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Balancing the Modern Uranium Budget in Bear Lake, Utah-Idaho

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Uranium concentrations and isotopes in lake sediments are widely used to constrain depositional ages and reconstruct past redox and hydrochemical conditions. However, robust interpretation of these records requires a mechanistic understanding of the processes governing uranium inputs, cycling, and burial in modern lake systems. In this study, we tracked the uranium budget of Bear Lake, a large balance-filled lake on the Utah–Idaho border in the northeastern Great Basin with a well-documented history of hydrologic sensitivity and paleoclimate change. Bear Lake is an alkaline, carbonate-rich lake with active authigenic carbonate formation and dynamic uranium cycling between water and sediments, making it a useful analog for marine carbonate systems. We measured uranium and strontium isotopes, major elements (Ca, Mg, Na, K), and trace elements (Li, Sr, U, Th) in Bear Lake, the Bear River, groundwater, and smaller tributaries throughout the watershed. We paired these water measurements with U-series isotope analyses of late Pleistocene authigenic carbonate from sediment cores to quantify the uranium budget and identify the hydrologic and weathering processes that control the lake's uranium balance. Preliminary results reveal a strong lithologic control on the concentration and isotopic composition of uranium entering the lake, with felsic terranes contributing higher uranium concentrations (up to 13.2 ppb) and lower $^{234}U/^{238}U$ activity ratios (~1.3), whereas mafic or carbonate terranes contribute lower uranium concentrations (as low as 0.12 ppb) and higher $^{234}U/^{238}U$ activity ratios (up to 5.8). These spatially variable inputs, together with shifts in watershed hydrologic balance and temporally heterogeneous mineralogy, produce a wide range of U and Th isotope compositions in authigenic carbonates. Modern lake water uranium concentrations and $^{234}U/^{238}U$ activity ratios are elevated (~2.55) relative to simple mixing of the input fluxes, suggesting that uranium remobilization via alpha recoil or organic matter oxidation in the sediment column during early diagenesis represents an important contemporary source of uranium to the lake.