Modeling CO_2 and carbon isotope dynamics in a floodplain aquifer

B. ARORA[1*], M. E. CONRAD[1], N. F. SPYCHER[1] AND C. I. STEEFEL[1]

[1]Earth Sciences Division, Lawrence Berkeley National Laboratory (*correspondence: barora@lbl.gov)

Although carbon fluxes in soils and groundwater are critical components of the global carbon budget, soil CO_2 dynamics are difficult to predict because of the presence of multiple sources and sinks as well as different biogeochemical processes that affect its uptake and release. Stable carbon isotopes provide a useful tool for quantifying soil CO_2 fluxes and for constraining the extent and rates of different abiotic and biotic reactions. The objectives of this study are to: (1) quantify the relative contribution of different pathways (atmospheric exchange, precipitation/ dissolution of carbonate minerals, and biotic heterotrophic and as well as chemolithoautotrophic reactions) on carbon fluxes in the subsurface of the Rifle site, CO (an alluvial aquifer bordering the Colorado River), and (2) associate $\delta^{13}C$ –CO_2 variations with the seasonal rise and fall of the floodplain water table and the observed temperature gradients.

A 2-D reactive transport model has been developed for the Rifle floodplain that includes a biogeochemical reaction network with multiple terminal electron acceptor processes, kinetic and equilibrium mineral precipitation and dissolution, as well as spatially distinct pools of Fe and S minerals and functional microbial populations. Equilibrium isotopic fractionation between inorganic carbon species and kinetic fractionation associated with organic carbon transformations are included in the model.

Results indicate that observed CO_2 fluxes cannot be explained by abiotic reactions alone, but require contributions from microbial activity (e.g., heterotrophic respiration, chemolithoautotrophy). The simulated CO_2 concentrations are also strongly affected by subsurface temperatures, which vary significantly over time and space at this site. $\delta^{13}C$ profiles in the unsaturated zone point to spatially-variable sources for the locally high CO_2 concentrations. An important conclusion from the study is that it is necessary to account for seasonal water table variations and temperature gradients to reasonally interpret lateral and vertical $\delta^{13}C$-CO_2 profiles and fluxes. In summary, measuring and modeling cabon isotopes at this site is proving to be useful to distinguish different pathways of CO_2 production.