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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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 twelfth quarter of Budget Period I.

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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.

This cooperative work between the research team at USC and the operational engineers and geoscientist at Venoco has generated new insight into the evaluation methods for the Monterey Formation and has resulted in the formulation of new approaches to describe reservoir dynamics and to simulate reservoir performance for forecasting purposes. The project has made several contributions to the tech transfer goal of the U.S. Department of Energy. The most prominent of these are; the development of an interactive database on the Monterey Formation, a conceptual model 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.

A primary goal of the Budget Period I activities was to prepare a detailed fracture model for the Monterey at South Ellwood. As we have seen from our examination of outcrop data and image logs, the proximity to both large scale and minor faults controls the development and orientation of fractures in the Monterey. A comprehensive review of all seismic, dipmeter and well log data was conducted during the Quarter and has helped us identify most of the significant faults at South Ellwood. This data is being used to create a new geologic model of the Monterey in GoCad.

Experimental

Not applicable for the work performed.

Results and Discussion

Task I- Database

We began a comprehensive update of the DOE Website during the quarter. We plan to replace out of date images and maps and have an updated database available for the next PTTC meeting.

Task II- New Data

No new data this Quarter.

Task III- Basic Reservoir Studies

Geologic Model

We have begun the process of creating a new geologic model for South Ellwood. Previous outcrop studies by Luyendyk and Eichhubl plus examination of the oriented core from 3242-19 and the image logs from 208-102 and 3242-7-2 have demonstrated the importance of small scale faults in controlling fracture development. During the Quarter we reviewed the picks of the stratigraphic markers for all subzones in both the Holly platform and exploration wells. Using stratigraphic sections through the field we were able to defining missing and repeated sections in the Siquoc and Monterey formations. Then using dipmeter, image log and the re-processed 3D seismic data we were able to define a series of normal and reverse faults that caused this disruption. We are presently creating a new geologic model in GoCad using this fault model as the framework.

Task IV--Stimulation

No Activity

Task V- Project Management

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

Database:
I. Ershaghi (USC) and Tim Rathmann (Venoco)

Reservoir Studies:
I. Ershaghi (USC) and Steve Horner (Venoco).

Geological Modeling
Marc Kamerling (Venoco)

Geophysical Modeling
Karen Christensen (Venoco)

Project Management:
Steve Horner (Venoco) and I. Ershaghi (USC)

Task VI-Technology Transfer

We gave the following presentations at the AAPG/SPE meeting in Long Beach California during May 2003.

Fluid Conductivity in the South Ellwood Fault – Boles J. and Horner S.
The Monterey Formation at South Ellwood – Kamerling M. and Horner S.
Estimation of Microfracture Support from Analysis of Production data – Heidari M and Ershaghi

Conclusions:

We have completed all of the major tasks assigned to budget period I. We continue to prepare a new geologic and reservoir simulation model based on the data developed during this budget period. This model will be used for selecting wells for recompletion, water injection or sidetracking during Budget Period II.

References

Luyendyk, B.P. and J. S. Hornafius, Neogene crustal rotations,
fault slip, and basin development in southern California, , Rubey Volume IV, edited by R.V. Ingersol and W.G. Earnst, Prentis Hall, New Jersey, 1987, pp 259-283.

Eichhubl, P. and R.J. Behl, Diagenesis, deformation, and fluid flow in the Miocene Monterey formation.

Shaw and Suppe, Faulting and folding in the Santa Barbara Channel, GSA Bull., May 94, p.610-625