Changing water, carbon and energy fluxes alters deep CZ structure and solute exports to streams

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Flushing of groundwater from the deep Critical Zone (CZ) (e.g. fractured bedrock aquifers) during relatively wet periods (e.g. spring snowmelt) controls concentration-discharge relationships in streamflow, with some contributions of dust or biologically-derived solutes from soil water and perched aquifers, and represents the greatest fluxes of water and bedrock-derived solutes from high-elevation, mountainous catchments in the southwestern United States. Yet, relatively little is known about the structure or function of the deep CZ and how it responds to changing inputs of water, energy and carbon from the surface, which will inform our understanding of its resiliency to disturbance (e.g. anthropogenic climate and landuse change, insect-driven tree mortality, fire, etc.) and modulation of near-surface processes.

This study probes the deep (>10 m) CZ in a lithologically-complex volcanic terrain in the Jemez Critical Zone Observatory, New Mexico, through geochemical and microbial analysis of continuous cores (up to 50 m depth), coupled to geophysical surveys, in different landscape positions and underlying parent materials. Chemical and isotopic analyses of high-frequency groundwater samples from multi-level monitoring wells installed in perched aquifers and fractured bedrock are coupled to the solid-phase geochemical results to investigate how dynamic fluxes of water, carbon and energy influence biogeochemical processes and CZ development. Similarly, high-resolution samples of stream waters along the rising limb of the hydrograph during spring snowmelt paired to soil and groundwater results help constrain the plumbing of the deep CZ, solute mobility, and connections to streamflow. In so far as deep CZ evolution depends on meteorologic and biologic inputs, these factors are changing (as our data show) in response to climate change and associated drought, forest dieback, fire etc. with likely consequences for deep CZ processes (e.g. the potential disconnection of the deep CZ with streams under drier conditions) in sub-humid to semi-arid environments.