Characterization of CO2 Induced Wellbore Cement degradation by Micro CT

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Wellbore cement integrity under CO2 geologic storage (CGS) conditions is a key factor to assure safe and permanent storage of CO2. Wellbore cement integrity may be impaired and the structure of cement may be altered as a result of CO2 attack. To understand how CO2-induced structure alteration in oil well cement under CGS conditions affects well integrity in CGS projects, this paper reports an experiment of reaction between CO2 and oil well cement under CGS conditions. Samples were scanned by Micro CT before and after reaction. The Micro CT is capable of operating at 140KV and 10W, has a maximum resolution of 10µm. To simulate the reaction between CO2 rich brine and oil well cement at CGS conditions, our team has developed a testing system which provides the storage temperature and pressure.

The samples were made by standard class G oil well cement used for CGS pilot projects. The cement was cured at CO2 storage formation conditions: 62℃, 17MPa, and 1 wt% NaCl solution. The curing was maintained for 14 days. The diameter of the samples was 10 mm. Every sample contained a small borehole at center (around 1 mm diameter) that made the samples suitable for examining seepage through small leakage pathways within cement. During the reaction experiment, the samples were placed in the high-pressure, high-temperaure testing system for 14 days, given a temperature of 62℃ and a CO2 partial pressure of 17MPa. The goal of this experiment is to evaluate how the geochemical reactions between dissolved CO2 and cement affect structure of the cement. Change of borehole geometry was not observed in the Micro CT images. However, a region with decreased porosity around the borehole due to CaCO3 precipitation and a region with increased porosity around the borehole due to Ca(OH)2 and C-S-H dissolution were observable. Initial distribution of cementitious materials and solution buffering governed the width of the high-porosity region and CaCO3 precipitation region. This study demonstrates a 3-D sample characterization technique that can be used to investigate CO2-induced structure alteration of oil well cement.