

SPECIAL COLLECTION: RATES AND DEPTHS OF MAGMA ASCENT ON EARTH

## U-Th baddeleyite geochronology and its significance to date the emplacement of silica undersaturated magmas†

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### ABSTRACT

Baddeleyite is a frequently found accessory mineral in silica undersaturated lavas. Because it is typically enriched in uranium, while having low initial lead, baddeleyite has long been a prime target for U-Pb geochronology of mafic rocks. The difficulties in retrieving small baddeleyite grains from volcanic samples and the lack of a detailed understanding of baddeleyite occurrence, however, have limited baddeleyite chronology largely to coarse-grained mafic intrusive rocks. Here, the development of U-Th in situ baddeleyite analysis using secondary ionization mass spectrometry (SIMS) is presented together with an assessment of baddeleyite occurrence in Quaternary silica-undersaturated lavas from Campi Flegrei (Naples, Italy). Samples studied comprise the pre- and post Campanian Ignimbrite (ca. 40 ka) lava domes of Cuma and Punta Marmolite, and Astroni and Accademia, respectively. The in situ sample preparation required initial identification of baddeleyite crystals from sawed and polished rock billets using scanning electron microscope (SEM) backscatter imaging and energy-dispersive X-ray analysis. U-Th baddeleyite isochron ages for intra-caldera Astroni and Accademia lava domes are  $5.01^{+2.6}_{-2.5}$  ka (MSWD = 2.0; n = 17) and  $4.36^{+1.13}_{-1.12}$  ka (MSWD = 2.9; n = 24), respectively. The ages for Punta Marmolite ( $62.4^{+3.9}_{-3.8}$  ka; MSWD = 1.2; n = 11) and Cuma ( $45.9^{+3.6}_{-3.5}$  ka; MSWD = 2.2; n = 11) predate the Campanian Ignimbrite. Rapid baddeleyite crystallization at the time of emplacement is supported by petrologic observations that >50% of the baddeleyite crystals documented in this study occur either in vesicles or in vesicle-rich regions of the host lavas whose textures developed over timescales of a few years to a few decades based on microlite crystal size distribution (CSD) analysis. Radiometric U-Th baddeleyite ages are mostly in agreement with previously determined K-Ar eruption ages, except for the Punta Marmolite lava dome whose U-Th baddeleyite age predates the K-Ar age by ca. 15 ka. Baddeleyite thus records eruptive emplacement with little evidence for significant pre-eruptive crystal residence, and has potential as an eruption chronometer for Quaternary silica-undersaturated volcanic rocks.

**Keywords:** Geochronology, baddeleyite, radiogenic isotopes, uranium series, igneous petrology, trachyte, secondary ionization mass spectrometry