Fractures as a Master Variable: Influences on Hydrologic Processes from the Watershed to the Local Scale

*Ellen Wohl[1], Daniel N Scott[2]

1. Department of Geosciences, Colorado State University, Fort Collins, CO, USA, 2. Department of Earth and Space Sciences, University of Washington, Seattle, WA, USA

Bedrock fracture geometry, specifically the orientation and spacing of fractures, strongly influences the rates and spatial patterns of rock weathering and erosion. This influence appears across spatial scales and creates both primary and secondary effects. At the largest scale, fracture geometry exerts a primary influence on watershed topographic characteristics such as relief, network shape, and channel orientation. These watershed topographic characteristics then influence the timing and magnitude of downstream fluxes of water, solutes, sediment, and organic matter. At progressively smaller scales, fracture geometry can exert a primary influence on longitudinal variations in valley geometry and channel gradient. These longitudinal variations can then affect the thickness of valley-bottom alluvium and therefore the potential for hyporheic exchange. The presence of hyporheic exchange affects water temperature and chemistry, as well as stream metabolism and biological productivity. Longitudinal variations in valley geometry can also influence channel and floodplain morphology; conveyance of base and peak flows; sediment volume, grain-size distribution, and residence time; aquatic and riparian habitat; and biomass and biodiversity. Fracture geometry can also exert a primary influence on ground water fluxes that help to create and maintain hillslope and floodplain wetlands. The abundance and distribution of wetlands strongly affects organic carbon stock, denitrification, habitat abundance and diversity, and biomass and biodiversity. Finally, at very local scales, fracture geometry can influence the relative importance and location of surface and subsurface flow paths that give rise to channel heads. The location and spatial density of channel heads affects response to hydrologic and other disturbances, as well as habitat, biomass, and biodiversity. Both fundamental conceptualizations and management of hydrologic processes require recognition of spatial variations in process and form that ultimately reflect bedrock fracture geometry. Watershed-scale management could be enhanced, for example, by explicitly including fracture influences on hydrology in delineating process domains and identifying hydrologically resistant or resilient portions of a watershed.

Keywords: bedrock, fracture, topography, drainage network, valley geometry, resilience

