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The Transport Capacity of Pyroclastic Flows: Experiments and Models of Substrate-Flow Interaction

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One of the more distinctive features of many ignimbrites is the presence of large lithics (some greater than meter scale) and pumices that have been transported great distances (>10 km) from the eruptive vent, sometimes over steep terrain and expanses of water. In many cases, these particles have been transported much further than can be explained by aerodynamic forces and ballistic trajectories. Their presence in distal deposits thus provides a measure of the interaction between particles in a flow. We examine the forces responsible for transport of large clasts and examine in detail the momentum transfer occurring when particles interact with their boundaries. We performed a suite of experiments to quantify the mass and momentum transfer that occurs when particles interact with a pumice-bed substrate and with water substrate, two geologically motivated flow end-members. We use the results of the experiments to develop boundary conditions for multiphase numerical models of eruptive behavior, and in a suite of simulations consider the role of the boundary in the transport of large clasts.

We find that clasts transported in dilute currents are particularly sensitive to the nature of the boundary, and while large particles can skip several times on a water substrate (and in extreme circumstances can increase their transport distances by $\tilde{5}0\%$) they travel less far than particles that impact pumice-bed substrates. All else being equal, large particles in dense pyroclastic flows are themselves relatively insensitive to the details of their boundaries; however, one of the most important ways boundary conditions influences large particles is not through direct interaction, but by changing the local concentration of fine particles. Momentum transfer from fine particles to large particles appears to be required to transport large clasts great distances. If initially dense flows become dilute during transport, for instance due to ash being captured by the surface tension of water, than the transport capacity of large particles in the flow is substantially decreased.