# Zama Acid Gas EOR, $CO_2$ Sequestration, and Monitoring Project

The Zama oil field validation test site is located in northwestern Alberta, Canada, and tests are being conducted to test the efficacy of simultaneous $CO_2$/$H_2S$ storage and enhanced oil recovery (EOR). A geomechanical model was created based on the unique geometry of the pinnacle reef and the contrasting anhydrite and dolomite lithologies. This model was used to predict the ultimate mechanical integrity of this system and the expected response to acid gas injection. Geochemical modeling has been conducted to determine the ultimate fate of injected gas.

## Goal

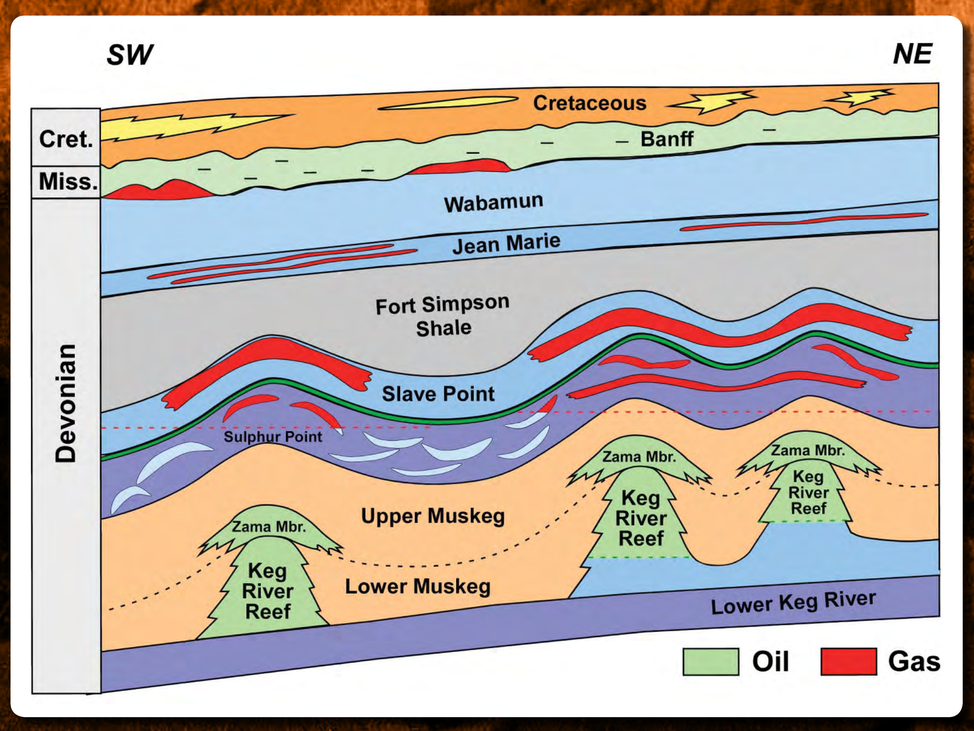
The goal of the Plains $CO_2$ Reduction (PCOR) Partnership's activities at the Zama site was to develop and implement a monitoring, verification, and accounting strategy that establishes the integrity of the Zama pinnacle reefs for $CO_2$-rich acid gas storage.

This was accomplished by carrying out assessments of the following:

- Baseline geology
- Rock mineralogy and composition of formation water
- Hydrogeological system
- Mechanical rock properties and stress regime
- Geochemical interactions between formation and injected fluids and reservoir rock and cap rock
- Wellbore integrity and leakage potential at the reservoir, local, and regional/subbasin scales

## Geologic Setting

Oil production in the Zama oil field is primarily from reservoirs in pinnacle reefs of the Middle Devonian Keg River Formation. These reef buildups were formed in a lagoon partially surrounded by carbonate banks. To date, over 800 pinnacles have been discovered in the Zama Subbasin.




## Reservoir Characteristics

| | |
|---|---|
| Area: ~40 ac at oil–water contact | Lithology: Primarily limestone |
| Thickness: ~400 ft | Injection Depth: 4900 ft |
| Res. Temp.: 160°F | Initial Res. Pressure: 2095 psi |
| OOIP: 3.5 million stb | Permeability: 100–1000 mD |

## Monitoring, Verification, and Accounting

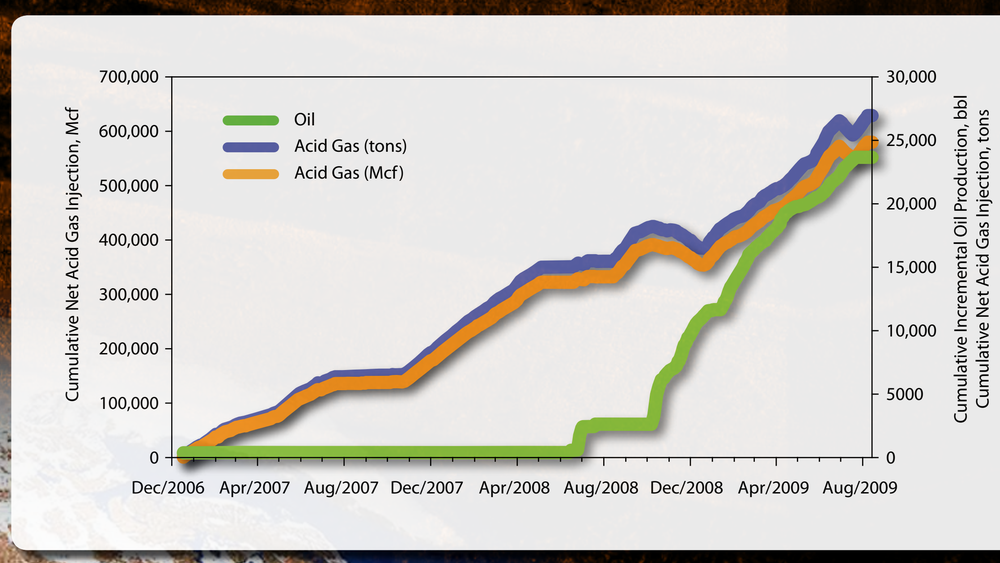
| Measurement Technique | Measurement Parameters | Application |
|---|---|---|
| Introduced and Natural Tracers | Travel time<br>Partitioning of $CO_2$ into brine or oil | Tracing movement of $CO_2$ in the storage formation<br>Quantifying solubility trapping<br>Tracing leakage |
| Fluid Composition | $CO_2$, $HCO_3$, $CO_3^{2-}$<br>Major ions<br>Trace elements<br>Salinity<br>Hydrocarbon composition | Quantifying solubility and mineral trapping<br>Quantifying $CO_2$–water–oil–rock interactions<br>Detecting leakage |
| Subsurface Pressure | Formation pressure<br>Annulus pressure<br>Groundwater aquifer pressure | Control of formation pressure below fracture gradient<br>Wellbore and injection tubing condition<br>Leakage out of the storage formation |
| Well Logs | Brine salinity<br>Sonic velocity<br>$CO_2$ saturation | Tracking $CO_2$ movement in and above storage formation<br>Tracking migration of brine into shallow aquifers<br>Calibrating seismic velocities for 3–D seismic surveys |

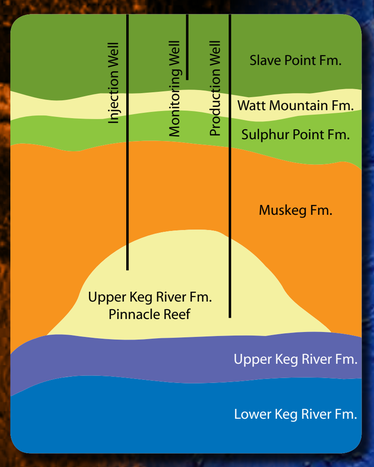
## Additional Monitoring

Monitoring of the site is achieved primarily through fluid sampling and pressure monitoring in both the target pinnacle reef and overlying strata. To more readily identify any leakage that might occur, a gas-phase tracer was injected early in the project.

## Injection

As of September 2009, 27,000 tons of acid gas has been utilized for EOR operations, resulting in an additional 24,000 barrels of oil production. While this project has been focused on one of the hundreds of pinnacle reefs that exist in the Zama Field, many of the results obtained can be applied not only to additional pinnacles in the Alberta Basin but also to similar structures throughout the world.




Zama Acid Gas Injection Site

carbon sequestration leadership forum


The PCOR Partnership, one of seven regional partnerships funded by the U.S. Department of Energy's National Energy Technology Laboratory Regional Carbon Sequestration Partnership Program, is managed by the EERC at the University of North Dakota in Grand Forks, North Dakota.