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Impact of CO_2 with impurities on integrity of wellbore cements during CCS

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CO_2 injected into geological reservoirs for storage will contain a range of impurities dependent on the specifications of the transport and storage operator(s). Such impurities include inert gases such as N_2 and Ar, as well as reactive components including SO_x, O_2, and H_2S. Upon injection into a (wet) reservoir, these components will partition between the CO_2-phase and the hydrous pore fluid, and some of the reactive species may introduce acidification (in addition to the acidification caused by the CO_2 itself), or other chemical reactions.

In the near-wellbore area, the partitioning impurities can potentially lead to enrichment of water-soluble impurities in the hydrous fluid and corresponding depletion of these impurities in the CO_2 plume. Because of this, even low (ppm-level) concentrations of reactive impurities need to be considered with regards to their potential impact on wellbore sealant integrity. As part of the Cementegrity project, we have performed exposure experiments on five different sealant compositions; three of which are based on Ordinary Portland Cement (OPC), one is based on Calcium-Aluminate Cement (CAC) and one is a granite-based geopolymer (GP). Using a purpose-built batch-exposure system, sample cylinders were exposed to water and supercritical CO_2 under simulated downhole conditions of 80°C and 8-10 MPa, for up to 16 weeks. The sealant samples were placed at two different levels in each exposure apparatus, so that samples were either exposed to wet supercritical CO_2, or to CO_2-saturated water. The effect of H_2S in the CO_2 stream was studied in a second series of experiments, where 2.2 mol% H_2S was added to the CO_2-phase to which the samples were exposed.

After exposure, the samples were retrieved and cross-sectioned perpendicular to the axial direction, so that the impact of exposure on sealant microstructure and composition could be studied using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). In this paper, we will focus on the different impacts of exposure conditions (wet sc. CO_2 vs. CO_2-saturated water) as well as the additional impact of H_2S.