

**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: **October 1, 2005**

Reporting Period End Date: **December 31, 2005**

Principal Investigator: Steve Horner

Issue Date: **January 31, 2006**

Cooperative Agreement No. **DE-FC26-00BC15127**

Submitting organizations:

Venoco Inc  
6267 Carpinteria Ave. Suite 100  
Carpinteria, CA 93013-1423

## **Progress Report October 1, 2005- December 31, 2005**

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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 ninth 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, enhanced water shut-off techniques and reprocessing of the 1982 3D seismic survey data to improve the geologic structural model. 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. A Middle Sespe prospect was identified by an exploration well drilled from a jack-up in 1985. We have used the reprocessed 3D to image the South Ellwood structure at Sespe level. 3120-15RD4 was drilled during 2004-2005 to appraise this Lower Sespe structure. A second exploratory well was completed during the Fourth Quarter of 2005 to test the North Flank block of the Monterey.

## **Experimental**

Not applicable for the work performed.

## **Results and Discussion**

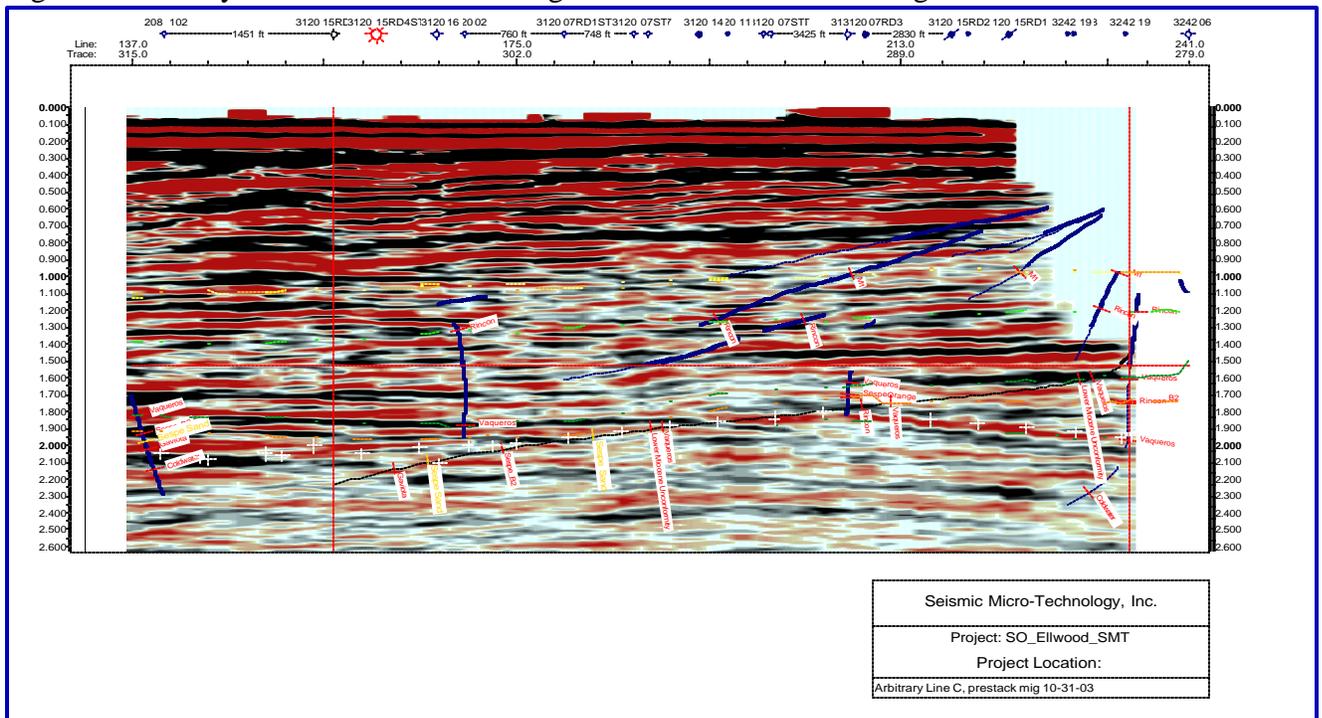
### **Task II – New Data**

A contract geophysicist from Subsurface Consultants was brought in to review the current 3D seismic interpretation. The poor data quality in area of the North Flank play precluded any further improvement in the current mapping. As a consequence, Venoco has decided to contract

Fugro to shoot a low energy seismic acquisition program over the North Flank block to resolve some of these uncertainties. This program will be shot in the late summer of 2006.

The consultant was able to make better progress on the South flank of the field. He established the existence of a large thrust fault at the Rincon /Vaqueros level that sets up the structural high under the platform. The 3120-15RD4 well appears to have penetrated the footwall of this fault and missed the target sands of the Middle Sespe that looked prospective in the 208-102 exploration well. There is a high at Sespe level in the footwall that the 3120-15RD4 well may have traversed. We are studying the 3120-15RD4 cuttings to confirm the stratigraphy in the footwall.

Figure 1 Arbitrary Seismic Section showing Well 3120-15RD4 Crossing White Thrust fault



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

The two existing group separators (V-107 and V-108) will be retrofitted with new internals to allow three phase water separation. NATCO, the original designer of the group separators has designed new vessel internals for retrofitting these vessels. Upgrades will include a new proprietary “Porta Test Revolution” inlet separation device, a higher water weir and new water level control, alarm and shutdown instrumentation. The “Porta Test Revolution” inlet separation device utilizes centrifugal force to separate gas from the liquid without foaming. The higher water weir will allow longer liquid retention time to provide more complete water oil separation. These improvements will reduce the water cut in the oil shipped to Ellwood to approximately 10%. The Revolution devices have arrived and during a platform shutdown in February 2005 we installed a new production header to direct all Holly produced fluids into a single production separator. Production separator V-107 was taken off line, cleaned, inspected and recoated. However since drilling operations continued on the Sespe and North flank wells, it was not possible to begin welding the internals in this vessel due to the limitations imposed by Venoco’s simultaneous operations policy. The modification of the two separators was postponed until the

end of drilling operations in January 2006. Water injection should begin in the first quarter of 2006.

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

Venoco conducted a review of Platform Holly modifications that would be required to accommodate additional ESP wells. Holly is run on shore power and the load factor for the subsea power cable must be closely monitored. We have developed a plan to raise primary separator pressure to 200 psi and mothball a 1500 HP sales gas compressor that boosts separator gas to pipeline operating pressure. This would free up enough spare power to supply five new ESP wells. Venoco plans to install four of these pumps during 2006. Since the retrofitted production separators will have sufficient capacity to meet all future production forecasts, we have decided to use conventional ESP's with no downhole separation capacity.

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

##### **Sespe Well 3120-15 RD4**

The Sespe well (originally called 3242-19 RD1) was renamed 3120-15RD4 by the California Division of Oil, Gas and Geothermal Resources since the producing interval is located on State lease 3120. The well reached a total depth of 14247' on January 17<sup>th</sup> 2005. Excellent gas shows were evident in the Middle Sespe, Gaviota and Coldwater formations. A 2-7/8" completion string was run to test a barefoot section in the massive sands of the Gaviota formation from 12965-13650'. This zone tested wet with minor traces of gas. The reservoir pressure was estimated to be 5500 psi. During testing, the tubing plugged with mud. The tubing was cleaned out with coiled tubing and the completion recovered. TCP guns were run and set on hanger to shoot the Middle Sespe sands. The completion string was rerun but it was not until six weeks later that the completion string was landed due to difficulties running the packer in the oil based mud completion fluid. The guns would not fire due to the presence of 60' of settled mud solids lying on top of the firing head. It was decided to pull the completion and recomplete the well with Calcium chloride brine. Recovery of the completion string took an additional two months as it required a washover string to clean out settled mud solids in the tubing-casing annulus.

A test was finally completed in October 2005. The Middle Sespe was perforated with TCP guns from 12515-12770'. Unfortunately the Middle Sespe tested at a very disappointing rate of 20 BFPD x 97% WC on gas lift. A set of memory gauges was hung in the well on November 5<sup>th</sup>, 2005. A long term build-up will be conducted to determine if the zone is damaged.

##### **North Flank Well 3120-18**

The Ames 3120-18 was drilled as a sidetrack from the 3242-13. 3120-18 was planned to test two objectives: The North limb of the South Ellwood field and the north limb of the bordering syncline. The well was spudded on November 18, 2005 and successfully drilled to a total depth of 11,259' MD (-5,210' ss) on December 7, 2005.

The well was drilled smoothly with no mechanical problems and no loss of drilling fluid. Hydrocarbon shows of interest are present from 4,630-4,773' in the M3 and 6,400-6,500'/7,247-7,295' in a repeat section of the M1. Minor shows were observed from 10,300-11,109 in another repeat section of the Monterey (M1-M7).

Figure 2 displays the northwesterly trace of the well and Figure 3 is a schematic cross section of the well penetration. The Upper Monterey (M1-M3) was encountered before the well became highly deviated and crossed a normal fault at which time the well re-entered the M1 unit of the Monterey. For approximately 3,300' the well bore traversed obliquely through the M1 very close to bed dip. At 8,119' the well encountered another Normal fault and entered the Sisquoc forming the synclinal axis. Another Normal fault was encountered at 9,350 on the north limb of the syncline. A third penetration of the Monterey was observed at 9,963' in which zones M1-7 were identified on the log. At 10,791' the Red Mountain Fault was encountered with reverse displacement placing Lower Monterey (M6-7) and Rincon in the well bore. The well was stopped in the basal Monterey/Upper Rincon.

Casing was set to 10,097' in the M1. The Monterey below 10,097 was then acidized and put on production on December 30<sup>th</sup> 2005. It tested 1300 BWPD of typical Monterey water with no traces of oil or gas at report time. A build-up test will be conducted to determine if the North flank block is in communication with the main field. Additional production testing is to occur in the M1 (6,407-6,498'/7,247-7,295') and the M3 (4,630-4,773').

### 3120-18 Well Path

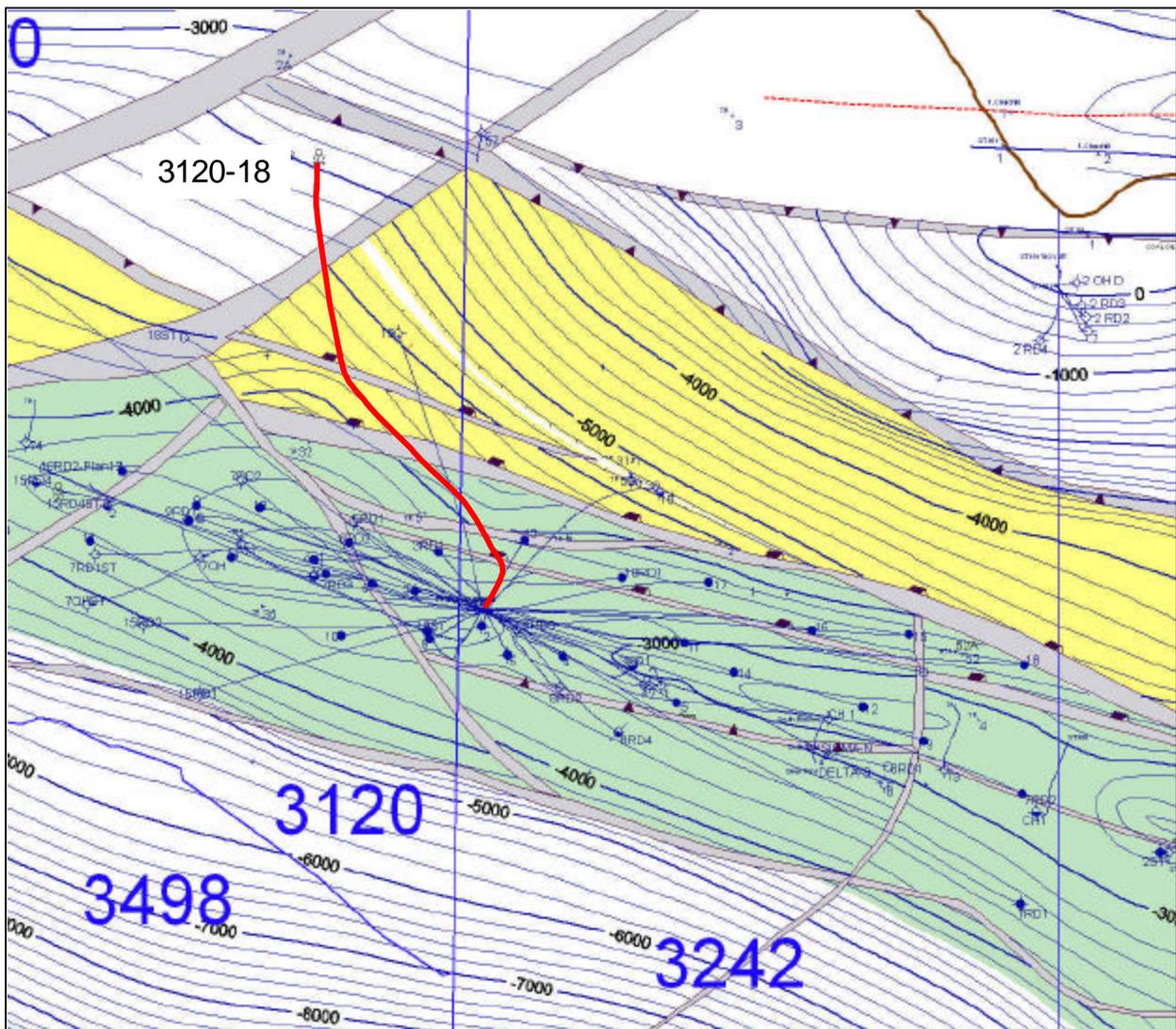


Figure 1

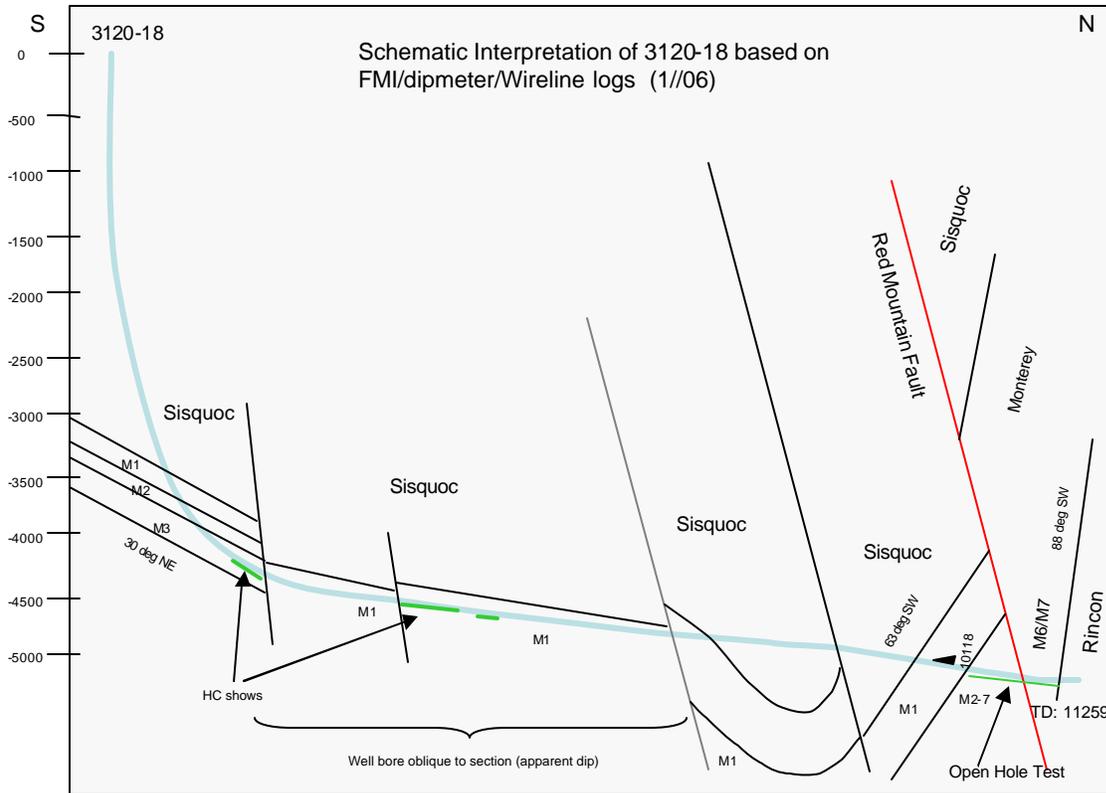


Figure 2

## Logging

Mud logging: Epoch: 3600'-11259'

LWD: Sperry Sun LWD: GR 3606'-11203'/Resistivity 7327'-11210'

Pipe conveyed: Schlumberger: Dual Spaced Sonic (DSI) 3596'-11013'; Resistivity (AIT-C) 3596'-7008'; Spectral Gamma Ray (HGNS) 3610'-11013'; Formation Micro Imager (FMI)/dipmeter 3659'-11007'

## Tops

	MD	SSTVD	N+/S-	E+/W-	TWTT	Dip	Dip Azm
Sea floor	292	-213					
Window for 3120-18	3600						
MONTEREY	3616	-3445					
M2	3955	-3744				36	035
M3	4275	-3991				34	027
M1 base reversed	4794						
Fault 3	6145						
M1 reversed top	8100	-4808					
Fault 9	8119						
Basal Sisquoc	8119	-4810					
Fault 10	9350						
M1 repeat 3	9963.5	-5047				63	195
M2 repeat 2	10161	-5158				65	195
M3 repeat 2	10404	-5108					
M4	10537	-5129					
M5	10609	-5141					
M 6a	10696	-5157					
M7a	10764	-5169					
Red Mtn Fault	10791	-5174					
Zone 7a repeat 2	10855	-5185					
RINCON	11109	-5204					
TD	11259	-5210					

## 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

Ted Carlsen, Dick Bischke

**Project Management:**

Steve Horner

**Task VI-Technology Transfer**

None.

**Conclusions:**

This is the ninth quarterly technical report for Budget Period II. Three significant new projects are in progress. An appraisal well was drilled to test the Sespe prospect identified from seismic reprocessing. This well is presently being production tested. A second exploratory well was completed at the end of the Fourth Quarter to appraise the Monterey North flank block. It has just begun testing at report time. In addition, we have completed design work to separate and re-inject all produced water back into the Monterey at Holly. Equipment has been purchased to modify the Holly separators and we expect to complete the project by Q1 2006.

**References**

**Analysis of Fracturing and Fluid-Flow Characteristics of the Monterey Formation, Santa Barbara Channel**, LaPointe, P.R., Belfield, W.C., Helwig, J.A, 1984, SPE 12734