Isotopic Evidence for Biogeochemical Interactions Between the Unsaturated Zone and Groundwater in the Rifle Floodplain

Mark E. Conrad (msconrad@lbl.gov) - Lawrence Berkeley National Laboratory, Susan Hubbard (PI), John N. Christensen (LBNL); Markus Bill (LBNL); Jiamin Wan (LBNL); Kenneth H. Williams (LBNL); Tetsu K. Tokunaga (LBNL) (Co-PIs).

One of the primary goals of the LBNL SFA 2.0 is to gain an understanding of the impact of microbial activity on the mobility of carbon in unsaturated environments. Our initial study site is the Old Rifle floodplain in western Colorado. The unsaturated zone at the site consists of alluvial sediments covered by approximately 2 m of locally sourced clean fill material overlying a 3-4 m thick perched aquifer. As part of SFA 2.0, depth-distributed gas samplers and suction lysimeters for pore water sampling were installed through the unsaturated zone at three different locations across the site. The concentrations and isotopic compositions of water and soil gas components have been monitored over the past year in order to gain insights into microbial activity in the unsaturated zone.

A combination of water isotopes and the isotopic composition of porewater strontium and uranium has been used to track infiltration of water through the unsaturated zone. Seasonal variations in the Î´D and Î´18O of precipitation are smoothed out in the upper part of the unsaturated zone and the average values are essentially the same as the groundwater making it impossible to use natural water isotopes to distinguish infiltration through the vadose zone from regional groundwater flow. To address this, we conducted an artificial snow event using deuterium-labeled snow in late February. Shifts in pore water Î´D values have been observed 2 m below ground surface, suggesting relatively rapid infiltration pathways for some surface waters. Vadose zone porewater is characterized by high 87Sr/86Sr and Sr concentrations. The influence of this strontium on the groundwater suggests that as much as 20% of the groundwater strontium is derived from vertical recharge.

Insights into metabolic activity in the unsaturated zone have also been gained from isotopic measurements. The Î´13C of CO_2 in the soil gas is in isotopic equilibrium with groundwater DIC and not bulk organic carbon in the vadose zone soils or dissolved organic matter in the pore water. This implies that high CO_2 concentrations (to >5% during the summer) in the lower part of the unsaturated zone are largely due to exchange of inorganic carbon between the groundwater and the pore gases and not heterotrophic microbial metabolism. Isotopic signatures of other vadose zone components, including the Î´15N of N2O and the Î´34S of porewater sulfate indicate that denitrification and sulfate oxidation may be important processes during certain times of the year.