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Identification of Large-Scale Dissected Landslides and Verification Through Microtremor Analysis Along the Median Tectonic Line in East Shikoku, Japan

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Abstract: It is difficult to recognize the existence of rock bodies whose landslide topography has been completely dissected. We have identified large-scale dissected landslide bodies along the Median Tectonic Line, Japan, by recognizing characteristic topographic features of landslides on a digital elevation model. We have proposed that H/V spectra obtained by microtremor surveys are an effective means of distinguishing a landslide body from a stable, sound rock-mass in the field.

Keywords: ***Dissected landslide, DEM, Microtremor.***

Introduction

Hasegawa (1992) identified eroded landslide bodies along the Median Tectonic Line (MTL) in the eastern part of Shikoku, Japan. However, those investigations were somewhat limited, and additional dissected landslide bodies may remain unidentified. It is essential to recognize the existence of these dissected landslides. The method proposed by Kanbara et al. (2021) was effective in identifying landslide bodies that were not previously noted by Hasegawa (1992).

Hasegawa et al. (2016) found that, although landslide risk was similar across sites in Nepal, actual landslide occurrence was lower in the Midland area near the epicenter than in the farther Himalayan Range. They suggested that dissected landslide bodies may attenuate seismic waves as they travel to the surface. We have investigated the landslide distribution along the MTL in the vicinity of Kirihata Hill and examined the characteristics of both new and dissected landslides. In addition, we have considered the extent of fragmentation of the rock mass in dissected landslide bodies and assessed whether the vibration characteristics derived from continuous microtremors could be applied to verify the presence of dissected landslides.

Study area

The study area lies in East Shikoku, between Mima and Awa Cities at the southern foot of the Sanuki Mountains, which consist of the Izumi Group. The Chichio Fault, part of the MTL active fault system, marks the boundary between the mountains and the Yoshino River lowland. According to the National Research Institute for Earth Science and Disaster Resilience (NIED) landslide distribution map (https://www.j-shis.bosai.go.jp/map/), numerous landslides occur in the Sanuki Mountains north of the Chichio and Iguchi Faults (Figure 1).

Research methods

Landslide geomorphological features

We applied a method that utilizes Digital Elevation Models (DEMs) to recognize landslide bodies based on three characteristics: 1) ridge discontinuity; 2) the landslide head being lower in elevation than the original slope; and 3) spreading of the landslide body to form a gentle slope. We identified previously undetected dissected landslide bodies in the area around Kirihata Hill. After identifying these landslide bodies (Figure 1), we considered the distribution of the landslide bodies in relation to the landslide topography published by the NIED. We also measured continuous microtremors in the Sanuki Mountains, the lowlands south of MTL, and Kirihata Hill to verify the identified landslide bodies through their vibration characteristics.

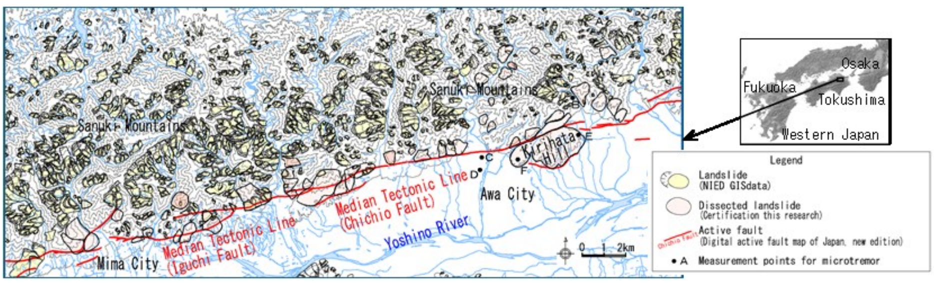

Figure 1, Location map of the study area showing the distribution of landslides and large-scale dissected landslides.

Relationship between MTL and landslide bodies

Landslide bodies, including large-scale dissected landslides, tend to be larger closer to the MTL (Figure 2). Furthermore, because large-scale dissected landslides are concentrated along the MTL, it is highly likely that these landslides were directly triggered by earthquakes associated with active faults. There are pronounced differences in the distribution density of landslides in areas where dissected landslides have occurred. This finding indicates that new landslides are less likely to occur within previously dissected landslides (Figure 1).

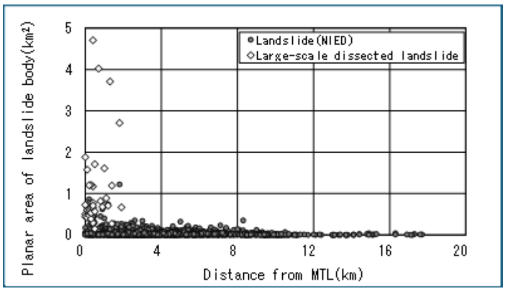

Figure 2, Landslide area vs. distance from MTL.

Verification of identified large-scale dissected landslides

Continuous microtremor measurements were obtained at a total of 20 locations; herein, we consider the results from two of these sites (Locality A in the Sanuki Mountains and Locality E on Kirihata Hill).

Characteristics of the H/V spectral ratio of the Sanuki mountains

The Izumi Group of the Sanuki Mountains is characterized by stable bedrock and consists of alternating sandstone-dominated layers and mudstones. At location A, the H/V spectral ratio is neither flat nor dominated by a distinct frequency (Figure 3) .

Characteristics of the H/V spectral ratio in Kirihata hill

Figure 4 illustrates an example of the H/V spectral ratio of continuous microtremors measured at Location E on Kirihata Hill, a dissected landslide body. The dominant period in the hill is about 0.4 Hz, distinct from that of the Sanuki Mountains.

Summary

The main findings of the study are as follows.

- Large-scale dissected landslides are concentrated along the MTL, suggesting that these dissected landslides are likely formed as a direct result of fault movements associated with the active zone of the MTL.
- Few new landslide topographies occur within dissected landslides. We hypothesize that the landslide movements have transformed these areas into fractured bedrock that is less prone to further landslides. However, verification of this hypothesis remains a challenge for future research.
- In the immovable Sanuki Mountains, no distinct dominant frequency was observed in the H/V spectral ratio, which is distinct from the vibration characteristics of Kirihata Hill.
- We consider that dissected landslides with unclear topography might be identifiable by analyzing continuous microtremors.
- The results of this study will assist with the broader recognition of eroded and ambiguous landslide topographies, enabling assessment of the risks associated with large-scale civil works and consideration of civil planning or countermeasures in advance.

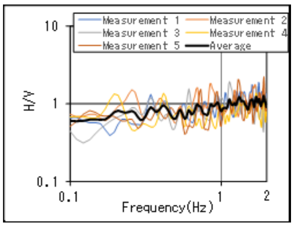

Figure 3, Representative H/V spectral ratio for Sanuki mountain (locality A).

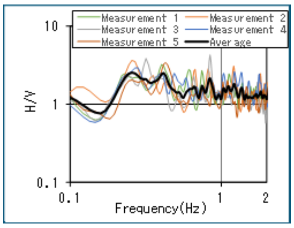

Figure 4, Representative H/V spectral ratio for Kirihata hill (locality E).

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