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

Reporting Period Start Date: **July 1, 2003**

Reporting Period End Date: **September 30, 2003**

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Progress Report July 1, 2003- September 30, 2003

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 final 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 was 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 completed a comprehensive update of the DOE Website during the quarter.

Task II- New Data

3242-12 Through Tubing Plugback

Based on a production log run during 2001, a through tubing plug had been set in 3242-12 during February 2002. This plug had been set in the middle of the M6A perforations and had no detectable effect on the production from the well. Production from the M6A appeared to be bypassing the bridge plug due to poor cement or through the extensive M6 fracture system. A second bridge plug was set on August 10th 2003, at 6450' between the M4 and M6A perforations where the cement bond was excellent. This time the plug back shut off 400 BWPD.

Table I Production History of 3242-12

Wellname	DATE	GROSS	CUT	NET	WATER	INJ. MCF	NET MCF	GOR	API	BEAN	CSG PSI	TBG PSI
3242-12	6/7/2003	1314	82%	237	1077	684	417	1.759	20.5	128	730	170
3242-12	7/5/2003	1299	82%	234	1065	708	764	3.265	20.5	128	780	180
3242-12	8/3/2003	1370	80%	274	1096	670	508	1.854	20.8	128	750	175
3242-12	8/10/2003	1298	90%	130	1168	677	608	4.677	20.8	128	700	160
3242-12	8/11/2003	1276	76%	306	970	663	496	1.621	20.8	128	690	130
3242-12	8/12/2003	1112	77%	256	856	694	552	2.516	20.8	128	670	160
3242-12	8/14/2003	1077	48%	560	517	687	530	0.946	20.8	128	670	130
3242-12	8/15/2003	839	81%	159	680	693	466	2.931	20.8	128	670	140
3242-12	8/16/2003	1064	80%	213	851	696	782	3.671	20.8	128	740	160
3242-12	8/17/2003	805	82%	145	660	827	468	3.228	20.8	128	780	190
3242-12	8/18/2003	877	78%	193	684	732	446	2.311	20.8	128	760	180
3242-12	8/19/2003	799	94%	48	751	771	407	8.479	20.8	128	800	140
3242-12	8/20/2003	884	94%	53	831	539	433	8.17	20.8	128	800	140
3242-12	8/27/2003	1063	92%	85	978	468	428	5.035	20.8	128	625	150
3242-12	9/12/2003	696	88%	84	612	776	412	4.905	20.8	128	710	140
3242-12	9/13/2003	850	80%	170	680	633	381	3.824	20.8	128	650	120

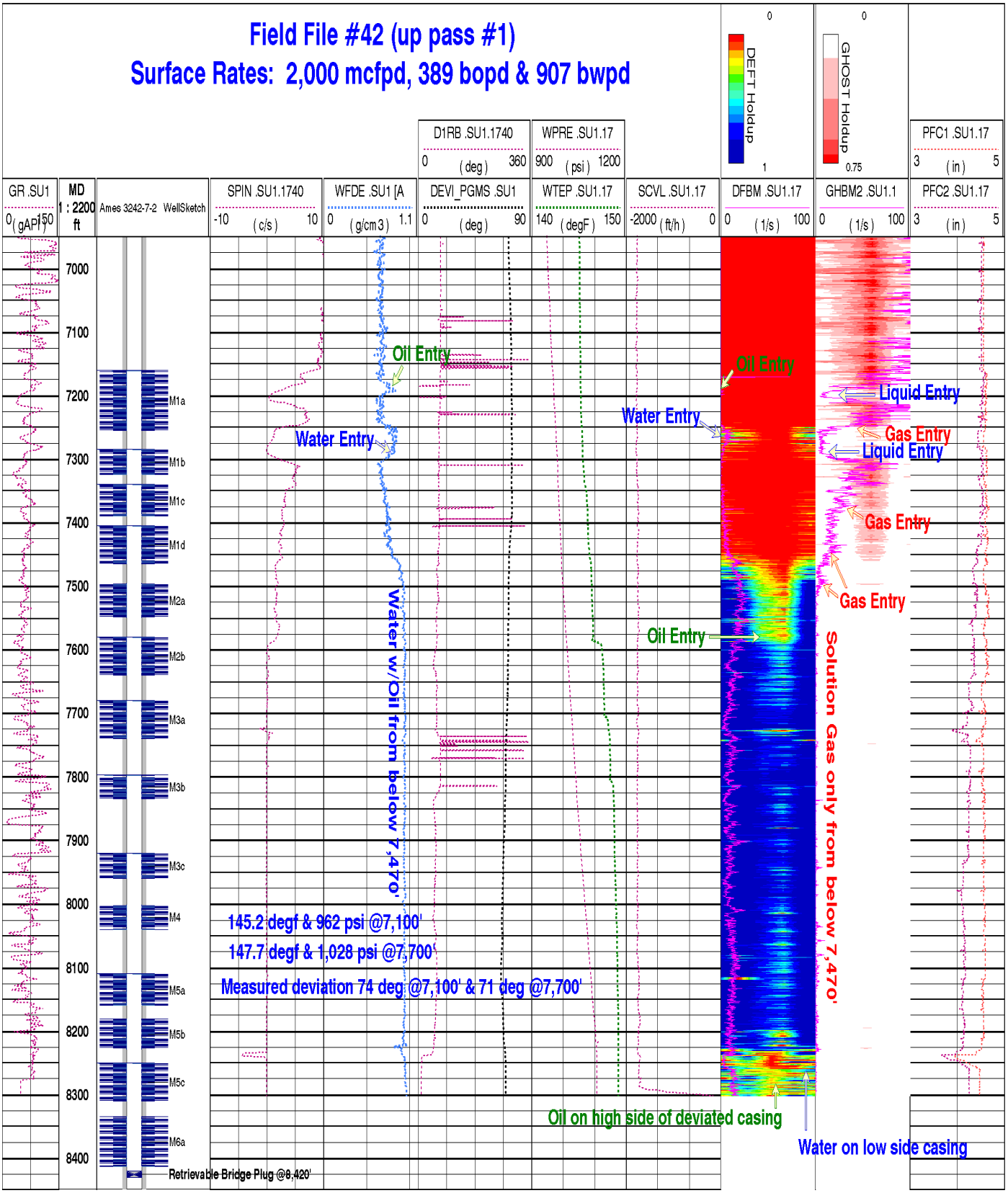
3242-7-2 Production Log

As previously reported, 3242-7-2 was worked over during February 2003 and plugged back to the Upper Monterey. This workover was highly successful such that oil production increased to over 800 BOPD. In April 2003, the gas production jumped to over 3 MMcf/d. A production log was run in August 2003 to identify the source of this gas production.

A Schlumberger production logging string consisting of the Ghost and DEFT flowview tools, a turbine spinner, gradiomanometer and pressure and temperature transducers was run on August 7th 2003. It was only feasible to perform a shut-in pass and three up passes due to extreme tool drag. It later appeared that the through tubing bridge plug set at 8420'in September 2002 had moved up the hole to 7800' and became entangled with the production logging string. A small amount of oil and gas was being produced from the perforations below the stuck plug at 7800' even under the highest drawdown conditions of 70 psi. Essentially all of the well's oil water and gas production 389 BOPD, 907 BWPD and 2 MMcf/d was coming from the zone of vertical beds that was perforated from 7160-7465'. The drawdown on these perforations was less than 50 psi which translates to a productivity index of 26 BPD/psi. A minor amount of oil and gas was

being produced from the M2 repeat perforations (7495-7650'). The plug was later removed from the well on October 31st 2003.

Figure 1 August 2003 Production Log from 3242-7-2

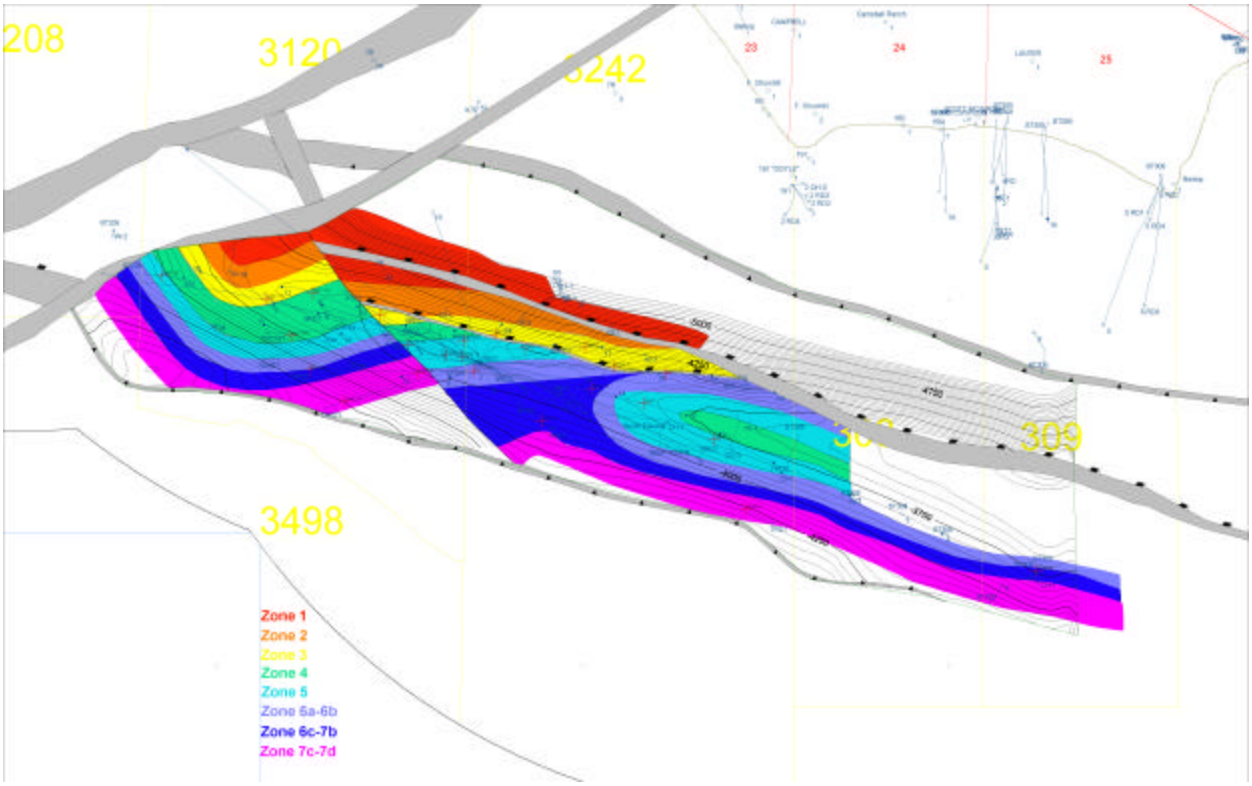


Task III- Basic Reservoir Studies

Geologic Model

A map of the Monterey zones which occur at the opal cristobalite to quartz transition was created from the Monterey gamma-ray zone correlations. The transition depth marks a large change in rock properties in the siliciceous rocks with the quartz having higher matrix density and increased fracturing. This transition was picked using X-ray diffraction (XRD) data from Mobil and Arco and neutron-density logs for wells without XRD data. This map revealed that the quartz phase rocks occur at or near the top of the Monterey Formation toward the north of the field but progressively deeper in the Monterey Formation to the south. This indicates that better reservoir rock occurs along the north flank of the structure which in general is supported by better well performance on the north flank than the south flank of the field. Quartz phase reservoir rock should occur at a depth on the south flank of the field which has as yet not been penetrated by wells. A northwest-southeast trending fault which is difficult to map from the seismic data is clearly revealed by this map.

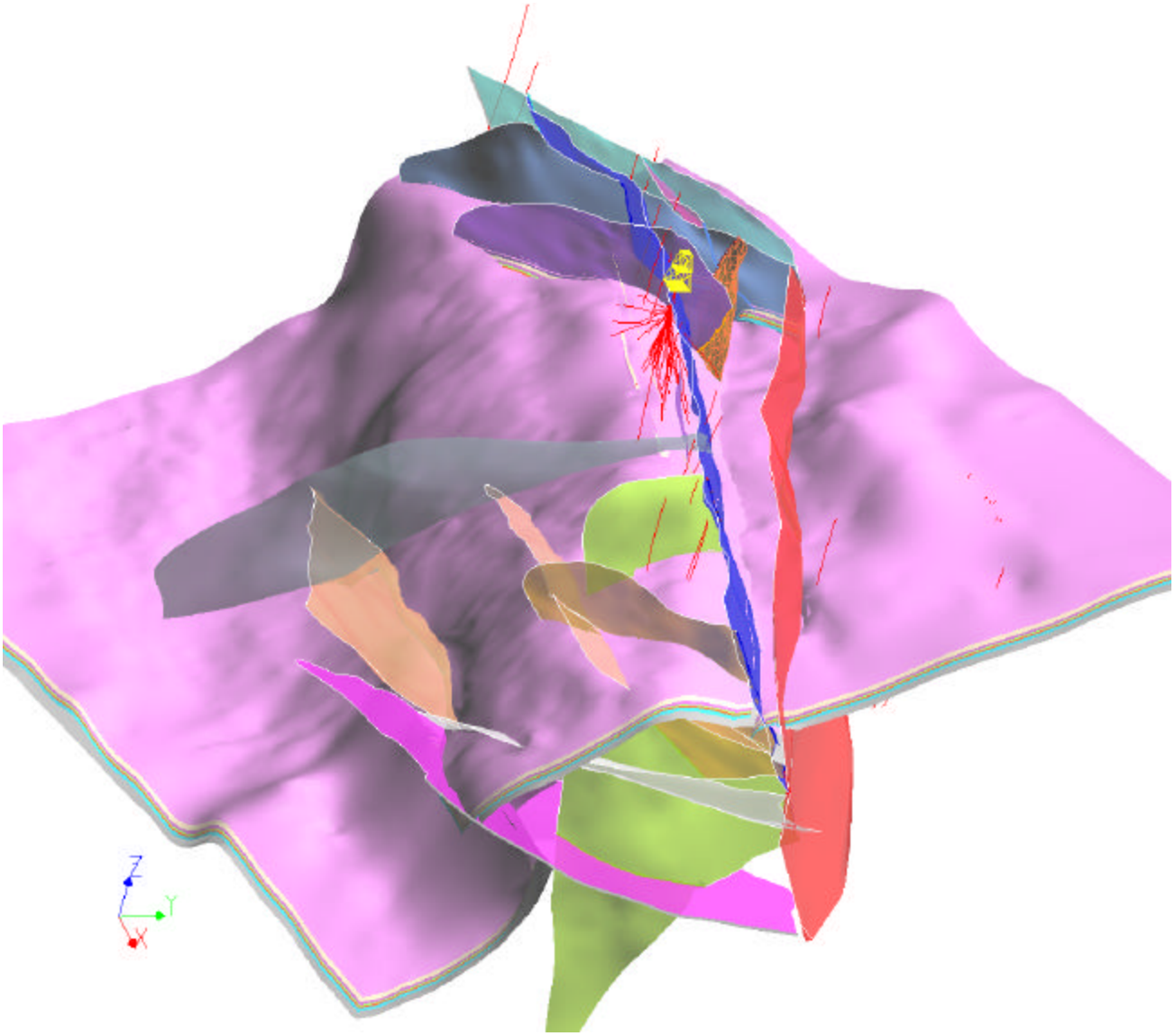
Figure 2 Map of Location of Opal CT/Quartz Transition at South Ellwood



The top of the Monterey Formation surface was created in a 3-dimensional modeling software (GOCAD). This surface was derived from the 3D seismic reflection data, well picks, and dipmeter data. Faults mapped from the seismic reflection data and well cuts were also entered and the Monterey surface cut by these faults. The top of the Rincon Formation (base Monterey) was much more difficult to map due to poor seismic imaging at that depth and fewer well penetrations. Therefore the true stratigraphic thickness of the Monterey formation as calculated from well data in the field and nearby wells was used to create a base Monterey surface. True Monterey zone thicknesses were input into the 3D model to create a stratigraphic 3-dimensional

grid for reservoir simulation. This grid has the 7 major gamma-ray zones plus the thicker zones were subdivided to make a more uniform grid cell size. Reservoir properties; porosity, permeability, oil and water saturations have been compiled from core data. These data and studies of the fracturing of the Monterey Formation are being used to populate the grid cells for reservoir simulation.

Figure 3 Image of 3D Geologic Model for South Ellwood looking West.



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:

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

During August 2003, we hosted a Monterey Symposium and Field trip at the West Coast PTTC meeting in Camarillo, California. Venoco gave three presentations at the technical meeting:

West Coast PTTC Workshop and Field Trip
Exploration and Development Potential of California Monterey and Deeper Rocks

Technical Presentations: 12:30 p.m. – 5:00 p.m. Wednesday, August 20, 2003
Field Trip: 8:00 a.m. – 5:00 p.m. Thursday, August 21, 2003

Co-Sponsored by: U.S. Department of Energy (DOE), University of Southern California (USC), California Independent Petroleum Association (CIPA), Western States Petroleum Association (WSPA), Independent Oil Producers' Agency (IOPA), State Lands Commission, Minerals Management Service (MMS), U.S. Department of Interior, Conservation Committee of California Oil & Gas Producers (CCCOGP), State of California, Department of Conservation, Division of Oil and Gas and Geothermal Resources (CADOGGR), Los Angeles Basin Section of SPE, San Joaquin Valley Section of SPE

Wednesday, Aug. 20, U.S. Dept of Interior, MMS, 770 Paseo Camarillo, Camarillo

12:30pm	**Registration**	
1:00	***Introduction***	**Karen Christensen**
1:15	***DOE's Perspective***	**Gary Walker,** NPTO
1:30	***Overview of the U.S. DOE/Venoco/USC Project in Revitalizing the South Ellwood Field***	**Steve Horner**
2:00	***Constructing a New South Ellwood Geologic Model***	**Marc Kamerling**
2:30	***Review and Distribution of Two New Public Domain Software***	**Iraj Ershaghi**
	• ***The PNM Model for Modeling Monterey Type Producing Fields***	
	• ***Automated Analysis of Monterey Conventional Well Logs***	
3:00	***Increasing Recoverable Reserves with Thru Tubing Bridge Plugs***	**Steve Horner**
3:30	**Break**	
3:40	***Biosteering Into the Monterey Formation***	**Ed Marks**
4:10	***Petroleum Potential of the Eocene-Oligocene Section of the North Margin Ventura Basin***	**Michael S. Clark**
4:40	***Overview of the Sespe Formation Field Trip***	**James Boles,** UCSB
5:00pm	**ADJOURN**	

U.S. Dept of Interior, MMS will provide the facilities for this workshop. West Coast PTTC appreciates their contribution.

Conclusions:

This is the final quarterly technical report for Budget Period I. We have completed all of the major tasks assigned to this budget period. A final report for Budget Period I will be presented in November 2003. We will prepare a new 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

Production Logging Advances in the Fractured Monterey, S.T. Grayson, J.J. Kohring, W.B. Elliot, Schlumberger; G.P. Hertfelder, T.B. Goeres, Arguello Inc.; and S.G. Horner, Venoco Inc. SPE Paper 76749