

Desilicification reaction rims of zircon xenocrysts: A new promising material for kimberlite geochronology

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Kimberlites are rare igneous rocks derived from the deepest-sourced melts (>150 km). They transport an abundant cargo of xenoliths and xenocrysts from the lithosphere and deeper convecting mantle that provide key insights into mantle composition at the time of emplacement. In addition, the significant temporal distribution (>2.5 Gyr) of kimberlites records secular changes in geodynamic processes, supercontinent and deep carbon cycles. Therefore, accurate dating of these rocks is essential. However, syn- and post-emplacement alterations of primary magmatic phases and the presence of exotic material of different ages and origins challenge reliable dating of kimberlites.

U–Pb dating of perovskite and Rb–Sr and ⁴⁰Ar/³⁹Ar dating of phlogopite are the main methods in kimberlite geochronology, but each has limitations. Perovskite may be absent in some kimberlites, and phlogopite is susceptible to alteration. In contrast, xenocrystic zircons are commonly present in kimberlites, and the zircon U–Pb system is relatively resistant to alterations. However, only mantle-derived kimberlitic zircons can reliably yield the timing of emplacement, and distinguishing them from crustal zircon xenocrysts and other mantle-derived zircon xenocrysts may be complicated.

This study presents a novel approach [1] to kimberlite dating by investigating desilicification reaction rims (DSRs) of zircon xenocrysts in the Kimozero kimberlites. These kimberlites intruded the Karelian Craton at 1.97 Ga, as determined by SIMS U–Pb dating of kimberlitic zircons, and were subsequently altered during low-grade regional metamorphism. DSRs in these kimberlites consist predominantly of baddeleyite and are typical of mantle-derived zircons in many kimberlites worldwide. However, the location and precise timing of DSR formation remain unknown. We identified that both 1.97 Ga kimberlitic zircons and 2.70–2.38 Ga crustal zircons in the Kimozero kimberlites have identical DSRs, indicating that these rims must have formed at crustal levels. Moreover, SIMS Pb–Pb dating of the rims yielded ages of 1.97 Ga, the same as kimberlitic zircons, indicating that the DSRs robustly record the timing of emplacement for the Kimozero kimberlites. These findings establish DSRs as a promising new material for kimberlite geochronology, even for strongly altered kimberlites.

[1] Melnik et al. (2022) *Journal of Geophysical Research: Solid Earth*, 127(9), e2022JB024482