Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)


HDS27-01 Room:102B Time:May 24 09:00-09:15

# Sector Collapse of Inagodake in Kita-yatsugatake Volcano and Landslide dams outburst disaters

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1. Introduction

Yatsugatake Volcano in Nagano Prefecture was violently shaken by an earthquake on 22 August, 887, which caused a large-scale sector collapse (Ishibashi, 2000, Inoue,2010). The collapse flowed down the Otsuki River in the form of a large-scale debris avalanche and blocked the Chikuma River upstream of the Shinano River, forming a gigantic landslide dam. In the area from Sakudaira to Nagano Basin along the Chikuma River, Ninna Flood sand covered rice paddies and houses.

2. Topographical feature of large-scale landslide dams

This disaster in mentioned in many historical materials, including records from the 887 earthquake and from the flood disasters of 888. These materials can be interpreted to show that on 22 August 887, in addition to the disaster caused by a violent earthquake (mega ocean-trench earthquake) that affected most of the main Japanese islands, a massive collapse occurred in the Yatsugatake Volcano, which blocked the Chikuma River and resulted in the formation of a huge landslide dam. Subsequently on 20 June, 888 (303 days later), the landslide dam collapsed, causing a heavy flood that washed away both houses, castles.

The altitude of the river bed at point of the river channel blockage was 1000 m above sea level. Debris including avalanche sediment present along the Otsuki River and there are many mudflow hill landforms and lakes including Lake Matsubara, resulting from the debris avalanche. Considering the existing of extrusive landforms such as mudflow hills near Lake Matsubara, I estimated to inundation height of 130 m and volume of 580 million m3, which would make it one of the largest landslide dams known to have occurred in Japan. This landslide dam formed along the Chikuma River and had an extremely large inundation volume, which gradually collected water for about ten months. The dam eventually became filled during torrential rainfall in the rain season. It suddenly failed 303 days later, caused a secondary debris avalanche. The water collapse behind the landslide dam flowed for over 100 km down the Chikuma River, which resulted in flooding and the deposit on the Ninna Flood sand (Kawasaki, 2010).

The landslide dam failure caused a secondary debris avalanche, which blocked the Aiki River near Koumi and formed Old Lake Aiki, which remained for over 600 years. Although Old Lake Chikuma 1 collapsed, Old Lake Cnikuma 2 (50 m height) existed for 123 years. Various place-names related to the lake; including Uminokuchi (enter the lake), Umijiri (exit the lake) and Koumi (small lake) still exist in the upper reaches of the Chikuma River. These names could be constructed as records of the landslide dam.

3. Secter collapse in the Kita-Yatsugatake and mega moved rock body in Inagodake

Kawachi (1983) suggested that the collapse of the eastern flank of Yatsugatake Volcano resulted in the formation of a horse-shaped caldera of 2.25 km in north-south length, 3.5 km in east-west length and 350 m in maximum relative height and estimated that the sediment from the Otsuki River debris avalanche amounted to 350 million m3. We later estimated the volume of the horseshoe-shaped caldera as over 1 billion m3 and postulate that this landform was a repeated debris avalanche as large as that which occurred in 887, along with volcanic activity.

Mt. Inagodake remains at the head of the caldera as a massive moved rock body, with an approximately 1000 m long axis, 200 m height, and 140 million m3 in estimated volume. This moved rock body may have been formed at the time of the sector collapse in 887. Alternatively moved rock mass may have exited earlier and the sector collapse may have occurred on a large scale that included is almost completely separated from the bedrock and may collapse significantly in the future as a result of earthquake activity, or post-volcanic activity. Consequently, we had to investigate the situation of mega moved rock body in Inogodake by GPS.

Keywords: Yatsugatake, Inagodake, sector collapse, landslide dam, debris avalanche

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HDS27-02 Room:102B Time:May 24 09:15-09:30

# Late Pleistocene to Early Holocene large landslides in Takamaga-hara, Mount Suisho of Hida Mountains

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We describe the geologic and geomorphic features of large landslides (rock avalanches) in the uppermost Kurobe River in the northern Japanese Alps. The source area of these landslides was a steep amphitheater on the west face of Mount Suisho (2978 m a.s.l). The landslide deposits fill the valley of the Iwagoke-kodani River, which is a subsidiary stream of the Kurobe River, and cover an area of approximately 1.53 $km^2$. Moreover, hummocks and depressions have developed on the top surface of the landslide deposits. The landslide deposits consist of a thick (>70 m) gravel layer with brecciated rock clasts; the gravel layer has an estimated volume of 4.6 x $10^7$ $m^3$. The lithology of the clasts in the gravel layer is the same as that observed on the rock slopes around the amphitheater at Mount Suisho. $^{14}C$ dating of seven wood fragments collected from the gravel layer provides age estimates of 10.187-9.631 cal ka. Meanwhile, sandstone fragments sampled from the amphitheater exhibit ages of 4.2-3.2 $^{10}Be$ ka, and a granodiorite specimen collected from a hummock surface produces ages of 68-40$^{10}Be$ ka and 21-12$^{10}Be$ ka. These ages, combined with the geographic separation of the sampling sites, suggest that multiple landslides occurred during the Last Glacial and the Late Glacial periods , as well as during the early Holocene epoch.

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HDS27-03 Room:102B Time:May 24 09:30-09:45

# Debris flow involving landslide dam: a case of Mochiyamadani, Miyagawa area, Mie Prefecture in 2011

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Miyagawa area in Mie Prefecture was suffered by heavy rain of the Typhoon Talas in 2011, followed by 2004 rain. Many landslides were induced by both the rains. Pre-existed slow landslides reactivated, while incipient rapid deep seated landslides occurred isolated or at adjacent slope of pre-existed landslides.

In Mochiyamadani, tributary of Miyagawa River, enlargement of 2004 landslide and debris/rock slide at a neighboring slope were occurred at the uppermost course in 2011. The moving mass flowed down as a debris flow, eroded landslide dam which was formed by 2004 rockslide at the middle course, increased its volume, and reached the confluence of Miyagawa River. The debris flow destroyed a check dam and a bridge in the lower course, and flushed a house at the opposite bank of Miyagawa River. Miyagawa River was temporary dammed and raised up river water level.

Keywords: 2011 heavy rain, debris flow, landslide dam, Miyagawa River

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HDS27-04 Room:102B Time:May 24 09:45-10:00

# Features and distribution of landslides triggered by heavy rainfall in the northern part of Kyushu in July 2012

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Many landslides occurred in the northern part of Kyushu island, following the heavy rainfall in July 2012. In this research, we aim to define the features and distribution of landslides triggered by the heavy rain. Moreover, we also contrived new application of the Landslide map published by NIED, by comparing features and distribution of landslides and the Landslide map.

Many landslide occurred in Aso area, Kumamoto Prefecture and Hoshino area, Fukuoka Prefecture which observed the total rainfall over 800 mm. Almost landslides occurred in Aso area were shallow landslide with less than 1m of thicknesses. On the other hand, in the Hoshino area, the landslide to which not less than 5 m in thickness and width exceed 100 m occurred although there is little number compared with Aso area. As a result of comparing the distribution and the features of landslide in both areas, it was revealed that the landslide occurred in both area differs in the scale and the morphology. The causes are considered to be geological units and the density of landslide topography. Therefore we can suppose the landslide susceptibility by combining the geological units and the Landslide map.

Keywords: Landslide, heavy rainfall in the northern part of Kyushu in July 2012, the Landslide map

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HDS27-05 Room:102B Time:May 24 10:00-10:15

# Iwatoyama landslide and natural dam caused by the AD 1714 Shotoku-Otari Earthquake in central Japan

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The Iwatoyama landslide, which caused the loss of 30 lives, was induced by the Shotoku-Otari earthquake (*M* 6 1/4) on April 28 1714. This landslide is considered to be related to the Itoigawa-Shizuoka Tectonic Line active fault system located in northern Nagano Prefecture and believed to have created a natural dam obstructing the Himekawa River. However, little detailed information is known on the geologic and geomorphic features of the Iwatoyama landslide and its natural dam. We performed geologic and geomorphic investigation by air photo interpretation, geological exploration, and re-examination of historical documents as well as interviewing local residents. The principal results are: (1) the Iwatoyama landslide started on the western face of Mount Iwatoyama (1,356 m ASL), and the landslide mass directly moved down onto the Himekawa River, (2) the landslide mass obstructed the Himekawa River, resulting in formation of a dammed lake with an elongated water area extending 4 km upstream, (3) the height and width of the natural dam are estimated to be 80 m and 460 m, respectively, (4) the duration of the dammed lake was three days, and finally the dam collapsed causing a catastrophic flood, and (5) an integrated study of geology-geomorphology and historiography is beneficial for reconstructing landslides that occurred in historical times.

Keywords: Historical earthquake, Earthquake-induced landslides, Natural Dam

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HDS27-06 Room:102B Time:May 24 10:15-10:30

# Effect of geological structure on the sediment supply rate and topography in a large landslide.

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Large-scale landslides continuously supply sediment into rivers after their initial formation by the erosion of exposed bed rock. We quantitatively examined characteristics of sediment supply processes in the Aka-kuzure, a large landslide in central Japan, based on the Airborn LiDAR data (2000, 2003, and 2007), and Terrestrial Laser Scanning data (2010 and 2011). By comparing these topographic data, two types of sediment supply processes were found in Aka-Kuzure: deeper landslides ($>$ 10 m in depth), and other erosion processes (erosion rate of $<$1 m yr$^{-1}$). In the areas underlined by alternate layer of sandstone and shale, erosion rate was different between the two geology; erosion rates in the sandstone and shale were about 1 m yr$^{-1}$ and 0.2 m yr$^{-1}$, respectively. In these areas, steep cliffs of sandstone (slope gradient of 60-80 degrees) and gentler slopes of shale (slope gradient of about 40 degrees) forms step-like topography. This topography retreatedalong the dip direction by the erosion. Consequently, geological structure in the Aka-kuzure affects spatial distribution of erosion rate as well as topography in the landslide.

Keywords: deep-seated landslide, Aka-kuzure, sediment supply, Shimanto terrane

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HDS27-07 Room:102B Time:May 24 10:30-10:45

# Relationship between rainfall condition and landslide magnitude-frequency in Japan

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Rainfall-induced landslides are important natural hazards that often inflict substantial damage to society. For assessing landslide hazards, a basic task is to understand the relation between historical landslide records and rainfall conditions. Although critical rainfall thresholds have been established in this context, little is known about the size characteristics of the resulting slope failures. This study examines potential correlations between landslide size distributions and total rainfall (mm), mean rainfall intensity (mm/h), maximum rainfall intensity (mm/h), or rainfall duration (h). We analyzed 4,848 rainfall-induced landslides that occurred throughout Japan during 2001 to 2011. We classified these landslides into two groups according to their estimated volume, and tested whether their size distribution is related to rainfall characteristics.

Results show that the frequency of small landslides surpasses that of large landslides at low values of total rainfall, mean rainfall intensity, and maximum rainfall intensity. In contrast, the frequency of large landslides increases with increases in these rainfall parameters. The cross-over values are the total rainfall of 200 - 270 mm, mean rainfall intensity of 3.5 - 3.8 mm/h, and the maximum rainfall intensity of 33 - 45 mm/h. With regard to the rainfall duration, the frequency distribution of large landslides is almost the same as that of small landslides. These results suggest that the total rainfall and the rainfall intensity affect landslide magnitude more than rainfall duration in the Japanese archipelago.

Keywords: landslide, magnitude-frequency, rainfall

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HDS27-08 Room:102B Time:May 24 11:00-11:15

# Development history of sagging geomorphology: examples from Mt. Kanmuriyama, Gifu Pref. and Mt. Tsuenomine, Mie Pref.

Satoru Kojima[1*], NIWA, Ryota[1], KAYAMOTO, Koichiro[1], Heitaro Kaneda[2], Hidehisa Nagata[3], IKEDA, Akiko[4], Toshio Nakamura[4], Tomoyuki Ohtani[1]

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Recently sagging geomorphic features like double ridges and uphill-facing scarps attract attention as precursors of large-scale landslides. Many types of large- and small-scale sagging landforms have been ubiquitously found in the Japanese mountainous regions by the analyses of detailed topographic maps made by LiDAR survey. The development history and processes, however, are unclear. We report the results of field and coring surveys on sagging geomorphology in Mt. Kanmuriyama area, Etsumi Mountains of Gifu-Fukui prefecture boundary and Mt. Tsuenomine area in Mie Prefecture, Kii Penisula.

Chert and sandstone formations of the Jurassic accretionary complex of the Mino terrane are widely distributed in the Mt. Kanmuriyama area. Sediments accumulated in the ridge-top depression (altitude: 1,131 m) northwest of Mt. Kanmuriyama were drilled by hand auger equipments in order to characterize the deposits. The sediments are composed of 1) conglomeratic orange mud, 2) light-yellow mud, and 3) alternating beds of dark-gray mud and carbonaceous mud/leaf litter mixture, in ascending order. The thickness of the sediments, increasing from east to west and 3 m in maximum, suggests that the depression has been resulted from the eastward slumping of the ridge-top. On the basis of the Kikai-Akahoya tephra (K-Ah) of 7.3 ka and AMS-14C ages measured on the wood fragments embedded in the sediments and the sediment accumulation rate estimated by these ages, the depression was formed about 11,000 years ago, and has been constantly filled up with the sediments.

Miocene sandstone and mudstone with minor amounts of conglomerate occur in the Tsuenomine area. There are several types of deformation landforms such as double ridge on top, uphill-facing scarps, landslide dam and buried dammed lake. Sediments accumulated in the ridge-top depression about 9 m thick were drilled, and they are massive mud changing to the muddy conglomerate at the bottom. Although the sediments include no plant remains suitable for the AMS-14C age determination, three layers of tephra at 0.8, 4.3 and 7.8 m depths are sandwiched, which are correlated to the Aira Tn (AT, 28-30 ka), Kuju-Daiichi (KJ-P1, 50 ka) and Kikai-Kuzuhara (K-Tz, 95 ka) tephras, respectively. These ages indicate that it takes more than 60,000 years for the sedimentation of the massive mud about 7 m in thickness.

Keywords: sagging geomorphology, landslide, Mt. Kanmuriyama, Mt. Tsuenomine

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HDS27-09 Room:102B Time:May 24 11:15-11:30

# Tectonic controls on gravitational deformation: a regional sagging mapping in the western Mino Mountains using LiDAR

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Many linear geomorphic features of gravitational origin, known as sagging or sackung, are recognized on and around high mountain ridges worldwide. A complete scanning and mapping of those sagging features in a given region, however, has ever been difficult because classic aerial-photograph examination does not allow detection of small geomorphic features under forest canopies. We here present the first complete distribution map of sagging features in a wide area using high-resolution airborne LiDAR and the elaborate DEM visualization that facilitates mapping and interpretation of small geomorphic features of various morphology and orientations. The target area is the western Mino Mountains, central Japan, where the ˜35-km-wide and ˜24-km-long area is characterized by relatively monotonous, moderate- to high-relief mountains of 1000-1600 m high and uneven active-fault distribution. The recently acquired 1-m-resolution LiDAR data of the Etsumi Sankei Sabo (Erosion Control) Office cover the entire western Mino Mountains, providing the rare opportunity to examine various controls on large-scale gravitational deformation and mass-wasting in a humid temperate tectonically active region. We produced stereo-paired Red Relief Image Maps to visualize DEMs and carefully mapped sagging features. Our mapping reveals that sagging feature prevails almost everywhere in the studied area, with a total number being as many as 10486 and a total length being as much as 716 km. The average line density is 0.68 km/km2. We also found a strong positive correlation between sagging-feature density and altitude, indicating that potential energy is a very important control for the formation of sagging features. The areas underlain by sedimentary rocks tend to show higher line density than those of igneous rocks. We also examined the impact of strong ground motions and static crustal strain associated with movement of active faults within the area and found that both parameters are positively related to sagging-feature density. In particular, the static strain has a stronger effect than strong ground motions, suggesting that we need to take into account static crustal strain associated with active faulting in accessing mass movement potential, in addition to strong ground motions.

Keywords: sagging, airborne LiDAR, active fault, Mino Mountains

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# Gravitational deformation and bedrock groundwater discharge in a hillslope underlain by accretionary sedimentary rocks

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Prediction of location and timing of deep-seated catastrophic landslides requires 1) detection of topographic signals formed by preceding gravitational deformation, 2) understanding of hydro-geological structure constrained by discontinuities in bedrock, and 3) revealing response of deep groundwater to rainfall infiltration. We curried out investigation of topography and geology, and hydrological observation in a high relief dip slope underlain by accretionary sedimentary rocks in Katsuragawa, Shiga Prefecture Japan. The observed hillslope has many scarplets and bedrock springs. Discharge from these springs shows a variety of response to rainfall, implying existence of multi system of groundwater aquifer in the bedrock.

Keywords: deep-seated catastrophic landslides, gravitational deformation, deep bedrock groundwater, bedrock spring, rainfall-runoff processes

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HDS27-11 Room:102B Time:May 24 11:45-12:00

# Topographic criteria for susceptibility mapping of earthquake induced landslide

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Topographic features were studied from viewpoints of earthquake types, such as off-shore and inland-epicentral earthquakes, and landslide types, such as shallow surface slide, debris slide and deep seated slide. Topographic types that are prone to cause each type of landslide due to each type of earthquake are proposed. They are gravitational creeping slopes, steep slopes or cliffs along gorge, old landslide of which toe part are incised, buried valley with weathered pyroclastic deposits and end part of active faults with strike slip sense. They are effective criteria for susceptibility mapping of earthquake induced landslide, using AHP method combined with lithological and structural data by each earthquake type.

Keywords: susceptibility mapping, earthquake induced landslide, topographic criteria

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# Geomorphological settings of the slope movements in the Matsushima Bay area induced by the 2011 Off-the Pacific Coast of

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Slope movements such as rock failures and rock slides were concentrated in the hilly areas of Matsushima Bay in Miyagi Prefecture by the 2011 Off-the Pacific Coast of Tohoku Earthquake. Geomorphological settings of the slope movements have been studied by the GIS-based analysis and stereoscopic slope maps which was produced from the 2m-mesh DEM taken by the Geographical Survey Institute, Japan.

90% of the slope movements which has been detected by interpreting Google Earth images and field survey occurred on the slopes more than 40 degrees in slope gradient and 10m in relative height. Though the frequency of them increases in concordant with the gradient, it is highest in the class of 10-20m in relative height where the steep slopes of marine erosion both at recent and Holocene time have been formed. The time-sequential comparison of the settlement house numbers indicates that they have been increased near such steep slopes. Since the risk of landslide disasters induced by earthquakes has increased, further measures against the slope disasters are required.

Keywords: Landslides, Matsushima, the 2011 Off-the Pacific Coast of Tohoku Earthquake, stereoscopic slope map

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HDS27-13 Room:102B Time:May 24 12:15-12:30

# The cases and their aspect of glacier lake outburst in the Himalayan range

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The risk evaluations by previous studies for glacial lake outburst flood (GLOF) have been conducted on shaky ground. ”Dangerous glacial lake” means many of different by various researchers and agencies. One glacial lake in Sagarmatha region, eastern Nepal is examples of that. Because the lake which has been considered as both side, very dangerous and not so dangerous. The former side, international donors and researchers spent presious time and money in recent for protection work. In order to give reliable evaluations, further detailed information and considerations are required.

The author had reported the past outburst events and occurrence tendency in the Bhutan Himalayas (an abstract paper in the JpGU 2012. Global Environmental Research, 16, 69˜80). Furthermore, I expand the area of observation into the Himalayan range. As the recent work, following results were obtained, 1) Most of outburst events had occurred till the 1970s in the Himalayan range. It means that glacial lake outburst is a part of transition phenomenon between from the Little Ice Age to the present climate, rather than just a recent global warning. 2) The location of outburst event is concentrated in the central and eastern Himalayas (Bhutan, Sikkim and Eastern˜central Nepal). 3) Flood records in the previous descripted data and local information is not always glacial lake outburst floods.

In this presentation, I will show the other condition and tendency of occurrence of outburst events which are related to the basement topography and so on.

Keywords: glacial lake outburst flood, glacial topography, climate change, case study, disaster prevention

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HDS27-14 Room:102B Time:May 24 12:30-12:45

# Self-potential variation in the rainfall-induced landslide flume test with two-layered sands

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Recently, rainfall-induced landslides occur frequently with increase of heavy rain. In order to mitigate landslide disasters, understanding of the landslide process and developing of early warning system are important. In this study, self-potential (SP) approach has been attempted to develop an early warning system for rainfall-induced landslides. Self-potential approach is a passive method to measure potential difference under the ground by using the electrodes set under the ground. And, this approach is low cost and easy to set up.

To understand the relation between self-potential changes and landslide, laboratory experiments have been performed. The main results are as follows;

(1)Expansion of saturated area is corresponding to that of the low potential area.

(2)The water flow directions changes from vertical to parallel to the slope.

(3)The trend of self-potential variations in saturated areas is explained by hydraulic gradient, theoretically.

(4)The transient changes of self-potential variation appear below sliding segment a few ten minutes before the main collapsed, when the apparent sand displacement starts.

In the previous laboratory experiments, we had used the uniform soil layer. However, a practical field has a complex and multiple layered sands. Therefore, in this study, we tried to the laboratory experiment with two soil layers.

The details will be provided in the presentation.