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Gas-driven filter pressing: insights into melt segregation from crystal mushes

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Gas-driven filter pressing relieves the gas pressure developed through second boiling by expelling melt from a crystal mush. It is thought to play a major role in magma fractionation at shallow depths (< 10 km). We present new 4D (3D and time) experimental data that constrain conditions under which gas-driven filter pressing can occur. We performed in-situ high-temperature high-speed synchrotron X-ray tomography (500-800 °C, 3 μm/pixel, 8 seconds per full 3D dataset) to collect real time information on the behaviour of hydrous haplogranitic (2.1 wt.% H_2O) and dacitic (4.2 wt.% H_2O) crystal mushes with a wide range of crystal contents (34-80 vol.%). The data constrain how the crystal content affects the efficiency of gas-driven filter pressing of silicic melt out of the crystal mush framework, and show that gas-driven filter pressing operates below the maximum packing fraction of the suspended phases (bubbles + crystals) of $\sim$74 vol.%. Above this value, the crystal mush is fated to fracture. These results provide essential constrain on the physical conditions under which gas-driven filter pressing can efficiently operate and force silicic melt out of the crystal framework. This also implies that, for effective gas-driven filter pressing, the crystal mush must inflate slowly relative to build-up of pressure and expulsion of melt. These observations suggest a possible explanation for the production of eruptible crystal-poor rhyolites in the Earth's crust.