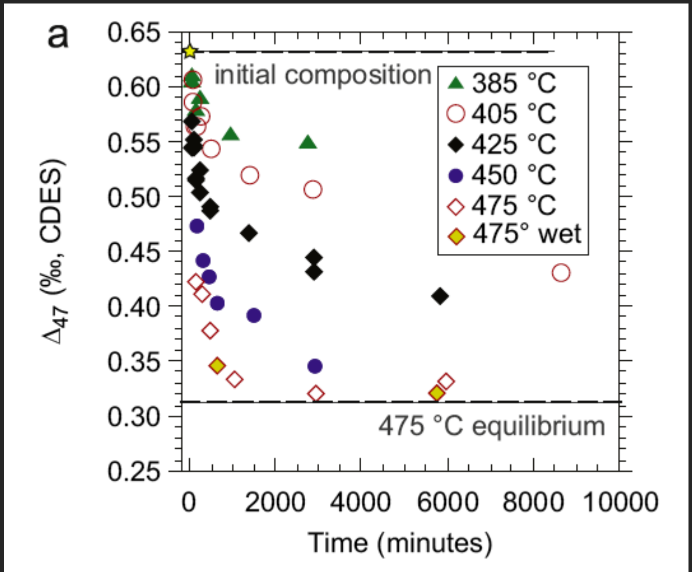
# Developing a carbonate clumped isotope geothermometer

In carbonate minerals, solid-state diffusion can lead to changes in the concentration of isotopic 'clumps' ($^{13}C$ and $^{18}O$ in the same carbonate molecule). The reaction forms the basis of an isotopic thermometer that increasingly leans to the right with decreasing temperature.

$$Ca^{13}C^{16}O_3 + Ca^{12}C^{18}O^{16}O_2 \leftrightarrow Ca^{13}C^{18}O^{16}O_2 + Ca^{12}C^{16}O_3$$

With support from ACS–PRF, we examined the kinetics of the solid-state $^{13}C$-$^{18}O$ reordering reaction. We determined Arrhenius parameters allowing the reaction rate to be predicted as a function of temperature.

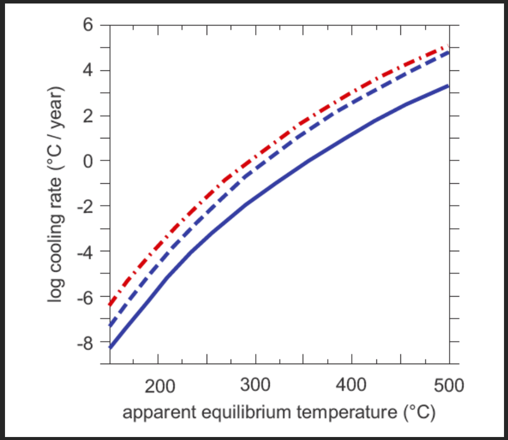



The first-order rate equation can be combined with the Arrhenius equation to predict the extent of clumped isotope reordering during heating at a specific temperature for a specific length of time.

$$\ln\left[\frac{\Delta_{47}^{t}-\Delta_{47}^{eq}}{\Delta_{47}^{init}-\Delta_{47}^{eq}}\right] = \ln\left[1-\frac{\Delta_{47}^{init}-\Delta_{47}^{t}}{\Delta_{47}^{init}-\Delta_{47}^{eq}}\right] = \ln[1-F] = -kt$$

$$k_T = K_o \ \exp(-E_a/RT)$$

The solid-state reordering process can also be used to record cooling rates of exhumed strata or rock units cooling after metamorphism. The final state of $^{13}C$-$^{18}O$ clumping of a rock gives it's apparent equilibrium temperature $T_{ae}$, which is a function of cooling rate.




$$dT/dt = \frac{\gamma R T_{ae}^2 k_{Tae}}{E_a}$$

Benjamin H. Passey
bhpassey@jhu.edu

Dept. Earth and Planetary Sciences, Johns Hopkins University