Japan Geoscience Union Meeting 2012
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HDS04-01 会場:102B 時間:5 月 20 日 09:00-09:15

台風 12 号による深層崩壊と、それに先だった重力斜面変形
Deep-seated catastrophic landslides induced by typhoon 12 and their precursory gravitational slope deformation

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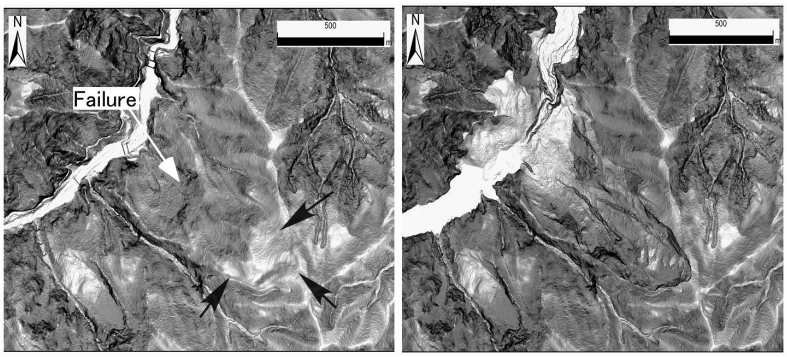
台風 12 号は、2011 年 9 月 2 日から 5 日にかけて西日本を横断し、特に紀伊山地に 2000mm を超える降雨をもたらし、14 以上の深層崩壊を発生した。これらの崩壊は、住居の直撃、天然ダムの形成、または増水した河川への突入による津波の発生を引き起こした。これらは面積 36000　から 549000　と大規模であり、最大の崩壊体積は 1500 万?と見積もられる。発生したものの内大規模な 14 の深層崩壊について、発生前の 1m － DEM 解析 および空中写真観察行った結果、１つの崩壊を除いて、いずれも発生前に将来冠頂となる位置に重力変形による小崖を伴っていたことがわかった。これらの小崖は、傾斜 33 °から 45 °、比高 2m から 50m で、空中写真では極めて注意深く観察して見出されるものが多い。斜面傾斜方向断面で考えると、その水平長と崩壊斜面水平長との比は 5〜21 %であり、これは発生前の斜面変形程度が小さかったことを示している。残りの一つの崩壊は、岩盤斜面の下方に崩積土が堆積し、その下部に崩壊があり、この崩壊が上方に拡大した結果上方岩盤斜面が不安定化したと解される。また、これらの崩壊の冠頂と崩壊最下部とを結ぶ線の傾斜はいずれも 27 °から 34 °であった。これらの特徴は、深層崩壊発生場所予測に重要な手掛かりとなるものである。

キーワード: 深層崩壊, 台風 12 号, 地形発達, 地質, 岩盤クリープ, 重力斜面変形
Keywords: deep-seated landslide, typhoon 12, slope development, geology, mass rock creep, gravitational slope deformation



Japan Geoscience Union Meeting 2012
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HDS04-02 会場:102B 時間:5 月 20 日 09:15-09:30

紀伊山地における降雨履歴と斜面の不安定性および深層崩壊の発生
Rainfall, slope instability, and deep-seated landslides in Kii Mountains Japan

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Prediction of deep-seated landslides by heavy rainfall needs combination of two complementary approaches that focus on geological and geomorphological predisposition of hillslopes, and hydrological triggering of final slope destabilization. Analyses of topography and rainfall history will provide a clue to understand processes leading to deep-seated landslides in mountainous landscape. This study reports the case of deep-seated landslides caused by typhoon 12 in 2011, in Kii Mountains, Japan. A GIS-based topographic analysis revealed the distribution of potential hillslope instability in the terrain, and hence offered an interpretation for location of the landslides. Timing and motion of several landslides are reconstructed by seismic-wave records. We examined relationships between preceding rainfall and volume or speed of sliding mass to evaluate threshold conditions leading to landslides.

キーワード: 深層崩壊, 降雨履歴, 地形発達, ハザードゾーニング
Keywords: deep-seated landslide, rainfall history, landscape evolution, hazard zoning

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HDS04-03 会場:102B 時間:5 月 20 日 09:30-09:45

2011 年台風 12 号によって発生した地すべりの地震波形記録
Seismic recordings of the Landslides caused by Typhoon Talas

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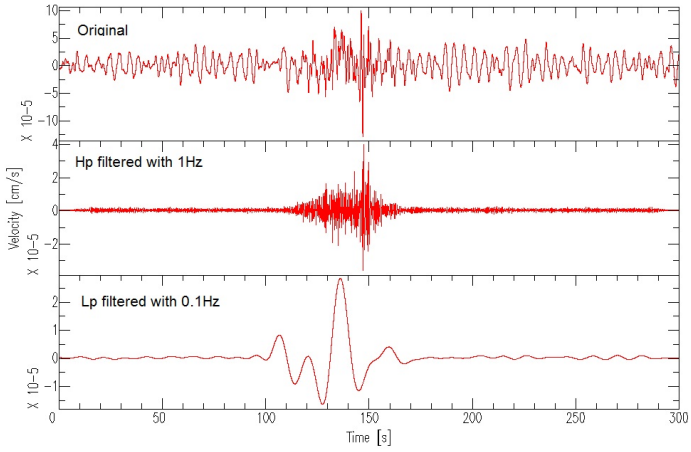
Typhoon Talas passed Japan Island on September 3-4, 2011 and brought substantial rainfall in western part of Japan. Total rainfall by this typhoon exceeds 2000mm in Kii peninsula, which caused many landslides in Nara, Wakayama, and Mie prefectures. 73 people were killed and 19 were reported missing by this typhoon.

The seismic signals due to these landslides are recorded by dense seismic network in Japan. The long-period surface waves are recorded by broadband seismic network (F-net) all over Japan (NIED, 2011), and short-period ground motions are recorded by the high-sensitive seismic network (Hi-net) as much as a few hundred km away. The landslide signals are usually tens of seconds long and have smooth onset, thus it is easy to distinguish to records of small earthquakes with couple of seconds duration. The typical landslide recordings are shown in Fig. 1, We applied back-projection technique (Spudich and Cranswick, 1984) to the records and determined the timing and location of each landslide signal.

We successfully detected several landslides in the continuous seismic recordings, and large events with volume more than 1 million m3 were located by the back-projection method. The seismic waveforms are very characteristic, and composed of high-frequency ground motion (frequency $>$ 1Hz) and low-frequency ground motion (frequency $<$ 0.1Hz). This complicated waveforms reflects the actual mechanism of landslides, and helps to understand the mass movement in time series.

The sequence of the landslides caused by Typhoon Talas can be located by the conventional source relocation technique in seismology. The seismic signal can tell the snapshot of the process of the landslides, which is rarely observed in visual (Suwa et al, Socio et al.). This is one of the most well-recorded landslide sequences all over the world. This seismic network is originally designed for locating seismic activities, but continuous records are very important to understand the mechanisms of the natural phenomenon as shown in this presentation.



Japan Geoscience Union Meeting 2012
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HDS04-04 会場:102B 時間:5 月 20 日 09:45-10:00

紀伊山地における 2011 年台風 12 号による深層崩壊の発生場
Occurrence site of deep-seated landslides induced by typhoon 1112 in the Kii Mountains

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Distribution of convex slope breaks and fluvial knickpoints which are regarded as ”erosion front” and deep-seated landslides induced by typhoon 1112 have been investigated to reveal how landslides develop in the context of long-term slope development. We analyzed mountain topography by using 10-m mesh DEM, topographic maps and aerial photographs in the central Kii Mountains, southwest Japan. We found that convex slope break is widely distributed about 200m above the present riverbed in study area, and it divides the area into lower dissected area and upper palaeosurface. Dissected area is divided into lower and upper parts by at least one slope break. These slope breaks were formed by active incision, and the incision dissected palaeosurface and propagated main stream to tributaries and downstream to upstream. Deep-seated landslides tend to occur in slopes with these slope breaks, because undercut slopes are unstable and partly suffered gravitational deformation. Topographic analysis by erosion front has the potential to identify the landslide-susceptible region roughly but widely.

キーワード: 深層崩壊, 侵食前線
Keywords: deep-seated landslides, erosion front

Japan Geoscience Union Meeting 2012
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HDS04-05 会場:102B 時間:5 月 20 日 10:00-10:15

The geological characteristics of the Leye landslide near Alishan, Taiwan
The geological characteristics of the Leye landslide near Alishan, Taiwan

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Serious landslides occurred in Leye region near Alishan, Taiwan in 2009 during Typhoon Morakot struck. This study investigated the mechanism of the Leye landslides and the characteristic of the nearby geological characteristics in the landslide area. The fluvial processes of the Tsengwen River should influence the landform thereby also influence the development of the Leye landslides. The landslide is triggered by the intense rainfall of Typhoon Morakot. Also, in the sedimentary formation of Leye region, the geological structures, such as synclines, anticlines and dip slopes control the displacement of the landslides. The mitigation works maybe helpful to retard possible complex the hazards in recent coming years. Emergency evacuation could be a better solution to mitigate the hazards in the Leye landslide area.

キーワード: Landslide, dip slope, mechanism, mitigation
Keywords: Landslide, dip slope, mechanism, mitigation

Japan Geoscience Union Meeting 2012
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HDS04-06 会場:102B 時間:5 月 20 日 10:15-10:30

台湾北部で下刻によって起きた山体の重力変形
Gravitational slope deformation induced by transient waves of incision in northern Taiwan

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At least 11% of the upper Shihmen Reservoir catchment is affected by gravitational slope deformation in the northern part of the Hueshan Mountain Range, Taiwan, where is underlain by Oligocene and Miocene sedimentary rocks and metamorphic rocks. The gravitational slope deformation has occurred as a response to the propagation of new incision waves to palaeosurfaces. Therefore, landscape evolution must be accounted for to predict and to evaluate potential sites of catastrophic landslides, most of which are preceded by gravitational slope deformation. Geomorphic analyses combined with cosmogenic nuclide dating revealed that at least three phases of transient waves of incision have propagated into paleosurfaces with a minimum age of ˜140 ka. Tectonically induced base-level fall triggered the first incision wave around ˜120 to 140 ka, dissecting palaeosurfaces and inspiring gravitational slope deformation. The second incision wave probably driven by global sea-level lowering during last glacial age has reached to the catchment around ˜13 to 15 ka with an enormously rapid incision rate of 20 mm a-1, inducing slope movements. Climate forcing such as increasing monsoonal precipitation during the last glacial-to-interglacial transition may have been another cause of the rapid incision. The third incision wave is apparently associated with a local base level change. The trigger and its initiation are as yet unknown This younger incision made steeper slopes (avg. 39.8 degree), over several tens to a few hundred meters above current river bed. These are small landslide-prone slopes since numerous numbers of smaller landslides are concentrated on the lowest steep part of the river-side hillslopes.

Surface exposure dating on slip surface of an ancient landslide on a dip slope reveals the occurrence of the landslide in the late Holocene epoch, suggesting the development of the deep-seated slope deformation creates suitable conditions in a long-term (in the order of millions of years) for the subsequent landslide activities since the paleosurface has been dissected by the first incision wave. Recent catastrophic landslides had been preceded by gravitational slope deformation of rocks with adverse geological structures, suggesting that major-landslide prone slopes are dip-slopes of alternating beds of sandstone and mudstone at the margins of the paleosurface.

キーワード: 山体重力変形, 下刻, 古地形, 宇宙線生成核種分析
Keywords: gravitational slope deformation, transient waves of incision, paleosurface, cosmogenic nuclide dating

Japan Geoscience Union Meeting 2012
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HDS04-07 会場:102B 時間:5 月 20 日 10:45-11:00

斜面崩壊地帯における自然電位観測に関する研究
In-situ self potential measurement for monitoring of landslide process

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YABE, Shuhei[1*], HATTORI, Katsumi[1], OTSUBO, Hiroshi[1], Edy Gaffer[2], Adrin Tohari[2], Kohri Sugianti[2], Boko Nurdiyanto[3], Iwan Maulana[3], Noor Effendi[3], Pri Harjadi[3], Suhardjono[3], Budi Waluyo[3], Byung-Gon Chae[4], HUANG, Qinghua[5]

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近年，集中豪雨の頻度が増加するにつれて，斜面崩壊の発生件数も増加する傾向にある．降雨に起因する斜面崩壊過程を把握し，斜面の監視や崩壊を予測することは重要な課題である．そこで我々は自然電位法（Self Potential ＝ SP）による斜面崩壊の早期予測システムの開発を試みている．これまでの室内実験の結果から、SP によって　地下での飽和域の成長，　鉛直方向から斜面方向への水流の変化，　崩壊 20 分前の SP のトランジェントな信号の出現が記録され，SP 法を用いた地下水モニタリングが有望であることがわかりつつある．しかし室内実験は二次元的で、土層が均質であるため、室内実験だけでは限界がある。そこで本研究では、インドネシア Pelabuhan Ratu の斜面崩壊地帯に観測点を設置し，実斜面による検証観測を開始した．

具体的には，SP 測定電極を斜面崩壊方向に 2 測線，直交方向に 1 測線の 3 測線，計 13 か所に埋設した．深さは 1.0, 2.5，4.0 m である．また，地下水流動（間隙水圧）を調査するために，テンシオメーターを設置した．テンシオメーターは 5 測線設け，各測線 0.5，1.0，1.5，2.0，3.0 m の深さに計 25 個設置した．テンシオメーターの結果から観測斜面は飽和もしくは飽和に近い状態にあることがわかった．また，地下の傾斜を求めるためのボアホールを 2 か所，及び雨量計を設置した．

その結果，実斜面では観測された SP 値と間隙水圧値には線形関係があり，両者を結び付ける界面動電結合係数 C ’は約－ 2.0 (mV/m) と算出された．ここで，界面動電結合係数 C ’とは飽和土層中を通過する流水の圧力と発生する電位に関する係数であり，水質が同じである限り土壌によって決まる．また，降雨に伴い SP の変動が大局的に変動することが確認された．そこで，この SP 変動は水の流動に伴うものであると考え，隣り合う電極の電位差を求めた．その結果，降水量の少ない日では鉛直下向きの流動と考えられる SP の変動が確認され，テンシオメーターから作成した等水理水頭線図の流動方向と一致した．しかし，降水量の多い日では，斜面方向の流動にと考えられる SP 変動が確認された．また，理論的に動水勾配を算出したところ，強雨にともない横方向の動水勾配が上昇する結果が得られた．つまり，降水量の多い日ではローカルな斜面方向の流動が生じていると考えられる．これは室内斜面崩壊実験から崩壊発生前に斜面方向の水の流動が卓越し，斜面崩壊が発生することが確認されており，斜面方向の水の流動は斜面崩壊の直前過程と関係がある可能性が示唆される．詳細は講演時に述べる．

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Statistical emulation of a landslide-generated tsunami model
Statistical emulation of a landslide-generated tsunami model

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Due to the catastrophic consequences of tsunamis, early warnings need to be issued quickly in order to mitigate the hazard. Additionally, there is a need to represent the uncertainty in the predictions of tsunamis' characteristics corresponding to the uncertain trigger features (e.g. either position, shape and speed of a landslide, or sea floor deformation associated with an earthquake). Unfortunately, computer models are expensive to run. This leads to significant delays in predictions and makes the uncertainty quantification impractical. Statistical emulators run almost instantaneously and may represent well the outputs of the computer model. In this paper, we employ the Outer Product Emulator to build a fast statistical surrogate of a landslide-generated tsunami computer model. This Bayesian framework enables us to build the emulator by combining prior knowledge of the computer model properties with a few carefully chosen model evaluations. The good performance of the emulator is validated using the Leave-One-Out method.

キーワード: landlslide, tsunami, statistical emulation, hazard assessment
Keywords: landlslide, tsunami, statistical emulation, hazard assessment

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HDS04-09 会場:102B 時間:5 月 20 日 11:15-11:30

TSUNAMI GENERATION BY GRANULAR LANDSLIDES IN VARIOUS SCENARIOS

TSUNAMI GENERATION BY GRANULAR LANDSLIDES IN VARIOUS SCENARIOS

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Tsunamis generated by landslides and volcanic island collapses account for some of the most catastrophic events. Major tsunamis caused by landslides or volcanic island collapse were recorded at Unzen in 1792, Krakatoa in 1883, Grand Banks, Newfoundland in 1929, Lituya Bay, Alaska in 1958, Papua New Guinea in 1998, and Java in 2006.

Source and runup scenarios based on real world events are physically modeled in the three dimensional NEES tsunami wave basin (TWB) at Oregon State University (OSU). A novel pneumatic landslide tsunami generator (LTG) was deployed to simulate landslides with varying geometry and kinematics. The LTG consists of a sliding box filled with up to 1,350 kg of naturally rounded river gravel which is accelerated by means of four pneumatic pistons down the 2H: 1V slope, launching the granular landslide towards the water at velocities of up to 5 m/s.

Topographical and bathymetric features can greatly affect wave characteristics and runup heights. Landslide tsunamis are studied in different topographic and bathymetric configurations: far field propagation and runup, a narrow fjord and curved headland configurations, and a conical island setting representing landslides off an island or a volcanic flank collapse.

Water surface elevations were measured using an array of resistance wave gauges. The granulate landslide width, thickness and front velocity were measured using above and underwater cameras. Landslide 3-dimensional surface reconstruction and surface velocity properties were measured using a stereo particle image velocimetry (PIV) setup. The speckled pattern on the surface of the granular landslide allows for cross-correlation based PIV analysis. Wave runup was measured with resistance wave gauges along the slope and verified with video image processing. The measured landslide and tsunami data serve to validate and advance 3-dimensional numerical landslide tsunami and prediction models.

キーワード: landslide, tsunami, volcano
Keywords: landslide, tsunami, volcano

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HDS04-10 会場:102B 時間:5 月 20 日 11:30-11:45

Debris flow hazards in Malaysia: The need for comprehensive mapping and risk assessment

Debris flow hazards in Malaysia: The need for comprehensive mapping and risk assessment

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Debris flow is quite common in hilly and mountainous areas. In Malaysia, it is the life-threatening landslide disaster, the type of landslides that killed many lives compared to other landslide types. While many natural debris flows have occurred in areas without human settlement, there were at least 15 cases of killer debris flows since year 1994, at least 137 people were killed. Several major debris flows events in Malaysia were (1) a multiple-landslide cum debris flow flooded a major highway in Genting Sempah, Selangor killed 21 road users that were in their idling vehicles when the road was blocked by a small landslip. The debris flow started from landslides at the headwaters of the steep mountain flanking the highway; (2) a debris flow devastated a local village in Pos Dipang, Perak in 1996, 44 people died. The debris flow nucleated by several landslides in the upper valley scouring the valley, subsequently created temporary dams along the river before the village. The village was eventually swept away by overwhelmed debris flood when the temporary dams broke; (3) in Johor, Vamei-Typhoon storm with the strength that capable of uprooting trees and heavy rain attributed to several induced landslides then debris flow in Gunung Pulai in the year 2001. Four houses were swept away by the debris flood and 5 were killed, due to debris accumulated before a bridge across the river broke, and; (4) in 2002, 16 lives perished when debris flow buried their village in Ruan Changkul, Sarawak. It buried an 8-unit long house, the 20,000 cubic meter debris was initiated from a landslide on the agricultural land on top of the hill. More recently, in August 2011, a debris flow in Sungai Ruil, Cameron Highlands buried 4 houses at a foot slope, 7 killed while 2 injured; the houses were situated 150m away from the source of the landslide.

In Malaysia, the debris flow landslide is becoming an alarming disaster as development are encroaching the fringe of highlands and mountainous areas. The hazards from the adjacent slopes or upstream located far away has yet to be considered in many risk assessment. Only a limited mapping and identification of debris flow were carried out at very local scale while there are many places in Malaysian topography of mountainous and dissected hilly terrain are vulnerable to debris flow. Currently, research on debris flows in Malaysia is still very limited to post-disaster investigation within the areas of debris flow where disasters occurred, particularly if death is involved.

A nation-wide mapping is proposed to be carried out to delineate areas of potential and vulnerable to debris flows. The first level of national mapping will rely on topographical and geological data to identify elements that are susceptible to debris flow with emphasising on the basin geometry, geomorphology, modelling of run-out distance of a debris flow and at-risk cultural elements.

キーワード: debris flow, landslide, Malaysia, debris flood
Keywords: debris flow, landslide, Malaysia, debris flood

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バッドランドでの岩石物性変化の観測-台湾南西部鮮新-更新統泥岩分布地域において-
Monitoring of the rapid weathering in a badland of Plio-Pleistocene mudstone area, southwest Taiwan

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We monitored water contents and electric conductivities beneath a slope surface in a badland, southwest Taiwan, where highly incised topography is formed by rapid erosion of about 10 cm/year on Plio-Pleistocene mudstone. Badland is characterized by dissected bold landscape with gullies and ridges. It is widely distributed in arid to semi-arid areas in the world (ex. South Dakota in America, Loess area in China, south Italy and southeast Spain). Slope surface in badland of weak mudstone is markedly characterized by surface crusting and desiccation cracks, which reach 10 to 20 cm depths. Erosion in such badlands is assumed to be related to high saline contents. We set sensors for temperature, water content, and electric conductivity at 0 to 40 cm depths beneath a slope surface and measured them at 10 minutes intervals from 2009 to 2011. A rain gauge was set 1 m above the ground in front of the monitoring slope and hygro-thermo meters were set 10 cm above the slope surface and with the rain gauge. About 1900 mm of precipitation occurred during the monitoring interval and over 96% of the rainfall was in the rainy season from May to September. Air temperatures and relative humidities gradually increased to rainy seasons from dry season. Water contents near the slope surface were lowest in the dry season and increased by infrequent rainfall events, and became quite high in rainy seasons. Salinity, which is estimated from electric conductivities and water contents, near slope surface was lowest in dry seasons and increased in early rain seasons. The increased salinity was diluted by heavy rainfall events in rainy seasons and intensive erosion occurred by the grain dispersion by the dilution. Water penetration depths were 30 to 40 cm in dry seasons and became much shallower to a depth of about 10 cm in rainy seasons. The decrease in the water penetration depths may be attributable to the self sealing of cracks by rock expansion when wet.

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