Greater Gallium sorption rates due to intense chemical weathering: variations across four CZOs in the United States

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Gallium (Ga) is of importance because of its uses in modern technology, such as in gallium arsenide, an important semiconductor. Ga may be an effective geochemical tracer for aluminum (Al) because the two elements share many physicochemical properties. Therefore, it is important to investigate and understand where Ga is found in the environment and how Critical Zone processes affect Ga.

We investigated Ga in the Critical Zone by measuring soil and rock samples down to six meters in depth from four Critical Zone Observatories (CZOs) across the United States: Calhoun CZO (South Carolina), Southern Sierra CZO (California), Boulder Creek CZO (Colorado), and Luquillo CZO (Puerto Rico). All lithologies were intrusive igneous rocks, but mean temperature and precipitation varied among CZOs. Gallium concentrations and distribution data were calculated for three fractions: (1) organic matter phase using acetic acid + H_2O_2 extraction, (2) secondary oxide fraction using citrate bicarbonate dithionite extraction, and (3) total phase using HF, HNO_3, and $HClO_4$ digestion. Gallium concentrations in the organic matter fractions ranged from below detection limits to 0.071 μg/g. Secondary oxide fraction of Ga ranged from below detection limits to 18 μg/g. Total Ga concentration ranges were 1-25 μg/g. Percent Ga distribution was calculated for the organic matter and secondary oxide fractions. %Ga distribution in the organic matter phase was < 1%, except for surface soils at Calhoun CZO which was 4.8%. The %Ga distribution in the secondary oxide fraction decreased at greater depths, except for Boulder Creek, where percentages were all <1%. Luquillo CZO, which had the most intense weathering due to highest temperature and precipitation, had the highest rates of Ga sorption. Quantifying the retention and sorption of Gallium in soil weathering could be useful for predicting Ga-rich bauxites, possibly increasing the Ga and Al supply for technological resources.