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NEW TECHNOLOGY FOR SULFIDE REDUCTION AND INCREASED OIL RECOVERY

SECOND QUARTER PROGRESS REPORT

December 20, 1998

Project work was initiated by Geo-Microbial Technologies, Inc. (GMT), Ochelata, Oklahoma for Contract Number DE-FG01-97EE15659 on June 18, 1997. The purpose of this project is to demonstrate reduction of sulfide contamination, as well as possible improvement of production in oil and gas production systems. This will be accomplished by application of the BioCompetitive Exclusion (BCX) process developed by GMT. A broad spectrum of well types and geographical locations is anticipated.

The BCX process is designed to manipulate indigenous reservoir bacteria with the addition of synergistic inorganic chemical formulae. These treatments will stimulate growth of beneficial microbes, while suppressing metabolic activity of sulfate reducing bacteria (SRB), the primary source of harmful sulfide production.

Second Quarter Progress

To date, the following projects have been initiated and are in progress:

West Texas - 10 production wells; weekly treatments for reduction of H₂S and FeS, and possible increase in oil and/or gas production.

Wyoming - 1 production well project to demonstrate the effect of large monthly treatments on H₂S/FeS and production.

Northwest Kansas - To demonstrate the effect on injection pressure by periodically treating an injection well.

Southwest Kansas - To demonstrate the effect of weekly treatments on 6 gas wells for the purpose of reducing H₂S. This project was initiated in June, 1997, and is continuing. Results are guiding us to try other treatment methodologies in order to achieve even better results.

Northeast Oklahoma - Periodic treatments of a waterflood injection well to demonstrate the effect on oil production from 4 production wells that are influenced by the injector.

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North Central Oklahoma - Weekly treatment of 1 production well for reduction of H₂S/FeS.

California - Multiple treatment strategies on 6 production wells to reduce H₂S/FeS and possibly affect oil and/or gas production.

All field data, both pre-treatment baseline and post-treatment monitoring have been and continue to be recorded and evaluated by GMT. Graphical representation of data indicates the need for any adjustments in treatment protocol and the relative success of the treatment process. These graphs will be presented at the conclusion of each project.

Laboratory work, field sampling and treatments, and monitoring have intensified throughout each project, and will enable us to evaluate the effectiveness of the BCX process in a variety of field environments.

Technology Transfer Activities

Plans are completed for GMT's Director of Field Operations, Mike Dennis, to attend the 8th Annual Produced Water Seminar in League City, Texas, January 15 - 16, 1998. Discussions with several national oil field service organizations are held for the purposes of initiating a new business venture to market the BCX technologies. Working with the Rocky Mountain Oilfield Testing Center (RMOTC) with new tests and with promotional literature (see attached handout) describing the BCX project.

FIELD APPLICATIONS™

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The Biocompetitive Exclusion Process Controls Iron and Hydrogen Sulfides

Product Developer: Geo-Microbial Technologies, Inc.

► THE PROBLEM

Reservoirs that produce hydrogen sulfide (H_2S) and iron sulfide (FeS) can cause significant production problems and safety hazards for producers. Hydrogen sulfide gas in even relatively small concentrations can be deadly when encountered unexpectedly in the field. It can also cause rapid corrosion of downhole and surface equipment.

Iron sulfide scale often causes restricted production by plugging flow paths in the reservoir, perforations, pump intakes, and tubulars. This problem may be especially acute in reservoirs flooded with water containing significant sulfates. The influx of sulfate can stimulate indigenous sulfate reducing bacteria (SRB), which metalolize the sulfate into hydrogen sulfide gas. The hydrogen sulfide then reacts with metallic compounds such as iron to form iron sulfide, which appears as a black scale.

Producers often use hydrochloric acid treatments to clean up iron sulfide scale. These treatments can produce deadly H_2S gas and are usually expen-

sive. If water disposal systems are required to handle sour produced water, the maintenance costs will increase even further as the pumps, filtration systems, injection lines, and injection wells are attacked by sulfide scale and corrosion.

► THE SOLUTION

Geo-Microbial Technologies, Inc. has developed a field treatment to reduce or eliminate iron sulfide and hydrogen sulfide problems in producing oil wells. In this process, called Biocompetitive Exclusion, proprietary blends of inorganic salts are introduced into the reservoir as a nutrient to the denitrifying bacteria (DNB), which causes these bacteria to flourish and denies essential nutrients for SRB metabolic action. The process produces by-products commonly used for improved oil recovery.

Geo-Microbial Technologies and RMOTC tested the Biocompetitive Exclusion process at the RMOTC field testing site (Naval Petroleum Reserve No. 3). The wells tested with the treatment demonstrated the technical and economic success of the Biocompetitive Exclusion process.

Treatment of RMOTC producing wells demonstrated that the biocompetitive exclusion process can significantly reduce hydrogen sulfide (H_2S) gas and iron sulfide scale to provide a safer working environment and reduce operating costs.

► THE BENEFITS

The Biocompetitive Exclusion process provides several benefits:

- Simple treatment and sustainable results.
- Reduced H_2S gas and FeS deposits.
- Reduced corrosion and increased life of production equipment.
- Potential of improved recovery from wells with significant damage.
- Improved safety in handling well fluids and servicing wells.
- Reduced cost compared to conventional treatments with biocides, corrosion inhibitors, and hydrochloric acid.

► THE FIELD PERFORMANCE

The RMOTC field was selected for testing the Biocompetitive Exclusion process because indigenous H_2S -generating bacteria were found in twenty Shannon Formation wells. In addition, the field production facilities were deteriorating from sour oil and gas production. During the RMOTC tests, a range of treatment practices, quantities, frequencies, and test wells were examined.

One test evaluated the effects of long-term treatment in a single well. Treatments on Well 72S10 were performed twice per week for 2.5 months using one gallon of nutrient

formula per treatment. The well was shut-in just before treatment, and nutrient formula was poured down the casing annulus. The well was then immediately placed back on pump.

At the start of treatment, the H_2S concentration in gas vented from the casinghead was 600 ppm. After one week of treatment, H_2S levels began to decrease, and after one month of treatment, H_2S levels did not rise above 10 ppm, as shown in the graph above. This sulfide suppression was likely caused by the establishment of dominant DNB populations which metabolize the sulfides.

Laboratory analyses of water samples showed that sulfates increased from 250 ppm before treatment to nearly 300 ppm during

treatment. This increase shows that treatment suppressed SRB populations, which reduced metabolism of sulfates into H_2S gas.

Before treatment, iron levels were in the 1 ppm range. During treatment, levels reached 4.29 ppm. After treatment stopped, iron levels decreased to below 1 ppm. The reduced iron concentration is the result of cleanup of iron sulfide by the DNB population.

► THE NEXT STEP

Additional testing of the Biocompetitive Exclusion process is planned to assess the potential for increasing production. The treatment tested at RMOTC has been commercialized as Max-Well 2000, which is available through The LATA Group, Inc. or Geo-Microbial Technologies, Inc.

The biocompetitive exclusion process suppressed H_2S gas over a 2.5-month period on a RMOTC producing well.

► FOR MORE INFORMATION:

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