The Causes and Consequences of “Rootless” Eruptions

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Project description

Rootless eruptions take many forms, but all involve steam explosions produced when hot volcanic flows interact with surface water. For example, rootless cones, or pseudocraters, form when lava flows traverse regions of damp ground or shallow standing water (see image); littoral cones form when lava flows enter the ocean; and secondary explosion craters form when pyroclastic flows enter river valleys. In all cases, the resulting explosions can be violent, and represent an under-appreciated hazard associated with volcanic flows of all kinds. The products of rootless eruptions also provide key information on past environments; for example, pseudocraters on Mars are used to infer locations of surface water in Mars past.

Studies of rootless eruptions are limited [1,2], and do not occupy a place in the hazard hierarchy generally used in volcanic hazard assessment. Models for rootless eruptions invoke both the thermal energy provided by the deposits and the permeability of either the primary deposits or the underlying in wet sediments. These models have yet to be quantified, particularly with respect to the porosity, permeability and over-pressure conditions required to generate explosions and to the mechanisms by which meteoric water interacts with volcanic flows to cause fragmentation.

To address these questions, we propose a broad project that includes (1) field studies of pseudocrater fields in NE Iceland and littoral cones in Hawaii, (2) quantitative analysis of fragmental particles from both deposits in the laboratory, (3) analogue experiments involving both viscous fluids (lava) and hot ash (pyroclastic material), and (4) numerical modelling. Field studies will include mapping, ground-penetrating radar profiling and classification of different cone types, as well as stratigraphic sampling of representative cone and tephra sections; additional field-based studies could include characterization (porosity, permeability) of existing substrates in regions prone to lava flow inundation. Laboratory work will involve grain size analysis followed by identification of components and quantitative analysis of both external and internal particle textures. Analogue experiments will start by examination of the behaviour of gas jets through room temperature viscous liquid (syrup) and through fragmental material; subsequent experiments will add the complications of temperature and phase changes (likely with molten lava at the Syracuse University Lava Project facility). Numerical modelling will couple heat flow with porous media flow to constrain conditions that could lead to explosions. The end goal will be to use this work to incorporate rootless eruptions into volcanic hazard scenarios.

[1] Mattox T. and Mangan M. (1997) Littoral hydrodynamic explosions: a case study of lava-seawater interaction

at Kilauea Volcano. J Volcanol Geotherm Res 75:1-17

[2] Hamilton CW, Fagents SA, Thordarsson T (2007) Explosive lava-water interactions I. architecture and emplacement chronology of volcanic rootless cone groups in the 1783-1784 Laki lava flow, Iceland. Bull. Volcanol. doi:10.1007/s00445-009-0330-6

Rootless cone, Lake Myvatn, Iceland