Geophysical Research Abstracts
Vol. 15, EGU2013-10122, 2013
EGU General Assembly 2013

Experimental Investigations into CO_2 Interactions with Injection Well Infrastructure for CO_2 Storage

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Wellbore integrity is an essential requirement to ensure the success of a CO_2 Storage project as leakage of CO_2 from the injection or any other abandoned well in the storage complex, could not only severely impede the efficiency of CO_2 injection and storage but also may result in potential adverse impact on the surrounding environment. Early research has revealed that in case of improper well completions and/or significant changes in operating bottomhole pressure and temperature could lead to the creation of microannulus at cement-casing interface which may constitute a preferential pathway for potential CO_2 leakage during and post injection period. As a part of a European Commission funded CO_2CARE project, the current research investigates the sealing behaviour of such microannulus at the cement-casing interface under simulated subsurface reservoir pressure and temperature conditions and uses the findings to develop a methodology to assess the overall integrity of CO_2 storage.
A full scale wellbore experimental test set up was constructed for use under elevated pressure and temperature conditions as encountered in typical CO_2 storage sites. The wellbore cell consists of an assembly of concentric elements of full scale casing (Diameter= 0.1524m), cement sheath and an outer casing. The stainless steel outer ring is intended to simulate the stiffness offered by the reservoir rock to the displacement applied at the wellbore. The Central Loading Mechanism (CLM) consists of four case hardened shoes that can impart radial load onto the well casing. The radial movement of the shoes is powered through the synchronised movement of four precision jacks controlled hydraulically which could impart radial pressures up to 15 MPa. The cell body is a gas tight enclosure that houses the wellbore and the central loading mechanism. The setup is enclosed in a laboratory oven which acts both as temperature and safety enclosure.
Prior to a test, cement mix is set between the casing and outer steel ring. A radial pressure is maintained on the wellbore casing during cement setting, i.e., the casing is in a state of tension, so that a microannulus can be created by subsequent contraction of CLM when the radial pressure is relieved. The aperture (permeability) of the microannulus can be controlled by varying the CLM pressure on the casing, which is maintained throughout a flow test. During a test, pure CO_2/brine saturated CO_2 is flown through the microannulus over a period of time to study its permeability behaviour under simulated downhole conditions. Evolution in permeability is monitored and the effluent is collected and analysed regularly. These experimental results will be used as an input to implement a time-dependent microannulus permeability in the numerical model to assess the impact of such behaviour on the storage performance of a CO_2 storage reservoir. The results of the first set of experiments, where the permeability behaviour of pure CO_2 was monitored over a 3 months period, are presented and discussed in this paper.