

## TECHNICAL PROGRESS REPORT

Title: APPLICATION OF ADVANCED RESERVOIR CHARACTERIZATION, SIMULATION, AND PRODUCTION OPTIMIZATION STRATEGIES TO MAXIMIZE RECOVERY IN SLOPE AND BASIN CLASTIC RESERVOIRS, WEST TEXAS (DELAWARE BASIN)

Cooperative Agreement No.: DE-FC22-95BC14936

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**OBJECTIVES** The objective of this Class 3 project is to demonstrate that detailed reservoir characterization of slope and basin clastic reservoirs in sandstones of the Delaware Mountain Group in the Delaware Basin of West Texas and New Mexico is a cost effective way to recover a higher percentage of the original oil in place through strategic placement of infill wells and geologically based field development. Project objectives are divided into two main phases. The original objectives of the reservoir-characterization phase of the project were (1) to provide a detailed understanding of the architecture and heterogeneity of two representative fields of the Delaware Mountain Group, Geraldine Ford and Ford West, which produce from the Bell Canyon and Cherry Canyon Formations, respectively, (2) to choose a demonstration area in one of the fields, and (3) to simulate a CO<sub>2</sub> flood in the demonstration area.

After the reservoir characterization and simulation of an area at the northern end of the Ford Geraldine unit were completed, the industry partner decided not to proceed to Phase 2, installation of a CO<sub>2</sub> flood in the demonstration area. A new industry partner, Orla Petco, Inc., will participate in the remainder of the project, which includes a field demonstration to be conducted in the East Ford unit. The East Ford unit is immediately adjacent to the Ford Geraldine unit and produces from the same Ramsey sandstone channel. The reservoir characterization phase of the project has been expanded to include East Ford unit. This additional reservoir-characterization task provides an excellent opportunity to test the transferability of the geologic model and log-interpretation methods developed during reservoir characterization of the Ford Geraldine unit to another Delaware sandstone field.

The objectives of the implementation phase of the project remain the same, to (1) apply the knowledge gained from reservoir characterization and simulation studies to increase recovery from a demonstration area, (2) demonstrate that economically significant unrecovered oil can be recovered by a CO<sub>2</sub> flood of the demonstration area, and (3) test the accuracy of reservoir characterization and flow simulation as predictive tools in resource preservation of mature fields. The goal is to develop a geologically designed CO<sub>2</sub> flood and well-completion program in a representative Delaware Sandstone field that can serve as a model for other fields in the play. Through technology transfer, the knowledge gained in this study can be applied to increase production from more than 100 other Delaware Mountain Group reservoirs.

## SUMMARY OF TECHNICAL PROGRESS

### Field Implementation

Phase 2 of the project began this quarter. Phase 2 will apply the knowledge gained from the reservoir characterization and simulation to increase recovery from the East Ford unit. The goal is to assess the effectiveness of CO<sub>2</sub> flooding to improve recovery in a mature Ramsey sandstone field. Orla Petco, Inc., the operator of the East Ford unit, began a CO<sub>2</sub> flood in the Ramsey sandstone in July 1995. All of the injection and production data generated since the flood was initiated have been made available to the project, which will allow a more complete evaluation of the success of the flood and a better comparison with the predictions made on the basis of the reservoir characterization and simulation. The CO<sub>2</sub> flood at the East Ford unit reached the response phase in December 1997, so data from this critical period of a CO<sub>2</sub> flood will be available to the project.

An evaluation of the impact of geologic heterogeneity on the CO<sub>2</sub> flood has been initiated. The connectivity between injector and producers wells is being evaluated on the basis of the geologic model for deposition of the Ramsey sandstone. Very good connectivity is predicted when both the injector and producer wells are located within the same channel (Ramsey 1 or Ramsey 2 sandstone). Fair connectivity is predicted if the injector well is in the levee facies and the producer well is in the channel facies. Poor connectivity is predicted if the injector well is located in the levee facies on one side of the channel and the producer well is in the levee facies on the other side of the channel. Each producer-injector well pair is being evaluated for the predicted connectivity in the Ramsey 1 and Ramsey 2 sandstones.

## Technology Transfer

Much of the effort this quarter focused on technology transfer. A project website was organized and placed on the internet. The site contains a project summary, with figures and brief text, the latest quarterly report, a list of publications that have resulted from the project, and information about project personnel. The website can be accessed at the following address:

[www.utexas.edu/research/be2/delaware project/index.html](http://www.utexas.edu/research/be2/delaware project/index.html)

The website can also be accessed from The University of Texas, Bureau of Economic Geology website at [www.utexas.edu/research/beg/](http://www.utexas.edu/research/beg/).

Compilation of production data from Delaware Mountain Group fields was completed this quarter. Fields in Texas and New Mexico that produce from Delaware Mountain Group sandstones were divided into Bell, Cherry, and Brushy Canyon reservoirs and mapped. Since the 1920's, approximately 379 reservoirs have been discovered in sandstones of the Delaware Mountain Group in west Texas and southeast New Mexico. These fields are the main targets for transfer of technology from this study. Original oil in place (OOIP) in the 63 largest of these reservoirs exceeded 1,800 MMbbl (Holtz, personal communication, 1994). The 107 largest Delaware sandstone reservoirs in Texas (individual production >100,000 bbl) have produced more than 234.1 MMbbl through March 1999. Production from all 220 Delaware sandstone reservoirs in Texas has been 236.8 MMbbl. The 78 largest fields in New Mexico (>100,000 bbl) produced 99.9 MMbbl through December 1998. Production from all 159 Delaware sandstone reservoirs in New Mexico has been 104.2 MMbbl.

Greatest production in Texas is from reservoirs in the Bell Canyon Formation; the 64 largest Bell Canyon reservoirs (>100,000 bbl) in Texas have produced 185.3 MMbbl of oil. The 36 largest Cherry Canyon reservoirs have produced 48.2 MMbbl, and the 3 largest Brushy Canyon reservoirs have produced 0.5 MMbbl. In New Mexico, the Brushy Canyon is the largest producing interval of the Delaware Mountain Group. The 36 largest Brushy Canyon fields (>100,000 bbl) produced 42.5 MMbbl through December 1998. The 16 largest Bell Canyon reservoirs have produced 30.7 MMbbl, and the 26 largest Cherry Canyon reservoirs have produced 26.7 MMbbl. Low recovery efficiencies from Delaware sandstone fields (average 15%) are caused mainly by low solution-gas drive energy, high water production, and geologic heterogeneities affecting reservoir displacement.

## PLANNED ACTIVITIES

The C02 flood in the East Ford field will continue next quarter. Evaluation of the results of the flood will be initiated and compared with the geologic interpretation of the field.

Two papers that are based on the results of this project will be published next quarter in the transactions volume of the 1999 Gulf Coast Section SEPM Research Conference "Advanced Reservoir Characterization for the Twenty-First Century", as follows:

Barton, M. D., and Dutton, S. P., 1999, Outcrop analysis of a sand-rich, basin-floor turbidite system, Permian Bell Canyon Formation, West Texas: Transactions of the Gulf Coast Section SEPM 19th Annual Research Conference, Dec. 5-8, 1999, Houston, Texas.

Dutton, S. P., and Barton, M. D., 1999, Application of outcrop analogs to reservoir characterization of Permian deep-water sandstones, Bell Canyon Formation, Ford Geraldine unit, West Texas (Delaware Basin): Transactions of the Gulf Coast Section SEPM 19th Annual Research Conference, Dec. 5-8, 1999, Houston, Texas.