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Magmatic-Hydrothermal Alteration and Deformation of Spodumene Pegmatites from Musha-Ntunga (Rwanda)

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LCT-type pegmatites in the Mesoproterozoic Karagwe-Ankole Belt of Central Africa are intimately linked with granitic complexes that were emplaced approximately 1 billion years ago. This study focuses on drill core samples from spodumene-bearing pegmatites in the Musha-Ntunga region of eastern Rwanda, which are associated with the lake Muhazi granitic pluton. Our approach integrates petrographic, Raman spectroscopy, cathodoluminescence microscopy, elemental geochemical techniques (EPMA and LA-ICP-MS), and X-ray diffraction of spodumene grains to investigate the mineralization sequence, microtextural variations, and lithium distribution across key paragenetic stages. These stages encompass primary magmatic crystallization, magmatic-hydrothermal and hydrothermal alteration, and subsolidus deformation.

We have identified five textural types of spodumene. The first two are primary magmatic coarse-grained spodumene (Spd type 1) and spodumene with symplectitic spodumene-quartz intergrowth rims (SQI; Spd type 2). Spd types 3 and 4 are finer-grained intergrowths developed during consecutive magmatic-hydrothermal to hydrothermal alteration events. Additionally, the pegmatites underwent localized deformation, evident through various textures such as sigma-clast-shaped porphyroclasts ("spodumene fish") and boudinage structures of deformed Spd type 1 crystals, indicative of both brittle and ductile deformation processes. The strained Spd type 1 crystals experienced partial recrystallization to fine-grained elongated crystals (Spd type 5), occurring in bands with muscovite, quartz and apatite, and emphasizing the primary orientation of foliation.

Spodumene grains can be (partially) replaced by albite, microcline, muscovite, and quartz during magmatic-hydrothermal activity; and by cookeite, eucryptite, lithiophilite and kaolinite during late-stage alteration.

Montebrasite is identified both as a late primary magmatic phase coexisting with spodumene and as a secondary recrystallized phase formed during magmatic-hydrothermal alteration and subsequent deformation. Other ore minerals present, including cassiterite, columbite-tantalite, and monazite, further record the transition from a magmatic to a hydrothermal and deformational regime.