Why aren't most high-SiO_2 rhyolites trapped in the crust?

OLIVIER BACHMANN[1], ANDREA PARMIGIANI[1], CHRISTIAN HUBER[2], SALAH FAROUGHI[2] AND YANQING SU[2]

[1]ETH Zurich, Switzerland (*baolivie@ethz.ch)
[2]Georgia Institute of Technology, Atlanta, GA, USA

High-SiO_2 rhyolites are extremely viscous magmas, which tend to move slowly in the crust, and would be expected to be trapped as granitic plutons. However, it has long been noticed that granites sensu stricto are typically less abundant in the rock record in comparison to their volcanic counterparts. A possible explanation for this observation is that such magmas are highly eruptible because: (1) they are produced by melt extraction from large upper crustal mushes, shielding them from rapid thermal death, and (2) that they accumulate exsolved volatiles, which increases the potential energy of the magma before an eruption. The possibility that such pools of rhyolitic melts are produced within the wombs of large crystals mushes is supported by a number of observations, including the ubiquitous presence of silicic cumulate fragments in large crystal-poor rhyolitic ignimbrites. Using fluid dynamics simulations and laboratory experiments, we show that the second criteria, the accumulation of exsolved volatites in crystal-poor lenses, is met for reservoirs including a mush zones transitioning fairly abruptly to melt-rich lenses. In the mush zone, an efficient transport of exsolved volatiles is made possible by crystal confinement which enhance the formation and preservation of stable « gas channels ». However, upon entering the crystal-poor environment, those channels break up, and lead to the generation of a bubble suspension where bubbles slow each other down as they ascent buoyantly. Hence, bubbles have a tendency to accumulate in the crystal-poor magma, affecting the stress state in the cap and promoting large eruptions. The multiphase fluid dynamics we study here provides an explanation for the efficiency of the exsolved volatile transport in crystal-rich magmas and the devolatilization of plutons.