Comparative study on shape and distribution of landslides caused by the 2012 Northern Kyushu heavy rainfall and the 2016 Kumamoto earthquake in the Aso region, Kumamoto, Japan

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The 2016 Kumamoto earthquake triggered many landslides in the Aso region, southwestern Japan. Previous studies have revealed the processes of some large representative landslides in the western Aso region, but they have not comprehensively dealt with lots of small landslides. Other studies have discussed landslide distribution and relationships with that of the heavy rainfall events in July 2012 in the northern part of the Central Cones of the Aso volcano. However, they have not been investigated the western part of the Aso region which has various topographical and geological characteristics. Therefore, this study compares the formation and distribution of landslides caused by the heavy rainfall and earthquake events in both the central and western part of the Aso region.

The study areas are the western part of the Aso region and the Sensuikyo region at the northern part of the Central Cones (Fig. 1). The western part was divided into three sites: site P (caldera walls and the outer rim), Q (western part of Central Cones), and R (river terrace and talus) based on geomorphological and geological characteristics. The Sensuikyo region is referred to as site S. This study utilized multi-temporal datasets derived from airborne lidar and photogrammetry using UAV photographs: (i) before the heavy rainfall, (ii) between the heavy rainfall and the earthquake, and (iii) after the earthquake. By using digital elevation data and a sediment transportation map, elevation lowering spots caused by the landslides were identified. Then terrain information and the indexes of shape and spatial distribution were analyzed at the elevation lowering spots.

From the analysis, it was found that the heavy rainfall induced 374 landslides and the earthquake triggered 440 landslides. Landslides affected by the two different events were recognized in sites P and S. In site S, the indexes of spatial distribution showed that the earthquake caused the displacement of regolith remained on the upper convex part of the slope. In site P, the shape indexes indicated that the former event led to removal of topsoil, whereas the latter event induced the failure of lava and pyroclastic rocks. In site Q, failed slopes are not as steep as locations where landslides occurred due to past heavy rainfall events, and remained thick unconsolidated topsoil is composed of volcanic ash. It slipped deeply in 2016 due to strong seismic shaking strengthened by topographic site effects on the convex part of the slope. In site R, landslide shapes and comparison with those in site P suggest that collapsed soil directly fell into rivers without erosion of topsoil.

This study has revealed that the distribution of landslides due to the earthquake is related to that by the heavy rainfall in the Sensuikyo region. On the other hand, in the western part of the Aso region, differences in shape and distribution are found between landslides caused by the two events. Moreover,

there are differences in the formation of earthquake-induced landslides among the different study sites.