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

Project Manager:	Larry A. Carrell Luff Exploration Company
DOE Project Officer:	Chandra Nautiyal Bartlesville Project Office

Reporting Period: July through September 1997

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Disclaimer

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Principal Investigators:
Mark A. Sippel
Larry A. Carrell

Project Manager:
Chandra Nautiyal
Bartlesville Project Office

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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) is 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

Significant reserve additions have been found by drilling targeted, vertical wells on the flanks of structural features in the Red River where wells on crestal positions have been producing for more than 20 years. Three seismically targeted, vertical wells were successfully drilled to the Red River D zone in Bowman Co., ND. Interpretations of amplitude for porosity and structural position were used to target the drilling locations.

A presentation was made in Denver at a meeting of the Denver Geological Study Group on July 24. On August 27, a technical paper was presented in at the regional AAPG meeting in Denver. Two workshop presentations and a talk at the IPAA annual meeting are scheduled for next quarter.

Summary of Technical Progress

Red River Targeted Drilling

Many Red River reservoirs in the Bowman-Harding county area of the southwestern porion of the Williston Basin have small areal extent of less than 2.6 km^2 (1 sq mile) with structural relief of 15 to 30 m (50 to 100 ft). Typical primary reserves from the Red River B zone are 25,800 m^3 (162,000 bbl) per well while Red River D zone completions typically recover 59,100 m^3 (372,000 bbl). The two 3D seismic surveys obtained during the cooperative project are over Red River reservoirs which are typical of this setting. The purpose of the surveys was to determine if structural and porosity compartments can be observed and whether there is potential for under-developed reserves on these features where wells have been producing for over twenty years and are near depletion. Targeted drilling based on 3D seismic interpretations has resulted in commercial production of untapped reserves at offset distances of less than 400 m (1300 ft) and down-dip from mature wells nearing depletion. The reserves developed as result of drilling three wells, targeting porosity blooms at flank position, appear to be approximately 111,300 m^3 (700,000 bbl). Additionally, the behind-pipe reserves and probable reserves of five additional locations are placed at 222,600 m^3 (1,400,000 bbl). These developed and probable reserve additions exceed

the expected ultimate recovery of existing wells prior to acquisition of 3D seismic. The examples of porosity development and encouraging production results from targeted drilling should provide analogy for other 3D seismic surveys of the Red River in the southwestern portion of the Williston Basin.

Water Injection Test in a Horizontal Well

Low water injectivity has been a deterrent to initiating waterflood projects in the Red River. To test water injection in a horizontal well, the M-20H Stearns well was drilled in the Buffalo Field (north area) in Harding Co., SD in December 1996. From testing at the M-20H Stearns well, it is concluded that with a lateral extension of 610 m (2000 ft) or more, an injection rate of 127 to 159 m^3 water per day (800 to 1000 bwpd) should be attainable in the Red River B zone. Based on computer simulation models, this injection rate would result in profitable waterflood projects with one horizontal injection well per 2.6 km^2 or 259 ha (1 sq mile or 640 acres). Details of completion and testing of the M-20H Stearns well were discussed in previous quarterly reports.

Luff Exploration has applied to South Dakota regulatory agencies for continual injection at the M-20H Stearns. Regulatory approvals are anticipated in November 1997.

Targeting Ratcliffe Reservoirs with 3D Seismic

The Mississippian Ratcliffe in Richland Co., MT has been evaluated for targeted drilling opportunities using integrated geological and geophysical study. Although funding is insufficient to test the conclusions made by the study, detailed results of the study can be found in the topical report covering reservoir characterizations of the Ratcliffe.

Technology Transfer

A technical presentation entitled "Characterization of Red River Reservoirs from 3D Seismic at Cold Turkey Creek Field" was presented at the American Association of Petroleum Geologists 1997 Rocky Mountain Section Meeting in Denver, August 27. This paper describes identification of variable development (primarily porosity) in the Red River B and D using zones using 3D seismic and presents results from successful drilling of porosity blooms in the Red River D zone.

Workshop presentations of project activities and successes in the Red River are scheduled for November 10 in Denver and November 14 in Billings. These workshops are designed for individuals and independent operators who are interested in exploration and development of Red River reservoirs in the southwestern portion of the Williston basin. The half-day workshop will provide reservoir characterizations from an integrated perspective of geology, engineering and seismic. Results from horizontal and vertical wells are to be presented as examples of reserve additions that are possible by primary and secondary in mature fields.

A presentation entitled "Demonstrating Improved Recovery in Williston Basin Carbonates" will be made at the Emerging Technologies Energy Conference in Houston on November 17. This conference will be held in conjunction with the 68th annual meeting of the Independent Petroleum Association of America.

Topical Reports

Topical reports covering reservoir characterizations of the Red River and Ratcliffe and lateral drilling technologies applied during the project were delivered in the past quarter.

Summary and Conclusions

Targeted drilling of Red River D porosity anomalies from 3D seismic has been very successful in Bowman Co., ND. Water injection into a horizontal well at Buffalo Field, Harding Co., SD has established that sufficient rates can be achieved to profitably waterflood the Red River B zone. Two technical presentations were made in the past quarter, one was an informal talk at a geological study group and the other was a formal talk at the AAPG section meeting. Both were in Denver. Next quarter technology transfer activities will include half-day workshop presentations in Denver and Billings and a talk at the IPAA annual convention in Houston.