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Long-runout landslide occurred in snowmelt period at the Higashi-kubiki Hill, Niigata, Japan: effects of snowpack on behavior of landslide movements

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The mountain areas and the western part of Japan, along the Japan Sea, have over 1.0 m snow accumulation in every winter. For this reason, snowmelt-induced landslides occur frequently in these regions. If a landslide occurs particularly in early snowmelt period, abundant snow potentially causes the landslide to travel long distance. However, because there have been few literatures reported details of landslide movements in deep snow condition, our understanding of landslide movements affected by snow is still limited. This work reports movements and topographies of the Kokugawa landslide, occurred in early snowmelt period at the Higashi-kubiki Hill, Niigata, and discusses the effects of snowpack on behavior of landslide movements.

On 7th March 2012, a snowmelt-induced landslide occurred at gentle slope (10-20˚) of the Higashi-kubiki Hill, adjacent to the Takada floodplain, Niigata, Japan, and destroyed eleven houses. Geology of the site consists of Neogene marine mudstone and Early Pleistocene conglomerate, while the slope surface is covered by loose materials (7-8m thick) composed of old colluvial deposits and spoil of gravel extraction in the 1980s.

The Kokugawa landslide occurred initially as a rotational slide, which continued to enlarge until the afternoon of 8th, then it tuned into earthflow. The estimated earthflow volume was 750,000 m3. Although the outer part of the sliding mass spread out and deposited at the foot of hill, 350-500 m downward from the top of the scarp, the main body of the sliding mass continued to move rapidly (approximately 15 m/h) without spread out after reaching flat paddy field. When the landslide occurred, about two meters snow covered the site. Snow on the paddy field was pushed by the sliding mass and swelled up several meters above the snow surface level. The swelled snow formed moraine-like snowpack of 5-20 m width. The sliding mass including the snowpack reached houses 250 m apart from the foot of hill on morning of 10th, and stopped after destroying them. The angle of apparent friction of the landslide after the stoppage was 0.15, which is as low as debris flows or extremely large landslides.

From field observation tied up with interpretations of airborne LiDAR and photography, we found that lateral ridges developed along the right side of the mass on the paddy field. At the boundary between the ridge and snowpack, slickenline was observed on flank of the ridge. Ground surface beneath the ridge was appeared to be undisturbed. Meanwhile, boring cores and trench profiles at the center of the mass revealed that about 1.0 m thick clay layer of the paddy field was lost, suggesting erosion of the ground by the sliding mass. These results indicate that the long travel distance of the Kokugawa landslide can be attributed to lateral confinement by compacted moraine-like snowpack.