UNIVERSITY OF CALGARY

GeoScience

University of Calgary
Department of Geoscience
Geoscience Research EXchange

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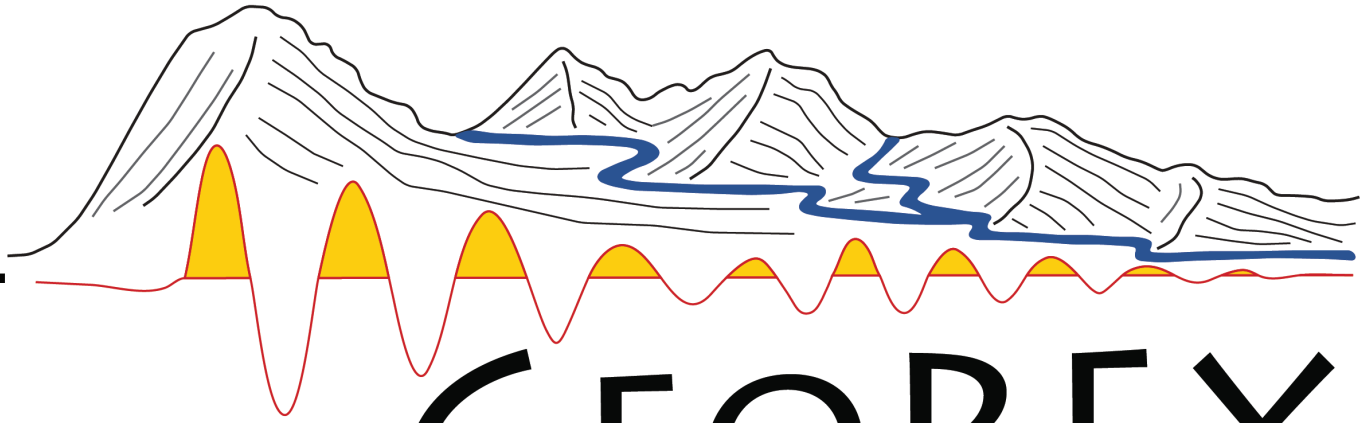
Abstract book and Program



GEOREX

Geoscience Research EXchange

A message from the organizers

Welcome to the third annual Geoscience Research EXchange (GeoREX) at the University of Calgary. We know how busy everyone is at this time of year, so we are pleased that you have made time to present and/or attend. We are excited to offer a wide variety of topics for you to enjoy and learn from.

The GeoREX symposium was developed to give graduate and undergraduate students an opportunity to present their research in front of fellow students, supervisors, and other staff and faculty members. We feel that effectively sharing our research with a multi-disciplinary audience is among the most important skills that we need to master as students, and that by sharing our research in this way, we are presenting ourselves with an opportunity to collaborate and explore new ideas.

Beyond sharing our research with other geoscientists, it is increasingly important that we are able to communicate our research and ideas with our non-geoscientist or even non-scientist peers. Godfrey Nowlan has devoted considerable time to communicating with and educating the public in geoscience, and he has generously agreed to talk to us about the importance of this work and what it means for the future of geoscience literacy.

Once again, we are grateful for the financial support of the Association of Professional Engineers and Geoscientists of Alberta (APEGA), Imperial Oil Esso, the Faculty of Graduate Studies and the Department of Geoscience. This event would not take place without their support, and we want to welcome representatives from these organizations to GeoREX.

Welcome to GeoREX, we hope you enjoy!

Sincerely,
The GeoREX organizing committee: Kimberley Bell, Hormoz Izadi, Danielle Kondla, Shawn Loo and Nadine Taube

P.S. – If you are interested in organizing GeoREX next year, please speak to one of us throughout the day or express your interest by sending an email to segloo@ucalgary.ca

Schedule

8:45 AM	REGISTRATION AND MORNING COFFEE
9:15 AM	Opening remarks ***GeoREX Committee***
9:30 AM	Constructing a time series of groundwater NO_3 recharge using regional sampling events in the Abbotsford-Sumas Aquifer, British Columbia ***Shawn Loo***
9:45 AM	Early Permian oceanic climate change in the Sverdrup Basin, Arctic Canada ***Daniel Calvo Gonzalez***
10:00 AM	Taphonomy and paleoenvironmental analysis of the Stephen Formation at Helena Ridge, Banff National Park, Alberta ***Chad Morgan***
10:15 AM	Petrophysical analysis and interpretation for the development of a shallow target in the Geoscience Field Research (GFRS) area for CO_2 sequestration ***Jessica Dongas***
10:30 AM	COFFEE BREAK
11:00 AM	Identifying methane occurrences and sources in groundwater in Alberta using geochemical and isotope data ***Jenifer Ing***
11:15 AM	Stratigraphic distribution and mineralogical variability of Pennsylvanian-Early Permian ooids in the Sverdrup Basin, Arctic Canada: Implications for global climate change ***Anirudh Bhargava***
11:30 AM	Can total dissolved gas pressure be a useful tool to understand ebullition in a peatland? ***Nicki Conforzi***
11:45 AM	New biostratigraphic data from the Cretaceous Cody Creek Formation, Eagle Plain Basin, northeastern Yukon, Canada ***Kimberley Bell***

12:00 PM	LUNCH BREAK WITH KEYNOTE LECTURE
12:15 PM	Keynote Lecture Earth Science Literacy: A Basic Requirement for Planetary Citizenship ***Godfrey Nowlan***
1:00 PM	BREAK
1:15 PM	Local signal regularity and smoothness as a means for seismic *Q* estimation ***Hormoz Izadi***
1:30 PM	Dispersed organic matter and stratigraphic sequences in the Murray Harbour Formation, Sverdrup Basin: The on-again off-again relationship ***Danielle Kondla***
1:45 PM	The role of non-condensable gases in geyser eruptions ***Bethany Ladd***
2:00 PM	Conodonts, phytoplankton and sunbathers: an evolutionary journey ***David Terrill***
2:15 PM	BREAK
2:30 PM	New approaches to the evaluation of groundwater resources in Canadian Prairie watersheds ***Elizabeth Munroe***
2:45 PM	Degassing processes in the standing water column of a monitoring well completed in gas-charged groundwater ***Tiago Morais***
3:00 PM	Rockin' the Bakken, sedimentology and stratigraphy of the Late Devonian- Early Mississippian Bakken Formation, SE Alberta, SW Saskatchewan ***Tarig Ibrahim***
3:15 PM	Closing remarks ***GeoREX Committee***

Keynote Biography: Godfrey S. Nowlan

Godfrey is an Earth scientist who conducted research for the Geological Survey of Canada from 1977 to 2013. He is a graduate of Trinity College Dublin (B.A.), Memorial University of Newfoundland (M.Sc.) and the University of Waterloo (Ph.D.). He is a specialist in Lower Paleozoic stratigraphy and biostratigraphy with a special interest in phosphatic microfossils. He has applied conodonts to solving problems in complex tectonic terranes and has also developed biostratigraphic schemes for many sedimentary basins. He has worked extensively on global correlation of the Cambrian, Ordovician and Silurian systems in various roles with the International Commission on Stratigraphy (1991-2010). He has published more than a hundred scientific articles on aspects of paleontology, stratigraphy, paleobiology and regional geology.

Godfrey has been active throughout his career in promoting public awareness of science through local, national and international organizations. He is co-founder of the Calgary Science Network and the Alberta Science Literacy Association. He has twice been Chairman of the Canadian Geoscience Education Network (1994 and 2010) and is a Director of the Canadian Federation of Earth Sciences. Godfrey has contributed consistently to science education in Canada through visits to classrooms and workshops for teachers on many Earth science subjects. He served as Program Chair on the Canadian National Committee for the International Year of Planet Earth (2007-2009) and is an author and co-editor of a forthcoming popular book on the geology of Canada. He is currently the Chair of the Canadian National Committee for Geoparks, responsible for development of Global Geoparks in Canada. He is well recognized for both his scientific contributions and his work on education and outreach to the public. He is a recipient of the Bancroft Award of the Royal Society of Canada for excellence in research and education (1992), the Golden Trilobite Award of The Paleontological Society (1993), the E.R.W. Neale Medal for public education and outreach from the Geological Association of Canada (GAC) 1995), the McNeil Medal of the Royal Society of Canada for scientific outreach (1996), the Ambrose Medal for service to the geological profession (GAC 2005), the Queen Elizabeth Diamond Jubilee Medal (2012) and the Billings Medal for contributions to Canadian paleontology (GAC 2013).

Earth Science Literacy: A Basic Requirement for Planetary Citizenship

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Earth is our home planet. It goes without saying that some understanding of how the planet works and how humans affect the planet should be a requirement for every citizen of Earth. This is the foundation of the concept of Earth Science Literacy. An Earth science-literate person understands the basics of how Earth systems work and knows where to find credible information about the Earth. It is perhaps more important now than at any time in the past, because we are in a period of relatively rapid change and the mineral, energy and water resources that have sustained us are being depleted.

Earth science literacy is a moving target, evolving as our understanding of the Earth is improved. The essential components of Earth science literacy are determined by Earth science research. These components are, in turn, interpreted by Earth science educators so that people can understand the essential aspects of each component. Unfortunately, the amount of Earth science in formal school science curricula in Canada is extremely limited and therefore the average Canadian is not as well informed as he or she might be.

To be Earth science literate, a person should understand that:

- Earth is ancient (4.6 billion years old);
- Earth is constantly moving and changing;
- Life has evolved on Earth: it has reacted to change and helps to make change;
- Earth is a complex of systems based on the interactions of rocks, water, air and life;
- Earth provides us with all of the resources we use every day;
- Earth processes can be hazardous to humans;
- Human activity has significantly modified Earth;
- Earth scientists conduct scientific research in order to understand our planet better.

What are we doing in Canada to improve Earth Science Literacy? The answer is quite a lot, but not nearly enough. We are fortunate in this country to have an extremely active group of people who are trying hard to spread Earth science literacy to school children and the general public. They are networked through an organization called the Canadian Geoscience Education Network (a part of the Canadian Federation of Earth Sciences).

One of the jewels in the crown of Canadian Earth Science outreach is EdGEO – a program of workshops for teachers. Founded in the early 1970s, it has delivered countless workshops for teachers across Canada. Another tremendous achievement is the development of Geoscape posters for most cities and many regions of Canada. These visually explain the landscapes, Earth and water resources and natural hazards within communities.

The United Nations-sponsored International Year of Planet Earth (IYPE 2007-2009) provided a recent opportunity for increasing the amount of Earth science outreach in Canada. Several significant projects were undertaken. The WHERE Challenge, a contest for students aged 10-14, asked contestants what on Earth is in your stuff and where on Earth did it come from? A new web site on Careers in Earth Sciences was also developed for IYPE. This site is aimed at children of junior high school age.

One major IYPE project is still in progress: a new book on the geology of Canada written for the general public. It is aimed at the interested non-specialist and features readable text, beautiful photographs and a vast array of new graphics that will be available for free download once the book is released. The book entitled *Four Billion Years and Counting: Canada's Geological Heritage* will be published in mid 2014. All of these developments are resident on a web site www.earthsciencescanada.com and the ongoing aspects have become the responsibility of the Canadian Federation of Earth Sciences.

Canada has many internationally recognized geologically significant sites; it has more geologically based UNESCO World Heritage Sites than any other country. It also has a wealth of magnificent national and provincial parks that display superb geology. These represent an incomparable opportunity to educate our fellow citizens about Earth science. Our spectacular geoheritage can be used to improve Earth Science literacy. One exciting new development emergence of Global Geoparks, supported by UNESCO of which there are about 100 worldwide. UNESCO's overall goal for the initiative is to integrate the preservation of significant examples of geological heritage within a strategy for regional, sustainable socio-economic and cultural development, while safeguarding the environment. This net result is a potent mix of Earth science education and local economic development based on Geotourism. Canada established it first Global Geopark in 2010 and more are on the way.

The weak position of Earth science in Canadian school curriculum is a major deterrent to Earth science literacy. Core Earth science principles typically appear once in elementary and once in junior high curriculum; in most provinces Earth science is not formally present in the high school curriculum. This leads to lower enrolments in Earth science programs. The vastly higher enrolment in life science programs means that most science teachers are biologists. Unfortunately, this cycle is self-perpetuating and very difficult to change.

The future of Earth science literacy in Canada is uncertain. The basic framework for an effective effort is in place: a dedicated, experienced, well networked body of expertise undertaking a great diversity of projects; a desire on the part of many agencies to improve Earth science literacy; a corporate sector willing to support initiatives; and a well developed plan. But there is still a long way to go to raise educational content in curriculum and at geoheritage sites. We also need to graduate more Earth scientists who go into other areas besides geoscience, such as teaching. Finally, there is a crying need for a funded body to develop, sustain and manage Canada's Earth science outreach effort, because it is conducted presently almost entirely by volunteers. Every graduate of a geology program should volunteer their services to improve Earth science literacy of their fellow citizens.

Constructing a time series of groundwater NO_3 recharge using regional sampling events in the Abbotsford-Sumas Aquifer, British Columbia

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The Abbotsford-Sumas Aquifer has a history of elevated groundwater NO_3 concentrations, which has led to a significant amount of research in the area. Among the most noteworthy studies were regional isotope studies of the sources of NO_3 in the aquifer[1,2]. These snapshot studies were helpful for describing the state of the aquifer at the time of the studies. However, the different groundwater ages of the samples used, made it difficult to relate the samples to changes in land use and practices. A relatively recent approach to understanding the relationship between groundwater NO_3 is to use the groundwater age to relate a sample to its estimated time of recharge rather than the time of sampling. This means that regional snapshot sampling events can be extended to a time series that tells the story of how NO_3 concentrations of recharge have changed over time. There is not much evidence of denitrification in the aquifer, so NO_3 transport is considered to be conservative in this work. There are other limitations to this approach such as the vertical dispersion of NO_3 as it is transported in the aquifer resulting in NO_3 deeper than expected and means that, which means that the NO_3 in a given sample may have recharged more recently than the water in the same sample. The purpose of this work is to use present and reinterpret previously published NO_3 concentration and isotope results[1,2] as time of recharge to see if they tell the same story. Several of the wells used had measured groundwater (^{3}H/He) ages, while the ages of the other wells were estimated using the relationship between age and sample depth below static water level.

References:
1 - Wassenaar L.I. 1995. Evaluation of the origin and fate of nitrate in the Abbotsford Aquifer using the isotopes of 15N and 18O in NO3 -. Appl. Geochem. 10:391-405.
2 - Wassenaar L.I., M.J. Hendry and N. Harrington. 2006. Decadal geochemical and isotopic trends for nitrate in a transboundary aquifer and implications for agricultural beneficial management practices. Environmental Science and Technology 40:4626-4632.

Early Permian oceanic climate change in the Sverdrup Basin, Arctic Canada

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Early Permian carbonate rock succession of the Sverdrup Basin, Arctic Canada, records a major climatic cooling trend. During the Asselian, warm-water like carbonates composed of calcareous algae, foraminifer and non-skeletal grains such as ooids or oncoids, formed on a carbonate platform favored by a regional, uniform and passive subsidence (Nansen Formation). This situation changed during the lower Sakmarian, as warm-water carbonates of the Nansen Formation gave way to cold-water carbonates of the overlying Raanes Formation and younger formations. This change represents the onset of coldwater sedimentation in the Sverdrup Basin as indicated by the presence of bryozoans, brachiopods and crinoids in the Raanes Formation, and sponge spicules in younger rocks. Simultaneously to this climatic change in the oceans, the opposite process occurred in the southern hemisphere. Temperatures shifted from cold to warm, causing the glaciers in Gondwana to melt. Some of the hypotheses to explain this change in the oceans could be the Early Permian closure of the seaway between the Tethyan Ocean and NW Pangaea during the formation of the Ural mountains; a regional upwelling along NW margin of Pangaea; or due to the northward paleolatitudinal shift of Pangaea during this period. The purpose of my research is to determine what process caused such an acute climatic change in the Permian oceans in NW Pangaea and how the switch from warm-water to cold-water carbonates took place in the Sverdrup Basin.

Taphonomy and Paleoenvironmental Analysis of the Stephen Formation at Helena Ridge, Banff National Park, Alberta

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Sedimentologic, paleontologic, ichnologic, and taphonomic analyses of the Middle Cambrian Stephen Formation on Helena Ridge, Castle Mountain reveal that the unit was deposited dominantly in peritidal environments. Trilobite systematic paleontology has also confrrmed earlier interpretations for the biozonal correlation of the Stephen Formation with the boundary between the Narao and Waputik members corresponding to the Glossopleura and Bathyuriscus-Elrathina zone boundary. The fossil assemblage includes stromatolites,inarticulate brachiopod fragments, and hyolithids; at least one species of the latter includes an interesting association of phosphate pellets and bacterial filaments likely preserved by a process known as cesspit preservation. In addition, seven trilobite species were identified; these include Glossopleura boccar (Walcott), Polypleuraspis insignis Rasetti, Alokistocare cf. paranotatum Rasetti, Chancia odarayensis Rasetti, Ehmaniella waptaensis Rasetti, Elrathina cf. cordillerae (Rominger), and Solenopleurella sp. The formation was also subdivided into three distinct taphofacies, which show a general deepening trend moving up the section; these include Taphofacies lA, 2A, and 3A (Speyerand Brett, 1986). Two major ichnofacies(Cruziana and Skolithos) reveal finer level cyclicity within the formation. Taphonomic analysis of the trilobite deposits on Helena Ridge also confirm shallow marine and peritidal conditions within the Stephen Formation, and experimental taphonomy suggests that the deposits of the Narao Member were likely wave dominated concentrations as opposed to tempestite event concentrations.

Petrophysical analysis and interpretation for the development of a geostatic model for the initial investigation and characterization of a shallow target in the Geoscience Field Research Station (GFRS) area for CO_2 sequestration

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In taking action to mitigate Greenhouse Gases emitted into the atmosphere primarily from fossil fuel sources, carbon capture and storage is a method of sequestration acting to reduce CO_2 concentrations. The proposed GFRS will act as a research development site of advanced technologies for monitoring subsurface fluid flow. A geostatic model for a shallow target at 300 m depth into a porous sandstone was constructed over a 5km radius about the main research well. It includes a wireline data suite from 198 wells, and was completed using the 2013.3 Version of Petrel™ E&P Software Platform. Effective porosity was derived by calculating the total porosity from the density and neutron logs, and shale volumes from gamma ray indices. Limited core data analyses were used to determine the linear regression relationship between the porosity and permeability in the sands, silty-sands, and shales. Petrophysical modeling of effective porosity and computed permeability was completed using a Gaussian random simulation function that honors the variogram settings from the 198 wells in the outer 10 km radius. The shallow target has a porosity range of 0 – 25% and the permeability of the formation above ranges up to a few mD. It is made up of silty-sands and impermeable coal layers that span up to 30 m thickness. The shallow target appears to be a promising injection site for CO_2 sequestration and will be assessed for risk and tested further using computerized injection simulations.

Identifying methane occurrences and sources in groundwater in Alberta using geochemical and isotope data to establish baseline groundwater quality

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With the expansion of oil and gas activities into unconventional reservoirs including shale gas plays, there are some public concerns about potential future contamination of Alberta's groundwater either by intrusion of formation water, flow-back water or stray gas contamination. A major challenge for environmental impact assessment in the context of non-conventional hydrocarbon exploitation is the definition of the non-impacted baseline conditions. Groundwater resources overlying low-permeability hydrocarbon host rocks may be impacted to different extents by naturally occurring deep saline fluids and by natural gas emanations and/or by previous human activities (e.g. conventional hydrocarbon production). Once non-conventional gas exploitation has started to a large extent, the establishment of baseline groundwater compositions is difficult giving rise to highly controversial debates about the occurrence and potential extent of environmental impacts of unconventional gas production.

In order to enable a scientifically sound assessment of potential future deterioration of freshwater resources in Alberta's aquifers, it is essential to first establish and understand the current baseline of groundwater quality. Therefore, a systematic assessment of the geochemical and isotopic composition of water and gases obtained from Alberta's groundwater observation well network (GOWN) with special emphasis on occurrences of the sources and processes controlling methane in Alberta's aquifers.

Stratigraphic distribution and mineralogical variability of Pennsylvanian---Early Permian ooids in the Sverdrup Basin, Arctic Canada: Implications for global climate change

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It is well established that several oscillations in the oceanic chemistries occurred over the geologic time, including periods of alternating calcitic and aragonitic seas. Changes in atmospheric conditions are correlated to these fluctuations. Calcitic seas occur at times of greenhouse conditions, whereas aragonitic seas occur during times of icehouse atmospheric conditions. Ooids are non---skeletal carbonate grains composed of a cortex and a nucleus. They can reflect the oceanic water chemistries from which they precipitated from. Cortex of an aragonitic ooid shows tangential arrangement around a nucleus whereas calcitic ooids are radially arranged. Therefore, a transition from a calcitic to an aragonitic sea can be inferred from the composition and structure of ooids. In this study, the stratigraphic distribution and mineralogical variability of Pennsylvanian to Early Permian ooids from the carbonate sediments of the Sverdrup Basin in Arctic Canada were examined with a petrographic microscope to better constrain the transition from a calcitic to an aragonitic sea. The basin was located at tropical latitudes along the western margin of Pangea and was an area of extensive carbonate deposition. The results reveal the presence of four types of ooids: tangential, micritic, radial, and bimineralic. There are three most accepted theories to explain the changes in the ooid cortex composition: (1) varying atmospheric conditions, i.e. fluctuations in atmospheric pCO_2, (2) changing Mg/Ca ratio in the oceanic waters resulting from oceanic crust production and submarine weathering, and (3) locally influenced kinetic factors. Our results, in conjunction with other lines of evidence, such as the proliferation of calcareous algae, suggests that a global increase in pCO_2 was the principal cause of the eradication of aragonitic ooids during the Early Permian along NW Pangea in spite of a prevailing high Mg/Ca ratio which should have favoured their production and preservation.

Can total dissolved gas pressure be a useful tool to understand ebullition in a peatland?

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Anaerobic decomposition in northern peatlands produces 20-39% of global methane emissions every year (IPCC, 2007). Gases produced in the subsurface of peat are released to the atmosphere via diffusion, ebullition, and plant-facilitated transport. The heterogeneity of peat makes ebullition spatially and temporally variable, and difficult to predict. It is important to understand the physical and environmental controls on methane-containing bubbles forming in the subsurface, and how they may lead to mass release of this greenhouse gas via ebullition. Total dissolved gas pressure (P_{tdg}) is a measured that can be used to infer the degree of saturation of all gases dissolved in water, which in turn allows us to predict when bubbles may form.

P_{tdg} is equal to the sum of partial pressures of each gas present in a system, and bubbles will form when P_{tdg} equals or exceeds the sum of atmospheric pressure (P_{atm}), water pressure (P_w), and capillary pressure (Pc). This study evaluated the utility of P_{tdg} measurements by comparing results to water content reflectometers, porewater concentration calculations and flux meters in Sibbald Wetland from July-September, 2013. Porewater gas composition gives us the partial pressure of gases present in solution, and should equal P_{tdg}. Without directly measuring P_c, we concluded that it significantly impacts bubble formation prediction in Sibbald Wetland because P_{tdg} significantly consistently exceeded the sum of P_{atm} and P_w alone. There was good comparison in free-phase gas predictions from P_{tdg} with changes in volumetric gas content (VGC) measured with water content reflectometers over the season.

New biostratigraphic data from the Cretaceous Cody Creek Formation, Eagle Plain Basin, northeastern Yukon, Canada

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The Eagle Plain intermontane basin represents the most northern portion of the Cordilleran foreland basin that developed during the mid to Late Cretaceous. Cretaceous strata in the basin are up to two kilometers thick and are assigned to the Whitestone River Formation and overlying Eagle Plain Group, with the later representing two major transgressive-regressive clastic cycles comprised in ascending order of the Parkin, Fishing Branch, Burnthill Creek and Cody Creek formations. The Eagle Plain Group was originally considered to range in age from Late Cenomanian to mid-Campanian based largely on regional transgressive-regressive cycles. Recently, biostratigraphic data have suggested that the Eagle Plain Group in the southern part of the basin ranges in age from the Albian to Cenomanian or possibly Turonian.

This study focuses on the palynological assemblages extracted from 100 shot hole samples collected from the Cody Creek Formation in the northern part of the Eagle Plain Basin and their comparison with palynological assemblages from the same formation in the southern portion of the basin. Southern Cody Creek strata contain Cenomanian to possibly Turonian assemblages, whereas northern Cody Creek strata contain Turonian to late Campanian assemblages, and an isolated late Maastrichtian assemblage. As a result, these shot hole samples have yielded the youngest terrestrial assemblages from the Eagle Plain thus far. Through palynomorph biostratigraphy, Cody Creek Formation strata appear time transgressive from the south to north. These new temporal data influence our perception of local and regional correlations and help refine our understanding of regional stratigraphy and tectonic history.

Local signal regularity and smoothness as a means for seismic *Q* estimation

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In seismic signal analysis, irregular structures and points of sharp variation contain critical information, thus making the study of a signal's local properties an appropriate mechanism for obtaining information from seismic data. The local regularity of a seismic event is de- termined by the wavelet transform modulus maxima and the associated Lipschitz exponent. As a means of classifying regularities of a signal and estimating the associated Lipschitz exponent, the linear and non-linear Mallat-Hwang-Zhong (MHZ) signal model based on the wavelet theory is reviewed and developed.

For isolated seismic events, resembling a delta function or a Heaviside function, the linear MHZ model is used to estimate the associated Lipschitz exponent and subsequently verify the theoretical properties of the exponent. However for practical settings, in particular, band-limited signal events, the more complex non-linear MHZ signal model must be applied in order to estimate the local regularity and the additional smoothness parameter.

Based on the synthetic vertical seismic profile (VSP) modelling, a relatively complicated mathematical mapping between the Lipschitz exponent and seismic quality factor *Q* is ob- tained. However, analysing the smoothness parameter results in an invertible power law relation between the aforementioned parameter and *Q*. Applying the non-linear MHZ model to the Ross Lake VSP field data captures the general absorption trend estimated by Zhang and Stewart (2006). Furthermore, the power law relation provides geophysically reasonable *Q* values comparable to the estimated values using traditional methods, such as the steepest descent. However, for a more robust mathematical relation between the Lipschitz exponent, smoothness parameter and seismic quality factor *Q*, additional theoretical and field data analysis is required.

Dispersed organic matter and stratigraphic sequences in the Murray Harbour Formation, Sverdrup Basin: The on-again off-again relationship

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This study investigates the depositional environment and hydrocarbon potential of Middle Triassic strata within the Sverdrup Basin in the Canadian Arctic. Core samples taken from three wells drilled at different spatial locations within the basin and intersecting different stratigraphic positions in the Murray Harbour Formation are examined. Geochemical analysis and reflected light organic petrology are used to characterize the geochemical compositions and maceral assemblages of the rocks. Results are combined with lithofacies analysis to reconstruct the depositional setting and assess hydrocarbon potential and reservoir suitability for future unconventional petroleum prospects. The most organic-rich samples are located near the base of regressive systems tracts and deposited in an outer marine shelf to slope environment. These depositional settings provide conditions necessary for high primary biomass productivity and subsequent deposition of autochthonous, hydrogen-rich organic matter. Dysoxic to anoxic bottom waters preserve organic matter and low energy water conditions located distal to the sediment source minimize clastic dilution. Well-defined, gradual cyclic depositional sequences are identified in one well, occurring at a much smaller scale than the two major sequences in the Murray Harbour Formation. The cycles are subtly defined lithologically and in geophysical well logs, but are clear in organic geochemical depth plots. Parameters that control organic matter production and preservation are similar in both large and small-scale sedimentary sequences in the Murray Harbour Formation, allowing identification and prediction of organic-rich zones.

The role of non-condensable gases in geyser eruptions

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Yellowstone National Park is home to the world's largest concentration of geysers. These periodically erupting springs are rare and incompletely understood, largely thought to be driven by hot water and steam. Non-condensable gases, primarily CO_2, are present in the waters of these features, but to our knowledge no field-based research has directly addressed the contribution of such gases to the geyser eruption mechanism. In November 2013, we sampled five hot water geysers and springs and one cool water bicarbonate-rich spring in Yellowstone. In order to determine the role of non-steam gases in geyser eruptions and understand the evolution of geyser waters on an eruption interval time-scale, we collected continuous in situ water quality data between eruptions and took series of major element chemistry, isotope, and dissolved gas samples. In particular, total dissolved gas pressure (P_{TDG}) and temperature measurements were used to isolate water vapor pressure, which is dependent only on temperature, and non-steam gas pressure. Results indicate that P_{TDG} is mainly controlled by water vapor in our hot water features, while CO_2 exerts the major control on P_{TDG} in the cool water spring. While CO_2 is a minor component of P_{TDG} in the hot water features, dissolved gas samples show increases in concentration before eruptions. We propose that ebullition of CO_2 may induce boiling to drive an eruption in hot water systems. This dataset is the first of its kind and provides a baseline for continued research.

Conodonts, phytoplankton and sunbathers: an evolutionary journey

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The evolution of conodonts has long been an enigma in the paleontological world, having mostly been known only from small apatite elements and little else. This began to change rapidly in the 1980s, the result of the discovery of the conodont's preserved body. The consensus since that time has gradually been building that conodonts represent a stem vertebrate, sharing many characteristics in both the hard and soft tissues with other vertebrates. Yet despite these advances, many aspects of conodont evolution and biology remain contentious. Who are the ancestors of conodonts? How did conodont elements evolve? Why do so many conodonts fail to preserve their basal plates?

In this presentation, we will review some of the most prevalent explanations regarding the evolutionary origins of conodonts and their ancestors, ideas surrounding ontogeny and preservation, as well as development of conodont tissues through time. Using observations from our recent work we will then supplement and elaborate on these hypotheses, viewing conventional thought from a new perspective and pursue new ideas regarding conodont evolution, ontogeny, biology, and preservation. Finally we will answer the age old question: what do conodonts, phytoplankton and sunbathers have in common?

New Approaches to the Evaluation of Groundwater Resources in Canadian Prairie Watersheds

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Groundwater is a critical source of fresh water in the Prairie Provinces; 23% of Alberta's population relies on groundwater. The Paskapoo Aquifer, covering 65000 km2 of central to southern Alberta, is the most significant supply of groundwater in the Canadian Prairies. With 100% of the surface water rights in the Bow River and the Oldman River watersheds already allocated and a population growth double that of the Canadian average, there will be an even greater demand on this heavily utilized groundwater resource.

This vital resource must be properly managed to maintain a strong economy.
The safe-yield of an aquifer has long been considered to be the amount of water that can be withdrawn that does not detrimentally deplete the aquifer storage. Consequently, it has been equated to the natural recharge of the aquifer. Unfortunately, the safe-yield method is evaluated using a theoretical flow model that was developed in the 1940s and makes many assumptions, particularly about the simplicity and homogeneity of the aquifer.

The Paskapoo formation is a highly complex and heterogeneous aquifer and consequently conventional methods of evaluating safe-yields in the region have failed in many cases. One of these case studies has been examined in detail, including a new pumping test on the abandoned wells to monitor the aquifer response in a systematic and scientifically rigorous manner. This has provided the unique opportunity to understand what caused the failure, study the actual aquifer response under varying conditions and propose new methods for the evaluation of the important aquifer.

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Degassing processes in the standing water column of a monitoring well completed in gas-charged groundwater

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Total dissolved gas pressure (P_{TDG}), a 'master' variable representing total groundwater gas concentration, is limited by water pressure. Accurate *in situ* P_{TDG} measurements are critical to measuring accurate gas concentrations, but difficult to obtain due to in-well degassing. This study monitoring vertical profiles of P_{TDG} and gas concentrations in a standing groundwater monitoring well water column before and after pumping to investigate in-well degassing processes. During the pre-pumping period, P_{TDG} values below the bubbling pressure (P_B) at all depths were consistent with water column degassing. Increases in P_{TDG} values were observed after pumping at all depths, as fresh groundwater with *in situ* P_{TDG} was pumped into the well screen. The P_{TDG} subsequently decreased at all depths over the 15 day post-pumping, suggesting a long-term in-well degassing process.

Pre-and post-pumping dissolved gas concentrations were used to evaluate the hypothesis that decreased P_{TDG} after pumping occurs due to i) buoyant migration of bubbles formed when $P_{TDG} > P_B$, ii) induction of convection currents as bubbles rise (increasingly so as bubbles increase in size during assent; and iii) consequent movement of deeper water (with higher P_{TDG}) up column, reinforcing the process. In each of two monitoring periods, groundwater gas concentrations throughout the water column in the well casing were mixed with the headspace above the water column (atmospheric gases in the pre-pumping period, and SF_6 tracer gas in post-pumping period). This gas behaviour is consistent with mixing of water in the well casing due to convection caused by bubble formation and buoyant transport.

Rockin' the Bakken: Sedimentology and stratigraphy of the Late Devonian-Early Mississippian Bakken Formation, SE Alberta, SW Saskatchewan

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The most prolific –recoverable- tight oil reserve in the world is found in a 30 meter thick, mixed siliciclastic- carbonate unit located in the Williston Basin, central North America. This unit is known as the Bakken Formation.

Upon its discovery in 1956, the Bakken Formation was described as a sandstone unit sandwiched between two organic-rich shale units. This tripartite extends through the subsurface of the Williston Basin in North Dakota, Montana, southeastern Alberta, southern Saskatchewan and southeastern Manitoba and is generally characterized by low porosity and low permeability. In this study, the analysis of eleven cores from the Bakken Formation in southeastern Alberta and southwestern Saskatchewan has led to the identification of six distinct lithofacies and four bounding surfaces. These stratigraphic units and surfaces were calibrated to well logs for regional correlations and to construct a sequence stratigraphic model for the Bakken Formation in the study area.

Samples recovered from the middle Bakken sandstone show evidence of reworked, abnormally-high colour alteration index CAI Silurian to Early Devonian condonts and detrital chert grains, a pattern consistent with sourcing from uplifted mountain ranges. Detrital zircon samples are currently being analyzed to test this hypothesis. Identification of potential provenances for the Bakken Formation siliciclastics will refine our understanding of the depositional settings associated with the Bakken deposits and the sediment dispersal path(s) in central North America during the Devonian-Mississippian time.

Notes

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