

Tracing cation and anion exchange in hydrotalcite minerals using stable C, O and Mg isotopes

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Hydrotalcite minerals are anionic clays that are under increasing interest for their ability to sequester atmospheric and aqueous contaminants, including atmospheric CO₂ and heavy metals in mine tailings ponds. Using stable isotopes to trace their formation pathways, as is typical for other mineral groups, is complicated by their ability to exchange anions with the local environment. Here we investigate how the stable C, O & Mg isotope signatures change over time.

An anion exchange experiment was conducted that converted iowaite [Mg₆Fe³⁺₂(Cl₂)(OH)₁₆·4H₂O] into pyroaurite [Mg₆Fe³⁺₂(CO₃)(OH)₁₆·4H₂O] over the course of 46 hours using atmospheric CO₂. Stable C and O isotopes reveal that the isotopic composition of the mineral changes over time and depends on carbonate availability, with carbon-limited conditions causing a depletion in δ¹³C values over time, and carbon-abundant conditions causing an enrichment.

A Mg exchange experiment was conducted by exposing synthetic pyroaurite to ²⁵Mg-enriched Mg²⁺_(aq) over 90 days. Stable Mg isotope results indicate that ²⁴Mg and ²⁶Mg from pyroaurite were entering solution while ²⁵Mg from solution was incorporated into the pyroaurite, indicating that exchange was occurring.

Exchange of C, O and Mg between pyroaurite and solution may complicate the interpretation of stable isotope data in tracer studies and implies that there is the potential for contaminants sequestered in hydrotalcites to be released.