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# Combined Second and Third Quarterly Technical Progress Reports

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## ENHANCED OIL RECOVERY WITH DOWNHOLE VIBRATION STIMULATION IN OSAGE COUNTY OKLAHOMA

### APPLICATION OF PETROLEUM TECHNOLOGIES ON NON-ALLOTTED NATIVE AMERICAN AND ALASKAN NATIVE CORPORATIONS LANDS

<b>CONTRACT NUMBER:</b>	<b>DE-FG26-00BC15191</b>
<b>CONTRACTOR:</b>	<b>OIL &amp; GAS CONSULTANTS INTERNATIONAL, INC. TULSA, OKLAHOMA</b>
<b>CONTRACT DATE:</b>	<b>JULY 13, 2000</b>
<b>ANTICIPATED COMPLETION:</b>	<b>NOVEMBER 12, 2001</b>
<b>GOVERNMENT AWARD:</b>	<b>\$525,000</b>
<b>PRINCIPAL INVESTIGATORS:</b>	<b>J. FORD BRETT ROBERT V. WESTERMARK</b>
<b>PROJECT MANAGER:</b>	<b>VIRGINIA WEYLAND NATIONAL PETROLEUM TECHNOLOGY OFFICE</b>
<b>REPORTING PERIODS:</b>	
<b>SECOND QUARTER</b>	<b>OCTOBER 1, 2000 – DECEMBER 31, 2000</b>
<b>THIRD QUARTER</b>	<b>JANUARY 1, 2001 - MARCH 31, 2001</b>

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## PROJECT OBJECTIVES

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The objective of this project is to demonstrate the impact of downhole vibration stimulation on oil production rates in a mature waterflood field. Oil & Gas Consultants International, Inc. (OGCI) will manage the project in close cooperation with the Osage Tribe as the tests will be conducted in Osage County, Oklahoma, the mineral estate of the Osage Tribe. The field is owned and operated by Calumet Oil Company. Phillips Petroleum Company will contribute their proprietary vibration core analysis of cores recovered from the pilot test area.

To achieve the project objectives, the work has been divided into nine tasks, some are concurrent, while other tasks rely on completion of previous steps. The operator, Calumet Oil Company operates several field in Osage County Oklahoma. The North Burbank Unit will be the site of the test. The team will then determine where within the field to optimally locate the vibration test well. With the location determined, the test well will be drilled, cored, logged and 7" production casing run and cemented.

In a parallel effort, OGCI will be designing, building, and testing a new version of the downhole vibration tool based on their patented and field proven whirling orbital vibrator. With the field test tool built to run in 7" casing. Reliability testing of the downhole tool and surface power source will be conducted in nearby field operated by Calumet Oil Company.

After the core is recovered, Phillips Petroleum Company will be conducting laboratory tests utilizing their proprietary sonic core apparatus to determine fluid flow response to a range of vibration frequencies. These results, in turn, will allow final adjustments to the frequency generation mechanisms of the downhole vibration tool.

One or more offset wells, near to the vibration test well, will be equipped with downhole geophones and or hydro-phones to determine the strength of signal and if the producing formation has a characteristic resonant frequency response. Surface geophones will also be set out and arranged to pick up the signal generated by the downhole vibration tool.

The downhole vibrator will be installed in the test well. Monitoring the production and injection for the pilot test area will continue. As the frequency of the downhole tool is changed, the recording of seismic signals, both on the surface and downhole, will also be conducted. The results of the data collection will be a matrix of varying vibration stimulation conditions corresponding to changes in production fluid rates and seismic responses.

The report on the results of the downhole vibration stimulation will be prepared and delivered using several venues. Technical papers will be submitted to the Society of Petroleum Engineers. Workshops are planned to be held for operators in Osage County and surrounding areas. A dedicated technical session on vibration stimulation may be

offered at the 2002 SPE/DOE/IOR Conference, bringing together the world's experts in this emerging technology. The final task will be to close out the project.

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## **SUMMARY OF THE PROJECT PROGRESS**

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### **Contract Status:**

Under DOE advisement, the project activities began June 14, 2000, where as the contract was signed on July 13, 2000.

The Contract was amended February 28, 2001. The purpose of the amendment was to:

1. Add incremental funding to the full amount of \$ 525,750
2. Change the contracting officer from Rhonda Lindsey to Virginia Weyland both of the NPTO in Tulsa
3. Change the field and operator from "Blazer Field operated by Grand Resources, Inc. to the North Burbank Unit operated by Calumet Oil Company"

### **Financial status:**

Two advance requests for funding have been submitted and the requested total of \$181,160 has been received. As of March 31, 2001, \$147,771 has been dispersed with an additional \$25,000 committed for work in progress. Spending is behind schedule since the drilling operation has been delayed.

In kind contributions to date have totaled \$ 53,650.

### **Schedule Status:**

The project schedule had slipped approximately four months primarily due to changing operators and moving the field test. The test well has not yet been drilled since the test site field location have changed with the change of operators.

Currently, the well is scheduled to be drilled this summer. Other project critical path activities are being conducted simultaneously.

### **Technical Progress:**

Phillips completed sonic core tests on several "old" cores in the area of the proposed field tests. "Old" in this sense means cores that were drilled as much as 40 years ago and stored at ambient conditions in a warehouse, with no attempt to preserve the cores. The "old" Bartlesville sandstone cores from near the Blazer field were obtained from the Oklahoma Geological Survey Core and Samples Library in Norman OK. The results from the these cores was disappointing. When the discouraging results from the offset "old" cores to the Blazer field were discussed with Phillips, a comparison was made to the results Phillips had obtained from "old" cores from another Osage County field, the North Burbank Unit (NBU). Phillips had operated that field for years and had performed sonic

tests on several cores that had been obtained in the 1970s. The "old" Burbank cores had responded favorably to the sonic core tests.

The present operator of the NBU, Calumet Oil Company, was approached about performing the vibration stimulation test at the NBU rather than the Blazer Field, since the NBU has much better reservoir characteristics and the "old" cores had responded positively during the Phillips sonic core tests. Calumet was agreeable to the field test. Since the NBU is about 1000' deeper than the producing formation at the Blazer Field, Calumet has agreed to contribute the additional drilling costs as part of their in kind contribution.

The agreements with Calumet are nearly finalized and a request for the change of operator was included in Amendment A001 signed February 28, 2001, by the Richard Rogus, Contracting Officer

OGCI finished the design, and has begun building the 7 inch field test version of the downhole vibration tool (DHVT). In the course of improving the present tool design, a novel method of constructing the tool has been implemented. An invention disclosure was given to OGCI's patent attorneys and we plan to apply for a patent.

The notice to DOE patent attorneys per the grant contract will be filled in a timely manner, after which, details on the new tool configuration will be included in the following quarterly reports.

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## **DISCUSSION OF TECHNICAL PROGRESS**

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*THIS SECTION OF THE QUARTERLY REPORT REVIEWS IN DETAIL, THE PROGRESS MADE DURING THE QUARTER ON EACH OF THE PROJECTS MAJOR TASKS AND SUB-TASKS.*

### **TASK 1: DEFINE MOST APPROPRIATE TEST AREA**

*MEET AS TEAM TO REVIEW FIELD PRODUCTION HISTORY AND SCOPE POSSIBLE LOCATIONS.*

The field test location has been move to the North Burbank Unit (NBU) field which is operated by Calumet Oil Company. It is the largest field on the Osage Reservation. Calumet Oil Company is currently producing approximately 1200 BOPD and 160,000 BWPD from the NBU. Final agreements have yet to be signed, but already one meeting had occurred to begin the screening process for selecting the tests area within the NBU.

This is a field Phillips operated in the past and Phillips has conducted sonic stimulations tests on cores from this field with encouraging results ( See Task 3 for details).

*REVIEW WELL LOGS, PRODUCTION RECORDS ETC. AND DETERMINE A PROPOSED TEST WELL LOCATION*

The screen criteria for selecting the test location have been discussed and agreed upon in first meeting with Calumet on this project these are follows:

- The area should have good net pay but low initial production tests. These areas
1. should have wells which may not have been flooded as thoroughly as wells with good thickness and high initial production tests
  2. The area should be serviced by a single tank battery, this will reduce complications when testing the wells and determining changes in oil production
  3. The area should have been under flood with the same pattern for at least one year, this will aid in establishing a solid baseline for production profiles prior to initiating the vibration simulation

*MEET TO DEFINE DRILLING LOCATION*

The meeting to discuss the test well location in the NBU has not yet taken place.

*Report to Osage Tribal Representatives of project plans*

On March 13, 2001, a request to present the project status at the April 18, 2001 at the Osage Tribal Council Meeting. The presentation will use much of the material used for the Society of Petroleum Engineers (SPE) Oklahoma City, Production Operations

Symposium presentation of SPE Paper 67303.

## **TASK 2: DRILL AND CORE TEST WELL**

### *PREPARE THE WELL PLAN AND PERMIT THE WELL*

The permit for the NBU test well has not been submitted

### *BID THE DRILLING RIG AND SERVICES*

Drilling contractors were contacted and bids procured by Calumet Oil Company. Two contractors have been short listed, based on anticipated availability of their rigs which is late June 2001.

### *AWARD THE DRILLING AND SERVICE CONTRACTS*

The drilling contract and the related service contracts have not yet been let since the rig contract is still being negotiated.

### **WORK ON THESE SUBTASKS HAS NOT COMMENCED.**

#### *PREPARE LOCATION*

#### *DRILL, CORE, AND CASE WELL*

#### *REPORT TO OSAGE TRIBAL REPRESENTATIVES OF PROJECT PROGRESS*

## **TASK 3 : DEFINE, CONDUCT & EVALUATE LAB TESTS**

### *DEFINE SUITE OF LAB TESTS*

Phillips has conducted numerous lab tests using their sonic core test apparatus. They have observed that cores from different reservoirs as well as different cores from the same reservoir respond at different vibration frequencies. The response is measured when a core is vibrated at the unique frequency. The amount of fluid flowing through the core increases, while holding other variables being constant. Because Phillips was the former operator of the NBU, they have available "old" Burbank sandstone cores drilled in the 1970s, which they have tested in their sonic core test cell.

Phillips has tested the flow through the core with only formation water to determine brine permeability and also with a mixture of formation water and oil to test the effects of two-phase flow and vibration. Phillips has tested both the continuous application of vibration and intermittent vibration as a means to improve oil recovery from the cores. The methods Phillips determines to be most effective in applying vibration stimulation in the lab will be used during the field tests.

*REVIEW BURBANK SANDSTONE CHARACTERISTICS*

Parameter	Value	Units
Area	36.5	sq. miles
Avg Thickness	53.3	feet
Acre Ft	128,000	Acre feet
Depth	2850	feet
Stock Tank Oil Gravity	39	API Gravity
Reservoir Volume Factor	1.2	reservoir bbls/stock
Original reservoir Pressure	1,200	psia
Original GOR	380	cubic feet/barrel
Temperature	120	degrees Fahrenheit
Viscosity	3.3	centipoise
Produced Water Salinity	85,000	Parts per million
Average Porosity	16.8	percentage
Connate Water Saturation	26	percentage
Average Permeability	50-100	millidarcy

*REVIEW OF LITERATURE*

There have been numerous articles, papers and bulletins published on the Burbank Sandstone, a major producing formation in western Osage County. Many of the reports were generated as deliverables from DOE sponsored projects.

The following is a list of publications which has been prepared by the NPTO technical library in Tulsa providing information on the many reports concerning DOE sponsored work in the North Burbank Unit.

Project Title: "Enhanced Oil Recovery with Downhole Vibration Stimulation"  
 Contract number: DE - FG2600BC 15191

CONTRACTOR	NPTO PUB ID	TITLE	PUBDATE
Phillips Petroleum Company	BERC/TPR-76/2	North Burbank Unit Tertiary Recovery Pilot Test	1-Jul-76
Phillips Petroleum Company	DOE/ET/13067-15	North Burbank Unit Tertiary Recovery Pilot Test-, Annual Report, May 1975-May 1976, 170 pp.	1-Jul-76
	BERC/TPR-77/5	North Burbank Unit Tertiary Recovery Pilot Test, Annual Report, May 1976-May 1977	1-Aug-77
Phillips Petroleum Company	DOE/ET/13067-30	North Burbank Unit Tertiary Recovery Pilot Test-, Annual Report, May 1976-May 1977, 196 pp.	1-Aug-77
Phillips Petroleum Company	DOE/ET/13067-45	North Burbank Unit Tertiary Recovery Pilot Test, Annual Report	1-Aug-78
Phillips Petroleum Company	BETC/TPR-78/8	North Burbank Unit Tertiary Recovery Pilot Test, Annual Report, May 1977-May 1978	1-Aug-78
Phillips Petroleum Company	DOE/ET/13067-60	North Burbank Unit Tertiary Recovery Test Pilot, Final Report	1-Jun-80
Keplinger and Associates, Inc.	APPENDDOE/BC/10033-2	An Evaluation of the North Burbank Unit Tertiary Recovery Pilot Test, Topical Report	1-Aug-82
Keplinger and Associates, Inc.	DOE/BC/10033-2	An Evaluation of the North Burbank Unit Tertiary Recovery Pilot Test, Topical Report	1-Aug-82
National Institute for Petroleum and Energy Research	NIPER-128	Comparison of a Finite-Difference Simulation with the Results from a Simplified Predictive Model Using Data from the North Burbank Chemical Flood Project, Topical Report	1-Nov-85
BDM-Oklahoma, Inc.	DOE/PC/91008-0376	An Exploration 3-D Seismic Field Test Program in Osage County, Oklahoma, Final Report, October 1998, 73 pp. (ORIGINAL REPORT # NIPER/BDM-0376)	1-Feb-99
BDM-Oklahoma, Inc.	DOE/PC/91008-0278	Mineral Resource Information System for Field Lab in the Osage Mineral Reserve Estate, Topical Report, September 1996, 162 pp. (ORIGINAL REPORT #: NIPER/BDM-0278)	27-Apr-99
BDM-Oklahoma, Inc.	DOE/PC/91008-0252	Field Laboratory in the Osage Reservation-- Determination of Status of Oil and Gas Operations, Status Report, May 1996, 3 pp. (ORIGINAL REPORT #: NIPER/BDM-0252)	27-Apr-99
BDM-Oklahoma, Inc.	DOE/PC/91008-0172	Field Laboratory in the Osage Reservation-- Determination of the Status of Oil and Gas Operations: Task 1. Development of Survey Procedures and Protocols, Status Report, September 1995, 45 pp. (ORIGINAL REPORT # NIPER/BDM-0172)	27-Apr-99

- *CONDUCT LAB TESTS*

Phillips completed sonic core tests on several "old" cores in the area of the proposed field tests. "Old" in this sense means cores that were drilled as much as 40 years ago and stored in warehouse ambient conditions, with no attempt to preserve the cores. The "old" Bartlesville sandstone cores from near the Blazer field were obtained from the Oklahoma Geological Survey Core and Samples Library in Norman OK. The results from the these cores was disappointing.

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**WORK ON THESE SUBTASKS HAS NOT COMMENCED.**

*EVALUATE LAB TEST RESULTS FOR FREQUENCY AND AMPLITUDE  
MEET TO REVIEW LAB TEST RESULTS & BRACKET FIELD TEST FREQUENCIES/AMPLITUDES  
REPORT TO OSAGE TRIBAL REPRESENTATIVES ON PROJECT PROGRESS*

**TASK 4 : DESIGN AND CONSTRUCT DOWN HOLE VIBRATION TOOL AND  
SURFACE POWER SOURCE**

*FRONT END SOURCE ENGINEERING - SELECT MOST APPROPRIATE POWER SOURCE*

Completed. A surface rod-rotating system will be used to power the DHVT.

*ENGINEER SOURCES TO SPECIFICATIONS*

Three steps to this subtask have been used to develop a robust and reliable downhole tool.

1. Conceptual Prototype. Completed.

2. Precision Prototype

An engineering design review was commissioned and completed for the precision prototype. This design review has been used in setting the

specifications for the field test version of the downhole vibrator.

### 3. Field Test Tool Design

The specifications for the field test version of the downhole vibrator to run in the 7" casing of the test well have been determined and drawings for manufacturing are complete.

#### *CONSTRUCT TOOL(S) & SOURCES*

The field test tool is designed to use 'off the shelf' items from downhole tool manufacturers including the slip mechanisms. The machine shop which will be used to construct the custom items has ordered the required material. They will assemble the 7" DHVT those with the standard items such as springs, bearings and seals.

#### *SURFACE TEST TOOLS*

The surface testing of the field test tool in conjunction with the power source life testing will be done at one of Calumet's field locations near the NBU Field.

#### *CONDUCT POWER SOURCE LIFE TEST*

Plans are being finalized to conduct the power source life testing of the field test tool and the rod rotating system in one of Calumet's wells (see above paragraph).

#### *REPORT TO OSAGE TRIBAL REPRESENTATIVES ON PROJECT PROGRESS*

This sub task has not yet been performed.

## **TASK 5 : INSTRUMENT TEST WELLS**

**WORK ON THIS TASK HAS BEEN PUT ON HOLD UNTIL THE NEW PILOT TEST AREA HAS BEEN SELECTED.**

At the suggestion of Ernie Majors, LBNL, the planning for this task was put on hold until the new pilot test area in the NBU is selected.

#### *ENGINEER SEISMIC MEASUREMENT SYSTEM*

#### *SPECIFY SEISMIC MEASUREMENT SYSTEM*

#### *INSTALL SEISMIC MEASUREMENT SYSTEM*

#### *REPORT TO OSAGE TRIBAL REPRESENTATIVES ON PROJECT PROGRESS*

**TASK 6 : CONDUCT FIELD VIBRATION STIMULATION TESTS**

**WORK ON THIS TASK HAS NOT COMMENCED.**

**TASK 7 : REPORT FIELD TEST RESULTS**

**WORK ON THIS TASK HAS NOT COMMENCED.**

**TASK 8 : TECHNOLOGY TRANSFER, PUBLICIZE TEST RESULTS**

*WRITE & SUBMIT SPE PAPER ABSTRACT: Completed*

*AUTHOR SPE PAPER*

The paper was submitted on January 10, 2001. SPE paper 67303 was given at the Production Operations Symposium (POS) in Oklahoma City, OK on March 27, 2001. The PowerPoint file used in that presentation is included on the CD ROM used to submit this report electronically.

*ESTABLISH A SPE/DOE/IOR 2002 SYMPOSIUM VIBRATION ENHANCED PRODUCTION WORKSHOP*

The topic of providing a one-day workshop at the SPE/DOE/IOR 2002 Symposium has been discussed at the planning meetings of the committee chairs for the symposium. The concept was positively received and will be voted on during April.

Potential course instructors include Peter Roberts, LANL, Ernie Majors LBNL, Bill Wooten, Applied Seismic Research and Bob Westermarck, Seismic recovery who will discuss the DOE project.

**WORK ON THE SUBTASKS LISTED BELOW HAS NOT COMMENCED.**

*PREPARE VIBRATION ENHANCED PRODUCTION WORKSHOP  
PUBLICIZE VIBRATION ENHANCED PRODUCTION WORKSHOP - PTTC, OIPA, BIA,  
CONDUCT BIA, TRIBAL COUNCIL AND OSAGE COUNTY OPERATORS VIBRATION ENHANCED  
PRODUCTION WORKSHOP DATE TBD  
CONDUCT DOE/IOR/SPE CONFERENCE VIBRATION ENHANCED PRODUCTION WORKSHOP  
DATE TBD  
CONDUCT PTTC OK CITY VIBRATION STIMULATION WORKSHOP  
CONDUCT PTTC /U OF KANSAS VIBRATION ENHANCED PRODUCTION WORKSHOP DATE  
TBD*

Project Title: "Enhanced Oil Recovery with Downhole Vibration Stimulation"  
Contract number: DE - FG2600BC 15191

*AUTHOR DOE CONFERENCE PRESENTATION DATE TBD  
PRESENT DOE CONFERENCE PAPER DATE TBD  
PRESENT DOE/BIA CONFERENCE PAPER DATE TBD*

**TASK 9 : FINISH AND CLOSE OUT PROJECT**

**WORK ON THIS TASK HAS NOT COMMENCED.**