Insights into granite-related mineralisation from in situ studies of accessory minerals

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Project description

There are contrasting models for the development of Cu-Au and Sn-W mineralisation associated with granitic rocks. Porphyry Cu deposits have recently been linked to the concentration of metals by accumulation of brines [1], and there are also models that link the type of mineralisation to the prevailing redox conditions. Tracking the evolution of fluid chemistry, magma sources, and redox state using the accessory minerals zircon and apatite in both fresh and altered granitic rocks has considerable potential for constraining the conditions that do and do not lead to mineralisation.

There is increasing evidence that whole rock granite samples can include mixtures of minerals that crystallised from different magma batches. Moreover in many parts of the world, and especially in highly mineralised provinces, fresh representative whole rock samples are difficult to obtain. This project therefore builds on recent studies that have used in situ analytical techniques to access the magmatic archives in apatite and zircon. High spatial resolution in situ analytical techniques ensure greater confidence in what is being analysed, particularly in complex, zoned grains with prolonged growth histories. The minor, volatile (CO_2, Cl, OH, S) and trace metal contents of apatite have been shown to link to those in whole rocks, and Sr, Nd and O isotope data can be routinely obtained in situ from these grains. Of particular interest to this project is that the redox conditions of the parent magmas can now be evaluated from the Mn content of apatite [2], while the fluid composition can be reconstructed from volatile contents. Zoned grains will enable temporal evolution to be deduced.

We will test this approach using three granitic systems; two are mineralised and one is not. All three contain abundant apatite and zircon. Cornwall is a classic area of granite-related mineralization, there is considerable information available, and it contains a greater diversity of metal mineralisation (e.g., Sn, W, Cu, Pb, Zn, As) than many other granite provinces. The Don Manuel igneous complex in northern Chile is a Cu-Mo mineralised porphyry system currently under investigation at Bristol. The Lluta Batholith in northern Chile is a non-mineralised granite spatially associated with large porphyry copper systems. The accessory mineral records from all three systems will be used to evaluate what, if any, geochemical characteristics distinguish mineralised and non-mineralised systems and how these characteristics varied during magmatic differentiation.

[1] Blundy, J., Mavrogenes, J., Tattich, B., Sparks, S. & Gilmer, A. (2015) Generation of porphyry copper deposits by gas-brine reaction in volcanic arcs. Nature Geoscience 8, 235-240

[2] Miles, A.J., Graham, C., Hawkesworth, C., Gillespie, M.R., Hinton, R.W., Bromiley, G.D. (2014) Mn in apatite: A new redox proxy for silicic magmas. Geochimi Cosmochim Acta, 132, 101–119.