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

Quarterly Technical Progress Report
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By
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Utah Geological Survey
Salt Lake City, Utah

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

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17th Quarter of the Project

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

Contract DE-FC22-92BC14953 -22

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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

Recompletion Of The Malnar Pike 1-17A1E Well

Introduction

The recompletion of the Malnar Pike 1-17A1E well (sec. 17, T. 1 S., R. 1 E., UBM) was the second step in a three-well demonstration. The first well, Michelle Ute 7-1 (sec. 7, T. 1 S., R. 1 E.) was discussed in previous 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 feet (150 m). Mechanical problems prevented a valid test of this recompletion technique. The Malnar Pike recompletion involved isolation, stimulation, and testing of much smaller intervals, treating at the bed scale, or as close to bed scale as was practical. The intervals were isolated using a bridge plug at the base and a packer at the top of the test interval.

Four separate treatments and tests were applied. The first two treatments resulted in communication above and below the test interval. Swab tests recovered water from both intervals after the treatment. The third and fourth treatments were mechanically sound and resulted in an increase in the daily oil production.

Dual burst thermal decay time (TDT), dipole shear anisotropy (anisotropy), and isotope tracer logs were used to identify beds for treatment and testing and for post-treatment evaluation.

Test number 1

The first interval stimulated and tested was from 13,366 to 13,470 ft (4073.9-4105.7 m) log depth (Fig. 1A). A temperature and spinner survey run early in the production history of the well, shows the perforation from 13,434 to 13,438 ft (4094.7-4095.9 m) was responsible for 17% of the oil production at that time. The TDT log shows this bed has a water saturation from 63 to 79%. The pre-treatment anisotropy log shows little to no fracturing in this bed. The perforated intervals 13,402 to 13,412 ft (4084.9-4087.9 m), and 13,486 to 13,494 ft (4110.5-4112.9 m), were identified as thief zones by the earlier temperature and spinner survey. The pre-treatment anisotropy log shows good fracture development in both thief zones. The perforated bed 13,414 to 13,418 ft (4088.6-4089.8 m), has a water saturation of 25 to 40%. All the other perforated beds in the test interval have water saturation ranging from 62 to 79% as indicated on the TDT log.

The interval was treated with 357 barrels (56,800 L) of hydrochloric (HCL) acid pumped at a maximum pressure of 7214 psi (49,700 kPa), an average pressure of 5500 psi (38,000 kPa), and at a maximum rate of 10 barrels per minute (bpm) (1600 Lpm). Communication occurred behind the casing (probably in the cement between the casing and the formation) above the packer and below the bridge plug. The communication can be identified on the isotope tracer (tracer number 1) and the post-treatment anisotropy logs. The communication greatly reduced the effectiveness of the treatment. Limited swab testing after the treatment recovered water. However, due to the communication it cannot be determined if the water is from the tested interval or the beds above or below the test interval, or all of them.

Test number 2

The second interval stimulated and tested was from 13,125 to 13,250 ft (4000.5-4038.6 m) log depth (Fig. 1B). The pre-treatment anisotropy log shows two perforated intervals with well developed fractures, 13,224 to 13,233 ft (4030.7-4033.4 m) and 13,165 to 13,180 ft (4012.7-4017.3 m). A two foot layer (13,228 to 13, 230 ft [4031.9-4032.5 m]) has a water saturation of 39%. The other perforated intervals have a water saturation ranging from 59% to more than 79% based on the TDT log.

The interval was stimulated with 95 barrels (15,100 L) of HCL acid pumped at a maximum pressure of 6810 psi (46,900 kPa), an average pressure of 6000 psi (41,000 kPa), and at a maximum rate of 10.2 bpm (1,600 Lpm). Communication occurred behind the casing (probably in the cement between the casing and the formation) above the packer and possibly below the bridge plug. The communication can be identified on the isotope tracer (tracer number 3) and the post-treatment anisotropy logs. The communication greatly reduced the effectiveness of the treatment. Limited swab testing after the treatment recovered water, but once again because of the communication it cannot be determined if the water is from the tested interval or the beds above or below the test interval, or all of them.

Test number 3

The third interval stimulated and tested was from 12,950 to 13,050 ft (3947.2-3977.6 m) log depth (Fig. 1C). The perforated interval 13,013 to 13,017 ft (3966.4-3967.6 m) has a water saturation ranging from 8 to 56% and the perforated interval 13,026 to 13,044 ft (3970.3-3975.8 m) has a water saturation range from 66 to 71% based on the TDT log. Although these two perforated intervals appear to be separate beds based on the gamma-ray log, the pre-treatment anisotropy log shows the beds communicate via fractures. Perforated intervals 12,994 to 12,996 ft (3960.6-3961.2 m) and 12,976 to 12,980 ft (3955.1-3956.3 m) have more than 80% water saturation and no fractures.

The interval was stimulated with 72 barrels (11,400 L) of HCL acid pumped at a maximum pressure of 8203 psi (57,000 kPa), an average pressure of 6000 psi (41,000 kPa), and at a maximum rate of 10 bpm (1,600 Lpm). A minor amount of communication occurred below the bridge plug. The communication is identified on the isotope tracer (tracer number 2) and the post-treatment anisotropy logs. The upper perforated intervals do not appear to have taken any acid. The tracer log shows that the perforated intervals 13,013 to 13,017 ft (3966.4-3967.6 m) and 13,026 to 13,044 ft (3970.3-3975.8 m) are in communication as indicated on the pre-treatment anisotropy log. Limited swab testing after the treatment recovered a minor amount of oil, gas, and water.

Test number 4

The fourth interval stimulated and tested was from 12,680 to 12,730 ft (3864.9-3880.1 m) log depth (Fig. 1D). The perforated intervals 12,700 to 12,706 ft (3870.9-3872.8 m); 12,710 to 12,712 ft (3874.0-3874.6 m); and 12,716 to 12,720 ft (3875.8-3877.1 m); are in a coarsing-upward sequence with the best developed fracturing (pre-treatment anisotropy log) and lowest water saturation (TDT [40 to 48%] log) near the top of the sequence. The lower portion of the sequence has water saturations ranging from 69 to 78%.

The interval was stimulated with 71 barrels (11,300 L) of HCL acid pumped at a maximum pressure of 7200 psi (49,600 kPa), an average pressure of 6700 psi (46,200 kPa), and at a maximum rate of 9.6 bpm (1,500 Lpm). The isotope tracer (tracer number 1) and post-treatment anisotropy logs show little to no communication above or below the test interval. Limited swab testing after the treatment recovered a minor amount of oil, gas, and water.

Fig. 1A-1D. Portions of the cased-hole logs ran in the Malnar Pike 1-17A1E demonstration well. Column A is a portion of the dipole shear anisotropy log ran before acid treatment. The greater the separation of the two lines (shaded in) the greater the density of fractures. Column B is a gamma-ray curve for correlation and bed identification. Column C is the anisotropy log ran after the acid treatments. Column D is from the isotope tracer log with the different tracers labeled 1, 2, and 3. The larger the curve, the more isotope left behind the casing, which helps determines where the acid went. The dual burst thermal decay time log (TDT) shows percent water saturation (Sw) in column E and column F diagrammatically shows oil (black) and water (white) in the pore volume of the rock.

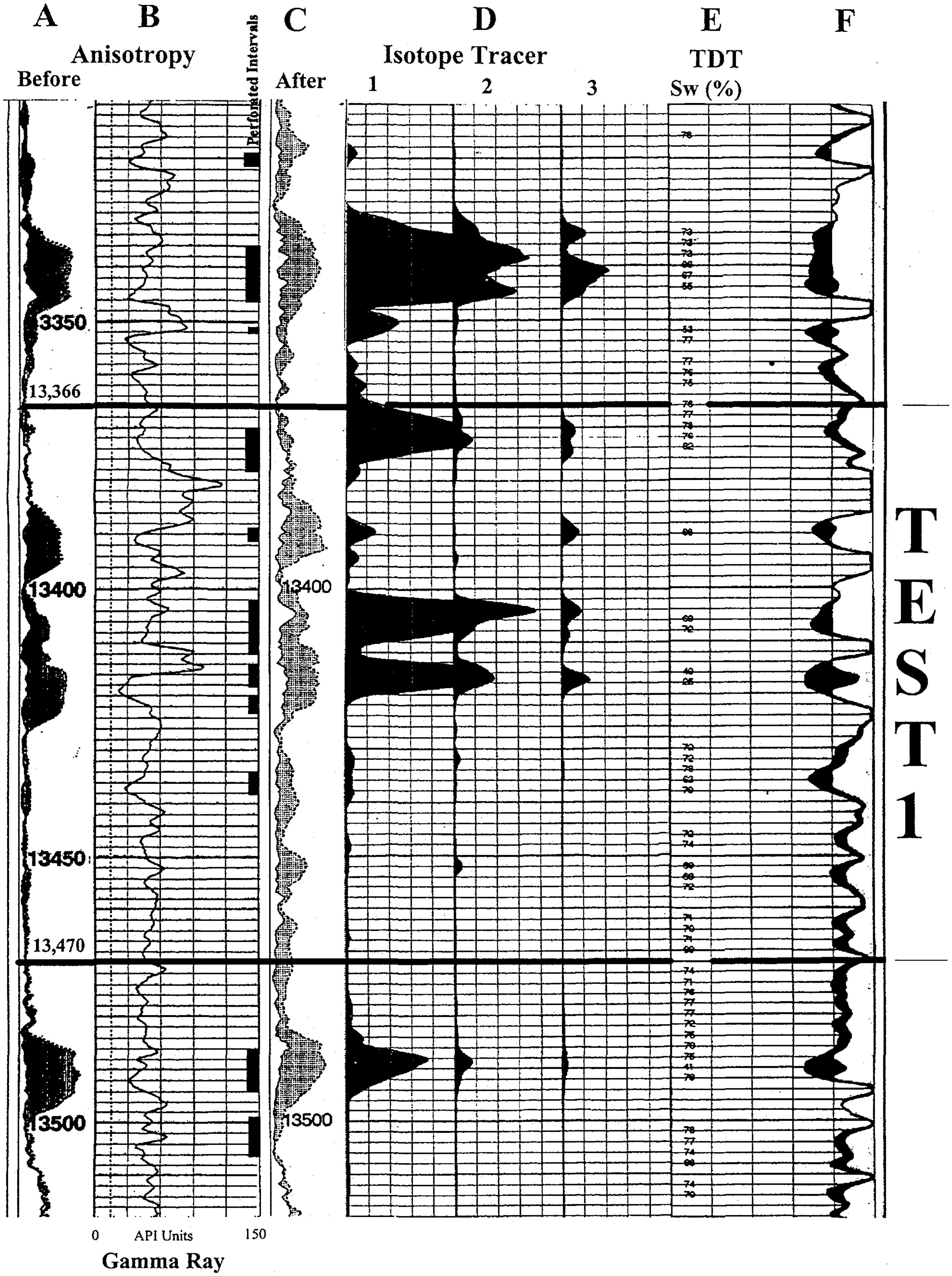
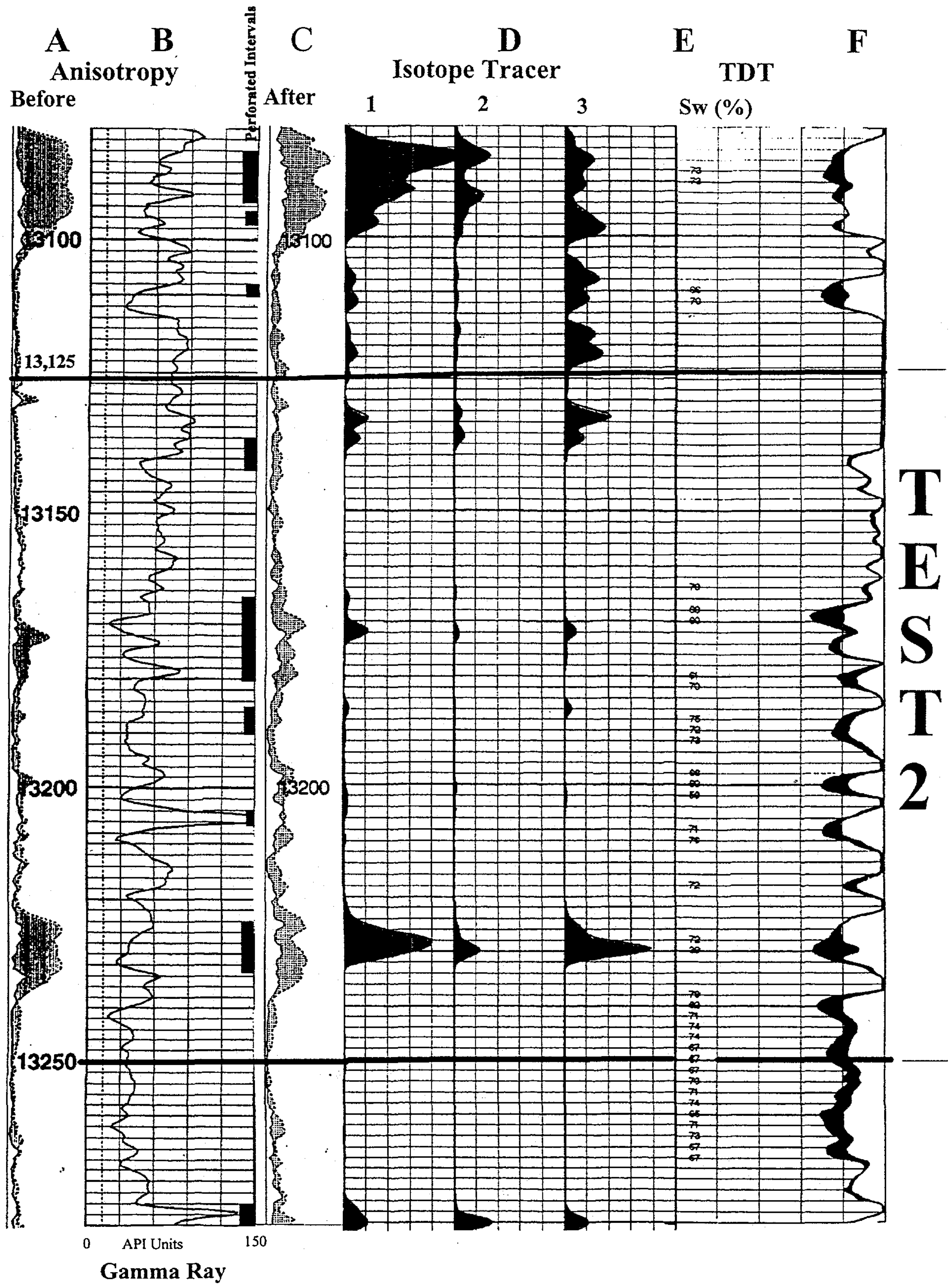

A
B
C
D
E
F
Anisotropy
Perforated Intervals
Isotope Tracer
TDT
Before
After
1
2
3
Sw (%)
13350
13,366
13400
13450
13,470
13500
T
E
S
T
1
0
API Units
150
Gamma Ray

Figure 1A.



A
B
Anisotropy
Before
Perforated Intervals
C
After
D
Isotope Tracer
1
2
3
E
TDT
Sw (%)
F
13100
13,125
13150
13200
13250
TEST 2
0
API Units
150
Gamma Ray

Figure 1B.

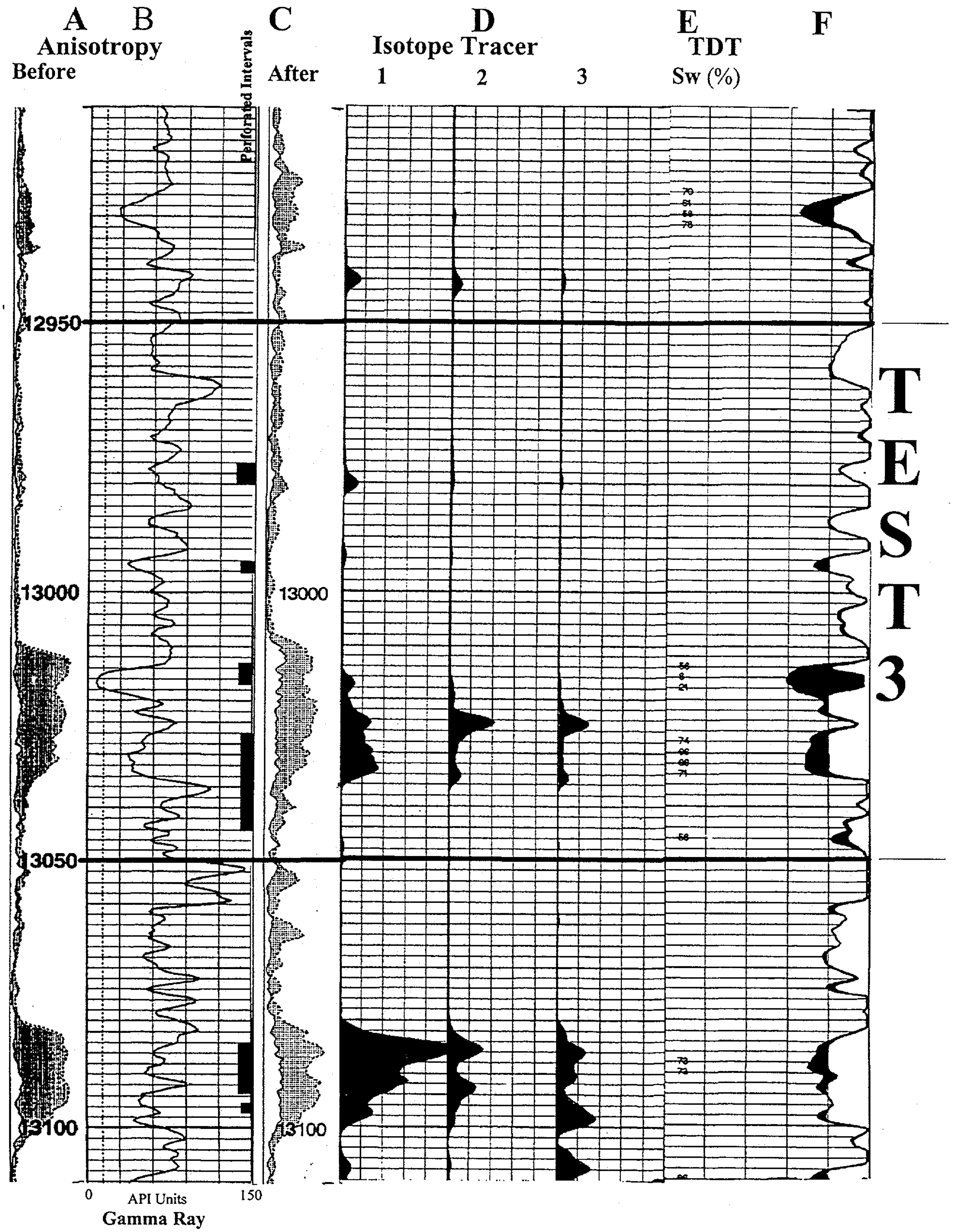

A B
Anisotropy
Before
Perforated Intervals
C
After
D
Isotope Tracer
1
2
3
E
TDT
Sw (%)
F
12950
13000
13050
13100
0
API Units
150
Gamma Ray
TEST 3

Figure 1C.

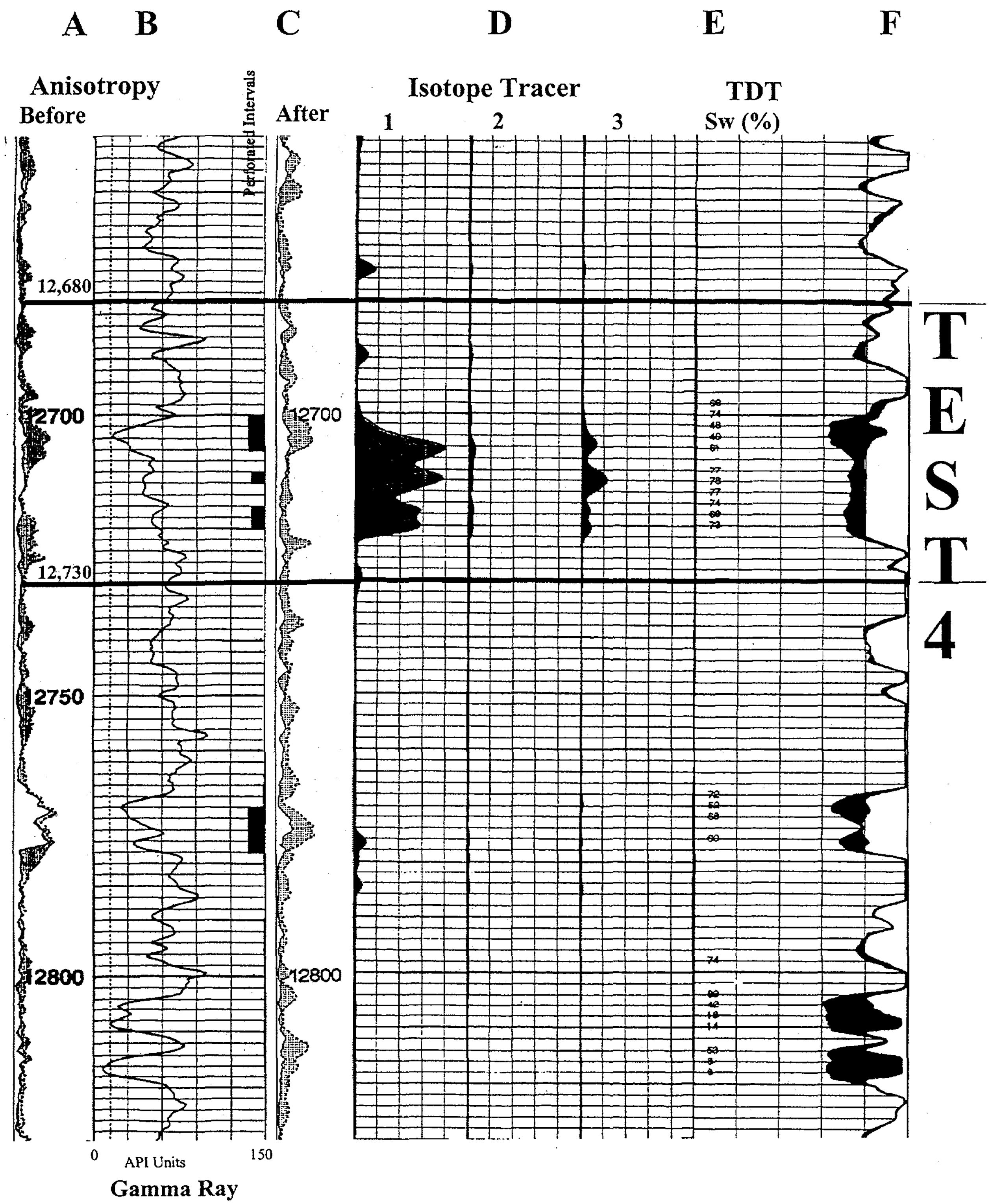

A
B
C
D
E
F
Anisotropy
Before
Perforated Intervals
After
Isotope Tracer
1
2
3
TDT
Sw (%)
12,680
12700
12,730
2750
12800
TEST 4
0
API Units
150
Gamma Ray

Figure 1D.

Preliminary production results

A bridge plug was placed at a depth of 13,060 ft (3980.7 m), above the first and second intervals that tested water. The daily oil-production rate has increased (Fig. 2) as a result of the treatment of the third and fourth intervals, but the well has not produced long enough to develop a stabilized rate.

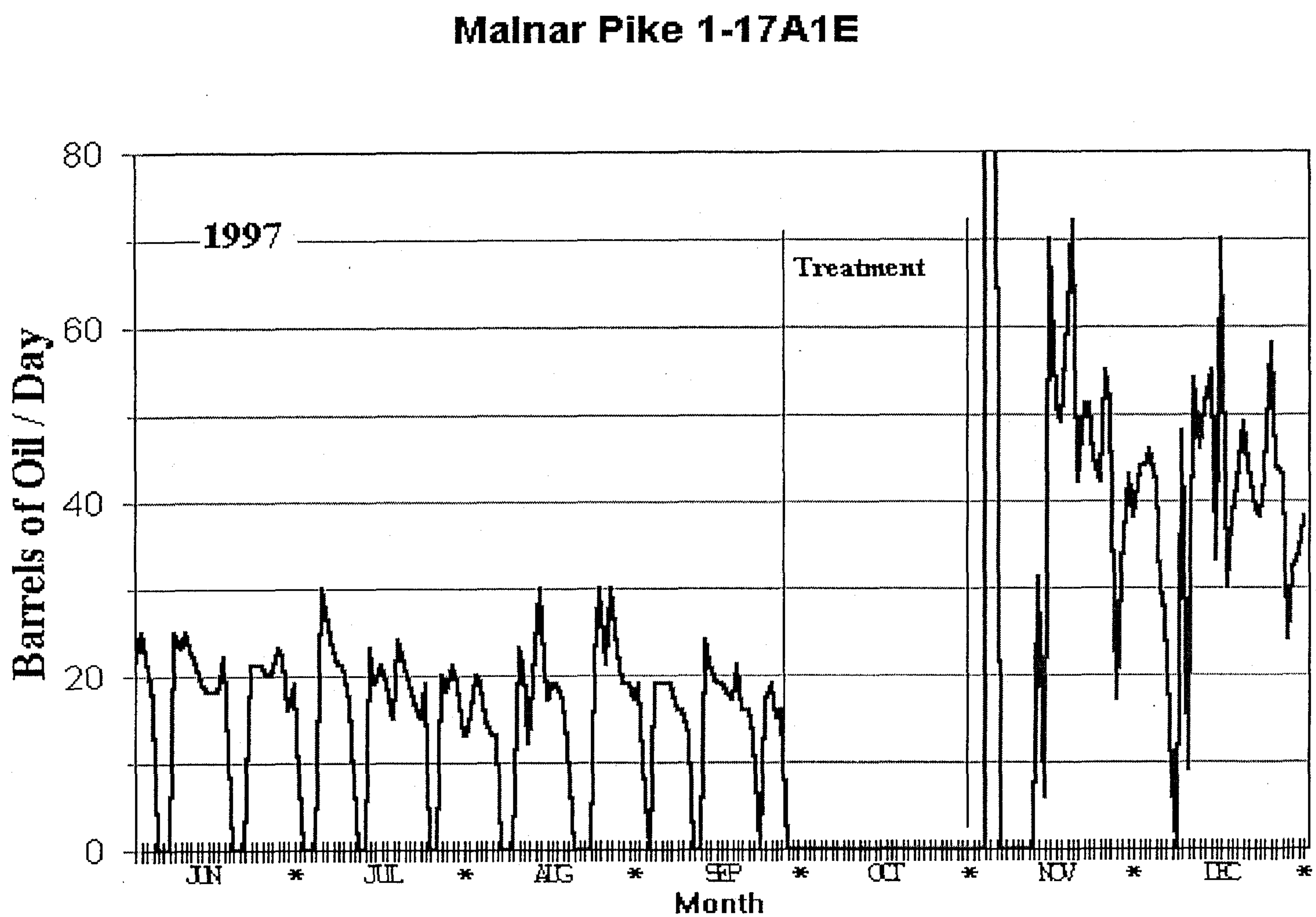


Fig. 2. Daily oil production from the Malnar Pike 1-17A1E demonstration well four months before and two months after the acid stimulation.

Conclusions and recommendations

Communication above and below the test intervals was a major problem. The Malnar Pike well has numerous perforations that have been acidized several times, increasing the potential for communication behind the casing. It is very likely that conventional acid treatments (typically a 500 to 1500 ft [150-460 m] interval) of older wells in the Bluebell field experience a similar problem. Much of the acid may be moving vertically through the cement and not into the formation.

Test results generally confirmed the interpretation of the anisotropy and TDT logs. Beds with fractures indicated in the anisotropy log generally took most of the acid while beds without fractures took little to no acid. The low treating pressure (about 7000 psi [48,000 kPa] versus the normal treating pressure of 10,000 psi [69,000 kPa]) was not high enough to hydraulically induce new fractures.

To effectively use this completion technique on wells in the Bluebell field, based on the experience of the Malnar Pike demonstration, we recommendation the following:

1. set both the packer and bridge plug between perforated intervals that are at least 50 ft (15 m) apart to reduce the risk of communication,
2. use the anisotropy and TDT logs and select beds that are fractured and have relatively low water saturation and,
3. use a treating pressure high enough to fracture the formation, especially if the anisotropy log indicates that some of the beds being treated do not have fractures.

Technology Transfer

The Utah Geological Survey maintains a Bluebell home 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, Second, and Third, 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, (8) daily activity reports of the Michelle Ute 7-1 and Malnar Pike 1-17A1E demonstration work and, (9) Abstracts prepared for the DOE/PTTC workshop on advanced logging techniques in Denver, CO. (Jan. 98) and, AAPG Annual Convention in Salt Lake City, UT (May 98). The home page address is ***http://www.ugs.state.ut.us/bluebell.htm***.