Initiation of Debris Flow Surges in Ohya Landslide, Central Japan

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INTRODUCTION

Debris flows can cause severe damages due to their destructive power and high velocity. Field observations undertaken in many countries revealed that debris flows are composed of multiple surges with abrupt increases in the discharge. However, the mechanism forming surges have not been understood yet. We conducted debris flow monitoring at multiple sites along a debris flow torrent using time lapse cameras (TLCs) in Ohya landslide, central Japan, to clarify initiation mechanism of debris flow surges. On September 8, 2016, our TLC system successfully captured initiation processes of the debris flow surges triggered by a heavy rainfall (total rainfall and maximum hourly rainfall of 156.0, 19.6 mm, respectively). In this study, we present initiation timing and location of debris flow surges based on the analyses of TLC images.

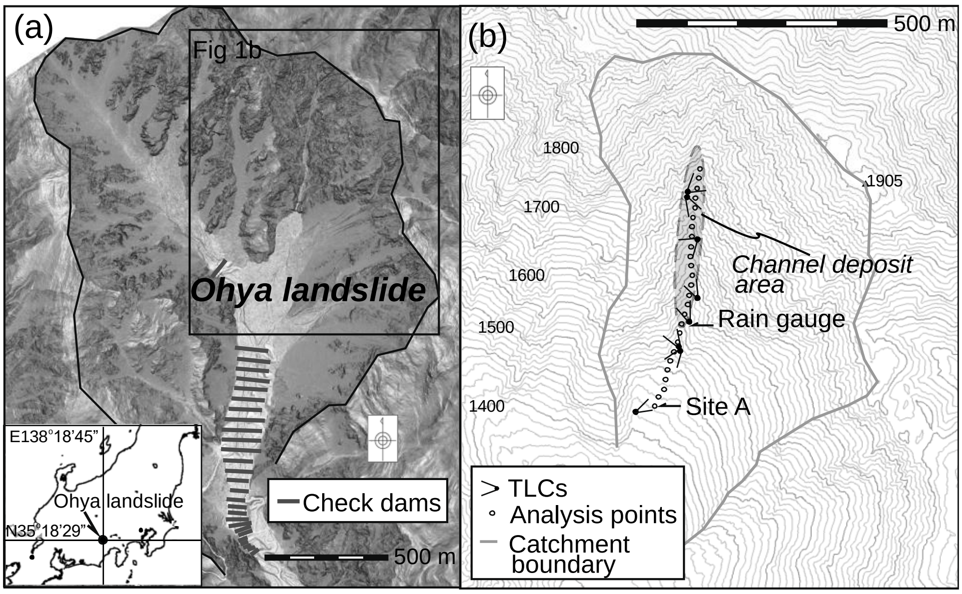

Fig. 1 Map of the Ohya landslide and upper Ichinosawa catchment: (a) Ohya landslide, (b) Ichinosawa catchment. Gentler and steeper terrains in Fig. 1a are expressed as light and dark colors, respectively.

STUDY SITE AND METHODOLOGY

The Ohya landslide has a total volume of 120 million m^3, and was initiated during an earthquake in A.D. 1707 (Fig. 1). The geological unit is Tertiary strata composed of well-jointed sandstone and highly fractured shale. The observation was undertaken in Ichinosawa catchment with catchment area of 0.4 km^2 in north part of the Ohya landslide. Unstable sediments have been supplied from outcrops into the valley bottom in the landslide scar since the original failure. Unconsolidated debris in the channel bed and talus cones is the source of debris flow material.

Eight time laps cameras (Brinno, TLC200pro) were installed in the initiation and transportation zones of debris flows with spacing of 50 − 100 m (Fig. 1). Interval of shooting was set 15 s. At 26 points along the torrents with spacing of 20 m (40 m in some sections), timing of the appearance of debris flow surges were analyzed on the TLC images. Rainfall was also observed by a tipping bucket-type rain gauge with a 0.2 mm per tip capacity.

RESULTS AND DISCUSSION

On September 8, 2016, total 163 surges were monitored in the period from 7:52 to 16:06. Time interval between surges were mostly less than 1 minute (Fig. 2). Initiation and termination points were different amongst surges. Some surges terminated within 50 m from the initiation point, although channel gradient was very steep (>25°). Initiation and termination of debris flow surges frequently changed channel topography, possibly affecting occurrence of subsequent surges. As a result of liner regression analysis, initiation point of the debris flow (i.e., distance from site A in Fig. 1) had a positive relationship with 10-minute rainfall intensity (P value<0.001). When rainfall intensity was high, sufficient water needed for initiation of the debris flow would be supplied to channel deposits even within a small basin. Thus, debris flow surges occurred in the upper part in the channel deposit area when rainfall intensity was high. Duration of each debris flow surge varied between analysis sites, indicating that surges develop and decay by the deposition and erosion of sediment as they travel down.

SUMMARY AND CONCLUSION

Our monitoring clarified that debris flow surges in the Ohya landslide was formed by intermittent mobilization of sediment storage at the multiple sites in the initiation zone. Initiation point of surges was located at upper stream when rainfall intensity was higher. Observation of other debris flows are desired to obtain general knowledge on the initiation mechanism of debris flow surges.

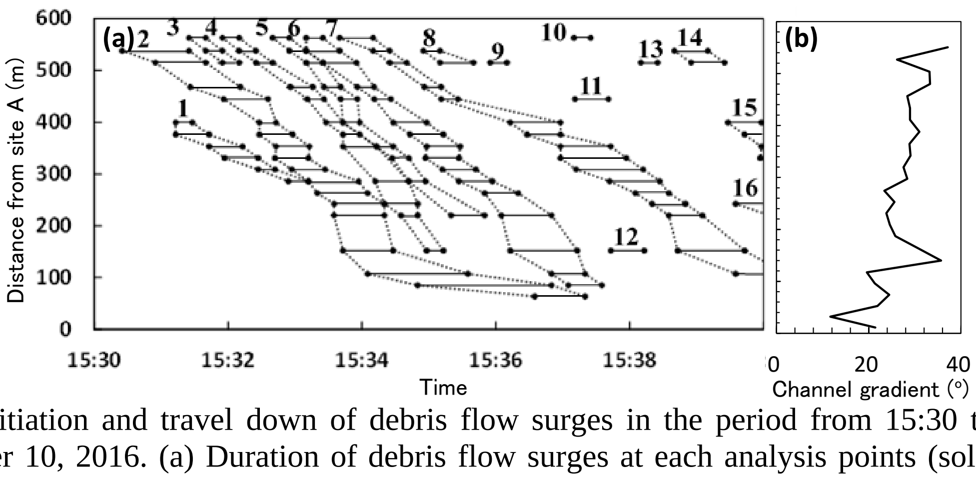

Fig. 2 Initiation and travel down of debris flow surges in the period from 15:30 to 15:39 on September 10, 2016. (a) Duration of debris flow surges at each analysis points (solid line). (b) Longitudinal profile of channel gradient.

Keywords: debris flow, surges, initiation zone, field observation