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Chemical lattice expansion of natural zircon during the magmatic-hydrothermal evolution of A-type granite

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Abstract

Although thermal lattice expansion is a well-documented nature of crystals, including zircon and zircon-type minerals, chemical lattice expansion of natural mineral is rarely reported. Here we present a comprehensive investigation on three types of natural zircon that records the evolution of the granitic system in Xiangshan, North China, and shows expanding crystallographic parameters induced by chemical incorporation instead of thermal expansion. Prismatic and oscillatory-zoned zircon grains (Type-1A), crystallized early in the granitic magma at high temperatures in a volatile-undersaturated environment, have the smallest lattice parameters (a = 6.603 Å, c = 5.971 Å). Prismatic and altered zircon grains (Type-1B), formed under volatile-saturated conditions and in the presence of F-rich fluid with numerous thorite and xenotime inclusions, have intermediate lattice parameters (a = 6.649 Å, c = 6.020 Å). Pyramidal zircon grains (Type-2), formed in a subsolvus granitic system at relatively low temperatures and coexisted with fluid inclusions, have the biggest lattice parameters (a = 6.677 Å, c = 6.010 Å). Trace elements, including Hf, Th, Ti, Y, and REE, and volatiles content, increase in the structure of zircon from the early to late magmatic origin, which is consistent with the expansion of the lattice parameters. The occurrence of the three zircon types in the Xiangshan arfvedsonite granites is interpreted to reflect the progressive fractionation of granitic melt from hypersolvus to subsolvus conditions. Therefore, we conclude that the lattice expansion of zircon in this study results from chemical incorporation of trace element and volatile components during the magmatic to hydrothermal evolution of granitic magma. Besides, the textural and compositional evolution of zircon can be used as efficient indices for the fractionation and evolution of A-type granitic system.

Keywords: Chemical lattice expansion, zircon, fractionation crystallization, magmatic-hydrothermal evolution, A-type granite