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**Integrated Approach Towards
The Application Of Horizontal Wells
To Improve Waterflooding Performance**

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Submitted by

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OBJECTIVES

The overall purpose of the proposed project is to improve secondary recovery performance of a marginal oil field through the use of an appropriate reservoir management plan. The selection of plan will be based on the detailed reservoir description using an integrated approach. We expect that 2 to 5% of the original oil in place will be recovered using this method. This should extend the life of the reservoir by at least 10 years.

The project is divided into two stages. In Stage I of the project, we selected part of the Glenn Pool field - Self Unit. We conducted cross bore hole tomography surveys and formation micro scanner logs through a newly drilled well. By combining the state-of-the-art data with conventional core and log data, we developed a detailed reservoir description based on an integrated approach. After conducting extensive reservoir simulation studies, we evaluated alternate reservoir management strategies to improve the reservoir performance including drilling of a horizontal injection well. We observed that selective completion of many wells followed by an increase in the injection rate was the most feasible option to improve the performance of the Self Unit. This management plan is currently being implemented and the performance is being monitored.

Stage II of the project will involve selection of part of the same reservoir (Berryhill Unit - Tract 7), development of reservoir description using only conventional data, simulation of flow performance using developed reservoir description, selection of an appropriate reservoir management plan, and implementation of the plan followed by monitoring of reservoir performance.

By comparing the results of two budget periods, we will be able to evaluate the utility of collecting additional data using state-of-the-art technology. In addition, we will also be able to evaluate the application of optimum reservoir management plan in improving secondary recovery performance of marginal oil fields.

Successful completion of this project will provide new means of extending the life of marginal oil fields using easily available technology. It will also present a methodology to integrate various qualities and quantities of measured data to develop a detailed reservoir description.

Summary of Technical Progress

During the last three months, we continued to implement the reservoir management plan in the Self Unit. Over the last three months, the production from the unit has increased up to 50 bbls/day (over 200% increase in the production). Based on the success so far, we will recomplete the other wells by the end of summer. For the Stage II of the project, we have expanded the scope of the project. Instead of concentrating only on Tract 7, we will evaluate all the areas currently operated by Uplands Resources. This way, we will be able to evaluate the best location for either multilateral or a horizontal well. The geological mapping is almost complete, and the geostatistical description and the flow simulation should start in early summer. Although not part of this project, we are conducting a 3-D seismic survey on the Glenn Pool Field. This should help us in better evaluating the channel sand structure.

Stage I Project Monitoring

Last summer, we started implementing the reservoir management plan in the Self Unit. Last quarter, after evaluating each individual well, we decided to install electrical submersible pumps to produce three wells. The production from the field improved significantly once the pumps are installed. Over the last three months, an average daily production has been approximately 50 bbls/day. Compared to a base line production of 13 bbls/day before the implementation, this is more than 200% increase in the production. Based on our current evaluation of the flow simulation results, we expect that the production from the unit should reach between 100 to 120 bbls/day once the implementation is complete.

Part of the reservoir management plan is to increase the water injection rate. We have installed the injection pump and have completed the piping to bring the water from the Arkansas river. We hope to have an increase in the water injection rate within two weeks.

Geological Mapping

During the first quarter of 1996, geology activities of the Glenn Pool project included continuation of Tract 7 study, evaluation of Tract 16, and field scale correlation.

A. Tract 7 Study

Tract 7 study focused on the revision of net sand isopach and facies maps for each DGI constructed for the Tract 7 and adjacent area (1.6 square miles) in the last quarter of 1995. This revision is necessary after the acquisition of additional well data. In addition, insights into the reservoir architecture of Bartlesville Sandstone gained from recent outcrop studies have greatly benefited this revision. In this version of facies architecture reconstruction, Bartlesville Sandstone (especially for DGI A-C) is less layer-cake than earlier believed. As a result of this observation, a thick and blocky sandstone within the top part of the Bartlesville Sandstone is more likely to be placed into one DGI rather than divided into more than one DGI's, resulting in DGI's A to C more channelized than the earlier interpretation.

The outcrop study has resulted in the recognition of a new facies for DGI F sandstone (about 40-50 ft thick). DGI F was interpreted as channel mouth bar deposits based on the Self 82 core characteristics and persistent blocky log shapes. Similar rocks have been observed in the lower part of Bartlesville Sandstone outcrops in the Eufaula Dam area. On the outcrop, these "massive" thick sandstones make lateral transition to cross-stratified and/or parallel-bedded thick sandstone. They are highly channelized, showing unidirectional paleoflow; they vary greatly in thickness according to the position relative to the channel thalwegs, and are made of many individual channels which are

stacked together and cut each other horizontally and vertically, resulting in a widespread distribution.

Thus, while the facies interpretation of DGI A to E is kept unchanged, DGI F is re-interpreted as braided-stream deposits. Facies interpretation for DGI G and H can not be done until the core study for these two intervals is completed.

Figure 1 through Figure 4 show as examples, the net sand isopach and facies map for DGI A, D, G, and H.

B. Tract 16 Evaluation

Tract 16, an 80-acre unit located immediately north of Self Unit, is being evaluated for horizontal drilling. However, the available development history record is not complete. Data survey has shown that at least 28 wells (maybe more) have been drilled in this unit (Figure 5), of which only 3 wells were logged, 9 wells show limited completion information, and the remaining 16 wells have no data. Currently none of the wells is active.

Based on the limited data available, initial geological analysis shows that DGI G and H sandstones are absent in the southern two-thirds part of the unit. DGI's A to C are the most likely potential for further oil recovery.

C. Field Scale Correlation

Field scale correlation is being performed for the purpose of broadening our understanding of larger scale variations of Glenn Sandstone and selecting a proper unit for horizontal drilling.

Detailed correlation to the DGI level is being conducted over an area of about 25 square miles, which covers the entire southern part of the Glenn Pool field, including all Uplands acreage and some immediately adjacent acreage. A total of 350 logs have been collected within the area. Thus far, correlation of these logs is approaching completion, showing that DGI's G and H are not as extensive as originally thought and the Bartlesville Sandstone thickens at the

expense of the underlying Savanna shale. Cross sections, structure maps and sandstone distribution maps for each DGI are being constructed to assist in selecting a proper location for horizontal drilling.

D. Near-Term Goals

1. Field scale evaluation
 - Stratal pattern of Bartlesville Sandstone in the southern part of the field: distribution of different DGI's.
 - Structure influence on the remaining oil/gas recovery: structure maps for different levels of Bartlesville Sandstone.
 - Selection of an appropriate reservoir unit for horizontal drilling.
2. Continuation of Tract 7 study
 - Construct the shale map to see the vertical separation between DGI's.
 - Analyze cores (if available) taken from the area adjacent to Tract 7, particularly for facies interpretation of DGI F to H.
 - Evaluate the petrophysical properties of each DGI based on the core data in Tract 7 and adjacent area.

Geophysical Interpretation

A. 3-D Survey

Acquisition has been completed on the first square mile of the 3-D seismic survey. The acquisition team has delivered the field data, notes and location map to Mercury International Tech for processing. The first task of converting the survey data into digital form is partially complete. From the work done so far, it is clear that the rest of the survey (10 square miles) must have digital positioning data at acquisition time. We estimate processing for the test square mile will require two to three weeks.

B. Anisotropy

Work continues on incorporating anisotropy into a seismic ray tracing computer program. This will give us a general tool for simulating, migrating and tomographically inverting seismic data.

Engineering Interpretation

Currently, we are concentrating on collecting the production and the well completion data from the property operated by Uplands Resources. The data collected are transformed into a data base which can be easily accessed for further processing. Once all the data are collected, the first step will be to compare the collected data with the geological map so that we will be able to evaluate which wells are completed in which geological DGI. This should allow us to identify potential areas with limited completions. The future work will include completing the data collection followed by a geostatistical description of the geological facies and the petrophysical properties. We currently have the program which can be used to simultaneously generate the geological and the petrophysical properties. We will then use the ECLIPSE simulator to flow simulate the performance and hence determine an appropriate reservoir management plan.

Technology Transfer Activities

Based on the results obtained during Stage I of the project, several presentations have been made to report the progress of our effort. We participated in the Traveling Workshop Series organized by the Petroleum Technology Transfer Council which demonstrated the success of various Class I projects to independent operators. Workshops at six places (Bartlesville, Oklahoma; Wichita, Kansas; Denver, Colorado; Billings, Montana; Oklahoma City, Oklahoma and Evansville, Illinois) were conducted. The response from small operators was very positive. We will also be presenting a paper on the reservoir management of the Self Unit for the Improved Oil Recovery Symposium which will be held in Tulsa, Oklahoma on April 22-24, 1996.

Net Sand Isopach and Facies Map, DGI A (Tract 7 & adjacent area)

Figure 1

CI=10ft

0 0.25 mile

Channel-fill sandstone

splay sandstone

flood plain mudstone

Net Sand Isopach and Facies Map, DGI D (Tract 7 & adjacent area)

Figure 2

CI=10 ft

0 0.25 mile

Channel-fill sandstone

splay sandstone

flood plain mudstone

Net Sand Isopach, DGI G (Tract 7 & adjacent area)

Figure 3

CI = 10 ft

0 0.25 mile

DGI G Sandstone

fSavanna Shale

(Tract 7 & adjacent area)

Figure 4

Cl= 10 ft

DGI H Sandstone

fSavanna Shale

Well Location Map for Tract 16, 21-17N-12E

(Note: there may be some other wells not shown in this map,
i.e. # 4, 14, 15, 16, ..., and so on.)

Figure 5

well with
completion data

well without
completion data

logged well

perforated
interval