Evaluating the paleohydrologic potential of triple oxygen isotopes across a natural salinity gradient in tropical Pacific lake waters.

Casey Saenger. Final Report

Paleoclimate data provides important constraint on the climate system that cannot be inferred from the brief observational record. This project tested the efficacy of $^{17}O_{excess}$ as a new paleohydrologic proxy in lacustrine settings using closed lakes on the central tropical Pacific atoll of Kiritimati. These lakes formed from isolated seawater after a mid-Holocene high stand, but variations in the timing of that isolation contribute to a range of hydrologic environments as indicated by salinities of <20 to >300‰. While this range of salinities is influenced by the degree of evaporation in each lake, it also likely reflects the relative influences near-marine lagoon water and precipitation.

With QRC support, I measured 49 lake and lagoon samples for $\delta^{17}O$, $\delta^{18}O$ and $\delta^{2}H$ (Figure 1) and compared data to *in situ* measurements of salinity. Consistent with the expectation that lake waters are influenced by evaporation, a plot of $\delta^{17}O$ vs $\delta^{18}O$ has a slope of 0.522 (Figure 2) that is shallower than the 0.528 observed in global meteoric waters. Furthermore, the deuterium excess and $^{17}O_{excess}$ show negative correlations with salinity, consistent with an evaporative impact.

To further explore the mechanisms responsible for variations in lake oxygen and hydrogen isotope composition, I have conducted a preliminary numerical modeling exercise. Using best estimates for modern precipitation and seawater isotope compositions, and established fractionation factors for equilibrium and kinetic fractionations associated with precipitation and evaporation, I have calculated how lake water might evolve with progressive evaporation at various temperatures and relative humidities. Furthermore, I have considered a series of starting compositions ranging from entirely precipitation to entirely seawater, with possible mixtures in between. Results are not conclusive, but suggest that the observed lake compositions could result from a number of scenarios rather than a singular mechanism. However, comparing multiple isotopes systems suggests that hypersaline lakes may be more likely to form from extreme evaporation of primarily meteoric water rather than mild evaporation of seawater. The results from this project indicate that paleoclimate reconstructions of past lake $^{17}O_{excess}$ would be difficult to interpret solely with respect to hydrologic variability and that further modern monitoring to fully understand the water balance of these lakes might be necessary before employing this potential proxy.

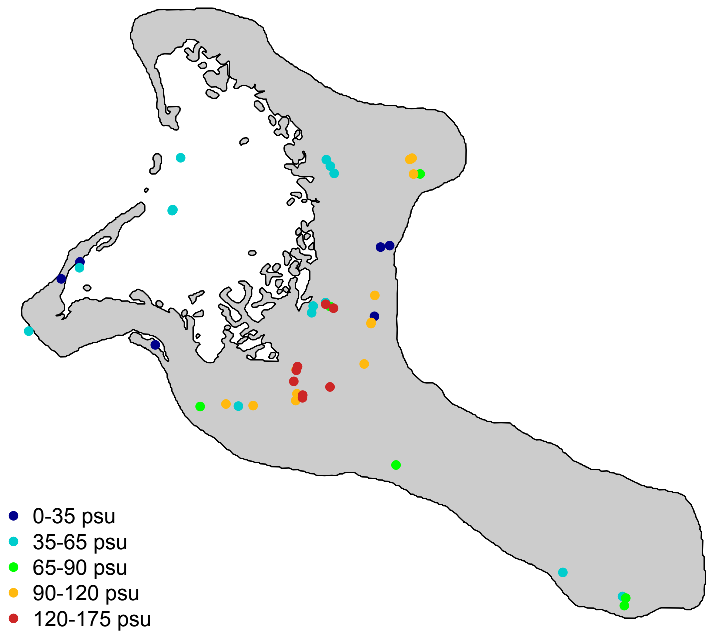

Figure 1: Map of lakes and coastal waters sampled in this study. Colors denote binned salinites and are consistent throughout other figures.

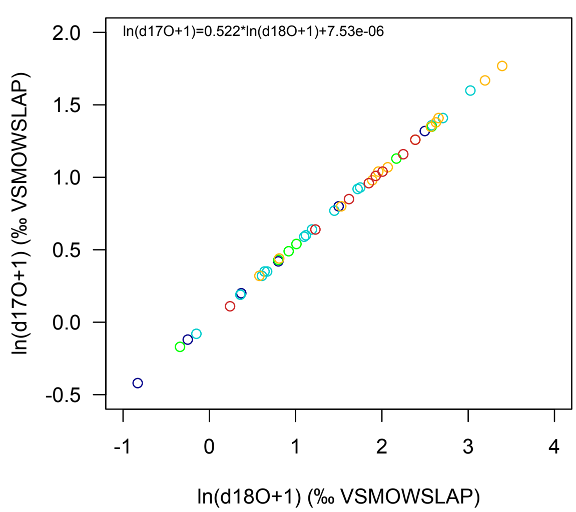

Figure 2: Plot of lake waters in triple oxygen isotope space. The best fit slope suggests a slope of 0.522 that is lower than the 0.528 of global meteoric waters. Colors denote salinity (see Figure 1)

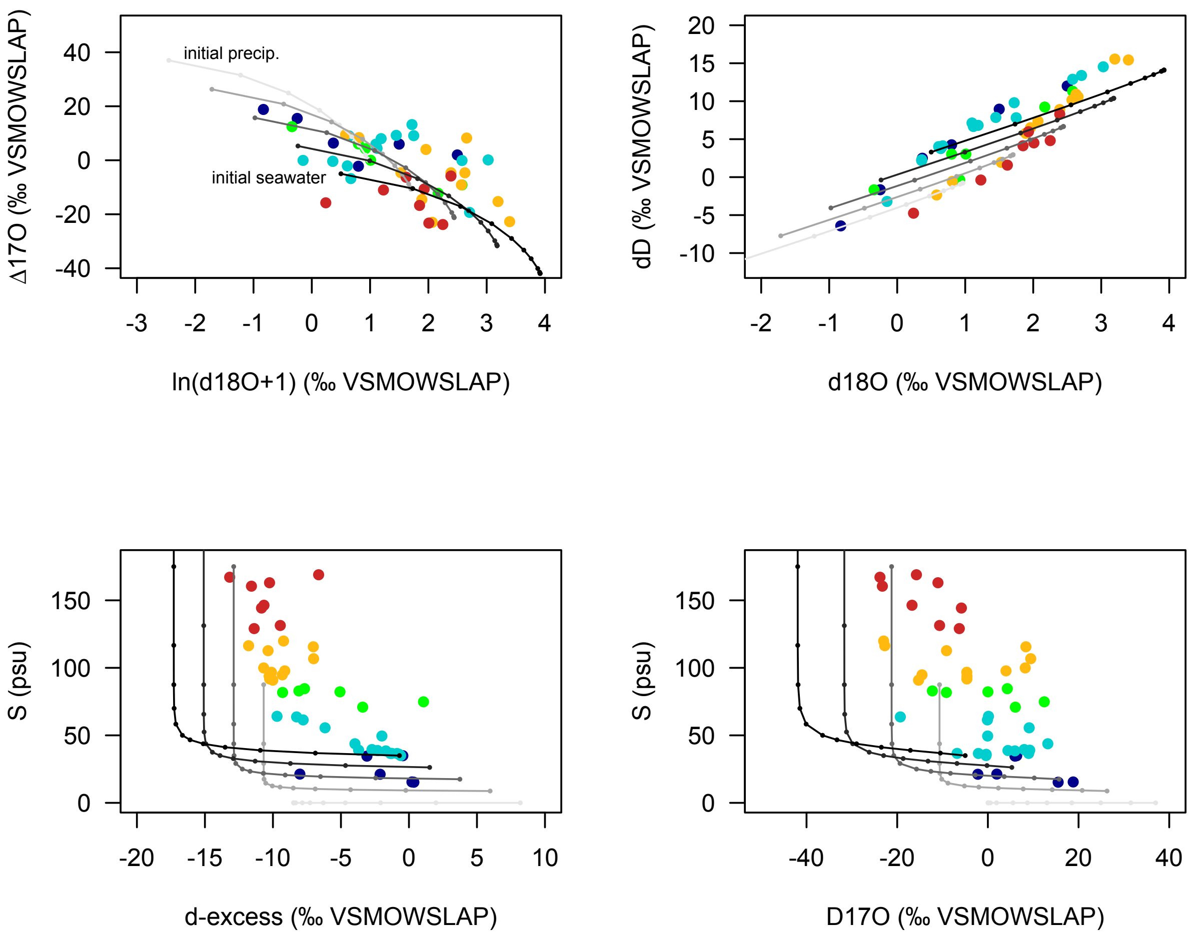

Figure 3: Results of preliminary isotope models calculating the evolution of lake waters with progressive evaporation. We consider 5 initial conditions ranging from entirely seawater (black) to entirely precipitation (lightest gray). Intermediate values indicate 75%, 50% and 25% seawater. From these initial conditions we calculated the isotopic evolution of lake waters. Dots for each initial condition represent the fraction of initial water remaining with values 0.95, 0.9, 0.85, 0.8, 0.75, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1. Initial lake and precipitation values come from modern observations. We assume a temperature of 25ºC and a relative humidity of 90% in the scenarios shown.