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Seismogenic lavas: fracture and eruption forecasting

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Volcanic dome-building episodes commonly exhibit acceleration in both effusive discharge rate and seismicity before explosive eruptions. In principle, this should enable the application of models such as the material failure forecasting method (FFM) to eruption forecasting. To date, however, such methods have been based exclusively on the seismicity of the surrounding country rock. It is clear, however, that the rheology and deformation rate of the lava ultimately dictate eruption style. The highly crystalline lavas involved in these eruptions are pseudoplastic fluids which exhibit a strong component of shear thinning as their deformation accelerates across the ductile to brittle transition. Thus, understanding the nature of the ductile-brittle transition in dome lavas may well hold the key to an accurate description of dome growth and stability. Here, we present results from laboratory rheological experiments conducted with continuous monitoring of micro-seismic (acoustic emission) output on samples from five volcanoes: Colima, Unzen, Bezimianny, Krakatau, and Tungurahua. Large volume samples (80 mm long by 40 mm diameter) were deformed in a high-load, high-temperature uniaxial press at temperatures of 940˚ and 980˚C and at stresses from 1 to 50 MPa. Our results reveal: (1) that domes lavas are seismogenic, and (2) that the character of the seismicity changes markedly across the ductile-brittle transition. Below strain rates of 10^{-4} s^{-1}, lavas behave in a ductile manner and are essentially aseismic. As the strain rate is increased, an exponential increase in micro-seismic activity, accompanied by crack growth and localization is observed. Complete brittle failure occurs at strain rates approaching 10^{-3} s^{-1} at 940˚C and 10^{-2} s^{-1} at 980˚C. Thus, molten lava may behave more like its volcanic rock equivalent than as a fluid at these higher strain rates. These results demonstrate for the first time that lavas can be seismogenic. They further suggest that observations of magma seismicity, com-

bined with FFM analysis, might be applied successfully to forecasting dome-building eruptions.