Multi-stage zircon growth during a single partial melting event – Insights from REE partitioning

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Zircon crystallisation in migmatites and associated leucogneisses is commonly interpreted to occur during terrain-wide cooling following the peak of metamorphism. However, detailed study of zircon zoning in both absolute REE concentrations and partitioning behaviour with associated garnet, has revealed a more complex history of zircon growth.

Metapelite underwent biotite-controlled vapour-absent partial melting at ~6 kbar and ~860°C, with production of sillimanite-spinel-garnet melanosome and segregation of quartzofeldspathic leucosome. REE distribution data from texturally constrained zircon and garnet indicate that early-crystallised zircon in metapelitic gneiss grew in equilibrium with peritectic garnet *during* partial melting. Later-crystallised zircon is REE-depleted and probably grew during crystallisation of trapped melts. In leucogneisses zircon cores grew prior to substantial garnet growth, but the main phase of zircon grew in equilibrium with peritectic garnet *prior* to entrainment. Late, HREE-depleted zircon crystallised with the leucogneiss. Late pegmatites contain garnet that is intensely HREE-depleted relative to *entrained* zircon, which grew in equilibrium with metapelite garnet.

The data indicate that zircon growth does not solely occur at a single stage of a P-T path during *terrain-scale* crystallisation of melts, but at various stages during melt generation, transport and crystallisation. Zircon growth is accounted for by local *domain-scale* compositional and physical parameters that lead to multiple zircon growth events occuring across a terrain at different times and in different textural sites. Continued melting and melt extraction allows for entrainment of previously formed zircon into melts that crystallise *later* in the P-T evolution of the terrain. As such, prediction of the timing of zircon growth during the P-T evolution of a terrain and linking of U/Pb ages to specific stages on a P-T path, may not be accurately described by generic P-T-X models. Instead, detailed domain specific modelling is required, underpinned by textural and geochemical criteria that describe locations of zircon growth and timing relative to associated metamorphic assemblages.

Monitoring Uranium transformations

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Researchers have commonly assumed that reduction of U(VI) to U(IV) under anaerobic conditions would sequester uranium in the subsurface as uraninite, which has low solubility and is easily formed in the laboratory. Using X-ray absorption spectroscopy (XAS), however, our group and others have shown that products of biostimulation are more complicated than previously thought. As the complexity of a system increases, the nature of the products becomes increasingly difficult to predict. A useful research method in complex natural sediments is measurement on length scales smaller than the scale of natural heterogeneity. We have used X-ray-based techniques to monitor contaminant transformations in the local atomic distribution around U during biogeochemical evolution of highly heterogeneous subsurface material from the Integrated Field Challenge Site at Oak Ridge National Laboratory. We have applied X-ray fluorescence (XRF) to map the spatial distribution of key elements and XAS to monitor changes in U valence state and U speciation as they occur in intact, undisturbed microcosms for >1 yr. We have also taken subsamples for microbial analysis and monitored aqueous-phase parameters to link the U transformations to biogeochemical processes. These results will be presented.