

**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: **January 1, 2003**

Reporting Period End Date: **March 31, 2003**

Principal Investigators: Steve Horner (Venoco), Iraj Ershaghi (USC)

Issue Date: **May 15, 2003**

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

Submitting organizations:

Venoco Inc
5464 Carpinteria Ave. Suite J
Carpinteria, CA 93013-1423

University of Southern California
University Park
Los Angeles, CA 90089-1147

Progress Report Jan 1, 2003- March 31, 2003

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or agency thereof.

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 eleventh quarter of Budget Period I.

Table of Contents

Progress Report Jan 1, 2003- March 31, 2003.....	2
Disclaimer	2
Abstract	2
Introduction.....	4
Executive Summary	4
Experimental	4
Results and Discussion	5
Task I- Database	5
Task II- New Data.....	5
New Infill well 3242-7-2	5
Task III- Basic Reservoir Studies	7
Pipeline Network Model	7
Task IV--Stimulation	10
Task V- Project Management	10
Database:	10
Reservoir Studies:	10
Geological Modeling	10
Geophysical Modeling.....	10
Project Management:	10
Task VI-Technology Transfer.....	10
Conclusions:.....	10
References.....	11

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 location was selected for first new development well targeting the undeveloped Eastern flank of the field. The 3242-7-2 well was drilled and completed during the third quarter of 2002. Advanced image logs were run throughout the Monterey section to identify the most prolific fractured intervals. During the present quarter, additional perforations were selected based on the image logs and the fracture study conducted earlier. These perforations were added during a workover conducted during February 2003. The well is currently producing 830 BOPD making it the second best producer on the platform. The well will be re-completed during February 2003 to reduce the water production from the Lower Monterey.

Perhaps the most significant achievement of this project is the completion of a new reservoir simulation algorithm developed specifically for the Monterey. A fully three phase, 3D Pipeline Network model is now ready for public release. The algorithm will be distributed by CMG as a fractured reservoir option for the IMEX simulator.

Experimental

Not applicable for the work performed.

Results and Discussion

Task I- Database

The paper on the database earlier presented at the 2002 Western Regional Meeting of SPE was updated for submission to SPE for the SPE library archives.

Task II- New Data

New Infill well 3242-7-2

3242-7-2 was the first well drilled by Venoco on Holly platform. The well was sidetracked from 3242-7-1 at a depth of 3274' and drilled eastward to tap reserves in the lower Monterey in a crestal location near the eastern limit of the 3242 lease. The Lower M5, M6 and M7 (8334-9036') were perforated selectively using the Formation Micro-Image log to pick the most heavily fractured zones. The well commenced production on July 1st, 2002 with a water cut in excess of 95%. On August 1st, 2002, Schlumberger ran their Gas Hold-up Optical Sensing Tool/Digital Entry FloView Tool production logging string over the perforated interval to determine the point of water entry. Two major entries of water were observed at 8550' and 8437'. Essentially all the hydrocarbons were coming in the top set of perforations from 8334-8414'. The oil-water contact was determined to be -3735' SS. This oil-water contact was 300' higher than originally anticipated. Comparing the production logging results with the Formation Micro-Image tool interpretation shows that two swarms of near vertical fractures oriented N-S at 8437' and 8398' are responsible for more than 60% of the well's production.

On the basis of the production logging results all perforations except for the topmost M5/M6 perforations 8334-8414' were abandoned with a wireline set inflatable bridge plug on September 21st, 2002 at 8420' MD. Additional perforations were shot through tubing in the M5 on October 26 and the M3-M4 on November 8, 2002. These perforations were not acidized and do not appear to be producing.

A workover was conducted during February 2003. Additional perforations in the vertical beds, M2 Repeat, M3 Repeat and M4 Repeat were shot using tubing conveyed guns on February 14th, 2003. All the perforations lie on the south side of a large thrust fault termed C3 that cuts 3242-7-2 just at the top of the vertical beds. All the perforations from M2 repeat through M5 were acid stimulated using a conventional 12-3% HCl/HF mud acid. The tubing was re-run and the well placed back on production on February 18th. The new perforations significantly enhanced the oil production from the well.

The following Table summarizes the production tests for the new well:

Table 1 Production History of 3242-7-2

Wellname	DATE	BFPD	CUT	BOPD	BWPD	GL MCF	NET MCF	GOR	API	CSG PSI	TBG PSI
3242-7	7/1/2002	704	98%	14	688	395	30			815	125
3242-7	7/2/2002	703	98%	14	689	422	3	0.214		805	130
3242-7	7/4/2002	1510	99%	15	1495	474	120			825	170
3242-7	7/5/2002	1545	99%	15	1530	606	26	1.733		825	185
3242-7	7/6/2002	1699	96%	34	1665	817	17	0.500		850	200
3242-7	7/7/2002	1637	90%	164	1473	844	119	0.726		860	200
3242-7	7/8/2002	1356	90%	136	1220	817	255	1.875		840	180
3242-7	7/9/2002	1979	97%	59	1920	883	248	4.203		870	210
3242-7	7/10/2002	1951	96%	78	1873	975	269	3.448		870	210
3242-7	7/11/2002	1938	97%	97	1841	1134	242	2.494		840	200
3242-7	7/12/2002	1887	95%	94	1793	1134	54	0.574		840	200
3242-7	7/13/2002	1834	95%	92	1742	1134	54	0.587		850	200
3242-7	7/14/2002	1782	96%	71	1711	1134	110	1.549		860	200
3242-7	7/15/2002	1791	93%	125	1666	1132	112	0.896		860	190
3242-7	7/16/2002	1750	91%	157	1592	962	302	1.924		865	200
3242-7	7/17/2002	1723	90%	172	1551	863	381	2.215		865	180
3242-7	7/18/2002	1604	89%	176	1428	857	407	2.313		865	210
3242-7	7/21/2002	1612	91%	145	1467	955	388	2.676		875	200
3242-7	7/23/2002	552	98%	11	541	937	69	6.273		880	120
3242-7	7/24/2002	1270	96%	51	1219	893	113	2.216		860	160
3242-7	7/25/2002	1522	91%	137	1385	893	469	3.423	21.5	865	190
3242-7	7/25/2002	1393	92%	111	1281	912	401	3.613	21.5	870	190
3242-7	7/31/2002	780	90%	78	702	411	268	3.436	21.5	835	200
3242-7	8/1/2002	1397	90%	140	1257	1048	306	2.186	21.5	870	200
3242-7	8/2/2002	1643	82%	296	1347	442	438	1.480	21.5	760	150
3242-7	8/5/2002	1575	91%	142	1433	414	466	3.282	21.5	735	150
3242-7	8/13/2002	1504	87%	195	1309	442	489	2.508	21.5	740	160
3242-7	8/17/2002	1491	81%	283	1208	442	477	1.686	21.5	750	150
3242-7	8/22/2002	1452	85%	218	1234	475	273	1.252	21.5	740	150
3242-7	8/23/2002	1432	87%	186	1246	475	273	1.468	21.5	740	140
3242-7	8/28/2002	1424	86%	199	1225	494	311	1.563	21.5	750	150
3242-7	9/1/2002	1473	80%	295	1178	429	347	1.176	21.5	745	155
3242-7	9/5/2002	1231	92%	98	1133	546	209	2.133	21.5	835	135
3242-7	9/6/2002	1524	91%	137	1387	572	320	2.336	21.5	880	125
3242-7	9/18/2002	1469	86%	193	1185	533	272	1.409	21.5	790	150
3242-7	9/19/2002	1360	88%	163	1197	488	317	1.945	21.5	795	150
3242-7	9/20/2002	1329	86%	186	1143	494	311	1.672	21.5	785	150
3242-7	9/22/2002	660	62%	251	409	385	244	0.972	21.5	780	100
3242-7	9/23/2002	897	64%	323	574	494	233	0.721	21.5	785	160
3242-7	9/24/2002	800	67%	264	536	507	259	0.981	21.4	775	145
3242-7	9/25/2002	715	62%	272	443	507	163	0.599	21.4	785	145
3242-7	9/26/2002	768	67%	253	515	598	163	0.644	21.4	845	130
3242-7	9/27/2002	679	64%	244	435	520	241	0.988	21.4	820	105
3242-7	9/29/2002	886	69%	275	611	520	168	0.611	21.4	760	120
3242-7	10/3/2002	896	78%	197	699	520	156	0.791	21.5	785	125
3242-7	10/16/2002	500	70%	150	350	520	78	0.520	21.5	780	120
3242-7	10/18/2002	879	66%	299	580	520	107	0.358	21.5	780	140

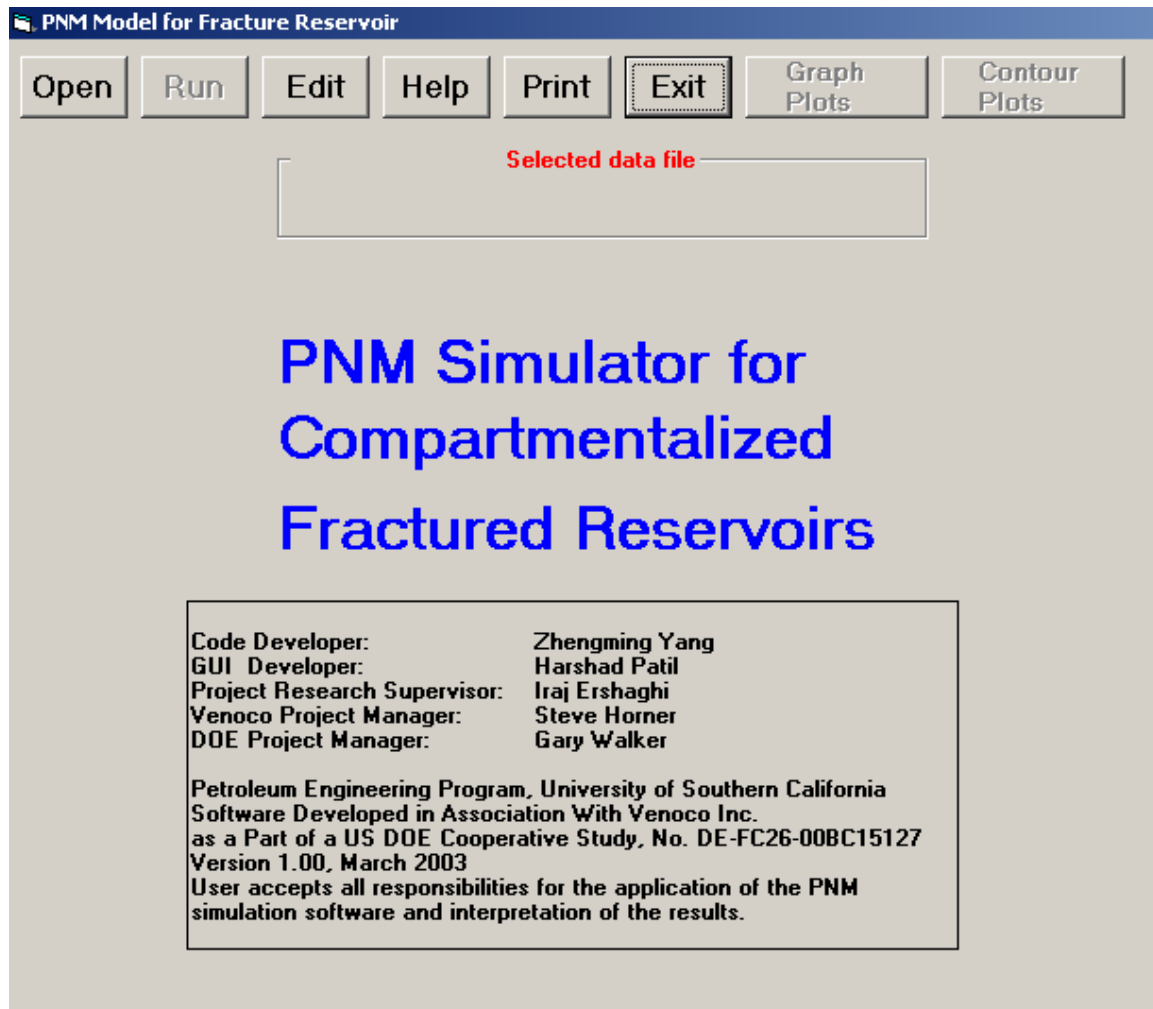
3242-7	10/19/2002	864	76%	207	657	520	150	0.725	20.5	800	130
3242-7	10/20/2002	807	78%	178	629	520	150	0.843	20.5	800	130
3242-7	10/27/2002	812	79%	171	641	677	82	0.480	21.5	865	130
3242-7	10/28/2002	569	82%	102	467	677	120	1.176	21.5	880	110
3242-7	10/29/2002	544	65%	190	354	780	173	0.911	21.5	880	135
3242-7	10/30/2002	540	70%	162	378	664	75	0.463	21.5	860	130
3242-7	10/31/2002	508	78%	112	396	481	102	0.911	21.5	780	110
3242-7	11/1/2002	483	70%	145	338	429	154	1.062	21.5	860	110
3242-7	11/6/2002	552	82%	99	453	466	118	1.192	21.5	780	120
3242-7	11/7/2002	559	74%	145	414	559	258	1.779	21.5	780	130
3242-7	11/9/2002	760	84%	122	638	703	160	1.311	21.5	865	140
3242-7	11/10/2002	649	83%	110	539	846	88	0.800	21.5	890	140
3242-7	2/22/2003	1546	90%	155	1391	520	125	0.806	21.5	935	125
3242-7	2/23/2003	1668	94%	100	1568	520	182	1.820	21.5	935	100
3242-7	2/24/2003	1747	89%	192	1555	520	60	3.200	21.5	935	160
3242-7	2/25/2003	1702	60%	681	1021	553	490	0.720	21.5	950	160
3242-7	2/26/2003	1714	62%	651	1063	533	539	0.828	21.5	950	170
3242-7	2/27/2003	1747	63%	646	1101	552	520	0.854	21.5	960	160
3242-7	2/28/2003	1708	51%	837	871	533	568	0.679	21.5	950	160
3242-7	3/1/2003	1662	54%	765	897	520	610	0.797	21.5	945	150
3242-7	3/2/2003	1466	51%	719	746	520	581	0.808	21.5	940	160
3242-7	3/3/2003	1606	60%	642	964	651	218	0.339	21.5	985	155
3242-7	3/4/2003	1544	45%	849	695	390	335	0.395	21.5	880	140
3242-7	3/6/2003	1107	90%	111	997	539	272	2.450	21.5	950	170
3242-7	3/7/2003	1500	57%	645	855	549	262	0.406	21.5	960	140
3242-7	3/8/2003	1400	58%	588	812	552	344	0.585	20.5	955	140
3242-7	3/9/2003	1241	59%	509	732	527	342	0.672	21.5	960	125
3242-7	3/10/2003	1350	53%	634	716	572	297	0.468	21.5	960	150
3242-7	3/14/2003	1662	50%	831	831	919	240	0.289	21.5	1020	185

Task III- Basic Reservoir Studies

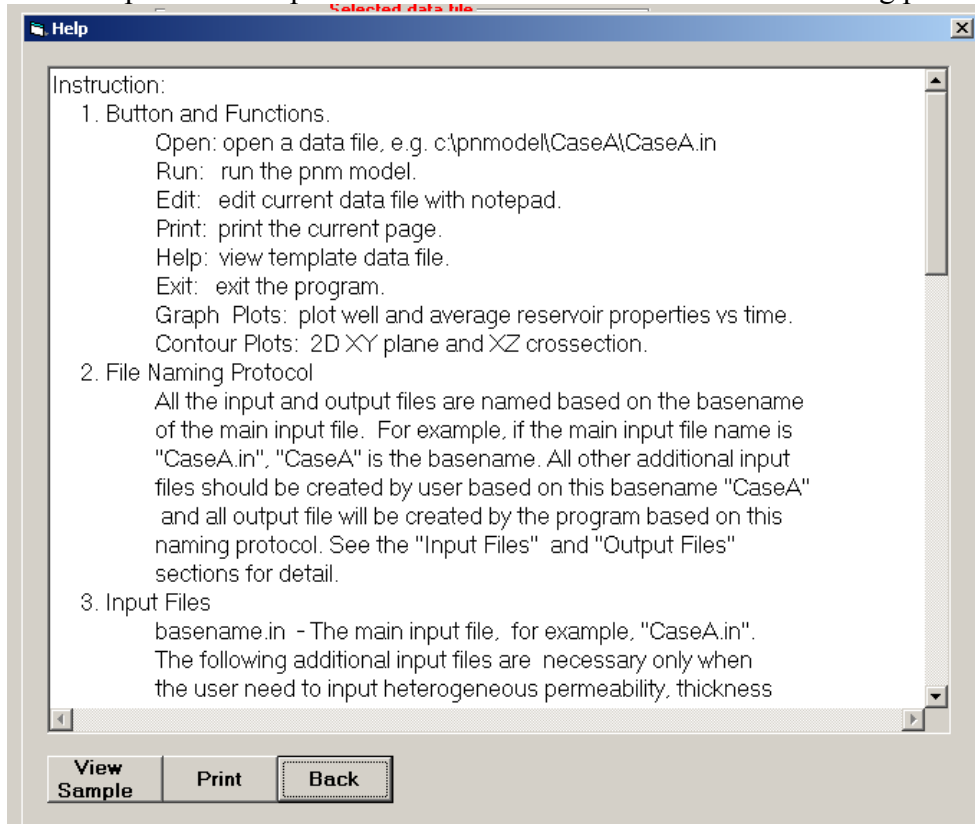
Pipeline Network Model

We substantially improved the Graphic Users Interface (GUI) for the software making it more users friendly. We completed the task of coding the three phase three-dimensional model and successfully tested the model with some test data sets.

Updated First Screen of the PNM Model

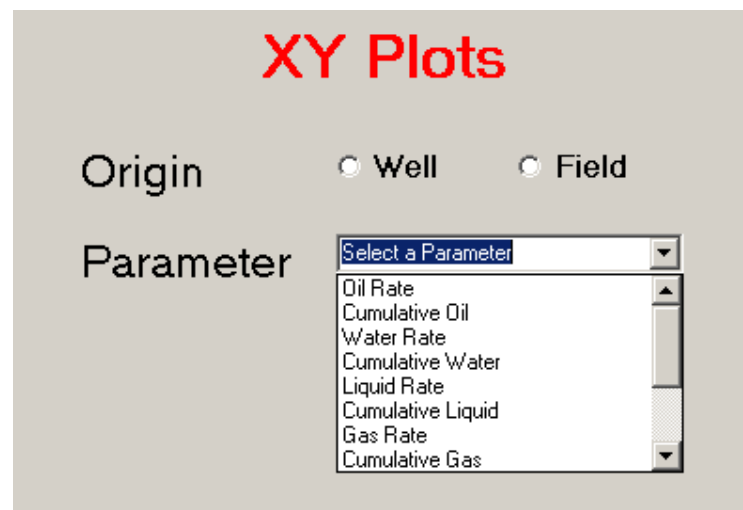


We incorporated a help section to orient the user with the file naming protocols.



We included additional options for generating graphical representation of the simulation results.

Menu options for Performance Plots



We also included capabilities for generating 2-D cross sectional representation of saturation and pressure data at various time steps. The model has been successfully tested against CMG STARS on 3D, three phase (Oil and Water and gas) with dual-porosity (matrix and fracture).

Work Schedule for the Next Quarter

The tentative work schedule for next quarter will be as follows:

- Complete Final Report for Budget Period I
- Propose commencement of Budget Period II
- Begin design of the first downhole separator ESP completion

Task IV--Stimulation

Successfully stimulated 3242-7-2 with a conventional 12-3 mud acid

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), Tim Rathmann (Venoco) and Kim Halbert (Venoco).

Reservoir Studies:

I. Ershaghi (USC), Zhengming Yang (USC), Steve Horner (Venoco), M. Kashfi (USC).

Geological Modeling

Marc Kamerling (Venoco), Karen Christensen (Venoco)

Geophysical Modeling

Karen Christensen (Venoco)

Project Management:

Steve Horner (Venoco) and I. Ershaghi (USC)

Task VI-Technology Transfer

We focused on preparation of the three SPE papers scheduled for presentation at the AAPG/SPE meeting in Long Beach California during May 2003.

We submitted an abstract for a poster session paper at the National Meeting of AAPG in Salt Lake City Utah to introduce a computer aided system for detection of productive intervals from conventional logs. The paper is titled: "A Fuzzy Expert System for Detection of By-Passed Intervals in a Geologically Complex Reservoir using Production-Calibrated Well Log Data" Ershaghi, M. Kashfi, K. Christensen, T. Rathmann.

Conclusions:

We have completed all of the major tasks assigned to budget period I. The significant milestones of the project have been the development of a Web-based database, development of a working 3D Pipeline Network model and the successful drilling of the first well on platform Holly in almost twenty years.

References

Grayson, Kohring, Elliot, Hertfelder, Goeres, and Horner, Production Logging Advances in the Fractured Monterey With the PSP and Ghost SPE 76749

Zahedi, Abdassah, Ershaghi and Horner, Simulation of Lithologically Complex and Fracture-dominated Monterey Production from the South Ellwood Reservoir SPE 77739

Zhan and Ershaghi, An Integrated Pipe Network Model for Simulation of Highly Fractured Reservoirs SPE 71616

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