Magmatic-Hydrothermal Crystal Mush within the Porphyry-Forming Environment – Spatial and Temporal Constraints

Lawrence C. Carter[1, 2], Ben J. Williamson[2], Simon Tapster[3], Gavyn K. Rollinson[2]
1. LC Geoscience, Cornwall, United Kingdom, 2. Camborne School of Mines, Cornwall, United Kingdom, 3. BGS, Keyworth, United Kingdom

Porphyry-type deposits are associated with large, long-lived magmatic systems, where mineralising fluids are mostly derived from mid- to shallow crustal magma or possibly crystal mush reservoirs. For the latter, what remains to be established is their role in the evolution, transport ,and focussing of fluids into relatively narrow and shallow (ca. 2- to 5-km-deep) zones of mineralisation. Even more problematic, however, is a paucity of first-order textural evidence for the presence of crystal mush in magmatic systems, including those that host porphyry-type deposits.

To address this, we have studied uniquely exposed cupolas and root zones of magmatic-hydrothermal systems in Saginaw Hill, Tuscon, Arizona, and in the archetypal Yerington District, Nevada. From field- to micro-scale (QEMSCAN, SEM-EDX-CL, EPMA, and TitaniQ) textural and geochemical studies, particularly observations of vermiform quartz in miarolitic cavity- and vein-mineralised aplitic dikes, we evidence the development of crystal mush-fluid pathways at the magmatic-hydrothermal transition. These are shown to be in close spatial association with unidirectional solidification textures and massive silica caps, indicative of magmatic undercooling and first-type boiling, and lie just below the main zone of porphyry mineralisation. By integrating our observations with zircon U-Pb CA-ID-TIMS and molybdenite Re-Os geochronology, we place spatial and temporal constraints on the formation of these features at the deposit to district scale and suggest that their presence should be considered in any new exploration models for porphyry- and similar-type deposits.