Understanding the long-term thermal conditions of magma storage in the crust: Are we there yet?

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Silicic magmas typically experience extended residence in shallow magma storage systems. Thermal conditions during this residence reflect the interplay between addition of hot magma via recharge versus conductive and advective (eruptive) heat loss, and also strongly influence eruptive behaviour. Thus considerable efforts have been made to constrain the thermal evolution and physical conditions of stored magmas.

Although our understanding of the thermal evolution of magmas has been strongly influenced by numerical modelling and related strategies, in recent years various approaches have been developed that can directly constrain thermal evolution via petrologic and geochemical means. These include diffusion within major and trace phases, combined dating and geothermometry of zircon, and trace element variations in accessory phases. Review of these reveals important new opportunities for constraining the thermal history of magma storage, for applying these techniques in new areas, and for relating thermal history to the processes that accumulate and erupt magmas stored within the crust. One emerging paradigm is that many magmas experience long periods of storage at relatively cool conditions, with << 10% of the total residence spent at conditions where the magma would have sufficiently low viscosity to erupt.

Another emerghing area of research are the conditions under which magmas are stored in systems that produce very large volcanic eruptions (>1000 km^3). Trace element diffusion suggests variations from those that experience long term “cold” storage, to others that show elevated temperatures (>~750°C) for several 10’s of thousands of years prior to eruption. We will present results from ongoing efforts aimed at understanding these differences, at looking at variations in the recorded thermal history within individual magmatic systems, and in applying multiple tools to the same eruption to constrain thermal evolution with greater confidence.