Dawsonite as a Temporary but Effective Sink for Geological Carbon Storage

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Abstract

Mineral trapping is recognized as the most secure carbon capture and storage (CCS) mechanism to ensure the long-term retention of carbon dioxide following its injection into permeable porous geologic formations. This process can immobilize CO_2 as carbonate minerals, typically as calcite, dolomite, ankerite, and siderite. Under some natural conditions, however, dawsonite ($NaAl(OH)_2CO_3$) is also stabilized, sometimes attaining significant volume fractions (VF) over 0.2 in some sedimentary formations that may originally have been rich in sodic feldspars. In this study, we used a dawsonite-rich (~10%) CO_2 gas reservoir in the Hailar basin in northern China as a natural analogue of a CO_2 storage site, along with 2D reactive transport modeling, to demonstrate that a large amount of dawsonite can be generated in sandstone formations, provided sufficient Na-rich feldspar and CO_2 gas are available. Modeling results show that dawsonite mineral trapping is thermodynamically favoured in the Hailar basin. While precipitated dawsonite can be preserved only in a hydrodynamically-closed system in the long term under high CO_2 fugacity and high Na activities in solution, short-term trapping of CO_2 in dawsonite (on the order of 10 kyr) is possible and lowers CO_2 pressure, which mitigates the risk of CO_2 leakage to the ground surface or overlying drinking water aquifers. The re-dissolution of dawsonite after a few thousand years facilitates progressive dissipation of the gas phase CO_2 over time. Consideration of reservoirs or saline aquifers with minerals or formation water that can provide a high abundance of dissolved sodium, significantly increases the number of potential CCS sites globally. Furthermore, alternating water-and-gas injection regimens could enhance the precipitation of dawsonite in Na-rich aquifers.