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DE92 000703

# MICROBIAL FIELD PILOT STUDY

**CONTRACT DE-FG22-89BC14246**

University of Oklahoma
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**CONTRACT DATE**
November 22, 1988

**ANTICIPATED COMPLETION**
June 30, 1992

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**REPORTING PERIOD**
April 1, 1991 - June 30, 1991

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## OBJECTIVE

The objective of this project is to perform a microbially enhanced oil recovery field pilot test in the Southeast Vassar Vertz Sand Unit (SEVVSU) in Payne County, Oklahoma. Indigenous, anaerobic, nitrate-reducing bacteria will be stimulated to selectively plug flow paths which have been preferentially swept by a prior waterflood. This will force future flood water to invade bypassed regions of the reservoir and increase sweep efficiency.

## SUMMARY OF TECHNICAL PROGRESS

### CHEMICAL, PHYSICAL AND MICROBIOLOGICAL PROPERTIES OF BRINE SAMPLES FROM WELLS 5-1, 5-2, 7-1, AND 7-2

The analysis of the brine provides important data about chemical composition and physical properties of brine and indigenous microorganisms present in the reservoir. This information is important when designing a suitable nutrient injection for stimulating the growth and metabolism of useful microorganisms.

#### Methods

Brine samples were collected from Wells 5-1, 5-2, 7-1 and 7-2 respectively using sterile techniques. The pH, temperature and sulfide analysis were performed on site.

Total carbohydrate content in brines was analyzed using Anthrone reaction (Manual of Methods for General Bacteriology ASM). Ammonia, phosphate and nitrate were analyzed with chemical kits

(Bacuettes of CHEMetrics, Inc.). Nitrite was analyzed using Hach chemical analysis kits. Volatile fatty acids were analyzed using gas chromatography.

Surface tension of the brines were measured using a surface tensiometer with water as the control.

Sulfate reducing bacteria, molasses-nitrate using bacteria, anaerobic heterotrophic bacteria and aerobic heterotrophic bacteria were enumerated as previously described (Knapp, et al., 1990). Tubes were incubated at 35°C and checked weekly for growth for 8 weeks until no more growth was observed.

**Results**

Chemical components, volatile fatty acids, and surface tension of the brines from Wells 5-1, 5-2, 7-1 and 7-2 are shown in Table 1. Carbohydrates, phosphate, nitrite, nitrate, acetate, butyrate and propionate were not detected in the brines. However, a low concentration of ammonia was detected in brine from each well. The brine from well 5-1 had the lowest surface tension of 59mN/m. The brine from well 7-2 had the highest surface tension of 68.7 mN/m, a difference of 9.3 mN/m.

Table 2 shows the results of bacterial analysis. The growth of aerobic bacteria in brines from well 5-1, 5-2 and 7-1 was observed at $10^{-1}$ dilution, only the brine from well 7-2 showed growth at $10^{-2}$ dilution. Growth of sulfate-reducing bacteria and molasses-nitrate-using bacteria in brine from well 5-1 was observed at $10^{-5}$ dilution and anaerobic heterotrophic bacteria were detected

at the $10^{-4}$ dilution. Brine from well 7-1 showed growth at $10^{-1}$ dilution in SRB medium, at $10^{-3}$ dilution in molasses nitrate medium and at $10^{-2}$ dilution in plate count broth.

**Conclusion**

Molasses-nitrate using bacteria had the largest population in all brine samples. Next were sulfate-reducing bacteria, then was anaerobic heterotrophic bacteria. Aerobic heterotrophic bacteria had the lowest population in the brine samples.

The brine from well 5-1 had the largest population of molasses-nitrate using bacteria, sulfate-reducing bacteria and anaerobic heterotrophic bacteria among four brine samples. The next was the brine from well 5-2. The brine from well 7-1 had the lowest population of bacteria.

**SOUTHEAST VASSAR VERTZ SAND UNITS**

During the period of April 1 to June 30, 1991, the results of the pressure fall-off and interference test conducted the previous quarter were analyzed and a tracer test was run on the pilot area.

The pressure fall-off test was conducted by stopping fluid injection into well 7-2. Pressures at the well surface versus time were recorded. Pressures at wells 5-1, 5-2, and 7-1 were monitored to allow estimation of interference effects.

Analysis indicated a transmissibility for 7-2 of 2300 mD-ft. A negative skin of 2.7 was determined. Well 7-2 was fractured prior to putting it back in service. Considering the negative

skin, the rock permeability is approximately 60 mD. Interference analysis of the 7-1 well by a type curve match to an exponential integral solution yields an interwell transmissibility of approximately 700 mD-ft. Wells 5-1 and 5-2 indicated interwell transmissibilities of 550 and 650 mD-ft., respectively. Based on the 14 foot thickness of the Vertz sandstone in that region, permeabilities are 50, 39, 46 mD, respectively for the three producing wells. The interference test indicates average interwell permeabilities between the injection well and the producing wells.

On April 11, 500 gm. of sodium fluorescein, dissolved in 10.bbl of SEVVSU brine was injected into well 7-2 in 40 minutes. The pilot test production wells, 5-1, 5-2, and 7-1, were sampled daily for tracer arrival for a period of 14 days.

Figure 1 is a plat map of the SEVVSU. Because wells 7-3 and 7-5 were both injectors, and pilot injection and production were balanced, it was expected that water injected in the 7-2 would go toward the west. However, 14 days after tracer injection, samples taken from wells 1A-9, 1A-1, and 1A-5 showed the presence of sodium fluorescein. Precisely when the tracer arrived at these wells is not known. This remarkable result led to a review of the events associated with the field surrounding the pilot area. Prior to injection in well 7-2, wells 7-3 and 7-5 both had injectivities in excess of 200 bbls per day of water. Once injection in the 7-2 started, the 7-3 injection rate fell to 160 bbls per day and well 7-5 averaged less than 25 bbl per day. It appears that reduced injection in wells 7-3 and 7-5 left the 7-2 as one of the primary

injectors for the line drive waterflood.

To overcome this problem the pilot operating policy has been changed. Fluid injection and production had been balanced in the pilot region. Now, the production/injection ratio has been changed to 2 to 1. The resulting decrease in reservoir pressures to the west is expected to divert flow from the 7-2 towards the pilot production wells. Another tracer test is planned for the next quarter.

| Well | Temp | pH | Surface Tension (mN/m) | Chemical Composition (ppm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $S^{=}$ | Total C | $NH_3$ | $PO_4$ | $NO_3$ | $NO_2$ | Acetate | Butyrate | Propionate |
| 5-1 | 22°C | 7.0 | 59 | 75 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5-2 | 23°C | 6.5 | 64.7 | 2 | 0 | 35 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7-1 | 23°C | 6.5 | 66 | 25 | 0 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7-2 | 22°C | 6.8 | 68.7 | 3.5 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 |

**TABLE 1.** Chemical composition and physical properties of brine samples from Wells 5-1, 5-2, 7-1 and 7-2.

| | Medium | | | |
|---|---|---|---|---|
| | SRB | Molasses Nitrate | Anaerobic plate count broth | Aerobic plate count broth |
| Well 5-1 | 1500 | 4600 | 1100 | 2.3 |
| Well 5-2 | 4600 | 200 | 150 | 2.3 |
| Well 7-1 | 430 | 4600 | 42 | 2.3 |
| Well 7-2 | 2400 | 11000 | 90 | 2.3 |

**TABLE 2.** Population of sulfate-reducing bacteria, molasses nitrate using bacteria, anaerobic heterotrophic bacteria and aerobic heterotrophic bacteria in brines from Well 5-1, 5-2, 7-1 and 7-2. [Most probable number of bacteria per milliliter]

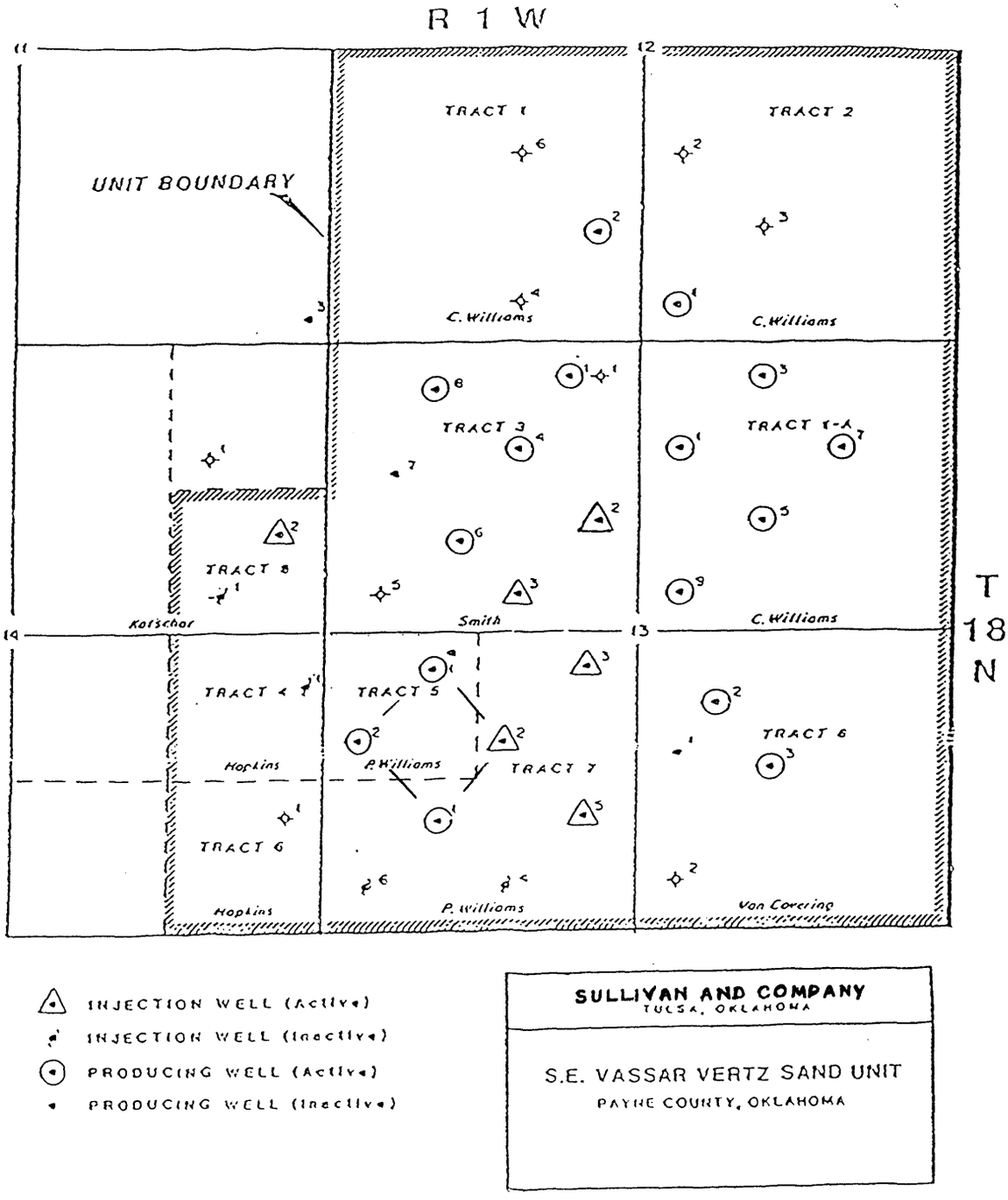


FIGURE 1 WELL SITES

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