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Reactive transport modeling of cement degradation in brines: effect of pH and CO_2 content

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As a CO_2 plume is moving into a reservoir, the chemistry of the fluid at the bottom of an abandoned well changes in successive stages. The first one consists in an increase of the CO_2 content of the brine, while brine saturation remains close to its initial value. A modular reactive transport model, Dynaflow, is used to analyze the reactivity of well cement paste during this first stage. The geochemical module accurately models aqueous speciation and mineral dissolution and/or precipitation within the porous material. Hydrated cement paste is found to dissolve in brines with various content in CO_2. Simulation of a reference case is successfully compared with experimental results, in terms of mineral zoning and dissolution rate. Between pH 2.4 and 5.0, the CO_2 content of a 0.5 M brine controls the degradation rate of cement whereas the pH does not affect it meaningfully. A minimum degradation rate is obtained when the CO_2 molality equals the total molality of aqueous calcium in equilibrium with portlandite. This minimum is related to the maximal amount of calcite precipitated and the relative decrease of the diffusivity within the calcite rich zone.