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Formation of the debris-flow fan along the foot of the Yoro fault scarp - toward the prevention of debris flow disasters

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Slope failures and debris flow events are triggered by meteorological forces such as heavy rains, or earthquake shaking. Recent earthquakes of 2004 Mid Niigata Prefecture Eq., 2007 Noto Hanto Eq., and 2008 Iwate-Miyagi Midland Eq. produced numerous landslides and debris flows to damage the adjacent areas. Geomorphic conditions such as slope angle and remained landslide masses have an important rule to control the occurrence along with seismic intensity (Moriya and Sugai, 2010 JpGU Meeting). In this paper, we demonstrate the evolutional processes of the debris flow fans developed along the foot of the Yoro fault scarp and discuss the potential of debris flow disaster triggered by the faulting activity.

Yoro fault, one of the most active reverse faults in Japan, is considered to produce two large historical earthquakes of 745 Tenpyo Eq. and 1586 Tensho Eq. along with the antepenultimate Eq. of about 2 ka. The Yoro fault has a potential to produce a huge earthquake of up to Mw 8 with the estimated recurrence interval of around a thousand years. The fault has made large relief between the Yoro mountain and Nobi plain with a constant vertical slip rate of over 1mm/y during the last 1 Ma (Sugai and Sugaiyama,1999). The Yoro fault scarp has been dissected by 31 tributaries with an area of over 0.2 km2 and the tributaries have made debris-flow fans at their mouths. Relation between fan area (Af) and drainage-basin area (Ad) can be expressed as a power function: Af = 0.43 Ad exp 0.85 (r=0.81). Relatively high exponent value indicates that the denudation rate is independent of the drainage size, resulting parallel retreat of the fault scarp.

At two artificial outcrops cutting the fan surfaces, AMS-14C dates of series of buried soil layers sandwiched between debris-flow units indicate that the latest three debris flow units can be correlated with the latest three large earthquakes above. Each debris flow unit deposits laterally continuously and has a thickness of around several ten cm. These indicate that each alluvial fan has grown intermittently through overflow deposition of debris produced by slope failure triggered by Yoro fault activity. Large earthquakes trigger lots of slope failures on the fault scarp and produce debris abundant enough to overspill the incised tributary channel which has been formed in inter seismic periods and under the erosion control against meteorological events. The fan surfaces, thus, have great risks with debris flow attack triggered by earthquakes even if the ground shaking is not harder than the alluvial lowland.

Keywords: Yoro fault, earthquake shaking, debris flow, alluvial fan, natural disaster, Nobi plain