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Quarterly Technical Report

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

DE-FC22-93BC14954

September 30, 1995

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

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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: July 1 through September 30, 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: July 1- Sept. 30, 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 majority of waterflood projects have produced only about 20% of the OOIP. Poor waterflood recovery is attributed to reservoir heterogeneity and poor reservoir management practices. 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.

Executive Summary

Three wells have been drilled by the project based on 3-D seismic and integrated reservoir characterization study. Oil production has increased in September to 54.0 m<sup>3</sup>/D (340 bopd) after the completion of the SU 21-16-9. Combination-attribute maps from 3-D seismic data closely predicted the net-pay thickness of the new well. Inter-well tracer tests with sodium bromide indicate a high-permeability channel between two wells. An oral presentation was made at the Rocky Mountain AAPG meeting in Reno, NV.

Summary of Technical Progress

Field Operations

The Sooner Unit is producing 54.0 m<sup>3</sup>/D of oil (340 bopd) and 325 m<sup>3</sup>/D of water (2045 bwpd) as of September, 1995 (Fig. 1 and 2). Cumulative oil production is 214,000 m<sup>3</sup> (1,346,000 bbl). This represents 20% of the original-oil-in-place (OOIP). The Unit is currently injecting 461 m<sup>3</sup>/D of water (2900 bwpd). 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. 3).

In September, a new well was completed. The SU 21-16-9 was targeted 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 10.3 m<sup>3</sup>/D of oil and 65.2 m<sup>3</sup>/D of water (65 bopd and 410 bwpd). This well is the third well drilled by the project (Fig. 3).

Two wells were completed as producers and one well was completed as a water-injection well. Oil production from the two producers is about 23.8 m<sup>3</sup>/D (150 bopd) or 44% of the Unit total.

### 3-D Seismic

The project acquired 19.9 km<sup>2</sup> (7.7 sq mile) of 3-D seismic which covered the entire Sooner Unit. It was found that the amplitude and isochron of the "D" Sand horizon wave-form correlate reasonably well with reservoir development; however, there are problems when one attribute map is solely used for prediction of reservoir development. For this reason, combination attribute-correlations were developed from empirical relationships between seismic attributes of the "D" Sand and adjacent lithology. Correlations were developed for gross thickness, net-pay thickness and hydrocarbon-porosity feet. These correlations predicted a net-pay thickness of 8.8 +/- 1.2 m (29 +/- 4 ft) for the SU 21-9-16 location. The actual net-pay thickness of the SU 21-16-9 well is 7.9 m (26 ft) with above-average porosity development (Fig. 4). Net-pay maps, based solely on electrical logs, predicted much thinner reservoir development at the location of the new well. A comparison of the differing reservoir development and trends with and without seismic can be made from the hydrocarbon porosity-feet map constructed from seismic-attribute correlations (Fig. 5) and the porosity-feet map made prior to field unitization using only electrical logs (Fig. 6). The multiple-regression correlation technique appears to be valid and offers the ability to selectively target higher-density drilling locations with confidence for improved waterflood sweep.

### Inter-well Injection Tracers

Sodium bromide was injected in the SU 10-28 well to test the degree of water channeling to the SU 7-28 well. This well pair has had the best secondary performance in the Unit with 15,899 m<sup>3</sup> (100,000 bbl) of oil produced at the SU 7-28 since water injection began at the SU 10-28 well. Current production at the SU 7-28 well is 5.5 m<sup>3</sup> of oil and 45.3 m<sup>3</sup>/D of water (35 bopd and 285 bwpd). The tracer material was detected at the SU 7-28 well in 24 hr. The presence of a high-permeability channel between these wells supports previous interpretations of a strong north-south

permeability trend in the reservoir and that gel-polymer treatments at injection wells may improve waterflood performance.

### Technology Transfer

An oral presentation <sup>1</sup> was made at the AAPG Rocky Mountain Section Meeting on July 18 in Reno, NV. The talk addressed the objectives, perceived advantages of horizontal drilling in a heterogeneous reservoir and reasons for the unsuccessful outcome.

A presentation covering advantages of 3-D seismic and waterflooding the "D" Sand along with material from the Colorado School of Mines Hambert-Aristocrat project (DE-AC22-93BC14891) is scheduled for November 15 in Denver.

### References

M.A. Sippel and S. Singdahlsen, "Targeted Horizontal Drilling at the Sooner "D" Sand Unit, DJ Basin, Colorado: A Case History," oral presentation at the 1995 AAPG Rocky Mountain Section Meeting, July 16-19, 1995, Reno, NV.

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