Dating a past landslide event found on tephra-mantled slope of Takanoobane lava dome, Aso volcano, Japan

*Takashi Kimura[1], Naoki Sakai[1], Yoshiro Tanaka[2], Ken Nagakura[2], Kazuhiko Matsuya[3]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Nippon Koei Co., Ltd., 3. GEOPLANNER Co., Ltd.

On 16 April 2016, strong earthquakes (Mw7.0 main shock and subsequent aftershocks; hereafter the 2016 Kumamoto earthquake) struck Kumamoto prefecture and triggered numerous landslides on hillslopes of Aso volcano, southwestern Japan. Landslide on tephra-mantled slope of Takanoobane lava dome (hereafter the Takanodai landslide) caused the most serious damage due to its long runout. To assess future risks for landslides on tephra-mantled slopes, it is important to clarify landslide history of the lava dome. We found a 100-m-wide hollow adjacent to the Takanodai landslide. This report shows the results of tephrostratigraphic observation at the hollow and radiocarbon dating for buried paleosols that indicate the occurrence of a landslide event about 7,200-7,000 years ago.

Takanoobane lava dome, a hummock formed by lava-flow eruption about 51,000 years ago (51ka), has very gentle slope of (5-15 degree). The slope is mantled by unconsolidated tephra layers (mainly consist of silty ash and soil) accumulated after the lava dome formation. The tephra layers include three key layer: Kusasenrigahama pumice (Kpfa; 30ka), pyroclastic fall deposits produced by the largest eruption after the Aso caldera formation (90ka~), and two widespread tephras, Aira-Tanzawa tephra (AT; 29ka) and Kikai-Akahoya tephra (K-Ah; 7.3ka). Accumulated thickness of the layers is about 13 m at the most. The Takanodai landslide formed slip surface in Kpfa or buried paleosol beneath Kpfa, and consequently eroded tephra layers accumulated during the last 30,000 years.

By using detailed topographic map developed based on LiDAR observation in January 2013, we found many hollows which could be formed by erosion of tephra layers on the slope of the lava dome. The Takanodai landslide occurred on southwest-facing slope, where no hollows were found before the 2016 Kumamoto earthquake. On south-facing slope adjacent to the landslide, a 100-m-wide hollow bordered by a horseshoe-shaped knick line were observed. Cross sections of the knick line had unclear, rounded shape with 3-6 m drop, suggesting that head scarp of past landslide(s) was buried under tephra layers produced after the landslide event.

In profile of boring core at the center of the hollow (BV28-1), tephra layers above the Takanoobane lava was only 4.80 m thick, and lacked three key layers (i.e., Kpfa, AT and K-Ah). The uppermost layer of BV28-1 was 2.30-m-thick kuroboku-loam alternations. Apparently disturbed soil layer, which included carbonaceous materials and fine particles of orange pumice (Kpfa?), was found between 2.30 and 3.15 m depth. Meanwhile, yellowish sandy ash-fall layer between 3.15 and 3.30 m depth appeared undisturbed due to its clear boundaries at the both sides. Buried paleosol just below the ash-fall layer was gradually changed dark-brownish silty soil to brownish volcanic ash soil at around 3.60 m depth, directly overlying the Takanoobane lava (4.80 m depth~).

Comparing these stratigraphic features to profiles observed in boring core at the top of the lava dome (BV28-2) and outcrops at the head scarp of the Takanodai landslide, unconformity of BV28-1 became clear. We considered that an erosional surface was located within the disturbed layer between 2.30 and 3.15 m depth, and the kuroboku-loam alternations above the layer developed after erosional event. In addition, the yellowish sandy ash-fall below the erosional surface could be correlated to either basal fall unit of Kpfa or Mizunomoto pumice 1 (MzP1; 31ka), based on its facies and mineral assemblage.

As results of radiocarbon dating (AMS method) for two paleosols sampled from BV28-1, we obtained conventional ^{14}C ages: 6,170±30 yrBP from kuroboku of 2.20 m depth, and 27,410±110 yrBP from

dark-brownish paleosol of 3.35 m depth. Calibrated results (2 σ) of these ages were 7,164-6,976 calBP and 31,445-31,064 calBP, respectively. The ages were match with our hypothetical process (i.e., timing and extent of past erosional events) which formed the present topographic and stratigraphic features on the slope of the lava dome.
The above results explain that tephra layers accumulated during the past 23,000 years (from the 30ka Kpfa eruption to the 7.3ka K-Ah eruption) has been eroded at the hollow observed in this study, while the erosional surface was buried under soil layer (kuroboku-loam alternations) developed during the last 7,000 years. This finding indicates the possibility that strong earthquake(s) struck Aso volcano regions just after the K-Ah eruption (about 7,200-7,000 years ago), and triggered mass movements on the slope of Takanoobane lava dome as same manner as the Takanodai landslide of the 2016 Kumamoto earthquake.

Keywords: Aso volcano, Takanoobane lava dome, Tephrostratigraphy, Kusasenrigahama pumice, paleosol, 14C age

