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Unravelling the CO_2 capture potential of serpentinites: evaluation of direct ex-situ carbonation feasibility in a Swiss context

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Mitigating CO_2 emissions requires the development of processes that can capture, store or utilize CO_2 at industrial scales. One of the main proposed solutions is CO_2 mineralization, a process that utilizes a source of cations (primarily Ca^{2+} and Mg^{2+}) to precipitate carbonate minerals, effectively storing CO_2 over geological timescales. Ex-situ carbonation is a technique that mimics geological processes, in which silicate minerals are dissolved using carbonic acid and release Ca^{2+} and Mg^{2+} that are eventually precipitating as calcite or magnesite. Numerous studies have shown that unaltered mafic and ultramafic rocks are prime feedstocks for carbonation due to their highly reactive silicates (olivine, pyroxenes). Other studies have shown that serpentines could also be used to store CO_2, provided that they are heat-treated prior to carbonation in order to increase their reactivity.

In this study, we apply those technics to evaluate whether the mafic and ultramafic rocks in Switzerland could be suitable for industrial-scale ex-situ carbonation, with a primary focus on serpentinites. We investigated two serpentine polymorphs: antigorite and lizardite, by conducting batch carbonation experiments at moderate temperature (90 to 150 °C) and CO_2 pressure (10 bars).

We demonstrate that despite their similar chemical compositions, the different crystal structures lead to different dissolution rates, affecting the carbonation efficiency. Moreover, we confirm that heat treatment drastically increases the dissolution rates, primarily due to the decrease of Si-O-Si connectivity allowing for greater CO_2 mineralization efficiency.

Ultimately, we discuss the feasibility of ex-situ mineralization in the case of Switzerland to mitigate hard-to abate CO_2 emissions (e.g., cement production, municipal waste incineration...). We use the results obtained experimentally and in the literature to determine the timescale of the carbonation reaction using geochemical modeling, and to evaluate the optimal parameters (pressure, temperature) to maximize CO_2 capture efficiency and meet industrial timescale requirements.