V201-P008 **Room: Poster Session Hall** **Time: May 14**

Transition of flow pattern in pyroclastic density currents

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Pyroclastic density current is a multiphase flow of hot pyroclastic particles and gas. The deposits exhibit extremely wide range in depositional volume, outflow distance, particle size, and in depositional structure.

One of the important character in depositional structure is the varieties from stratified to massive facies. It has been generally recognized that these two facies relate to two end-member models of pyroclastic density currnets; pyroclastic surges, in which particles are carried by turbulence, and pyroclastic flows, in which flow dynamics influenced by the interaction between particles. Because these models have been developed based on different assumption for the flow mechanisms, it is difficult to understand the scaling relationship between the assumptions for these models.

The aim of this study is to present the experimental results for the understanding of the linkage between flow and surge, especially focused on the effects of particle size on flow dynamics.

The analogue experiments used in this study have been carried out as follows:

1. Formation of initial granular flow. Granular material was released from particle tank onto the horizontal ground under different ambient fluid, air and water.

2. Observation of a lateral flow produced by 1. on the ground. We observed the flow velocity, flow volume and the arrival distance using image processing.

Based on these observation, we summarize the experiments as follows:

1. Under the condition of constant volume of granular material released from the tank, the flow front advanced at almost constant speed and the flow volume increased with increasing particle size. This indicates that particle size effects mainly on entrainment in flow motion.

2. After granular material collide with the ground, there formed the second phase of the horizontal motion. Although the almost constant speed of flow head, two depositional structures were observed, which reflected the particle size. This indicates that particle settling motion can be neglected in describing the dynamics of flow front. This is in harmony with the published paper on particle-supported flow.

3. We observed more clear billow structure on wake of flow front with decreasing particle size. The final distance of deposit increased with decreasing particle size. This result suggests that the duration of flow influence on the extent of development of billow structure.

4. Flow regimes transition reflected by particle size, and the density ratio of flow to ambient fluid. We have determined the relationship between Particle Reynolds number (Rep) and the duration ratio of flow to particle. The flow regime diagram suggests that pyroclastic density currents which has particles at larger than Rep 10ˆ2 order behave as a flow, and smaller at Rep 10ˆ-1 order behave as a surge. The insights obtained from these experiments is applicable to wide range of natural granular flow. For example, if we measure the average particle size at outcrop, flow regime diagram help us to understand the base information of flow dynamics (such as laminar, transition, or turbulent) from particle size information.