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Phreatomagmatic explosive eruption processes informed by field and experimental studies

Greg Valentine (1), Alison Graettinger (2), and Ingo Sonder (3)

(1) Dept. Geology & Center for Geohazards Studies, University at Buffalo, Buffalo, USA (gav4@buffalo.edu), (2) Dept. Geology & Center for Geohazards Studies, University at Buffalo, Buffalo, USA (ahgraett@buffalo.edu), (3) Dept. Geology & Center for Geohazards Studies, University at Buffalo, Buffalo, USA (ingomark@buffalo.edu)

Phreatomagmatic explosive eruptions occur during the lifetime of nearly every volcano. Maar-diatremes form excellent case studies to understand such eruptions because most of these volcanoes are monogenetic so that the effects of the dominant phreatomagmatic activity are not overprinted by other processes as might occur at a polygenetic volcano. Diatremes preserve evidence of magma injection and explosions at various levels, in the form of irregularly shaped intrusions and vertical domains of country rock breccia and pyroclasts, and usually have subsidence features around the outer parts. Field data on intrusions in diatremes give analog information on the sizes of magma batches that might fuel phreatomagmatic explosions, and therefore the energies of individual explosions. Tephra rings often are dominated by country rock clasts, with progressively deeper-seated clasts appearing at progressively higher stratigraphic levels in the tephra. Scaled experiments with buried explosives show that only shallow explosions (<200 m) can deposit material onto tephra rings, and coarse ballistics are emplaced onto tephra rings mainly by explosions less than 100 m deep; therefore the presence of deep-seated lithics is related to mixing by multiple (non-erupting) explosions at various depths within the diatremes, not necessarily to progressive deepening of explosions. Excavation of experimental craters shows that mixing occurs through a combination of upward displacement and progressive disaggregation of host material domains, and marginal subsidence. Experimental explosion jets show a range of behaviors that depend on the scaled depth of explosions (physical depth scaled against explosion energy) and on the effects of pre-explosion crater morphology. Many scaled depth and pre-explosion crater combinations result in jets that collapse back into the crater and expel fine-grained density currents that travel radially outward. Field observations of fine-grained ash beds in tephra rings are commonly assumed to record extremely efficient fragmentation, but it is likely that in many cases this is just the result of jet dynamics. The experiments also are “monitored” in the same way that real eruptions are monitored, with seismic, strong motion, acoustic, electrical field, and infrared and visible light high-speed videography. The approach provides many opportunities for “add-on” studies that apply to volcanic explosions in general.