Depositional Features and Transport Mechanism of Debris Avalanches: the 1980 Mount St. Helens, Usu Zenkoji, and 1792 Unzen Mayuyama Debris Avalanches.

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INTRODUCTION

More than 20 dynamic emplacement models have been proposed to explain the high mobility of large volcanic debris avalanches [1]. Formation processes of debris-avalanche blocks, jigsaw cracks, and hummocky surface morphology are not yet clearly explained. To explain these formation processes and transport mechanism, the 1980 Mount St. Helens (USA), Usu Zenkoji (Japan), and 1792 Unzen Mayuyama (Japan) debris avalanche deposits were surveyed.

MOUNT ST. HELENS DEBRIS AVALANCHE

The 1980 debris avalanche deposit is distributed at the northern foot of Mount St. Helens Volcano, Washington, USA. Hummocks, <500 m in diameter, are distributed on the debris avalanche deposit. Fresh hummocks sometimes show steep slopes up to 25º-35º (angles of repose). Debris-avalanche blocks composed of the same rock types are located in close proximity to one another. This suggests that hummocks were formed by disaggregation due to lateral speading and gravitational collapse. Deformations structures in debris-avalanche blocks include block deformations accommodated by normal faults, and vertical cracks filled by debris-avalanche matrix. These types of deformation also suggest disaggregation due to lateral extension.

USU ZENKOJI DEBRIS AVALANCHE

The Zenkoji debris avalanche deposit, 7-8ka, <2km^3, is widely distributed at the SE foot of Usu Volcano. Echelon-type deformation of unconsolidated debris-avalanche blocks made of Toya ignimbrite and river deposits were observed. In the proximal area, amoeba-like thin debris-avalanche matrix was injected into the debris-avalanche block made of Toya ignimbrite. This structure indicates that fractures observed in the debris-avalanche blocks were caused by shear stress, the cracks were then filled by injection of debris-avalanche matrix, produced at the bottom of the debris avalanche. Many jigsaw cracks were observed in debris-avalanche blocks made of massive Somma lava. Budding-type connections between cracks were common, indicating that these cracks were formed by shear stress. This suggests that jigsaw cracks in the debris-avalanche block were not formed by collision between debris-avalanche blocks but by large shear stress within the debris-avalanche block due to a large velocity gradient in the laminar boundary layer at the bottom of the flow.

UNZEN MAYUYAMA DEBRIS AVALANCHE

The 1792 Unzen Mayuyama debris avalanche deposit is distributed at the eastern foot of the 4ka Mayuyama lava dome, which is located at the eastern part of Unzen volcanic complex. In 1792 debris avalanche produced a tsunami killing >15,000 residents. Approximately 3.3 km away from the 1792 debris avalanche source area several ca. 6m-high outcrops are located within remnant hummocks. Debris-avalanche blocks within these outcrops are homogeneous and vary in the degree of fragmentation. Less fragmented portions contain angular blocks (up to m-sized) with pervasive jigsaw cracks. Highly fractured sections consist of 10s of cm-sized jigsaw clasts to <sand-sized particles where the original structure of the block can be reassembled. These sections occasionally contain pulverized, elongated, and sheared clasts that remained intact. Blocks in outcrops ~1km from the source display abundant jigsaw cracks. The northern margin of the amphitheater contains a debris-avalanche matrix outcrop.

Due to the weight of the overlying mass (300-500m high, 1km wide) and underlying topographical variations, initiation of sliding occurred unequally throughout the mass resulting in shear stress-induced jigsaw cracks. The sliding mass progressed as a laminar plug flow during the main stage of transport, preserving jigsaw cracks and angularity. Strong shear stress resulting from friction between the sliding mass and underlying basement concentrated along the margins and base, creating debris-avalanche matrix during the acceleration stage. Debris-avalanche matrix continued to form during transport from shear stress and entrainment of basement. A dramatic decrease in slope angle caused the sliding mass to disaggregate laterally. After cessation of movement, unstable sections of the mass collapsed forming hummocks.

REFERENCES

[1] Takarada, S., Ui, T., and Yamamoto, Y. (1999) Depositional features and transportation mechanism of valley-filling Iwasegawa and Kaida debris avalanches, Japan, Bulletin of Volcanology, 60, 508-522.