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TITLE: ECONOMIC RECOVERY OF OIL TRAPPED AT FAN MARGINS USING HIGH ANGLE WELLS AND MULTIPLE HYDRAULIC FRACTURES

Cooperative Agreement No.: DE-FC22-95BC14940

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Objective

This project attempts to demonstrate the effectiveness of exploiting thin-layered, low-energy deposits at the distal margin of a prograding turbidite complex through the use of hydraulically fractured horizontal or high-angle wells. The combination of a horizontal or high-angle well and hydraulic fracturing will allow greater pay exposure than can be achieved with conventional vertical wells while maintaining vertical communication between thin interbedded layers and the wellbore.

A high-angle well will be drilled in the fan-margin portion of a slope-basin clastic reservoir and will be completed with multiple hydraulic-fracture treatments. Geologic modeling, reservoir characterization, and fine-grid reservoir simulation will be used to

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select the well location and orientation. Design parameters for the hydraulic-fracture treatments will be determined, in part, by fracturing an existing test well. Fracture azimuth will be predicted by passive seismic monitoring of a fracture-stimulation treatment in the test well using logging tools in an offset well.

Summary of Technical Progress

The long radius, near horizontal well has been drilled. Well conditions dictated that a 5 in. production liner, in addition to the originally-planned 7 in. production liner, were necessary to case the target formation.

Swept-out sand intervals and a poor cement bond behind the 5 in. liner precluded two of the three originally planned hydraulic fracture treatments. All pay intervals behind the 5 in. liner were therefore perforated and stimulated with a non-acid reactive fluid.

Following a short production period, the remaining pay intervals in the well, behind the 7 in. liner, were then perforated. The well was returned to production to observe production trends and pressure behavior prior to stimulation of the newer perforations.

Completion Operations

Production Performance

Yowlumne Unit B 91X-3 was originally completed by perforating all pay intervals behind the 5 in. production liner. This primarily included Sand C and a small interval at the base of Sand B (Fig. 1). The perforations were then stimulated with a non-acid reactive fluid consisting of a blend of KCl water, iron chelating agents, mutual solvents, and surfactants.

The initial production rate was 220 BOPD and 20 BWPD. However, in less than two and one-half months oil production had declined to 160 BOPD, and water cut had increased to 35% (Fig. 2). The gas-oil ratio (GOR) remained fairly constant at 450 SCF gas per STB oil.

Additional Wellwork

Because of production decline, additional pay intervals were perforated. This represented Sands A and B, behind the 7 in. production liner (Fig. 1).

The well was returned to production without stimulation. The initial production rate was approximately 230 BOPD. However, after a month and a half the well had declined to 160 BOPD, same as the pre-wellwork rate (Fig. 2).

The producing water cut of 43% is slightly higher than before. The biggest change though was the GOR, which increased from 450 SCF/STB to 1200 SCF/STB.

Future Plans

The new perforations will be stimulated with a similar non-acid system as that used on the original perfs. The well will be returned to production for a clean up period and to observe production trends and pressure behavior.

A hydraulic fracture treatment will then be designed for Sands A and B (through the new perfs in the 7 in. production liner).

Technology Transfer

Dr. Mike Clark gave a talk with abstract on the reservoir characterization aspect of this project on November 11, 1997 at the Pacific Coast Oil Show in Bakersfield, California.

Figure 1. Actual well path relative to major Yowlumne sand intervals. Also shown are existing perforated intervals.