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APPLICATION OF INTEGRATED RESERVOIR MANAGEMENT AND
RESERVOIR CHARACTERIZATION TO OPTIMIZE INFILL DRILLING

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Application of Integrated Reservoir Management and Reservoir Characterization to
Optimize Infill Drilling

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14181

FINA OIL & CHEMICAL COMPANY**QUARTERLY TECHNICAL PROGRESS REPORT****"APPLICATION OF INTEGRATED RESERVOIR MANAGEMENT AND
RESERVOIR CHARACTERIZATION TO OPTIMIZE INFILL DRILLING"****INSTRUMENT NO. DE-FC22-94BC14989 -22****NORTH ROBERTSON UNIT DEPARTMENT OF ENERGY
CLASS II OIL PROGRAM PROJECT****REPORTING PERIOD: 03/13/98 TO 06/12/98**

This Quarterly Progress Report summarizes the technical progress of the project from 03/13/98 TO 06/12/98.

ACTIVITY II. -MANAGEMENT AND ADMINISTRATION**PROJECT MANAGEMENT AND ADMINISTRATION - TASK II.1.1****Project Status**

The eighteen 10-acre infill wells which were drilled as part of the field demonstration portion of the project are all currently in service with no operational problems. These wells consist of fourteen producing wells and four injection wells. The producing wells are currently producing a total of approximately 376 bopd, down from a peak rate of 900 bopd. The four injection wells are currently injecting a total of 140 bwipd. Unit production is currently averaging approximately 2,600 bopd, 12,000 bwpd and 18,000 bwipd. Current individual production rates for the fourteen project producing wells is tabulated below:

<u>Well #</u>	<u>BOPD</u>	<u>BWPD</u>	<u>MCFPD</u>
505	21	69	6
1509	7	13	9
1511	38	62	22
2705	14	47	10
3017	21	7	9
3018	24	137	41
3319	38	7	60
3532	33	47	13
<u>Well #</u>	<u>BOPD</u>	<u>BWPD</u>	<u>MCFPD</u>

3533	35	128	10
3534	15	75	10
3535	44	117	20
3537	31	202	10
3538	25	63	12
3604	30	64	10

ACTIVITY II.2 - FIELD DEMONSTRATION

FIELD OPERATION & SURVEILLANCE - TASK II.2.2

Inter-Well Tracer Program

An inter-well tracer program was designed for the North Robertson Unit with the objective of obtaining critical information in regards to preferential (directional) fluid flow, breakthrough time between injectors and producers, and to evaluate the potential of direct communication between injector and producer. The wells selected for the tracer program are Wells #3539 & #1504. Samples are being taken at the six nearest offset producing wells to # 3539 and # 1504, which are Well Nos. 3522, 3526, 3533, 3535, 3537, and 3538; and Well Nos. 1506, 1507, 1509, 3010, 3014, and 3017, respectively. The goal in the selection of a tracer material for the injected water was to choose a tracer that would travel through the formation with the injected water and whose behavior would mimic that of the water. As discussed in previous reportings, there exists a number of good water phase tracers currently available, each having their own distinct advantages and disadvantages. However, for this project, it was decided to use tritiated water to trace the injected water.

Of the water phase radioactive tracers, tritiated water is the preferred material and is the standard by which all other tracers are judged. Since it is water, it has the exact flow properties of the injected water and, therefore, will behave analogous to the injected water in the formation. This means that there will be no lagging the flood front or holdup in the reservoir. In addition, tritiated water is a beta emitter, meaning that it gives off low energy radiation, thereby requiring only very thin shielding. In fact, in the concentrations found in the produced water during a tracer test, the radiation is so low that it will not penetrate a sheet of paper. Of the water phase radioactive tracers, tritiated water is the lowest cost, easiest to detect, and has an excellent record of successful use as a water phase tracer.

During the design process for the tracer program, sensitivities were performed to assure that the peak concentrations predicted at the producer wells never exceed the NPC unrestricted discharge limit for the subject tracer. In other words, the levels allowed by the NPC in drinking water. This guideline is used for both chemical and radioactive tracers. The end result is that tracer quantities were chosen so that the produced fluids will be nonhazardous and detection levels will be within an effective analytical range even when assuming wide variations in flow patterns.

The exact quantity of each tracer to be used is based on the distance between injectors and producers, the volume of injected water treated, the permeability distribution existing in the reservoir, the

analytical limits of the tracer and mixing which occurs in the reservoir. A streamtube type simulator, based on the work of Brigham, was used to model the flow of tracer in each formation layer. This streamtube simulator was used to calculate the amount of each tracer material required at the injector in each pattern area to result in a detectable concentration at the producing wells surrounding the subject injector.

The reservoir properties in each of the pattern areas were assumed to be the same except for the net and gross thickness of the Clearfork formation.

Based on previously discussed simulation and model runs, 1 curie of tritiated water was injected into Well #1504 and 3 curies injected into Well #3539. These volumes were estimated to allow for reasonable breakthrough times and still result in detectable tracer concentrations at the offset producing wells. The tritiated water was injected into both wells on March 24, and the sampling process was begun.

Sampling Program

Samples of the produced water were analyzed prior to injection of any tracer to obtain a background reading of existing chemicals in the reservoir. Following the injection of the tracer, samples of the produced water are being taken at predetermined intervals and analyzed for the presence of tracer. The samples will be taken from the six nearest offset producing wells surrounding each of the two injectors.

The following sampling schedule is being followed for the interwell tracer program:

Time (weeks)	Sample Frequency (per well)	Number of Samples (per well)
Base	1 sample	1
1	1 per day	7
2-4	3 per week	9
5-20	1 per week	16
21-78	2 per month	29

Total samples per well for 1.5 years: 62

The tracer will remain in the reservoir for an indefinite period of time. The presence of watered out intervals, fractures, poor cement bond, or faults in the field can lead to rapid breakthrough. For this reason it is extremely important that samples be taken frequently immediately after (if not during) tracer injection. Less frequent samples are necessary as time goes on.

Every third sample is being analyzed for detection of the tracer. If tracer is detected, then back samples will also be analyzed to determine the exact time of breakthrough. Following this schedule, there would be a total of 62 samples/ 21 analyses per well for the first 1.5 years.

As of the end of this reporting period, there have not been any indications of tracer breakthrough in any of the samples taken at the 12 project producing wells. Sampling is currently continuing as per the original schedule.

Magnetohydrodynamics

One of the major operational problems at the North Robertson Unit is the existence of paraffins and scales in both the produced and injected fluids. In an effort to reduce the amounts of both paraffin and scale in these fluids, magnetic fluid conditioning tools were placed in strategic locations to test their effectiveness in several different situations. In early March, tools were placed in the production string on 3 producing wells, Nos. 1203, 2228 & 604, on injection Well #3101, and on the 6" water transfer line running from Battery #3 to the central injection facility. Millipore filter tests were run prior to installation at these locations in order to monitor effectiveness. The first set of test data are provided at the conclusion of this section.

Paraffins in crude oil formations normally are in a liquid state, but precipitate from the crude when the equilibrium temperature and pressure change. As crude oil comes up the production tubing, the majority of cooling occurs in the flowing fluid as gas breaks out of solution. This cooling effect causes paraffin crystals to form in the flowing liquid. This is defined as the cloud point. Because of their often tacky nature, they adhere to and build up on tubing walls. Where flow lines are exposed to significantly colder outside temperatures, the pipe wall itself can also become a site for deposition.

Paraffin formation and deposition take place by four mechanisms: chemical, mechanical, electrical and thermal. A properly designed magnetic system can alter the chemical, mechanical, and electric properties of the crude as it passes through the magnetic fields. These changes have the effect of also altering the thermal (cloud point) mechanism.

Magnetic Fluid Conditioning tools work by directing fluids through strong permanent magnetic fields within the tool. This alters the physical characteristics of crude by increasing the solubility of the oil and decreasing the cloud point (up to 60 degrees F.), pour point and viscosity. The altered growth pattern of paraffin and scale crystals decreases the sediment and emulsions formed by the paraffin and water molecules locking together which in turn inhibits the buildup of solids in the well and production equipment.

Magnetic fluid conditioners, commonly referred to as only magnets, appear to affect the adhering properties of paraffin particles that form in the flowing oil. Paraffin particles formed in untreated oil appear to be gooey and tacky. Those in treated oil were more brittle and less tacky. The end result is a change in solubility and a lower cloud point (temperature at which paraffin starts to come out of solution). In addition, the temperature of deposition, viscosity, pour point are altered, all of which serve to inhibit paraffin and scale formation. A good analogy is to think of powder sugar and how it

tends to stick to everything but when it is clustered together to form granular sugar it tends to roll off surfaces.

As reported earlier, test data on the 6" transfer line from Battery #3 to the central injection station indicates that the magnets are performing fairly well. Prior to installation, the following volumes were measured on millipore tests using a standard .45 micron filter:

Jan 7 - 180 ml
Jan 8 - 240 ml
Jan 9 - 300 ml
Jan 23 - 200 ml
Mar 3 - 190 ml

Following the installation of the magnetic fluid conditioners, the following results were obtained:

April 6 - 410 ml
April 21 - 380 ml

Also, the pressure required to move fluids through this line from the battery to the injection facility has decreased approximately 10 psig since installation of the magnets.

The magnet installation on Injection Well # 3101 has apparently had no effect on performance. Injection rates and pressures have remained constant. However, one of the 3 producing wells which had the magnets installed in the production string had a rod part and required that the rods and downhole pump be pulled out of the hole. Surface inspection of the rod string indicated no presence of paraffin. In the past, this well has had severe paraffin problems.

PUBLICATIONS AND PRESENTATIONS - TASK II.4.3

Published Papers and Professional Meeting Presentations:

1997 Annual DOE/BDM International Reservoir Characterization Technical Conference, March 2-4, 1997, Houston, TX.

- Oral presentation and poster session on project material
- "Improved Characterization of Reservoir Behavior by Integration of Reservoir Performance Data and Rock Type Distributions."

Oklahoma Geological Society Circular, *Platform Carbonates in the Southern Mid-Continent*, (in press), K.S. Johnson, March 1997.

- "Environments of Deposition for the Clear Fork and Glorieta Formations, North Robertson Unit, Gaines County, Texas."

1997 DOE/BDM Annual Contractor Review Meeting, June 16-20, Houston, TX .

- Oral presentation

1998 PBS/SEPM Core Workshop, February 26, Midland, Tx.

- Display of core taken during DOE field demonstration

Several papers are currently being finalized for publication with the AAPG, publication dates unknown at this time.

**Paper on Core-Log modeling for Class II Projects, being published by BDM (Mike Fowler).
Publication date unknown.**