Calcite clumped-isotope thermometry reveals conditions of burial diagenesis & temperatures of fluid migration along faults

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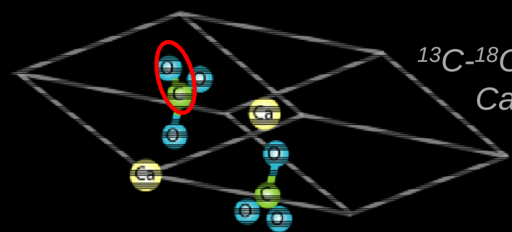
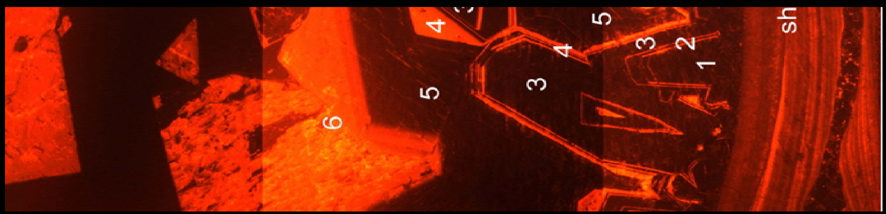
We are developing clumped isotopes as a tool to quantify temperatures (±1-2° C) of sub-surface carbonate growth and re-crystallization and the $\delta^{18}O$ of fluid-rock systems in basins. To do this, we are testing the method in well-characterized natural systems and precipitating >50° C calcite to improve the thermometer calibration.



^{13}C-^{18}O clumping in $CaCO_3$ (calcite)

A single clumped isotope measurement gives independent estimates of the growth temperature and $\delta^{18}O$ of carbonate minerals, enabling the $\delta^{18}O$ of diagenetic waters from which the minerals grew to be calculated

Conventional $\delta^{18}O$ and petrographic/CL analysis would suggest all diagenetic calcites in this sample (below) grew from meteoric waters at Earth surface temperatures. But clumped isotope temperatures of 14-122° C for multiple phases of primary and diagenetic calcite in the same specimen demonstrate this is not the case & constrain water-rock ratios (≤0.01 wt %) in the diagenetic micro-environment.



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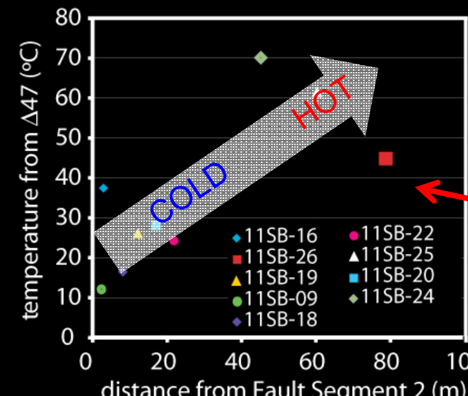

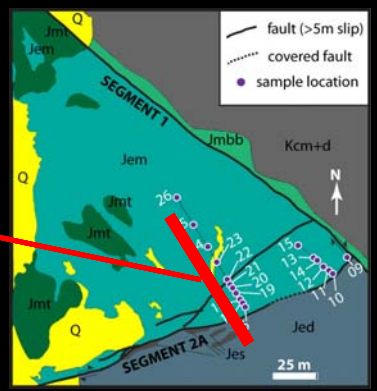

Bergman, Huntington et al., *in prep*

Clumped isotope results from the Moab Fault, Paradox Basin, Utah, show that the growth temperature of calcite vein cements increases with distance from the fault. Within 5 m of the fault, cements grew from shallow meteoric waters. At >40 m from the fault, cements reflect thermal equilibration with host rock at > 2 km depth.