ACID GAS INJECTION FOR ENHANCED OIL RECOVERY AND LONG-TERM STORAGE IN ZAMA PINNACLE REEFS

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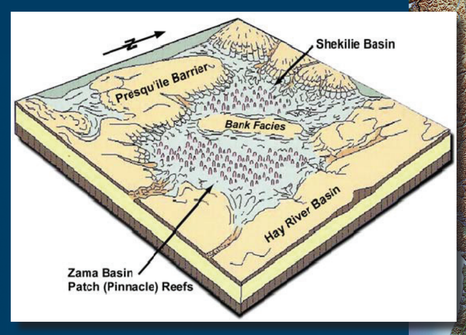
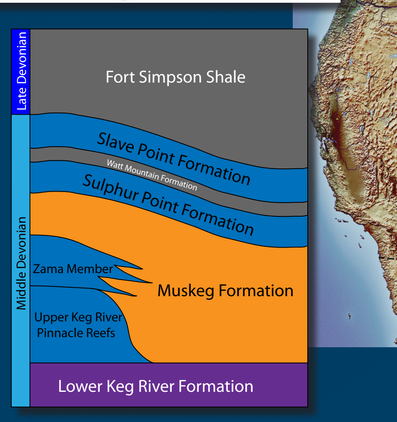
Abstract

One of the Plains CO_2 Reduction (PCOR) Partnership's key demonstration activities is working with Apache Canada on the Zama Acid Gas Project. Apache is currently injecting acid gas (Carbon Dioxide [CO_2] and hydrogen sulfide [H_2S]) into six pinnacle reefs in the Zama Field in northwestern Alberta, Canada. In addition, there are more than 600 carbonate pinnacle reefs in the Zama Field, with documented estimates of original oil in place exceeding 1 million barrels each. This project aims to better understand the injection and long-term storage of acid gas and the enhanced oil recovery (EOR) potential in the active acid gas injection pinnacles and to better understand and predict the EOR and storage potential in the Zama Field and other pinnacles worldwide.

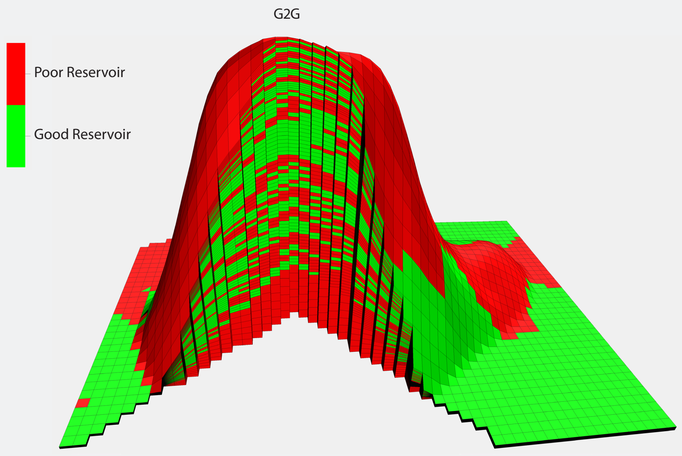
A rigorous methodology of characterizing the six pinnacle reservoirs with the aim of better understanding the potential for acid gas injection for EOR and CO_2 storage potential was developed. A detailed fluid model was constructed that accounted for the effects of H_2S and gas liberation on minimum miscibility pressure. Reservoir simulation models were constructed to investigate optimization of EOR potential and estimate CO_2 storage capacity under various scenarios. The models were history-matched, and several predictive scenarios were run, focusing on both oil recovery and CO_2 storage.

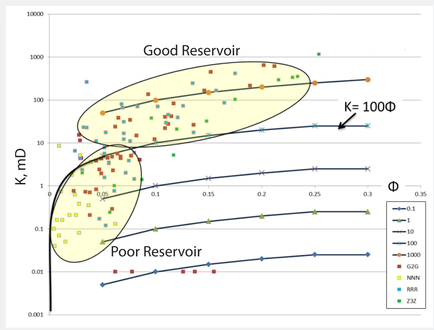
These efforts show promise to successfully conduct tertiary oil recovery at pinnacle reefs of the Zama area and store greenhouse gas in pinnacle structures. Furthermore, the research demonstrates a robust evaluation methodology for similar projects in pinnacle reefs and demonstrates the global potential for these types of reservoirs for EOR and CO_2 storage.

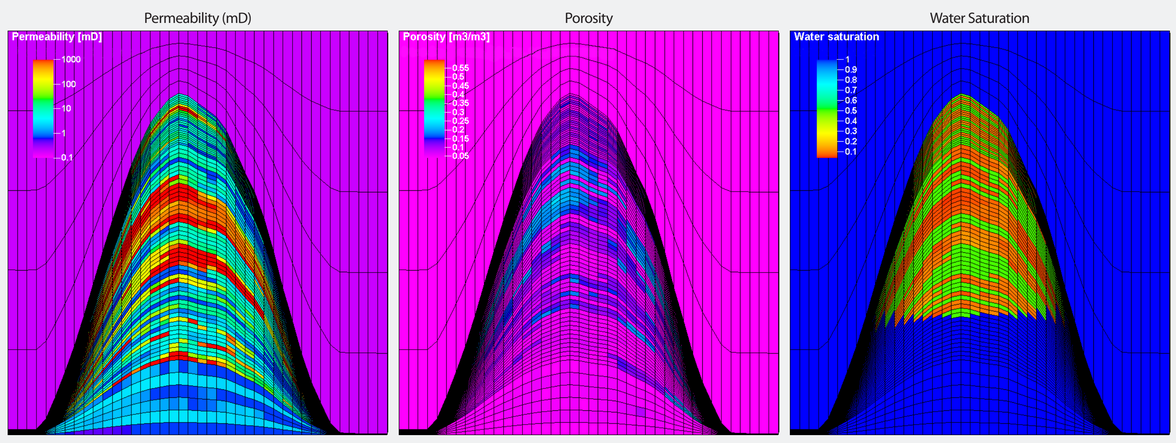




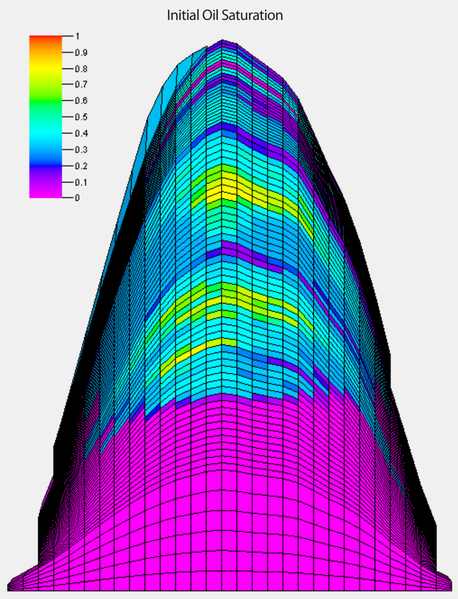
Geologic Modeling







Dynamic Modeling for CO_2 EOR and Storage Potential

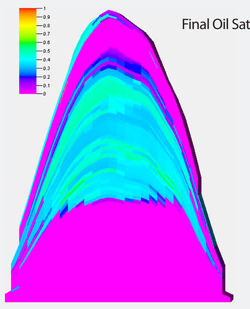


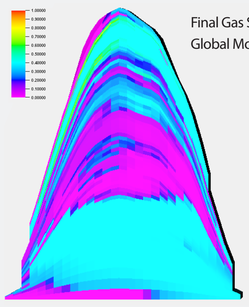
CO_2 Utilization and Incremental Recovery Factors

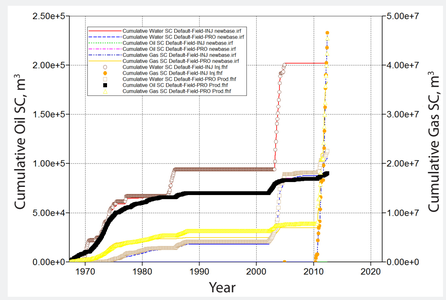
Pool	OOIP, MMStb	CO_2 Utilization Factor UF, Mscf/bbl		Incremental Recovery Factor RF, %	
		Pessimistic	Optimistic	Pessimistic	Optimistic
Keg River F	4.30	22.90	9.73	12.60	22.00
Keg River G2G	3.71	5.60	4.77	4.40	15.00
Muskeg L	2.70	13.15	3.98	1.60	9.80
Average		10.02		6.20	15.60

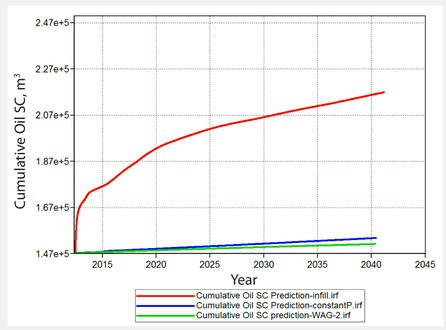
CO_2 Utilization, Incremental Recovery, and Storage Capacity for the Three Extra Pools

Pool	OOIP, MMStb	CO_2 Utilization Factor UF, Mscf/bbl	Incremental Recovery Factor RF, %		Storage Capacity, Mtonnes (M_{CO_2} = OOIP × RF × UF × $\rho_{CO_2,sc}$)	
			Pessimistic	Optimistic	Pessimistic	Optimistic
Keg River Z3Z	2.38	10.02	6.20	15.60	83	209
Keg River RRR	4.70	10.02	6.20	15.60	164	412
Keg River NNN	3.53	10.02	6.20	15.60	123	310









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

This material is based upon work supported by the U.S. Department of Energy (DOE) National Energy Technology Laboratory under Award No. DE-FC26-05NT42592.

Financial support from DOE to perform this work is greatly appreciated. The authors would like to thank Apache Canada Ltd. for providing necessary data to perform this work. The generous software support of Schlumberger and Computer Modelling Group Ltd. is gratefully acknowledged. The authors acknowledge Dr. Jyoti Shah, Dr. Dayanand Saini, and Mr. Damion Knudsen for their important contributions to the work presented. The authors also acknowledge Ms. Megan Grove and the members of the EERC's Editing and Graphics staff for their help with poster preparation.

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