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The dynamics and mixing of turbulent plumes in a turbulently convecting environment with application to persistent volcanic activity

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Persistently-active volcanoes are characterised by long-lived degassing, lasting from years to millennia, without any significant eruption of magma. The volumes of gas released at persistently-active volcanoes imply that degassed melt must be convectively recycled within the magmatic system. In this presentation we investigate how the competition between the buoyant motion of small volatile bubbles and thermal convection of viscous magma controls the bubble distribution and hence volatile solubility within volcanic systems.

Under conditions typical of the magmatic system of persistently-active volcanoes, small volatile bubbles can generate coherent turbulent buoyant in magma. In this study, we investigate the turbulent motion of buoyant plumes released into turbulently convecting environments using laboratory experiments and theoretical models. By assuming that the turbulent environment removes fluid from the plume at a rate proportional to a characteristic environmental velocity scale, we derive a model describing the fluid behaviour. For the example of pure buoyancy plumes, entrainment dominates near the source and the plume radius increases with distance, while further from the source removal, or extrainment, of plume material dominates, and the plume radius decreases to zero. Theoretical predictions are consistent with laboratory experiments, a major feature of which is the natural variability of the convection. We extend the study to include the evolution of a finite, confined environment and predict two end-member regimes: a well-mixed environment at all times (high convective velocities), and a ‘filling box’ model similar to that of Baines & Turner (1969) (low convective veloc-

ities). These regimes, and the motion of the interface in a ‘filling box’ experiment, match experimental observations. We find that the convecting filling box is not stable indefinitely, but that the density stratification will eventually be overcome by thermal convection. The distribution of gas bubbles within magma chambers has significant implications for measurements of emitted gas ratios and their interpretation for predictions of changes in volcanic activity.