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Patterns of accelerating rates of volcano-tectonic seismicity preceding basaltic flank eruptions

A. Bell (1,2) and C. Kilburn (1)

(1) Department of Earth Sciences, University College London, UK, (2) Now at School of Geosciences, University of Edinburgh, UK, (a.bell@ed.ac.uk)

Analysis of volcano-tectonic (VT) seismicity before basaltic flank eruptions and non-eruptive dyke intrusions at Kilauea volcano, Hawaii reveal that many events are preceded by systematic accelerations in the rate of VT earthquakes located in the edifice surrounding the shallow magma reservoir. These sequences can be well modeled by an exponential acceleration in the rate of earthquakes, consistent with the prediction of theoretical models based on concepts of fracture growth, evolving over durations of between weeks and years and with different characteristic exponential timescales. Systematic relations are found between the total number of earthquakes involved in a sequence, the characteristic timescale of the exponential acceleration and the duration of the sequence, suggesting that although the initial stress conditions may vary between events, the underlying controls persist. The patterns indicate that for these events, dyke injection is controlled by the failure of the volcanic edifice surrounding the shallow magma reservoir, driven by magma over-pressure but controlled by the material properties of the rock. We argue that similar patterns should be expected at other basaltic volcanoes and that they promise improved forecasting of the likely timing of dyke injection.