☐ **Talk** ☒ **Poster**

Elemental mapping of CO_2-attacked wellbore cement using SEM-EDS versus synchrotron XRF microprobe

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Geochemical interactions between CO_2 and well bore cement is crucial to understand and prevent structural degradation[1]. In this study, we have studied the interaction of Class H cement with CO_2 in the presence of real formation water and compare the results with those from lab-made synthetic brine solution (0.873 M NaCl) that has been conventionally used in similar studies[2,3,4]. An additional goal of this study was to visually compare the elemental mapping results generated by conventional SEM-EDS and synchrotron-based X-ray fluorescence mapping tools. Cured Class H cement cores were reacted for 14 days at 60 °C and 100 bar CO_2 in Parr reactors with (a) synthetic brine solution and (b) real formation water solution. We studied the extent of chemical alterations in the cement using synchrotron micro-XRF probe at NSLS-II, scanning electron microscopy along with electron dispersive spectroscopy (SEM-EDS), and X-Ray diffraction (XRD). The micro-XRF Fe maps confirmed the presence of a prominent secondary Fe-rich zone on the exterior of the cement core after reaction with CO_2-saturated synthetic brine, whereas the cement core reacted with CO_2-saturated real formation water exhibited a less-extensive Fe zone. Intriguingly, this Fe-enriched zone was not obviously observable in SEM-EDS elemental maps, attributable to lower elemental resolution of SEM-EDS compared to micro-XRF. In comparison to the secondary Fe-rich zone, Ca-enriched carbonated zones were observed in both cement samples using both SEM-EDS and the synchrotron micro-XRF probe. XRD analysis showed that calcite ($CaCO_3$) was the only observable carbonate in the carbonated zone, regardless of the reaction solution being synthetic brine or real formation water. In addition to providing scientific understandings about cement-CO_2 interactions under CO_2 sequestration conditions, this study distinctly shows the different analytical strengths of SEM-EDS versus synchrotron micro-XRF. While SEM is essential for visualizing pore structures, micro-XRF can resolve elemental distributions that might not be identifiable in EDS maps.

References

[1] Kutchko, B. G.; Strazisar, B. R.; Dzombak, D. A.; Lowry, G. V.; Thaulow, N. Degradation of Well Cement by CO2 under Geologic Sequestration Conditions. Environ. Sci. Technol. 2007, 13 (41), 4787–4792.

[2] Carey, J. W. Geochemistry of wellbore integrity in CO2 sequestration: Portland cement−steel−brine−CO2 Interactions. Rev. Mineral. Geochem. 2013, 77 (1), 505−539.

[3] Jun, Y.-S.; Giammar, D. E.; Werth, C. J. Impacts of Geochemical Reactions on Geologic Carbon Sequestration. Environ. Sci. Technol. 2013, 47 (1), 3−8.

[4] Li, Q., Lim, Y.M., Flores, K.M., Kranjc, K., Jun, Y.-S., 2015a. Chemical Reactions of Portland Cement with Aqueous CO_2 and Their Impacts on Cement's Mechanical Properties under Geologic CO_2 Sequestration Conditions. Environ. Sci. Technol. 49, 6335–6343.