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Trace Element Signatures of Quartz from Li-Cs-Ta Pegmatites as Exploration Vectors for Li-mineralization: Examples from Austria and Ireland

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Increased demand for lithium has led to renewed interest in known lithium-cesium-tantalum (LCT) pegmatite occurrences and an exploration surge for new lithium resources, particularly in regions with low raw material production and heavy importation (e.g., the European Union). Trace element concentrations in quartz were determined from two well-known LCT pegmatite regions in Europe to test the applicability of quartz as a pathfinder mineral for Li-mineralization. The Moylisha area (SE Ireland) and the Eastern Alps (Austria) represent two distinctly different geological histories. The spodumene-bearing (mineralized) and spodumene-free (barren) pegmatites at Moylisha form a late Silurian to early Devonian NE-SW-striking pegmatite belt that intruded the East Carlow Deformation Zone along the SE margin of the late Caledonian S-type Leinster Batholith. Contrastingly, pegmatites of the Eastern Alps are associated with late Permian lithospheric thinning/basaltic underplating that formed a larger pegmatite province spanning the Eastern Alps. They were metamorphosed at up to eclogite-facies conditions during the Alpine orogeny.

All analyzed pegmatites contain assemblages including feldspar, quartz, muscovite ± spodumene. LA-ICP-MS analysis shows quartz from mineralized pegmatites in both regions as distinguishable from that in barren pegmatites by higher concentrations of Al, Li, Ge and B, whereas barren pegmatite quartz contains higher Ti. Principal component analysis of quartz data shows that Al and Li signatures characterize quartz in pegmatites from Moylisha whereas Ge and B signatures characterize quartz in pegmatites from the Eastern Alps. In quartz from pegmatites and associated leucogranites across the Eastern Alps, concentrations of Al, Li, Ge and B increases eastward with highest concentrations occurring at the Wolfsberg lithium deposit, showing its utility as a vector towards significant Li-mineralization. The coupled substitution $Al^{(3+)} + Li^{(+)} \rightarrow Si^{(4+)}$ governs the Li content in quartz, and concentrations of >100 $\mu g g^{-1}$ Al and >30 $\mu g g^{-1}$ Li represent an important threshold for spodumene mineralization.