THE MONTHLY MAGAZINE OF THE CANADIAN SOCIETY OF PETROLEUM GEOLOGISTS

RESERVOIR

JUNE 2007
VOLUME 34, ISSUE 6
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THE MONTHLY MAGAZINE OF THE CANADIAN SOCIETY OF PETROLEUM GEOLOGISTS

RESERVOIR

JUNE 2007 - VOLUME 34, ISSUE 6

ARTICLES

DEPARTMENTS

FRONT COVER
Petra, Jordon. A tomb carved from the soft sandstone of the Cambrian Um Ishrin Formation. Liesegang banding formed from deposition of iron and manganese compounds during the flow of mineral-rich fluids. Photo by Philip Benham.

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Please submit RESERVOIR articles to the CSPG office. Submission deadline is the 23rd day of the month, two months prior to issue date. (e.g., January 23 for the March issue).

To publish an article, the CSPG requires digital copies of the document. Text should be in Microsoft Word format and illustrations should be in TIFF format at 300 dpi., at final size For additional information on manuscript preparation, refer to the Guidelines for Authors published in the CSPG Bulletin or contact the editor.

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Advertising inquiries should be directed to Kim MacLean. The deadline to reserve advertising space is the 23rd day of the month, two months prior to issue date. All advertising artwork should be sent directly to Kim MacLean.

The RESERVOIR is published 11 times per year by the Canadian Society of Petroleum Geologists. This includes a combined issue for the months of July/August.

Advertisements, as well as inserts, mailed with the publication are paid advertisements. No endorsement or sponsorship by the Canadian Society of Petroleum Geologists is implied.

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Additional copies of the RESERVOIR are available at the CSPG office for $3.00.

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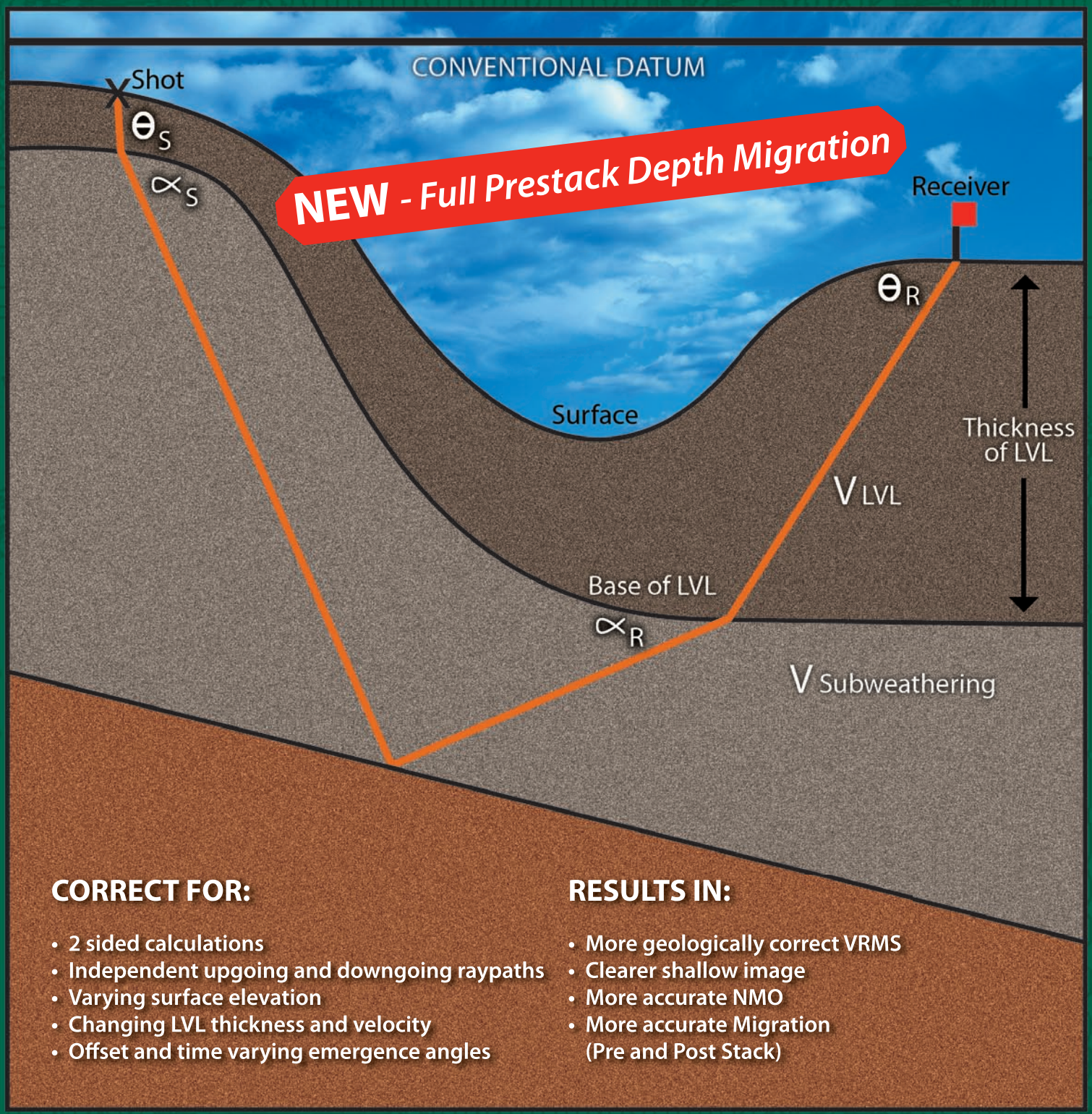

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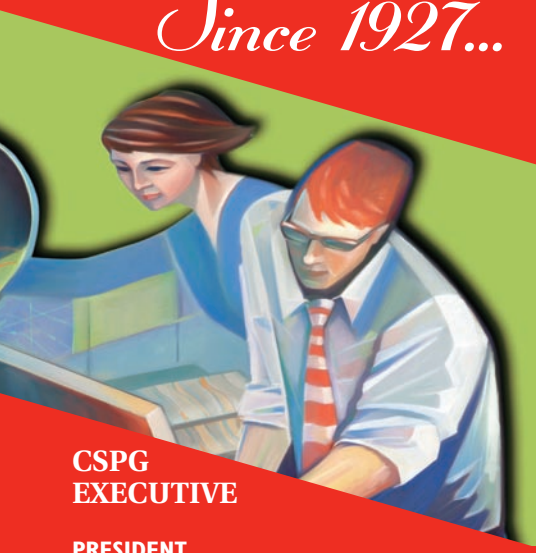

CSPG EXECUTIVE

EXECUTIVE COMMENT

A message from the CSPG Outreach Director, David Middleton

Future Visions– Reaching out together with the CSPG Trust

The CSPG and the CSPG Educational Trust Fund (CSPG Trust) are partners in developing the future geoscientists that will maintain the society that we know. We need to find the geologists that will fuel your car (or golf cart) in the future. The shortage of petroleum staff predicted in the next 5-10 years, often referred to as "the big crew change", will impact every company. It is apparent to anyone across Canada that we are not the only industry facing a shortage of staff, from restaurants with closed signs "due to staff shortages", to the skilled tradespeople required for facilities and building sites across Canada, to medical professionals in clinics and hospitals. We are all competing for the future employees required to maintain our profession, our economic security, and our society.

So why does the CSPG and the CSPG Trust care? We see the role that geologists play in securing our energy future, and because we are typically very passionate about our jobs. Geology is ESI (Earth Science Investigation), providing a challenging and rewarding career. Our jobs demand the intelligent and creative application of skills, knowledge, and salesmanship with continual learning and experimentation with ideas, with like-minded staff, and generally speaking, provides great fellowship, well paying jobs, and a lot of fun.

In the mission of the CSPG, we identify the goals to advance the science of petroleum geology, foster professional development and esprit de corps of members, and promote community awareness of the profession. The Trust promotes community awareness of petroleum geology and the impact geoscientists have on society. The CSPG Trust and CSPG Outreach work together effectively to deliver on this. The CSPG Trust provides the funding element for programs, while the CSPG provides the organizational and strategic direction and delivery of the programs.

The CSPG Outreach Committees and their respective chairs (Student Industry Field Trip, Honorary Address, Regional Scholarships, Graduate Thesis Awards, University Outreach, Visiting Lecture programs, Special Events, K-12 Outreach, and 100 Jobs) provide the committed volunteers to organize, promote, and deliver the programs. These programs often have a lot of history behind them, like the SIFT program running for 30 years now, while others such as the 100 Student Jobs are just underway.

While the CSPG Trust originally had run the programs, the decision was made several years ago to focus the CSPG Trust on fundraising, and the CSPG would manage the programs. It was apparent that our committees were spending their valuable volunteer time soliciting donations to put on the events, rather than using their geological expertise and passion about geology and science to excite their audience at the graduate, school, and public levels. The CSPG provides the organizational structure, defined operational plan, and a structured budget and resources to allow the committees to deliver a well respected, diverse, and enriching program across Canada. The CSPG and our fantastic office staff, ably led by Tim Howard, provide operational resources and support to all the committees to achieve program goals.

The CSPG Trust has an independent Board of Directors to maintain the arm's length requirements of the Trust charter and government regulations, as the CSPG Trust is a registered charity with the Canadian Revenue Agency. The CSPG Trust provides the fuel to the outreach program of the CSPG. Originally the CSPG Trust was created to provide funding for the long-running Student Industry Field Trip program, however, expansion to other areas soon happened, and for many years, the CSPG Trust has not been able to meet the funding requirements of the committees that make up CSPG Outreach. The great efforts from our Corporate Relations staff, Kim MacLean and her assistant, have allowed the CSPG and CSPG Trust to deliver our existing programs,

(Continued on page 7...)

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EOR and the Expanding Field of Carbon Dioxide Flooding • September 16, 2007 $50. Held in Lexington, Kentucky, with AAPG Eastern Section Meeting.

Seismic Stratigraphy and Seismic Geomorphology into the 21st Century • September 22-23, 2007 $650 for AAPG members, $750 for non-members ($100 more after 8/24/07). Held in San Antonio, Texas, in conjunction with SEG Annual Meeting

Practical Salt Tectonics • November 16-17, 2007 $850 ($100 more after 10/4/07). Held in Athens, Greece with the AAPG Eurpean Region meeting.

Fractures, Folds, and Faults in Thrusted Terrains: Sawtooth Range, Montana • September 10-15, 2007 $2,600 ($100 more after 8/13/07). Begins and ends in Great Falls, Montana

Sedimentology and Sequence Stratigraphic Response of Paralic Deposits to Changes in Accommodation: Predicting Reservoir Architecture, Book Cliffs • September 20-27, 2007 $2,100. ($200 more after 8/9/07). Begins and ends in Grand Junction, Colorado.

Modern Terrigenous Clastic Depositional Systems • September 22-29, 2007 $2,500 ($100 more after 8/24/07). Begins in Columbia and ends in Charleston, South Carolina

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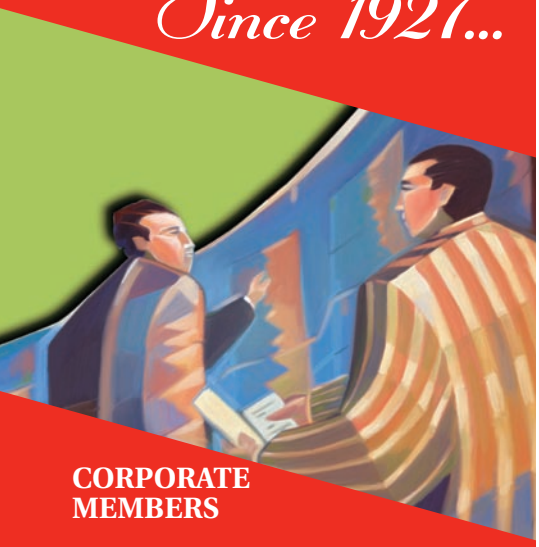

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AS OF APRIL 24, 2007

(...Continued from page 5)

but it is time to move to a secure and stable funding framework. It is towards this future that the CSPG Trust is executing the current case for support, and contacting petroleum and service companies of all sizes to assist us in reaching our funding goal of a secured foundation trust to provide a consistent income to deliver the programs required.

When I look at what is required to secure the number of geologists required for the future, the CSPG must increase the outreach activity levels to promote the awareness of petroleum geology and petroleum geologists. We need to change the perception of our industry in the minds of young people, to reveal how environmentally aware our members and corporations are, and how proud we are to be in this career. We need to keep reminding the public that "If it can't be grown, it has to be mined!"

We need to expand our scholarship programs and make certain that petroleum geology is taught across the country. We need to advocate with the provincial education departments that geology is deserving of an increased role in the science education of our youth. Do you not think it sad that in Alberta, where petroleum geology has powered the provincial economy and treasury to financial security and stability, geological concepts are taught in single modules in Grades 3 and 8? This happens in a province whose path to a solid future has been possible by our geological bonanza. Why can we not provide visiting lecturers to every university in Canada, to talk about the exciting work being done by geologists, and inspire our future geologists? Why don't we let every student know that rocks are not just something to skip across the water, but tell a fascinating story about the earth and the earth's dynamic history?

We have the passion, the strategy and ideas to make these things happen. We have a plan. What we need are two things from our members. We need the continued energy of volunteers to bring your passion, fascination, and excitement about geology and science to our young future geologists. We need the funding to provide for increased programs to reach out across the country to inspire children about careers in petroleum geology. We need your donations, your company's donations, and your investment in the future of petroleum geology.

If you wish to donate personally, check out the CSPG Trust on the CSPG website www.cspg.org/trust/trust-about-programs.cfm, for a direct link to our donations site at CanadaHelps.org. Use your influence in your company to secure matching grants to your donation from your company. Encourage your company to support the CSPG Trust in achieving the funding to provide for the future. Help us reach out to the students of today, to inspire them to become the geologists of tomorrow.

We have aggressive plans. If you can ask yourself: "Where are the Geoscientists for the Future?" and you care about the answer, you will make a difference. Thank you for your interest and support over the past years, and this will be my last Executive Comment column, as I will pass over the Outreach program to the incoming Outreach Director, Greg Lynch of Shell Canada. I know under his capable leadership, our programs will continue to thrive. If you have any questions, comments or concerns, or, especially, to volunteer, please contact myself or Greg Lynch, the Assistant Outreach Director.

How we made a high-impact gas discovery in a maturing basin (Western Canada)

SPEAKER
Marian J. Warren
EnCana Corporation

11:30 am
Tuesday, June 5, 2007
Telus Convention Centre
Calgary, Alberta

The cut-off date for ticket sales is 1:00 pm, Thursday, May 31st.*
Tickets are $31.00 plus GST.

**Please note: Due to the recent popularity of talks, we strongly suggest purchasing tickets early, as we cannot guarantee seats will be available on the cut-off date.*

EnCana's 2001 gas discovery at Ferrier, Alberta in the lower Mississippian Banff Formation was a significant new pool discovery in a long-active, competitive part of a maturing basin. Subsequent development of the pool has produced > 50 Bcf equivalent of gas and condensate, at gross production rates of up to 100 mmcfe/day. The gas has been produced from dolomitized crinoidal grainstone reservoir, with up to 30% porosity and several hundred mD to several Darcies permeability.

Most drilling east of the foothills in western Canada pursues stratigraphic plays. Earlier drilling in the Ferrier area focussed on subcrop plays in younger Mississippian carbonates, and on overlying Mesozoic clastic plays. A few deepened wells encountered dolomite porosity in the Banff formation, significantly down-dip from its subcrop edge, culminating in local development of three 20-30 Bcf pools in the 1990s. Further exploration drilling encountered only wet porosity or tight limestone.

We used a regional, interdisciplinary exploration approach to high-grade the most prospective play fairways. EnCana's discovery, the largest pool in this new play, was significantly down-dip from known wet porous trends. Our strategy focused on defining regional stratigraphic, structural and diagenetic fairways, in order to locate 3-D seismic surveys to best image the Banff porosity. Conventional amplitude and AVO analysis, coupled with a regional sequence stratigraphic model, have been critical in distinguishing Banff Formation shales from reservoir, and thus dramatically reducing the initially high reservoir risk on this play. We adjusted our exploration approach and business strategy as our understanding of other play risks, reserve distribution, and play fairway evolved.

BIOGRAPHY:

Education:
1997: Ph.D. – Queen's University, Ontario
1990: M.S. – University of Vermont, Burlington, Vermont
1984: B.A. – Williams College, Williamstown, Massachusetts

Experience:
2002-06: Geologist, EnCana Corporation (Projects in France, Chad, and Alberta foreland basin)
1997-2002: Geologist, PanCanadian Petroleum (Projects in Quebec, Alberta foreland basin, Alberta foothills)

Publications and Awards:
2002: Co-recipient of the CSPG's Medal of Merit
2004: AAPG Matson Award

Publications
- *Depositional styles in a low accommodation foreland basin setting: an example from the Basal Quartz (Lower Cretaceous), southern Alberta; B. A. Zaitlin, M. J. Warren, D. Potocki, L. Rosenthal, R. Boyd; Bulletin of Canadian Petroleum Geology, 2002 (CSPG Medal of Merit, 2002)*
- *The Selkirk fan structure of the southeastern Canadian Cordillera: tectonic thickening in response to inherited basement structure; M. Colpron, M. J. Warren, R. A. Price; Geological Society of America Bulletin, 1998*

External Publications at EnCana:
- *A High-impact Gas Discovery in a Maturing Basin (Western Canada); M. Warren, A. Lowe, and M. Gilhooly (AAPG Best Paper Award, 2004)*
- *Extensional faulting, paleodrainage patterns and impact on hydrocarbon reservoir quality and distribution during foreland basin subsidence: A case study from the Lower Mannville of south-central Alberta; M. J. Warren*
- *Everything you ever wanted to know about the Chevron construction but were afraid to ask; M. Cooper and M. Warren (structural technique talk)*
- *Tectonic inversion of the Laurentian rifted margin in southwestern Canada; M. J. Warren and R. A. Price*
- *A regional "break-up" unconformity within the Neoproterozoic(?) to Lower Cambrian Hamill Group, S.E. Canadian Cordillera, and implications for syn- and post-rift basin configuration and regional paleogeography; M.J. Warren and R. A. Price*
- *Thick-skinned reactivation of Early Paleozoic basement "highs" and along-strike variations in Taconic structural style, Vermont and southern Quebec (Appalachian Humber Zone); M. Warren and M. Colpron*
- *Thin- versus thick-skinned thrusting and tectono-stratigraphic relationships in the Humber Zone of Quebec and Newfoundland: M. Cooper, M. Warren, J. Porter-Chaudhry*

Professional Memberships:
- *American Association of Petroleum Geologists*
- *Canadian Society of Petroleum Geologists*

Professional Interests:
- *Developing and testing exploration plays*
- *Basin evolution and petroleum systems*
- *Tectonics and sedimentation in varied tectonic settings*
- *Structural geology and rock mechanics*
- *Presenting training courses for petroleum geoscientists*
- *Going in the field!*

Dr. Marian Warren has been selected by the AAPG to perform a series of lectures throughout North America as a part of there distinguished lecturer program. The AAPG Distinguished Lecture Series was developed to offer outstanding speakers on current research and applicable geology.

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The Calgary Chamber of Commerce… to lead and serve the business community, valuing diversity

SPEAKER
Heather Douglas
President and CEO,
The Calgary Chamber of Commerce

11:30 am
Tuesday, June 19, 2007
Telus Convention Centre
Calgary, Alberta

The cut-off date for ticket sales is 1:00 pm, Thursday, June 14th.*
Tickets are $31.00 plus GST.

Back in 1965, the majority of baby boomers were looking for work for the first time, Calgary's population was hovering around 300,000, and the thought of $72/barrel oil was a pipedream. What a difference four decades makes. Today, the boomers are leaving the workforce at an alarming pace. Ironically, just as Canada's fastest growing city nears one million people. While it's anyone's guess what oil futures might be in six months, I'd bet money on the predictions that our future labour challenges will loom larger than today.

According to Canadian Association of Petroleum Producers (CAPP) statistics, the average demographic of the today's oilpatch is white, male, and 54. By 2011, a wave of senior executives, seasoned technical support, and savvy field supervisors will retire. By 2015, estimates predict that 65% to 75% of the oilpatch will be gone. Who's going to do the work as Generation X and Y currently represent only 25-35% of Alberta's labour pool?

The Small Explorers and Producers Association's (SEPAC) situation is marginally better than CAPP's. While the demographic is somewhat younger, the juniors continue to battle with the challenge of little technical, regulatory, and community relations support available at competitive costs. Every accounting firm, reserves estimating and classification organization, property appraisal company, and securities advisor faces the same scarcity of talent – with much of it also departing within the decade.

Many SEPAC executives are confident they can sell their companies to royalty trusts, now and in the future. Agreed. However, as the trust companies are now discovering, the capital markets have begun to examine not only the board of directors and executive team, now the analysts also look for solid engineering, geophysical, geological, environmental, financial, and land negotiation talent embedded within to mitigate risk. No technical support? Expect the analysts to discount the share value.

(Continued on page 10...)

(...Continued from page 9)
What's the solution? It's multi-layered and needs time to take hold. It involves a long-term vision and formidable leadership. The Calgary Chamber of Commerce has embarked on a multi-pronged advocacy effort to ensure this city's economy and the energy industry doesn't stall:

- Action from government on issues they can do to streamline the process to bring in new immigrants, recognize their foreign credentials, and deal with the tax issues (e.g., change the Canada Pension Plan Act to allow seniors to work and not be penalized);
- Leadership from the oilpatch to train and mentor their Generation X and Y technical staff, recognize and hire the pools of untapped labour, and recognize international credentials;
- Long-term planning to establish the kind of future environment that creates, attracts, and retains the workers we need; and
- Articulate a stewardship vision that reflects the balance between conservation and future resource development.

As the boomers retire, good help isn't hard to find – it's nearly impossible. The boomers must concentrate on grooming the next wave of innovative, young talent, hire and inspire immigrants, and ride out the on-going oil and natural gas commodity cycles.

BIOGRAPHY

Heather Douglas was appointed to the position of President and CEO of The Calgary Chamber of Commerce as of October 1, 2005.

Prior to joining The Chamber, Heather Douglas was the Founder and President of Strategic Public Affairs (SPA), a worldwide combination of external and internal affairs and communications professionals. She has more than 20 years experience in journalism and public affairs, has directed media, government, and shareholder relations, crisis communications, and image and reputation management for three major Canadian companies (one a Fortune 500 affiliate).

Douglas is the former Manager, Public and Government Affairs for Mobil Oil Canada where she successfully directed several of Canada's largest public consultation programs – including the Hibernia offshore oil and the Sable natural gas projects. Mobil sent her to run Mobil's Public and Government Affairs Department in the United Kingdom and Norway, assigned her to special projects in the Far East, and brought her to Washington D.C. to work with several Asian embassies.

Douglas has also served as Vice President, Public Affairs and Government Relations with Atomic Energy of Canada (AECL), her duties included building relationships with foreign governments on behalf of the Crown Corporation. She also headed their worldwide media relations, stakeholder relations, crisis communications, and public consultation programs. She was an officer of the Corporation and a member of its Executive Council.

Douglas has co-authored two books and has spoken at numerous seminars and conferences. Her topics range from energy and communications to negotiation strategies. Douglas is currently working toward her doctorate in political science.

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Operational strategies for drilling horizontal CBM Wells

SPEAKER

Derek Krivak
Stealth Ventures Ltd.

12:00 Noon
Wednesday, June 13, 2007
ConocoPhillips Auditorium
3rd Floor – west side of building
401-9th Avenue SW (Gulf Canada Square)
Calgary, Alberta

Nova Scotia has long been known for its richness in coal deposits and historical mining activity. The Cumberland and Stellarton Basins in Nova Scotia have been targeted as prospective Coalbed Methane (CBM) resource plays dating back to the 1980s and '90s with Algas and Amvest respectively. With the closure of underground mining operations in these basins, the identification of massive amounts of gas and the commitment of government, Stealth Ventures Ltd. is bringing new technology and techniques in the understanding and development of the Stellarton and Cumberland Basins in Nova Scotia.

Stealth will give a high level overview of the play, its geological setting, and resource potential, and discuss some of the techniques and strategies in developing "wildcat" CBM plays. Practical examples of operational difficulties will be discussed as well as ways to combat them.

BIOGRAPHY

Mr. Krivak has over 10 years of oil and gas experience with the past six years focusing on unconventional gas. His Coalbed Methane, Shale Gas, and Tight Gas experience with the Gas Technology Institute (GTI) and the Alberta Research Council (ARC) have covered projects throughout North America. Currently he holds the position of Chief Operating Officer for Stealth Ventures Ltd., a Calgary-based junior oil and gas company active in Nova Scotia Coalbed Methane, and Saskatchewan and Alberta shale gas plays. Derek remains an active participant on the Canadian Society for Unconventional Gas technical committee and is a member of the Board of Directors.

INFORMATION

EPRD noon-hour talks are free and do not require registration. Non-CSPG members are also welcome to attend. Please bring your lunch. If you would like to join our email distribution list, suggest a topic, or volunteer to present a talk, please send a message to Michelle. Hawke@bp.com. Division talks are sponsored by IHS (http://www.ihs.cim)

Exploring for "Giants" in offshore West Greenland: New play concepts and hydrocarbon prospectivity in an emerging Frontier Rift Basin

SPEAKERS

Robert I. Gardner
EnCana Corporation
Neil D. Ethier
Talisman Energy Inc.
Mark A. Cooper
EnCana Corporation

12:00 Noon
Wednesday, June 27, 2007
Encana Amphitheatre
2nd floor, East end of the
Calgary Tower Complex
1st Street and 9th Avenue S.E.
Calgary, Alberta

The challenge of finding new petroleum resources has prompted renewed exploration in the frontier rift basins of offshore West Greenland. Results from the recently drilled Qulleq-1 well in combination with a newly acquired seismic database have facilitated a complete re-evaluation of the area.

Exploration activities in offshore West Greenland were initiated in the early seventies and resulted in five exploration wells, which primarily tested the Tertiary section. Minor amounts of hydrocarbons were detected in only one of these wells (Kangamiut-1) and resulted in a hiatus in exploration activities. In 2000, Statoil drilled the exploration well Qulleq-1 which proved the presence of a Santonian sandstone reservoir overlain by a thick Campanian shale seal. The key geological risk in the basin remains the presence of source rock; however, the recent discovery of widespread onshore seeps in the Nuussuaq Basin in combination with satellite-identified slicks in the offshore basin areas provides evidence of a working petroleum system. These findings, in combination with the interpretation of an extensive modern seismic grid have revealed all the required ingredients for a potential World Class petroleum basin.

New regional exploration models have been developed which unravel the rift basin expansion, evaluate facies distribution, and identify viable source kitchens. Prospective areas have been high-graded by utilizing a Common Risk Segment Mapping technique that incorporates all pertinent engineering and geological exploration risks. Within the areas of reduced risk, numerous structural and stratigraphic leads have been identified which could have the potential of trapping significant resources.

BIOGRAPHY

Robert Gardner is a Professional Geologist who received his B.Sc.(Hon) from the University of Calgary in 1984. He has spent the last ten years leading a variety of international and frontier exploration projects for EnCana Corporation. These operated new venture projects were primarily focused in North Africa, the Middle East, Europe and in the North Atlantic offshore regions. Rob is currently with EnCana's Offshore and International Division working on various new venture assignments in addition to running their exploration endeavours in West Greenland. Robert has authored numerous publications and has held previous geotechnical positions with Core Laboratories and Petrel Robertson.

INFORMATION

The International Division talks are free and open to anyone. Donuts and muffins are provided by Gore Surveys but feel free to bring your lunch. The facilities for the talks are provided complements of EnCana Corporation. For further information, to volunteer to give a talk, or to list your name on the contact list, please contact Bob Potter at (403) 863-9738 or ropotter@telusplanet.net.

High Tech Petroleum

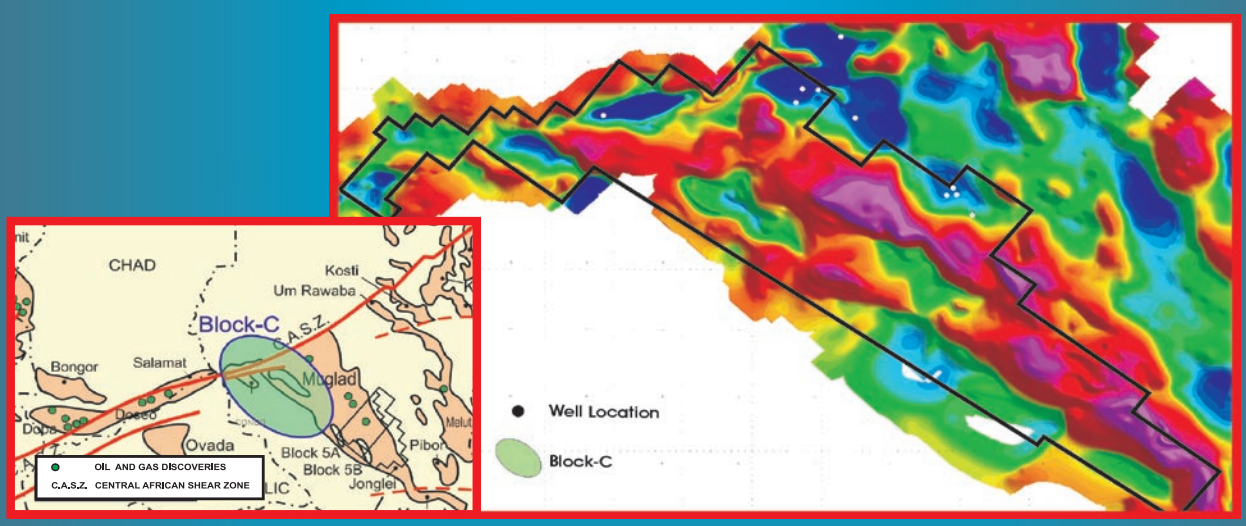
FARM-IN OPPORTUNITY

ONSHORE EXPLORATION LICENSE
BLOCK-C, WEST MUGLAD BASIN, SUDAN

Radisson Hotel, Central London, UK
4-8 June, 2007

High Tech Petroleum Company (Hi Tech), cordially invites representatives from potential oil companies to attend a Farm-out presentation of Block-C in Sudan. This event will take place in Ballroom 3 at the Radisson Hotel, on June 4th, 2007 from 10:00 am and will include a coffee break and lunch. Registration of delegates start at 9:00 am on June 4th, 2007.
Three Data Rooms will be available for the technical data review and delivery of the data packages will be available from June 5th to 8th, 2007.
Companies interested in attending the Opening Session Presentation are requested to send the names of their representatives by email or fax to EREX as soon as possible to assure booking of their delegates. A Farm-Out Brochure will be sent upon signing of the Confidentiality Agreement (C.A.).

Milestone	Date
Information Memorandum & Opening Presentation	June 4th, 2007
Virtual Data Room	June 5th-8th, 2007
Physical Data Room	June 5th-8th, 2007
Bid Closing Date	July 15th, 2007



Hi Tech holds 65% participating interest in the exploration license of Block-C to the west of the prolific oil Muglad Basin in Central Sudan. Hi Tech is willing to farm-out 20% - 30% working interest for the exploration of Phase 2 of Block-C. The Concession area is 65,000 Km^2 (about 16 million acres), including eight sub-basins having Mesozoic and Tertiary sediments up to 10500m thick. Eight exploratory wells have been drilled in three sub-basins. One well tested water and traces of oil from the Upper Cretaceous sandstone reservoirs and oil shows were encountered in others wells from other sub-basins. Mapped prospects are estimated to be about 1200 MMBBL of unrisked mean oil reserves.
Block-C is covered by almost 9500 km of 2D seismic and 174 km^2 of 3D Seismic.
Hi Tech has appointed **EREX** Petroconsultants as exclusive advisor for the farming-out project.

For Details of Access to the Virtual and Physical Data Rooms , please contact:

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Mr. Nazih Tewfik
General Manager
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Ceratopsian symposium at the Royal Tyrrell Museum, September 22-23, 2007

Ceratopsians (horned dinosaurs) are anatomically unique animals with a 95 million year evolutionary history extending from the Late Jurassic to the end of the Cretaceous. During the past century, ceratopsians have been the basis for innovative and groundbreaking palaeobiological and evolutionary interpretations that relate to many other dinosaurs. More recently, studies of ceratopsian biomechanics, growth, diversification, biogeography, and other aspects have resulted in an explosion of information about this intriguing group.

On September 22-23, 2007, the Royal Tyrrell Museum in Drumheller, will host the first ever Ceratopsian Symposium. The goal of the symposium is to bring together 200 palaeontologists, geologists, and palaeontological enthusiasts to share the results of their recent research and their interest in ceratopsians. Approximately 75 contributors will offer a variety of oral and poster presentations. Keynote speakers, Peter Dodson, Catherine Forster, David Eberth, and special guest Robin Mackey, will speak on ceratopsian evolution, biology and ecology, and preservation. A published abstract volume and book presenting the results of the symposium will follow. The symposium is being convened by Donald Brinkman, Brenda Chinnery-Allgeier, Michael Ryan, David Eberth, and Philip Currie.

The symposium coincides with the opening of a new ceratopsian dinosaur exhibit at the Royal Tyrrell Museum that will feature many new kinds of horned dinosaurs from Alberta. Other significant events associated with the symposium include:

- Ice-breaker, Royal Tyrrell Museum, on the evening of Friday, September 21
- Viewing of new specimens, including Alberta's newest ceratopsians
- Barbeque at the Royal Tyrrell Museum on Saturday, September 22
- Post-symposium field trip to Dinosaur Provincial Park (Monday, September 24)

INFORMATION

For further information about this event and registration please go to www.tyrellmuseum.com and click on the Horned Dinosaur Symposium Button or contact Don Brinkman at 403-820-6214.

To present a talk at a future Palentology Division event please contact Division Chair Philip Benham at 403-691-3343 or programs@albertapaleo.org. Visit the APS website for confirmation of event times and upcoming speakers: http://www.albertapaleo.org/

RESOURCE ASSESSMENT *and GIS*

by Ben McKenzie

This is the fourth of a series of articles discussing oil and gas resource assessment.

ISSUES AFFECTING RESOURCE ASSESSMENT

"About the only thing that any estimator can say with certainty about his (resource) estimate is that it is wrong."

Richard P. Sheldon, USGS Chief Geologist

"There are three kinds of lies: lies, damn lies, and statistics."

Benjamin Disraeli, British Prime Minister

The introductory quotes above illustrate two basic problems with statistical analysis. By definition, an estimate is an approximation, which means it is not exactly correct – which, in turn, means it is wrong to some degree. A goal of statistical analysis is to determine how valid an answer might be, i.e., the probability that the answer is correct (or, in this case, how wrong is wrong). Likewise, Disraeli's ranking of lies with statistics being the worst possible highlights the potential harm that can result from incorrect or misinterpreted statistics.

There are a number of ways in which resource assessments can fail in that they provide misleading conclusions – either intentionally or (most commonly) unintentionally. Some of these are related to geological limitations and others are fundamental to statistical analysis regardless of the application. Statistically, there are four main categories of misuse (Jaffe and Spirer 1987):

1) Lack of knowledge of subject matter: This includes not understanding the basic data being used and not knowing how to test the results for validity. Numbers do not interpret themselves – they can make sense and can be understood only in light of some particular context. Thus, the results of an analysis are somewhat dependent on the skill of the researcher.

   A variation of this occurs when the experience and bias of the researcher affects the results of an analysis. An oft-repeated example in exploration is that of a roomful of geologists using the same data points in making a map – the result being as many different interpretations as there are geologists. This highlights a basic problem of analysis in that incomplete data may be interpreted in numerous ways, all of which, individually, can be perfectly valid for the data used.

2) Quality of the basic data: In a worst-case scenario, data required for some analyses may not be available, or even exist. If there is data available, there are issues as to whether it can be verified. There are a number of ways in which data may be invalid or misrepresented. This may be the result of the manner in which it was collected, e.g., poor wording in data collection forms, variation in data collection methods, data entry errors, oversights, etc.; poorly defined terminology, i.e., definitions vary among users and purposes and this affects how a result may be viewed; the data may be not appropriate for the purpose at hand, e.g., trying to make detailed statements given only general data; or the data may be incomparable, so that conclusions based on a particular dataset are not appropriate for a different area, i.e., inappropriate analogs.

   Because of the effort and expense required to collect data and the fact that data historically has rarely outlived the project that collected them, the concept of metadata has gained popularity. Metadata, or "data about data", promotes understanding and management of how information assets and processes are derived, the fundamental relationships between them, and how they are used. According to Porter (Porter 2004), the final conclusion of a scientific study is less important than the evidence and testing used to support it and, thus, a premium is placed on the reliability, objectivity, and repeatability of the data and its analyses. This is because the data used tends to be heterogeneous and diverse, as do the users of that data. Thus, the questions asked of and goals sought from a dataset vary with the researcher. This means that the conclusions derived may vary widely, even though the data is the same – e.g., is a glass half full or half empty (or, more appropriately stated in the terms of this report, should we panic because we have used half the known petroleum resources or not worry because we still have 50% of the reserves left).

3) Preparation of the study and report: Experiments must be designed to give clear and identifiable results so that their validity can be ascertained. Presentation of this data is extremely important because the majority of users will not have the background and / or time necessary to fully understand the raw data used to support the conclusions drawn from the work. There are a number of ways in which graphical presentations can be misleading (Huff 1954; Monmonier 1991). These include simple design issues such as overcrowding, confusing or missing labels, false proportions, and changing scales on an axis to emphasize a particular portion of a curve. Monmonier also pointed out that "A good map tells a multitude of little white lies; it suppresses truth to help the user see what needs to be seen." While there is a valid need to simplify the infinite complexity of the real world when representing it on a map, it is important that the mapmaker (and map user) recognize the potential for misinterpretation that can result from such a simplification.

   Likewise, the results of a study can be subject to misdirection in a variety of ways. Unjustified precision in numbers can lead to false confidence in results (e.g., is a result of 0.60000 really that precise or is it just formatted to display that way). Results can be misrepresented by not including enough background information to allow for evaluation – in essence, they are derived from a "black box". Bias can be injected by concentrating on a particular portion of the population studied. Essential elements might be omitted, which will change the way the results are viewed. Huff, in his classic "How to Lie with Statistics" gave the example of navy recruiters in the early 1900s comparing the naval death rate during the Spanish-American War (9 per 1000) with that of civilians in New York City during the same period (16 per 1000) to show that it was safer to be in the navy than out of it. While the statistics were correct, they didn't account for the differences between the two groups (young, healthy men vs. the wide variation in health and age of the general population of New Yorkers). Faulty conclusions can also result from varying definitions, conflicting views, or

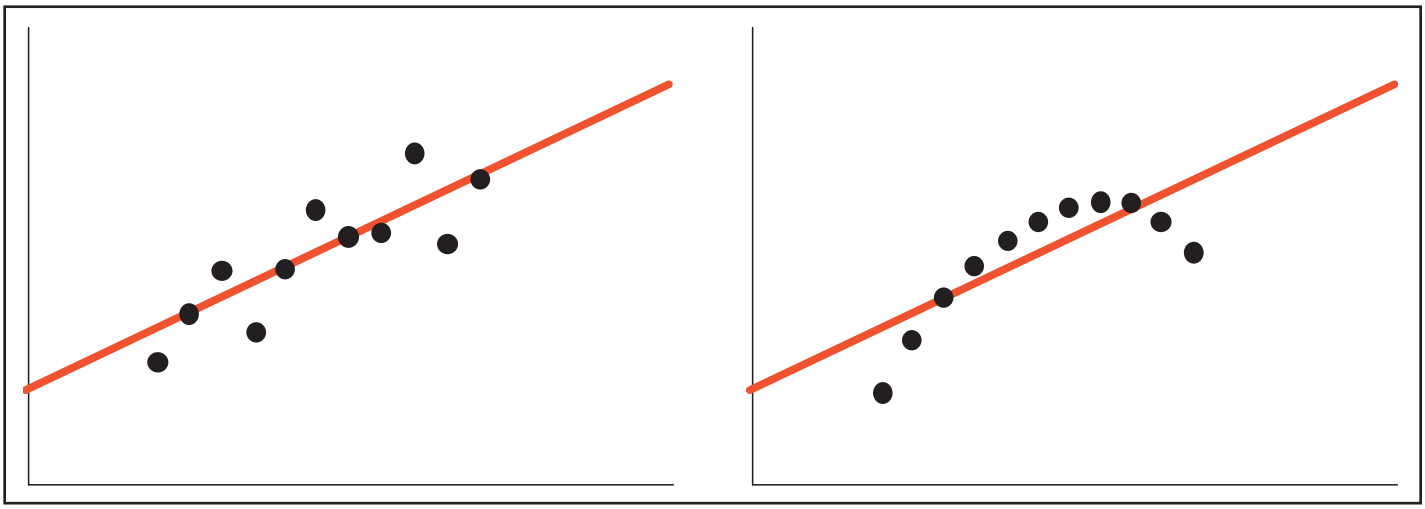

Figure 1. An example of two datasets with obviously different trends, but both yielding potentially the same line of regression (Jaffe and Spirer 1987).

blatant misinterpretation. For example, natural gas is commonly related to oil for reporting purposes by converting it to barrels of oil equivalent. The conversion factor can be based on either the energy equivalent or the monetary value equivalent. Unfortunately, neither conversion is very accurate and the ratio has range from under 5,000 cubic feet of gas per BOE to over 20,000 (the currently accepted standard is 6,000 ft^3 per BOE). If it were not clear which conversion factor was used, the value of a petroleum company's reserves could be significantly over- or undervalued.

4) Statistical methodology: The analyst's purpose may be to explore a dataset looking for trends or to evaluate the effectiveness of some approach or to compare multiple methods, etc. There are a number of assumptions that will be made with any dataset. Some of these could be that the population has a particular distribution of values, a certain range of error, are or are not random, etc. Once the analysis is complete, the analyst must then summarize the results to make it comprehensible to the user. There are many different statistical methods, many of which can perform similar (but not exactly the same) functions. The analyst's purpose and the nature of the data should determine which statistical tool to use.

One of the main methods of statistical analysis is regression, where a line is drawn through a series of points in a two-dimensional plot. The purpose is to allow for the prediction of a value along one axis based on a value from the other axis. A possible misuse of this method is when the predicted value is based on a value outside the range of data from which the line was determined. Another error arises where the data is better fit by some other type of line (Figure 1).

A variation of this problem is Simpson's Paradox. This refers to the reversal of results when groups of data are analyzed separately and then combined. This is illustrated in Figure 2 where data are plotted to show the relationship between pool size and number of pools for a hypothetical population of pools. For the aggregated example on the left, the population exhibits a positive correlation. If the data is disaggregated into two subsets, it displays a negative correlation. Simpson's Paradox highlights the dangers of analyzing aggregate datasets (Fotheringham, Brunsdon et al. 2002).

While Simpson's Paradox is normally demonstrated with aspatial data, it applies equally to spatial data where the aggregation is over locations. A somewhat related

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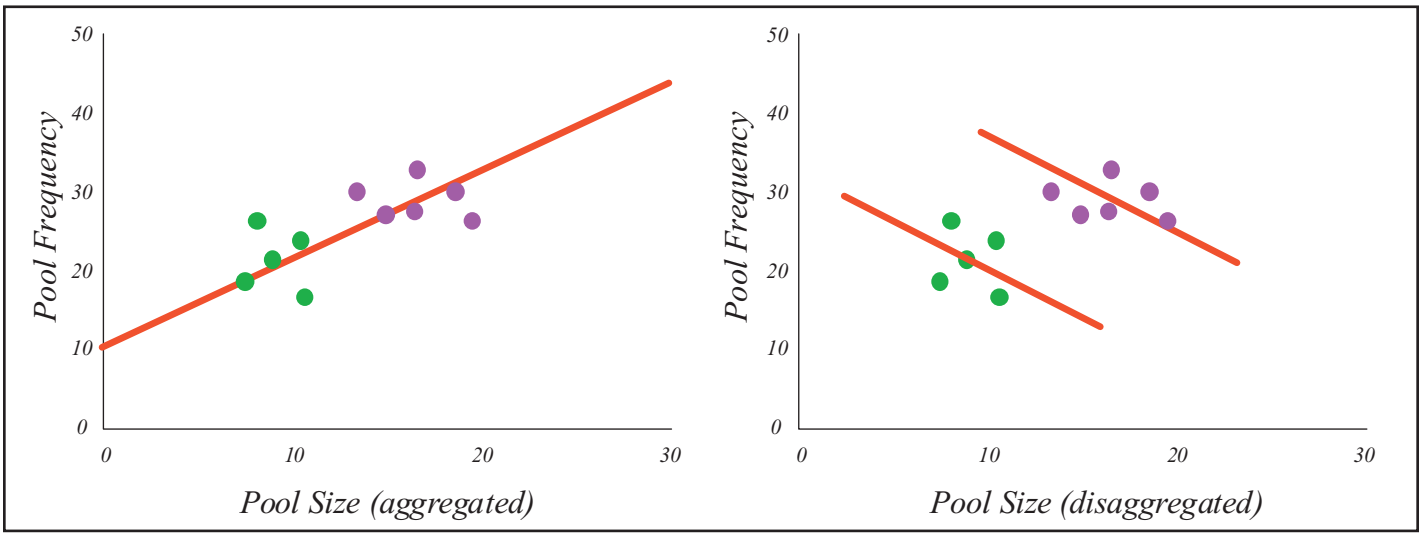

Figure 2. An example of Simpson's Paradox.

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problem has long been identified in the analysis of spatially aggregated data (e.g., census tract data) where the results of the analysis depend on the definition of the areal units for which the data are reported. This is known as the modifiable areal unit problem (MAUP) or as the zone definition problem. There are two components to the modifiable areal unit problem – the scale effect, where different results can be obtained from the same statistical analysis at different levels of spatial resolution; and the zoning effect, where different results can be obtained due to the re-grouping of zones at a given scale. One solution to this issue is to use spatially disaggregated data. Unfortunately, such data are frequently unavailable for a variety of reasons.

Oil and gas reserves data are an example of the analysis being dependent on the definition of the areal units. Reserves data is released on the basis of pool entities. The number of wells in a single pool may range from one to many thousands. If there is more than one well in a pool, then the reserves data is released in an aggregated form, i.e., the pool parameters are averages. The main reasons for this data aggregation are confidentiality and / or lack of detailed test data and the personnel to analyse it. As a result, pool reserves tend to be an incomplete compilation of the data from individual wells. Also, as more wells are drilled around a discovery and the pool is developed, these pool averages will change due to natural variation from one well to another.

Another approach is to report the results at the most spatially disaggregated level possible and then to demonstrate the sensitivity of the results to both the scale and zoning effects through a range of test groupings. If the results can be shown to be relatively stable over a wide range of zoning systems, then there can be greater confidence that the results are not simply artifacts of the way the data are arranged.

Another problem related to aggregated data is the situation where inferences are made that, while true for the global dataset, are incorrect when applied to individual components or locations within the dataset. This is known as the ecological fallacy. It results from thinking that relationships observed for groups necessarily hold for individuals. The opposite of this situation is known as the atomistic fallacy, where modeling spatial behaviour solely at the individual level is prone to missing the context in which that behaviour occurs – i.e., not seeing the forest for the trees.

In cases where the data has a geographical component, it may not be totally clear how random the pattern observed is. If there is any systematic pattern in the spatial distribution of the data, the data is said to be spatially autocorrelated. If the pattern is such that nearby locations are more similar to each other than to distant locations, the pattern is termed positively spatially autocorrelated. This is such a common occurrence that it is known as the First Law of geography (Longley 2001). The opposite case where nearby locations are unlike (negatively spatially autocorrelated) is much less common. Between these two endpoints of positive and negative autocorrelation are random patterns which exhibit no spatial autocorrelation.

Autocorrelation is of concern to geographers and other spatial analysts for two main reasons. First, the search for spatial patterns is a dominating theme of geographical research. Recognizing the impact features have on each other and their distribution aids in correctly identifying the spatial pattern that exists for that particular dataset. Second, inferential statistics assumes the data being analyzed is independent of one another (i.e., randomly distributed). Identifying the degree of spatial autocorrelation will help determine the type of statistical test to use.

Relationships can also be subject to change

over time or space. This is termed non-stationarity and there are several reasons why this can occur. One obviously relates to sampling variation. For example, if several subsets of a dataset were modelled, the resulting parameter estimates would not be exactly the same because variations would exist in the different samples of data used. Another possible cause of observed spatial non-stationarity in relationships is that some relationships are intrinsically different across space. As well, it is possible that the model from which the relationships are estimated is incorrect and that one or more relevant variables are either omitted or are misspecified. Thus, the question arises, are the spatial variations in relationships due to model misspecifications or are they due to intrinsically different local spatial behaviour? Local modeling is a potential aid in identifying the missing variables, which can then be added to the global model and the procedure re-run.

Traditionally, most methods of spatial point pattern analysis have involved the calculation of a global statistic that describes aspects of the whole point pattern. From this global analysis, a judgment would be reached as to whether the overall pattern was clustered, dispersed, or random. Potentially interesting spatial variations could be masked by the global statistic in this analysis. A number of methods are available for examining local variations in spatial relationships. Some of these are local forms of point pattern analysis, local filters, and local measures of spatial dependency. Spatial dependency (autocorrelation) is the extent to which the value of an attribute in one location depends on the values of the attribute in nearby locations. It is possible for both positive and negative autocorrelation to exist in the same data set. Using only global measures of spatial autocorrelations would fail to pick up these different degrees of spatial dependency. Diagnostic measures for autocorrelation include the joins count statistic, Moran's I, and Geary's C. The joins count test determines spatial autocorrelation by counting the number of occurrences in the map of each of the possible joins between neighboring areal units. Limitations of the joins count are that it works only for binary units, the results are not easy to interpret, and equations for the expected values of the counts are fairly formidable. Moran's I is a simple translation of a nonspatial correlation measure to a spatial context and is usually applied to areal units where numerical ratio or interval data are available. It employs a covariance term between each areal unit and its neighbors. Geary's Contiguity Ratio, C, is similar to Moran's I but uses the sum of squared differences between each areal unit and its neighbors. These are global statistics that tell whether or not an overall configuration is autocorrelated but not where the unusual interactions are (O'Sullivan and Unwin 2003).

One of the first methods of developing local forms of point pattern analysis was the Geographical Analysis Machine (GAM). The basic components of GAM were 1) a method for defining sub-regions of the data; 2) a means of describing the point pattern within each of these sub-regions; 3) a procedure for assessing the statistical significance of the observed point pattern within each sub-region, considered separately from the rest of the data; and 4) a procedure for displaying the sub-regions in which there are significant patterns. The emphasis was on identifying interesting local parts of the data rather than simply providing a global average statistic. Other techniques for depicting local relationships in univariant data sets include the spatially lagged scatterplot, the variogram cloud plot, and the Moran scatterplot.

A significant task in resource assessments (or in any mapping project) is the prediction of exact values of attributes at unsampled locations from measurements made at control points within the same area. This task is known as spatial interpolation and it can be done with proximity polygons, by using the local spatial average derived from either a fixed distance or a fixed number of nearest neighbors (two things wrong with this approach is that the limit chosen is arbitrary [MAUP] and in some cases the nearest points may be significantly distant from the sample point), by inverse distance weighting (IDW), by Kriging, or a number of other methods (O'Sullivan and Unwin 2003).

Specifying a finer or coarser grid, altering the choice of neighboring control points, altering the actual distance used, and changing the distance weighting function equation can modify the IDW procedure. There is no one right way to do the interpolation and frequently several methods are used to identify the one that gives the smallest error value.

Kriging is a statistical interpolation method that is optimal in the sense that it makes best use of what can be inferred about the spatial structure in the surface to be interpolated from an analysis of the

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control point data. Kriging uses the control point data as a sample to find optimum values of the weights for the data values included in the interpolation at each unknown location. This is done by 1) producing a description of the spatial variation in the sample control point data, 2) summarizing this spatial variation by a regular mathematical function, and 3) using this model to determine the interpolation weights.

Kriging is based on the regionalized variable theory, which assumes that the spatial variation of a data set is statistically homogeneous throughout the surface. Point sets that contain anomalous pits or spikes or abrupt changes are not appropriate for kriging interpolation. Kriging differs from classical linear regression in that it does not assume that the variables are independent or that the observations are a random sample. Kriging has a variety of statistical algorithms to generate these values, each with different assumptions and predictive results. Some of the more common algorithms are: simple, ordinary, universal, indicator, and disjunctive (Davis 2002).

Simple kriging is the mathematically least complicated form of kriging. It is based on assuming that: 1) the observations form part of a regionalized variable surface; 2) the mean, spatial covariance, and semivariance do not depend on spatial location (i.e., the variable possesses stationarity); and 3) the mean is known (e.g., when the variable has been standardized or results from a function fitted by least squares, the mean is zero).

Ordinary kriging, like simple kriging, requires that the data set possess process stationarity and a normal distribution. Stationarity is where the statistical properties of the data do not change over time – the mean and variance are constant over time. This differs from simple kriging in that the mean does not have to be known in advance.

Universal kriging removes the restriction that the regionalized variable must have a constant mean. This allows the data to have a trend (i.e., systematic change). Universal kriging assumes that the regionalized variable consists of two components – drift and residuals. The drift is the

average value within the neighborhood of a regionalized variable and is the slowly varying, nonstationary component of the surface. Residuals are the differences between the actual observations and the drift. Thus if the drift is removed from a regionalized variable, the resulting residuals will be stationary and ordinary kriging can be applied.

A more specialized form of kriging is indicator kriging, where the regionalized variable is coded into binary classes and the predicted value can be interpreted as a probability of occurrence. Indicator kriging is a special case of disjunctive kriging, which is a non-linear distribution-dependent estimator for regionalized variables that do not have simple (Gaussian) distributions. While these forms of kriging may do more than ordinary kriging, the costs are higher in that the assumptions are difficult to verify and the solutions are mathematically complicated (ESRI 2005a).

Kriging is computationally intensive and rounding errors could become significantly large with larger datasets. All the results depend on the model fitted to the estimated semivariogram from the sample data and the validity of any assumptions. If the correct model is used, Kriging has the advantage over other methods in that the estimated values have minimum error associated with them and this error is quantifiable. Local univariate statistical methods are of limited use with large, complex spatial datasets. For these, there is a need to understand local variations in more complex multivariate relationships. Several methods have been developed to produce local versions of regression analysis. These include spatially adaptive filtering, multilevel modeling, and geographically weighted regression. Spatially adaptive filtering allows coefficients to vary locally while compensating for drift of regression parameters over time. This works on a "predictor-corrector" basis. When a new multivariate observation occurs, the existing regression coefficients are used to predict the dependent variable. If the prediction does not perform well, the values of the regression coefficient are adjusted and tried again. Multilevel modeling attempts to separate the effects of place and individual characteristics in order to avoid the problems of the atomistic and the ecological fallacies. This is done by using an individual-level model representing disaggregate behavior with a global-level model representing contextual variations in behavior. However, there are some problems with the application of multilevel modeling to spatial processes that limits it usefulness.

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One is that it implies that whatever spatial process is being modeled is discontinuous, i.e., the process is modified in exactly the same way throughout a particular spatial unit, but as soon as the boundary of that unit is reached, the process is modified in a different way.

Most spatial processes are continuous and many will be unrelated to arbitrary boundary locations based on administrative or political decisions. Although continuous, attributes may still be location-dependent. It is not unusual for parameter values of spatial relationships to "drift" through space. One way of addressing the issue of drift and avoiding artificial boundaries is moving window regression. Moving window regression produces a smoother surface of parameter estimates than separate regressions but it still represents a discontinous technique. Results are dependent on the size of the window or region chosen with larger windows producing smoother results than smaller windows. Edge effects also pose a problem as the windows towards the edge of the map area will contain fewer points for regression than those windows towards the center of the map area. This will result in higher standard errors for those windows.

Geographically weighted regression attempts to solve the problem of representing a continuous spatial process with a discrete weighing system by weighting each data point according to its distance from the regression point. For a given regression point, the weight of a data point is at a maximum when it shares the same location as the regression point. This weight decreases as the distance increases between the two points. For each location, the data will be weighted differently so that the results of any one calibration are unique to a particular location. This method is sensitive to the bandwidth (a measure of the distance-decay in the weighting function) chosen. Bandwidth indicates the degree to which the surface is smoothed – smaller bandwidths have a steeper distance-decay weighting function and produce a rougher surface than larger bandwidths. Similar to the moving window regression edge problem, areas of sparse data will cause the local modeling to be calibrated on few data points. This will result in large standard errors and undersmoothed surfaces. A way around this problem is to adjust the bandwidth depending on the amount of data in the area around the regression points.

In addition to the generic statistical and spatial problems, there are a variety of geological and engineering issues that affect resource assessment. These relate to the determination of reserve size, which is a critical factor in the background data used for assessments. A common part of assessment methodology has discovered pools being ranked by original hydrocarbon volume-in-place and fitted to a log normal distribution. Estimates of that original volume-in-place are difficult to make and are frequently adjusted as the pool is produced. As mentioned previously, hydrocarbon accumulations fall into two main categories – conventional and continuous. Volumes-in-place for continuous accumulations are extremely difficult to estimate because there is no clear cut-off for the reservoir parameters used for the calculation. Even with the conventional accumulations, basic measurements are not always well defined.

Fundamental to conventional accumulations is the assumption that hydrocarbons are subject to the relative buoyancy of oil or gas to water. This gives rise to a hydrocarbon / water contact that, in turn, helps define the areal extent of the pool, which is then used to calculate the pool's volume. In the early stages of pool development, the actual contact may not have been intersected, resulting in uncertainty in the areal extent of the pool. Figure 3 illustrates this by showing the change in pool area

based on two wells. The reservoir in well 1 is completely filled with hydrocarbons, while the reservoir in well 2 is completely wet. The hydrocarbon / water contact lies somewhere between the two wells. As is obvious from the plan view, the areal extent of the pool could vary significantly. Also, frequently, the hydrocarbon / water contact is not sharply defined. Instead, it exists as a transition zone that may extend vertically for tens of meters. The pool volume may be significantly affected by where the cutoff is made.

Within the reservoir, there are other parameters that are subject to significant variation. The primary ones are porosity, water saturation, and permeability. Porosity and water saturation are usually determined from petrophysical logs that measure rock and fluid properties immediately adjacent (i.e., within a few meters) to the wellbore. Detailed analyses of occasional core samples are used to calibrate the well logs. However, it is important to remember that even the core analyses are representative only of the 20 or so centimeters occupied by the wellbore. Beyond that, values are only estimates based on interpretation of secondary data (i.e., the well logs, as opposed to actual samples of the rocks and fluids). Given that a large proportion of the hydrocarbon resource exists as one-well pools and that a pool may be assigned an area of 2.6 square kilometers (one square mile), there is ample room for variation in the pool's reservoir parameters to allow for significant differences in the estimates of hydrocarbon volume-in-place.

Once the volume-in-place is determined, a recovery factor is assigned to indicate the percentage of hydrocarbons that can be reasonably and economically produced. Determining this amount (the ultimately recoverable resource) is the goal of resource assessment. Of the three attributes mentioned above, permeability has the most pronounced affect on recovery factor. It is also the most difficult to estimate and requires detailed core, test, or production data to do so.

In addition to primary (i.e., rock and fluid analyses) and secondary (i.e., well logs) data, there is a third category of data – remote sensing – used for determining resource size. Remote sensing is intended to provide a lot of data for a little cost. It is primarily used in remote areas where access is difficult, or in regional studies covering large areas, or detailed studies where it is more cost-effective than point sampling (i.e., drilling wells). Satellite imagery, aeromagnetic, gravity, geochemical, and seismic are all forms of remote sensing. Of these, seismic data, in particular, heavily influences resource assessment. Almost no prospects are drilled today without some seismic control. In the early delineation of an oil or gas field, seismic is the primary means used to define structural closure. From this, volumetric calculation of in-place volumes is possible.

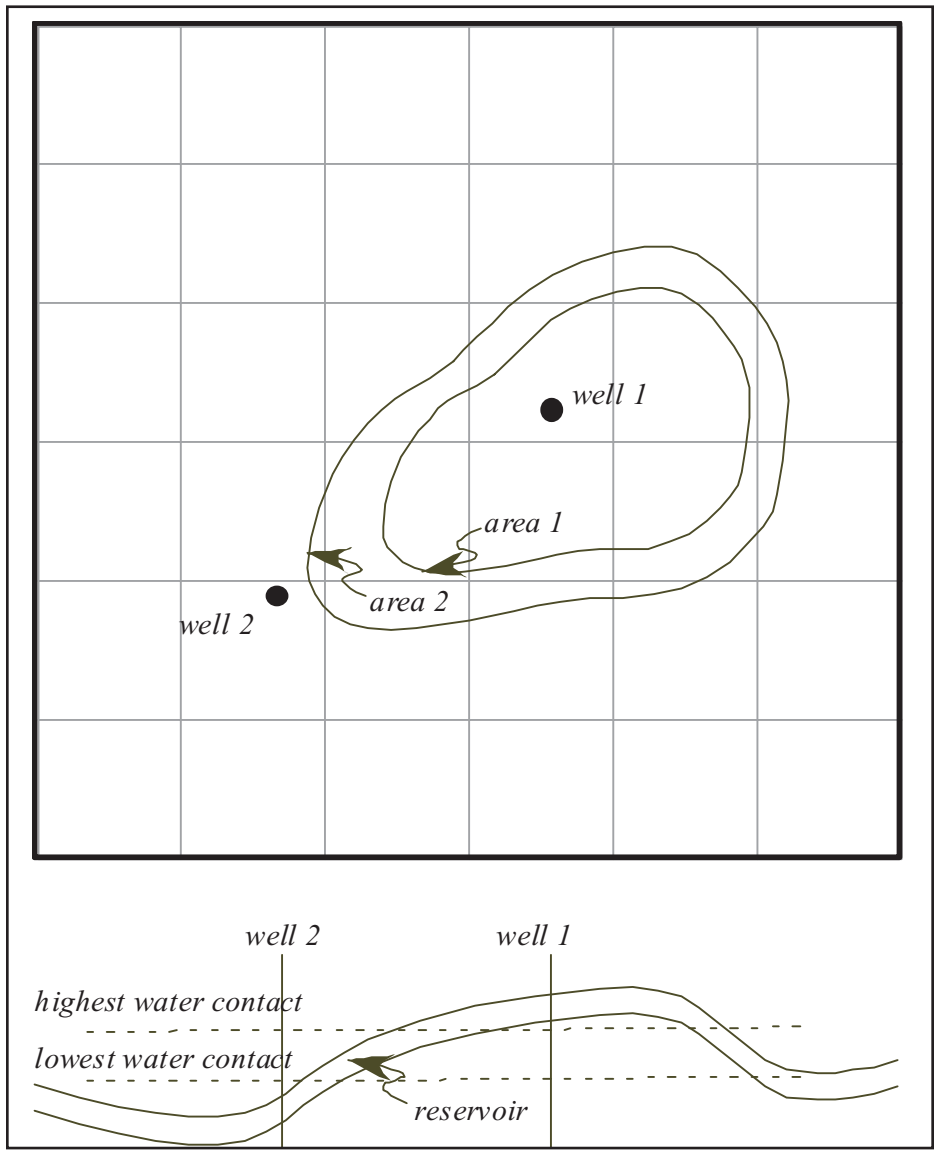

Figure 3. Possible variations in areal extent based on well control.

In seismic interpretation, velocity models based on geologic controls are used to convert travel time of seismic waves into depths. These velocity models are based on averaged values of different rock types, depths, and structures. Similar to the "predictor-corrector" model described previously, the initial velocity model is developed on a 'best guess' basis. The model is adjusted as more data becomes locally available from well control. A subtle variation in the velocity model and resulting time-depth conversion can modify the gross rock volume under closure by significant amounts (Berman 2004).

In summary, there are a number of factors that affect the quality of data used in resource assessment. These range from simple input errors to misinterpretation of poorly presented data to variations in interpretation of indefinite data. All contribute to the uncertainty inherent to the assessment process. Sources of uncertainty include issues of accuracy, statistical precision, and bias in initial values, as well as in estimated predictive coefficients and estimations of errors. There are two general approaches to uncertainty estimation – analytical (theory based) and empirical (observation based). The analytical approach works best for procedures that do not change. Although it can be very labor-intensive to set up, it will provide very rapid computation

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of uncertainty estimates afterwards. The empirical approach relies heavily on computer resources and less on statistical expertise. Monte Carlo simulation is a commonly used empirical approach (Mowrer and Gongalton 1996).

To be continued…

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CALENDAR OF EVENTS

CSPG Field Trip
June 20, 2007
Exploration Targets in the Canadian Rocky Mountain Foothills: Calgary to Moose Mountain, a Helicopter-supported Field Trip.

Instructor(s): Andrew C. Newson, B.Sc., P.Geol. and Deborah Sanderson, M.Sc., P.Geol.

CSPG Member Earlybird: $450+GST/
Non-Member: $625+GST *(Includes ground & helicopter transportation, lunch and snacks)*

For more information visit www.cspg.org

Upper Devonian Reef Strata and Hydrothermal Dolomitization in the Southern Northwest Territories
September 10-14, 2007

Instructor(s): Dr. Alex J. MacNeil, Imperial Oil Resources and Dr. Brian Jones, University of Alberta

CSPG Member Earlybird: $2048+GST/
CSPG Member: $2275+GST/
Non-member: $2844+GST *(The fees include accommodation, ground transportation, lunches, and guide book (airfare not included))*

For more information visit www.cspg.org.

1st Annual CSPG Education Week
October 29th to November 2nd, 2007
Calgary, Alberta

Join us for a thrilling week of continuing education, a second chance to take the soldout 2007 CSPG Convention Courses:

- Practical Sequence Stratigraphy: Concepts and Applications – Ashton Embry
- Architecture of Fluvial Reservoirs – Andrew Miall
- Stratigraphic Setting of Lower and Middle Triassic Strata – James Dixon.

Contact Travis.Hobbs@encana.com

ROCK SHOP

Canadian Society of Petroleum Geologists

18th ANNUAL MIXED GOLF TOURNAMENT

FRIDAY, AUGUST 24, 2007 – D'ARCY RANCH GOLF CLUB

Format: Modified Texas Scramble, shotgun start at 8:00 am. Teams will be assigned according to handicap or average score. This is a fun tournament open to both men and women. Registration includes a Continental Breakfast, Dinner, Green Fees and Power Carts.

Entry Deadline: Deadline August 3, 2007. (Priority will be given to CSPG Members)

http://www.cspg.org/events/events-social-golf.cfm

☐ CSPG - Member # _____ ☐ Non Member

Name: _____

Company: _____

Address: _____

Phone (daytime): _____ Phone (evening): _____

Email: _____

☐ Male ☐ Female Club Handicap or average 18 hole score: _____

Can you help out on the day of the tournament (scoring, etc.) ☐ Yes ☐ No

Guest Name: _____ (One guest allowed per CSPG Member.)

☐ Male ☐ Female Club Handicap or average 18 hole score: _____

Please note: A waiver form must be signed by EACH participant 5 business days prior to the Mixed Golf Tournament. A waiver form will be distributed to you once your registration form has been processed. If a waiver form is not signed prior to the tournament, your registration will be removed from the tournament. All registrations must be accompanied by full payment. All Cancellations or Amendments to registrations must be received in writing via fax or mail. Phone requests will not be accepted. The Cancellation or Amendment must be received in the CSPG Office by 4:00 pm on August 17, 2007. A 15% cancellation and administration fee will apply.

For more information contact: Brenda Pearson at 515-3410, David Middleton at 296-4604 or David Caldwell 809-7400.

$ _____ $80.00 – Member

$ _____ $120.00 – Non-Member/Guest

$ _____ $25.00 – Extra Meal Ticket (Non-playing guests. Maximum 15 spots; first-come, first served.)

$ _____ TOTAL (GST Included. GST # 118836295)

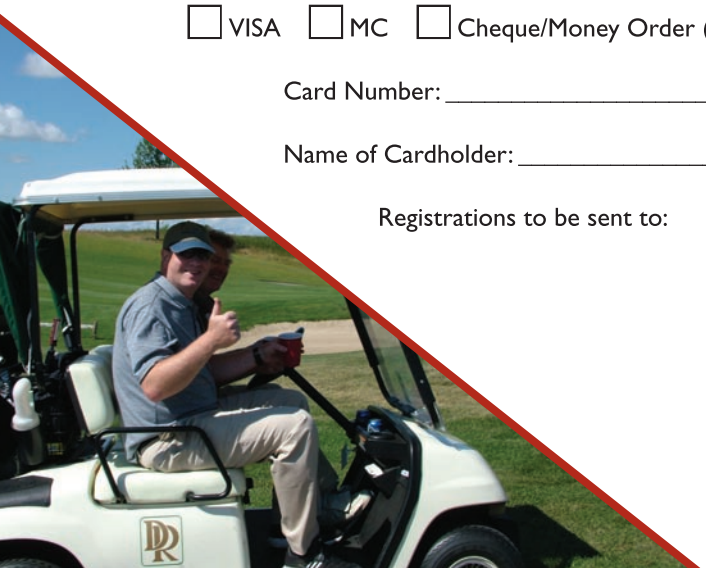
☐ VISA ☐ MC ☐ Cheque/Money Order (Payable to CSPG)

Card Number: _____ Expiry: _____

Name of Cardholder: _____ Signature: _____

Registrations to be sent to:

Canadian Society of Petroleum Geologists
Attn: Mixed Golf Tournament
600, 640 – 8 Avenue SW
Calgary, Alberta T2P 1G7
Phone: (403) 264-5610 Fax: (403) 264-5898



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EXPLORATION AND ENERGY POTENTIAL IN THE ARCTIC

Declining reserves in the mature Western Canada Sedimentary Basin are enticing industry to look North again as companies are jockeying for a growth position in the 21st Century. More than a dozen sedimentary basins occur in the vast area north of 60 degrees latitude (Fig. 1). Compared with the Western Canada Sedimentary Basin (WCSB), most northern and arctic basins are immature and under explored. Yet, earlier rounds of exploration have revealed significant conventional resources in a variety of settings. The time has come to reassess the resources that lie beneath the frozen north, beyond the information provided by the pioneering drilling and seismic activity of the 1960s through to the early 1980s. With the supply of conventional oil declining around the world and the depletion of North American gas reserves occurring at a time of increasing demand brought on by emerging economies, the Arctic has become an important target for insuring a sustained hydrocarbon supply for North America.

The Mackenzie Delta remains one of the most promising basins of Canada's North, if not in the entire circumarctic region. Discoveries have been made, large gas fields have been delineated, and a large number of exciting, yet unexplored possibilities exist both inland and offshore. Last year, resuscitating an old drilling caisson, Devon Canada drilled the first offshore well in more than 15 years. Intense seismic activity has been conducted by a number of companies. Some players have bailed out; others have jumped in, all the while monitoring ongoing deliberations on Mackenzie Valley pipeline development. Will the Beaufort-Mackenzie area fulfill its enormous promise in our lifetime? Farther south, exploration has been continuous, though limited, in the Mackenzie Valley since 1994. While still nurturing the dream of finding another Norman Wells, exploration companies have made headways in relatively unexplored areas

Figure 1. Sedimentary basins of Arctic Canada (photo: GSC)

overcoming some remarkable challenges in terms of seismic acquisition and drilling. Interesting possibilities, and indeed signicant discoveries, occurred at Colville Hills, Summit Creek, Liard Plateau, and Cameron Hills.

(Continued on page 30...)

(...Continued from page 29)

Several small basins occur in the Yukon Territory, but most of them have received little industry attention. One exception is the Eagle Plains Basin where there has been renewed activity in recent years, including drilling. Likewise, Peel Plateau is currently the focus of industry interest and the area is being actively promoted by territorial geosciences offices. Compared with its Canadian counterparts, most sedimentary basins of neighbouring Alaska's North Slope are mature, having been the focus of sustained industry activity for nearly half a century. Prudhoe Bay has been a productive field ever since its discovery in 1968. The Arctic National Wildlife Refuge (ANWR) remains shrouded in a cloud of mystery and much has to be learned about its resource potential. It is an area currently in the 'crosshairs' of all kinds of industrial, economic, political, and environmental interests. Beyond Prudhoe Bay and ANWR, northern Alaska still holds promise, and some Canadian companies are actively investigating the potential there.

The Arctic Islands is the other region of Canada's far north where significant resources were discovered during the nineteen seventies. The Bent Horn oil field in the Parry Island Fold Belt was producing sweet crude up until the early 1990s, when it was prematurely shut-in. The Sverdrup Basin (Fig. 2) is one of Canada's most promising petroleum provinces containing two of Canada's largest gas fields, Drake and Hecla on Melville Island. Beyond the original simple plays explored by industry, bold new ideas are needed to reassess prospectivity in the promising Mesozoic succession. The time has come to reexamine the Franklinian and Sverdrup basins in the light of new technologies and play concepts.

Arctic Canada is also blessed with two continental shelves of about the same length and width as the rich Norwegian Shelf. To say that these shelves are poorly understood is an understatement. One can argue that we know more about the geology of Mars or Venus than about the nearly 2,000 kilometer long Polar Continental Shelf, arguably the Earth's ultimate frontier. However, a recent acquisition of geophysical data to delineate Canada's offshore jurisdiction under the Law of the Sea should lead to a better understanding of that region. Far better understood is the Eastern Continental Shelf that borders Ellesmere and Baffin islands where a handful of wells have been drilled, including in neighbouring West Greenland. There is a resurgence of industry interest in this region as indicated by the acquisition of new seismic data. Large volumes of gas hydrates are known to exist in the frozen ground of the Arctic, particularly in the Mackenzie Delta and Sverdrup Basin. In addition, estimates of the amount of methane energy resources contained in natural gas hydrates defy the imagination. Even if only a fraction of those estimates proves to be recoverable, gas hydrates would be a sizeable resource, perhaps fulfilling the promise of being the "energy of the future".

Figure 2. Industry geologists visiting Sverdrup Basin outcrops on Axel Heiberg Island in 2004. (photo: Beauchamp)

NORTHERN AND ARCTIC ISSUES IN THE 21ST CENTURY

Beyond its energy potential, the North is hot, and in more ways than one. On any given day, your average media outlet will showcase two or three stories about the North. Sometimes it is about energy and the competing plans for constructing a pipeline. Often it is about the North's fragile environment and the pressure brought on by climate change. Other times it is about endangered wildlife species and threatened traditional aboriginal ways of life. Sovereignty and security issues regularly make it to the front pages as do a plethora of political, environmental, societal, and political issues, each of them with broad-ranging implications for both northerners and southerners, including industry planners and explorationists.

Since the last round of exploration in the far north, the voice of aboriginal people in northern Canada has grown in importance and is now a force to reckon with. Ever since the Berger inquiry imposed a ten-year moratorium on oil and gas development in the Mackenzie Valley, several aboriginal nations have settled their land claims, and more are well on their way to doing so. Contrary to the views expressed by a number of southern-based lobby groups and opinion makers, aboriginal nations of the north and Arctic Canada are not necessarily adverse to economic development and the exploitation of natural resources. Increasingly native people want to be partners in economic ventures, both to benefit from the economic spin-offs and to ensure that development is done in a manner that is sustainable and respectful of the environment and traditions. Understanding aboriginal cultures, where they are coming from and where they are going, is an essential first step before exploring in the North. Thirty years after the Berger inquiry, there is now not one, but two, competing plans

Figure 3. Muskox surviving in harsh Arctic environment (photo: Beauchamp)

to bring stranded Arctic gas to southern markets, the Mackenzie Valley pipeline and the Alaska pipeline. Trying to follow the latest developments in the pipeline saga is akin to a roller coaster ride, with each turn and loop bringing its own excitement. However, plans are still moving forward as the environmental assessment of the MVP pipeline hearings draw to a close.

The Arctic is a harsh, fragile, and unforgiving environment (Fig. 3). This constitutes a major trump card in any future oil and gas development. As recent exploration efforts have shown, environmental stewardship is an important, potentially costly, but necessary, step to ensure success of energy-related projects. No one wants another Exxon-Valdez on their hands. From assessing the effect of seismic waves on Beluga whales to looking into the consequences of destabilized permafrost on drilling and production infrastructures due to climate change, environmental implications are magnified tenfold in the North. The Arctic is akin to the "canary in the mine" when it comes to climate change and global warming. It is the region where the predicted changes will occur first and in the most dramatic fashion. Arctic sea ice is already thinning rapidly, and some of the major continental ice sheets have started to recede at a fast pace. Polar bears have become the poster child for climate change, as their habitat is indeed threatened by shrinking ice. Beyond the media frenzy and political maelstrom, the issue of climate change is real and will have both positive and negative impacts on how northern and arctic energy resources will be developed in the future. From the very real possibility that some of the large onshore gas fields of the Mackenzie Delta will become offshore in a not-so-distant future to the many transportation opportunities offered by a thinner or absent sea ice cover, the issue of climate, especially in the Arctic cannot be ignored by industry planners.

Figure 4. Sea ice at Otto Fiord, NW Ellesmere Island (photo: Beauchamp)

Ice is perhaps the most important single feature that sets the North and the Arctic apart from the south (Fig. 4). Whether it rests in the ground, lies on top of rivers and lakes, or blanket the land or the seas, ice can be both friend and foe to exploration geologists. Ice roads are an important component of northern exploration, and the ever-shortening freezing season in the North is a cause of concern to many. In contrast, the thinning and disappearance of arctic sea ice opens all kinds of interesting possibilities for shipping stranded resources from the far North. Ice has been used to build drilling islands in the first round of exploration, a technology that may not be appropriate in a rapidly warming arctic. But will drilling caissons and ship hulls be strong enough to resist the enormous pressures brought on by drifting icebergs and multi-year ice, a process bound to increase through climate change? Understanding what's happening with the cryosphere and how it will evolve in the future is an important factor for industry to ponder.

Ever since Martin Frobisher set foot in the Arctic, the issue of ownership has surfaced at various times and in various forms. Except for tiny Hans Island between Greenland and Ellesmere, Canadian sovereignty over the Arctic islands is not disputed by any country. It is the marine seaways and the offshore areas that are at stake, as many countries, especially our US neighbor, would like the Northwest Passage to be an international seaway. Likewise, Ottawa and Washington interpret the offshore boundary between Alaska and the Yukon quite differently. In addition, many countries, including Canada are looking into extending their offshore jurisdiction through the United Nations Convention on the Law of the Sea (UNCLOS). Beyond the almost anecdotal Hans Island issue, these other sovereignty issues are a concern to the Canadian government as they bear mulitple implications, some of which will have direct consequence for the future exploration, development and transportation of natural resources including oil and gas.

In a recent survey among industry decision-makers (Harrison, 2006), the sorry state of the current regulatory process in the North was seen as the single most important barrier to a new era of exploration. Against the back-drop of devolution from the Federal

(Continued on page 32...)

Figure 5. Drilling rig on Cornwall Island in the 1970s (photo Embry)

(...Continued from page 31)

Government to the Territorial authorities and the First Nations administrations and land-claim organizations, the current regulatory process is a maze so complex that it constitutes a serious impediment to developing, let alone exploring for, northern energy resources. But between the one-stop shop dreamed by industry and the politically loaded bureaucratic labyrinth that exists now, one can hope that common sense will prevail to improve a process that is detrimental to both northerners and southerners.

ENERGY FROM THE ARCTIC: WHERE DO WE GO FROM HERE?

So where do we go from here? After the early rounds of exploration in the sixties to early eighties, a period of dormancy in the 1990s, and a resurgence of interest at the dawn of the 21st Century, industry is once again at the cross-roads when it comes to Northern and Arctic exploration (Fig. 5). On a broad scale, the next steps will much depend on the world economy, the North American gas market and the price of commodities. On a local scale, a number of barriers will have to be overcome before industry returns in droves to the Arctic. Some of these are technological and environmental challenges; others relate to the regulatory process and the willingness of northern populations to see resource development take place on their lands. Much also depends on whether one or more pipelines is built and whether arctic gas can be shipped by sea using existing or new technologies. The 2007 CSPG Gussow Conference (Fig. 6) on Arctic Energy Exploration (www.cspg.org), to be held in Banff, October 15-17 2007, will provide a forum for Canada's leading experts on Arctic oil and gas development to share their experience, expertise and vision as to where industry has been, currently is, and should be, in the far North.

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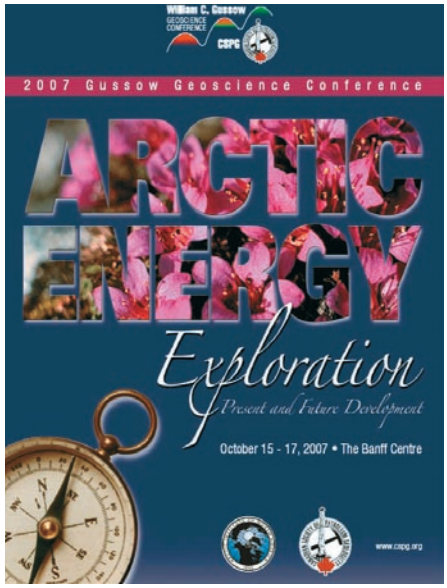

Figure 6. Poster for the 2007 Gussow Conference on Arctic Energy Exploration

CSPG AWARD
President's Awards

The 2006 CSPG President's Awards were presented at the Technical Luncheon held on Tuesday, April 24th at the Telus Convention Centre. The CSPG President's Award is our Society's highest service award. It is generally bestowed on one or more individuals for the critical role they have played in staging a hallmark event. During 2006, that hallmark event, the product of several years of diligent preparation and volunteer time, was the joint CSPG-CSEG-CWLS Annual Convention.

And what a convention it was! The convention received 4,678 delegates, which generated registration revenues of $1.25 million. Total revenues were $1.99 million against total expenditures of $0.99 million, yielding a gross profit of $1.01 million. The CSPG portion of this profit was $453 thousand, which made this convention our Society's most profitable to date. The technical program was also top notch, including more than 200 oral papers and 70 posters. Placing the poster displays in the centre of the exhibits floor was a new idea for this convention - and it was favourably received. The core conference was outstanding, drawing on reservoir systems from across Canada, plus a very popular display on kimberlites and diamonds.

All committee members are to be thanked profusely for their efforts, but it was Mark's, Kevin's, and Roy's thoughtful recruiting, inspiration and guidance that is being especially acknowledged by this award. Therefore, in recognition of the outstanding leadership provided to the 2006 joint convention by the general co-chairs, the CSPG was very proud to present the 2006 President's Award to Mark Cooper, Kevin Marsh, and Roy Benteau.

MARK COOPER

Mark Cooper was the CSPG general co-chairman for the 2006 Convention. Mark graduated with a B.Sc. geology degree from Imperial College, London in 1974, and with a Ph.D. from Bristol University in 1977. He taught geology at University College Cork prior to joining BP in 1985 to work on structurally complex basins based in London. Mark was sent on an assignment to BP Canada in 1988, where he worked on exploration in the foothills including the successful Sukunka-Bullmoose play in NE British Columbia. Mark also served with BP in Colombia on the team that drilled the discovery wells on the Cupiagua, Volcanera, and Florena Fields. In 1994 he joined PanCanadian and worked on the BC foothills, western Newfoundland, Quebec, the Gulf of Mexico, the Scotian Shelf, and various international projects. He was involved with frontier and international projects through the formation of EnCana in 2002 and he currently manages the Middle East and Global New Ventures groups for EnCana. He has published over 50 papers, co-edited a book on Inversion Tectonics and has served as an advisory editor for the Journal of the Geological Society. He was a co-winner of the CSPG Link Award in 1997, served as an AAPG Distinguished Lecturer for 1999-2000 and was a co-winner of the AAPG Matson Award in 2002. Mark has been heavily involved with both the Canadian Society of Petroleum Geologists and the AAPG, serving on committees in both organizations over the last 10 years. Mark was unable to attend; on his behalf, Colin Yeo accepted the Award and spoke from Mark's prepared statement that he was, "accepting this award on behalf of the excellent committee that I had the privilege of working with on the convention and I wish to take this opportunity to thank them for all their hard work that resulted in the success of the meeting. I would also like to thank EnCana for the opportunity to tackle this task."

KEVIN MARSH

Kevin Marsh was the CSEG general co-chairman for the 2006 Convention. Kevin earned his B.Sc. in Geography from Queen's University in 1978. He also holds a certificate in Geophysics from SAIT. After graduation, Kevin spent his early career working at Western Geophysical Company as a Junior Seismic Processor. In the early 1980s, he moved to Digitech systems until 1985 when the Processing Centre was closed due to the NEP. Kevin landed at Dome Petroleum for 1.5 years when a takeover meant seeking a new position at Pulsonic Geophysical as Processing Group Leader. While at Pulsonic he took a brief position in 1994 at Pulsonic Nigeria before returning to Calgary. In 1997 he left Pulsonic and joined Statcom Ltd., holding the position of Senior Processor and Marketing Manager. In 2005 he joined Geo-X Processing, a Division of Divestco, as a Seismic Processing Group Leader. His primary role has been processing 2D and 3D seismic prospects in a group setting. Kevin is a member of the CSEG, and has most recently been the Co-Chair (CSEG) for the 2006 Joint Convention. Mark thanked his fellow chairs and the members of the committee who supported him.

ROY BENTEAU

Roy Benteau was the CWLS general co-chairman for the 2006 Convention. Roy has over 30 years in the petroleum industry. He has spent the last 4 years with EOG Resources Canada in their Calgary office as a Petrophysical Specialist and more recently as Coordinator of Shallow Gas Exploration. He started his career in Calgary's oil industry with Amoco Canada's exploration department in 1973, where he was involved in all aspects of exploration and exploitation in the Central and Northern areas of the Western Canadian basin. Mr. Benteau held the position of Staff Geologist at Canterra Energy Ltd. in the Exploitation Geology Section, functioning as Lead Geologist in the Eastern and Rainbow Districts. He also worked for a number of internationally-known petroleum engineering consulting firms, serving as Manager of Geology and Petrophysics, and where he participated in and supervised geological characterization studies oriented toward optimizing recovery. He has also acted on behalf of Canadian exploration companies in evaluating international investment opportunities. Mr. Benteau has published a number of papers dating back to 1976, that draw on and illustrate his diverse technical and geographic experience. Mr. Benteau is a member of CWLS, APEGGA, SPWLA, AAPG, and CSPG. Roy also thanked his fellow chairs and committee members, and the CSPG for recognizing his efforts.

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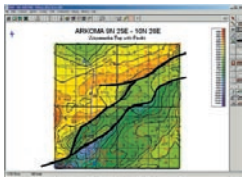

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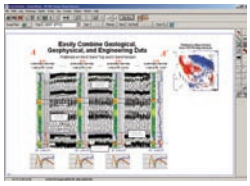

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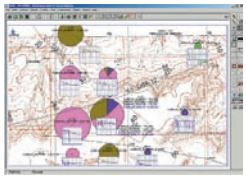

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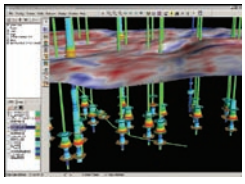

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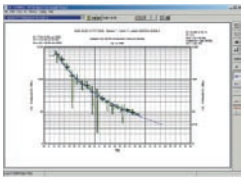

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CSPG AWARD
H.M. Hunter Award

Figure 1. Ian McIlreath accepting award from Ashton Embry.

The H.M. Hunter Award was created to recognize those individuals who have served the Society in a variety of capacities over many years. The 2006 Hunter Awards were presented at the CSPG's Technical Luncheon on Tuesday, April 10, 2007 at the Telus Convention Centre by the Luncheon Chair, Ashton Embry. Also in attendance was the Hunter Award Committee Chair, Craig Lamb. Two very deserving individuals were on hand to receive their presentations and thank the Society and their colleagues for their awards.

IAN MCILREATH

Ian McIlreath has been an active member of the Society since the mid-1970s. For over 30 years, he has volunteered his time on numerous committees, conventions and conferences, and has served on the Executive.

Ian's earliest contributions focused on leading four field trips and chairing the Technical Luncheon Program. He subsequently chaired, or helped organize seven conferences and was General Chairman of GeoCanada 2000, the first geological conference bringing together geological organizations from across Canada. Currently, he is chairing the Convention committee which coordinates all the Society's technical meetings. In addition to volunteering on conferences, Ian has been a member of 23 different committees since 1979. As well, he served on the Executive first as a Director in 1979 and subsequently as Vice President, President and Past President from 1982 to 1984. Ian has also contributed to the Society's technical knowledge base. He has co-authored three CSPG related publications and has made 13 oral and poster presentations at various CSPG sponsored events.

The presentation of this award recognized Ian's significant and numerous contributions to the CSPG over the past three decades.

JACK PORTER

Jack Porter has been a member of the Society since 1960 and over the past 47 years has seen the organization evolve from a local focus to a national one. Since joining, Jack has actively volunteered his time in support of the CSPG and the industry.

Jack's main interests have been in documenting the history of the Society and of Canadian petroleum geology in general. He has served with the Archives and History Committee for numerous years and his "Vignettes of Canadian Petroleum Geology" which appear regularly in the The Reservoir, provide insight into the historical contributions of petroleum geologists to our country. In addition to his work in documenting the history of our profession, Jack has served on the Stratigraphic Nomenclature Committee, the 2002 Convention organizing committee, and in 1976, served as a Director on the Executive.

This award recognizes Jack's dedication and service to the Society over the past 4.5 decades.

Figure 2. Jack Porter accepting award from Ashton Embry.

THANK YOU *to our volunteers*

Thank you to all the volunteers on the Organizing Committee who made the 2007 CSPG CSEG Convention a success!

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19th ANNUAL CSPG-CSEG
10km Roadrace and Fun Run

Summer is just beginning, and thoughts of fall are the furthest thing from your mind, but now is the best time to register and start training for the 19th annual CSPG-CSEG 10km Roadrace and FUN RUN! The event features a 10km run followed by a post-race social, with pizza and refreshments and loads of door prizes. The run appeals to all caliber of runners, attracting some of Calgary's top runners as well as first-time runners. So if you are looking for a competitive race or just want to have fun, come join us!

The run will take place on Wednesday, September 12, 2007 (note date is incorrect in the CSPG calendar) beginning at 6:00pm at the Eau Claire YMCA. The route will take you on an out-and-back course along the beautiful Bow River pathways, finishing at the Eau Claire YMCA. Following the race, all racers, volunteers, and guests are invited to gather for awards, draw prizes, refreshments, and some friendly camaraderie. This is a good way to get out and meet with old friends, as well as make new ones within the industry

The race is open to all members of the CSPG, CSEG, and CAPL, and the general public, however, space is limited to 200 participants. So register early to avoid disappointment! There will be NO race day registration. Register on-line ONLY, at www.cspg.org/events/events-social-funrun-register.cfm.

To help you, Gord Hobbins of Gord's Running Store has developed a 10km race training guide for novice runners. Try it out and benefit from some expert advice, you may be surprised how easy it can be to gently get yourself in condition for your first race.

GORD'S 12 WEEK TRAINING GUIDE FOR NOVICE RUNNERS

Guidance/Tips: For novice runners who wish a do-it-yourself program at your leisure.

- Run for short durations between 3 and 5 times per week according to schedule, with your long run days being the key to your training program.
- If your running shoes are giving you some problems, get some which fit and match your gait.
- Guide allows for a gradual increase to a comfortable load; your legs may need some conditioning at first.
- Yes, times are in minutes. The secret is to be regular and not beat yourself up.
- Wear a hat and cool shades. Keep well hydrated. It really helps.
- Gently stretch those calves and quads afterwards.
- Take along a friend and convince them to sign for CSPG, CSEG, and the RoadRace as well.
- There are many running/training groups in town if interested in more.

Many thanks go out to our sponsors and volunteers who make this event possible each year!

We hope to see you there!

MINUTES OF RUNNING PER DAY:

Week	Mon	Tues	Wed	Thurs	Fri	Sat	Sun
June 26-July 2	–	10-15 min	–	10-15 min	–	–	15 min
July 3-9	–	10-15 min	–	10-15 min	–	–	20 min
July 10-16	–	10-20 min	0-10 min	10-20 min	–	–	25 min
July 17-23	–	10-20 min	0-10 min	10-20 min	–	–	30 min
July 24-30	–	10-20 min	0-10 min	10-20 min	0-10 min	–	25 min
July 31-Aug 6	–	10-20 min	0-10 min	10-20 min	0-10 min	–	35 min
Aug 7-13	–	15-25 min	0-10 min	15-20 min	0-10 min	–	25 min
Aug 14-20	–	15-25 min	0-10 min	15-20 min	0-10 min	–	40 min
Aug 21-29	–	15-25 min	0-10 min	15-25 min	0-10 min	–	25 min
Aug 28-Sept 3	–	15-25 min	0-10 min	15-25 min	0-10 min	–	45 min
Sept 4-10	–	20-30 min	0-10 min	15-25 min	0-10 min	–	25 min
Sept 11-13	–	Rest	10 KM RUN				

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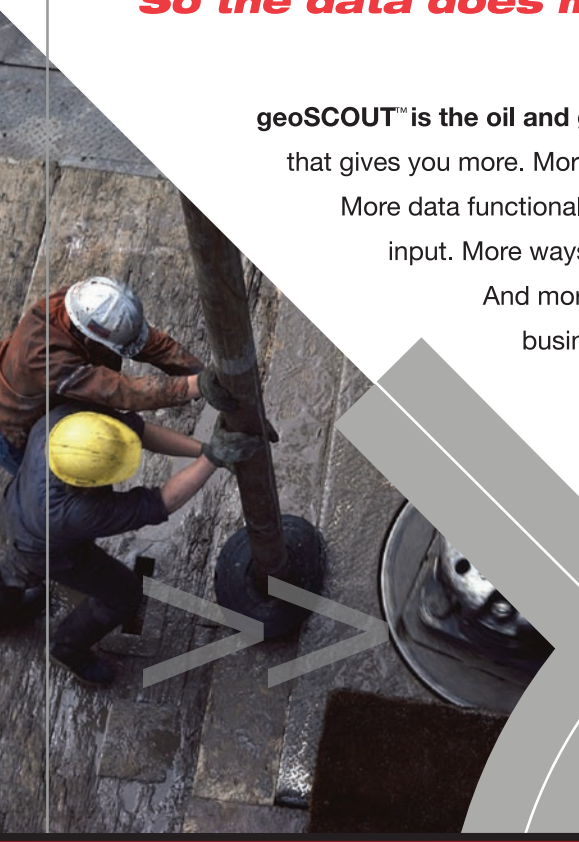

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