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Unraveling the whole darn thing: Weathering and erosion and critical zone architecture

SUZANNE P ANDERSON

University of Colorado Boulder

Presenting Author: Suzanne.Anderson@colorado.edu

Landscapes in dynamic equilibrium have rates of weathering and denudation adjusted such that material is removed at the rate it is produced, and hillslope form therefore remains the same [1]. How is this balance achieved? We explore this question in Gordon Gulch, part of the former Boulder Creek CZO in the montane zone of the Colorado Front Range.

The denudation rate of the Precambrian gneiss and granite bedrock, determined with *in-situ* ^{10}Be, is 3.1 cm/ka (820 kg/ha/yr) [2]. Modern solute fluxes account for less than 3% of this mass loss [3]; hence most denudation is accomplished by physical erosion processes. The semi-arid conditions (P-ET ~0.02 m/yr) limit modeled chemical alteration to a thin (1-2 m) surface layer [4] and incomplete weathering keeps primary mineral abundances essentially uniform throughout the ~12 m thick regolith [5]. Nonetheless, the terrain is soil mantled and punctuated with bedrock tors. Aside from tors, the soil is uniformly 0.4 m thick on S- and N-facing hillslopes. Significant differences in radiation and vegetation across slope aspects affect water flowpaths [6] and possibly solute fluxes but are not (yet?) manifested in different soil composition across aspects. Although the (slightly) weathered rock layer parallels the surface topography, seismic refraction shows it is ~5 m thicker under N-facing than S-facing slopes (average across both aspects is 11.7±3.1 m). The thickness of weathered rock in Gordon Gulch reflects frost cracking during Quaternary glacial climate conditions [7] that dominate the roughly 380 kyr residence time for material in the weathered profile [5]. Weathering and denudation rates balance over the timescale for weathered profile development, which in most landscapes builds substantial inertia to change into the system.

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