

## Isotope tracking of microbial sulfate reduction in oil reservoirs

MARK E. CONRAD<sup>1</sup>, CHRISTOPHER G. HUBBARD<sup>1</sup>,  
ANNA ENGELBREKTSON<sup>2</sup> AND JOHN COATES<sup>1,2</sup>

<sup>1</sup> Earth Sciences Division, Lawrence Berkeley National  
Laboratory, Berkeley, CA, USA; (msconrad@lbl.gov)

<sup>2</sup> Department of Plant and Microbial Biology, UC Berkeley,  
Berkeley, CA, USA

Seawater injection as a secondary oil recovery technique is considered to stimulate microbial sulfate reduction in oil reservoirs, leading to reservoir souring. Souring leads to major issues with oil production and refining. Several techniques to remediate souring have been tried, with the most common being addition of nitrate to the injected seawater. Tools are needed to monitor the onset of souring and track the efficiency of treatment options. Microbial sulfate reduction is known to impart large, characteristic shifts in the sulfur and oxygen isotope compositions of the residual sulfate and byproducts of the process that can be distinguished from other processes that may be occurring in the reservoir including precipitation of sulfate and/or sulfide minerals, dilution or sorption onto reservoir materials. In this contribution, we present preliminary experimental results designed to explore the use and sensitivity of isotopic signatures of sulfate and sulfide to monitor reservoir souring.

Two sets of column experiments to simulate reservoir souring and treatment with nitrate have been conducted. In the first set, seawater with and without nitrate was introduced to columns. Appearance of sulfide in the effluent from the untreated columns was observed after 5 days, but measurable shifts in the  $\delta^{34}\text{S}$  of the effluent sulfate were observed after only 2 days, indicating that sulfate reduction had already begun. In the nitrate columns, sulfide in the effluent was not observed until 3 weeks after the experiment began, but a shift in the  $\delta^{34}\text{S}$  of the sulfate was observed after only 1 week. In the second set of experiments, the columns were allowed to go sour before nitrate was added. Effluent sulfate dropped to less than 5% of the influent concentrations. The  $\delta^{34}\text{S}$  of the residual sulfate was  $\sim 60\%$  higher and the  $\delta^{18}\text{O}$  was  $\sim 15\%$  higher. After nitrate addition, sulfide disappeared and both the  $\delta^{34}\text{S}$  and  $\delta^{18}\text{O}$  values of the effluent sulfate returned to baseline after  $\sim 10$  days. With time, the  $\delta^{34}\text{S}$  of the sulfate dropped to 2% less than the influent values indicating re-oxidation of sulfide precipitates in the columns. These results indicate that isotopic monitoring of microbial sulfate reduction is highly sensitive, potentially providing early indicators of reservoir souring processes. Future work will include isotopic monitoring samples from oil reservoirs and incorporation of isotopic effects into reservoir reactive transport models.

## Evaluation of precipitation isotope variability across the tropical Pacific in SWING2 simulations and observations

JESSICA L. CONROY<sup>1,2\*</sup> KIM M. COBB<sup>2</sup>  
AND DAVID NOONE<sup>2</sup>

<sup>1</sup>Department of Geology, University of Illinois Urbana-Champaign, IL, USA

(\*correspondence: jconroy8@mail.gatech.edu)

<sup>2</sup>School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, GA, USA

<sup>3</sup>Department of Atmospheric and Oceanic Sciences, and Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder, CO, USA

Isotope-equipped global climate models (GCMs) enable simulations of the stable isotopic composition of precipitation, but isotope simulations from different models may vary because of differences in hydrologic and isotopic fractionation schemes. However, different isotope model simulations are rarely considered together, allowing assessment of the distribution of simulated precipitation isotope variability relative to observations. Here we present an evaluation of tropical Pacific precipitation isotope variability in GCMs participating in the second Stable Water Isotope Intercomparison Group (SWING2) experiment and in observations. The tropical Pacific is an important target for such model-data comparisons, as it plays a key role in shaping global hydroclimate variability, and is home to many water isotope-based proxies of paleoclimatic change. We present examples highlighting variability in the strength of the isotopic 'amount effect' across the tropical Pacific. The models that best capture mean annual precipitation in the tropical Pacific are not the models that best simulate the mean annual stable isotopic composition of precipitation, suggesting precipitation amount is not the only influence on precipitation isotope variability in the tropical Pacific. The strength of the relationship between precipitation and precipitation  $\delta^{18}\text{O}$  values varies between the western, central, and eastern equatorial Pacific. In the western equatorial Pacific, there is more variability among simulations, but precipitation  $\delta^{18}\text{O}$  values have a stronger relationship with basin-wide precipitation relative to local precipitation. In the central and eastern equatorial Pacific, precipitation  $\delta^{18}\text{O}$  values are strongly correlated with regional precipitation across most simulations. In many simulations of the eastern tropical Pacific, precipitation has a more spatially expansive relationship with basin-wide precipitation compared to precipitation  $\delta^{18}\text{O}$  values.