Sr and U isotopes reveal the influence of lithologic structure and weathering on surface-groundwater interaction along a mountain stream (Hyalite Canyon, MT)

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Changing climate and precipitation patterns are projected to reduce snowpack storage and late summer stream flows in mountain headwaters of the western United States. Ecosystems, agriculture, and municipalities depend on late summer flow in rivers traversing intermountain basins. Therefore, improved understanding of groundwater storage contributions to mountain streams is increasingly important.

In this work we use $^{87}Sr/^{86}Sr$ ratios and $^{234}U/^{238}U$ activity ratios (UARs) as indicators of water-rock interaction and surface-subsurface hydrologic exchanges along Hyalite Creek, a mountain headwater tributary within the Missouri River basin. Mainstem and tributary flow was sampled from 2100 to 1690 m elevation during 2016 and 2017, focusing on presumed base flow conditions in February and August. Stream water in upper Hyalite Creek has low $^{87}Sr/^{86}Sr$ values (0.70846-0.70921), typical of Tertiary volcanic host units, and low UAR values (1.50–1.72), consistent with more aggressive weathering of U from soils during recharge. In middle Hyalite Creek, UAR in the mainstem increases to 3.20 reflecting inflows of groundwater associated with Madison Group limestones. Local springs discharging from the Madison have UAR values of 5.23-5.29 and $^{87}Sr/^{86}Sr$ of 0.70835. In lower Hyalite Creek, progressive increases in $^{87}Sr/^{86}Sr$ values (0.70973-0.71202) and decreases in UAR (2.12-1.69) are consistent with localized inputs of water stored in the Archean gneiss. Groundwater from wells completed in the gneiss have $^{87}Sr/^{86}Sr$ values of 0.73687-0.74497 and UARs of 1.28-1.85. We use mixing models to quantify the spatial distribution of fractional additions from groundwater end-members to stream water. We argue that diverse groundwater inputs drive seasonal variation in streamflow within the mountain headwaters, and are key to understanding sensitivity of these systems to climate change.