

**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 March 1, 2004- June 30, 2004**

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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 third 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 of 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 the fourth quarter of 2004.

## **Experimental**

Not applicable for the work performed.

## **Results and Discussion**

### **Task II – New Data**

A pressure build-up survey was conducted on 3242-12 during a platform shutdown in May 2004. The Monterey reservoir pressure at the datum was determined to be 1324 psia.

#### **Task IV-1—Produced Water Re-Injection**

The Holly separators were designed for three phase operation but they currently operate in two phase mode, separating produced gas for shipment to Ellwood via the 6" gas line. During the quarter, we commissioned a study of the three phase separation capacity of the two Holly production separators. This study showed that the production separators can be reconfigured at minimal cost to separate up to 40,000 BFPD at Holly. We intend to complete these modifications by year end 2004 and expect to separate more than 90% of the produced water from the Monterey at Holly. This water will be re-injected into the Monterey in wells 3120-10 and 3242-8-4. On the basis of the simulation model prepared by USC, this produced water re-injection will add as much 6 MMBO to the Monterey ultimate recovery by partially arresting the pressure decline.

Since final oil polishing will be conducted at Ellwood, we plan to ship produced water back to Holly for re-injection. We will be using the 4" fuel gas line to ship this produced water from Ellwood to Holly. This line is normally used to supply utility grade fuel gas to the light the flare pilot. Since several Holly wells produce sweet gas from the Sisquoc formation up the annulus, we plan to collect this gas and send it to the flare pilot. The Santa Barbara Air Pollution Control District requires that this gas be scrubbed to meet utility gas specifications. We are constructing a gas scrubber to remove the slight amount of hydrogen sulfide present in this gas. We expect to have this system in place by the third quarter of 2004. We have also installed a MicroMotion meter on the Holly test separator. This meter has no moving parts yet it accurately determines the liquid flow rate and water for the well in test. This data will be used to optimize gas lift rates and monitor the performance of the water injection project.

#### **Task IV-2—Downhole Water Separation ESP's**

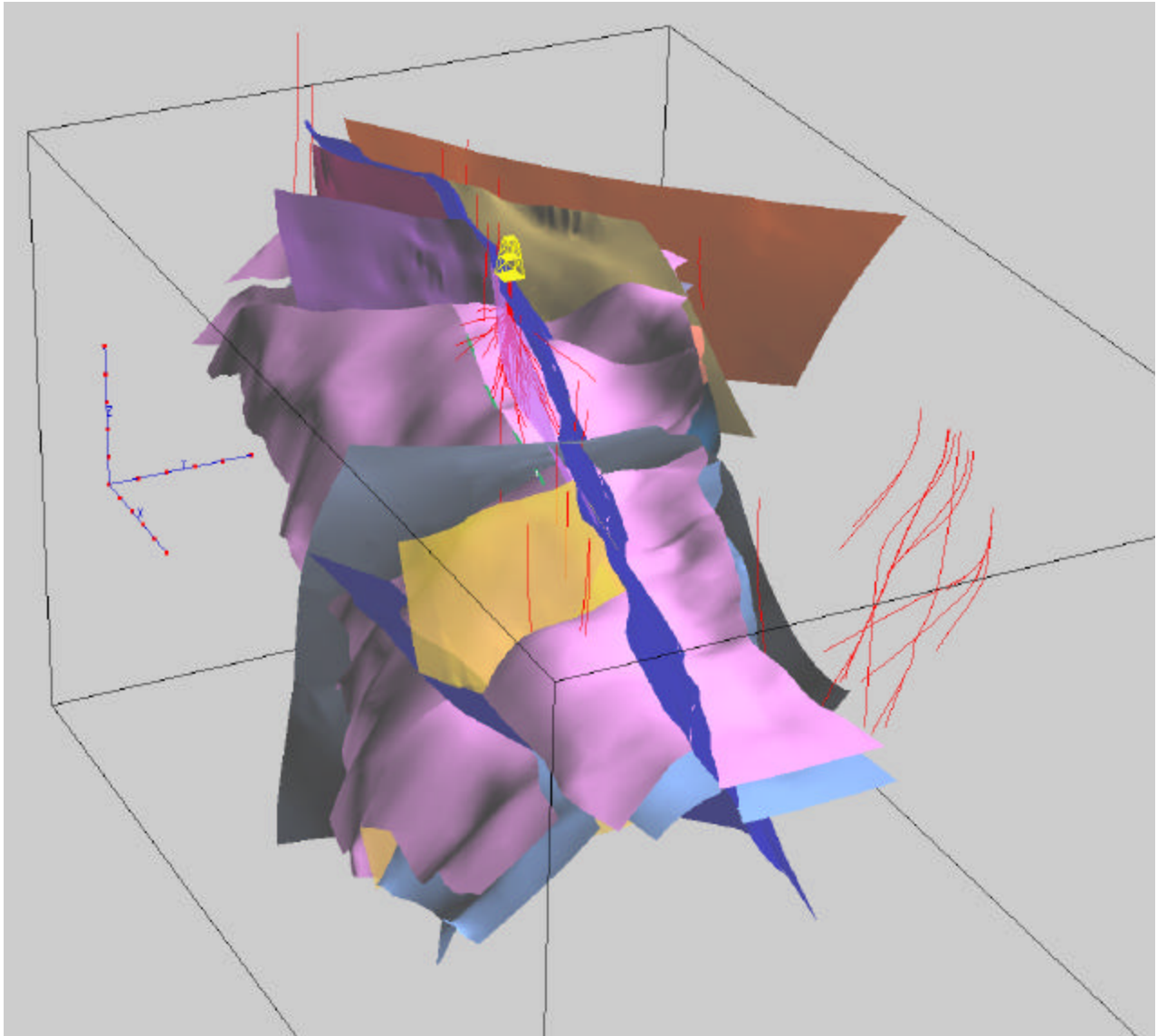
No Activity.

#### **Task IV-3—Development of New Fault Blocks**

##### **South Ellwood 3D seismic re-processing**

The major effort this past quarter has been to incorporate the structural interpretation from the re-processed seismic data and additional well data interpretation into the new 3D reservoir simulation model. This process involves creating a 3-dimensional structural model in GOCAD and converting this structural model into a 3-dimensional cellular grid suitable for import into the reservoir simulation software. The new and revised faults and stratigraphic horizons interpreted from the pre-stack time migration 3D seismic volume were exported as time surfaces. These surfaces in two-way travel time were then converted to depth using the velocity data discussed in the last quarterly report. Fault surfaces were then compared to faults observed in the wells that had been loaded into the 3D model. Being able to view the fault surfaces interpreted from the seismic reflection software and the faults interpreted from the well data in 3 dimensions greatly improves the interpretation process. This is typically an iterative process. Fault cuts in the wells posted in the seismic reflection software are used to identify important faults and map them. Often fault cuts in the wells could be assigned to a particular fault by comparing the fault cuts to fault surfaces in the 3D model. Minor adjustments could be made to the fault surfaces generated from the seismic reflection data so that they matched the faults identified in the wells. This helps to correct for local velocity variations. The top and base of the Monterey formation were also re-

mapped using the re-processed seismic reflection data. These were exported as surfaces in two-way travel time, converted to depth, and imported into the 3D software. Construction of 3D geologic model is underway with particular emphasis on defining structural control in the North flank block. The following plot shows a screen capture of the current model in GOCAD.



### **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, Chris Knight

#### **Project Management:**

Steve Horner

## **Task VI-Technology Transfer**

Presented the following paper at the May Pacific Section AAPG Meeting in Bakerfield:  
Enhancing Structural Interpretation with Borehole Stress Data from Dipole Sonic, Steve Grayson, Marc Kamerling and Lee Swager

### **Conclusions:**

This is the third 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. We have begun design work to separate and re-inject all produced water back into the Monterey at Holly. These two projects could add more 35 MMB of reserves to South Ellwood field.

### **References**

SPE 38786 A New Method in Calculating Water Cut and Oil and Water Volumes Using Coriolis Meter, Al-Mubarak, A.M. 1997