Effects of Shear Strain on the Deformation and Degassing of Highly Viscous Magmas

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To characterise the rheological behavior and the influence of deformation on degassing of magmas containing gas bubbles (12-36 vol.%) and crystals (0-42 vol.%) suspended in a silicate melt matrix, we performed simple shear experiments at high pressure and temperature (150-200 MPa; 723-823 K) in a Paterson-type deformation apparatus to total strains between γ=0 and γ=10. The experimental setup allows for escape of gas if bubble connectivity is reached on the outer portions of the samples. Three-dimensional imaging and analysis of deformation microstructures was performed by x-ray tomography using Blob 3D and Quant 3D software. Bubble coalescence begins at gammas as low as 0.3 at bubble contents of 20 vol.% and increases with deformation to produce planar bubble networks at gamma 5 with bubble contents of 16 vol.%. Bubble connectivity, localization of strain and the tendency for brittle failure of samples increase with crystal content. Decreasing bubble content with increasing strain, along with strain-hardening rheological behaviour, suggests significant shear-induced outgassing due to the development of connected bubble or fracture networks. Three dimensional analysis of samples provides evidence for the formation and subsequent closure of permeable pathways, which is an effective mechanism for degassing of samples, and may be analogous to the modality of degassing of magma during ascent in volcanic conduits. These experiments provide insights into the processes leading to the transitions from explosive to effusive activity observed at many silicic volcanoes, as well as the formation of flow-banded obsidian.

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