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Multi-stage metasomatic Zr mineralization in the world-class Baerzhe rare earth element Nb-Zr-Be deposit, China

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Abstract

Magmatic and metasomatic zircon occurs in many alkaline igneous rocks and both are potential economic reservoirs of Zr, and in some places, rare-earth elements. The Baerzhe deposit in China is an example of a system where both types of zircon occur. Previous studies recognized deuteric and variably altered magmatic zircon in a transsolvus miaskitic granite, as well as four types of metasomatic zircon in a transsolvus agpaitic granite. In this study, the relationships among, and origins of, zircon and how these relate to models for rare-metal mineralization are assessed. In situ backscattered electron (BSE) and cathodoluminescence (CL) imaging, Raman spectroscopy (including mapping), and chemistry of zircon from the agpaitic granite were conducted, combined with evaluation of published data on zircon from Baerzhe. Their textural, spectroscopic, and chemical characteristics suggest that the four types of metasomatic zircon in the agpaitic granite were not subjected to metamictization or intense alteration, with trace-element accommodation largely following a xenotime substitution mechanism. The most abundant type of metasomatic zircon in the agpaitic granite occurs in zircon-quartz pseudomorphs and exhibits comparable CL, Raman spectral, and chemical features to rare zircon that has partially replaced elpidite. This confirms that the pseudomorphs formed by complete replacement of elpidite. The pseudomorph zircon occurs in association with snowball quartz that contains inclusions of zircon, aegirine, and albite, and with secondary quartz containing aegirine. This is consistent with their coeval formation during Na metasomatism. The restriction of Na metasomatism to the agpaitic granite indicates that this event and the associated zircon formation resulted from early autometasomatism of the agpaitic phase. REE- and Be-rich zircon that replaced magmatic amphibole crystallized as a result of reaction with a REE- and Be-rich fluid that most likely was responsible for the later REE-Nb-Be mineralization that affected both the miaskitic and agpaitic granites. The miaskitic granite contains deuteric and altered magmatic zircon with different chemical characteristics to the four types of metasomatic zircon in the agpaitic granite. This suggests that secondary Zr mineralization in the miaskitic granite formed from different fluids to those that metasomatized the agpaitic granite and may also have resulted from autometasomatism. This study reveals a complex picture for the formation of zircon at Baerzhe, the character of which can vary significantly, both temporally and spatially. Such variable chemistry of the various types of zircon resulted not only from their different origins (magmatic vs. metasomatic), but also from localized water-rock interaction that involved multiple stages of fluids. Zircon in both the miaskitic and agpaitic phases was mainly the product of autometasomatism that was constrained to their parental granites.

Keywords: Zircon morphology and chemistry, rare metal mineralization, alkaline systems, agpaitic granite