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:

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RECIPIENT:

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Jackson, MS 39201

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NINTH 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**

Chemical and microbiological analyses of injection water and production fluid are continuing and have been expanded to include all four patterns. Test patterns (control and test) involves eight injectors, 23 producers, and 2 newly drilled wells. Routine tests being conducted on the water are calcium carbonate, chloride, nitrate-nitrogen, phosphate, potassium, sulfate, sulfide, aerobic heterotrophs, anaerobic heterotrophs, aerobic oil-degrading bacteria, and anaerobic oil-degrading bacteria. Routine tests on oil are aliphatic profile, gravity, viscosity, surface and interfacial tension. Test data received from Hughes Eastern Corporation for wells located in all patterns (test and control) were entered into the database for GOR, and WOR calculation.

Task 1.7:**Analysis of Baseline Data**

The analysis of baseline data is continuing.

Phase II:**Implementation**

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

Task 2.1**Design of Field Demonstration**

The design of the nutrient injection skids and initiation of nutrient injection were completed and reported in a previous Quarterly Progress Report. During the current quarter, nutrient injection continued with few problems. The test pattern waterflood injection rates vary from 330 BWPD in the 34-9 No. 2 well (Test Pattern 2) to 700 BWPD in the 11-5 No. 1 well (Test Pattern 3). Test Patterns 1 and 3 receive nutrients consisting of potassium nitrate and monosodium hydrogen phosphate while Test Patterns 2 and 4 receive molasses in addition to the other nutrients. Test Patterns 1 and 3 exhibit a downward trend in injectivity which may indicate microbial growth causing permeability restriction. The other two test patterns are injecting at a relatively constant rate. Consistent increases in oil production have occurred in some wells.

During March a project coordination meeting was held to discuss changes to the nutrient injection schedule which might speed the microbial process. It was decided that an increased rate of molasses addition would result in the greatest response per volume of nutrient injected. Effective April 1, 1996, the molasses injection rate in Test Pattern 4 (NBCU 2-6 No. 1) is to be increased to 35 gallons per week and the mid-week phosphate injection in Test Pattern 1 (NBCU 2-14 No. 1) is to be replaced by 35 gallons of molasses. The increased molasses injection will provide a carbon source for the microbes which is more easily metabolized than crude oil.

Analysis of produced water in Test Pattern 1 continues for detection of the Tritium tracer injected on April 27, 1994. To date the tracer has been detected in the 2-13 No. 1 and 11-3 No. 1 wells.

Task 2.3**Reservoir Characterization**

Petrophysical studies of recovered core sample from newly drilled wells are continuing.

Chemical and microbiological analyses are continuing on samples from wells in all patterns. Gas chromatographic data from all patterns continue to be evaluated for evidence of microbial activity. Also, nitrate-nitrogen, found in the fluid from one of the test wells as reported last quarter, has not been found in any more samples and therefore is not considered significant. Nitrate-reducing organisms should be stimulated by the nutrient additions and indeed are still being found in samples from several of the wells in the first two test patterns, but also in some injection water samples and therefore is of questionable significance. Tests for this physiological group of microorganisms are now being conducted monthly. Other chemical, microbiological, and petrophysical parameters of fluids from injector wells (8) and producer wells (25) are still being monitored. To date, none of the parameters being monitored by laboratory analyses have demonstrated changes that definitely can be attributed to microbial activity in the reservoirs.

It was decided to carry out coreflood experiments in the laboratory that parallel the feeding regimes now being employed in the field, particularly since the amount of nutrients has been increased. Six new core plugs were prepared from the last remaining cores obtained from the recently drilled well (34-3-No.2). The core plugs are being monitored with emphasis on flow rate through the plugs.

REFERENCES AND PUBLICATIONS

A manuscript entitled "Utilization of Indigenous Microflora in Permeability Profile Modification of Oil Bearing Formations " by A. Alex Vadie, James O. Stephens, and Lewis R. Brown, has been submitted for presentation at the SPE/DOE Tenth Symposium on Improved Oil Recovery to be held in Tulsa, OK, Apr. 22-24, 1996.

PLANS FOR NEXT QUARTER

Monitoring of the influent of the injector wells and effluent from the production wells will continue.

Laboratory coreflood experiments will continue.