Infering diffusion rates and closure K/Ca dating of micas and K-feldspar

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The rates and timescales of processes that deform rocks under tectonic stress underpin our understanding of rheology, continuous vs. punctuated tectonic processes and fluid flow episodes. Dating mineral systems in ultra high pressure rocks has provided key insights into rates and timescales in subduction zones. However, U-Pb isotope geochronology is challenged by lack of mineral growth and Ar-Ar geochronology is commonly affected by excess argon.

We have performed SIMS measurements at Edinburgh University using the Cameca 1270 in order to estimate relative differences in diffusion rates between Ca and Ar in these systems. Our approach has been to analyse well characterised gem quality K-feldspar and micas known to exhibit age profiles.

The well studied Itrongay K-feldspar from Madagascar [e.g. 1] has Ar-Ar ages at the grain boundaries around 420 Ma but increasing over several hundred microns to ages around 470 Ma in the cores of grains, reflecting an extended cooling history. K/Ca data on the same grain indicate similar ages but a very different profile allowing us to estimate the relative diffusion rates and thus likely differences in closure.

The Presidential Range of New Hampshire, USA, offers an ideal site to study argon age profiles in muscovite [e.g. 2]. An earlier study using a UV laser to profile the grains at high spatial resolution and measure Ar-Ar ages confirmed the age ranges measured by stepped heating and laser fusion with individual samples yielding age range of tens of millions of years in the range 290-350 Ma. Age profiles also stretched over hundreds of microns.

Using the relative age profiles of Ar-Ar where diffusion rates are relatively well constrained we are able to infer diffusion rates for Ca and constrain the K/Ca geochronometer. Combining this approach with in situ Rb/Sr ages profides an amazing opportunity to gain a better understanding of the tectonics, thermal history and fluid history of these key zones in the Earth's crust.