



The Latest

from the
Petroleum Technology
Research Centre
Winter/Spring 2004

in innovation for the oilpatch

Renewed Funding Announced for PTRC

The Petroleum Technology Research Centre received a \$10 million vote of confidence March 5, 2004, when its partners in the Governments of Canada and Saskatchewan announced their renewal of funding for the next four years. Each level of government will contribute \$5 million, the federal government's funds being split 80/20 between Natural Resources Canada and Western Economic Diversification.

Ralph Goodale, Minister of Finance, spoke on behalf of the federal government at a press conference at the PTRC in Regina. He praised the PTRC's tradition of collaboration between research and industry. He also remarked that the PTRC's work is having an impact far beyond the oilpatch, for example, in helping Canada achieve its climate change goals.

Mark Wartman, Minister of Agriculture, Food and Revitalization, represented the Saskatchewan government at the event, on behalf of Industry and Resources Minister Eric Cline. He noted that the renewed funding agreement will help develop the province's sizeable oil reserves, of which

only 15 per cent are recoverable using today's technology.

Frank Proto, Chair of the PTRC Board of Directors, said that the centre, although established only five years ago, has already conducted significant research and attracted international recognition. Both the Weyburn CO₂ Monitoring and Storage and the Vapex III projects are being conducted by multi-agency research teams and funded by consortia of international clients in the private and public sectors. The University of Regina, a founding PTRC partner, now has one of the leading petroleum engineering schools in North America.

Mr. Proto concluded the event with this vision of the PTRC's role for the future: "We are industry driven. We provide a forum for the oil and gas industry to exchange ideas, problems, and experience with those conducting the research. The result is we produce more oil; we have a cleaner environment; we help in the creation of jobs; and the Governments see royalties and taxes increase to give them a return on their investments."

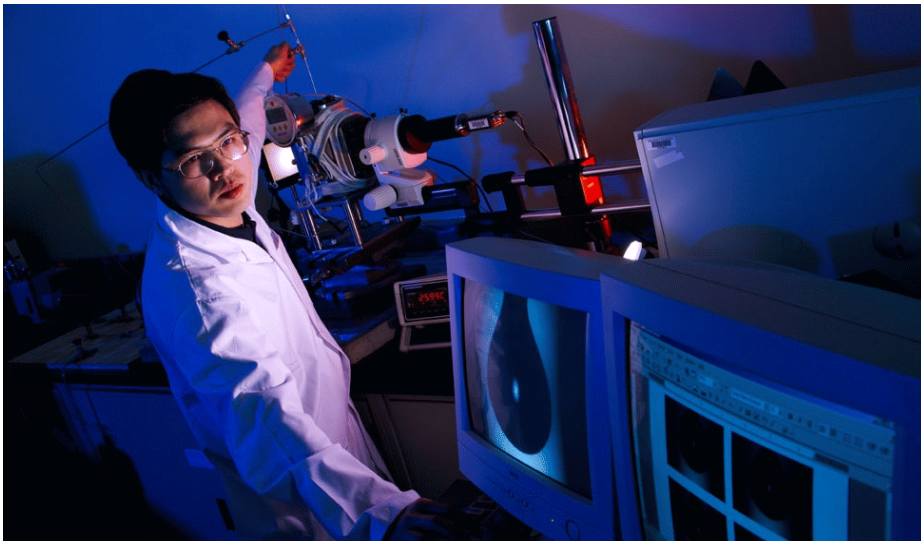
Moving right along...

The PTRC is delighted with the announcement of the generous renewal of our funding by the federal and provincial governments. We would like to thank the many people in the private and public sectors who have championed our vision and worked behind the scenes to help ensure the continued success of the PTRC.

We are also very proud of the ongoing and newly approved projects that fit within our four core areas as defined by our Technical Advisory Committee. At this time, we are particularly proud to present our newest project proposals, summarized starting on Page 2 of this edition of *The Latest*. These proposals represent the next step in meeting the challenge of moving laboratory technology to the field for testing.

It is this commitment to advancing and applying technology, we believe, that makes the PTRC the most effective avenue for solving an oilpatch concern. In the near future, our focus on field demonstration will continue to sharpen. We are expecting real and rapid progress, for example, with Vapex applications in collaboration with industry partners. Stay tuned!

~ Mike Monea, Executive Director



U of Regina Ph.D. student Tony Yang measures interfacial tension and wettability in an oil-brine-CO₂-rock system. His research is helping to improve miscible/immiscible flooding and post-cold flow production.

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.

New PTRC Project Proposals for 2004-5 and 2004-6

Core Area 1:

Heavy Oil Cold Flow

Analyzing the Wormhole Structure in Cold Heavy Oil Production

Cold flow production, whereby oil is co-produced with sand, is widely applied to heavy oil reservoirs in unconsolidated sand formations. This project is aimed at optimizing field operations and cold-flow/post-cold-flow success rates through developing an understanding of wormhole development patterns and their effect on oil production and well response. The deliverable will be a semi-analytical model that couples reservoir and wormhole hydraulics, incorporating a range of available field data. **Project Leader:** Gary Zhao; email gang.zhao@uregina.ca.

Wormhole Stability to Solvents and Steam

This study will investigate the stability and permeability of wormholes during solvent or steam injection for post-cold production recovery of heavy oils in western Canada. A key issue in designing these recovery processes is whether high permeability channels will remain stable, providing a network for solvent/steam distribution, or collapse during injection/production cycles. The measured permeability of the

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 CO₂ huff-n-puff technology for light oils. In the lab, this process recovered significant oil when waterflood residual oil saturation was higher, and is thus expected to be more applicable to medium oil reservoirs. The goal is to optimize the process by adding a surfactant to the gas stream to maximize recovery. Flue gas will also be tested. **Project Contact:** Sam Huang; email huang@src.sk.ca.

Immiscible CO₂/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 by a) considering the special requirements

wormholes will be used in separate numerical calculations of post-cold production processes. This project will combine experimental modeling (both at low and high pressure) and theoretical calculations. **Project Leader:** Bernard Tremblay, email tremblay@src.sk.ca.

Multi-Well Cold-Flow (Production) Predictive Numerical Model

This project aims at filling an urgent need—expressed by many oil companies—for a multi-well predictive numerical model of the cold flow process. This would describe the genesis and growth of wormholes following vertical well perforation. Such a model would allow producers 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 proposed numerical model would improve on existing models, which are non-predictive, limited to single wells, and dependent on a priori assumptions about reservoir parameters. **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. The work will focus on selecting an effective sandy solid-reinforced gel system, and testing it in the lab and in the field. **Project Leader:** Bernard Tremblay, email tremblay@src.sk.ca.

of pressure-depleted reservoirs, b) improving simulation of expected relative permeability effects in the field through use of gas/water co-injection, c) testing addition of chemicals to assist the process, and d) including comparative economic analysis.

Project Contact: Sam Huang; email huang@src.sk.ca.

Improved Pressure Decay Method for Measuring Solvent Diffusivity in Heavy Oil

This project aims at improving the pressure decay method for measuring the diffusion coefficient of solvent in heavy oil. Experimental tests and theoretical analyses will be performed to identify which of the three boundary conditions (i.e., equilibrium, quasi-equilibrium and non-equilibrium) at the solvent-heavy oil interface best describes the interfacial mass transfer. A new numerical model will be developed to determine the diffusion coefficient from the pressure-time curve measured in a much shorter time. A moving-boundary mass transfer model will be established to consider the oil swelling effect on the measured solvent diffusivity in heavy oil. Finally, the existing pressure decay method will be extended to study the diffusion processes of multi-component solvents in heavy oils. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

Core Area 3:

Enhanced Waterflooding

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

Previous SRC research found that, even when a surfactant provided ultra-low interfacial tension between oil and water, the ASP system did not perform well if a bank of crude oil could not be formed. 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. **Project Contact:** Sam Huang; email huang@src.sk.ca.

Optimizing Heavy Oil Waterflooding

This project is aimed at increasing the success rate of heavy oil waterfloods by ascertaining the factors that promote or

constrain oil recovery. It will build on the results obtained in a recent SRC study, which, for example, indicated that oil viscosity at reservoir conditions was a key parameter. The work will continue to increase the understanding of how the waterflooding process works at the laboratory level and will apply this knowledge in numerical modeling of the process.

Project Leader: Doug Soveran; email soveran@src.sk.ca.

Enhanced Waterflooding Using Colloidal Gas Aphrons – Year 2

This project will build on recent, considerable progress in developing microbubble solutions (aphrons) to improve the sweep efficiency of heavy oil waterfloods. Last year, major strides were made in producing stable aphrons solutions. Now the project team (SRC and Alberta Research Council) will focus on improving methods to increase oil recovery. **Project Leader:** Doug Soveran; email soveran@src.sk.ca.

Core Area 4:

Near Wellbore Conformance Control

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

A novel recovery method for waterflooded oil reservoirs that is reliable, efficient and relatively low cost is proposed to be developed and applied in this project. It will utilize multi-vibro energy sources to stimulate detachment/coalescence of oil in the reservoir and improve its mobility. A comprehensive understanding of EOR by seismic and mechanical-vibration stimulations will be established through theoretical, numerical, and experimental studies; and form the basis of a new simulation software package for use by industry. **Project Leader:** Liming Dai; email Liming.Dai@uregina.ca.

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

This project aims at helping producers to avoid or postpone bottomwater water coning and thereby improve oil production and reduce water handling costs. An understanding of how sand/shale reservoir layers block water flow can lead to

improved decision-making, for example, for optimal placement of horizontal wells. The feasibility of artificial chemical barriers will also be tested. Experimental and numerical results will be integrated into an analytical method to support field development strategies in either thick or thin formations.

Project Leader: Gary Zhao; email gang.zhao@uregina.ca.

Active Bottomwater Reservoirs

This project addresses the many reservoirs in Saskatchewan and Alberta in which the oil zone overlies an active bottomwater zone. The proposed research will investigate the factors that cause water channeling, a prevalent concern. It 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. Work will involve experimental physical modeling and numerical simulation. **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 overcome water coning or cresting. Excessive water production can reduce oil production rates and ultimate recovery while increasing operating costs and disposal volumes. The dual completion concept will provide restoration of pressure stability at the oil-water contact, enabling segregated, simultaneous production of oil and water. This work will investigate applications using both vertical and horizontal wells for recovery of light to heavy oil at different reservoir pressures and result in analytical and/or empirical models. **Project Leader:** Muhammad Ayub, email muhammad.ayub@uregina.ca.

Current project updates follow on Page 4.

The PTRC will be at the
Global Petroleum Show in Calgary,
Alberta, June 8-10, 2004.
Come visit us at **Booth 7419** in
Round-Up Centre Hall D,
by the Gulf Publishing Centre Stage.

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. The new equipment has been assembled and is being commissioned. The literature survey and the assessment of correlation/prediction methods for asphaltene precipitation have been completed. **Project Leader:** Norman Freitag; email freitag@src.sk.ca.

Propane / Heavy Oil Diffusion Measurement

The goal of this work is to improve the performance prediction and design of Vapex projects, through development of a technique to accurately measure molecular diffusion coefficients of Vapex solvents into heavy oil. The effort to develop the optical system was delayed by unexpected costs, but we plan to pursue it if further funds are approved. The U of R team completed writing a program based on the diffusion equation, which can be used to support the processing of measured diffusion data in this and other projects. As well, we are proposing a separate avenue of experiments using sandpacs that will examine dispersion of solvent due to convective mixing during flow in the reservoir. **Project Leader:** Bernard Tremblay; email tremblay@src.sk.ca.

Core Area 2:

Miscible / Immiscible Gas Injection

Immiscible CO₂ / 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. The focus is on an immiscible water-alternating-gas injection process. PVT analysis was conducted on both reservoir oil and several mixtures with injected gas (CO₂, N₂ and enriched flue gas). The performance of the WAG process in cores packed in the reservoir sands was evaluated with injected solvents. More questions than answers were found in this project phase, in that the incremental oil recoveries were less than half of that obtained in a previous WAG process study on Senlac oil (about the same oil viscosity at the reservoir temperature).

To answer the questions raised in the Phase I study, we have proposed a new phase of study which will build on the Phase I

Generic Modeling of Wormholed Reservoirs

Promising laboratory modeling results were observed in this project, which is aimed at improving sweep efficiency of post-cold flow processes in wormholed reservoirs. A baseline experiment obtained up to 18% additional recovery of initial oil in place when hot water was injected in a sandpack containing preformed open wormholes. (The recovery from primary production was 4% IOIP.) The next step is to repeat this test with closed wormholes. The physical scaled modeling is being complemented by numerical calculations to extrapolate these results to the field. The final report is expected to be complete in March 2004. **Project Leader:** Bernard Tremblay; email tremblay@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. The work has been completed and a brief final report is being prepared. **Project Contact:** Brian Kristoff; email kristoff@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. Recent work includes PVT tests which the students are undertaking to determine how much CO₂ diffuses, and how quickly. As well, we ordered a new pressure cell with a larger window. **Project Leader:** Peter Gu; email peter.gu@uregina.ca.

developmental work. It will measure the key physical properties for heavy oil saturated with CO₂ or enriched flue gas at candidate reservoir conditions. **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, CO₂) and gas mixtures, oil heaviness, and porous medium. Students are preparing and assembling the equipment for various baseline experiments. **Project Leader:** Muhammad Ayub; email muhammad.ayub@uregina.ca.

Core Area 3:

Enhanced Waterflooding

Heavy Oil Waterflooding Scoping Study

The production and injection histories of heavy oil waterfloods in Alberta and Saskatchewan have been collected. Five reservoir parameters could be used as screening criteria. Operational strategies have been analyzed for their effect on the success of the waterflood. These have included injection throughput, incorporation of horizontal wells, and selection of injection wells. The statistical portion of the study is complemented by interviews with engineering and field personnel. These have proven very insightful. The project will finish with a workshop at which industry participants will have the opportunity to share their experiences with heavy oil waterfloods and see presentations by specialists. **Project Leader:** Doug Soveran; email soveran@src.sk.ca.

Low-Cost Chemicals for Enhanced Waterflooding

The objective of the project is to determine if low-cost caustic substitute (sodium carbonate) can be sufficiently purified and act as effectively. A laboratory scale processing unit has been set up. Several tests to optimize the removal of suspended solids using an inclined plate settler have been completed. The operating limits of the settler have been determined. The final piece in the process, an oxidation reactor, is being assembled and will be tested shortly. **Project Leader:** Cindy Jackson; email jackson@src.sk.ca.

Enhanced Waterflooding Using Colloidal Gas Aphron (CGA) Solutions

This project is examining the use of microbubble solutions to lower the density of injected water to sweep previously unaccessed areas of the reservoir. Several promising surfactant combinations were identified that produce long-life bubble solutions. Work is progressing at the Alberta Research Council to test these solutions in a high-pressure aphron generator. Once they verify the stability of the bubbles, ARC will perform a core displacement test. SRC continues to work on ways to combine a polymer with the bubble solution to increase its viscosity. SRC will also complete tests using a two-dimensional visual physical model to verify the flow path of a low-density solution. **Project Leader:** Doug Soveran; email soveran@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. The technique entails modifying natural polymers to better adsorb on reservoir surfaces and plug reservoir pores. This quarter, adsorption tests, carried out by our partner at the U. of New Brunswick using some modified polymers, showed that cationic starches with relatively high molecular weight and high charge density tend to adsorb strongly on core samples. Flow tests with these polymers will be carried out by the University of Regina 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

The goal of this project is to develop an easy-to-use information system for reservoir engineers and managers to screen potential wells for implementing suitable near-wellbore conformance control techniques. This quarter, the work on improving the database and the rule-based portion of the Expert System was continued to near completion. Currently, we are working on how new data could be added to the database by the field engineer and how to assign appropriate weight to the new data, based on the experience of the reservoir engineer. The comments received from our industry partners have been implemented as part of this system development. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.

Developing Near Wellbore Conformance Technologies for Wormholed Reservoirs

This project aims at developing new and modified techniques for effectively blocking the wormholes in Lloydminster-type reservoirs. It is believed that a successful conformance control technique would greatly increase the ultimate oil recovery from these fields. This quarter, experiments continued on screening more surfactants and foam-stabilizing materials. As well, the flow experiments progressed to the next step where the resistance of foams were tested in hollow tubes of 1/4-in. diameter. Based on the results obtained, new formulations for the gel-foam systems have been developed and experiments are underway. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.

Other Areas:

Re-Injection of Recycled CO₂—Changes to CO₂-Oil Miscibility over the Year 2003

These subtasks of the IEA Weyburn CO₂ Monitoring and Storage project have a small but crucial role in forecasting how long CO₂ will be sequestered following its injection for enhanced oil recovery. The work statement has been modified to extend sampling into March 2004. An attempt to extend water solubility measurements in supercritical CO₂ to brine was unsuccessful. However, information from measurements with pure water and recently uncovered literature will be sufficient for the project objectives to be met. **Project Leader:** Norman Freitag; email freitag@src.sk.ca.

Application of Gels for CO₂ Conformance

This project has been completed, and the final report will be delivered shortly to PTRC. During this research, we were able to design and formulate a series of gel systems that could effectively block the flow of carbon dioxide and water in porous media. These results could be used for designing and implementing successful field tests in Saskatchewan. As a next step to this project, we will be proposing field tests to our industry partners through PTRC-Industry programs. **Project Leader:** Koorosh Asghari; email koorosh.asghari@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.

Biosurfactant-Enhanced Technologies for Remediation of Petroleum-Contaminated Sites

Good progress was made in this quarter to finalize R & D of the enhanced bioremediation process for removing subsurface hydrocarbon contamination. Biosurfactants were isolated from two strains of soil and synthesized in bulk production. Several experimental conditions were selected and optimized to regulate the production process, which is significant for industrial applications. Meanwhile, the performance of the biosurfactants in enhancing bioremediation, as well as their toxicity and biodegradability, have been quantified using the fully-loaded pilot-scale model. Research outputs in this quarter demonstrated applicability of the newly-developed technology and would be helpful for facilitating technical transfer in the future. **Project Leader:** Gordon Huang; email Gordon.Huang@uregina.ca.

Selective Permeability Reduction by Polyacrylamide Polymers for SK Reservoirs

The experiments designed for this project are completed, and a final report on the findings will be delivered to PTRC in the near future. In brief, the results obtained for this research indicate a very promising outlook for implementing this process in order to reduce water production without adversely affecting oil production. Based on these results, we will propose field tests to potential oil company partners operating in Saskatchewan and Alberta through PTRC-Industry programs. **Project Leader:** Koorosh Asghari; email koorosh.asghari@uregina.ca.