

# Oil & Natural Gas Technology

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## Quarterly Report

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### Bridging the Gap between Chemical Flooding and Independent Oil Producers

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## TABLE OF CONTENTS

Executive Summary .....	1
Progress, Results and Discussion.....	1
Task 2: Identify and Select Candidate Reservoirs .....	1
Task 3: Design Efficient Chemical Formulations. ....	5
Milestone Status.....	5
Scheduling and Workload Issues .....	6

## LIST OF TABLES

Table 1 – Interview status with the top 30 companies for oil production in Kansas. ....	2
Table 2 – Selected leases for laboratory studies. ....	3
Table 3 – Information listed in TORP’s database of Kansas oilfields. ....	3

## **EXECUTIVE SUMMARY**

The task to identify, evaluate and select oil leases in Kansas that are favorable candidates for chemical flooding is progressing well. This is being accomplished through contacts and interviews with technical personnel from the oil production companies. Databases of oilfields and oil reservoirs in Kansas were prepared from public data but the databases did not aid in the identification of leases for chemical flooding applications. Five leases have been selected for laboratory studies to design chemical systems for flooding applications. Crude oil samples have been collected from three of the leases and laboratory testing on these oils was initiated.

## **PROGRESS, RESULTS AND DISCUSSION**

This research project will demonstrate the potential of “next generation” chemical flooding processes and will provide the design work that is necessary for Independent Oil Producers to make an informed assessment for implementation of a pilot or demonstration project. Laboratory testing is a major focus of the design process and this testing will be conducted to design proper chemical formulations for specific oils/reservoirs. Field response to chemical flooding will be determined through reservoir simulations. Economics of pilot/demonstration and field applications will be evaluated. Laboratory, simulation and economic results will be dispersed through technical papers and presentations to independent oil operators. Designs of chemical floods provide the basis for demonstration projects and a starting point for independent oil operators to implement the new chemical flooding technology. We anticipate government-sponsored field projects to demonstrate the benefits of new chemical flooding technologies to Independent Oil Producers.

The Project Management Plan was updated (Task 1) during the first quarter of the project. Progress on Tasks 2 and 3 accomplished during the second quarter of the project (Jan. –April 2009) are reported.

### **Task 2. Identify and Select Candidate Reservoirs**

The principle objective of Task 2 is the selection of approximately ten oil leases in Kansas for which laboratory studies will be conducted on the crude oils in the effort to design efficient chemical formulations for flooding applications. Two approaches were used to identify and evaluate potential leases/reservoirs: Personal contacts with technical employees of companies producing the largest amounts of oil in Kansas and an evaluation of a database of public information about Kansas oilfields. Personal contacts with personnel from the oil producers proved the best approach.

**Contacts with Oil Producers.** The remaining 15 of the top 30 oil producers in Kansas were contacted to discuss chemical flooding applications for their leases. The top 30 oil producers were determined using 2008 oil production figures from the Kansas Geological Survey. The top 30, from the 5,900 companies that produced oil in Kansas, produced more than 42% of the Kansas oil production in 2008 and that production was mostly in central and western Kansas. Eastern Kansas oil production was not represented by the top 30 and this issue is addressed below.

The status of our interviews with the top 30 oil producers is shown in Figure 1. Follow up interviews with six companies remain to identify and evaluate their prospective leases. Only one company did not respond to our repeated attempts to contact. Several companies did not operate

**Table 1 – Interview status with the top 30 companies for oil production in Kansas.**

Rank	Oil Producer	Interest ?	Comment*	CITY_STATE	% of KS prod.	2008 Oil Production (bbls)
1	Murfin Drilling Co., Inc.	y	<b>Selected lease</b>	WICHITA, KS 67202-1216	3.61%	1294330
2	Vess Oil Corporation	y	<b>Selected lease</b>	WICHITA, KS 67206-6619	3.47%	1244390
3	Berexco, Inc.	y	<b>Selected 2 leases</b>	WICHITA, KS 67208-1380	3.43%	1231574
4	EOG Resources, Inc.	n	No waterfloods	OKLAHOMA CITY, OK 73112	2.87%	1029843
5	American Warrior, Inc.	yt	follow up	GARDEN CITY, KS 67846	2.39%	858811
6	OXY USA Inc.	y	follow up	HOUSTON, TX 77227-7570	2.10%	752623
7	Anadarko Petroleum Corporation (Merit)	n	No oil production	HOUSTON, TX 77251-1300	2.00%	716858
8	McCoy Petroleum Corporation	y	No prospects	WICHITA, KS 67206-2366	1.31%	469483
9	Hartman Oil Co., Inc.	y	follow up	WICHITA, KS 67206	1.31%	468983
10	Presco Western LLC (Ellora Energy)	n	No waterfloods	BOULDER, CO 80301	1.27%	454820
11	Ritchie Exploration, Inc.	y	No prospects	WICHITA, KS 67278-3188	1.25%	447815
12	Farmer, John O., Inc.	y	No waterfloods	RUSSELL, KS 67665-2635	1.23%	441760
13	Mull Drilling Company, Inc.	n	No waterfloods	WICHITA, KS 67202-1510	1.13%	405873
14	Lario Oil & Gas Company	n	No waterfloods	WICHITA, KS 67202-3805	1.11%	398623
15	Woolsey Operating Company, LLC	n	No waterfloods	WICHITA, KS 67202-1729	1.08%	388151
16	Merit Energy Company	y	<b>Selected lease</b>	DALLAS, TX 75240-7312	1.08%	386347
17	T-N-T Engineering, Inc.	n	No info on WF	WICHITA FALLS, TX 76308	1.02%	364747
18	Mai Oil Operations, Inc.	?	follow up	DALLAS, TX 75225-5520	1.01%	361315
19	Loeb, Herman L.	n	No candidates	LAWRENCEVILLE, IL 62439	0.98%	350948
20	Schmitt, Carmen, Inc.	n	No interest	GREAT BEND, KS 67530	0.88%	316524
21	Cimarex Energy Co.	y	follow up	TULSA, OK 74103	0.87%	313940
22	Abercrombie Energy, LLC	n	No prospects	WICHITA, KS 67202-1316	0.85%	306413
23	PetroSantander (USA) Inc.	y	<b>3 good leases</b>	HOUSTON, TX 77057-1798	0.85%	305733
24	Falcon Exploration, Inc.	y	follow up	WICHITA, KS 67202-1719	0.81%	291009
25	Elysium Energy, L.L.C. (Noble Energy)	n	No waterfloods	DENVER, CO 80202	0.78%	279848
26	L.D. Drilling, Inc.	n	No response	GREAT BEND, KS 67530	0.77%	274848
27	Palomino Petroleum, Inc.	n	No waterfloods	NEWTON, KS 67114-8827	0.75%	269687
28	Larson Operating Company	y	Arbuckle WF	OLMITZ, KS 67564-8561	0.75%	267881
29	Oil Producers Inc. of Kansas	n	No waterfloods	WICHITA, KS 67206-6603	0.71%	255101
30	Pintail Petroleum, Ltd.	n	No prospects	WICHITA, KS 67202-2024	0.68%	243775

\* WF is waterflood,

waterfloods on their leases, primarily because their production was from natural water-drive reservoirs in the Arbuckle and Mississippian formations.

Through the interviews, it became evident that leases with mature or maturing waterfloods are the best candidates for evaluation of chemical flooding that would be implemented in about three years. Waterfloods were identified because (1) an oil operator has made the assessment that the reservoir will respond favorably to a flooding process, (2) reservoir information is generally more common in waterflooded leases, and (3) oil companies understand that enhanced oil recovery processes are the only option besides plugging wells and abandoning the field. Reservoir information is critical for successful designs and we have found that this information is limited for most reservoirs in Kansas.

Technical criteria and judgments about the oil producers were used to evaluate and select the best waterfloods. The most important criterion was evidence that indicated an efficient volumetric sweep of the reservoir. This was often judged by a significant and sustained oil recovery response during water injection. We consider the efficient volumetric sweep of the reservoir the most important factor affecting the general performance of a chemical flood.

No criteria on oil, water or rock properties were used to select leases in central and western Kansas. These regions of the state have crudes that are light to medium weight, reservoir rocks are both sandstones and carbonate rocks and brines cover a wide range of total dissolved solids and hardness concentrations. Temperatures of Kansas reservoirs are less than about 145°F and most, if not all, chemicals proposed for chemical flooding can be applied in this temperature range. Work reported in the literature indicates chemical formulations can be designed for these ranges of fluid and rock properties.

Technical personnel from the oil companies were asked to survey their company's waterflood properties and present what they determined were their best-performing leases. In these interviews which were typically in person, we assessed the performance of the waterfloods and determined the types of data they had available. In addition, we judged their interest and the capability of the oil company to engage in a relatively expensive chemical flooding project. Through this process we have selected the five leases from four different companies listed in Table 2. One lease producing from a Morrow sand and operated by PetroSantander is intended to be selected. Our discussions with the oil companies indicate that the largest percentage of waterfloods is conducted in Lansing-Kansas City formations. Three selections are from this formation, although diversity of formations is a factor in the selection process. Oil samples from three leases have been secured in order to initiate laboratory studies that are described below under Task 3 activities. A minimum of four additional leases will be selected by 30 June 2009.

**Table 2 – Selected leases for laboratory studies.**

Lease	Formation	Field	County	Oil Operator
Trembley	Lansing-Kansas City	Trembley	Reno	Berexco
Celia South WF	Cherokee Lime	Celia South	Rawlins	Murfin
Tobias	Simpson sand			Berexco
Missouri Flats	Lansing	Missouri Flats NE	Gove	Merit
Wahrman	Lansing Kansas City	Beaver Creek	Rawlins	Vess
(TBD-3 options)	Morrow sand		(SW Kansas)	PetroSantander

The top 30 oil production companies in Kansas do not produce significant amounts of oil in the eastern portion of the state. Eastern Kansas oil production is characterized by shallow depths

and oils with lower API gravities than in central and western Kansas and this brings different opportunities for chemical flooding applications. We identified the top 10 oil producers in eastern Kansas and are in the process of contacting and interviewing them about candidate leases for chemical flooding. Initial interviews have suggested that many of the reservoirs in eastern Kansas were heavily fractured at discovery to accelerate primary production rates. Also, many of the reservoirs are waterflooded but the waterflood performance is lacking in part due to the fracturing practices at discovery. We plan to select at least one or two eastern Kansas leases for laboratory evaluation. Due to the shallow depths and much lower drilling and completions costs as compared to the remainder of the state, economic considerations may make eastern Kansas reservoirs favorable for chemical flooding.

### **Database of Kansas Oil Fields.**

Databases of Kansas oil fields were assembled with the purpose to aid in the selection of leases for the laboratory studies. Databases were assembled in an Excel spreadsheet from a database derived from public data and maintained by the Kansas Geological Survey (KGS). [KGS's database can be queried by the public at <http://www.kgs.ku.edu>.] KGS obtains field names, counties in which the field is located and producing zones from public records that the Kansas Corporation Commission (KCC) requires when wells are initially drilled. Production data are obtained from public records from the Kansas Department of Revenue where production is given by lease. The information is cross referenced by location. The KCC also has public information on injection wells such as location, status, injected volumes, etc. This information would aid in determining waterflooded leases but the information is not in digital form and therefore not included in the KGS database. The effort to convert this information in a usable, digitized form was beyond the scope of this work.

Our two "working" databases can be found online at <http://www.torp.ku.edu>. Both versions present the information listed in Table 3 for Kansas oilfields. Reservoirs are broadly defined as a producing zone in a particular field. The "reservoir" version of the database has one reservoir (a field-producing zone combination) on each row. There are 9,765 reservoirs (rows in the database) by our definition. It is noted that the production figures in this database are for the field and are listed only once in one of the producing zones for that field. The "field" version has all producing zones (reservoirs) in a field listed on the row for that field. This representation is not unique but allows for some manipulations to be easier. This presentation gives 6,536 fields (rows in the database).

We have found that types of information derived from the public records did not assist in the identification, evaluation or selection of leases for chemical flooding application. A major issue with the data is the allocation of the oil produced in a field to the producing zones (reservoirs). Also, the zones were identified when the well was initially completed and subsequent completions in other additional zones are not known. We will determine if there is a reasonable method to allocate oil produced from a field to the various production zones (reservoirs). If successful, this will allow for the identification of the resource base for chemical flooding in Kansas.

**Table 3 – Information listed in TORP’s database of Kansas oilfields.**

Field name  
 Producing zones (up to 9 zones)  
 Discovery date  
 Total cumulative oil production (bbls)  
 Total cumulative gas production (mcf)  
 Area (acres)  
 Total number of wells  
 2008 oil production (bbls)  
 Number of oil wells in 2008  
 2008 gas production (mcf)  
 Number of gas wells in 2008  
 Location by county (up to 19)

**Task 3: Design Efficient Chemical Formulations for selected Oil/Brine/Reservoir.**

**Task 3.1: Conduct laboratory tests using crude oils and field brines.**

Phase behavior studies using crude oils from three of the selected leases were begun in the laboratory. Chemical formulations are mixed with the crude oil and the resulting phase behavior is visually observed. We have identified chemical formulations that exhibit desirable phase behavior features for two of the crude oils. Since visualization is vital to phase behavior studies, we are constructing a shadow box to take detailed pictures of the liquid mixtures which will allow for the visual recording of data.

**MILESTONE STATUS**

Task	Project milestone Description	Planned		Actual		Comments, explanation of deviations from plan
		Start Date	End date	Start date	End date	
1	Project Management Plan updated	10/1/08	11/30/08	10/08	12/08	The Project Management Plan was updated and approved.
2	Development of database of KS reservoirs – Critical 1	10/1/08	3/31/09	11/08	3/09	Databases were prepared and are available online. The databases were not helpful in the process to select leases for Task 3.
2	Reservoirs/leases selected for study – Critical 2	10/1/08	6/30/09	1/09		Five of a minimum of ten leases have been selected for study in Task 3.
3.1	Acid numbers of oils determined	3/31/09	9/30/09			
3.1	Phase behavior studies completed – Critical 3	3/31/09	9/30/10	1/09		Phase behavior studies have been initiated for crude oils from there selected leases
3.1	Efficient chemical formulations designed for a minimum of two crude oils based on phase behavior studies.- Critical 4	3/31/09	9/30/10			
3.1	Flow tests completed in lab rocks	6/30/09	9/30/10			
3.2	Flow tests completed in reservoir rocks	6/30/10	3/31/11			
3.2	Efficient chemical formulations designed for a minimum of two applications based on flow experiments.- Critical 5	6/30/10	3/31/11			
4	Simulations completed – Critical 6	12/31/10 3/	6/30/11			
4	Economics completed	3/31/11	9/30/11			



## **SCHEDULING AND WORKLOAD ISSUES**

The level of effort to contact and interview personnel from interested oil companies was underestimated. However, this process should be concluded on time by 30 June 2009.

Laboratory studies require surfactant samples from the major world-wide suppliers. A significant and unanticipated effort was required to develop the relationships with the surfactant industry and to negotiate agreements on chemical analysis and confidential information issues. These agreements have been completed and surfactant samples have been acquired.

Laboratory studies by graduate students were started earlier than scheduled due to a timing issue between the start date of the project and the availability of graduate students at the start of a school year.

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