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The Grainsize Characteristics of Coignimbrite Deposits

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Due to their long atmospheric residence time, identifying the source and understanding the dispersion processes of fine-grained ash is of great importance when considering volcanic hazard and risk. An exceptionally efficient mechanism to supply large volumes of fine-grained ash to the stratosphere is the formation of co-ignimbrite plumes. Such plumes form as air is entrained at the top of propagating pyroclastic density currents, allowing a neutrally buoyant package of gas and ash to loft to high altitudes, consequently dispersing over large areas. The study of ash deposits on land and in deep sea cores has demonstrated that such events have played a major role during ignimbrite-forming eruptions, including the Tambora 1815, the Minoan (Santorini), the Campanian Ignimbrite, and the Younger Toba Tuff eruptions, as well as during more recent, pyroclastic flow-forming, intermediate sized eruptions (Vulcanian to Plinian in style), e.g. Mount St. Helens 1980, Fugen-dake (Unzen) 1991, Pinatubo 1991, Montserrat 1997 and Tungurahua 2006 eruptions.

Published, as well as new results from the study of co-ignimbrite deposits, show that co-ignimbrite plumes can rise to high altitudes into the atmosphere (the co-ignimbrite plumes from the May 18, 1980 Mount St Helens blast and the Campanian Ignimbrite eruptions reached 30 - 35 km a.s.l,), potentially distribute enormous volumes of ash (the 75 ka Toba eruption and the Minoan eruption of Santorini settled >800 km3 and >25 km3 of co-ignimbrite ash, respectively), and contribute much of the ash to very large (60±6 vol% of the Campanian fallout deposit 130 to 900 km from vent), as well as intermediate size (up to 58 wt% and 52 wt% in the 2006 Tungurahua and May 18, 1980 Mount St. Helens fallout deposits, respectively) explosive eruptions. Comparison of new data with those from the published record shows that co-ignimbrite deposits are strikingly similar, regardless of eruption conditions, and have distinct grain size characteristics. The deposits are very fine grained (< 100 microns), have unimodal grain size distributions skewed towards the fines, and are more poorly sorted in medial to distal areas than tephra fall deposits from vent-derived plumes at the same distance. Deposits from a single eruption show constant grain size over hundreds to thousands of kilometres, except for a slight coarsening close to source in some cases. In intermediate size eruptions, co-ignimbrite ash often settles synchronously to vent-derived tephra, leading to bimodal grain size fallout deposits. These observations highlight the propensity of the ash to remain in the atmosphere for extended periods of time, and pose important questions regarding how the ash is deposited, and especially the role of aggregation. The uniformity of co-ignimbrite ash means that, with regards to real-time dispersion modelling during an eruption, few assumptions are required for the initial grain size, however depositional assumptions utilised when modelling vent-derived plume dispersion, may not be able to accurately reproduce co-ignimbrite depositional patterns.