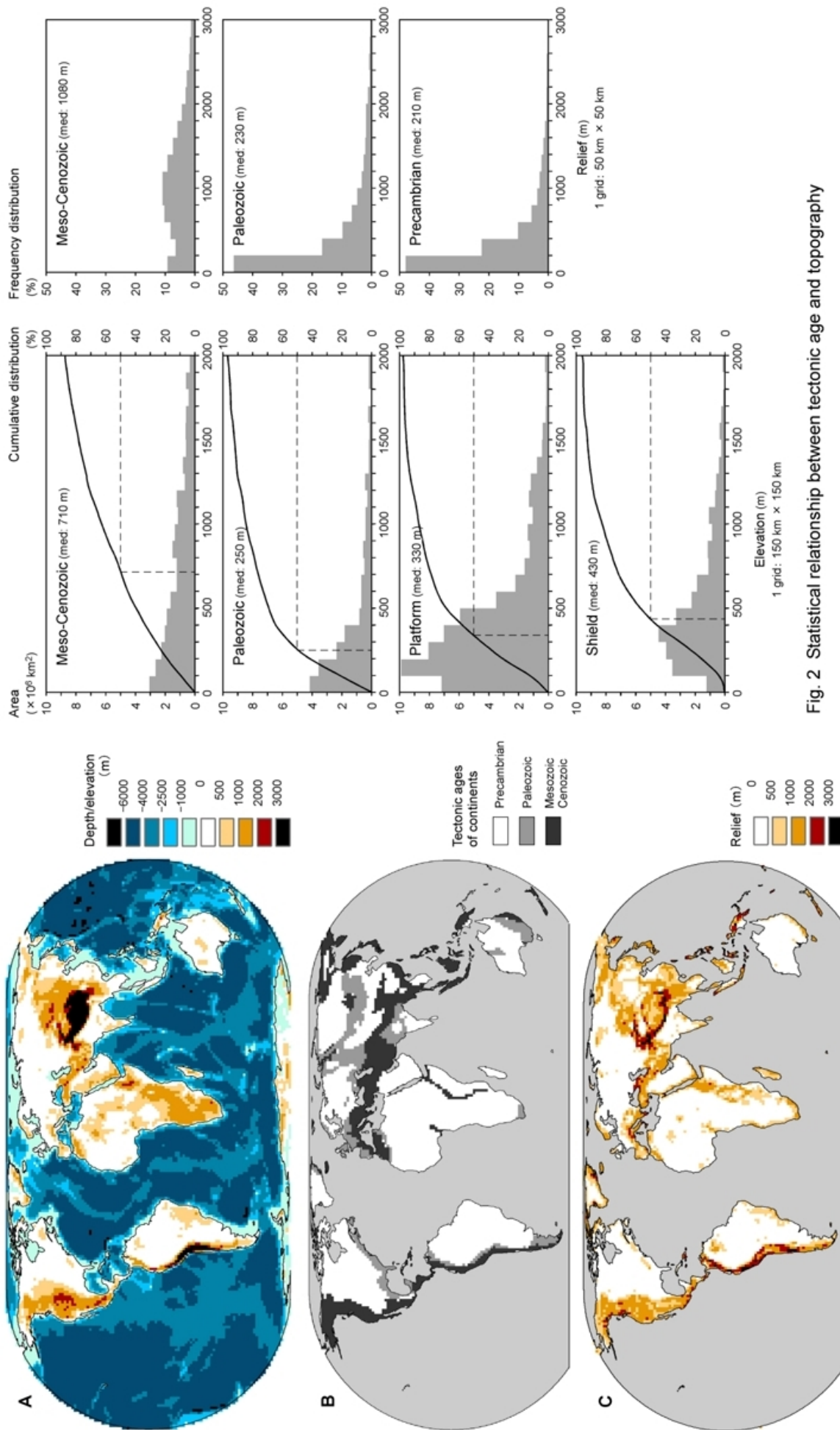


Fig. 2 Statistical relationship between tectonic age and topography

Data source:  
 Amante, C. and Eakins, B.W. (2009) ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis, NOAA Technical Memorandum NESDIS NGDC-24.  
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Fig. 1 Global elevation (A), tectonic ages (B) and relief (C). A grid size is 150 km x 150 km.





## Relationships between rainfall, fluctuation of water level and landform changes in the upper reaches of the River Azusa, central Japan

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The upper reaches of the River Azusa in central Japan is a gravel-bed braided river flowing down the Northern Japan Alps. In this reaches landforms of the riverbed change yearly or once a couple of years. This study aims to clarify the relationships between rainfall, water level fluctuation and landform changes. The observation using interval shooting cameras has carried out since July, 2011. These have taken the images of the riverbed and recorded the conditions in every 15 or 20 minutes. The results are as follows. Despite relatively large drainage basin rainfall-runoff response is quite fast. About 30 minutes after the start of a rainfall the water level began to rise. The amount of the water level rise to the rainfall was different when the rainfall event occurred. During the Baiu rainy season the relatively less rainfall caused larger water level rise than after the end of the Baiu. Only one major landform change event was recorded during the observation. It occurred on 19 June, 2013. The heavy rain recorded 166 mm of the daily rainfall caused bankfull discharge, which was about 1 meter water level rise. These relationships between rainfall, water level rise and landform changes was caused by the geomorphological characteristics of the Kamikochi valley, which has thick gravel deposits more than several tens of meters and their water storage characteristics.

Keywords: rainfall-runoff, water level fluctuation, landform change, interval shooting camera, upper Azusa River, Kamikochi

Hydraulic conditions of erosion and crevasse spray sedimentation generated by the breach of Kinugawa River around Misaka area, Joso City on September 10, 2015.

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When flooding occurs in the large rivers, the special terrain is generated around the breach point. First of all, it scraped deep flood flow the marsh, making erosion terrain called crevasse channel. The crevasse spray deposits are around the channel. Especially crevasse spray deposits have been frequently reported in the fluvial sediments of geologic era, however modern sedimentological and geomorphological report is limited yet.

Through September 9 to 11, 2015, large flooding and landslides disaster around the East Japan was generated by the influence of the Typhoon No. 18, named "2015 Kanto and Tohoku heavy rain disaster.". The left bank of Kinu River was breached over a period of about 200 m, a large flooding disaster occurred on 10 September 10 around 12:50 in Misaka area in Joso City, Ibaraki Prefecture. Various sedimentary structures were observed, such as heavy erosional terrain caused by the supercritical flow around the breach point, the bed form 3D dune-ripple control by the changing flow velocity in the crevasse spray deposits, and fabric of rubbles indicating flow direction.

Keywords: crevasse spray, Kinu River, Misaka area, Joso City, hydraulic condition, Geomorphology, Sedimentology

## Wind duct experiments on reptation particle motions using a high speed video camera

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Aeolian reptating particles, splash particles by saltating grain collision to bed, were surveyed with wind duct (width: 9 cm, depth: 56 cm, length: 7 m28 cm), using high speed video camera (Sony, NEX-FS700R /FS700RH). 3.8 mm diameter particles of polypropylene (specific gravity: 0.9) were selected for experimental material in order to trace particle motion tracks easier. The video camera, which was set aside in the center part of the wind duct, recorded 960 frames per second. Polypropylene particles were laid at 24cm thickness. Wind condition was constant: 18 m/s. From 40 particle motion tracks, we analyzed grain speeds, accelerations and jumping heights. Most saltating particle showed more than 100 cm/s in speed and repetitions between accelerations during jumping stage and rapid decelerations after hitting the bed. While reptating particles showed less than 50 cm/s in speed and less accelerations and decelerations. Jumping heights of particles were clue to distinguish between reptation and saltation. In this experimental, if jumping height exceeds twice the grain diameter, particle shows continuous saltating motion. We had also noticed that creep mode movements, moving only by wind action, were very rare phenomena.

Keywords: aeolian sediment transport mode, saltation, reptation, creep, high speed video camera, particle motion analysis

## Causal connection between denudational and depositional mechanism: an approach based on stream analysis at Eastern Yoro Mountains

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The eastern side of Yoro Mountains presents steep landscape due to active uplifting and associated river incision. As the mountains faces low-lying Holocene river delta, sedimentary deposits yielded in the mountains form alluvial fans at eastern foot of the mountains. Many researchers have described topographic features of alluvial fans, and there are some general empirical agreements about them. For example, it is widely accepted that gradients of fan slope have negative correlation with catchment area. In the other hand, experimental miniature alluvial fans clarified that increase in sediment discharge and decrease in water discharge steepen fan slopes. To verify the effect of sediment discharge in real world, denudation rate of catchments or accumulation rate of alluvial fan should be obtained. Instead of directly measured denudation rates, hillslopes and relief ratio of catchment area were commonly used to discuss the relation. However, independency of denudation rate on hillslopes is reported in steep landscapes of "threshold slope". Likewise, relief ratio tends to have negative relation with catchment area, thus effect of increasing relief ratio is difficult to separate from that of decreasing catchment area. As another reference, channel steepness is defined based on stream-power incision model and is expected to have positive correlation with incision rate and rock strength. Incision rates of bedrock river, expressible as channel steepness, would control landscape denudation rate in steep mountains. Therefore, this presentation reports channel steepness of the eastern Yoro Mountains and discusses effect of the channel steepness on fan slopes.

Keywords: mountain river, threshold hillslope, denudation, chi plot, fan slope

## Effects of piedmont deposition on the development of experimental erosion landform

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The development experimental landform with rainfall-erosion and uplift is considered to be controlled by various factors, such as rainfall intensity, permeability and strength of material, and the width of deposition area. In order to understand the way of experimental landform development, effects of these factors should be examined individually. The effects of the width of deposition area surrounding the uplifted area (60 x 60 cm square) were examined by comparing runs with different deposition area. Specifications of those runs are listed below. Rainfall intensity are 80-90 mm/h and all runs are in the steady state phase\*\*(Ouchi, 2015).

	.....deposition area.....	uplift duration	.....permeability	.....uplift rate
run27	.... 10cm	.....960h	.....2.94cm/s	.....0.36mm/h
run32	....20cm	.....1000h	.....1.84cm/s	.....0.36mm/h
run30	....10cm	.....1160h	.....2.99cm/s	.....0.1mm/h
run31	....20cm	.....1160h	.....4.68cm/s	.....0.1mm/h

In the first stage of experiments, fluvial erosion with the development of valley systems dominates in the uplifted area, and in the deposition area sediments deposit to form alluvial fans with frequently shifting the place of deposition. Sections of alluvial fans observed after the experiments reveal that those alluvial fans advance with keeping nearly constant gradient of deposition surface. After alluvial fans fill the area of deposition, the area becomes the area of transport and this accelerates fluvial erosion in the uplifted area. Valley incision into the uplifted area increases the area of slopes and as a result promotes slope failures. Slope failures occur frequently and dominate the landform change after relief reaches a certain height. Channels become conduits of sediments produced by slope failures, and the average height becomes rather stable. This stable average height indicates the achievement of balance between erosion and uplift height (steady state).

Wider deposition area requires longer time of alluvial fan development to fill the area, and this helps prolonging the period of fluvial erosion and slowing the development of valley systems. Relatively slow valley incision and prolonged period of fluvial erosion allow the uplift increase the height of sand mound. The average height of uplifted area after becoming stable is higher with wider deposition area. The height of fan apex, which determines the base level of erosion in the uplifted area is higher with wider deposition area. After the deposition area turns into the area of transport, landform changes look similar regardless of the width of deposition area. Shapes of longitudinal channel profiles show good similarity despite the difference in deposition area, except for their height and length. Ridges, however, tend to be separated in the run with narrower deposition area, probably because accelerated fluvial erosion during the period of lower relief promotes the development of wide and shallow valleys.

\*\*Ouchi, S. 2015. Experimental landform development by rainfall erosion with uplift at various rates. *Geomorphology* 238: 68-77.

Keywords: rainfall-erosion experiment, width of deposition area, development of alluvial fans, fluvial erosion, slope failures, uplift rate

## Development of Landform Classification Polygons using 250-m DEMs in the Asia-Pacific Region

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Classifications of topography using DEMs have been widely used for various purposes, for example, automatic searches of steep slopes and valley heads where landslide susceptibility is high, estimation of grain size or erosion resistance, and estimation of seismic amplification. However, most former studies used pixel-based approaches which could not handle increasing noise associated with enlarging the resolution of DEMs. Previously the corresponding author developed a pixel-based automated classification method of plains, terraces, hills, mountains and volcanos using slope gradient, texture and convexity calculated from a DEM (Iwahashi, 1994), then produced 1-km grid landform classification data using SRTM30 (Iwahashi and Pike, 2007). In this study, the authors developed the Iwahashi and Pike (2007) method and produced landform classification polygons of East Asia, Southeast Asia, and the western part of North America using an interpolated 250-m DEM of GMTED2010.

Classifications of raster images such as DEMs are typically done by thresholding, regression, or data mining using geometric signatures. In this study, the authors made the polygons of homogeneous geographic areas by multiresolution segmentation (Baatz and Schäpe, 2000) before classification. We used the three geometric signatures which were used in Iwahashi and Pike (2007). In the case of the polygon-based method, the variation range of usable classification techniques is wider than a pixel-based case, because of a large decrease in the quantity of data. There are many options for the polygon-based method; for example, in choice of geometric signatures, tuning of geometric signatures, scale parameter for segmentation, method of classification, and tuning of classification. In this presentation, we introduce trials and considerations in the Asia-Pacific region.

The results in this presentation show good performance in extracting meadows and classification of intermediate landforms such as terraces, fans and hills in the regions of steeper and various landforms in orogenic zones such as Japan or the western coast of North America. On the other hand, the results do not show enough performance in extracting small landforms for very flat and simple plains such as deltas in a continental region. Mountains may be classified as rock mass classification; however, regional climate differences should be taken into account from differences of erosion styles in volcanos between mid-latitude zones and tropical zones.

This study was carried out within a framework of Grants-in Aid for Scientific Research.

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Keywords: object-based segmentation, DEM, landform classification, GMTED2010, Asia-Pacific

Examination of the paleo-sea level inferred from emerged wave-cut features along the west coast of the Noto Peninsula, central Japan

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In the west coast of the Noto Peninsula, the crust deformation in Holocene has not been revealed because of lack of the reliable indicator of paleo-sea level. The wave-cut notch is able to be the indicator, but it is difficult to distinguish them from features formed by salt weathering which are abundant on surface of sea cliffs in this area (Kobayashi et al., 2015). In addition, the distribution of the wave-cut notch is controlled by rock types and cracks, and they formed above sea level because of wave convergence due to surrounding landform. Therefore identification of paleo-sea level is not easy.

Ito et al. (2002) revealed that the height of the retreat point of the notch in sea caves was almost equal to paleo-sea level recognized from erosive features around the cave in the Echizen coast, central Japan. In the west coast of the Noto Peninsula, notches in sea caves are also formed and most of them are not constrained by geological structures. Moreover, these features are well preserved from weathering. Therefore, the present study aimed to reveal the height of wave-cut notches in sea caves and that on the sea cliffs which coexist with benches and are not controlled by geological structures along the west coast of the Noto Peninsula. The measurement of the height was demonstrated not at the recess but near the entrance of sea caves to avoid influence of convergence of waves.

The investigation revealed that paleo-sea level records estimated from wave-cut notches were around an altitude 2 m. These features are considered to form at the same time from vicinity of them. Therefore, the crustal tilting from the time these features formed to the present is not seen in this area.

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Kobayashi, W., Hamada, M., Yamaguchi, H., Takayama, T., Ishigami, S., Hiramatsu, Y., 2015, Shapes and origins of notches and caves on sea cliffs, the Noto Peninsula, central Japan. Abs, Sub, JpGU, meet, 2015, HGM22-P04.

Keywords: sea cave, wave-cut notch, paleo-sea level



## Magnitude-frequency distribution of mega-collapses in Japan

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A number of researches have already investigated magnitude-frequency relationship of slope deformation, such as slope failures and landslides. On the other hand, the relation between magnitude and frequency of the mega-collapse (i.e. sector collapse) mainly occurred on the volcanic edifice have not been necessarily discussed enough. And also, it is unclear whether the occurrence pattern of the mega-collapses can be related to that of the smaller events. This study, to make the effort to tackle the above challenges, investigates the magnitude-frequency distribution of slope failures in Japan, including the largest events, and discusses its geomorphological significance. The study stands mainly upon the existing datasets by Yoshida (2010) for the mega-collapses on the volcanoes, and by Machida et al. (1987) for the events relatively smaller but more abundant in number. Based on these, the magnitude-frequency distribution of slope failures in volumetric scale equal to and more than  $10^7$  m<sup>3</sup> could be investigated as,  $\log N(x) = a - bx$ , where  $N(x)$  is cumulative number of events larger than and equal to  $x$ ,  $x$  is the magnitude expressed by  $\log V$ ,  $V$  is the volume of a slope failure, and  $a$  and  $b$  are constants. Constant  $b$  ranges from 0.7 to 0.8, which indicates that the smaller events are exactly susceptible to have occurred frequently. In addition, based on the reanalyzed data once had been shown by Ohmori and Hirano (1988), originally collected by Construction Ministry of Japan during 1975-1983, similar constant  $b$  value is obtained for the events with a volumetric scale equal to and more than  $10^{5-6}$  m<sup>3</sup>. From the above, this study is successful in offering a new understanding of the magnitude-frequency distribution of mega-collapses in Japan. Considering recent records for the past millennium or bit more in Japan, the obtained magnitude-frequency relationship shows substantially the situation during several tens thousands years. This speculation enables us to predict event probability along with the recurrence intervals for any event with a certain magnitude. For example, mega-collapses with a volume of  $10^9$  m<sup>3</sup> should occur repeatedly at least every 1000 to 2000 years in anywhere in Japan, from a probabilistic viewpoint. Such above investigation indicates that mega-collapses are never "rare" events in the geomorphological time-scale.

Keywords: sector collapse, volume, exponential regression

## Geomorphic setting on surface failure position by water line analysis

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As the spatial resolution of Digital Elevation Model (DEM) has become higher, we can investigate geomorphological properties of smaller scale surface failures using DEM. However, there are problems of how to distinguish failure cells from non-failure cells and how to analyze them. We traced water lines to identify target cells on hilly slopes.

The study area is the hilly area in Hiroshima city, where over a hundred surface failures occurred in 2014.

In analysis, 3 cells were determined on the water line; head cell located at the head of each surface failure, upper cell upward adjacent to the head cell, and lower cell downward adjacent to head cell.

We calculated slope angle, flow accumulation, and profile curvature for the head-, upper- and lower-cells.

Flow accumulation is defined as relative water quantity on each individual cell supplied from upstream areas (cells).

We compared vertical slope shape (concave, convex, straight) and its change along the water line between the failure slopes and un-failure ones, and had a tentative conclusion that combination of vertical slope shapes along the water line is one of the important geomorphological features for detecting the slope segment easy to failure.

Keywords: 2014 Hiroshima sediment disaster, Surface failure, Geomorphological setting, Geomorphological analysis, Water line

Relationship between the geomorphological characteristics of tributaries and the development processes of the fluvial terrace in the upstream area of the Tama River, central Japan

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Mountain rivers run through many tributary junction points, and thus the characteristics of the tributaries affect the landform and deposits of the mainstream (Shimazu, 1990, 1991; Nogami, 2010). However, few studies have discussed the effect of tributaries on the river terrace development. This study discusses the relationship between the geomorphological characteristics of tributaries and the development processes of the fluvial terraces since the Last Glacial around the tributary junction points in the Tama River, central Japan.

In the upstream area of the Tama River, several terrace levels have been formed since the Last Glacial. The highest terrace in this area (Aoyagi terrace) is a fill-top terrace composed of valley filling deposits (Takagi, 1990). Takahashi and Sugai (2016) pointed out the possibility that the valley filling of the mainstream had almost finished before MIS 4.

Aoyagi terrace in this area is distributed discontinuously around tributary junction points, and inclines toward the direction across the mainstream valley. The slope of the present tributaries incising into the Aoyagi terrace is from 150 to 300 permil, indicating that these tributaries are debris flow tributaries (Shimazu, 1990, 1991). On the other hand, the slope of the Aoyagi terrace is from 100 to 150 permil; this slope is gentler than that of the tributaries of the present. From the above, it is interpreted that Aoyagi terraces around the junction points of tributaries were formed as alluvial cones by the debris flow from the tributaries (Larson et al. 2015) during the Last Glacial in the upper reach. During the Last Glacial, the slope of tributaries decreased along with the valley filling of the mainstream. In spite of that, the slope of the tributaries had retained to be steeper than 80 permil, therefore the tributaries had continued to supply debris flow deposits to form alluvial cones. These alluvial cones were truncated by lateral migration of the mainstream after the Last Glacial Maximum. Subsequently, the slope of the tributaries has increased because of the incision since the Post Glacial.

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Keywords: fluvial terrace, Tama River, tributaries, alluvial cone, debris flow, junction points

Estimation of fluvial incision rates based on artificial channel modification  
"Kawa-mawashi" in Boso Hills, Central Japan

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Fluvial incision is a basic factor of basin landscape evolution as well as lateral erosion and recession of water fall. Quantification of incision processes, therefore, are helpful in order to unravel geomorphic processes of basin. In this study, we estimated incision rates using some artificial abandoned channels constructed by "Kawa-mawashi" since the Edo period. The incision rates are estimated from a set of height ( $H$ ) and period ( $T$ ) since construction age of "Kawa-mawashi". The height ( $H$ ) is the difference of height between the present and the abandoned riverbeds. We selected eight channels having a drainage area of 4 ~ 32 km<sup>2</sup>. Bedrocks of those channels are composed of sedimentary rocks from the Neogene to the Quaternary period. Results show the incision rate of 0.7 ~ 22.1 (average rate: 5.8) mm/y. It suggests that the incision rate is controlled by hydrologic condition and bedrock characteristic.

Keywords: incision rate, bedrock channel, artificial channel modification, abandoned channel

## Fluvial breaking and abrasion mechanisms acting upon gravel-sand grains utilizing the difference of grain lithology

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Downstream fining of fluvial clastic sediments has been generally attributed to two processes: hydraulic sorting and pristine grain production, controlled by breaking and abrasion mechanisms. We investigate the role and presence of these mechanisms focusing on downstream lithological compositional and roundness changes on both sand and gravel fractions. Roundness is strongly responsive to both breaking and abrasion acting upon detritus (e.g. Krumbein 1941). Although sands may be produced from coarser grains, they were not investigated alongside gravels in previous downstream fining studies. We studied two tributaries originated from the Ashio Mountains constituted by the Ashio Belt, a Jurassic sedimentary rocks accretionary complex, in the watershed of Tone River. Breaking and abrasion mechanisms acting upon detritus was revealed by both field survey (cobbles-coarser pebbles) and laboratory analysis (finer pebble and granule-coarse sand grains), utilizing grains of contrasting durability (hard chert and fragile shale). For the evaluation of grain roundness, nine sets of standard roundness images classified by Krumbein (1941) was adopted as standard.

The downstream increase in chert/shale ratio of cobble-pebble and downstream rounding of shale pebble-sand grains occurred, in spite of a low chert detrital supply. The results suggested that pristine sand grains were produced from gravels and sands by breaking mechanism, which leads to grain size reduction and higher angularity, and by abrasion mechanism, which gives rise to grain rounding while keeping nearly unchanged size and produces angular pristine produced finer particles, during transport, considering with the existence of changes in chert grains roundness. Additionally, the contrasting trend of downstream roundness changes between the two rivers is recognized, which might have been caused by the different gradients among the researched section of the rivers. Therefore, it is possible to reveal the relationship between the river gradient and breaking and abrasion mechanisms in this study.

This study was supported by the Sasakawa Scientific Research Grant from The Japan Science Society.

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Keywords: gravel-sand, breaking and abrasion mechanisms, lithological composition, roundness, Ashio Mountains

Study on content and constitution of learning to deal with Geomorphology in Geography A  
-Focusing on the relationship in the units and in the social life-

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Geography being taught in high school, is composed of a system geography (physical geography, human geography) and regional geography. Therefore, it has a feature that disciplines of humanities and social sciences and natural sciences are complex. Treatment of physical geography is focused on to consider, such as the relationship between human beings living in the guides of course of study. Among the guides of course of study, it is mentioned natural environment as one of the geographical environment, which is one of the elements to achieve the goal of understanding the world and the region. However, in the current geography education it has been pointed out that it is an exhaustive and list specific handling of rote learning and facts (Takebe 1998), especially in the state it is difficult to capture the dynamic nature environment. In this study, we will arrange the handling of content related to the geomorphology of physical geography unit. Further consideration of the relationship between the unit and human geography specific unit. Proactive learning at the micro scale of learning and everyday life level on a global scale is expected in the learning objectives of geography A in the guides of course of study.

Among them, the challenges of the unit of geographic considerations of living area, "the natural environment and disaster prevention" is installed, the application of the real life of physical geography field, including the geomorphology has been expected. Thus, geography A has become a subject structure is essential for real life. Because it is because has a configuration that conforms to the purpose of the geographic targeting a relationship with human life. In order for the purpose of linking the more content of the subjects in real life, it is important to find a meaning to look for improvement of the guides of course of study and textbooks. It is necessary to the discussion of the positioning and teaching methods and content of geography A. This is because, in the establishment and of compulsory discussion of "geography comprehensive", there is a high possibility that the geography A reorganization of the subjects is the basis is carried out.

First, extract the terminology related to geomorphology for textbook six books of geography A, which is used in the current. For frequent terms, to organize what is being used how in the unit of the geomorphology. Then, the extraction for their appearance point of the other unit, reveal that the relationship or have been applied in the manner which is what you have learned in the unit of the geomorphology. As a result, in the category of textbooks of the current geography A can be for terms that limit resistance, to consider more meaningful usage.

In addition, in order to evaluate whether the geographical A has it been actually achieved that goal, I searched for the term in a major newspaper about the geomorphology term, phenomenon that appeared in the extracted textbook. Period is the past three years in consideration of the influence of the Great East Japan Earthquake. As a result, in a phenomenon that has been attracting attention or are treated or apparent in the real world, it is able to consider whether those that help in how real life terrain terms that are treated to a textbook. We can discuss the discrepancy with the information to be used in the topographic content and real life in a textbook. I will report details of the discussion that day.

Keywords: Education of geography, Learning of geomorphology, Relationship, Practicality

