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Radiogenic strontium isotope ratios tracing nutrient from fractured shale to sagebrush

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Mountainous watersheds in the US West provide water to millions of people but are anticipated to be strongly affected by climate change and other environmental stressors. Projected trends, including aridification and altered precipitation patterns, could alter watershed processes, including hydrologic fluxes, vegetation distributions and bedrock weathering, that govern the exports of water and solutes. Our recent studies at the East River watershed, Colorado, suggest that deep-rooted plants, especially sagebrush (Artemisia tridentata), may have a role in shale bedrock weathering. Sagebrush roots extend 1–2 m beneath the ground-surface penetrating through fractures in the actively weathering saprolite, causing local changes in mineralogy and geochemistry. While these roots are likely to access bedrock water resources, we hypothesize that the roots also accelerate bedrock weathering leading to increased mobility and acquisition of geogenic nutrients. This potential coupling between belowground sagebrush biogeochemical cycling and bedrock weathering could influence trends in watershed ecology and exports accompanying climate change.

Radiogenic strontium isotope ratios ($^{87}Sr/^{86}Sr$) can provide insight into the source, transport and biogeochemical cycling of metal nutrients, particularly Ca and Mg, in bedrock, soil, water and plant tissues. Here we used $^{87}Sr/^{86}Sr$ ratio measurements of soil, bedrock and plant tissue to investigate the source of sagebrush nutrient.

The $^{87}Sr/^{86}Sr$ ratio exhibit a strong gradient from top soil to fractured shales near the bedrock environment. The trend suggests either that Sr is derived from a combination of atmospheric and bedrock inputs, or that it's due to preferential weathering of certain minerals in the shale.

The $^{87}Sr/^{86}Sr$ ratio of individual sagebrush plants exhibit a smaller gradient from aboveground stems to the deepest roots, suggesting that plants acquire Sr from a range of depths. This trend, however, is much smaller than the overall variability in the $^{87}Sr/^{86}Sr$ ratios between individual plants. This illustrates that plants grow within distinct geochemical and hydrologic microenvironments even within a single hillslope, and that plant Sr isotope ratios may be sensitive signatures of belowground variability and that plant acquisition of deep geogenic nutrients may be variable.

Further studies of the soil-to-bedrock mineral, geochemical and microbial composition are ongoing to quantify the origins of belowground heterogeneity.