Cities on Volcanoes 9
November 20-25, 2016
Puerto Varas, Chile
'Understanding volcanoes and society: the key for risk mitigation'

The Influence of Bed Roughness on Lava Flow Emplacement and Morphology: A Laboratory and Field Study

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Volcanology, Lava Flows, Experimental Volcanology, Fieldwork, Unmanned Aerial Systems

The ability to predict lava flow paths and advance rates is of extreme importance to the protection of property and infrastructure. The influence of substrate characteristics such as roughness and cohesion on flow emplacement has not been studied thoroughly despite evidence that topographic features on the order of flow thickness can affect lava emplacement. We present results from laboratory and field investigations of the influence of substrate roughness on the mobility and morphology of lava flows. We performed scaled laboratory experiments where a fluid was extruded onto sloping planes with varying degrees of bed roughness. To capture the complex rheology of natural lavas, we employed a range of fluids, including corn syrup (simple viscous), polyethylene glycol (solidifying), and molten basalt (strong temperature-dependence). In all experiments, flow front velocities were reduced with increasing substrate grain size. However, this trend diminishes with time within the duration of experiments, as fluids filled in the substrate pore spaces. The 2014–2015 Holuhraun lava flow in Iceland provides an opportunity to test our theory at a natural flow. The largest lava flow in centuries, Holuhraun interacted with beds of different roughnesses, including a braided-river system. The very gradual slope of the underlying terrain suggested that Holuhraun would have been sensitive to variations in roughness. Using photos collected by small unmanned aerial vehicles (UAV), we created digital terrain models (DTMs) and orthomosaics of the flow edges. Our results reveal interaction of the flow with existing topography and possibly changes in flow emplacement processes in response to the interaction with the braided streambed. Our investigations demonstrate the necessity of including substrate characteristics in models used for prediction and interpretation of lava flows. Further, understanding of the scales at which roughness affects lava flows can drive recommendations for sampling resolutions when characterizing terrains in areas of active volcanism.