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Formation of inner gorge and landslide occurrence by knickpoint recession in the Kii Mountains, southwest Japan

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Fluvial and hillslope landforms, especially knick point, inner gorge and gravitationally deformed slope, have been investigated to reveal how landslides develop in the context of long-term slope development. We analyzed mountain topographies by using 10-m mesh DEM, topographic maps and aerial photographs in the Kii Mountains, southwest Japan. Airborne Laser Scanning has been applied for typical gravitational 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 landslide occurrence.

We found widely extended relict paleosurfaces in higher elevations (900-1700 m) and inner gorges along the present rivers. The average slope angle was 27 degrees for the paleosurfaces and 37 degrees for the inner gorge slopes, respectively. The upstream end of an inner gorge coincided with a knickpoint of the river, which suggests that the inner gorges were made by the recession of knickpoint, which is the “erosion front”. Field geological investigation indicated that these knickpoints and inner gorges are not due to lithological effect.

The boundaries of inner gorges and paleosurfaces were convex slope breaks except for the places where gravitational slope deformation occurred. Gravitational slope deformation occurred on inner gorge slopes with outfacing structure, where convex slope breaks were not clearly observed. These facts suggest that gravitational deformation was induced by the instability caused by the undercut of outfacing slopes and that convex slope breaks were not made or erased by the gravitational slope deformation. Many recent large, catastrophic landslides occurred on these gravitationally deformed slopes, suggesting that these slopes were susceptible to landslides. In addition, the crown of rock slope failures are aligned along the convex slope breaks, which indicates that inner gorge slopes below the slope breaks are susceptible to slope failures.

Following coupling of fluvial and slope process could be deduced from the facts stated above: Fluvial incision made a knick point, which recessed upstream, cut the foots of paleosurfaces, destabilized the nearby slopes, and then gravitational slope deformation started particularly on outfacing slopes. Some of the gravitational deformation developed to catastrophic landslide. Slopes where significant slope deformation did not occur became steep inner gorge slopes.