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Dynamics and Deposits of Coignimbrite Plumes

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Fine ash in the atmosphere poses a significant hazard, with potentially disastrous consequences for aviation and, on deposition, health and infrastructure. Fine-grained particles form a large proportion of ejecta in Plinian volcanic clouds. However, another common, but poorly studied phenomena exists whereby large amounts of fine ash are injected into the atmosphere. Coignimbrite plumes form as material is elutriated from the top of pyroclastic density currents. The ash in these plumes is considerably finer grained than that in Plinian plumes and can be distributed over thousands of kilometres in the atmosphere. Despite their significance, very little is known regarding coignimbrite plume formation and dispersion, predominantly due to the poor preservation of resultant deposits. As a result, consequences of coignimbrite plume formation are usually overlooked when conducting hazard and risk analysis. In this study, deposit characteristics and numerical models of plumes are combined to investigate the conditions required for coignimbrite plume formation.

Coignimbrite deposits from the Campanian Ignimbrite eruption (Magnitude 7.7, 39 ka) are well sorted and very fine, with a mode of between 30 and 50 microns, and a significant component of respirable ash (less than 10 microns). Analogous distributions are found for coignimbrite deposits from Tungurahua 2006 and Volcan de Colima (2004-2006), amongst others, regardless of magnitude, type or chemistry of eruption. These results indicate that elutriation processes are the dominant control on coignimbrite grainsize distribution. To further investigate elutriation and coignimbrite plume dynamics, the numerical plume model of Bursik (2001) is applied. Model sensitivity analysis demonstrates that neutral buoyancy conditions (required for the formation of the plume) are controlled by a balance between temperature and gas mass flux in the upper most parts of the pyroclastic density current. In addition, results emphasize the importance of entrainment into the established plume, a process that is still poorly defined. The numerical results, and the consistent fine grained nature of ash in the deposits, highlight the importance of physical dynamics in the parent pyroclastic density currents for coignimbrite plume formation and stress the need for tailored methods to investigate hazard and risk from such events.

Bursik, M. Effect of wind on the rise height of volcanic plumes. Geophysical Research Letters, 28(18), 3621–3624, 2001.