Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.10654

Tracking magmatic volatile and non-volatile trace elements with amphibole in arc magmas

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Amphibole is a common mineral phase in hydrous arc magmas and can be used to track how changes in magmatic compositions and volatile element abundances vary with magmatic evolution and pressure-temperature conditions [e.g., 1–3]. The relatively complex crystal structure of amphibole is more compatible with a broad swath of trace elements than other common volcanic minerals such as plagioclase or pyroxene. Recent experimental compilations [4, 5] provide a framework to directly relate amphibole compositions to melt chemistry. Here we focus on its ability to track melt trace element compositions.

Data from the dacites of the 1980 eruptions of Mount St. Helens and the 1991 eruption of Mount Pinatubo show that high-Al amphibole compositions generally track primitive melt lithophile trace elements, while low-Al amphibole tend to track more evolved melt. We also show that Li and Cu, known for potential partitioning into a magmatic volatile phase, are strongly decoupled from lithophile trace elements, and thus maybe controlled by decoupled volatile behavior in the magma. Other base metals associated with magmatic-hydrothermal ore deposits, however, correlate well with non-volatile incompatible elements. While Li and Cu concentrations can vary by 2 orders of magnitude between different samples from the same eruption, concentrations are broadly similar across single hand-samples and Li and Cu concentrations are not consistently zoned across single crystals. This suggests Li and Cu diffusion in amphibole and melt is rapid, equilibrating over small domains in magmas and throughout crystals, yet also preserves heterogeneity within a magma body that is far greater than other trace elements.

We are expanding this work to include amphibole compositions in a survey of Alaska-Aleutian volcanic rocks across the entire arc (e.g., Hayes, Katmai, Kasatochi, Davidof, Buldir) so we can determine how amphibole tracks magma composition across a range of diverse volcanic arc suites and bulk compositions from basalt to rhyolites.

[1] Holland & Blundy (1994), *CMP* 116, 433–447. [2] Ridolfi & Renzulli (2012), *CMP* 163, 877–895. [3] Rowe et al. (2008), *JVGR* 178, 593–607. [4] Zhang et al. (2017), *Am Mineral* 102, 1353–1367. [5] Humphreys et al. (2019), *CMP* 174, 9.