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The generation and evolution of anisotropic gas-permeability during viscous deformation in conduit-filling ignimbrites

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Gas-permeability plays a governing role in the pre-explosive pressurization of volcanic edifices. Pressurization may only occur once the total volume flux of gases emitted by an underlying magmatic or hydrothermal source exceeds the flow capacity of the permeable pathways present in the edifice.

We have measured the physical properties (strain, porosity, permeability and ultrasonic wave velocities) of bread-crust bombs recovered from the deposits of the 2350 B.P. eruption of Mt Meager, BC, Canada. These rocks represent a conduit-infilling pyroclastic breccia that underwent various degrees of welding and deformation and present a remarkable opportunity to constrain the nature and timescale of mechanical processes operating within explosive volcanic conduits during repose periods between eruptive cycles.

Here we present data from permeability measurements along the directions of maximum and minimum shortening which help quantifying the effect of vesicle microstructure on permeability. Permeability is measured by applying a range of confining pressures (between 3.4 and 17.2 MPa) to each sample and imposing a constant head (of 0.2 to 3.5 MPa) across the sample. The permeability is then determined using a modified version of Darcy's law applicable to compressible fluids.

These rocks display a profound directionality in the measured physical properties resulting from the deformation-induced fabric. For all samples the permeability across the elongation fabric is highly correlated to the sample porosity whereas along the elongation fabric there is little effect of porosity on permeability. At porosity values of about 20% the permeability seems to reach a minimum at 10^{-16} m^2 and does not change significantly with further reduction of porosity. Further, the effect of confining pressure on the permeability of these samples appears to be more pronounced across the elongation fabric than along the elongation fabric.

The deformation fabric has a significant effect on the gas-permeability of the deposit. Porosity, on the other hand, appears to play a secondary role. This, fabric dependent, anisotropic permeability evolution of fragmental deposits during welding directly affects the gas escape from, and transport through the deposit and, therewith, plays a key role in the gas-pressure distribution and evolution within the volcano.