

2013 Company Prospectus



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Applied Reservoir Enterprises Ltd. (ARE) is a privately held engineering consulting company incorporated in the Province of Alberta, Canada. Originally founded in 1990, by M.R. (Mike) Carlson, the company specializes in technical reservoir engineering. ARE offers consulting engineering services in the following areas:

- **General Reservoir Engineering**
- **Thermal Recovery (SAGD)**
- **Black Oil, Compositional and Thermal Simulation**
- **Geomechanics / Caprock**
- **Government Applications and Hearings**
- **Expert Testimony**
- **Peer Reviews**
- **Training**

ARE staff have worked on projects in the following areas:

Abu Dhabi
Alberta (Canada)
Algeria
Argentina
Australia
Austria
Arizona (U.S.)
Bangladesh
British Columbia (Canada)
Columbia
Cuba
Dubai
Former Soviet Union
India
Indonesia
Manitoba (Canada)
Mexico
New Mexico (U.S.)

Oman
Ontario (Canada)
Peru
Qatar
Romania
Saskatchewan (Canada)
Turkey
Venezuela

Past clients are outlined in the following. References for a project similar to yours will be provided on request. The numbers indicate where more than one project has been completed.

Ackroyd LLP
Alberta Oil Sands Inc
Amerada Hess Canada Ltd. (four)
Amoco Canada Petroleum Ltd.
Barrington Petroleum Ltd.
Bauerberg-Klein (Argentina)
Baytex Energy
Big Guns Energy Services
Canadian Hunter Exploration Ltd. (two)
Canadian Natural Resources Ltd.
Canadian Petroleum Institute (eight)
Cenovus
Cimarron Petroleum Ltd.
Co-Enerco (six)
Corexcana
Computer Modelling Group (four)
Connacher Oil and Gas Limited
Culshaw Petroleum Services Inc.
Czar Resources Ltd. (two)
E-T Energy Ltd
ELAN Energy (two)
Encal Energy Ltd.
Franco-Nevada Oil and Gas
Geosimm Technologies Inc.
High Point Resources Ltd.
Home Oil Company Ltd.
HOT Engineering Gmbh
International Pedco Energy Corp (three)
McDaniel & Associates Consultants Ltd.
Newmont Mining Corporation Limited (3)
Newport Petroleum Corporation
Omega Hydrocarbons Ltd. (five)
Orbit Oil & Gas Ltd.
Page Petroleum Ltd.
PanCanadian Resources Limited (four)
Petroleum Society of CIM (two)
Petro Management Group
Petrorep Resources Ltd.

Petro-Canada Resources
Petroleum Industry Training Services
Phillips Petroleum Canada Ltd. (two)
Place Resources Corporation (two)
Player Petroleum Ltd. (two)
Pridmore Enterprises Ltd.
Race Rocks Resources (four)
Reliance Engineering Group Ltd.
Remington Energy Inc. (two)
Rigel Oil & Gas Ltd. (three)
Royal Bank of Canada
Society of Petroleum Engineers (multiple)
Southern Alberta Institute of Technology
Sceptre Resources (three)
Shiningbank Energy Ltd. (three)
Sherritt International Corporation (two)
Scientific Software-Intercomp (three)
Stampeder Exploration Ltd.
Suncor Inc., Resources Group (eight)
Taurus Reservoir Solutions
TransAlta Corporation (two)
Tyson Energy Corp.
Ulster Petroleums Ltd.
Westrock Energy Consultants
Western Star Exploration Ltd.
Woodside Offshore Petroleum Pty.
(Western Australia)
Yorkton Securities

Mission Statement

Applied Reservoir Enterprises Ltd. aims to furnish clients with:

1. A thorough analysis of problems within a broad scope of petroleum engineering;
2. Practical recommendations; and,
3. Comprehensive and readable reports.

Objectives

ARE has studied approaches in consulting that provide the most useful results to an operating company, gas marketer, or financial institute. These observations are based on experience within operating companies, an international technical consulting firm, a major evaluations company, and over a decade as an independent consultant. The mission statement reflects this experience.

Confidence

It is imperative that the work be done as

thoroughly (or more so) than the client would do himself. This thoroughness must be presented to the client in such a way that the client is confident in the analysis.

Recommendations

Clients need answers to their problems. Recommendations need to provide a clear course of action. In most cases this requires that “little bit extra” over a summary of technical results. Information should be provided in a format that they could use immediately.

Communication

The true value of work performed must include a “communication factor” and a “knowledge retention factor”. ARE uses:

1. A formal presentation of results at the end of the project.
2. A clearly documented and readable report. Enough detail must be presented to enable the client to continue the project at a future date.

Technical Work

ARE’s business has historically been divided equally between evaluations, general reservoir engineering and numerical simulation. This broad background can be an advantage:

1. During the course of economic evaluations the client’s technical understanding of the property can be improved.
2. Most simulation studies depend on the quality of the geological input. Geological experience is therefore a great asset when completing these studies.
3. A background in exploitation and evaluation assists in assessing simulation results and the economic implications.

Approach To Consulting Assignments

Multi-Disciplinary Studies and Staff

ARE typically maintains a full time staff of two people; the principal and an office manager. Many studies that ARE has conducted require multi-disciplinary staff. Most of these studies utilize senior professionals. A number of projects require junior staff to optimize costs and/or meet tight timing constraints.

Although ARE has maintained full time technical staff for a number of extended periods; it has been found that the variations in individual projects makes it more effective to utilize associates in their respective disciplines at different levels. The company maintains relations with a number of associates who are familiar with the work style of the company.

Our largest projects utilized 6 senior professionals and lasted approximately 2 years. Personnel for this project included a senior geologist, a specialist log analyst, a hydrogeologist, a geomechanics specialist, an AEUB hearing specialist, a senior reservoir engineer, as well as a geostatistics expert. (This project also involved a senior law partner).

Most projects during the last 5 years have involved multiple staff on projects. In ARE's view the success of projects is strongly determined by the actual individuals working on the project. Staff selection is usually outlined in project proposals with staff tailored to meet the needs of individual projects.

Cost Effectiveness

ARE provides what we believe is a cost-effective report. As a small speciality company, with overhead kept to a minimum, it is our experience that we can produce a report for the same price or less than the larger firms, and provide a superior product as outlined in the following pages.

General Reservoir Engineering

Reservoir Reviews

Reservoir reviews are performed for a variety of purposes. This typically includes identifying upside potential for an acquisition, screening properties for optimization potential, reserves determination (i.e. without economics) and determining the applicability of horizontal wells. Many people refer to this as "Bread and Butter Reservoir Engineering".

This process normally consists of a review of geology, production performance, and past engineering analysis. To be effective requires a very broad range of experience. Most EOR property optimization hinges on identifying unswept areas, which is controlled by reservoir continuity. This requires geological knowledge. To quickly identify anomalous performance, which suggests optimisation opportunities, requires an exposure to a large number of properties throughout Western

Canada. Finally, a good knowledge of technical reservoir engineering is required to know whether past work has covered all possibilities and to identify what the next steps should be.

In many cases it is not known exactly how big a time commitment is required for a reservoir. Under these circumstances ARE typically splits a potential project into two parts. The first part is normally a screening process that lasts from a few days to a few weeks. At the end of this time period, interim results are presented. The client may then decide whether or not to continue.

In a very large number of cases adequate information is obtained from screening studies to make an informed decision. ARE believes this is the most cost effective way of approaching many studies.

Reservoir Simulation

Widespread Use

Reservoir simulation is a maturing market. During the past two decades the speed and capacity of computer hardware has increased. Concurrently, the real price of computers has dropped. Large scale simulations are now economic. With Alberta's oil reservoirs in advanced stages of depletion, production optimisation will become necessary. More widespread use of numerical modelling will occur.

Dangers

The numerical procedures within the models have improved. Models are more stable and have become much easier to run. There are, however, many dangers in reservoir simulation. Models will run numerically in spite of basic errors in reservoir description or choice of grid. Reservoir simulation requires specialized knowledge of numerical considerations. For these reasons it can be desirable to have a specialty consultant perform these studies.

Critical Issues

Reservoir simulation studies vary greatly in quality. The most important differences are reservoir description, proper layering, and comprehensive checking of output data. Most predictions should be checked against offset analogies. The emphasis on ARE's reservoir simulation is therefore as follows:

1. **Comprehensively prepared reservoir descriptions.** The first step is a good understanding of the depositional environment. This requires a basic knowledge of geology. It is critical for a simulation engineer to be able to read logs, since this is one's "window" into the reservoir.
2. **Detailed layering calculations are normally required.** This involves either specifying the correct layers, or the correct development of pseudo relative permeability curves. For instance, there are statistical techniques that have been available for over 25 years that are not commonly implemented.
3. **Checking offset information.** This aids in identifying critical modelling parameters. Frequently, unrepresentative models can be weeded out by comparison to offsetting production.
4. **Providing a quality report.** Simulation involves an enormous amount of input data. A report should include a copy of the basic data input deck. There is no other method of reproducing the results in the future without this information. A run by run history match log should be

supplied. The changes should be described so that the client will know what decisions and assumptions were made. Results should be displayed graphically. This allows rapid assimilation of the results and provides a vital quality control check.

ARE has prepared a considerable amount of material on preparing simulations comprehensively, which include numerous courses, a textbook, as well as a 2 part JCPT Distinguished Author Series *What You Should Know About Assessing Simulation Results For Economic Evaluations*.

Geomechanics

Geomechanics is important from two main perspectives: cap rock integrity and enhancement of production performance. Both of these areas rely on concepts from Geological Engineering.

Caprock Integrity

A significant caprock failure occurred on the Joslyn SAGD property in 2006, and it had a wide impact on the approval process for future SAGD projects. Two reports were released by the Alberta Government:

1. "Total E&P Canada Ltd., Surface Steam Release of May 18, 2006, Joslyn Creek SAGD Thermal Operation, ERCB Staff Review and Analysis, February 11th, 2010"
2. "Summary of Investigations into the Joslyn May 18th, 2006 Steam Release, Total E&P Canada Ltd."

The latter report is very large, and a number of potential mechanisms are postulated without definitive resolution. The ERCB currently requires that caprock integrity be addressed in applying for a license for a commercial project.

Enhancement of Production Performance

The effects of geomechanics is based on:

1. Extensive documentation in the literature
2. Laboratory results
3. Numerical simulations
4. Field observations

Geomechanics is not currently included in standard petroleum engineering programs. This is a classic area where cross-disciplinary understanding is critical, much like the link between reservoir simulation and geology.

Government Applications

An application prepared by an independent engineer may have more weight with the ERCB. Applications or written correspondence to the government have been made on the following:

- gas conservation
- common purchaser hearing

- water injection wells
- temporary battery applications
- communication tests
- waterflood project reports
- royalty holidays
- allowables
- sour gas flaring permits\
- gas over bitumen hearings

Applications have been made to both the Alberta and Saskatchewan governments.

Expert Testimony

Expert testimony requires a number of different skills in addition to technical excellence. The ability to communicate information to a non-technical audience or different disciplines can be of vital importance. The principal spent many years in Toastmasters developing presentation skills. He is a Past President and Past Educational Vice-President of Palliser Toastmasters.

Most disputes on which ARE has worked have been resolved without a government hearing or court trial.

The methodology used, which has been developed from past engagements, is as follows:

1. In conjunction with legal counsel identify the key legal or regulatory issues. The technical approach must be directed to resolving this point.
2. Reviewing or studying the relevant technical issues, which apply to the case.
3. At completion of technical work, reviewing with the client's counsel the results of the technical review or study.
4. Preparing reports and statements of expert witness that are readable to non-technical people.
5. Extensive use of references and support material. In the adversarial process most experts' views are often viewed as biased to their clients. The use of outside material establishes that sound engineering has been applied.
6. In many cases there are industry wide differences in opinion on important issues (otherwise the matter would most likely have been previously settled). For instance, there is very limited data on bitumen relative permeabilities, some of which indicates temperature sensitivity and some of which does not. All of this data was presented to provide a complete background. Importantly, the *most applicable data* shows temperature dependence and this point was emphasized rather than simply presenting only temperature dependent data.

ARE does not charge a premium for hearing or courtroom time. Although the adversarial process can be stressful and experience with cross-examination is beneficial: the questions posed by counsel and/or government staff; are no different and no more difficult than those questions that well informed technical clients would make. Prior preparation is the key.

In addition, an interest in legal and regulatory issues in the oil and gas industry is an asset. ARE has

found this area to provide significant and interesting challenges.

Peer Reviews

In most peer reviews, due diligence is usually the underlying motivation: have all the significant aspects of development plans been adequately thought out and problems anticipated?

Realistically, it is not likely that a technical expert can replace man-years of work in a few short days. However, an outside person has experience gained from how other companies have dealt with similar issues, is independent of internal politics and, because they are external, can help find the holes that are difficult to spot when immersed in a project.

Having one's work peer reviewed is (at least for me) always somewhat stressful. Yet there are very few projects where some constructive suggestions cannot be made. In ARE's view, providing a balanced experienced analysis with a cooperative and constructive approach is key to these projects.

Log Analysis

The requirements of log analysis for reservoir engineering are different than the requirements for exploration or reserve booking:

1. For reserves, water saturations and porosities must be calculated with "reasonable certainty". The exploration formation evaluation seeks to identify potential to test. The two analyses are at opposite risk extremes. The geologist wants to test anything that might produce hydrocarbons; the engineer can only book reserves for zones that will produce economic hydrocarbons with a high degree of certainty.
2. In reservoir simulation productivity must be quantitatively predicted. Results must be reconciled with production data and other reservoir engineering calculations such as material balance or reservoir simulation.
3. For enhanced oil recovery, most commonly waterfloods, determining the degree of heterogeneity (layering) is of the utmost importance. Log analysis must include an estimate of permeability. Reservoir characterization will often use statistical techniques to determine where layers should be divided or to generate a permeability distribution.

These requirements are somewhat specialized and unique to reservoir engineering applications.

Due to these fundamental differences in approach, ARE typically prefers to either be responsible for log analysis, or to be involved in the specification of log analysis. ARE has gained substantial experience in conventional and computerized log analysis for reservoir engineering applications.

Familiarity with log analysis is very important to general reservoir engineering. Fairly simple correlation, combined with production performance, often provides very valuable information on communication within a reservoir.

Pressure Transient Analysis

Pattern Recognition

Better interpretations of pressure transient buildup tests are made with a strong background in general reservoir engineering. Well test analysis frequently does not give a unique solution. Thus, the final interpretation relies on an overall knowledge of the reservoir. As an example, ARE analyzed a number of tests from a foothills gas reservoir as part of an economic evaluation. Improvements were made to the existing AOF and buildup conclusions by amalgamating results from many tests, structural geology, and core data. The new perspective was more consistent, and changed the client's perception of the reservoir. Development drilling priorities were changed based on this study.

Economic Evaluations

A report prepared by ARE offers the following advantages:

1. Detailed Write-ups
2. Reserves Continuity Tables
3. Reconciliation Of Change In Value
4. Year Round Preparation Using A Reserves Database
5. An Optimized Program Of Work
6. Complete Coverage of Corporate Revenue
7. Proven Quality Reports (References)
8. Preparation By Experienced Engineers
9. Potential To Utilize Technical Experience Gained

Over the years, Applied Reservoir Enterprises Ltd. has developed many features in our reports, which we believe will provide clients with the best report available. The details of these features consume a considerable amount of space and are documented in an example report, which will be supplied upon request. A summary of these features is outlined below:

Concentration of Value

The first step in preparing an evaluation is to determine how the value of a corporation is distributed amongst various properties. The central issue is accurate risk assessment. Companies with broad geographic holdings that have a long production history can safely be evaluated by analyzing a large number of properties, with moderate attention to detail. Alternatively, if a company consists of a single property, or the majority of value is concentrated in a newly developed area, more detailed evaluation is required.

Detailed Write-ups

ARE provides a summary of reserves and value, a geological description, how reserves were determined, the operating costs, future capital required, gas contract information and economic assumptions utilized. This provides two main advantages:

1. It provides background information to those who are not familiar with the company; and,
2. It allows the expert reader to assess risk, without having to repeat the evaluation himself.

Detailed reports provide more confidence to those reading the report.

Areas Not Evaluated In Detail

All production not evaluated in detail will be evaluated in a group run. This technique allows 100 percent of a client's cash flow to be included. Due to the widely dispersed holdings, relatively little risk is involved with this assumption.

Reserves Database

ARE typically uses a reserves database, such as RESERVES a product of Merak Projects Ltd. This allows all of the working interest, production forecast, operating cost data etc. to be entered. The evaluation can be prepared by updating the evaluation date at the end of the year. Using this technique, which has been used extensively by the principal on an in-house reserves data base system, allows reserves to be maintained on a year round basis. By setting up a schedule, the reserves can be evaluated on an appropriate timetable. It is suggested that properties and exploration additions be reviewed in quarterly meetings.

ARE has used and evaluated this software on previous consulting projects. Computer files of either the database or datafiles will be provided to the client at no additional charge.

Reserves Reporting

The principal of ARE has extensive experience in corporate reserve reporting. The following would be included in a report prepared by ARE:

1. **Reserves Continuity Table:** This will show the previous reserves, changes, exploration additions, the amount of production that has been retired, and the current reserves. An explanation will be provided for the changes.
2. **Reconciliation Of Change In Value:** This table identifies what has changed the value of a company, which would include changes in:
 - a. Price,
 - b. Production forecast
 - c. Royalties
 - d. Operating costs
 - e. Taxes
 - f. Reserves

The tables above were developed in conjunction with internal auditors and has been successfully used for the financial reporting on a number of Canadian and American companies.

Price Forecasts

Two price forecasts will be prepared and included in the report. The first is a constant dollar forecast, which is required for ceilings test reports and other financial and securities reporting.

The second forecast will be an inflated price forecast. ARE prepares its own price forecast as shown in the attached example evaluation. In the past ARE has run other forecasts, and signed the reports.

These forecasts were supplied from the company's appropriate bank and were not significantly different from that prepared by ARE. It is our understanding that most banks will typically re-run consultant's evaluations using their own price projections. Providing a run with the bank's own forecast promotes good will.

It is our policy to run a third forecast provided by the client and provide summary output at no additional charge. Most operating companies have an in-house corporate price forecast, which is used as a basis for comparison.

Recognition of Reports

All of the banks that ARE staff has worked with maintain their own private evaluation experts or consultants to vet *all* evaluation reports and *all* significant assets. Furthermore, Canadian banks will re-run *all* evaluations utilizing their own price forecasts. In the past, good quality reports prepared by ARE staff have enhanced clients' relations with their bankers.

Training

The supply of technically-trained engineers will decline sharply when the current baby boomers retire—and many of them hope to retire early. As a result, significant additions of new junior staff will be required.

In addition, the securities regulators in Canada have re-defined the rules with significant changes in reporting requirements. The U.S. regulators are following suit with similar changes as a result of accounting failures such as Enron. *These regulations make high levels of technical expertise mandatory at senior (board) levels.*

Meanwhile technical change has been accelerating, the extensive training programs developed in the 1970's and early 1980's have been largely abandoned, and trained engineers now have considerably more mobility than in the past. This has created a challenge for employers: how to provide the necessary training for their up-and-coming staff.

Training Options

There are numerous options in taking courses. Some of these include courses:

- Provided in-house
- In academic institutions
- From technical societies
- From training services companies

ARE has taught in all of these venues and all have their advantages. ARE has experience working for operating companies and believes its strength includes practical experience from a number of different companies, countries, and projects.

Courses have been developed in a variety of reservoir engineering disciplines. The company now has significant experience teaching these courses in the international market place and course

evaluation forms indicate that they have been successful. A listing of the courses ARE teaches may be found in the Company Prospectus.

ARE has been preparing for the development of this market for over ten years. Specifically courses have been developed in a variety of reservoir engineering disciplines. The company now has significant experience teaching these courses in the international market place and course evaluation forms indicate that they have been highly successful. ARE has also prepared a textbook on *Practical Reservoir Simulation*, published by PennWell in 2003.

Past Projects

A brief outline of the style and scope of past projects is outlined in the following:

Evaluations

Decision Cycle Compression – Abu Dhabi – Giant Onshore Carbonate Field

Simulation support in Houston and Abu Dhabi. Work was on Middle East giant carbonate reservoir. DCC is an intensive decision management tool for developing oil and gas fields.

Independent Reserves Report

Prepared evaluation for two offshore heavy oil reserves in fractured chalk reservoirs. Report used to successfully underwrite company on New York stock exchange (SEC report). Included due diligence review.

Sale of small company

Reporting required for Vancouver Stock Exchange (VSE). Company's oil and gas assets sold based on report.

Technical review of waterflood

Performance of waterflood reviewed for potential acquisition.

Evaluation of Disposition Packages

Prepared evaluation of packages placed on market by Norcen. Subsequent bids were within 2 percent of successful bidders.

Foothills Sandstone Gas Reservoir

Independent audit for internal reserves bookings. Evaluated reserves data base system for future acquisition.

Foothills Carbonate Reservoir

Independent engineering report for dispute resolution and sale of property.

Property Swap Evaluation

Northern B.C. and Alberta. Evaluated both sides of a property swap between two companies, which was successfully consummated.

Past Peer Review Projects

Are staff have done a number of peer review projects

- For bank – operators development plans – for financing
- US base oil company – progress to date on SAGD project
- ERCB application SAGD commercial application review
- Siberian mature oil and gas field – Tyumen, Russia
- Major property review – Petro-Canada

- Decision Cycle Compression project in Abu Dhabi
- Reservoir Simulation Reviews
 - Benson Midale Beds
 - Midale Ordovician Yeoman
 - Loon Lake Slave Point G
 - Valhalla Doe Creek T, U and BB Pool
 - Material Balance Studies
 - Sylvan Lake Pekisko B
 - Manyberries Sunburst Q Pool

Reservoir Simulation

Reservoir Gridding for Reservoir/Geomechanical Reservoir Simulation

Deep water Gulf of Mexico

Generated reservoir simulation grid for combined geomechanical and reservoir modelling

Research on in situ stress states for offshore Gulf of Mexico

Gas Over Bitumen Hearing Alberta Energy and Utilities Board

ARE was initially retained to evaluate an application to produce gas over bitumen from an offsetting producer. Initial communication was established with the operator and negotiation attempted. The gas producer insisted on having a hearing. This hearing was the longest and most complex hearing ever heard by the Board. (The Surmont gas over bitumen hearing was the previous record holder). ARE coordinated a major multidisciplinary technical study, which included geology, petrophysical analysis, hydrogeology, extensive thermal simulation, simulation of gas pool performance and interference, geostatistics and geomechanics. Several submissions were made including electronic submittals. Expert witness panels appeared for both the main and interim hearings.

Ostracod Channel Simulation

Reservoir simulation of mature gas flood. This pool involved a complex of braided channels. Significant increase in recovery factor was predicted by simulation.

Glauconite Channel Pool

This reservoir was simulated to apply for waterflood from AEUB. Report used to successfully obtain waterflood. Waterflood has now been implemented.

HCMF Compositional Reservoir Simulation

This pool was modelled using a compositional simulator. Objective of simulation was to ensure HCMF had been successful and to make government application for blowdown to British Columbia government. Approval was successfully obtained. History matched miscible flood performance and provided blowdown predictions.

Charlie Lake Reservoir Simulation

Successful simulation and history match of pool with horizontal water injectors. This pool had variable reservoir quality and a gas cap. The depletion strategy for this pool was changed significantly as a result of this study. This pool was previously modelled; unsuccessfully, by a large industry consultant.

Doe Creek Waterfloods

Waterflood optimization using simulation. Update of study previously completed.

Gas Condensate

A field wide study of this Wabamun, near critical sour gas reservoir, identified field wide geological and pressure transient analysis trends. The effects of liquid dropout (peak CVD dropout 40%) on well productivity were explained in terms of reservoir heterogeneity. Anomalous results from previous studies resolved and pertinent reservoir mechanisms identified.

Blueberry Update

Previous simulation updated after infill drilling. History match improved with additional data. Purpose of study update was to evaluate further infill drilling and pressure maintenance.

Pekisko Subcrop

Conceptual reservoir simulation for horizontal well in carbonate subcrop karst reservoir development. Identified probable well productivity and placement of injection wells for potential waterflood.

Brazeau River

Prepared compositional simulation for performance prediction of highly volatile (sour) Nisku oil reservoir. Considerable EOS research done on resolving difficulties in obtaining representative fluid samples and obtaining reliable lab data. Study integrated with pressure transient analysis results. Compositional effects on pressure transient analysis investigated. Cases examined included primary production, acid gas re-cycling, sales gas injection and waterflooding.

Blueberry Debolt

Black oil reservoir simulation of the south and north pool. Carbonate reservoir trapped on the updip limit of thrust fault in northeastern British Columbia. History matching identified important changes in interpretation related to original gas cap size, direction of water influx, infill drilling locations as well as optimal method of future depletion.

Retrograde Condensation

Effects of retrograde condensation was investigated on well productivity. Accurate forecasts were required to commit to a sour gas plant in the Deep Basin area of Alberta. The effects of a hydraulic fracture were directly modelled with surprising results. Productivity impairment was not as great as previously predicted in literature. Findings presented to SPE Low Permeability Reservoir and Rocky Mountain Regional Symposium in March 1995.

Saskatchewan Viking

Evaluated waterflood response in the Dodsland area of Saskatchewan. PVT properties were resolved in the study and the effects of hydraulic fractures were modelled directly. Based on this work, expected waterflood response in the Viking was reduced over previous methodologies. The results of this work were presented in an internal SSI technical symposium, at the 3rd Saskatchewan CIM conference in September 1989, and was subsequently published in JCPT.

Dodsland Waterflood

The previous work described above was extended to include the effects of stratification in the Viking sandstone. This further downgraded waterflood performance expectations. Waterflood response in this formation consists solely of a levelling of production. This has an important impact on economics. The existing waterflood was discontinued based on study recommendations. Paper written and published in JCPT.

Cross-Sectional Study

This was a follow-up study to previous 2D areal simulation of a large carbonate reservoir. Reasons for lack of waterflood response in the previous study were identified (three phase relative permeability).

Major Beaverhill Lake Waterflood Study

A large simulation was required. There were over 100 wells in this Swan Hills Unit. Historically, it has been difficult to get good quality history matches in Beaverhill Lake reservoirs. This study resulted in an excellent history match. Numerous optimization opportunities were identified. Many of these recommendations have been successfully implemented. This study was presented at the International CIM/SPE Conference held in Calgary during June, 1990. Paper subsequently published in JCPT.

Depletion / Gas Coning

The subject of this analysis was a small Glauconite Channel oil pool. A gas cap was located structurally above the producing well interval. The presence of the gas cap was demonstrated by material balance and numerical simulation. The effects of production rate on ultimate recovery were evaluated. A GOR penalty relief application was successfully obtained with this study.

Waterflood Feasibility

A follow-up to the study described above. The reservoir history match was updated slightly. Predictions of waterflood performance were made and economics prepared.

Water-Gas Coning

Completed for a shallow low-pressure gas reservoir that was underlain by a water leg. Possible coning of water in the field was investigated using numerical simulation. Water production history in an offsetting reservoir was also examined. Only minor coning was predicted due to the extremely high permeability (3,000 mD).

GOR / Gas Saturations

Initiated as part of the defence for a litigation. The dispute centred upon the ownership of solution gas produced from an oil leg. The pressure history of the associated gas cap was reviewed. Simulation was used to relate the initial producing GOR and the initial gas saturations in the reservoir. Technically this project is similar to earlier work in the Dodsland Viking. Waterflood response in this project was verified.

Horizontal Wells

A data set was constructed for Oil India using CMG's IMEX black oil model. Data extrapolation was required due to age of pool and missing data. A horizontal well was positioned below a gas cap and above an active water leg to maximize recovery by minimizing coning.

Waterflood Performance

The performance of the Lower Amaranth formation was reviewed. Simulation was used to demonstrate communication with the underlying Mississippian formation. Modelling was also used to show effect of communication on buildups. Simulator output analyzed using conventional computerized well analysis. Mississippian pay mapped. Sensitivities were run to evaluate a potentially more effective waterflood pattern.

General Reservoir Engineering

SAGD Development Program

Developed drilling locations for development of field. Intensive 3D geological mapping using Petrel. Prepared reserves estimates. Selection of services for wellsite supervision, drilling contractor, loggers, cementers and core analysis. Government applications to SR&DP and well licenses. AEUB Agent for Newmont in Alberta

Charlie Lake Reservoir Review

A 3 day review of reservoir performance. Project later extended to include complete reservoir simulation

Beaverhill Lake Unit Study

2-day update of previous reservoir study.

Deep Foothills Carbonate Reservoir

This pool is a large (approximately 2 TCF) pool located in the foothills of Alberta. The Beaverhill Lake is below the structural deformation from overthrusting in younger sediments. The fluid in this reservoir is very sour, which makes it difficult to characterize. Technical review of subject reservoir. In particular, investigation of compositional effects and variation in composition with depth.

Material Balance Review

A material balance was reviewed as part of a dispute resolution. Identified multiple solutions based on different PVT data handling.

Belly River Waterflood

A waterflood feasibility study was prepared for a Belly River oil pool. Continuity was evaluated using a fence diagram. Waterflood response was estimated by examining an offset pool. Economics were prepared.

Horizontal Wells

The potential for horizontal wells has been evaluated in three reservoirs. These analyses consisted of screening reservoir performance for the Pekisko in Alberta, Frobisher-Alida beds in Saskatchewan and the Viking in Saskatchewan.

Concurrent Production

The client requested a proposal for a major simulation to investigate the effect of associated gas cap production on a waterflooded oil leg. This issue was resolved, at a significant saving in cost, by discussions with the ERCB and negotiation amongst the oil leg and gas cap operators.

Keg River

This reservoir had been on production for an extended period of time. An infill well was drilled and encountered unexpected amounts of gas. Material balance and production data was used to estimate water-oil and oil-gas contacts. PVT data was correlated regionally to other wells.

D-3 Leduc

The client requested a material balance study and production decline analysis of remaining reserves. Based on analysis of historical performance, PVT correlations and a review of previous PVT tests, the understanding of fluid properties was enhanced. Analytical calculations and water breakthrough analysis identified the migration path of water influx into the reservoir. This work provided the necessary background to proceed with a highly successful workover program.

Foothills Carbonate

Reviewed historical performance of major foothills property acquired by client. A complete re-analysis of all data was done including computerized pressure transient analysis, computerized log analysis, PVT review, structural

interpretation and reservoir description. Recommended workover has been implemented.

Gas Contract Reserves

Prepared reserves and conducted gas contract reserves base negotiation. This negotiation spanned most of the deep basin area of Alberta.

Log Analysis

Log analysis is an integral part of completions, production optimization, reservoir descriptions and reserves calculations. Recently, while with a major consulting firm, this expertise was expanded to include computer processed log interpretation. Projects include:

1. Gas Over Bitumen hearing. Non-standard methods are required to evaluate unconsolidated sands. There are also radioactive sands present.
2. Bangladesh log analysis for reserves determination and subsequent simulation studies. Difficult analysis due to gas and heavy/radioactive mineral assemblage.
3. Glauconite Channel: detailed layering produced for secondary recovery schemes, including statistical layering technique.
4. Log evaluation of large gas-condensate discovery in overthrust belt on east side of Peru.
5. Slave Point conventional computerized analysis.

Courses Instructed

Industry

Advanced Reservoir Simulation (Bauerberg-Klein / CAREC)

Course on compositional modelling for gas condensates, miscible floods and volatile oil simulations. Workshop included training in tuning, history matching and 6 problem sets. Taught in Lima Peru.

Reservoir Simulation In Practice (Scientific Software - Intercomp)

Presented 2 days of a 5-day industry simulation course. Topics covered were:

- single well studies
- coning problem set
- cross sectional studies
- pseudo relative permeability
- PVT input
- well representation

Course presented 3 times.

Reserves Course

Instructor for half day of in-house reservoir engineering school relating to reserves. Technology Transfer. (Home Oil Company Limited).

Responsible for in-office technology transfer program with foreign (Bangladesh) engineers on CIDA project. (Scientific Software-Intercomp).

Practical Reservoir Simulation, Using, Developing and Assessing Results

Five day course on reservoir simulation. Course included formal instruction; example

problem sets on computers with simulator and anecdotes of previous problems. The course was run twice. (Petroleum Society of CIM)
Course twice in Ploesti, Romania – Module 2 (HOT Engineering GmbH / Petrom)
3 day version of course for PIECE in Houston Texas in 2011. Scheduled to be taught as 5 day course in 2013.

Numerical Simulation of Petroleum Reservoirs

Taught 10 day industry simulation course for CUPET, Majagua Cuba
Taught 5 day industry simulation course at UNACAR (Mexican University) to PEMEX engineers

Thermal Reservoir Simulation

3 day introductory course for co-op students and recent graduates (Petro-Canada) – taught 3 times.
5 day course for Nexen Inc. in June 2010 (RPS Energy Canada Limited)
5 day course for SPE in 2012 (ARE), 2011, and 2010 (RPS).

Applied Reservoir Management

5 day industry course for HLS India, New Delhi, India. (Halliburton)
5 day course in Campina, Romania (HOT) February 2006.
5 day course in Vienna Austria (HOT), July 2007
5 day course Dhamman, Saudi Arabia May 2008 (HOT)
5 day course in-house course for RAG April 2008 (HOT)
5 day course Dubai October 2008 (HOT)
5 day course Abu Dhabi November 2008 (HOT)
5 day course Wien June 2010
5 day course Wien July 2011
Two 5 day courses in Qatar for HOT engineering May 2012
5 day course in Vienna for HOT Engineering July 2012

Introduction To Reservoir Engineering Basics (Encana / PanCanadian Petroleum Ltd.)

Two-day basic reservoir engineering course for reservoir engineering training program (course taught four times).

PETROM Module 3 – Predicting Performance via Material Balance and Simulation

10 day course on use of material balance, simulation history matching tuning and predictions, Ploesti, Romania (HOT Engineering GmbH).

Reservoir Management of Coning Prone, Heterogeneous and Tight Reservoirs

Taught 6 day course in Dehra Dun India (ONGC Management Engineers)

Advanced Reservoir Engineering

Taught 12 day industry course at NAFTAGAS (Sonatrach) Hassi-Masoud, Algeria.

EOR Simulation

Taught 10 day course on EOR and reservoir simulation. Also water and gas coning.
(Majagua Cuba, CUPET)

In-house Training

In-house heavy oil course for visiting Egyptian engineers.

Two day course at Calgary industry learning centre

Reserves Course (Home Oil Company Ltd.)

Half day of in-house reservoir engineering school relating to reserves.

Reservoir Engineering Course

Three-week course taught for Libyan engineers and field personnel.

Course was taught at the Nisku training centre.

Academic Institutions

Natural Gas Reservoir Engineering

Taught two 5 day courses on natural gas reservoir engineering. (National Engineering University of Peru UNI). First week taught in Lima with second week in field location (Talara – Northern Peru

Fractured Reservoir Engineering

Taught 5 day industry simulation course at UNACAR (Mexican University) to PEMEX engineers

Two day short course to Chinese geologists on training tour in Canada (Sunwing).

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Taught 5 day industry simulation course at UNACAR (Mexican University) to PEMEX engineers

Volatile Oil and Condensate Reservoirs

Taught 5 day industry course at UNACAR (Mexican University) to PEMEX engineers

Economics for the Petroleum Industry ECO-310 (Southern Alberta Institute of Technology)

Taught introductory course at SAIT covering basic engineering economic concepts, input data for economics and the use of PEEP.

Mr. M.R. (Mike) Carlson

Bio

Mike Carlson founded Applied Reservoir Engineering & Evaluation, Ltd., a petroleum engineering consulting firm specializing in reservoir engineering, numerical simulation, and economic evaluations in 1990. He has more than 32 years of experience in the petroleum industry, working for such corporations as AMOCO Canada, Home Oil, Petro-Canada and Canadian Hunter. He has taught various short courses in the use of production and exploitation simulation software for such companies as Scientific Software-Intercomp and McDaniel & Associates Consultants Ltd. He has authored more than 20 different technical papers and is a member of SPE, APEGGA, the Canadian Well Logging Society, and the Canadian Society of Petroleum Geologists. He has served as technical program committee chairman for the Canadian Institute of Mining, Metallurgy & Petroleum (CIM), director of the National Board of the Petroleum Society of CIM, and was on the Industry Advisory Committee for the University of Regina Petroleum Engineering. He is the author of *Practical Reservoir Simulation*, (2003, PennWell). Currently, he is most active in the development of a Steam Assisted Gravity Drainage (SAGD) projects in north-eastern Alberta.

Education

University of Toronto, Canada

B. App. Sc. In Geological Engineering – graduated 1979.

Geological engineering is oriented to the design of foundations, earth and rock structures.

The curriculum includes courses in geology, soil mechanics, rock mechanics, and groundwater.

University of Calgary, Canada

Graduate Level Courses. Reservoir Simulation I, Applied Reservoir Simulation and Thermal Recovery Methods. (Grade Pt. Avg. 3.53)

Employment Summary

April 2012 – Present

President, Applied Reservoir Enterprises Ltd., Calgary

- Expert witness in patent litigation regarding SAGD process. Prepared expert witness report and provided analysis of rebuttal responses. (Cenovus)
- Expert panel member for cap rock integrity for ERCB hearing (Alberta Oil Sands Inc.)
- Electrical modelling of E-T Energy's pilot project using STARS
- Technical Project Manager for Fateh/Mishrif study of carbonate reservoir in Persian Gulf. Presented results in Istanbul Turkey. (Petro Management Group)
- Reservoir Simulation support for Mexican multi-frac horizontal well (WestRock Energy Consultants Ltd.)
- Training courses in Vienna (HOT Engineering GmbH.)
- Thermal Reservoir Simulation Course (SPE) in Calgary
- Reservoir Management Course in Qatar (HOT Engineering GmbH – run twice)

- Advanced Reservoir Simulation Workshop (Bauerberg-Klein) Course taught in Lima Peru for CAREC.
- Subsidence study of Pembina Cardium multi-frac well depletion

Sept 2009 – April 2012

Manager Reservoir Engineering, RPS Energy Group

Managed group of 10 people. Group activities included reservoir simulation, economic evaluations, corporate reserves, SAGD, peer reviews, expert witness for two projects. The Calgary office had a very high profit margin in the RPS organization.

Nexen:

- Peer Review Pad 14 and 15 at Long Lake
- In house reservoir engineering support
- Geomechanical review JACOS Hangingstone Project
- Geomechanical models for Long Lake Pads 12,13, 14 and 15 (partial)

Investment Fund SAGD Operator Property Review

Peer Reviews

- For bank – operators development plans - for financing
- Marathon Oil – progress to date on SAGD project
- Van Yogan field in Siberia (TNK-BP)

Alberta Oil Sands Inc

- Geomechanical Simulation
- ES-SAGD Simulation

Silverbirch

- Geomechanical Design. of shallow project

Conventional Simulations

- Chinook – Thorsby Glauconite pool performance
- Penngrowth – three different reservoirs
- Questerre – waterflooding with horizontal multifrac wells
- Arawak – Dodsland horizontal multifrac well infills

OptiCanada

- Review and simulation of performance of Long Lake property – Opti has 35 percent working interest

Review for Acquisition

- Reviewed property for possible acquisition

EM-SAGD Development support

- Electromagnetic induction SAGD development assistance for Siemens AG in Erlangen in Germany.

Development Plans

- Petro America – heavy oil development in Columbia
- Petro-Minerales – heavy oil development in Columbia
- Reactivation of old heavy oil area in Texas

Litigation Support

- Ackroyd LLP – CPDFN and Conklin Metis re MEG Energy Development (settled).

- Ackroyd LLP – Support to CPDFN (settled) and Conklin Metis re Petrobank THAI in situ combustion process (application withdrawn)
- Ackroyd LLP – Support for local interveners re Koch Gemini SAGD project (settled).
- Blakes LLP – support for Saskatchewan heavy oil litigation (Cenovus)

March 2008 – August 2009

Principal Reservoir Engineer – InSitu Oilsands, Petro-Canada

Hired principally to provide geomechanical advice to prevent caprock failure of MacKay River project, due to offset Joslyn catastrophic steam release (May of 2006). Significant accomplishments – recognition of cap rock leakage into overlying Wabiskaw C sand through Wabiskaw D mudstone. geomechanical modelling of possible failures, identification of condensation induced water hammer as a significant safety risk, modelling of steam induced water hammer and mitigation. Lewis testing program has now been successfully implemented in the field. A second program has been conceptually designed.

Worked as consultant engineer from March 3rd to June 27th, 2008. Full time from July 7th, 2008 until August 2009.

- Provided expert advice on Reservoir Engineering for Oil Sands Depletion Planning for both In Situ and Mining properties. This included analytical assessments, reservoir simulation using both Exotherm and Stars, and geomechanical assessments
- Provide wider reservoir engineering and oil & gas industry perspective to Petro-Canada's oil sands projects.
- Work closely with the oil sands reservoir engineering manager and staff to be fully aware of all of the technical reservoir engineering work in oil sands. This includes meeting with each of the reservoir engineers on a regular/appropriate basis to review their evaluations and provide advice and guidance as needed.
- Hands on oil sands reservoir engineering evaluation work including analysis of data and reservoir simulation. Initial project will be to assist with developing Lewis testing program.
- Identify opportunities for joint work between asset teams, lead/act as coordinator as appropriate including coordinating monthly oil sands reservoir engineering meetings, and training programs. Thermal Reservoir Simulation course for co-op students.
- Development of reservoir engineering skills, tools, and processes, etc., leading and/or coordinator activities as appropriate.
- Peer reviewer for Major Property Reviews for all oil sands properties and other Petro-Canada properties as appropriate
- Attends weekly Reservoir Engineering Supervisor meetings.

01/2006 – 12/2007

Vice-President Engineering, Silverwing Energy Inc.

Responsible for all engineering functions and most production functions. During the past year at Silverwing the company's production has doubled. Gas plants have been built in South Beavertail and at Boundary Lake. A booster compressor and gathering system was started-up in Buick and a gas gathering system plus two sweetening units were installed in

South Beavertail. Engineering done for gathering system in Umbach. Other highlights include:

- Corporate Reserves – coordinated annual reports prepared by Gilbert Lausten Jung
- Marketing – transportation, tie-in, gas contracts and processing
- Production Reporting
- Economic Evaluation – Tomahawk farm-in and development
- Joint Venture CO&O for gas plant construction.
- Sale of Boundary Lake Plant to Altagas
- Computerized log analysis
- Pressure transient analysis
- Hiring operator – NE BC
- HSE program implementation
- Critical sour well applications
- Accounting support

Company taken public during this time period (IPO). Assisted with engineering functions on IPO and due diligence.

10/1999 – 10/2006

President, Applied Reservoir Engineering Ltd.

Principal of consulting petroleum engineering firm specializing in reservoir engineering, numerical simulation and economic evaluations.

Significant courses – see courses taught section.

Berrymoor Jurassic R, N and GGG pools (Shiningbank Energy Inc.)

Effect of gas cap production on oil leg

Thermal Fractured Reservoir (Reservoir Team / Shell International E&P / PDO)

Qarn Alam field in the Sultanate of Oman

Thermal and black oil reservoir modelling of steam pilot and development using STARS and IMEX (CMG)

Two trips for a total of 10 weeks in Oman

Reservoir Model Input (Sheritt International)

Input structural cross-sections for overthrust reservoir in Cuba into geological mapping package

Geomechanical Grid (Taurus RS / Shell International E&P)

U.S. Gulf of Mexico offshore reservoir

background research on stress states offshore Gulf of Mexico

Decision Cycle Compression – ADCO – Giant Onshore Carbonate Field (CMG/Gaffney-Cline)

Simulation support in Houston and Abu Dhabi.

Work was on Middle East giant carbonate reservoir.

DCC is an intensive decision management tool for developing oil and gas fields.

Optimized reservoir simulations (IMEX – CMG) and converted datasets from Eclipse.

Fractured Reservoir Engineering (Sunwing)

two day short course to Chinese geologists on training tour in Canada
 SAGD Stratigraphic Drilling Program (Newmont Mining Corporation of Canada Ltd.)
 two 18 well drilling programs on oil sands lease in Christina Lake area.
 follow-up to successful government hearing.
 Organized data for subsequent sale of property.
 Property sold to KNOC for \$315 mm Canadian
 Gas over Bitumen Alberta Energy and Utilities Board – Bitumen Submission (Newmont Mining Corporation of Canada Ltd.) – This was a major 2 year project.

- Expert witness for main and interim hearing (economics, reservoir simulation, thermal simulation (using Geosim and STARS), and log analysis)
- Submission preparation for 6 person panel (log analysis, geology, hydrogeology, geomechanics, gas reservoir simulation, thermal reservoir simulation, geostatistics, economics)

Aerial Ostracod (Player Petroleum)
 Reservoir simulation of mature gas flood. Significant increase in recovery factor.
 Stanmore Glauconite Pool (Player Petroleum Ltd.)
 Reservoir simulation for waterflood (Eclipse). Government application
 Government approval successfully obtained
 Brassey HCMF Compositional Reservoir Simulation (Canadian Hunter Exploration)
 History match miscible flood (GEM – CMG) and provide blowdown predictions.
 Valhalla Doe Creek T and U Pools (Petrorep Resources Ltd.)
 Waterflood optimization using simulation. Update of study previously completed.
 Technical Support – Kotaneelee Litigation (McDaniel and Associates Consultants Ltd.)
 Continuation of previous work on this project.
 Kakut Charlie Lake Reservoir Review (Shiningbank Energy Ltd.)
 3-day review of reservoir performance and review of previous simulation study.
 Project extended to include complete reservoir simulation
 Morse River Unit No 1. (Shiningbank Energy Ltd.)
 2-day update of previous reservoir study.
 Caroline Swan Hills Reservoir (Newport Petroleum)
 Technical review of subject reservoir.

07/1998 – 02/1999

Senior Staff Reservoir Engineer, Reserves Advisor, Team Leader, Reserves Management for Gulf Canada Resources Limited

Originally hired into technical consulting group reporting to Vice President North America (Calgary) as Senior Staff Reservoir Engineer. Initial assignment Red Earth Keg River, waterflood technical support. Assignment changed upon arrival to Team Leader - Reserves Management, reporting to Director (manager) Business Enhancement.

House Mountain Unit No. 2

Waterflood optimizations increased value of property by \$10 mm.

05/1997 – 06/1998

Vice President Technical Services, McDaniel & Associates Consultants Ltd.

Sold Startup Company to McDaniel & Associates Consultants Ltd. Services marketed under Applied Reservoir Engineering Ltd., A Division of McDaniel & Associates Consultants Ltd. Responsibilities include marketing, bid preparation, staffing, supervision of reservoir studies and technical appraisal of (outside) reservoir simulations for evaluation purposes. Strategic change to highly supported technical staff. Procured expanded computing facilities.

Acquisition Support (Amoco Canada Petroleum Company Ltd.)

Provided technical backup for purchase bid on sour gas condensate reservoir. Reservoir was to be developed with horizontal wells.

Litigation Support - Kotaneelee (Duncan, Kelly)

Prepared questions for lawyer to cross-examine expert witness.. Reservoir is structurally complex dolomite sour gas reservoir located in Yukon Territories.

Varadero and Boca de Jaruco Thrust Faulted Chalk Reservoirs - Cuba (Sherritt International Corporation)

- Large numerical simulation (Eclipse) with approximately 150,000 grid blocks, of which 100,000 were active, used for Varadero field. Major change in reservoir characterization made based on history match results. Heavy oil ranged from 9 to 12 degrees API.
- Boca Reserves and drive mechanism assessed by conventional reservoir engineering methods including material balance. Reservoir has moderately strong water drive.
- Reports made for securities reporting to SEC (IPO on NYSE). Also included due diligence.

George Kiskatinaw (Rigel Oil and Gas Inc.)

- Sandstone reservoir in Peace River Arch. Preliminary study resulted in successful infill well. Correctly predicted amount of gas pay drilled. (Eclipse).
- Follow up study requested for AEUB application and to evaluate alternate depletion strategies.

Progress Halfway Pool (Phillips Petroleum Canada Inc.)

Small reservoir study to evaluate communication between possible gas cap well and main body of reservoir. Identified water influx and suggested optimized waterflood.

Boundary Lake Halfway Reservoir (Rigel Oil and Gas Inc.)

Optimized waterflood identified, which should result in substantial upside.

Cecil Charlie Lake (Corexcana and Anderson Exploration Ltd.)

Study identified performance related to fractures. Horizontal well predictions made as well as an assessment of waterfloods. Waterflooding was not thought to be effective based on simulation and offsetting waterflood failure.

Reservoir Simulation Reviews

- Benson Midale Beds
- Midale Ordovician Yeoman
- Loon Lake Slave Point G
- Valhalla Doe Creek T, U and BB Pool

Material Balance Studies

- Sylvan Lake Pekisko B
- Manyberries Sunburst Q Pool

Pipeline Reserves Study and Gas Storage Candidate Selection (Interprovincial Pipeline Ltd.)

Prepared report on projected gas discoveries and location of known (established) reserves in Northern Alberta.

02/1990 – 04/1997

President, Applied Reservoir Engineering & Evaluation Ltd.

Principal of consulting petroleum engineering firm specializing in reservoir engineering, numerical simulation, and economic evaluations.

Expert Evaluation for Litigation (Canadian Hunter Exploration Ltd.)

Evaluated material balance study results for litigation.

Montney Waterflood Evaluation - Valhalla (Suncor Energy Inc.)

Performed reservoir simulation on low permeability reservoir with hydraulically fractured wells. Recommended against waterflooding due to relative permeability data and lower performance expected from fractured wells. Detailed modelling of core flood results.

Near Critical Sour Gas Retrograde Condensate - Wabamun Gold Creek (Ulster Petroleum)

Evaluated producing trends and pressure transient analyses for the Gold Creek Wabamun field. Successfully matched GOR behaviour. (Two previous consulting studies failed).

Detailed description of fractured reservoir provided.

Sour Gas Field PVT Sampling Program - Horizontal Well (Suncor Inc., Resources Group)

Design of sour gas PVT sampling program for very sour reservoir in northern Alberta.

Gas Field Deliverability Study (Computer Modelling Group)

Reservoir simulation of large gas field in northeast B.C. Objective of work was to develop a long-term deliverability plan for the field. Core asset for the operating company.

Horizontal Well Evaluation (Barrington Petroleum Ltd.)

Pekisko reservoir in the Twining area.

Pembina Nisku Near Critical Volatile Oil Reservoir Model (Home Oil Company Limited)

- Preparation of compositional simulation to predict optimal method of reservoir development.
- Extremely difficult fluid to characterize. Some samples indicated dew point system with very high CVD dropouts (over 40 percent) to extremely volatile bubble point systems (Bo over 4).
- Extensive monitoring of laboratory work was required. Problems documented in "Obtaining PVT Data For Very Sour Retrograde Condensate Gas and Volatile Oil Reservoirs: A Multi-disciplinary Approach", presented at the SPE Gas Technology Conference held in Calgary, April 28th - May 1st, 1996.

Single Well Gas Condensate Reservoir Simulation (Suncor Inc, Resources Group)

Effects of retrograde condensation on single well productivity were investigated.

Modelled hydraulic fracture directly with compositional simulator. Less productivity impairment was identified than previously indicated in literature. Presented results at SPE Low Permeability Reservoirs and Rocky Mountain Regional Symposium in late March 1995.

Blueberry Debolt Reservoir Optimization Study (Suncor Inc., Resources Group)

The North and South Pool were both modelled to determine optimal continued

- development. This field is trapped by the updip termination of the Debolt on a thrust fault. Difficult boundary conditions, extensive production history (36 years), considerable geological extrapolation required.
- Foothills Development Study (Suncor Inc, Resources Group)
Stolberg, Red Hat, Mountain Park and offsets
- Reservoir Simulator Demonstration (Computer Modelling Group)
Data set from reservoir input into simulator model to demonstrate model capabilities, in particular, the use of horizontal well option. Old and limited data extrapolated using correlations.
- Reservoir Simulation / Production Prediction (Stampeder Exploration)
Kerrobot Area
- Well Test Interpretation (Suncor Inc., Resources Group)
Umbach area gas well
- Technical Support - Simonette Leduc Reservoir (Suncor Inc., Resources Group)
Supported staff and provided equipment for major reservoir study
- Waterflood Study - Waskada Field (Omega Hydrocarbons Ltd.)
Waskada and Mississippian
- Waterflood Simulation Study (Page Petroleum Ltd. / Royal Bank of Canada)
The effects of layering were investigated on a mature waterflood in the Dodsland area of Saskatchewan. Study recommendations have been implemented.
- Gas Oil Ratio / Drainage Study (Omega Hydrocarbons Ltd.)
- Performed numerical simulation to quantitatively determine gas saturations over time.
 - Appeared as expert witness in Court of Queens Bench (Province of Alberta).
 - Recently (Sept '95) reviewed waterflood performance and recommended combined peripheral and pattern drive.
- Multi-well Computerized Log Analysis (Scientific Software - Intercomp)
Large gas reservoir in Bangladesh with a difficult analysis, due to presence of heavy and radioactive minerals.
- Log Analysis Presentation, Dhaka Bangladesh (Scientific Software - Intercomp)
The techniques to analyze logs in Bangladesh were presented to the staff of the Bangladesh Oil Gas and Mineral Corporation (BOGMC).
- Economic Evaluations
- Major property evaluation - foothills sandstone gas reservoir. Independent audit for internal reserves booking. Evaluated reserves database software for future acquisition. (Amerada Hess Canada)
 - Major property evaluation - foothills carbonate gas reservoir. Independent engineering report for dispute resolution (potential litigation) and sale of property.
 - Property swap - northeastern B.C. and northern Alberta. Evaluations used as basis of exchange of properties (Petro-Canada and Phillips Petroleum Canada Inc.)
- Reservoir Engineering Review Keg River Reef (Amerada Hess Canada)
- Material Balance Study (Amerada Hess Canada)
Sturgeon Lake field
- Horizontal Well Evaluations (Omega Hydrocarbons)
Entwistle area Pekisko and Wilmar Frobisher-Alida.

Waterflood Feasibility Study (Orbit Oil and Gas Ltd.)

Tindastoll Belly River B pool.

Vacation Relief (Orbit Oil and Gas Ltd.)

Work consisted of general shallow gas reservoir engineering. Did evaluation of properties for acquisitions. Reviewed horizontal well potential in Twining Pekisko.

01/1988 – 01/1990

Consultant (employee) Scientific Software-Intercomp (Intercomp Resource Development and Engineering Ltd.)

SSI is an international consulting firm specializing in exploration and production services. Responsible for conducting reservoir simulation studies, computerized log analysis, economic evaluations, and audits of evaluations, within budgets. Also, instruction of industry courses in reservoir simulation.

Southwestern Saskatchewan Waterflood Study

- Best presentation at 1989 SSI internal technical symposium (\$5,000 U.S. prize).
- Presented Saskatchewan CIM Conference in Sept. '89.
- Published in January 1992 issue of JCPT.

Major Waterflood Study

- Alberta carbonate reservoir, 75+ wells, multi-layer, Beaverhill Lake
- Presented at CIM/SPE technical conference in June 1990
- Published in May 1992 issue of JCPT.

Log Analysis and Petrophysics

- Six reservoir study in Bangladesh (CIDA sponsored project). Results presented in Dhaka Bangladesh.
- Cashirari and San Martin Fields in Peru (PCIAC project)
- Glauconite channel for simulation study

Economic Evaluations

Rhodes Energy

Sunlite Oil Canada

Canadian Futurity Oil and Gas

Glauconite Reservoir Simulation

Study successfully obtained GOR penalty relief.

09/1981 – 01/1988

Group Leader Reserves, Home Oil Company Limited

Responsibilities included the supervision of senior technologists (4) and a junior engineer, booking and reporting of all exploration and development reserves, reporting of corporate reserves, preparation of ceilings tests and net asset values.

- Specific recommendations made for resolving inter-department conflicts. Technical projects were identified for the future.
- Successfully reduced variance between Home and the external reserves auditor - McDaniel and Associates

- Responsible for securities reporting of Home's international reserves in Australia, Indonesia (Malacca Straits) and U.S.
- Involved in defence of Hiram Walker Resources. Interface for White Knights.
- Acquisitor (Gulf) sold company to Interprovincial Pipeline Limited (IPL) based on internal reserves evaluation. Based on improved calculations, an uplift of over \$100 million dollars was recognized. This transaction exceeded one billion dollars. An IPO was raised on TSE and NYSE. Responsible for "due diligence" proceedings and interface with external evaluators.
- Used and enhanced a large computer database.
- Tertiary economics prepared for Swan Hills Unit No. 1 and Mitsue Gilwood Unit No. 1.

Group Leader Northern Alberta Reservoir

Responsibilities include reservoir engineering and exploitation in Northern Alberta. Existing properties optimized and new areas developed. Supervised one technician and one technologist.

Operations Engineer (Southern District)

Responsible for monitoring and optimizing production, completions, facilities, workovers, budgeting and government liaison.

06/1979 – 07/1981

Drilling Engineer, Amoco Canada Petroleum Company Ltd.

Responsible for assisting drilling engineers and design of completion and kill procedure for Steep Creek blowout.

New Well Completions Engineer

Responsible for most new well completions in Pembina (Drayton Valley) District office. Scheduled rig moves and prepared well completion programs. Keeping up was a major accomplishment with between 7 and 11 service rigs operating during the peak of the boom.

Lease Engineer

Pembina Cardium D and F leases, Rat Creek B and C leases. Potential polymer flood analyzed – well testing and obtaining samples.

Training Summary

Advanced Reservoir Simulation (Bauerberg-Klein / CAREC)

Course on compositional modelling for gas condensates, miscible floods and volatile oil simulations. Workshop included training in tuning, history matching and 6 problem sets. Taught in Lima Peru.

Reservoir Simulation In Practice (Scientific Software - Intercomp)

Presented 2 days of a 5-day industry simulation course. Topics covered were:

- single well studies
- coning problem set
- cross sectional studies
- pseudo relative permeability
- PVT input
- well representation

Course presented 3 times.

Reserves Course

Instructor for half day of in-house reservoir engineering school relating to reserves. Technology Transfer. (Home Oil Company Limited).

Responsible for in-office technology transfer program with foreign (Bangladesh) engineers on CIDA project. (Scientific Software-Intercomp).

Practical Reservoir Simulation, Using, Developing and Assessing Results

Five day course on reservoir simulation. Course included formal instruction; example problem sets on computers with simulator and anecdotes of previous problems. The course was run twice. (Petroleum Society of CIM)

Course twice in Ploesti, Romania – Module 2 (HOT Engineering GmbH / Petrom)

3 day version of course for PIECE in Houston Texas in 2011. Scheduled to be taught as 5 day course in 2013.

Numerical Simulation of Petroleum Reservoirs

Taught 10 day industry simulation course for CUPET, Majagua Cuba

Taught 5 day industry simulation course at UNACAR (Mexican University) to PEMEX engineers

Thermal Reservoir Simulation

3 day introductory course for co-op students and recent graduates (Petro-Canada) – taught 3 times.

5 day course for Nexen Inc. in June 2010 (RPS Energy Canada Limited)

5 day course for SPE in 2012 (ARE), 2011, and 2010 (RPS).

Applied Reservoir Management

5 day industry course for HLS India, New Delhi, India. (Halliburton)

5 day course in Campina, Romania (HOT) February 2006.

5 day course in Vienna Austria (HOT), July 2007

5 day course Dhamman, Saudi Arabia May 2008 (HOT)

5 day course in-house course for RAG April 2008 (HOT)

5 day course Dubai October 2008 (HOT)

5 day course Abu Dhabi November 2008 (HOT)

5 day course Wien June 2010

5 day course Wien July 2011

Two 5 day courses in Qatar for HOT engineering May 2012

5 day course in Vienna for HOT Engineering July 2012

Introduction To Reservoir Engineering Basics (Encana / PanCanadian Petroleum Ltd.)

Two-day basic reservoir engineering course for reservoir engineering training program (course taught four times).

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Taught two 5 day courses on natural gas reservoir engineering. (National Engineering University of Peru UNI). First week taught in Lima with second week in field location (Talara – Northern Peru)

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Volatile Oil and Condensate Reservoirs

Taught 5 day industry course at UNACAR (Mexican University) to PEMEX engineers

PETROM Module 3 – Predicting Performance via Material Balance and Simulation

10 day course on use of material balance, simulation history matching tuning and predictions, Ploesti, Romania (HOT Engineering GmbH).

Reservoir Management of Coning Prone, Heterogeneous and Tight Reservoirs

Taught 6 day course in Dehra Dun India (ONGC Management Engineers)

Advanced Reservoir Engineering

Taught 12 day industry course at NAFTAGAS (Sonatrach) Hassi-Masoud, Algeria.

EOR Simulation

Taught 10 day course on EOR and reservoir simulation. Also water and gas coning. (Majagua Cuba, CUPET)

Economics for the Petroleum Industry ECO-310 (Southern Alberta Institute of Technology))

Taught introductory course at SAIT covering basic engineering economic concepts, input data for economics and the use of PEEP.

Publications, Presentations and Awards

1. Awarded \$5,000 U.S. for best presentation at SSI's 1988 internal technical conference.
2. "A Dodsland - Hoosier Waterflood Study", presented at the 3rd CIM Saskatchewan Petroleum Conference. Published in the Journal of Canadian Petroleum Technology in January of 1992. Co-author R.J. Andrews.
3. "The East Swan Hills Unit Waterflood Optimization Study: A Multi-Disciplinary Approach". Presented at the Joint CIM/SPE International Technical Conference held in Calgary during June of 1990. Published in May 1992 edition of JCPT. Co-authors P. MacLean, H. Hornford, and G. Czyzewski.
4. "Choosing & Obtaining Software for the Small or Independent Consultant", invited presentation made to the Computer Oriented Geological Society during February of 1993.
5. "The Effects of Reservoir Heterogeneity on Predicted Waterflood Performance in The Dodsland Field", presented at the Fifth Petroleum Conference of the South Saskatchewan Section of the Petroleum Society of CIM, October 18th-20th 1993. Published in December 1995 edition of JCPT 1995.
6. "The Effects of Retrograde Liquid Condensation On Single Well Productivity Determined Via Direct (Compositional) Modelling Of A Hydraulic Fracture In A Low Permeability Reservoir", presented at the SPE Rocky Mountain Regional and Low Permeability Reservoirs Symposium, in March of 1995. Also re-presented, by invitation, at 1995 CMG (Computer Modelling Group)

- annual Technical Advisory Committee (TAC) meeting, June 1995. Published in JCPT Special Edition Vol. 38, No. 13.
7. "Tips, Tricks and Traps for Oil Material Balance Calculations", presented at the 46th ATM of the Petroleum Society of CIM, May 1995, published JCPT December 1997.
 8. Panelist and speaker, "Forging Our Future: The Emergence of Entrepreneurial Consulting", Theme Session for the 46th ATM of the Petroleum Society of CIM, May 1995.
 9. "Ownership of Solution and Evolved Gas: Technical and Legal Perspectives"; presented at the 46th ATM of the Petroleum Society of CIM, May 1995. Co-author Mr. Glenn Friesen, Partner of McCarthy Tetrault (then largest law firm in Canada). Published in JCPT.
 10. "Reservoir Engineering Implications of Hydrogeology", presented at CSPG annual conference (Canadian Society of Petroleum Geologists) in May 1995.
 11. "The Future Of The Oil and Gas Industry Until 2015", presented to the Native Indian Trade Association's Aboriginal Canada Construction Expo '95, on behalf of the Petroleum Society of CIM, November 27th, 1995 (conference televised nationally on CPAC).
 12. "Obtaining PVT Data For Very Sour Retrograde Condensate Gas and Volatile Oil Reservoirs: A Multi-disciplinary Approach". Co-author W.B. Cawston, Anderson Exploration Ltd (Home Oil).
 13. Petroleum Society of CIM, Technical Luncheon "What You Should Know About Assessing Simulation Results For Economic Evaluations", presented September 23rd, 1996.
 14. Two Part Distinguished Author Series, JCPT, "What You Should Know About Assessing Simulation Results for Economic Evaluations", Part I and Part II, May and August 1997.
 15. "Optimization Of The Blueberry Debolt Oil Pools: Significant Production Increases For A Mature Pool", Presented at the 48th Annual Technical Meeting of the Petroleum Society of CIM, June 1997, Calgary, Alberta. Co-authors, S.Chugh, R. Bora, P. Loczy, and M. Byl. Published JCPT 50th Anniversary Special Edition.
 16. "Reservoir Characterization Of Fractured Reservoirs In Western Canada", presented at the 48th Annual Technical Meeting of the Petroleum Society of CIM, June 1997, Calgary, Alberta. Published JCPT 50th Anniversary Special Edition.
 17. "Simulation of Gas Condensate Systems", invited presentation, Geoquest (Schlumberger) Canadian Technical Forum and Users Meeting, April 26th to 28th, 1998, Canmore, Alberta, Canada.
 18. "Fractured Reservoir Characterization", presentation in SPE Forum, Fractured Reservoirs, St. Maxime, France, September, 2000.
 19. "Geomechanical and Thermal Reservoir Simulation Demonstrates SAGD Enhancement Due to Shear Dilation", P.M. Collins, M.R. Carlson, D.A. Walters, A. Settari, Presented at OilRock 2002, Austin Texas, October 2002.
 20. Practical Reservoir Simulation; textbook, 529 pages, published October 2003, PennWell Publishing
 21. JCPT Distinguished Author Series, "SAGD and Geomechanics", June 2003. Reply and Discussion in September issue of JCPT.
 22. "SAGD and Geomechanics Poster Session", SPE Advanced Technology Workshop "Field Development Planning in Challenging Conditions: The Geomechanics Dimensions", November 3rd to 7th, 2003, Stresa, Italy.

23. "A Brief History of Gas Condensate Reservoir Engineering", Advanced Technology Workshop, Gas Condensate Reservoir Development and Management, May 19th to 20th, 2004, League City, Texas.
24. "Mitigating Condensate Impairment by Fracking", Advanced Technology Workshop, Gas Condensate Reservoir Development and Management, May 19th to 20th, 2004, League City, Texas.
25. Invited Presentation Thermal Operations and Production – Tunisia, May of 2009.
26. CSUG/SPE 147300; Pseudo-Component, "Thermal, Reservoir Simulation Study of A Proposed, Low Pressure, Steam-Assisted Gravity Drainage Pilot Project In Northeast Alberta", M.M.E. Uwiera-Gartner, M. R. Carlson, and C.T.S. Palmgren, Unconventional Resources Conference held in Calgary, Alberta, Canada, 15–17 November 2011.
27. SPE 147302 "Evaluation of the Clearwater Formation caprock for a proposed, low pressure, steam-assisted gravity-drainage pilot project in Northeast Alberta", M.M.E. Uwiera-Gartner, M. R. Carlson, and C.T.S. Palmgren, SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 30 October–2 November, 2011.
28. NURETH14-600; "And now for something completely different: condensation induced water hammer and steam assisted gravity drainage in the Athabasca oil sands, M. R. (Mike) Carlson", The 14th International Topical Meeting on Nuclear Reactor Thermalhydraulics, NURETH-14 Toronto, Ontario, Canada, September 25-30, 2011. Published in *Kerntechnik* 77 (2012) 2, Carl Hanser Verlag, Munchen.
29. WHOC11-520; Reservoir design of a shallow LP-SAGD project for in situ extraction of Athabasca Bitumen, C. Palmgren, I. Walker; M. Carlson, M. Uwiera; M. Torlak, Proceedings for the 2011 World Heavy Oil Congress [WHOC11].
30. "What every SAGD engineer should know about condensation induced water hammer"; May 5th, 2010. Presentation at the SPE Technical Luncheon, Calgary Section. Website: http://speca.ca/PDF/SPE_WhatSAGDknow.pdf.
31. Carlson, M.R., "What every SAGD operator and engineer should know about potential failure by condensation-induced water hammer", *Journal of Canadian Heavy Oil Association*, September 2010.
32. Recent Perspectives in SAGD; October 13th, 2010, Calgary Section of the Society of Petroleum Engineers, Technical Luncheon.
33. Analyzing How To Utilize Technical Testing Methodologies To Ensure Caprock Integrity; In Situ Oil Sands Summit 2011, May 24-25, 2011 Calgary, Canada.
34. Issues for evaluating Caprock Integrity on SAGD projects, December 6th, 2011, Canadian Heavy Oil Association, Calgary, Alberta. Presentation available on CHOA website.
35. "A discussion about condensation induced water hammer and caprock integrity"; Society of Petroleum Engineers, Edmonton Section, Dinner presentation at U of Alberta Faculty Club, January 10th, 2012.
36. Detailed Consideration of the Proposed Joslyn Failure Mechanism, CETI, February 2012. M.R. (Mike) Carlson;
37. SPE 156962 An Analysis of the Caprock Failure at Joslyn, SPE Heavy Oil Conference Canada held in Calgary, Alberta, Canada, 12–14 June 2012.
38. "The caprock failure at Joslyn, An analysis", *Journal of the Canadian Heavy Oil Association*, January 2013.

39. “What really happened at Joslyn, the official report, alternate explanations, and what “everyone” thinks they know”, SPE Caprock Integrity for Thermal Applications, April 8-10th, 2012, Banff, Alberta, Canada.

Discussion

Call M. R. (Mike) Carlson at the address below. There is no charge or obligation for an informal review of your problem.

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