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High carbonate $\delta^{11}B$ as a potential indicator for past habitability

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This study focuses on Lake Salda as a modern terrestrial analogue for Jezero crater, Mars, and compares it with three other high-pH closed-basin lakes in southwest Turkey. Lakes Salda, Acıgöl, Yarsılı, and Burdur, exist in the same climate, with similar annual temperatures and precipitation rates, but have differing local bedrock. Lake Salda is surrounded by serpentine-bearing ultramafic rocks, whereas the other lakes are predominantly surrounded by limestone. Salda alone contains actively growing thrombolitic hydromagnesite structures. Determining what makes Lake Salda unique in this respect can provide insight into potential past habitable and productive paleoenvironments on Mars.

Here we explore applications of boron isotope fractionation in the alkaline lakes and the Salda thrombolites. Borate ($B(OH)_4^-$) and boric acid ($B(OH)_3$) exist in a pH-driven equilibrium, with borate dominating at pH > 8.6. ^{11}B preferentially fractionates into boric acid over borate. Phyllosilicates, like serpentine, adsorb charged ions like ^{10}B-rich borate, the leaving remaining water $\delta^{11}B$-enriched.

The composition of the groundwater feeding Lake Salda is indicative of interaction with altered ultramafic rock (high pH, high [Mg], low [B]). $\delta^{11}B$-enriched groundwater leads to a $\delta^{11}B$-enriched Lake Salda, whose alkaliphilic microbial colonies induce precipitation of $\delta^{11}B$-enriched hydromagnesite thrombolites. Laser ablation ICP-MS/MS reveals that the Lake Salda thrombolites are enriched in ^{11}B in a manner consistent to lake pH (~9) and $\delta^{11}B$ and a mechanism where borate ions are predominantly incorporated into carbonates. Furthermore, if Lake Salda were to dry out, the ^{11}B-enriched thrombolites would remain as evidence of its past composition, and potentially as an indicator of subsurface serpentine. If similar carbonates were to be returned from Mars, $\delta^{11}B$ may be used as a fingerprint for a Salda-like setting and as an indicator lake waters and climate that contained suitable ingredients for life.