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Crystallinity–vesicularity interrelation in silicic pyroclasts – Neutron and X-Ray Computed Tomography constraints on magma permeability

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The permeability of magma controls gas escape during magma ascent and thus may control eruption behaviour, varying from quiet degassing to explosive fragmentation (Mueller et al., 2008). Yet, the spatial distribution of connected vs. isolated vesicle structures in magma remains poorly constrained. Additionally, the crystal distribution may influence magma permeability: a) do fractures in crystals provide additional pathways to melt-based volatile migration? and b) do low surface-tension crystal faces catalyse bubble nucleation and growth?

In felsic pyroclasts, the size, shape and interconnectivity of vesicles and phenocrysts have been quantified by 3D tomography. We applied high resolution neutron computed tomography (NCT) at 20 μm and X-ray Computed Tomography (XCT) at 5–10 μm resolution on large samples of 15–50 cm^3 to investigate the 3D structure of vesicular (Φ = 0.45–0.72), silica-rich pyroclastic material from various explosive eruptions. Samples are of the 2004 vulcanian and the 1783 plinian eruption of Asama (Japan), the 1997 eruption of Soufrière Hills Volcano (Montserrat) and the June 1991 vulcanian event of Unzen (Japan).

Volume reconstructions of the pore space and different crystal phases were calculated with Tomoview, our custom-made software. The reconstructed volumes showed an interrelation between vesicle and crystal distribution. Differential overlapping of crystal and vesicle subvolumes trace the crystal outlines exceptionally well. Furthermore, Tomoview detected connected pathways that frequently exploited inter-fracture space of fragmented crystals. Crystal fragmentation thus appears to provide an additional mechanism for generating pore space. The evolution of a permeable network may thus be affected by the crystal content, which ultimately biases the eruptive behaviour of silicic magma.