Pre-eruptive exsolved gas: implications for deformation and atmospheric loading during eruptions

MARIE EDMONDS[1], BRENDAN MCCORMICK[1], JULIET BIGGS[2]

[1]Earth Sciences Department, University of Cambridge, Downing Street, Cambridge, CB2 3EQ, United Kingdom (*me201@cam.ac.uk*)
[2]Earth Sciences Department, University of Bristol, Queen's Road, Bristol, BR BS8 1RJ, United Kingdom

Observations of volcanoes from space are becoming a critical component of volcano monitoring, but we lack quantitative models with which to interpret multiple datasets in tandem. Up to now, observations of atmospheric sulfur loading and of ground deformation during volcanic eruptions have been treated independently, but they are fundamentally linked. If magmas are vapor-saturated prior to eruption, the bubbles cause the magma to become highly compressible, resulting in only very muted ground deformation being measured at the surface. The bubbles contain the sulfur-bearing gas that is eventually injected into the atmosphere during eruptions. We present a forward model incorporating gas-melt thermodynamic equilibria and the physics of compressibility for bubbly magma that allows the surface deformation and the sulfur mass loading into the atmosphere to be predicted as a function of intrinsic parameters, paving the way for quantitative interpretation of multiple volcano monitoring datasets and a better understanding of the conditions under which magmas are stored prior to eruption. We use constraints provided by observations and by petrological studies of magmas to make estimates of the amount of exsolved gases coexisting with magmas in a range of settings and use these to infer the size and composition of gas clouds associated with explosive eruptions of different magnitudes. Applications of such an understanding range from reconstructing the size and impact of large explosive eruptions over the past few thousand years from proxy records (e.g. ice cores) to evaluating the relative contributions of non-explosive and explosive forms of volcanism to volcanic outgassing into Earth's atmosphere over long timescales.