DOE/BC/14990--8

TITLE: APPLICATION OF RESERVOIR CHARACTERIZATION AND ADVANCED TECHNOLOGY TO IMPROVE RECOVERY AND ECONOMICS IN A LOWER QUALITY SHALLOW SHELF CARBONATE RESERVOIR

Cooperative Agreement No.: DE - FC22 - 94BC14990

Contractor Name and Address: Oxy USA, Inc. (Oxy), Midland, Texas

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Anticipated Completion Date: December 31, 1996 - Budget Period 1

Government Award for Current Fiscal Year: $2,023,000

Principal Investigators: Archie R. Taylor (Oxy)

Project Manager: Chandra Nautiyal, Bartlesville Project Office

Reporting Period: April 1, 1996 - June 30, 1996

OBJECTIVES

The Class 2 Project at West Welch was designed to demonstrate the use of advanced technologies to enhance the economics of improved oil recovery (IOR) projects in lower quality Shallow Shelf Carbonate (SSC) reservoirs, resulting in recovery of additional oil that would otherwise be left in the reservoir at project abandonment. Accurate reservoir description is critical to the effective evaluation and efficient design of IOR projects in the heterogeneous SSC reservoirs. Therefore, the majority of Budget Period 1 was devoted to reservoir characterization. Technologies being demonstrated include:

1. Advanced petrophysics
2. Three dimensional (3-D) seismic
3. Cross-well bore tomography
4. Advanced reservoir simulation
5. Carbon dioxide (CO_2) stimulation treatments
6. Hydraulic fracturing design and monitoring
7. Mobility control agents

SUMMARY OF TECHNICAL PROGRESS

West Welch Unit is one of four large waterflood units in the Welch Field located in the Northwestern portion of Dawson County, Texas. The Welch Field was discovered in the early 1940's and produces oil under a solution gas drive mechanism from the San Andres formation at approximately 4800 ft. The field has been under waterflood for 30 years and a significant portion has been infill drilled on 20-ac density. A 1982-86 pilot CO_2 injection project in the offsetting South Welch Unit yielded positive results. The recent installation of a CO_2 pipeline near the field allowed the phased development of a miscible CO_2 injection project at the South Welch Unit.

The reservoir quality is poorer at the West Welch Unit due to its relative position to sea level during deposition. Because of the proximity of a CO_2 source and the CO_2 operating experience that would be available from the South Welch Unit, West Welch Unit is an ideal location for demonstrating methods for enhancing economics of IOR projects in lower quality SSC reservoirs. This Class 2 project concentrates on the efficient design of a miscible CO_2 project based on detailed reservoir characterization from advanced petrophysics, 3-D seismic interpretations and cross wellbore tomography interpretations.

During the quarter, work continued on the simulation history match using only the base geologic model generated from available wellbore data. Tomography processing methods were further refined and 3-D surface seismic data was reprocessed to increase the frequency and decrease the bin size.

PETROPHYSICAL ANALYSIS

Integration of crosswell seismic and wellbore data with the available crosswell lines continued.

3-D SEISMIC INTERPRETATION

The surface seismic data has been reprocessed to decrease the bin spacing and increase frequency. Advances made since the initial processing in 1992 were used to enhance the data. The result is a greatly improved seismic section with, increased signal to noise ratio, more dense areal spacing and higher frequencies. Figures 1 and 2 compare the before and after sections respectively.

TOMOGRAPHY

The crosswell seismic processing continues to be refined. Compressional wave processing is complete for the 15 lines. Shear wave processing is ongoing. The early results show the shear wave data will give more detail than the compression wave

data collected at the same sampling rates. This is due to the lower shear wave velocities which results in more accuracy in the processing.

The degree of convergence has been limited for the current lines, which have five foot vertical resolution, since the numerical model grid is about 5' vertical by 80' horizontal. Under these circumstances, the time and expense to obtain additional convergence was not justified.

FRACTURE STIMULATIONS

Cost estimates for Budget Period 2 fracture treatments were made using the information gained from the previous fracture treatment. The fracture treatments will be performed during the early part of Budget Period 2 with the purpose of improving injectivity and sweep improvement of the CO_2 flood. Preliminary simulation runs have shown the treatments will be able to accelerate and improve recovery.

CYCLIC CO2

Based on the work to date, an estimated 40 MSTB of oil will be produced during the first year of the project by the treatment of 17 producing wells.

NUMERICAL SIMULATION

A preliminary history match was made for the base geologic model and the results used to make limited forecasts for screening economics. The grid is 57 X 65 X 9 layers resulting in an approximate 80 ft. grid size to minimize the numerical dispersion effects. Steady state simulations and production type curves were used to provide permeability and effective thickness multipliers for the history match. The steady state simulations matched the late waterflood history when reservoir saturations are relatively constant thus setting the permeability-thickness needed for the history match. The type curves are plots of WOR versus fraction of oil recovered to determine the net pay thickness needed to modify the reservoir description to match the historical performance.

The history match in Fig. 3 shows effective water injection was about 60-70% during most of the flood history. The model shows that most losses occurred when surface injection pressures were at 1800 psi during the late 1970s and 1980s. Since injection pressures were lowered in 1990, injection volumes are close to 100% effective. This result correlates well with the fracture gradients from the available step rate tests. Utilizing the different relative permeabilities by rock type is the only remaining step in the base geologic model history match.

TECHNOLOGY TRANSFER

Results of the fracture monitoring and modeling were presented at the Southwest Petroleum Short Course at Texas Tech University in Lubbock, Texas during April 1996. The method of using seismic attributes for estimation of reservoir properties was presented at the Permian Basin Geophysical Society's annual meeting May 17 and in a poster session at the AAPG Annual meeting May 19-23, 1996 in San Diego.

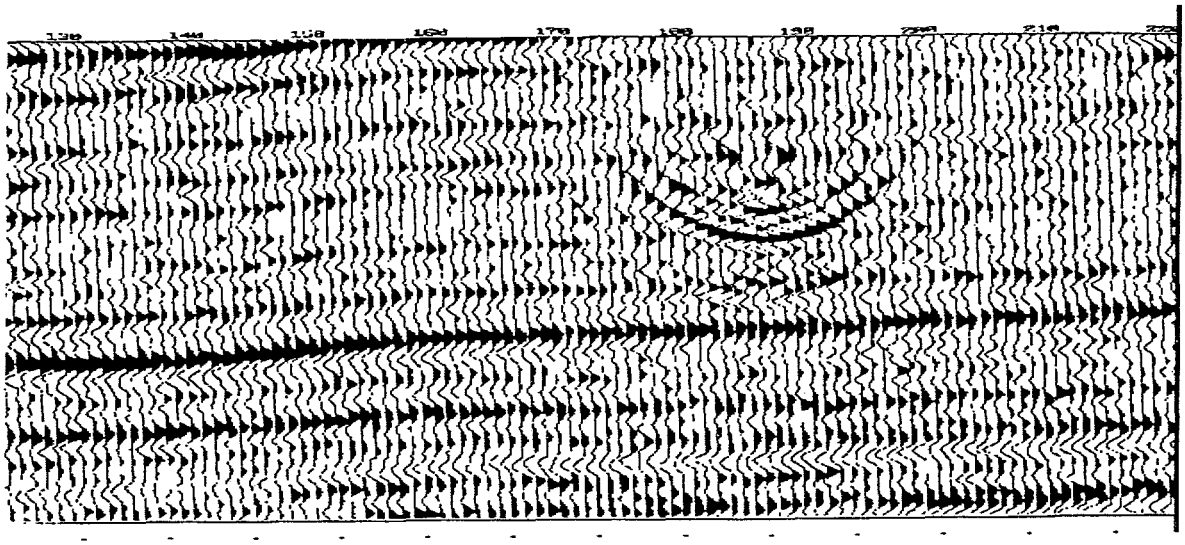

Figure 1 1992 processed seismic section.

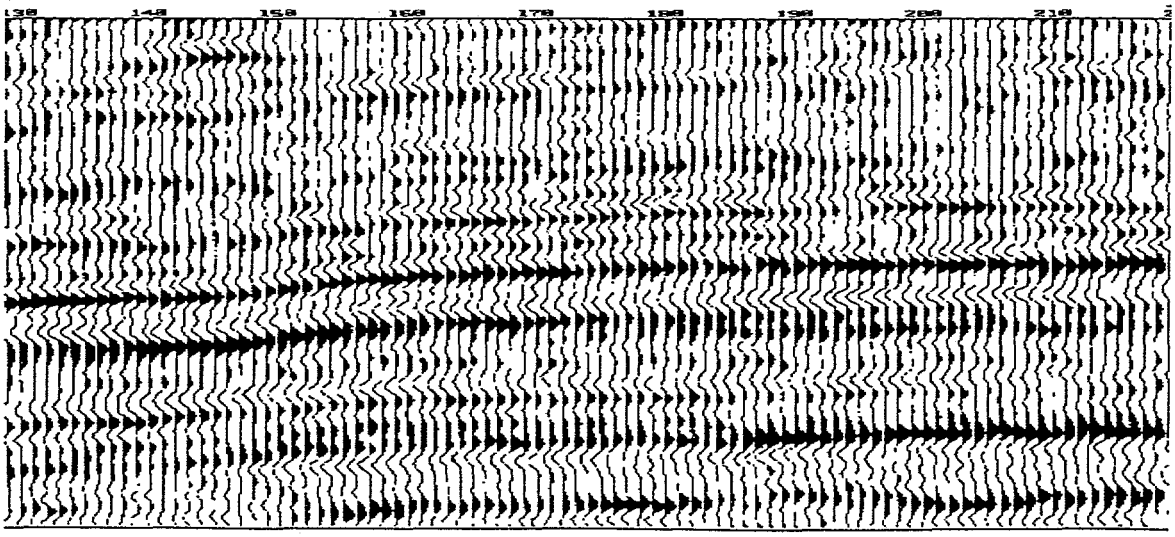

Figure 2 Current processing seismic section with smaller bin spacing.

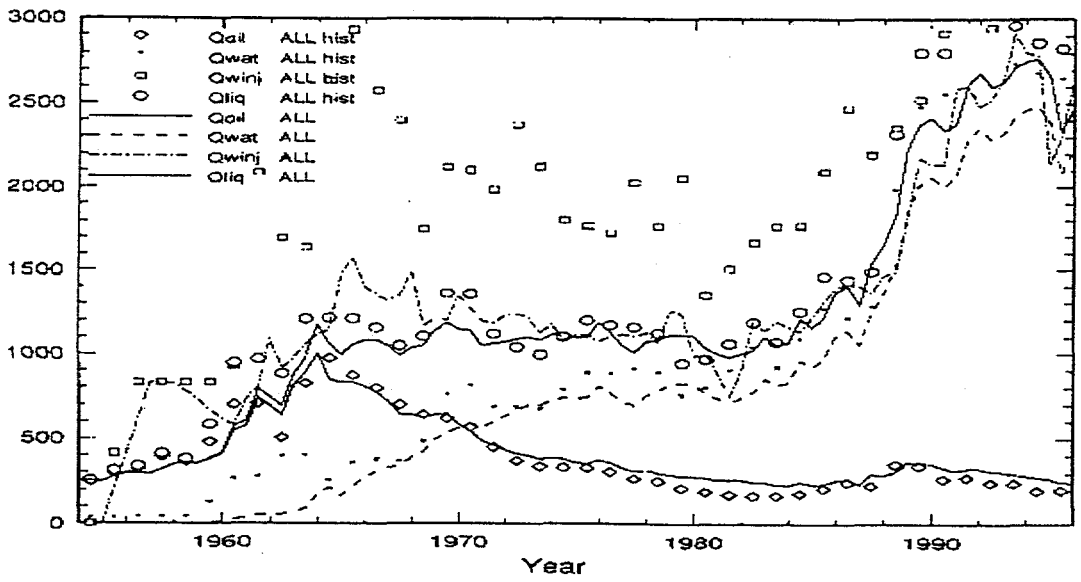

Figure 3 Project area preliminary history match.