An investigation of spatial patterns of bedrock weathering at the hillslope scale via multi-scale geophysical methods

Shawn S. Lee

ABSTRACT

The critical zone (CZ) comprises the near-surface region of the Earth where physical and chemical processes form porous soil and weathered bedrock. Outside of boreholes, road cuts, and landslides, the subsurface structure of the CZ is still relatively invisible and therefore is unmapped relative to surface topography, yet the structure of the CZ plays an integral role in water cycling. Here, we characterize this structure and its variability within the Coastal Belt of the Northern California Coast Ranges. We compare borehole data at the Eel River Critical Zone Observatory with seismic and resistivity surveys to develop probabilistic maps of weathering profile structure via logistic regression. Drilling revealed thin soils and 0.5-4 m of saprolite, underlain by up to 23 m of weathered argillite. We compare spatially detailed data from boreholes with surface geophysical surveys to develop ranges of most probable seismic and resistivity values of interfaces between (1) saprolite and weathered bedrock and (2) weathered and unweathered bedrock. The average resistivity value is 245 ohm-m for the saprolite and weathered bedrock transition, and 94 ohm-m for the weathered to unweathered bedrock transition. P-wave velocities calculated via regression ranged from 350-761 m/s for saprolite and soil, 761-2364 m/s for weathered bedrock, and > 2364 m/s for fresh bedrock. We investigate weathering profile structure across different hillslopes by extending our regression results to surveys without boreholes. Results reveal spatial variability in weathering profile structure, whereby weathering thickness consistently increases upslope from channels incising into unweathered bedrock. In this tectonically active environment, we find that weathering profiles penetrate deeply beneath hillslopes in a potentially systematic pattern. This suggests broad scale consistency in weathering process across the landscape that operates at the hillslope scale where channels remain unweathered and ridgetops show deep weathering.

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