Magma-water Interactions During Subglacial Rhyolite Eruptions

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Field characteristics of Quaternary subglacial rhyolite volcanoes in Iceland are used to infer a vast range of magma-water interaction mechanisms during individual eruptions. Relationships between phreatomagmatic ash, vesicular bombs, pumiceous peperite intrusions and juvenile water-lain sediments indicate that magma-water ratios and confining pressures at the glacier base were susceptible to sudden change. In our models, the extreme temporal and spatial variability of eruption mechanisms reflects the rapidity with which meltwater supply and confining pressure may fluctuate within subglacial cavities. The timescale of these fluctuations appears to have been shorter than the time taken for rising magma to adjust texturally to the new conditions, and quenching has produced frozen 'fossils' of non-equilibrium systems such as fragmentation fronts around ribbons of vesiculating magma. Our interpretations of lithofacies associations at Dalakv sl, Torfaj÷kull, Iceland are used to illustrate these models.

To complement the field studies, simple numerical models of melting and ice deformation during subglacial rhyolite eruptions have been developed to predict the evolution of subglacial cavities and resultant eruption mechanisms. As with subaqueous eruptions, the confining pressure and rate of magma-water heat transfer exert a critical influence on the style of eruption, since they mediate the conversion of water to steam and resultant explosivity. However, the subglacial environment is complicated by energy exchange with ice and the presence of a constraining ice roof, which may limit the volume of the growing volcanic edifice.