Predicting the geochemical impact of SO_2 impurities on carbon storage

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SO_2 is a common impurity in CO_2 streams captured from coal fired power plants. The presence of SO_2 during geologic carbon storage is expected to intensify brine acidification through production of sulphuric acid resulting in enhanced mineral dissolution and precipitation. Being able to predict the effects of CO_2 with SO_2 injection on a storage site is critical for assessing risk of leakage and contamination. This study combined H_2SO_4-brine-rock experiments with reaction path modelling to improve our ability to predict CO_2-SO_2 geologic storage. Sedimentary rocks were reacted with a synthetic H_2SO_4-brine at different pH, temperature and sample particle size to evaluate the pH and temperature dependency of reaction rates and to enhance our ability to upscale from the benchtop to the reservoir. While the rate data for most minerals proved adequate, for compositionally variable minerals, like chlorite and ankerite, rate parameters derived from published sources had to be adjusted to provide a good fit to the experimental data. The experimentally derived kinetically controlled models were then upscaled to reservoir scale, modified to include CO_2 and O_2 and run for 100 y. The models predicted rapid carbonate dissolution at the beginning of the modelling period followed by slower, more linear silicate dissolution. The initial carbonate dissolution buffered the SO_2 induced acidification within the first year after injection resulting in a CO_2 dominated system. Compared to pure CO_2 storage the CO_2-SO_2-O_2 reservoir models resulted in enhanced carbonate reaction extent and the precipitation of sulphates and oxides. Further, a greater porosity increase was predicted for CO_2-SO_2-O_2 storage, which has significant ramifications for the safety of the seal and the storage capacity of the storage formation.