

Geological and Hydrogeological Site Characterization for Saline Aquifer CO₂ Storage in the Redwater Leduc Reef, Alberta, Canada

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The Devonian Redwater Leduc reef, located northeast of Edmonton in Alberta, Canada, represents an excellent opportunity for the storage of several hundred megatonnes (Mt) of CO₂ captured from large stationary sources such as oil sands upgraders, refineries and chemical plants in the region. The bioherm reef is located at a depth of about 1000 metres (m) and has a massive areal extent of roughly 600 km² with a thickness of up to 290 m. This reef grew on the platform carbonates of the Cooking Lake Formation (Fm.) and shales of the Ireton Fm. laterally encase and seal the reef. Only the updip rim of the reef was oil charged yet it was the third largest oil pool in Western Canada (1.3 billion barrels OOIP). The Heartland Area Redwater Project (HARP) is conducting a detailed site characterization for a Carbon Capture and Storage (CCS) pilot in the huge water-saturated portion of the reef.

Comprehensive analysis of well logs, core and rock properties has resulted in a carbonate facies model for the reef with three major units identified by facies type, stacking patterns, and individual cycles of growth. All three units consist of foreslope, reef margin and interior lagoon sediments. Only the western margin of the reef and Cooking Lake aquifer are dolomitized, which significantly increases the porosity and permeability forming the main conduit for fluid flow between the reef and underlying aquifer. A deterministic 3-D reservoir model has been generated focusing on the structure and distribution of porosity and permeability in the reef to be utilized for history matching and predictive reservoir simulations. Hydrogeology of the storage target, including the immediately underlying and overlying aquifers, was completed in order to ascertain the hydrodynamics and degree of hydraulic communication. The hydrogeology was undertaken to properly evaluate and assess fluid migration and CO₂ containment. Evaluation of salinity and hydraulic head distributions, and vertical pressure gradients revealed the strong aquifer support from the underlying Cooking Lake aquifer and also confirmed the seal integrity of the Ireton aquitard.

Results of site characterization for this CCS project and the close proximity of the Redwater Leduc reef to CO₂ sources, make it an ideal storage target. The stratigraphic architecture and structural setting of the Redwater Leduc reef presents a unique opportunity to study the fate of large volumes of CO₂ stored in a reefal carbonate system.