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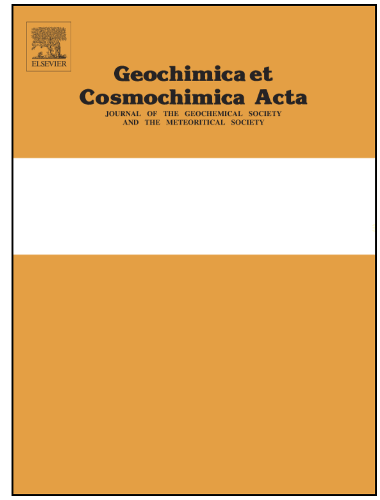

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The magmatic–hydrothermal transition in rare-element pegmatites from southeast Ireland: LA-ICP-MS chemical mapping of muscovite and columbite–tantalite

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Abstract

The processes involved in the magmatic–hydrothermal transition in rare-element pegmatite crystallization are obscure, and the role of hydrothermal mechanisms in producing economic concentrations of rare elements such as tantalum remains contentious. To decipher the paragenetic information encoded in zoned minerals crystallized during the magmatic–hydrothermal transition, we applied SEM-EDS and LA-ICP-MS chemical mapping to muscovite- and columbite-group minerals (CGM) from a rare-element pegmatite of the albite-spodumene subtype from Aclare, southeast Ireland.

We present a three-stage model for the magmatic–hydrothermal transition based on petrography, imaging and quantification of rare-element (Li, B, Rb, Nb, Sn, Cs, Ba, Ta, W, U) zoning, integrated with geochemical modeling and constraints from published literature. Stage I marks the end of purely magmatic crystallization from a peraluminous granitic melt. In stage II, polymerized silicic melt and depolymerized alkaline aqueous melt coexist as immiscible media, both of which influence muscovite and CGM crystallization. Stage II also marks the onset of phyllic alteration of primary mineral assemblages. Hydrothermal fluid release causes further resorption of primary minerals and eventual precipitation of fine-grained albite in stage III.

Muscovite and CGM both exhibit trace-element zoning, while CGM also show major-element zoning. Petrographic relationships and geochemical markers such as Ta# (=Ta/[Ta+Nb]) of individual mineral zones reveal that both mineral species crystallized contemporaneously over all three stages. Furthermore, Rayleigh fractional crystallization of muscovite is efficient in fractionating Ta from Nb. Tantalum and Nb are additionally fractionated by halogen-rich aqueous media, which remobilize both elements, but redeposit