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Triple Oxygen Stable Isotope Analysis of Mineral Hydration Waters by Thermogravimetry-Enabled Laser Spectroscopy

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The triple oxygen stable isotope composition ($^{17}O/^{16}O$ and $^{18}O/^{16}O$ ratios, expressed as $\delta^{17}O$ and $\delta^{18}O$ values) of water and hydroxyl molecules bound into the crystal structure of hydrated minerals can yield information on the environment of mineral formation. We have developed an approach for the triple oxygen stable isotope analysis of mineral hydration waters based on coupling a thermogravimetric analyzer instrument to a laser-based isotope ratio infrared spectroscopy instrument (Picarro L-2140i), abbreviated as TGA-IRIS. The ability of TGA-IRIS to yield detailed water content data and oxygen isotope values of water at specific thermal evolution temperatures allows for differentiation of water at various binding strengths on mineral particle surfaces and from within the hydrated mineral matrix.

We present methodology details and example $\delta^{17}O$, $\delta^{18}O$, and $D'^{17}O$ values on liquid water samples including VSMOW and GISP. We also present example values from a range of hydrated minerals, including sulfates, smectites, serpentines, chlorite and iron oxides. Generally, water yielded at temperatures less than ~150 °C corresponds to surface-sorbed water, while higher temperatures can dehydrate and dehydroxylate water and hydroxyl molecules from within the mineral matrix. TGA-IRIS offers the possibility to isotopically differentiate the various oxygen reservoirs in hydrated minerals, which may allow single mineral geothermometry on specific minerals. Triple oxygen isotope analyses by TGA-IRIS are likely to open new avenues and possibilities for research on hydrated minerals.