

## Are crystal-rich inclusions in spodumene crystallized aliquots of boundary-layer melt?

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The constitutional zone-refining model for the crystallization of granitic pegmatites stipulates that a highly-fluxed and incompatible element-enriched boundary-layer liquid develops at rapidly advancing crystal growth fronts in undercooled granitic melts. It has been argued that crystal-rich inclusions in granitic pegmatites represent the products of entrapped boundary-layer melts and are thus not representative of the bulk-melt composition. A key example given in support of this claim is the crystal-rich inclusions in spodumene from the Tanco pegmatite, Manitoba. According to London [1], boundary layer melts are erratically variable and chemically more evolved than the bulk-melt, and this is precisely the characterization that describes the silicate-rich inclusion at Tanco. However, at Tanco, inclusions of the same character and composition occur in two types of spodumene: 1) primary magmatic spodumene laths, and 2) secondary spodumene, formed together with quartz by the isochemical breakdown of petalite. Although it is conceivable that a boundary-layer melt developed at the growth front of primary magmatic spodumene and petalite, it is unlikely that this ephemeral and spatially-restricted melt was available for entrapment in secondary spodumene during the transformation of petalite to spodumene + quartz.

Inclusions in both secondary and primary spodumene contain an assemblage of minerals (mainly quartz, cookeite and zabuyelite, with rare cesium analcime, albite, nacohlite, and Ca-Mn carbonates) that is essentially identical to the alteration assemblage in the lithium-rich zones at Tanco [2]. Image analysis measurements of 450 inclusions reveal a positive correlation between volume percent of solid phases in an inclusion and inclusion size, indicating extensive necking after precipitation of the solids. These observations suggest that the crystal-rich inclusions are not crystallized aliquots of boundary-layer melts but are instead samples of aqueous-carbonic fluid that had dissolved spodumene and precipitated quartz, cookeite and zabuyelite during and after entrapment.

[1] London (2008) *Canadian Mineralogist Special Publication* **10**.

[2] Černý (1972) *Canadian Mineralogist* **11**, 714-726.

## Dissolved <sup>231</sup>Pa/<sup>230</sup>Th in the U. S. GEOTRACES North Atlantic Zonal Transect

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The North Atlantic Ocean displays zonal gradients in many of its properties. The western basin has more recently ventilated deep waters [1] and also a greater standing crop of suspended particulate material [2]. Both of these factors have the potential to induce zonal concentration gradients in <sup>231</sup>Pa and <sup>230</sup>Th. These radionuclides are produced uniformly throughout the water column by the decay of U. The balance between their subsequent redistribution by adsorption onto sinking particles (scavenging) and ocean circulation is not well known and incites debate over the interpretation of sedimentary <sup>231</sup>Pa/<sup>230</sup>Th ratios with significant paleoceanographic consequences.

New results from the U. S. GEOTRACES North Atlantic Zonal Transect, completed over two legs in 2010 and 2011, will be presented that highlight the contrast between east and west <sup>231</sup>Pa/<sup>230</sup>Th distributions. Furthermore, the deconvolution of the influences of deep water ventilation and scavenging intensity on <sup>231</sup>Pa/<sup>230</sup>Th distributions can be discussed in light of indicators of particle concentrations from transmissometry and indicators of ventilation such as chlorofluorocarbons and <sup>14</sup>C [3]. Nepheloid layers, or more turbid waters containing resuspended sediments near the seafloor, were sampled in both the eastern and western basins. The increased scavenging intensity associated with these layers in environments of contrasting circulation patterns further informs our deconvolution of the two effects. These observations contribute to a more complete understanding of the chemical cycling of <sup>231</sup>Pa and <sup>230</sup>Th in the modern ocean and may inspire new directions for the interpretation of sedimentary records.

[1] Broecker et al. (1991) *GRL* **18**, 1-3. [2] Biscaye and Eittrich (1977) *Mar. Geol.* **23**, 155-172. [3] Holzer et al. (2010) *JGR* **115**, C077005.