Implications of the Magma-Mush Concept for Lithium Enrichment Processes in LCT Pegmatites

Louis R. G. Penfound-Marks[1], Ben J. Williamson[1], Julian F. Menuge[2], Lawrence C. Carter[1]
1. Camborne School of Mines, University of Exeter, Cornwall, United Kingdom, 2. iCRAG, the SFI Research Centre in Applied Geosciences, and School of Earth Sciences, University College Dublin, Belfield, Dublin 4, Ireland

LCT pegmatites are the world's premier hard-rock source of Li, which is used in rechargeable batteries and an increasing range of other high-tech and green technologies. Despite this, the mechanisms that concentrate Li in pegmatites are poorly understood, hampering the development of exploration models. Processes advocated by other authors include fractional crystallization, constitutional zone refining, and melt-melt-fluid immiscibility under supercritical conditions. Although these could cause short-lived saturation with respect to minerals such as spodumene and petalite, their crystallization would stop as Li melt concentrations fall. These processes cannot therefore explain sustained crystallization of Li phases through almost the entire volume of certain pegmatites, especially of spodumene in most spodumene pegmatites.

As part of the EU H2020 GREENPEG project, we are studying the implications of the magma-mush concept for the enrichment of Li in pegmatite-forming systems, initially based on unzoned to weakly zoned spodumene pegmatites in the Leinster belt of south-east Ireland. From theoretical considerations, we propose that Li in the magma source variably diffuses from solid phases into melts and fluids which then migrate through crystal-mush pathways and evolve to more Li-rich compositions due to percolative reactive flow. Fluids are sourced from a relatively larger volume than melts and move more rapidly through the crystal mush due to their comparatively low viscosity and surface tension. As Li melt concentrations fall due to the crystallization of Li-bearing phases, so the flow of Li-rich fluids through the mush refertilises the melts due to diffusion of Li along chemical potential gradients. Macrotextural evidence in support of the presence of fluid-crystal mush and percolative fluid flow includes aplite and quartz (originally fluid) mingling/flow channels, chaotic and jumbled pegmatite structures, and multiple generations of magmatic and hydrothermal spodumene. The results of ongoing micro-textural and chemical studies will be discussed.