Source water tracing in a flashy mountainous stream - Pahsimeroi River, US Rocky Mountains

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Identifying mixing between ground and surface water is challenging in fractured aquifer settings, where baseflow occurs at difficult-to-delineate point locations. Particularly in regions where multiple mineralogically distinct lithologies contribute to solute yields, chemical indicators that allow delineating characteristic mineral fingerprints of source rock and water end-members are critical. This study assesses water mixing in the Pahsimeroi River, a small flashy stream draining two heavily deformed mountain ranges each characterized by numerous normal faults that juxtapose impermeable bedrock with pervious alluvial sediments. To estimate the input of various sources to streamflow, a multiple end-member mixing system was established using two tracers: (1) $^{87}Sr/^{86}Sr$ ratios, and (2) carbonate and silicate weathering rates (CWR_{carb}/CWR_{sil}) which were each constrained based on specific weathering reactions following a major ion inversion technique. Our results show that the input from carbonate sources (tributaries and springs) decreases from 81% in the main stream headwaters to 6% in the lowlands while the corresponding input from volcanic and metamorphic sources increases from 19% to 81% and 0% to 12%, respectively. Although seasonal variations are muted, the metamorphic source input is higher in winter than in summer months; a trend that is reversed for the volcanic and carbonate source contributions. Alluvial groundwater exhibits highly variable $^{87}Sr/^{86}Sr$ vs. CWR_{carb}/CWR_{sil} values indicating a poorly mixed reservoir which is consistent with the local fractured aquifer setting. The data further indicates a characteristic trend towards increasing baseflow inputs from volcanic rock aquifers particularly in the downstream sections where the basin shallows and decreases in width. This confirms baseflow estimates from flow duration curves and suggests groundwater sustains perennial flow in the agriculturally developed lowlands.