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The Latest

from the
Petroleum Technology
Research Centre
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in innovation for the oilpatch

Industry Interest Deep, Diverse

Executive Director Michael Monea scans the PTRC horizon

The PTRC was established primarily with the goal of advancing and serving western Canada's oilpatch. Yet we always anticipated that our work would make its impact felt far beyond the boundaries of a single industry in a single region. We've been proven right: deep interest is being expressed by diverse parties around the globe.

Notably, the Weyburn CO_2 Monitoring and Storage Project, launched by the PTRC in 2000, is attracting positive notice and opportunities to broaden our horizons. For example:

- Two large foreign automotive manufacturing companies could come on board because they both want to be part of a global sustainability movement in which emissions are balanced by proven sequestration activities.
- The US Department of Energy's Carbon Capture Project is interested in using the extensive data set from the Weyburn project to study real-world applications of sequestration in order to improve long-term risk assessment.
- Petro-China is a possible partner on CO_2 sequestration. They, in turn, can offer us expertise on learning technologies related to tight oil reservoirs which can be applied in west-central Saskatchewan's heavy oil area.
- SwedPower, Europe's fifth largest energy company, is keen to explore the potential of sequestration to contain the emissions from their coal-fired electricity plants.
- Because CO_2 extraction and sequestration are intertwined issues, we'll be working with the International CO_2 Capture Test Centre at the University of Regina.

We're already rolling out Phase II of the Weyburn Project, as the activities under Phase I will wind down by May 2004. In late October, we got together with many of the project's major clients in Brussels, Belgium, at a workshop hosted by TOTAL and sponsored by the International Petroleum Industry Environment Conservation Association. The theme was "Carbon Dioxide Capture and Geological Storage: Contributing to Climate Change Solutions."

Industry clients of the PTRC's core program were updated on progress in a project review presentation held in Calgary on October 7. The session contributed a lot of useful feedback to the research teams; thanks again to all those who attended.

Finally, the PTRC is staffing up to handle the administrative backlog. Joan Beisel, a new employee at the Saskatchewan Research Council, will be dedicating a portion of her time to providing us with financial and project management expertise. This will mean more timely, efficient service to our clients.

PTRC Project Update

Core Area 1:

Heavy Oil Cold Flow

Phase Behaviour Data for Vapex Correlations

This project is aimed at enabling oil producers to operate Vapex field projects at optimum fluid property conditions. It will lay the groundwork for defining the range of conditions, governed by phase behaviour issues, for successful Vapex implementation. All the major components of the new PVT (phase behaviour) apparatus have been received and are being assembled; only minor auxiliary pieces remain to be delivered. The literature survey and the assessment of correlation/ prediction methods for asphaltene precipitation are nearing completion. **Project Leader:** Norman Freitag; email freitag@src.sk.ca.

Propane / Heavy Oil Diffusion Measurement

The development of a technique to accurately measure diffusion coefficients of Vapex solvents into heavy oil (to improve the performance prediction and design of Vapex projects) is proving to be less straightforward than expected. The optical method being developed did not work as hoped. A proposal is being written for continued work in this area using a refractive laser source as a means of measuring density variations in the visual cell to determine diffusion coefficients. **Project Contact:** Brian Kristoff; email kristoff@src.sk.ca.

The Petroleum Technology Research Centre is a partnership of Natural Resources Canada, Saskatchewan Industry and Resources, the University of Regina, and the Saskatchewan Research Council.

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Generic Modeling of Wormholed Reservoirs

Could wormhole structures in reservoirs be employed to aid sweep efficiency of post-cold flow processes? This project is using 3D scaled physical modeling to find the answer. The pressure drop in the model was measured with and without wormholes. Six scaled physical model runs were done to test various wormhole configurations and injection strategies. Significant differences in oil recoveries were observed for the experiments. Additional work will be coordinated with Dr. M. Dong and students from the University of Regina. This will include experimental model runs and numerical simulation. The final report is expected to be complete in March 2004. **Project Contact:** Brian Kristoff; email kristoff@src.sk.ca.

Cold Flow Field Data Acquisition

This scoping project is aimed at assessing the availability of good quality field production and reservoir data to guide the development of new and effective follow-up processes for primary production heavy oil fields. A number of producers have been contacted and field data, where available, collected. Published information has also been collected and analyzed. The results of a major study, conducted by a consortium of research organizations some time ago, have been analyzed as well. Preparation of the final report for this project is underway. **Project Leader:** Patrick Jamieson; email jamieson@src.sk.ca.

Solvent-Based Post-CHOP in Wormholed Reservoirs

Results from this project will lead to improved recovery from wormholed reservoirs while reducing capital and operating costs of solvent injection. Our experiments indicate a two-way pattern of CO_2 diffusion: there is quick, turbulent mixing of the solvent into the heavy oil accompanied by extraction of the lighter components. These results are helping us to understand the mechanisms of heavy oil recovery and to predict the amount of recovery. Three-phase tests began in the high-pressure cell at elevated temperature to characterize CO_2 diffusion from one phase to another. The two cases under study are a) CO_2-saturated brine surrounding heavy oil and b) CO_2-saturated heavy oil surrounded by brine. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

Core Area 2:

Miscible / Immiscible Gas Injection

Enhanced Oil Recovery by Flue Gas / CO_2 Huff and Puff in Saskatchewan Reservoirs

Experimental work for the first phase of this project is complete; the final report is being reviewed before distribution to clients. Significant recovery of a relatively light oil was obtained in sandpack corefloods using an enriched flue gas/CO_2 huff and puff process. A key criterion for these good results was higher waterflood residual oil saturation. It is thus expected that a CO_2 huff and puff process may be more applicable to reservoirs with more viscous oil, where high residual oil saturations are typical. The project team is proposing a second phase which would demonstrate the viability of the process in a medium oil reservoir, and optimize it by adding a surfactant in the gas stream. **Project Leader:** Sam Huang; email huang@src.sk.ca.

Immiscible CO_2 / Enriched Flue Gas Injection for Heavy Oil Recovery

This project's aim is to develop a viable, cost-effective EOR method for thin heavy oil reservoirs and accelerate its application. We're focusing on investigating immiscible water-alternating-gas injection and on improving a suitable numerical model to simulate this method. Phase behaviour analyses were done on the reservoir fluid–CO_2 system. Sandpack corefloods (one each with pure CO_2 and N_2) were carried out using a water-alternating-gas process. The CO_2 run obtained incremental recovery of nearly 4% initial oil in place with a very heavy oil. A fivefold reduction in viscosity occurred as the saturation pressure was raised. A coreflood using an enriched flue gas will be done to test the effect of type of gas under the same run conditions. On the simulation front, the upgraded version of the STARS simulation package was received, applied, and found to be able to represent the flue gas phenomenon. **Project Leader:** Sam Huang; email huang@src.sk.ca.

Effects of Capillary Pressures, Interfacial Tension and Viscosity in Vapex

This project seeks to improve predictive models and reservoir screening criteria for Vapex field application. A primary question is the roles played by capillary pressure and interfacial tension in propagating the vapor/gas chamber formed in the reservoir during the Vapex process. This project will examine the effect of type of solvent gas (e.g., butane, methane, CO_2) and gas mixtures, oil heaviness, and porous medium. The project team is now very close to running these planned experiments. The physical model was built and delivered by a commercial company. We are assembling the auxiliary components and purchasing software. We will perform some baseline tests to fine-tune procedures and model operation. Two thesis students will be performing the experimental work and analyzing the results. **Project Leader:** Muhammad Ayub; email muhammad.ayub@uregina.ca.

The Latest, the quarterly newsletter of the Petroleum Technology Research Centre, is edited by Brenda Tacik. Please address any comments or questions about this publication to tacik@src.sk.ca.

Core Area 3:

Enhanced Waterflooding

Heavy Oil Waterflooding Scoping Study

The production and injection histories of all Saskatchewan and Alberta heavy oil waterfloods have been collected. Reservoir viscosity has been revealed as the best determinant, among several influencing factors, of a waterflood's success. This was confirmed by some numerical simulation of a generic waterflood. We completed company interviews to generate information about waterflood practices; respondents provided much insight into their research needs during these sessions. We are now working on setting up a workshop at which industry participants will have the opportunity to share their waterflood experiences and see presentations by specialists. **Project Leader:** Doug Soveran; email soveran@src.sk.ca.

Low-Cost Chemicals for Enhanced Waterflooding

This project's goal is to reduce the costs of chemically enhanced waterflooding by identifying low-cost sources of caustic or caustic substitute (such as sodium carbonate from cleaned pulp smelt) and confirming their effectiveness. We are assembling a laboratory-scale extraction and purification unit to process a caustic substitute and provide materials for tests. The extended absence of a team member is delaying progress. **Project Leader:** Cindy Jackson; email jackson@src.sk.ca.

ASP Flooding in SW Sask. Medium Oil Reservoirs

Promising results from this work—incremental recovery of 20% initial oil in place in a reservoir rock coreflood—have been documented in the final report (now being reviewed before distribution to clients). The lab work showed that, although it is crucial to attain low interfacial tension between the oil and the displacing alkaline-surfactant-polymer solution, this is not sufficient to assure good performance. The in-situ formation of an oil bank appears to play a critical role. Therefore, the project team is proposing a new study phase focusing on oil coalescence and movement mechanisms (e.g. wettability) in the reservoir. Improved understanding of these mechanisms is expected to promote development of more cost-effective ASP flood technologies. **Project Leader:** Sam Huang; email huang@src.sk.ca.

Enhanced Waterflooding Using Colloidal Gas Aphron (CGA) Solutions

This project is examining the use of microbubble solutions to lower the density and raise the viscosity of injected water to sweep previously unaccessed portions of a reservoir. A significant discovery resulted from our screening of a wide variety of surfactants. One of these was found to create relatively long-lived bubbles (days rather than minutes). We are planning to test the lifespan of this aphron solution in a two-dimensional scaled physical model. The work will then revert to our partner on this project, Alberta Research Council, who will test this very promising solution under high pressure and in a coreflood. **Project Leader:** Doug Soveran; email soveran@src.sk.ca.

Modified Polymers for Water Permeability Reduction

This project's aim is to develop a means to overcome excessive water production, improve sweep efficiency, and increase oil recovery. The technique entails modifying natural polymers to better adsorb on reservoir surfaces and plug reservoir pores. This quarter we conducted preliminary tests to characterize the adsorption behaviour of five different cores with three commercial polymers, of differing molecular weight and charge density. Work by our partner at the University of New Brunswick (UNB) is underway to modify commercial starch polymers. We are planning flow tests with these polymers to determine the resulting residual resistance factors. **Project Leader:** Mingzhe Dong; email mingzhe.dong@uregina.ca.

Core Area 4:

Near Wellbore Conformance Control

Information System for Saskatchewan Reservoirs for Applying Conformance Control Techniques

Enabling managers and reservoir engineers to select suitable conformance control processes for any given reservoir is this project's aim. This quarter, the structure of the database was completed, and data for a few hundred wells were entered into the system. A set of rules for selecting conformance control measures was developed and implemented in the knowledge-based part of the program. The graphical user interface in Visual Basic accommodates searches for problem wells and is a means of response for the program to suggest suitable conformance control methods. We are currently testing the program to ensure that all its components are integrated correctly. The project was discussed with industry sponsors in Calgary in early October; we are improving the database and the interface on the basis of their input. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.

Developing Near Wellbore Conformance Technologies for Wormholed Reservoirs

A modified gel-foam system may have the potential to block wormholes effectively, thereby improving the sweep efficiency of waterfloods in Lloydminster-type reservoirs which have undergone cold production. This quarter, further samples of surfactants and surfactant stabilizers were received. We tested these products for a range of compositional factors to determine the optimal composition. The most promising gel-foam systems were tested for the effect of presence of oil on their performance and for structural integrity (formation and strength). A few flow experiments were conducted in 1/4-in tubes filled with glass beads. More experiments are underway and conclusions on the performance of the gel-foam systems will be made based on results. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.

Other Areas:

Re-Injection of Recycled CO_2—Changes to CO_2-Oil Miscibility over the Year 2002

These subtasks of the IEA Weyburn CO_2 Monitoring and Storage project have a small but crucial role in forecasting how long CO_2 will be sequestered following its injection for enhanced oil recovery. Phase behaviour studies confirmed that the Weyburn CO_2 flood is operating in the miscible region as planned. Water solubility in supercritical CO_2 at reservoir conditions is being measured. This will help to determine if the injected gas can dry out rock in the regions around the injection wells to the extent that the integrity of the wellbore seal and the overlying caprock is damaged. **Project Leader:** Norman Freitag; email freitag@src.sk.ca.

Displacement of Heavy Oil Via Interfacial Instability

This project is aimed at developing a viable, cost-effective non-thermal EOR technique for heavy oil reservoirs, in which the major recovery mechanism is the oil's self-dispersion into and transport through the water phase. Phase II testing got underway with delivery of field oil and water samples from two oil companies. Studies will include emulsification, adsorption and coreflood tests; the latter will be done in 1-metre-long sandpacks, in contrast to the short sandpacks used in Phase I. The report on this earlier phase is being written. **Project Leader:** Mingzhe Dong; email mingzhe.dong@uregina.ca.

Application of Gels for CO_2 Conformance

This project examined optimal gel composition for conformance control of carbon dioxide in Weyburn field, with the aim of increasing CO_2 sweep efficiency. We are now finalizing the data analysis. All gel systems tested showed promising results for blocking the flow of both water and carbon dioxide in a carbonate medium. In future, we would like to study the effect of various placement techniques/parameters (e.g., flow rate, well selection, injection method) on the performance of these gel systems. We plan to write a proposal for industry sponsorship. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.

Biosurfactant-Enhanced Technologies for Remediation of Petroleum-Contaminated Sites

Good progress was made this quarter on developing an enhanced bioremediation process to reduce hydrocarbon contamination of soils. We isolated biosurfactants resulting from two strains of soil bacteria. These were found to perform well under various western Canadian conditions, including high-clay-content soil. The contaminant under study in this quarter's work shifted from diesel fuel to gasoline. Tests were done in the pilot-scale model to verify the performance of an enhanced-strain complex; results show a significant reduction of the contamination concentration level compared with that achieved by conventional bioremediation. The pilot model has been prepared to apply, and evaluate the efficiency of, the enhanced process using the newly developed biosurfactants. **Project Leader:** Gordon Huang; email Gordon.Huang@uregina.ca.

Interfacial Phenomena in CO_2 Flooding

This project is aimed at improving understanding of how CO_2 miscible flooding enhances oil recovery and sequesters CO_2. All of the tasks have been completed; a student is writing the final report for submission to the PTRC. We are proposing a further phase to conduct CO_2 corefloods to determine recovery at reservoir pressure and temperature, and to study wettability change in corefloods. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

Separation of Oil / Water Emulsions Using a Coalescer Column

The goal of this project is to develop an effective mechanical phase separation technique for petroleum industry applications, particularly those involving high-water-cut oil production. All the tasks have been completed. Two-phase flow tests showed that the pressure drop increased only slightly compared with single-phase flow. Parametric studies focused on the effect of four main factors on separation efficiency: flow rate, inlet oil concentration, column length, and packing size. Coalescence was improved when a moderate flow rate and a small fiber size was used, and was impaired when the inlet oil concentration was relatively high. Lengthening the coalescing bed did not increase efficiency. The results will be contained in a report to be submitted soon to the PTRC. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

Detection and Reuse of Chemicals in Chemical EOR

In any chemical EOR process, a substantial portion of the chemical will be produced. This completed project showed that it is feasible to recover and re-inject the chemicals to reduce the capital cost and environmental impact of chemical floods. This quarter, a number of corefloods were conducted to finish testing different alkaline-surfactant-polymer injection schemes. In the alkaline-alone flood, 90% of the chemical was recovered, whereas only 10% of surfactant, when used, could be recovered. A graduate student has written the final report for presentation to the PTRC. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

Selective Permeability Reduction by Polyacrylamide Polymers for SK Reservoirs

This project is examining the potential for using polyacrylamide injection as a means of selective permeability reduction. The goal is to enable oil companies to improve oil production by reducing water production. Following completion of tests in sandpacks, we did two experiments in cores in the absence of oil. We found that permeability of water was reduced by a factor of 4 to 6 in cores, and by 2 to 3 in sandpacks. We are currently repeating the core experiments in the presence of oil. We will be seeking an opportunity to collaborate with an industry sponsor on a field test of this technique. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.