Abstract

The Weyburn and Midale oilfields in Saskatchewan, Canada are operated by Cenovus Energy currently contain the largest amount of injected anthropogenic CO₂ on the planet. Since 2000 there has been 25 million tonnes of CO₂ stored in these reservoirs, and an additional 3 million tonnes stored injected annually. The Petroleum Technology Research Centre (PTRC) has managed a decade of world-leading, peer reviewed research undertaken by the IEAGHG Weyburn-Midale CO₂ Monitoring and Storage Project (WMP).

The latest project, the Saskatchewan CO₂ Oilfield Use for Storage and EOR Research project (SaskCO2USER), also managed by the PTRC, and is conducting applied research for commercial applications in high priority areas for CO₂-EOR operations, relevant to future recognition of CO₂ geological storage. Research is conducted by North American and European organizations, providing an international context to findings for commercialized applications. This portion of the project is conducted by the Saskatchewan Geological Survey, it will investigate the effect of injected CO₂ on the rock framework and the pore space. This work will build upon the rich datasets from the Weyburn and Midale fields to better inform prospective CO₂-EOR operators, government regulators and service providers on how to improve the efficiency of CO₂-EOR operations, maintain the safety and integrity of CO₂ storage, and limit liabilities and risks during operations.
Previous research has demonstrated that CO₂ injection has impacted the porosity and permeability of carbonate rocks, thus affecting sweep efficiency and storage capacity. Such dissolution of carbonate minerals due to CO₂ injection can increase the EOR sweep efficiency and storage capacity of the reservoir by increasing porosity and, in turn, enhancing permeability. Alternatively, precipitation of carbonate minerals can potentially block pore space and decrease permeability, which is detrimental to sweep efficiency, and may lead to decreased storage capacity. Two observations wells have recently been drilled in an active CO₂-EOR field. Numerous drill stem tests (DST) and extensive core intervals were recorded from the two wells. This field scale “laboratory” will provide a rare opportunity to investigate the results of injected CO₂ on the carbonate framework and pore space at an active injection site leading to a better understanding of the response of the carbonate framework and pore space over the last 15 years of CO₂ injection. The outcomes of this project will assist in determining which reservoir scale processes are occurring, if any and will be important to CO₂-EOR field operators.

Numerous analytical techniques were utilized to investigate possible effects of injected CO₂ on the cores. This study focused on the Midale beds which is the main injection and production formation for the WMP. Quantitative Evaluation of Minerals by Scanning (QEMSCAN) was used to measure the quantitative mineral modal abundance and porosity in each sample. Mineral grains are identified using back-scattered electron imaging and qualitative energy dispersive X-ray (EDS) spectra. EDS x-ray mapping can be used to detect individual elements present in specific crystals with a 20 µm spacing interval. EDS x-ray mapping can determine if traces of other minor elements such as iron or magnesium can be observed in calcite or dolomite crystals. Cathodoluminescence (CL) was also utilized to determine if the internal structure of the rock framework was different in the pre-CO₂ versus the post-CO₂ cores. CL can provide the basis for understanding the origin, diagenesis and porosity development that can occur in carbonate rocks. CL can distinguish the carbonate phases, cement growth on pre-existing crystals as well as porosity evolution; such
petrographic analysis can aid in understanding if different conditions were present in the formation and diagenesis of carbonate reservoirs.

Comparing the analytical data from the pre-CO$_2$ and post-CO$_2$ cores indicates that there is not any major effect on the reservoir from the injected CO$_2$. In the post-CO$_2$ cores there seems to be no evidence of dissolving the existing rock framework thus creating new pore space and conversely there was no evidence of precipitation of new minerals. The cores were subjected to the CO$_2$ flood for 5 to 9 years. The findings from this project will aid CO$_2$-EOR operators, service providers and government regulators on how to better understand, manage, regulate and develop future CO$_2$-EOR projects.