**Feasibility of Optimizing Recovery and Reserves from a
Mature and Geological Complex Multiple Turbidite
Offshore California Reservoir Through the Drilling and
Completion of a Trilateral Horizontal Well**

**Quarterly Report
July 1 - September 30, 1996**

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Office of Fossil Energy
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THIRD QUARTERLY TECHNICAL PROGRESS REPORT

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**FEASIBILITY OF OPTIMIZING RECOVERY AND RESERVES FROM A MATURE
AND GEOLOGICAL COMPLEX MULTIPLE TURBIDITE OFFSHORE CALIFORNIA
RESERVOIR THROUGH THE DRILLING AND COMPLETION OF A TRILATERAL
HORIZONTAL WELL**

Cooperative Agreement: DE-FC22-95BC14935

Institution: Pacific Operators Offshore, Inc.

Report Date: September 30, 1996

Award Date: September 1, 1995

Anticipated Completion Date:

Funding for FY 1995: \$814,718

Program Manager: Steven F. Coombs

Principal Investigator: Pacific Operators Offshore, Inc.

C0-Participants: University of Southern California/ Coombs and Associates

Contracting Officer's Representative: Edith Allison

Reporting Period: July 1, 1996- September 30, 1996

Objectives

The main objective of this project is to devise an effective redevelopment strategy to combat producibility problems related to the Repetto turbidite sequences of the Carpinteria Field. The lack of adequate reservoir characterization, high-water cut production, and scaling problems have in the past contributed to the field's low productivity.

To improve productivity and enhance recoverable reserves, the following specific goals are proposed:

- Develop an integrated database of all existing data from work done by the former ownership group.
- Expand reservoir drainage and reduce sand problems through horizontal well drilling and completion.
- Operate and validate reservoirs' conceptual model by incorporating new data from the proposed trilateral well.
- Transfer methodologies employed in geologic modeling and drilling multilateral wells to other operators with similar reservoirs.

Summary of Technical Progress

Pacific Operators Offshore, Inc. received pre-award authorization for this project effective May 9, 1995 and final approvals were obtained effective September 1, 1995. To date a significant amount of progress has been made on development of a database, which includes production data (project task 1.1.1), well log data (project task 1.1.2), well completion data (task 1.1.3) well test and PVT data (project task 1.1.4). Further, since the last progress report (April-June, 1996) additional work

has been completed in the various data analysis tasks, specifically Well log Data (task 1.1.2), gas analysis and historical API gravities (task 1.1.4), stratigraphy and micro lamination (task 1.2.1), reservoir performance (task 1.2.2) and Details of this work are discussed in this report.

Task 1.1.2 - Database: Well Log Data

Calculations of all petrophysical attributes is complete for all wells with useable data. All computed data has been exported to the Stratigraphic Geocellular Model.

Using annotated computed logs and the marker data, the determination of oil/water contacts has been started. For the purpose of computer aided mapping, estimation of depth corresponding to the oil water contact within each layer for individual wells are being prepared.

Task 1.1.4 - Database: Well Test / PVT Data

All available gas analysis data have been digitized. Table 1 shows a typical gas analysis data set. Also the historical API gravity measurements have been digitized. Figure 1 shows a comparison of the API gravities for two Wells A-4 and A-9. Chronological drop of API gravities are attributed to the loss of the light components during the solution gas drive process.

Task 1.2.1 - Stratigraphy and Micro lamination

Information related to the lithology column for all the cored sections have been digitized. Each data point is assigned with a six digit number to completely define the lithological specification. Table 2 lists the definition of each digit. These codes will be used with Well log data for further micro lamination studies.

Task 1.2.2 - Reservoir Performance

Productivity of Horizontal Wells

A preliminary study of the expected productivity of horizontal wells producing from E-1, F-1 and F-3 sands in the Carpinteria offshore field, using pseudo steady state method presented by Babu and Odeh (SPERE Nov. 1989, p.417-421), has been completed. Reservoir and fluid parameters utilized in this study are given in Table 3. Figure 2 shows the effect of well length on the productivity index, PI, for the three sands. The effect of oil viscosity is presented in Figure 3. It can be observed oil viscosities significantly affect estimated PI's is when they are less than 5 cp. The effect becomes negligible for higher oil viscosities. Figure 4 depicts the linear effect of horizontal permeability on PI.

The horizontal permeability in the X and Y direction are assumed to be equal. The vertical to horizontal permeability ratio is assumed to be 80 percent in all cases. The effect of permeability ratio on PI is shown in Figure 5. As can be seen, this effect for E-1 and F-3 sands is negligible for

all values of vertical to horizontal permeability ratios greater than 20 percent. Examples of other parametric studies on expected productivities are shown in Figures 6 and 7. In general, for the range of applicable reservoir data, the proposed horizontal drilling can substantially increase the productivity of new wells in the Carpinteria sands.

1.2.3 Production Allocation

The production allocation program has been tested. Two modifications are being incorporated to take into account reservoir pressure history and changes in fluid saturations. Also efforts are underway to modify the material balance program by adding unsteady state and pseudo steady state water influx models.

1.3.1 Management and Administration

Monthly meetings were held with the participants in the project (USC, Coombs and Associates,.....) to review the progress of various tasks.

1.4.1 Tech Transfer

During this period we completed the following activities:

1. Bi weekly meeting at USC on the geology and production issues related to slope and basin reservoirs.
2. March 1, 1996: Pacific Operators hosted a tour of their offshore Platforms including a presentation on the field recovery potential to representatives from the DOE and the local congresswoman, Rep. Andrea Seastrand.
3. March 13, 1996: Made a presentation on the Carpinteria Redevelopment project at the API Energy Day
4. July 8, 1996: Presentation to regulatory agencies (Minerals Management Service and California State Lands Commission) on recovery potential of the Carpinteria field using convention reservoir engineering techniques.
5. August 21, 1996: Review of geology, drilling problems and reservoir issues presented New York investment community visiting in Santa Barbara.
6. June - September, 1996: Provided internship to three college students who received supervised instructing relating to the project.
7. August - Present: Developed a Pacific Operators maintained web site for online reporting on the progress of the Class III project. The address for this web site is: <http://www.pacops.com>

8. Attended Tech Transfer planning meeting with other Class III project in Valencia, CA.
9. Participated in brain-storming sessions related to the initial formation of the west coast PTTC.
10. Conducted sessions with the CSLC to demonstrate that the State portion of field has significant remaining reserves and that it should be included in the Class III study for potential drilling.
11. Pacific Operators was invited to contribute its reservoir database as an example of slope and basin reservoir as a part of the on-line database under development between USC and LLNL.

TABLE 1
TYPICAL GAS ANALYSIS

Well No.: A-6 , Sample # 1, Date : 7-25-68	
Component	Mole per cent
He	< .01
CO2	3.28
N	0.06
CH4	84.34
C2H6	2.67
Propane	4.1
I-Butane	0.84
N-Butane	1.81
I-Pentane	0.82
N-Pentane	0.74
Hexane	0.52
Heptanes and Heavier	0.82
Specific Gravity	0.7487
Heating Value	
Dry	1237
Wet	1215

TABLE 2

A	B	C	D	E	F
Texture	Grain Size	Composition	Sortness	Oil Present?	Color
1. Sandstone 2. Siltstone 3. Shale 4. Mudstone 5. Sand w/ traces of clay 6. Sand w/ traces of silt 7. Sand w/ traces of silt & clay 8. Siltstone w/ traces of sand 9. Sand w/ silt and/or shale	1. Very Fine Grain 2. Fine Grain 3. Medium Grain 4. Large Grain	1. Soft 2. Hard 3. Firm	1. Poor 2. Fair 3. Good	1. Yes	1. Olive Gray 2. Gray 3. Gray-Green 4. Brown 5. Yellow 6. Black 7. Yellow-Brown 8. Black-Brown

TABLE 3
Reservoir and Fluid Properties

Parameter	E-1 sand	F-1 sand	F-3 sand
Well length, feet	1500	1500	1500
Sand Width, a, feet	2000	2000	2000
Sand Length, b, feet	3000	3000	3000
Sand thickness, h, feet	45.60	107	42
Wellbore radius, r_w , feet	0.25	0.25	0.25
Oil viscosity, cp	20.0	8.5	8.5
Oil formation volume factor, bbl/STB	1.065	1.07	1.07
Permeability in x direction, md	425	223	223
Permeability in y direction, md	425	223	223
Permeability in z direction, md	340	178.4	178.4
x_0 , feet	1000	1000	1000
z_0 , feet	41.04	96.3	37.8
y_1 , feet	500	500	500
y_2 , feet	2000	2000	2000
Skin factor	0	0	0

Figure 1- Historical API Gravity Data For Wells A-4 and A-9

Figure 2- Effect of Well Length on Productivity Index

Figure 3- Effect of Oil Viscosity on Productivity Index

Figure 4- Effect of Horizontal Permeability on Productivity Index

Figure 5- Effect of Vertical Permeability on Productivity Index

Figure 6- Effect of Sand Width on Productivity Index

Figure 7- Effect of Sand Length on Productivity Index