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

Contract DE-FC22-92BC14953

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DISCLAIMER

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

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Utah Geological Survey (UGS)
Salt Lake City, Utah

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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 and 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

Introduction

July 1 - September 30 was the final quarter of the geologic and reservoir characterization phase of the project. The quarter was spent synthesizing the individual tasks into a set of final recommendations and designing an oil field program to demonstrate the various aspects of the study. The demonstration consists of three parts: (1) recomplete several zones in the Michelle Ute well, (2) redrill and stimulate a few select beds in the Malnar Pike well, and (3) select a location, drill, and complete a new well. The demonstration includes both improved reservoir evaluation and stimulation techniques.

Characterization Study

Characterization of outcrop and core shows the best potential reservoir rock type in the Green River and Wasatch Formations is arenite. Intergranular permeability of $>$ 0.1 mD occurs only when clay content is 4% or less and intergranular porosity is $>$ 5%. Total gamma-ray count, which is generally logged in most wells, is a poor indicator of clay content. Uranium content, which contributes to the total gamma ray count, varies independently of clay content. Clay content is generally less in the Wasatch Formation than in the Green River Formation.

Examination of core from the Bluebell field shows that all potential reservoir rock types are moderately fractured, and that fracture density is not depth related. Two approximately orthogonal fracture sets (NW-SE and W-E) are present at the surface but in the subsurface, fractures tend to be oriented NW-SE at shallow depths and W-E at deeper horizons. Most fractures in the Bluebell cores are 90% or more calcite filled.

Homogeneous reservoir simulation models of the Michelle Ute and Malnar Pike wells show that the wells only drain a 400-foot (120-m) radius. Even in the 400-foot (120-m) radius area, the remaining oil saturations are fairly high. The pressure influence of a well is also felt over a similar distance. In the Michelle Ute and Malnar Pike wells, additional beds were perforated during a period of years following the initial completion. In both wells the first set of perforations accounted for most of the oil produced. In the models, low absolute permeabilities were used to match the production history. It was necessary to use progressively lower permeabilities as new beds were perforated in both wells in order to match the histories. The low permeabilities employed in the history match indicate that: (1) even though there is a great deal of oil still in the reservoir, unless the permeabilities are artificially enhanced, it is not producible at economic rates and (2) the new zones perforated have lower permeabilities than initially opened zones. It may be that formation damage continues behind pipe, in unperforated zones, so that when they are eventually opened these zones do not produce as well as the

initially opened zones or, the stimulation treatments are less effective as more beds are added.

Single-well reservoir simulations were also performed using dual-porosity, dual-permeability fractured models. These fractured reservoir models show that the radius of influence of the well on the reservoir is about 1000 feet (300 m). Most wells in the Bluebell field are drilled at one well per section, therefore little of the oil-in-place is currently being drained.

Even state-of-the-art reservoir engineering techniques do not permit reliable identification of individual beds or facies that are significant oil producers. Drill-stem test data, water analyses, and core and fracture data, provide limited data. Even more critical is the total lack of any production history of individual beds. Based on criteria derived from the characterization study, various bed parameters (clay content, bed thickness, porosity, saturation, oil volume, and drilling shows) have been evaluated, mapped, and volumetric calculations and reservoir simulations done in the study area. The evaluation is a better characterization of the reservoirs than previously done. This evaluation will be compared to the actual results from the demonstration wells to quantify the reliability of the various individual bed parameters and the overall comprehensive analysis.

Data were gathered on 246 stimulation treatments conducted within the Bluebell field. The data were evaluated by the Halliburton Energy Services Tech Team in Denver, Colorado, and Vernal, Utah. The evaluation has resulted in specific recommendations for the fluids, additives, volumes, and rates for the stimulation treatments to be used in the demonstration wells.

Recent work by Coastal Oil and Gas Corporation (ANR Production) in neighboring Altamont field has shown that poor diversion during a stimulation treatment can result in the stimulation fluids going into only one or two highly permeable (intensely fractured?) intervals. Large increases in the amount of diversion material has improved the number of beds they are able to stimulate. Coastal's results indicate that original pressure zones in the well may partially control where treatment fluid goes.

Proposed Demonstration

A three-part demonstration is recommended to show how oil recovery can be improved from old and new wells in the Bluebell field: (1) recomplete the Michelle Ute well, (2) recomplete the Malnar Pike well, and (3) drill and complete a new well. The three-part demonstration will employ the results of the characterization study and analysis of individual beds in the Michelle Ute, Malnar Pike, and neighboring wells. Each part of the demonstration is designed to allow detailed documentation of success or failure of each aspect of the characterization and stimulation techniques.

Michelle Ute Well: The first part of the demonstration will be to recomplete the Michelle Ute well by stimulating individual pressure zones (each about 500 feet [150 m] thick) using a high-diversion, low-friction treatment.

Volumetric calculations and reservoir simulations show the Michelle Ute well has much less oil-in-place per individual bed than the Malnar Pike well. Therefore, we anticipate many more beds will need to be stimulated in the Michelle Ute well for the treatment to be economical.

Using drilling mud data, several pressure zones were identified in the Michelle Ute well. The top of a pressure zone is defined by a drilling "kick", requiring an increase in mud weight. Pulsed neutron decay and dipole sonic logs will be run before treatment to further evaluate remaining oil saturations and determine which beds currently have open fractures. Each pressure zone will be stimulated separately, and each will contain a different radioactive tracer. After all zones have been stimulated and the well is cleaned, tracer, temperature, spinner, and dipole sonic logs will be run. The logs will quantify how well the treatment fluids were dispersed, which beds are producing and how much, and how many beds had fractures opened or induced by the treatment. The results will be compared to the original formation evaluations and the beds in the Malnar Pike well will be re-evaluated.

Malnar Pike Well: The second part of the demonstration will be to horizontally drill 10 feet (3 m) directionally into three or more key beds in the Malnar Pike well. Pulsed neutron decay and dipole sonic logs will be run in the Malnar Pike well if they are shown to be effective in the Michelle Ute well. Cased-hole logs will be used with the revised formation evaluations to help select individual beds for stimulation. Three or more beds will be drilled horizontally for a distance of up to 10 feet (3 m) using an extended-reach hydro-jet lance tool. The beds will be isolated and individually stimulated using a pinpoint injection tool. After the well has been stimulated and cleaned, temperature and spinner logs will be run to determine the contribution each bed is making to the production of the well. The results will be compared to the formation evaluations made before treatment. The formation evaluation parameters proven to be the most reliable in the Michelle Ute and Malnar Pike wells will be determined.

New Well: The third part of the demonstration will be to select a location and drill, evaluate, perforate, and stimulate a new well based on the knowledge gained from the characterization study and results of the first two parts of the demonstration.

The oil-producing beds identified in Michelle Ute and Malnar Pike wells will be correlated and mapped. These data will be used to help select a location for a new well. Formation evaluation, selection of perforated intervals, and type of stimulation in the new well will be based on the experience gained from the Michelle Ute and Malnar Pike demonstrations.

Benefits and Value

Michelle Ute and Malnar Pike wells are barely economic given production amount and current petroleum prices. Recompletions have been attempted in both of these wells with little success. Improved recompletion techniques will increase the total recovery and prevent premature abandonment of Michelle Ute, Malnar Pike, and many other wells in the Uinta Basin. The Bluebell field encompasses 249 sections (square miles). There are 33 sections within the field boundary that have

never been drilled, and 123 sections that have only one well per section. Demonstration of an improved completion technique, increasing primary recovery, will make additional development drilling much more economically appealing.

The low recovery in older wells and the possibility for hundreds of additional development wells gives Bluebell field and the Uinta Basin a potential that could be in the hundreds of million barrels of oil. But even a more conservative 5 to 10 percent incremental increase in recovery could result in tens of millions of barrels from the Bluebell field. After the demonstrations have been completed and evaluated the financial benefit resulting from the project will be more accurately determined.