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Identification of scale effects in dissolution trapping from the response of a push-pull experiment

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During geological storage of carbon dioxide in deep saline aquifers part of the stored carbon dioxide dissolves in the brine. This dissolution trapping is one of the key trapping mechanisms of CO_2 and its understanding important when making estimates of the performance of the storage. Dissolution occurs in the carbon dioxide and brine interfaces, i.e. into brine in contact with the edges of the free phase carbon dioxide plume and into residual brine left inside the plume after the push stage.

In this modeling study the scale effect of dissolution trapping for CO_2 in a deep saline aquifer and the use of a push-pull CO_2 injection-withdrawal test in quantifying field scale dissolution trapping, and in particular the relevant spatial and temporal scales of this process, is investigated. A push-pull test consists of two stages. First, a push stage during which supercritical carbon dioxide is injected into the formation; then, a pull stage during which formation fluid is withdrawn. The second stage needs not be initiated immediately after the first, a waiting period of varying duration may be applied. Different withdrawal fluid compositions are obtained depending on the resting period between the injection and the withdrawal stages. The different waiting times between injection and withdrawal of CO_2 permits buoyancy to act for different periods and alter the carbon dioxide plume shape. The different plume shape can in turn give rise to different carbon dioxide-brine interfacial areas, where mixing and dissolution occurs.

In comparing scenarios with different waiting time between injection and withdrawal this effect of mixing was studied. The injection-withdrawal was simulated into a sandstone target layer located at a depth of 1600 m, with properties similar to the Heletz formation where an injection experiment is planned. Simulations of the push-pull test were carried out with the TOUGH2/ECO$_2$N simulator. The preliminary results indicate that a test sequence with multiple push-pull stages in a series could be useful tool for analysis of the dissolution trapping.