From Earth's surface to the shallow crust: Updates on clumped isotope studies at the University of Washington

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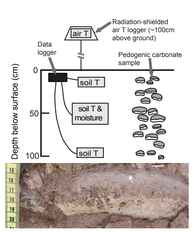
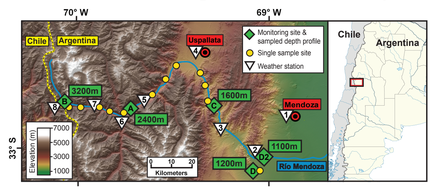
1. Hot or not? Impact of seasonally variable soil carbonate growth on T(Δ_{47}) & $\delta^{18}O$ records

This study examines the impact of seasonally variable soil carbonate formation on paleotemperature and δ18O records from paleosol carbonate.

APPROACH

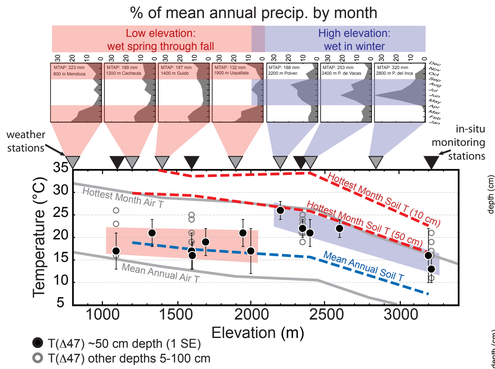
We collected Holocene soil carbonates and monitored environmental conditions along the eastern flank of the Andes (33°S) over 2 km of relief and ~15 °C range of mean annual air temperature.



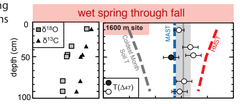


(Left) Soil pit monitoring & carbonate sampling. (Right) Map of sampling & monitoring sites and weather stations.

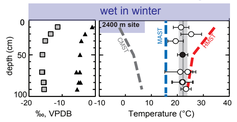
RESULTS



T(Δ47) for soil carbonates collected in the winter-precipitation zone >2 km elev. reflect summer soil temperatures, consistent with Passey et al., 2010; Quade et al., 2011; in press.



T(Δ47) below ~2 km is closer to mean annual soil temp.

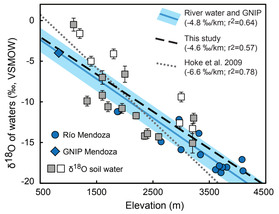


(Above) T(Δ47) vs. elevation in summer vs. winter precipitation zones. (Right) Soil T & carbonate T(Δ47), δ13C, δ18O vs. depth.

TAKE HOME

Results may reflect the dominance of summer precipitation below ~2 km, which likely delays soil drying and carbonate growth until fall.

(Right) Even though T(Δ47) cannot be used to reconstruct elevation here, soil water δ18O values calculated using T(Δ47) reflect modern river water δ18O values - significantly improving on previous estimates based on mean annual air temperatures.



Precipitation season seems to impact seasonally variable carbonate formation, which greatly impacts carbonate T(Δ47) & estimates of soil water δ18O values.

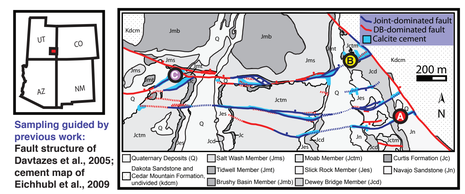
Details in: Peters, N.A., Huntington, K.W., Hoke, G.D. (2012). Hot or not? Impact of seasonally variable soil carbonate formation on paleotemperature and O-isotope records from clumped isotope thermometry. Earth and Planetary Science Letters. doi: 10.1016/j.epsl.2012.10.024.

2. The fluid superhighway: Interactions of structures and fluid flow along the Moab Fault

This study investigates the interactions of deformation structures and fluid flow along the Moab Fault in the Paradox Basin, Utah, one of the best-studied normal faults in clastic rocks.

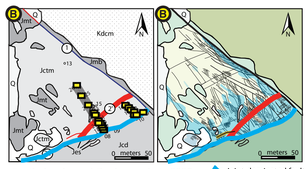
APPROACH

We measured the growth temperature of fracture-filling calcite cements (Right) precipitated at varying distance from fault segments (Below) dominated by different types of deformation structures: (1) joints, (2) deformation bands (DB) & slip surfaces.

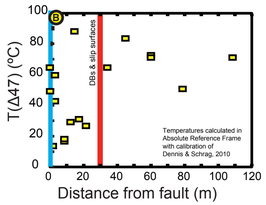


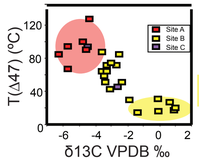
Sampling guided by previous work: Fault structure of Davtazes et al., 2005; cement map of Eichhubl et al., 2009

RESULTS



Fault structure of Davtazes et al., 2005; cement map of Eichhubl et al., 2009





hot, upward migrating basin fluids

cool, downgoing meteoric waters

(Above) The spatial pattern of cement T(Δ47) suggests that intensely jointed zones associated with fault intersections enable rapid downfault migration of cool surface waters and that deformation-band faults with their associated slip surfaces compartmentalize fluid flow.

(Left) T(Δ47) vs. δ13C for sites A,B,C indicates mixture of shallow & deep fluid sources.

TAKE HOME

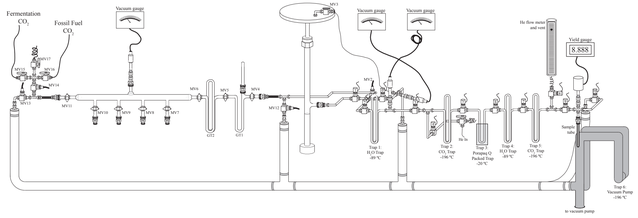
Our data confirm that the relationship between faults and fluid flow can vary greatly over short length scales, and suggest that some fracture zones can be highly conductive to depths as great as 2 km.

Details in: Bergman, S.C., Huntington, K.W., Crider, J.G. Use of carbonate clumped isotope thermometry to study interactions of structures and fluid flow, Moab Fault, Paradox Basin, Utah. Submitted to the American Journal of Science.

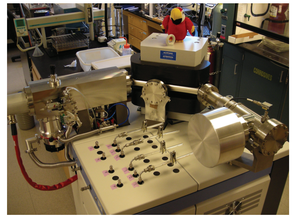
3. New facility for clumped isotope mass spectrometry of CO_2

With the installation of a new MAT 253 in UW's IsoLab in November 2012, we will now prepare carbonate samples offline using established techniques and measure samples automatically.

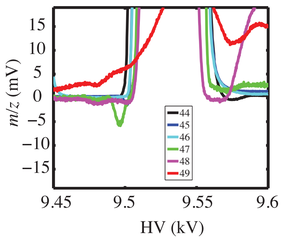
NEW FACILITY

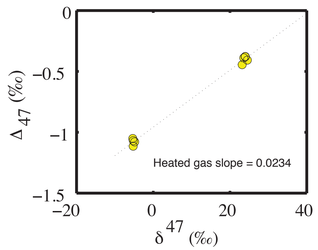


Our preparation line will allow for absolute reference frame equilibrated gas creation as well as carbonate digestion. We currently have gases equilibrating with three disparate waters at 4 °C, 25 °C, and 60 °C and will also use the 25 °C gases for the 1000 °C treatment. Carbonate samples and equilibrated gases will be processed automatically but offline. Ten samples at a time will be loaded onto a tube cracker (yet to be installed) and run automatically.



RESULTS





(Left) While we intend to measure and correct for the Pressure Baseline (as in He 2012), it doesn't appear to be different from zero at this stage.

(Right) Initial results of a heated gas equilibrated with local deionized water and with enriched water show a larger slope than other reported reference frame slopes (Dennis 2011).

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