Acid Gas Injection for Enhanced Oil Recovery and Long-Term Storage in Zama Pinnacle Reefs

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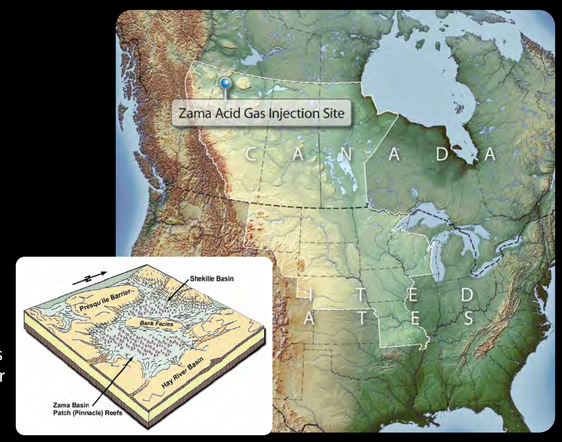


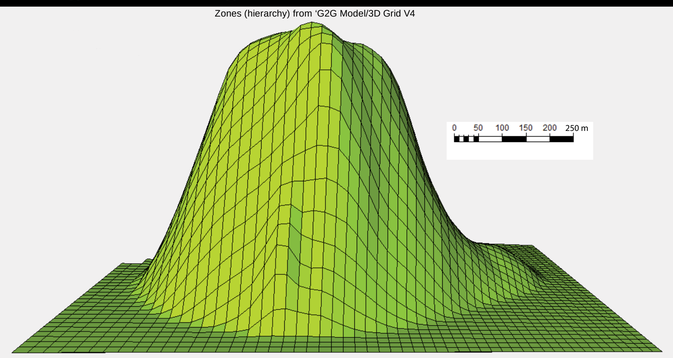
Abstract

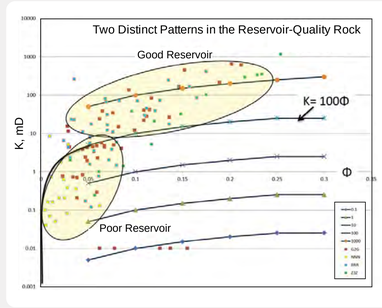
An acid gas disposal and enhanced oil recovery (EOR) site in northwestern Alberta, operated by Apache Canada Ltd., has been the subject of simulation work performed by the Energy & Environmental Research Center at the University of North Dakota. The purpose of the simulations performed was to increase our understanding of the reservoir in order to test the efficacy of monitoring, verification, and accounting techniques for carbon capture and storage.

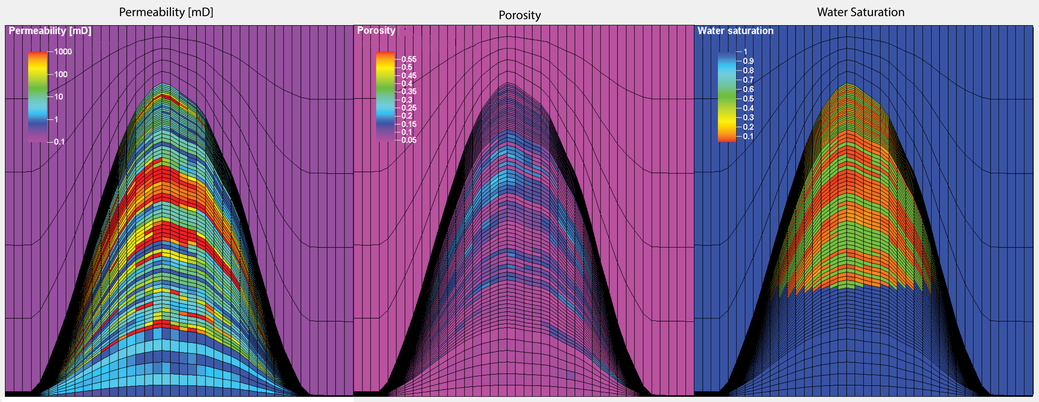
The hundreds of pinnacle reefs throughout the world hold in excess of 1 million barrels of oil each. These pinnacles represent an excellent opportunity to recover incremental oil through EOR and have a large potential to store CO_2. This research is to investigate the potential of conducting tertiary oil recovery in pinnacle reefs in the Zama area and the potential for long-term CO_2 storage. Furthermore, the research provides a robust methodology for the evaluation of similar projects in other Zama pinnacle reefs.

A detailed review was carried out which evaluated the historic data for all of the targeted pinnacles. As a part of this evaluation, fluid behavior was studied for both EOR efficiency and long-term storage purposes. A high-resolution heterogeneous geocellular model was constructed for each of the three pinnacles under investigation. Each of these models was run through a high-resolution history match and long-term predictions for EOR and scenarios to investigate using pinnacle reefs for CO_2 storage. Based on this workflow, the CO_2 sweep efficiency, storage capacity for each pinnacle, and the potential injection programs were estimated.

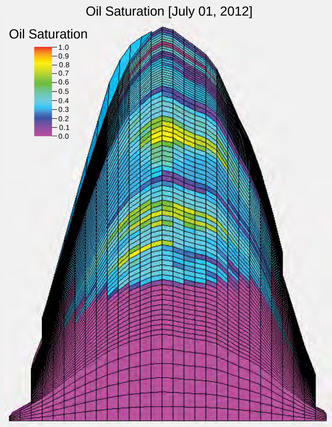
Geologic Modeling







Dynamic Modeling for CO_2 EOR Potential and Storage

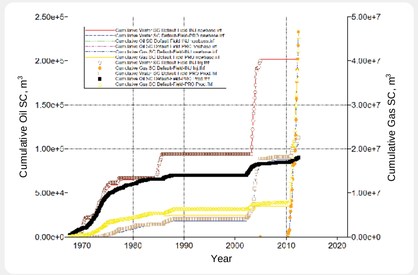


CO_2 Utilization Factor and Recovery Contribution

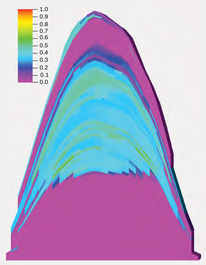
Pool	OOIP (MMstb)	CO_2 Utilization E_u (lb/bbl)		Recovery Contributed by CO_2 E_{rCO_2} (%)	
		Pessimistic	Optimistic	Pessimistic	Optimistic
Keg River G2G	3.71	687.20	590.00	4.40	15.00
Muskeg L	2.70	1625.00	492.50	1.60	9.80
Keg River F	4.30	2831.20	1202.50	12.60	22.00
Average	-	1238.07		6.20	15.60

Estimates on CO_2 Storage Capacities for Three Extra Pools

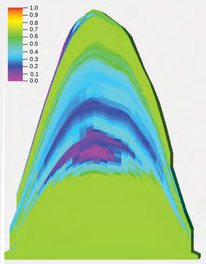
Pool	OOIP (MMStb)	E_u (lb/bbl)	E_{rCO_2} (%)		Storage Capacity (Mtonnes)	
			Pessimistic	Optimistic	Pessimistic	Optimistic
Keg River Z3Z	2.38	1238.07	6.20	15.60	83	209
Keg River RRR	4.70	1238.07	6.20	15.60	164	412
Keg River NNN	3.53	1238.07	6.20	15.60	123	310

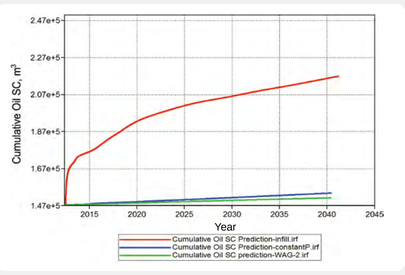


Oil Saturation [April 01.2041]



Global Mole Fraction (CO_2) [April 01.2041]





Summary

This investigation of the geologic storage of CO_2 in the Zama pinnacles was focused on acid gas injection in partially depleted hydrocarbon reservoirs for the purpose of simultaneous EOR, acid gas disposal, and CO_2 storage. The feasibility of using existing wells as storage sites and the potential risks and factors related to the degradation of the cap rock in long-term storage were examined. High-resolution geocelluar models for the F, G2G, and Muskeg L pools were constructed. Each model was history-matched to production data, and estimates for EOR and storage efficiencies were made. Dynamic injection simulations were conducted, with multiple scenarios developed to investigate using these pinnacles for CO_2 storage and to provide information for EOR program design and optimization. The simulation work also allowed for the extrapolation of potential oil recovery and CO_2 storage efficiency in other Zama pinnacles. The results of these efforts indicate that the combination of EOR, acid gas disposal, and CO_2 storage can be successfully conducted in the pinnacles in the Zama area, and this approach could be applied to similar pinnacle reef structures in other geologic formations.

Acknowledgments

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