Bane or boon of mineral alteration: Petrochronology of fluid- and deformation-related events

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Changing views on U-Pb chronometers: the bane?

Publications on U-Pb geochonology of zircon in particular have exhorted its mechanical and chemical robustness for several decades. Zircons are forever, has become a widely used phrase. However, *in situ* studies on micron-scale internal textures (Fig. 1) (e.g. [1]), changes in trace elements during deformation (e.g. [2]) and low-T zircon crystallization (e.g. [3]) have shown that 'zircon is forever changing' would be more appropriate. Polyphase monazite and xenotime have similar also been observed (e.g. [4]).

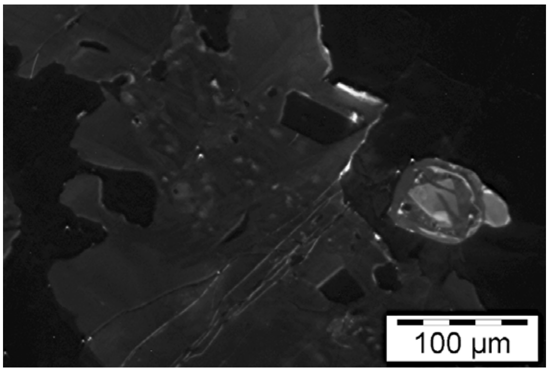

Figure 1: example of reactive zircon bahaviour: CL-bright zircon filling cracks in corundum and on grain boundaries in a fluid-altered metasediment.

Boon: robust chronometry from altered minerals

The described reactivity of these minerals that are robust and precise U-Pb chronometers presents a boon to studies on polymetamorphism, deformation or fluid-infiltration. Multiple events may be recorded to allow petrochronological interpretation by *in situ* analyses at the micron scale. Although precise dating may be restricted to larger domains, textures and trace element fingerprinting can provide the link to chronology. This is in considerable contrast to other mineral chronometers, that record such event, but are less robust chronometers, and therefore provide temporal contraints that are a function on the thermal history.

[1] A. Rimsa *et al*. (2007) *Am. Min*. **92**, 1213–1224. [2] N.E. Timms & S.M. Reddy (2009) *Chem. Geol*. **261**, 11–23. [3] D.C. Hay & T.J. Dempster (2009) *J. Petrol*. **50**, 571–589. [4] A. Möller (2000) *J. Conf. Abs*. **5**, 713.

Overview of Plutonium (Pu) transport in the vadose zone: Field experiments, mathematical modeling, soil-plant interactions and future research questions

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Understanding reactive transport processes in the vegetated and heterogeneous vadose zone requires a broad interdisciplinary approach. Such an approach is illustrated by the analysis of 11-year Pu lysimeter experiments at the Savannah River Site which showed anomalous Pu distributions below the source with migration above the source. The initial conceptual model of the transport process was based on steady-state and then fully transient soil water movement coupled to REDOX reactions between reduced and oxidized Pu species. Simulations from this model yielded reasonable below-source transport, but little above-source transport. The conceptual model was then modified to include Pu absorption by plant roots and upward movement in the transpiration stream. Resulting simulations in the 51-L lysimeters were consistent with Pu activity concentrations in the top 20 cm of soil and implied Pu transport into the shoots of the annual grasses growing in the lysimeters and an accumulation on the soil surface. Such a residue has now been verified by isotope ratio analysis. At this point it became clear that plants were an important pathway for Pu transport. This motivated laboratory experiments on corn that have verified rapid Pu transport in the transpiration stream and the probable involvement of Pu complexing agents in the transport process. These metal-complexing chemicals (siderophores) can greatly increase the mobility of iron (Fe), an essential mineral. Various plants may cometablize Pu with Fe, elements with nearly identical ionic radii, thereby increasing the mobility of complexed Pu in plant xylem by several orders of magnitude compared to the non-complexed molecule in the reduced state in soil (e.g. retardation factor in corn xylem is 1-10 and in many soils is 10^4-10^5). Throughout this study, mathematical models were used to analyze data. This analytical process can be conceived as a type of computer-aided thinking. Such an approach has been used to derive future research questions, test hypotheses and to visualize complex, nonlinear, property relationships. Computer-aided thinking differs from classical prediction in that results must be highly constrained by experimental data.