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Stable silicon isotope fractionation reflects the routing of water through a mesoscale hillslope

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The variety of transit times and pathways water takes from infiltration to discharge through a hillslope determines the dynamic storage of the system, the capacity for water-rock-life reactivity, and ultimately the chemical composition of streamflow. The major solute concentrations recorded in these streams are often relatively invariant across a wide range of flow rates. Stable isotope fractionation of metal(loid) elements, such as silicon, are now offering a means to reveal the processes generating this invariance in stream chemistry through the study of concentration - isotope ratio - discharge (C-R-Q) relationships. However, in natural systems the interpretation of silicon isotope signatures (δ^30 Si) is complicated by a mixture of mineral precipitation and plant uptake controls. Here, we use three replicate artificially constructed hillslopes at the Landscape Evolution Observatory (LEO) in Tucson, Arizona as model catchments devoid of vegetation. By using the LEO hillslopes, we limit δ^30 Si fractionation solely to the effects of mineral precipitation. This unique environment enables us to test the effects of varying transit time distributions (TTDs) on δ^30 Si signatures. We collected samples and measured δ^30 Si from the discharge at the outlet of each hillslope during three randomized storm events. Despite highly variable irrigation scenarios, the δ^30 Si in aqueous discharge reflects consistent upgradient fractionation, retaining a signature across the three hillslopes defined by the unique hydrologic flow paths of the system. Our results expand upon previous work attributing intrasite variability in silicon stable isotope signatures to the hydrologic routing of fluid through catchments.

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