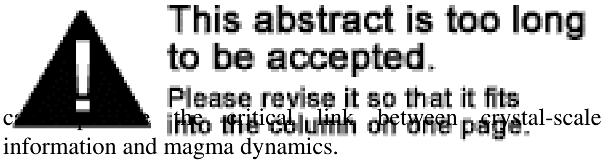
Crystal ages and timescales of magma reservoir processes

KARI M. COOPER[1]

[1] Dept. of Geology, University of California, Davis, CA 95616, USA; kmcooper@geology.ucdavis.edu

The timescales of crustal magmatic processes such as crystal growth, crystal and magma residence, and assimilation of crustal material have generally been difficult to quantify. Chemical variations within crystals may preserve a record of magmatic processes that are averaged (and therefore obscured) in glass or whole-rock analyses. In addition, advances in micro-analytical techniques have led to a growing recognition that crystals entrained in magmas may be only partially related to the host magma; instead, they often record a complex history of crystal growth and storage in different magmas and/or isolated chemical or thermal environments within a given magma. Therefore the crystals may contain more information about the dynamics of magma reservoir systems than is preserved in the liquids. Crystal ages measured using U-series disequilibria provide the temporal control critical to unraveling this source of information about magma reservoir dynamics.

Unraveling the complex record contained within crystals requires combinations of age data with other types of information, which can lead to unique insights. For example, ages of major phases (e.g., plagioclase) in basaltic to intermediate lavas are commonly hundreds to a few thousands of years older than eruption ages, whereas durations of crystal residence at magmatic temperatures inferred from diffusion timescales are commonly tens to hundreds of years. This suggests that crystals were stored in the reservoir at relatively low temperatures for hundreds to thousands of years, perhaps as a crystal mush. Discordant crystal ages derived from different parent-daughter pairs (e.g., ^{230}Th-^{238}U vs. ^{226}Ra-^{230}Th vs. ^{210}Pb-^{226}Ra) measured on the same mineral separates is most easily explained by old cores surrounded by younger rims, reflecting protracted and/or episodic crystal growth spanning tens of thousands of years. This pattern has been observed in several arc systems (e.g., Mt St Helens, Tonga, Soufriere) suggestin that recycling of earlier generations of crystals within a given magmatic system ("antecrysts") is a common if not ubiquitous process. Furthermore, combining crystal ages with trace-element and/or isotopic composition of crystals can potentially link these different stages of crystal growth to different magmatic events (e.g., recharge or assimilation). Finally, overlapping ages of chemically-distinct crystal populations in some cases (e.g., Mt St Helens) requires that multiple crystal populations (presumably derived from distinct magma batches) can be stored in chemically-isolated regions of the reservoir system, but that these regions are all still within the "active" part of the reservoir subject to remobilization and eruption. Thus, crystal ages can in many



ca[illegible] the critical link between crystal-scale information and magma dynamics.