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The use of X-ray micro-computed tomography to visualize and quantify lithium-bearing silicate minerals in pegmatites: Examples from the Tanco Pegmatite, Manitoba, Canada

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Abstract

X-ray micro-computed tomography (micro-CT) has been used in the geosciences to visualize the spatial arrangement of minerals and pores within rock samples. It is a powerful technique that can potentially be used to analyze lithium minerals as well, owing to its unique ability to non-destructively image microstructures and quantify mineral abundances in three dimensions (3D). The Tanco pegmatite in Manitoba, Canada, has a high abundance of the lithium-bearing mineral spodumene. In this study, all spodumene-quartz intergrowths were collected from zones 45 or 50 of the Tanco pegmatite. Three textural groups of spodumene and quartz intergrowths (SQUI) were recognized: the most abundant type of spodumene-quartz intergrowths observed at Tanco are elongated and oriented crystals, hereafter referred to as (1) "classic SQUI," less common are quartz-spodumene intergrowths <1 mm referred to here as (2) micro-SQUI and intergrowths of stubby crystals of spodumene and quartz that are more than 1 cm, termed (3) macro-SQUI.

The relative 3D relationships between spodumene and quartz in the different SQUI groups were spatially correlated and quantified by micro-CT. The micro-SQUI group showed a mesh of multiple, complexly intergrown spodumene and quartz symplectites. The classic SQUI type showed a unidirectional crystallization texture in the samples, whereas the macro-SQUI group did not show a preference for crystallographic orientation. The relative proportions of the minerals comprising SQUI within small drill core sample volumes were quantified in three dimensions and contrasted to low spatial resolution bulk assay methods such as Rietveld X-ray diffraction (XRD) and bulk ICP-MS. The quantified results from micro-CT were categorized as spodumene and a "less dense than spodumene" fraction that included mostly quartz with minor amounts of muscovite, analcime, and albite. The absolute percentage differences between the micro-CT quantifications of spodumene from 6 out of 8 samples were within ±7% of Rietveld XRD results and 7 out of 9 samples were within ±10% of the calculations based upon the whole-rock geochemistry.

Although not all intergrowths of spodumene and quartz are interpreted to have originated by replacement of petalite, there are many instances where this texture resulted from the breakdown of petalite; this texture has been termed "SQUI." This should result in intergrowths containing a weight percent ratio of 60% spodumene to 40% quartz. Our micro-CT results show spodumene modal abundances between 54 to 70 wt%, suggesting that SQUI can have multiple origins and that the currently accepted assumption is too simplistic.

Our research shows that micro-CT can successfully be used as a 3D visualization and quantification tool of Li-silicate minerals while providing additional contextual information that low spatial resolution bulk techniques cannot provide. This study also shows the diverse possibilities of utilizing micro-CT analysis in visualizing silicate textural information between minerals with density differences of at least 0.55 g/cm^3, which includes investigating spodumene and quartz in 3D, highlighting an impactful use of micro-CT as a critical mineral visualization and quantification tool in pegmatites. This is important as the texture of spodumene can assist in determining the origins of lithium mineralization and can influence metallurgical processes. Understanding these aspects is vital for identifying further mineralization within deposits and assessing their economic viability.

Keywords: X-ray computed tomography, lithium, spodumene, pegmatite, Special Collection: Pegmatites