Hydrogeomorphic Characteristics of Fissures Developed during 2016 Kumamoto Earthquake

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INTRODUCTION

The April 2016 Kumamoto Earthquake triggered sediment disasters, such as debris flows and landslides (Ishikawa et al., 2016). Numerous fissures also developed in both forest and grasslands during the earthquake (Kimura and Sakai, 2017). Fissure is defined as topographic cracks formed by local concentration of ground motion. Fissures may affect the occurrence of subsequent landslides. For instance, Tainosho and Fujita (1996) showed that fissures induced by the 1995 Southern Hyogo Prefecture Earthquake caused many landslides during rain events 4, 6, 9 and 10 months after the earthquake. In addition, Owen et al. (2008) mentioned that rainfall triggered numerous slides on slopes with fissures developed during the 2005 Kashmir Earthquake in the Himalaya of northern Pakistan and India.

Fissures can also alter hydrological pathways in the soil. Previous studies showed the importance of preferential flow paths caused by decayed roots and animal borrows related to the development of perched water tables in soils (Sidle et al., 2000). Development of vertical preferential flow paths by fissures can provide rapid flow to the sliding surface (**Fig. 1**). Therefore, the distribution and density of the fissures are important to assess preferential flow that may enhance the probability of occurrence of subsequent landslides. To address these questions, this study aims to investigate the distribution and density of earthquake-induced fissures and their hydrogeomorphic characteristics.

STUDY SITE AND METHOD

The study was conducted in the Tokosegawa-Nigorigawa Basin (6.9 km^2 and 6.1 km^2, respectively) located west of the Aso Caldera (2°53'7.53"N and 131° 0'23.11"E). Elevation ranges from 277 m to 1326 m and the mean hillslope gradient is 16.7°. Mean annual precipitation and temperature during the past three decades is 2832 mm and 13 ºC, respectively (AMeDAS, Aso-Otohime, 8 km northeast of our study sites). Underlying geology of the area consists of volcanic deposits, such as tuff and basalt with rhyolite from 2 to 5 m below the soil surface. Land cover in these basins is 54% forest with Japanese cedar (*Cryptomeria japonica*) and cypress (*Chamaecyparis obtuse*), 36% grass with silver grass (*Miscanthus sinensis*) and Sasa-bamboo (*Pleioblastus chino* var: vaginatus), and 10% other cover.

Distribution of fissures was identified on aerial photos taken in April 2016 after the earthquake. We identified the details of fissures as much as possible from these photos. Fissures on photos were then compared to those identified from LiDAR data with fissures defined as ranging in length from 1 to 160 m. These data are compiled into ArcGIS. Then we selected one location for detailed investigations with depth (≥ 15 cm) and width (5 - 200 cm) of each fissure every 5 m in the field. Because of soil deposition within fissures, we also measured the likely initial depth of fissures (depth + soil deposition) every 5 m by using simple probes to find a more resistant soil layer. Detailed hydrological measurements were also conducted in fissures by using tensiometers and TDR.

RESULTS

Mean (± standard deviation) depth, width, and soil deposition depth of fissures were 44.2 (± 12.1) cm, 71.5 (± 45.5) cm, and 54.4 (± 24.5) cm, respectively in the study area. Thus, initial depth of fissures might be approximately 1 m. Because the depth of the landslide scar located near the fissures was 0.7 m, therefore, initial depth of fissures may reach the potential sliding surface. Based on preliminary hydrological measurements, we confirmed the presence of vertical flow paths within the fissure during several rain events.

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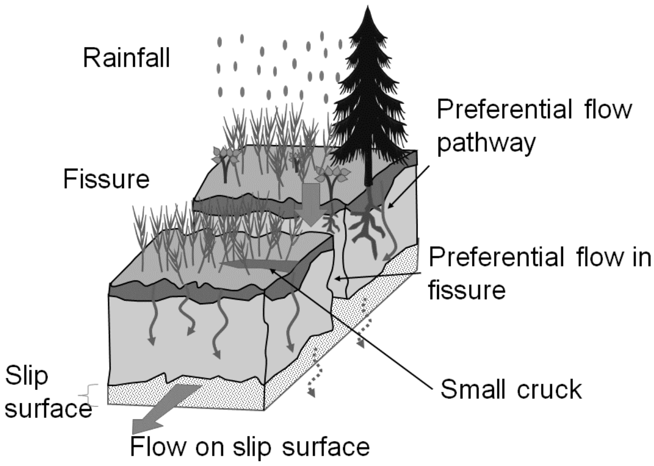

Fig. 1 Schematic illustration of Preferential flow system

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