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Abstract and Summary Volume

Cover photograph

Pillow basalts, NWT;
Viktor Terlaky, Senior Petroleum Geologist at the Northwest Territories Geological Survey

The picture was taken near Sunset Lake and shows Archean pillow basalts in the southern Slave Province, NWT. The basalts are part of the Beaulieu River Volcanic Belt, which overlies the Sleepy Dragon Gneissic Complex. The base of the volcanic belt consists of a thick sequence of basaltic and rhyolitic rocks interfingered with minor interflow sedimentary rock. These supracrustal rocks were intruded by younger mafic Proterozoic dykes, as observed in the foreground of this photo.

Compiled by D. Irwin, S.D. Gervais, and V. Terlaky

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INDIGENOUS ENGAGEMENT IN THE MINING SECTOR: LESSONS FROM ONTARIO

ABOUCHAR, J.

WILLMS & SHIER ENVIRONMENTAL LAWYERS LLP, TORONTO, ON
JABOUCHAR@WILLMSSHIER.COM

The Government of the Northwest Territories is consulting about a Discussion Paper (August 2017) for a Mineral Resources Act (MRA). One of the topics is how to promote meaningful engagement between mining proponents and Indigenous partners, and to better define and clarify rights and responsibilities of governments, mining companies, Indigenous communities and other partners and stakeholders. The discussion paper recognizes that clear guidance can ensure that legal obligations are met, rights protected and common pitfalls that could frustrate engagement, consultation and the regulatory process are avoided.

About 10 years ago, Ontario embarked on its Mining Act Modernization process including similar goals around Indigenous engagement. This presentation will give a brief overview of the Ontario Mining Act modernization intended to clarify the roles, responsibilities and timing of Indigenous consultation and engagement. The balance of the presentation will assess how it has been working on the ground in practice. It is hoped that the presentation may provide food for thought for parties interested in and responding to the NWT Discussion Paper on an MRA.

Topics of discussion will include:

- Exploration Plans, Exploration Permits, Closure Plans and the requirements for Indigenous consultation.
- Who does what?
- Dealing with disputes.
- Assessment work credits for engagement and consultation.
- Withdrawing sites of Aboriginal cultural significance.
- Remaining areas of uncertainty/ disagreement in consultation process.

EVIDENCE FOR MAFIC-MAGMA DERIVED HYDROTHERMAL FLUIDS IN RARE EARTH ELEMENT SIGNATURES AND MELT INCLUSIONS OF MAGMATIC AND HYDROTHERMAL APATITE FROM THE CANTUNG W-CU SKARN DEPOSIT, NORTHWEST TERRITORIES

ADLAKHA*, E.E.[1], HANLEY, J.J.[1], FALCK, H.E.[2], and BOUCHER, B.[3]

(1) SAINT MARY'S UNIVERSITY, HALIFAX, NS
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(3) UNIVERSITY OF NEW BRUNSWICK, FREDERICTON, NB
ERIN.ADLAKHA@SMU.CA

The distribution and abundance of major, minor, and trace elements in hydrothermal and magmatic apatite associated with the Cantung W-Cu skarn deposit, Northwest Territories, Canada was studied to constrain

the origin of mineralizing fluids. Skarn-hosted apatite of hydrothermal origin occur in carbonate-hosted garnet-clinopyroxene, amphibole and biotite skarn, and precedes scheelite and silicate crystallization. Skarn-hosted apatite are compositionally similar to magmatic apatite with respect to Mn, Fe, Pb, and Sr contents, but show very different chondrite-normalized rare-earth element (REE) and Y abundance patterns. Skarn-hosted apatite exhibit four different patterns: i) negatively sloped (average La_N/Yb_N range 3.9 to 10) patterns with negative Eu anomalies (average Eu_N/Eu^* ranging 0.3 to 0.4; whereby $Eu^* = \sqrt{[Sm_N*Gd_N]}$) are most common and reflect equilibrium with fluids derived from a felsic magma, ii) flat patterns (average $La_N/Yb_N = 1.3$) and strong negative Eu anomalies (average Eu_N/Eu^* of 0.09), record the evolution of the felsic magma during fractional crystallization of feldspar and light REE (LREE)-rich phases, iii) steeply dipping (average $La_N/Yb_N = 127$) patterns with negative Eu anomalies (average $Eu_N/Eu^* = 0.6$) indicate diffusion of heavy REEs (HREEs) into surrounding garnet, or crystallization of apatite from metamorphic fluids, and iv) concave up patterns with positive Eu anomalies (Eu_N/Eu^* ranging 1.5 to 8.8) suggest equilibration with fluid derived from an amphibole-saturated mafic magma. Mafic magmas in the system are evidenced by the presence of high-Mg mafic melt inclusions in xenocrystic magmatic apatite in the nearby, early (with respect to skarn formation) Mine Stock monzogranite pluton, and the presence of lamprophyre dykes near sites of mineralization. The data indicates that high W contents in fluids may ultimately be sourced from mafic magma through mixing with a felsic melt in a deep crustal magma chamber. Skarn-associated apatite can be differentiated from magmatic apatite by relative abundances of Mn, Fe, Sr, As and REE.

DIAVIK DIAMOND MINES - 2016 SOCIO-ECONOMIC MONITORING AGREEMENT PERFORMANCE

ALTY, R.

RIO TINTO, YELLOWKNIFE, NT
REBECCA.ALTY@RIOTINTO.COM

At Diavik, sustainable development is integrated into everything we do. Our operations provide benefits and opportunities for local communities, businesses, and governments. We work with all our stakeholders to deliver substantial and lasting benefits.

The Diavik sustainable development report is a requirement under the Diavik socio-economic monitoring agreement (SEMA). Through this report information on annual training, employment, business benefits, and community initiatives are available to the public. During this session of the Geoscience discussion, we will be sharing the Diavik Diamond mine performance under the SEMA up to and including December 2016.

FIVE YEARS OF MONITORING TEST SECTIONS ALONG HIGHWAY 3 NEAR YELLOWKNIFE, NORTHWEST TERRITORIES

ARENSON*, L.U.[1], STIRLING, J.L.[1], SETO, J.T.C.[2], and ABU BAKAR, M.[3]

(1) BGC ENGINEERING INC., VANCOUVER, BC
(2) BGC ENGINEERING INC., EDMONTON, AB
(3) DEPARTMENT OF TRANSPORTATION, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
LARENSON@BGCENGINEERING.CA

The Yellowknife Highway (NWT No. 3) travels from the Mackenzie Highway near

Fort Providence to Yellowknife, and is the only all-weather road access from southern Canada. In the mid-1960s it was constructed as a clay road embankment with a gravel surface. The last 100 km of the highway is in an area of extensive discontinuous permafrost in the Great Slave Lowlands, with terrain alternating between bedrock outcrops and ice-rich lacustrine sediments.

Ground temperatures are typically warmer than -1°C and extensive permafrost degradation has been noted in recent years. The final 100 kilometres of Highway 3 was re-aligned between 1999 and 2006 to be much straighter and to maximize the length built on bedrock to provide a stable embankment foundation. Coarse blast rock was used as material for the embankment fill. However, higher than expected maintenance efforts were required following the reconstruction. In 2012, four test sections were constructed to evaluate potential mitigation techniques for road embankments constructed on warm permafrost foundations. The test sections involved various levels of embankment reconstruction, from dressing the existing side slopes, to partial and full replacement of the road embankment fills. Thermistors were installed in the test sections to measure embankment temperatures and inspections have been carried out to monitor the thermal and structural performance of the road embankment.

We present results from five years of monitoring, which were, on average, 0.6°C warmer than the 1981-2010 mean air temperature. During the last three years, air temperatures have been significantly warmer than the long-term average, which resulted in higher than normal distress to Highway 3's embankments, including the test sections. While some of the mitigation designs seem to show a relative cooling of the road embankment temperatures, it did not stop further degradation and road deformation. In addition, an initial evaluation of the results indicates that the geotextile reinforcement installed in the road embankment to limit differential settlements within high embankments at the bedrock to ice-rich sediment deposit interfaces may not have been sufficiently extended over the bedrock sections. Nevertheless, it was demonstrated that an air convection shoulder constructed of cobbles and boulders can reduce the temperatures at the toe of the embankment in this area on average by 2.5 degrees over the 5 years. For the test sections with a thin embankment, the geogrid reinforcement and the cellular concrete seemed to have provided additional stability to the fill, as the road surface at these sections have not experienced visual distress.

Five years of monitoring of the test sections along Highway 3 have demonstrated that the construction and maintenance of highway infrastructure on warm, ice-rich permafrost is extremely challenging and a paradigm shift in road design is required. Engineers, owners, and the public must accept that and thereby budget for such roads requiring significant ongoing maintenance efforts. Designing such roads to preserve the ice-rich and warm permafrost foundation is likely uneconomic, if not impossible, particularly during a period of an increasingly warming climate. Consequently, some extent of permafrost degradation must be accepted in the design.

EFFECT OF LEGACY POLLUTION FROM GOLD MINES ON MERCURY METHYLATION IN LAKES NEAR YELLOWKNIFE, NORTHWEST TERRITORIES

AZDAJIC*, M., BLAIS, J.M., POULAIN, A.J., and YUMVIHOZE, E.

UNIVERSITY OF OTTAWA, OTTAWA, ON
MAZDA030@UOTTAWA.CA

Mercury (Hg) is a global pollutant that bioaccumulates in aquatic and terrestrial foodwebs as monomethylmercury (MMHg). Microbial activity is the main driver of MMHg production, with sulfate reducing bacteria being a major contributor. The roasting of arsenopyrite at Giant Mine in Yellowknife, NWT, has created strong environmental gradients of sulfate in lakes in the surrounding area with distance from the mine. Whereas total Hg levels remain constant with increasing distance from the mine, the ratio of MMHg relative to total Hg increases with proximity to the stack. We hypothesized that high sulfate in lakes near the mine may be responsible for elevated MMHg concentrations in those same areas. To test our hypothesis, we sampled water and sediments from lakes spanning a range of distance to Giant Mine. We determine simultaneous methylation and demethylation rates using stable isotope analysis and characterized the microbial community using high throughput sequencing of 16S rRNA genes. By analyzing methylmercury production and microbial community composition, we have identified sulphate as being the main driver of both final concentrations of methylmercury and microbial community structure.

KELVIN AND FARADAY KIMBERLITE EMPLACEMENT GEOMETRIES AND IMPLICATIONS FOR SUBTERRANEAN MAGMATIC PROCESSES

BARNETT, W.[1], STUBLEY, M.[2], HRKAC, C.[3], HETMAN, C.M.[1], and MCCANDLESS*, T.[4]

(1) SRK CONSULTING, VANCOUVER, BC
(2) STUBLEY GEOSCIENCE LTD., COCHRANE, AB
(3) AURORA GEOSCIENCES LTD., YELLOWKNIFE, NT
(4) MCC GEOSCIENCE INC., VANCOUVER, BC
MCCGEOSCIENCE@GMAIL.COM

The Kennady North Project kimberlites are located approximately 280 kilometers east-northeast of Yellowknife, in the Northwest Territories of Canada. The unusual geometry and extent of the kimberlite magmatic system is revealed by renewed exploration drilling activities by Kennady Diamonds since 2012. It has become clear that the system comprises multiple intrusive dykes within which several volcaniclastic bodies have developed, all within 11 kilometres of the Gahcho Kué kimberlite cluster and diamond mine. The detailed exploration of the entire system provides unique evidence for subterranean volcanic conduit growth processes that may have scientific and practical exploration benefits.

The identified Kennady North Project volcaniclastic bodies are named Kelvin, Faraday 1, Faraday 2 and Faraday 3, and have complex geometries atypical of the more common subvertical kimberlite pipes. Rather, these pipe-like bodies are inclined between 12 and 30 degrees towards the northwest. Kelvin has sharp angular change in trend towards the north. On-going detailed petrographic studies have shown

that the pipes contain layers of complex volcaniclastic units with variable volumes of xenolithic fragments, as well as coherent magmatic layers. The pipe textures include evidence for high energy magma and country rock fragmentation processes typically observed in open volcanic systems.

The pipes have developed within a shallow 20 degree northwest dipping kimberlite dyke system. Detailed structural geology studies, using fault observations in oriented and unoriented drill core, have identified at least two important fault-fracture trends. The first fault-fracture system is parallel to the dyke segments, and likely related to the intrusion of the dykes and the regional stress tensor during emplacement. The second fault system is subvertical and north-south striking, parallel to the lithological layering within the metasedimentary country rock. The north-south faults match the contact geometry of the Kelvin pipe's north-south limb exactly.

The dykes have been 3-D modelled along with the pipes. Three possible renditions of the dykes have been created, based on different interpretations of dyke segment continuity. The renditions have been labelled "Optimistic", "Realistic" and "Pessimistic". The assumptions made have important implications for developing dyke-type mineral resources.

The realistic dyke model defines dyke segments that intersect the Kelvin pipe, and those intersections match geometric trends and irregularities in the pipe shape. The coincidental geometries strongly imply that the pipe development interacted with a penecontemporaneous dyke system. The north-south faults also controlled the local trend of Kelvin pipe development, possibly by enhancing fluid permeability, alteration and brecciation along the faults, connecting from one shallow dipping dyke to the next above. Breccia bodies have been observed on similar dipping dykes at Snap Lake mine that intersect fault structures. We conclude that the pipe development geometry and process is governed by a combination of stress, structure and magmatic fluids, and speculate on the nature of the energy required for fragmentation and development of the pipe at some still unknown depth in the crust.

EXPLORATION ASSESSMENTS DIGITAL DATA FORMATTING — A PROPOSED NATIONAL STANDARD

BELANGER, A.

PROSPECTORS AND DEVELOPERS ASSOCIATION OF CANADA, TORONTO, ON
ACBELANGE@GMAIL.COM

This presentation will provide an overview of the need for improved exploration assessment data in all jurisdictions across Canada and the PDAC's Exploration Assessment Data Digital Formats project that outlines a standard set of guidelines for the submittal of data in a digital format.

A robust mineral exploration sector is vital to the success of Canada's mineral industry. Without mineral exploration success, there will be no discoveries of mineral deposits, some of which eventually become the mines of tomorrow. With respect to exploration effectiveness, Canada now ranks below Australia and Canada's return on exploration investment was only 0.77 for every dollar spent between 2005 and 2014, while Australia's was 0.97. This question of discovery performance is a technical one. There are a number of variables affecting the discovery performance of companies exploring in Canada, including the greater costs of exploration at depth and in remote

areas. However, one key variable affecting discovery performance is the availability of geoscience information to assist with land acquisition and targeting decisions.

Improvements to the type, quality, quantity and accessibility of geoscience data available to all companies and stakeholders within the mineral exploration industry can positively impact discovery rates. Canadian jurisdictions have a wide range of requirements for prospectors, mineral exploration companies and mining corporations for submitting digital data in exchange for assessment credits. No jurisdictions require metadata to be submitted, or specify any minimal standards for data submission such as what table and field names should be included and how metadata should be organized. For subsequent users of the assessment data, integrating data embedded in PDF files with existing exploration databases is difficult and time consuming. The guidelines presented here, if adopted, will facilitate the submission of assessment data in digital form with hopes of improving data sharing, exploration efficiency and discovery rates.

A NEW FRONTIER FOR THE ACASTA GNEISS COMPLEX: THE OLDEST EVOLVED CRUST ON EARTH

BELOSEVIC*, M.B., CHACKO, T., and HEAMAN, L.M.

UNIVERSITY OF ALBERTA, EDMONTON, AB
BELOSEVI@UALBERTA.CA

The mechanisms of formation of our planet's earliest crust are the subject of debate among many scientists around the world. Because of Earth's geologically active nature, rocks formed during the first billion years of Earth history are relatively rare, making it difficult to draw precise conclusions about the processes operating at that time. As such, the few localities worldwide that are known to contain rocks from the first billion years of Earth history need to be intensively studied. The Acasta Gneiss Complex (AGC) in Northwest Territories, Canada is one such locality. It is an enclave of highly deformed, amphibolite-grade, mixed gneisses on the western margin of the Slave craton. Despite the fact that the AGC occupies a total area of ~1300 km^2, to date, nearly all previous geological work in the AGC has been conducted on a 6 x 6 km area surrounding the original discovery site of old rocks on the Acasta River. Thus, the vast majority of the AGC remains unstudied.

In order to further our understanding of the AGC as a whole, we carried out a field campaign on a new area (informally "Moose Lake") within the AGC, approximately 9 km southwest of the original discovery site. The objectives of the study include: 1) the preparation of a 3 x 5 km geological map of the Moose Lake field area, 2) obtaining representative samples of the rock units for subsequent petrographic, geochemical and isotopic study, 3) using zircon uranium-lead (U-Pb) geochronology to determine the magmatic and metamorphic ages of the rock units, and 4) integrating the field and laboratory data into a geological and tectonic model for the formation of the AGC.

The Moose Lake field area contains five major lithologies: mixed granitoids (tonalitic to granodioritic gneisses and syn-tectonic granitoids), coarse-grained metagabbro, fine-grained amphibolite, garnet-biotite gneisses possibly of metasedimentary origin, and a later-stage, foliated granodiorite. The area is regionally metamorphosed to amphibolite grade and displays a dominant NE-SW trending, steeply dipping foliation. The rock units in the Moose Lake area are

broadly similar to those documented in the Acasta River area, although the foliated granodiorite unit is more regionally extensive at Moose Lake. In-situ U-Pb ages have been obtained for each of the major units by laser ablation multi-collector inductively coupled plasma mass spectrometry. The most significant discovery is a well constrained age of 3730.3 ± 3.0 Ma for the metagabbro, which although one of the most prominent units of the AGC, had not previously been well constrained.

COST-EFFECTIVE WATER BASELINE ENVIRONMENTAL MONITORING OF NORTHERN WATERWAYS

BENNETT, J.[1], YUE, B.[1], CHAMBERLAND, J.[1], and ADLAKHA*, P.[2]

(1) C-CORE, OTTAWA, ON
(2) C-CORE, HALIFAX, NS
PAUL.ADLAKHA@C-CORE.CA

Local and community based water sampling form the backbone of any water monitoring program. Sample analysis can yield information on water chemical content, temporal changes, and variability through time, and can help community members, scientists and governments make informed decisions. The keys to success for any regional or even territorial water monitoring program are to maximize in-situ sampling, while developing techniques and tools to understand changes within regions at which in-situ sampling is either not possible, or sparse. This talk will present an example of satellite remote sensing techniques using freely available data that can, and are being used to help fill this gap in water monitoring within the Northwest Territories (NWT).

Communities along the Slave River and Delta (SR&D), in collaboration with the Government of the Northwest Territories Department of Environment and Natural Resources (ENR), have observed and defined changes in their aquatic environment. Through satellite remote sensing research and development that was initiated under a previous NWT Cumulative Impact Monitoring Program (NWT CIMP) project (2011), and a committed community sampling program, a 10-year archive of water temperature and suspended sediment concentrations was generated and made available through a community based web-portal in 2016.

The water products have continued to be generated and uploaded to the portal through the 2017 season, and community work, now funded by ENR, has continued within the SR&D and onto Great Slave Lake to expand the product suite up the lake and toward the Mackenzie River. The end goal of this project is to provide a portal that will contain all water related products and history from the NWT-Alberta border, all the way up the Mackenzie Delta.

CURRENT STATUS OF MINERAL TENURE IN THE NORTHWEST TERRITORIES

BHUIYAN, M.

MINING RECORDER'S OFFICE, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
MOHAMMAD_BHUIYAN@GOV.NT.CA

A brief snapshot of the state of mineral tenure and exploration activities, stages of various mining company projects and a brief description of exploration benefit incentives to encourage and support prospectors, companies and work required to be done to keep mineral claims in good standing.

MARIAN WATERSHED STEWARDSHIP PROGRAM

BIRLEA, M.

TŁĮCHǪ GOVERNMENT, BEHCHOKǪ̀, NT
MICHAELBIRLEA@TLICHO.COM

The Tłı̨chǫ Government is working together with Wek'èezhìi Land and Water Board (WLWB) and other partners to develop the Marian Watershed Community-Based Aquatic Effects Monitoring Program. This is a community-based monitoring program that is being developed based on the questions and needs of the Tłı̨chǫ people.

Tłı̨chǫ Lands have been under Moratorium since the signing of the Tłı̨chǫ Agreement in 2005 and on June 1, 2013, the Moratorium was lifted as the Tłı̨chǫ Wenek'e or Land Use Plan came into force. With the potential for future development of Tłı̨chǫ Lands, the Tłı̨chǫ people have expressed concern about impacts on the water and wildlife they are so dependent upon. The objective of the Marian Watershed Monitoring Program is to begin collecting baseline information about the water and fish on Tłı̨chǫ lands and in locations the Tłı̨chǫ feel are the most important, prior to any major development pressure (such as the NICO mine by Fortune), and to continue collecting this data over time. Community members are being trained to collect samples, analyze the samples, and report findings back to the rest of the community members.

A pilot project was conducted at Hislop Lake, upstream of the planned NICO Mine site, in the fall of 2013. This project included the training of eight community members and a field program where the newly trained Environmental Monitors worked with scientists to investigate the concerns of the elders and community members.

A workshop was organized by the Department of Culture and Lands Protection (DCLP) in the spring of 2017 to bring back the results from the Hislop Lake camp and to develop a long term monitoring plan that truly addresses the concerns of the elders. We identified important field sites along the Marian River from Hislop Lake to Marian Lake, which will be visited on a four-year cycle. The DCLP organized the fifth field program this fall on Hislop Lake, where the Environmental Monitors worked with the scientist to investigate the concerns from the elders and communities.

The ongoing program will facilitate enhanced understanding of fish health and water chemistry each year, ensure active monitoring of Tłı̨chǫ waters by Tłı̨chǫ people, and prioritize meaningful communication back to community members.

AN EXPERIMENTAL STUDY OF PERMAFROST RESTORATION UNDER THE SEISMIC LINE IN THE WETLAND-DOMINATED ZONE OF DISCONTINUOUS PERMAFROST, NORTHWEST TERRITORIES, CANADA

BRAVERMAN*, M.[1] and QUINTON, W.L.[2]

(1) GHD, WATERLOO, ON
(2) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
MICHAEL.BRAVERMAN@GHD.COM

Thermosyphons are closed-system heat extraction devices. They extract heat from the ground, cooling permafrost and contributing to the maintenance of temperature below zero. Two types of thermosyphons are known: passive and hybrid thermosyphons. Passive systems do not require any external power to operate.

The hybrid installation combines the passive system, which operates in winter time and a refrigeration compressor, which maintains the negative soil temperature in summer time. The most common type of thermosyphon is the carbon dioxide filled vessel under a pressure varying from about 2100 to 4800 kPa. Thermosyphon technology is successfully used for stabilization of building foundations and frozen core of dams, and in thermopiles along the pipelines. While passive thermosyphons do not require extensive maintenance, they do require specially trained personnel for installation. Also, the high cost of the thermosyphons limit their extensive use under linear infrastructure. The liquid based thermosyphon was developed as an inexpensive alternative to the carbon dioxide system as part of a collaborative R&D project with Wilfrid Laurier University and GHD Canada. The technical aspects of experimental thermosyphon are described and discussed. Also, this article presents the test results obtained from the degraded permafrost site equipped with the proposed type of thermosyphons.

THE TECHNICAL OPPORTUNITIES AND ECONOMIC IMPLICATIONS OF PERMAFROST DECAY ON PUBLIC INFRASTRUCTURE IN THE NORTHWEST TERRITORIES

BROWN, S.

NWT ASSOCIATION OF COMMUNITIES,
YELLOWKNIFE, NT
SARA@NWTAC.COM

Through funding from Canadian Northern Economic Development Agency (CanNor), the NWT Association of Communities, working with geotechnical experts and environmental economists, produced a report which provides an economic analysis linking climate change and ambient air temperature to permafrost decay and premature infrastructure failure in 33 Northwest Territory communities. The report adopts two economic perspectives: one identifies the economic value at risk when public infrastructure fails prematurely; and, the second identifies the lost economic activity associated with the economic value at risk.

We focus our analysis on eight types of infrastructure in the 33 communities:

- Over 1,740 government buildings;
- 611 km of community roads and 1,319 km of highways;
- 96 bridges and 230 culverts;
- 42 sewer systems assets and 72 drinking water assets; and
- 28 airports.

Based on the analysis, we conclude there is a high likelihood of significant economic costs in all 33 NWT communities that can be attributed to permafrost impacts on community, territorial and federal assets. The total costs of the permafrost impact on assets in the 33 communities is in the order of $1.3 billion. On an annual basis, the economic losses are likely in the order of $51 million. The study also compares the value at risk relative to the $5.2 billion worth of infrastructure. The study concludes with recommendations of next steps and technical opportunities that may be realized.

PREDICTING LIQUID WATER CONTENT IN PERMAFROST FROM TEMPERATURE TIME SERIES: THE IMPORTANCE OF A STRUCTURALLY SOUND MODEL

BROWN*, N. and GRUBER, S.

CARLETON UNIVERSITY, OTTAWA, ON
NICK.BROWN@CARLETON.CA

Ground temperature measurements are typically used to monitor permafrost. In thawing permafrost, temperature changes with time are often very slight, intuitively creating the misleading impression that little change occurs. During this time, latent heat transfer is strong and the amounts of ice, liquid water, and energy in the soil can change strongly while temperature change is subdued. Given that changes in subsurface ice and liquid water contents are significant for human and biophysical systems, as well as for calculating the latent heat associated with ground energy fluxes, it would be desirable to monitor these changes in warming permafrost. Unfortunately, such measurements are rarely collected.

Previous studies have demonstrated that soil properties can be estimated by using observed temperature time-series to fit the parameters of a numerical model. To this end, two techniques, the differential evolution search algorithm and generalized likelihood uncertainty estimation, are used to estimate soil properties from temperature data using the GEOtop model. In this, we aim to estimate changing liquid-water content in soil based on fitted model parameters. Both methods exhibit promising results with synthetic data, and are able to accurately estimate soil properties, even with the addition of noise into the synthetically generated 'observational' data. Tests with field data, however, demonstrate that even when fitted parameters are suitable for reproducing temperature observations, they may not be appropriate for calculating liquid water contents. The choice of cost function is known to significantly influence the results in parameter-fitting studies, so the effect of incorporating information about heat content into the cost function is also evaluated. This new cost function is shown to yield poorer estimates of soil properties with the exception of the soil freezing temperature.

We conclude the mismatch between model structure and measured locations to be the likely cause for the difference in performance between synthetic and observed data. For example, seasonal variation of water content within the active layer, heterogeneity and 3D effects near the surface, or the loss of excess ice can affect how well the assumed 1D homogeneous soil column can represent reality. An understanding of how the uncertainty in model parameters propagates to predictions of liquid water content derived from temperature data will be essential as permafrost continues to thaw. The current inability to fitted model parameters suitable for simulating liquid-water content in permafrost points to our limited capacity to monitor and predict relevant change in permafrost.

STATUS REPORT ON THE GNWT'S PETROLEUM RESOURCES DIVISION'S CURRENT AND PLANNED ACTIVITIES

BUTTERS, T.I.

PETROLEUM RESOURSES DIVISION, GOVERNMENT OF NORTHWEST TERRITORIES, INUVIK, NT
IAN_BUTTERS@GOV.NT.CA

The Government of Northwest Territories' (GNWT) Department of Industry, Tourism and Investment (ITI) is responsible for the administration of onshore oil and gas interests in the Northwest Territories. This talk will highlight the Petroleum Resources Division's (PRD) current and planned activities for fiscal year 2017-2018. Topics covered are 1) an update of industry activity; 2) the current state of oil and gas tenure including exploration licenses, significant discovery licenses, production licenses, and a description of lands currently available for expressions of interest; 3) the recent marketing and promotion initiatives; 4) the anticipated release of the NWT Oil and Gas Strategy in 2018; 5) petroleum resource characterization and assessment of the NWT's Liard and Central NWT corridor (Canol and Bluefish) shale basins; 6) an update on the review of the Petroleum Resources Act and the Oil and Gas Operations Act carried out under the GNWT's mandate commitment.

ASSESSING AND MONITORING PERMAFROST ALONG THE DEMPSTER HIGHWAY, YUKON, USING BOREHOLE DATA AND ERT SURVEYS

CALMELS*, F., ROY, L.-P., and GRANDMONT, K.

YUKON COLLEGE, WHITEHORSE, YT
FCALMELS@YUKONCOLLEGE.YK.CA

The Dempster Highway is a pan-territorial road with an important value as a tourist and economic corridor. Now linked all the way to Tuktoyaktuk, it provides the Vuntut Gwitchin First Nation an access to the southern reaches of their traditional territory. It is therefore critical to perpetuate the Dempster Highway as climate changes in the upcoming decades.

In this regard, understanding the potential impacts of climate change on the Dempster Highway is of the utmost importance to support decisions regarding highway construction and maintenance. Already, climate-related events such as flooding and differential settlement due to permafrost thaw have caused damage to the highway. The Northern Climate ExChanges (NCE) and Yukon Highways and Public Works (HPW) are partnering to establish a functional plan taking in account climate change, as climate-aware planning and engineering will help provide a robust justification for certain work and will also contribute to cost-effective maintenance of the highway.

We present here preliminary results of a large-scale survey aiming to fill important gaps in climate change monitoring and data collection for this region of Yukon. Field investigations included onsite mapping of surficial geology, landforms and features related to permafrost occurrence; permafrost core drilling to investigate ground ice content, soil nature; active layer thickness probing to determine seasonal thaw depth; electrical resistivity tomography (ERT) and ground penetrating radar surveys.

Ground temperature monitoring was implemented; instrumented boreholes will provide a ground thermal monitoring network, and an improved understanding of the permafrost conditions and their potential to respond to climate change.

A total of 17 sites have been investigated, from km 82 to km 458, in both glaciated and unglaciated terrain. The NCE have implemented permafrost monitoring stations at 10 sites, complementing 3 sites already monitored by HPW. Some critical sites that have been investigated in detail, are discussed. A special focus has been on

identifying and mapping massive ice bodies, as their thaw constitutes a major threat for the highway.

The array of permafrost monitoring stations will inform and orient future maintenance policies of HPW; and combined with borehole and geophysical data; it also will contribute to develop the highway as a permafrost research corridor. It will be integrated to the monitoring network that has been progressively developed by the NCE with HPW, currently including more than 40 stations across Yukon.

INTEGRATING UTILITY SCALE SOLAR AND ENERGY STORAGE INTO CANADIAN MINING OPERATIONS RELYING ON DIESEL BACKED MICRO-GRIDS

CAMERON, D.

SOLVEST INC., WHITEHORSE, YT
DCAMERON@SOLVEST.CA

In recent years utility scale solar and energy storage technology has seen a dramatic global uptake in remote mining operations however, the Canadian mining industry has yet to build a single project. The presentation answers why this has yet to occur in Canada and presents three case studies which make a compelling financial argument for why this is about to change.

HOW MIGHT AIRBORNE PARTICULATES IMPACT CARIBOU AROUND AN OPEN PIT MINE IN THE ARCTIC?

CHEN*, W.[1], LEBLANC, S.G.[1], WHITE, H.P.[1], MILAKOVIC, B.[2], ROCK, C.[2], SHARAM, G.[2], O'KEEFE, H.[3], COREY, L.[3], CROFT, B.[4], ADAMCZEWSKI, J.[4], PELLISSEY, J.S.[5], TRACZ, B.[5], GUNN, A.[6], and BOULANGER, J.[7]

(1) NATURAL RESOURCES CANADA, OTTAWA, ON
(2) ENVIRONMENTAL RESOURCES MANAGEMENT LTD., VANCOUVER, BC
(3) DOMINION DIAMOND EKATI CORPORATION, YELLOWKNIFE, NT
(4) ENVIRONMENT AND NATURAL RESOURCES, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
(5) WEK'ÈEZHÌI RENEWABLE RESOURCES BOARD, YELLOWKNIFE, NT
(6) CIRCUMARCTIC RANGIFER MONITORING AND ASSESSMENT NETWORK, SALT SPRING ISLAND, BC
(7) INTEGRATED ECOLOGICAL RESEARCH LTD., NELSON, BC
WENJUN.CHEN@CANADA.CA

Boulanger et al. (2012) estimated the zone of influence (ZOI) for caribou around the Ekati-Diavik mining complex to be 14 km, using caribou aerial survey data and satellite collar data. To date, little is known about the underlying mechanisms that influence the size of the ZOI. Simulations using an air dispersion model showed that the dispersion of airborne particulates (e.g., total suspended particulates, TSP, and fine particulate matter less than 2.5 mm, $PM_{2.5}$) had similar spatial ranges from the mining complex (Rescan, 2006). Airborne particulates include coarse particulate matter (mainly from road dust) and $PM_{2.5}$ (from many sources including road dust, diesel fuel combustion, burning of garbage, and forest fire smoke). Air quality related to the dispersion of airborne particles

from the mining complex was thus suggested to be a possible mechanism contributing to the ZOI for caribou.

Many people observed that this was a vague proposition, which didn't specify how exactly airborne particulates from the mines might have impacted caribou's behaviour and thus the ZOI. Our CIMP project entitled "Satellite Monitoring for Assessing Resource Development's Impact on Bathurst Caribou (SMART)," explores specific ways or mechanisms with which airborne particles might affect caribou. First, dust deposition may influence the availability and quality of caribou forage. Caribou may taste the difference in forage and respond. Second, caribou may see a dust plume from a mining road and move away from it. Finally, caribou may smell the difference in air quality and respond accordingly.

For the first mechanism, our study estimated that the zone of dust disturbance around the Ekati Diamond Mine is about 1 km, a conclusion supported by a convergence of observational evidence. Within the 1 km distance from a busy road, we found an increase in the amount of dust on leaves, and a reduction in lichen availability associated with the increase in soil pH. For the second mechanism, our analysis indicated that the distance within which caribou see a dust plume is about 2 km, assuming that the height of a dust plume is 8 m and the visual threshold is less than 2% of the dust plume visible. These assumptions were made on the basis of field observation and other studies. Nevertheless, we emphasize that the height of a dust plume may vary with wind speed, vehicle type and its travel speed, and road conditions. Together, our results regarding these two mechanisms suggest that dust impacts on caribou behaviour could reach up to 2 km, but cannot explain the 14 km ZOI.

Regarding the third mechanism (i.e., caribou may smell and thus react to the difference in air quality), there are many unanswered questions. For example, what are the tempo-spatial patterns of TSP and $PM_{2.5}$ around the Ekati Diamond Mine? Which kind and level of TSP and $PM_{2.5}$ changes may be detectable by smell? In this presentation, we will report our initial analysis on these questions, using field surveys, remote sensing products, and other monitoring data.

PALEOECOTOXICOLOGY AS A TOOL TO ASSESS THE TOXICITY OF LAKE SEDIMENTS AT GIANT MINE

CHENEY*, C.L.[1], POTHIER, M.P.[1], POULAIN, A.J.[1], THIENPONT, J.R.[1], KOROSI, J.B.[2], KIMPE, L.E.[1], and BLAIS, J.M.[1]

(1) UNIVERSITY OF OTTAWA, OTTAWA, ON
(2) YORK UNIVERSITY, TORONTO, ON
CCHEN257@UOTTAWA.CA

Giant Mine released particulate arsenic trioxide to the atmosphere from its roaster stack, which was consequently deposited to the surrounding landscape. Here we characterize the extent of contamination to lake sediments within a 30 km radius of the roaster stack with Pb-210 dated lake sediment cores, which can reconstruct conditions in lakes prior to the onset of mining operations. Metal concentrations in sediment profiles were determined for multiple lakes downwind of the roaster stack. Profiles of multiple metals including arsenic, antimony, and lead track a peak in contamination during the height of mining operations, which decreases with distance. Toxicity tests in Daphnia indicate lake water collected 1 km from the mine decrease Daphnia survivorship, despite the mine being inactive for over 10 years. Assessment of bioavailability using microbial

bioreporters indicate that arsenic in porewater is 70% bioavailable. Principal Component Analysis (PCA) of metals in the sediment dated prior, during, and after the cessation of mining activities show clustering of chemically similar lakes prior to mining, with divergence during operations, and little change occurring since after the mine closure. These results suggest that lakes in the Yellowknife region were contaminated from mining operations at Giant Mine, and that the aquatic ecosystems continue to show lingering contamination from past mining activities. Future work examining multi-trophic level responses to contaminant exposure in dated sediments will improve our understanding of the impact of mining operations to the aquatic environments near Yellowknife, and will help predict the timing of ecosystem recovery.

REGIONAL IMPACT ASSESSMENT: A NEW STRATEGIC PATH FORWARD FOR THE NORTHWEST TERRITORIES

CLIFFE-PHILLIPS, M.A.

MACKENZIE VALLEY ENVIRONMENTAL IMPACT REVIEW BOARD, YELLOWKNIFE, NT
MCLIFFEPHILLIPS@REVIEWBOARD.CA

During most environmental assessments conducted by the Mackenzie Valley Environmental Impact Review Board, there are many instances where concerns or issues are raised that are not specific to the project being assessed, but the onus has fallen on the developer to address these concerns. Many of these issues relate to inadequate or unavailable baseline information, pre-existing and cumulative effects, and lack of sufficient understanding of the relationship between landscape change and those who use the land.

There is an opportunity to use regional environmental impact assessment to address these issues outside of a single project and at a regional scale. With proper design, implementation, and execution of regional impact assessment, the following improvements can likely be achieved: 1) better informed, streamlined and timely project assessment; 2) improved understanding of cumulative impacts; 3) improved involvement of Indigenous groups and land users; 4) thresholds and objectives that can be used in project assessment, and 5) better informed decision making by Boards and government.

MINING MATTERS: RAISING AWARENESS THROUGH PARTNERSHIPS

CLINTON, L.A.

MINING MATTERS, TORONTO, ON
LCLINTON@MININGMATTERS.CA

Mining Matters is a charitable organization dedicated to bringing knowledge and awareness about Canada's geology and mineral resources to students, educators and the public. The organization provides current information about rocks, minerals, metals, mining and the diverse career opportunities available in the minerals industry.

Travelling to Canada's North from their home base in Toronto, Mining Matters educational teams work with community, corporate, education and government partners to customize Earth science programming for youth; delivering school programs, summer camps and community events that educate participants about Canada's geology and mineral resources, mineral exploration, mining, sustainability, careers and the relevance of mining to quality of life. The organization's teacher

training program provides professional development workshops and teacher resource kits to deliver effective Earth science curriculum. Using hands-on educational resources, created by educators and Earth science experts to meet curriculum expectations, the teams inspire teachers and spark student interest in Earth science and mineral resources.

CANADIAN MINERAL EXPLORATION HR OUTLOOK

COFFIN, L.M.

MINING INDUSTRY HUMAN RESOURCES COUNCIL, OTTAWA, ON
LCOFFIN@MIHR.CA

The mineral exploration industry is both highly volatile and poorly understood, prompting the Mining Industry Human Resources Council (MiHR) to partner with the Prospectors and Developers Association of Canada (PDAC) to investigate the particular experiences and perspectives of the wide variety of people working in Canada's mineral exploration sector. This presentation will showcase how MiHR and PDAC were able to fill a gap in labour market information by developing and deploying a robust survey of individuals and organizations working in exploration.

This research offers a new look at many topics in exploration from a broad and national lens, including women in exploration, work integrated learning and the career outlook for students. Key observations include a need for increased collaboration between industry and educational institutions and better career awareness and attraction efforts. Results also illustrated an absence of a mid-career workforce.

EARNING AND MAINTAINING SOCIAL LICENCE IN AN URBAN, RECREATIONAL AND BROWNFIELD ENVIRONMENT WITH AN UNSETTLED LAND CLAIM

CONNELLY, D.M.

ILE ROYALE ENTERPRISES LTD., YELLOWKNIFE, NT
DCONNELLY@ILEROYALE.COM

TerraX Minerals Inc. is advancing a district scale exploration project in close proximity to its most impacted stakeholders: Yellowknife, N'dilo, Detah; and amongst cabin country, infrastructure and recreational trails. For five years, the Yellowknife City Gold Project (YCGP) has co-existed with multiple land uses and over 40 stakeholder groups. In addition to traditional means of engagement for more remote projects, TerraX has partnered on a number of initiatives with its stakeholders to promote co-usage of exploration trails and winter roads with communities, tourism, recreational, education, government and industrial stakeholders. This presentation updates previously discussed initiatives focused on the YCGP's urban and brownfield environments; and shares new partnerships including the development of the Ranney Hill Geological Interpretive Trail, the Yellowknife Gold Loppet and Mining Matters NWT all in the context of land claims.

OVER-WINTER FLOWPATHS THROUGH TALIK NETWORKS IN DISCONTINUOUS PERMAFROST TERRAINS

CONNON*, R.F.[1], BRAVERMAN, M.[2], and QUINTON, W.L.[1]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) UNIVERSTY OF WATERLOO, WATERLOO, ON
RFCONNON@GMAIL.COM

Rapid climate warming in northwestern Canada has led to unprecedented rates of permafrost thaw. Near its southern edge, the occurrence of permafrost is often restricted to peatlands, where the large thermal offset between the ground surface and the permafrost table is able to preserve permafrost even where mean annual temperatures exceed 0°C. Peatlands differ from mineral soils as they have a much higher porosity, and therefore higher volumetric water content when saturated. The latent heat requirements to re-freeze saturated peat can often limit the penetration of the freezing front, leaving a residual talik, a layer of ground at depth, that does not refreeze. This perennially unfrozen layer erodes into the underlying permafrost and offers year-round flow conduits for energy and water. Studies at the Scotty Creek Research Station (SCRS) in the southern Northwest Territories, Canada have examined the evolution of taliks over multiple years. The SCRS is located in the headwaters of Scotty Creek, where permafrost exists solely beneath forested peat plateaus. These plateaus are interspersed by permafrost-free wetlands (channel fens and flat bogs), where saturated conditions typically limit the development of trees. Channel fens route water to the basin outlet, whereas bogs typically store water, but can also transmit it to fens during periods of high moisture supply. Taliks are only found on peat plateaus and have the potential to offer subsurface flowpaths to wetlands in the winter season. The effect of taliks on the basin water balance is not well understood.

To quantify the direction of flow and subsurface flux between taliks and wetlands, five taliks with a direct subsurface connection to a wetland were instrumented with pressure transducers. Two of the taliks were located at the edge of a fen and three were located at the edge of a bog. The centre of the wetland feature was also equipped with a pressure transducer to calculate the hydraulic gradient. One talik was instrumented with thermistors and soil moisture sensors to track the downward progression of the freezing front. During winter, taliks on plateaus that border wetlands can provide a flowpath for water transfer into the wetland, or can receive water from wetlands as the confining layer of ice exerts pressure on the subsurface water and forces it laterally into the taliks of plateaus. It was found that taliks along the edges of fens received water over the course of the winter as the hydraulic gradient from the fen to the talik progressively increased over the season. Conversely, it appears that groundwater from plateaus was slowly released into bogs over-winter. The direction of flow can have important implications on the magnitude of thaw as the influx of water into the plateau and the advective transport of energy can enhance thaw and erode the plateau. Quantifying over-winter flows through talik networks is necessary to develop an understanding of the cycling and storage of water in discontinuous permafrost terrains.

THE INFLUENCE OF MEADOWBANK MINE ON CARIBOU SEASONAL HABITAT USE

COULTON*, D.[1], KIM, J.[2], VIRGL, J.[3], STEVENS, C.[4], DE LA MARE, C.[4], QUESNEL, J.[5], and VANENGEN, R.[5]

(1) GOLDER ASSOCIATES LTD., YELLOWKNIFE, NT
(2) GOLDER ASSOCIATES LTD., CALGARY, AB
(3) GOLDER ASSOCIATES LTD., SASKATOON, SK
(4) GOLDER ASSOCIATES LTD., EDMONTON, AB
(5) AGNICO EAGLE MINES LIMITED, TORONTO, ON
DANIEL_COULTON@GOLDER.COM

Barren-ground caribou are a migratory species and their ability to locate suitable resources and avoid predators among seasonal ranges is important to their survival and reproductive success and coping with environmental variability. Exploration for mineral resources since the mid-1990s has occurred in the seasonal ranges of barren-ground caribou across Canada with several mines being developed. Previous studies have detected caribou avoiding areas adjacent to mines and roads. However, baseline information on caribou habitat use was not available in these studies, so inferences about changes to distribution required assumptions based solely on post-development data. The Meadowbank Mine (Mine) was developed in 2007 and is connected to the community of Baker Lake, Nunavut, by a 103.5 km all-weather access road (AWAR). Barren-ground caribou from the Lorillard and Wager Bay herds have seasonal ranges that overlap these two developments during spring, fall and winter and have been collared since 1999. Thus, collared animals from these herds allow for comparison of pre- (baseline) and post-development caribou distribution. A simple linear regression approach was used to evaluate whether differences in caribou use and amount time spent in areas adjacent to the Mine and AWAR during pre- and post-development periods supported predictions of an avoidance hypothesis. The results did not indicate avoidance during post-development in either spring or fall seasons but did during winter. However, the changes detected in winter were based on five collared animals during the post-development period so this result comes with uncertainty. There is also uncertainty about changes not detected during spring and fall because the number of collared caribou available are generally limited. Importantly, the Mine and AWAR are located outside of core areas used by either herd so any reduction in the use of suitable habitat may affect only a small proportion of the animals in these herds. Finally, whether changes associated with a development ZOI matter to caribou population demography is a question that has not been answered empirically.

QUANTIFYING THAW MECHANISMS IN DISCONTINUOUS PERMAFROST: IS TALIK FORMATION A TIPPING POINT?

DEVOIE*, È.[1], CRAIG, J.R.[2], QUINTON, W.L.[3], and CONNON, R.F.[3]

(1) UNIVERSITY OF WATERLOO, WATERLOO, ON
(2) UNIVERSITY OF WATERLOO, WATERLOO, ON
(3) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
EGDEVOIE@UWATERLOO.CA

Rapid climate warming in northern Canada is resulting in rapid permafrost loss. At the southern limit of permafrost, thaw is

observed as a loss in extent of permafrost cored peat plateaux. The precursor to loss of permafrost is thought to be the formation of confined taliks. Taliks form when the net ground heat flux is positive, i.e. more energy is gained by the soil during the summer than can be lost through the winter. Under this condition, the entire soil column is unable to refreeze, and a thawed region is left between the base of the active layer and the top of the frozen permafrost table. The presence of this talik affects the hydrology of the system, especially over-winter when the system was previously (i.e. prior to talik formation) quiescent, but more importantly in this context, the formation of taliks is thought to be a tipping point in permafrost thaw and the main thaw mechanism in discontinuous permafrost peatlands.

The thermodynamic impacts of taliks will be investigated to quantify and test these hypotheses. A one-dimensional thermodynamic model of active layer evolution including conductive, sensible and latent heat has been developed. This model will be used to simulate a soil column with and without a confined talik. The freeze-thaw process will be applied to these soil columns for several possible climate scenarios, to determine evolution of the respective soil columns. It is anticipated that under certain conditions the talik system will exhibit permafrost thaw when forced with the same ground heat flux as the system without a talik, that will remain stable. The formation of a talik is therefore a tipping point, in which an anomalously warm year (as has been observed at the Scotty Creek Research Station) can result in widespread thaw in previously stable regions, given the same climate forcing before and after the anomalous year. Additionally, taliks can form a conduit for water when they connect adjacent wetland features. The potential impact of advection-driven thaw on permafrost is investigated, and the relative magnitudes of advective and conduction driven thaw are compared to better quantify thaw drivers in the discontinuous permafrost system.

VOLCANIC SETTING OF THE SUNRISE VMS DEPOSIT, CAMERON-BEAULIEU VOLCANIC BELTS, SLAVE PROVINCE

DEWOLFE*, Y.M.[1], LILLEY, S.C.[1], and KNOX, B.[2]

(1) MOUNT ROYAL UNIVERSITY, CALGARY, AB
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
MDEWOLFE@MTROYAL.CA

The Sunset Lake area, including the Sunrise VMS deposit, is located within the Neoarchean Cameron-Beaulieu volcanic belts along the northeast margin of the Sleepy Dragon Complex. The age of the volcanic strata, and the volcanic stratigraphy is unknown, therefore cannot be correlated with any other volcanic strata in the Cameron-Beaulieu volcanic belts. The Sunrise VMS deposit (historic indicated resource 1.52 Mt at 5.99% Zn, 2.39% Pb, 0.08% Cu, 262 g/t Ag, 0.67 g/t Au) is a banded polymetallic Zn-Pb-Cu-Ag-Au sulfide lens hosted by rhyolitic volcaniclastic rocks; however, the host stratigraphy is not well understood.

The Sunset Lake area was subject to forest fires in 2014, and as a result there is excellent outcrop exposure in this area. It was previously mapped as a large rhyolite body, but detailed mapping as a part of this study suggests it is more complicated and comprises numerous lithofacies, including pillow basalt, rhyolite flow-dome complexes and volcaniclastic units. The footwall to the Sunrise deposit consists, from oldest to

youngest, of pillow basalt (>200 m), formerly glassy rhyolite lobes enclosed by masses of in situ hyaloclastite (~100 m), felsic volcaniclastic rocks ranging from tuff breccia to tuff with depositional units between 2 – 10 m totaling ~100 m, and a massive (~ 100 m), weakly quartz and plagioclase porphyritic rhyolite dome with brecciated margins. Adjacent to the weakly porphyritic rhyolite dome is a strongly sericitized and silicified rhyolite tuff to lapillistone that hosts the Sunrise deposit. Mineralization at surface consists of a 3 – 4 m thick massive sulfide lens, dominated by pyrite, with minor sphalerite and chalcopyrite, and a strike length of about 120 m. The deposit is overlain by pervasively carbonate altered pillow basalt. Along strike ~ 2 km to the south the stratigraphy is dominated by intermediate to mafic pillow lavas with subordinate amounts of associated volcaniclastic rocks.

The footwall to the Sunrise deposit comprises rhyolite flow-dome complexes and a thick sequence of rhyolitic volcaniclastic rocks, which end abruptly along strike to the south, where the stratigraphy is dominantly coherent intermediate to mafic lavas. This abrupt lateral transition in lithofacies is interpreted to represent a synvolcanic structure such as a caldera wall. Thus, the Sunrise deposit is located on the margin of a rhyolite dome within a small (~ 2 x 2 km minimum estimate) subsidence structure. A rapid change from coherent rhyolite of the dome, to the rhyolite volcaniclastic rocks that host the deposit, suggest that the deposit corresponds with an area of faulting, fracturing and the accumulation of permeable debris on the margin of the dome, all contributing to a favorable environment for the formation of a VMS deposit.

NAVIGATING ENVIRONMENTAL RISK: WHEN AND HOW TO APPLY THE PRECAUTIONARY PRINCIPLE

DONIHEE, J. and BIRCHALL*, C.J.

WILLMS & SHIER ENVIRONMENTAL LAWYERS LLP, OTTAWA, ON
JDONIHEE@WILLMSSHIER.COM

The precautionary principle is used inconsistently in Canada. This creates a problem for industry proponents in the Territories because:

- There is uncertainty when the principle will apply to projects; and
- It is not clear how the principle will be applied by courts and administrative tribunals.

The Supreme Court of Canada has adopted one version of the precautionary principle: where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Since its adoption by the Supreme Court, the principle's formulation and usefulness has been variable at best. Some statutes articulate formulations of the precautionary principle similar to that referenced by the Supreme Court while others refer to a "precautionary approach". For example, the Canadian Environmental Assessment Act states that the federal government must exercise its powers in a manner that "applies the precautionary principle" and that proposed projects should be "considered in a careful and precautionary manner". Whereas the federal Oceans Act characterizes the precautionary approach as "erring on the side of caution". These formulations differ

from that adopted by the Supreme Court and offer little in the way of guidance as to how they will be applied.

Further, the courts disagree about the precautionary principle's purpose. Some argue that it prevents decision-makers from taking a laissez-faire approach to environmental management. Others suggest that it is a potentially paralyzing zero tolerance approach to environmental risk. However, some courts have decided that the paralyzing effect of the precautionary principle can be addressed through adaptive management.

Administrative tribunals in environmental impact assessment and regulatory contexts have also applied a version of the precautionary principle in their decision-making. The Mackenzie Valley Environmental Impact Review Board (MVEIRB) and Nunavut Impact Review Board (NIRB) have both recently endorsed a "precautionary approach". The Land and Water Boards in the Mackenzie Valley also make decisions relying in part on "precautionary" considerations that inform adaptive management.

Canada's approach to the precautionary principle stands in contrast to the approaches taken by other countries. Courts in Australia and New Zealand have developed detailed legal tests outlining how and when the precautionary principle should be interpreted and applied. Drawing from these examples, we will propose an option for a more consistent decision-making framework relating to the precautionary principle.

PERMAFROST ENGINEERING AT LAVAL UNIVERSITY: UNDERSTANDING DEGRADING PERMAFROST TO DEVELOP ENGINEERING TOOLS FOR ADAPTING CANADA'S NORTHERN TRANSPORTATION INFRASTRUCTURE

DUMAIS*, S., DORÉ, G., KONRAD, J.-M., and LEMIEUX, C.

UNIVERSITÉ LAVAL, QUÉBEC, QC
SIMON.DUMAIS.2@ULAVAL.CA

Construction of roads, highways and airstrips in permafrost areas inevitably affects the thermal regime of frozen soils, which may cause thermal degradation of the underlying permafrost. The ongoing northern research programs at the Civil Engineering Department of Laval University focus on improving current knowledge on permafrost degradation and ability to adapt by developing expertise, procedures and techniques to better understand and to mitigate instabilities affecting transportation infrastructure.

Regarding the understanding of degrading permafrost: microgravimetry and road profilometry techniques have been adapted for the detection of thaw-sensitive permafrost; a laboratory testing procedure was developed to characterize the mechanical behavior of marginally frozen soils subjected to cyclic loading and; an oedometric core-barrel for in situ measurement of thaw consolidation properties of permafrost has been designed and manufactured at Laval University.

An engineering framework for the assessment of thaw consolidation of permafrost is currently being developed. The

analysis combines a large-strain thaw consolidation numerical model and an improved characterisation of the consolidation properties of thawing soil. Field studies on embankment spreading and retrogressive thaw slumps are currently underway at sites located on the Inuvik-Tuktoyaktuk Highway and on the Dempster Highway, respectively.

Adaptation techniques and methods for transportation infrastructure built on thaw-sensitive permafrost have been developed: simple calculation tools to quantify the impact of limiting heat-intake using high-albedo surfacing; methodology for taking into account snow accumulation along the embankment; quantification of heat transfer around culverts to support the design of low-impact drainage systems and; optimized design tools for convective mitigation techniques using numerical modelling.
Finally, a methodology and software tool is being developed to quantitatively calculate the risk associated with common permafrost-supported embankment infrastructure dangers. The analysis uses variable geotechnical, climate and permafrost parameters to determine probabilities of occurrence based on user-input serviceability limits or ultimate limit states while direct costs of a danger's occurrence and its impact to safety and on communities are also considered.

EVALUATION OF MAJOR CARVING STONE DEPOSITS AND QUARRIES THROUGHOUT THE QIKIQTAALUK OF NUNAVUT: 2016-17 RESULTS

ELGIN*, R.A.[1], STEENKAMP, H.M.[2], TIMLICK, L.[3], and THERRIAULT, I.[2]

(1) QIKIQTANI INUIT ASSOCIATION, IQALUIT, NU
(2) CANADA NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
(3) UNIVERSITY OF MANITOBA, WINNIPEG, MB
RELGIN@QIA.CA

Large deposits of artisanal carving stone (i.e. serpentinite, soapstone and argillite) represent a commodity of special significance to northern communities and provide the raw materials that drive a fundamental part of a multi-million dollar arts and crafts industry. In addition to providing a simple economic lifeline to many Inuit artisans, stone carvings provide an important means for the continuation of traditional practices and an instantly identifiable symbol of northern culture.

Within the Qikiqtaaluk of Nunavut, all major carving stone quarries lie on land administered by the Qikiqtani Inuit Association on behalf of Inuit from the thirteen regional communities. As a result of intensive, community-driven quarrying since the 1960s, several major deposits have been slowly stripped of their surface resources and transformed into unregulated quarries with little understanding of best development practices and subsurface resource geometry. To account for the continuing demand for artisanal stone and the growing need for a specialized management plan, the Qikiqtani Inuit Association has created a program to address these issues through a series of geological-based initiatives. Through

partnerships with the Canada-Nunavut Geoscience Office, the Department of Economic Development and Transportation and the University of Manitoba, a two year program has focused on understanding the geochemistry of major deposits, critical to the survival of the carving stone industry, along with localized field mapping and land surveys to better constrain the available resource limits.

The results of this program have built on recent studies to create a better understanding of the characteristics and formation of major resources, along with significant revisions of estimates of existing carving stone. This collaborative effort between government, academic and land management associations forms the basis of several prospective community-driven development opportunities that permit Inuit to benefit and better develop their local resources in line with the best needs of community.

OVERVIEW OF THE SLAVE PROVINCE GEOPHYSICAL, SURFICIAL MATERIALS AND PERMAFROST STUDY UPDATE — REVITALIZING MINERAL EXPLORATION AND FACILITATING SUSTAINABLE DEVELOPMENT IN A KEY ECONOMIC REGION

ELLIOTT, B.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
BARRETT_ELLIOTT@GOV.NT.CA

In 2016 and 2017, the Northwest Territories Geological Survey (NTGS) has been implementing a program to generate new baseline geophysics datasets, to develop new mineral exploration methodologies to assist the next round of diamond discoveries in the Slave Geologic Province. Associated permafrost studies will develop methodologies for permafrost monitoring, which will inform infrastructure and land-use planning. The research is focused in NTS map sheets 75M and 75N, with targeted work in 76C and 76D. This project is funded through the Strategic Investments in Northern Economic Development (SINED) of the Canadian Northern Economic Development Agency (CanNor). Highlights include:

- Over 90,000 line-km of new regional and targeted high resolution airborne geophysics datasets;
- Generation of new 1:50,000 scale surficial geology and sampling suitability maps in 75M, 75N, and 76D covering approximately 3,400 km^2;
- The release of approximately 50,000 km^2 of 1:50,000 scale surficial geology maps donated by GGL Resource Corporation in the Slave Geological Province;
- A compilation of the geophysical responses of known kimberlites in the Slave Geological Province;
- 3D models of the DO-27 / DO-18, Monument and Coppermine indicator trains with implications for mineral exploration;
- Studies on indicator mineral transport, glacial dynamics with implication for mineral exploration;
- Installation of a thermistor network to study the impact of climate change on permafrost and terrain sensitivity designed to inform potential infrastructure development;

- A case study applying passive seismic methods to determine overburden thickness and to detect contrasting bedrock type;
- The application of hyperspectral analysis to detect a hydration front in the kimberlite host rocks;
- The application of a variety of lab and field based methodologies to detect kimberlite pathfinder elements in soil and till samples.

Our research partners include the Canadian Mining Institute Research Organization (CAMIRO), Palmer Environmental Consulting Group Inc., DCGeo Applied Sedimentary Geology, the University of Waterloo, the University of Toronto, Lakehead University, Simon Fraser University, Carleton University and the University of British Columbia. Much of this work was made possible by logistical support provided by Kennady Diamonds Incorporate and by data donations from Dominion Diamond Ekati Corporation, North Arrow Minerals Incorporated, GGL Resources Corporation and Kennady Diamonds Incorporate. The field program was carried out with assistance from Aurora Geosciences Ltd.

This presentation will highlight new datasets, geological models and methodologies generated over the course of this study and provide an update on forthcoming scientific publications from the NTGS and our project partners.

HYDROTHERMAL REGIME OF STREAM CHANNELS IN THE TUKTOYAKTUK COASTLANDS AND ANDERSON PLAIN, NORTHWEST TERRITORIES, CANADA

ENSOM*, T.P.[1], MARSH, P.[1], and KOKELJ, S.V.[2]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
ENSO5730@MYLAURIER.CA

Across the Arctic, the movement of water and extent of winter freezing in streams have important implications for hydrology, aquatic habitat, and infrastructure. Knowledge of winter hydrothermal dynamics in small tundra stream systems in continuous permafrost is limited. Climate warming, altered fall precipitation regimes including greater rainfall and related changes in snow, and increases in tundra vegetation height and coverage are likely delaying active layer freeze-back in autumn and early winter, increasing the potential for winter water movement. This could change the hydrothermal regime of small tundra stream systems, with unknown hydrological and ecological implications. In areas with ice-rich permafrost, these changes could result in significant alterations in channel slope and cross section, with unknown impacts on hydrology and ecology.

The Inuvik to Tuktoyaktuk Highway (ITH) is a 130 km project spanning the taiga-tundra ecotone across the western portion of Anderson Plain and Tuktoyaktuk Coastlands north of Inuvik, Northwest Territories. The ITH crosses several hundred streams or smaller riparian systems with contributing watersheds whose areas range from less than one square kilometre to 360 square

kilometres. Highway construction and recent collaborative research between the Northwest Territories Geological Survey, Northwest Territories Department of Infrastructure, and others has yielded observations of winter hydrological activity in tundra streams draining several of the small watersheds along the ITH route. This winter flow can pose challenges to infrastructure operation.

The objectives of this research are to describe the thermal regime of tundra stream channels and adjacent riparian systems in continuous permafrost, quantify winter runoff and convective thermal energy export from watersheds, and identify the watershed characteristics and meteorological and subsurface thermal conditions that contribute to stream icings at the highway. Temperature will be measured by thermistor cables installed beneath streambeds, on streambeds, and in adjacent riparian areas. Monitoring sites have been established in locations unaffected by the ITH and also beneath bridges at sites where icings have been observed. The timing and rate of icing accumulation will be determined through monitoring by automated cameras. Geotechnical data from pre-construction investigations of ITH water crossings and regional permafrost investigations will facilitate a modelling component in GEOtop intended to identify the sensitivity of winter discharge to watershed morphology and meteorological factors and to explore the influence that these factors have on thermal regime of stream channel and riparian cross-sections.

This research will provide detailed thermal descriptions of stream cross-sections, explore the sensitivity of winter hydrothermal dynamics to changing conditions in the Arctic, and investigate the interaction of hydrological and permafrost processes.

NORTHWEST TERRITORIES MINERAL EXPLORATION AND MINING OVERVIEW 2017

FALCK*, H.E.[1], CAIRNS, S.R.[1], ROBB, M.[2], and POWELL, L.[1]

(1) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(2) DEPARTMENT OF INDUSTRY, TOURISM AND INVESTMENT, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
HENDRIK_FALCK@GOV.NT.CA

The mineral industry has shown signs of an upswing in 2017, as evidenced by an increase in the amount of staking, combined with a decrease in the rate of claims lapsing. Commodity prices in general, have seen improved outlooks as 2017 progressed. Copper, lithium and tungsten prices have increased through the summer of 2017, rebounding zinc and lead prices have been steadily recovering while gold prices have held relatively constant. This upturn has translated into an increase in staking activity in the NWT. While 85 claims covering 42,000 Ha were staked in 2016, over 270 claims covering 182,000 Ha were added in the first three quarters of 2017. The enthusiasm must be tempered by the number of cancelled claims, which greatly exceeds the staked claims. Much of the released area covered the prospective uranium prospects west of the Thelon Game Sanctuary.

As diamonds are the only commodity currently mined in the NWT, global changes in the diamond markets can have appreciable impacts in the north. In November 2016, the Indian government enacted a demonetization program for 500 and 1000 Rupee banknotes, which was immediately reflected in a price and demand

drop for smaller diamonds. By the summer 2017, this disruption to diamond trading had abated and full activity returned to all segments of the diamond market. The weaker Canadian dollar has also strengthened the projections of the mines whose products are quoted in US dollars.

Despite tough financial market conditions, NWT mineral producers continued to advance their projects in 2017. In mining news, DeBeers and Mountain Province completed the first year of operation at Gahcho Kué mine in September. Both Diavik and Ekati mine are proceeding with major mine expansions, which increase the longevity of these mines. The total estimated value of minerals and diamonds produced in the NWT in 2016 was $1.27 billion, of which diamond production of 10.5 million carats accounted for 100 percent of the value, following the closure of the Cantung mine in 2015. Production for 2017 should be significantly higher than this as Ekati is mining the high-grade Misery Pipe and the Gahcho Kué mine will report its first full year of production. Based on reported production of 7.5 million carats to June 30th 2017, total diamond production should exceed 15 million carats in 2017.

Explorers have been increasingly able to raise money for exploration activities. The territory saw activity at several diamond, gold, base metal and lithium exploration projects. Canadian Zinc published a positive Feasibility Study for Prairie Creek. Kennady Diamonds received promising new results on their Kennady North property. Nighthawk completed the work to expand the resources at Colomac with an extensive drill program. Closer to Yellowknife, TerraX continued drilling gold and base metal targets on their enlarged Yellowknife Gold Project with good results. In 2016-2017, the Mining Incentive Program (MIP) provided $400,000 to ten exploration projects. 2017-2018 saw the MIP budget increase to $1 million; this funding has been dispersed to 14 exploration projects, (seven prospectors and seven companies).

NEOPROTEROZOIC DEFORMATION IN EASTERN MACKENZIE MOUNTAINS AND MACKENZIE PLAIN, NORTHWEST TERRITORIES

FALLAS*, K.M.[1], MACLEAN, B.C.[2], and MACNAUGHTON, R.B.[1]

(1) GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
(2) GEOLOGICAL SURVEY OF CANADA (RETIRED), CALGARY, AB
KAREN.FALLAS@CANADA.CA

Bedrock mapping and reflection seismic interpretation, conducted as part of the Geological Survey of Canada's Mackenzie Project of the GEM program, has documented a regional folding event affecting Tonian strata of the Mackenzie Mountains Supergroup (MMSG), Coates Lake Group, and their lateral equivalents (Hematite Creek Group and Shaler Supergroup). The area definitely affected by folding includes the eastern Mackenzie Mountains and central Mackenzie Plain, approximately 300 km x 500 km, but folding may extend beyond this region. This folding event does not involve Cryogenian to Cambrian strata unconformably overlying the MMSG. In western and central Mackenzie Mountains, stratigraphic constraints suggest the folding occurred between deposition of the Coates Lake Group and deposition of the overlying Rapitan Group, between 732 and 717 Ma based on current dating of these units. The broad, regional folds have wavelengths from 30 to 100 km, and amplitudes of 2-3 km, and are cross-cut by a low-angle

unconformity at the contact with younger units. Current models for the Neoproterozoic evolution of northwestern Canada emphasize Tonian deposition in an epicratonic basin, followed by Cryogenian to Ediacaran extension, or possibly transtension and extension. Recognition that this general extensional history was disrupted by a regional-scale contractional event significantly modifies our understanding of the tectonic history and stratigraphic evolution of the region.

ACTIVITY UPDATE — NORTHWEST TERRITORIES GEOLOGICAL SURVEY PETROLEUM GEOSCIENCES GROUP

FIESS, K.M.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
KATHRYN_FIESS@GOV.NT.CA

The Northwest Territories Geological Survey (NTGS) Petroleum Geosciences Group promotes the development of energy resources in the Northwest Territories (NWT) by evaluating resource potential, generating regional and thematic geoscience knowledge to underpin successful exploration, and providing scientific advice to inform policy and regulatory decisions. The group conducts petroleum systems evaluations, basin analysis, and provides other regional geoscience information to support industry exploration for oil and gas. It also engages in resource assessments.

Our regional area of focus over the next five years extends from the Peel Plateau and Plain in the north, southwards through the Central Mackenzie Corridor to Cameron Hills and westward to the Liard Basin in the southern NWT. The "Shale Basin Evolution in the Central NWT" project (Shale Basin Project) was initiated in 2014 to provide in-depth geoscience studies of Middle to Upper Devonian and Cretaceous age shales. This project covers the Central Mackenzie Valley (CMV), Peel Plateau and Peel Plain areas and will integrate historical data sets with data acquired from field studies, recent drilling and seismic surveys. We are currently compiling data sets for input into basin modeling studies for this region.

In 2016, our group enhanced the types of geoscientific research conducted for the Shale Basin Project by initiating a collaborative research program with Dr. Murray Gingras of the University of Alberta. The primary goal of the collaboration is to assess the reservoir quality of the Middle to Upper Devonian age Horn River Group Shales of the Central Mackenzie Valley, using sedimentology, ichnology and geochemical parameters. Chemostratigraphic and sedimentological datasets will be integrated to establish a sequence stratigraphic framework for the Horn River Group.

In January 2017, the Petroleum Geosciences Group introduced a new type of publication called Petroleum Play Summaries. These publications provide an overview of geoscience information about the oil and gas potential of a known or proposed NWT exploration region. The "Canol Formation and Bluefish Member Shale Play Summary" is currently available for download at http://www.nwtgeoscience.ca/services/petroleum-play-summaries. We plan to produce a Liard Unconventional Resource Play Summary before fiscal year end.

Although no new resource assessments have been commenced, our group will eventually update the assessment of the unconventional petroleum resources of the Bluefish and Canol shale by incorporating seismic data

into regional structural and isopach mapping of key intervals. Digital seismic data was recently purchased and will be interpreted in fiscal 2018-19. Pertinent data from the recently drilled Canol resource play wells in the CMV will also be incorporated into the resource assessment.

Other activities our group has recently undertaken include a conventional gas resource mapping project and participation in interdivisional working groups for petroleum-related legislative policy and regulatory guidelines review.

LOCAL STRATIGRAPHY OF THE DUO LAKE FORMATION AT HOWARDS PASS IN THE SELWYN BASIN REGION, NORTHWEST TERRITORIES

FLOWER*, A.F.[1], FISCHER, B.J.[2], and MELCHIN, M.J.[1]

(1) ST.FRANCIS XAVIER UNIVERSITY, ANTIGONISH, NS
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
ANDREW.FLOWER23@YAHOO.COM

Howards Pass is a major, 38 km-long district of shale-hosted zinc-lead deposits in western Northwest Territories and eastern Yukon. Fifteen separate deposits are hosted by carbonaceous lime mudstone and mudstone of the Ordovician-Silurian Duo Lake Formation. A recent structural re-interpretation of the district suggests it lies within a thrust duplex, as opposed to the simple syncline of the previous model. The recognition of this duplex calls into question the existing stratigraphic framework, since that framework was based on lithostratigraphic correlation in a (potentially) structurally disrupted area of poor exposure. Successful prediction of ore distribution during mining will rely on a valid structural model, yet such models cannot be tested without a robust framework for the internal stratigraphy of the host unit.

The present study will ultimately test the usefulness of high-resolution carbon-isotope stratigraphy in detecting imbricate thrusts within the Duo Lake Formation, however, this phase of the work focusses on lithostratigraphy. In 2016, drill core from two separate deposits was logged and sampled, and an outcrop section was measured and sampled. A zone of high strain at the base of Duo Lake Formation in all three sections and numerous smaller faults throughout the formation support the model of a regional duplex structure with a basal décollement and numerous imbricate thrusts.

Lithological features indicate deposition in a deep-water, organic-rich, marine setting. Detailed lithological study found insufficient evidence to recognize members in the three studied sections. Furthermore, none of the accepted members of Duo Lake Formation was clearly recognizable. Although compositional units could be identified in each section based on the amounts of silica, sulphides, and lime in the rock, none of the units was present in all three sections. This lack of continuity could reflect facies changes in primary depositional units, however, it is also possible that the distributions of silica and sulphides were modified by secondary processes, or the distribution of compositional units is the result of imbricate faulting that has repeated or omitted different portions of the stratigraphy in the different localities studied. The work so far supports the regional duplex model of the Howards Pass district.

ICORE-IL: ACHIEVING REGULATORY EXCELLENCE THROUGH COLLABORATIVE INNOVATION

FROESE, C.

ALBERTA ENERGY REGULATOR, EDMONTON, AB
COREY.FROESE@ICOREGLOBAL.CA

In 2017, the Alberta Energy Regulator formed a non-profit entity called the International Centre of Regulatory Excellence (ICORE). ICORE is meant to provide a central node for the international regulatory community to share and collaborate on the development of best practices on regulation, with an initial focus on the natural resource sector. A key component of this collaborative environment is the ICORE Innovation Lab (ICORE-IL). ICORE-IL will provide a space for regulators and researchers to co-create regulatory solutions that are common across jurisdictions. This would range from collaborating on specific issues and span through development of regulatory processes or informing regulatory policy changes. The ICORE-IL is in the initial design and build stage with the first project proposals under development. The intent of this presentation will be to introduce northern regulators, communities and industry to ICORE and provide an overview of the range of regulatory innovations that will be addressed through the ICORE-IL.
ICORE-IL projects will focus in the areas of Regulatory Actions (Design and Delivery), Regulatory Performance and Regulatory Organizations. The IL will address specific issues that confront regulators today but also work with the research community to look forward at external factors that may drive change in the regulatory system. Initial projects will include assessing technologies to support long term regulatory management of mining infrastructure, regulatory management within a cumulative effects framework and application of community based monitoring in Northern Canada. This presentation is intended to provide delegates with an overview of ICORE and update on activities, specifically as they pertain to regulatory issues being faced in Northern Canada.

UPDATE ON RECENT AND PLANNED ACTIVITIES OF THE OFFICE OF THE REGULATOR OF OIL AND GAS OPERATIONS

FULFORD*, J., NAUGLER, T., HEPPELLE, B., and CAMERON, K.

OFFICE OF THE REGULATOR OF OIL AND GAS OPERATIONS, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
TARA_NAUGLER@GOV.NT.CA

Office of the Regulator of Oil and Gas Operations (OROGO) holds regulatory responsibility for oil and gas operations in the onshore Northwest Territories outside of the Inuvialuit Settlement Region and federal areas. This presentation will provide a brief update on OROGO's activities over the past year and our plans for the coming year. Areas of focus will include OROGO's efforts to further its strategic objectives of enhancing certainty and predictability in regulatory decision-making and promoting accessibility and transparency in its work as OROGO maintains its readiness for a return of oil and gas activity to the NWT. The presentation will update conference attendees on OROGO's Well Watch Program, the implementation of OROGO's Well Suspension and Abandonment Guidelines and Interpretation Notes and newly proposed Geophysical Reporting guidelines, along with a brief overview of OROGO operations.

RESPONSE OF STREAM MACROINVERTEBRATES TO RECENT WILDFIRES IN THE NORTH SLAVE, SOUTH SLAVE, AND DEHCHO REGIONS, NORTHWEST TERRITORIES, CANADA

GARNER*, C.S.[1], PISARIC, M.F.J.[1], and CHIN, K.S.[2]

(1) ENVIRONMENTAL SUSTAINABILITY RESEARCH CENTRE, ST. CATHARINES, ON
(2) ENVIRONMENT AND NATURAL RESOURCES, GOVERNMENT OF NORTHWEST TERRITORIES YELLOWKNIFE, NT
CG09UY@BROCKU.CA

High-latitude regions are currently undergoing rapid ecosystem change due to differences in annual temperature and precipitation trends, and modified disturbance regimes. Since 2012, the Northwest Territories (Canada) has been experiencing severe drought and wildfire seasons. In 2014 alone, wildfires within the Northwest Territories consumed over 3.4 million hectares of forested land; 1.4 times larger than the national yearly average for Canada. Wildfire is one of the most important agents influencing age structure and composition of the forest stand; as such, it is a critical factor in ecosystem dynamics. The impacts of wildfire on terrestrial systems garner more attention compared to aquatic habitats. This is especially true when considering aquatic ecosystems located in the boreal forest biome, where the impacts of fires on stream ecology and chemistry is relatively understudied. Freshwater ecosystems, such as lakes and streams, are highly relied upon by northern communities for their cultural significance and economic and environmental goods and services they produce, including country foods.

This study examines the impact of recent wildfire on freshwater streams within the North Slave, South Slave, and Dehcho regions of the Northwest Territories (Canada) through analysis of their water chemistry and benthic macroinvertebrate assemblages. Benthic macroinvertebrates, or the macroscopic organisms living within/on the substrate of these streams, were sampled following methodologies outlined by the Canadian Aquatic Biomonitoring Network (CABIN). Biological indices (ex. EPT relative abundance) were calculated and compared statistically to determine relationships regarding benthic diversity and abundance. Results of this study suggest that recent wildfires cause at minimum short-term perturbations in water quality, such as increased turbidity and TSS. In addition, results indicate slight structural changes in invertebrate communities of burned streams compared to unburned streams, including increased richness and abundance of collector-gatherer taxa.

WHAT IS REDI AND WHY NOW?

GORDON*, V., NORRIS, A., and BYRNE, M.

INDUSTRY, TOURISM AND INVESTMENT, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
VALGORDON@NORTHWESTEL.NET

Resources and Energy Development Information or REDI, is a Government of the Northwest Territories (GNWT) wide initiative led by the Department of Industry Tourism and Investment, which brings together all the relevant departments under one umbrella who can speak to the various pieces of the resource development puzzle. We have found that there is a general lack of understanding about how government operates, how resource development happens and who is responsible for what in the GNWT. REDI gives people a chance to

ask government all of those burning questions in a safe and non-confrontational manner. REDI will be implemented in three distinct phases. A tradeshow style format which allows for discreet one-on-one conversations with subject matter experts, a website that will be used as our "virtual tradeshow" until we can get to each community, and the final piece will be an educational tool-kit that can be used by our schools as teaching aids for the sciences. The public has been demanding information for a long time, now is the time to bring the information to them.

THE NORTHWEST TERRITORIES POWER CORPORATION: PLANNING FOR THE FUTURE

GREWAL, J.

NORTHWEST TERRITORIES POWER CORPORATION, HAY RIVER, NT
JGREWAL@NTPC.COM

The Northwest Territories Power Corporation (NTPC) mission is to generate, transmit and distribute electricity in a safe, reliable, efficient and environmentally sound manner, while at the same time striving to reduce reliance on fossil fuels. An update will be given on NTPC's vision that encompasses the framework in which NTPC works. Subjects to be addressed will be overall considerations, such as working with stakeholders to support development while ensuring that safety and environmental protection remain paramount, and that compliance with all applicable legislation and regulations is ensured.

TOWARDS BETTER MONITORING OF PERMAFROST THAW: SUBSIDENCE AND ICE CONTENT

GRUBER, S.

CARLETON UNIVERSITY, OTTAWA, ON
STEPHAN.GRUBER@CARLETON.CA

Subsurface temperature monitoring alone provides an incomplete representation of permafrost thaw. This is because close to 0ºC, latent heat transfer due to phase change becomes increasingly important in thawing soil. Consequently, large amounts of energy can be either exported with meltwater runoff or expended on raising the unfrozen water content of permafrost while only generating minimal temperature change. While the impacts of ice melt are important, they are not well observed with temperature monitoring alone.

To better quantify local permafrost change, three pilot installations to a depth of around 2 m were made in summer 2017 near Yellowknife. They measure profiles of temperature and unfrozen water content as well as surface heave and subsidence with hourly resolution.

Temperature is calibrated to 0.02ºC and unfrozen water content has a repeatability of a fraction of a percent. Absolute calibration of unfrozen water content is in progress and will require extensive laboratory work. This presentation will show first results obtained from July to November (subsidence/heave) and September to November (temperature and unfrozen water). The results from mid-September are available – fingers crossed for downloading more just before the Geoscience Forum.

This work is aimed at broadening the range of methods available to quantify permafrost thaw. This is expected to be useful for monitoring changing natural environments, for providing meaningful data to test computer models and to monitor permafrost change near relevant infrastructure.

INDIGENOUS BUSINESS, THE NORTH AND THE MINING SECTOR — A TRIPLE WIN

GRUNER, P.

DET'ON CHO CORPORATION, YELLOWKNIFE, NT
PAUL@DETONCHO.COM

Indigenous business in the North is a win for the communities that they represent, the Territories that they operate in, and the mining sector that they serve. Det'on Cho with its group of companies and hiring practices has effectively provided quality services to its various mining clients, employed and developed Yellowknife Dene First Nation members, and assisted in contributing to the local economy in a meaningful way. Healthy Indigenous Corporations are good for all stakeholders in the North.

ACTIVITIES OF THE CANADA-NUNAVUT GEOSCIENCE OFFICE 2017

HAM, L.

CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
LINDA.HAM@CANADA.CA

The Canada-Nunavut Geoscience Office (CNGO) is Nunavut's de-facto geological survey. The CNGO was established in 1999 and operates as a tripartite government office being co-funded and co-managed by three partners – Natural Resources Canada, Indigenous and Northern Affairs Canada and the Government of Nunavut's Department of Economic Development and Transportation.

The mandate of the CNGO is to provide accessible geoscience information and expertise in Nunavut to support sustainable and responsible development of Nunavut's natural resources (mineral and energy resources), and to develop and promote geoscience education, training, and capacity building.

Research work to date has focussed on regional and detailed mapping, including bedrock and surficial geology mapping, aeromagnetic surveys, geochemical surveys, and carving stone resource mapping. Thematic studies include detailed research (e.g., Paleozoic stratigraphy) to understand Nunavut's geology and mineral resources (i.e., Meadowbank gold mine, lead-zinc potential of Borden Basin). Energy-related research (uranium, petroleum) and research for infrastructure needs (permafrost studies, aggregate studies) are conducted collaboratively with university and other government partners. Data dissemination, including publication of maps, reports and datasets, through publicly accessible websites, and community communication and outreach efforts ensures that research results are distributed in a timely manner.

Recent work has concentrated on 1) geological research (mapping) for responsible natural resource development; 2) mapping for climate change and permafrost; 3) mapping for infrastructure; and 4) data dissemination and capacity building. The Tehery Lake-Wager Bay collaborative project completed its third field season of mapping in an area of complicated structural and geological relationships; the mapping has resulted in the identification of new rock

types and refinement of previous work. Paleozoic stratigraphic research and surficial mapping were conducted over the Boothia Peninsula. Stratigraphic work provides essential data for detailed stratigraphic divisions and evaluating the ages of the different stratigraphic units, allowing for definitive correlation of the Paleozoic rocks with the other Arctic islands. For the surficial work, understanding ice-flow direction and important geomorphological processes are critical for interpreting the geochemistry and mineralogy of surficial sediments. Such baseline data is important for future mineral exploration and possible resource development in the area, as well as for infrastructure studies (permafrost conditions, granular aggregate sources). A collaborative project over the Kilohigok paleosol in the western Kitikmeot Region is determining the economic potential of this sedimentary basin. Continuing work on permafrost and surficial research continues over the western Hudson Bay area.

A new project, the Qirniqtalluk project of northwestern Baffin region, is a multi-faceted research project started in 2017 with community information sessions followed by aeromagnetic surveying for the southern portion of the study area. The aeromagnetic data is being collected with significant results and targets being identified. This geophysical work is the initial step to a larger field mapping project proposed for 2018-2019.

CGNO disseminates its geoscience data through many avenues, including the annual Summary of Activities initiated in 2012.

NORTHWEST TERRITORIES-ENVIRONMENTAL STUDIES RESEARCH FUND: PROVIDING FUNDING FOR RESEARCH IN THE NORTHWEST TERRITORIES RELATED TO THE ENERGY INDUSTRY

HANSEN, K.

GEO-KEN ASSOCIATES LTD., CALGARY, AB
KENFHANSEN@GMAIL.COM

The NWT-Environmental Studies Research Fund (ESRF) is now into its third year of operation. Authorized under the Petroleum Resources Act, the ESRF provides financial support for environmental and social studies pertaining to exploration, development and production activities on petroleum lands. The petroleum industry provides the funding required to support this research and the administration of the ESRF. Companies holding Exploration, Production and Significant Discovery Licenses in the NWT are assessed an annual levy based on acreage held within the Territory.

The Environmental Studies Management Board (Board) oversees operation and management of the ESRF. The Board is composed of representatives from government, industry and the public in the NWT. Board Members are appointed by and serve at the pleasure of the Minister of the GNWT Department of Industry Tourism and Investment. Current focus for the Board is on developing cost-effective strategies for maintaining baseline monitoring programs across those areas of the NWT likely to see oil and natural gas development in the future. Wildlife and water are the current priority research areas for the ESRF.

MANTLE COMPOSITION, AGE AND GEOTHERM BENEATH THE DARBY KIMBERLITE FIELD, WEST CENTRAL RAE CRATON

HARRIS, G.A.[1], PEARSON*, D.G.[1], LIU, J.[2], HARDMAN, M.F.[1], and KELSCH, D.[3]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) CHINA UNIVERSITY OF GEOSCIENCES, BEIJING, CHINA
(3) BLUESTONE RESOURCES INC., VANCOUVER, BC
GDPEARSO@UALBERTA.CA

New geological and geophysical research on Canada's Rae craton are providing an increasingly good baseline for diamond exploration. This study uses mantle xenoliths and xenocrysts from the Darby property, located ~ 200 km southwest of the community of Kugaaruk, Nunavut, to provide new information on the lithospheric mantle and diamond potential of the western portion of the central Rae. Peridotite xenoliths containing enough fresh olivine have a median Mg# value of 92.5, indistinguishable from the median value of 92.6 typical of cratonic peridotites world-wide. Only four of the fourteen peridotitic xenoliths contain garnet. Of these, garnet in one sample is classified as harzburgitic (G10), giving a minimum pressure of 4.7 GPa using the P38 geobarometer (38 mW/m2 model geothermal gradient), while garnets from three peridotites classified as lherzolitic (G9). Of the 52 peridotitic garnets picked from concentrate, one grain has a wehrlite affinity and 51 are lherzolitic.

Lherzolitic diopsides from kimberlite heavy mineral concentrate yield a lithospheric thickness of ~ 200 km. The four garnet peridotite xenoliths and 49 peridotitic garnets from concentrate yield two distinct modes in mantle sampling depths using Ni thermometry, when projected to the Cpx geotherm. A cluster of samples from the higher Ca/Cr lherzolitic garnets equilibrated at 765 to 920 °C, while a group of peridotitic garnets (50 % of xenoliths and 28 % of concentrate) from the lower Ca/Cr lherzolitic garnets with anomalously high Ti concentrations yielded super-adiabatic TNi values. The aluminum-in-olivine thermometer applied to olivine concentrate, filtered for those from the "garnet facies", showed that a mantle sampling portion exists at Darby that is clearly derived from the diamond stability field. This mantle sampling component is not evident in the garnet Ni temperatures. A suite of pyroxenitic/eclogitic xenoliths are a feature of each Darby kimberlite target. New screening techniques indicate that these rocks likely originate close to the crust-mantle boundary.

Osmium isotope analyses of the Darby peridotites reveal whole-rock Re-depletion ages ranging from Mesoarchean to Paleoproterozoic. The pyroxenite/eclogite xenoliths have very radiogenic Os isotope compositions and provide the first age information from pyroxenites/eclogites beneath the Rae craton. Their resulting Archean whole rock TMA ages are consistent with a Mesoarchean age of the western Central Rae lithosphere older than the lithosphere beneath the Repulse Bay block in the East section of the Rae craton (Liu et al., 2016).

The highly depleted olivine compositions, thick cold lithosphere, and Archean ages of the Darby peridotite xenoliths clearly indicate the presence of ~ 200 km thick cold cratonic lithospheric mantle beneath the western segment of the central Rae craton circa 540 Ma. The Archean model ages of most of the pyroxenites/eclogites support this, notwithstanding the fact that some of

these rocks could be sampling either crust or mantle lithologies very close to the crust-mantle boundary. Mantle sampling occurred across the geotherm, well into the diamond stability field at Darby.

IMPACTS OF FOREST FIRES ON DISCONTINUOUS PERMAFROST IN THE SOUTHERN NORTHWEST TERRITORIES

HOLLOWAY*, J.E. and LEWKOWICZ, A.G.

UNIVERSITY OF OTTAWA, OTTAWA, ON
JEAN.HOLLOWAY77@GMAIL.COM

Forest fire is rarely taken into account in predictive modeling of permafrost change even though severe fires have been shown to accelerate degradation. Moreover, the frequency and magnitude of fires is increasing as the climate warms. Wildfire is particularly important in the sporadic and extensive discontinuous permafrost zones where frozen ground is buffered by forest vegetation from increasing air temperatures. Our research goal is to examine permafrost change following the extensive fires of 2014 in the southern NWT in order to improve predictive modelling of the fate of permafrost in the region.

A total of 18 burned and unburned sites representing a range of climatic, ecological and permafrost conditions were established in 2015 and 2016 along a 300 km long latitudinal transect from Kakisa to 80 km north of Yellowknife. Unburned control sites were chosen at the northern and southern ends of the transect to determine baseline impacts of climate change. At each site, air temperature, near-surface ground temperature, and snow depth are being monitored continuously. In addition, direct current electrical resistivity tomography (ERT) surveys are being conducted annually or more frequently along permanent electrode arrays. This geophysical technique provides an image of the electrical properties of the ground to a depth of 25 m which can be interpreted as frozen and thawed zones. At the time of the ERT surveys, frost table depth is measured using a titanium probe inserted into the ground until resistance is met.

Mean annual air temperatures in 2015-16 and 2016-17 varied between -0.7°C and -3.0°C along the latitudinal gradient. Burned sites were warmer than unburned ones: surface offsets averaged 0.5°C greater and the thermal offsets were 0.1°C smaller. Average frost table depths at burned sites were 17 cm greater than at unburned sites, and were generally greater in 2016 and 2017 compared to 2015. This reflects the ongoing impact of the burned surface because mean summer air temperatures differed by only 0.3°C between 2015 and 2017. Results from ERT surveys show the development of a thicker thawed layer in the near-surface and the possible loss of permafrost within some sites. The most-affected sites are underlain by coarser-grained substrates (generally sand and gravel) with thin organic layers, whereas peatland sites are less impacted. These results indicate the heterogeneity of permafrost reaction to forest fire at the landscape scale and suggest that permafrost may persist in peatlands while degrading elsewhere in the region.

FOREST RESOURCE MODELING AND ECOSYSTEM CHANGE MONITORING IN THE NORTHWEST TERRITORIES USING AIRBORNE LASER SCANNING

HOPKINSON*, C.[1], CHASMER, L.[1], MAHONEY, C.[1], and HALL, R.[2]

(1) UNIVERSITY OF LETHBRIDGE, LETHBRIDGE, AB
(2) CANADIAN FOREST SERVICE, EDMONTON, AB
C.HOPKINSON@ULETH.CA

Over the last decade, active airborne laser scanning (ALS) sampling of forest and permafrost ecosystems has been taking place across the southern portions of the Northwest Territories Taiga Plains and Taiga Shield ecozones from Nahanni to Yellowknife. Initially, these were site-specific locations related to collecting baseline watershed, geomorphological and forest attribute data to support dedicated collaborative research objectives through the Canadian Consortium for lidar applications research (C-CLEAR), with support from NRCan (CFS and GSC), Environment Canada and university groups. In 2008, the first systematic repeat data collection was conducted over Scotty Creek near Ft. Simpson with further ALS data collections in and around this site in 2010, 2011, 2015 and 2016. Following our pioneering ALS transect sampling work in Alberta and Nova Scotia, in 2010, 2011 and 2016, ALS sampling campaigns were conducted across the same general area to support systematic ecosystem monitoring and forest inventory model development. These data have proven key in mapping permafrost-related ecosystem change rates as well as in facilitating the scaling up of plot-based models to ecozone-scale as part of a hierarchical workflow involving field, airborne and satellite data sources. A brief overview of these initiatives will be presented as well as plans for future forest and wetland ecosystem monitoring and change trajectory mapping through the integration of ALS with archive satellite optical imagery. The presentation will finish by highlighting new opportunities from large area active satellite platforms that will soon be launched; i.e. NASA's ICESat 2 and the Canadian Space Agency's RadarSat Constellation mission. With these new mapping and monitoring platforms, ALS is expected to play a key role in calibrating new baseline landcover attribute map products over the immense regions of sparsely populated lands that make up the NWT.

STRATIGRAPHY, GAMMA-RAY SPECTROMETRY, AND URANIUM PROSPECTIVITY OF THE KILOHIGOK PALEOSOL IN THE BEAR CREEK HILLS, KITIKMEOT, NUNAVUT

IELPI*, A.[1], MICHEL, S.[1], GREENMAN, J.W.[2], and LEBEAU, L.E.[1]

(1) LAURENTIAN UNIVERSITY, SUDBURY, ON
(2) CARLETON UNIVERSITY, OTTAWA, ON
AIELPI@LAURENTIAN.CA

The Kilohigok Basin covers a vast portion of the Kitikmeot Region of Nunavut and remains one of the last major Proterozoic basins in Arctic Canada lacking a modern exploration background, particularly for uranium. A Paleoproterozoic passive margin encompassing fluvial and nearshore-marine deposits (Kimerot Group) is exposed in the Bear Creek Hills surrounding Bathurst Inlet, and represents the earliest filling event of the Kilohigok Basin. This passive margin succession nonconformably sits atop metasedimentary rocks of the Archean Yellowknife Supergroup, which is part of

the Slave Province of the Canadian Shield. This presentation deals with the result of field work conducted in the area during the 2017 summer season, and illustrates the stratigraphy, paleogeography, and gamma-ray spectrometry of a ~2.0 Ga horizon of paleo-weathering found at the contact between the Kimerot Group and Yellowknife Supergroup, known in the region as the Kilohigok paleosol.

The Kilohigok paleosol comprises a 1.5 m-thick, rusty-weathered horizon intersected by quartz veins and derived from metapelite and meta-iron formations of the Yellowknife Supergroup, and underlies a sloping paleotopography that displays up to 10 m of relief per 1 km along strike. Gamma-ray spectrometric profiles ran through the paleosol helped in the identification of anomalous values of radioactivity (up to 867.5 nSv/h), which correspond to peak concentrations of uranium slightly over 120 ppm. In the Bear Creek Hills, the Kilohigok paleosol is overlain by fluvial conglomerate and sandstone that show evidence of intense chemical weathering and sericitization, and point to production and routing of detritus from the hinterland of Slave Craton at 2.0 Ga. These results complement ongoing studies along the Kilohigok paleosol over a transect of over 200 km, and suggest that portions of the so-far underexplored Kilohigok Basin may host in place prospective uranium resources.

NWT CUMULATIVE IMPACT MONITORING PROGRAM UPDATE

KANIGAN, J.C.N.

(1) ENVIRONMENT AND NATURAL RESOURCES, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
JULIAN_KANIGAN@GOV.NT.CA

The mandate of the Northwest Territories Cumulative Impact Monitoring Program (NWT CIMP) is to analyze scientific and traditional knowledge to monitor the cumulative environmental impacts of land and water use in the NWT. Cumulative impacts are changes to the environment caused by human actions or a combination of human actions and natural factors through time and space.

Monitoring cumulative impacts is an important part of environmental regulation and integrated system of environmental management in the NWT. The legal mandate for NWT CIMP comes from the Gwich'in, Sahtu, and Tłı̨chǫ land claim agreements, and Part 6 of the Mackenzie Valley Resource Management Act. Aboriginal governments and organizations help to guide the program through the NWT CIMP Steering Committee.

NWT CIMP is focused on cumulative impact monitoring that provides information to regulators and the public that supports environmental decision-making. As such, the program emphasizes the monitoring priorities of co-management boards including the Mackenzie Valley Environmental Impact Review Board and the Mackenzie Valley Land and Water Board. Examples of how NWT CIMP projects results were used last year to help make effective decisions include the generation of water quality data for water licensing requirements, candidate conservation area planning and fish harvest quotas for Great Slave Lake.

The program strives to include communities in as many aspects of cumulative impact monitoring as possible. NWT CIMP's vision "To watch and understand the land and to use it respectfully forever" is recognized by supporting the following activities: A) Working with partners to understand key

monitoring and research priorities; B) Coordinating, conducting and funding environmental research and analysis; and C) Reporting and communicating results to northern decision-makers and the public. NWT CIMP has supported approximately 200 individual projects since 2002; most of which have been related to water and fish, caribou, traditional knowledge and capacity building.

All NWT CIMP project results are available for download on the NWT Discovery Portal www.nwtdiscoveryportal.enr.gov.nt.ca or by contacting nwtcimp@gov.nt.ca.

HOW TECTONIC STRAIN RATE INFLUENCE SEISMIC HAZARD FROM INJECTION-INDUCED EARTHQUAKES

KAO*, H.[1,2], HYNDMAN, R.[1,2], JIANG, Y.[1], VISSER, R.[1], SMITH, B.[1], BABAIE MAHANI, A.[1,3], LEONARD, L.[2], GHOFRANI, H.[4], and HE, J.[1]

(1) GEOLOGICAL SURVEY OF CANADA, SIDNEY, BC;
(2) UNIVERSITY OF VICTORIA, VICTORIA, BC
(3) GEOSCIENCE BC, VANCOUVER, BC
(4) WESTERN UNIVERSITY, LONDON, ON
HONN.KAO@CANADA.CA

Most induced earthquakes in North America are associated with injection operations, including hydraulic fracturing (HF) and wastewater disposal (WD), during hydrocarbon development. A rapid increase of injection-induced earthquakes (IIE) is often linked to a significant increase in seismic hazard. However, there are many areas where large-volume injections do not produce any IIE. Statistically, only ~1% of WD and ~0.3% of HF wells in western Canada have been associated with $M_L \geq 3$ IIE. In this study, we derive the regional tectonic strain from geodetic measurements and compare with regional seismic pattern. We conclude that the regional tectonic strain rate plays an important role in the distribution of IIE in western Canada. While most natural earthquakes in our study area occur in the high-strain Canadian Cordillera, the regional seismic pattern is dominated by IIE, both in number and moment, along a 150-km wide NW–SE band of moderate strain rate in the easternmost Cordillera. In the flat Western Canada Sedimentary Basin (WCSB) further to the east, both strain rate and seismicity are very low despite of injections. Our analysis suggests that although injection in areas with moderate tectonic strain may temporarily increase the local seismic hazard, widespread IIE over an extended period of time may deplete the available tectonic moment and could, under the right conditions, reduce the seismic hazard in the long term.

REGULATION IN AN ERA OF RECONCILIATION - WHAT SHOULD THE WAY FORWARD LOOK LIKE?

KARA, N.

STRATOS, TORONTO, ON
NKARA@STRATOS-STS.COM

Given the massive review of the federal role in environmental assessments that has taken place over the last year, this is a timely opportunity for a discussion of the regulatory process underpinning the approval of major resource projects in Canada. Two experts will engage in an interactive dialogue on what the way forward could/should look like, exploring the intersections between issues as free, prior and informed consent, regulatory certainty, the duty to consult, foreign investment and the commodity cycle. Special attention will be given to a discussion of the co-management system in the North, and lessons that could be drawn

from these governance systems for environmental assessment regimes in southern Canada.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY — 2017 OVERVIEW

KETCHUM, J.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
JOHN_KETCHUM@GOV.NT.CA

The Northwest Territories Geological Survey (NTGS) is a division of the Department of Industry, Tourism and Investment (ITI), Government of the Northwest Territories (GNWT). It carries out and supports geoscience studies that contribute to a modern, comprehensive geoscience knowledge base for the Northwest Territories. This knowledge is used by stakeholders and NTGS staff to support evidence-based decisions. NTGS staff also provide advice and educational/outreach services to individuals, communities, governments, and industry.

Most of the 23 staff members belong to one of five working groups. These are Mineral Deposits and Bedrock Mapping, Petroleum Geosciences, Environmental Geoscience, Geoscience Information Services, and Geomatics and Information Technology. Many staff also collaborate on research with external partners. Chief among these are the Geological Survey of Canada and university Earth Science departments across Canada. Collaboration with other ITI divisions and GNWT departments is common in addressing land-based government objectives and decisions.

During 2017, field research was conducted in the Slave craton, East Arm Basin, Interior Plains, and Cordillera, with significant funding support from the Canadian Northern Economic Development Agency, the Geological Survey of Canada's Geo-mapping for Energy and Minerals program, the Polar Continental Shelf Program, and Polar Knowledge Canada.

NTGS highlights for 2017 include but are not limited to: opening a new Geological Collections Storage Facility in Yellowknife; completion of a new five-year strategic plan; distributing $1 million of Mining Incentive Program funding; new mineral claim staking influenced by NTGS geoscience information; and launching new web applications that allow clients to discover and download a wide range of NWT geoscience information.

The NTGS welcomes Dr. Gideon Lambiv Dzemua to the position of Industrial Minerals Resource Geologist. Gideon has a wide range of geological and project management experience in Canada and Africa and joined the NTGS in early November 2017.

PINE POINT MINING

KEY, J.

PINE POINT MINIING INC., TORONTO, ON
PAMGR@MININGNORTH.COM

In 2017, Darnley Bay Resources, now renamed Pine Point Mining, acquired the former Pine Point Mine site and surroundings and began active exploration to advance the project.

A preliminary economic assessment (PEA) released earlier this year projects a “robust economic return” with a 13 year mine life, employing an average of 321 people. The project as currently envisioned is a series of 10 open pit deposits mined in sequence. Total mineral resources included in the PEA

mine plan are 25.8 million tonnes of measured and indicated resources grading 2.94% zinc and 1.12% lead, and an additional 3.7 million tonnes of inferred resources grading 2.90% zinc and 0.77% lead.

BEDROCK MAPPING OF THE BEAULIEU RIVER VOLCANIC BELT AT SUNSET LAKE, SLAVE CRATON, NORTHWEST TERRITORIES

KNOX, B.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
BERNADETTE_KNOX@GOV.NT.CA

In 2017 the Northwest Territories Geological Survey conducted the second year of a multi-year bedrock mapping initiative along the Beaulieu River Volcanic Belt at Sunset Lake in the southern Slave Province. The study area is approximately 110 km east-northeast of Yellowknife. Due to a recent forest fire the current exposure is excellent and has allowed for detailed mapping at 1:10,000 scale, in an area previously mapped at 1:50,000 scale.

The four-week bedrock mapping program conducted along the Beaulieu River in the Sunset Lake area added details related to lithology, alteration types, alteration intensity, and the primary, ductile, and brittle structures with the goal to increase the understanding of the economic potential in the Beaulieu River Volcanic Belt and placing it within its context in the Slave Craton.

The Sunset Lake area preserves an uncommonly complete geological history of the Slave Craton. The volcanic belt sits structurally above rocks of the Central Slave Basement Complex (Sleepy Dragon Complex) as well as preserved quartzites, ultramafic rocks, and conglomerates of the Central Slave Cover Group. The volcanic rocks and associated supracrustal rocks are dominated by tholeiitic basalts (pillows, massive, pillow breccias etc.), minor andesites, dacites, rhyolites, interflow argillites, banded iron formation and many variations of volcaniclastic deposits. Although interflow sediments are found throughout the volcanic deposits, there is an increase in thickness and abundance towards the structural top of the basin. These rocks are all variably intruded by volcanic dykes, and the Amacher Granite. A conformable contact was observed south of Sunset Lake between the volcanic belt rocks and the turbidities of the Burwash Formation. The region has experienced multiple distinct ductile deformational events at greenschist- to lower amphibolite-facies metamorphic conditions. The Beniah fault zone has been reactivated numerous times at different crustal levels.

The Beaulieu River Volcanic Belt has experienced multiple generations of mineral exploration and contains known mineral endowment, along with potential for additional discoveries. Located within the 2017 study area is the "Sunrise" volcanogenic massive sulphide (VMS) deposit. It has historic indicated resource of 1.52 Mt at 5.99% Zn, 2.39% Pb, 0.08% Cu, 262 g/t Ag, 0.67 g/t Au. A detailed mapping (1:2,000 scale) and geochemical program around the Sunrise VMS deposit aims to understand the numerous lithofacies to gain understanding of the volcanic stratigraphy.

The current mapping initiatives are targeted to increase our understanding of the regional and local setting of the Sunrise VMS deposit and provide additional tools for future exploration.

IMPLEMENTING REMOTE SENSING TOOLS TO EXAMINE PERMAFROST DYNAMICS AND IMPACTS TO INFRASTRUCTURE

KOKELJ*, S.V.[1], VAN DER SLUIJS, J.[2], FRASER, R.H.[3], TUNNICLIFFE, J.[4], LANTZ, T.C.[5], RUDY, A.C.A.[6], LAMOUREUX, S.F.[7], RUSK, B.[7], and MORSE, P.D.[8]

(1) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(2) NWT CENTRE FOR GEOMATICS, YELLOWKNIFE, NT
(3) CANADA CENTRE FOR MAPPING AND EARTH OBSERVATION, OTTAWA, ON
(4) UNIVERSITY OF AUCKLAND, AUCKLAND, NEW ZEALAND
(5) SCHOOL OF ENVIRONMENTAL STUDIES, VICTORIA, BC
(6) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(7) QUEEN'S UNIVERSITY, KINGSTON, ON
(8) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
STEVE_KOKELJ@GOV.NT.CA

Climate-driven thaw is altering permafrost landscapes and increasing the stresses on northern infrastructure and communities. The rapid rates of change have heightened the need for monitoring and research tools that are cost-effective, flexible, and that can accommodate timely acquisition of imagery at site-specific and regional scales. Emerging remote sensing tools and spatial analysis techniques are advancing site investigations and terrain mapping studies. Unmanned Aircraft Systems (UAS) have been implemented to study fine-scale permafrost dynamics and infrastructure impacts. UAS methods were used to assess the volume of materials displaced by thaw slumps, and to quantify earth flow dynamics and the displacement of road embankments. These studies were accomplished by deriving high-resolution digital terrain models and implementing image correlation techniques from repeat surveys. These results provide new information on modes of slope failure, geotechnical behaviour of materials, and mechanisms of downslope sediment transfer. Along the Dempster Highway, UAS were used to monitor uplift or settlement associated with the development or degradation of injection ice. The surveys combined with active layer and ground temperature data and road maintenance records provide information on the processes of ice accumulation and icing development adjacent to northern roads. UAS can also be used to monitor the evolution of anthropogenic disturbances such as borrow pits. Repeat UAS surveys were conducted to derive digital terrain models of borrow pits for regulatory monitoring and to inform possible mitigations. These monitoring products are shown to effectively track thaw-related impacts, drainage pathways, downslope sedimentary linkages, ice features and landscape morphology. These process-oriented studies and infrastructure monitoring activities are contextualised by regional-scale terrain mapping using LiDAR and high-resolution satellite imagery. Terrain mapping is improved through field validation exercises and the development of standard keys for interpreting landscape forms and processes. The increasing availability of high-resolution imagery and interests in permafrost landscape change are yielding a growing number of spatial datasets, which describe patterns of landscape change, geohazards and permafrost geomorphic characteristics. These fine- to medium-scale mapping products and associated field investigations can be used to validate coarse-resolution Landsat derived change products which are valuable tools for monitoring landscape change and assessing spatial patterns and downstream effects. Integrating multi-scale

remote sensing approaches has been useful in linking a process-based understanding of thaw-driven impacts with broad-scale permafrost landscape change.

THE DUTY TO CONSULT ABORIGINAL PEOPLES: BACKROUND AND LEGAL UPDATE

KRUGER, T.

LAWSON LUNDELL LLP, YELLOWKNIFE, NT
TKRUGER@LAWSONLUNDELL.COM

The duty to consult Aboriginal peoples arises where the Crown (i.e. the federal and/or territorial government) "has knowledge, real or constructive, of the potential existence of the Aboriginal right or title and contemplates conduct that might adversely affect it." The duty may be triggered where the Crown grants authorizations for mining projects to proceed.

The content of the duty varies with the circumstances and falls along a "spectrum." The effect of good faith consultation may be to reveal a "duty to accommodate", but does not provide Aboriginal groups with a "veto".

Third parties (such as mining companies) do not have a legal duty to consult. However, the Crown may delegate "procedural aspects" of consultation to industry proponents seeking a particular development.

This session will explore the duty to consult, touch on recent case law from the Supreme Court of Canada, and provide practical tips for project development in the NWT.

INTEGRATING CHEMOSTRATIGRAPHIC AND SEDIMENTOLOGICAL DATASETS TO ESTABLISH A SEQUENCE STRATIGRAPHIC FRAMEWORK FOR THE DEVONIAN CANOL FORMATION, CENTRAL MACKENZIE VALLEY AND MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES

LAGRANGE RAO*, M.T.[1], HARRIS, B.[1], FIESS, K.M.[2], TERLAKY, V.[2], and GINGRAS, M.K.[1]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
MAYA1@UALBERTA.CA

The Middle to Late Devonian Canol Formation is an organic-rich shale historically known as the source rock for the oil produced from the Kee Scarp Reefs at Norman Wells, NWT. Recent interest has shifted to its potential as an unconventional hydrocarbon reservoir with seven long cores drilled by industry over the past six years. The Canol Formation is a member of the Givetian to Frasnian Horn River Group in the Mackenzie Mountains and Central Mackenzie Valley of the Northwest Territories. Previous studies have included the Canol Formation in an overall depositional and sequence stratigraphic model for the Horn River Group with a focus on the Kee Scarp and Ramparts formations, but did not include a detailed stratigraphic analysis of the Canol Formation. This study aims to integrate chemostratigraphic and sedimentological data in order to established a preliminary sequence stratigraphic framework for the Canol Formation.

The dataset consists of samples and observations collected from the Mountain River outcrop, the MGM Shell East Mackay I-78 core, and the Husky Little Bear N-09 and H-64 cores. The outcrop and cores were logged in detail with observations focusing on lithology, contacts, and sedimentary structures. Portable X-ray Fluorescence (XRF) equipment was used to collect high-resolution elemental composition data at an interval of 10 cm for the cores and 10 cm - 100 cm at the Mountain River outcrop. Elemental proxies were used in conjunction with sedimentological observations to identify Transgressive-Regressive (T-R) cycles in each core and outcrop. Regression was interpreted where continentally derived sediment abundance increases and biogenic silica abundance decreases. Conversely, transgression was interpreted where continentally derived sediment abundance decreases and abundance of biogenic silica increases. Elements that are almost exclusively derived from continental sediment (Al, Fe, K, Ti) were used as a proxy for continental sediment input. In addition, the ratio of Si/Zr was used as a proxy for the abundance of biogenic silica compared to clastic silica. Zirconium is almost always exclusively derived from detrital sediment, therefore a high ratio of Si/Zr reflects a greater abundance of biogenic silica. If the ratio of Si/Zr is low, a decreased abundance of biogenic silica is interpreted. This information was supplemented by the interpretation of paleoredox conditions using geochemical proxies such as Mo and V enrichment. Preliminary results suggest that time-synchronous maximum regressive and maximum flooding surfaces can be identified and correlated to establish a preliminary sequence stratigraphic framework for the cores and outcrop included in this study. The purpose of establishing a sequence stratigraphic framework is to enable high-resolution subsurface mapping of clay-lean and silica-rich sweet spots, making it a valuable step in assessing the unconventional reservoir potential of the Canol Formation.

DEVELOPING AND ENGAGING INDIGENOUS WORKERS FOR THE CANADIAN MINING SECTOR

LAROUCHE, P.

MINING INDUSTRY HUMAN RESOURCES COUNCIL, OTTAWA, ON
PLAROUCHE@MIHR.CA

Hiring Indigenous peoples is a shared human resource priority of mining employers. Despite this, opportunities for greater inclusion of Indigenous workers in the mining industry exist.

The Mining Industry Human Resources Council (MiHR) recently completed a three-year study on Indigenous employment in the mining sector to enable informed discussion on career development and employment barriers. This presentation will provide an overview of the research findings and discuss how one of the proven industry programs, Mining Essentials: training to employment program for Indigenous peoples, has created rewarding employment opportunities.

Mining Essentials helps companies and communities meet their joint hiring and employment targets. It allows companies to benefit from a local, skilled and empowered workforce, and fosters economic development that results in healthy communities. Mining Essentials has been delivered successfully across Canada, involving 27 mining companies, 15 educational partners, and 36 Indigenous organizations/communities.

CREATING A NWT MINERAL RESOURCES ACT

LEESON, N.

INDUSTRY, TOURISM AND INVESTMENT, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
NICK_LEESON@GOV.NT.CA

The management of Northwest Territories' (NWT) public lands and natural resources devolved to the Government of the Northwest Territories (GNWT) in 2014. Since then the GNWT has the authority to improve its legal frameworks to reflect the Northwest Territories' uniqueness. The GNWT is preparing to develop a new, leading-edge, made-in-the-NWT Mineral Resources Act (MRA). The MRA will be designed to meet the needs of the NWT, harmonize with co-management, increase investment in mining, promote a sustainable and diversified economy, protect the natural environment, and respect the rights and traditions of Indigenous peoples.

Preparing the MRA is a six-step process that began with research, in collaboration with stakeholders and experts. The GNWT is currently in step two: conducting an extensive public engagement process. Up until the end of December 1st, 2017, the GNWT is seeking ideas from the public to guide the development of the MRA. Your input is encouraged.

SCHEELITE-BEARING HIGH FLUID-FLUX SKARNS AT THE METASOMATIC SKARN FRONT AND THEIR RELATIONSHIP TO OTHER MINERALIZATION AT THE CANTUNG W-CU SKARN, NORTHWEST TERRITORIES

LENTZ*, C.P.E.[1], MCFARLANE, C.R.M.[1], and FALCK, H.E.[2]

(1) UNIVERSITY OF NEW BRUNSWICK, FREDERICTON, NB
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
CARLIN.LENTZ90@GMAIL.COM

The Cantung W-Cu skarn is located within the Canadian Cordillera, approximately 400 km to the NE of Whitehorse, YT. It is part of a NW-SE trending belt of tungsten deposits related to Mid-Cretaceous felsic magmatism that was emplaced into Neoproterozoic rifted margin and Paleozoic passive margin rocks originating from Laurentia. It was first hypothesized that the skarn mineralization at Cantung was associated with the granites which underlie the deposit; however, even the early researchers of the deposit were perplexed by the lack of endoskarn developed within the granite. The lack of alteration within the granite immediately in contact with the exoskarn coupled with the local cross cutting of the strata-bound skarn mineralization in the Ore Limestone by smaller granitic stocks off the Mine Stock granite body, all suggest that the Mine Stock is not responsible for the mineralization at Cantung. It is believed that their formation in fact post-dates mineralization.

The main skarn facies at Cantung include the following: garnet ± pyroxene, pyroxene ± pyrrhotite, amphibole ± pyrrhotite, and biotite ± pyrrhotite. In general, the garnet ±

pyroxene skarn facies at Cantung is only very weakly mineralized in scheelite. Another type of skarn was identified with anhydrous minerals; it is characterized by an abundance of scheelite as well as other calcium and ferrous iron bearing phases. A notable feature is the potentially large size of the scheelite crystals (up to 3-4 cm) in comparison to all other skarn facies at Cantung. The most characteristic feature of these skarns is the presence of hydrothermal calcite; it appears that the more calcite which is present, the larger the scheelite crystals can achieve. Many of these structures contain minerals which exhibit unidirectional growth textures from the outermost parts towards the innermost. There is a general transition from anhydrous and higher temperature minerals such as garnet and pyroxene at the outermost parts of the structures towards more hydrous and low temperature minerals such as allanite, epidote, and clinozoisite at the innermost parts of the structures. These structures appear to have an irregular pattern, which sometimes cuts across pre-existing strata. This suggests they could result from local fluid overpressuring along preexisting permeable zones or could possibly form their own pathways through volumetric contraction due to the growth of more dense phases such as garnet.

To understand the physio-chemical conditions responsible for the formation of these skarns; EPMA analysis, µXRF EDS mapping, and LA ICP-MS trace element mapping of both anhydrous and hydrous skarn minerals was conducted. Using new software developments, fully quantitative data from trace element maps was extracted preserving the intricate zoning which preserves the history of the growth of various skarn minerals. The results show that these skarn minerals are strongly zoned and that their zoning reflects the growth of these minerals into the ancient fluid pathways. Their zoning records the progressive evolution of fluid compositions and fractionation of major and trace elements in those fluids.

THE FORMATION OF A CANADIAN PERMAFROST ASSOCIATION

LEWKOWICZ, A.G.[1], KARUNARATNE*, K.C.[2], ALLARD, M.[3], ARENSON, L.U.[4], BROWN, S.[5], BURN, C.R.[6], CALMELS, F.[7], DORÉ, G.[3], DUMAIS, S.[3], GRUBER, S.[6], HOEVE, E.[8], IDREES, M.[9], KOKELJ, S.V.[2], MALENFANT LEPAGE, J.[3], MARSH, P.[10], MCLEOD, K.[11], MOORMAN, B.[12], ROY-LÉVEILLÉE, P.[13], SMITH, S.L.[14] and TURETSKY, M.R.[15]

(1) UNIVERSITY OF OTTAWA, OTTAWA,ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(3) LAVAL UNIVERSITY, QUEBEC, QC
(4) BGC ENGINEERING INC., VANCOUVER, BC
(5) NWT ASSOCIATION OF COMMUNITIES, YELLOWKNIFE, NT
(6) CARLETON UNIVERSITY, OTTAWA, ON
(7) YUKON RESEARCH CENTRE/NORTHERN CLIMATE EXCHANGE, WHITEHORSE, YT
(8) TETRA TECH EBA, YELLOWKNIFE, NT
(9) YUKON GOVERNMENT, WHITEHORSE, YT
(10) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(11) GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
(12) UNIVERSITY OF CALGARY, CALGARY, AB
(13) LAURENTIAN UNIVERSITY, SUDBURY, ON
(14) GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA, OTTAWA, ON
(15) UNIVERSITY OF GUELPH, GUELPH, ON
KUMARI_KARUNARATNE@GOV.NT.CA

In northern Canada, permafrost is a dominant influence over landscape and ecosystem processes, and on infrastructure. The impacts and costs of climate change and permafrost thaw have heightened the societal relevance of the topic and increased the number of scientists, engineers, and practitioners interested in permafrost issues. The formation of a national permafrost association has emerged from this rapid growth of permafrost stakeholders and will address a number of needs.

The association would bridge the scientific and engineering aspects of the field, connecting different communities in science (e.g. geography, geomatics, Quaternary geology, biogeochemistry, physics, hydrology, and ecology) and engineering (e.g. geotechnical, structural, and mining). The multidisciplinary nature of permafrost is recognized as fundamental to solving societal problems associated with permafrost, and collaborating across disciplines will be needed to deal with the consequences of thawing permafrost.

The association would foster mentoring. Presently, there is a demographic gap in experience in the field of permafrost. Many scientists and engineers are either approaching retirement or early in their careers. At the same time, some practitioners and researchers have entered the field from cognate areas in mid-career with great enthusiasm but relatively limited field experience. The association would help facilitate the exchange of knowledge and skills among these groups.

The association would help advance a domain that bridges different organisational structures (corporations, governments at all levels, communities, and universities) and would provide practitioners, northern communities, First Nations, Inuit, media and the general public with a point of contact for information on Canadian permafrost conditions. The association would confer additional legitimacy on the representatives of Canada to the International Permafrost Association ensuring that the international organisation responds to Canada's needs.

The concept of forming an association has been discussed on a number of occasions during the past five years. In April 2017, the Canadian National Committee for the International Permafrost Association (CNC-IPA) decided to form a Steering Committee for a Canadian Permafrost Association to move the proposal for an association forward and give it legitimacy in the community. The 2017 Yellowknife Geoscience Forum will mark the first opportunity for the association's Steering Committee to present progress to date and invite feedback from others interested in permafrost in Canada.

WHAT'S IN A TIME SERIES? UTILIZING METRICS TO SUMMARIZE AND COMPARE SPATIO-TEMPORAL PERMAFROST SITE CHARACTERISTICS ON A LARGE SCALE

MACDONALD, S.

CARLETON UNIVERSITY, OTTAWA, ON
MACDSTU@GMAIL.COM

With a growing interest in climate change and its effects on northern climates and permafrost along with advancing technology, there has been a rapid increase in the amount of temperature data that is being collected at sites all across northern Canada and the world. In addition, more efforts are being put into pooling these data and making it available publicly, such as via

the Global Terrestrial Network for Permafrost (GTNP) online database. Yet there is an increasing disparity between the amount of data collected and the methods that can be used to analyze it meaningfully, thoroughly, and on a wide scale.

One approach to doing this is via a metric. Currently, the most common metric that is used to "measure" a site is the mean annual air/surface/ground temperature, and there is an approximate relationship between the mean temperature and the probability of there being permafrost or not: the lower the mean temperature, the more likely that there is permafrost present. By comparing mean temperatures, one can also decide which areas are more and less susceptible to thaw. Beyond this and other "bulk" statistics such as measurements of deviation or variance, however, there are very few metrics that can be gleaned from temperature time series that can summarize comparable site characteristics in a meaningful way.

The goal of this presentation will be to suggest ways in which useful metrics can be devised and programmed so that key aspects of sites - or, at least, proxies for key aspects at sites - can be rapidly extracted from their corresponding time series for comparison. The approach used is heavily dependent on phase lag analysis of coupled time series, which measures the time delay (lag) between temperature changes in the air and the proportional changes they cause in the surface temperature. Consider that a temperature logger sitting on the surface of the ground would have a very short lag, while one sitting below an organic or clay layer or a large amount of snow cover would have a much longer lag.

After explaining a little about the rudiments of lag theory, I will show how it can be applied to quickly get summary values that are relatable to spatial site aspects such as soil properties and snow cover, and how these values can then be utilized for an understanding of the spatio-temporal variation across any number of sites. For example, comparing the lag measurements and proportionality of air to surface temperature in the summer can provide information about the thermal diffusivity properties of the soil, while looking at the evolving lag series over the winter can provide an understanding of which sites are more or less likely to be affected by the insulating effects of snow cover. These can then be compared from year to year to decide whether site properties are changing or staying relatively constant.

INTEGRATING HIGH RESOLUTION FIELD OBSERVATIONS AND MODELLING IN ORDER TO IMPROVE OUR UNDERSTANDING OF HYDROLOGICAL CHANGE IN THE ARCTIC NORTHWEST TERRITORIES

MARSH*, P.[1], WALKER, B.[1], MANN, P.[1], TOURE, A.[1], WILCOX, E.[1], JITNIKOVITCH, A.[1], RUDY, A.C.A.[1], ENSOM, T.[1], DERKSON, C.[2], and SONNENTAG, O.[3]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) ENVIRONMENT AND CLIMATE CHANGE CANADA, TORONTO, ON
(3) UNIVERSITY OF MONTRÉAL, MONTRÉAL, QC
PMARSH@WLU.CA

The climate is changing across the NWT at an unprecedented rate, transforming all aspects of the environment, including vegetation, snow and permafrost. At the Arctic treeline near Inuvik, and along the

Inuvik to Tuktoyaktuk Highway (ITH), the temperature is warming dramatically, precipitation is decreasing, and shrubs are expanding across the tundra. In response, the hydrological system is changing in unexpected ways. As one example, although spring snowmelt is occurring earlier in the year, streamflow is occurring later. The reason for this is poorly understood, and current hydrological models are unable to predict this change. These, and other unexpected changes to lakes and streams requires a greatly improved understanding of changes in climate, vegetation and permafrost in order to understand past changes, and consider future implications of a changing climate on the arctic environment, communities and infrastructure. In this presentation, we will describe a series of integrated field observations at the Trail Valley Creek research watershed south of Tuktoyaktuk, NWT, in the western Canadian Arctic and along the ITH. This paper will focus on describing novel observation methods to characterize the arctic environment, including the use of unmanned aerial systems, cosmic ray sensors, and eddy covariance systems, for example. These datasets will be used to test the high resolution hydrologic models required to understand past, and future, changes in hydrology.

THE SOUTH RAE MAPPING PROJECT: NEW RESULTS FROM BEDROCK MAPPING

MARTEL*, E.[1], REGIS, D.[2], PEHRSSON, S.J.[2], THIESSEN, E.J.[3], ACOSTA-GONGORA, P.[2], and JAMISON, D.[4]

(1) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(2) GEOLOGICAL SURVEY CANADA, OTTAWA, ON
(3) SIMON FRASER UNIVERSITY, VANCOUVER, BC
(4) UNIVERSITY OF WATERLOO, WATERLOO, ON
EDITH_MARTEL@GOV.NT.CA

The Rae craton extends from the Athabasca Basin to Baffin Island and covers more than 15% of the Northwest Territories' landmass. Although the Rae craton is four times the size of the Slave craton and as big as the Superior craton, its complex tectonic history and metallogenic potential is poorly understood. Recent efforts by the Geological Survey of Canada, through the Geo-mapping for Energy and Mineral program in collaboration with the Northwest Territories Geological Survey, have led to a better understanding of this remote, under-explored region.

Field work was conducted in 2012, 2015 and 2016 in the southern Rae craton in southeastern NWT. Bedrock mapping at 1:250,000 scale was completed over parts of 4 map sheets NTS 75A, B, G and H. Thematic complementary research includes U-Pb geochronology, Ar-Ar geochronology, lithogeochemistry, metamorphic petrology, economic geology, and structural analysis.

The southern part of the Rae craton has been subdivided into eight tectonometamorphic domains (from east to west: Snowbird, Firedrake, Ena, McCann, Penylan, Howard,

Lynx, and Porter). Studying the unique tectonometamorphic history of each domain will allow for a better understanding of the Rae craton's assembly and ultimately the amalgamation of Laurentia. With the exception of the Proterozoic Penylan domain rocks, the study area is mostly comprised of Archean metaplutonic rocks and less extensive Archean to Paleoproterozoic metasedimentary rocks. Rocks of the Snowbird domain include a metasedimentary sequence (<2.73 Ga) intruded by ultramafic sills (ca. 2.63 Ga) which host Ni-Cu mineralization. The Firedrake domain consists mostly of amphibolite facies orthogneiss (2.69-2.66 Ga) with relict granulite assemblages, injected by extensive granodiorite migmatite (1.84-1.82 Ga). The McCann domain is dominated by Archean metaplutonic and metasedimentary rocks metamorphosed at high temperature (820 °C) and moderate pressure (7 kbar) during the Arrowsmith Orogeny (ca. 2.35 Ga). Proterozoic gabbro dykes (2.27 Ga) have in turn been metamorphosed at high pressure. The Penylan domain consists of a Proterozoic gabbroic anorthosite complex (ca. 2.04 Ga) and associated quartz-syenite/monzonite intrusions (ca. 2.03 Ga). Preliminary results indicate that these rocks have been metamorphosed to high-pressure granulite conditions at 1.84 Ga. The Howard domain consists of previously unmapped metasedimentary rocks and meta-andesite. This domain's magnetic signature extends north to the Boomerang Uranium deposit, adjacent to the Thelon Basin. The Howard, Lynx, and Porter domains record a strong greenschist grade overprint (age uncertain), which likely obliterated older higher pressure and/or temperature assemblages. Preliminary monazite U/Pb geochronology suggests that the high grade metamorphism occurred at 2.57 Ga.

Five of the eight domains (Snowbird, Firedrake, Ena, McCann, and Penylan) record high pressure (8-12+ kbar) and high temperature (850 °C) at peak metamorphism (1.9 Ga) during early phases of the Trans-Hudson Orogeny (Snowbird Orogen). A number of crustal-scale structures across the southern Rae craton, one of which was newly recognized during this study, partially accommodated exhumation of this large high-pressure terrane during the early phases of the Trans-Hudson Orogeny (1.9-1.86 Ga). REE mineralization and alkaline magmatism are spatially and temporally associated with these structures.

TREE-RING RECONSTRUCTION OF STREAMFLOW IN THE SNARE RIVER BASIN, NORTHWEST TERRITORIES, CANADA

MARTIN*, J.P. and PISARIC, M.F.J.

BROCK UNIVERSITY, ST. CATHARINES, ON
JEANPHILMARTIN@GMAIL.COM

Drought is an important component of many ecosystems in North America, resulting in environmental and socioeconomical impacts. In the context of ongoing climatic and environmental changes, issues of drought are becoming problematic in northern Canada, which have not been traditionally associated with drought-like conditions. Since this region relies heavily on the production of hydroelectricity as an energy source, prolonged drier than average conditions can threaten the energy security of some northern communities. Across Northwest Territory (NWT), water levels and streamflows were significantly lower in 2014/2015. The Government of the NWT was forced to purchase diesel fuel at a significantly higher cost to generate enough electricity to supplement the reduced power

generation normally supplied by the Snare River hydroelectric system.

The aims of this presentation are i) to present jack pine and white spruce tree-ring chronologies from southern NWT; ii) to reconstruct past streamflow of the Snare River basin; iii) to evaluate the frequency and magnitude of extreme drought conditions, and iv) to identify which large-scale atmospheric or oceanic patterns control regional hydraulic conditions.

Preliminary results show that the growth of jack pine and white spruce populations is better correlated with monthly climate indices rather than seasonal/annual hydraulic conditions. Nonetheless, we present a streamflow reconstruction of the Snare River that is well correlated with the summer North Atlantic Oscillation (NAO) index, albeit the strength of the correlation is non-stationary. Spectral analysis corroborates the synchronicity between negative NAO conditions and drought conditions in the southern NWT. From an operational standpoint, considering that the general occurrence of positive/negative NAO can be predicted, these results could facilitate hydroelectric planning in the Northwest Territories.

PREDICTIVE MAPPING OF PERMAFROST THAW SETTLEMENT HAZARD NEAR LAC DE GRAS, NORTHWEST TERRITORIES

MCKILLOP*, R.J. and SACCO, D.A.

PALMER ENVIRONMENTAL CONSULTING GROUP INC., VANCOUVER, BC
ROBIN@PECG.CA

Permafrost terrain across northern Canada exhibits a variable response to disturbance by climate change or anthropogenic activities. Ice-rich permafrost is most sensitive to disturbance and vulnerable to thermokarst, which is the result of differential ground settlement in response to the melting of ground ice. Proactively distinguishing areas of ice-rich permafrost from ice-poor permafrost is critical to the routing, design and maintenance of new roads and highways, upgrades to northern community infrastructure, and adaptation to changes in vegetation communities and wildlife habitats.

In order to inform ongoing and future resource industry activities within a 2,100 km^2 area northeast of Lac de Gras, Northwest Territories, we completed permafrost thaw settlement hazard mapping in association with a detailed surficial geology mapping project funded by the Northwest Territories Geology Survey. Permafrost mapping was derived using a project-specific, semi-automated classification of terrain units on the accompanying, 1:20,000-scale surficial geology map prepared through interpretation of stereo aerial photography and LiDAR-derived elevation data. The interpretation of permafrost characteristics was based on an understanding of local landform-ground ice associations, as determined by available borehole information and surface expressions of ground ice (e.g., ice-wedge polygons, enlarging thaw ponds).

A permafrost thaw settlement hazard classification was developed to represent the likelihood and potential magnitude of thaw settlement within a particular map unit in response to an unspecified natural or anthropogenic disturbance to the ground thermal regime. The likelihood of thaw settlement within a particular map unit was determined based on the percentage of similar map units that contain indicators of ground ice: high likelihood (>50% of

polygons that represent similar landforms exhibited evidence of ground ice); moderate likelihood (10-50% exhibited evidence of ground ice); and low likelihood (<10% exhibited evidence of ground ice). The potential magnitude of thaw settlement was defined based on the relative thickness of surficial material within a polygon, given the observed propensity for the thickest deposits to exhibit the most severe (highest relief) thermokarst settlement: high magnitude (typically >5 m of surficial material); moderate magnitude (typically 2-5 m of surficial material); and low magnitude (typically <2 m of surficial material).

Permafrost thaw settlement hazard was defined based on a combination of the likelihood and potential magnitude of thaw settlement within a particular map unit, yielding a five-level hazard classification. The highest thaw settlement hazards occur in terrain dominated by thick till hummocks, many of which already exhibit spectacular thermokarst landforms, including thaw ponds, thermal erosion gullies, "eye-liner slumps" and central collapse basins. Complex assemblages of 30 m-deep, crater-like landforms are a testament to the severity of previous thermokarst activity in areas thought to have preserved buried glacial ice, and serve as a precedent for what may occur elsewhere in response to climate change or anthropogenic activities.

THE GEM-2 GLACIAL SYNTHESIS PROJECT: OVERVIEW AND REPORT OF FIELD ACTIVITIES IN THE KIVALLIQ REGION, NUNAVUT

MCMARTIN*, I.[1], TREMBLAY, T.[2], GODBOUT, P.-M.[3], CAMPBELL, J.E.[1], and KERR, D.E.[1]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
(3) UNIVERSITÉ DU QUÉBEC À MONTRÉAL, MONTRÉAL, QC
ISABELLE.MCMARTIN@CANADA.CA

A new project was initiated as part of the GEM-2 Program in mainland Nunavut and Northwest Territories to compile and document glacial features and reconstruct the glacial history in a poorly mapped core region of the Keewatin Sector of the Laurentide Ice Sheet (LIS). This updated regional compilation will provide a much needed framework for an improved understanding of glacial dispersal patterns. Targeted fieldwork was completed in 2017 in the Baker Lake and Arviat areas, NU, to answer questions related to the nature of the landscape and surficial materials under the Keewatin Ice Divide (KID), the chronology of glacial and deglacial events, and glacial dispersal characteristics along paleo-ice streams. The post-glacial marine limit of submergence was examined, measured and sampled for terrestrial cosmogenic nuclide (TCN) exposure dating and infrared stimulated luminescence dating. Significant variations in the elevation of marine limit across the area are associated with ice margins in contact with the Tyrrell Sea close to the remnants of the KID. The terrain around the KID varies in surface material composition and thickness, drainage development and degree of weathering. West of Arviat and near Baker Lake the

terrain is indicative of a warm-based, erosive glacial regime, and grades into an intermediate cold-based, protective (non-erosive) terrain NE of Baker Lake towards the uplands south of Wager Bay. The determination of relative erosion rates in till and bedrock under the KID using TCN exposure dating will help to evaluate how glacial sediments can be used for mineral exploration in areas potentially complicated by inherited compositional signatures. Surface till composition examined in three ice stream terrains suggests long-distance transport of distinctive lithologies. Geochemical and lithological analyses of surface till samples, coupled with lithogeochemical analysis of distinct Dubawnt Supergroup lithologies, will be integrated with previous regional sampling results and the updated glacial history to permit a better evaluation of glacial transport characteristics in areas of shifting ice flows and ice streams and across relict landscapes preserved under non-erosive basal ice regimes (ice divide and/or cold-based ice).

INFRASTRUCTURE, NATURAL RESOURCES, AND THE ADVANCEMENT OF AN INNOVATIVE CANADIAN LNG TECHNOLOGY

MILLER*, P.E.[1] and NIKIFORUK, C.F.[2]

(1) SONOMA RESOURCES LTD., CALGARY, AB
(2) PTX TECHNOLOGIES INC., CALGARY, AB
PMILLER@SONOMARESOURCES.CA

Natural gas is abundant, clean, cheap, and in its liquid state (LNG) it is safe in transport. Support for LNG's creation and distribution through infrastructure development can help to solve many of the NWT's energy and investment disadvantages.

Sonoma Resources, in conjunction with PTX Technologies, has developed a new, innovative liquefaction technology which improves the economics of LNG use, and is economically scalable for both small and medium sized commercial applications. The use of this technology at Sonoma's planned regulatory-approved 80,000 USgpd LNG facility in northern Alberta will enable delivery of LNG to road connected mines and communities in the NWT at very competitive pricing compared to other fuel providers. The cost savings in the use of LNG are impressive, and can make the difference in mine feasibility.

Transportation infrastructure and LNG distribution are vitally linked. Establishment of this supply chain will create a robust environment for investment in mines and other projects, and may also lead to development of stranded NWT reserves of natural gas.

HOW STANDARDS HELP REDUCE THE VULNERABILITY OF ARCTIC INFRASTRUCTURE

MOORE, C.

STANDARDS COUNCIL OF CANADA, OTTAWA, ON
CHRISTIE.MOORE@SCC.CA

Rapid environmental and economic changes are having a profound impact on the physical and built environments of the Arctic. Permafrost degradation is posing a significant challenge to owners, operators and maintenance professionals of northern infrastructure. As a consequence, new policies and mechanisms are needed to help northern communities adapt and reduce the vulnerability of their infrastructure to the impacts of climate change. Since 2011, five standards have been developed and incorporated into regulatory policies and guidelines across the North in critical areas,

including managing changing snowload risks for northern community infrastructure and moderating the effects of permafrost degradation on existing building foundations. The latest NISI standard, "CAN/BNQ 2501-500: Geotechnical Site Investigations for Building Foundations in Permafrost," is the most downloaded standard to date, speaking to the demand for permafrost research and standardized guidance in the North.

This session aims to explore how standards have been successful in leveraging the latest in permafrost research to reduce the vulnerability of Arctic infrastructure and how, through engaging northern infrastructure experts, permafrost scientists and local policymakers, Canada has become a global leader in Arctic-focused standardization.

KENNADY NORTH PROJECT 2017 FIELD SEASON UPDATE

MOORE*, R.[1], HRKAC, C.[2], and NELSON, L.[2]

(1) KENNADY DIAMONDS INC., VANCOUVER, BC
(2) AURORA GEOSCIENCES LTD., YELLOWKNIFE, NT
RMOORE@KENNADYDIAMONDS.COM

The Kennady North Property, wholly owned by Kennady Diamonds Inc. (KDI), is located 280 km northeast of Yellowknife adjacent to the DeBeers/Mountain Province Gahcho Kué mine site. Exploration on the property dates back to the 1990s, during which time several kimberlites were discovered. KDI re-initiated exploration in 2012 and has since completed extensive geophysical, till sampling, diamond drilling, and large-diameter reverse circulation (RC) drilling bulk sampling programs.

In 2017, KDI completed a large-diameter RC drill program to bulk sample the Faraday 2 and Faraday 3 kimberlites, and to collect a mini-bulk sample from the Faraday 1 kimberlite. Following the RC program, diamond drilling and ground geophysical surveys continued on the property. Operations were split between summer and winter field efforts.

The RC drill pads and a seasonal spur road off the Gahcho Kué seasonal road were completed in January to coincide with the opening of the Tibbit-Contwoyto winter road and facilitated the mobilization of a second large diameter RC rig, operated by Midnight Sun Drilling Inc., to the property. The first RC drill rig was already on-site, allowing for drilling to commence before the opening of the winter road.

A total of 262.6 tonnes of Faraday 2 kimberlite, 276.4 tonnes of Faraday 3 kimberlite, and 26.4 tonnes of Faraday 1 kimberlite were obtained via RC drilling between January 19 and April 10. The bulk samples were processed by Dense Media Separation (DMS) at the Saskatchewan Research Council in Saskatoon. The results of this work were used to estimate a maiden inferred mineral resource of 5.02 million carats for the Faraday kimberlites. The resource is contained in 3.27 million tonnes of kimberlite with a grade of 1.54 carats per tonne and an average value of US$98 per carat assuming a 1 mm diamond bottom cutoff size. The Faraday resource adds to the indicated resource of 13.62 million carats of diamonds declared for the Kelvin kimberlite in 2016. The Kelvin resource is contained in 8.50 million tonnes of kimberlite with a grade of 1.60 carats per tonne and an average value of US$63 per carat.

Diamond drilling commenced in July 2017. The program consisted of nine HQ-diameter holes for a total of 2,766 meters. Diamond

drilling focused on extending the Faraday 2 kimberlite at depth and delineating the Faraday 1-3 kimberlite complex. The first hole at Faraday 1-3 and a single hole drilled at the Kelvin kimberlite were completed for geotechnical purposes.

Aurora Geosciences Ltd. conducted geophysical programs in the winter and summer of 2017. All work was completed on and adjacent to Blob Lake, located approximately 14 km southwest of Kelvin camp and 3 km southwest of the Gahcho Kué mine site. The winter program comprised 5,780 stations of ground gravity, 451.4 line-km of total field magnetics, and 401.8 line-km of OhmMapper capacitively-coupled resistivity. The summer program comprised 6,146 ground gravity stations and bathymetry surveys for 12 lakes.

Exploration results have been very encouraging, and Kennady Diamond Inc. anticipates the continuation of this success in 2018.

TRAILS – ITH: COLLABORATIVE GEOSCIENCE TO SUPPORT INFRASTRUCTURE MANAGEMENT IN A CHANGING NORTH

MORSE*, P.D.[1] and KOKELJ, S.V.[2]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
PETER.MORSE@CANADA.CA

Permafrost evolution of the western Canadian Arctic landscape is subject to unprecedented transformative pressures. Climate-driven thaw is accelerating geomorphic changes, altering hydrological systems, and affecting nutrient and carbon cycles, all of which have ecological and societal implications. As well, the new Inuvik to Tuktoyaktuk Highway (ITH) represents the largest manipulation of surface conditions in the region. In this heterogeneous, ice-rich permafrost environment, the nature of responses to these pressures, will vary with geotechnical and thermal properties of subsurface materials and landscape factors.

The Transportation Resilience in the Arctic Informed by Landscape Systems (TRAILS) activity, funded by the Climate Change Geoscience Program, NRCan, operates in partnership with Northwest Territories Geological Survey to conduct innovative permafrost research with territorial and academic partners to address questions regarding landscape change and inform infrastructure management decisions. TRAILS - ITH treats the ITH as a landscape transect for conducting multidisciplinary research on permafrost thermal conditions, terrain sensitivity, and climate change impacts on terrain and infrastructure. The research is predicated on the development of high-quality surficial geology and terrain maps, assessment of subsurface ground ice and material properties, monitoring and summary of ground thermal data, and data availability.

The first goal of this project is to work with partners to consolidate available ground temperature and geotechnical data. Secondly, we aim to improve permafrost terrain and surficial geology maps. Third, we will support the analysis and synthesis of ground ice data. The project will also analyse ground thermal data from across the treeline transition, examine local scale variability with respect to natural gradients and infrastructure, and support permafrost modelling to examine future scenarios. Finally, the project will synthesize these

datasets to re-examine the role of glacial legacy and post-glacial landscape modifications on contemporary terrain sensitivity and embankment performance. Two early research activities relate to borehole and terrain mapping projects.

In February 2017, 16 thermally-instrumented boreholes were established. Multiple proxies collected are aimed at examining the suite of subsurface ground ice, geotechnical, carbon and geochemical conditions encountered across a range of environments representing ice-marginal moraine, lacustrine plain and riparian areas. This investigation revealed massive ice juxtaposed against ice-poor granular deposits; organic deposits, up to 4-5 m thick in tundra, overtop of ice-rich lacustrine deposits; and ice-poor gravels laid down on relatively near-surface silty shale. Together these data illustrate the heterogeneity implicit in this glaciated and post glacially modified landscape. Quaternary deposits and Holocene environmental history exert strong control over landscape variation and the physical, geochemical, and carbon characteristics of permafrost. Geochemical and carbon flux changes can be anticipated under warming climate conditions or as a result of physical disturbance such as quarry activities.

In May 2017, a terrain mapping exercise was initiated using very high-resolution imagery and LiDAR data to identify surficial geomorphological features and landscape types within 5 km of the ITH. These data will provide an important platform for understanding ground ice distribution and testing/validating remote sensing tools, and will facilitate assessment of landscape change and revision of the local surficial geology.

USING THE PAST TO INFORM THE FUTURE: A PALEOECOLOGICAL PERSPECTIVE OF THE IMPACTS OF DROUGHT AND FIRE ON LAKES AND FORESTS

MOSER*, K.A.[1], PISARIC, M.F.J.[2], TURNER, K.W.[2], CECI, M.[2], GARNER, C.[2], HARRIS, D.M.[2], MARTIN, J.P.[2], PRINCE, T.[2], SIA, M.[1], and VISCEK, J.A.[2]

(1) UNIVERSITY OF WESTERN ONTARIO, LONDON, ON
(2) BROCK UNIVERSITY, ST. CATHARINES, ON
KMOSER@UWO.CA

Throughout the Arctic and sub-Arctic, there are numerous ecological stressors affecting the landscapes and biota of this environmentally sensitive region. Climate change is chief amongst these. A warming climate during the 20th century, which has occurred at rates and magnitudes in the North that exceed those in most other parts of the world, has led to cascading impacts. In sub-Arctic and Arctic regions of Canada, widespread climate warming is thought to be affecting disturbance regimes including those related to wildfire and drought. The 2014 fire season in Northwest Territories was notably severe with ~390 reported fires burning nearly 3.5 million hectares of forest cover. Similarly, warm and dry conditions caused low lake levels and reduced stream flow. As a result hydroelectric power generation was severely curtailed in both 2014 and 2015. The purpose of our research is to examine the cumulative impacts of drought and wild fires and their effects on forests and aquatic systems in the southern NWT.

Our first objective is to determine the duration, intensity and frequency of fire and drought during the past several 100s to

1000s of years, allowing us to determine specific links between fire frequency and climate. Our second objective is to determine the magnitude and direction of change in hydrology, nutrient concentrations and lake primary production in response to warming temperatures. Lake primary production, a measurement of the photosynthetic rate of primary producers, is an important measurement as increases in lake primary production can lead to a degradation of freshwater quality. By comparing records from lakes recently affected by wildfire and those unaffected by wildfire, we will gain an understanding of the connections between wildfire, nutrient concentrations, and lake primary production in the context of climate warming.

Our research is using a multi-proxy, paleoecological approach to determine long-term (2000 years) records of drought, wildfire and water quality. To accomplish the overall objective of our research we will use dendrochronology (tree ring analysis) and paleolimnology (analysis of lake sediment records) in combination with modern sampling. This is a powerful combination that allows us to examine ecosystem response to multiple stressors at a wide range of temporal scales. Dendrochronology is being used to reconstruct river flows and precipitation in the Snare River system during the past 2-3 centuries. Lake sediment records from four lakes in the Yellowknife area spanning the past ~2000 years are being analyzed for diatoms (used to infer past lake levels and drought), sedimentary chlorophyll a (as a measure of lake production and water quality), and macroscopic charcoal (forest fires). Contemporary lake conditions are being measured and will be compared to paleolimnological findings to evaluate whether lake responses to drought and wildfire are within the range of natural variability. The impact of forest fires on streams is being studied by examining communities of macroinvertebrates (bugs living in streams). Preliminary results from the first year of a three year project will be presented.

PROVENANCE, REGIONAL CORRELATIONS AND TECTONIC SIGNIFICANCE OF THE PORTER LAKE AND LYNX LAKE OUTLIERS, SOUTH RAE CRATON, NORTHWEST TERRITORIES

NEIL*, B.[1], PEHRSSON, S.J.[2], GIBSON, H.D.[1], MARTEL, E.[3], THIESSEN, E.J.[1], and CROWLEY, J.[4]

(1) SIMON FRASER UNIVERSITY, BURNABY, BC
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(3) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(4) BOISE STATE UNIVERSITY, BOISE, ID
BNEIL@SFU.CA

Recent bedrock mapping in the south Rae craton, Northwest Territories, was carried out as part of the GEM2 South Rae Project, a collaborative effort between the GSC and NTGS. Mapping ~50km east of the Nonacho basin identified two Paleoproterozoic sedimentary units informally termed the Porter Lake outlier (PLO) and Lynx Lake outlier (LLO). The unmetamorphosed PLO, and low-metamorphic-grade LLO are in the Porter and Lynx domains, and are separated from amphibolite to granulite facies rocks of the Penylan and McCann domains to the east by the Howard Lake shear zone (HLsz). Presented herein are the results of field work and detrital zircon LA-ICPMS – U-Pb age and trace element data from both outliers.

Arkose and polymictic conglomerate of the PLO were deposited in alluvial fan and fluvial settings after ca. 1.92 Ga. An upper Nonacho Gp correlation is proposed for the PLO based on its similar detrital signature and maximum depositional age. Furthermore, the clast lithologies and sedimentological characteristics of the PLO conglomerate match descriptions of the Thekulthili Fm. (upper Nonacho Gp). The PLO is therefore assigned a minimum depositional age of ca. 1.83 Ga, as constrained for the Nonacho Gp by the cross cutting Sparrow Dyke swarm. Detrital zircon dates (ca. 2.80-2.67, 2.55-2.3, and 2.0-1.9 Ga) within the PLO indicate derivation from the Taltson-Thelon orogen and/or Queen Maud block. The poorly sorted and coarse nature of PLO however suggests a local provenance. These seemingly contradictory outcrop observations and detrital zircon data present possible implications regarding the southern extent of the Queen Maud block and its relationship to the understudied Porter domain. Sedimentary clasts indicate that the PLO was derived, at least in part, from a recycled sedimentary source. A possible source is the lower Nonacho Gp, which possesses an adequately similar detrital signature to have supplied detritus to the PLO.

Zircon from the quartzitic and metapelitic LLO indicate it was deposited after ca. 2.05 Ga. Overall, the detrital zircon dates match the age of Archean greenstone belts in the central Rae craton, widespread ca. 2.6 Ga plutonism of the Rae craton and ca. 2.03 Ga igneous crystallization in Penylan domain immediately east of the study area. Grains coeval with igneous crystallization in the Penylan domain comprise the youngest population and possess "rift-chemistry" (Nb/Th >100). Based on the maximum deposition age and detrital signature, the LLO may be temporally correlative with assemblages 2-3 of the Amer and Ketyet River groups. The location of the LLO along strike from these groups and the rift affinity of the youngest detrital zircons supports previous models for ~2.33–1.95 Ga rifting along the length of the Rae craton.

The ca. 1.92-1.83 Ga PLO and <2.05 Ga LLO were likely at or near the surface during ca. 1.84 Ga metamorphism in the Penylan domain. Their location west of the HLsz therefore corroborates previously proposed east side up movement on the HLsz to juxtapose amphibolite-granulite facies rocks of the Penylan and McCann domains with the relatively low-grade Porter and Lynx domains.

TRANSPORTATION CORRIDORS AND ACCESS TO RESOURCES IN THE NORTHWEST TERRITORIES

NEUDORF*, R.[1] and STRAND, P.[2]

(1) DEPARTMENT OF INFRASTRUCTURE, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
(2) DEPARTMENT OF INDUSTRY, TOURISM AND INVESTMENT, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT
MATT_FOURNIER@GOV.NT.CA

In a largely greenfields region like the NWT, there are opportunities to plan new infrastructure projects with resource potential firmly in mind. Under the GNWT Department of Infrastructure's (INF) Transportation Strategy, INF is advancing the planning for three transportation corridors: the Tłı̨chǫ All-season Road, the Slave Geological Province (SGP) Access Corridor, and the Mackenzie Valley Highway.

The SGP is a region of high mineral

potential and is host to the NWT's diamond mines and most of the NWT's past producing gold mines. The SGP has the potential to sustain the NWT mineral development cycle for decades to come. The current route being advanced was based on mineral potential mapping to guide the planning to maximize the potential for future resource projects.

This talk presents an overview of the current infrastructure initiatives and priorities underway and planned by the GNWT, highlighting the role of mineral potential mapping in scoping of the SGP route.

PLACER GOLD AND THE QUATERNARY STRATIGRAPHY OF THE REDSTONE RIVER, AN ORIENTATION STUDY IN THE FOOTHILLS OF THE MACKENZIE MOUNTAINS

NORMANDEAU*, P.X.[1], YAKELEYA, D.[2], FALCK, H.E.[1], and DUK-RODKIN, A.[3]

(1) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(2) MINERAL INCENTIVE PROGRAM, TULITA, NT
(3) GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
PHILIPPE_NORMANDEAU@GOV.NT.CA

Gold panning and prospecting from streams is commonly associated with the famous placer fields of the Yukon, California and Alaska. A new discovery seeks to add the foothills of the Mackenzie Mountains to this list. Tales of historic gold prospecting along the Redstone River were passed down through several generations to Harriet Gladue, the Yakeleya brothers' grandmother. Reconnaissance prospecting fueled by a desire to verify the tales led to the staking of the Harriet claims. Bulk stream and bank sediment sampling in 2016 funded by the Government of the Northwest Territories' Mineral Incentive Program returned samples with 5, 7 and 8 gold grains and gold concentrations from 558 to 610 ppb.

The Quaternary history of the foothills of the Mackenzie Mountains is complex and placer gold has not been previously reported from the area. There are no documented sources for gold in this region. Previous mapping by the Geological Survey of Canada identified a complex stratigraphic sequence composed of colluvial, alluvial, glaciofluvial and ice-contact deposits overlying Laurentidien and Cordilleran tills as well as westward sourced pre-glacial sediments. The regional mapping also suggested the potential for pre-glacial alluvial gravels in abandoned paleo-drainage pathways, a setting common for placer gold deposits in the Klondike.

An orientation study was conducted in the summer of 2017 by the Northwest Territories Geological Survey (NTGS) in collaboration with claim holders in the area, to assess the surficial sediment stratigraphy of a part of the Redstone River, and assess the gold potential identified by traditional knowledge. The current field investigation centers on the confluence of Harriet Stream with the Redstone River (63° 55', 125° 32'), 30 km east of Wrigley Lake. The Harriet Stream valley runs west to east and contains large terraces of alluvial sediments. The investigation also took place over the Moose Nest Creek valley which runs north to south and briefly connects with the Harriet Stream before reaching the Redstone River. The Moose Nest Creek meanders through a large floodplain rich in organic matter and flanked by gently sloping walls overlain by glaciolacustrine sediments. Preliminary

results from 7 bulk stream and bank sediment samples taken within the 2017 NTGS led sediment sampling returned 1 to 2 gold grains in 5 samples. Gold grains are present in the alluvial terraces and in stream sediment proper of the Harriet Stream both downstream and upstream of Moose Nest Creek. Gold grains are also present in raised eastward flowing stratified gravels 300 meters above the Redstone River south of the Harriet Stream. These gravels are partially overlain by glaciolacustrine sediments and contain weakly developed soils. Field investigations support the possibility of a paleo-drainage connection between the Wrigley Lake and the Redstone River through the Harriet Stream's valley. Direct drainage could have taken place either during deglaciation through catastrophic drainage of pro-glacial lakes or during pre-glacial times.

REGIONAL AND LOCALIZED DISTRIBUTION OF ARSENIC IN SOIL IN THE YELLOWKNIFE REGION

OLIVER*, J.T.[1], MAITLAND, K.M.[1], JAMIESON, H.E.[1], and PALMER, M.J.[2]

(1) QUEEN'S UNIVERSITY, KINGSTON, ON
(2) CARLETON UNIVERSITY, OTTAWA, ON
J.OLIVER@QUEENSU.CA

Historical mines in the Yellowknife area produced airborne emissions containing arsenic trioxide (As_2O_3) from the roasting of gold-bearing arsenopyrite (FeAsS) ore. Recent studies have highlighted a persistent legacy in local lake sediments and surface waters 50 years after the bulk of these emissions were released. Questions still remain about the amount and nature of arsenic residing in soils. The objectives of this research are: 1) to characterize the regional distribution of arsenic in Yellowknife area soils; 2) to identify factors that explain regional and local patterns of distribution; and 3) to identify the various phases of arsenic present in local soils.

A total of 479 near-surface soil samples were collected within a 30-km radius of Yellowknife during the past three summers to explore regional variation in soil arsenic concentrations. Site locations were focused on undisturbed areas to minimize human influence and determine the effects of legacy airborne emissions. Sampling targeted soils from four distinct terrain units, including: outcrop soils, forest canopy soils, forest outcrop soils, and peat.

Total elemental analyses have been completed on samples from the Public Health Layer (0 to 5 cm) at all sites. Arsenic concentrations in peat samples range from 2.9 to 3,400 mg/kg with a median of 96 mg/kg. Concentrations in outcrop soils range between 3.5 and 3,000 mg/kg with a median of 165 mg/kg. Forested outcrop soils range from 2.1 to 4,700 mg/kg arsenic with a median of 150 mg/kg. Finally, arsenic concentrations in samples from forested canopy areas range from 1.0 to 1,300 mg/kg with a median value of 38 mg/kg. Non-parametric comparisons determined that arsenic concentrations in forested areas are significantly different than all other terrain units ($p < 0.018$), and no significant differences were observed between the remaining terrain units.

Distance from the Giant Mine roaster is an important control on the concentration of arsenic in regional soils (R adj. = 0.543) despite substantial local variations. Spatial analyses performed in ArcGIS indicate that soils surrounding Giant Mine, and to a lesser extent Con Mine, are elevated in arsenic relative to background concentrations. Micro-analytical techniques were used to characterize the mineralogy and arsenic

hosting phases in soils. Anthropogenic sources of arsenic are characterized by the presence of As_2O_3 and distinctive arsenic-bearing iron-oxides derived from roaster stack emissions. Preliminary results indicate As_2O_3 is present in 89% of samples tested (n = 71). Identification of the mineralogy of arsenic is important because speciation influences the bioaccessibility of arsenic, which is essential to consider for risk assessment.

This regional soil sampling initiative complements previous lake, sediment, and soil geochemical surveys undertaken in the area. This research provides important insight into connections between terrestrial and aquatic systems in the region by providing information on soil geochemistry, mineralogy, and mobility. This research is also an important source of information to support ongoing risk assessments to human and ecological health from arsenic derived stack emissions.

UPDATE ON THE GEOLOGICAL SURVEY OF CANADA'S GEO-MAPPING FOR ENERGY AND MINERALS PROGRAM

OZYER, C.A.

GEOLOGICAL SURVEY OF CANADA,
CALGARY, AB
CARL.OZYER@CANADA.CA

The Geo-mapping for Energy and Minerals (GEM) program is laying the foundation for responsible land-use and resource development in the North by providing modern public geoscience that will set the stage for long-term decision making.

Geoscience knowledge produced by GEM supports evidence-based exploration for new energy and mineral resources and provides important inputs that help northern communities to make informed decisions about their land. Building upon the success of its first five-years, GEM continues to produce new, publicly available, regional-scale geoscience knowledge in Canada's North.

The GEM program was first launched in 2008 as a five-year, $100 million initiative to produce new, publicly available, regional-scale geoscience knowledge in Canada's North. In 2013, the GEM program was renewed until 2020 with an additional $100 million.

In its first five years (2008–2013), Geo-mapping for Energy and Minerals program undertook 20 field projects in the three territories and the northern parts of six provinces (Ontario, Quebec, British Columbia, Saskatchewan, Manitoba, and Newfoundland and Labrador); completed 35 regional geophysical surveys; released over 840 open files of new geoscience maps and data, published on the Natural Resources Canada Website; and delivered more than 800 technical information sessions at venues frequented by industry, government and NGOs.

Taking into account remaining knowledge gaps where modern geological mapping is most needed, both onshore and offshore, the GEM program defined six regions of interest: the Mackenzie Corridor region, the Northwestern Cordillera region, the Rae Craton region, the Baffin Island region, the Hudson Bay / Ungava region, and the Western Arctic region. Key activities of the GEM program involve on-the-ground field observations, the assessment and analysis of legacy samples and data, targeted airborne geophysical surveys and remote sensing, and advanced laboratory investigations.

In 2017, research scientists from the GEM

program successfully carried out 27 research activities, 26 of which will produce an activity report, 12 of which included fieldwork. Research activities include geological, geochemical and geophysical surveys. These activities have been undertaken in collaboration with provincial and territorial governments, Northerners and their institutions, academia and the private sector. GEM will continue to work with these key partners as the program advances. This presentation will provide an overview of GEM activities conducted in 2017.

PERMAFROST MONITORING IN THE HUDSON BAY LOWLANDS: PRELIMINARY RESULTS FROM THE ONTARIO FAR NORTH

PACKALEN, M.S.[1], PIRONKOVA, Z.[2], MCLAUGHLIN, J.W.[1], and ROY-LÉVEILLÉE*, P.[3]

(1) ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, SAULT STE. MARIE, ON
(2) ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, PETERBOROUGH, ON
(3) LAURENTIAN UNIVERSITY, SUDBURY, ON
MAARA.PACKALEN@ONTARIO.CA

Hudson Bay Lowlands (HBL) forms the largest continuous peat complex in Canada, the second largest in the world, and represents a globally significant carbon store in excess of 30 Pg of biospheric carbon. This physiographic region, which extends through the continuous, discontinuous, and sporadic permafrost zones of Ontario, Manitoba, and Quebec, is home to several remote indigenous communities and hosts several infrastructure development projects against a backdrop of rapid climatic change. Yet information on permafrost conditions in the HBL is limited to a few studies near Churchill and Wapusk, in Manitoba, and along the Quebec coast. This research focuses on the Ontario Far North, a particularly understudied portion of the HBL, to investigate permafrost thermal conditions and geomorphological change associated with permafrost degradation.

Five permafrost stations, with maximum sensor depth ranging from 4-11 meters, are located in the continuous zone near Peawanuck and in the discontinuous zone west of Attawapiskat. Here we present an eight-year continuous record of ground thermal regime and permafrost temperatures for four permafrost monitoring stations installed since 2009. Mean annual air temperature at the monitoring stations ranged from -2.9°C near Peawanuk to -0.6°C in the discontinuous permafrost zone, however near surface ground temperature was near 2°C at all sites (±0.5°C). Permafrost temperatures were warm, with the lowest top of permafrost temperature measured near Peawanuk, at -0.6°C, while near Victor mine the top of permafrost temperature varied from -0.1 to -0.4°C. At the deepest monitoring station, located in the discontinuous zone, mean temperatures were above 0°C at = 10 m depth.

Changes in the extent of palsas and peat plateaus in the HBL are investigated using Worldview-2 satellite imagery in combination with georeferenced historical aerial photographs. Using a representative site in the sporadic discontinuous zone, results indicate a 26.3% decrease in the area occupied by palsas and peat plateaus between 1954 and 2011. This is consistent with qualitative observations of extensive palsa and pleat plateau degradation in both the discontinuous and continuous permafrost zones of the HBL. These records, together with remotely sensed images and ground surveys, are further used to delineate permafrost extent and evaluate carbon

dynamics in the HBL. Active areas of research include assessment of hydrological and ecological changes in HBL associated with permafrost degradation at a range of spatial and temporal scales, supported by a network of stream gauges, Eddy Flux towers, and peat and permafrost sampling.

TMAC RESOURCES — HOPE BAY EXPLORATION AND GEOSCIENCE UPDATE

PARSONS, S.

TMAC RESOURCES INC., TORONTO, ON
SCOTT.PARSONS@TMACRESOURCES.COM

TMAC's efforts are devoted to the exploration, evaluation and development of Hope Bay Greenstone belt that hosts three known gold deposits: "Doris"; "Madrid"; and "Boston". TMAC completed a Preliminary Feasibility Study (effective date of March 31, 2015), that demonstrated the technical feasibility and commercial viability of Doris, Madrid and Boston. TMAC poured its first gold bar on February 9, 2017 and achieved commercial production, effective June 1, 2017, at its Doris Mine and Mill Complex.

The 2017 exploration and geoscience programs were designed to support several aspects of exploration at Hope Bay ranging from immediate production support, through advanced exploration, to the generation of regional targets in preparation for drilling. A key strategy of the exploration program is to develop and maintain a project pipeline consisting of highly prospective targets at various stages of evaluation.

LINKING WILDFIRE ACTIVITY AND METAL FLUXES TO NORTHERN LAKES AT DECADAL TIMESCALES

PELLETIER*, N.[1], BLACK, J.[2], CHÉTELAT, J.[3], PALMER, M.J.[4], PELLISSEY, J.S.[5], TRACZ, B.[5], VERMAIRE, J.C.[1], and VAN DER WIELEN, S.[6]

(1) CARLETON UNIVERSITY, OTTAWA, ON
(2) YELLOWKNIFE DENE FIRST NATION, YELLOWKNIFE, NT
(3) ENVIRONMENT AND CLIMATE CHANGE CANADA, OTTAWA, ON
(4) CARLETON UNIVERSITY, OTTAWA, ON
(5) WEK'ÈEZHÌI RENEWABLE RESOURCES BOARD, YELLOWKNIFE, NT
(6) TŁĮCHǪ GOVERNMENT, BEHCHOKǪ̀, NT
NICOLAS.PELLETIER2@CANADA.CA

Current drought conditions in northwestern Canada are conducive to more frequent and severe wildfires that may mobilize mercury and other metals accumulated in soil and biomass. There is evidence that wildfires can remobilize and transport mercury within and outside catchments by atmospheric volatilization, particulate emissions and catchment soil erosion. However, the effect of fires on mercury fluxes to nearby lake sediments remains unclear. In this study, we use a combination of eight dated lake sediment cores and two nearby ombrotrophic peatland cores to investigate the effects of wildfires on mercury fluxes to lake sediments. Lakes varying in catchment size and distance from recent fire events were sampled. Mercury concentrations in the environmental archives were measured, and macroscopic charcoal particles (>100 µm) were counted at high resolution in the sediments to observe the co-variation of the local fire history and mercury fluxes. Mercury flux recorded in ombrotrophic peat cores provided an estimate of the historical atmospheric mercury flux from local and

regional atmospheric deposition. The mercury flux recorded in lake sediments corresponds to the sum of direct atmospheric deposition and catchment transport. In combination, these archives will allow for the partitioning of mercury loading attributable to catchment transport from direct atmospheric deposition. After correcting the fluxes for particle focusing and terragenic elements input, flux from different lakes are compared based on their catchment size and their temporal and spatial proximity known fire events. Altogether, our preliminary results using these paleolimnological methods provide new insights on mercury transport processes that are predicted to become more important under a changing climate.

PRELIMINARY STRUCTURAL CONSTRAINTS ON THE GEOMETRY OF SELWYN BASIN FROM LITTLE OWLS LAKE TO HOWARD'S PASS, NAHANNI MAP SHEET (NTS 105I), NORTHWEST TERRITORIES

PENNER*, B.[1], HICKEY, K.A.[1], KENNEDY, L.[1], MARTEL, E.[2], and FALCK, H.E.[2]

(1) UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
BPENNER@EOAS.UBC.CA

Mesozoic crustal shortening related to continental collision during the Cordilleran Orogeny is well documented throughout Yukon and Northwest Territories. In the Nahanni region of southwest NWT, rocks of the Selwyn fold belt have undergone penetrative ductile deformation and preserve several generations of folding and foliation development. The internal geometry and kinematic history of the Selwyn Basin is not well defined over much of its length, and its kinematic relationship to the adjacent Mackenzie foreland fold and thrust belt to the northeast is also poorly constrained. This study aims to address some of these deficiencies via a detailed structural analysis of penetrative deformation of the southern Selwyn Basin.

Structural data was collected along two staggered SW-NE sections in the Nahanni region of NWT and Yukon. The northern section, from Summit Lake to Howard's Pass, traverses the Selwyn Basin, the overlying Earn Group, and the March Fault, a regional WNW-striking fault previously interpreted as a thrust. The southern section, from Little Owls Lake to the Fork Creek range, traverses the Hyland Group. North of Little Owls Lake, a regionally consistent, moderately to steeply dipping, penetrative foliation is observed in most outcrops, and it is axial planar to folding at all scales. At Little Owls Lake, three fabrics are consistently observed: a moderately steep dipping crenulation foliation (S1) axial planar to NW-plunging and NW-dipping inclined folds; an overprinting subvertical crenulation cleavage (S2) axial planar to upright folds (F2); and a late northeast-striking, steep crenulation cleavage (S3) with no associated mesoscopic or macroscopic folding (S3). Based on similar attitudes and fold geometries, the S2 fabric observed at Little Owls is correlated with the regional foliation observed north of Little Owls along both sections. Chlorite-zone metamorphism extends across both sections, and both grade into biotite-zone metamorphism along the Fork Creek range. At the southern end of the Fork Creek range cordierite, andalusite, and rare staurolite porphyroblasts are developed in coarse-grained biotite-quartz schists. This zone of higher metamorphic grade is spatially

associated with the Nahanni pegmatite suite, and is likely a function of heat conducted from a source intrusion at depth. Poorly constrained discontinuities in the F2 fold train are interpreted as late, high-angle normal faults with minor offset. No structural or stratigraphic evidence for significant thrusting was observed during mapping across the March Fault.

The development of penetrative foliations, fold continuity, and lack of evidence for thrust shortening along the section together indicate that, in contrast to the Mackenzie FAT belt, there is no geometric requirement for significant displacement along thrust faults within the Little Owls to Howard's Pass sections. Fewer deformation events are recorded along the Fork Creek range and along the Summit Lake section than in the Little Owls Lake area. This may indicate that deformation propagated from south to north (present coordinates) along the section, and/or from deeper to shallower stratigraphic levels in the crust.

CMIP5 CLIMATE SCENARIOS COMPARED TO METEOROLOGICAL DATA FROM 2006 TO 2016 FOR YELLOWKNIFE, INUVIK AND IQALUIT

PROSKIN, S.A.

THURBER ENGINEERING LTD., CALGARY, AB
SPROSKIN@THURBER.CA

The Intergovernmental Panel on climate change has completed comprehensive temperature and precipitation projections using various Global Climate Models (GCM) and Representative Concentration Pathways (RP) scenarios of carbon dioxide emissions for the future. These data are available to the public under The Coupled Model Intercomparison Project Phase 5 (CMIP5). The long-term climate simulations include historical ones for 1850 to 2005. Other long-term simulations are available for 2006 to 2100 for the range of RCP scenarios. Although the data are available to the public, the datasets are huge and are found in the Net CDF/CF format - a binary and header-based data form and the variable data are stored in multidimensional arrays.

A new user of the CMIP5 data for future climate projections would typically want to know what is the reliability and relative uncertainty in using such projections. For most engineers, this would entail a comparison of the simulations with measurements. This presentation takes a selection from the CMIP5 simulations of mean monthly temperature for the period 2006 to 2016 for three sites (Yellowknife, Inuvik and Iqaluit) and compares them to the Environment Canada meteorological station mean monthly temperatures. The objective is to investigate what a new user would learn about the reliability of CMIP5 temperature projections from such an approach. A secondary objective is to show how some open-source tools can be used to process and visualize the data. Surface temperature data are needed in ground thermal analyses for geotechnical design of earth structures founded on permafrost.

THE COPPERMINE RIVER TRANSECT: A SLICE THROUGH 700 MILLION YEARS OF EARTH'S HISTORY

RAINBIRD*, R.H.[1], SKULSKI, T.[1], DAVIS, W.[1], HALVERSON, G.P.[2], MERCADIER, J.[3], IELPI, A.[4], MEEK, R.[4], TURNER, E.C.[4], and LORON, C.[5]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) MCGILL UNIVERSITY, MONTREAL, QC
(3) UNIVERSITÉ DE LORR, VANDOEUVRE-LES-NANCY, FRANCE
(4) LAURENTIAN UNIVERSITY, SUDBURY, ON
(5) UNIVERSITÉ DE LIÈGE, LIÈGE, BELGIUM
ROB.RAINBIRD@CANADA.CA

The 2017 Coppermine River transect examined a thick succession of Precambrian strata that include Paleoproterozoic (ca. 1.7 Ga) clastic and carbonate sedimentary rocks of the upper Hornby Bay and nonconformably overlying Mesoproterozoic (ca. 1.5 Ga) Dismal Lakes groups, volcanic and younger clastic sedimentary rocks of the 1.27 Ga Coppermine River Group, and disconformably overlying clastic sedimentary rocks of the Mesoproterozoic (ca. 1.1 Ga) lower Rae Group. These rocks were examined and sampled along a superbly exposed, roughly south to north transect through the shallowly dipping (< 15 degrees) Coppermine Homocline, beginning at Dismal Lakes and following the Coppermine River to the Hamlet of Kugluktuk. Our current understanding of this area from newly acquired and ongoing research is as follows: 1) Uranium mineralization in sandstones of the Hornby Bay Group is contemporaneous with the widespread 1.27 Ga Mackenzie magmatic event and similar diagenetic fluids to those identified in the Athabasca Basin contributed to deposition of the uranium. We have initiated a detailed, property-scale, study of hydrothermal fluids to gain deeper insight on the physical and chemical controls on uranium mineralization; 2) New and compiled stratigraphic and geochemical results allow detailed stratigraphic subdivision of the Coppermine River Group. Lowermost Coppermine River Group flood basalts are approximately contemporaneous with the underlying Muskox layered intrusion and are part of the Mackenzie magmatic event. Middle to upper Coppermine River basalts were fed by the Mackenzie dyke swarm. High magnesium basalts and picrites in the lower succession are being evaluated for their nickel and platinum group element resource potential; 3) detailed stratigraphic and sedimentological studies of immature, mainly fluvial, sandstones in the upper Coppermine River Group (Husky Creek Formation) are providing valuable insight on the dynamics of Precambrian river systems. Regional distribution and thickness estimates show that sedimentation was focused in a region straddling the Coppermine River valley and interbedded basaltic lava flows indicate that deposition was contemporaneous with the latter stages of Mackenzie magmatism; 4) Detailed stratigraphic and sedimentological studies of the lower Rae Group, which is uniquely exposed in the Coppermine River valley, reveal a storm-dominated shallow marine or possibly lacustrine paleo-environment. Such studies also provide a context for Kupfersheifer-style copper sulphide mineralization that has been explored at the interface between reducing black shales in the Rae Group and oxidizing red sandstones in the underlying Husky Creek Group.

ENVIRONMENTAL DNA – REAL TIME RESULTS IN THE FIELD TO CONFIRM THE PRESENCE OF TARGET SPECIES

REECE, P.[1], MURDOCH, M.[2], BONHOMME*, E.[3], THOMAS, M.[4], HANNER, R.[4], and CROOKES, S.[4]

(1) STANTEC CONSULTING LTD., SIDNEY, BC
(2) STANTEC CONSULTING LTD., FREDERICTON, NB
(3) STANTEC CONSULTING LTD., YELLOWKNIFE, NT
(4) BIODIVERSITY INSTITUTE OF ONTARIO, GUELPH, ON
MARY.MURDOCH@STANTEC.COM

Project proponents require rapid and reliable assessment of biota in aquatic habitats to support regulatory requirements and management decisions such as environmental assessments and mitigation planning. Sampling the environment for environmental DNA (eDNA) has recently emerged as a reliable and cost effective method for biomonitoring. eDNA is DNA shed by organisms into their surrounding environment. The environment is sampled and then tested for the presence of DNA from the target species of interest. This new approach does not require the capture, or even visual confirmation of the target species. As compared with conventional field surveys, sampling for eDNA is rapid, less labor-intensive, and provides an objective way to confirm species presence or absence. It also provides distinct advantages with respect to worker safety. While the promise of benefits is high, a substantial constraint remains in that the analysis of eDNA is predominantly performed by academic research laboratories that lack a commercial model for delivery of timely and reliable results, with predictable costs.

A field-based eDNA sampling and testing tool has recently emerged and provides real-time results in the field. This means no searching for an appropriate laboratory, no prolonged wait (weeks or months) for results, and minimal training required by field staff. In addition, since field employees can obtain samples from shore without entering a watercourse or waterbody, safety risks are significantly reduced.

We will review the proof-of-concept testing that has been conducted to demonstrate the benefits of this eDNA field tool to confirm the presence of aquatic species, along with the quality control measures that have been built into the tool to provide reliable results. We will also review examples of how eDNA sampling has been incorporated into monitoring projects to augment conventional survey approaches and to address challenging questions for the energy and transportation industries.

PALEOENVIRONMENTAL RESEARCH ON EARLY CENOZOIC SEDIMENT FILLS IN LAC DE GRAS KIMBERLITE PIPES: PROGRESS AND PROSPECTS

REYES*, A.V.[1], WOLFE, A.P.[1], TIERNEY, J.E.[2], SIVER, P.A.[3], ROYER, D.L.[4], GREENWOOD, D.R.[5], BURYAK, S.[1], and DAVIES, J.H.F.L.[6]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) UNIVERSITY OF ARIZONA, TUCSON, AZ
(3) CONNECTICUT COLLEGE, NEW LONDON, CT
(4) WESLEYAN UNIVERSITY, MIDDLEBURY, CT
(5) BRANDON UNIVERSITY, BRANDON, MB
(6) UNIVERSITY OF GENEVA, GENEVA, SWITZERLAND
AREYES@UALBERTA.CA

Several Lac de Gras kimberlite pipes host thick accumulations of stratified post-

eruptive lacustrine sediment and peat. Given the range of Lac de Gras kimberlite emplacement ages, these fills - though rare - provide a unique sedimentary archive of paleoenvironments during the sustained Early Cenozoic "greenhouse" interval, in a high-latitude region otherwise devoid of Phanerozoic sediment cover. Extensive exploration drilling has provided a valuable window into this unique sedimentary record, which would have otherwise remained covered by Quaternary glacial deposits. Our focus to date has been multidisciplinary study of the Giraffe pipe sediment fill: an ~80 m-thick sequence of post-eruptive lacustrine silt overlain by peat, which paints a remarkable picture of a humid-temperate Middle Eocene forest ecosystem on the Canadian Shield. Post-eruptive chronology is provided by interbedded distal tephra horizons, likely sourced from Alaska, that have been dated by glass fission-track and zircon U-Pb techniques. Paleoclimate proxies derived from pollen, wood cellulose oxygen isotopes, and biomarkers converge on reconstructed mean annual temperatures >17 °C warmer than present, with mean winter temperatures above freezing, and mean annual precipitation ~4x present. Two independent reconstructions of CO_2 from well preserved conifer foliage suggest that this warming occurred under relatively modest atmospheric CO_2 concentrations of 430-630 ppm. These findings provide direct field-based evidence for dramatic past arctic warming at CO_2 concentrations that were well within the range of projections under "business-as-usual" emissions scenarios, underscoring the capacity for exceptional polar amplification of climate change under modest CO_2 concentrations once both fast and slow feedbacks processes become expressed. Our studies at Giraffe pipe also highlight the scientific value of archived exploration drill core in the Lac de Gras kimberlite field, particularly with respect to pipes that are unremarkable for the purpose of diamond exploration.

CENTRAL MACKENZIE VALLEY BASIN ANALYSIS PROJECT

ROCHELEAU, J.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
JONATHAN_ROCHELEAU@GOV.NT.CA

Middle to Upper Devonian strata in the Central Mackenzie Valley of the Northwest Territories have been extensively studied by the Northwest Territories Geological Survey (NTGS) and the Geological Survey of Canada. Large sample and analytical datasets are now available, particularly for the Horn River Group. Large-scale basin modeling that combines data from multiple geological disciplines to analyze the formation and evolution of sedimentary basins in order to aid in the evaluation of hydrocarbon resources has, however, to date not been completed for the region. The NTGS will use available lithogeochemistry, petroleum geochemistry, thermal maturity, biostratigraphy, mineralogy, stable isotope geochemistry, structural geology, and tectonostratigraphy as inputs for a new basin modelling project covering the Mackenzie Plain and portions of the adjacent Peel Plateau, Peel Plain and Franklin Mountains regions.

Currently the NTGS petroleum group is in the preliminary phase of the two-year basin modelling project. The first phase consists of the identification of gaps: datasets that are either lacking entirely or available only in non-digital form. Of particular interest is the incomplete structural dataset for the study area. Structural features such as troughs and arches are rarely available in a usable digital format, and must be digitized and annotated

for incorporation into a basin model. This process entails converting features on a hardcopy map or scanned image into vector features in a geographic information system (GIS). The features are traced and represented as points, lines or polygons as appropriate. A review of relevant scientific literature will be undertaken to identify features that need to be digitized and to determine when these structural features were active.

The next phase of the project will involve the creation of a basin model using specialty software with the existing datasets as inputs to the model. The objective is to test iterations of the model until the end result is a reasonable match to current known conditions in the basin. This will lead to an accurate model for burial history, thermal maturity, maturity history, and hydrocarbon migration. There is the possibility that the model may potential new hydrocarbon plays. Ultimately, the results of this project will be incorporated into the NWT Petroleum Atlas.

TRACING THE BREADCRUMBS BACK TO THEIR SOURCE: EXPLORING GEOLOGICAL FACTORS CONTROLLING PRODUCTION OF ATYPICAL GLACIAL DISPERSAL PATTERNS OF INDICATOR MINERALS

ROSS*, M.[1], KELLEY, S.E.[1], JANZEN, R.J.D.[1], STIRLING, R.A.[1], NORMANDEAU, P.X.[2], and ELLIOTT, B.[2]

(1) UNIVERSITY OF WATERLOO, WATERLOO, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
MAROSS@UWATERLOO.CA

Tracing surficial dispersal patterns of indicator minerals within glacial sediments in the main up-ice direction has greatly contributed to numerous mineral discoveries of economic value in the Northwest Territories. However, many cases have also reported perplexing scenarios of dispersal trains seemingly lacking a source, or known sources without a spatially associated dispersal train at the surface. These 'special' cases often hinder exploration efforts, and tend to remain poorly understood; yet these cases are becoming increasingly important to decipher as exploration moves into more complex terrains.

We present an overview of our research done in the Lac de Gras area over the past few years in collaboration with the Northwest Territories Geological Survey and their partners investigating the effect of multiple ice flows, variable bedrock topography and drift thickness, and the complexities of glacial sedimentary environments on 2D and 3D mechanical (detrital) dispersion. Our research draws from surface and subsurface datasets from various sources at both the regional and local scales. We show that despite the occurrence of relatively long, continuous, surficial patterns extending in the direction of the latest-strongest ice flow event in the region, a subtle record of the time-transgressive glacial history is also frequently preserved. These records yield information about the net effect on sediment dispersion of multiple ice flow phases, bedrock geology, basal topography, and glacial depositional processes. Our findings suggest these geological factors played a key role in producing some of the most irregular and enigmatic dispersal patterns in the region. They also offer insights into how to best characterize and explain the signal (or lack thereof) from elusive buried sources of potential economic interest.

BROAD-SCALE GEOPHYSICAL CONTROLS ASSOCIATED WITH THERMOKARST LANDSCAPE SENSITIVITY

RUDY*, A.C.A.[1], LANTZ, T.C.[2], KOKELJ, S.V.[3], and LAMOUREUX, S.F.[4]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) UNIVERSITY OF VICTORIA, VICTORIA, BC
(3) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(4) QUEEN'S UNIVERSITY, KINGSTON, ON
ASHLEY.RUDY@GMAIL.COM

Permafrost landscapes are undergoing rapid changes as increasing temperatures and changing precipitation regimes are intensifying thermokarst processes associated with active layer thaw and melting ground ice. Retrogressive thaw slumping (RTS) is an intensive form of slope thermokarst that can transport large volumes of sediment and solutes downslope, alter drainage networks and affect downstream riparian ecosystems. The abrupt increase in the extent and rate of RTSs in the past decade reflects changes in landscape stability and poses substantial risk to northern infrastructure and ecological systems, both terrestrial and aquatic. Through the utilization of statistical modelling, the aim of this research is to examine the broad-scale geophysical controls on landscape sensitivity to RTSs and to develop a regional RTS susceptibility map.

Broad-scale (15 x 15 km grid cell) mapping of terrain affected by RTSs has been completed for a large area (1,274,625 km^2) of the Northwest Territories and adjacent Yukon and Nunavut using moderate resolution (SPOT5) imagery. The resulting gridded RTS inventory was used to calibrate and validate the model with 70% of disturbed and undisturbed grid cells used to build the model and 30% reserved for an independent model validation. Using random forest modelling, the spatial patterns of RTSs were investigated in relation to specific geophysical variables (i.e., distance to glacial limit/Laurentide Ice Sheet, slope, permafrost characteristics, surficial geology, etc.). The random forest model calibrated and validated well with correct classification of 90% for the model and 83% for independent validation. Model results highlight the impact of glacial legacy and ground ice preservation on the large-scale pattern of RTS susceptibility. Other important variables relevant for RTS initiation were, slope (standard deviation), surficial geology, ground temperature and lake density. Modeled probabilities were then classified into susceptibility classes producing a broad scale map of RTS susceptibility.

This research is an important next step providing a better understanding of broad-scale geomorphic and climatic processes associated with thermokarst development. This framework is necessary to anticipate the consequences of climate change on terrestrial and aquatic ecosystems. Consequently, it will make a vital contribution to allow northern communities and policymakers to make more informed decisions on infrastructure development, water resources and heritage assets.

NUNAVUT EXPLORATION OVERVIEW 2017

RUSSER, M.

INDIGENOUS AND NORTHERN AFFAIRS CANADA, IQALUIT, NU
JEFFREY.SCOTT@AANDC.GC.CA

Mineral exploration and development in Nunavut during 2017 focused primarily on

gold, with lower level of activities reported in base metals and diamond exploration. Spending intentions indicated an approximately 20 per cent drop in overall exploration expenditures, down to $163 million, which puts Nunavut in fifth place relative to the other Canadian provinces and territories.

TMAC Resources Inc. and Agnico Eagle Mines Ltd. were the most active companies in the territory, and are both focused on gold. TMAC's new gold mine at Doris North entered commercial production this year, while exploration continued underground below the diabase dyke and to the south at the Boston and Madrid deposits. Agnico Eagle expects to invest $1.2 billion US over three years to advance Meliadine and Amaruq to production, scheduled for 2019. Agnico Eagle also conducted an extensive exploration program of geophysical surveying, till sampling and rotary air blast drilling between the two deposits.

Auryn Resources embarked on a major exploration program at its 100 per cent-owned Committee Bay project, including over 30,000 meters of rotary air blast drilling. The company also completed a till sampling program and acquired high-resolution drone imagery at its Gibson-MacQuoid gold project. Following the revised recommendation of the Nunavut Impact Review Board, Sabina Gold and Silver continued exploration drilling at the Goose property. The company intersected a new high grade mineral zone at Llama, with results from other drilling pending. Other gold projects active in 2017 included Pistol Bay (Northquest Ltd.), Kiyuk (Cache), Kuulu (NxGold), Baffin Gold (Kivalliq Energy), South Kitikmeot, Hard Cash and Yandle Properties (Silver Range).

Baffinland Iron Mine Corporation, operating the Mary River iron mine, budgeted $4.2 million towards exploration which included infill drilling and ore characterization, ground geophysics, sampling, and additional staking. Baffinland has applied for permission to upgrade the tote road to a rail line and construct a second ore dock and ship loader to accommodate capesize vessels, allowing an increase in ore transportation capacity to 12 million tonnes. Aston Bay's Storm (copper) and Seal (zinc) projects were the only targets for base metal exploration in 2017. The program on these two prospects located on Somerset Island consisted of airborne gravity gradiometry survey and a short field program examining important surface zones and a historical core review.

Exploring for diamonds in 2017, Dunnedin Ventures conducted an extensive till sampling survey at the Kahuna project in preparation for a drilling program. North Arrow embarked on a drilling campaign and collected a mini-bulk sample from its Naujaat Diamond Project. Peregrine Diamonds concentrated its efforts on advancing the exploration of the CH-6 kimberlite at its Chidliak Diamond Project by completing over 5,000 metres of drilling.

The mineral potential of the territory continues to generate interest, with a number of projects continuing into advanced stages and permitting. Nunavut now boasts an operating mine in each of the three regions, with two anticipated in the near term.

WHY YOUR KIM-BEARING TILL SAMPLES MAY NOT BE LEADING YOU TO KIMBERLITE

SACCO*, D.A.[1], MCKILLOP, R.J.[1], and WARD, B.C.[2]

(1) PALMER ENVIRONMENTAL CONSULTING GROUP INC., VANCOUVER, BC
(2) SIMON FRASER UNIVERSITY, BURNABY, BC
DAVID@PECG.CA

Kimberlite indicator mineral (KIM) concentrations in till are commonly used in glaciated areas such as Northwest Territories to identify glacial dispersal from a kimberlitic source. However, sampling of till that has been modified by post-depositional processes, or material that is not till, can obscure the original glacial dispersion and mislead exploration efforts. The recognition of subtle changes in material type or the occurrence of till modification is obstructed by periglacial processes that homogenize the landscape. Due to restrictions of scale, it is nearly impossible to identify and represent these subtle landscape variations in regional-scale surficial mapping. The uniform till cover depicted in the regional mapping does not reflect reality, and therefore does not provide the necessary surficial context to inform till sampling programs and evaluation efforts.

The Northwest Territories Geological Survey and several private exploration companies have recognized the importance of identifying differences in material type and processes that can remobilize and alter the composition of till. Recent improvements in the availability of high-resolution imagery and digital elevation data have provided the means to perform more detailed surficial studies at a scale that is more applicable to diamond exploration. As a result, multiple high-resolution surficial mapping and associated sediment sample data evaluations have been initiated in and around the Lac de Gras region. These studies have reinforced that there is significant spatial variation in the suitability for till sampling, and found that subglacial meltwater corridors and glacial lakes were common. Furthermore, many of the previously collected till samples were affected by these processes, which can have a significant influence on KIM concentrations and the shape of their dispersal patterns. Meltwater can truncate dispersals and concentrate heavy minerals. Glacial lakes can either dilute or concentrate heavy minerals depending on whether the environment was proximal or distal. Specific landform assemblages and characteristics have been documented that can be used to identify these dispersal-modifying processes, and used to produce a surficial context that is more suitable to exploration. This improved surficial context facilitates the collection of in situ till samples and the interpretation of existing surface sediment data resulting in lower-risk exploration targets.

NEW GEOSCIENCE CONSTRAINTS FOR BOOTHIA PENINSULA, NUNAVUT: UPDATE ON THE GEM-2 INTEGRATED GEOSCIENCE OF THE NORTHWEST PASSAGE PROJECT

SANBORN-BARRIE*, M.[1], REGIS, D.[1], FORD, A.[1], OSINCHUK, A.[2], DRAYSON, D.[3], BALLINGER, J.B.[4], and UGALDE, H.[4]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) UNIVERSITY OF ALBERTA, EDMONTON, AB
(3) UNIVERSITY OF MANITOBA, WINNIPEG, MB
(4) BROCK UNIVERSITY, ST. CATHARINES, ON
MARY.SANBORN-BARRIE@CANADA.CA

Much of Boothia Peninsula, north-central Nunavut was mapped in 1962 (Blackadar, 1967, GSC Bulletin 151) when its Precambrian exposures were broadly subdivided into mafic and felsic gneisses and granitic rocks. This largely textural classification at 1:506,880 scale provided minimal insight into protolith and crustal affinity which, in turn, has long hampered understanding of the tectonic evolution of this region and its integration into regional tectonic models. With a mandate to provide modern, relevant geoscience for Canada and its stakeholders, NRCan's Geomapping for Energy and Minerals (GEM) program is acquiring new geophysical and geological data for Boothia Peninsula and Somerset Island. This will significantly upgrade the geoscience framework of this area, provide precise age determinations and lithogeochemical characterization of its main units, expand the impact of mainland GEM findings, and ensure relevant data and knowledge is made available to an isolated region of Nunavut that, due to global warming and the resulting increased shipping, will increasingly be exposed to issues related to resource assessment and economic development.

High-resolution aeromagnetic data acquired in 2013-16, provided a foundation on which to conduct bedrock mapping during 6-weeks in 2017. Metasedimentary rocks and their migmatized equivalents, coincident with quiet magnetic zones of little amplitude, are widespread and range from semipelite through inhomogeneous diatexite to homogeneous diatexite/peraluminous garnet ± sillimanite ± cordierite leucogranite. Localized tonalitic gneiss may reflect an older basement substrate. Metasedimentary rocks are cut by a mafic plutonic suite dominated by diorite-quartz diorite ± gabbroic anorthosite. The mafic suite typically contains hornblende-clinopyroxene-orthopyroxene-magnetite ± biotite and is expressed as linear high amplitude magnetic anomalies. Several generations of felsic granitoid rocks include voluminous K-feldspar porphyritic biotite-garnet quartz monzonite-granodiorite, whose origin and involvement in regional shearing will be a focus of graduate research. Widespread garnet-bearing leucogranite sills typically display lower strain than their hosts, suggesting relatively late-stage emplacement due to elevated geotherms. Weakly foliated to massive orthopyroxene alkali-feldspar granite and hornblende syenogranite underlying southeastern Boothia Peninsula correspond to magnetic anomalies of moderate amplitude. These may, in part, correlate with a pluton dated at ca. 1846 Ma (J. Ryan, unpublished U-Pb data, 2009) to the adjacent south.

The deformational history of Boothia Peninsula is polyphase with widespread, strongly developed, shallow to flat-lying fabrics revealed to be a S_1+S_2 transposition fabric, axial planar to inclined to recumbent

F_2 folds. F_2 folds and fabrics are refolded by upright F_3 folds, and are sinistrally deflected by a regional southwest-striking, moderately northwest-dipping shear zone that extends at least 160 km, transecting the southern part of the peninsula. Many of these deformation features are evident in the magnetic data as discontinuities of the main trends, offsets in otherwise continuous anomalies, and curvilinear trends following the folds. The timing of sedimentary deposition, magmatic activity, and structural development will be determined so that their significance with respect to the Archean Rae, ca. 2.5-2.35 Ga Arrowsmith and ca. 2.0-1.9 Ga Thelon orogens can be assessed.

THE INFLUENCE OF SEDIMENT FOCUSING ON THE SPATIAL AND DEPTH DISTRIBUTION OF ARSENIC IN LONG LAKE SEDIMENTS

SCHUH*, C.E.[1], JAMIESON, H.E.[1], PALMER, M.J.[2], and MARTIN, A.J.[3]

(1) QUEEN'S UNIVERSITY, KINGSTON, ON
(2) CARLETON UNIVERSITY, OTTAWA, ON
(3) LORAX ENVIRONMENTAL SERVICES, VANCOUVER, BC
C.SCHUH@QUEENSU.CA

The distribution of sediments in a lake is largely controlled by sediment-focusing processes that redistribute fine-grained sediments from shallow-water areas of erosion to zones of accumulation in deeper parts of the lake basin. The spatial extent of these zones is dependent on several lake morphometric variables including water depth, fetch, and basin slope. In Long Lake, which is used for recreational purposes by Yellowknife residents, recent work has shown that sediment arsenic (As) concentrations are elevated relative to Canadian and regional guidelines. The degree of As enrichment can be attributed to the aerial deposition of arsenic trioxide (As_2O_3) originating from Giant Mine and other historical ore-roasting operations in the Yellowknife area. Arsenic trioxide has persisted in lake sediments for more than 60 years, though its partial dissolution has resulted in the formation of As-bearing Fe-oxyhydroxide and As-bearing sulphides, phases which are known to be less bioaccessible than As_2O_3. However, the role of lake morphometry in controlling the distribution, solid-phase speciation, and mobility of As in Long Lake sediments is not fully understood.

Forty-seven sediment cores were collected in July 2016 to assess the spatial and depth distribution of As, total organic carbon (TOC), and other relevant geochemical variables in Long Lake sediments. Sample locations were chosen to maximize spatial coverage of the basin. The top 20 cm of each core were sub-sectioned in 5 cm intervals. Linear regression modelling was used to explore the relationship between As, other redox-sensitive elements, TOC, and water depth in all sediment depth intervals. Dialysis arrays (peepers) were also deployed at two shallow-water sites to collect high-resolution profiles of dissolved species in bottom water and porewater, and to determine the rate of As diffusion across the sediment-water interface.

Arsenic concentrations in Long Lake sediments range from 2.2 to 3420 mg/kg. Two distinct types of sediment As concentration profiles were identified: *Type 1* profiles, in which the highest As concentrations occur at depth in the sediment column; and *Type 2* profiles, in which As concentrations are highest at the sediment surface. These profile types are interpreted to represent areas of sediment accumulation and erosion, respectively, and are influenced by both water depth and

proximity to basin slopes. Sediment As concentrations and TOC were strongly correlated with water depth in surficial sediments; however, these correlations weaken with increasing sediment depth. At both peeper sites, the diffusion of dissolved As across the sediment-water interface accounts for >90% of the measured dissolved As concentration in surface waters.

The results indicate that the spatial and depth distribution of As in Long Lake sediments is controlled by both water depth and basin slope. Sediment focusing directly influences the distribution of As in sediments by concentrating fine-grained As_2O_3 particles in areas of sediment accumulation. This process indirectly affects the solid-phase speciation and mobility of As through the concomitant accumulation of organic carbon in depositional zones, which drives the redox state of porewaters to more reducing conditions, that may in turn enhance rates of As diffusion into the overlying water column.

A SEISMOLOGICAL OVERVIEW OF THE INDUCED EARTHQUAKES IN THE DUVERNAY PLAY NEAR FOX CREEK, ALBERTA

SCHULTZ*, R.[1], WANG, R.[2], GU, Y.J.[2], HAUG, K.[1], and ATKINSON, G.[3]

(1) ALBERTA GEOLOGICAL SURVEY, EDMONTON, AB
(2) UNIVERSITY OF ALBERTA, EDMONTON, AB
(3) WESTERN UNIVERSITY, LONDON, ON
RYAN.SCHULTZ@AER.CA

The presentation summarizes the current state of understanding regarding the induced seismicity in connection with hydraulic fracturing operations targeting the Duvernay Formation in central Alberta, near the town of Fox Creek. It demonstrates that earthquakes in this region cluster into distinct sequences in time, space, and focal mechanism using (i) cross-correlation detection methods to delineate transient temporal relationships; (ii) double-difference relocations to confirm spatial clustering; and (iii) moment tensor solutions to assess fault motion consistency. The spatiotemporal clustering of the earthquake sequences is strongly related to the nearby hydraulic fracturing operations. In addition, a preference for strike-slip motions on subvertical faults with an approximate 45º P-axis orientation was identified, which is consistent with expectation from the ambient stress-field. The hypocentral geometries for two of the largest magnitude (M ~4) sequences that are robustly constrained by local array data provide compelling evidence for planar features starting at Duvernay Formation depths and extending into the shallow Precambrian basement. These lineaments are interpreted as subvertical faults orientated approximately north-south, consistent with the regional moment tensor solutions. In conclusion, the sequences were triggered by pore-pressure increases in response to hydraulic fracturing stimulations along previously existing faults.

ARCHAEOLOGY FOR SEABRIDGE GOLD'S COURAGEOUS LAKE EXPLORATION PROGRAM: A BOLD SURVEY PLAN

SEIP, L.P.

ERM CANADA CONSULTANTS, VANCOUVER, BC
LISA.SEIP@ERM.COM

Conducting archaeological studies early in the mining life cycle can provide

opportunities to engage with local communities, assist with preliminary mine site design, and preserve the heritage of the North. There are many challenges in conducting archaeological fieldwork in the north and one of the most common is that modern geologists often target the same resources that people have been targeting for 1000s of years for making stone tools. Results of archaeological study will be discussed, as well as some of the challenges of archaeological research in the north and how they were addressed to meet the needs of Seabridge Gold's Courageous Lake Project in the NWT.

TERRAX MINERALS INC. — YELLOWKNIFE CITY GOLD PROJECT — UPDATE ON DRILLING

SEXTON*, A., HEBERT, E., MCALLISTER, B., STUDD, D., FINDLEY, A., OVERHOLT, C., MACKAY, D., STOKES, I., CHADWICK, T., HARKEMA, S., GABRIEL, D., WALLACE, S., HARRIS, J., and CAMPBELL, S.

TERRAX MINERALS INC., YELLOWKNIFE, NT
AS.GEOVECTOR@BELLNET.CA

During 2017 TerraX completed 14,690 metres of diamond drilling in 43 NQ drill holes. The majority of this drilling was completed on the Mispickel, Sam Otto and Daves Pond targets with 12,187 metres in thirty-four drill holes. The remainder of the drilling was completed on the Samex target at Banting Lake, 3 drill holes totaling 919 metres, and the extension of the Con Shear on the Southbelt property, 6 drill holes totaling 1,585 metres. Gold mineralization was intersected in all targets. The most significant gold mineralization was intersected at the Dave's Pond and Sam Otto targets.

The 2017 drilling extended the strike length of the Daves Pond zone to 400 metres and tested the vertical depth to 125 metres. This zone consists of higher grade gold bearing quartz veins hosted within mafic volcanics and intermediate to felsic tuffs of the Banting Group. These zones are 2 to 6 metre wide shear zones with 3 to 5%, 1 to 10 cm, boudinaged, quartz-chlorite-pyrite-arsenopyrite-stibnite veins. These veins are sub-parallel to the main schistosity, cutting it at low-angle. Some of the more significant intersections are:

- 10.90 g/t Au over 2.08 m in hole TSO17-016
- 13.96 g/t Au over 1.90 m in hole TSO17-019

The 2017 drilling extended the strike length of the Sam Otto zone from 350 metres to 750 metres and increased the vertical depth to 325 metres. This zone consists of quartz veins hosted in intermediate and felsic tuffs of the Banting Group. The overall width of the mineralized zone is 123 to 143 metres with grades of 0.48 g/t to 0.59 g/t gold. Within this wider package there are footwall, main and hanging wall zones that range from 7 to 10 metres in width with grades of 1.10 g/t to 2.19 g/t gold. The gold mineralization is best developed in a wide shear zone. This zone has well developed sericite alteration, cross-cut by pyrite and arsenopyrite mineralized quartz veins. Fine-grained, <1-2% pyrite and <1-3% arsenopyrite needles occur throughout the altered wallrock to the quartz veins. Moderate developed matrix chlorite, biotite and silica occur throughout the zones. Some of the more significant intersections are:

- 0.59 g/t Au over 123.50 m including 2.19 g/t over 10.81 m in hole TSO17-026
- 0.48 g/t Au over 143.00 m including 2.07 g/t over 7.00 m in hole TSO17-028

THAW DEPTH MONITORING IN THE MACKENZIE VALLEY, NORTHWEST TERRITORIES

SMITH*, S.L. and DUCHESNE, C.

GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
SHARON.SMITH@CANADA.CA

In permafrost regions, increases in thaw depth in response to a warming climate have considerable implications for landscape stability, infrastructure integrity, drainage and ecosystems. In ice-rich terrain, increases in thaw depth can result in significant ground settlement due to melting of excess ice. This leads to a reduction of the thawed layer so that over time, active layer thickness (i.e. thickness of the seasonally thawed layer) may change very little even though the lower boundary of the active layer continues to progress deeper into the ground.

Mechanical probing is often used to monitor active layer thickness but this method does not consider changes in surface elevation over time and therefore does not provide an accurate picture of the loss of frozen ground that may occur in response to a warming climate. Thaw tubes however, do allow tracking of both thaw penetration, relative to a fixed datum, and thaw settlement. Thaw tubes have been used, by the Geological Survey of Canada, throughout the Mackenzie Valley since the early 1990s as part of a permafrost monitoring program. Records up to 25 years long exist for over 40 sites.

Analysis of thaw depths indicates that at sites located within ice-rich terrain, increases in thaw penetration (measured relative to original ground surface) over the last two decades can be as much as double the increase in active layer thickness over the same period. For example, data from two sites in the Central Mackenzie Valley indicate that between 1993 and 2014 thaw penetration increased by 21-29 cm, a process which was accompanied by 12-15 cm of settlement. The active layer thickness over this period, however, only increased by 10-12 cm. The loss of frozen ground over time, may therefore be considerably more than that indicated by the change in active layer thickness alone.

Data analysis from the active layer monitoring network help describe relations between thaw penetration, settlement and ground conditions. These results can advance our understanding of changes in regional permafrost conditions. They can also contribute to better representation of active layer processes in models and improved prediction of future permafrost conditions.

CHARACTERISTICS, METAMORPHIC ASSEMBLAGES AND PRELIMINARY IN SITU MONAZITE AGES OF TWO DISTINCT SUPRACRUSTAL ROCK PACKAGES IN THE TEHERY LAKE–WAGER BAY AREA, NORTHWESTERN HUDSON BAY, NUNAVUT

STEENKAMP*, H.M.[1], WODICKA, N.[2], and GUILMETTE, C.[3]

(1) CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(3) UNIVERSITÉ LAVAL, QUÉBEC CITY, QC
HOLLY.STEENKAMP@CANADA.CA

The Tehery Lake–Wager Bay area (western Hudson Bay, Nunavut) comprises mostly felsic to intermediate Archean orthogneiss, and Archean to Paleoproterozoic supracrustal rocks of the Rae craton. Recent geological mapping has led to the identification and division of the supracrustal rocks into two packages based on their lithological and metamorphic assemblages, relative abundances, and structural character. The ultimate goal of this research is to better define the orogenic processes operating at mid-crustal levels in this portion of the Western Churchill province during the early- through terminal-collisional phases (1.92–1.80 Ga) of the Trans-Hudson orogen.

The Lorillard supracrustal package contains a diverse lithological assemblage intruded by boudinaged ultramafic rocks, and is preserved as laterally discontinuous panels that are foliation-parallel within the basement orthogneiss. Rock types include biotite ± garnet psammite–semipelite, garnet + biotite ± sillimanite ± cordierite pelite, quartzite, iron formation, and garnet-bearing metabasite. The proportion of mafic to aluminous units is nearly equal. This supracrustal assemblage resembles the Paliak supracrustal belt found along Wager Bay, and contains 2.70 Ga andesitic volcanic rocks. Metamorphic assemblages in the Lorillard supracrustal package indicate upper-amphibolite peak conditions with retrogression (decompression) to lower-amphibolite conditions. Preliminary results from *in situ* SHRIMP monazite dating suggest the Lorillard rocks experienced conditions conducive for monazite growth at ca. 2.70–2.67 Ga, 2.6 Ga, and 1870–1820 Ma.

The Pennington supracrustal package occurs primarily in synformal structures north of the Chesterfield shear zone. This assemblage is characterized by thick basal quartzite with sillimanite and muscovite, abundant biotite psammite, lesser garnet + biotite ± sillimanite semipelite–pelite, and discrete layers of biotite + hornblende metabasite. The aluminous units are more abundant than the mafic units. This supracrustal package resembles the Paleoproterozoic Ketyet River Group documented to the west-southwest. In contrast to the Lorillard supracrustal package, rocks of the Pennington supracrustal package preserve lower amphibolite-facies assemblages with minimal retrogression, and monazite with *in situ* SHRIMP ages of ca. 1870–1830 Ma.

Studies are underway to link the timing of monazite growth with the growth and breakdown of other mineral phases, and to investigate the potential link between major structures and the distribution of metamorphic assemblages in the different supracrustal packages. This information will help unravel the tectonometamorphic histories of the two supracrustal sequences, which will provide further geological

context for the Tehery Lake–Wager Bay area within the Trans-Hudson orogen.

A PERSPECTIVE ON FISH HABITAT PROTECTION IN THE NORTH UNDER RECENT AND FORTHCOMING CHANGES TO THE FISHERIES ACT

STEVENS*, C.[1] and CLIPPERTON, K.[2]

(1) GOLDER ASSOCIATES LTD., EDMONTON, AB
(2) GOLDER ASSOCIATES LTD., CALGARY, AB
CESTEVENS@GOLDER.COM

The Government of Canada recently launched public consultation on implementing new changes to the Fisheries Act, with changes expected within the year. Five years since the last major revision to the Fisheries Act in 2012, there remains limited available data on how those amendments influenced both the efficiency of regulatory processes and the effectiveness of protections to safeguard fish and fish habitat and aquatic species at risk. We provide a private sector perspective on the recent changes and expected amendments to the Act for mining developments in the North. We review the introduction of the staged process of project Self-Assessment and Fisheries and Oceans Canada (DFO) Request for Review options for regulatory oversight, which is a feature of the Fisheries Act that received criticism during recent public consultation. The process is assumed to be beneficial (in terms of timeliness and cost) for proponents of projects or activities where minor impacts can be effectively mitigated, while simultaneously allowing for DFO resources to be targeted towards projects with the highest risk of causing serious harm and requiring an Authorization and offsetting plan. We also discuss the often criticized terminology included under Section 35 for the current prohibition of "serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery" and how in practice is similar to the previous prohibition of "the harmful alteration or disruption, or the destruction, of fish habitat" (HADD). However, there remains some uncertainty around the application of the Act to waterbodies where small-bodied species are concerned. Impacts to Ninespine Stickleback, a common species throughout the North, can result in a range of regulatory approaches and outcomes from a Self-Assessment to an Authorization application.

DEPTH PROFILES OF GEOCHEMISTRY AND ORGANIC CARBON FROM PERMAFROST AND ACTIVE LAYER SOILS IN THE NORTHERN SLAVE GEOLOGICAL PROVINCE, NORTHWEST TERRITORIES, CANADA

SUBEDI, R.[1], CASTAGNER, A.[1], KOKELJ, S.V.[2], and GRUBER*, S.[1]

(1) CARLETON UNIVERSITY, OTTAWA, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
RUPESH.SUBEDI@CARLETON.CA

The geochemistry of permafrost is relevant for understanding the impacts of thaw or past environments. Permafrost geochemistry and organic carbon were investigated in the Lac de Gras region, Northwest Territories, Canada. Here, the surface cover consists of mostly thin till derived from shield bedrock and has undergone only moderate shifts in ecosystems since deposition. The area thus represents a geomorphic and climatic setting that differs from other more intensively studied permafrost areas in northwestern

Canada. In 2015, permafrost and active-layer samples from 24 sites were collected in soil pits and in boreholes with depths up to 10 metres to examine the vertical and spatial distribution of water content, organic matter content and soluble cations. These varied between the active layer, near-surface permafrost and the permafrost at depth. Near-surface solute enrichment of permafrost was evident at some sites in each terrain type, but the majority of sites had lower cation contents in near-surface permafrost than in the active layer. Active-layer organic soil was often solute-rich compared to till or esker mineral soils at similar depth. This difference was attributed to organic soils sequestering more solutes in the active layer, relative to underlying mineral soil permafrost. In the Lac de Gras area, the absolute concentration of soluble cations in the active layer and near-surface permafrost of mineral soils is about one order of magnitude lower than those reported in previous studies from northwestern Canada. In July 2017, additional fieldwork was conducted near the Kennady Diamonds Inc. (KDI) camp. Here, 13 soil pits and 13 boreholes were sampled for geochemical analyses. These new analyses will help expand this study and evaluate the spatial variation of soil geochemistry in the northern Slave Geological Province.

NOVEL KIMBERLITE EXPLORATION TOOLS: DELINEATING COUNTRY ROCK HYDRATION ASSOCIATED WITH KIMBERLITES USING VIS-SWIR HYPERSPECTRAL POINT DATA COLLECTED FROM DRILL CORE

TAPPERT*, R.[1,2] and TAPPERT, M.C.[1]

(1) HYPERSPECTRAL INTELLIGENCE INC., GIBSONS, BC
(2) LAKEHEAD UNIVERSITY, THUNDER BAY, ON
RALF@HYPERSPECTRAL-INTELLIGENCE.COM

Many kimberlite ore bodies are relatively small and the presence of overburden can make it challenging to intersect a kimberlite target during exploration drilling. If kimberlite is not intersected during drilling, it can be difficult to decide whether an existing kimberlite body has been missed or whether the geophysical target was not kimberlite. A preliminary spectroscopic study conducted in 2017 provides evidence that kimberlites with sizes exceeding 30 meters hydrate the adjacent country rock. The detection of such 'hydration halos' in barren country rock drill cores can provide crucial evidence for the existence of nearby undiscovered kimberlites. To gain a better understanding about the size and morphology of hydration halos around different kimberlite ore bodies, hyperspectral point data were collected from drill cores comprised of crustal rocks recovered in close proximity to known kimberlites (e.g., Kelvin, Farraday, and Pikoo kimberlites). The information obtained as a result of this study will likely serve as a foundation for the development of a rapid, low-cost kimberlite exploration tool that can help evaluate kimberlite potential in

areas where kimberlite was not intersected during drilling.

LITHOSTRATIGRAPHY, CHEMOSTRATIGRAPHY, THERMAL MATURITY, AND SOURCE-ROCK POTENTIAL OF THE HORN RIVER GROUP AT TWO OUTCROPS IN THE SOUTHERN PEEL PLATEAU AREA, NORTHWEST TERRITORIES

TERLAKY*, V., FIESS, K.M., and ROCHELEAU, J.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
VIKTOR_TERLAKY@GOV.NT.CA

The Givetian-Frasnian aged Horn River Group comprises the Hare Indian, Ramparts, and Canol formations, and is present over large areas of the Mackenzie Plain, Peel Plain and Peel Plateau regions of the Northwest Territories. Recently, the organic-rich shale Bluefish Member of the Hare Indian Formation and the Canol Formation have been the focus of research as self-sourcing unconventional reservoirs with excellent economic potential. In the summer of 2016, two outcrops in the southern Peel Plateau were selected for field examination and sampling to fill areal gaps in existing datasets of the Horn River Group. This talk highlights the analytical results obtained from the sampling program at these two outcrops.

The 70 m long section at Arctic Red River East and the 52 m long section at Flyaway Creek expose the top of the Hume Formation, overlain by a near-complete section of the Horn River Group. In the field, the sections were photographed and described in detail. Spectral gamma-ray measurements and samples for geochemical and mineralogical analysis were taken at one metre intervals. Laboratory analyses conducted include: source-rock analysis to determine the TOC content, maturity, and quality of the shales as a hydrocarbon source rock; vitrinite reflectance analysis to determine the thermal maturity of the rocks; major, minor and trace element lithogeochemical analysis to determine the chemical make-up of the rocks used as proxies for various paleoenvironmental indicators; X-ray diffraction (XRD) analysis to determine the mineral make-up of the rocks; and thin-section analysis to determine grain size, sorting, composition, and fossil identification.

The Bluefish Member and Canol Formation are organically rich, with TOC ranges of 2.84-8.20 and 1.51-8.12%, respectively – a trend mirrored by high gamma-ray counts and elevated uranium concentration. Source rock analysis derived T_{max} data indicate that both units are postmature with a mean value of 612 °C. Vitrinite reflectance values range widely from 0.65-2.15 $\%R_0$, indicating a rock maturity between the oil and condensate wet gas zone, although these results are questionable due to data quality issues resulting from weathering and small particle size. The Bluefish Member has moderate and variable silica content (22-66%), whereas the Canol Formation has relatively more consistent and elevated values (62-89%), suggesting higher rock brittleness. The SiO_2/Zr ratio trend suggests that the Bluefish Member has predominantly terrestrial silica input, whereas the Canol Formation has increased biogenic silica. The relative input of terrigenous material is determined by the terrigenous input profile (TIP) and Th/U ratio. The Bluefish Member shows an increasing trend of terrigenous input, whereas the Canol Formation suggest sustained reduced terrigenous input. Proxies

for paleoredox conditions include the Ni/Co ratio and the enrichment factor of vanadium (EFV). Although values are susceptible to weathering effects, results are likely useful for overall trends. The Bluefish Member, and the lower and upper 10 m of the Canol Formation were deposited under at least partially anoxic conditions (EVF>1 and Ni/Co ratio >7), whereas most of the middle of the Canol Formation was deposited under oxic or dysoxic conditions (EVF<1 and Ni/Co ratio <7).

EVOLUTION OF <2.0 GA METASEDIMENTARY ROCKS INVOLVED IN 1.9 GA BURIAL METAMORPHISM AND EXHUMATION ADJACENT TO THE SNOWBIRD TECTONIC ZONE, SOUTHEAST RAE CRATON MARGIN, SOUTHEAST NORTHWEST TERRITORIES

THIESSEN*, E.J.[1], GIBSON, H.D.[1], REGIS, D.[2], and PEHRSSON, S.J.[2]

(1) SIMON FRASER UNIVERSITY, BURNABY, BC
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
ERICJAMESTHIESSEN@GMAIL.COM

The earliest tectonic entities that were active during amalgamation of the supercontinent Nuna occur bounding the western Churchill province; the Taltson-Thelon Magmatic zone (TMZ, 1.99-1.92 Ga) to the west and the Trans Hudson Orogen (THO, 1.86-1.80 Ga) to the east. Bisecting the western Churchill province is the enigmatic Snowbird Tectonic Zone (STZ) that demarks the boundary between the Rae (west) and Hearne (east) cratons and exhibits a significant high grade metamorphic footprint along its trace in the south Rae craton at ca. 1.94-1.90 Ga. This metamorphic footprint in the southeastern Rae craton considerably overlaps the metamorphic ages ascribed to the TMZ (1.94-1.92 Ga) bounding the southwest Rae craton. The intervening south Rae craton is only 400 km between these orogens and the few studies that have attempted to reconcile their competing effects within the Rae provide pressure-temperature-time-deformation (P-T-t-d) data that point to 1.94-1.92 Ga events in the TMZ and 1.92-1.90 Ga events in the STZ. To complicate matters, Archean rocks in the south Rae craton may have experienced up to 5 tectonometamorphic events and high-grade examples have been shown to preferentially record the older >2.0 Ga events, thus they underrepresent younger histories.

Paleoproterozoic metasediments aged <2.0 Ga, however, have proven to be very important in reconstructing the burial and relative metamorphic signatures of distinct crustal domains at ca. 1.9 Ga, but these studies are primarily concentrated north of Lake Athabasca in Saskatchewan and within the TMZ. In Northwest Territories the largest crustal domains adjacent to the STZ, the Snowbird domain, contains Paleoproterozoic and Archean metasediments that have been mapped over an extent of ca. 50 x 230 km and extend into northern Saskatchewan.

Herein we examine the timing and nature of regional loading of <1.96 Ga metasediments and related movement of exhumational structures in the Snowbird domain to gain a better understanding of polyphase regional metamorphic events. State-of-the-art techniques (in situ U-Pb monazite geochronology, rutile and zircon thermometry, quartz-in-garnet barometry and pseudosection analysis) are utilized to examine two <2.0 Ga metasedimentary

packages along the western margin of the Snowbird domain; the results provide a detailed P-T-t-d history between 1.94-1.84 Ga. We conclude the Snowbird domain has undergone regional metamorphism with peak conditions of 850 °C and 8 Kbar at 1.92 Ga along a clockwise P-T path with exhumation and cooling recorded as early as 1.91 Ga coeval with exhumation along major crustal-scale structures. This single-stage metamorphic path is consistent along the trace of the STZ within <2.0 Ga metasedimentary rocks and its signature dissipates towards the TMZ. Coeval greenschist-facies metasedimentary rocks separate the TMZ and STZ, and lead us to suggest 1.94-1.90 Ga metamorphism along the STZ is not significantly influenced by TMZ events and is likely the product of a major regional tectonic event associated with the STZ boundary. This work is part of a NTGS-GSC collaboration funded by the Geo-mapping for Energy and Minerals program.

TEMPORAL AND SPATIAL VARIABILITY OF SNOW WATER EQUIVALENT, SNOW DEPTH, AND SNOW DENSITY AT LOCAL AND REGIONAL SCALES IN A 14,000 KM^2 SUB-ARCTIC BASIN

TOKARSKI*, D., RICHARDSON, M., and PALMER, M.J.

CARLETON UNIVERSITY, OTTAWA, ON
DEREK.TOKARSKI@GMAIL.COM

End of year, basin-wide, snow water equivalent (SWE) is an important hydrologic variable for use in hydro-power management and spring water level prediction. For large northern basins, SWE is often estimated using a sparse network of snow survey sites. Despite many advances in measurement technology and remote sensing, estimating basin-wide SWE remains a challenge and an active area of research. In remote northern basins simply increasing the number of sites to improve SWE estimates can be costly. In this study, historical snow surveys (1978-2017) conducted by the NWT Power Corporation across the ~14,000 km^2 Snare River basin near Yellowknife, NWT at a network of ten survey sites (with approximately ten SWE observations per site) were analyzed to identify local and regional scales of variability in SWE, snow depth, and snow bulk density. Two late winter field seasons (2016, 2017) of enhanced snow surveys were conducted. These included extensive depth measurements at existing sites, 16 new sites, and surveys conducted on lakes.

The coefficient of variation of SWE for sites measured north of treeline was 0.74 compared with a much lower value of 0.28 south of treeline. The relation between snow depth and SWE was also much stronger north of treeline (R2=0.91) compared to south of treeline (R2=0.55). With consideration of these differences and the time required to perform a snow depth measurement compared to a density measurement, optimal sampling ratios were computed. For sites north of treeline, a depth to density ratio of 10:1 was found to be optimal, and for sites south of treeline, the optimal ratio was 5:1. Uplands, both north and south of treeline, had a mean of 35% more SWE compared to adjacent lakes. Snow on lakes was consistently shallower and denser, and all snow cover properties measured were less variable. The number of samples needed to achieve SWE estimates within a specific confidence interval on lakes was less than a quarter of that required for adjacent uplands.

Between site-variability of snow properties

were also assessed on an inter-annual basis. Sites north of treeline were poorly correlated to each other whereas sites south of treeline were strongly correlated. North of treeline sites consistently contributed approximately three times the error to basin wide SWE estimates than sites south of treeline. Therefore, sampling strategies for this large sub-Arctic basin should be refined for improved efficiency and accuracy by accounting for differences in both within and between-site variations in snow depth and density. Specifically, basin-wide annual SWE estimates can likely be improved by increasing the number of sites visited in the northern half of the basin. Increasing the depth to density measurement ratio at these sites will help to offset the time cost required to visit more sites in the north. However, long-term records indicate a statistically significant trend towards increasing variability in the depth to SWE relation, implying that the sampling regime may need to be adapted in the future in response to climate change impacts on snow hydrology.

RECENT SURFICIAL GEOLOGY PROJECTS AT THE CANADA-NUNAVUT GEOSCIENCE OFFICE

TREMBLAY, T.

CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
TOMMY.TREMBLAY@CANADA.CA

This presentation will provide an overview of the results obtained at the Canada-Nunavut Geoscience Office (CNGO) from different surficial geology projects since 2010 on Boothia Peninsula, Melville Peninsula and southeastern Baffin Island (including Hall Peninsula). The focus will be on till, glaciofluvial sediments and river sediments geochemistry and heavy mineral content. The context of glacial, glaciofluvial, fluvial and colluvial transport will be discussed. The Canada-Nunavut Geoscience Office (CNGO) has a mandate to promote mineral exploration in the territory; this includes gathering baseline information about the geochemistry and mineralogy of surficial sediments. Mineral exploration, geotechnical, environmental and aggregate resource studies require accurate surficial geology maps and glaciodynamic interpretations. Publications with detailed versions of those results can be found online on cngo.ca, in the CNGO Summary of activities published since 2012, and on geoscan.nrcan.gc.ca.

AIRBORNE MAG/EM DATA INTEGRATION OF SLAVE PROVINCE KIMBERLITES, NORTHWEST TERRITORIES

UGALDE*, H.[1], FURLAN, A.[1], VEGLIO, E.[1], MILKEREIT, B.[1], MIRZA, A.M.[2], and ELLIOTT, B.[2]

(1) UNIVERSITY OF TORONTO, TORONTO, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
HERNAN.UGALDE@UTORONTO.CA

As part of the Slave Province Geophysical, Surficial Materials and Permafrost Study, the Northwest Territories Geological Survey (NTGS) commissioned high resolution geophysical surveys in the Slave Geological Province (SGP). The high resolution aeromagnetic survey was flown from February to April 2017 and comprise 87,600 line-km of data flown at 100 m line spacing and nominal aircraft terrain clearance was 60 m with drape flying over the Central Slave craton block. The horizontal gradient magnetic and frequency domain EM (FDEM) survey was flown from February to March 2017 acquired at 75 m line spacing over 6 other blocks with nominal terrain

clearance of 60 m to maintain bird height of 25 m, covering 4,580 line-km (Munn Lake, Margaret Lake, Zyena Lake, Lac de Gras West, Big Blue and Mackay Lake). The objective of this work is to develop multi-parameter models to help mineral exploration and mining companies better understand the range of geophysical signatures associated with kimberlites in the SGP.

A regular geophysical-based approach for kimberlite exploration usually involves inverting geophysical data with limited geological input. In this contribution we present different ways of looking at the geophysical data and try to obtain a more thorough geological understanding out of it. The workflow starts with a complete GIS compilation of all the ancillary data available in the area: previous industry reports, geology, remote sensing, topographic layers. Secondly, we compute a number of interpretation sub-products from the total magnetic intensity data (tilt derivatives, analytic signal, and other edge detection routines). The next stage involves the computation of a susceptibility distribution from the FDEM data (Tschirhart et al., 2015). With this we are able to generate a magnetic model of the near surface susceptibility distributions, which are then subtracted from the observed data. The resultant map shows anomalous sources that could be associated to either remanent magnetization and/or deeper sources.

Following the work of Sterritt (2006), post-emplacement alteration is ubiquitous in kimberlite pipes. Alteration results in production of secondary oxide minerals and alteration of primary oxide minerals to phases with different magnetic susceptibilities (e.g. non-magnetic iron oxides). This can lead to a dramatic increase of magnetic susceptibility due to serpentinization (Clark, 1997). On the other hand, remanent magnetization can change the polarity of the observed magnetic anomalies or even completely remove the expected signature due to an equal but opposite combination of remanent and induced magnetic components. Therefore, a thorough compilation of petrophysical and mineralogical data over kimberlites and altered rocks in the vicinity of known occurrences is critical for the geological understanding of the existing geophysical data.

This contribution will show some preliminary processing and compilation work completed over the Slave province kimberlites using the newly acquired geophysical data.

INTEGRATING INUIT QAUJIMAJATUQANGIT (IQ) AND CARIBOU COLLARING DATA INTO SCREENING LEVEL RISK ASSESSMENT AT THE AGNICO EAGLE MEADOWBANK MINE, NUNAVUT

VANENGEN*, R.[1] and BAXTER, L.[2]

(1) AGNICO EAGLE MINES LTD., BAKER LAKE, NU
(2) CONSULTANT, GUELPH, ON
RYAN.VANENGEN@AGNICOEAGLE.COM

Currently, analysis of contaminant concentrations in soil and vegetation is conducted every three years at the Agnico Eagle Meadowbank Mine, located 70 km north of Baker Lake, Nunavut, in order to verify initial impact predictions. Caribou were, and continue to be, a particular focus of this Wildlife Screening Level Risk Assessment (SRLA) program, since they are frequently identified as an important species to Inuit stakeholders. The SLRA analysis

includes a calculation of hazard quotients (HQs) for minesite and reference areas, using updated exposure data and toxicity reference values (TRVs), as available. Agnico's partnership with the GN to support caribou collaring provides a means to verify assumptions about the amount of time animals spend in the Meadowbank area, reducing some uncertainty in the exposure assessment, and highlighting the potential for indirect value in this type of multi-agency collaboration. Under both baseline (2006) and operational conditions (2011, 2014), HQ values have been <1 (negligible risk) for all COPC/ROC combinations except chromium and beryllium for Lapland Longspur. These results demonstrate the relatively high concentrations of naturally occurring chromium in area soils, and utility of robust baseline monitoring in interpreting the results of assessments conducted under operational conditions.

INDIN LAKE GOLD PROJECT — 2017 COLOMAC UPDATE

WAYCHISON*, W. and BYRON, M.

NIGHTHAWK GOLD CORP., TORONTO, ON
BILLWAYCHISON@GMAIL.COM

Nighthawk Gold Corp. is a Canadian based mineral exploration company currently focused on advancing its Indin Lake Gold Property, a 222,203-acre land package located 200 kilometres north of Yellowknife, Northwest Territories within the Indin Lake Gold Camp.

An Inferred Mineral Resource estimate of 2.101 million oz gold at a 1.64 g/t gold average grade (0.6 g/t gold cut-off) is defined at its Colomac Gold Project. Only a small portion of the mineralized Colomac and Goldcrest intrusions are captured by this 2013 estimate, leaving an underexplored and highly prospective deposit that hosts several newly discovered extensive, high-grade gold zones, and broad domains of lower grade mineralization.

Details will be presented for Nighthawk's model for gold mineralization, as defined by geochemical studies on Colomac drill core sampled during its 2012 and 2014 exploration program. The data confirms Colomac's analogue to that of the Golden Mile gold deposits, Kalgoorlie, Western Australia; all are hosted by a differentiated mafic sill of similar age with a more sodic, siliceous, and brittle, upper portion that is amenable to clean fracturing during regional structural deformation, fluid transport, and mineral deposition, and within which gold is preferentially concentrated. This contrasts with the ductile behavior of the (gabbroic) lower portion of the sill and the surrounding mafic volcanic rocks. The identification of hydrothermal breccias within the quartz diorite is consistent with Nighthawk observations at other Colomac Zones, and is further visual evidence of hydro-fracturing and the (precursor to) mineralization proposed by Nighthawk for Colomac.

Differentiated mafic intrusions are known to contain significant gold deposits, and Kalgoorlie's Golden Mile dolerite is one of the world's largest with production more than 60 million ounces of gold to date. It also hosts higher grade gold zones, but at Colomac the existence of similar distinct zones had not been documented until Nighthawk's discovery of Zone 1.5 in 2014, a well constrained, high-grade domain targeted based on the Kalgoorlie model. Nighthawk has identified similar bodies at Zone 3.5 and Zone 2.0, and other possibilities along strike.

Results of Nighthawk's 2017 drill program have extended the near surface dimensions of the high-grade core to Zone 1.5 to be upwards of 200 metres long, 30 to 50 metres

in true width, extending from surface to 350 metres, and open to depth. While the latest drilling to depth, i.e. C17-15C, has expanded Zone 1.5 by an additional 250 metres to a vertical depth of 600 metres, and delivered a three-fold expansion of the mineralized true width of Zone 1.5 to over 150 metres suggesting the sill expands to depth, opening vast new areas for exploration. Better 2016-17 results from Zone 1.5 include hole C16-03B, which cut 72.65 metres (50 metres true width) of 5.58 g/t gold, including 17.80 metres of 17.72 g/t gold, and C17-08, which returned 55.35 m (51.00 m true width) of 3.00 g/t gold, including 19.50 m of 5.58 g/t gold, and 6.80 m of 10.45 g/t gold.

Ongoing regional exploration continues to illustrate the potential of this underexplored gold camp.

GEOCHEMICAL VECTORING ON GOLD SYSTEMS USING CARBON ISOTOPES

WEBB, D.R.

DRW GEOLOGICAL CONSULTING LTD., VANCOUVER, BC
DAVE@DRWGCL.COM

Ore-related metasomatic alteration is imparted upon structurally and chemically modified supracrustal rocks in the Yellowknife Greenstone Belt. Evidence suggests that the formation of these gold deposits involved large volumes of weakly saline, near neutral CO_2/CH_4-rich fluids at 390 ^oC +/- 15 ^oC with fO_2 near the pyrite-pyrrhotite transition. Gold mineralization was enhanced by fluid-gas unmixing of carbon species induced by pressure fluctuations that caused periodic excursions in the Eh of the fluids, destabilizing the soluble gold complexes. These shifts in eH can be tracked in part by the $\delta^{13}C$ of the aerially extensive carbonates that are ubiquitous around the large gold deposits in Yellowknife. The redox shifts can be corroborated by mineralogical data at the Con Mine.

LINKING PERMAFROST GEOMORPHOLOGY TO ORGANIC MATTER RELEASE AND DECOMPOSITION

WEISS, N.

STOCKHOLM UNIVERSITY, STOCKHOLM, SWEDEN
NIELS.WEISS@GMAIL.COM

Extensive Pleistocene permafrost deposits are widespread throughout the Arctic and are highly susceptible to climatic change. Millennia of aeolian sedimentation and syngenetic permafrost accretion have resulted in thick layers of fine-grained, ice-rich material with a relatively high organic matter (OM) content. Climate-driven geomorphological activity can cause substantial changes in these landscapes, and lead to the release and decomposition of large amounts of (previously sequestered) OM, in turn resulting in greenhouse gas emissions.

The potential climate feedback is controlled by the amount of OM stored in permafrost (quantity), its intrinsic capacity to decompose (quality), and the amount of material that can become available for decomposition (availability). OM quantity inventories are increasingly accurate, and the importance of detailed quality assessments is widely recognised. Geomorphological studies in permafrost landscapes, however, are less commonly linked to OM decomposition, despite its great significance.

Different permafrost degradation processes result in different OM release pathways. For

example, thermal erosion causes abrupt release, whereas steady deepening of the active layer happens more gradually. Furthermore, different release mechanisms affect OM differently: sudden release involves the bulk, whereas gradual active layer deepening involves preferential breakdown of more labile components.

Here we illustrate the importance of degradation processes using results from a case study of a 5 m-deep exposure in Yedoma (ice-rich aeolian permafrost) in NE Siberia, Russia. Chemical characterisation revealed strata of more- and less-decomposed material throughout the profile (cryopedolith), consisting of different types of OM with contrasting quality, and thus different rates of in situ decomposition after thawing. The same exposure, however, included a section of recently thawed permafrost material, where we suggest that sudden ground ice melt has resulted in the release of most of the OM, regardless of quality. Although this might intrinsically not be the most labile source of OM, an improved understanding of the frequency and extent of such events is essential to properly evaluate their significance.

THE EXPERT PANEL REPORT ON THE REVIEW OF ENVIRONMENTAL ASSESSMENT IN CANADA: HOW THE MACKENZIE VALLEY MEASURES UP

WHELER, B.

MACKENZIE VALLEY ENVIRONMENTAL IMPACT REVIEW BOARD, YELLOWKNIFE, NT
BWHELER@REVIEWBOARD.CA

The Expert Panel for the Review of Environmental Assessment in (southern) Canada recommended the formation of an Impact Assessment Commission to: provide guidance on strategic, regional, and project impact assessment; provide effective co-ordination across jurisdictions; ensure Aboriginal rights and Treaty rights are considered and the duty to consult and accommodate is fulfilled; conduct impact assessment in a timely, effective, transparent manner; and ensure impact assessment is evidence-based and includes Indigenous Knowledge and public participation. This presentation will compare the assessment framework and practices in the Mackenzie Valley with the Expert Panel's recommendations and will begin to explore areas where the Review Board may need to prioritize policy or process work, such as: strategic or regional assessment, follow-up programs to ensure measures are implemented and effective, and continuing efforts to improve the incorporation of Traditional Knowledge.

NUMERICAL GEOTHERMAL ANALYSIS: AN IMPORTANT COMPONENT FOR THE DESIGNS AND EVALUATIONS FOR STRUCTURES IN PERMAFROST REGIONS

ZHANG, G.

TETRA TECH CANADA INC., EDMONTON, AB
GUANGWENGORDON.ZHANG@TETRATECH.COM

Ground temperature is a key parameter in most designs and evaluations in permafrost engineering. However, ground temperature naturally varies with space and time and changes with a change in a ground thermal boundary condition that can be induced by a new construction, operation, or simply climate change. A numerical geothermal analysis using a finite element method is an effective tool to evaluate and predict ground thermal conditions for a project for which ground thermal conditions or their changes are critical.

A numerical geothermal analysis is widely used to evaluate the long and short term impact of infrastructure development on in-situ permafrost in cold regions. Typically this infrastructure can include: shallow and deep foundations, mine tailings and waste rock storage facilities, landfills, landfarms, roads and embankments, water and tailings dams, pipelines, tunnels, open pits, deep gas/oil wells, shafts, and artificial ground freezing facility, etc. A typical geothermal analysis includes the following key steps:

- Gathering site information including climatic data and measured ground temperatures,
- Conducting a calibration thermal analysis to determine key site specific input parameters,
- Simulating the site specific construction or operation conditions to predict the short-term and long-term thermal performance of a subject earth structure,
- Conducting parametric sensitivity analyses to assess the potential project risks due to uncertainties of input data, and
- Finalizing the analysis to provide a set of key parameters for design, construction or operation.

Six typical projects will be summarized in this presentation to demonstrate the important role and application of a numerical geothermal analysis. These will include:

- A building shallow foundation with a heat pump system,
- A Thermopile building foundation,
- A frozen core dam with a thermosyphon system,
- A dry stack tailings facility,
- A mined-out open pit with water filling, and
- A deep gas/oil well thaw study.

BASELINE, INDICATORS AND UNCERTAINTIES OF GREAT SLAVE LAKE FISHERIES ECOSYSTEM UNDER MULTIPLE PRESSURES

ZHU*, X.[1], LEA, E.[2], TALLMAN, R.F.[1], CHAPELSKY, A.J.[1], LEONARD, D.L.[3], CARMICHAEL, T.J.[1], and EVANS, M.[4]

(1) FISHERIES AND OCEANS CANADA, WINNIPEG, MB
(2) FISHERIES AND OCEANS CANADA, INUVIK, NT
(3) FISHERIES AND OCEANS CANADA, YELLOWKNIFE, NT
(4) ENVIRONMENT AND CLIMATE CHANGE CANADA, SASKATOON, SK
XINHUA.ZHU@DFO-MPO.GC.CA

Great Slave Lake (GSL) is a typical oligotrophic system, simultaneously experiencing multiple vectors of natural and anthropogenic disturbances. Assessment of these impacts has become somewhat of a challenge due to a lack of available baseline information. Since 2011, an integrated ecosystem-based survey, including limnology, zooplankton and benthos as well as fish and fisheries, has been implemented over the main basin of GSL during June through August. The overarching objectives of this multiple-year field survey were 1) to establish baseline conditions of GSL ecosystem, 2) to explore the effective indicators of the ecosystem, and 3) to characterize baseline-centered uncertainties accounting for spatiotemporal dynamics, effective sample sizes and observation errors.

As a result of size of the lake, the baseline survey was rotated annually between

Resolution Bay, Moraine Bay, Yellowknife Bay and Simpson Islands while the western basin of GSL was repeated every summer. Firstly, water temperature showed a consistent thermocline structure 10-15 m below the surface, whereas turbidity varied depending on discharges from the Slave River, which are altered by water regulation and natural fluctuations of precipitation. Secondly, copepods dominated zooplankton abundance, comprising 80% of all samples. Approximately 78 % of the total zooplankton density from all samples occurred in shallow sites (<20 m) and was negatively correlated to depth. Benthic invertebrates were dominated by ostracods (mean ± SE; 599 ± 74 individuals/m²) and amphipods (551 ± 47 individuals/m²) which accounted for over 69% of the total density of benthic invertebrates, followed by oligochaetes, bivalves and chironomids. Thirdly, among 387 effective gillnet settings, three coregonids, Lake Whitefish, Least Cisco and Lake Herring, dominated the multispecies community compositions. The spatial distribution of total fish abundance differed among management areas whilst significant differences in biomass density were strongly related to variables of depth, thermal stratification and conductivity. Lastly, several sources of uncertainty were identified due to the nature of the deepest parts of the lake, frequency of repeated sampling and effective sample size. Incorporated with these baseline, indicators and uncertainties identified, we recommend further long-term integrated monitoring activities be continued in association with capacity-building of indigenous communities, integration of traditional ecological knowledge and co-management regimes.

Abstracts - Poster Presentations

Presenting Author denoted by *

CUMULATIVE IMPACT INFORMATION AND ENVIRONMENTAL ASSESSMENT DECISION-MAKING IN THE MACKENZIE VALLEY, NORTHWEST TERRITORIES

ARNOLD*, L.[1], HANNA, H.[1], and NOBLE, B.[2]

(1) UNIVERSITY OF BRITISH COLUMBIA, KELOWNA, BC
(2) UNIVERSITY OF SASKATCHEWAN, SASKATOON, SK
LAUREN.ARNOLD@ALUMNI.UBC.CA

In a setting where resource development is advancing at a rapid pace, an understanding of cumulative impacts, which result from the combination of environmental stressors, is vital for informed decision-making. This project examines Environmental Assessment (EA) in the Mackenzie Valley, Northwest Territories (NWT) and how information about the cumulative impacts to freshwater systems is used to guide decisions about development activities.

EA is an established tool for assessing development projects, but is often criticized for its project-based focus and limited scope. Cumulative Effects Assessment (CEA), is increasingly seen as a way of improving EA, but since it requires multiple information types and large scales of analysis integrating it into EA processes has proved challenging in practice. Monitoring cumulative impacts is a requirement of The Mackenzie Valley Resource Management Act (MVRMA) (1998) as well as comprehensive land claim and self-government agreements in NWT; however, it is unclear whether information about cumulative impacts is being effectively used to inform EA decisions. A recent NWT Environmental Audit (2015) has highlighted this weakness and the need to provide meaningful cumulative effects information to decision-makers.

This project is conducted in collaboration with the Government of Northwest Territories, Cumulative Impact Monitoring Program (CIMP). The research involved two stages: 1) a document review of all 36 completed EA reports since the implementation of the MVRMA, and 2) semi-structured interviews with representatives from EA decision-making organizations, and organizations acting as interveners providing formal input during EA processes including territorial government, research, and First Nation government and management organizations. The goal of the document review was to explore how cumulative impacts are evaluated throughout EA processes. Interview questions were designed to further investigate the findings of the document review and focused on four key areas: how cumulative impacts are defined, what information and issues are evaluated for freshwater cumulative impacts, the information needs of the organizations, and the practices and challenges of decision-making. A total of 16 semi-structured interviews were completed in Yellowknife by telephone during July and August 2017.

The preliminary findings suggest that there is uncertainty in terms of the process and responsibility for assessing cumulative impacts during EA. Challenges exist for decision-making and intervening organizations in obtaining and interpreting both technical data and value-based information and knowledge about the potential cumulative impacts of proposed projects. The poster will present the preliminary results of this research in detail, focusing on how cumulative impacts are considered, the key challenges for cumulative impact evaluation and decision-making within EA, and potential opportunities for improved processes.

CHARACTERIZATION OF ARSENIC-HOSTING SOLID PHASES IN GIANT MINE TAILINGS AND TAILINGS DUST

BAILEY, A.S. and JAMIESON*, H.E.

QUEEN'S UNIVERSITY, KINGSTON, ON
JAMIESON@QUEENSU.CA

Dust from the tailings at Giant mine, an abandoned mine in northern Canada, has been a concern among local residents, particularly those from Ndilo, a Yellowknives Dene First Nation community located approximately 2.5 km southeast of the site. Historically, roaster waste containing arsenic (As) trioxide was co-deposited with flotation tailings, thereby increasing the potential risk to human health since arsenic trioxide is the most toxic and bioaccessible solid form of arsenic. Presently, there are approximately 16 million tonnes of tailings covering 95 hectares on the Giant mine property. These tailings are left vulnerable to high velocity winds after snow melt in the late spring, when it is too cold to apply a dust suppressant to the tailings. The main objective of this research is to characterize the fine fraction of the tailings (particles <63 µm in diameter) and dust that could be inhaled or ingested from Giant mine to identify the As-hosting solid phases therein. Surface tailings material was sampled from three of the tailings impoundments on site, and sieved to <63 µm. From May to July of 2016, a total suspended particulate (TSP) high volume air sampler was set up to continuously sample airborne material coming from the tailings. For the surface tailings and dust samples, bulk chemical data was determined via inductively coupled plasma-optical emission spectrometry (ICP-OES) and -mass spectrometry (ICP-MS); mineralogical data via scanning electron microscope (SEM)-based automated mineralogy, electron microprobe analysis (EMPA), and synchrotron-based micro X-ray diffraction (µXRD), micro X-ray fluorescence (µXRF); and oxidation state data for As via X-ray absorption near edge structure (XANES). Bulk chemical data show elevated concentrations of As, Sb, Zn, Pb, Cu, and Ni. The As in the tailings is a mix of As^{1-}, As^{5+}, and As^{3+}, and is more concentrated in the <63 µm fraction (3000 – 9300 ppm As) than in the unsieved tailings. Roaster-generated Fe-oxides (maghemite), Ca-Fe arsenate, and arsenopyrite comprise the majority of As-bearing particles in the surface tailings; Ca-Fe arsenate poses the greatest risk to human health of these three as it is the most bioaccessible. Fe-oxides were the only As-host found in the dust. Very little arsenic trioxide was found in the tailings, and no arsenic trioxide was found in the dust samples. This is because the tailings that were exposed to arsenic trioxide-bearing roaster emissions during the 1950s and 1960s have long since been buried by more recent tailings. However, previous studies have shown that the soils near the Giant mine tailings do contain arsenic trioxide from historic stack emissions, indicating that these soils might actually

present a higher risk than the tailings themselves.

SPATIAL ANOMALY DETECTION WITH MULTIVARIATE GEOCHEMICAL DATA FROM THE MACKENZIE MOUNTAINS

CABRAL PINTO*, F.[1], PRADES, C.[1], FALCK, H.E.[2], and DEUTSCH, C.[1]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
FAPINTO@UALBERTA.CA

Anomaly detection plays an important role in geological exploration – to find the locations where there are anomalous concentrations of ore minerals on the earth. Univariate and multivariate techniques for anomaly detection are based on data transformation and clustering techniques. Different algorithms can be combined to identify multivariate anomalous samples, going beyond the anomalies recognizable from individual measurements and adding more value to the analyses.

In addition to straightforward univariate anomalies, three methods for multivariate anomaly detection were applied on stream silt samples from the Mackenzie Mountains: (1) small anomalous clusters, (2) Lack of Uniform Clustering Classification (LUCC) anomalies, and (3) spatial anomalies.

The analyses were performed on pathfinder elements for sedimentary hosted copper-base metals deposits. The goal is to identify samples that are anomalous in the multivariate space. The first method uses different combinations of clustering and data transformations for finding small anomalous clusters. The idea behind this method is that samples related to ore deposits have some similar patterns that make them different from the common patterns, so they can be detected as a different cluster.

The LUCC method relies on the fact that multivariate anomalous samples are likely far from cluster centroids in multivariate space. Consequently, applying different clustering configurations on different data transformations will likely lead to disagreement when assigning these samples to clusters. This method measures disagreement between different clustering methods on different data transformations. The spatial anomaly method identifies samples that are different from the surrounding samples in the geographic space. This method is based on the number of samples assigned to a different cluster before one of the same cluster is encountered.

The results show at least one anomaly type at 228 locations out of a total of 8959 sample locations, approximately 2.5% of the total. The small anomalous cluster method detected a total of 128 anomalies and it is followed by LUCC (117), univariate (73), and spatial anomalies (18).

There are 30 locations where all three multivariate methods detected an anomaly. The anomalies are not randomly distributed. Another interesting observation is that almost all univariate anomalies are considered multivariate anomalies, but there are many multivariate anomalies that are not identified by one variable at a time. The anomaly locations were checked against 44 showings in the area – known ore deposits that have been or are in production or advanced exploration. 90% of the showings have an anomalous sample closer than 10 km, 70% closer than 5 km and 30% closer than 1 km. Although further validation is

required, the multivariate methods appear promising to complement conventional analyses.

THE NEW GOVERNMENT OF THE NORTHWEST TERRITORIES GEOLOGICAL MATERIALS STORAGE FACILITIES AND OTHER INITIATIVES FOR THE LONG-TERM PRESERVATION OF GEOLOGICAL SAMPLES

CAIRNS, S.R.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
SCOTT_CAIRNS@GOV.NT.CA

A new storage facility and laboratory housing the growing geological collections of the Northwest Territories Geological Survey (NTGS) in Yellowknife officially opened on September 22, 2017. The facility provides clients access to drill cores from mineral deposits across the NWT, archived hand samples collected during mapping and geological research, thin sections, and geochemical powders.

An unheated storage warehouse holds the physical collection, and a separate heated facility allows for sample study and logging. Client access to the collection is supervised and arranged by appointment with the NTGS. Logging and non-destructive testing of samples from the collection is unregulated. Destructive testing of sample materials requires a research agreement with the NTGS. Research agreements will be predicated on obtaining the most data possible from a sample and destroying the smallest amount of sample possible for the testing. All data generated from such testing will be provided to the NTGS and will become publically available. Reports detailing the client's interpretations of the test results are welcomed by the NTGS but are not mandatory.

With construction of the storage facility complete, the chore of accurately describing the contents of the collection to allow clients to easily discover materials continues. The challenge now lies in developing an accurate and comprehensive searchable database from a diverse array of digital and paper records currently describing the collection.

New donations to the collection are welcomed on a case by case basis. The NTGS is interested in curating well-characterised samples from mineral occurrences not represented in the collection. Drill holes best exemplifying the mineralisation, structure and stratigraphy of a showing are most desired. Sample donations along with data such as drill logs, sections, geochemistry, and photos are preferred.

Storage space at the facility is limited; thus housing collections of drillcore beyond a representative hole for a deposit is impractical. Diamond drilling is expensive, and the entire core record from an exploration program is valuable and worthy of long-term curation. To assist the long-term preservation of these materials when left onsite, the NTGS intends to continue to stabilise and preserve core farms through shoring-up racks, re-affixing box labels, cross-stacking the cores from ailing racks, and fire-smarting storage areas as time and resources allow. To facilitate this field preservation program, the NTGS welcomes information on the location of these materials, storage style, condition of the materials, core rack maps, logs, and any other information adding value to the materials. The NTGS can also provide advice on best preservation practices for

core collections in the field, and suggest ways to archive drill core to maximize chances for long-term survival and utility of the collection.

INVESTIGATION INTO THE EXTENT OF SLUMPING AND ITS IMPACT ON LANDSCAPE MORPHOLOGY WITHIN THE THOMSEN RIVER WATERSHED IN AULAVIK NATIONAL PARK, NORTHWEST TERRITORIES

CONWAY*, H.[1] and CHEYNE, E.[2]

(1) PARKS CANADA, INUVIK, NT
(2) AURORA RESEARCH INSTITUTE, INUVIK, NT
HAYLEIGH.CONWAY@PC.GC.CA

In our warming climate, permafrost slumping continues to occur along the banks of the Thomsen River (and its tributaries) in Aulavik National Park, on Banks Island. Community members from the town of Sachs Harbour are concerned about the impacts that sediment released by slumping may be having on local fish populations and have encouraged Parks Canada to study this phenomenon in detail. Therefore, in 2016 a multidisciplinary project was undertaken to study the chemical and biological impacts of permafrost slumping on the Thomsen River watershed. In 2017, the focus was on investigating the extent of slumping in the Thomsen River watershed and the amount of sediment being released into the watershed. Using a DJI Inspire 1 UAV, we mapped 10 slumps on 2 different watersheds, and have calculated the surface area and volume of each slump using PhotoScan software. This has allowed us to make conclusions about the life cycle of a slump, the rate of change of slumping in our study area, make predictions about the future of the Thomsen River watershed, and discover trends across the Arctic and North America.

WHERE HAVE ALL THE GARNETS GONE – LENA WEST PALEO-CLIMATE

DAVIES, R.[1] and DAVIES*, A.W.[2]

(1) TALMORA DIAMOND INC., TORONTO, ON
(2) TALMORA DIAMOND INC., HOUSTON, TX
RAUCHDAVIES_TX@SBCGLOBAL.NET

Talmora Diamond Inc. has explored the west flank of the Melville Hills in the Lena West diamond region of the Northwest Territories since 2003.

The standard Canadian diamond exploration model of sampling glacial tills for kimberlite indicator minerals (KIMs) and using pyrope garnets to define mineral trains leading to geophysical targets worked for the Dharma kimberlite but the Darnley Bay kimberlites are magnetic anomalies that were subsequently sampled down-ice. In spite of pyrope garnets occurring widespread across Lena West no other pyrope train was defined and the kimberlite source of most Lena West pyropes has not been found.

Diamondex proved that most if not all Lena West pyropes within the Cretaceous basin are secondary, pre-Cretaceous and their source lies to the east, probably outside the basin in the Melville Hills.

Cluster analysis shows the similarity of pyropes across Lena West as far east as the Paleozoic dolomites on the west flank of the Melville Hills but they differ from those of Darnley Bay and Dharma. The same holds for other KIMs. The number of ilmenites and chromites have peak values outside the Cretaceous basin in the Melville Hills but the number of pyropes drops dramatically. So, “where have all the garnets gone?”

It was noted that pyropes that are recovered show diagenetic alteration and laterite was

noted in the background mineralogy. Pieces of laterite were noted in the field. Some rusty coloured clay recovered from a magnetic anomaly has a chemical composition similar to tropically weathered kimberlite from Sierra Leone. Kennecott noted that drill holes within the Cretaceous basin west of the Melville Hills intersected remnants of a paleo-laterite.

Fossil evidence indicates Arctic Canada was warm and wet during the early Eocene thermal maximums (50-55 Ma). Tropical weathering will have affected the tops of kimberlite pipes and destroyed garnets and chrome diopside but will have had little effect on ilmenite and no effect on chromite.

Tropical weathering affected all parts of the Canadian craton but the weathering was invariably eroded and any remnants were removed by glaciation. A rare example of lateritic alteration of kimberlite in Canada is Peregrine's CH-7 kimberlite on Baffin Island. It has a 100 m thick surface zone described as fresh kimberlite mixed with kimberlite completely altered to red mud. About 300 m of this pipe has been eroded since emplacement and most since Eocene warming.

In the Melville Hills, the Cretaceous sea interrupted erosion of Jurassic kimberlites. There was also very little erosion in the Horton River valley and upland plateau since Eocene warming. Subsequent glaciation was absent or weak so that the weathered tops of kimberlite pipes, with missing pyropes, should be preserved.

The effect of weathering related to the warmest period of the past 65 million years has been preserved in the Melville Hills. Weathering alters remnant magnetism and pyrope garnets will not be useful for defining mineral trains. However, diamond grades of weathered kimberlite should be higher and vertical mining may be an alternative to open pit mining to reduce environmental footprints.

BEHAVIOR OF A REINFORCED, HIGH FILL EMBANKMENT FOLLOWING WINTER CONSTRUCTION NEAR TUKTOYAKTUK, NORTHWEST TERRITORIES

DE GUZMAN, E.M.B.[1], ARENSON*, L.U.[2], ALFARO, M.C.[1], and DORÉ, G.[3]

(1) UNIVERSITY OF MANITOBA, WINNIPEG, MB
(2) BGC ENGINEERING INC., VANCOUVER, BC
(3) UNIVERSITÉ LAVAL, QUÉBEC, QC
LARENSON@BGCENGINEERING.CA

The Inuvik to Tuktoyaktuk Highway (ITH), Northwest Territories, Canada, which is planned to open to the public on November 15, 2017 will be Canada's first all-weather access to the Arctic Ocean. The 120 km highway will provide a land connection to the northern community of Tuktoyatuk and is located above the Arctic Circle, in the zone of continuous permafrost. In order to protect the environment and preserve the permafrost under the embankment fill, construction of the highway was only carried out during the winter. However, there is limited understanding as to how frozen embankments fills compacted in the winter behave and how the insufficient compaction impacts the overall embankment performance. In April 2015 two instrumented test sections were constructed at a section of the embankment where the fill exceeded a height of 5 m. Next to the 20-m long reference section not containing geotextiles layers, a 20-m long test section was constructed with three (east side) and four (west side) layers of a wicking woven

geotextile, Mirafi® H2Ri supplied by TenCate. Both the reference and test sections are continuously monitored for their performance. Strain gauges were installed on the geotextiles to measure elongation during the initial stages of construction and natural thawing during the spring and summer following winter construction. They are further instrumented with thermistors for temperature readings, ShapeAccelArrays (SAAs) for the vertical and lateral movements, vibrating wire piezometers for porewater pressures, and thermal conductivity sensors for suctions.

This poster presents results from the first 2.5 years of monitoring. The thermistors confirm that the foundation of the embankment is cooling and the permafrost table is rising into the fill as expected. On the other hand, warming was observed at the toe, likely because of increased snow accumulation and water ponding during the summer. The SAAs show that the reinforced section experiences approximately 25% less lateral displacement than the control section, however, the vertical displacements were slightly higher in the reinforced section. Finally, strains in the reinforcement form during early summer (July / August) as the thaw front penetrates the embankment. The strains were the highest during the first thaw season following construction and have since significantly declined. Unfortunately, thaw has not progressed to the pore pressure transducers or the thermal conductivity sensors, hence none of these data are available.

MONITORING PERMAFROST EROSION PROCESSES AND IMPLEMENTING ADAPTATION MEASURES IN KUGLUK TERRITORIAL PARK, NUNAVUT

DUCHARME*, M.A.[1], IKPAKOHAK, F.[2], PAPATSIE, L.[3], PETRASEK-MACDONALD, J.[3] , ALLARD, M.[1], and COULOMBE, S.[4]

(1) UNIVERSITÉ DE LAVAL, QUÉBEC, QC
(2) COMMUNITY JOINT PARKS MANAGEMENT COMMITTEE FOR KUGLUK TERRITORIAL PARK, KUGLUKTUK, NU
(3) DEPARTMENT OF ENVIRONMENT, GOVERNMENT OF NUNAVUT, IQALUIT, NU
(4) POLAR KNOWLEDGE CANADA, CAMBRIDGE BAY, NU
MARC-ANDRE.DUCHARME@CEN.ULAVAL.CA

This ongoing community-based research project takes place in Kugluk Territorial Park approximately 12 km outside the community of Kugluktuk. The community members in Kugluktuk regularly use the Park area and its surroundings to access traditional camping and hunting grounds that are essential for sustenance, culture, and well-being. This project addresses a very specific climate change impact: enhanced erosion and gullying of terraces along the riverbank of the Coppermine River. ATV trails in Kugluk Park are particularly affected. More specifically, changes linked to climate change such as change in vegetation and snow cover, change of active layer thickness, and melting of ice wedges have intensified soil instability thus contributing to increased rates of erosion.

Permafrost thaw also contributes to destabilizing the ground conditions and triggering erosion, slumping, and mudslides. As these changes continue to threaten soil and ground integrity, the Community Joint Parks Management Committee (CJPMC)

identified the need to find a suitable long-term route for the trail as a top priority in their Park's Management Plan. In response to this priority, the Nunavut Parks and Special Places Division and Climate Change Secretariat at the Government of Nunavut's Department of Environment (GN DOE) are working with the community of Kugluktuk and Centre d'Études Nordiques (CEN) from Laval University to support this priority. In July 2017, territorial stakeholders, university researchers, and researchers from the Cambridge Bay's Canadian High Arctic Research Station joined local Nunavut Parks staff along with local youth and an Elder to establish permafrost mapping and monitoring sites in Kugluk Territorial Park as the first phase in this two-year project. The methodology involves mapping erosion landforms by multi-year photo interpretation from 1954 to 2010, measurements of cliff retreat rates, permafrost temperature monitoring, active layer monitoring and geotechnical properties (consolidation cell test and particle size analysis) as well as mapping changes of surface drainage patterns related to permafrost thaw. The process in addressing this issue and the lessons learned along the way will provide experience at the community and regional level on how to address impacts of permafrost thaw, erosion, and slope instability and the challenges of doing so.

GEOLOGICAL SURVEY OF CANADA BEDROCK MAPPING AND STRATIGRAPHIC STUDIES, SHIELD TO SELWYN TRANSECT, NORTHWEST TERRITORIES

FALLAS*, K.M. and MACNAUGHTON, R.B.

(1) GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
KAREN.FALLAS@CANADA.CA

As a contribution to the Mackenzie Project of the Geological Survey of Canada's (GSC) Geo-mapping for Energy and Minerals Program, bedrock mapping and stratigraphic studies spanning the Colville Hills region to the northeastern margin of the Selwyn basin have been underway since 2015. Our work improves existing geological maps of the area, clarifies the stratigraphic history of the region with a focus on Neoproterozoic to Silurian units, and refines the structural relationships across the Mackenzie Platform from the plains deep into the deformed belt. This transect includes sedimentary strata hosting petroleum systems in the Colville Hills, Mackenzie Plain, and Peel Plain & Plateau, as well as mineral systems in the northern Mackenzie Mountains. Therefore, an improved understanding of the tectono-stratigraphic history is expected to provide new insights into these systems.

Fieldwork within the Colville Hills (NTS map areas 96K, 96L, 96M, and 96N) was conducted in 2015, and new map compilations at 1:250,000 scale for this area are now in press. In 2016, a GSC field party conducted mapping and stratigraphic studies in the northern Mackenzie Mountains (NTS map areas 106G and 106H) to document geological relationships in the southwestern Mackenzie Platform. Map compilation and stratigraphic research in this region is

currently underway. Mapping activities shifted southward into the Bonnet Plume Lake area (NTS 106B) in 2017 to examine the transition from the Mackenzie Platform to the Selwyn Basin, near the Northwest Territories-Yukon boundary. Samples were collected for stratigraphy, biostratigraphy, geochemistry, geochronology, and thermochronology studies related to the mapping activity. Lab work is underway and results are being incorporated into new structural and stratigraphic interpretations. Additional field work is planned for the Bonnet Plume Lake and Wrigley Lake (NTS 95M) map areas in summer 2018.

FORMING A SEQUENCE STRATIGRAPHIC FRAMEWORK FOR THE HARE INDIAN FORMATION USING HIGH-RESOLUTION CHEMOSTRATIGRAPHY AND SEDIMENTOLOGY, CENTRAL MACKENZIE VALLEY, NORTHWEST TERRITORIES

HARRIS*, B.[1], LAGRANGE RAO, M.T.[1], FIESS, K.M.[2], TERLAKY, V.[2], and GINGRAS, M.K.[1]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
BSHARRIS@UALBERTA.CA

The Givetian-aged Hare Indian Formation is part of the Middle to Late Devonian Horn River Group, and is composed of the lower organic-rich Bluefish Member and the upper relatively organic-poor Bell Creek Member. Previous studies have examined the chemostratigraphy of the Hare Indian Formation with a sampling interval of 0.1-1 m or coarser and only in the broader context of the lithostratigraphy of the Horn River Group. In contrast, this study uses high-resolution chemostratigraphy collected with a portable x-ray fluorescence (XRF) instrument in core at a 10 cm interval with additional measurements taken where features of interest are present, and outcrop measurements ranging from 10 cm to 1.0 m spacing. Data collected in this study are from the MGM Shell East Mackay I-78 core, the Husky Little Bear N-09 and H-64 cores, and the Mountain River outcrop (65° 14' 21.7" N, 128° 35' 40.6 " W). The data are interpreted in a transgressive-regressive (T-R) sequence stratigraphic framework using elements predominantly detrital in origin (Al, K, Fe, and Ti; collectively termed terrigenous indicators) as geochemical proxies to infer maximum flooding surfaces and maximum regressive surfaces. Regression is interpreted where the terrigenous indicators increase; conversely transgression is inferred where these indicators decrease. Other geochemical proxies used in this study are molybdenum enrichment to suggest paleoredox conditions, and Si/Zr to infer silica source and to identify biogenic versus detrital silica. Preliminary XRF results suggest regression throughout the Bluefish Member, and a predominantly terrigenous rather than biogenic source of silica. Molybdenum enrichment in the Bluefish Member suggests primarily euxinic conditions, with some variability. These data will be used to establish a sequence stratigraphic framework that will enable the mapping and characterization of potential unconventional reservoirs in the Hare Indian Formation as well as contribute to a better understanding of the sequence stratigraphy of the Horn River Group in the Mackenzie Corridor.

ASSESSING FACTORS INFLUENCING XYLOGENESIS OF JACK PINE (PINUS BANKSIANA), YELLOWKNIFE, NORTHWEST TERRITORIES

HARRIS*, D.M., PISARIC, M.F.J., and MARTIN, J.P.

BROCK UNIVERSITY, ST. CATHARINES, ON
DH10XC@BROCKU.CA

The climate of northern regions is changing at a rapid pace, however the natural variability of climate in these regions is not fully understood due to the lack of long-term historical climate data. Dendrochronology, the study of tree growth rings, is one tool that may be used in order to extend these records. This research identifies factors influencing xylogenesis (cellular development) of jack pine (Pinus banksiana) in the Yellowknife, NT region to better refine future northern dendrochronological research as well as create more robust tree ring chronologies in relation to historical climate patterns in this region.

A multiproxy approach was used to identify the impacts of climate on cellular development processes, by means of a combination of cellular growth analysis and a continuous record of stem radial displacement patterns throughout the growing season. Weekly microcores (small punches from the outer most portion of the tree stem) were extracted from 13 jack pine trees to produce a chronology of cellular development throughout the growing season. Results from microcore cell counts identify early cell development began late April to early May 2017. First lignified (mature) cells were identified during the period between late June to early July, followed by a period of rapid cell production throughout the month of July (~3 cells/week). Latewood cells begin developing middle to late August, signaling the end of the growing season. In addition to microcores, automatic point dendrometers (high precision sensors) have been installed on each tree within the study site creating a continuous record of radial stem displacement (stem swelling) in response to environmental conditions. Stem swelling patterns will further identify the dynamics growth patterns of this species. The multiproxy investigation of jack pine growth dynamics will provide valuable information on the impacts of climate change on tree growth within the northern boreal forest.

Results from this research will help inform dendrochronological research in this region, enabling the extension of the relatively short instrumental climate data records for the Yellowknife region. Information on the climate-growth relations of jack pine in the Yellowknife area are needed to better understand how changing climatic conditions may impact this widespread northern species.

TOWARDS UNDERSTANDING HYDROLOGICAL PATTERNS PRODUCING DROUGHT IN THE SNARE RIVER SYSTEM, NORTHWEST TERRITORIES

HICKMAN*, J.[1], ENGLISH, M.[1], and KOKELJ, S.V.[2]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
JHICKMAN@WLU.CA

The Snare River hydroelectric power system is operated by the Northwest Territories Power Corporation (NTPC) and uses four hydroelectric power stations to supply electricity to Yellowknife and surrounding communities. In the last decade, multiple

drought events and low water levels have severely hampered the production of hydroelectricity for more than half of the population of the NWT. To compensate for the loss of hydroelectric power production during these times, diesel fueled generators are utilized at a significant cost. The International Governmental Panel on Climate Change (IPCC, 2014) reports amplified warming in large portions of the NWT and predicts this trend will continue over the next several decades, which may have changing effects on the annual water budget and impact the regularity in which hydroelectric power can be generated. Of significant concern to NTPC and the citizens of the NWT is whether drought conditions will become more frequent in the future, and result in a potentially non-sustainable expense. This research examines the hydrological mass balance over a period of 15 years: 1999 to 2014, a period that experienced both elevated water inputs and droughts.

The objective of this study is to quantify the components of the annual hydrological mass balance in the Snare River watershed, inclusive of river discharge (Q), snowpack water equivalent (SWE), rainfall (R), evapotranspiration (ET), and storage (S). With very little climatic and hydrological research conducted in the unregulated upper Snare River watershed, a significant absence of usable data exists for the area. As such, this study uses numerous data extrapolation techniques to complete an annual hydrological mass balance, including methods for the estimation of SWE, ET, R, and S in the absence of in-situ field measurements. Using a theoretical probability model, patterns in antecedent conditions leading to drought can then be identified. This type of analysis can be used to gain increased understanding in how specific environmental conditions may lead to predictable hydrological conditions in the watershed. By studying a 15-year period over which a broad range of conditions were experienced, we can examine which conditions most commonly lead to low water levels, and what the recovery time of the watershed was following the low water conditions. By broadening our range of knowledge surrounding the impacts of antecedent conditions, our capacity to predict low-flow events will be improved, thereby reducing unnecessary spending on diesel fuel due to uncertainty in future ability to generate hydroelectric power.

CHARACTERIZATION OF THE CANTUNG TAILINGS: ESSENTIAL INFORMATION TO ASSESS FEASIBILITY OF REPROCESSING

JAMIESON*, H.E.[1], DOBOSZ, A.[1], PAWLIK, M.[2], JAMIESON-HANES, J.H.[3], SALMABADI, E.[2], and FALCK, H.E.[4]

(1) QUEEN'S UNIVERSITY, KINGSTON, ON
(2) UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC
(3) UNIVERSITY OF WATERLOO, WATERLOO, ON
(4) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
JAMIESON@QUEENSU.CA

The Cantung Mine is an unusually large and high-grade deposit that developed in a package of folded and overturned limestone above a Cretaceous granite intrusion. Cantung was the western world's largest tungsten producer during its operation from 1962 to 1985 and previously the source of nearly 10% of global tungsten production. Until October 2015, a total of 108,300 tonnes of tungsten (as WO_3) was recovered but a less well-defined amount was discarded with the tailings. This study seeks

to characterize those tailings to better determine the potential economic value versus potential environmental liability stored at the site.

Fifty samples were collected from surface to 30 m depth in four tailings ponds. In addition, a bulk sample from the Flat River tailings, which had been released during the early stages of mining, was taken from the stream bank. These samples varied in tungsten content from 0.11 to 0.65% W. The higher values are comparable to ore grades at proposed or operating tungsten mines.

To investigate potential issues with froth flotation, 40 grams of each sample were mixed with 100 mL of distilled water, then centrifuged, and the liquid phase was assayed for metal content and the pH measured. Despite the presence of 2.7 to >10% S, mostly in the form of pyrrhotite, a pH of 7 to 8.3 was maintained during these experiments. This suggests that acid-generating sulphide oxidation was either limited or the solution rapidly neutralized by the dissolution of other minerals, probably carbonates. As a result, for most samples the concentration of calcium was elevated (400 to 600 ppm) such that it is likely to interfere with a fatty-acid type of surfactant used in froth flotation. Total organic carbon, which is known to be a depressant in froth flotation, was also measured in the tailings but found to be negligible.

A subset of the samples has been characterized at Queen's University using scanning electron microscopy coupled with automated mineralogy (Mineral Liberation Analysis, or MLA) to determine the variation in mineral proportions, the grain size distribution and liberation of scheelite grains. Two dissimilar samples (Surface of Tailings Pond 4 and Flat River tails) have been used to optimize the Mineral Reference Library and customize the software to determine modal mineralogy. Particle size analysis of the scheelite grains shows that the scheelite in the Flat River tails is significantly coarser that the scheelite in the Tailings Pond 4 sample, probably due to either coarser crushing in the early stages of production or loss of fines by fluvial erosion. Liberation analysis indicates that approximately 30% of the scheelite in the Flat River tails is well-liberated (75 to 100% free surface), and 40% of the scheelite in the Tailings Pond 4 sample is liberated to the same degree. Less than 10% in both samples is unliberated (<25% free surface). In addition to particle size and liberation, MLA will also be used for acid-base accounting for the remaining samples, thus providing a comprehensive characterization of the tailings that can improve decisions on reprocessing.

COMMUNITY-BASED MONITORING FOR BETTER DECISION-MAKING

KEATS*, B.J.[1] and EVANS, P.C.[2]

(1) ROYAL ROADS UNIVERSITY, VICTORIA, BC
(2) TRAILMARK SYSTEMS, VICTORIA, BC
BETH.KEATS@TRAILMARKSYS.COM

Community-Based Monitoring (CBM) is gaining increasing recognition as an approach to research that can involve local people and their knowledge to gather information to support resource management decisions and understand environmental change. Moreover, it is a potential site of knowledge co-production between scientists and indigenous knowledge holders that can result in the production of a "multiple evidence base" to produce novel insights.

Despite CBM's great potential for trans-disciplinary knowledge production, more

investigation into the challenges and best practices is required to understand the ways that CBM can be better represented, understood and applied to contribute to regional, scientific monitoring programs.

This presentation will focus on the preliminary results of research into these very questions, funded by the NWT Cumulative Impact Monitoring Program, in collaboration with the North Slave Métis Alliance.

THE APPLICATION OF 3D INDICATOR MINERAL DATASETS TO REGIONAL-SCALE MODELLING OF GLACIAL SEDIMENTS IN THE LAC DE GRAS AREA, NORTHWEST TERRITORIES

KELLEY, S.E.[1], ROSS*, M.[1], STIRLING, R.A.[1], NORMANDEAU, P.X.[2], and ELLIOTT, B.[2]

(1) UNIVERSITY OF WATERLOO, WATERLOO, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
SAMUEL.KELLEY@UWATERLOO.CA

The Slave Geological Province, Northwest Territories, has a long and complicated glacial history. A fragmentary record of that long glacial history exists in the landscape, even in areas of thin discontinuous till cover. In drift prospecting, understanding the net effect of glacial processes at play is key to interpreting dispersal patterns seen at the surface. In many cases, dispersal patterns are interpreted to be continuous. Yet, in reality, dispersal trains frequently occur in areas of discontinuous till cover with variable till thickness, features that hint at a more complex evolution.

Results from the Northwest Territories Geological Survey's Slave Province Surficial Materials and Permafrost Study demonstrate the effect that bedrock topography and multiple ice flow phases have on the dispersal of kimberlite indicator minerals and pathfinder elements within the till column, even within areas of discontinuous till cover. Here, we build upon those results, utilizing a 3D indicator mineral dataset generously donated by Dominion Diamond Ekati Corp. and North Arrow Minerals Inc., constituting 700+ boreholes covering ~1,400 sq. kilometers between Lac de Gras, Courageous and Mackay Lakes. Our study area encompassing this dataset contains a diverse range of surficial materials, from thick drumlinized till to extensive till veneer interspersed with bedrock outcrops. Thus, we will use this large dataset, in conjunction with field observations and legacy mapping, to create a regional-scale three dimensional model of glacial sediment thickness and composition which captures the natural diversity of surficial geology of the region. Through the use of our model, we will characterize discontinuous dispersal patterns in three dimensions, as well as examine relationships between dispersal trains and landform assemblage, bedrock lithology, and post-glacial reworking. This work has the potential to inform future drift prospecting efforts in the North, by providing real-world analogues for dispersal trains occurring in varying surficial settings, as well as highlighting the usefulness of legacy geoscience datasets in advancing the collective exploration knowledge.

RECONNAISSANCE SURFICIAL GEOLOGY, INDIN LAKE, NORTHWEST TERRITORIES, NTS 86-B

KERR, D.E., O'NEILL, H.B., WOLFE, S.A., and MORSE*, P.D.

GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
HUGHBRENDAN.ONEILL@CANADA.CA

The glaciated landscape within the study area exhibits large-scale ice flow features such as drumlinoids, crag-and-tails, fluted bedrock, as well as striations, which record westward to southwestward ice flow during the last glaciation. Glacially scoured bedrock dominates the map area. Discontinuous till veneer occurs throughout the map area. Glaciofluvial landforms, including eskers, kames, and outwash plains, are part of meltwater corridors which generally trend westward and southwestward. During deglaciation, which began about 10.5 ka BP, a small number of recessional moraines were formed. Glaciolacustrine sediments, associated with Glacial Lake McConnell, were deposited in the southwestern regions. Associated glaciolacustrine deltas and beaches occur between 290-330 m elevation, marking high lake levels associated with the position of the eastward receding ice front during deglaciation. Isolated deltas unrelated to Glacial Lake McConnell were observed at 370 m and 390 m. Postglacial eolian sediments exhibit dunes recording both north-northwestward and south-southeastward paleowind directions.

GEOLOGY OF THE K6-252 KIMBERLITE COMPLEX, ALBERTA

MCCANDLESS*, T.[1], DESGAGNES, B.[2], SHIMELL, M.[2], and READ, G.[2]

(1) MCC GEOSCIENCE INC., NORTH VANCOUVER, BC
(2) SHORE GOLD INC., SASKATOON, SK
MCCGEOSCIENCE@GMAIL.COM

The Buffalo Head Hills (BHH) kimberlites comprise the third largest district of diamond-bearing kimberlites in Canada, with 41 kimberlites distributed over 6,000 km^2. The older kimberlites dated at ~85Ma were emplaced coevally with deposition of marine strata. Systematic drilling at the K6 and K252 kimberlites indicates that these kimberlites are coeval eruptive centers that comprise a larger kimberlite complex, similar to those observed at Fort a la Corne, Saskatchewan. The K6 kimberlite is bilobate with two depositional centers or vents identified by gravity, with the northern vent forming a topographic high. Several kimberlite units have been identified on the basis of macrocryst, lapilli, matrix and xenolith modal abundances. Olivine-rich volcaniclastic kimberlite (OLRVK) is an interbedded unit at the contact between the Cretaceous Dunvegan and the overlying Kaskapau Formations. Interbedded juvenile lapilli-rich VK (JLRVK) kimberlite rests stratigraphically above the OLRVK and within the Kaskapau Formation. Both units increase in thickness to the northwest toward K252. The youngest unit and greatest by volume is the main volcaniclastic kimberlite (MVK), resting on top of the upper Kaskapau Formation but cross-cutting lower marine strata and defining the northern vent at K6.

The K252 kimberlite is 300 m northwest of K6 and has several distinct kimberlite units,

of which two are clearly interbedded with the Kaskapau Formation and identical to those observed at K6. These include an OLRVK as two definable interbedded lenses, and a JLRVK above the OLRVK as observed at K6. The final and most voluminous unit is a matrix-supported VK (MSVK).

The K6 and K252 kimberlites are temporally and spatially related, with the earliest interbedded OLRVK and JLRVK units connecting the two bodies. When projected at 1:1 scale and correlated to a single datum, the interbedded units stratigraphically align, further supporting the interpretation of K6-252 as a single kimberlite complex. The K6-252 complex is likely not unique, and these conclusions have significant implications for the exploration and economics of the BHH kimberlites.

ESTIMATING OVERBURDEN DEPTH IN A PERMAFROST-RICH ENVIRONMENT USING PASSIVE SEISMICS: RESULTS FROM THE 2017 PRELIMINARY SURVEY AT KENNADY CAMP, NORTHWEST TERRITORIES

MCPEAK*, S.[1], MALLOZZI, S.[1], SAMSON, C.[1], ELLIOTT, B.[2], and HUNTER, J.[3]

(1) CARLETON UNIVERSITY, OTTAWA, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(3) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
SARA.MCPEAK@CARLETON.CA

Passive seismics is a relatively new exploration method in which vibrations from distant earthquakes are used as a source of signal. Data is processed to estimate the depth of the interface between the overburden and the underlying bedrock. Passive seismics has never been tested before in a permafrost-rich environment.

Between July 11-23rd, 2017 a Tromino seismograph was used to collect passive seismic data over areas of known depth to overburden near Kelvin camp, owned by Kennady Diamonds Inc. and located approximately 300 km north-east from Yellowknife, NWT. The geology of the study area consists of Slave craton bedrock, glaciolacustrine sediments, alluvial sediments, and organic deposits. Ice-bearing permafrost is also present in the study area to considerable depth (> 30 m). Kelvin camp falls within a continuous (underlies 90-100% of landscape) and discontinuous (underlies 50-100% of landscape) permafrost zone.

The Tromino is a seismograph instrumented with a broad-band three-component velocity sensor that records ambient seismic activity. Measurements at 95 stations were taken using the seismograph. Data was collected along 7 transects across the ~0.5 km long Kelvin kimberlite pipe at 50 m spacing. Data was also collected above 25 RC boreholes. To collect data, the seismograph was placed on the surface of the ground and recorded data for 30 minutes. The ground surface consisted of relatively loose sediment and it was challenging at times to place the seismograph into firm ground. Nevertheless, 64 out of the 95 stations returned valid data showing Horizontal-to-Vertical component Spectral Resonance (HVSR) with fundamental frequency ground resonance associated with a large seismic shear velocity contrast at depth. The frequency of the peak resonance may be associated with the shear wave velocity of the unconsolidated sediment and the depth to bedrock.

To derive depth to bedrock from the seismic

data, knowledge of the velocity-depth profile in the near-subsurface is required. At this early stage of the project, this information is not yet available; hence, the regional profile from the Ottawa non-permafrost thick soil area was used as a preliminary minimum depth estimate. Using this assumption, preliminary results show that the depth estimates to bedrock range between 0.5-2 m in most the survey area. In a 0.55 km by 0.4 km region immediately east of the main grid, the overburden is thicker and depth to bedrock can reach values in excess of 3 m. When future shear wave velocity measurements of overburden are made, refined depth estimates may increase by as much as a factor of 10.

In years two and three of the project, additional passive seismic data will be acquired, together with data from other geophysical techniques, including the shear wave refraction seismic technique to obtain a local velocity-depth profile for the survey area as an independent geophysical estimate of overburden thickness. The performance of passive seismics will be evaluated in different situations: thin versus thick overburden, permafrost of variable thickness, and overburden of different composition. Borehole measurements, for which the depth to bedrock is known, will also be used to validate the passive seismic data.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY GEOPHYSICAL ACTIVITIES, 2017-2018

MIRZA, A.M.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
ASIF_MIRZA@GOV.NT.CA

The Northwest Territories Geological Survey (NTGS) holds a large collection of government and industry geophysical data and has the mandate to make these data available to the public. However, while the NTGS's online data access systems are being upgraded, there is no single place where clients can discover what data exist in this collection. To aid users in finding available geophysical data, all publically available airborne electromagnetic, radiometric, and gravity data conducted in the NWT by federal and territorial governments, and industry are represented here on compilation maps, these finding aids will be published as an NWT Open Report in the near future.

New high-quality geophysical data are collected by government and industry in areas where data are lacking; industry-acquired data are added to the NTGS collection by donation and as a requirement of the NWT Mining Regulations. We present the details of two government geophysical surveys flown in 2017, and the outline of one upcoming project.

The NTGS conducted a high-sensitivity fixed wing aeromagnetic survey in the central Slave craton, parts of NTS 75M & 75N. The aeromagnetic survey was flown with east-west traverse line spaced 100 m apart and north south control lines spaced 600 m apart. The nominal aircraft terrain clearance was 60 m with drape flying. A total of 87,696 line-kilometres of data was acquired, covering approximately 7,500 km^2. The aeromagnetic data is published by as NWT Open Report 2017-014 (Mirza and Elliott, 2017).

The NTGS also contracted a second survey, a helicopter-borne electromagnetic and horizontal-gradient magnetic survey consisting of six blocks. Blocks were flown

with an east-west traverse lines spaced 75 m apart and north south control lines separated 750 m. The nominal terrain clearance was 60 m to maintain a bird height of 25 m. A total of 4,578 line-kilometres of data was acquired, covering ground on parts of NTS 75M, N, and 76D. The NTGS published the survey as NWT Open Report 2017-015 (Mirza and Elliott, 2017).

Both new airborne geophysical datasets are expected to stimulate private sector activity and investment by providing insight into possible locations of intrusions and fault structures that could be related to mineralization of interest, especially kimberlite.

The Geological Survey of Canada (GSC) are flying a fixed wing aeromagnetic reconnaissance in the NWT Mackenzie Mountains, parts of NTS 95M, N, 105O, P and 106A, B, C. The survey is designed with 800 m line and 2400 m tie line spacing. The nominal aircraft terrain clearance is 250 m with drape flying. The results of this project will be published in a joint publication of the NTGS and GSC. Previous to this study, there was no aeromagnetic data available for this area, and these new high-resolution aeromagnetic data can be used by multiple stakeholders to enhance geoscience knowledge, promote mineral exploration, and inform land use planning decisions.

INFLUENCE OF TERRAIN AND HIGHWAY CONSTRUCTION ON THERMOKARST DISTRIBUTION, NORTH SLAVE REGION, NORTHWEST TERRITORIES, CANADA

MORSE*, P.D.[1], WOLFE, S.A.[1], and MCWADE, T.L.[2]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) CARLETON UNIVERSITY, OTTAWA, ON
PETER.MORSE@CANADA.CA

Permafrost degradation is occurring widely in the circumpolar north and is expected to have broad-reaching effects on the land and its inhabitants. However, there is little quantitative information on thermokarst distribution and development in northern Canada, including southern North Slave, NT. Permafrost in the region is presently degrading, and modelling suggests the discontinuous permafrost extent will decline significantly. Differential thaw subsidence has already occurred along Highway 3, affecting drivability and maintenance costs on this important transportation artery. The objective of this study was to quantify thermokarst development in order to evaluate the dominant terrain controls, and the influence of Highway 3, on the distribution of thermokarst. We mapped the location and size of thermokarst ponding (a change from forest cover to water) in a 1430 km^2 study area by comparing historic and modern remotely sensed imagery from 1945, 1961, and 2005.

Permafrost in the region developed in a time-transgressive manner during Holocene lake-level recession, from glacial Lake McConnell to the present-day level of Great Slave Lake (5 $mm \cdot a^{-1}$ over the last 8000 years). The past inundation has left uplands of extensive wave-washed bedrock outcrops

with depressions filled with glaciolacustrine (GL) and glaciofluvial sediments. In contrast, GL deposits cover more of the landscape, nearly 70 % of the exposed surface, at lower elevation in Great Slave Lowlands. Ground ice accumulation accompanied permafrost aggradation into the fine-grained sediments, and is evident on the landscape in the form of widespread lithalsas.

Highway 3 was constructed during the mid-1960s and preferentially aligned to cross terrain underlain by fine-grained sediments to avoid bedrock and waterbodies. Local silt and clay used to construct the road embankment was sourced from shallow borrow pits developed along the right-of-way. Following construction, many borrow pits developed into ponds. Major highway realignments between 1999 and 2006 maximized bedrock traverses to reduce the construction on thaw-sensitive permafrost and limit embankment settlement.

Thermokarst ponding is widespread in the study area (n = 3138). The individual area of most new ponding is typically small (< 5000 m^2) but ranges up to 45 000 m^2. Thermokarst development is dominantly constrained within GL deposits, and decreases with elevation. Highway construction has substantially affected thermokarst development. Compared to undisturbed GL deposits, ponding density is an order of magnitude greater within 200 m of Highway 3, where more than 95 % of ponding has developed since 1961 and about half of the borrow pits have developed into thermokarst ponds.

Thermokarst is likely widespread throughout the region as GL deposits are extensive. The transition of approximately 3.57 km^2 of land cover from forested permafrost terrain to water bodies differs from the low subarctic where permafrost peatlands degrade to fens. Reduced thermokarst ponding at higher elevation may relate to the limited GL sediment cover, but also to greater time for past thermokarst development due to earlier emergence following lake-level recession. Regardless, thermokarst development will likely continue in low-lying forested GL deposits that should be avoided by new infrastructure construction.

THE GEOLOGY OF THE FARADAY 2 KIMBERLITE PIPE, NORTHWEST TERRITORIES, CANADA

NELSON*, L.[1], HETMAN, C.M.[2], and DIERING, M.[2]

(1) AURORA GEOSCIENCES LTD., YELLOWKNIFE, NT
(2) SRK CONSULTING, VANCOUVER, BC
LINDSAY.NELSON@AURORAGEOSCIENCES.COM

The diamondiferous Faraday 2 kimberlite pipe is located in the Archean Slave Craton, approximately 10 km north of the Gahcho Kué Diamond Mine. Faraday 2 is one of four inclined pipes comprising the Kelvin-Faraday kimberlite cluster. The bodies have tube-like shapes and trend towards the northwest. Extensive kimberlite sheets are associated with the pipes. Some of the sheet complexes have strike lengths of over 1000 m. The kimberlites intrude metaturbidites of the Yellowknife Supergroup.

Faraday 2 was first targeted because of kimberlite indicator mineral anomalies in glacial till and magnetic and gravity anomalies from geophysical surveying. De Beers Canada intersected kimberlite at Faraday 2 in 2001. Kennady Diamonds Inc. re-initiated exploration in the area in 2012 and has since completed extensive drilling and sampling programs. In 2017, a 262.2-tonne bulk sample was collected using large-

diameter reverse circulation drilling. Faraday 2 has an irregular morphology and non-typical inclined orientation. To date, the pipe has been delineated over 450 m; it varies in width between 20 and 60 m and between 60 and 90 m in vertical thickness. The pipe is inclined towards the northwest, turning further towards the west with increasing depth. The southeastern section of the kimberlite is inclined at 30°, steepening to 40° as the kimberlite turns towards the west, and shallowing to between 0 and 20° in the most northwesterly portion of the body. Faraday 2 is 200 m below the ground surface at its current northwestern limit.

Detailed logging of drill core, petrographic studies, microdiamond and macrodiamond results combined with 3D modeling in Leapfrog Geo have defined the irregular external morphology of the pipe and the internal geology. Faraday 2 is infilled with multiple phases of kimberlite, forming layered units with contacts that are sub-parallel to the pipe walls. The different phases of kimberlite present are related to separate emplacement events. The dominant pipe infill is volcaniclastic kimberlite with lesser volumes of coherent and transitional kimberlite. The major volcaniclastic kimberlite unit at Faraday 2 is classified as a 'Kimberley-type' pyroclastic kimberlite (KPK), formerly referred to as a tuffisitic kimberlite breccia (TKB). It is characterized by thin-skinned pelletal-shaped magmaclasts (formerly pelletal lapilli) and country rock xenoliths set within a matrix comprised of serpentine and microlites with variable proportions of ash-sized particles.

The sub-horizontal, inclined orientation of the pipe, internal geology, and close relationship to kimberlite sheets within Faraday 2 are generally similar to the other kimberlites in the Kelvin-Faraday cluster. This inclined pipe orientation is atypical of previously-described KPK systems.

UNDERSTANDING LAND USE PLAN CONFORMITY DETERMINATION FOR APPROVED REGIONAL LAND USE PLANS

PHILLPOT*, D. and STRETCH, V.

DEPARTMENT OF LANDS, GOVERNMENT OF NORTHWEST TERRITORIES, YELLOWKNIFE, NT

DARHA_PHILLPOT@GOV.NT.CA

Regional land use plans are used by developers during project planning and by regulators to evaluate project proposals as the first step in the permitting process. The intent of this poster is to clearly outline the conformity evaluation process associated with land use authorizations in order to increase understanding of how and why conformity checks are completed using approved land use plans. Translation of this knowledge is key to achieving more successful and timely applications for development projects in the Northwest Territories (NWT). Topics covered include the current state of land use plans in the NWT, the functions of land use plans, what conformity determination is and who does it, how conformity requirements in approved plans are implemented and enforced, and where to find information on land use plan conformity. The poster will provide an example of the Government of the Northwest Territories process to ensure conformity with land use plans.

EVOLUTION OF INCIPIENT LOWLAND THERMOKARST FEATURES IN THE BLACKSTONE RIVER VALLEY, YUKON

ROY-LÉVEILLÉE, P.

LAURENTIAN UNIVERSITY, SUDBURY, ON
PROYLEVEILLEE@LAURENTIAN.CA

Widespread thermokarst initiation and the acceleration of thermokarst development in permafrost peatlands can result in ecological change, threaten the cultural integrity of northern indigenous people, change rates of carbon storage and release at high latitudes, and affect the geomorphology of Arctic and subarctic landscapes. Despite the multilayered significance of intensified thermokarst activity the processes controlling the early stages of thermokarst development and the factors differentiating features that will stabilize from those that will continue to expand are still poorly understood. Here we present preliminary observations of conditions associated with the stabilization or expansion of incipient thermokarst ponds in the Blackstone River valley, central Yukon. In this large valley located near the limit between continuous and discontinuous permafrost, the alluvial deposits of the river bed are surrounded with extensive moraines and outwash deposits. The vegetation cover is dominated by tundra, and ice wedge polygon networks are extensive. Signs of ice wedge degradation are widespread in several parts of the valley. However, comparison of recent remotely sensed imagery with historical aerial photographs indicates that several degradation features have been stable for at least 20 years, while others have expanded rapidly. This stabilization is associated with vegetation growth in the thaw features, causing partial terrestrialization of incipient ponds and cooling of the ground beneath. Mean annual temperatures near the ground surface beneath small ponds with dense *Carex spp*. or aquatic mosses ranged from -1.5 to -2.7°C, whereas such temperatures ranged from 0.3 to 2.9°C beneath similarly shallow but unvegetated or sparsely vegetated water in expanding ponds. Expanding ponds exhibiting signs of aggressive shore erosion were often connected to thermo-erosion gullies, which visibly contributed to destabilising the shore bank. Such association with thermo-erosion gullies also enabled rapid degradation along some banks of seasonal ponds, preventing the stabilization that could result from prolonged loss of contact between the bank foot and water every summer.

IMPLICATIONS OF THAWING PERMAFROST ON WATER IN THE NORTHWEST TERRITORIES

RUDY*, A.C.A.[1], CONNON, R.F.[1], DEVOIE, É.[2], BRAVERMAN, M.[1], WILCOX, E.[1], WALKER, B.[1], BALSER, J.[1], QUINTON, W.L.[1], and MARSH, P.[1]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) WATERLOO UNIVERSITY, WATERLOO, ON
ASHLEY.RUDY@GMAIL.COM

Climate change is substantially impacting Northwestern Canada resulting in it being one of the most rapidly warming regions on Earth. Changes in air temperature, precipitation, ice/snow cover, wildfire regimes, and vegetation all have implications for permafrost stability. Collectively, these changes will alter physical and biogeochemical processes on land and in rivers, lakes, and wetlands with direct implications for water quality and quantity. The Northwest Territories spans from sporadic to continuous permafrost

zones making it well situated to examine changing permafrost conditions and necessary as climate warming directly challenges infrastructure stability. To adapt and prepare for permafrost changes, a complementary collection of field data, combined with modelling, is necessary to understand the factors driving changes in the thermal state of the permafrost and its implications on the hydrological system.

Wilfrid Laurier University and the Government of the Northwest Territories signed a 10-year (2010-2020) Partnership Agreement to expand the Territories' capacity to conduct environmental research and monitoring. This partnership builds upon two consecutive Canada Foundation for Innovation (CFI) investments that provide a state of the art infrastructure platform for partnership research, training and engagement. With many sites across the NWT, the Wilfrid Laurier research sites span the discontinuous to continuous permafrost boundary and represent two very different but representative regions within the NWT. These research sites include the Scotty Creek Research Watershed, located near the southern extent of discontinuous permafrost, and the Trail Valley Research Watershed, located in continuous permafrost at the edge of the boreal forest-tundra ecotone. Research at these watersheds is focused on the integrated dynamics and variability of snow, active layer depth, permafrost, thermokarst, shrub expansion and forest change, and changing soil water storage, lake levels and streamflow. Automated science infrastructure has been installed at both research stations and includes numerous climate stations that record a suite of meteorological and physical variables and are complemented by active layer and permafrost temperature thermistors, water level recorders and frost table measurements.

At Scotty Creek, research has shown that the rate of permafrost thaw has accelerated since the initiation of field activities in 1999 with thaw resulting in the loss of tree cover and the conversion of forested peat plateaus to wetlands. Additionally, seismic lines and winter roads cross the study area and since their emplacement have become permafrost free-areas due to the removal of trees. The position and evolution of the frost table has been recorded throughout the thaw season for multiple years across the landscape to investigate changing permafrost conditions and recent research has shown an increase in the formation of taliks. Permafrost conditions at Trail Valley are more variable due to changing snow conditions, and shrub expansion. Deepening active layers and the thaw of ice-rich ground has led to the initiation of ground subsidence and thermokarst. The continued partnership between Laurier and the Government of the Northwest Territories will encourage interdisciplinary research with the focus on understanding how climate warming-induced change impacts permafrost.

STRUCTURAL FRAMEWORK FOR THE CANTUNG TUNGSTEN DEPOSIT, NORTHWEST TERRITORIES

SALMABADI*, E.[1], HICKEY, K.A.[1], and FALCK, H.E.[2]

(1) UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
ESALMABADI@EOAS.UBC.CA

The Cantung W-Cu-Au skarn has been one of the western world's most significant sources of tungsten for over the past 50 years. Since opening in 1962, an estimated total of 7.68 Mt of ore has been extracted from the Cantung mine at an average grade

of ~1.4 % WO_3. The deposit is spatially and genetically associated with 101 to 97 Ma monzogranite plutons of the Tungsten plutonic suite. At Cantung, the main Mine Stock was emplaced into shallow-water carbonates of the Lower Cambrian Sekwi Formation and the underlying siliciclastic rocks of the Lower Cambrian Vampire Formation. Beyond the confines of the Cantung deposit and the Mine Stock, these units are macroscopically folded as part of a regional NW-SE trending fold event thought to be related to the Cordilleran Orogeny. At Cantung, Vampire and Sekwi host rocks are also folded and have a well-developed foliation that has been overprinted by contact metamorphism and skarn alteration. The mine stock is not folded or internally ductily deformed and emplacement is thought to have been post-tectonic. However, there is some evidence for foliation development during contact metamorphism and there are geometric inconsistencies between folds in the mine and those developed regionally. To better understand the geometric and kinematic relationship of deformation in the Cantung host rocks to the history of regional deformation, and how this might relate to the spatial distribution of fluid flow and skarn mineralization, we have undertaken a structural study of the Cantung mine and surrounding regions.

Structural data was collected along four SW-NE sections in the area between the Flat River and the Upper Hyland Valley. Additional data was collected from the mine underground workings and open pit at Cantung. In Vampire Formation units to the west of the mine, beyond the aureole of the Mine Stock, a pervasive, steeply-dipping, penetrative foliation (S_1) is developed and this is axial-planar to subhorizontal plunging, upright, NW-SE striking folds that form the regional fold train. S_1 is over-printed by a pervasive, but weakly developed, shallow dipping S_2 crenulation cleavage and by S_3 kinks. The F_1 folds become tighter with larger amplitude and shorter wavelength closer to the mine. At Cantung, the axial planes to large F_1 folds dip moderately or shallowly to the southwest. Within the contact metamorphic aureole above the Mine Stock at Cantung, a subhorizontal crenulation cleavage developed synchronously with growth of cordierite porphyroblasts. This foliation is tentatively correlated with S_2 and this deformation event may have been responsible for folding F_1 fold into a shallower dipping orientation above the Mine Stock suggesting emplacement of the stock was syntectonic. Given a syntectonic timing of pluton emplacement, better insight on the structural history of the deposit and the surrounding area will aid in understanding the potential connection between macro-scale fold structures and the genesis and distribution of smaller-scale fracture networks that may have influenced the spatial distribution of mineralization.

TELESEISMIC INVESTIGATION OF THE CRUST AND MANTLE LITHOSPHERE UNDERLYING BANKS ISLAND, NORTHWEST TERRITORIES: IMPLICATIONS FOR RESOURCE POTENTIAL

SCHAEFFER*, A.J.[1], AUDET, P.[1], CAIRNS, S.R.[2], ELLIOTT, B.[2], FALCK, H.E.[2], ESTEVE, C.[1], and SNYDER, D.[3]

(1) UNIVERSITY OF OTTAWA, OTTAWA, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(3) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
ANDREW.SCHAEFFER@UOTTAWA.CA

The tectonic evolution of the Beaufort Sea continental margin has contributed to establish this region as a major potential petroleum reservoir. Controlled source off-shore seismic data suggest that Banks Island represents the western edge of the rifted margin established during the opening of the Arctic Ocean. In this scenario rifting caused Banks Island to subside and accumulate sediments rich in petroleum source material. The cooling and further subsidence of these sediments is important for understanding the thermal maturation of petroleum products. Conversely, recently published surface-wave based velocity models of North America indicate seismic velocity at 100-150 km depths is similar to those beneath Canada's diamond mines in the central Slave craton north of Yellowknife. These results suggest that Banks Island basement is instead part of the Canadian Shield and any kimberlites found thereon would be promising candidates to contain diamonds. Furthermore, seismicity located within the Mackenize River Delta and offshore in the Beaufort Sea has been previously observed, however its origin is currently unknown, though may potentially be related to incipient subduction of oceanic lithosphere beneath the North American craton.

The inference of thick cratonic-like lithosphere underlying Banks Island is incompatible with this being a tectonically disrupted and thinned margin of the Canada Basin. The question, therefore is how can one reconcile mantle structure typical of the Canadian Shield with crust typical of a rifted passive margin. Resolving these questions requires high-resolution seismic models obtained from an array of broadband seismograph stations. Here we present in-progress results on the structure of the crust and uppermost mantle underlying the western Canadian Arctic based on data obtained from the Banks Island Seismograph Network (BISN), an array of 4 stations installed over the summer of 2015; these are augmented with other stations in the region, including the USArray Transportable Array, CNSN and POLARIS stations on the mainland and neighbouring Arctic Islands. We compute receiver functions, teleseismic shear-wave splitting and ambient noise cross-correlations. Crustal thickness across Banks Island is ~30 km, with a slight thinning northward towards Prince Patrick Island. Anisotropy orientations indicate margin parallel fabrics, perpendicular to those expected for a tectonically extended margined; however, the source depth of these fabrics remains uncertain. Crustal structure across the region is complex, indicative of the extensive sedimentary cover.

TRAILS: COLLABORATIVE PERMAFROST TERRAIN MAPPING, DEMPSTER AND INUVIK TO TUKTOYAKTUK HIGHWAYS CORRIDOR

SLADEN, W.E.[1], MORSE*, P.D.[1], KOKELJ, S.V.[2], SMITH, S.L.[1], JARDINE, S.[1], KOKOSZKA, J.[2], VAN DER SLUIJS, J.[3], and PARKER, R.J.H.[1]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
(3) NWT CENTRE FOR GEOMATICS, YELLOWKNIFE, NT
PETER.MORSE@CANADA.CA

Together, the Dempster (DH) and Inuvik to Tuktoyaktuk (ITH) highways create Canada's northernmost all-season road and the only one to provide access to the Arctic Ocean. The combined 870-km-long corridor traverses a variety of glaciated and non-glaciated terrain through Yukon and Northwest Territories, ranging from the

Ogilvie Mountains in the south to the Arctic Coastal Plain in the north. Permafrost is continuous in 91 % of the corridor, but the varied relief, climate, vegetation, forest fire regimes, and landscape histories nevertheless have produced highly variable permafrost conditions. The technology and awareness of climate change in 1979, when the DH opened, contrast sharply with those that prevailed during the development of the soon-to-be-opened ITH, and a number of geotechnical challenges remain. Though the ITH was well investigated, many questions also remain regarding the role of glacial legacy and post-glacial landscape modifications on contemporary terrain sensitivity and embankment performance.

The Transportation Resilience in the Arctic Informed by Landscape Systems (TRAILS) research activity, Natural Resources Canada, operates in partnership with territorial and academic institutions, including the Northwest Territories Geological Survey and Department of Infrastructure, and also with the support of Transport Canada. The purpose is to conduct innovative permafrost research to address questions regarding landscape change in order to inform infrastructure management decisions. The DH-ITH corridor provides a landscape transect for conducting multidisciplinary research on permafrost thermal conditions, terrain sensitivity, and climate change impacts on terrain and infrastructure.

A primary goal of TRAILS is to improve permafrost terrain and surficial geology maps by developing a robust classification scheme and mapping methodology. In May 2017, we initiated a terrain mapping exercise using very high-resolution imagery and LiDAR data to identify geomorphological features and landscape types within the 10-km-wide corridor. The imagery is rendered in 3-D with Summit 3D software, and digitized features are input directly to ArcGIS using DAT/EM's Capture Interface. To date, 13 images, comprising 445 km (51 %) of the corridor, have been orthorectified and pan-sharpened, and 4 images (24 %) have been rendered in 3-D. Six test sections have been mapped to test and refine mapping methodology. Additional feature attributes will be assigned according to available geoscience data including surficial and bedrock geology, fire history, and drainage basin. These data will provide an important platform for understanding ground ice distribution and testing/validating remote sensing tools, and will facilitate assessment of landscape change and revision of the local surficial geology.

A PILOT PROJECT TO INCREASE PUBLIC ACCESSIBILITY OF PERMAFROST INFORMATION

SMITH*, S.L.[1], O'NEILL, H.B.[1], WOLFE, S.W.[1], MORSE, P.D.[2], KERR, D.E.[2], BRODARIC, B.[2], KOKELJ, S.V.[3], and KARUNARATNE, K.C.[3]

(1) GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(3) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
SHARON.SMITH@CANADA.CA

Knowledge of the thermal and geotechnical properties of subsurface materials is critical for planning infrastructure development in permafrost regions. Data from borehole logs acquired during geotechnical investigations and scientific research projects can further support engineering design and adaptation of infrastructure to climate change. Although such geotechnical borehole

information is currently available in published database compilations, such as Geological Survey of Canada Open Files, much of these data are in various formats, often in print form and not digitally accessible. A pilot project has been initiated to develop a Permafrost Information Network (PIN) to compile and increase the accessibility of available records.

The pilot project will make use of existing web architecture developed for the Groundwater Information Network (GIN), which connects a variety of groundwater information from federal, provincial, and territorial sources. The goal of the PIN pilot project is to adapt the existing GIN capabilities for permafrost-related information, allowing users to view borehole locations, geotechnical properties, and stratigraphy through a web application, and download the data for analysis. At the end of the initial testing phase, a limited amount of geotechnical information will be available through PIN. The future goal is to collaborate with additional data holders and connect to their data compilations through PIN applications. This can help federal and territorial organizations make new information publicly available on an ongoing basis. Other types of information such as ground temperature records (time series data) can be incorporated into PIN in the future.

Through multi-agency project planning and collaboration, the PIN initiative can identify the processes and resources to increase access to baseline information to support decision making in northern Canada. It can also contribute to a broader objective of developing a Canadian geoscience information network.

INVESTIGATING THE DIVERSE GLACIAL GEOLOGY SOUTH OF LAC DE GRAS, NORTHWEST TERRITORIES, AND ITS POTENTIAL IMPLICATIONS FOR DRIFT PROSPECTING

STIRLING*, R.A.[1], KELLEY, S.E.[1], ROSS, M.[1], NORMANDEAU, P.X.[2], and ELLIOTT, B.[2]

(1) UNIVERSITY OF WATERLOO, WATERLOO, ON
(2) NORTHWEST TERRITORIES GEOLOGICAL SURVEY, YELLOWKNIFE, NT
REBECCA.STIRLING@UWATERLOO.CA

Drift prospecting has been used extensively southwest of Lac de Gras to find buried diamondiferous kimberlites. However, the surficial geology of that area is characterized by a great diversity of glacial deposits and landforms as well as variable drift thickness. The effect of this heterogeneity on the surface and near-surface expression of kimberlite indicator mineral trains is poorly understood and could have important implications. This study aims to gain an in-depth understanding of the complex surficial geology south of Lac de Gras and its potential effects on dispersal patterns in order to improve drift prospecting strategies in this and other challenging regions.

In July 2017, we conducted fieldwork in two key areas south of Lac de Gras where sediments from a variety of glacial sub-environments (subglacial, supraglacial, glaciofluvial, and glaciolacustrine) were identified and sampled (n=51). We also measured ice flow indicators (e.g., striation) at numerous outcrops (n=18). Samples and data collected will help to determine not only the ice flow direction and relative flow ages, but also the composition of different types of glacial sediments, and possible

post-glacial lacustrine reworked sediments found in the area. We will use that information to explore glacial entrainment mechanisms and glacial dispersal processes, relevant to exploration that complement an 3D indicator mineral dataset donated by Dominion Diamond Ekati Corp. and North Arrow Minerals Inc. The latter will be particularly useful to map till thickness variability and understand the effect of bedrock topography on 3D dispersal patterns. Overall, landform assemblages, drift thickness and composition, and bedrock topography in source and dispersal areas will be analyzed for their implications on KIM occurrence patterns. This work will advance the knowledge of the surficial geology within an area of complex glacial geology, bringing new insights into this prospective region.

USING PALEOLIMNOLOGY TO ESTABLISH BASELINE CONDITIONS AND TRENDS FOR CONTAMINANTS AND CLIMATE FOR A COMMUNITY-BASED AQUATIC ECOSYSTEM MONITORING PROGRAM, MARIAN WATERSHED, NORTHWEST TERRITORIES

TELFORD*, J.V.[1], WOLFE, B.B.[1], HALL, R.I.[2], and HUM, J.[3]

(1) WILFRID LAURIER UNIVERSITY, WATERLOO, ON
(2) UNIVERSITY OF WATERLOO, WATERLOO, ON
(3) LANDS PROTECTION DEPARTMENT, TŁĮCHǪ GOVERNMENT, BEHCHOKǪ̀, NT
JAMESVAUGHNTELFORD@GMAIL.COM

In 2005, full surface and sub-surface land rights of 39,500 km^2 in the central Northwest Territories (Tłı̨chǫ Lands) were acknowledged in the Tłı̨chǫ Agreement. Driven by the ethos that the preservation of the health of the land and water are a top priority in the face of potential industrial development and climate warming, the Tłı̨chǫ Government developed the Marian Watershed Stewardship Program (MWSP). The Marian Watershed covers a substantial portion (23,000 km^2) within Tłı̨chǫ Lands and is a main region for fishing, hunting, and transportation. The primary objective of the MWSP is to establish baseline data through the sampling of water, sediment, and fish that can serve as reference points for detecting effects of ongoing climate change and potential mining, such as Fortune Minerals proposed NICO mine. In collaboration with the MWSP, this research aims to establish baselines of hydroecological conditions and lake sediment metal concentrations to better inform continued monitoring. Paleolimnological methods are being applied to sediment cores from nine lakes throughout the watershed. Sediment cores dated using ^{210}Pb and ^{137}Cs are being analysed for physical (loss-on-ignition, grain size), geochemical (organic carbon and nitrogen elemental and isotope composition, cellulose oxygen isotope composition), and biological (diatoms) parameters, and metal concentrations. Results from Nico Lake, located adjacent to the NICO deposit, shows a narrow range of concentrations for most metals during the past 900 years, with the exception of arsenic. When normalized to cobalt and lithium to account for changes in concentrations due to erosional intensity and supply from the catchment, arsenic is enriched between about ~1940-2000 relative to the pre-industrial As/Co, As/Li ratio that existed during the Little Ice Age (~1580 and ~1940). Prior to ~1580, arsenic is also enriched, exceeding values apparent in the latter half of the 20th century. The stratigraphic record clearly shows evidence that natural processes can lead to arsenic enrichment at this location, which may

confound ability to detect anthropogenic sources. Ongoing studies of other lake sediment cores will be used to further understand mechanisms that drive stratigraphic variation in arsenic concentrations and other metals of concern throughout the watershed.

SURFICIAL SEDIMENTS, LAND COVER MAPPING AND PERMAFROST CHARACTERISTICS IN THE WESTERN HUDSON BAY AREA, NUNAVUT

TREMBLAY*, T.[1], OLDENBORGER, G.A.[2], BELLEHUMEUR-GÉNIER, O.[2], SHORT, N.[3], and LEBLANC, A.-M.[2]

(1) CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(3) CANADA CENTRE FOR MAPPING AND EARTH OBSERVATION, OTTAWA, ON
TOMMY.TREMBLAY@CANADA.CA

The Western Hudson Bay project is a Canada-Nunavut Geoscience Office (CNGO) –led geoscience project collecting and compiling surficial geoscience and permafrost data for infrastructure. Western Hudson Bay area lies in the continuous permafrost zone, where 90–100% of the ground surface is underlain by permafrost. Permafrost and ground ice are important features of the landscape that can significantly affect land-based infrastructure. This poster presents 1) fieldwork conducted in Rankin Inlet to determine ground temperatures, and provide information on permafrost and ground ice conditions for the region; 2) a methodology for interpreting land cover from RapidEye images to enhance spatial knowledge on potential aggregate sources (gravel deposits), bedrock outcrops, bouldery tills, wet areas and freshly eroded sediments; 3) the digital compilation of geology data for the area. This poster also presents an integration of modern and traditional knowledge on permafrost conditions. Recent fieldwork involved the installation of several permafrost and ground temperature monitoring stations along with ground geophysics, airborne mapping, and satellite remote sensing of seasonal ground displacement. Site locations were chosen to represent a variety of conditions including developed and undeveloped land, and different geological settings. From new data in Rankin Inlet, average summer ground temperature is -5.6°C at 12 m depth for a site on developed land and -6.6°C at 7 m depth for a site on undeveloped land. These results are in agreement with other contemporary ground temperature data available for the area, but could suggest warming of the permafrost if we compare them with historical ground temperatures. Results are site specific, but observations indicate correlation between surficial geology, apparent conductivity and seasonal ground displacement that could be used for permafrost mapping. A remote sensing interpretation methodology was designed to extract relevant land cover information for infrastructure studies from RapidEye satellite images. In collaboration with the Geological Survey of Canada's mapping group, existing paper surficial geology maps were digitalized and compiled for the area, and surficial geochemistry data is currently compiled in a single database at CNGO.

AN OVERVIEW OF BOOTHIA PENINSULA - SOMERSET ISLAND, NORTHERN NUNAVUT, DERIVED FROM AIRBORNE MAGNETIC DATA – INITIAL FIELD INTEGRATION RESULTS

UGALDE*, H.[1], BALLINGER, J.B.[1], SANBORN-BARRIE, M.[2], and REGIS, D.[2]

(1) BROCK UNIVERSITY, ST. CATHARINES, ON
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
HUGALDE@BROCKU.CA

The Geo-mapping for Energy and Minerals (GEM-2) program from Natural Resources Canada is laying out the foundations for extensive integrated geoscience programs in Canada's North. One of the activities within the Rae craton is the Boothia Peninsula-Somerset Island project: Integrated Geoscience of the Northwest Passage.

Besides updating the geological map of the area, this project is focusing in elucidating the extent, age and character of crustal domains underlying Boothia Peninsula and Somerset Island; identifying any mineral resources attributed to, and affected by the rifting and collision of the Thelon Tectonic Zone in the area; and expanding the impact of mainland GEM-2 Rae-Chantrey findings north across the Arctic Islands. The integration of airborne geophysics and remote sensing with all the available field geological data and ancillary analysis is paramount to fulfilling these objectives, since these tools can add continuity to sparse field observations.

The geology of the region consists of mostly high-grade metasedimentary rocks intruded by a mafic plutonic suite and voluminous metagranitoids. The region is partly covered by glacial till, particularly over western Boothia Peninsula. Historically, little in-depth study has been done of the area with the first extensive survey conducted in 1962, and a later mapping campaign in 1986-92.

Interpretive study of airborne geophysical data for this region started with an aeromagnetic survey flown over the area in 2016. These data were processed and compiled with previous GEM-2 surveys flown to the north and south of the current project area in 2013 and 2014. The compiled dataset provides a wealth of data to complement ongoing geological mapping of the area and for regional correlation. Preliminary geophysical interpretation work in the southeast part of the survey area shows several deformation events that resulted in at least two generation of folds and three main orientations of brittle faults. From younger to older, the main structural trends are east northeast, northeast and northwest. Cross-cutting relationships between dykes allow to separate at least 2 different swarms in the area, striking northwest and northeast. In terms of lithology, each of the main lithological units is characterized by a distinct pattern: metasediments are weakly magnetic and show minor low amplitude magnetic anomalies; intrusives have a moderate response with medium wavelength and amplitude; and late gabbroic dykes are characterized by their strong magnetic anomalies. These patterns provided a preliminary definition of contacts, which were verified and refined during the field mapping.

The first field mapping campaign during July-August 2017 involved bedrock mapping and collection of samples for petrological, geochronological and geochemical studies with targeted surficial studies across Boothia Peninsula and

Somerset Island. In this contribution we show the integration of the first field mapping results with the previous interpretation work conducted on the geophysical data.

EVALUATING LAKE WATER BALANCES IN RELATION TO CATCHMENT CHARACTERISTICS NEAR YELLOWKNIFE, NT, AND THEIR HYDROLOGICAL RESPONSE TO VARYING CLIMATIC CONDITIONS

VISCEK*, J.A. and TURNER, K.W.

BROCK UNIVERSITY, ST. CATHARINES, ON
JOE.VISCEK@GMAIL.COM

Freshwater lakes are prominent features throughout northern boreal regions which provide important habitat for flora and fauna, and resources for local communities. Increasingly, concern has been placed on better understanding how these northern lakes respond to fire disturbance and drought, which have been associated with changes in climate conditions during recent decades. Wildfires have been particularly intense in the Yellowknife, Northwest Territories, area over the past several years, and their influence on aquatic systems remains unclear.

This research project integrates a number of analyses to identify the relative significance of climatic and catchment controls on the hydrology of 19 lakes in the Yellowknife region. The study lakes – located within a 300 km radius of Yellowknife – were selected to reflect a range of catchment characteristics, with lake surface areas ranging from approximately 0.1 to 159 km^2 (avg=11.8 km^2), situated within both burned and non-burned catchments. Several datasets have been generated for the lakes, including water level measurements from installed data loggers and seasonal water isotope compositions (i.e., δ^2H and $\delta^{18}O$) from lake water samples. These data are providing key insights into the contemporary water balance conditions of the lakes. Preliminary data suggest that the study lakes may experience annual water level fluctuations in the range of approximately 0.18 to 1.4 m.

The extent of each study lake catchment has been delineated using 10-m raster, Digital Elevation Model (DEM) data provided by the NWT Centre for Geomatics. Using the Spatial Analyst extension in ESRI ArcMap 10.5 software, the DEM data was merged; with raster units then filled for sinks and assigned flow direction values. Using the Arc Hydro Tool, Batch Watershed Delineation for Polygons, the catchments for the study lake polygons were then delineated from the modified DEM data. Study lake catchments were found to range from approximately 0.7 to 25,015 km^2 in size (avg=2,617 km^2). Several study lake catchments were determined to fall within larger study lake catchments. Catchment characteristics, including proportion of major land cover types and burn area will be identified using remotely sensed data (e.g., Landsat) in conjunction with ArcGIS Spatial Analyst tools. Relative land cover information among delineated catchments will be compared to evaluate correlations with lake hydrological conditions.

Historical lake hydrological conditions will be reconstructed using cellulose-inferred $\delta^{18}O$ isotope records from extracted lake sediment cores, to determine whether contemporary lake hydrological conditions are within the range of natural variability. Further, data collaborations with the National Aeronautics and Space Administration (NASA) - University of

California, Los Angeles (UCLA) AirSWOT program will help evaluate whether AirSWOT, an airborne analogue to SWOT (Surface Water Ocean Topography) remote sensing technology, can be used to broaden the scale of lake hydrology studies. The findings generated during this research program will enhance our knowledge of how warming northern climate and associated landscape changes and disturbance are influencing lakes. The work is part of a broader research project that is using a multi-proxy, paleoecological approach to determine long-term (i.e., 2000 years) records of drought, fire and water quality to inform future policy planning.

SURFACE TILL GEOCHEMISTRY AND LITHOGEOCHEMICAL EXPLORATION FOR A CONCEALED KIMBERLITE

WICKHAM*, A.P. and WINTERBURN, P.A.

UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC
AWICKHAM@EOAS.UBC.CA

In regions where recent glaciation has buried kimberlites under glacial sediments, surface geochemical detection methods are better interpreted when coupled with a comprehension of the landscape formation processes. Geochemical anomaly generation and preservation are controlled by surface materials, themselves a product of often complex landscape evolution. The glacial, post-glacial, and cryoturbation processes that have affected the landscape have, in turn, affected the dispersal of geochemical signatures in the till. Results from research at the Kelvin kimberlite, Northwest Territories will help to refine exploration practices, resulting in reduced costs whilst improving exploration success.

The Kelvin kimberlite (Kennady Diamonds) is located eight kilometers from the Gahcho Kué diamond mine in the Northwest Territories. The kimberlite is an inclined pipe that outcrops beneath a lake. It has a surface projection towards the NW more than 600 m long, most which, however, is concealed under gneiss and is not exposed at the bedrock-till interface. The research site is covered in a veneer of glacial till and is characterized by low relief (30 m total), occasional swamps and frost boils. Vegetation is sparse and is dominated by low shrubs and grasses.

Surface materials were mapped for use in the assessment of the geochemical response. 215 soil samples were collected from the oxidized upper B-horizon above the kimberlite, both up-ice, and up to 1 km in the down-ice direction. Samples were sieved to -180 microns and analyzed by four acid ICP-MS and aqua-regia digestion ICP-MS. Initial results indicate the soils to be primitive with little degradation of the original mineralogy. Additional samples were collected for Spatiotemporal Geochemical Hydrocarbons (SGH) analysis. Diamond drill core of the gneiss host-rock is being analyzed by fusion ICP-MS, total-carbon and aqua-regia ICP-MS to identify and characterize the alteration mineralogy surrounding the kimberlite pipe and assess lithological host-rock variability which may contribute to the surface anomalies.

MAPPING GROUND ICE POTENTIAL IN CANADA

WOLFE*, S.A., DUCHESNE, C., O'NEILL, H.B., and PARKER, R.J.H.

GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
STEPHEN.WOLFE@CANADA.CA

Ground ice is widespread in permafrost regions. The thaw of ground ice initiates different thermokarst processes depending on ice type, host sediments, and distribution. These processes are dramatically affecting landscapes and human activity in northern North America, but our current knowledge of ground ice distribution and the impacts associated with the thaw of ice-rich permafrost is inadequate.

The Permafrost Map of Canada (MCR 4177) is the primary source representing ground ice in Canada, but has limitations including poor differentiation of ground ice types and coarse spatial resolution. Mapping at the national scale necessarily includes extrapolation based on limited data and expert knowledge. Our objective is to present the methodology and early results from a new national-scale mapping effort of three common ground ice types: (1) segregated ice, (2) wedge ice, and (3) buried ice. The ground-ice potentials are based on knowledge of glacial and post-glacial sedimentary processes as well as past and present environments from existing national-scale datasets. These include the Surficial Geology of Canada (GSC CGM 195), the Deglaciation of North America (GSC Open File 1574), the Glacial Map of Canada (GSC Map 1253A), Paleovegetation Maps of Northern North America (GSC Open File 4682), and the Permafrost Map of Canada (MCR 4177).

Permafrost is commonly ice-rich due to segregated ice formed during initial permafrost aggradation, and its accumulation over time from repeated freezing and thawing of the active layer. Wedge ice forms within permafrost in regions where air temperatures are conducive to thermal contraction cracking of the ground. Buried ice, represented here primarily by glaciogenic ice, is preserved within permafrost by a sediment cover. The surficial geology, glaciation, paleo-biome, and permafrost map data combined with knowledge-based associations between environmental conditions and ground ice are used in a model within a GIS to determine ground ice potentials for these three ice types.

(1) Buried ice potentials are defined for 22 surficial sediment types. Potentials are highest within thick till, moderate within glaciofluvial sediments, and absent in sediment veneers and bedrock. Buried ice potential is reduced in areas of past inundation, and modified by paleo-biome distributions. The potentials are further modified by modern permafrost distribution. (2) Segregated ice potentials are assessed initially by the frost susceptibility of each surficial sediment type. Areas of marine inundation also define potential for saline permafrost. The potentials are then modified based on past biomes and present-day permafrost distributions. (3) Wedge ice potentials are initially based on the surficial material type, and the time exposed to biomes associated with conditions favourable to thermal contraction cracking. The potentials are then modified by the present-day permafrost distribution.

Preliminary maps for the three ground ice types are presented. These enhance the existing national-scale representation of ground ice on the Permafrost Map of Canada, and represent a fundamental step towards understanding the impacts that climate warming and permafrost thaw will have on permafrost regions in North America.

WATER QUALITY DATA TO SUPPORT CUMULATIVE EFFECTS DECISION-MAKING IN THE MACKENZIE VALLEY, NORTHWEST TERRITORIES

WONG*, L.[1], NOBLE, B.[1], and HANNA, K.[2]

(1) UNIVERSITY OF SASKATCHEWAN, SASKATOON, SK
(2) UNIVERSITY OF BRITISH COLUMBIA, KELOWNA, BC
LINDSAY.WONG@USASK.CA

Cumulative effects assessment and management of freshwater systems remains an enduring challenge to responsible resource management decisions across Canada's North. Recent practice and research indicates a clear need to improve how cumulative effects are assessed and managed, and to bridge the gap between environmental impact assessments and environmental effects monitoring programs. This research examines how environmental monitoring programs in the Mackenzie Valley, Northwest Territories, contribute to the identification, understanding and management of cumulative effects to freshwater systems. This involved a review of databases to assess the nature of monitoring conducted by project proponents for environmental impact assessments and under water licensing requirements, and the monitoring conducted by government agencies for environmental effects monitoring. Semi-structured interviews complemented the review to determine the utility of existing data to develop environmental baselines and to predict cumulative effects. Interviewees included staff from land and water boards, industry proponents, consultants, independent mine oversight boards and various levels of government.

Preliminary findings suggest that understandings of both the definition of and responsibility for cumulative effects assessment and management remain unclear. Ultimately, this may be preventing cumulative effects from being assessed, and appropriately managed, in a comprehensive, consistent and systematic manner. While it is evident that a great deal of environmental monitoring is conducted in the Northwest Territories, results indicate it requires a more deliberate approach to ensure that the data collected support cumulative effects assessment and management initiatives at both the local (i.e. project) and more regional scales. Further analysis of current government-led monitoring programs is required to enable a comparison with data collected under proponent-based monitoring programs. These results will both aid in advancing the integration of proponent- and government-led environmental monitoring and be of direct value for regulatory decision making by land and water boards in the North.

STATISTICAL MODELS FOR INTERPRETING SPATIOTEMPORAL DYNAMICS OF ALLOMETRIC GROWTH OF SUBARCTIC LAKE WHITEFISH POPULATIONS

ZHU, X.

FISHERIES AND OCEANS CANADA, WINNIPEG, MB
XINHUA.ZHU@DFO-MPO.GC.CA

Many statistical models have been used for allometric growth of fishes. Among these, a power-function model (W = aLb) has become conventional to describe the weight (W) - length (L) relationship, indicating both individual and cohort fitness. Condition factor is also determined through this power-function, assuming regression coefficient b

is constant (a = WL-b). The primary objective of this study, using a total of 4924 Lake Whitefish from a fishery-independent survey in the main basin of Great Slave Lake (GSL), June–August, 2011–2016, is to develop a multimodel inference (MMI) framework to address the appropriateness of log-transformed length and weight model selections. Four candidate models, linear, quadratic, cubic and piecewise are included. Information-based MMI indicated that allometric growth patterns may be biased when arbitrarily selecting a linear model. Although measurements of the morphometric variables and parameter estimates are sensitive or related to fitness of individuals, substantial spatiotemporal variation may influence our ability to interpret the changes in allometric growth of subarctic populations of Lake Whitefish in the oligotrophic GSL. The potential application and associated uncertainties of MMI statistical models for the evaluation of cumulative changes in fish population abundance, hydroclimate environment and exploitation are discussed.

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