

# Carbon Fixation using Seawater for Sustainable Large-Scale Carbon Capture and Storage—Using stable isotopes for quantification

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Subsurface carbon mineralization is considered the most stable method of carbon capture and storage; a process where dissolved CO<sub>2</sub> is injected into the subsurface, reacting with mafic or ultramafic minerals (e.g., basalt) to release cations (e.g., Ca<sup>2+</sup>, Mg<sup>2+</sup>, Fe<sup>2+</sup>), ultimately precipitating into carbonate minerals. Existing methods of mineral carbonation are freshwater intensive, thus sustainably implementing mineral carbonation carbon storage on the Gigatonne scale will likely involve seawater for CO<sub>2</sub> dissolution depending on the location<sup>1</sup>. While efficient carbon mineralization has been demonstrated in seawater experimentally in conditions relevant to mineral carbonation<sup>2</sup>, no field-scale seawater investigations of mineral carbonation have been undertaken to date.

Stable isotopes of calcium (d<sup>44</sup>Ca) and magnesium (d<sup>26</sup>Mg) can be applied to compare the efficiency of mineral carbonation in seawater to that in freshwater, however the most reliable estimates will require accurate isotopic fractionation factors ( $\alpha$ ) for carbonate mineral precipitation at relevant conditions and accurate methods for disentangling the different processes (e.g., basalt dissolution, anhydrite precipitation). Here, we measure d<sup>44</sup>Ca and d<sup>26</sup>Mg during mineral carbonation from seawater at varying temperatures and CO<sub>2</sub> partial pressures to understand how these variables impact the calculated  $\alpha$  for carbonate precipitation. We use radiogenic strontium (<sup>87</sup>Sr/<sup>86</sup>Sr) as a proxy for basalt dissolution. Estimates of carbon mineralization using d<sup>44</sup>Ca and d<sup>26</sup>Mg are compared to alternative methods (acidification and non-dispersive infrared (IR) CO<sub>2</sub> gas analyzer, furnace and solid state IR, mass balance calculations). Findings of this work will be used in conjunction with post-injection measurements of d<sup>44</sup>Ca, d<sup>26</sup>Mg, and <sup>87</sup>Sr/<sup>86</sup>Sr to evaluate the efficiency of mineral carbonation from seawater. This study highlights key variables to consider when using d<sup>44</sup>Ca and d<sup>26</sup>Mg

to investigate subsurface processes and lays a foundation for the first field-scale investigation of carbon mineralization in seawater.

<sup>1</sup> Marieni, Chiara, et al. "Mineralization potential of water-dissolved CO<sub>2</sub> and H<sub>2</sub>S injected into basalts as function of temperature: Freshwater versus Seawater." *International Journal of Greenhouse Gas Control* 109 (2021): 103357.

<sup>2</sup> Voigt, Martin, et al. "An experimental study of basalt-seawater-CO<sub>2</sub> interaction at 130° C." *Geochimica et Cosmochimica Acta* 308 (2021): 21-41.