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Baddeleyite with xenocrystic zircon inclusions in the Cambrian Spread Eagle Gabbro, western Avalon Peninsula, Newfoundland

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High-precision geochronology of volcanic marker horizons within sedimentary sequences is essential for absolute dating of the fossil record. Rift-related sequences often lack widespread felsic tephra suitable for dating, but contain mafic lavas, which can rarely be dated directly, but sometimes indirectly through correlation with their feeder dikes. Precise dating of mafic rocks remains a challenge due to scarcity, small crystal size and/or limited preservation of datable accessory minerals. Inheritance is generally considered less problematic compared to felsic rocks. Here, we show otherwise.

In order to more precisely date rifting of Avalonia from Gondwana and faunal evolution within the embryonic Rheic Ocean throughout the middle to late Cambrian, we investigated baddeleyite from the (sub-)alkaline gabbroic and monzonitic Spread Eagle Intrusive Complex, western Avalon Peninsula, Newfoundland. In-situ microtextural analysis revealed that primary baddeleyite, usually $\leq$10 μm in the shortest dimension, is often partially replaced by metamorphic zircon. In addition, we identified anhedral zircon cores in some baddeleyites. Geochronologic analysis by secondary ionization mass spectrometry (SIMS) is limited by beam overlap when the two minerals are intergrown, often resulting in mixed ages between ca. 500 and 300 Ma for baddeleyite – metamorphic zircon, and >600 Ma for baddeleyite – zircon inclusion pairs. Based on these ages, we conclude that relict zircon xenocrysts were overgrown by magmatic baddeleyite at ca. 500 Ma. The only other knowledge of similar textures is from kimberlites where feather-like baddeleyite overgrowths on zircon megacrysts occur. These, however, differ from the conterminous baddeleyite mantles in the Spread Eagle Gabbro.

Ages and textures imply that zircon xenocrysts were partially dissolved in a zircon-undersaturated melt, causing local baddeleyite oversaturation at the dissolution interface. Baddeleyite shielded relict zircon from complete dissolution. The occurrence of such zircon xenocrysts and their possible preservation in baddeleyite will depend on the availability of zircon in country rock, entrainment mechanism, and the kinetics of dissolution and crystallization. Based on our study of Spread Eagle Gabbro, we conclude that for accurate dating of similar rocks, three potential types of zircon intergrown with baddeleyite have to be considered: (1) younger metamorphic/hydrothermal replacement zircon, (2) coeval igneous zircon overgrowth, and (3) older xenocrystic zircon inclusions, as discovered here. Discrimination between these endmembers is not always straightforward using petrography only, especially as they can exist in combination. Pre-screening by SIMS can aid in resolving these age differences, providing important constraints for subsequent high-precision dating using bulk techniques.