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Geochronology of Mafic Intrusions

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Baddeleyite (ZrO_2) is today recognized as a key mineral for dating the emplacement of mantle-derived rocks such as gabbros, alkaline (Si-poor) rocks and dolerite dykes and sills, but also in hydrothermally-driven deposits (Heaman and LeCheminant, 1993). In magmatic rocks, baddeleyite occurs as a late accessory phase, crystallizing in interstitial spaces together with hydrated Fe-Mg phases and alkali feldspar. Initially, baddeleyite typically contains tens to some hundreds of parts per million U, but virtually no Pb, allowing us to use the ^{238}U and ^{235}U decay schemes. Our ability to obtain precise U-Pb ages from the analysis of just a few minute baddeleyite grains (Krogh, 1973) combined with improved separation techniques (Söderlund and Johansson, 2002), have greatly increased the number of baddeleyite age determinations made over the last twenty years. The vast majority of published baddeleyite U-Pb dates are done through chemical dissolution of baddeleyite grains, which are then age determined using ID-TIMS (Isotopic Dilution - Thermal Ionization Mass Spectrometry).

Baddeleyite that is isolated from fresh dolerite samples to produce ID-TIMS analyses typically plot discordant by up to a few percent in the concordia diagram. However, there are numerous examples showing that fresh baddeleyite grains have relatively narrow Pb/U ranges leading to clustered or overlapping error ellipses that plot below the concordia. This often complicates more traditional robust linear regressions and especially, the interpretation of intercept dates (unless the timing of the event which caused the discordance is known, i.e. using forced lower intercept in the regression). This dilemma, in addition to: (1) baddeleyite's sensitivity to transform into secondary zircon during hydrothermal events and metamorphism (Davidson and van Bremen, 1988), and (2), difficulties to extract micro-baddeleyite (≤ ~20 μm) in many samples, have called for development and refinement of *in situ* analytical techniques (LA-ICPMS or SIMS) of polished rocks sections or of extracted baddeleyite grains mounted in epoxy (e.g. Schmitt et al., 2010). However, there are a number of elemental (and isotopic) biases inherent in these techniques owing to e.g. crystallographic orientation (Wingate et al., 1999), down-hole fractionation and other matrix affects (e.g. Sylvester et al., 2008), that put severe limitations on the accuracy of the Pb/U dates. On the basis of our current knowledge of discordance in baddeleyite, reproducible ^{207}Pb/^{206}Pb dates probed from inner portions of baddeleyite grains should still provide accurate crystallization ages of a rock.

In this contribution I present a review on the use of baddeleyite as a geochronometer for obtaining emplacement ages of mafic rocks, and also discuss alternative geochronometers that could merit further attention in the future for obtaining accurate crystallization ages of rocks that lack zirconium-minerals.

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