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The Correlation Between Run-up and Repose Time of Volcanic Eruptions

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Volcanoes commonly make precursory signals before an eruption. The intensity of those precursory phenomena vary substantially in size and duration for different volcano. The precursors are thought to be related to magma ascent beneath the volcanic edifice. So a measure of the time of the precursory activity, or run-up time (Δt), should be related to the dynamics of magma ascent and so to the magma viscosity. Another observable strongly related to the magma viscosity is the interevent repose time (r). The time between eruptions is controlled by the recharge of the magma chamber and the accumulation of pressure. Both of these processes are also sensitive to magma viscosity.

In this study, we investigate the relationship among repose time, run-up time and viscosity by using well-documented eruptions around the world during the last 60 years to compile a database of 54 eruptions. Since the details of the magma viscosity are subject to large uncertainties, we use a large dataset which encompasses extreme variations and enables us to use silica content as a first-order proxy for gross viscosity differences. Thus we have a data set where viscosity of the magma varies by 7 orders of magnitude and thus becomes the most dominant parameter in the system.

The data collected show a strong correlation between run-up times and repose times and magma viscosity; fitting the data with a regression line we have: $\log(\Delta t) = 1.1\log(r) - 3.5$ the slope significantly greater than zero at the 99% confidence level (P-value$<$0.01). We observe that repose time is approximately 10^4 x viscosity and run-up time is 10 x viscosity. The correlation between run-up time and viscosity is well-predicted by a model of diking where the propagation velocity of magma moving toward the surface is controlled by a combination of viscous flow and brittle failure of the crust. The repose time is less precisely modeled, but is consistent with magma recharge models inferred in previous published works. This strong correlation between precursory activity, repose phase and magma chemical composition could be very useful to put some constraint on the eruption behavior both for physical modeling the eruptive dynamics and for a probabilistic volcanic hazard assessment.