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The volatile budget of evolved and crystal rich silicic magmatic bodies

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Assessing the volatile budget of a magmatic body is key for inferring its eruptability. This becomes particularly challenging in water-rich and shallow silicic magma reservoirs that likely store extensive amount of exsolved volatiles. These exsolved volatiles (mainly H2O), due to their buoyancy, may potentially escape the reservoir (outgas). However, as (1) magma bodies are known to spend most of their supra-solidus life at high crystallinity and (2) vapor being mostly non-wetting in crystal-bearing silicic magmas (i.e. vapor tends to form bubbles with melt films coating crystals), the tendency of bubbles to migrate upwards will be unavoidably hindered by resistive capillary stresses. Here we use numerical calculations at the scale of crystals and bubbles to explore the conditions under which gas migration at high crystallinity can become efficient. We investigate the onset of bubbles mobility and efficient vapor transport at the pore-scale over a range of (1) crystallinity, (2) vapor volume fraction and (3) crystal size. We then insert these results as a parameterization into a thermo-mechanical magma reservoir model, and track the outgassing history during long-term cooling of magma bodies as they are stored in the upper crust. Our pore-scale results suggest that outgassing can be efficient over crystallinities that range from about 40 to 60% (i.e. for typical crystal sizes of 1 to 5 mm) because (1) of the balance between buoyancy and capillary stresses and (2) the positive effect of crystal confinement on vapor connectivity. However, thermo-mechanical feedbacks due to volume changes within the reservoir during outgassing and the visco-elastic response of the wall-rock have the potential to slow down outgassing even when outgassing is not transport limited (above the dynamic percolation threshold for gas migration).