THIRTEENTH QUARTERLY PROGRESS REPORT

TITLE:

THE UTILIZATION OF THE MICROFLORA INDIGENOUS TO AND PRESENT IN OIL-BEARING FORMATIONS TO SELECTIVELY PLUG THE MORE POROUS ZONES THEREBY INCREASING OIL RECOVERY DURING WATERFLOODING

COOPERATIVE AGREEMENT NUMBER:

DE-FC22-94BC14962

RECIPIENT:

Hughes Eastern Corporation
Mtel Centre South Building
200 South Lamar Street, Suite 1050
Jackson, MS 39201

DATE OF REPORT:

April 20, 1997

AWARD DATE:

January 1, 1994

ANTICIPATED COMPLETION DATE:

June 30, 1999

GOVERNMENT AWARD:

\$286,168 (Current Year DOE Share)

PROGRAM MANAGER:

James O. Stephens
Hughes Eastern Corporation

PRINCIPAL INVESTIGATORS:

Lewis R. Brown
Mississippi State University

Alex A. Vadie
Mississippi State University

CONTRACTING OFFICER'S REPRESENTATIVE:

Martin J. Byrnes (412) 892-4486
U.S. Department of Energy
Federal Energy Technology Center
P.O. Box 10940 MS 921-118
Pittsburgh, PA 15236-0940

DOE PROJECT OFFICER:

Rhonda P. Lindsey
U.S. Department of Energy
Bartlesville Project Office
P.O. Box 1393
Bartlesville, OK 74005

REPORTING PERIOD:

January 1, 1997 - March 31, 1997

US/DOE Patent Clearance Provided on April 10, 1997 by Mark Dvorscak DOE Chicago Field Office

THIRTEENTH QUARTERLY PROGRESS REPORT

OBJECTIVE

The objective of this work is to demonstrate the use of indigenous microbes as a method of profile control in waterfloods. It is expected that as the microbial population is induced to increase, that the expanded biomass will selectively block the more permeable zones of the reservoir thereby forcing injection water to flow through the less permeable zones which will result in improved sweep efficiency.

This increase in microbial population will be accomplished by injecting a nutrient solution into four injectors. Four other injectors will act as control wells. During Phase I, two wells will be cored through the zone of interest. The core will be subjected to special core analyses in order to arrive at the optimum nutrient formulation. During Phase II, nutrient injection will begin, the results monitored, and adjustments to the nutrient composition made, if necessary. Phase II also will include the drilling of three wells for post-mortem core analysis. Phase III will focus on technology transfer of the results. It should be pointed out that one expected outcome of this new technology will be a prolongation of economical waterflooding operations, i.e. economical oil recovery should continue for much longer periods in the producing wells subjected to this selective plugging technique. Results from work under DOE Contract No. DE-AC22-90BC14665 will be incorporated as appropriate.

SUMMARY OF TECHNICAL PROGRESS

Phase I. Planning and Analysis

The concepts for the new technology to be evaluated in this project are scientifically sound and have been proven to be effective in laboratory experiments. Nevertheless, it is necessary to perform laboratory tests on live cores from the reservoir of interest. Two wells will be drilled for this purpose and special core analyses will be conducted in order to fine tune the exact concentration of, and schedule for, additions of nutrients to the injection water.

While the main purpose for drilling the two wells is to obtain cores suitable for use in the laboratory work, a secondary purpose is to obtain production data which will indicate the sweep efficiency of the existing waterflood. At the conclusion of Phase I, a specific feeding regime will have been formulated for each of the injection wells. Since the injection wells all vary in terms of years of service, differences in channeling are anticipated and a different feeding regime may be needed for each well.

The work for Phase I of the project has been divided into seven tasks as described below.

Task 1.1: The Drilling of Two New Injection Wells for the Acquisition of Cores and Other Data.

Completed

Task 1.2: On-Site Handling of Cores

Completed.

Task 1.3: Core Analysis to Determine MEOR Requirements

Completed.

Task 1.4: Microbial Analyses of Cores

Completed.

Task 1.5: Laboratory Waterflooding Test of Live Cores

Completed.

Task 1.6 Acquisition of Baseline Data

Acquisition of baseline data has been completed.

Task 1.7: Analysis of Baseline Data

The analysis of baseline data has been completed.

Phase II: Implementation

This phase involves initiation of nutrient injection and the analysis of results.

Task 2.1 Design of Field Demonstration

Completed

Task 2.2 Drill Three Additional Wells

As reported in the Twelfth Quarterly Progress Report, three wells were drilled in the last quarter of 1996. The NBCU 2-5 No. 2 well was put on rod pump in mid-January and initially pumped 1.4 m³/day of oil (9 BOPD) and 43.4 m³/day of water (273 BWPD) with 991 m³/day of gas (35 MCFD). During March the well tested an average of 1.1 m³/day of oil (7 BOPD) and 26.7 m³/day of water (168 BWPD).

The NBCU 2-13 No. 2 was also placed on rod pump during January and initially pumped 2.9 m³/day of oil (18 BOPD) and 6.7 m³/day of water (42 BWPD) with negligible gas production. During March the well tested an average of 3.5 m³/day of oil (22 BOPD) and 1.7 m³/day of water (11 BWPD).

The NBCU 2-11 No. 3 continued to flow throughout the first quarter, but was put on rod pump the first week of April. In mid-January the well flow tested 2.9 m³/day of oil (18 BOPD), 113 m³/day gas (4 MCFD) and 34 m³/day of water (214 BWPD) with 586 kPa (85 psi) flowing tubing pressure. However, by the end of the quarter the oil rate had fallen to 0.3 m³/day of oil (2 BOPD) with 36 m³/day of water (226 BWPD). It is believed the well will produce at a higher oil cut if it can be produced in a "pumped off" condition which would put more drawdown on unswept, high oil cut portions of the sand. The diamond core recovered from the well indicated some portions of the sand to be better swept by water than other portions.

Task 2.3 Reservoir Characterization

Petrophysical studies of recovered core sample from the 3 newly drilled wells are in progress.

Task 2.5 Analysis of Results

Monthly collection of produced fluids from the test and control wells in all patterns continued with the following tasks performed,

- (1) Aliphatic profile (Gas chromatographic analysis),
- (2) API gravity and absolute viscosity under reservoir temperature,
- (3) pH of produced water,
- (4) Surface tension (ST) of produced water (water-air),
- (5) Interfacial tension (IFT) for produced oil-water system,
- (6) Microbiological population,
- (7) Inorganic analyses (nitrate, phosphate, sulfate, sulfide, chloride, potassium, and hardness).

Production data on all wells in all patterns continue to be evaluated and the trends reported in the last quarterly report are continuing.

Analyses of sections of cores from the newly drilled wells is continuing. Thus far nitrate ions and phosphate ions have been found in 80% and 22%, respectively, of the samples examined.

A preliminary electron microscopic examination of samples of five sections of core from each of the three newly drilled wells has been conducted and microorganisms have been found in three, one, and two, sections of wells 2-5 No. 2, 2-13 No. 2, and 2-11 No. 3, respectively. X-ray diffraction analyses of the above mentioned core samples has not shown the presence of barium in any of the specimens.

REFERENCES AND PUBLICATIONS

PLANS FOR NEXT QUARTER

Monitoring of the influent of the injector wells and effluent from the production wells including the three newly drilled wells, will continue.

Analyses of cores from newly drilled wells will continue and will be expanded to include gas chromatographic and x-ray diffraction analyses.