DOE/BC/14953-25
(OSTI ID: 14227)

INCREASED OIL PRODUCTION AND RESERVES FROM IMPROVED COMPLETION TECHNIQUES IN THE BLUEBELL FIELD, UINTA BASIN, UTAH

Quarterly Technical Progress Report
July 1, 1998-September 30, 1998

By
Craig D. Morgan

Report Issue Date: September 1998

Performed Under Contract No. DE-FC22-92BC14953

Utah Geological Survey
Salt Lake City, Utah

DISCLAIMER

DOE/BC/14953-25
Distribution Category UC-122

Increased Oil Production and Reserves from Improved Completion Techniques in the Bluebell Field, Uinta Basin, Utah

By
Craig D. Morgan

November 1999

Work Performed Under Contract No. DE-FC22-92BC14953

Prepared for
U.S. Department of Energy
Assistant Secretary for Fossil Energy

Gary Walker, Project Manager
National Petroleum Technology Office
P.O. Box 3628
Tulsa, OK 74101

Prepared by
Utah Geological Survey
1594 West North Temple, Suite 3110
Salt Lake City, UT 84114

Quarterly Technical Progress Report
07/01/98 - 09/30/98
20th Quarter of the Project

14227

Increased Oil Production And Reserves From Improved Completion Techniques In The Bluebell Field, Uinta Basin, Utah

Contract DE-FC22-92BC14953 -25

Gary Walker
U.S. Department of Energy
National Petroleum Technology Office
Contracting Officer's Representative

Craig D. Morgan
Program Manager
Utah Geological Survey
(801) 537-3370

OBJECTIVES

The objective of this project is to increase oil production and reserves in the Uinta Basin by demonstrating improved completion techniques. Low productivity of Uinta Basin wells is caused by gross production intervals of several thousand feet that contain perforated thief zones, water-bearing zones, and unperforated oil-bearing intervals. Geologic and engineering characterization and computer simulation of the Green River and Wasatch Formations in the Bluebell field will determine reservoir heterogeneities related to fractures and depositional trends. This will be followed by drilling and recompletion of several wells to demonstrate improved completion techniques based on the reservoir characterization. Transfer of the project results will be an ongoing component of the project.

SUMMARY OF TECHNICAL PROGRESS

Completion of the John Chasel 3-6A2 Well

Introduction

The completion of the John Chasel 3-6A2 well (section 6, T. 1 S., R. 2 W., UBM) is the third step in a three-well demonstration. The first two wells, Michelle Ute 7-1 (sec. 7, T. 1 S., R. 1 E.) and Malnar Pike 17-1 (sec. 17, T. 1 S., R. 1 E.) were discussed in previous progress reports. The Michelle Ute was planned as a high-diversion, high-pressure, three-stage recompletion. Each stage or interval was intended to span about 500 vertical ft (150 m). Mechanical problems prevented a valid test of this recompletion technique. The Malnar Pike recompletion involved isolation and stimulation of much smaller intervals, testing at the bed scale, or as close to bed scale as was practical. Production results are still erratic but the oil production rate in the Malnar Pike well improved slightly.

The Chasel 3-6A2 well was drilled, logged, and perforated as discussed in the previous quarterly report. The well was stimulated with two separate acid treatments but poor cement bond between the casing and the formation, followed by partial collapse of the casing delayed the completion of the well.

Pre-treatment evaluation

Most wells in the Bluebell field are completed by perforating 40 or more beds. Perforations are usually selected based on drilling shows with minor reliance on geophysical well logs. The objective of completing the 3-6A2 well was to use geophysical well logs to select far fewer beds than customary for completion, hopefully reducing completion costs, increasing the production rate, and greatly reducing the volume of water produced. Nineteen beds between 14,574 to 15,746 ft (4445.1- 4802.5 m) gross vertical interval were selected for perforating, far fewer than in most other wells in the Bluebell field. The thermal decay neutron time (TDT) log was the primary tool used for selecting perforations, along with fracturing identified on the dipole shear anistropy log, and exceptional drilling shows. The density-neutron porosity log was evaluated but log porosity was not a deciding factor. The previous quarterly report included a list of the beds selected for perforating and a qualitative analysis of the fracturing and oil saturation based on the dipole shear anistropy and TDT logs for each bed.

Treatment and testing

The 3-6A2 well was completed by acidizing the perforated intervals in two separate treatments. The first treatment was of the lower 12 perforated beds, and the second treatment was of all 19 perforated beds. The first treatment consisted of 5500 gal (20,815 L) of 15% HCl at a maximum pressure of 10,000 psi (68,950 kPa), an average pressure of 6750 psi (46,550 kPa), a maximum rate of 15 bbl/min (2350 L/min) with an average of rate 12.3 bbl/min (1950 L/min). Communication occurred behind the casing around the packer with 3570 gal (13,500 L) pumped. The well was swabbed for a day, recovering acidic water estimated to be 5 to 6% oil cut. The second treatment consisted of 6500 gal (24,600 L) of 15% HCL at a maximum pressure of 10,007 psi (68,990 kPa), an average pressure of 8000 psi (55,160 kPa), a maximum rate of 19.7 bbl/min (3100 L/min), with an average rate of 14.5 bbl/min (2300 L/min).

The isotope tracer log indicated that most of the acid entered perforated and nonperforated beds at depths from 15,130 to 15,340 ft (4611.6-4675.6 m). The isotope log showed extensive communication behind the casing in this interval. Limited swab testing recovered acid water and no oil. Based on this limited test the operator believed the well was producing water. A fluid entry log was run which showed fluid entering the wellbore at 15,191 to 95 ft (4633.3-28.9 m); and 15,224 to 27 ft (4643.3-8.2 m); while 18 bbl/day (2850 L/day) were going into the perforations from 15,305 to 13 ft (4668.0-3.9 m). A cast iron bridge plug was set at 15,320 ft (4672.6 m) and a retainer was set at 15,000 ft (4575.0 m). The interval which included perforated beds nine through 19 (see Quarterly Report 19 for table of beds) was cement squeezed. The cement which was tagged at 14,172 ft (4322.5 m) was drilled out. Beds 14 through 17, and bed 19 were reperforated, beds one through seven were below the cement resulting in a total of 14 beds left open above the cement.

The well was swab tested and recovered mostly oil. The entire perforated interval was acidized with 12,000 gal (45,420 L) of 15% HCL at a maximum pressure of 10,000 psi (68,950 kPa), an average pressure of 8700 psi (59,950 kPa), at a maximum rate of 6.7 bbl/min (1050 L/min), and an average rate of 5.4 bbl/min (850 L/min). Swab testing after the treatment recovered drilling mud and then the tubing had to be pulled because it was plugged with cement chips. While the tubing was out of the hole the well began to flow. The shut in pressure at the well head was 2500 psi (17,160 kPa). The operator flowed the well in an attempt to reduce the pressure so they could run the tubing back in the hole. One day the well flowed 124 BO (17.4 MT), 255 MCFG (7220 m^3), and 0 BW; the next day it flowed 133 BO (18.6 MT), 125 MCFG (3550 m^3), and 0 BW. The operator eventually stopped the flow and ran the tubing back into the hole. They discovered that the casing was partially collapsed at 15,354 ft (4682.9 m) and 15,573 ft (4749.8 m) with a tight spot that had to be swedged at 14,700 ft (4480.6 m).

A retainer was set at 15,400 ft (4693.9 m) and cement was dumped on top of the retainer to a depth of 15,355 ft (4680.2 m), eliminating from production the lower seven perforated beds. Swab testing of the remaining seven perforated beds is continuing.

Post Treatment Engineering Analysis of the Michelle Ute and Malnar Pike Wells

The work this quarter focused on assessing the impact of treatments in project wells, particularly Malnar Pike. In Malnar Pike, two test intervals were evaluated: test interval three, between 12,950 to 13,050 ft (3947.2-3977.6 m) and test interval four between 12,680 to 12,730 ft (3864.9-3880.1 m). A bridge plug was set at 13,060 ft (3980.7 m) so that the perforations below this depth are not contributing to production. After the treatment the oil production increased from about 20 BOPD (2.8 MTPD) to about 35-40 BOPD (4.9-5.6 MTPD).

The dual-porosity, dual-permeability model employed previously to match oil and gas production from Malnar Pike was modified to assess the treatment. Relevant matrix and fracture properties used in the model are presented in Table 1. The model aerial extent was 40 acres (16.2 h). The well intersected 109 layers: 55 oil-bearing layers separated by 54 non-oil-bearing layers.

When measured water saturations were used in the model, water produced from the model was two times the actual water produced in the field. In order to match the field water production, water relative permeabilities were altered. The new set of relative permeabilities are shown in Table 2. The cumulative oil, gas, and water production as predicted by the model are compared with the actual field totals in Table 3. As can be seen from the table, the agreement between the model predictions and field data is excellent. The model predicted a total oil rate of 15 BOPD (2.1 MTPD) in October 1997. Several different strategies were attempted to match the post treatment rate of about 40 BOPD (5.6 MTPD). Only the properties in the affected zones were changed at the treatment time. All of the strategies and corresponding rates after treatment are listed in Table 4. It was hypothesized that the treatment would have increased fracture permeabilities, extent of fracturing, and/or frequency of fracturing. Each of these options were examined either in isolation or in combination with other options. One final option of adding a new zone was also examined.

Table 4 demonstrates that it is possible to realize the gains in production by a variety of methods. Increasing the fracture permeability to 22 mD appeared to provide the most realistic increase in production. However, in most of the strategies examined, the production rate decreased to about 25 BOPD (3.5 MTPD) after about six months. The scenario where an equivalent new zone was added to the reservoir was the only scenario in which the production remained steady at around 31 BOPD (4.3 MTPD) well after the zone was opened. The zone added to the model was 30 ft (9.1 m) thick with a porosity of 0.14 and an initial oil saturation of 0.7. The zone had a matrix permeability of 1.5 mD and fracture permeability of 2.2 mD (properties of the older zones). Assuming only 3% recoverable oil from the zone (based on the performance of the well) it was hypothesized that net reserves of about 27,000 BO (3780 MT) were added to the well.

The Michelle Ute model was also revised. Field water production from Michelle Ute is shown in Figure 1. There are apparently two distinct modes in the water production behavior. The water production rate is very low for about 2700 days of production (ending December 1992). Only about 5300 BW (742 MT) are produced to this point. The rate drastically increased at this time and the total production reached about 25,000 BW (3500 MT) at 4600 days of production (ending June 1998). In order to match this behavior, two sets of water relative permeabilities were employed; a set for the first 2700 days and a different set after 2700 days. These relative permeabilities are shown in Table 5. Treatment of the Michelle Ute well did not change its oil production rates over the long term. The effect of the treatment from a modeling point of view is currently being examined.

Table 1: Parameters for the Malnar Pike Model

Parameter	Value
Modeled depth (feet)	9582 - 14,360
Grid description (blocks)	8 x 8 x 109
Grid block size in the x and y dimensions (feet)	165
Grid size in the z-dimension (feet)	Variable
Porosity	0.0 - 0.22
Matrix permeability (mD)	0.1 - 2.5
Fracture porosity	0.000002
Fracture permeability (mD)	0.02 - 22
Fracture frequency - one fracture every (feet)	10
Pressure (depth dependent)(psi/ft)	0.5
Initial oil saturation	0.1 - 0.8
Initial gas/oil ratio (scf/stb)	1100
Initial bubble point pressure (psi)	4795

psi: pounds per square inch
scf: standard cubic feet
stb: stock tank barrels

Table 2: Relative permeabilities used to obtain the history match for the Malnar Pike well

Water Saturation	Relative permeability (mD) to water	Relative permeability (mD) to oil
0.22	0.0	1.0
0.3	0.05	0.1
0.35	0.1	0.05
0.4	0.15	0.0175
0.5	0.5	0.0073
0.6	0.7	0.005
0.8	0.9	0.003
0.9	0.96	0.001
1.0	1.0	0.0

Table 3: Production match between the model and field data - Malnar Pike well. Oil in Mstb, gas in MMSCF, and water in Mstb.

Production as of December 1993				Production as of October 1997			
Field Data		Model Predictions		Field data		Model Predictions	
Oil	93	Oil	100	Oil	113	Oil	125
Gas	79	Gas	87	Gas	96*	Gas	119
Water	100	Water	102	Water	122*	Water	110

* -extrapolated from available data

Table 4: Different strategies used in emulating the treatment in Malnar Pike

Strategy	Production rate immediately after treatment (stb/day)	Production rate 4 months after treatment (stb/day)
1. Increase fracture permeability in affected zones from 2.2 to 22 mD	39	25
2. Increase extent of fracturing in the affected zones from 495 feet to 660 ft	29	22
3. Combine strategies 1 and 2	35	23
4. Increase fracture frequency to one every 5 ft	41	24
5. Add a new zone 30 ft thick of porosity 0.14 and oil saturation 0.7	39	31

Table 5: Relative permeabilities (mD) used in matching water production from Michelle-Ute over the entire time interval

Water Saturation	Water relative permeability for the first 2700 days	Water relative permeability for after 2700 days	Oil relative permeability
0.22	0.0	0.0	1.0
0.3	0.0	0.0	0.7
0.4	0.0	0.0	0.4
0.5	0.003	0.02	0.3
0.6	0.009	0.06	0.05
0.8	0.015	0.1	0.03
0.9	0.021	0.14	0.0
1.0	0.03	0.2	0.0

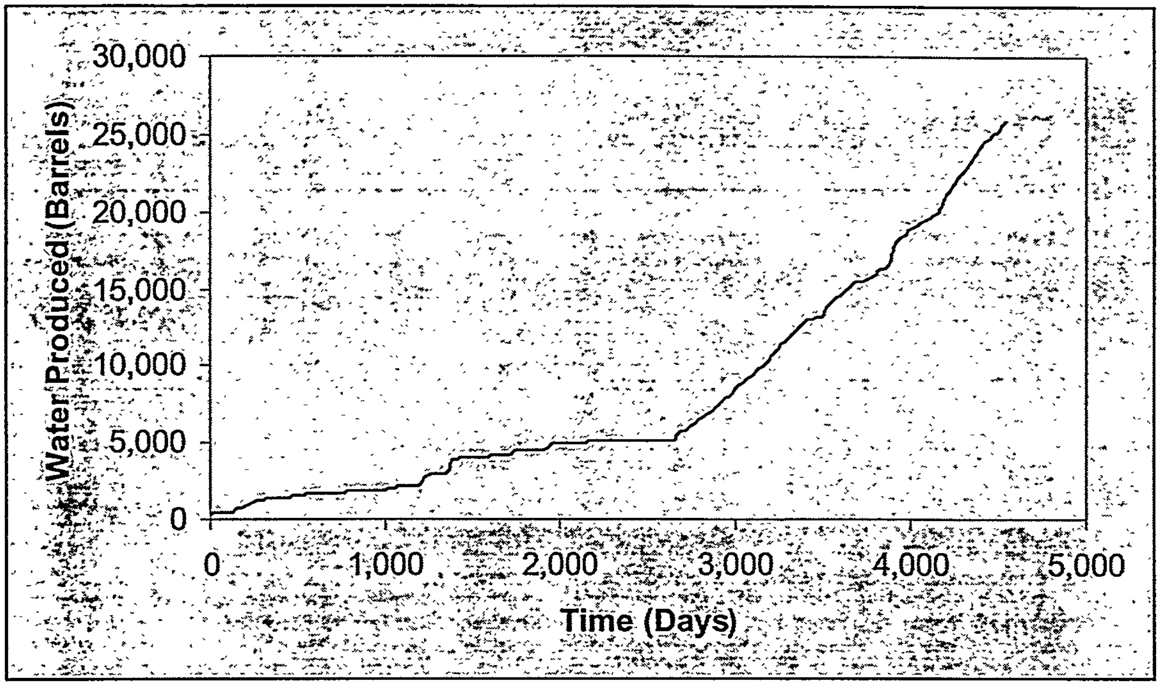

Figure 1. Water produced from the Michelle Ute well; notice the sharp transition at around 2700 days.

Technology Transfer

The Utah Geological Survey maintains a Bluebell web page on its web site containing the following information: (1) a description of the project, (2) a list of project participants, (3) each of the Quarterly Technical Progress Reports, (4) a description of planned field demonstration work, (5) portions of the First and Second Annual Technical Reports with information on where to obtain complete reports, (6) a reference list of all publications that are a direct result of the project, (7) an extensive selected reference list for the Uinta Basin and lacustrine deposits worldwide, and (8) daily activity reports of the demonstration wells. The web page address is ***http://www.ugs.state.ut.us/bluebell.htm***