Hydropedology and Hydrologic Connectivity of an Oak-Woodland Hillslope in the Northern Sierra Foothills of California

Katelin Alldritt, Toby O'Geen and Randy Dahlgren
University of California, Davis Department of Land, Air and Water Resources

Introduction

Hydropedology is the study of how soil morphology and stratigraphy influence hydrologic processes, which is particularly relevant at the hillslope scale, where soil stratigraphy and spatial variability can exert first-order control on the hydrologic flow paths. Hydrologic connectivity is a condition by which different stratigraphic units across the hillslope become hydraulically linked via subsurface water flow (Steiglitz et al 2003). Hydrologic connectivity occurs when isolated patches of saturation become connected across the hillslope (Western et al 1996, Hopp and McDonnell 2009, Ocampo et al 2006). Understanding soil stratigraphy and its influence on hydrologic connectivity and stream flow generation has implications for water resource sustainability, water quality and other ecosystem services (Devito et al 2005).

Q1: Hydrostratigraphic Units

Six Hydrostratigraphic Units (HSUs) were identified:
- Biomantle = permeable, bioturbated, continuous and homogenous
- Permeable Argillite = stable, near continuous
- Claypan = low permeability, >40% clay content, abrupt clay increase from above zone, discontinuous
- Weathered bedrock type 1 = high bulk density, fractured
- Weathered bedrock type 2 = low bulk density, massive
- Hard bedrock = Metavolcanics

Q2: Hydrologic Connectivity

Figures 4 and 5. (Left) Duration of saturation for each tensiometer depth at all five tensiometer sites during one stream flow event (black line). Numbers on the side of each row correspond to the tensiometer sites (1-5). The colors represent the hydrostratigraphic unit (s). The grey bars highlight the stream flow peaks and corresponding tensiometer data. Missing data (e.g. tensiometers 1 and 5) was due to sensor failure. Stream flow event induced by multiple precipitation event. (Right) Hillslope velocities (cm/hr) as modeled with HYDRUS 2D. Sections correspond to sections in Figure 3. The continuous surface zone of rapid velocities (blue) corresponds to connected subsurface lateral flow in the biomantle.

Q3: Flow Path Connection and Disconnection

Figures 6 and 7. (Left) Close ups on upper, middle and lower sections of the hillslope, which are hydrologically disconnected. (Right) Water table connection time series at a large hard bedrock berm site. The color scale for both figures is in matric potential (cm H2O).

Conclusions

- Complex hillslope stratigraphy comprised of a discontinuous claypan, undulating bedrock topography and highly variable weathered bedrock.
- Primary hydrologic flow path during connectivity was rapid subsurface lateral flow in the biomantle.
- Presence of a claypan decreased effective soil depth, increased antecedent wetness and created a perched water table.
- Undulating bedrock created disconnected perched water tables along the hillslope.
- Isolated zones of wetness only became connected when a storm event saturated the entire subsurface and moved the water table into the biomantle.
- Further investigation on the hydrologic role of weathered bedrock would improve understanding of hillslope hydrology.

References


