Geophysical Research Abstracts,
Vol. 11, EGU2009-6722, 2009
EGU General Assembly 2009

Topographic evolution indicated by the distributions of knickpoints and slope breaks in the tectonically active Kii Mountains, southwestern Japan

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To reveal the interaction between fluvial erosion and mass-movement during long-term development of mountain topography in a tectonically active area, distributions of knickpoint, convex slope break, and mass-movement landforms have been investigated by the analysis with DEM and by the interpretation of topographic maps and aerial photographs in the watershed of the Totsugawa River, central Kii Mountains, southwestern Japan. Airborne Laser Scanning has been applied for the typical slope deformation area to examine the topography in detail. Field geological investigation has been conducted to reveal the effect of geology on knickpoint formation and mass-movement occurrence.

We found that there are paleosurfaces in higher elevations from around 600 m to 1300 m and that each river dissecting the surfaces has 2 or more knickpoints. The watershed slopes had 2 continuous convex slope breaks, of which higher one forms the periphery of the paleosurfaces. The intersection of a main channel and a convex slope break coincided with a knickpoint of the river, suggesting that a knickpoint, which had been formed by base level lowering, retreated upstream and made convex breaks on the slopes of both the sides. These knick points were not due to the lighological contrast. Some knick points reached as far as about 100 km from the mouth of the Totsugawa River.

Convex slope breaks coincided with the tops of slope failures in many locations, suggesting that they had been made by slope failures; small tributary valleys developed by the local upward retreat of the breaks. Landslide units consisting of a head scarp and a gentle convex slope below it occur widely near the higher slope breaks: they shifted the convex slope breaks upward along the head scarps or cut them. In the “deformation area”, there were complex topographic expressions of deformations, such as linear depressions, scarplets, steps, convex slopes, and so on in variable scales. Deformation areas also included clearly defined landslide units as above. On the adjacent slopes of “deformation areas”, convex slope breaks were usually clearly identified, but in the “deformation area”, they were not. This suggests that gravitational deformation have been induced by the instability caused by the undercut that formed nearby convex slope breaks. Most of the gravitational deformations occurred on outfacing slopes, indicating that they were more susceptible to the gravitational instability than infacing slopes.

The findings described above suggest that long-term landscape development in the study area could have the following history: knickpoints, which had been created by the base-level lowering induced by accelerated upheaval, retreated upstream, forming the convex slope breaks on valley slopes by slope failures and dissecting the paleosurfaces. Undercut valley slopes became gravitationally unstable, gradually deformed, and finally slid in some parts. Outfacing slopes were more susceptible to the slope deformation. After the first knickpoint formation and upstream migration, second knickpoint were made and retreated upstream and made valley in valley.