Modelling zircon crystallisation and dissolution in crustal-scale magmatic systems

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The evolution of crustal scale magmatic systems controls the style of volcanic eruptions and the distribution of magmatic-hydrothermal ore deposits. Zircon is a key mineral for tracking the evolution of these systems as it allows resolving temporal changes in physical and chemical parameters by combining high-precision geochronology with isotope and trace element geochemistry. Interpreting complex zircon age distributions nevertheless remains challenging.

Here we combine a two-dimensional thermal model of an incrementally assembled crustal-scale magmatic system [1,2], phase equilibria modelling employing MELTS and Perple_X and experimental calibrations of zircon solubility [3,4] in silicate melts to quantify crystallization and dissolution of zircon during the protracted evolution of the magmatic system. The model quantifies changes in excess zirconium content over time while resolving spatial heterogeneities within the magmatic system. This allows predicting zircon age distributions for different parts of the system and as a funtion of multiple parameters (e.g. magma flux, parental melt composition, crustal lithology and geothermal gradient). Our model provides a framework for interpreting complex distributions of zircon U-Pb dates in crustal-scale magmatic systems. We compare our model results with recent high-precision U-Pb datasets from exposed crustal sections and find that our model reproduces observed distributions in remarkable detail allowing a more confident interpretation of the data.

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