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Compaction creep of wet granular feldspar aggregates and the effect of CO_2 injection

S.J.T. Hangx and C.J. Spiers

0.0.1 High Pressure and Temperature Laboratory, Faculty of Geosciences, Utrecht University, P.O. box 80021, 3508 TA, Utrecht, The Netherlands

Geological storage of carbon dioxide in clastic reservoirs and aquifers will result in several effects on the injected host rock: (1) mineralisation, due to water-CO_2-rock interactions, and (2) geomechanical effects, such as compaction due to dissolution, reaction, or enhanced microcracking. The extent of mineralisation reactions depends on the availability of reactive cations present in Ca-rich feldspars, Fe,Mg-rich clays and micas, and Fe-oxides. Geomechanical effects of dissolution and microcracking are expected to depend on factors such as pH, grain size, temperature, and effective axial stress.

We performed uniaxial compaction creep experiments on granular aggregates of wet feldspar, to simulate feldspar-rich sandstones. Our aim was to study mineralisation reactions and geomechanical effects of CO_2 injection under reservoir conditions. To maximise any contribution of reaction we used Ca-rich feldspars, i.e. anorthite and labradorite. During the experiments, several factors were varied in order to determine their individual effect: (1) grain size, d = 15-300 μm, (2) temperature, T = 25-150˚C, (3) CO_2 pressure, P_{CO2} = 0-100 bar, (4) effective axial stress, σ_{eff} = 0-80 MPa, and (5) pore fluid composition. Control experiments were also performed on wet granular quartz samples, dry granular feldspar, and wet feldspar samples containing pure water as a pore fluid (no CO_2 pressure).

Our experiments on wet feldspar showed that compaction was significantly enhanced by the introduction of water to the sample. In addition, increasing the temperature increased the rate and amount of compaction. However, injection of CO_2 inhibited compaction, and hence creep rates, of the feldspar samples. We found no evidence of reaction products in our experiments and thus infer that reaction played no role in controlling compaction. However, compaction rate was found to increase with increasing grain size and cumulative acoustic emission counts systematically with compaction strain. On this basis we infer that microcracking is the main mechanism causing compaction. This was true in wet and wet CO_2-bearing samples.

Our CO_2 tests imply that injection of carbon dioxide into clastic reservoirs and aquifers will inhibit microcracking mechanisms, so that geomechanical effects related to such processes are likely to be minimal. More research needs to be done on the long-term effect of CO_2 injection, in order to quantify the effect of mineralisation on deformation as well as on CO_2 fixation.