Thermal histories of magma storage and implications for magma mixing

KARI M. COOPER[1*], ADAM J. R. KENT[2], CHRISTIAN HUBER[3], ALLISON E. RUBIN[1], KEVIN SCHRECENGOST[1], WIM DEGRUYTER[3] AND PHILIPP RUPRECHT[4]

[1]Department of Earth and Planetary Sciences, University of California, Davis, One Shields Ave., Davis, CA 95616, USA (*correspondence: kmcooper@ucdavis.edu)
[2]CEOAS, Oregon State University, 104 Ocean Admin, Corvallis, OR 97331, USA
[3]Georgia Institute of Technology, Atlanta, GA 30332, USA
[4]LDEO, 61 Route 9W, Palisades, NY 10964, USA

The thermal, and therefore physical, conditions of magma storage (e.g., crystal mush vs. liquid-dominated bodies) exert a fundamental control on the time scales and processes of magma mixing. However, although thermal evolution of magma bodies has been modeled [1-3] observational evidence linking time scales to thermal conditions of storage (i.e. thermal histories) has been lacking. We have recently developed a new method of constraining thermal histories of magma storage by combining U-series dating of crystals (which provides the total time of storage) with modeling of trace-element diffusion within crystals (which constrains the time spent at high temperatures) to reconstruct thermal histories of magma storage [4].

To date, we have applied this technique to plagioclase in samples from Mount Hood, OR [4], and Lassen Volcanic Center, CA, with work in progress at Volcan Quizapu, Chile, and Okataina Volcanic Complex (OVC), New Zealand. In addition, we have applied this technique to zircon at the OVC [5]. Initial results for all locations are strikingly similar, with extended durations of crystal storage occurring at temperatures below the transition between largely-liquid magma and crystal mush, and only a small percentage of pre-eruptive storage times occurring at higher temperatures. The implications of these observations are that either magma mixing occurs rapidly, at high-temperature conditions that are unusual for the magma as a whole, or that mixing must occur within a low-temperature crystal mush. We are combining these results with numerical modeling to better define the time scales and processes involved in mixing in these mush-dominated systems.

[1]Gelman *et al.* (2013), *Geology* **41**, p. 759-762; [2]Annen *et al.* (2011), *JGR* **113**, B07209; [3]Degruyter and Huber (2014), *EPSL* **403** p. 117-130. [4]Cooper and Kent (2014), *Nature* **506** p. 480-483. [5] Rubin et al. (2014), AGU Fall Meeting abstract V31F-02.