B24B-04 Bottom-up Controls on Critical Zone Connectivity (Invited)

Tuesday, 10 December 2024

16:45 - 17:00

150 B (Convention Center)

Abstract

Vertical connectivity in the critical zone -- the relative ease or difficulty of the movement of water, nutrients, and solutes between shallow and deep levels of the subsurface -- is a primary control on the structure and function of the critical zone, but it is challenging to observe and measure. We suggest that lateral variations in the thickness and vertical structure of the critical zone can provide a proxy for the efficacy of vertical connectivity in the shallow subsurface. A thicker CZ (i.e., greater depth to unweathered bedrock) implies that reactive fluids in chemical disequilibrium with the surrounding rock penetrate deeper, while a thin CZ implies the reverse. If we view CZ thickness as a simple measure of vertical connectivity, existing data suggests that bedrock properties -- including metamorphic foliation, fracture density, and weatherable mineral content -- exert substantial influence on the hydrological properties that likely control CZ connectivity. In one Arizona watershed, for example, a perched water table at the soil/saprolite boundary on the north-facing slope can be simply explained by the orientation of metamorphic foliation. Strong lateral variations along a weathering granite ridge in Wyoming appear to result from lateral changes in fracture density, with greater fracture density allowing higher vertical connectivity and thus deeper weathering. And in the South Carolina Piedmont, recent data show a stark contrast in critical zone thickness and porosity on an interfluve where the only significant change is in the dip of foliation -- with higher dip angle again leading to thicker weathering. These observations imply that landscape-scale geophysical data -- especially in combination with drilling, sampling, geochemistry, biological, and geomicrobiological data -- can provide new insights into the causes and consequences of lateral variations in critical zone connectivity.

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