COBRA
OIL & GAS CORPORATION

MAXIMIZING PRODUCTION FROM RESIDUAL OIL ZONES IN WESTERN NORTH DAKOTA

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MAXIMIZING PRODUCTION FROM RESIDUAL OIL ZONES IN WESTERN NORTH DAKOTA

EXECUTIVE SUMMARY

Cobra Oil & Gas Corporation (Cobra) is investigating methods and strategies to maximize oil recovery within Madison oil fields in western North Dakota. The objective of the project is to use new and existing reservoir characterization and laboratory analytical data coupled with state-of-the-art static and dynamic computer modeling to design and implement pilot-scale field injection tests for developing and optimizing production strategies within residual oil zones (ROZs) of the Madison Group's Mission Canyon Formation. The development and implementation of production strategies for North Dakota's ROZ formations would create jobs, increase oil and gas investments, revitalize North Dakota's legacy fields, and increase state tax revenue. This program is administered by the Energy & Environmental Research Center (EERC), with funding from the North Dakota Industrial Commission (NDIC) Oil and Gas Research Program (OGRP) and Cobra. This progress report presents an overview of activities from June 1, 2024, through November 30, 2024.

During the reporting period, the EERC and Cobra team completed Task 2 and is in progress with the final items of Task 3.

Task 2: Reservoir Characterization is now mostly complete with final reporting remaining. The geologic model was finalized through iterations with Task 3 for the simulation model. The uncertainty analysis of the geologic model was completed.

The team completed single-well modeling and sensitivity for Task 3: Numerical Simulation for Production Optimization. The geologic model was converted for simulation and matched to the historic production. Preparation for optimization and sensitivity for the area of interest is ongoing.

This period's focus for Task 4: Data Collection and Field Testing was to upgrade equipment and infrastructure with the scalability for project results. Producing wells underwent equipment upgrades to appropriately match increases in produced fluid, as did gathering and separation facilities. Fluid levels and downhole pressure data were obtained to better model and monitor reservoir pressure.

MAXIMIZING PRODUCTION FROM RESIDUAL OIL ZONES IN WESTERN NORTH DAKOTA

DESCRIPTION OF PROJECT

The Madison Group in North Dakota is a mature play that has produced nearly 1 billion barrels (bbl) of oil from ~6000 wells. Portions of the oil-bearing zones in the Madison Group with high water saturation (e.g., Mission Canyon Formation) have historically been bypassed. Total oil-in-place reserves for the Mission Canyon are estimated to be up to 500 million bbl (Burton-Kelly and others, 2018). High-water-saturation fields and depleted Mission Canyon fields exhibit properties and behavior similar to residual oil zones (ROZs). ROZs contain remnants of stranded oil within sections of rock requiring unique production strategies or enhanced oil recovery (EOR) methods to produce. In recent efforts, considerable volumes of oil have been produced from ROZs through CO_2 injection or depressurization within ROZs (Harouaka and others, 2014; Melzer and Trentham, 2015).

Since 2018, Cobra Oil & Gas Corporation (Cobra) has been the operator of a Mission Canyon field (the project field) in Renville County, North Dakota. Cobra has evaluated oil production strategies from reservoir zones with high water saturation and has successfully increased oil production, reservoir deliverability, and oil cut in 16 wells through depressurization and acidized simulation experiments. Gross production in the project field is up ~250% since 2018 because of these efforts. Previous studies have also demonstrated the potential of EOR as a viable method to significantly increase oil production out of the Mission Canyon Formation throughout North Dakota (Dotzenrod and others, 2017; Burton-Kelly and others, 2018). Burton-Kelly and others (2018) estimated that CO_2 EOR could generate an additional 60–90 million bbl of oil in North Dakota's Mission Canyon Formation.

The current research is investigating methods and strategies to maximize oil recovery within Mission Canyon fields in western North Dakota. Example strategies may include further depressurizing experiments of the ROZ to lower the reservoir pressure within a radius around the wellbore and/or CO_2 injection into the ROZ. To test possible operation and completion strategies, Cobra subcontracted with the Energy & Environmental Research Center (EERC) at the University of North Dakota (UND) to evaluate existing data from the project field. The data will be utilized to generate a geologic model and perform numerical dynamic simulation to evaluate production and EOR strategies to maximize production from the Mission Canyon ROZs. Cobra will validate the simulation results by applying select production strategies in the project field. The objective of the project is to use new and existing reservoir characterization and laboratory analytical data coupled with state-of-the-art static and dynamic computer modeling to design and implement pilot-scale field injection tests for developing and optimizing production strategies within ROZs of the Mission Canyon Formation. The goal of the pilot tests is to determine the viability of production and EOR strategies developed through numerical simulation for stimulating oil production in the Mission Canyon Formation.

ACCOMPLISHMENTS

Project Management

The project remains on time and on budget. Resources have been identified for all project tasks. A core workshop occurred on January 25–26, 2024, in Grand Forks, North Dakota. Regular meetings between Cobra and the EERC have occurred every 2 weeks.

Deviations from Original Scope of Work and Associated Lessons Learned

The starts of Tasks 1–3 were delayed to November 2023 compared to the original Gantt chart in the proposal. This delay is not anticipated to affect the final deadline of the project. Table 1 has been updated to reflect the current expected timeline of work. Changes from the last reporting period are for Task 3: History Matching, which is now expected by year-end 2024.

Table 1. Project Milestones and Deliverables

Milestone (M)/Deliverable (D)	Expected Completion Date	Actual Completion Date
Task 1: Data Audit	February 2024	February 2024
Task 1: Core Workshop	January 2024	January 2024
Task 2: Stratigraphy	April 2024	March 2024
Task 2: Petrophysics	April 2024	April 2024
Task 2: Geologic Model	May 2024	May 2024
Task 2: Uncertainty Analysis	June 2024	June 2024
Task 3: History Matching	December 2024	November 2024
Task 3: Optimization Scenarios	February 2025	
Task 3: Sensitivity Analysis	February 2025	
Task 4: Field Activities	June 2025	
Final Report and Project Summary	August 2025	

Task 1 – Data Assembly

The EERC will work with Cobra on software procurement, data assembly, and data audit activities to identify data necessary for Tasks 2 and 3 and other data gaps. Activities in this task include a core description workshop for the selected field to determine the need for additional core analyses from existing core, collection of public and Cobra-released well data (e.g., well logs, core analysis, production data, fluid characterization, well histories), and review of assembled data for gap analysis. Results will include maps, statistics, and summary PowerPoint slides for input data to be used in other tasks.

Task 1 – Data Assembly was completed February 2024

Task 2 – Reservoir Characterization

The EERC will collaborate with Cobra to create a field-scale geologic model for the targeted ROZ. This will include petrophysical evaluations and stratigraphic correlation, leveraging existing core data and geophysical well logs. Petrophysical interpretations will be used to populate the geologic model of the selected field with applicable properties (e.g., lithofacies, porosity, permeability, and water and oil saturations). Petrophysical property uncertainty analyses will be conducted to create a suite of geologic models available for numerical simulation history-matching and sensitivity analyses for validation against historic field production. Results will include maps, well interpretations, summaries of created models and uncertainty analysis, and a knowledge gap assessment with data collection recommendations.

Accomplished This Reporting Period

The geologic base case model was completed during the reporting period along with iterative adjustments to the model to ensure fluid flow within the history-matching process. Volumetric uncertainty was completed on the base case model adjusting the facies, porosity, and oil–water-contact to provide a range of original-oil-in-place estimates. From the 2000 completed cases, volumetric p10, p50, and p90 estimates were identified. Task 2 results are being prepared for summary conclusions, recommendations, and final reporting.

Task 3 – Numerical Simulation for Production Optimization

The EERC will coordinate with Cobra to evaluate strategies to optimize production from the potential ROZ for the selected field using numerical simulation. EERC-proposed activities will include the creation of a fluid model based on available pressure, volume, temperature (PVT) data for the reservoir; calibration of the Task 2 geologic models through a history-matching process using historic operational data for the selected field; and conducting predictive simulations designed to improve oil production from the field. Working with Cobra, the EERC will develop a case matrix of strategic scenarios for numerical evaluation. Suggested scenarios include evaluating production changes from recompletion and operational changes and evaluating responses from EOR methods (e.g., carbon dioxide injection). A sensitivity analysis will be conducted to inform plans to optimize potential ROZ development and support field development. Results from this task will include predicted incremental oil production and associated pressure response for the cases investigated and learnings from the sensitivity analysis, including a recommended optimization strategy.

Accomplished This Reporting Period

The historical production maps for the field have been completed. Based on the data availability, initial water cut, overall water cut, and cumulative production of oil, gas, and water have been compared and analyzed. Production analysis identified two main water production mechanisms: co-flow from the oil–water transition zone and water coning from the bottom aquifer. A sensitivity analysis was performed on a single-well model to study the long-term oil production behavior, demonstrating that current oil production could be maintained for over a 10-year period provided aquifer pressure support continues.

The geologic model from Task 2 was converted into a simulation model using the same set of equation-of-state as previously completed single-well models. Field pressure data were received from Cobra-operated wells. A systematic quality assurance and quality control (QA/QC) procedure was performed for the large-scale simulation model; results showed that the porosity and permeability values reported in the well files were valid for simulating the liquid flow in the reservoir. Preparation for optimization and sensitivity analysis has begun.

Task 4 – Data Collection and Field Testing

To facilitate Tasks 2 and 3, additional data collection is required to fill knowledge gaps. Activities for this task will be discussed and designed based on Cobra's planned operations. Activities for this task could include:

- Well testing and assessment of operational changes to existing wells.
- PVT tests to characterize oil behavior.
- Cased-hole well log data collection to determine current reservoir fluid saturations.
- Additional testing of existing cores (e.g., routine core analysis, x-ray fluorescence, x-ray diffraction, scanning electron microscopy, mercury injection capillary pressure).
- Recompletion of a well to validate select forward-modeling result scenarios.
- Well acidized stimulation.

Accomplished This Reporting Period

For this reporting period, Task 4 used results from Tasks 2 and 3 on the field aquifer drive to change well operations to produce more overall fluid from the reservoir. To test Tasks 2 and 3 results, upgrades to surface and downhole equipment were applied to increase water handling, fluid separation, and overall production capacity. Cobra upgraded two producing wells from progressive cavity pump to electric submersible pump, upsized two progressive cavity pumps, and lined out two wells with increased capacity rod pumps. Upgrading downhole production output required additional fluid separation and handling capacity at the surface. At a central gathering facility, Cobra upgraded two heater treaters, added free water knockouts, and plumbed new gathering lines. The increase in produced fluid also required additional disposal capacity. Cobra worked over a saltwater disposal well to yield higher injection rates, and a water supply well was repurposed into a disposal well. During this period, field data collection was continued to monitor reservoir pressures. Cobra collected 97 acoustic backside fluid levels and pulled downhole pressure recorders via wireline on two wells.

EXPENDITURES

Expenditures for This Reporting Period Only			
Project-Associated Expense	**NDIC Share**	**Cobra Share**	**Total**
Labor – Engineering and Field	$114,712.50	$114,712.50	$229,425.00
Facilities, Equipment, Gathering	$40,631.18	$40,631.19	$81,262.37
Stimulation	$0	$0	$0
Well Service Rigs	$143,987.24	$143,987.25	$287,974.49
Downhole Production Equipment	$169,901.59	$169,901.60	$339,803.19
Facilities and Administration	$0	$0	$0
Travel	$0	$0	$0
Subcontractor – EERC	$152,893.47	$152,893.48	$305,786.95
Laboratory	$29,182.26	$29,182.25	$58,364.51
Total	**$651,308.24**	**$651,308.27**	**$1,302,616.51**

Cumulative Expenditures			
Project-Associated Expense	**NDIC Share**	**Cobra Share**	**Total**
Labor – Engineering and Field	$168,791.25	$168,791.25	$337,582.50
Facilities, Equipment, Gathering	$61,793.68	$61,793.69	$123,587.37
Stimulation	$0	$0	$0
Well Service Rigs	$167,964.74	$167,964.75	$335,929.49
Downhole Production Equipment	$169,901.59	$169,901.60	$339,803.19
Facilities and Administration	$0	$800	$800
Travel	$0	$0	$0
Subcontractor – EERC	$370,301.61	$370,301.62	$740,603.23
Laboratory	$36,006.08	$36,006.08	$72,012.16
Total	**$974,758.95**	**$975,558.99**	**$1,950,317.94**

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