Characteristics of a Landslide Occurred in May 2015 in Mt. Hakusan and its Influence on Downstream System

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INTRODUCTION

Japan is a volcanic country, and there are more than 111 of active volcanoes in Japanese archipelago. Scenic landscapes weaving volcanoes, caldera lakes and hot springs are important tourism resources. However, volcanic areas are susceptible to natural disasters not only by direct eruption but landslide due to solfataric alteration. Mt. Hakusan, which is the highest mountain in Ishikawa Prefecture (2702 m above sea level), is an active volcano and repeated natural disaster in a historic time. In early May 2015, a large landslide occurred in the mountainside of Mt. Hakusan, which is a headwater area of Tedori River Basin. We could not witness the landslide occurrence because it is a remote place. Massive fine sediment generated from the landslide has flown down to downstream and estuary, giving influence on local industry. It is a very important to extract the factors to cause these mass movement by analyzing with volcanic characteristics and geomorphological process to predict future disasters in this region. The purpose of this study is to clarify the factors triggered landslide in 2015 and its influence on this basin.

STUDY SITE AND METHOD

Mt. Hakusan locates in the headwater of Tedori River basin. The upstream portion is generally steep, a large-scale landslide distributed widely. Geology of the basin varies from the Hida metamorphic rocks of Paleozoic, to Quaternary volcanic deposits. The dissection process of volcano has created barren landforms such as landslide and slope failure, and generated a large amount of sediment. The biggest natural disaster triggered by deep seated slope failure in the Ishikawa prefecture's history had occurred in 1934 in the southern part of Mt. Hakusan. Due to alternation of bedrocks by hydrothermal activity, numerous topography of large scale landslides has been recognized before the 2015 landslide. A series of aerial photos since 1947 and LiDAR data taken before and after the landslide were employed to analyze the geomorphological change caused by the landslides. The rainfall and turbidity were provided by Kanazawa Regional office of MILT.

RESULT AND DISCUSSION

1) Landslide topography

Topography change before and after the landslides was shown in **Fig. 1**. The landslide that

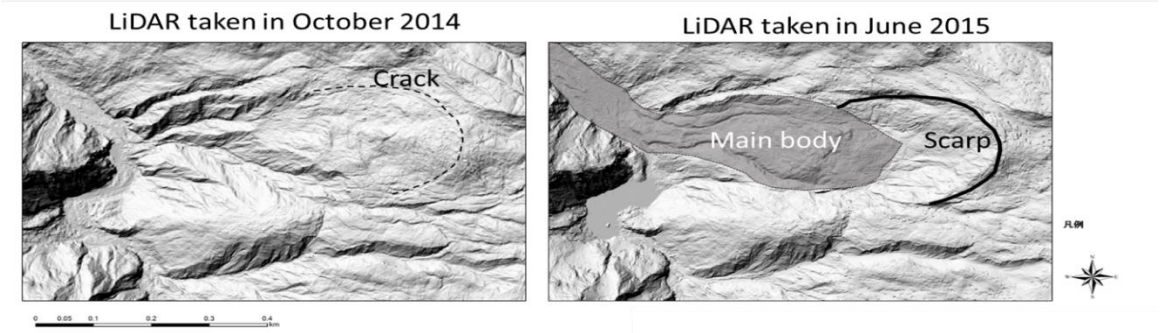

Fig. 1 Hillshade relief map before (left) and after (right) the landslide.

collapsed in May 2015, was 800m in length and 300m in width. The length of the scarp was 400m in length and 300m in width, collapse depth was up to 45m. The elevation difference was about 400m. A remarkable scarp has already existed around 1780m in elevation and a break line have been recognized in the middle slope at 1500m. Newly formed scarp was located under the break line between 1390m and 1550m, the landslide area was 6.4ha, and degraded sediment volume was amount to 1.3 million cubic meters. Collapse sediment was slipped down and widely deposited to cover the original slope to 500m distance of a stream (altitude 1180m) and have gone down to the downstream portion, which of thickness was up to 35m, average 11m, deposited sediment volume was estimated to be 748 000 cubic meters.

2) Factors affecting the landslide in May 2015

In August 2014, monthly precipitation was 535.5 mm and torrential rainfall of 81 mm/day was recorded. The minor slope failure had occurred in the lower portion the 2015 landslide in November 2014. This failure was regarded as a precursor phenomenon, and it seems that the whole slope has been unstable. During the winter 2014, it had a heavy snowfall more than 600 mm per month. Although there was no high precipitation during spring, snow melt has kept on much longer than normal year. This highest snowfall and longer snow melt may be responsible for triggering the landslide.

3) The influence of turbid water generated from the landslide

Since May 2015, high concentration of suspended solids has flown down to the main channel of Tedori River (**Fig.2**), which has been seriously affected on agricultural land and freshwater fisheries, estuaries and coastal areas. Before the beginning of May, initial turbidity was not observed. However, after the intense rainfall on May 4, even during no rain period, high concentrations of turbid water with three digits have been continuously recorded. Just in May 6, the highest peak was observed at 3500 ppm. The second highest peaks around 2500 ppm were also observed by the rainfall in the following period. High concentrations of turbid water were also observed in June and July, but the duration gradually become shorter. These sediments have seriously damaged agricultural industry by burying paddy field and irrigation canal. Further, they made it impossible for coastal fishery by adhering stationary net and breaking them.

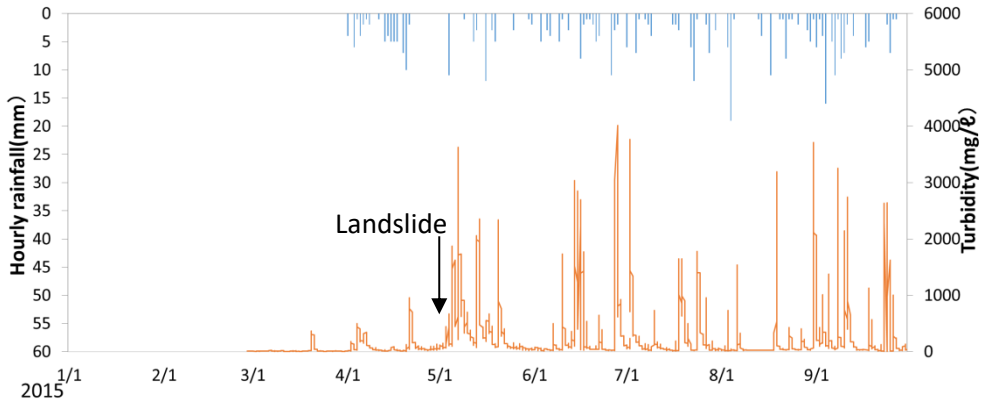

Fig. 2 Turbidity and hourly rainfall the downstream of Tedori River

CONCLUSIONS

A large-scale landslide occurred in May 2015 in headwaters of Tedori River at the mountainside of Mt. Hakusan. Airborne LiDAR data and series of aerial photos taken for past 60 years were employed to analysis topographical features and geomorphological factors triggered the landslide. The landslide was 800m in length and 300m in width, total generated sediment volume was 1.3 million cubic meters. This landslide occurred within the old landslide body. The downstream area received wider influences by highly turbid water to rice paddy, fresh water and coastal fisheries. The counter measures were extremely difficult due to not only no access road to the landslide, but the limitation of action under the strictly protected areas of national park. Although Forestry Agency is currently carried out to scatter erosion protection material using a helicopter, a fundamental measure should be taken such as early vegetation recovery by native species, cut off sources of turbid water and enhancing sedimentation using abandon rice paddy in future.

Keywords: Mt. Hakusan, Tedori River Basin, landslide, turbid water and countermeasure