14  Alberta’s Cardium: Evolution of Cutoffs & Evaluation Procedures in Response to Horizontal Drilling

17  27th Annual CSPG Mixed Golf Tournament August 26

21  GeoConvention 2016: Thank you for all your support

23  2015 Honorary Membership Award
FEATURED SPEAKERS*

- Greg Soule, Brazil
  Unconventional Resources in Turbidite Sands of the Recôncavo Basin, Onshore Brazil: Core to Seismic Interpretation

- Jonathan Garrett, Michigan
  Regional Chemo- and Sequence Stratigraphic Analysis of the A-1 Carbonate, Michigan Basin, USA

- Bryan Turner, Oklahoma
  The Use of Chemostratigraphy to Refine Ambiguous Sequence Stratigraphic Correlations in Marine Mudrocks. An Example from the Woodford Shale, Oklahoma

- Carlos Molinares-Blanco, Oklahoma
  Woodford Shale (Unconventional Resource) Core from the Arkoma Basin, Oklahoma: Litho/Sequence Stratigraphy, Palynology, Chemostratigraphy, Hardness, and Organic Geochemistry

- Steve Sonnenberg, North Dakota
  The Giant Continuous Oil Accumulation in the Bakken Petroleum System, U.S. Williston Basin

- Riley Brinkerhoff, Montana
  The Bakken-Three Forks Petroleum System in the Northern Williston Basin as Displayed by the Douts 4-7 Core, Burke County, North Dakota, USA

- Cornelius Rott, Germany
  Reservoir Quality of a Diagenetically Altered Shallow Marine Carbonate Interval in the Permian Zechstein (Ca2), East Germany – Implications for Porosity Prediction Using Seismic Inversion Data

- Rob Sadownyk, Turkey
  Mezardere Slope Fan Exploration Model, Thrace Basin, Turkey: Integration of Core, Outcrop, Seismic and Well Log Data

* View full list of speakers at: www.cspg.org/CSPG/Conferences/ACE/Speakers

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**ARTICLES**

**Annual Convention and Exhibition 2016:** Technical Program Sets a High Bar .......... 13

**Alberta’s Cardium:** Evolution of Cutoffs & Evaluation Procedures in Response to Horizontal Drilling ............................................................. 14

**27th Annual CSPG Mixed Golf Tournament August 26** ........................................ 17

**Talking with Architects** an interview with Andrew Miall ........................................ 18

**2015 President’s Award** .......................................................................................... 19

**2015 Honorary Membership Award** ........................................................................ 20

**Introduction to the Special Edition of the Bulletin of Canadian Petroleum Geology** .. 21

**GeoConvention 2016:** Thank you for all your support .............................................. 25

**DEPARTMENTS**

**Message from the Board** ....................................................................................... 5

**Division Talks** ........................................................................................................ 8

**Rock Shop** ............................................................................................................. 7, 16, 17

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**FRONT COVER**

**Grande Cache, Alberta.**

The cliff face (background) of Mount Hamel is dominated by the kink-folded Jurassic-Cretaceous aged Minnes Group, which comprises the hangingwall of the Cowlick Thrust. The footwall of the Cowlick Thrust is comprised of beautifully deformed Gates, Moosebar, Gladstone, Cadomin, and Minnes Group. Specifically, the anticlinal in the foreground (footwall of the Cowlick Thrust) has coals and sandstones of the Minnes Group at its core, and enveloped by the Cadomin.

Stephen Michalchuk – SMichalchuk@ikkumarescorp.com
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How to Talk to Your Boss About Training

Times are tough for geoscientists. If we are still employed we feel lucky and asking for time and money to attend a conference can be perceived as a risky proposition. With the AAPG Annual Convention and Exhibit (ACE) coming to Calgary June 19-22 there is an opportunity to attend the largest gathering of petroleum geoscientists in the world with a great technical program at a low cost to your employer. Even in good times we need to be prepared with a clear message of how our attendance at a conference like ACE results in value for the shareholders of our companies. Geoscientists who work in the service industry attend conferences to meet their customers and keep up with their competitors. Geoscientists from exploration and production companies sometimes struggle to sell the value of attending conferences. Geoscientists add value by increasing production, maximizing profit (reducing costs), and developing creative business opportunities that will profit in the future. If you can relate your training to one or more of those three things, you make it easier for your boss to justify the expense. You need to do some homework and be prepared to have the discussion – here are some tips.

Production
These days it is not so much about drilling new wells but optimizing the wells on production or adding incremental low-cost barrels. We need to be able to look at the old data and see something new. Conferences are great for learning new methods and understanding different perspectives. Review the technical program being offered at ACE and find those abstracts that might offer new insight into your reservoir or play (http://ace.aapg.org/2016/program/at-a-glance). For example, could understanding thermal conductivity (Monday at 5:15, Theme 7) change your interpretation of the thermally altered zone in your 4D seismic data and allow you to optimize the steam strategy in your SAGD development?

Profit
We cannot control the price of the commodity we sell, but we can reduce costs to increase our profit. The exhibit hall is packed with service companies who have solutions for reducing costs. You can see the latest innovations, learn best practices and find opportunities to address the economic and technical challenges affecting your company’s ability to make a profit. Plan your visit to the exhibit hall and locate your suppliers (select Exhibition Hall from the Networking and Events dropdown at ACE. AAPG.org). Meet the business managers and negotiate prices, this may lead to better contract terms for your business.

Opportunities
The goal is not just to survive this economic downturn, but to be in a position to create new opportunities or to maximize value in the assets that are to be sold. Geoscientists are the optimists who point their companies in these new directions and conferences like ACE facilitate the ecosystem where the ideas germinate. The technical program is predominately composed of presentations and posters that will help us optimize value creation for when the rigs return. What can be learned from how Shell de-risks the Duvernay (Monday at 2:30, Discovery Thinking)? How does their approach differ from the researchers at University of Alberta (Monday 8:25, Theme 6) and what is the reservoir impact of the middle carbonate (Monday poster, Theme 6)? Find an opportunity that can potentially increase the
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Instructor: Dr. Rick Sarg  
**Fee: 750 USD**  
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**Friday June 17, 2016**
Instructors: Euan Macaulay & Alan Vaughan  
**Fee: 600 USD**  
ACE SC 4 | Fractured Reservoirs in Compressional and Adjacent Foreland Basin Settings

**Saturday June 18, 2016**
Instructor: Andrew Miall  
**Fee: 800 USD**  
ACE SC 8 | Principles of Stratigraphy

For more information and to register go to [ACE.AAPG.org](http://ACE.AAPG.org)
value of your business and plan to dive deep into the discussion with the goal of building a better understanding of how your company might profit by participation. Even better, have the deep thinking stimulate a new idea and a new opportunity. Conferences provide opportunities to collaborate with colleagues and competitors. Perhaps the best plan is not to compete, but to partner. You never know what partnership might be born from a casual conversation beside a poster or over a coffee between sessions.

All my examples above are from Monday at ACE – one day. There is another two full days of a rich technical program plus an international core conference, field trips, and short courses. This is a full week of stimulating content with inspiring people that will spark the ideas you need to bring value to your shareholders. Attendance at conferences like ACE is not a luxury; your company needs you to be there for solid business reasons. Your shareholders don’t want to jest survive the downturn; they want to thrive and your participation at ACE should help that happen.
Mining Structural Data: applying learnings from underground datasets to unconventional reservoirs

SPEAKER
Jon Noad

12:00 noon
Thursday May 5, 2016
Schlumberger
Second Floor of the Palliser One Building
125 9th Ave, Calgary, AB

ABSTRACT
Production from unconventional reservoirs is a relatively recent phenomenon. In contrast, mining dates back thousands of years, and as a result has gone through many of the teething problems that are now facing the oil industry. In addition, the hands on nature of mining has provided unique insights into the behaviour of rocks under stress, and the structural frameworks in which they are situated.

Mines of all kinds can provide valuable data, and examples that will be presented include an underground Portland Stone mine in the United Kingdom, which is mining building stone using a room and pillar system, the only mine of this type in the country. The mine has accessed natural fractures in the subsurface, as well as complex depositional patterns highlighted by chert replacement, that have necessitated novel mining approaches that can readily be applied to unconventional production.

Another mine under the spotlight will be St. Helena Gold Mine in the Free State of South Africa. The extensive faulting, and associated stress regime, has had enormous implications for mining, many of which compare closely with production challenges in structurally complex reservoirs in western Canada. The methodology for building structural maps of the subsurface will be discussed, as well as fault gouge and smear, and geomechanical remediation through rock bolting and shaft pillars. This analogue is particularly appropriate as the carbon rich ore body represents a “frozen” hydrocarbon deposit.

Even mines focusing on igneous rocks and their associated minerals can yield important data on fracture distribution and fault behaviour. Examples from chromite and vanadium mines in Mpumalanga, mining within the Bushveld Complex in South Africa, demonstrate how even relatively small scale faulting can prove disastrous to horizontal well paths, while slumping and the development of pot holes can actually enhance potential production. The encroachment of gabbro in such subsurface deposits bears many similarities to secondary cementation of reservoirs, with consequent potential as an analogue to silica and calcite cements.

If you want to gain a very different perspective on structural geology in the mining industry, and its potential impact on hydrocarbon reservoirs, this is a talk that you should not miss.

BIOGRAPHY
I am primarily an exploration geologist with 18 years of experience in the oil industry. After graduating in 1985, I worked for five years in South Africa as a mining geologist. This was followed by a stint as a marine geologist, analyzing cable routes, leading to an MSc and PhD in Sedimentology, the latter working in eastern Borneo on shoreface systems and fossil mangroves.

I then joined Shell International, exploring across the Middle East before moving to Canada in 2006. Roles at Shell Canada and Murphy, including Team Lead Frontier and Exploration Manager, focused on western Canadian plays and the Orphan Basin. I joined Husky as Geological Specialist in 2012, at various times managing the G&G New Grad Program, managing Geological Training, running all subsurface peer reviews, and working as the Sedimentological Advisor for western Canada. I left Husky in February 2016.

Outside the office I love running, geological fieldwork, wildlife photography, and trying to keep up with a very active four year old!
The Rock Shot: 
Road to Dougga, 
Tunisia

SPEAKER
James P. Duggan
Consultant

Dougga or Thugga (Arabic: تقد) is an ancient Roman city in northern Tunisia, located on an active, 65 hectare archaeological site. It was used by the Punics, Romans and Byzantines and later fell under decline. The impressive ruins that are visible today give some idea of the resources of a small Roman town on the fringes of the Empire.

The Main Talk: 
The Three Dimensional Relationship of Mud Volcanoes to Strike Slip Tectonics in the Columbus Basin, Trinidad

SPEAKER
Gavin Elsey
Niko Resources

ABSTRACT
The presentation will focus on the interpretation of 1000sqkm of re-processed marine 3D seismic data on the East Trinidad Shelf in the Columbus Basin. The Plio-Pleistocene sediments in this area are in excess of 10km thick and consist of a series of deltaic sands and shales. This basin is characterised by North East – South West trending compressional ridges and North West – South East trending extensional faults that have been active simultaneously throughout the Plio-Pleistocene and into the Quaternary. This style of deformation, which combines elements of compression with extensional faulting is the result of the right lateral strike slip motion that has occurred in the Columbus Basin due to the oblique convergence of the Caribbean and South American plates.

Active tectonism, rapid sediment deposition and hydrocarbon generation have resulted in overpressure and the occurrence of a large number of mud volcanoes. Excellent examples of mud volcanoes can be observed on the present day sea floor and throughout the Plio-Pleistocene section within the 3D seismic volume. AVO and attribute analysis has helped to distinguish possible direct hydrocarbon indicators and channels from mud volcano flows. Improved seismic imaging has made it possible to map the extent of the mud volcanoes and to better understand their relationship to folding and faulting. Improvements in processing have also allowed for mapping of the Plio-Pleistocene deltaic sediments into the cores of these anticlines, which have previously been mis-interpreted as entirely shale cored.

BIOGRAPHY
An Explorationist with a BSc in Geological Sciences from the University of Leeds and an MSc in Basin Evolution and Dynamics from Royal Holloway Collage, University of London. Gavin has 17 years of oil and gas industry experience and has worked in many different basins, including the South Caspian, the Canadian Beaufort-MacKenzie, the North Sea, East coast India, Bangladesh, Brazil, Western Canada and Trinidad. His interests include cave exploration, scuba diving, alpine mountaineering and skiing.
Dietary reconstructions using dental mesowear and microwear of Mammuthus, Mammut and Loxodonta, and implications for the end-Pleistocene extinction

SPEAKER
Tasha S. Cammidge
University of Calgary

7:30 p.m.
Friday May 13, 2016
Mount Royal University, Room B108

ABSTRACT
Climate change is an ever-growing issue in modern times. Anthropogenic climate change is causing rapid alterations to the Earth in a way not seen since the end of the Pleistocene (~11,000 YA). The effects of climate change can be investigated through dietary reconstructions of large-bodied mammals during the end-Pleistocene extinction, and may allow us to predict how modern mammals will deal with similar changes. Mammoth (Mammuthus) and mastodon (Mammut) are abundant in the North American fossil record and have closely-related extant counterparts (Loxodonta), making them an ideal model for these studies. To investigate if, and how, climate change contributed to the extinction of large-bodied end-Pleistocene mammals, two different dietary reconstruction techniques will be utilized. The first of these, dental mesowear analysis, involves measuring the angles between cusps on the tooth, which indicates the abrasiveness of the diet over an animal's lifetime. Preliminary results have indicated that Mammuthus diet was the same before and after the end-Pleistocene extinction. However, the resolution of mesowear may be too low to detect a difference between pre- and post-glacial time periods, and thus will need to be combined with other techniques. The second method utilized is dental microwear analysis, which compares the number of microscopic pits and scratches on enamel, and indicates the diet during the last few weeks of an animal's life. Combined, these techniques will allow us to make inferences about the end-Pleistocene extinction, as well as to predict how modern large-bodied mammals may deal with climate change today.

BIOGRAPHY
Tasha received two undergraduate degrees from the University of Calgary, one in archaeology and the other in zoology. During this time a fascination with the past developed and two undergraduate research projects ensued to pursue this interest. Tasha has so far completed a year and a half of a master’s degree in palaeontology at the University of Calgary under Dr. Jessica Theodore and Dr. Brian Kooymen. This project has primarily focused on dietary reconstructions of mammoth and mastodon, in order to investigate the cause of their extinction more thoroughly. Following her master’s, Tasha plans to continue research in palaeontology.

INFORMATION
This event is presented jointly by the Alberta Palaeontological Society, the Department of Earth and Environmental Sciences at Mount Royal University, and the Palaeontology Division of the Canadian Society of Petroleum Geologists. For details or to present a talk in the future, please contact CSPG Palaeontology Division Chair Jon Noad at jonnoad@hotmail.com or APS Coordinator Harold Whittaker at 403-286-0349 or contactprograms1@albertapaleo.org. Visit the APS website for confirmation of event times and upcoming speakers: http://www.albertapaleo.org/
The High Arctic Large Igneous Province in Canada: age and implications for petroleum systems

SPEAKER
Keith Dewing
Geological Survey of Canada - Calgary
keith.dewing@Canada.ca

12:00 noon
Tuesday May 24, 2016
ConocoPhillips Auditorium
Gulf Canada Square
401 - 9th Ave SW. Calgary, AB

ABSTRACT
The Sverdrup Basin is a Carboniferous to Paleocene sedimentary basin that underlies the northern portion of the Canadian Arctic Islands. Extensive exploration by the Panarctic consortium and others in the 1960s to 1980s discovered 19 gas and oil fields in the central and western part of the basin. The northeastern part of the Sverdrup Basin (under Axel Heiberg and Ellesmere islands) were considered unprospective due, in part, to widespread igneous activity.

The igneous intrusions and flows are part of the High Arctic Large Igneous Province (HALIP) that was widespread in the circus-Arctic area, including Franz Joseph Land, Svalbard, Greenland and Canada, between 130-95 Ma. Recent studies of the Canadian portion of HALIP provide better age control and show a more continuous record of volcanism through this time; define the extent and stratigraphic level(s) of intrusions; the morphology of dykes and sills; and geochemistry of igneous rocks.

Magma preferentially intruded shale, especially organic-rich Triassic units of the Schei Point Group, which was the likely source of most of the discovered oil and gas in the Canadian Arctic Islands, and Permian van Hauen Formation. The relative timing of sill emplacement and hydrocarbon migration can be determined in some cases. The observation that gas wetness and bitumen reflectance was not affected by all igneous intrusions supports the interpretation that there was an active petroleum system either synchronous with or post-dating the igneous activity in the northeastern part of the Sverdrup Basin.

BIOGRAPHY
Keith Dewing is a research scientist at the Geological Survey of Canada in Calgary. His work is mainly on lower Paleozoic stratigraphy of the Canadian Arctic Islands, as well as thermal maturity and sediment-hosted mineral deposits. Prior to joining the GSC in 1999, he worked for Cominco’s Polaris Zn-Pb Mine and on resource models for the oil sands in Alberta. He has a PhD from the University of Western Ontario.

INFORMATION
BASS Division talks are free. Please bring your lunch. For further information about the Division, to join our mailing list, receive a list of upcoming talks, or if you wish to present a talk or lead a field trip, please contact either Steve Donaldson at 403-808-8641, or Mark Caplan at 403-975-7701, or visit our web page on the CSPG website at http://www.cspg.org.
A workflow for vertical and horizontal near-wellbore permeability modeling in the McMurray Formation

SPEAKER
Olena Babak
Cenovus Energy Inc.

12:00 noon
Wednesday May 25, 2016
Husky Conference Room A, 3rd Floor,
+30 level, South Tower, 707 8th Ave SW,
Calgary, Alberta

ABSTRACT
McMurray Formation is the most volumetrically important source of bitumen in Canadian oil sands. While there are many parameters that affect prediction of bitumen recovery in commercial in-situ oil sands projects, absolute permeability is the most important geological parameter. In this talk we describe a customized micro-modeling workflow for estimation of vertical and horizontal permeability in the McMurray Formation using high resolution micro-resistivity images and core photos. All steps required to calculate permeability logs calibrated to core plug measurements are detailed. To show a general applicability of the method, a case study of several wells from the Foster Creek and Christina Lake projects of Cenovus Energy Inc. is conducted. The wells are specifically selected to be different in terms of facies, their sequences and interval lengths.

BIOGRAPHY
Dr. Olena Babak is a Sr. Geostatistician / Geomodeler at Cenovus Energy’s Geosciences Centre of Excellence, where she carries-out, reviews and supervises quantitative geological evaluations, geostatistical analysis and geomodeling work, as well as conduct research into improvement of methodologies and tools for better modeling of heterogeneity and uncertainty in petroleum reservoirs.

Olena is a professional engineer with more than 9 years of experience in building reservoir models for variety of geological depositional environments. Practical and theoretical methods she developed for improved geostatistical modeling, data analysis, uncertainty quantification and resource estimation have been integrated in the best practices of many companies.

Dr. Babak is a member of Geomodeling Committee at CSPG. She holds a Ph.D. in Geostatistics from the University of Alberta (2008), an M.Sc. in Industrial Engineering from the University of Iceland (2005) and an M.Sc. degree in Statistics from the Ivan Franko National University of Lviv (2004). Olena has published 23 journal papers and more than 30 conference articles and technical papers/reports.

INFORMATION
There is no charge for the division talk and we welcome non-members of the CSPG. Please bring your lunch. For details or to present a talk in the future, please contact Weishan Ren at renws2009@gmail.com.
The year was 2006. Pluto had lost its status as a planet at the same time as the New Horizons space probe was launched on a 9-year voyage to explore the outer edges of the solar system. The population of Earth exceeded 6.5 billion and the billionth song was purchased on iTunes. Global production of oil was 85 million barrels in an $80 price environment and the AAPG Annual Conference and Exhibition (ACE) was held in Calgary, Alberta, Canada. Ten years later, we are seeing close-up pictures of Pluto sent back from New Horizons, having successfully arrived at the edges of the solar system, and ACE returns to Calgary, as it does once every decade, this time in an extremely challenging and uncertain oil price/production environment.

Whether you are an optimist or a pessimist, scientific discussion and debate – the ‘collision’ of ideas – are essential for technological progress in any field. In our day-to-day endeavours, and particularly in this current economically stressed and technically tense atmosphere, we may have limited, if any, opportunities for this kind of interaction. Ironically (or maybe obviously), technological progress is absolutely necessary in geoscience today, and therefore the scientific exchange of ideas is, in fact, more imperative than ever. In June, Calgary will host one of the biggest occasions of the year to do just that.

ACE has been an annual event for 99 years; in the past five years, the average attendance was 6,900 people from 78 different countries. Every year, it is the chance for attendees to learn, to teach, to meet their peers, to discover grand ideas, to see things from a different perspective, to push the limits of their own and others knowledge and understanding, to explore to the edges of the known world. Whether we come from industry or academia, are just starting our careers or ready to pass on our wisdom and experience, are unemployed or underemployed or happily employed, from the northern or the southern hemisphere, we all have a similar desire for discovery, development and growth. AAPG’s ACE provides that space.

The technical program at ACE is always stellar. This year the geo-community has pushed the technical program to new levels. Despite low commodity prices, a record number of abstracts were received (see chart) requiring the technical committee to raise the standard of what will be accepted. Very simply, this year the technical program is exceptional. These high-quality submissions are organized under nine general Subtheme headings spanning all the topics relevant to the timely overall Theme: ‘Redefining Reservoir’, which is probably the most pertinent question asked of petroleum geoscientist in the last half century.

ACE 2016 will cover a diverse and relevant set of topics including Siliciclastics, Carbonates, Energy and the Environment, Geochemistry, Basin Modeling, Petroleum Systems, Structure, Tectonics, Geomechanics, and Geophysics. Furthermore, specific and focused sessions have been organized to highlight current thinking around Unconventional Resource development and Oil Sands development. Please see the website for the detailed technical program ACE.AAPG.org.

ACE 2016 once again brings to Calgary classic sessions such as The History of Petroleum Geology, Discovery Thinking, and the SEPM Research Forum (focusing on Foreland Basin Drainages and Deposition) drawing together the foremost experts and current thinking in these important and challenging areas. Additionally, the renowned CSPG International Core Conference will take place following the ACE technical sessions and is well known as one of the must-attend events of the year for geoscientists. This two-day event provides an incredible opportunity for all of us to engage and dig into the rocks we spend our careers trying to understand.

To compliment an exceptional technical program, a series of short courses and field trips are being offered providing an opportunity to cost effectively increase, refine, and refresh our technical skill sets. Our short courses and field trips offer timely, high quality training while taking advantage of all the geological wonder that surrounds the beautiful city of Calgary. Please see the ACE 2016 website for a full listing of all short course and field trip listings.

The AAPG Annual Convention and Exhibition only arrives in Calgary once every ten years. This world class technical convention provides a remarkable opportunity for our scientific community to come together and reenergize for the future. The technical program, core convention, field trips, and short courses all provide an excellent opportunity to revive and develop new skill sets, collaborate on new ideas and interpretations, and be proactive as we ready ourselves for the next chapter of our industry.
Over the past seven years the Cardium Formation of south-central Alberta has come back into the spotlight thanks to horizontal drilling. Horizontal wells are able to exploit the poorer quality reservoir usually found below the better, ‘conventional’ Cardium sandstone and conglomerate reservoirs. However, the conventional approach of calculating reserves for the good quality reservoirs cannot be applied to the entire Cardium sequence. The recoverable resources volume calculated using the conventional volumetric method is too low to meet the forecasted production from the horizontal wells. For these reasons, a new methodology for evaluating recoverable resources within the Cardium is proposed.

The Cardium Formation was deposited within the western margin of the Cretaceous Western Interior Seaway. It is bounded above and below by the shales of the Wapiabi and Blackstone Formations respectively. The Cardium sediments are shoreface to offshore deposits with numerous coarsening upward parasequences that grade from bioturbated mudstone at the base to sandstone above. Conglomerates may overlie the uppermost sandstone either as thin transgressive veneers or as thick shoreface deposits. Historically, the conglomerates and high porosity sandstones were the original targeted reservoirs for vertical production. More recently the lower porosity sandstones and bioturbated silty, sandy mudstones have become accessible with the use of horizontal drilling and multistage fracturing.

For reserve analysis purposes, the Cardium can be divided into three zones (as seen in Figure 1): the conglomerate zone, the sandstone zone, and the transition zone. The conglomerate zone, where present, is the uppermost pay interval and can be clast or mud supported. On logs it often appears clean but dense due to its variable siderite content. The conglomerate zone has average petrophysical parameters, determined from special core analyses (SCAL), of 6% total porosity, 10% water saturation (Sw), and permeabilities ranging in the 100’s to 1000’s of mD. The sandstone zone consists of interbedded very fine to medium grained sands and shales. It is cleanest at the top with the shale content increasing down section to 30%. Logs and cores were used to determine the total porosity within the sandstone zone, which ranges between 4 and 18%. A strong correlation is seen between the density curve, using the sandstone scale, and porosity readings from core analysis. Within the sandstone zone the permeabilities range from 0.5 to 10 mD. The transition zone is the lowermost pay interval. It is composed of bioturbated silty, sandy, mudstone, with an increasing shale volume moving down section. The volume of shale ranges from 30% at the top to 70% at the base. Here the total porosities range between 3.5 to 7% on average. The transition zone is the tightest of the three zones with permeabilities of 0.1 to 0.5 mD. It is distinguishable from the sandstone zone due to the increasing gamma, decreasing resistivity and increasing neutron-density separation that are attributed to the increased shale content.

A horizontal well’s recoverable resource is determined by combining the well’s hydrocarbon pore volume (HCPV), recovery factor, and drainage area. The original methodology for evaluating recoverable resource began by subdividing the well, first into coarsening upward cycles and then into the three zones. Each of these zones were evaluated individually and then combined to yield the total HCPV for the well. Within the conglomerate zone average parameters of 6% porosity and 10% Sw were applied to the total thickness. A porosity cutoff of 6% was used to calculate the pay within the sandstone and transition zones. Here, water saturations were calculated using bulk volume waters (BVW) of 0.180 for the sandstone and 0.270 for the transition. These BVW values were determined from SCAL using low permeability samples selected because they represented the sandstones and shales.

As longer term production data for the horizontally drilled wells was analyzed, in many cases it became apparent that the recoverable resources were greater than the original methodology was predicting. Therefore, the original methodology needed to be modified to recognize the recoverable resources from within the lower porosity reservoirs. It is recognized that standard petrophysical techniques using a modern suite of digital logs can be used to determine the petrophysical
parameters needed for recoverable resource calculations. However, the methodology outlined here needed to be efficiently applied to thousands of well logs of variable vintage and log quality that often are only available as raster images. Regionally, porosity trends were identified within the Wapiabi and Blackstone shales that encase the Cardium Formation. Within these shales there is little variability in the porosity readings, thus the average porosity is identified as the shale baseline. The shale baseline is constant along strike, but decreases as you move down dip due to compaction from increasing depth of burial. It represents the porosity that is attributed to the non-reservoir portion of the rock, where the sand content is very low and the pores are filled with water. Porosity readings greater than the shale baseline are attributed to increases in sand content and have the potential to store hydrocarbons.

The revised methodology is similar to the original, except that it uses the shale baseline as the porosity cutoff instead of a constant 6% on the sandstone density scale. Once the regional shale baseline is determined the porosity logs are then normalized to this value. For example, if the regional shale baseline is at 3% but the well log is reading 2%, then the porosity curves must be shifted one porosity unit to the left.

SCAL data is still used to calculate the sandstone zone $Sw$; however, the BVW curve has been revised using additional core data, as shown in Figure 2. The transition zone $Sw$ calculation has changed to account for its variable shale content. The low porosity data points (green circles) in Figure 2 are attributed to the shales, greatly impacting the $Sw$. As the average porosity drops below 3.5% the $Sw$ approaches 100%. To calculate the $Sw$ for the transition zone its volume of shale ($V_sh$) and inversely the volume of sand ($V_ss$) need to be determined. This is done by comparing the separation between the neutron and density curves within the transition zone to that of the shale below. The transition zone $V_sh$ is equal to the transition porosity separation divided by the shale porosity separation. The BVW within the transition is the weighted average of the $V_sh$ BVW and the $V_ss$ BVW. For the $V_sh$ BVW the shale porosity is equal to the shale baseline, and the $Sw$ is equal to 100%. For the $V_ss$ BVW the sand porosity is calculated by subtracting the sum of the $V_sh$ times the shale baseline porosity from the transition zone normalized density log porosity; and then dividing by the $V_ss$. The $Sw$ for the sand is then calculated using the calculated $V_ss$ porosity with the sandstone BVW curve seen in Figure 2.

A sample well showing the variability of the HCPV calculations between the two methodologies is shown in Figure 3. The 100/07-29-048-11W5 well has a thick interval within the sandstone and transition zones that has less than 6% porosity. At a 6% porosity cutoff the 07-29 well has a HCPV of 0.362. However, by using the shale baseline method a new HCPV of 0.658 is...
calculated instead. For wells where the shale baseline is at 6%, or where the reservoir is comprised of highly porous rock, the variability in the HCPV and subsequently its recoverable resources will be negligible.

The revised methodology calculates significantly more recoverable resources within the lower porosity reservoirs and is consistent with the production trends observed from newer horizontal wells.

**Acknowledgements:**
The revised Cardium evaluation methodology proposed here is the result of the extensive work the team of geologist and engineers at GLJ petroleum consultants have done over the past seven years. The majority of the geological research and well evaluations were conducted by the author, Mirek Zaoral and Dayna Muscoby. The author appreciates GLJ management’s editorial assistance and approval to publish this work.

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**Figure 3. Sample HCPV calculation for the 100/07-29-048-11W5 with the original methodology in blue and the revised methodology in orange.**
Mark your calendars and get ready for the 2016 CSPG Mixed Golf Tournament on August 26th at Lynx Ridge Golf Course. The four-golfer, best-ball tournament includes a round of golf, meals, plenty of hospitality and good times, and a chance to network with your colleagues and industry sponsors. The tournament committee is trusting that the weather will cooperate this year, after last year’s unseasonable rain, wind & snow and the subsequent cancellation of the event. This year we hope that we return to the typical August golf, where the course is at its finest, with the inviting fairways, smooth greens, spectacular mountains and the ever-beckoning water hazards and sand traps to capture errant golf shots.

This is a fun tournament, with balanced teams that allow all golfers to contribute to the team score, while having a great time enjoying the day and the fellowship of golfing as a team, and developing your network of geoscientists.

Please watch for further announcements and information in the CSPG Reservoir, and make sure to register on-line at the CSPG website www.cspg.org. Register early to avoid disappointment!

We thank our previous sponsors from 2015 and look forward to the return of members, guests and sponsors to enjoy the event. A big thank you to our continuing committee members, Darin Brazel, Penny Christensen, Norm Hopkins, Jeff Boissoneault, and co-chair Brenda Pearson.

You can address registration inquiries to David Middleton at 403-296-8844 (dmiddleton@suncor.com), or to Kristy Casebeer, CSPG Coordinator at 403-513-1233 (Kristy.casebeer@cspg.org).

If you are interested in sponsoring the tournament this year, please contact Darin Brazel at dbrazel77@gmail.com.

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Dr. Andrew Miall for many years has been a contributor to both academia and industry, offering courses and publications in the Earth Science community. With the publication of Dr. Andrew Miall's new book titled “Stratigraphy: A Modern Synthesis”, the Reservoir is pleased to talk with Andrew regarding his thoughts and perception of our industry today and going forward.

Describe yourself in three words.
Field geologist, synthesizer and historian.

Best field memory.
Several moments during my early days in the Arctic, where I was excited to be collecting data where virtually no sedimentology had been done. Much later, the lengthy trips across Canada that I did with Nick Eyles and my wife Charlene, to conduct research for “Canada Rocks: The Geologic Journey” publication.

What Attracted you to the earth science discipline?
I first heard about geology as a sixteen-year-old high school student in England. Learning about the rivers and seas that had formed the Cretaceous strata where I lived fascinated me. I knew within a matter of weeks that I wanted to be a geologist, and the study of paleogeography, through sedimentology and stratigraphy, has been my passion ever since.

Who are the early influences on your work during your early education and training?
Mr. Berry, my high school geography and geology teacher, then, later, Brian Rust, my doctoral supervisor at University of Ottawa. But in many ways the most important influence was the stimulating intellectual atmosphere at the GSC office in Calgary where I worked from 1972 to 1979. This was really where I learned the trade of basin analysis.

What areas of geology did you want to focus your career on and why? Where did you feel you could best apply your own personal insights into steering academic advancement?
It started with my Ph.D. studies in the Arctic and my developing interest in the origins of fluvial deposits, which led me into the early work on facies studies and vertical profile analysis. I was cooperating with the Walker-Middleton school of sedimentology at McMaster University from the mid-1970s onward. Studies of facies architecture and sequence stratigraphy came much later.

What is some of the advice you give students regarding the application of geology to the various industries (mining/environmental/oil & gas)?
Try to get practical experience as soon as you can, through summer positions. A good educational background is essential, but a demonstrated enthusiasm and professional curiosity is just as important.

The science of Geology is filled with ‘unorthodox’ thinking / paradigms (things that have really changed the course of the Science). Are there certain paradigms that you feel have influenced or shaped the Science as we know it today? Not only within the discipline of Stratigraphy, but Geology in general?
The most important paradigm, or guiding principal, in geology is “field context”. Where do our rocks, our samples, our sections, come from and how do they relate to their geological surroundings? Given the highly technical nature of many geological sub-disciplines it is easy to lose sight of this in the laboratory. If we cannot eventually answer a question about the origin of the rocks, then we are no longer doing geology. Having said this, the multidisciplinary nature of the science provides unlimited opportunities for “thinking outside the box”. Joseph Barrell was probably the first to think in modern terms about the importance of time in stratigraphy, in a remarkable paper published in 1917. There are many later steps forward, such as Tuzo Wilson’s insights into plate tectonics and Peter Vail’s work on sequence stratigraphy.

What was your inspiration for writing your new book “Stratigraphy: A Modern Synthesis”?
I have been developing a growing realization of the interconnectedness of the many sub-fields of sedimentary geology. The maturation of sequence stratigraphy as our primary descriptive and interpretive tool has highlighted the importance of facies studies, and has emphasized the need for more accurate chronostratigraphic methods. This, in turn, has stimulated substantial progress in the techniques of radioisotopic dating, which have helped to confirm the reality of orbital forcing as a major control on the sedimentary record.

What are the key messages you are hoping to purvey to the reader? How will the concepts you have introduced in your book influence workers today?
The key message is that earth science has changed dramatically in the last few decades. New tools have allowed workers to be far more precise and quantitative in their interpretation and the ability of stratigraphy to throw light on earth processes has never been greater. Strata provide the master record of “Deep Time”, as well as being the basis for our industry. Earth scientists need to keep up to date with developments in the various components of stratigraphy and the ways in which they are integrated; this is why I wrote the book.

The nature of stratigraphy in the rock record is almost philosophical in terms of what gets preserved and what doesn’t (i.e. Derek Ager’s ‘New Catastrophism’) – How do you
feel the currently proposed “Anthropocene” age will be recorded? Do you feel it is a valid Geologic age given the dramatic and episodic climatic changes recorded in the rock record? Are there things in the rock record that we as society can learn from and take away (make applicable) in today's society?

The increasing accuracy and precision of dating methods has highlighted the ways by which elapsed time is recorded (and not recorded) in the rock record. The exploration of geological processes and their rates is becoming much more detailed as a result, but we are also becoming aware of how fragmented the rock record actually is. The influence of the human species on geological processes is indisputable, but this has taken many thousands of years to develop, and the argument about when the “Anthropocene” began are historical or philosophical, not geological questions. The stratigraphic record has much to say about the processes of natural climate change, but this fact has yet to make much of an impression on the public debate about global change.

Where do you see our industry going and how can students/professionals today best prepare for this?
Many in society would like to see the end of the petroleum industry because of the problem of greenhouse gas emissions. However, the alternative energy sources available to us, with the exception of nuclear power, are quite inadequate to provide the necessary substitutes at the present time. Even if this was not the case, industry should be investing heavily in researching and developing alternative energy technologies because fossil fuels are not infinite. King Hubbard’s Peak Oil prediction will not occur for many decades, but the arguments on which the peak concept was based are incontrovertible. In the meantime, the petroleum industry continues to be important to society’s energy needs. The current recession within the industry, based on global overproduction, cannot last. Everyone, from CEOs to beginning students, need to hunker down and figure survival strategies, so that all the essential components of industry will still be available as demand increases. In this regard, the work of societies such as the CSPG remains as important as it ever was.

CSPG 2015 AWARD CITATION

Paul is a long-time CSPG member and started his CSPG volunteer career in 1994; he is receiving this award because of the many contributions he has made to CSPG over the years.

Paul has served on the Structural Geology Technical Division, twice on the Board of Directors, as a Trustee of the CSPG Foundation (formerly the CSPG Educational Trust Fund) and is currently the General Chair for AAPG ACE 2016 which, this year, has the largest technical program with the highest technical rating in the history of the AAPG. He was Co-Chair of GeoConvention: recovery 2011 which set a new standard not just for CSPG's own Scientific Program, but for Canadian Earth Sciences in general. Paul has provided new course offerings to the Continuing Education program on the subject of fracturing. He has provided leadership and instruction in the field at CSPG Division meetings, Technical Luncheons, at Symposia and through peer-reviewed technical publications, most notably with his contributions to the Triangle Zone volume of the BCGP, and with a series of articles in the Reservoir.

Recently Paul has initiated the CSPG Ambassador program which is helping to raise the national profile of the CSPG amongst geoscientists in industry, academia and within various levels of government across Canada. Paul, in conjunction with his Co-Chair of GeoConvention: recovery 2011

Rob McGrory, has lead, organized and built consensus among CSPG, CSEG and CWLS to create the GeoConvention Partnership LLP. He has been an innovator and visionary for the retooling of the CSPG Educational Trust Fund into the CSPG Foundation. As he looks towards the future, Paul has brought to the forefront the 100th anniversary of the CSPG (2027) and has given ideas and direction as to how to acknowledge this milestone appropriately.

Paul received a B.Sc. (honours, geological sciences) from Queen's University in 1980 and a Ph.D. from the University of Calgary in 1991. He initially worked for Amoco Canada then moved to Morrison Petroleums, Northstar Energy, and Devon Canada before beginning an international consulting practice. He is currently President of Shale Petroleum Ltd. a private oil company based in Calgary, Alberta. His expertise is in fracture systems, petroleum exploration and development in structurally complex reservoirs. He teaches field courses in Structural Geology/Geophysics in the Canadian Rockies and field seminars on Fractured Reservoirs in Wyoming. He is an Adjunct Professor in the Department of Geology and Geophysics at the University of Calgary and is a Past President (2013) of the CSPG. In addition to his CSPG membership, Paul is also a member of the CSEG, AAPG and APEGA.

The President's award is CSPG’s most prestigious volunteer recognition. It is awarded for sustained and distinguished service to the Society. Recipients are selected by the President at the end of their term. Past winners share the traits of providing exemplary leadership in a variety of roles and capacities that the Society recognizes as a model of service and achievement to be emulated. Many recipients continue their contributions to Society programs and events, such that this award often provides a milestone in a distinguished career of exemplary membership.

The 2015 recipient of the President’s Award as chosen by 2015 CSPG President Tony Cadrin, is Dr. Paul MacKay.
Honorary Membership is awarded for distinguished service to the Society. This year’s recipient is Dr. Dale Leckie.

Dr. Dale Leckie received his Honours B.Sc. from the University of Alberta in 1979. He then went to McMaster University where he received his M.Sc. in 1979 and his Ph.D. in Geology in 1983.

He started his career as a research geologist with Petro-Canada Resources in Calgary in 1982. In 1985, he moved to the Geological Survey of Canada as a research scientist. In 1998, he joined Wascana Energy, later to become Nexen, where he became Chief Geologist. In 2014, Dale retired from Nexen and took a post as Adjunct Professor in the Department of Geoscience at the University of Calgary.

Dale joined CSPG in 1981 and has been heavily involved ever since. He has won the CSPG Medal of Merit three times, multiple awards, and presented at a dozen Technical Luncheons. Dr. Leckie co-chaired the 1988 CSPG conference and then co-edited the resulting Memoir. He was involved as Chair for the Gussow conferences three times. During his year as President in 2014, Dale spearheaded several joint venture collaborations for conferences with SEPM, AAPG and SPE. In 2015-2016, he was the Associate Editor for Bulletin Special Publication on “Oil Sands and Heavy Oil Symposium.”

Dr. Leckie has also published extensively: more than 75 refereed scientific journal publications, 16 CSPG Bulletin papers, six CSPG Memoirs and more than 180 abstracts. A quick review of his publishing record shows his simply outstanding contributions to Canadian and world geology.

Dale Leckie has always been a mentor to many. His true strength was in encouraging the dissemination of that knowledge to the geological community at large. Dale was always willing to support and motivate his employees and peers, both in supportive words and practical aid. Dr. Leckie has been an influence to a generation of geoscientists, be it through his research, his mentorship, his writing, his expertise or his friendship.

Dale Leckie has made a big impact on geology in Canada on all levels: as a teacher, a mentor, a researcher, a writer, an explorationist, a volunteer and a friend. CSPG is proud to welcome Dr. Dale Leckie as an Honorary Member.
INTRODUCTION TO THE SPECIAL EDITION OF THE BULLETIN OF CANADIAN PETROLEUM GEOLOGY from the 2014 Gussow Conference on Advances in Applied Geomodeling

By David L. Garner, TerraMod Consulting Inc., Olena Babak, Cenovus Energy, Clayton V. Deutsch, University of Alberta

Geomodeling has proliferated among earth science and engineering professionals as a body of techniques, software packages, and workflows for subsurface reservoir characterization. Although not a recognized professional discipline or university degree option, geomodeling is a multidisciplinary subject with a growing technical community. Geomodeling is treated as an enabling technical field and focal point in the petroleum industry subsurface teams, with major software development dedicated to the subject and practitioners assuming the role and title. The broad subject typically draws from the fields of geology, geophysics, geostatistics, petrophysics, reservoir engineering, and increasingly geomechanics, computer science, and data analytics. The field of geostatistics is a fundamental aspect of geomodeling, providing many core algorithms. The other associated fields provide concepts, context, inputs, constraints, and direction for the technology applications and for multidisciplinary team efforts to deliver meaningful models and results.

The motivation for companies is to pursue exploration, development, and production with increased efficiency and sustainability. The geomodeling proposition is to add value through improved reservoir management decisions. More accurate and precise geomodels lead to improved well planning and prediction of the behavior of alternative extraction technologies. Thus, geomodeling will improve recovery and reduce risk. Yet, gaps exist between the application of geomodeling, geostatistical methods, capabilities of software tools, and appropriate practice and ease of use. With a world-wide user base of technical people accessing geomodeling technology possibly exceeding 20,000 people, practical gaps exist in practitioner skills, training opportunities, and mentoring. There are numerous challenges to adapt technology needs to address unconventional problems, apply actionable research results, and improve workflow steps.

The Canadian Society of Petroleum Geologists’ Gussow Geoscience Conferences are convened with a focus on new and emerging issues related to the petroleum industry. The intention is to bring together recognized experts from diverse disciplines to provide a broad range of perspectives on the conference theme. The Gussow Geoscience Conference entitled “Closing the GAP II: Advances in Applied Geomodeling for Hydrocarbon Reservoirs,” was held September 22–24, 2014 with approximately 120 participants. Nine papers were collected from the conference presenters, reflecting a wide variety of high level technical innovation from the petroleum industry producing companies, technical software service companies, universities, and government-sponsored research groups. These paper submissions sample topics from each of the following six conference session themes:

(Continued on page 22)
In most instances, a geomodel workflow exercise begins with a geological conceptual model. The study area includes working concepts to guide data interpretations and model set-up. Structural, stratigraphic, and sedimentary architectures are among the assumptions used in the model framework and layering options. Geologists are ultimately grounded by their knowledge of outcrops and field work. The image of an outcrop provides visual details which may represent the sparsely sampled subsurface data. The challenge is to model what is interpreted from the outcrops to enhance realism. The response is to model by honoring geological rules and inferred statistics.

The data acquired from the subsurface comes in many forms. The measurements from well logging, coring, seismic sources, completions, production, and surveillance all sample physical aspects of rock and fluid. The volume support of each property measurement is important to its use and precision for modeling. To use the measurements, normalization and scaling to the desired perspective are often required to ensure that the relationships of parameters reflect the same volume of rock. At any one common scale, there are effective properties and statistics. Rescaling models and associated parameters are ongoing topics of study.

A structural framework model and realizations of facies control the numerical modeling of continuous rock properties. Realistic lithological stacking patterns and other facies relationships are critical for establishing the correct reservoir connectivity. Scalar rock properties, such as porosity, are handled with simple workflows. Vector and tensor properties related to connectivity and flow require additional consideration. Permeability is a rate constant that changes with scale in a non-linear manner. The saturation of different fluids is influenced by the lithological patterns, gravity, and capillary effects. Modeling reservoir flow behavior involves many of these factors combined to give a reasonable response. With many diverse data types, scaling and property modeling are topics of on-going research.

Modeling uncertainty is an important topic because the subsurface structure, facies, and properties are not known precisely or accurately. Relatively widely spaced wells and large-scale geophysical data combined with heterogeneity at all scales lead to inevitable uncertainty in facies and other rock properties. This state of incomplete knowledge affects exploration and development decisions. In this broad multidisciplinary context, uncertainty modeling is the analytics-based practice of quantifying the deemed-to-be important unknowns in parameters and responses with statistical summaries. The implementation strategies are varied in scope and rigor. There are trade-offs, depending on goals and information available. It is common for practitioners in the petroleum industry to anchor the statistical summaries of model parameters or responses to probabilities, such as P10, P50, and P90, for further analysis and decision making. A middle outcome for one analysis may not provide the mid-point for another. Accounting for multiple model scenarios or stochastic realizations provides the means of avoiding inadvertent anchoring and the unexpected outlier response from non-linear behavior. Computational expense and lack of practical tools remains a shortcoming. Strategies to use additional realizations effectively include rejecting non-physical or improbable outcomes or clustering families of similar responses to make tailored selections. Model checking, validating, and fairness are important themes that may be underemphasized.

Post-processing is a catch-all term for the effective use of models, whether stochastic or deterministic. 2D maps may be combined; 3D models may have additional calculations applied. Models may be fed to another process. Examples include volumetrics, connectivity calculations, and well planning. Workflows for modeling uncertainty overlap with post-processing.

The Gussow Conference Closing the Gap II provided a relevant and stimulating environment for professionals to gather and share success stories, recent research, and (perhaps most importantly) concerns and gaps that present an ongoing challenge. The included papers will provide perspectives on a sampling of topics of current interest under the umbrella of geomodeling. As gaps in technology are addressed and the hydrocarbon industry goals evolve, new questions will arise, and the community will become closer to understanding the rich geological complexity and consequent uncertainty of petroleum reservoirs.
NEW ISSUE OF THE BULLETIN

ISSUE CONTENTS

Introduction to the Special Edition from the 2014 Gussow Conference on Advances in Applied Geomodeling
D.L. Garner, O. Babak and C.V. Deutsch

A review of three geostatistical techniques for realistic geological reservoir modeling integrating multi-scale data
B. Doligez, M. Le Ravalec, S. Bouquet and M. Adelinet

Stratigraphic rule-based reservoir modeling
M.J. Pyrcz, R.P. Sech, J.A. Covault, B.J. Willis, Z. Sylvester and T. Sun

Stratigraphic rule-based reservoir modeling (cont.)

Surface prediction using rejection sampling to handle non-linear constraints
P. Abrahamsen, P. Dahle, V.L. Hauge, A. Almendral-Vazquez and M. Vigsnes

A discussion of the importance of particle size distribution data for characterizing Athabasca Oil Sands
O. Babak

Advances in micromodeling using resistivity borehole images
J.G. Manchuk, D.L. Garner and C.V. Deutsch

Optimization of variograms used for truncated plurigaussian simulation
S. Sadeghi and J.B. Boisvert

Use of connection constraints for checking and enhancing geological models
J-M. Chautru, R. Meunier, H. Binet and M. Bourges

Stochastic regridding of geological models for flow simulation
S. Lajevardi and C.V. Deutsch

Enabling cross-discipline collaboration and forward modeling through advanced subsurface geocellular earth modeling
R. Dusterhoft, S. Siddiqui and C. Davila

SPECIAL

GEOMODELING

ISSUE

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GEOCONVENTION 2016: THANK YOU FOR ALL YOUR SUPPORT

By Dustin Menger, Director, GeoConvention Partnership

On the heels of a GeoConvention program that exceeded expectations despite a perfect storm of unfavorable economic conditions, a competing event and a date change, I would like to start by thanking our sponsors, exhibitors, presenters, delegates, volunteers and visitors for their continued support through the thick and the thin. Your participation in GeoConvention 2016 is very much appreciated and speaks loudly to your commitment to the success of GeoConvention.

The goal for GeoConvention 2016 was to simply return as much as we could to all of our supporters in these difficult times – lower price points for our delegates, further pricing reductions for those who were unemployed, unique sponsor benefits, and an exhibit floor layout that was designed to yield the best possible exhibitor and visitor experience. This was seen as our opportunity to give back to our supporters and our members for their years of support.

In addition, GeoConvention 2016 aimed to introduce new initiatives and programs as we continue to grow the event beyond the standard annual format that has been the GeoConvention model of the past, to an industry-leading technical and networking program that will set the new standard going forward.

We were very privileged this year to have an exceptional committee that was able to drive these new initiatives and achieve our goals by putting together a diverse technical offering including financial discussions, a session for those who find themselves unemployed, a workplace diversity and culture session as well as specialized sessions hosted by the Canadian Society for Gas Migration (CSGM) and another hosted by the Society of Petroleum Engineers (SPE). In total, we hosted 239 talks over 37 sessions with another 78 poster presentations, numbers that were similar to even some of our best years. I am extremely proud of our team of volunteers who took the 2016 challenge head-on to provide amazing technical content, meaningful networking events and diverse luncheons. Of particular note, the Alumni event saw a substantial increase in attendance from last year with the focused attention of the committee in driving the success of the event by ensuring return for the universities who participated and for their alumni.

Our exhibit floor, while smaller than years past, was well attended with a drop of only 200 visitors from 2015 with the common feedback being that the business being done and the conversations that took place were some of the best they had experienced on an exhibit floor. Again, I would like to thank all of our exhibiting companies for joining us!

In looking forward, under the formal Partnership Agreement between the CSEG, CSPG and CWLS, now in its second year, GeoConvention will continue to grow in our diversity, reach and footprint with the full-time commitment and consistent direction of the GeoConvention board. As part of this growth, our two-day offsite program will be coming up in the winter of 2017 as we push the opportunities that GeoConvention provides in terms of unique technical content, knowledge sharing and networking opportunities.

For 2017, the formal GeoConvention conference and exhibition is back in May: May 15th through May 19th with the CSPG Core Conference being hosted on the 18th and 19th. Please join us as we continue to build on the strength of our technical program and our diversity as we grow GeoConvention, the premiere geoscience conference in Canada.
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