Geophysical Research Abstracts
Vol. 16, EGU2014-6212, 2014
EGU General Assembly 2014

Fine ash enrichment of fall deposits from explosive eruptions by co-PF ash: nature, significance and implications

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Most highly explosive volcanic eruptions (Violent Strombolian, Subplinian to Plinian) are accompanied by the emplacement of pyroclastic flows (PF) and consequently the formation of co-pyroclastic flow (co-PF) elutriation plumes (Campanian Ignimbrite (39 ka BP), Pinatubo (15 June, 1991), Mount St Helens (18 May, 1980), Tungurahua (16 August 2006)). Similar to explosive plumes (i.e. produced at the vent), co-PF plumes can rise through the atmosphere to high altitudes (one of the 18 May, 1980 Mount St Helens co-PF plumes rose up to 30 km a.s.l.) and be transported downwind great distances (more than 2000 km for the Campanian Ignimbrite). Detailed analyses of the componentry and the morphology of the ash fractions (<90 μm) of Mount St Helens (18 May 1980) fall deposit and Tungurahua (16 August 2006) fall and co-PF deposits have been carried out in order to describe the nature of the ash entrained in co-PF plumes and to advance our understanding of the secondary fragmentation mechanisms leading to the formation of elutriated ash. The componentry distribution of the 18 May 1980 Mount St Helens fall deposit samples indicates that a substantial amount of the distal ash (> 150 km from the vent) comprises edifice-derived particles which were produced during the early stage of the eruption (blast and consecutive landslides) and consequently transported in co-PF plumes. Detailed grain size analyses of the August 2006 Tungurahua and Campanian Ignimbrite fall and co-PF deposits, along with a thorough compilation of published data from well constrained explosive eruptions, provide strong evidence that the fine ash enrichment of fall deposits from magmatic eruptions is related to synchronous sedimentation of co-PF ash. These data allow us to demonstrate the significant impact of fine ash incorporation on the physical characteristics of fall deposits (isopach shapes, grain size, density, volume, etc.) and hence on the determination of the style, magnitude and intensity of explosive eruptions. We propose methods to subtract the co-PF ash mass input from magnitude and intensity estimations based on grain size distribution deconvolution and isomass map corrections. These corrections are not straightforward because they depend on the packing of the fall deposit, which in turn depends on many factors including the timing of deposition, the grainsize distributions of both the co-PF and the main plume products, and the extent of compaction.