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Streamline-based Simulation of Geological CO2 Storage: Otway Case-Study

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Three of the most important challenges for the near future: maximizing oil extraction, securing fresh water supplies and mitigating climate change through Carbon Capture and Storage (CCS), require a better understanding of flow in porous media.

It has been shown by Qi et al [1] that an optimum injection strategy for CO2 storage can result in up to 90% of the injected CO2 being trapped in the pore network of the rock during the injection phase of a CO2 storage project. When the non-wetting phase saturation increases and then decreases in the pore space, part of the non-wetting phase is trapped in pores as a residual saturation. Injection of CO2 and water in alternating cycles can be used to engineer this trapping. With time, CO2 will dissolve in the brine surrounding it and finally precipitate as carbonate.

The Otway Project, taking place in the south-east of Australia and lead by the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), is the world's largest research and geosequestration demonstration project [2]. CO2CRC has proposed testing the concept of using residual trapping to improve storage security by using Huff and Push injections. In this case, CO2 is injected in a depleted gas reservoir together with methane. The Huff and Push injection mechanism consists of a single well which alternates injection and production. Initially, brine is injected followed by a mixture of CO2/CH4/other gases (77/20/3 mole%) followed by a shut-in period. Then, when production starts the water front should move faster towards the production well and immobilise CO2 in the micro pores of the rock. Very little production of CO2 should be observed, confirming that it has been immobilized within the formation.

Traditional grid-based reservoir simulations are used to predict fluid behaviour and to design injection strategies that maximize both oil extraction and trapping of carbon dioxide in the rock formation. Unlike conventional grid-based simulations, streamline-based simulators have the advantage of solving transport equations in 1D, which decreases the CPU (Central Processing Unit) time without losing accuracy. The current in-house streamline-based simulator has been extended to include compressibility. This 3-component (hydrocarbon, carbon dioxide and brine) 2-phase (aqueous and hydrocarbon) research code allows the CO2 to dissolve in both aqueous and hydrocarbon phase, water to dissolve in the hydrocarbon phase and assumes that hydrocarbons only exist in the hydrocarbon phase.

The extended compressible streamline simulator will be used to simulate Huff and Push injection in the different geological scenarios taken from the Otway Project. A detailed study will be carried out to optimise the injection scheme and understand how reservoir variability can influence CO2 trapping. Streamline simulations will be compared against commercial simulations (ECLIPSE) regarding convergence of results and simulation times.

1. R Qi, T C LaForce and M J Blunt, "Design of carbon dioxide storage in aquifers," International Journal of Greenhouse Gas Control 3 195-205 (2009).
2. Website accessed on 14th January 2010: http://www.co2crc.com.au/otway/