Experimental research of casing cement alteration by interaction with supercritical CO_2 for geological sequestration

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In CO_2 geological sequestration, the most important thing is to prevent leakage of CO_2 from the reservoir. The alteration of the casing cement by exposed supercritical CO_2 may cause the leakage of CO_2. The purpose of this study is to know the influence of alteration degree by supercritical CO_2 between the casing cement–sandstone interface.

Experimental specimens are composed of Berea sandstone and oil well cement. The sandstone is prepared in the form of cylinder (25 mm in daimeter and 90 mm in length) with a drilled hole (7 mm in diameter) at the center. Then oil well cement is solidified in the hole. The experimental specimens and solution are set in reaction cambers. Two kinds of solutions are prepared (distilled water and 3% NaCl solution). Then the chambers are backfilled with CO_2. The temperature and pressure in the cambers are kept at 60°C and 10MPa, respectively, during experiments (3 or 9 weeks). In these conditions, CO_2 exists as supercritical fluid. After the experiments, the specimens are examined by microscopic observation and analyzed by SEM-EDS and XRD.

In all experimental specimens, mineral precipitation was observed in the pores of sandstone at 0.6-0.8mm far from the interface of the cement. The precipitation was identified as aragonite and calcite.

This short period experiment result implies that carbonate mineralization in the pore of sandstone near cement might disturb flowing of CO_2 and water in the reservoirs and that the cement degradation may be constrained. There is an possibility that the carbonate minerals precipitated in the pore could be dissolved due to continueous interaction with acidc brine and that the long period experiments must be done.

Residual strain and domain orientation in quartz

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Quartz commonly exhibits undulatory extinction when examined with a polarizing microscope with crossed polarizers. This effect is known to be caused by fragmentation of the single crystal into domains separated by dislocation walls and showing some degree of rotational disorder around the c-axis. This domain structure is attributed to deformation in a non-hydrostatic stress field. In this case, quartz crystals showing these optical effects might exhibit some residual strain, up to the maximum elastic limit.

We performed Laue X-ray microdiffraction on several quartz samples using the micro-diffraction beamline 12.3.2 of the Advanced Light Source at the Lawrence Berkeley Laboratory [1]. The experiments were done with a 1 x 1 μm white (5 keV < λ < 22 keV) X-ray beam with spatial resolution between 5 and 25 μm. We document significant residual strain in quartz crystals in stishovite-bearing rocks from the Vredefort meteor impact crater in South Africa and granite adjacent to the Santa Rosa mylonite zone in Southern California.

The residual strain, expressed as equivalent strain $\varepsilon' = \mathrm{sqrt}(\varepsilon_{11}^2+\varepsilon_{22}^2+\varepsilon_{33}^2)$, reaches mean values around 5×10^{-3} with a distribution maximum around 1.5×10^{-3} in the Veredefort sample. This is an order of magnitude higher than the strain measured in a hydrothermally grown synthetic single crystal. Furthermore, the amount of equivalent strain measured seems to anticorrelate with the fragmentation of the individual crystals. The fragmentation, as evidenced by the number of sub-peaks a given Laue spot envelope is comprised of, is observed on a sub-micron level in the shocked quartzite. The quartz grain from the unshocked Santa Rosa granite sample shows single crystal fragments of several 10's of microns in size.

The orientational variation between domains within an undulatory grain shows an amplitude of about 3 degreess.

[1] N. Tamura, A.A. MacDowell, R. Spolenak, B.C. Valek, J. C. Bravman, W.L. Brown, R. S. Celestre, H.A. Padmore, B.W. Batterman and J.R. Patel (2003) *J. of Synchrotron Radiation* **10,** 137-143.