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Massive Pollucite ((Cs,Na)₂Al₂Si₄O₁₂ x H₂O) – Processes of extreme Caesium Enrichment within LCT Pegmatites

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Lithium Caesium Tantalum (LCT) pegmatites are the sole resources for the rare metal Cs. The alkali metal Cs is principally used in form of chemical compounds (e.g. Cs-formate, CsCl, CsI) in the oil/gas exploration and chemical industry. Its annual consumption is estimated to be a few 10.000 kg.

Average concentrations of Cs for the continental crust are estimated to be 2 ppm [1]. Mineralogically, vast amounts of Cs substitute into major rock forming minerals (e.g. feldspar, mica). Albeit extremely rare, Cs can form discrete minerals like pollucite ((Cs,Na)₂Al₂Si₄O₁₂ x H₂O) where Cs is a major component. Pollucite forms a solid solution series with analcime and contains between 5 to 41 wt.% Cs₂O. Occurrences of pollucite are restricted to the geochemically most enriched and highest fractionated portions of LCT pegmatites. Despite its frequent occurrence in LCT pegmatites, economic quantities are only known from several localities worldwide (e.g., Bikita/Zimbabwe, Tanco/Canada).

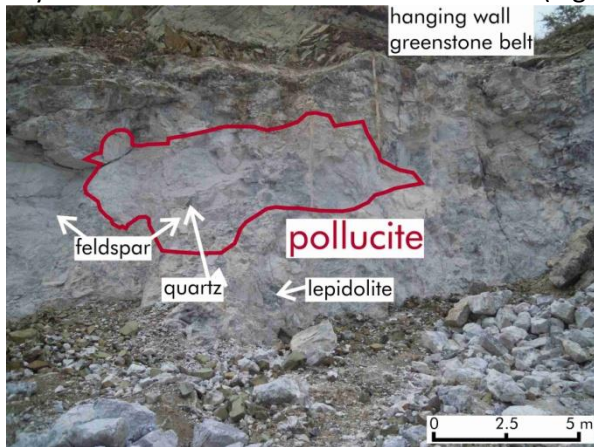


Figure 1: Massive pollucite lense within the upper portion of the pegmatite in the Bikita Main Quarry.

At the Bikita LCT pegmatite deposit, pollucite is found as several almost monomineralic lensoid bodies that occur in the upper portions of the pegmatites. Individual ore bodies have dimensions of up to 100x100x15 m. Furthermore, the massive pollucite lenses are characterised by a prominent vein network filled with lepidolite, petalite and quartz.

New geochemical, mineralogical and mineral chemical data [2] suggest a five stage model for Cs enrichment and the formation of the massive pollucite lenses within the Bikita LCT pegmatite deposit. After emplacement, initial crystallisation formed the border and wall zone of the pegmatite, while immobile elements (i.e., Cs, Rb) are enriched

in the remaining melt and fluid. A relatively small portion (0.5-1 vol.%) of immiscible melt of fluid, depleted in SiO₂ and enriched in Al₂O₃ and immobile elements will separate and ascend gravitationally to the upper portions of the pegmatite where it crystallizes as analcime. The remaining melt crystallizes separately to form the inner portions of the pegmatite. Crystallisation is accompanied by ongoing fractionation and enrichment of incompatible elements in the remaining melt and fluid. As analcime forms a solid solution series with pollucite, the analcime is able to substitute any available Cs from the melt and associated hydrothermal fluid. This substitution is further enhanced as analcime is subjected to a negative thermal expansion (1 vol.%) when cooled below 400 °C. This causes the formation of cracks that are used as conduits for the circulating hydrothermal fluids and will be later filled by lepidolite, petalite and quartz. Furthermore, late stage mineral replacement reaction and subsolidus self-ordering

processes in feldspars release additional Cs into late stage hydrothermal fluids that is incorporated into the massive pollucite lenses.

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References:

- [1] Rudnick RL and Gao S (2014) In: Treatise on Geochemistry (Second Edition) Vol. 4, Elsevier, 1-51
- [2] Dittrich T et al. (2015) Final project report: 536p.

