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The Latest

from the Petroleum Technology Research Centre
Fall 2004

in innovation for the oilpatch

Super Model Money for Vapex

Two levels of government announced September 29, 2004, that they are committing a total of $750,000 for Vapex research at the PTRC. The funds will go toward designing, purchasing, and installing a three-dimensional high-pressure scale model that will allow researchers to test the new technology under realistic reservoir-like conditions and develop it more quickly for commercial applications.

Vapex, or vapour extraction, is considered by industry experts and researchers to hold tremendous promise for economic and environmentally sound recovery of significant volumes of heavy oil.

The Honourable Ralph Goodale, Canada's Minster of Finance, spoke at the Sept. 29 announcement on behalf of the Honourable Stephen Owen, Minster of Western Economic Diversification (WD). Under the Canada-Saskatchewan Western Economic Partnership Agreement (WEPA), WD is matching funds with Saskatchewan Industry and Resources (SIR).

Mr. Goodale stated that "Vapex technology will further enhance the strong performance of Saskatchewan's oil industry." SIR Minister Eric Cline predicted that "significant economic, social and environmental benefits will result from the PTRC's work on this project."

Vapex involves injecting hydrocarbon solvent gases such as butane and propane into heavy oil reservoirs to reduce the oil's viscosity and increase its mobility. Because no heat is applied, the process has the potential to emit less greenhouse gas than current oil production practices.

The PTRC has initiated a major new industry/researcher collaborative program known as JIVE (Joint Implementation of Vapour Extraction). Its aim is to assess, develop, and demonstrate the Vapex process in several heavy oil fields. The new model will provide key data for understanding, optimizing, and applying the technology.

A model of the Weyburn CO_2 project drew enthusiastic visitors to the PTRC booth at GO-Expo in Calgary last June. The model depicts the completed facilities and explains how CO_2 injection and sequestration work. It was built by a University of Regina craftsman.

R&D Programs Gain Momentum, Support

Executive Director Mike Monea scans the PTRC horizon

I'm very excited about the new partnerships and programs being forged at the PTRC. They are strengthening our ability to have a substantial, beneficial, and enduring impact on industry practices and public policy.

Risk assessment of greenhouse gas sequestration is proving to be an area of huge interest and potential. It will be a key component of Phase II of the Weyburn CO_2 Storage and Monitoring Program just getting underway. We plan to develop an international network of expertise in risk assessment modeling to be the centerpiece of a separate PTRC program matching the Weyburn effort in size and substance.

Recent developments highlight the growing support for this venture:

& **Statoil** of Norway has committed the complete data set from their North Sea CO_2 injection program. This, combined with the PTRC's data from the Weyburn CO_2 project, will give the new network's modeling results—for a range of geological conditions—unmatched credibility and depth.

& We've signed several MOUs with other parties to enable collaborative research on geological storage of greenhouse gases and assessment of associated risk. They include the **University of Melbourne** and the Cooperative Research Centre for Greenhouse Gas Technologies (**CO2CRC**) of Australia, the Netherlands Organization for Applied Scientific Research (**TNO**), and **CO_2 GeoNet**, a new integrated European network of excellence dedicated to meeting the challenge of enabling geological storage of greenhouse gases. *Cont'd on P. 2*

PTRC Project Update

Core Area 1:

Heavy Oil Cold Flow

Analyzing the Wormhole Structure in Cold Heavy Oil Production (CHOP)

Wormhole structures are thought to be generated during the CHOP process and to provide the main conduits for fluid flow; therefore, it's critical to understand the effects of these structures for primary and post-cold production. To study these effects, we've developed a comprehensive semi-analytical model coupling the reservoir/wormhole flow. The model has the flexibility to incorporate any wormhole hydraulic model, which is necessary for considering the foamy oil and sand flow in terms of the pressure drop along wormholes. The effects on cold production of wormhole patterns, scales, diameters, and branching, and pressure drop along the wormhole, have been analyzed extensively. The model can be applied to analyze the possible wormhole structures and to optimize/predict the reservoir fluid production in the heavy oil cold production process. Further communication with industry is underway. **Project Leader:** Gary Zhao; email gang.zhao@uregina.ca.

Wormhole Stability to Solvents and Steam

This project's aim is to study the stability and permeability of wormholes during solvent or steam injection for post-cold production recovery of heavy oils in western Canada. A wormhole stability visualization cell has been designed for the purpose and is being machined. The longitudinal permeability of the wormhole will be measured. In parallel, an apparatus is being built to measure the cohesive strength of the oil sands under different solvent concentrations. The results will be used in combination with the wormhole stability experiments to develop a general wormhole stability criterion for field applications. **Project Leader:** Bernard Tremblay, email tremblay@src.sk.ca.

Multi-Well Cold Production Predictive Numerical Model

This project aims at developing a multi-well predictive model in order to estimate oil reserves, infill drilling schedules, watering-out potential, reservoir wormhole network morphology prior to post-cold production, and optimum water shut-off strategies. The first stage of the project—development of a single well model in Cartesian coordinates—is advancing well. In parallel to this work, a review of the literature on the geology of the Lloydminster area is underway to characterize the permeability/porosity distribution within the cold production reservoirs as input for the cold production model. **Project Leader:** Bernard Tremblay, email tremblay@src.sk.ca.

Drilling through Wormholed Reservoirs

The goal of this applied research is to develop an efficient means to minimize lost circulation when horizontal wells are being drilled through wormholed reservoirs, and to block off any connected or neighbouring wormholes. A polymer gel has been identified which has the potential to serve as both a fluid loss material and a wormhole blocking agent. The viscosity and yield stress of the gel are being measured. The leak-off of the gel through a sand pack and its breakdown after acidization will be measured shortly. **Project Leader:** Bernard Tremblay, email tremblay@src.sk.ca.

Phase Behaviour Data for Vapex Correlations

This project, aimed at enabling oil producers to operate Vapex field projects at optimum fluid property conditions, is nearly complete and the final report is being written. The new equipment is working well; we have confirmed its accurate operation by reproducing data published by others for a simple system. However, while doing initial Vapex system measurement, we identified the need to develop better procedures because the current ones are not as accurate as expected. Therefore, we will develop techniques (cont'd p. 3)

R&D Programs Gain Momentum, Support *cont'd from P. 1*

At the recent 7th International Conference on Greenhouse Gas Control Technologies in Vancouver (at which we presented a well-received session on the Weyburn project) we sensed a real mood of collaboration. There is a strong desire to work with the PTRC to build this new international network, now established on three continents (North America, Europe, Australia). Governments around the world will be interested in using our results to set policies for geological storage.

On the enhanced oil recovery (EOR) side of the gas injection equation, both Saudi Aramco (of Saudi Arabia, an OPEC member) and Repsol-YPF (of Argentina) have expressed interest to us in the EOR benefits of CO_2 storage.

In practical terms, we've purchased several thousand dollars worth of computers with a grid network that will allow us to link up with any researcher we choose. We're setting up a series of workshops for researchers on risk assessment to define the projects which will be PTRC-managed and run similarly to the Weyburn program. These meetings will be held in London, England, and Santa Cruz, California.

Another program with the potential to grow as large as either Weyburn or risk assessment is our work on **Vapex** technology. We've signed an MOU with **Nexen Canada** to collaborate on the development and field pilot testing of the Vapex process. We will be seeking sponsors for, and contributing expertise and laboratory facilities to, this research program.

I'm delighted to have so much meaningful progress to report since our last newsletter. Our Core program is also making important strides, reported here in brief updates. Initial phases are wrapping up, and new phases beginning with a focus, in most cases, on field application of new technologies.

for low pressure systems and defer some of the experimental data-gathering to the follow-up project to be offered under the PTRC's Field Development program. **Project Leader:** Norman Freitag; email freitag@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. The project is slightly behind schedule but will likely be completed by the end of 2004. As the major research component, interfacial tension measurements have been done for CO_2 and oil under reservoir conditions for a large operating pressure range (0.1-30 MPa) at two temperatures: 27 and 58EC. A graduate student is now processing the data. With respect to the dispersion coefficient part of the project, a Ph.D. student is writing the numerical simulation program to study convection dispersion of solvent in heavy oil, and the experimental set up is being designed and developed. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

Core Area 2:

Miscible / Immiscible Gas Injection

Surfactant-Assisted Gas Huff-n-Puff Oil Recovery in Medium Oil Reservoirs

This project will extend, to medium oils, previous promising PTRC research on CO_2 huff-n-puff technology for light oils. The goal is to optimize the process by adding a surfactant to the gas stream to maximize recovery. We procured and characterized medium oil samples from the candidate reservoir, and prepared live oil for use in testing. The next step is to carry out corefloods in Berea sandstones of the huff-n-puff process with CO_2 and surfactant. **Project Contact:** Sam Huang; email huang@src.sk.ca.

Immiscible CO_2/Enriched Flue Gas Injection for Heavy Oil Recovery (Phase II)

Immiscible gas injection has the potential to cost-effectively recover incremental heavy oil while making producers eligible for greenhouse gas credits. This study will build on Phase I developmental work. We obtained a heavy oil sample (viscosity 2,500 mPa‰s) from the candidate reservoir, and characterized the PVT properties of this oil in mixtures with CO_2 and enriched flue gas (30% CO_2). Three corefloods with pure CO_2 in sandpacks yielded mixed results: one WAG flood was encouraging, but another using a higher gas ratio was not as successful. Results from a water-gas co-injection process were not good. Further corefloods are planned with flue gas. **Project Contact:** Sam Huang; email huang@src.sk.ca.

Measurement of Solvent Diffusivity in Heavy Oil & Evaluation of Solvent-Based Recovery Processes

This project, aimed at providing measured diffusivity data for different solvents in heavy oil at different temperatures and pressures, is progressing well. The experimental set up including the diffusion cell was established; this will enable us to use and improve the pressure decay method to measure diffusivity. A graduate student has completed measurements on methane and CO_2, each in heavy oil, and is now working on propane. The three boundary conditions (i.e., equilibrium, quasi-equilibrium and non-equilibrium) at the solvent-heavy oil interface are being examined for these three solvents, and numerical analysis will be undertaken by using experimental data to determine the diffusion coefficient from the pressure-time curve measured in a much shorter duration. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

The Latest, the 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.

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.

Solvent-Aided Waterflooding

Results from numerical simulations showed that high oil recoveries are possible in Lloydminster reservoirs, especially thin ones, through combined water and solvent drives. However, economical recovery of the solvent remains a question still being investigated through simulation. **Project Leader:** Norman Freitag; email freitag@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. The first phase, consisting of measuring interfacial tension and constructing the oil-water drainage capillary pressure curve, is concluding. Experimental data achieved so far are quite encouraging and depict the anticipated trend. The second phase, to begin soon, will involve testing and proving the actual physical model for the Vapex experiment. Data achieved from the first and second phases will then be combined and simulated using CMG's GEM simulator to reach the final goal. **Project Leader:** Muhammad Ayub; email muhammad.ayub@uregina.ca.

Core Area 3:

Enhanced Waterflooding

Assisted Oil-Bank Formation (AOBF) during Alkaline/Surfactant/Polymer (ASP) Flooding

This project's aim is to develop a cost-effective AOBF technology by focusing on the largely neglected effects of oil ganglia coalescence and wettability alteration on improving oil recovery. Two flow tests were carried out in a micromodel set up to allow observation of the injected surfactant's reaction with the residual oil and the movement of the oil to form an oil bank. A new lens was purchased which significantly improved imaging of the process; however, it is planned to manufacture a dedicated, better-suited micromodel and rerun the tests. We obtained a new oil sample from the candidate reservoir, and on the basis of its properties, selected a new surfactant. The U of R is measuring the interfacial tension of this surfactant with the oil. **Project Contact:** Sam Huang; email huang@src.sk.ca.

Heavy Oil Waterflooding Scoping Study

This project has nearly been completed and will serve as the basis for a follow-on project, "Optimizing Heavy Oil Waterflooding," scheduled to start shortly. A workshop at which industry participants will have the opportunity to share their experiences with heavy oil waterfloods and see presentations by specialists will be held in October in Calgary. **Project Leader:** Doug Soveran; email soveran@src.sk.ca.

Enhanced Waterflooding Using Colloidal Gas Aphron (CGA) Solutions

This nearly completed project is examining the use of microbubble solutions to lower the density of injected water to sweep previously unaccessed areas of the reservoir. Results have been very technically promising, much more so than the previous aphron-related research by our partners at the Alberta Research Council. The follow-on year of this project will focus on creating certain types of aphrons and verify that they do in fact recover more oil. **Project Leader:** Doug Soveran; email soveran@src.sk.ca.

Low-Cost Chemicals for Enhanced Waterflooding

This project's goal is to determine if sodium carbonate, a low-cost substitute for caustic, can be sufficiently purified and act as effectively. Waste smelt was obtained from a local pulp mill. Suspended solids were removed using a flocculation procedure with the inclined plate settler. Eighteen oxidation tests were performed, and were successful at removing 87% of the sulphide content. The interfacial tension of the purified smelt product is being measured and a final report is being written. **Project Leader:** Cindy Jackson; email jackson@src.sk.ca.

Modified Polymers for Water Permeability Reduction

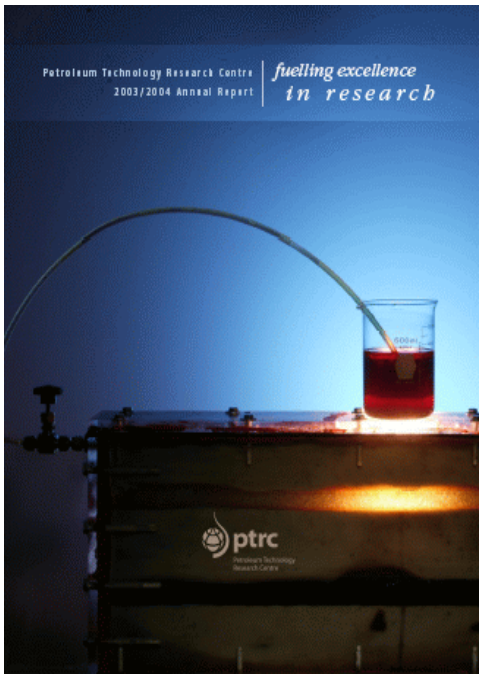
This project is developing a means to overcome excessive water production, improve sweep efficiency, and increase oil recovery. Natural polymers are being modified to better adsorb on reservoir surfaces and plug reservoir pores in water channeling regions. Our partners at the U of New Brunswick synthesized several modified starch samples for flow tests, carried out at U of Regina. The goals were to 1) compare the starches' residual resistance factors (RRF) with that of a commercial polyacrylamide, and 2) investigate the factors in increasing the starches' RRF in waterfloods in reservoir cores. Preliminary results with Berea cores showed that the modified starches could provide an RRF of about 7.2 after several PV injection, compared with 3.8 for the commercial polyacrylamide. More flow tests will be performed to screen the modified starch samples and to reduce the injection volume of polymer solution needed for reaching a high RRF. This project is looking for core samples for use in these tests. **Project Leader:** Mingzhe Dong; email mingzhe.dong@uregina.ca.

Canada's Gain

Dr. Koorosh Asghari (left) and his wife Azita (centre) beam with pride moments after becoming Canadian citizens in Moose Jaw, Sask., in October. Koorosh, an associate professor of Petroleum Systems Engineering at the University of Regina, is a leading PTRC researcher. PTRC Executive Director Mike Monea (right) was delighted to sponsor the couple for Canadian citizenship and extends, on behalf of the PTRC, a warm welcome to Koorosh and Azita .

Koorosh earned his M.Sc and B.Sc degrees in his native Iran and his Ph.D. in chemical and petroleum engineering at the University of Kansas. His research interests include in-situ permeability modification, mobility control, and selective permeability reduction.

PTRC 2003/04 Annual Report Available



The most recent PTRC annual report, entitled "Fuelling Excellence in Research," is now available. It contains a feature on the Weyburn CO_2 Monitoring and Storage Project, articles on key projects in the core research areas, profiles of PTRC researchers, brief updates of all PTRC-funded projects, and selected publications. It also contains the full financial report for the fiscal year.

You can obtain your copy by e-mailing horn@src.sk.ca (please put PTRC Annual Report in the subject line) or phoning 306-787-9400. A pdf version of the document can be found shortly on the nearly completed revamped PTRC internet home page. Speaking of our home page, we thank you for your patience as we get our new, improved site up and running. We expect the launch date to be no later than November 1, 2004.

Core Area 4:

Near Wellbore Conformance Control

EOR by Seismic and Mechanical-Vibration Stimulation of Reservoirs with Multi-Vibro-Energy Sources

This project will develop a novel recovery method for waterflooded oil reservoirs utilizing multi-vibro energy sources to stimulate detachment/coalescence of oil in the reservoir and improve its mobility. Good progress has been made since the project's start a few months ago. A thorough literature survey (of academic studies and technical reports from oil production fields) was done and reported in detail. Experimental models to study the relationships among pressure, geometric dimensions of oil slug, oil viscosity and flow volumetric velocity were designed and installed; testing has begun. The effects of elastic waves on mobility of multiphase liquid in porous media are also being studied. A preliminary analytical model of the response of liquid to the wave motions generated by two vibratory sources is established. A finite element model for an idealized porous media saturated with liquid is developed. **Project Leader:** Liming Dai; email Liming.Dai@uregina.ca.

Development of Bottomwater Reservoirs in Sandstone and Carbonate Formations Implementing Flow Barrier

Simulation results from a 3D numerical simulation model using Computer Modelling Group's STARS Simulator were analyzed to investigate strategies to apply natural flow barrier(s) for developing a bottomwater reservoir. All of the simulation cases studied have indicated that water cut can be postponed and greatly reduced, cumulative oil production increased, and the cumulative water production decreased dramatically when barriers exist below the horizontal producer. Further experiments will be conducted to study the possibility of field implementation in conventional and heavy oil reservoirs. Experimental setup is in progress. **Project Leader:** Gary Zhao; email gang.zhao@uregina.ca.

Active Bottomwater Reservoirs

In many reservoirs in Saskatchewan and Alberta, the oil zone overlies an active bottomwater zone; therefore, water channeling is a prevalent concern. This project will develop a method to predict recovery and a method to improve the recovery process through the strategic placement of blocking and mobility control agents. As scheduled, work began September 1; a student is conducting a literature review. **Project Leader:** Ezeddin Shirif; email ezeddin.shirif@uregina.ca.

Control of Water Coning by Dual Completion

This project is aimed at helping producers adopt and implement simple dual completion techniques to prevent or at least delay water coning or cresting. A graduate student was hired and is being trained to conduct experiments. Much of the time has been employed for a literature review and thus to createadequate feedback. A box-type transparent physical model is being designed to run experiments considering all possible scenarios associated with the 'Dual Completion' technique and to address the issue in greater detail. **Project Leader:** Muhammad Ayub, email muhammad.ayub@uregina.ca.

Developing Near Wellbore Conformance Technologies for Wormholed Reservoirs

This project aims at developing new gel-foam systems for blocking wormholes in reservoirs under cold flow production. A series of foaming agents and foam stabilizers were tested, and one of each product was selected for a mixture to be added to a polyacrylamide-Cr(III) gel system. This system was tested under various flow conditions in a new physical model designed and built in PTRC laboratories. The results indicate that this new gel-foam formulation effectively blocks the wormhole. More experiments are underway to study the effect of various parameters such as residual oil saturation on the performance of this conformance control technology. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.