DOE/BC/14982--6

TITLE: "AN INTEGRATED STUDY OF THE GRAYBURG/SAN ANDRES RESERVOIR, FOSTER AND SOUTH COWDEN FIELDS, ECTOR COUNTY, TEXAS"

Cooperative Agreement No.: DE-FC22-94BC14982

Contractor Name and Address: Laguna Petroleum Corporation, P.O. Drawer 2758, Midland, Texas 79702-2758

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DISCLAIMER

Objective

The objective of this study is to demonstrate a methodology for reservoir characterization of shallow shelf carbonate reservoirs which is feasible for the independent operator. Furthermore, it will provide one of the first public demonstrations of the enhancement of reservoir characterization using high resolution three dimensional (3-D) seismic data.

This particular project will evaluate the Grayburg and San Andres reservoirs in the Foster and South Cowden Fields of Ector County, Texas. The investigators will showcase a multi-disciplinary approach to waterflood design and implementation, along with the addition of reserves by selective infill drilling. This approach in reservoir development will be applicable to a wide range of shallow shelf carbonate reservoirs throughout the United States. Technology transfer will take place through all phases of the project.

SUMMARY OF TECHNICAL PROGRESS

Production problems associated with shallow shelf carbonate reservoirs are being evaluated by a technical team integrating subsurface geological data, engineering data and 3-D seismic data. The team is using a network of state-of-the-art industry standard software running on high performance computer workstations.

The reservoir description is an integration of the 3-D seismic interpretation with the geologic model derived from the core description, thin section study, log analysis and cross section work. Geological evaluation of the Grayburg/San Andres reservoirs during this quarter has included the correlation of a total of 18 formation tops (Santa Rosa through San Andres), including detailed parasequence sets within the Grayburg formation within the area of the project. Computer files have been created in Scientific Software Intercomp's WorkBench software, and in Schlumberger's IESX 3-D Seismic Interpretation software containing all tops and sub-sea depths.

Twenty-four Grayburg and seven San Andres thin sections have been evaluated from the J.E. Witcher Well No. 6. This evaluation has been valuable in formulating a depositional model and in definitively dividing the Grayburg and San Andres reservoirs into distinct layers or "units".

Both the project geologist and geophysicist are working together using the IESX and WorkBench software to integrate their interpretations from digital well logs and the 3-D seismic data. Formation tops for the Yates, Seven Rivers, Queen, Grayburg, San Andres, and Glorieta formations are being interpreted by correlating the seismic data to synthetic seismograms computed from sonic or pseudo-sonic log curves. Interval times in the interpretation agree with the interval times from a velocity survey from the Blair French No. 1 Moss Well located within the study area. Interpretation of the Yates, Seven Rivers,

Queen, Grayburg, and San Andres formation tops through the 3-D seismic volume is nearly complete.

Interpretation of detailed sequence stratigraphy in the 3-D seismic data volume for the Grayburg/San Andres reservoir requires depth to time conversion of the subsurface interpretation of well log data. Transfer functions are currently being developed between the log depths in feet and the seismic depths in time.

The integrated interpretation of the reservoir sequence stratigraphy from the well control and 3-D seismic data will complete the 3-D seismic interpretation for Phase I of the study. Porosity zones will be correlated through the reservoir and input into reservoir simulation models assuming that reservoir compartments mostly conform to the sequence stratigraphy. Quantitative extraction of reservoir properties from seismic attributes will be attempted utilizing modern log data obtained in Phase II of the study.

The presence of clinoforms, in both the reservoir portion of the Grayburg and the San Andres is significant. These clinoforms correlate to facies changes (the presence of the grainstone shoal) seen in the core and on the cross sections. The extent seems to be influenced by the presence of paleostructures identified by both seismic and geologic mapping. These facies changes have lateral continuity, as identified in the 3-D seismic volume, which would have been difficult to predict from well control alone. Identification of the facies belts will impact the design of the waterflood. Work is presently being concentrated on the Witcher lease where the core provides optimum facies information.

The Grayburg and San Andres formations are characterized by a high degree of stratigraphic heterogeniety and lenticularity. The flow compartments are randomly oriented and often interspersed with deposits of anhydrite which serve as flow barriers. These features tend to hinder the sweep efficiency of waterfloods and lower secondary recoveries. Additonally, high permeability stringers, or channels, further reduce waterflood recoveries. With the aid of a 3-D developed reservoir model, the various heterogeneities and barriers may be delineated in order that an optimal design of the flood pattern may be evaluated.

During the reporting period the bulk of the engineering study done by Dr. David A. Rowland was concentrated on preliminary modeling of the Witcher lease using a DOE program called BOAST and Scientific Software Intercomp's WorkBench software program.

Boast Simulator: A reservoir model of the Witcher lease was constructed using the DOE program called BOAST. Initially, the input data was identical to that reported in the Sun Oil Company waterflood feasibility study of the Witcher over ten years earlier (1). The total estimated volume of OOIP for the Witcher lease reported in this study is 6.293 MMSTB. The reported total oil produced from this lease through 1994, as shown in Table 1, is 1.909 million barrels. This implies nearly a 30% recovery efficiency for the lease to-date. However, one very significant result revealed in this early simulation effort was that insufficient oil was present to allow the simulation to continue throughout the entire 55-year

Table 1. PRODUCTION STATISTICS

A. Witcher Lease

YEAR	ANNUAL	CUMULATIVE	YEAR	ANNUAL	CUMULATIVE
1940	15,839	15,839	1970	64,883	981,089
1941	55,808	71,647	1971	103,117	1,084,206
1942	29,319	100,966	1972	65,905	1,150,111
1943	46,585	147,551	1973	55,099	1,205,210
1944	96,952	244,503	1974	68,376	1,273,586
1945	86,934	331,437	1975	60,081	1,333,667
1946	65,999	397,436	1976	52,875	1,386,542
1947	51,722	449,158	1977	47,775	1,434,317
1948	43,011	492,169	1978	39,040	1,473,357
1949	28,889	521,058	1979	35,271	1,508,628
1950	29,621	550,679	1980	31,066	1,539,694
1951	25,082	575,761	1981	33,587	1,573,281
1952	22,958	598,719	1982	27,352	1,600,633
1953	17,182	615,901	1983	24,593	1,625,226
1954	18,252	634,153	1984	21,778	1,647,004
1955	57,523	691,676	1985	27,818	1,674,822
1956	45,740	737,416	1986	28,368	1,703,190
1957	28,419	765,835	1987	21,694	1,724,884
1958	20,346	786,181	1988	23,127	1,748,011
1959	18,331	804,512	1989	26,485	1,774,496
1960	16,736	821,248	1990	28,818	1,803,314
1961	12,544	833,792	1991	32,986	1,836,300
1962	7,998	841,790	1992	28,930	1,865,230
1963	6,909	848,699	1993	22,882	1,888,112
1964	12,009	860,708	1994	21,308	1,909,420
1965	13,923	874,631			
1966	10,722	885,353			
1967	8,687	894,040			
1968	10,861	904,901			
1969	11,305	916,206			

life of the production. The reason for this failure was attributed to the fact that an insufficient oil volume was assumed in the volumetrics. Only after increasing parameters of average porosity, net pay and oil saturation was a simulation of the entire lease history possible. This factor will be taken into account in the geological/geophysical analysis of this study in trying to locate additional reserves.

WorkBench Simulator: Using the same data employed while making BOAST simulator runs on the Witcher lease, a history run was made using Scientific Software Intercomp's WorkBench. The results are very similar for both models. Especially noteworthy is the fact that when using the OOIP suggested by the earlier waterflood feasibility study, the simulation blows-up after around 20 years of history-matching production. Only after increasing the OOIP was the model able to run the completion of history.

Technology Transfer

This reporting period the project's technical team presented a talk to the Society of Independent Professional Earth Scientist's (SIPES) in Midland, Texas. The team has submitted an abstract for the West Texas Geological Society's Fall Symposium, which will be held November 1st and 2nd 1995. Members of the project team were interviewed by Ellen Hopkins, a freelance writer, and George Van Dam with the Odessa American.

REFERENCES

1. Daniels, David W.: "Waterflood Feasibility Study - J.E. Witcher Lease, Foster Field, Grayburg and San Andres Formations," Sun Exploration & Production Company, September, 1984