Importance of Proper Curing and Aging of Cements in Laboratory Testing for CCS Applications

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Carbon capture and subsequent geological storage requires wellbore cement that is resistant to CO_2 for at least several centuries. Conventional API Class oil-well cement based on Portland cement is thermodynamically unstable against CO_2. Previous laboratory studies have shown that the carbonation reactions often cause destabilization and formation of fractures. However, published findings vary greatly, owing to the multitude of methods used to prepare cement samples for studying their interaction with corrosive environments.
In the course of the EUDP-coordinated research project Greensand Phase II, a systematic trial matrix of cement types (API and non-API) and additives have been mixed and cured in sample cells under actual downhole conditions. These samples for lab testing were cured at reservoir pressure and temperature, since the alternative of hardening under atmospheric conditions would not represent the reality and would render the cement more sensitive to CO_2 attack.
Complementary slurry characterization ensured that all formulations met oilfield specifications in terms of density, rheology, thickening time and compressive strength development.
Subsequently, the cement plugs were aged in synthetic formation water under reservoir conditions to generate a comparable degree of maturation, regardless of the specific cement type and formulation. Each cement plug was prepared as unconfined as well as confined in steel pipe. Prior to final aging under CO_2-containing environments for varying durations, every single plug was non-destructively 3D imaged by X-ray micro-CT to ensure reproducible homogeneity without defects and to characterize the pre-testing state. Post-aging micro-CT imaging with 3D pre-post alignment and complementary SEM analysis were performed to detect the type, severity and localization of the CO_2-induced changes. More than 250 cement plugs were produced and processed using this workflow within the project to date.
First results from the research project will be presented and an concluding outlook will be given.