An Advanced Fracture Characterization and Well Path Navigation System for Effective Re-Development and Enhancement of Ultimate Recovery from the Complex Monterey Reservoir of South Ellwood Field, Offshore California

Quarterly Technical Progress Report

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Progress Report January 1, 2004- March 31, 2004

Disclaimer

Abstract

Venoco Inc, intends to re-develop the Monterey Formation, a Class III basin reservoir, at South Ellwood Field, Offshore Santa Barbara, California.

Well productivity in this field varies significantly. Cumulative Monterey production for individual wells has ranged from 260 STB to 8,700,000 STB. Productivity is primarily affected by how well the well path connects with the local fracture system and the degree of aquifer support. Cumulative oil recovery to date is a small percentage of the original oil in place. To embark upon successful re-development and to optimize reservoir management, Venoco intends to investigate, map and characterize field fracture patterns and the reservoir conduit system. State of the art borehole imaging technologies including FMI, dipole sonic and cross-well seismic, interference tests and production logs will be employed to characterize fractures and micro faults. These data along with the existing database will be used for construction of a novel geologic model of the fracture network. Development of an innovative fracture network reservoir simulator is proposed to monitor and manage the aquifer's role in pressure maintenance and water production. The new fracture simulation model will be used for both planning optimal paths for new wells and improving ultimate recovery.

In the second phase of this project, the model will be used for the design of a pilot program for downhole water re-injection into the aquifer simultaneously with oil production. Downhole water separation units attached to electric submersible pumps will be used to minimize surface fluid handling thereby improving recoveries per well and field economics while maintaining aquifer support.

In cooperation with the DOE, results of the field studies as well as the new models developed and the fracture database will be shared with other operators. Numerous fields producing from the Monterey and analogous fractured reservoirs both onshore and offshore will benefit from the methodologies developed in this project.

This report presents a summary of all technical work conducted during the second quarter of Budget Period II.

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Introduction

The Field Demonstration site for this Class III (basin clastic) Program Proposal is the South Ellwood Field located offshore California. The Monterey Formation is the main producing unit in the South Ellwood Field and consists of fractured chert, porcelanite, dolomite, and siliceous limestone interbedded with organic mudstone. This reservoir has an average thickness of 1,000 feet, and lies at subsea depths of approximately -3,500' to -5,000'.

Venoco and USC jointly submitted an application to conduct a DOE co-operative investigation of the Monterey formation at South Ellwood in June 2000. The DOE granted this application in July 2000.

Executive Summary

Venoco and USC prepared a proposal for a DOE sponsored joint investigation of the fractured Monterey formation. It was agreed that Venoco would construct the geologic model for the field and gather new reservoir data as appropriate. USC would then develop a simulation model that would be used to optimize future hydrocarbon recovery. Joint Venoco-USC teams were established to manage the flow of data and insure that Venoco and USC activities remained synchronized. A co-operative agreement was signed with the DOE on July 31, 2000.

During Budget period I, Venoco worked with USC to develop a new geological and engineering model of the Monterey formation. This cooperative work between USC and Venoco has made several contributions to the tech transfer goal of the U.S. Department of Energy. The most significant of these were; the development of an interactive database on the Monterey Formation, a new simulation algorithm for the description of fracture-controlled Monterey Reservoirs, a pattern recognition method for analysis of well log data and methods for subsurface control of high water production. USC no longer participates in the project after the conclusion of Budget Period I activities.

The primary goal of the Budget Period II is to develop the new fault blocks identified as a result of the field re-evaluation conducted during Budget Period I. Most prominently, the large North Flank block running parallel and to the north to the main field area was determined to be probably oil bearing. This fault block lies in a bad seismic data area. The old 3D data was reprocessed to enhance the data quality in this area and refine this prospect. The North Flank prospect is now being prepared for drilling during 2004.

Experimental

Not applicable for the work performed.

Results and Discussion

Task II – New Data

Pressure gradient surveys were conducted on wells 3120-16, 3242-9, 3242-12 and 3242-16 for the purpose of gas lift optimization.

Task IV-1—Produced Water Re-Injection

No Activity.

Task IV-2—Downhole Water Separation ESP's

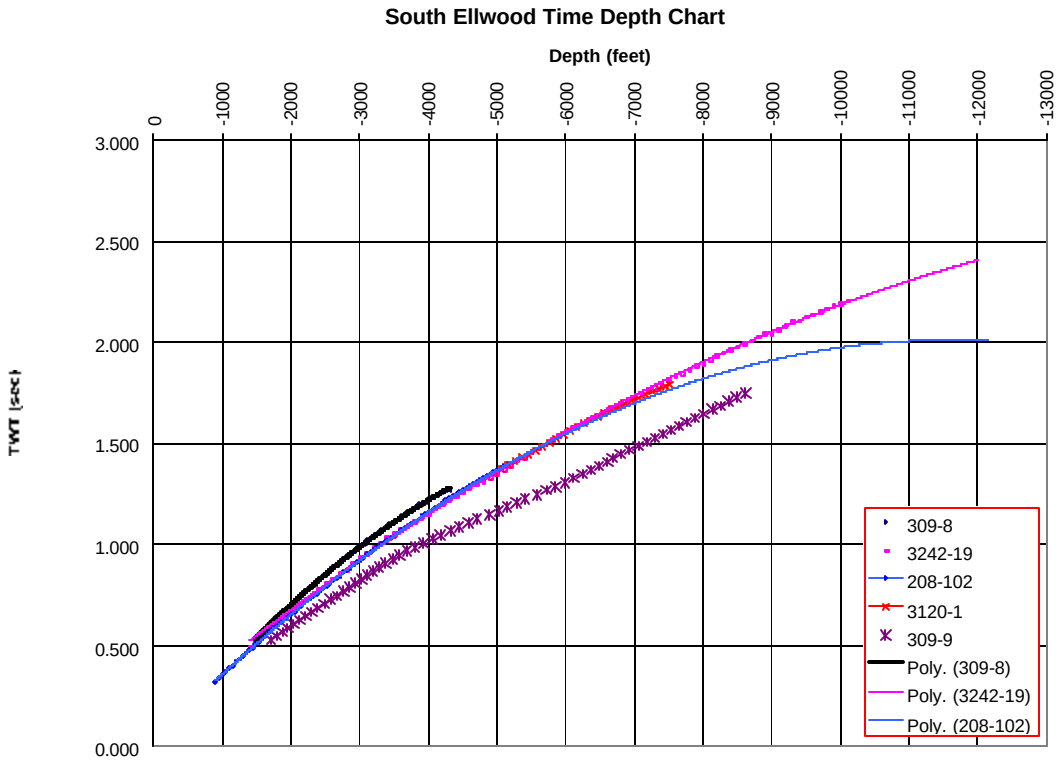
No Activity.

Task IV-3—Development of New Fault Blocks

South Ellwood 3D seismic re-processing

A major effort this quarter was to complete the interpretation of the re-processed 3D seismic survey. The new interpretation resulted in improved locations and orientations of numerous faults, and the top and base of the Monterey Formation and several shallower and deeper horizons. In addition several faults which were imaged very poorly or not at all in the earlier processing can now be mapped with the pre-stack time migration processing. The horizon and fault surfaces have been converted from seismic two-way travel time to depth using velocity functions developed from velocity check shot surveys in the State 208 #102, State 3242 #19, and State 309 #8 wells. Sonic logs from the State 3120 #1, and the State 309 #9 wells were converted to travel time curves and used to improve the velocity model and the interpretation. The velocities along the crest of the structure are fairly consistent (Figure 1). However, the velocity at the State 309 #9 well is a bit faster because it drilled through an up thrusted block.

Figure 1. Two-way travel time vs depth for wells at South Ellwood Field.



In order to improve the structural interpretation along the northern margin of the field we have also resorted to mapping with 1983 vintage 2D seismic surveys which extend further north than the 3D survey. These were re-examined in light of the newly re-processed 3D survey. The data are of poor quality but were still useful for mapping surface faults and fold traces. This work helped fill the gap between the field area and the coastal outcrops and revealed several faults and folds which aided in the interpretation of the structual picture around the north and western areas of the field.

Core Analysis

We have also been continuing our work on the reservoir properties of the Monterey formation. Samples from core numbers 3 and 4 from State 309 #9 well were recovered from the University of Texas core repository in Houston and sent out for X-ray diffraction analysis. This analysis is used to determine whether the silica phase of the Monterey rocks are in the opal A (amorphous silica), opal-crystobalite, or quartz phase. Monterey reservoir quality is greatest in the quartz phase. Results from this analysis show that the Monterey Formation in the State 309 #9 well is entirely in the quartz phase up to the highest sample available (Zone 3). Perhaps more significantly, no opal CT was observed. The South Ellwood field Monterey rocks lie within the transition from opal CT to quartz and typically have some opal CT even among the rocks largely in the quartz phase. This suggests that this area which is now relatively shallow was once buried much deeper and was originally the source rock for the South Ellwood field. It also indicates that the north flank of the field is most likely entirely in the quartz phase and of the best reservoir quality of the Monterey Formation.

Table 1 X-Ray Diffraction Data from 309-9

	Whole Rock Mineralogy (Weight %)									
Depth	Quartz	K-Feld	Plagio	Calcite	Dolomite	Pyrite	Fluorapatite	Gyps	Clay	Quartz Cryst I
4303	97	Tr	Tr	2	Tr	Tr	0	0	1	1.39
4306	67	Tr	1	28	Tr	1	0	0	3	2.43
4310	10	Tr	Tr	1	85	1	0	0	3	n/a
4321	55	1	1	29	1	2	0	0	11	2.68
4323	62	3	3	10	1	5	6	0	10	2.85
4617	71	1	1	19	Tr	2	0	0	6	1.81

Tr = Trace (<0.5%)

Task V- Project Management

Project review meetings were held on a monthly basis in Carpinteria. Individuals working on the project during this quarter included:

Reservoir Studies:
Steve Horner

Geological/Geophysical Modeling
Marc Kamerling

Project Management:
Steve Horner

Task VI-Technology Transfer

No Activity

Conclusions:

This is the second quarterly technical report for Budget Period II. Using the new seismic reprocessing, we are continuing to develop the first location for a new fault block appraisal well.

References

Isaacs, C.M.; Guide to the Monterey Formation in the California Coastal Area, Ventura to San Luis Obispo, Pacific Section American Assoc. Petr. Geologists, Vol 52, 91 p