

Oxygen isotope fractionation between gypsum and its formation waters: Implications for past chemistry of the Kawah Ijen volcanic lake, Indonesia

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ABSTRACT

Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) provides an opportunity to obtain information from both the oxygen isotopic composition of the water and sulfate of its formation waters, where these components are commonly sourced from different reservoirs (e.g., meteoric vs. magmatic). Here, we present $\delta^{18}\text{O}$ values for gypsum and parent spring waters fed by the Kawah Ijen crater lake in East Java, Indonesia, and from these natural samples derive gypsum-fluid oxygen isotope fractionation factors for water and sulfate group ions of $1.0027 \pm 0.0003\text{‰}$ and $0.999 \pm 0.001\text{‰}$, respectively. Applying these fractionation factors to a growth-zoned gypsum stalactite that records formation waters from 1980 to 2008 during a period of passive degassing, and gypsum cement extracted from the 1817 eruption tephra fall deposit, shows that these fluids were in water-sulfate oxygen isotopic equilibrium. However, the 1817 fluid was $>5\text{‰}$ lighter. This indicates that the 1817 pre-eruption lake was markedly different, and had either persisted for a much shorter duration or was more directly connected to the underlying magmatic-hydrothermal system. This exploratory study highlights the potential of gypsum to provide a historical record of both the $\delta^{18}\text{O}_{\text{water}}$ and $\delta^{18}\text{O}_{\text{sulfate}}$ of its parental waters, and provides insights into the processes acting on volcanic crater lakes or any other environment that precipitates gypsum.

Keywords: Gypsum, oxygen isotopes, crystalline water, sulfate group, isotope fractionation factor, Kawah Ijen, volcanic lake