Multi-Stage Fluid Alteration of the Agua Santa Pegmatite (Brazil): Implications for Mineral Zonation and Exploration

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Zoning is commonly observed in lithium bearing pegmatites, however overprinting by metasomatic and/or hydrothermal alteration obscures and complicates the identification and interpretation of zoning. The 65 m wide Agua Santa (AS) pegmatite in Minas Gerais, Brazil, is a spodumene-bearing pegmatite within a NE/SW trending shear zone that hosts significant Li deposits (such as the Cachoeira -CBL- and the Xuxa -Sigma- mines). Four distinct mineralogical zones have been identified in the field:

- Zone 1 (top of the pegmatite): Quartz + albite + tourmaline, overprinted by albitization.
- Zone 2: Quartz + K-feldspar + minor tourmaline/mica, with graphic textures.
- Zone 3: Quartz + K-feldspar + tourmaline.
- Zone 4 (innermost): Spodumene clusters (variably altered) + quartz K-feldspar,+ marking lithium saturation.

The AS pegmatite is considered to be a good example of a fractionated pegmatite as evidenced by white micas geochemistry results with elevated Cs (up to 2500 ppm) and Rb (up to 6000 ppm), and low K/Rb ratios (e.g. 18) suggest this pegmatite formed from a highly fractionated granitic melt. Furthermore, high aluminium (e.g. 40 wt.%) contents in these micas suggest that these melts were sourced from Al-rich metasedimentary protoliths, or strongly interacted with albitizing or other late-stage fluids.

Multi-stage alteration of magmatic minerals is evident from: (1) pervasive albitization, with albite primarily replacing quartz, K-feldspar and most importantly spodumene; (2) secondary quartz-mica veining; and (3) late clay overprinting. Albitization of spodumene diminishes the economic potential of pegmatites, but the origin of such fluids remains uncertain. Further stable isotope analysis of quartz will help identify the source of these metasomatizing fluids and whether they are meteoric or hydrothermal in origin.