# Effect of apatite crystal environment on its closure temperature

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High temperature thermochronology (>150°C) is used to study a range of processes from planetary accretion and meteorite impacts to exhumation of deep crust. Thermochonology assumes radiogenic daughter isotopes are dispersed by volume diffusion. A second fundamental assumption which is commonly made by practicioners (e.g. [1]) is that there is complete loss of the daughter isotope once it reaches the crystal boundary. These assumptions are intrinsic to Dodson's equation for closure temperature [2], but are they always valid?

We have created a MATLAB script which models the ingrowth and volume diffusion of $^{208,\ 207,\ 206,\ 204}$Pb in apatite inclusions that have complex geometries and $^{238,235}$U and $^{232}$Th zonation. The host mineral and inclusion are assumed to be in equilibrium at the boundary according to the distribution coefficients between the phases ($Kd=C_{host}/C_{inclusion}$). The distribution coefficient is assumed to be constant throughout the time. As a first test, models for spherical geometries with different distribution coefficients were run.

Our preliminary results suggest that for an apatite inclusion in a medium with diffusive properties of alkali feldspar, the actual Pb-in-apatite closer temperature significantly differs from that calculated using Dodson's equation [2]. The difference varies with Kd, grain size and cooling rate. For a cooling rate 50 °C/Myr and radii from 150 to 10 μm, model predictions are respectively 27 to 44 °C higher for Kd=15, 49 to 65 °C for Kd=5, and 83 to 104 °C for Kd=1. A deeper understanding of the grain boundary is required to model the case of Kd<<1, suggesting that the host phase is not tolerant to Pb. The modelling also predicts lead concentration profiles in the host mineral as a function of volume diffusion, which may be used for resolving certain time-Temperature (t-T) topologies. These results indicate the importance of understanding the influence of the crystal petrological environment when constructing t-T solutions. Investigations of our model of apatite inclusions are on-going, including comparing predicted and measured data.

[1] Cochrane *et al.* (2014) GCA **127**, 39-56. [2] Dodson (1973) CMP **40 (3)**, 259-274.