Proceedings of the 2nd World Congress on Civil, Structural, and Environmental Engineering (CSEE'17)
Barcelona, Spain – April 2 – 4, 2017
ISSN: TBA
DOI: TBA

An Experimental Study of Geomechanics Aspects of CO_2 Sequestration in Saline Aquifers

Rathnaweera T and Ranjith PG
Monash University, Australia
Wellington Rd & Blackburn Rd, Clayton VIC 3800, Australia

Geo-sequestration of carbon dioxide (CO_2) in deep saline aquifers is one of the most feasible approaches to mitigate global warming. However, dissolution of injected CO_2 in brine has some effects on geomechanical properties in the reservoir rock. There is also a significant variation in the mineral composition of reservoir rock upon exposure to CO_2, which changes the mineralogical and micrological structure of the rock mass and consequently changes the geomechanical properties of the reservoir rock. Therefore, this study provides a comprehensive evaluation of the potential changes in aquifer geomechanical characteristics caused by injected CO_2 under in situ conditions, highlighting the factors affecting the integrity of reservoir rock properties. The factors considered are brine concentration, injection pressure, depth (confining pressure), temperature and mineral composition of the reservoir rock. In addition, the consequences of leakage and the mechanisms of failure of the reservoir rock due to changes in geomechanical properties are also discussed. The experimental series was started by evaluating the geomechanical behaviour of natural formations under brine-saturated conditions and then CO_2 was injected into brine-saturated samples to investigate the influence of CO_2 on the geomechanical proprieties of reservoir rock. For the triaxial strength tests, undrained experiments were performed using the newly-developed triaxial set-up.

The natural aquifer's mechanical behaviour was characterised based on the salinity effect in both uniaxial and triaxial stress environments. According to the results of the salinity tests, the presence of NaCl in the pore fluid causes the reservoir rock mechanical properties to change. Uniaxial strength tests on brine-saturated samples confirmed a strength gain in reservoir rock compared to water-saturated samples, which was also shown by triaxial test results. The maximum strength gain was observed in samples saturated with higher percentages of NaCl (20 and 30%). According to scanning electron microscopy (SEM) analysis, when the aquifer has a higher percentage of salinity, there is a significant number of NaCl deposits in the pore structure of the rock mass, and these deposits enhance the reservoir rock strength by reducing the number of voids. In addition, confining pressure also plays a considerable role in reservoir rock strength, and it causes the reservoir rock strength to increase. Moreover, the applicability of the conventional Mohr-Coulomb criterion to represent the stress state of brine-saturated reservoir rock was also investigated. The results confirmed a considerable deviation of the measured triaxial data of brine-saturated Hawkesbury sandstone from the conventional Mohr-Coulomb failure criterion, especially at high confining pressures. In order to correct this deviation, the present study modified the conventional MohrCoulomb failure criterion, based on experimental data and a modified version was proposed. The proposed model was finally validated and its accuracy confirmed in predicting the stress-strain behaviour of reservoir rock in deep saline aquifers. According to the results of CO_2-reacted samples, the interaction between injected CO_2, brine and reservoir rock causes the Hawkesbury sandstone strength to be reduced in CO_2 sequestration in deep saline aquifers. For instance, supercritical CO_2 reaction causes around 32.89%, 17.65% and 14.75% uniaxial compressive strength reductions and 1.8%, 57.45% and 92.3% Young's modulus reductions in brine-saturated Hawkesbury samples with 10%, 20% and 30% NaCl concentration brines, respectively. According to the SEM, X-ray diffraction (XRD) and X-ray florescence (XRF) results, considerable quartz mineral corrosion and dissolution of calcite and siderite minerals were observed during the interaction of CO_2, brine and reservoir rock. The dissolution of these minerals weakens the graincemented bonds, accelerating the failure mechanisms of the pore matrix

Keywords: Deep saline aquifers, reservoir rock, geo-mechanical properties, salinity, mineralogical.