Quarterly Technical Report

**"ADVANCED SECONDARY RECOVERY DEMONSTRATION
FOR THE SOONER UNIT"**

DC-FC22-93BC14954

December 31, 1995

Award Date: October 21, 1992
Completion Date: November 30, 1995

Government Award:	\$788,592.86
Total Estimated Cost of Project:	\$1,577,185.72

Project Manager: Terry J. Cammon (Diversified Operating Corp)
Contracting Officer's Representative: Edith Allison (DOE-BPO)

Reporting Period: October 1 through December 31, 1995

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**ADVANCED SECONDARY
RECOVERY DEMONSTRATION
FOR THE SOONER UNIT**

Contract No. DE-FC22-93BC14954

Diversified Operating Corporation
Denver, Colorado

Contract Date: Oct. 21, 1992
Anticipated Completion Date:
Nov. 30, 1995

Government Award: \$788,592

Principal Investigators:
Mark A. Sippel
Terry J. Cammon

Project Manager:
Edith Allison
Bartlesville Project Office

Reporting Period: Oct. 1- Dec. 31, 1995

Objective

The objective of this project is to increase production from the Cretaceous "D" Sand in the Denver-Julesburg (D-J) Basin through geologically targeted infill drilling and improved reservoir management of waterflood operations. This project involves multi-disciplinary reservoir characterization using high-density 3-D seismic, detailed stratigraphy and reservoir simulation studies. Infill drilling, water-injection conversion and recompleting some wells to add short-radius laterals will be based on the results of the reservoir characterization studies. Production response will be evaluated using reservoir simulation and production tests. Technology transfer will utilize workshops, presentations and technical papers which will emphasize the economic advantages of implementing the demonstrated technologies. The success of this project and effective technology transfer should prompt-re-appraisal

of older waterflood projects and implementation of new projects in oil provinces such as the D-J Basin.

Background

The Sooner "D" Sand Unit is located about 100 miles northeast from Denver. The Cretaceous "D" Sand has good primary recovery but disappointing waterflood performance. The nearest ten waterflood projects in the area of the Sooner Unit produced only an average of 2 percent incremental oil from waterflooding after an average primary recovery of 16 percent OOIP. Poor waterflood recovery is attributed to reservoir heterogeneity, poor reservoir management practices and lack of infill drilling. Three-dimensional (3-D) seismic had not been used in the D-J Basin for exploration or development of "D" Sand reservoirs prior to this project.

When the Sooner "D" Sand Unit was formed, there were many predictions of secondary performance. The average predicted ultimate recovery was 363,000 bbl (57,700 m³) incremental over primary recovery of 939,000 bbl (149,300 m³) for a total recovery of 1,302,000 bbl (207,000 m³) without drilling additional wells. After two years of experience with waterflooding at the Sooner Unit in 1992, it was apparent that the reservoir was responding only slightly better than had been originally predicted with the ultimate recovery projected at 1,556,000 bbl (247,400 m³) or 22.6 percent of OOIP.

Executive Summary

Three wells have been drilled by the project based on 3-D seismic and integrated reservoir characterization study. Oil production averaged 412 bbl (65.5 m³) per day during October through December 1995. The increase of proved-producing reserves attributed to activities performed during the project is placed at 305,000 bbl (48,500 m³). An oral presentation was made at a workshop in Denver on November 17, 1995.

Summary of Technical Progress

The Sooner Unit produced an average of 412 bbl (65.5 m³) oil and 1698 bbl (270 m³) water per day during the fourth calendar quarter of 1995 (see Fig. 1 for plot of field production history). The current projected ultimate (primary and secondary) recovery is 1,861,000 bbl (295,900 m³) which represents 27.0 percent of the original-oil-in-place (OOIP). Cumulative oil produced through December 1995, is 1,437,000 bbl (228,500 m³). The OOIP is placed at 6,900,000 stock-tank bbl (1,097,000 m³). Diversified Operating plans to drill five additional infill locations using 3D seismic and integrated reservoir characterizations from which it is anticipated that ultimate recoverable reserves will be increased to 2,252,000 bbl (358,000 m³) or 32.6 percent of the OOIP.

The Unit currently has 11 producing wells, five water-injection wells, one water-supply well and five shut-in wells. One well has been plugged since the project began in October 1992 (Fig. 2).

The SU 21-16-9 was drilled in September 1995, based on 3-D seismic interpretation and is located approximately in the SESE of section 16, T. 8 N., R. 58 W. Production from the well is currently 198 bbl (31.5 m³) per day of oil and 149 bbl (23.7 m³) of water. This well is the third well drilled by the project. Two wells were completed as producers and one well was completed as a water-injection well.

The increase in recovery achieved by activities performed during this project is placed at 305,000 bbl (48,500 m³) over ultimate recovery projections in 1992. This improved recovery has been achieved by the drilling of three wells and re-alignment of injection wells.

Table 1. Ultimate Recovery Projections

Primary EUR	939 Mbbl
Pre-Project Waterflood	1556 Mbbl
Project Activity	1861 Mbbl
Future - 5 Wells	2252 Mbbl

An effective tool for targeting infill and edge locations at the Sooner Unit has been found in

attribute correlation of 3D seismic with petrophysical data. This approach to seismic interpretation has proven valuable in subsequent 3D seismic surveys for "D" Sand in the Denver Basin and is should hold promise for other regions with similar depositional environments.

It has become clear that major difficulty for efficient waterflood recovery in the "D" Sand is caused by reservoir architecture and resulting heterogeneity because reservoir fluid viscosities and permeability in the "D" Sand indicate favorable waterflooding conditions. It is concluded that some infill drilling and down-spacing is necessary for optimal recovery of secondary oil because reservoir size and reservoir heterogeneity prohibit development of regular five-spot patterns with the original 40-acre well spacing. While it is a significant conclusion that a solution to poor secondary recovery is higher density wells, blanket infill drilling is concluded not to be as economical as targeted infill wells.

A model of projected development economics based on targeted locations compared to blanket infill drilling for the Sooner Unit is shown in the following table:

Table 2. Comparison of Incremental Economics for Development Drilling at Sooner "D" Sand Unit

	8 Targeted Wells	20 Blanket Infill Wells
Recovery	640 Mbbl	768 Mbbl
Rec. Factor	9%	11%
Capital Exp.	\$1,800,000	\$4,500,000
Lease Exp.	\$1,902,000	\$3,262,000
3D Seismic and Study	\$250,000	
Profit	\$4,818,000	\$2,788,000
Incremental	\$2,030,000	

Technology Transfer

An oral presentation¹ was made in Denver on November 17, 1995 at a workshop which presented examples of reservoir characterization studies for three eastern Colorado oil fields. Project results and activities will be also presented during January and February 1996, with the BDM-PTTC "Traveling Technology Workshops." This traveling workshop will visit seven cities and present material from four U.S. Department of Energy Class I projects.

References

M.A. Sippel and S. Singdahlsen, "Waterflood Success at The Sooner 'D' Sand Unit", oral presentation at workshop entitled *Reservoir Characterization: Does It Help? - Case Studies of 3 Fields in Eastern Colorado*, Petroleum Technology Transfer Council, Denver, Colorado, November 17, 1995

Figure 1: Production history of the Sooner Unit since waterflooding operations began in 1990. Curve 1 is the projected trend prior to project activities. Curve 2 is the current projected trend. The incremental reserves between these curves are 305,000 bbl.

Figure 2: Map of the Sooner Unit.

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