OBJECTIVE

The project objective was to understand the successful water flood in the Monument Butte unit and apply it to other units and other reservoirs. Expanding the Monument Butte Water Flood was also one of the objectives.

SUMMARY OF TECHNICAL PROGRESS

Field Drilling and Production Results The Monument Butte unit is being extended mainly on the west side and on the north side. Many of the new wells have only been recently completed and a production update will be provided in the next quarterly report. A new well 5-33, drilled and completed in the Travis unit continues to produce oil and gas. Well 12-21 was drilled and completed in Boundary. A production update on both the Travis and the Boundary Units will also be provided in the next quarterly report.

Modeling the Boundary Unit

Synopsis:

A reservoir model for the Boundary Unit has been presented. This was by far the most complicated reservoir model developed during the project. An effort is made to represent reservoir geology (porosity, thickness) at 2 feet resolution. Two types of reservoir models were developed; one without hydraulic fractures and with hydraulic fractures. The simpler of the two models, without hydraulic fractures is described in this report. This model had a total of 28 layers and about 6000 grid blocks.

Reservoir Description

The Boundary unit has six wells which have been completed in different regions. They are 7-20, 9-20, 15-20, 5-21, 11-21 and 13-21. Out of these, the well 5-21 has been shutdown and has never
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been operational. The remaining five wells encompass different regions of essentially six types of sands i.e. D1, D2, C, Castle Peak (CP), Lower Douglas Creek (LDC) and A3. General descriptions of each of these sandstones are presented below.

D1 Sandstone

This is the uppermost sand layer and is present at an average depth of 5235 feet. D1 sandstone is located only in well 13-21 with 11 feet of gross and 6 feet net thickness. This sandstone is quite compact with an average porosity of 11.3%. Since D1 sandstone is located only in 13-21 it is limited to a narrow region in the unit.

D2 Sandstone

The D2 sandstone is present in the maximum number of wells covering four out of the five productive wells i.e. 7-20, 9-20, 5-21 and 13-21. Log analyses have shown this sandstone to be divided into lobes; the lobes being separated layers of shale. Well 7-20 has 30 feet of net D2 (36 feet gross) which is divided into two lobes of 8 feet and 22 feet. The upper lobe of 8 feet has an average porosity of 16.6% while the lower 22 feet lobe has an average porosity of 16.2%. The lower lobe of 7-20 has been found to have a water-oil contact at a depth of about 10 feet from the top. This complicates its modeling and representation in the simulator.

Well 9-20 has 11 feet of net D2 sandstone which is also divided into two lobes of 6 feet and 5 feet each. The log analysis shows the sand to be highly porous with an average porosity of 18.67% in the upper lobe and 18.0% in the bottom lobe.

Well 5-21 has 13 feet of net D2 (20 feet gross) which again is present in two lobes of 6 feet and 7 feet. The average porosities are 14.67% in the upper lobe and 13.71% in the lower lobe.

Well 13-21 also has D2 in two lobes with net thicknesses of 4 feet and 12 feet, with average porosities of 15.0% and 17.0% for the upper and lower lobe respectively.

There also exists a structural gradient in the Boundary Unit. Well 7-20 is downdip of 9-20 which is completed in zones structurally below 13-21. The fact that oil-water contact was observed in 7-20 is consistent with the reservoir structure.

C Sandstone

C sandstone is present in two wells i.e. 7-20 and 11-21. In 7-20, there is net 7 feet of C with an average porosity of 15.28%. In 11-21 C sandstone is present in two lobes of thickness 9 feet and 6 feet each. The upper 9 feet has an average porosity of 14.22% and the lower 6 feet has an average porosity of 15.0%. Based on the stratigraphic locations, the upper lobe of C sandstone in 11-21 is represented to be communicating with the sand in 7-20 and the bottom lobe in 11-21 is not in communication with any other well.

LDC Sandstone

The LDC sandstone is present only in 15-20 with a net thickness of 41 feet (54 feet gross). It is divided into three lobes. The upper lobe has a net thickness of 5 feet and an average porosity of 12.6%, middle lobe has 13 feet net and an average porosity of 14.0% while the bottom lobe has a net thickness of 23 feet and an average porosity of 13.6%. Since LDC is present only in 15-20, this well does not communicate with any other well.

A3 Sandstone

This sandstone is found only in two wells i.e. 7-20 and 9-20. The net 25 feet of A3 in 7-20 is divided into three lobes with net thicknesses of 9 feet, 6 feet, and 10 feet and average porosities of 15.56%, 12.33% and 14.6% in the upper, middle and lower lobes respectively. The well 9-20 has two lobes of A2 sandstone. The upper lobe has a net thickness of 5 feet and an average porosity of 13.2% while the lower lobe has a net thickness of 3 feet with an average porosity of 11.67%.

CP Sandstone

The CP sandstone is present in wells 9-20 and 5-21. This is the deepest sand in the reservoir. The wells 13-21 and 11-21 were not drilled deep enough to verify the presence or absence of this
sandstone in other areas of the reservoir. In 5-21, CP sandstone is present as two beds with net sands of 2 feet and 8 feet and average porosities of 11.0% each. In the well 9-20, the sandstone has three components of 5 feet, 8 feet, and 6 feet net and average porosities of 11.8%, 12.5% and 13.67% in the upper, middle and lower lobes respectively. The beds are at the same stratigraphic horizons in both wells. The two lobes in 5-21 are thus assumed to be communicating with the upper and the middle lobe in 9-20 while the bottom lobe in 9-21 is independent.

Simulation Analysis

Reservoir simulation of the Boundary unit was performed using a 28 layer, 16 × 13 grid model. The 28 layers consist of 14 oil bearing sandstone layers, 1 aqueous layer, and the rest impermeable shale barriers separating the sandstones. Every attempt was made to incorporate the geologic information available as accurately as possible in the simulation data. A general description of the Boundary Unit is presented in Table 1. Computed average value of porosities were assigned to different layers although the data was available at 2 foot intervals. This is because representing separate 2 feet layers individually would have greatly increased the number of grid blocks making a single simulator run impossible in a reasonable amount of CPU time, even on fast SPARC10 machines. In the order of increasing depths the 14 oil-bearing layers were: D1 (1 layer), D2 (2 layers), C (2 layers), LDC (3 layers), A3 (3 layers) and CP (3 layers). The parameters employed in Boundary Unit simulation are given in Table 2. The water-oil contact in well 7-20 was modeled as a separate aqueous layer directly beneath the lowest D2 sandstone layer in 7-20. Assumptions were made as to the extent of the aquifer, since enough data is not available to establish its extent. A comparison of the actual and simulated cumulative oil and cumulative gas produced in the Boundary Unit is shown in Figures 1 and 2 respectively.

TECHNOLOGY TRANSFER

A paper titled Solid Precipitation in Reservoirs Due to Nonisothermal Injections was presented by M. Deo, A. Miharia and R. Kumar (SPE 28967) at the International Oilfield Chemistry Symposium in San Antonio, Texas, in February, 1995.

PUBLICATIONS

“Water Flood Project in the Monument Butte Field, Uinta Basin,” presented by John D. Lomax, Annual meeting of the Interstate Oil and Gas Compact Commission, December 6-8, 1992, Salt Lake City, Utah.

“Water Flood Project in the Uinta Basin,” presented by Milind D. Deo, Monthly meeting of the Salt Lake section of the Society of Petroleum Engineers, February 16, 1993, Salt Lake City, Utah.
Table 2: Reservoir Parameters employed in Simulation of Boundary Unit

<table>
<thead>
<tr>
<th>Layer # in the model</th>
<th>Sand Identification</th>
<th>Porosity</th>
<th>Initial Reservoir Pressure (psi)</th>
<th>Bubble Point Pressure (psi)</th>
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"Green River Formation Water Flood Demonstration Project", Yearly Report to be published by the U.S. DOE, 89 pp.


Figure 1: Cumulative Oil production from the Boundary Unit: Comparison of actual and simulated values

Figure 2: Cumulative Gas production from the Boundary Unit: Comparison of actual and simulated values
Figure 1
Figure 2
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