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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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 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. 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 at the West Welch Unit is poorer than other San Andres reservoirs 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. Efforts to include the cross well seismic and 3D seismic continue. Additional problems, with the cross well seismic processing, were identified and correction methods are being pursued.

PETROPHYSICAL ANALYSIS

Integration of cross well seismic and wellbore data with the available cross well lines continued. Proper depth placement of the cross well signal is important to get a good correlation to the wellbore data. Correlations, tying the wellbore data and cross well data, showed the depths were not consistent across the interwell space. The computed velocities show completely horizontal layering although the structure dips to the south.

Cross well seismic velocity values show excellent correlation with the wellbore sonic logs in the source wells. However, receiver wells do not show reasonable correlations. Additional processing of the cross well data is continuing to try to obtain consistent relationships between the cross well seismic, 3D seismic and wellbore values.

3-D SEISMIC INTERPRETATION

Efforts to combine the 3D seismic and cross well seismic encountered the same depth problems described in the previous section.

3D data from the revised processing has been incorporated with the wellbore data using the seismic guided methods described by Schultz[1]. The average interval properties are used as grid point values in the mapping package to guide the reservoir property distribution between wells. The results can then be put into the reservoir simulator to aid in defining layers with barriers to flow that traps oil. If this oil volume is large enough, infill drilling could be justified.

TOMOGRAPHY

The cross well seismic processing continues to be refined. Shear wave and vertical seismic profile (VSP) processing was completed on the 15 lines. The results show the shear wave data has more detail than the compression wave lines. Due to the lower shear wave velocities, processing the data collected at the same sampling rate as the compression wave gives more accuracy.

Depths of the cross well signals are not consistent for both source and receiver. The problems became especially apparent when the cross well VSP's were completed. Many VSP's showed reflections outside the pay interval. The software used for depth correlation needs modification to get the signal on depth for correlation purposes.

FRACTURE STIMULATIONS

Cost estimates for two sizes of fracture treatments were obtained for the injection wells in the project area. The fracture treatments will be done during the early part of budget period two with the purpose of improving injectivity and sweep improvement of the CO2 flood. The smaller jobs were designed for the north area where the wells have been infilled with the larger jobs designed for the injectors in the south area on wider spacing.

NUMERICAL SIMULATION

Relative permeability curves, reflecting the differences seen in the laboratory data, were put into the reservoir simulator and the history match was revised. The new curves improved the waterflood history match.

Simulation of the water alternating CO2 injection test on the 4816 well is providing the final changes to the relative permeability hysteresis curves. When these changes are made, the final prediction cases for the base geologic model will be made.

TECHNOLOGY TRANSFER

Three technology transfer events occurred during the third-quarter of 1996. Project Manager Archie Taylor made a presentation based on SPE 35230, "Fracture Monitoring Using 'Low Cost' Passive Seismic" to a company-wide gathering of Oxy U.S.A., Inc. engineers. Team member Scott Hickman made a presentation titled "Application of Advanced Technologies in Characterizing Complex Carbonate Reservoirs" to the SPE sections in Oklahoma City and Duncan, Oklahoma.