Investigation of wellbore integrity for Ordos CCS demonstration project in China
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Abstract
The Ordos CCS project operated by Shenhua Group is the first demonstration project for CO\textsubscript{2} storage in deep saline aquifer in China [1]. The injection commenced in 2010 and had completed in 2015 for the first phase. There was approximately 300,000 tonnes CO\textsubscript{2} injected into the brine-saturated low-permeability sandstone and carbonate aquifers at depths of more than 1620m in the northeastern Ordos Basin, China [2]. Despite this demonstration project is currently only under monitoring stage, understanding of wellbore integrity is crucial as it could provide recommendations for the application of lessons learned to the design and construction of new CO\textsubscript{2} injection wells for the future phase of this project, or even other new CCS project.

Wellbore integrity (especially for well cements) under geologic carbon storage conditions is closely associated with the degree of cement carbonation [3]. Extensive studies on the integrity of well cements in contact with CO\textsubscript{2} and CO\textsubscript{2}-brine have been reported during last decade [4]. Those studies have indicated that cement degradation in the well adjacent to the caprock can be key issue with respect to well integrity, since it may cause potential CO\textsubscript{2} leakage pathways [5, 6]. Therefore, the aim of this study is to investigate wellbore integrity by the in situ the CO\textsubscript{2}-brine-wellbore cement-rock geochemical interactions with the ultimate goal of understanding well leakage risks for CO\textsubscript{2} storage site.

Core samples were collected for the Inject Well One and the Monitoring Well One of the Ordos CCS site, respectively. The numbers of composite cement-rock core samples were prepared by using Portland Class G cement, which were then imaged by X-ray CT and micro-CT scanners, respectively [6]. Following baseline geochemical characterisation (XRD, SEM/EDX), the core samples are aged using a set of 10 hydrothermal vessels to mimic in situ geological conditions (Pmax = 21 MPa, Tmax = 70°C) for 6 months and then up to 12 months. Core samples placed in the vessels were covered with synthetic brines that mimic the formation water of saline aquifer in the Ordos project. Due to the complex composition of natural brines, only major ions were considered to prepare the synthetic brines in this study, including Na\textsuperscript{+}, K\textsuperscript{+}, Mg\textsuperscript{2+}, Ca\textsuperscript{2+}, Sr\textsuperscript{2+}, Ba\textsuperscript{2+} and Cl\textsuperscript{-} [7, 8]. Liquid CO\textsubscript{2} was injected to saturate the synthetic brine and the curing temperature and pressure conditions were adjusted and maintained during the hydrothermal studies. The liquid samples would be collected to conduct the ICP-OES analysis. Finally, the geochemical experiments will be completed by characterisation of

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solid and liquid sample, the change of porosity and permeability will also be compared. Furthermore, the composite cement-rock core samples will also be investigated by continuous flooding of CO2-saturated brine [9]. Finally the results of these series of experiments will then be employed as input data for numerical modelling of the behaviour at the cement-rock interface by the code of TOUGHREACT. These results (both experimental and numerical) could then be applied to further understand the effects of the wellbore cement and CO2 interaction under geologic storage conditions on wellbore-cement integrity.

References: