University of Calgary
Department of Geoscience
Geoscience Research Exchange

April 15, 2016

Abstract Book and Program

GEOREX
GEOSCIENCE RESEARCH EXCHANGE

A message from the organizers

Welcome to the sixth annual Geoscience Research EXchange (GeoREX) at the University of Calgary. We are pleased to have an extensive line-up of talks and posters this year covering a wide variety of topics in earth science. We are also pleased to announce awards for the best graduate and undergraduate talks and posters this year

thanks to the generous support of Imperial Oil Esso.

The annual GeoREX symposium was initially introduced as a low pressure environment for both undergraduate and graduate students to communicate their research and ideas with other earth science students, supervisors, and faculty and industry members. Sharing our research in such a multidisciplinary environment provides us all with an opportunity to explore new ideas and seek out new collaborative efforts, all while gaining critical experience in communicating the results of our research. With these efforts at collaboration in mind, we are pleased to welcome students and faculty Mount Royal University to this year's event. We hope to see this become a tradition for students from both of Calgary's universities.

Finally we would also like to thank Imperial Oil Esso, and the Department of Geoscience at the University of Calgary for their generous support of this annual event. This event could not take place without this support, and we would like to issue a special welcome to representatives from each of these organizations to GeoREX.

Welcome to GeoREX 2016, we hope you enjoy your day!

Sincerely,

The GeoREX organizing committee: Jason Abboud, Elinda Dehari, Hormoz Izadi, Mary Kruk, Jessica Guselle, Jason Levesque, Nadine Taube

PS – If you are interested in getting involved with GeoREX next year, please speak to one of us throughout the day or express your interest by sending an email to georex@ucalgary.ca.
Keep in mind: If nobody steps up, GeoREX is not going to happen.

Oral Presentation Schedule

8:00 AM	REGISTRATION AND MORNING COFFEE
8:45 AM	Opening remarks ***GeoREX Committee***
9:00 AM	Predicting the microseismic response in a naturally fractured shale reservoir using a discrete fracture network model ***Mason MacKay***
9:15 AM	Geochemical and isotope analysis of fluid sources from an AOS SAGD facility: A new approach to minimizing scale formation during petroleum production ***Christine Ciszkowski***
9:30 AM	Low pressure metamorphism of the Rossland Group, southeastern British Columbia ***Andrea Morgan***
9:45 AM	Experimental simulation of partitioning behaviour of organics into the water following a submarine oil spill ***Aprami Jaggi***
10:00 AM	COFFEE BREAK
10:15 AM	POSTER SESSION 01
10:45 AM	Is water washing an important petroleum system process? ***Ranya Algeer***
11:00 AM	The effect of bacterial degradation on bituminite reflectance ***Dane Synnott***
11:15 AM	Isotopes in Space – unraveling planetary birth ***Nikola Van de Wetering***
11:30 AM	A quest for accurate in situ dissolved gas concentration estimations using field-measured total dissolved gas pressure (PTDG) ***Randal Evans***
12:00 PM	LUNCH BREAK

1:00 PM	Calibration of Middle to Late Jurassic palynostratigraphy to Boreal ammonite zonations in the Sverdrup Basin, Canadian Arctic ***Anne Nguyen***
1:15 PM	Design assessment for local seismograph network: Application to the Liard Basin ***Anton Biryukov***
1:30 PM	On the path of discovery: The controversy and science behind Chicxulub Crater ***Wyatt Petryshen***
1:45 PM	Hydrogeophysical survey of groundwater flow pathways in an Alpine headwater basin ***Craig Christiensen***
2:00 PM	AFTERNOON COFFEE BREAK
2:15 PM	POSTER SESSION 02
2:45 PM	Establishing hydrochemical and hydrostratigraphic baseline conditions in the shallow bedrock aquifer at a geo-energy field research station ***Terri Cheung***
3:00 PM	Computational modeling of heat dispersion under various conditions ***Zoë Vestrum***
3:15 PM	Molecular characterization of dissolved organic matter in water bodies by ultrahigh resolution mass spectrometry ***Aprami Jaggi***
3:30 PM	BREAK and mingling
4:00 PM	Award Ceremony and Closing remarks ***GeoREX Committee***

Morning Poster Session

Poster #

GRE-1 Impact of waste water effluent on the biogeochemical cycle of Cd
Andrew Bellavie

GRE-2 The Piltdown man
Jessica Burylo

GRE-3 The influence of sedimentary fabric on fracture characteristics of two shoreface sandstones of the Lower Cretaceous Moosebar Formation, west central Alberta
Jenna Sie

GRE-4 Clay mineral genesis and Mesoamerican archeology in Mexico's Costa Grande Region
Cody Will

GRE-5 Nutrient distribution and export in a wastewater impacted section of an oligotrophic river
Nadine Taube

GRE-6 An approach to a practical petroleum charge and reservoir fluid residence time dating method
Roshanak Sonei

GRE-7 Morphological analysis of conodont P2 elements: Hart River Formation, Peel River areas of Yukon Territory
Chen Shen

Afternoon Poster Session

Poster #

GRE-8 Geology of the Oversight Property, Cooke Mountain, Washington: Mapping, petrography, subsurface interpretations, and economic implications

Tyler Glubrecht

GRE-9 Nonstationary L1 adaptive subtraction with application to internal multiple attenuation
Scott Keating

GRE-10 Thermal maturity and biodegradation geochemistry assessments by ultrahigh-resolution mass spectrometry and principal component analysis
Luciana Assis Terra

GRE-11 Unveiling geochemical processes during ombrotrophic peat bogs formation in northeastern Alberta – Case study of Mildred peat bog
Gabriela González-Arismendi

GRE-12 Rare anomalous optical anisotropy in Almandine, Ideally $Fe_3Al_2Si_3O_{12}$
Nesyereb Suarez

GRE-13 Earliest Triassic refuge at Shangsi China: A potential analogue for modern marine crisis
Amanda Godbold

GRE-14 The description of three distal tibiae from Early Miocene Nepak, Uganda
Jessica Burylo

Oral presentation abstracts

Predicting the microseismic response in a naturally fractured shale reservoir using discrete fracture network model

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The goal of this study is to characterise a shale gas reservoir using a geomechanical facies approach and to improve our understanding of the controls that natural fractures play in microseismicity. Each geomechanical facies is used to populate a distinct element model. The model predicts the microseismic response of natural fractures to a change in the stress regime that is associated with hydraulic stimulation. The modelling approach consists of creating a discrete fracture network (DFN), then incorporating the DFN into a deformable matrix based on elastic properties of the rock. The stress regime in the model is perturbed and a simulated microseismic response is created in order to assess where and how fracturing occurs. The simulated response is compared to the actual microseismic spatial distribution, and the model is iteratively refined. Interpretation of the results enables understanding of the potential relationship between natural fractures and geomechanical parameters and how they behave under different stress regimes. A case study of a shale gas reservoir is provided and conclusions about the location of fracture-enhanced permeability are made.

Geochemical and isotope analysis of fluid sources from an AOS SAGD facility: A new approach to minimizing scale formation during petroleum production

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Mineral (scale) precipitation can significantly hinder production in petroleum reservoirs. This includes steam assisted gravity drainage (SAGD) operations used for bitumen recovery in the Athabasca oil sands region of northeastern Alberta, Canada. Variations in scale compositions and their formation conditions have been observed throughout SAGD facilities and often require costly and laborious mechanical and/or chemical treatment efforts. Hence, we investigate methods to prevent or at least minimize scale formation by applying select geochemical and isotopic tracers to identify source contributors to mineral precipitation. Pore water, bottom formation water, and steam condensate and returned emulsions (produced bitumen and water) were sampled from a SAGD reservoir in Alberta and analysed for geochemical and isotope parameters. Results indicate distinct concentrations of dissolved Na and Cl and δ18O and δ2H values for the three fluid sources. Significant differences in δ13CDIC, δ11B, δ34S values and 87Sr/86Sr ratios were also observed between bottom formation water and steam condensate and returned water samples, and hence constitute excellent tracers for bottom water influx. Scale sampled from multiple steam injector and production wells will be analysed for δ18O, 13CDIC, δ34S, δ11B, 87Sr/86Sr and trace elements and results assessed to determine the fluid sources and reservoir dynamics that contributed to its formation.

Low pressure metamorphism of the Rossland Group, southeastern British Columbia

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The area around the towns of Salmo and Nelson in southeastern British Columbia contains metamorphosed early Jurassic volcanic and sedimentary strata, and several large mid Jurassic intrusions belonging to the Nelson Suite. The oldest unit of interest in this study is the Archibald formation, and its equivalent, the Ymir Formation. They are a sedimentary layer containing argillite, siltstone, and conglomerates. The layer above it is the Elise Formation, composed of basaltic flows and tuffs. The youngest layer of interest is the Hall formation, composed of argillites, siltstones, and conglomerates. These units are intruded by a number of Jurassic plutons, and have been metamorphosed to sub-greenschist through amphibolite facies. There is uncertainty as to whether the changing metamorphic grade is due to regional metamorphism or contact metamorphism associated with the intrusions, and the depth at which the metamorphism occurred.
This study has used both the petrographic microscope and the electron microprobe to examine a large suite of metapelitic and metavolcanic rocks from the region. This has allowed mineral assemblages to be identified, permitting the delineation of mineral isograds for metavolcanic and metapelite assemblages. Compositional analyses of amphiboles and feldspars combined with equilibrium phase diagram modeling have been used to better constrain burial depths during metamorphism associated with cordilleran orogenesis. The close coincidence between the isograd pattern and the external contacts of the intrusions suggest that the main driver for metamorphism was heat provided by the multiple intrusive bodies at shallow depths within the crust

Experimental simulation of partitioning behaviour of organics into the water following a submarine oil spill

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Oil compounds, such as hydrocarbons and other heteroatom species, partition into the water phase following petroleum spillage, depending on the pressure, temperature and composition of the oil and water. The traditional shake flask method for determining oil-water partition ratios of benzene, toluene, ethylbenzene and xylene (BTEX) fails to accurately model the extremes of high pressure, low temperature and dissolved gases found in submarine oil spill conditions. A customized oil-water partitioning device has been constructed to experimentally simulate the partition behaviour of BTEX compounds under subsurface oil spill conditions, using live oil (methane-charged) with saline waters over a range of pressure (2-15MPa) and temperature (4–20°C). This data may be used in near-field and far-field distribution modeling of the environmental fate of BTEX compounds and assist in the prediction of their migration pathways from potential oil spills.

Is water washing and important petroleum system process?

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Water washing is one of the in-situ natural alteration processes affecting geochemical composition and bulk physical properties of petroleum accumulations but it remains only qualitatively described and the extent and true importance of the process remains unknown. It causes removal of the more water soluble light alkanes, aromatic hydrocarbons and other non-hydrocarbons from petroleum through contact with moving formation waters in reservoirs, during migration, reservoir storage and potentially during production. Therefore, quantitative determination of organic compound partitioning, between oils and water phases in the subsurface, which occur during water washing, is necessary to better understand the distribution of these compounds and hence develop reliable parameters that can be used to assess the real impact of water washing on crude oil composition with realistic subsurface water flow rates. However, most of the geochemical literature is qualitative in nature and no data has been reported on the quantitative aspects of the oil-water partition process at subsurface conditions for aromatic species, especially heteroaromatic compounds such as alkylated benzothiophenes and derivatives, which have commonly reported in “water washing” studies.
In this study we quantitatively assess the effect of water washing on petroleum by conducting water washing experiments in the laboratory to determine partition coefficients of aromatic species in dead crude oil/brine systems under nominal deep reservoir temperature and salinity conditions (90°C; 100,000 mg/L Sodium chloride; 1 bar). Also, we describe the distribution properties of water-soluble acids, bases, and neutral NSO compounds of the washed oils using high-resolution FTMS in ESI ionization mode.

The effect of bacterial degradation on bituminite reflectance

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Within bituminite particles, high reflectance oxidation rims (HROR) were observed in close proximity to framboidal pyrites. Through examining a maceral with the framboidal pyrite physically removed, high-density reflectance measurements were made. Additional measurements were taken in the form of transects across the maceral, allowing an examination of the relationship between reflectance and distance from the bacterial sulfate reduction (BSR) zone. A baseline reflectance value of approximately 0.50%Ro was measured, with peak values of approximately 0.75%Ro being measured adjacent to the pyrite. This variability in bituminite reflectance (BRo) was not induced via thermal catagenesis, but could however be accounted for by a diagenetic process. This process involves the labile organic matter (OM) entering a BSR zone. In this zone, anaerobic bacteria reduces dissolved sulfate to oxidize OM. This process results in the formation of bacterially derived framboidal pyrite in close proximity to HROR in bituminite macerals. Although there has been a previous report of elevated BRo associated with biogenic gas in the regional scale, there was no microscopic evidence of such occurrence reported. This study examines low reflectance bituminite particles with embedded framboidal pyrite and associated HROR.
Examination of the measured transects yielded a very rapid drop in reflectance a few microns away from the BSR zone. This demonstrates that the bacterial processes are not uniform on the micron scale and selective of reaction sites. This study also demonstrates the magnitude of

variation that can be expected when measuring Bro, which could result in significant overestimation of thermal maturity.

Isotopes in Space – Unraveling planetary birth

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As modern geochemical techniques continue to develop, as does our understanding of isotopic systems on Earth; and even more so, the understanding of isotopic systems in our solar system. This presentation gives an introduction to the geo-cosmochemical theories and techniques used to understand the formation of terrestrial planets of our solar system. Stable isotope characterisation of extraterrestrial rocks, including meteorites, lunar and planetoid materials, provide invaluable information regarding the fractionation of volatile and siderophile isotopes during planetary formation. There is an ongoing debate regarding the origin of the Earths budget of siderophile elements (Au, Co, Fe, Ir, Mo, Ni, Os, Pd, Pt, Re, Rh, Ru, Ge, Ag and W); whether these are attributed to early Earth formation, or from later extraterrestrial bombardment. In this presentation, isotopic techniques utilising siderophile elements S, Te and Pd, and their respective roles in deciphering core formation, and extraterrestrial bombardment on Earth are discussed.

A quest for accurate in situ dissolved gas concentration estimations using field-measured total dissolved gas pressure (PTDG)

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Numerous geochemical applications require dissolved gas sampling to understand the natural evolution and abundance of gases in groundwater. Dissolved gas sampling is a poorly refined method and is fraught with problems and challenges. As of yet there is no commonly accepted standard operating procedure. In this study various gas sampling approaches, which seek to estimate in situ dissolved gas concentration, were evaluated and compared. Total dissolved gas pressure (PTDG) was monitored in tandem with gas sampling to understand how PTDG can provide insights into gas dynamics in the subsurface, and thus better inform dissolved gas sampling. Eight Alberta Environment GOWN (Groundwater Observation Well Network) monitoring wells, which were known to be gas charged, were sampled in this study. A wide variety of PTDG values measured in the field program confirmed that in situ groundwater gas pressure, and thus in situ dissolved gas concentration, can only be estimated after wells are purged (without significantly decreasing hydraulic head) and monitored to observe that PTDG approaches an asymptotic (equilibrium) value. Comparison of estimated gas concentrations using various sampling approaches confirmed that i) gas concentrations are likely to be underestimated unless PTDG is considered in sampling and/or analysis; ii) free phase gas formation during sampling biases gas concentration results. Further studies which serve to evaluate and compare dissolved gas sampling methods, as well as integration of PTDG measurements, are recommended to better inform a widely accepted protocol for accurate estimations of in situ dissolved gas concentrations.

Calibration of Middle to Late Jurassic palynostratigraphy to Boreal ammonite zonations in the Sverdrup Basin, Canadian Arctic

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The Sverdrup Basin of the Canadian Arctic is a rift basin containing sediments ranging in age from the early Carboniferous to Paleogene. Age determination of strata in the Sverdrup Basin can improve correlations in the basin subsurface; however, detailed chronostratigraphy in high-latitude Mesozoic basins is limited by the paucity of ammonites, partly due to cold climate conditions of the Boreal Sea relative to the lower latitude Tethys Sea. We use quantitative palynostratigraphy to calibrate pollen and spore signatures to rare ammonite occurrences. Unlike ammonites in the Sverdrup Basin, pollen and spores are abundant and widespread in both Boreal and sub-Boreal provinces and can be used to reconstruct high-latitude paleoenvironments and improve chronostratigraphy. By integrating quantitative and statistical palynology with ammonite stratigraphy, we strive to produce a palynological signature that can be calibrated with age-diagnostic ammonite occurrences to improve intra- and inter-basin correlation. Palynological analyses (Q-mode and R-mode cluster analyses) of the Jameson Bay, Sandy Point, McConnell Island, Ringnes and Awingak formations reveal similar trends in the relative abundance of terrestrial pollen and spore taxa in two stratigraphic sections at Axel Heiberg Island in the Sverdrup Basin. Distinct palynoassemblages correspond to fourteen ammonite taxa. This work also provides insight into Middle to Late Jurassic paleoclimate of the Sverdrup Basin. Based on the relative abundance of ecologically important spore and pollen taxa such as Taxodiaceae-Cupressaceae and Laricoidites magnus pollen, we interpret a paleoenvironmental setting with humid lowlands with drier upland regions that supported a diversity of terrestrial ecosystems.

Design assessment for local seismograph network: Application to the Liard Basin

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Induced seismicity has been rapidly transforming from an occasion to a serious societal concern. Despite the majority of induced events being far from disruptive, it has been noticed that a harmful event can be triggered after a swarm of relatively weak earthquakes (EQs). Therefore the ability to timely detect and characterize the small precursors may greatly facilitate safety-related business decisions.
The main purpose of this study is to assess the performance of a regional network to be deployed in Liard Basin as a function of earthquake depth and site noise conditions. The performance here was characterized by the magnitude of completeness metric (Mc). The values of Mc exhibited major and minor sensitivity to the earthquake depth in the cases of small-scale and Liard basin networks, respectively. This phenomenon was explained by a relatively large and small depth-to station-spacing ratio on a large and a small scale, respectively.
The severity of Mc variation as a function of detection picks number suggested the necessity of having the pessimistic and optimistic distributions for induced seismicity analysis.

On the path of discovery: The controversy and science behind Chicxulub Crater

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The breadth to which scientific misconceptions are transmitted in science can lead to an inability in differentiating between healthy scientific reasoning and unfounded rationalizations. To contextualize certain aspects of the Nature of Science I have developed a geological case study analyzing the discovery of Chicxulub crater. In 2010, scientists published a consensus in the Journal of Science asserting the Chicxulub asteroid impact was the mechanism behind the K-Pg mass extinction. Despite this publication, a number of opponents still question the impact's effect in the K-Pg extinction. Enhanced by personal communications with key scientists in the controversy, this case study explores the collection and analysis of evidence used for locating the crater. The case study walks the reader through this history, revealing evidence as it became known, illustrating how different scientists attribute different meanings to evidence, perpetuating the controversy. The narrative strives to explore the processes and products of hypervelocity impacts, highlighting the techniques used in identifying hypervelocity impact craters. A learning goal of this case study is to have students form a knowledge base dealing with certain aspects of the nature of geology, in particular, emphasizing the tentativeness and uncertainty in science. The case, and associated activities help students to develop an understanding of impact science as a possible mechanism of mass extinction events. This case is a part of a larger project of historical case study development generously funded by the Taylor Family Foundation for Teaching and Learning, and the Tamaratt Professorship in Geoscience.

Hydrogeological survey of groundwater flow pathways in an Alpine headwater basin

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Alpine regions of the Canadian Rocky Mountains are important sources of freshwater for the semiarid Canadian Prairies. Yet, only recently have studies demonstrated that groundwater plays an important role in storage and subsequent release of snowmelt and rain. With limited case studies available in this region, a general understanding of groundwater flow processes in the alpine zone remains elusive.
We present a new case study of a complex, first-order watershed in the Front Ranges of the Eastern Canadian Rocky Mountains. Located adjacent to the Kananaskis River Valley, this site is unique in having multiple geomorphological features in close proximity. At the glacially carved headwall of the valley, springs emerge from large talus cones, leadings to streams diverted by a complex array of moraines. These converge in an alpine meadow and lead to an ephemeral tarn lake. No surface outlet from the tarn is present, yet flow is observed from a perennial spring immediately adjacent to the lake, demonstrating the significance of groundwater flow in this system.
We employ two geophysical methods to investigate the subsurface: electrical resistivity tomography, seismic refraction tomography. Combining these data sets, we establish the geometry of different hydrogeological units and delineate saturated and unsaturated zones. Finally, using the geophysical interpretations and along with geochemical sampling, we develop a preliminary model of groundwater flow routing.

Establishing hydrochemical of partitioning and hydrostratigraphic baseline conditions in the shallow bedrock aquifer at a geo-energy field research station

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Geo-energy and geo-engineering approaches such as underground gas (e.g. CO2, CH4) storage and hydraulic fracturing of shale gas or shale oil reservoirs have propensity to cause adverse environmental impacts. Of these potential impacts, subsurface gas release (i.e. fugitive gas) is a key concern. In order to detect potential gas migration and determine the potential impact of fugitive gases on shallow aquifers, thorough hydro-stratigraphic characterization and hydrogeochemical baseline characterization needs to be conducted prior to energy resource development. CMC Research Institutes Inc., has established a multi-disciplinary field research site aiming to advance knowledge on geo-energy related containment and monitoring research with specific focus on fugitive gases. Currently the site is comprised of a gas injection well, two deep monitoring wells, a domestic or 'farmer's' well and two groundwater-monitoring boreholes. During installation of initial site infrastructure, a baseline study was conducted to fully characterize the shallow (0 – 106 m) depths. Consequently, numerous depth-discrete core samples were collected for gas analysis by rock crushing and degassing of rock core in volatile organic analysis vials (VOA) and isojars. Isotopic analysis of rock core reveal that δ13C-CH4 for the upper 106 m deep subsurface ranges from -85‰ to -65‰, therefore indicating the methane is of a biogenic origin in the fresh water zone. Hydro-stratigraphic characterization was achieved through core logging of lithology and fractures, accompanied with downhole geophysical logging. From these multiple data sets, a depth discrete, 27 port Westbay multilevel system was designed to allow groundwater quality sampling and head monitoring at isolated depths.

Computational modeling of heat dispersion under various conditions

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Geodynamics is the study of dynamic movements of the Earth. This field of study usually focusses on the mantle and the driving forces of plate tectonics. Since the mantle is only dynamic on a geological time scale and is only observed through remote sensing methods, computational modelling provides a method to visualize its behaviour over time. Complete models of mantle dynamics involve coupling of the energy equation to model heat flow and the momentum equation to model fluid dynamics. This investigation reduces the complexity of the model to understand the basic implementation of physical laws and boundary conditions. The physical laws implemented were Fourier's Law of thermal conduction and the heat equation. The boundary conditions used were constant temperature, zero heat flux, constant heat flux and a combination. This study found that computational modelling of the mantle may not be as complicated as you think.

Molecular characterization of dissolved organic matter in water bodies by ultrahigh resolution mass spectrometry

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The objective of this study is to identify molecular markers unique to each source input from Bow & Elbow Rivers, Glenmore reservoir in Calgary, Gulf of Mexico and Arctic Sea by analyzing their dissolved organic matter (DOM). DOM exists as a highly functionalized and complex mixture of organic compounds, which act as biogeochemical tracers, capable of providing valuable insights into the origins of their parent waters and the diagenetic alterations that may have occurred within those waters during transport. For example, DOM in natural waters near oil seepage and spillage may represent a near terminal degradation product of petroleum. DOM was extracted from the water samples collected from varying depths and locations via solid phase extraction and then analyzed using Fourier transform ion cyclotron resonance mass spectrometry (FTICR-MS). Hitherto, DOM analysis provided bulk chemical characteristics and molecular information for only a small fraction of DOM. Nowadays, with the high mass accuracy offered by ultrahigh-resolution mass spectrometry it is possible to fingerprint the molecular formula of different sources and the transformation processes undergone by organic matter.
The analyzed extracts show a high concentration of polar and high molecular weight compounds. For instance, in the freshwater source Glenmore reservoir we saw more than thirty different combinations of heteroatoms and an almost perfect Gaussian distribution of highly oxygenated species from O2 to O16. Such rapid and comprehensive screening of DOM allows for analysis of compounds with poorly understood environmental and human health impacts and enable tracing of contamination sources in a water body.

Poster presentation abstracts

Impact of waste water effluent on the biogeochemical cycle of Cd

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The mobilization of Cd from the earth's crust by anthropocentric activities has led to increased deposition to terrestrial and aquatic environments (1). The ecotoxicity of Cd and its tendency to bioaccumulate have been well documented since the 1950s (1). Mobilization and transport of Cd in aquatic environments is in part mediated by the presence of chelating agents. In the environment, Natural chelating agents, such as humic acids (HA), are present in soils as products of decaying organic matter. Synthetic chelating agents, such as Ethylenediaminetetraacetic acid (EDTA) and Nitrilotriacetic acid (NTA) in detergents and foods, are introduced to aquatic ecosystems through discharges of wastewater effluent. This project focused on the chelation chemistry of Cd in the confluence of wastewater effluent and natural waters using Size Exclusion Chromatography- Flame Atomic Adsorption Spectroscopy (SEC-FAAS). Chromatograms showed an increase in retention time implying that Cd shows a higher affinity for chelation by EDTA, even when initially present as a Cd-HA complex.

The Piltdown man

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In 1912 a hoax was created that lead science astray for four decades. A modern human skull and an orang-utan jaw were planted in Piltdown, England, so Britain could be home to the earliest known man. The specimen, who became known as Piltdown Man, fit exactly with what scientists expected early humans to look like; possessing a large brain, primitive face and residing in England. It remains unclear, who ultimately planted these forged materials.
This case is part of a series created by the team of Glenn Dolphin with the goals of teaching the nature of science through historical case studies, address required geoscience curriculum for classrooms, encourage inquiry-based learning and maintain flexibility to promote usability in a wide range of class types. This case follows the events of the hoax until this find was proven false in 1953. The student experiences new events and information as they unfold, just as the scientists of the day would have, including the finding of new specimen that strengthened the case for the Piltdown Man. They experience the unfolding of new science that aided in the unraveling of the forgery, including curriculum surrounding fluorine dating techniques. Lastly, this case addresses the shifting paradigms of society as it struggles to move from a Eurocentric view of human origins, to an Africa-based model. This model shows human ancestors to have obtained a modern body before the enlargement of our brains. This case exemplifies how science involves more than empirical evidence, it becomes a process involving racial judgement and patriotic pride.

Influence of sedimentary fabric on fracture characteristics of two shoreface sandstones of the Lower Cretaceous Moosebar Formation, west central Alberta

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Reservoir properties, such as preferential flow pathways, can be better understood by studying the connectivity and continuity of natural fracture networks. By quantifying the fracture networks observed in outcrops, extrapolation of fracture populations within the subsurface can aid in maximizing fluid extraction. In this study, the influence of sedimentary fabric on the fracture network of two shoreface sandstones was analyzed to determine the effect of internal fabric on fracture characteristics. Two thick shoreface sandstones of the Lower Cretaceous Moosebar Formation (equivalent to the Wilrich/basal-Falher members of the Spirit River Formation) were chosen because of their lithological similarities but different sedimentary fabric. Collection of outcrop scanlines allows comparison of fracture characteristics and observation of the influence of fabric controlled by hummocky cross-stratification (Sandstone A) and bioturbation (Sandstone B). Scanlines were measured on three distinct sedimentary facies within each sandstone based on bed thicknesses: Facies 1 (5-30cm), Facies 2 (30-60cm), and Facies 3 (60-250cm). Although individual fracture characteristics of each facies is not directly applicable to the subsurface, relative ratios between corresponding facies can likely be applied. For example, a 50m visual scanline provides fracture intensities of Facies 3A and 3B of 2.8f/m and 1.8f/m, respectively. Facies 2A and 2B have fracture intensities of 3.3f/m and 2.8f/m, while Facies 1A and 1B are 4.4f/m and 3.2f/m. Therefore, the overall ratio of Sandstone A to B correlates to an average of 25% higher fracture intensity in Sandstone A. Results of this analysis suggest that internal fabric, mechanical bed thickness and presence of mud, have an effect on fracture characteristics of shoreface sandstones.

Clay mineral genesis and Mesoamerican archeology in Mexico's Costa Grande Region

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Analysis of Mexican clay deposits in Costa Grande indicates a correlation to regional Mesoamerican pottery. The geology and archeology sites of southern Mexico's Costa Grande region is underrepresented in research and literature, relative to the rest of Mexico. The Costa Grande region encompasses highland sources of sediment as well as marine sediment sources, both potential clay sources. Distal clay used as adobe for resurfacing a temple at La Soledad de Maciel correlates mineralogically with Mesoamerican clay pottery from the same archeological site. Clay sediment genesis in the Coste Grande region is not represented in Spanish or English research literature despite having a broad impact on archeological studies. Mesoamerican clay artifacts are suspected key to creating maps of clay source rocks and sedimentation inputs. A study of Mesoamerican artifacts and geologic samples using Raman spectroscopy, X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR) will provide mappable and timeline data of clay sources, transportation, and anthropological usage of clays. The correlation of clay origin to clay deposition, in relation to time (via dated artifacts) will indicate changes in sediment source. The results of this study and invitations to disseminate in local forums will help improve the current archeologic, geologic, and earth science education in the Costa Grande region.

Nutrient distribution and export in a wastewater impacted section of an oligotrophic river

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The relative masses of wastewater-derived phosphorus (P) and nitrogen (N) stored in sediment, hyporheic zone, biomass, and water column of an oligotrophic river affected by wastewater treatment plant (WWTP) effluent were evaluated. Sediment stored 98% of total P and total N in a 25km long river reach. Epilithic algae, macrophyte biomass, surface water and porewater contributed a small amount (<2%) to the nutrient storage in the river.
The highest nutrient export during open water period (May to October) occurs in the water column with 42 tons of P as Total Phosphorus (TP) and 1100 tons of N as Dissolved Inorganic Nitrogen (DIN). The amount of nutrients exported by surface water is orders of magnitude higher than any other flux. The water column in the river reach seems to be an important component for DIN storage and export whereas P is stored to a higher degree in sediment porewater. High N/P ratios in the water column are the reason for this discrepancy in storage. The export of nutrients by senescing epilithic algae and macrophytes is negligible in comparison to water column transport. The different storage dynamics of the two nutrients can lead to modification of the amount, timing, and form of nutrient export and thus impact nutrient stoichiometry downstream.

An approach to a practical petroleum charge and reservoir fluid resistance time dating method

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Dating Geological events is one of the key tools in geological exploration. However, due to the lack of a practical method, dating petroleum charge and residence time from analysis of crude-oil alone is currently not viable. The objective of this research is to evaluate the viability of age dating techniques using chemical proxies based on natural gamma irradiation products of crude oils, within the reservoir rocks. As a case history, high resolution sampling procedures were conducted within 4 wells of Athabasca oil sands and 150 reservoir core samples were collected. Considering a horizon with a high intensity spike in the gamma ray log which extends laterally across the area, location of the samples was determined. This horizon will characterize sweet spots with high concentrations of major radioactive elements (U, Th, K) associated with reservoir features (e.g. shale intervals).
Basic geochemical analyses were carried out on the samples using extraction and a suite of quantitative liquid chromatography, gas chromatography-mass spectrometry techniques. This will allow us to look into detailed compositional profiles of different compound classes and identify any general and local compositional variations within the reservoir relating to oil charge and large scale biodegradation impacts. The next step is to explore potential variations in the oil chemistry related to the variations in the concentrations of major radioactive isotopes of U, Th, K, and the

decay systematics of these elements. We discuss the compositional variations seen in the reservoir petroleum column and review some of the challenges in conducting such developmental studies.

Morphological analysis of conodont P2 elements: Hart River Formation, Peel River areas of Yukon Territory

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Conodont samples from the Upper Mississippian Hart River Formation, Yukon Territory yielded abundant specimens from four species in three genera. The conodont animal had fifteen elements that comprise an apparatus and Amanda Lanik is reconstructing these apparatuses for her MSc. The P2 elements are distinguished on aspects of cusp morphology and three morphotypes (P21, P22 & P23) were interpreted through morphologic observation and empirical methods. Chen Shen in a GLGY 599 project investigated 161 P2 elements and measured the 38 most complete to determine whether they could be distinguished using principal component analysis (PCA). In addition, this study investigated temporal variations to determine how one P2 type changed with stratigraphic position. Measurements were acquired using the Motic Images Plus 2.0 software on a desktop PC and data were analyzed using PAST software. The analysis yielded three principal components that accounted for 90.77% of variation: PC1 contrasts the cusp height and ventral denticle number, PC2 contrasts ratio of cusp height to mean denticle height versus the mean denticle height, and PC3 contrasts the ratio of cusp base width to mean ventral denticle width and the ratio of cusp height to cusp base width. A scatter plot of the six most completely measured specimens distinguished two groups P23 and P21. Analysis was limited by incomplete datasets because specimens were broken, but some clusters were identified. In addition P21 specimens showed a fluctuating trend temporally. Future work will consider additional variables to distinguish the morphotypes.

Geology of the Oversight Property, Cooke Mountain, Washington: Mapping, petrography, subsurface interpretations, and economic implications

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The Oversight property is located in Ferry County, Washington. The area hosts altered, oxidized and low-grade metamorphosed stratigraphy from the Quesnellia terrane, along with an abundance of later intrusions. The stratigraphy of the Oversight property is identical to the bordering volcanogenic Overlook gold deposit, except that the Overlook deposit was classified as overturned (Rasmussen, 1993; Cheney, 1998). The gold at Overlook was hosted in a tabular massive magnetite/sulphide body and was mined from 1990-1992. Exploration at Oversight has been targeting the same massive magnetite/sulphide body along with associated gold rich veins which, are hosted in the upright stratigraphy.
This study conducted detailed outcrop scale exploration mapping and sample collection throughout the Oversight property. Ten separate lithologies were identified and analyzed, including carbonates and clastics from the Permian Attwood Group, a conglomerate from the Triassic Brooklyn formation, three separate Eocene (?) intrusions—two of which had been previously unstudied, and the economically targeted massive sulphides/magnetite.

Two separate subsurface models were proposed, a linear projection model and a fold-fault model, in order to explain the contrast between the overturned stratigraphy at Overlook and the seemingly upright stratigraphy at Oversight.
The volcanogenic depositional model applied to Overlook by Rasmussen (1993) was also adopted for the interconnected Oversight deposit. However, the specific depositional categorization proposed by Rasmussen (1993) was challenged. Instead, a more simplistic and frequently occurring model of low base metal VMS with later replacement of iron oxides is suggested.

Nonstationary L1 adaptive subtraction with application to internal multiple attenuation

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Multiple reflections are frequently undesirable in the processing and interpretation of seismic data. Computationally inexpensive multiple removal algorithms are restricted to special cases and typically fail in more complex environments. In these situations, inverse scattering internal multiple prediction offers a reliable method of predicting the multiples in measured data in a purely data driven manner, applicable to complex media. The generated multiple predictions are inexact however, and so cannot be directly subtracted from the data. Adaptive subtraction is process of matching the predicted multiples to those observed prior to the subtraction. Classic, L2, stationary adaptive subtractions however, are prone to unwanted removal of primary reflections and inadequate matching to observed multiples when the desired corrections are time or space variant. This research highlights the advantages of an L1, nonstationary adaptive subtraction over the L2, stationary one, particularly focusing on the case of internal multiple removal. Examples on both synthetically modeled and physically modeled data are shown.

Thermal maturity and biodegradation geochemistry assessments by ultrahigh-resolution mass spectrometry and principal component analysis

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The development of a multivariate analytical protocol for the geochemical assessment of crude oil samples using electrospray ionization in negative mode, coupled to Fourier transform ion cyclotron resonance mass spectrometry (ESI-N FTICR-MS) and Principal Component Analysis (PCA) is shown in this work. Previously data [1,2] were used as reference datasets, which include genetically related samples generated under differing levels of thermal stress, or samples obtained from different depths in a reservoir containing biodegraded oil. Samples were analyzed using a 12 Tesla Bruker Apex mass spectrometer, and raw data was processed using Composer software (Sierra Analytics). Ragnarok (Aphorist Inc.) was used for FTICR-MS data visualization, while Matlab R2014b (Mathworks) and PLS_Toolbox (Eivenvector Research Inc.) were used for PCA analysis. Detected molecular formulae and their monoisotopic intensity were organized in a matrix, where the heteroatom class, double bond equivalent (DBE) were labeled for compositional sorting. Data were mean centered, and the two first principal components explained 99.3% of the variance in both datasets. Class N1 (typically alkylated carbazoles) DBE 9 and DBE>12 species showed opposite trends with increasing oil thermal maturity. For the

biodegradation set, an increase in relative abundance of class O2 DBE 1-3 species, potentially naphthenic acids, was observed for samples closer to the oil-water transition zone. Such results show that ESI-N FT-ICR MS data, allied to PCA, was proven valuable for semi-automated geochemistry interpretations, identifying critical DBEs, carbon numbers and/or heteroatom class changes related to the geochemical processes of interest.

Unveiling geochemical processes during ombrotrophic peat bogs formation in northeastern Alberta – Case study of Mildred peat bog

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Ombrotrophic peat-bogs cover 75% of Northeastern Alberta surface [1]. Developed predominantly by atmospheric water input, these peatlands are optimal recorders of paleoenvironmental and anthropogenically induced changes. In this study, we evaluated subtle compositional changes on a peat-bog core located nearby the Athabasca Oil Sand mining areas by Gas Chromatography Mass Spectrometry (GC-MS) and Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FTICR-MS) using electrospray ionization in negative ion (ESI-N) and atmospheric pressure photoionization in positive (APPI-P) ion modes. The core contains four subfacies described from bottom to top as sediment overlay by transition, peat, and living layers, which were subsampled and cold extracted.
The total extractable organics, relative to the total sample mass, varied from 0.4 to 2.7 wt%. Peat-bog APPI-P FTICR-MS spectra show the presence of hydrocarbons with 0 to 22 double bond equivalents (DBE) with a strong predominance of DBEs 2, 6 and 8 species. Similar class HC DBE distribution was found in sediment spectra, although with higher relative intensities than the peat-bog. ESI-N FTICR-MS spectra showed high relative intensities for nitrogen-containing compounds and classes O2-10 compounds, particularly towards the top of the peat-bog section. The abundance of such compounds decreases with depth, concomitant with an increase in O4- to O2-bearing and pyrrolic nitrogen species. GC-MS data, on the other hand, shows that n-alkanes, with n-alkan-2-ones maximizing at C27 or C29. These presented an odd over even predominance, as well as a prevalence of phytosterols (sitosterol and stigmasterol) over triterpenoids. Together, these results indicate autochthonous higher plant detritus. Changes in molecular composition with depth may suggest specific biomarkers fingerprinting and in situ biomass input. Ongoing microbial degradation and humification processes of these compounds can also explain the observed molecular changes. Moreover, the distribution of alkyl-phenanthrenes in the sediment and adjacent peat-bog indicates the presence of thermally mature organic matter, which is likely a fingerprint of the compounds derived from the oil sands. The characterization approach reported in this study shows great potential for investigating recent and ancient natural fingerprint of oil-derived compounds as well as biomass markers in peat-bogs formed in the Athabasca Bituminous Sand Region, which has major implications for land reclamation studies.

[1] Vitt et al. (1994). Artic and Alpine Research. 26 (1): 1-13.

Rare anomalous optical anisotropy in Almandine, ideally $Fe_3Al_2Si_3O_{12}$

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Almandine (Alm), ideally Fe3Al2Si3O12, with cubic crystal system and space group $Ia\bar{3}d$ is the focus of this study. An Alm sample from the Rocky Mountains fold-and-thrust belt in the Solitude Range, British Columbia has been found as optical anisotropic. This phenomena has been observed for a century in other different garnet compositions. During past years, several hypotheses such as twining, cation ordering, and strain have been assigned as the possible explanation to this anomaly. For this study, new techniques such as electron probe microanalysis (EPMA), and synchrotron high-resolution powder X-ray diffraction (HRPXRD), have been applied in order to study the crystal chemistry and structure to help to explain this optical anomaly in the specific case of Alm. The sample was studied in two different fragments (Alm-1 and Alm2). Rietveld refinement of HRPXRD data was performed, and an intergrowth of three and four cubic Alm phases were found for Alm-1 and Alm-2 respectively, along with a minor phase of quartz for both. The a cell parameter and weight percent for each phase are as follows for Alm-1a: 11.56615(4) Å and wt. %: 70.9(1), Alm-1b: 11.55999(1) Å and wt. %: 24.2(1), Alm-1c: 11.54858(7) Å and wt. %: 1.8(1), quartz: a =4.91432(6), c=5.4060(1) Å and wt. %: 3.2(1); for Alm-2a: 11.58726(3) Å and wt. %: 29.2(1), Alm-2b: 11.57206(4) Å and wt. %: 41.9, Alm-2c: 11.56069(5) Å and wt. %:16.3(1), Alm-2d: 11.54978(4) Å and wt. %: 8.4(1), quartz: a =4.91412(4), c=5.40573(7) Å and wt. %: 4.1(1). Single-phase refinement was also performed for each fragment in order to compare this results with the multi-phase refinement. The a cell parameter varies from one phase to the other, due to compositional variations between them. These Alm phases were matched with EPMA results. Based on Alm content, compositions range from {Fe2.080Mg0.122Mn0.221Ca0.557}Σ=2.980[Al1.969Si0.045Ti0.006]Σ=2.020(Si)3.000O12, Alm69.35Grs17.67 Sp7.37Py4.07 to {Fe2.399Mg0.316Mn0.002Ca0.245}Σ=2.962[Al1.996Cr0.001Si0.039Ti0.002]Σ=2.038(Si)3.000O12, Alm79.98Grs8.12 Py10.52Sp0.08Uv0.04.

Earliest Triassic refuge at Shangsi China: A potential analogue for modern marine crisis

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In the coming century, the ocean may be faced with a series of environmental perturbations that have no recent analog. Therefore, it is important to look back in Earth's history, to times such as the end-Permian mass extinction or EPME, when comparable environmental conditions provide a

baseline for comparison with the present-day. The EPME is associated with acidification, anoxia and warming of the ocean. The synergistic effects of these conditions might be especially informative for understanding future changes in marine ecosystems. More importantly, understanding how marine refugia were developed and maintained following the EPME could help predict marine ecosystems that are most likely to survive and predominate in the coming centuries. Refugia are sanctuaries to which organisms migrate during times of environmental stress and are therefore essential to the survival of key species during mass extinction events. The capability of refugia to protect threatened species can be seen clearly in a large bedding surface within bed 29 at the Shangsi section, South China. This surface provides a snapshot of an oligophotic outer-shelf ocean floor during the earliest Triassic. Echinoderm groups experienced extreme bottlenecks during the EPME however; bed 29 at Shangsi contains a significant echinoid community. Abundant microbial mats found within bed 29 could have served as a major food source and firm substrate for echinoids. Geochemical evidence indicates that anoxic conditions prevailed during this interval, but the occurrence of bivalves and trace fossils indicate that bottom water conditions were temporarily oxygenated within this isolated marine refuge.

The description of three distal tibiae from Early Miocene Nepak, Uganda

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Three distal tibiae were found in Napak Uganda, BUMP 99, BUMP 764 and 2381. These specimens have not yet been described or assigned to taxa, but one has been qualitatively and informally assigned to Limnopithecus. This report aims to confirm or deny this suggestion and provide possible taxon for these tibiae. To accomplish this, we conducted body-size estimates of each tibial articular surface and other known dental material of Limnopithecus and a population of 33 Macaca fuscata tibiae. The Macaca population provides a canon of how much variation is typical within a primate of similar size to specimens 99, 769 and 2381. It is used to assess whether the body size estimates from the tibiae fall within an acceptable range as the body size estimates from the dental remains of other primates that are known to live in Napak at a similar time. The variation within the Macaca population show a coefficient of variation of 19.2%. Specimens 99 and 2381 fall well within this range for Lomorupithecus, and 2381 falling also within the range for Kalepithecus. However they both show the greatest similarity with Limnopithecus, falling 3.4% and 0.2%, respectively, from the published weight estimates for the species, though, both do not share enough morphological similarities with each other to be considered the same taxa. Specimen 769 does not fall within 19.2% of the mean of any known primate species from early Miocene Napak, in being significantly smaller than even Micropithecus. It is concluded that either Micropithecus shows a greater variation than modern macaques, or specimen 764 represents species not yet described from this area.

NOTES

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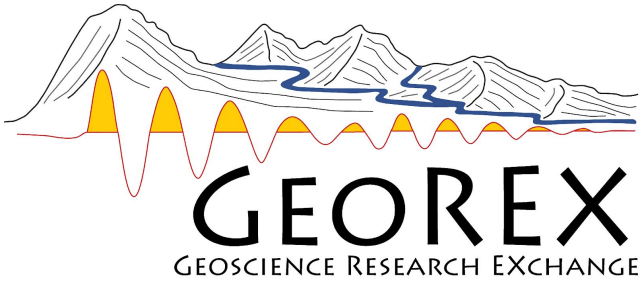
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