DOE/BC/14984--12

BC/14984-12

**IMPROVED RECOVERY DEMONSTRATION FOR
WILLISTON BASIN CARBONATES**

QUARTERLY TECHNICAL PROGRESS REPORT

Cooperative Agreement DE-FC22-94BC14984

Luff Exploration Company
Denver, Colorado

Award Date: June 10, 1994
Completion Date: December 31, 1997

Government Award: \$1,778,014

RECEIVED

APR 07 1997

OSTI

Project Manager:

Larry A. Carrell
Luff Exploration Company

DOE Project Officer:

Chandra Nautiyal
Bartlesville Project Office

ACQUISITION & ASSISTANCE DIV.

97 FEB -4 AM 9:18

RECEIVED
USDOE/PETC

Reporting Period: October through December, 1996

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

U.S. DOE Patent Clearance is not required prior to the publication of this document

MASTER

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

IMPROVED RECOVERY DEMONSTRATION FOR
WILLISTON BASIN CARBONATES
COOPERATIVE AGREEMENT DE- FC22-94BC14984

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed or represented that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**IMPROVED RECOVERY
DEMONSTRATION FOR WILLISTON
BASIN CARBONATES**

Contract No. DE-FC22-94BC14984

Luff Exploration Company
Denver, Colorado

Contract Date: June 10, 1994

Anticipated Completion: December 31, 1997

Government Award: \$1,778,014

Principal Investigators:
Mark A. Sippel
Larry A. Carrell

Project Manager:
Chandra Nautiyal
Bartlesville Project Office

Reporting Period: Oct. 1 - Dec. 31, 1996

Abstract

The purpose of this project is to demonstrate targeted infill and extension drilling opportunities, better determinations of oil-in-place, methods for improved completion efficiency and the suitability of waterflooding in certain shallow-shelf carbonate reservoirs in the Williston Basin, Montana, North Dakota and South Dakota.

Improved reservoir characterization utilizing 3-dimensional (3D) and multi-component seismic are being investigated for identification of structural and stratigraphic reservoir compartments. These seismic characterization tools are integrated with geological and engineering studies. Improved completion efficiency is being tested with short-lateral and horizontal drilling technologies. Improved completion efficiency, additional wells at closer spacing and better estimates of oil-in-place will result in additional oil production by primary and enhanced recovery processes.

Executive Summary

A seismically targeted vertical well was successfully completed in the Red River D zone in Bowman Co., ND. Interpretations of amplitude for porosity and structural position were used to target the drilling location.

Re-entry drilling of lateral drain holes in the Ratcliffe with slim-tool technology was attempted during the fourth quarter in two wells in Richland Co., MT. One attempt was mechanically successful and the other was not. Production evaluation is in progress.

Operations for horizontal drilling from surface was performed at two locations in the Red River area of Bowman Co., ND and Harding Co., SD. These wells were drilled on subsurface structures where there has been production for more than 15 years. The Bowman Co. well was mechanically successful but has not yielded encouraging oil production from the Red River B. Operations at the Harding Co. well were suspended after unsuccessful efforts to recover stuck drill pipe in the lateral section. The Harding county well was to be used for a water-injection test through a 1200 m (4000 ft) lateral in the Red River B.

Summary of Technical Progress

Ratcliffe Re-Entry Lateral Completions

Two wells in the North Sioux Pass Field were selected for re-entry lateral completion in the Ratcliffe. These wells are the No. 2-16 State and M-17 Trudell (Fig. 1). The laterals were to be drilled out from 14 cm (5-1/2 inch) casing with steered-motor technology with planned extensions of 610 m (2000 ft). The planned orientation of the laterals were to be normal to the fracture orientation observed from the 1-17R Federal core and FMI log data (Fig. 2).

No. 2-16 State
API No. 25-083-21418
Section 16, T.26N., R58E.
Richland Co., MT

A lateral drain hole was drilled with slim-tool

technology with a horizontal length of 604 m (1982 ft) in the 2.1 m (7 ft) porosity zone of the Ratcliffe (Fig. 2). The lateral was drilled successfully after two attempts. On the first attempt, a casing window was cut from 2705 to 2707 m (8875 to 8881 ft) and a whipstock was emplaced. Operations commenced on November 14, 1996, with directional control and measurement-while drilling (MWD) provided by Baker Hughes Inteq. It was determined that the directional tools were not building sufficient angle and correct azimuth after drilling only 17 m (57 ft). The well was plugged back with cement to 2708 m (8884 ft). The second attempt was successfully drilled in 15 days. The Ratcliffe porosity bench remained relatively flat throughout the course of the lateral with a downward dip rate of about 1 percent. Sample shows were good throughout the lateral. The well has not pumped long enough for withdrawal of all load water and to evaluate a stabilized oil-cut. It is currently producing at 2.1 m³ oil and 20.0 m³ water per day (13 bopd and 126 bwpd).

M-17 Trudell
API No. 25-083-21808
Section 17, T.26N., R.58E.
Richland Co., MT

Slim-tool technology was used to attempt drilling a short-radius drain hole in the Ratcliffe through a casing window. A casing window was cut from 2633 to 2635 m (8639 to 8646 ft) and a whipstock was emplaced. Operations commenced on December 17, 1996. Kick-off was at a depth of 2636 m (8648 ft) with directional control and MWD provided by Baker Hughes Inteq. After drilling only 13 m (44 ft) to 2649 m (8692 ft), it was determined that the directional tools were not building sufficient angle or correct azimuth. Operations were suspended on December 27.

Red River Targeted Drilling

B-27 Muslow-State
API No. 33-011-00819
Section 27, T.130N., R.102W.
Bowman Co., ND

Drilling operations were completed at the B-27 State-Muslow well in Bowman Co., ND (Fig. 3). The vertical well was targeted from a 3D seismic survey over Cold Turkey Creek Field. Results from the well are encouraging. Commercial porosity was developed in the Red River B and D zones.

Contiguous cores were cut across the entire upper Red River section from 2847 to 2905 m (9340-9530 ft). These cores covered all four porosity benches (A, B, C and D zones) in the Red River (Fig. 4). Sonic and density logs were obtained for further synthetic-seismogram study and evaluation of the 3D seismic survey.

Drillstem tests (DST) were run in the Red River B, C and D zones. The B zone test indicated normal permeability for the interval with drawn-down pressure at 12,700 kPa (1842 psig). Original reservoir pressure was 26,890 kPa (3900 psig). The C zone DST was indicated to have low permeability with only 15 m (50 ft) of mud recovered. The shut-in pressure was 22,194 kPa (3219 psig). The D zone recovered 506 m (1660 ft) of fluid and had a shut-in pressure of 26,841 kPa (3893 psig).

Evaluation of electrical log and core data indicate 2.1 m (7 ft) of pay in the Red River B zone with 16.3 percent porosity and water saturation of 21.0 percent. The C zone indicate 3.0 m (10 ft) of porosity which average 8.7 percent and water saturation of 47.2 percent. A productive thickness of 7.6 m (25 ft) with 11.4 percent porosity is calculated for the D zone. Water saturation in the D zone is 47.4 percent.

The D zone was perforated from 2903 to 2912 m (9524 to 9554 ft) and acidized. The completed interval is producing 22 m³ oil and 13 m³ water per day (140 bopd and 80 bwpd) with a fluid level of 1219 m (4000 ft) from surface. The B zone is also productive and remains behind pipe. Plans for completion of the B zone will be made after the D zone is fully evaluated and

analysis is completed of feasibility for secondary recovery by waterflooding in the B zone.

Red River Lateral Drilling

No. 1-26H Greni
API No. 33-011-14400
Section 26, T.129N., R.103W.
Bowman Co., ND

Luff Exploration Company participated in drilling a horizontal completion in the Red River B zone reservoir at State Line Field, Bowman Co., ND (Fig. 5). The objective of the well was to exploit additional primary reserves by overcoming poor drainage caused by heterogeneity. The No. 1-26H Greni well is the fourth well on a small Red River feature that has produced over 143,090 m³ (900,000 bbl) of oil from B and D zones of the Red River since 1973.

The well was drilled on the west side of the structure and encountered the Red River B at a subsea datum which was 20 m (67 ft) low to the most updip well. A lateral reach of 846 m (2775 ft) was drilled in the Red River B. The vertical portion of the hole was drilled with 22.2 cm (8-3/4 in) bit using an invert mud system. The lateral portion of the hole was drilled in less than four days with a 15.6 cm (6-1/8 in) bit using a fresh-water mud system. A MWD gamma ray was run throughout both the build and lateral sections.

The well has been producing from the open-hole lateral section in the Red River B zone since October 1996. Production has been disappointing at 2 m³ oil and 52 m³ per day (10 bopd and 330 bwpd). The drilling of the No. 1-26H Greni appears to have resulted in a mechanical success but a failure with regard to reservoir development. The relatively low structural position to offset production and poor oil cut indicate completion of the lateral below an oil-water contact. Results from this well indicate that commercial oil saturation in Red River B zone is not ubiquitous and that understanding trapping (either structural or stratigraphic) is important (at least in this immediate area) for placement of horizontal wells in the Red River B horizontal play.

M-20H Stearns
API No. 40-063-20536
Section 20, T.22N., R4E.
Harding Co., SD

The M-20H Stearns was spudded on November 15, 1996. The well was drilled with the objective of evaluating water injection through a horizontal open-hole completion in the Red River B zone. Drilling operations were suspended after 50 days when efforts to retrieve stuck drill pipe in the lateral section were unsuccessful.

Drilling plans called for a vertical pilot hole with a drillstem test of Red River B porosity to establish structural, pressure and fluid relationships with nearby producing wells before plugging back to the Interlake to kick-off the build section. A lateral reach of 1219 m (4000 ft) was planned which was to traverse between two producing wells in the Red River B zone (Fig. 6).

Total depth of the 22.2-cm (8-3/4 in) vertical hole was reached at 2755 m (9040 ft) in the Red River after 22 drilling days. Electrical logs were run and a drillstem test was run across the Red River B zone. The hole was then plugged back to the Interlake at 2467 m (8094 ft). The plug was dressed to 2536 m (8321 ft) prior to beginning drilling operations for the build section. Drilling of the build section required 8 days and 17.8-cm (7-in) casing was set at 2751 m (9025 ft), 2664 m true vertical depth (8741 ft). The lateral section was drilled with a 15.6-cm (6-1/8 in) bit and fresh water for drilling fluid. After 11 hr of drilling the lateral section, the drill pipe became stuck. The lateral reach from the 17.8-cm (7-in) casing was 309 m (1015 ft). Fishing efforts were unsuccessful.

The DST in the Red River B zone indicated oil and depleted reservoir pressure of 7529 kPa (1092 psig). Reservoir pressure of 7584 kPa (1100 psig) was determined by fluid build-up at an offset well in June 1996. Electrical logs indicate 3.0 m (10 ft) of net pay in the Red River B zone with maximum porosity of 27 percent. These data confirm previous data analysis and characterization of the B zone reservoir. The reservoir assumptions for the planned water-injection test are concluded to be valid.

Current plans are to put the well on pump

with the drill pipe still in the hole. It is hoped that this will remove blockage and allow eventual removal of the stuck drill pipe. If fluid entry rate after 30 to 60 days is encouraging, plans are to initiate the water-injectivity test.

Ratcliffe Geophysical

Interpretation of 3D seismic data at North Sioux Pass, Richland Co., MT are in progress for the Ratcliffe. The 3D seismic survey covers approximately 38 sq km (15 sq miles) in T.26N, R.58E. (Fig. 1).

Red River Geophysical

Interpretation of 3D seismic at Cold Turkey Creek and Grand River School continues. Attribute studies in the Red River have been augmented from sonic and density log data collected from the B-27 Muslow-State well at Cold Turkey Creek (Fig. 3).

Summary and Conclusions

Field demonstrations are in progress to collect data for evaluation of horizontal completions in both the Red River and Ratcliffe. It has been found that slim-tool technology from cased holes for re-entry drilling of horizontal drain holes is still developmental. Building the correct curve and azimuth is not easily done on the first attempt. A vertical well in the Red River tested attribute analysis of 3D seismic data for prediction of porosity development. Plans for a water-injectivity test in a new horizontal completion in the Red River B zone at Buffalo Field have been postponed because drill pipe became stuck during drilling operations. Remedial options for the well are being analyzed. Interpretation of 3D seismic continue for both the Ratcliffe and Red River.

North Sioux Pass 3D Seismic Survey

Figure No. 1: Map of North Sioux Pass Field, Richland Co., MT.

Federal 1-17R, North Sioux Pass

Figure No.2: Porosity log across the Ratcliffe interval from the No. 1-17R Federal, North Sioux Pass Field, Richland Co., MT.

3D Seismic Surveys, Bowman Co., ND

Figure No. 3: Map of Cold Turkey Creek and Grand River School Fields, Bowman Co., ND.

B-27 Muslow-State Red River Log

Figure No. 4: Porosity log from the B-27 Muslow-State well in Cold Turkey Creek Field, Bowman Co., ND.

1-26H Greni - State Line Field

Figure 5: Map of State Line Field, Bowman Co., ND. The No. 1-26H Greni was drilled as a new horizontal well for the Red River B zone.

Figure 6: Map of Buffalo Field (north area), Harding Co., SD. M-20H Stearns well was to test water injection through a horizontal completion in the Red River B zone.