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Conduit dynamics in transitional rhyolitic activity recorded by tuffisite vein textures from the 2008-2009 Chaitén eruption

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Conduit processes govern the mechanisms of hazardous silicic eruptions, but our understanding of complex conduit behaviour is far from complete. Observations of recent Chilean rhyolite eruptions have revealed the importance of hybrid activity, involving simultaneous explosive and effusive emissions from a common vent[1]. Such behaviour hinges upon the ability of gas to decouple from magma in the shallow conduit. Tuffisite veins are increasingly suspected to be a key facilitator of outgassing, as they repeatedly provide a transient permeable escape route for volcanic gases. However, we have limited insights into the interactions between tuffisites and foams that appear critical to efficient outgassing[2], and into how heterogeneous conduit magma responds to pressure perturbations related to repeated disruption or slip of dense magma plugs.

Here we provide a detailed characterization of an exceptionally large tuffisite vein within a rhyolitic obsidian bomb ejected during transitional explosive-effusive activity at volcán Chaitén, Chile in May 2008. Vein textures and chemistry provide a time-integrated record of the invasion of a dense upper conduit plug by deeper fragmented magma. Quantitative textural analysis reveals diverse vesiculation histories of varied juvenile clast types.

Using vesicle size distributions, bubble number densities, zones of diffusive water depletion, and glass H_2O concentrations, we propose a multi-step degassing/fragmentation history, spanning deep degassing to explosive bomb ejection. Rapid decompression events of $\sim$3-4 MPa are associated with fragmentation of foam and dense magma at $\sim$200-300 metres depth in the conduit, permitting vertical gas and pyroclast mobility over >100-200 metres. Permeable pathway occlusion in the dense conduit plug by pyroclast accumulation and sintering preceded ultimate bomb ejection, which triggered a final bubble nucleation event.

Our results highlight how the vesiculation response of magma to decompression events is highly sensitive to the local melt volatile concentration, which is strongly spatially heterogeneous. Repeated opening of pervasive tuffisite vein networks promotes this heterogeneity, allowing juxtaposition of variably volatile-rich magma fragments that are derived from a wide range of depths in the conduit. This process enables efficient but explosive removal of gas from rhyolitic magma and creates a complex textural collage within dense rhyolitic lava, in which neighbouring fused clasts may have experienced vastly different degassing histories.

[1] Schipper CI et al 2013 JVGR 262, 25-37.
[2] Castro JM et al 2012 EPSL 333, 63-69.