Investigating pore-scale processes controlling the volatile transport in silicic magma reservoirs.

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Our limited understanding of exsolved magmatic volatile phase (MVP) transport in magma reservoirs with variable crystallinities does not allow us to constrain important concepts such as (1) how fast volatiles move in reservoirs, and (2) when and where they can accumulate. Consequently, we need more sophisticated physical models to shed light on the non-linear interactions between the exsolved MVP, silicate melts, and the crystal matrix. The study reports the use of multiphase numerical modeling to calculate the mass transport of the MVP in a crystalline skeleton that is initially saturated with a silicate melt. We focus on capillary channels formation of the MVP, as these channels represent paths of low resistivity for rapid volatile transport in magmatic environment. The host medium (crystalline matrix) can be homogeneous or display sudden transitions in crystallinity, in order to test two potential configurations that are thought to be important in magma reservoirs: (1) high crystal content magmas (homogeneous crystal mushes) and (2) regions of transition between high crystal content magmas and a melt-rich layer (crystal-poor silicic cap overlying a mush zone).

The stability of these channels are studied in two different physical contexts, In the first experiment, we studied the thermal reactive transport associated with the percolation of a hot buoyant volatile phase in an homogeneous crystal-rich mush zone. In such a situation, we observe that an increase in porosity due to thermal dissolution of the crystalline network can lead to a break-up of the volatiles capillary channels with a consequent decrease in volatile and heat flux through the system. Similar concepts can be applied to chemically reactive systems important for ore deposit formations. In the second experiment, the MVP transport behavior at the transition from a high crystallinity medium (crystallinty >0.5 where the volatiles mainly ascend buoyantly through the capillary channels) and a low crystallinity medium (crystallinity 0.2) was studied. We find that capillary channels break as they penetrate into the crystal-poor layer (capillary pinch-off). Moreover, the viscosity contrast between the MVP and the melt causes a sudden increase in viscous dissipation as the transport regime of the MVP shifts from capillary channels to disconnected bubbles/slugs in the melt-rich layer. As a result, the MVP tends to accumulate in the melt-rich layer. The accumulation of MVP in the crystal-poor layer can affect the physical properties of the latter, and greatly impact the eruptibility of the system.