2018

Yellowknife Geoscience Forum

Abstract and Summary Volume

Cover photograph

Carcajou River, NWT;
Viktor Terlaky, Senior Petroleum Geologist at the Northwest Territories Geological Survey

The picture was taken following a rainstorm along Carcajou River, NWT, which resulted in a spectacular rainbow across the river valley. In the background are outcrops of the Late Devonian Imperial Formation, interpreted to be submarine turbidite deposits. The light bands are sandstone bodies intercalated with the darker shale intervals, representing periodic activity in sedimentation.

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

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IBAS - TO REGULATE OR NOT: WHAT IS THE REST OF CANADA DOING?

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The Government of the Northwest Territories is developing a new Mineral Resources Act ("MRA"), which will reflect the unique circumstances of its mineral sector. In 2017, the Government of the Northwest Territories sought input from northerners through a series of public engagement efforts, ranging from community "drop-in" events to submissions via social media and telephone.

Many participants, including members of Indigenous governments and organizations, as well as the public, gave feedback that the MRA should explicitly include Impact Benefit Agreements ("IBAs"), the royalties structure of the MRA should be a clear status quo until a broader review can be completed, and the MRA should increase transparency and accountability in IBAs.

This presentation discusses the plausibility for regulating and standardizing IBAs and the revenue-sharing component of IBAs in the Northwest Territories, and the potential impacts of this standardization. Specifically, this presentation draws on experiences in the Yukon, British Columbia, and Ontario to understand government approaches to IBAs, revenue sharing, and transparency. The hope is that this presentation may provide key considerations, and perhaps some guidance, on regulating IBAs and resource sharing.

Topics of discussion will include:

- Current approaches of governments to IBAs
- The Current Revenue Sharing Structure in the Northwest Territories
- The Yukon's Land Claims Agreements: Opportunities and Challenges
- British Columbia's Benefit Sharing Agreements: Opportunities and Challenges
- Ontario's Resource Revenue Sharing Agreements: Opportunities and Challenges
- Potential Impacts of Standardizing IBAs and Other Key Considerations

SEABRIDGE DISCOVERS NEW GOLD ZONES AT COURAGEOUS LAKE

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Seabridge Gold's Courageous Lake Property contains the entire Courageous Lake Greenstone Belt 240 km Northeast of Yellowknife. The property consists of two past producing gold mines (the Salmita Mine and the Tundra Mine). Seabridge Gold have defined the FAT deposit with proven and probable reserves of 91 million tonnes at 2.20 g/T Au equaling 6.5 Moz of gold. (Lechner, 2012). The Walsh Lake deposit has an inferred resource of 4.62 million tonnes at

3.24 g/T Au equalling 482,000 oz of gold (Lechner, 2014). The belt is a bimodal volcanic succession with episodic 2600 Ma Banting Group felsic and mafic volcanic rocks deposited on a granitoid basement. Burwash formation turbidite facies sedimentary rocks overly the Banting formation volcanic rocks. Metamorphism to greenschist facies occurred at 2660 Ma tilting the strata to vertical.

Mineralisation in the FAT deposit are stratabound domains contained entirely within the felsic volcanic rocks. Gold is hosted within three different morphologies of arsenopyrite crystals. The earliest of these mineralisation phases is interpreted to form at the same time as volcanism in a low sulphidation epithermal environment. Gold in the FAT deposit is refractory. Seabridge's current exploration target is the Tundra Salmita trend, an 8 km prospective contact between the Banting Volcanic rock and Burwash Sedimentary rock. This contains the historic Salmita and Tundra mines. The Walsh Lake Deposit is the Southern extension of the Tundra Mine and forms on the contacts between felsic volcanic and sedimentary rock and between felsic volcanic and mafic volcanic rock. Average gold grade is higher at 3.24g/T and the gold is free milling.

Seabridge completed a PFS on the FAT deposit in 2012. This identified several potential improvements to the project to make it more capital efficient including the discovery of near surface, free milling satellite deposits. These are envisaged as early mine life and will reduce payback time on initial capital expenditure for development. Because of this, Seabridge completed the delineation of the Walsh Lake deposit from 2012 to 2013. In 2014, a VLF and ground mag survey was completed over the Tundra Salmita trend to identify Walsh Lake signatures and explore for similar targets. Seabridge completed a 7000 m diamond drilling program on six of these targets in winter 2018. Of these six targets, two have met the criteria for follow up. The Olsen target included intercepts of 40.4 m of 3.04 g/T Au and the Marsh Pond target included intercepts of 24 meters of 2.13 g/T Au. Seabridge is currently evaluating the potential of these targets for drilling to a resource classification. The Banting formation volcanic rock and Burwash formation sedimentary rock contact exists for 56 km along the entire greenstone belt. Gold pathfinders identified in the Tundra-Salmita drilling by Seabridge can be used to evaluate and prioritise further targets along the belt.

GOLD MINERALISATION AT THE FAT DEPOSIT, COURAGEOUS LAKE, NORTHWEST TERRITORIES

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The Courageous Lake Greenstone Belt (CLGB) is hosted in the Yellowknife Supergroup of the Central Slave Province, NWT, Canada: a fertile gold district that includes the former Giant, Con and Lupin orogenic gold mines. The largest deposit in the CLGB is the FAT deposit, which has a proven and probable reserve of 91 MT at 2.20 gpt gold owned by Seabridge Gold Inc. The FAT deposit differs from other gold deposits in the Yellowknife Supergroup in that deformation and shear textures are intermittent, and where present, deformation does not correlate spatially with mineralisation. The CLGB formed as a volcanic succession that was deposited on a 3218 Ma sodic granitoid gneissic complex. Periodic volcanism commencing at 2660 Ma formed an extrusive cycle of mafic flows to

rhyolitic tuffs. The felsic units reach a maximum (post compression) thickness of 1800 m proximal to the FAT deposit. Volcanic textures of the rocks hosting the FAT deposit are well preserved sub-aerial lapilli and lesser amounts of ash and bomb tuff. There is periodic intercalation with aqeuously reworked beds. These are overlain by greywacke turbiditic rocks. Three distinct structural/metamorphic events have affected the Courageous Lake Greenstone Belt:
1. compression and vertical tilting of stratigraphy and associated regional dynamothermal metamorphism to mid-greenschist facies commencing at 2592 Ma;
2. concurrent discreet thermal metamorphism associated with local granitic intrusions; and
3. late retrograde hydrothermal alteration.

Gold is refractory within acicular and rhombic arsenopyrite. Petrography, SIMS, EMP and LA-ICP-MS analysis have defined three arsenopyrite styles of distinct crystal habit with distinct inclusion abundance, Au enrichment and zoning and trace element zoning. The greatest enrichment is in the earliest type of arsenopyrite, attributed to hydrothermal events associated with volcanism. Later, heterogeneous, less enriched arsenopyrite is a result of metamorphic recrystalisation. A strataform quartz body with arsenopyrite and sulphate in textural equilibrium has sulphur isotopes indicative of an Archean ocean sinter.

Terraspec and EMP analysis identify sericite mineralogy to be dominantly end-member muscovite. Early sericite associated with syn-volcanic arsenopyrite is Mg-rich compared to late, metamorphic Al-rich sericite.

NORTHWEST TERRITORIES SURFACE RIGHTS BOARD

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The NWT Surface Rights Board (SRB) is mandated to resolve disputes over terms and conditions and compensation, between holders of surface or subsurface rights and the occupant of the surface when an agreement cannot be reached by the parties through negotiation or mediation.

The Northwest Territories (NWT) SRB is an institution of public government established by the Surface Rights Board Act of the NWT. The SRB Act came into force generally on April 1, 2014. However, the specific provisions governing SRB operations did not come into force until April 1, 2016.

The purpose of the NWT SRB is to fairly resolve matters in dispute regarding access to lands in the NWT and waters overlying those lands in the Mackenzie Valley and the compensation to be paid for that access. These lands include Gwich'in Land Claim Settlement lands, Sahtu Land Claim Settlement lands, Tłı̨chǫ Land Claim Settlement lands, as well as private, Commissioner's and Crown lands. It also includes Inuvialuit Land Claim Settlement lands. To do so, the NWT SRB makes orders setting out the terms and conditions on which a person (such as an individual, corporation, government, etc.) may access those lands and waters as well as the compensation to be paid for that access.

The NWT SRB Act meets Canada's obligations arising from the Gwich'in

Comprehensive Land Claims Agreement and the Sahtu Dene and Métis Comprehensive Land Claims Agreement to establish surface rights legislation in the NWT.

All members and alternate members must be residents of the NWT. Further, at least one member and one alternate member must be a resident of Inuvik or the NWT portion of the Inuvialuit Settlement Region, the Gwich'in Settlement Area, the Sahtu Settlement Area and the Mowhì Gogha De Nįįtlèè

The Board has all the power, rights and privileges of a superior court with respect to the attendance and examination of witnesses, the production and inspection of documents and all other matters necessary or proper in relation to Applications for, Reviews of, or Termination of Orders.

Subject to sections 85 to 88 (Review and Amendment of an Access Order), an order of the Board and any decision made by the Board in respect of an application for, or a review of, an order is final and binding and is not subject to appeal to, or review by, any court.

The NWT SRB is pleased to report significant progress in all facets of its work. Its operations are established with key management controls in place. Rules of Procedure and SRB By-laws are in place. A professional development framework supports member capacity to deliver on the SRB's mandate; and, all the SRB's work is consistent with its updated five-year strategic plan, supporting business and expenditure plan.

LIQUEFIED NATURAL GAS FOR POWERING NORTHERN COMMUNITIES AND INDUSTRY

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Over the past 8 years, we have seen North American oil/diesel commodity pricing separate from natural gas pricing due the vast discovery of natural gas resources in North America. This has provided a price advantage for natural gas as an energy source to replace traditional diesel fuel in all large industries, including remote power, heating, and all forms of transportation (rail, marine, and trucking). More particularly, gas can be liquefied in Canada into LNG form using local natural gas sources, and transported to proximal end users to replace diesel fuel. This provides a price advantage, typically between 25-50%, as well as an environmental benefit because natural gas is a much cleaner burning fuel source. Natural gas reduces carbon dioxide emissions up to 30% versus diesel, and has significant advantages, 90%, when looking at SOx, NOx, and particulate emissions. Ferus Natural Gas Fuels has been building a business in Northern Canada to offer this LNG service to remote communities and mining operations so that they can realize the benefits of natural gas as a fuel.

ARCHEAN AND PROTEROZOIC AGE DISTRIBUTIONS IN DETRITAL ZIRCONS RECOVERED FROM PLEISTOCENE ESKER SYSTEMS IN THE ACASTA GNEISS COMPLEX, NWT

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Bedrock terranes in excess of 3.7 Ga are exceedingly rare and contain information critical to further understanding the early Earth during its initial stages of differentiation and crust formation. The AGC (Acasta Gneiss Complex: 2.94 – 4.03 Ga) is one of only a handful of such Hadean/Eoarchean bedrock terranes worldwide. Despite its importance, the AGC is heavily under-mapped and under-explored. We exploit a Pleistocene esker system that traverses the AGC to efficiently sample fine-grained sediments derived from this complex gneiss terrane. Zircons extracted from these sediments are used to assess the relative proportion of different age bedrock units exposed at the surface.

The esker systems are composed of locally sourced AGC and regional bedrock that have been eroded, entrained, and deposited by the Laurentide Ice Sheet during the last glaciation. Detrital zircons, recovered from the sediment and dated by laser-ablation inductively-coupled-plasma mass-spectro-metry, provide a mixed population of U-Pb ages representative of bedrock found up-ice-flow from the esker sampling sites. Zircons were recovered from two discrete grain size fractions, 1 – 50 mm and less than 250 µm, to assess the impact of grain size on sediment transport distance in esker systems.

At each sampling site along the esker transect, the detrital zircon U-Pb dates for the two grain size fractions yielded similar modes and abundances, with subtle differences related to grain size and source proximity. Prominent modes in age distributions from the samples coincide with known ages of currently mapped bedrock in the AGC, Wopmay Orogen, and Slave Craton. A mode of ~ 3.37 Ga is present in all samples, and is the dominant mode in two of the three westernmost samples. Recent high-resolution bedrock mapping of a small part of the AGC has identified km-sized plutonic bodies of this age. The prominence of this age population in the esker sediments strongly suggests that 3.37 Ga plutonism is widespread in the region. The easternmost sample from the esker transect was collected outside of the mapped AGC boundary, yet contains an abundance of zircons from 2.94 - 3.95 Ga. Given west-trending esker flow directions, the AGC likely extends further east than previously mapped, and undiscovered outcrops in excess of 3.7 Ga remain.

2018 INTRODUCTION TO PROSPECTING COURSES

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Two Introduction to Prospecting courses were held in 2018, both in Yellowknife. The

first course was attended by residents of communities across the Northwest Territories, and the second by people from the Yellowknife area. The courses were held from June 21-24 and were organized by the Mine Training Society, and received sponsorship from the GNWT Department of Industry, Tourism and Investment, in addition to technical and in-kind support from Northwest Territories Geological Survey, Northwest Territories Mining Recorder's Office, the NWT Mine Training Society, TerraX Minerals Inc., and Aurora College.

This presentation will discuss the 2018 Introduction to Prospecting courses': goals and objectives, outreach efforts, pre-course planning and organization, course curriculum, outcomes, and attendance. We will also present the improvements made from previous Introduction to Prospecting courses, and improvements that can be applied to future outreach programs. Additionally, we will preview the Introduction to Prospecting course video.

LONG-TERM MONITORING FINDS NO EFFECT OF AN ARCTIC MINE ON MIGRATORY BIRDS

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The Hope Bay Project, an underground gold mine, is located on the Arctic coast of Nunavut, approximately 100 km southwest of the township of Cambridge Bay and 50 km east of Bathurst Inlet. We analyzed long-term monitoring data for upland breeding birds, waterfowl and raptors collected from 2004 – 2017 at the Hope Bay Project to determine if the construction and operation of the mine has affected local bird populations. The long-term dataset was collected as part of the Project compliance program and based on a before-after, control-influenced (BACI) design. Monitoring data was grouped into periods with and without project activity during four time periods: 1) prior to construction (2004-2006), 2) during construction (2007-2012), 3) a period of care and maintenance (2013-2014), and 4) continued construction and operations (2015-2017). Upland birds were monitored used point counts and the Program for Regional and International Shorebird Monitoring (PRISM) protocols. Waterfowl were monitored using aerial transects and ground based surveys during nesting. Raptors were monitored using nest surveys to determine occupancy and productivity. Generalized additive mixed models (GAMM) were used to explore changes in bird species relative abundance and Shannon diversity indices. Results for upland birds indicated: 1) no effect on bird density beyond a localized area (300-1,000 m), 2) a non-significant effect on bird diversity. Results for waterfowl indicated: 3) no effect on the density of birds with distance from the project using several distance thresholds (300 m, 500 m, 1,000 m and 1,800 m). Results for raptors indicated: 4) no effect on raptor occupancy or breeding success using a continuous analysis, 5) a small effect on breeding using a categorical value of 1,500 m to separate test from control nests. These results indicate that the effects of mining activity on birds is either non-existent, or localized to the immediate project area.

SOCIO-ECONOMIC DEVELOPMENT: APPLYING THE GENDER LENS

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De Beers Group efforts in the Inclusion and Diversity (I&D) space both inside and outside the company have been gaining momentum as we continue to foster our partnership with UN Women. Current I&D programs across De Beers Canada are focusing on gender equality, making the company more inclusive and empowerment of women and girls.

The presentation will highlight actions implemented within De Beers Canada Inc. to promote socio-economic development applying the female lens, specifically the: UN Women Partnership, STEM & Other Scholarships, STEM Impact Camp, Women in Mining Luncheon.

CLUSTERING BASED ANOMALY DETECTION FOR EXPLORATION GEOCHEMISTRY

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Unsupervised learning is the field of machine learning (ML) where there are no response variables to train the algorithm, the purpose is to examine the input data for associations and patterns. This characteristic of unsupervised learning makes it a suitable tool for mineral exploration purposes, where it is commonly not known the location of nearby deposits, and therefore, there is no reliable response variable to train a supervised learning algorithm. One of the most important areas of unsupervised learning is cluster analysis. It is defined as the process of classifying data instances into groups based on their similarities.

In addition to straightforward univariate anomalies, three cluster-based methods for multivariate anomaly detection were developed and 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 first method uses combinations of clustering and data transformations for finding small anomalous clusters; the second uses different clustering methods on different data transformations for identifying samples that do not clearly belong to any cluster; the third recognizes samples that are different from the surrounding samples in the geographic space.

The analyses were performed on pathfinder elements for tungsten/intrusion deposits. The goal is to identify samples that are anomalous in the multivariate space. The proposed methods are capable of identifying several showings, that is, known mineral deposits in advanced exploration or production stage in the Mackenzie Mountains. Some of these showings are not detected from traditional univariate methods, which supports and motivates the use of multivariate anomaly detection methods for mineral deposit exploration. Although further validation is required, the multivariate methods appear promising to complement conventional analyses.

GEM-2 GLACIAL SYNTHESIS PROJECT: HIGHLIGHTS OF 2018 FIELD ACTIVITIES IN THE HEALEY LAKE AREA, NORTHWEST TERRITORIES AND NUNAVUT

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Targeted surficial geological studies were conducted this past summer in an area between Aylmer Lake, Northwest Territories (NWT) and the western edge of the Thelon Wildlife Sanctuary in the NWT and Nunavut. Fieldwork focused on questions related to the nature of the glacial landscape, landforms and associated surficial materials, the chronology of glacial and deglacial events, and glacial transport – dispersal characteristics in this largely unmapped west-central region of the Keewatin Sector of the Laurentide Ice Sheet (LIS).

Field observations, till sampling and striation mapping indicate the landscape mirrors the complex nature of its glacial history. Spatial variability in geomorphology, surface material composition, thickness and degree of weathering results from changes in substrate lithology, basal thermal conditions (warm-based to cold-based) and paleo-ice flow dynamics. The landscape of the central region around Healey Lake is bedrock-controlled; dominated by low relief, weathered and frost-shattered outcrops, block fields, with thin veneers of till and boulders reminiscent of relict terrains preserved under non-erosive, cold-based ice conditions. Small patches of warm-based ice terrains with glacially moulded and polished outcrops recording an older southwest flow, and thicker till deposits are interspersed throughout this area. Surrounding the central region, streamlined and thick drift terrains dominate. In the southeast, both crosscutting streamlined landforms (palimpsest) and landforms with diverging orientations (relict) indicate preserved terrains related to older ice-flow directions. In the east-northeast, streamlined landforms overprint the southwest flow and suggest the late-deglacial Dubawnt Lake Ice Stream extended further west/northwest than previously mapped. A series of ice marginal glacial lakes, ice-contact glaciofluvial deposits and minor moraines record the retreat of the ice margin across the study area. The most prominent ice margin feature is a large N-S trending hummocky ice-contact glaciofluvial complex along the western border of the Thelon Game Sanctuary. This major ice retreat still-stand position is interpreted as a southwestern extension of the McAlpine Moraine System.

The variability in till composition is related to net glacial erosion and transport and provenance. Future till geochemical, indicator mineral and lithological analytical results will be used to evaluate glacial transport characteristics under shifting glacial dynamics and basal ice conditions over time. Geochronological samples were collected to constrain ice margin retreat history (absolute ice-free dates), and to test for degree of inheritance/glacial erosion (relative age dates). This work is intended to improve the geoscience framework for mineral exploration. This GEM-2 project is a collaboration between the Geological Survey of Canada, the Northwest Territories Geological Survey and Canada-Nunavut Geoscience Office.

COMPARING THE MEASUREMENTS OF AIRBORNE PARTICULATE MATTER AROUND A MINE AND AN AMBIENT SITE WITHIN THE BATHURST CARIBOU SUMMER RANGE

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Many community members and decision makers in governments and industries have a keen interest in understanding the mechanisms of the zone of influence on caribou by mining operations. This understanding is fundamental to design and implement mitigation measures effectively. Caribou might alter their behaviour when they hear a noise from a mining operation, see a mining operation, taste a difference in forage due to dustfall, or smell a difference in the concentration of airborne particulates matter (e.g., fine particulates matter less than 2.5 micrometer $PM_{2.5}$, or the total suspended particulates TSP). How far can these mining-generation disturbances reach? At what temporal frequency do these disturbances occur? Answering these questions is especially challenging for $PM_{2.5}$ and TSP because they are highly variable temporally and spatially, affected by local sources at a mine and/or far away sources (e.g., forest fire smokes), and dependent on weather conditions (e.g., time since the last rain event, wind direction, and wind speed). To address this challenge, we conducted measurements of $PM_{2.5}$ and TSP at locations around the Ekati Diamond Mine during the summers of 2016 and 2017, and at an ambient location near the Daring Lake Tundra Ecosystem Research Station during the summer of 2018.

In this presentation, we will compare results between measurements at the Ekati mine and the ambient location. Specifically, we attempt to address the following questions. Were the concentrations of TSP and $PM_{2.5}$ measured near the mine significantly higher than those measured at the ambient site? How did the increases in the concentration of TSP and $PM_{2.5}$ happen? What were the difference and similarities in terms of impacts of weather conditions and source locations between the mine and the ambient site?

REMOBILIZATION OF LEGACY ARSENIC FROM CONTAMINATED SEDIMENT IN YELLOWKNIFE BAY

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A two year study (2018 to 2020) is investigating the present-day and future stability of legacy arsenic contamination in Yellowknife Bay sediments that originated from local gold mining activities. Using a combination of quantitative methods (field and laboratory experiments, paleolimnology, and mass balance modelling), we will estimate the diffusion of arsenic from sediments to overlying water in the bay, investigate environmental factors that control this process, and develop predictions of how long-term environmental change from climate warming during the 21st century could impact arsenic cycling and levels of water arsenic in Yellowknife Bay. This information will inform stakeholders and decision makers who are involved in the environmental management of this important waterbody for residents of Ndilǫ, Detah, and Yellowknife.

This presentation will focus on initial field incubation experiments that were conducted in Yellowknife Bay in August of 2018. Twelve sediment cores were collected at sites of varying water depth and distance from the Giant Mine site. The cores were incubated in holders near shore or at the lake bottom for six days to maintain in situ temperature and light conditions. Overlying water in each of the cores was sampled on days 0, 2, 4 (or 5) and 6 to measure short-term fluxes of arsenic from contaminated sediment.

Both positive and negative exchange of arsenic was observed between overlying water and sediment in the cores. Three cores from shallow water sites (depth of 1-3 m) showed a small loss of arsenic from the overlying water at a rate of -49±3 µg/m^2/day. In contrast, offshore cores collected in deeper water (depth of 7.5-19 m) showed an increase of arsenic in overlying core water, with a wide range in sediment flux of 30-1520 µg/m^2/day and a mean of 525±522 µg/m^2/day. The sediment flux of arsenic from a core collected at the tailings beach at the north end of Yellowknife Bay was minimal (45 µg/m^2/day), possibly due to the low porosity of the tailings.

Another mining contaminant, antimony, was also measured to determine sediment fluxes for comparison with arsenic. In five of the cores, there was no detectable change in antimony concentration in overlying water. In the remaining seven cores, a small flux of antimony was observed between sediment and overlying water (37±34 µg/m^2/day).

Sediment flux measurements of arsenic will be discussed in relation to sediment characteristics, sediment porewater profiles, and site location. Next steps in the study will also be outlined. Preliminary results showed there was substantial short-term flux of arsenic from contaminated sediment to overlying water during summer near the Giant Mine site. Sediments of Yellowknife Bay are a leaky reservoir of legacy arsenic.

UPDATE ON THE EXPLORATION PROGRAM AT PINE POINT

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Pine Point Mining Limited, a wholly-owned subsidiary of Osisko Metals Incorporated, is undertaking definition drilling at the formerly producing Pine Point Mining Camp. The Pine Point lead and zinc deposits are Mississippi Valley Type (MVT) hosted in carbonate rocks and formed within a Devonian age barrier reef. The original mine was operated by Cominco Ltd. and produced high-quality

zinc and lead concentrates for over 25 years. The Mine closed in 1988 although significant supporting infrastructure remains. Past production was 65 Mt of 10% combined Lead and Zinc and at shutdown there was 50 million tonnes of "unclassified historical resources" calculated by Cominco Ltd (not NI-43-101 compliant) that remained in the ground. The focus of the 2018 program is to upgrade these historical mineral resources into a NI43-101 compliant, Inferred Mineral Resource Estimates. To accomplish this goal, a 700 drill hole program is underway to confirm the Cominco drill hole database that Pine Point Mining Limited has in hand and, where needed, define these resources further to an Indicated Mineral Resource in 2019. That Resource base will then be used for economic studies as the company continues to de-risk the project.

ENHANCING THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS – AN UPDATE FROM THE MACKENZIE VALLEY ENVIRONMENTAL IMPACT REVIEW BOARD

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The Mackenzie Valley Review Board is the organization responsible for the Environmental Impact Assessment (EIA) process in the Mackenzie Valley, Northwest Territories. This EIA process is designed to prevent significant adverse impacts to people and the environment, and to ensure the views of Indigenous people and the public are meaningfully considered. With an organizational goal of continual improvement and responding to evolving legislation and best practices, the Review Board has undertaken numerous initiatives aimed at enhancing the EIA process in the Mackenzie Valley. We will provide an overview of the organization's current policy and process improvement initiatives, with highlights including: new environmental assessment initiation guidelines, updated rules of procedure, transboundary cooperation, as well as discussing the evolving role of the Board in the Crown consultation process and the assessment of impacts on aboriginal rights.

MINING MATTERS INDIGENOUS COMMUNITIES EDUCATION AND OUTREACH PROGRAMS

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Mining Matters Indigenous Communities Education and Outreach Programs (ICEOP) recently celebrated a significant 15-year milestone. In May of 2002, the inaugural program was delivered in Cambridge Bay, Nunavut. Today, ICEOP has expanded to include more than 35 community-based initiatives. With sensitivity to the importance Indigenous communities play in resources stewardship, management and development, ICEOP offers customized 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. ICEOP includes professional development workshops and teacher resource

kits to deliver effective Earth science and mineral resources curricula, using hands-on educational resources, created by educators and Earth science experts to meet curriculum expectations. Mining Matters also connects to and engages with Indigenous communities through participation in conferences, community gatherings and festivals across Canada. Since 2016 Mining Matters has delivered programs in the Northwest Territories in collaboration with community, industry, education and government partners. Programs have been delivered in Yellowknife, Behchokǫ̀, Ndilǫ, Detah, Fort Good Hope, Délı̨nę, Norman Wells, Colville Lake, Tulita, Fort Liard, Fort Simpson and Fort Providence. A recent educational partnership utilized Mining Matters resources to engage children in Inuvik, Tuktoyuktuk and Aklavik. In addition, teachers from Hay River, Gamètì, Wekweètì and Whatì have participated in the organization's professional development workshops.

ADVANCING SOCIAL LICENCE IN A COMPLEX ENVIRONMENT: YELLOWKNIFE CITY GOLD PROJECT

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The Yellowknife City Gold Project (YCGP) which directly benefits and impacts over half the NWT's population is unique among Northern projects.

YCGP's 780 sq. km. span crown, commissioner and municipal lands surrounding the City of Yellowknife and YKDFN Communities of Ndilǫ and Detah. It shares multiple land uses including: hydro, road, airport and communications infrastructure; tourism, harvesting, residential and agriculture lands; recreational trails and lakes, permitted and unpermitted cabins and mine reclamation projects.

While 90% of the population impacted by the YCGP live in the City of Yellowknife, the YCGP is in Chief Drygeese Territory within the unsettled Akaitcho Land Claim and is overlapped by the Môwhì Gogha area of the settled Tłı̨chǫ Land Claim and the asserted North Slave Métis Claim.

Together with next generation projects in the North, YCGP faces an emerging and perhaps largest challenge to social licence: the risk of increasing international opposition to high-carbon projects that rely on diesel or LNG. It is simply smarter and safer for mining companies to avoid risking their global social licence and invest in places with competitive carbon-free energy.

INCREASINGLY SOCIAL LICENSE TO OPERATE REQUIRES PROJECTS TO AVOID CARBON BASED ENERGY

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Global investors and resource companies increasingly seek to avoid the risks of using carbon based energy. Today, investment decisions on mineral development are not driven by economics alone. Issues that affect social licence - climate change chief among them - are equally prominent.

Globally, there is a growing intolerance among financial institutions, investors, mining companies and the public for materials that have large carbon footprints.

The risk of growing international opposition to high-carbon projects, that rely on diesel or LNG increasingly flashes red in the boardrooms of global resource companies. It is simply smarter and safer for them to avoid risking their global social licence and invest in places with competitive carbon-free energy.

The North must address the risks of carbon based energy if it wants to attract major mining companies with the capacity to develop multi-generational projects.

If the NWT and Nunavut are to continue to open their geology to mineral exploration and development they must bring alternatives such as hydro and tidal power to their territories.

THE UTILITY OF CLINOPYROXENE IN DIAMOND EXPLORATION

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Clinopyroxene single-crystal thermo-barometry is an essential tool in the identification and evaluation of prospective kimberlites. The paleogeothermal gradient preserved by clinopyroxene xenocrysts elucidates the thermal structure of the underlying lithospheric mantle; indicates the depth to and thickness of the "diamond window".

The widely used clinopyroxene thermometer-barometer of Nimis and Taylor (2000) requires that clinopyroxene equilibrated with both garnet and orthopyroxene. With the rare exception of wehrlites, equilibration with orthopyroxene is nearly a given for the majority of chrome-diopside clinopyroxene xenocrysts. Demonstrating equilibration with garnet, however, is a major obstacle for clinopyroxene-based thermobarometry. The most commonly used method for clinopyroxene discrimination is an Al_2O_3-Cr_2O_3 diagram proposed by Ramsay and Thompkins in 1994 supplemented with an additional MgO-Al_2O_3 from Nimis (1998) and an additional 1-dimensional filter based on chemical composition. Despite the aggressiveness of the filtering method, single-clinopyroxene pressure-temperature results have large scatter that can obscure the true paleogeothermal gradient. This is especially true of areas where the lithospheric mantle has undergone chemical modification by melt/fluid influx. Using a database of clinopyroxenes derived from kimberlite-borne mantle-derived lherzolites, we have developed a simple and effective discrimination plot that identifies clinopyroxene from garnet lherzolites and simultaneously removes clinopyroxene from metaosomatised peridotites.

Calculated paleogeothermal gradients from clinopyroxene xenocrysts cut across model conductive geotherms which can complicate the interpretation of thermobarometry data. Grütter (2009) presented a solution to the problem by way of relative reference geotherms. He used xenocryst data from three Canadian locations with different thermal structures as references in comparison to the dataset under investigation. Taking a cue from this earlier work, we have developed a new set of relative reference geotherms that are based on single-clinopyroxene thermobarometry data for xenoliths from well-characterized regions – Somerset Island, Kaapvaal on-craton, and the Central Slave. A simple linear fit through the data produces sub-parallel clinopyroxene reference geotherms that are simpler to use and easier to visualize

compared to the xenocrysts reference geotherms.

Using these two new and simple tools will greatly help maximize the utility of clinopyroxene data in large exploration databases.

THE UNIVERSITY OF REGINA GEOTHURMAL PROJECT IN SASKATCHEWAN

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In 2014, a research team at the University of Regina initiated a proposal to construct a deep geothermal energy demonstration project on the university campus, using heat from the Williston Sedimentary Basin. This work is a continuation of research completed by the University when an exploratory geothermal test well was constructed in 1979. Hydrogeology of the site was investigated to demonstrate the potential of sedimentary basin geothermal energy and documented in over 40 publications and reports. The second well required to complete the project was never drilled and the project was abandoned. Current interest in reducing our carbon foot print and exploring alternative energy sources has resulted in renewed interest in the use of geothermal energy on campus. Geothermal energy can provide reliable, base-load heating, which is available on demand, has no storage requirements and no direct emission of greenhouse gases. This renewed project will showcase clean, green energy technology and infrastructure, with scientific, social and engineering research components. This energy source will integrate into existing heating infrastructure, and be immediately operational. To complete this project, two 2200 m deep wells will be drilled to the Deadwood aquifer beneath the University campus. Hot water from this aquifer will be pumped to the surface via the source well, where the heat will be extracted in a heat exchanger located in the heating plant on campus. The cooled water will be re-injected back into the same aquifer using the second well for disposal. The resulting heated surface fluid is then distributed using the district heating system to provide base-load heating for space and domestic water at Kisik Towers (300,000 ft^2 area), domestic water at two other residence towers, the university pool and combustion pre-heating at the Central Heating Plant. This load represents approximately 60% of the capacity of this geothermal-doublet system which has a total capacity to provide base load heating for ~1.2 mill ft^2. The economic value of the system is based upon the avoided cost of purchasing natural gas. Our forecasting suggests that for the first five years there is sufficient cost recovery; however, due to chronically low natural gas prices, these savings become less predictable further out. This risk is mitigated when the federal carbon tax is added to the purchase price of natural gas, slated to begin in 2019. By including the value of the anticipated carbon-tax-avoided by 2023, the university could save between $90 and 100,000 per year with the geothermal system operating at roughly 60% capacity. This value will increase as the carbon tax-rate increases and if new buildings still in the planning stage, utilize a larger portion of the system capacity. Innovation and operational experience applied in a Canadian social, geological and engineering context are required to effectively utilize this resource. The university location provides opportunities for research aiding the commercialization and acceptance of geothermal energy, along with the training of

highly qualified personnel. This technology has widespread application throughout southern Saskatchewan and extensive areas of Canada possessing geothermal development potential.

STREAM SEDIMENT GEOCHEMISTRY AND HEAVY MINERALS, SOUTHERN MACKENZIE, NT

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Stream sediments have long been used as a mineral prospecting tool and is an effective method to quickly evaluate the prospectivity of an area. Government stream sediment and water surveys date back to the early 1970s and have been carried out in all ten provinces and three territories. Under the Southern Mackenzie Surficial Mapping Activity of Geological Survey of Canada's GEM-2 Program (Mackenzie Project), a multi-year stream sediment and water study was initiated in 2017 and continued in 2018.

Past mineral resource assessments carried out by the Northwest Territories Geological Survey, as part of the Protected Areas Strategy (PAS) in the Trout Lake and Kakisa areas, revealed the presence of elevated levels of chalcopyrite ($CuFeS_2$), sphalerite ((Zn,Fe)S) and galena (PbS) in the heavy mineral concentrate (HMC) fraction of till samples. Preliminary isotopic analysis of these base metal indicator minerals (GSC OF 8449) has shown that those PAS sulphide grains are not derived from Pine Point. Stream sediment samples collected in 2017 substantiated the presence of chalcopyrite while revealing additional significantly elevated sphalerite and galena grain counts in several locations where there are no known subcropping mineral occurrences. Past producer, Pine Point lead-zinc Mine, lies ~75 km to the east-northeast of the nearest stream sediment site with elevated sphalerite and galena grain counts, and is not likely the source as samples between these sites have only background-level grain counts.

The 2018 stream sediment sampling strategy was designed to augment existing samples, resample a few of the 2017 sites with elevated grain counts, and target a number of coincident till and stream sediment sites in proximity to those with elevated grain counts. A total of eight bulk stream sediment and water samples were collected northeast and southwest of Fort Providence. Planned 2018 stream sediment sampling in the Hay River area was not feasible as a consequence of high water levels.

Stream sediment and water samples were collected in accordance to the Geological Survey of Canada's former National Geochemical Reconnaissance (NGR) methodology. At every site possible, three samples were collected: bulk stream sediment for the heavy mineral fraction, silt-size sediment and a water sample. The bulk sediment was processed to obtain indicator mineral grain counts, while the silts and waters underwent geochemical analyses. Diligent NGR QA/QC practices facilitate data compatibility and compilation, whether it be from the early NGR surveys or recent GEM drainage geochemical studies. After publication, all data will be uploaded into the GSC's Canadian Database of Geochemical Surveys.

CO-MANAGEMENT AND CROWN CONSULTATION – WHERE HAVE WE GOTTEN TO?

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Recent Supreme Court of Canada decisions in Chippewas of the Thames and Clyde River indicate that the Crown's Duty to Consult may be satisfied by the proceedings conducted by co-management (administrative) tribunals. Governments have begun notifying Aboriginal rights holders that they will rely on these proceedings to satisfy their consultation obligations. Is it as simple as that? This presentation will review the law on consultation and provide a realistic assessment of the role of co-managers in Crown consultation.

HYBRID ENERGY SYSTEMS: DELIVERING RELIABLE HEAT AND POWER IN REMOTE LOCATIONS

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Remote reliable energy provision (heat and power) is extremely costly, and in northern Canada, with the exception of a few communities, the default technology is diesel fuel. Climate conditions and the long period of little or no sun generally eliminate wind, solar, tidal, biomass and hydro as reliable sources of renewable energy. Yet, at certain times of the year, some of these can contribute to energy systems, providing that other sources can sustain supplies for extended periods (winter months) when renewable sources are weak or absent. We consider that a combination of deep geothermal heat sources combined with a shallow ground-source heat pump storage facility can serve as the year-round reliable energy source, and other sources can be used when available. Different sources available seasonally lead to the concept of an integrated Hybrid Energy System (HES), a more complex analogy of the hybrid electric vehicle that balances the use of stored (battery) energy and actively generated (gasoline-sourced) energy.

We will show a series of options involving various energy sources, and we will factor in the additional component of energy storage of various types (mechanical, thermal, chemical). Energy storage increases HES flexibility: e.g., waste heat from one technology (compression of air for mechanical storage of energy) can be stored using another technology (a heat georepository), or used (a greenhouse or habitat) to displace other sources (deep geothermal heat). These options all reduce overall dependence on a single source (e.g. diesel engines), reduce the amount of energy needed overall, and overcome issues such as fragile fuel supply lines. Although the extreme cold of the north is viewed as a severe penalty, which it certainly is, it also allows for potential value input. Two examples: Organic Rankine Cycle engines can operate more efficiently when the ambient temperature is extremely cold; and, the extended summer sun availability at high latitudes means that collecting heat from the sun (far more efficient than photovoltaic energy) could help in creating a heat repository on a seasonal basis.

Finally, we note that some systems are more effective if hybridization is viable. In the

north, ground-source heat pumps continue cooling the ground as the years go by, reducing the effectiveness of such systems. However, deep geothermal heat or local waste heat can replenish the ground temperature, sustaining the seasonal efficiency of the heat pump system.

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

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In 2016 and 2017, the Northwest Territories Geological Survey (NTGS) implemented the Slave Province Geophysical, Surficial Materials and Permafrost Study to generate new baseline geophysics datasets, new surficial mapping products and new mineral exploration methodologies to assist the next round of diamond discoveries in the Slave Geologic Province (SGP). Associated permafrost studies will develop methodologies for permafrost monitoring which will inform infrastructure and land-use planning. The research was focused in NTS map sheets 75M and 75N, with targeted work in 76C and 76D. This project was funded through the Strategic Investments in Northern Economic Development of the Canadian Northern Economic Development Agency. This presentation will highlight new surficial geology mapping products, surficial geological models and exploration methodologies generated over the course of this study and provide an update on forthcoming scientific publications from the NTGS and our project partners. Preliminary plans for future geophysical and bedrock and surficial geology work in the SGP will also be presented.

CANTUNG TUNGSTEN MINERALIZATION: LONG AND SHORT RANGE SIGNATURE IN PELITIC ROCKS

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The Tungsten belt, located along the Northwest Territories/Yukon border in the Mackenzie Mountains, represents one of the largest tungsten metallogenic regions in North America. Tungsten deposits along the belt are carbonate-replacement skarn deposits associated with peraluminous Cretaceous magmatism and are commonly spatially associated with gold showings. Of the known tungsten deposits, Cantung has the highest grade (reserve grades well above 0.7 WO_3 %) and coarsest scheelite. However, other showings such as Mactung and Lened may be volumetricly larger or have been explored to a lesser extent. The relationship between intrusions and tungsten deposits is well established. Therefore, exploration efforts have recently focused on identifying the "right plutons". Plutons of age and geochemical signature similar to those outcropping at Cantung have been widely recognized in the Tungsten belt but deposits have been more elusive. Comparable tungsten metallogenic provinces elsewhere in

the world are characterized by the occurrence of regionally extensive crustal-derived batholiths that generate numerous deposits at spatial scales of hundreds of kilometers. Therefore, Cantung and Mactung may only represent a portion of the mineral endowment with additional resources yet to be discovered and characterized.

Both Cantung and Mactung are hosted in Cambrian sequences consisting of folded Precambrian to Silurian argillite and carbonate units. The ore occurs in the carbonates. The high buffering capability of carbonates makes them an unlikely candidate to generate long range geochemical anomalies. However, fluid-rock interaction in metapelites can cause trace element anomalies extending kilometers away from the main system. Regionally extensive Precambrian metapelites underlying and surrounding skarns in Cantung and Mactung provide a unique opportunity to test whether tungsten deposits generate distal geochemical signatures in the underlying and surrounding metapelites that could be used to identify additional non-exposed tungsten anomalies.

Skarns are characterized by the occurrence of alteration zonation with marked fronts. Geochemical changes in the different alteration zones provide information on how major and trace elements are buffered from proximal to distal in the mineralized lithologic unit. They also provide information on which elements are least likely to be buffered locally and therefore most likely to be good distal indicators. Therefore, local geochemical changes can provide a first order clue of potential distal indicators.

In this study we aim to define the local (decimeter scale) and regional (100s of meter scale) effects of fluid rock interaction in both the carbonate and the metapelites associated with well-known tungsten resources in the Tungsten belt. The objective is to define the characteristics and spatial scale of geochemical anomalies generated in the argillites below the skarn and within the carbonate by the mineralizing fluid and, additionally, by the spent fluid in the argillite above the skarn.

HYDROTHERMAL REGIME OF STREAM CHANNELS – TUKTOYAKTUK COASTLANDS AND ANDERSON PLAIN

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In permafrost regions, the movement of water and extent of winter freezing in streams have important implications for hydrology, terrestrial and aquatic ecology, land use, and infrastructure. Although the hydrology and thermal characteristics of large Arctic streams and rivers have been investigated, knowledge of contemporary winter hydrothermal dynamics in smaller, more extensive tundra stream networks is limited. Climate warming, changing precipitation regimes and increases in tundra vegetation height and coverage may combine to delay active layer freeze-back, increasing the potential for winter water movement. This could influence stream hydrothermal regime, with significant hydrological and ecological consequences.

The primary goal of this research is to improve our understanding of the hydrothermal regime of small stream

channels in continuous permafrost in the Tuktoyaktuk Coastlands and Anderson Plain, NWT, and to explore the implications of a changing climate. It is hypothesized that insulation from snow cover in combination with adequate watershed storage capacity can permit flow to continue through winter in small stream channels. To test this hypothesis, water and ground temperature in, beneath, and adjacent to streams of varying catchment size across treeline is being monitored. Morphological and ecological parameters of contributing watersheds are being compared, and the hydrological activity, thermal conditions and the distribution, timing, and magnitude of stream icings indicative of winter water movement are being described for several streams intersected by the 130-km Inuvik to Tuktoyaktuk Highway (ITH).

The ITH has likely increased the surface expression of winter water movement in regional streams, and has facilitated logistics and field observations. An additional research objective is to describe the causes of the icings and ground injection ice occurring at stream crossings along the highway. It is hypothesized that changes to the stream thermal regime caused by bridge structures or culverts contribute to the upstream development of icings. Concurrent continuous monitoring of streambed temperatures, hydrostatic water level upstream and downstream of highway crossings, snow accumulation and icing size is intended to aid the investigation of causes and processes of formation. The development of icings is a concern because of the potential for unsafe road conditions, highway blockages, or highway damage.

This research provides new insight on winter hydrology in permafrost areas, and demonstrates that significant mass and heat continues to move through small hydrological systems in winter. The results will inform hydrological modeling, understanding the evolution of stream chemistry and will help inform the design, operation and mitigation of hydrological issues associated with linear infrastructure in permafrost.

NWT MINERAL EXPLORATION AND MINING OVERVIEW 2018

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Turbulent political times at the national level with trade negotiations, rising interest rate and newly implemented tariffs have made it difficult to gain an impression of the mood of the mineral industry in the NWT. However, one of the most reliable indicators of exploration health, claim staking vs lapsing, continues to trend on an upswing that started in 2017. In 2017, the total number of claims staked increased over previous years, however 2017 cancelled claims still resulted in a net loss of area with mineral tenure. In the first three quarters of 2018, claims covering 178,868 Ha were added and only 51,058 Ha released; a significant increase in area covered by mineral claims. New staking included large areas in the Mackenzie Mountains, complimented by a re-staking of claims in the Lac de Gras region and an expansion of claims in the Yellowknife area.

Although diamonds remain the only commodity currently mined in the NWT, several new commodities targeting green energy alternatives and battery technologies emerged or advanced this year. Lithium and cobalt were much discussed in the press, and vanadium was also represented by new projects.

At the Diavik mine, the opening of the A21 project was celebrated ahead of schedule in August. The first ore was uncovered in March and the new pit is scheduled to reach full production capacity during the fourth quarter of 2018. In the first half of 2018, the Gahcho Kué diamond mine recovered over 3,570,000 carats of diamond with grades of the ore and value of the stones outperforming expectations. Positive results from the production were augmented by mine-site exploration success and identifying additional tonnage in the Hearne pipe as well as the discovery of the Currie kimberlite within the shell of the Tuzo pit. At the Ekati mine, current surface operations include the Pigeon, Sable and Lynx open pits. Underground operations at the Koala pit will be concluded by the end of 2018. The Misery Underground Project is now underway and the expansion of Misery Camp is slated for early 2019.

The Territory saw activity at several diamond, gold, base metal and lithium exploration projects. Pine Point Mining expanded their exploration efforts with an aggressive drill program to define new resources in the Pine Point Zinc district. Nighthawk continued exploring the Indin Lake volcanic belt and improved the continuity of the resources at Colomac. Closer to Yellowknife, TerraX continued drilling gold targets including the Crestaurum Shear and the extension of the Sam Otto zone on their enlarged Yellowknife Gold Project with good results. Far Resources was able to intersect high grade lithium concentrations at Hidden Lake.

2017-2018 saw the Mining Incentive Program (MIP) budget increased from $400,000 to $1 million; this funding was dispersed to 13 exploration projects (seven companies, and six prospectors). 2017-2018 MIP support resulted in additional exploration investment of over $2.5 million, and led to many encouraging advancements in the funded projects.

ESTIMATING THE COST OF CLOSURE AND RECLAMATION: GUIDELINES FOR MINES IN THE MACKENZIE VALLEY

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In November 2017, the Land and Water Boards of the Mackenzie Valley, in collaboration with the Government of the Northwest Territories and Indigenous and Northern Affairs Canada, released the Guidelines for Closure and Reclamation Cost Estimates for Mines (the Closure Cost Guidelines). The Closure Cost Guidelines outline the expectations of proponents when submitting closure cost estimates for mining projects. These expectations include collaboration with authorities, use of the GNWT's RECLAIM model, development of supporting documentation, and more. The Guidelines also explain the Boards' process for setting security during a water license proceeding (e.g., for a new water license) and during the term of a water license. This presentation will be an overview of the Guidelines.

CONVENTIONAL RESOURCE GAS MAPPING PROJECT

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The Conventional Gas Resource Mapping Project was initiated last year to support an Northwest Territories Geological Survey (NTGS) strategic plan objective, "…to provide geoscience knowledge as required to support community initiatives to develop local natural gas supplies for electricity generation." To this end, a scoping level geoSCOUT project was completed to show the distribution of known natural gas resource volumes with respect to communities and existing pipeline and road infrastructure. A more comprehensive second phase of this project will be initiated in Fiscal 2018-19 to create publication quality maps, shapefiles, and metadata in an ArcGIS project. The results of the ArcGIS project will be made available as an NTGS Open Report by fiscal year-end. This presentation will review the scoping results of the 2017-18 Conventional Gas Resource Mapping Project.

2018-19 ACTIVITY UPDATE – PETROLEUM GEOSCIENCES GROUP

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During Fiscal 2017-18, the Petroleum Geosciences Group at the Northwest Territories Geological Survey (NTGS) advanced work on four projects. These include the Shale Basin Evolution Project in the Central Northwest Territories (NWT), Petroleum Play Summaries, Conventional Marketable Gas Resource Mapping, and Petroleum Legislation Review. The purpose of this presentation is to review the work completed during Fiscal 2017-18 and the Petroleum Group 2018-19 work objectives.

The Shale Basin Evolution Project is a multi-year project initiated in 2014. Dr. Murray Gingras of the University of Alberta joined the research team in 2016 to help achieve the project goals and provide enhanced objectives. This project will provide an assessment of the reservoir quality of Middle to Upper Devonian age shale of the Central Mackenzie Valley, using sedimentological, ichnological, and geochemical parameters. Chemostratigraphic, biostratigraphic, and sedimentological data will be used to establish a basin-wide sequence stratigraphic framework for the Horn River Group shales. These shales include the Bluefish and Bell Creek members of the Hare Indian shale and the Canol Formation. Basin-wide outcrop, core, chip samples, and well log data collection and analysis are incorporated into the project work. Petroleum systems analysis software will also be used to conduct basin modeling studies using multiple Horn River Group shale datasets. Potential hydrocarbon generation history, migration models, resource volumes, and prospective trends will be evaluated. The team also conducted fieldwork along the western and southern edges of the Mackenzie Plain and Peel Plateau, respectively during Fiscal 2016-17 and 2018-19. The 2018-19 project work focuses on industry core and chip sample data from five recently drilled wells in the Central Mackenzie Valley and on recently acquired outcrop samples.

Petroleum Play Summaries are a hybrid product designed to provide petroleum industry explorationists with a summary of key technical parameters and basic mapping for known conventional or unconventional hydrocarbon plays in the NWT. The summaries are printed as pamphlets and primarily distributed at technical conferences. The Liard Unconventional Play Summary is nearly complete, and pamphlets should be available for distribution before the end of November 2018.

The Conventional Gas Resource Mapping Project was initiated last year to support an NTGS Strategic Plan objective … to provide geoscience knowledge as required to support community initiatives to develop local natural gas supplies for electricity generation." To this end, a scoping level geoSCOUT project was completed to show the distribution of known natural gas resource volumes with respect to communities and existing pipeline and road infrastructure. A more comprehensive second phase of this project will be initiated in Fiscal 2018-19 to create publication quality maps, shapefiles, and metadata in an ArcGIS project. The results of the ArcGIS project will be made available as an NTGS Open Report by fiscal year-end.

A workgroup was formed in the fall of 2016 to review the Petroleum Resource Act and the Oil and Gas Operations Act and identify areas of the legislation in need of updating. The manager of the Petroleum Geosciences Group served as a subject matter expert on the team until February 2018.

GEOTHERMAL ENERGY POTENTIAL IN YUKON: RESULTS OF RECENT STUDIES BY YUKON GEOLOGICAL SURVEY

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Yukon Geological Survey (YGS) is evaluating the geothermal energy potential of Yukon to help determine the viability of developing these resources. Renewable power is not a top-of-mind issue for Yukoners, as the bulk of our power is generated from renewable sources (mainly hydro, with increasing components of solar and wind). However, projected power demands for potential new mine developments over the next ten to twenty years will exceed Yukon's current power capacity, and consultations around new hydro developments have met strong public opposition. Additionally, although our power grid is currently over 90% renewable, four communities are off-grid, and the majority of Yukon homes and businesses are heated with hydrocarbons. All hydrocarbons used in the territory are trucked from the south.

Previous geothermal investigations in Yukon include numerous regional and site-specific studies by the Geological Survey of Canada (Grasby *et al*., 2012. GSC Open File 6913), Yukon Energy Corporation (unpublished studies) and the Canadian Geothermal Energy Association (CanGEA, 2016). Our current research builds on these studies and has three components:

- Modeling regional heat flow in the mid to shallow crust;
- Calculating potential heat production from young granites; and
- Direct measurement of thermal gradient in two ground temperature monitoring wells.

Heat flow was modeled by Witter and Miller (2017) by calculating Curie Point depths (CPD) using public domain regional aeromagnetic data from NRCAN. CPD estimates were subsequently improved upon by Li *et al*. (2017. YGS Open File 2017-3) using a global EMAG2 magnetic dataset as discussed in Witter *et al*. (2018. 43rd Workshop on Geothermal Reservoir

Engineering). The Curie Point, defined as the temperature above which a magnetic substance loses its magnetic properties, corresponds to a temperature of roughly 580°C for the commonly occurring mineral magnetite. CPDs calculated for Yukon correspond well with the heat flow map of Grasby *et al*. (2012. GSC Open File 6913), with the shallower CPDs occurring across southern Yukon.

Additional, shallow sources of potential heat were identified by calculating the heat generated from the natural radiogenic decay of U, Th and K in granites. Using the technique of Rybach (1981. *in* Geothermal Systems: Principles and Case Histories), heat-production values were calculated from existing whole rock geochemical data. Granites in southern Yukon locally have significantly higher heat production values than "average" granites (over 10µW/m^3 vs. 2.45µW/m^3 for an average granite). Notable are Cretaceous granites which have higher heat generation values compared to younger Paleogene ones.

Direct ground temperature data were collected from two 500 metre-deep wells drilled between November 2017 and March 2018. One well is located midway between Takhini hot spring (46°C surface water temperature) and a granite pluton that yielded a heat-production value of 5.96µW/m^3. The granite is thought to provide a heat source to infiltrating meteoric waters, possibly in permeable carbonate rocks. The second well targeted the Tintina trench, a major dextral fault that transects Yukon. This location was selected to assess whether enhanced permeability in the fault creates a locally elevated geothermal gradient.

As results of this work are written up over the next few months, YGS is taking some time to engage communities regarding results obtained to date and assess interest in carrying out further research.

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

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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 its plans for the coming year. Areas of focus will include the anticipated reduction in on-the-land liability as a result of OROGO's Well Suspension and Abandonment Guidelines, the electronic availability of well history and seismic program information, new Guidelines under development in 2018-19 and OROGO's Well Watch Program.

ENERGY RESILIENCE AND INDEPENDENCE FOR CANADA'S NORTH

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This talk will present an overview of diesel consumption in Canada's North and will discuss highlights and conclusions from KPMG's recent study "Assessment of Potential Diesel Demand in Mines and Remote Communities in Northern Canada."

It will also feature a case study relating to TUGLIQ Energy's renewable energy experience at Glencore's RAGLAN Mine in the Canadian Arctic, and suggest frontier demonstrations, experiments and deployments that should be undertaken to effect a timely and orderly energy transition in Canada's North. Emphasis will be given to the current energy situation in Canada's North, evolving trends, and practitioners' views on reliability, operating and maintenance, smart grid stability, resilience and energy independence.

ORGANIC MATTER CONTROL ON THE DISTRIBUTION OF ARSENIC IN LAKE SEDIMENTS IMPACTED BY ~65 YEARS OF GOLD ORE PROCESSING IN SUBARCTIC CANADA

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Climate change is profoundly affecting seasonality, biological productivity, and hydrology in high northern latitudes. In sensitive subarctic environments exploitation of mineral resources led to contamination and it is not known how cumulative effects of resource extraction and climate warming will impact ecosystems. Gold mines near Yellowknife, Northwest Territories, subarctic Canada, operated from 1938 to 2004 and released more than 20,000 tonnes of arsenic trioxide (As_2O_3) to the environment through stack emissions. This release resulted in elevated arsenic concentrations in lake surface waters and sediments relative to Canadian drinking water standards and guidelines for the protection of aquatic life. A meta-analytical approach is used to better understand controls on As distribution in lake sediments within a 30-km radius of historic mineral processing activities. Arsenic concentrations in the near-surface sediments range from 5 $mg.kg^{-1}$ to over 10,000 $mg.kg^{-1}$ (median 81 $mg.kg^{-1}$; 5->10,000 $mg.kg^{-1}$; n=105). Distance and direction from the historic roaster stack are significantly ($p<0.05$) related to sedimentary As concentration, with highest As concentrations in sediments within 11 km and lakes located downwind. Synchrotron-based µXRF and µXRD confirm the persistence of As_2O_3 in near surface sediments of two lakes. Labile organic matter (S1) is significantly ($p<0.05$) related to As and S concentrations in sediments and this relationship is greatest in lakes within 11 km from the mine. These relations are interpreted to reflect labile organic matter acting as a substrate for microbial growth and mediation of authigenic precipitation of As-sulphides in lakes close to the historic mine where As concentrations are highest. Continued climate warming is expected to lead to increased biological productivity and changes in organic geochemistry of lake sediments that are likely to play an important role in the mobility and fate of As in aquatic ecosystems.

GEOTHERMAL ENERGY POTENTIAL OF NORTHWEST TERRITORIES

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Northern Canada faces unique challenges of numerous remote communities largely separated from electrical grid systems. Thermal and power needs are typically met by truck transported hydrocarbons, which in some cases is subject to winter roads and/or seasonal freeze and break up of ice bridges that limits shipments to narrow windows through the year. Potential to develop local energy resources can provide communities with energy sovereignty along with greater energy security. We examined the broad geothermal energy potential of the NWT with particular respect to communities with higher potential. The broad area of eastern NWT underlain by the Canadian Shield has low heat flow and geothermal gradients limiting resources potential largely to potential heat pump systems, or potentially Enhanced Geothermal Systems that is still in a technology development stage. Some notable exceptions are geothermal potential of abandoned mines where large water filled mine tunnels allow high volume production and heat extraction. Sedimentary basins of the western NWT have inherently low thermal conductivity and act as thermal blankets trapping radiogenic heat. These regions also have higher heat generation. Drilling by the petroleum industry define regions of high temperature geothermal resources at depths associated with known aquifer units, suggesting potential for sufficient fluids production rates to produce net power at surface along with associated direct heat use. Potential issues with scaling associated with brines from these levels could cause some technical challenges however. Further research on potential hot sedimentary aquifers could help focus potential exploration targets for geothermal systems.

THE THERMOCHEMICAL CONDITIONS OF THE DIAVIK LOWER CRUST: A KIMBERLITE-HOSTED XENOLITH STUDY

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Thermochemical variables such as lower crustal heat production and Moho temperatures in cratonic regions offer critical insight in constraining the thermal and geodynamic evolution of the lithosphere. In this study, 15 lower crustal granulite xenoliths erupted via the A154N kimberlite at the Diavik mine in the NWT, Canada were studied to quantify the thermal properties of the local Moho and the effects of different heat production models on geotherm models. We quantitatively constrain the thermal properties of the local Moho and the effects of different heat production models on ancient Moho temperatures, the effects of crustal thickness on Moho temperatures, and potential lower crustal compositions. We evaluate the effect of these parameters on total lithospheric thickness estimates.

In order to test the accuracy of deep crust thermal calculations, we estimated the ambient temperature of the lower crust at the time of kimberlite eruption through garnet-biotite Fe-Mg exchange geothermometry (Ferry & Spear, 1978). Rim compositions

from touching garnet-biotite pairs were used in the calculations and yielded temperatures of 524 ± 77°C (n=20). These represent a maximum estimate of the ambient lower crustal temperature as the closure temperature of garnet-biotite Fe-Mg exchange between garnet and biotite may be higher than the ambient temperature.

The primary objective of this study is to quantify lower crustal heat production and its effects on the thermal architecture of cratons. The concentrations of the main heat-producing elements (HPEs) U, Th, and K were quantified via LA-ICP-MS and EPMA in multiple mineral phases per xenolith. By combining these measurements with mineral modes, we derived reconstructed bulk-rock HPE concentrations that were utilized to calculate a range of lower crustal heat production values. This method is preferred over whole-rock analyses as 1) kimberlite is generally enriched in HPEs (Tappe *et al*. 2013) and can bias trace-element data for their xenoliths and 2) data on individual minerals allows for theoretical lower crustal compositions to be calculated on an idealized basis. A lower crust comprising exclusively mafic granulite (garnet, plagioclase, clinopyroxene ± orthopyroxene) provides a lower bound to heat production (0.07 ± 0.04 W/m^3) whereas a lower crust made exclusively of high-grade metasedimentary rocks yields an upper bound (0.42 ± 0.08 W/m^3). Both endmembers are present as xenoliths in the A154N kimberlite but mafic granulites predominate following the worldwide trend (Rudnick, 1992). We model the lower crust comprising 20% metasedimentary granulites and 80 % depleted mafic granulites, in accordance with the present xenolith collection. Using this preferred crustal model, we calculate an average heat production of 0.12 ± 0.05 W/m^3) for the lower crust beneath Lac de Gras. Utilizing heat flow measurements (Russell *et al*. 2001; Mareschal *et al*. 2004) and crustal thickness estimates (Mareschal *et al*. 2004) in conjunction with these HPE determinations, the Moho temperature underlying A-154N can be calculated to be 502 ± 10°C. Using these values along with available mantle xenolith thermobaromtetry (Hasterok & Chapman, 2011) the geotherm is extrapolated to present a mantle potential temperature of 1365°C, at 200 km (FITPLOT, Mather *et al*, 2011).

PHASE CHANGE AND WATER MOVEMENT IN SHALLOW PERMAFROST INFERRED FROM BOREHOLE OBSERVATIONS OF LIQUID WATER CONTENT AND TEMPERATURE NEAR YELLOWKNIFE, CANADA

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Three experimental installations for measuring temperature and liquid water content as well as surface heave/subsidence were made in summer 2017 near Yellowknife. All three quantities are measured with hourly resolution. The measured depths for temperature and liquid water content extend from 0.1 to around 2 metres. Temperature is calibrated to +/- 0.02 ºC except for one borehole that is accurate to only +/- 0.1 ºC. Water content is measured with a repeatability of a fraction of a percent, but absolute calibration is a work in progress. Surface heave/subsidence is measured with an accuracy of +/- 0.5 mm. This contribution will show results based on data from July 2017 to June 2018, possibly to November 2018.

The derived freezing characteristic curves, although limited by the temperature range experienced at each depth, are of high quality and predominantly show clear hysteretic behaviour. Water movement in the frozen soil can be inferred during periods when the experimental freezing curves (volumetric liquid water content as a function of temperature) deviate from their otherwise smooth exponential shape. Additionally, short episodes of increasing liquid water content occur in cooling permafrost. This contribution will present the major phenomena observable from the combined data set of temperature, liquid water content and subsidence. Inferred water content in freezing soil will be discussed in more detail.

This work contributes to better understanding the behaviour of near-isothermal permafrost. This is important because permafrost in many locations is subject to thaw i.e., the gradual loss of ground ice. Here the relevant changes of material properties are incompletely understood based on temperature observation alone.

THE MINE WE WANT TO SEE – A PERSPECTIVE ON SUSTAINABLE MINING IN CANADA'S NORTH

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The mining sector is enjoying a resurgence. Yet long-term success in today's dynamic landscape demands a re-orientation of the approach to the business of mining. Implementing sustainable practices across the lifecycle is key to achieving the both the stability and agility required to reduce risk, minimize environmental impact, enhance community benefits for mutual success, encourage innovation, and maximize shareholder value.

This presentation will analyze the growing influence of sustainable mining, and look at five pillars that support its practice from an environmental, health, safety and social (EHSS) lens. These key pillars include: 1) building operational excellence; 2) fostering holistic water management; 3) driving social performance; 4) engaging across the project lifecycle; and 5) managing closure from the start. We will examine how sustainable mining applies and what it looks like for the Northwest Territories and elsewhere in the North. We will identify the drivers of change in society and the economy that, in turn, drive changing expectations and requirements for project performance. The drivers include positive forces that are changing market demand, and the disruptors – both of which require companies to build a new narrative and revise their approach. The mining sector can accomplish this by investing in their people, transforming their processes, improving their stakeholder relationships, and optimizing their supply chain, resulting in an integration of business, community and environmental objectives. It requires a holistic view of what you were, what you are now, and the legacy you want to build for the future. The presentation concludes with highlighting the work required to define the strategy and objectives to achieve 'the mine we want to see'.

DIAVIK DIAMOND MINE UPDATE

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Over the past year, the Diavik Diamond Mine continued to make significant contributions through its mining operation on Lac de Gras, NWT. The mine is the second largest diamond mine in the NWT (and in Canada), but the largest producer of Canadian rough diamonds. Production has been augmented in 2018 with the official opening and start of mining from a new ore body called A-21.

ACTIVITIES OF THE CANADA-NUNAVUT GEOSCIENCE OFFICE 2018

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The Canada-Nunavut Geoscience Office (CNGO), established in 1999, operates as a tripartite government office being co-funded and co-managed by three partners – Natural Resources Canada, Crown-Indigenous Relations and Northern Affairs Canada and the Government of Nunavut. The CNGO is Nunavut's de-facto geological survey with the mandate to provide accessible geoscience information and expertise 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.

Most of CNGO's research involves collaboration with university and government partners. 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. Thematic studies include detailed research (e.g., Paleozoic stratigraphy) to understand Nunavut's geology. Research for infrastructure needs includes permafrost and aggregate studies and energy-related research involves petroleum and uranium studies. Data dissemination – publication of maps, reports and datasets through publicly accessible websites – and community communication efforts ensure the timely release of research results. The CNGO disseminates its geoscience data through many avenues, including the annual Summary of Activities initiated in 2012.

A new project over a large area of northwestern Baffin region is a multi-faceted collaborative research project involving CNGO and several Canadian universities (Laurentian, UQAM, McGill). The project's mandate is to fill in some of the remaining gaps in geoscience knowledge. In 2018, bedrock and surficial geology mapping on the southern part of the study area followed on a geophysical survey; the northern part will be studied in 2019. A Strategic Partnership Grant from the Natural Science and Engineering Research Council of Canada allowed collaborative research projects for graduate students. These thematic research projects were focused on the tectonic history of the area; the possible record of Earth's early lifeforms in old sedimentary rocks; the thickness of beds and presence of fossils in younger sedimentary rocks; and the glacial history of the region.

Bedrock mapping focused on the Wager shear zone on the northwestern coast of Hudson Bay is currently the subject of a M.Sc. thesis. The Western Hudson Bay compilation project along the western coast of Hudson Bay from the Manitoba border to Rankin Inlet is compiling all existing aggregate, mineral potential, surficial geology, land cover, and permafrost data for

this area. The western Kitikmeot region contains several areas with well-exposed sedimentary rocks. These rocks were part of a collaborative study between Laurentian and the CNGO to understand better the geological history of the land, and to explore for economic commodities such as uranium and carving stone.

Understanding ice-flow direction and important geomorphological processes is critical for interpreting the geochemistry and mineralogy of surficial sediments. Surficial interpretation studies continued over Southampton Island and Foxe Peninsula. Lake sediment data from Baffin Island is being reanalysed, using updated analytical techniques. A continuing project using the RV Nuliaiuk is gathering information to support infrastructure development in the city of Iqaluit by characterizing the seabed morphology, sediments, and marine geohazards.

NORTHWEST TERRITORIES ENVIRONMENTAL STUDIES RESEARCH FUND: FUNDING RESEARCH IN THE NWT RELATED TO THE PETROLEUM INDUSTRY

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The Northwest Territories Environmental Studies Research Fund ("NT-ESRF") is now into its fourth year of operation. Authorized under the Petroleum Resources Act, the NT-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 costs of the NT-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 NT-ESRF Management Board ("Board") oversees operation and management of the fund. The Board is composed of representatives from government, industry and the public. Board Members are appointed by and serve at the pleasure of the Minister of Department of Industry, Tourism and Investment, Government of the Northwest Territories. The Board supports high-calibre research related to the petroleum industry and will continue 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. While wildlife and groundwater research are the current priority, funding has also been provided for innovative projects such as the Aurora Research Institute native seed initiative. Maintaining research programs that support fact based decision-making related to energy development, is an excellent investment in the future of the petroleum industry in the NWT.

A SEQUENCE STRATIGRAPHIC FRAMEWORK BASED ON HIGH-RESOLUTION CHEMOSTRATIGRAPHY AND SEDIMENTOLOGY OF THE HARE INDIAN FORMATION, CENTRAL MACKENZIE VALLEY, NORTHWEST TERRITORIES

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The Givetian age Hare Indian Formation, part of the Middle to Late Devonian Horn River Group and located in the Mackenzie Mountains and Central Mackenzie Valley of the Northwest Territories, is a mudstone comprising a lower organic-rich shale named the Bluefish Member, and an upper grey shale named the Bell Creek Member. Previous studies of the Hare Indian Formation have assessed geochemistry at a fairly coarse sampling rate, 0.5 metre or coarser, and focused on the lithostratigraphy of the Horn River Group. This study uses high-resolution data collected using a portable x-ray fluorescence (XRF) instrument and attempts to integrate these geochemical data with sedimentological data in order to produce a sequence stratigraphic framework. Sample spacing ranges from 10 centimetres to 1 metre for both core and outcrop samples, with additional sampling around features of interest. Cores analysed in this study include the MGM Shell East Mackay I-78 core, the Husky Little Bear N-09 and H-64 cores, and the Conoco Phillips Loon Creek O-06 and Mirror Lake N-20 cores. Outcrop data are from the Mountain River (65° 14’ 21.7” N, 128° 35’ 40.6” W), the West Powell Creek (65° 16' 37.20" N, 128° 46' 26.40" W), and the Dodo Canyon (65° 0' 7.20" N, 127° 20' 45.60" W) outcrops. Data are interpreted in a transgressive-regressive (T-R) sequence stratigraphic framework using elements associated with detrital origin (Al, K, Fe, Ti; together referred to as terrigenous indicators) as geochemical proxies to infer maximum flooding and maximum regressive surfaces. Regression is interpreted where terrigenous indicators increase; conversely transgression is inferred when indicators decrease. In addition, proxies including molybdenum, nickel, and vanadium enrichment are used as paleoredox indicators, and the ratio of silicon to zirconium is used to infer silica source (terrigenous vs. biogenic). Early results suggest regression throughout the Hare Indian Formation, with two parasequences within this overall trend. Data also indicate a primarily terrigenous source of silica, and euxinic conditions during deposition. The sequence stratigraphic framework formed from these data will assist in the mapping and characterization of unconventional reservoirs in the Hare Indian Formation, and assist in the understanding of the sequence stratigraphy and depositional environment of the Horn River Group.

ENBRIDGE LINE 21 SEGMENT REPLACEMENT PROJECT

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The Enbridge Line 21 Segment Replacement Project replaced 2.5 kilometers of pipeline below the Mackenzie River using intersect horizontal directional drill technology. Through a partnership with local Indigenous

communities, a joint environmental management committee was formed to focus on protecting the land and water, and support local training and employment. On September 27, 2018, the Norman Wells Pipeline was restarted successfully.

Successful execution of this Project required creativity to overcome logistical challenges. The replacement pipeline was installed over 140 metres below the river, significantly deeper than the replaced pipeline. The intersect drill spanned over 2100 metres. Due to the remote location and sensitive environment, equipment was barged to one of the worksites and over 14,000 wooden mats were used to construct an 11 kilometre road. The construction window was short and the intersect drill was highly technical.

This presentation will focus on the construction aspects of the Project.

UPDATE ON THE BIOENGINEERING TECHNIQUES FOR REVEGETATION OF RIPARIAN AREAS AT THE COLOMAC MINE, NT: SEVEN YEARS LATER

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Factors such as nutrient poor soils, harsh climate, remote locations, and high costs make revegetating disturbed areas in northern environments a challenge. A case study is presented where innovative bioengineering and project planning techniques were employed to revegetate and remediate three riparian areas at Colomac Mine, an abandoned gold mine 220 km north of Yellowknife, NT. The revegetation plan focused on establishing pioneer species and facilitating natural recovery and succession. A "rough and loose" technique was used to allow the soil to capture and retain moisture, trap windborne seed, promote easy root penetration and prevent erosion. Harvesting and planting local willow cuttings (*Salix sp*.), alder (*Alnus viridis*) seeds, and sedge plugs ensured that the vegetation planted at these sites was adapted to local climate and soils. Monitoring included vegetation counts, percent vegetation cover and photographic documentation. After seven years, vegetation cover was 80% to 100% where bioengineering techniques were used, and there was no further loss of the plants and cuttings that had survived during the first two years. Dense thickets of alder were growing in drier areas. Fifty five plant species not planted have germinated. The bioengineering techniques implemented provided a successful, cost effective, and local approach to revegetation.

RESULTS OF THE TUNDRA MINE, NT REVEGETATION TRIAL USING LOCALLY HARVESTED PIONEER SPECIES INSTEAD OF GRASS SEED AND FERTILIZER

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The abandoned Tundra Gold Mine, 240 km northeast of Yellowknife, NT, is located in the transition zone between the boreal forest and the tundra. The shorter growing season,

extreme cold, low precipitation, shallow depth of nutrient poor rocky soils, desiccating winds and the presence of permafrost make revegetation efforts challenging. The 2015 trial focused on establishing locally harvested pioneer species to facilitate natural recovery and succession as an alternative to using native and non-grass seed and fertilizer. The soils were mechanically loosened creating a 30 m by 70 m plot of offset holes on the side of the former tailings pond leaving six control plots (4 m by 4 m) within the trial to compare growth on loosened soils to compacted soils. No soil amendments were added. After one year 81% of the 93 1.2 m long live dormant willow (*Salix athabascensis*) cuttings produced shoots. 90 transplant plugs each of *Juncus stygius, Juncus drummondii, Equisetum arvense* and *Carex aquatilis* were planted in 30 groups, half in the control plots and half in the adjacent rough and loose, with an 83% and 86% survival rate, respectively. Significant plant growth was observed in the second year over the first year when plants were diverting resources to root growth at the expense of shoot growth.

HYDROTHERMAL AND METAMORPHIC FLUID-ROCK INTERACTIONS ASSOCIATED WITH DIRECT SHIPPING IRON ORE IN THE MARY RIVER GROUP, NORTH BAFFIN ISLAND

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Originally discovered in the mid 1960s, regional geological mapping has identified direct shipping iron ore (DSO) within high-grade gneisses correlated to the Mary River Group (MRG) on Northern Baffin Island. The MRG forms the northern extension of the central Rae Committee Bay Belt. On north Baffin the MRG is characterized by lower metagreywacke overlain by a BIF-komatiite-quartzite cover sequence. Regionally, the BIF member hosts high-grade magnetite ores, with grades averaging 65 wt % Fe.

Baffinland Iron Mines' direct shipping ore deposits and prospects cover a vast extent of Northern Baffin Island, covering variable metamorphic and structural terranes. This study uses Deposit No. 1, Baffinland's flagship deposit, as a type-section for MRG stratigraphy and a comparative benchmark for fluid-rock interactions in the DSO forming processes. Detailed petrography, bulk rock geochemistry and microprobe mineral analyses have been employed to determine the protoliths of the host-rock units to try to correlate them to traditional MRG stratigraphy.

LA-ICP-MS analysis has been used to determine that least-altered BIFs across the study areas in the MRG have very similar major oxide, trace element and rare earth element (REE) patterns, typical of Algoma-type BIFs found in the Prince Albert and Woodburn Lake groups on mainland Nunavut as well as other districts globally. As there is no global standard for Algoma-type BIFs, Deposit No. 1 serves as the baseline for regional comparisons. At the mineral scale, enrichment and depletion trends of major oxides are typical of DSOs globally, however significant regional variation is observed in trace elements and REEs. These variations are attributed to fluid source and country rock differences as well as disparate metamorphic grade. Fluid chemistry, metamorphic grade and structural preparation/control are seen to have an effect on the physical characteristics of the ore.

Timing of the metamorphic events that led to the natural beneficiation of the DSO is congruent across the MRG. Metamorphic zircon, monazite and titanite dating has tied the ore forming event to the Transhudson Orogen at ~1.83 Ga. LA-ICP-MS techniques were used for in-situ dating of monazites in DSO, as well as a novel new approach of directly dating hematite itself. Dates from rocks hangingwall and footwall to the orebodies have been used to correlate MRG stratigraphy across North Baffin, decipher regional metamorphic events and to help shape deposit formation models.

ECONOMIC FACTORS AND THEIR IMPLICATIONS FOR THE DEVELOPMENT OF A COMMERCIALLY VIABLE GEOTHERMAL PROJECT

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Geothermal energy requires accessing warm to hot brines useful for electrical generation or direct-use. The development pathway can be an up-hill battle; both time consuming and costly. Although geothermal energy provides developers with significant long-term stability, low operating costs (OPEX), and high energy availability (above 90%); getting into production is the challenge. Currently, brine temperatures above 170°C are best suited for electrical generation with greater efficiencies the higher the brine temperatures. Systems generating electricity from dry steam (for example the Geysers in California) offer the greatest efficiencies. Electricity can also be generated from brines with temperatures between 120°C and 170°C. These systems generally use an Organic Rankin Cycle system. Wells must be pumped as they do not spontaneously flow like those at higher temperatures and the brine is used to heat a secondary fluid that run the generator. Several companies are working on turbines and heat-engines that produce electrical energy from waters as low as 70°C. It is project specific whether these low-temperature systems are efficient enough to be economical because they require large pumped water flows. Pumping requires significant energy called “parasite load”. Geothermal Power plants that use pumped wells typically expend 50% of their energy needs on parasite load. Pumping costs become an important consideration for the OPEX of these plants; ultimately determining if the plant can be economic. As an example, to generate 1 MWe from water with temperatures between 110°C and 120°C, requires between 60 and 70 kg/sec of mass flow.

Some authors have suggested that existing gas and oil wells can be used to produce geothermal power. Typical gas and oil wells have a diameter of 4 ½ or 5 ½ inches. Volumetrically, a one-foot section of pipe holds 3 to 4.5 liters of brine at these pipe diameters. Geothermal wells use larger diameter pipe (9 ⅝ to 13 ⅜) which can hold between 10.5 and 31 liters of fluid in a one-foot section. This volume difference means that the potential mass flux of larger diameter wells is significant and can result in the useful production of brines to power electrical generation. It is also why oil and gas wells are unlikely to be useful for electrical generation. Oil and gas wells might flow enough fluid for direct-use purposes, but the value of the energy may not be enough to offset the pumping costs.

In the context of the Northwest Territories (NWT), the most likely geothermal development area is within the northern parts of the Western Canada Sedimentary basin extending northward from Alberta. Currently, information is limited as to the

potential brine flows that could be produced from purpose drilled geothermal wells in NWT. Although transmission is available in some area, building infrastructure is costly. For direct-use applications the load (consumers) must be relatively close to the source. But given the mean monthly temperatures in NWT are below 0°C for 7 months of the year, the heat value from even a low-temperature geothermal resource could be of significant value even for small communities.

OSISKO METALS – EXPLORING TWO SIGNIFICANT BASE METAL CAMPS

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Jeff Hussey is President, CEO and director of Osisko Metals. Osisko Metals is a Canadian exploration and development company creating value in the base metal space. The Company has secured significant positions in Canada's two premier historical zinc mining camps, namely the Pine Point Camp ("PPMC") located in the Northwest Territories and the Bathurst Mining Camp ("BMC"), located in northern New Brunswick. At Pine Point, the objective is to upgrade 50 Mt of near surface historical zinc resources that Cominco outlined between 1964-1988. Pine Point is unique as it is the only pure play, open pit zinc development project globally. Following the conversion of the historical resources to NI43-101 categorization, the next step is to proceed with an innovative brownfield exploration program in 2019. The plan is to utilize updated geological interpretations and modern tools including LIDAR and airborne gravity geophysical surveys that were not available to previous operators. In the BMC, Osisko Metals is also focused on upgrading historical resources and performing brownfield exploration in the 3rd largest Volcanogenic Massive Sulphide camp in the world. Osisko Metals also owns a portfolio of grassroot exploration projects in Québec.

HIGH-GRADE IRON ORE DEPOSITS AT MARY RIVER NORTH BAFFIN ISLAND, NUNAVUT

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The Mary River area on northern Baffin Island is emerging as a major high-grade iron ore camp with several variably delineated deposits, the largest in excess of 600 mt of 66% Fe. Hosted within a prominent Algoma-type banded iron formation (BIF), the deposits are preserved and thickened within fold belts of variable scale. The direct shipping ores (DSO) are characterized by exceptionally high Fe grades, low deleterious element content, and a high lump potential. The ore requires no processing, only crushing and screening.

First production occurred in August 2014 at Deposit No. 1. Delineation drilling continues, and exploration drilling has resumed at Deposits 2 and 3. The ores are being shipped to the European and Japanese steel industries and are marketed as Lump (DSP) and Fine (SSF) products. During 2017, 2.9 mt of DSP (68.1% Fe) and 1.2 mt of SSF (67.1% Fe) were shipped. Production in 2018 is anticipated to be ~6 mt of DSO.

THE FURY AND HECLA GEOSCIENCE PROJECT: OVERVIEW OF THE 2018 REGIONAL BEDROCK MAPPING AND THEMATIC RESEARCH

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The multi-disciplinary Fury and Hecla Geoscience Project is led by the Canada-Nunavut Geoscience Office in partnership with McGill University, Laurentian University, and the Université du Québec à Montréal. Through 2017–2020, the project aims to generate new geoscience knowledge in the under-explored areas of northern Baffin Island and Melville Peninsula around the Fury and Hecla Strait. These areas are underlain by Archean to Paleoproterozoic rocks of the Rae Craton basement, Meso- to Neoproterozoic sedimentary rocks of the Fury and Hecla Group, and (sub-)volcanic products tentatively related to 1.27 Ga Mackenzie and 723 Ma Franklin igneous events. Specifically, the project aims to improve the mapping resolution and tectono-thermal history of the basement rocks; provide a solid framework for the sedimentology, stratigraphy, micro-paleontology, and sedimentary provenance of the hitherto poorly detailed Fury and Hecla Group; constrain the timing, duration and paleomagnetic signature of (sub-)volcanic magmatic events; and explore the potential for economic mineral and carving stone deposits in the study area.

Here we highlight the field observations and preliminary interpretations from the 2018 field season. Most basement rocks comprise variably deformed granodioritic–monzogranitic orthogneiss with pods and lenses of ultramafic, mafic and supracrustal rocks at amphibolite facies, which are cut by monzo- to syenogranite dykes, sills and small plutons. Foliated K-feldspar-phyric monzodiorite predominates in the east, while mafic, ultramafic, siliciclastic and iron-rich supracrustal rocks (possibly correlative with the 2.72 Ga Mary River Group) were found in the western part of the study area. Large, deformed mafic–ultramafic intrusions are associated with magnetic anomalies; their potential for mineralization is being evaluated.

Sedimentologic and stratigraphic work in the Fury and Hecla Group focused on sandstones, shales, and minor carbonates found in the Nyeboe, Sikosak Bay, Agu Bay, Whyte Inlet, and Autridge formations. The Nyeboe Formation preserves evidence of a remarkable variety of sub-aerial to shallow-marine depositional environments. Black shale samples from the Agu Bay and Autridge formations represent prospective targets for Rhenium-Osmium geochronology and host well-preserved assemblages of microfossils. Basaltic flows and gabbro dykes and sills across the study area were systematically sampled to constrain their age and paleomagnetic records, and test correlations with the Mackenzie and Franklin igneous events through geochemistry. The Hansen Formation, previously interpreted as a set of sub-aerial lava flows in the Fury and Hecla Group, has been tentatively reappraised as a sill that cuts the basin stratigraphy. Potential for uranium mineralization is demonstrated where the

nonconformity between the Rae Craton basement and Fury and Hecla Group is displaced by fault zones that are cored by quartz stock-work.

DIRECT DISCOVERY OF CONCEALED KIMBERLITES WITH MICROBIAL COMMUNITY FINGERPRINTING

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Mineral exploration in Canada is becoming increasingly complex as the majority of undiscovered commodities are likely deeply buried beneath significant glacial overburden and bedrock, reducing the effectiveness of many existing tools. The development of innovative exploration protocols and techniques is imperative to the continuation of discovery success. Preliminary experimentation has demonstrated the potential viability of microbial fingerprinting through genetic sequencing to directly identify the projected subcrop of mineralization in addition to the more distal entrained geochemical signatures in till. With the advent of inexpensive modern sequencing technology and big-data techniques, microbiological approaches to exploration are becoming more quantitative, cost effective, and efficient. The integration of microbial community information with soil chemistry, mineralogy and landscape development coupled with geology and geophysics propagates the development of an improved decision process in mineral exploration. Soils over porphyry, kimberlite, and VMS deposits have undergone microbial community profiling. These community-genome derived datasets have been integrated with trace metal chemistry, mineralogy, surface geology and other environmental variables including Eh and pH. Analyses of two kimberlites in the Northwest Territories show significant microbial community shifts that are correlated with subsurface mineralization, with distinctive microbial community profiles present directly above the kimberlite. The relationship between microbial profiles and mineralization leads to the use of microbial fingerprinting as a method for more accurately delineating ore deposits in glacially covered terrain. As databases are developed, there is potential for application as a field based technique, as sequencing technology is progressively developed into portable platforms.

ARSENIC FROM LEGACY ROASTER EMISSIONS IN SOILS IN THE YELLOWKNIFE AREA

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The objective of this research was to investigate concentrations and speciation of arsenic in soils within 30 km of Yellowknife to identify whether arsenic in soils is from a natural geologic source or is derived from past industrial activities. Over 400 samples were collected as soil cores from locations not on mine property and undisturbed by buildings, roads, mining or other visible human activities. This was done to minimize the influence of recent post-mining activities and examine the effect of natural processes

and the legacy of airborne emissions from former ore roasting. Most of the analyses have been conducted on the Public Health Layer (top 5 cm). The concentration of arsenic in these near-surface soils measured up to 4700 mg/kg with some of the highest concentrations found near the new Giant Mine bypass road west of the former Giant Mine roaster. Forty soil samples collected from below the Public Health Layer (approximately 10 cm to 40 cm below the surface) were analysed and are lower in total concentration of arsenic than the corresponding samples from the Public Health Layer, with the exception of two samples.

Mineralogical analysis was conducted on almost 100 soil samples and, of these, 80% contained arsenic trioxide, indicative of roaster stack emissions. The common occurrence of arsenic hosted as arsenic trioxide also explains why arsenic concentrations are highly variable at the local scale, and even between field duplicates, likely because of the uneven distribution of very arsenic-rich compounds in the soil samples. Another roaster-generated compound, iron oxide, was also recognized in the soils. Arsenic content in iron oxides from samples collected near Con Mine was significantly less than arsenic content in iron oxides from Giant Mine, offering a potential avenue for distinguishing contamination between the two mine sites.

Remediation guidelines for arsenic in Yellowknife area soils were established based on an estimated natural background concentration of 150 mg/kg with a reasonable upper limit (90th percentile) of 300 mg/kg. The current guidelines of 160 mg/kg (residential) and 340 mg/kg (industrial) were largely based on this background estimate and the assumptions that: 1) there was limited public access to arsenic-bearing soils; and 2) that exposure would be limited by the cold climate. These new results indicate many areas within and near Yellowknife where soil concentrations in the most accessible part of the soil profile are much higher than current guidelines and that arsenic is hosted primarily as arsenic trioxide, which is considered one of the most bioaccessible forms of solid phase arsenic. In light of this new information, it is suggested that the remediation criteria for soils in the Yellowknife area be revisited to reflect potential increased public exposure to high arsenic soil in the region.

THE NORTHWEST TERRITORIES "LINE OF DELIMITATION" A PRODUCT OF DEVOLUTION – DESIGNED USE VS. INTERPRETED USES

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The line of delimitation is a boundary line which splits oil and gas licences in the Beaufort Delta between onshore (territorial) and offshore (federal) jurisdiction. The line of delimitation for the Northwest Territories was created during and as a result of the devolution process between the Government of Canada, the Government of the Northwest Territories and Indigenous governments. One of the main purposes was to define the limits of federal and territorial responsibilities; another was to define the limits of the resources for governance.

The line of delimitation is ideal for splitting oil and gas licences between the two jurisdictions, however it does not split discovery areas between the jurisdictions. The line also is not a complete line from the Yukon border to the Nunavut border. There

are many possible reasons for this, but in any event this needs to be addressed as the intended use was splitting licences, but without a complete line from border to border there is a great deal of ambiguity in the eastern portion of the coastline of the Northwest Territories, even though the original intent of the line was not to continue across to the Nunavut border, it has been used by various groups as a means to delimit other resource jurisdictions.

There is no other provincial area in Canada with the unique combinations of resources straddling the coastline with three different levels of government; federal, territorial and indigenous governments. As part of Arctic policy and governance advancement, there should be a concerted effort to create a line of delimitation for all three territories and the federal governments' offshore jurisdiction.

COMPILATION OF NORTHWEST TERRITORIES PERMAFROST DATA

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Knowledge of permafrost conditions is an essential component of environmental research and monitoring, resource development projects, and infrastructure design and performance monitoring. In the north, various needs drive the collection of permafrost geotechnical and ground temperature data including government and industry infrastructure projects, academic research, and regulatory monitoring. Research programs typically summarize the permafrost conditions in academic publications. Regulatory monitoring data accompanies reporting to the responsible authorities. Geotechnical information collected for development purposes is usually summarized in infrastructure design and maintenance reports.

Although ground temperatures are regularly measured in the Northwest Territories (NWT), the data usually reside with the research institute, government agency, or private industry consultant that collected them. Data are typically not retained by institutions that are best suited to manage and archive temperature data and records, such as the Northwest Territories Geological Survey (NTGS), or the Geological Survey of Canada (GSC). As geotechnical and ground temperature data are expensive to collect, especially in remote areas, it is beneficial for the Government of Northwest Territories (GNWT) to house this information and make it publicly accessible for use in research, monitoring, and future development projects.

Permafrost data collected in the NWT are being compiled by the NTGS and collaborators at Carleton University, Wilfrid Laurier University, GSC, and Tetra Tech Canada Inc. Metadata templates have been developed for ground temperature records and geotechnical data so that information is described in a common and standardized way. The metadata templates include information on project details, site location and conditions, instrument installation, ground temperature record, permafrost conditions, and related publications and data. Metadata helps with understanding the conditions in which the permafrost data were collected and with the interpretation of those data.

A significant amount of permafrost data has been collected along the Inuvik to Tuktoyaktuk Highway (ITH) corridor. The

ITH geotechnical legacy represents a focal point for developing a data management system because of the volume and quality of the data, the relevance to a major infrastructure investment, and the national and international research interest in the region. The GNWT is working to find resources to develop and sustain an ITH permafrost data management system, which can act as a model for data collected across the territory. The collection and management of NWT permafrost data is becoming increasingly important because climate change is influencing environmental systems, transportation and community infrastructure, and the frequency and severity of geohazards. Capacity investment is required to preserve permafrost data so they can inform decisions on mitigation, climate change adaptation, and responsible development.

EMERGING TECHNOLOGIES AND FUTURE COMMODITIES

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With the rise in demand for minerals used in emerging technologies (including electric cars, high-speed rail, renewable energy, and advanced weapon systems), Northwest Territories mining projects focused on tungsten, cobalt, lithium, zinc, beryllium, and others commodities are advancing to address the anticipated demand. Recent mergers and acquisitions in the Northwest Territories mining space, along with current mining operations, focusing on the diamond mines and operations in Northwest Territories will also be discussed.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY OVERVIEW FOR 2018

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With a territorial election scheduled for late 2019, there is an ongoing effort by the Government of Northwest Territories (GNWT) to complete priority actions and initiatives mandated by the 18th Legislative Assembly. The Northwest Territories Geological Survey (NTGS) is active on several of these initiatives. NTGS staff are helping to implement the Climate Change Strategic Framework, the Knowledge Agenda, and an initiative currently termed the Knowledge Economy. We also participate in a multi-departmental committee that focuses on Yellowknife-area legacy contamination. NTGS collaborates extensively with other divisions of the Department of Industry, Tourism and Investment and with the departments of Infrastructure, Lands, and Environment and Natural Resources. Our primary goal is to be a reliable source of impartial advice and research-based information – in other words, to fulfill the "honest broker" role that geological surveys across Canada strive for.

In terms of more traditional work objectives, the NTGS remains focused on projects that address important geoscience knowledge gaps. Most of these projects also anticipate future needs associated with resource exploration, land use decisions, and understanding the effects of climate change. For example, bedrock mapping continues in the Archean Slave Province in the region of a proposed all-weather road. Although several greenstone belts in this region are withdrawn from mineral claim staking, others remain

open and have been prioritized for detailed remapping. Similarly, the undeveloped Mactung tungsten deposit has seen renewed mapping and NTGS-supported graduate student work in order to update the geoscience knowledge of this world-class resource. The Cantung mine area is also being studied to better understand the bedrock geology of the deposit and the area and the potential for recovery of tungsten mineralization from mine tailings.

Permafrost research at the NTGS has a current northern focus as thaw slump and landslide activity increases and the Dempster and Inuvik-to-Tuktoyaktuk highways experience permafrost-related change. There is a need for additional permafrost research capacity within the GNWT to address fundamental goals of the Climate Change Strategic Framework. The NTGS appreciates the efforts of senior managers and other departments and research groups in recognizing and addressing this need.

Petroleum geoscience research continues to target basin evolution, thermal modelling, and petroleum potential of the Central Mackenzie Valley region with a focus on the Devonian Horn River Group shales. Another project has gathered information on conventional discovered natural gas resources that are relatively shallow and close to infrastructure. Some of these resources may be amenable for additional study and possible development. The Petroleum Geosciences Group is also seeking funds for geothermal research and is co-hosting a one-day geothermal workshop immediately following this Geoscience Forum.

Geoscience information, geomatics, and information technology services and client-focused projects continue to be capably addressed by two working groups within the NTGS. The Mining Incentive Program, geoscience education and outreach, NTGS publications, map production, web services, and other activities delivered by these groups both underpin and complement the research-related work conducted by most other NTGS staff.

WASTE ROCK MANAGEMENT AT PINE POINT

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Development of a Waste Rock Management Plan for the Pine Point development project is underway. Various rock formations from former open pits are being evaluated by sampling pit walls and waste rock stockpiles. Historical and current tests from different formations are being used for the analysis. Future studies will qualify waste rock types and quantify volumes of potential waste rock from mining activities. Preliminary results indicate that future waste rock management at Pine Point is expected to be relatively straightforward as the majority of the waste rock will be dolomitic limestone that has a high neutralization potential. A small component of the waste rock may need to be segregated and contained due to sulphide content. It is expected this rock can be easily distinguished for classification and appropriate disposal. Existing dry and wet open pits at Pine Point are currently being considered as potential sites for disposal of waste rock.

MARIAN WATERSHED STEWARDSHIP PROGRAM

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The Tłı̨chǫ Government is working together with Wek'èezhìi Land and Water Board (WLWB) and additional partners to develop the Marian Watershed Stewardship Program (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 K'eagoti (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 2018 to bring back the results from the 2017 samples season (K'eagoti - Hislop Lake) and to develop a long term monitoring plan that truly addresses the concerns of the elders and communities.

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.

NEW PUBLIC RELEASE OF 1:50,000 SCALE SURFICIAL MAPPING AND A DEGLACIATION HISTORY OF THE SOUTHERN SLAVE GEOLOGICAL PROVINCE: A MAJOR DATA DONATION

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Surficial geology maps at 1:50,000 scale covering 84 NTS sheets in the southern Slave

Geological Province (SGP) and interpretation of the area's deglaciation was recently received and published by the Northwest Territories Geological Survey (NTGS). The mapping and interpretations were completed by the first author and owned by GGL Resources Corp. (GGL) who have now donated the compilation to the public. The compilation of the database, editing, formatting, and publication was facilitated through a collaboration between John Knight, GGL, Aurora Geosciences, and the NTGS. This presentation describes the publicly available digital database and outlines the publication's main scientific results.

The mapping of surficial materials was completed from the air between 1995 and 2012 using ground truthing. It emphasized the reworking of surficial materials by meltwater. The 1:50,000 maps were compiled into five overview maps at 1:200,000, each of which covered a region containing distinctive mixes of deglaciation features. Overview map A (south-west), centered over Gordon Lake, displays extensive areas of fluvially washed bedrock, an extensive boulder field and small yet widespread areas of reworked till and glaciofluvial sediments. Overview map B (north), from Mackay Lake to Point Lake, displays continuous till cover broken by well-ordered esker complexes within well-defined melt-water erosion corridors hosted by till. Overview map C (center), centered over Mackay Lake, display less ordered esker complexes hosted by a mix of till and moderately reworked till. Overview map D (south-east), from Courageous Lake to Walmsley Lake, displays a mix of all of these features. Overview map E, that covers the Desert Lake area to the south-west of Yellowknife, displays a large drumlin field.

The interpretation of maps A to D indicates that the area can be divided into three distinct elevation zones representing different deglaciation processes. A washed bedrock zone below approximately 380 meters above sea level (a.s.l.) includes vestiges of both esker complexes and till. A transition zone between approximately 380 meters a.s.l. and 420 meters a.s.l. includes disrupted esker complexes that are mostly hosted by moderately reworked till. An esker complex zone, present above approximately 420 meters a.s.l., includes esker complexes displaying varying degrees of order and fluvial reworking.

The differences between the surficial features in the three elevation zones are thought to be related to the coherence of the seal between ice and bedrock, ice and bedrock topography and the presence of glacial lake McConnell. In the washed bedrock zone, disorganized bedrock-controlled wasting of the ice sheet, from west to east, took place under the influence of glacial lake McConnell. In the esker complex zone, self-organized channeled wasting of the stagnant ice sheet took place. The degree of ordering and the active length of the complexes are strongly influenced by ice and bedrock topography. The transition zone joins the two.

This compilation offers the first publicly documented large-scale evaluation of till preservation state over the Slave Geological Province. It is a valuable new tool to assess till sampling suitability for the design of drift exploration programs.

BEDROCK MAPPING IN THE JOLLY LAKE AREA: A NEW LOOK AT THE >3.0 GA BASEMENT GRANITES AND THEIR RELATIONSHIPS TO THE CENTRAL SLAVE COVER GROUP AND THE NORTHERN-MOST BEAULIEU RIVER VOLCANIC BELT

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In 2018 the Northwest Territories Geological Survey conducted the first year of a multi-year bedrock mapping initiative in the Jolly, Mohawk, and "Dragon" lakes area. The study area is approximately 230 km north-northeast of Yellowknife and west of Courageous Lake. Previously mapped at 1:250 000 scale, this area has been revisited as it sits adjacent to the proposed all-season Slave Geological Province access corridor. Mapping within the northern-most Beaulieu River Volcanic Belt was conducted at 1:10 000: the surrounding granitoid complex warranting mapping at 1:50 000 scale.

The objectives of the project were to: 1) increase the detail of mapping of an area of granites comprising Central Slave Basement Complex rocks and post-tectonic granitic plutons to establish their relative age, 2) to study the relationships of the pre-, syn-, and, post-volcanic belt aged plutonic bodies with the 2.9-2.8 Ga Central Slave Cover Group and the ca. 2.7 Ga volcanic rocks of the Beaulieu River Volcanic Belt, 3) elucidate the nature and timing of thermotectonic events both prior to and subsequent to volcanic belt deposition, 4) provide a more detailed understanding of the architecture of the Slave craton with which to place regional Au and VMS mineralizing events, 5) and to gain a better understanding of the geological history and crustal architecture of this area in advance of the proposed All-Season Slave Geological Province access corridor.

Local geology in the Jolly Lake area is dominated by granitoid rocks of various ages, both as part of the Central Slave Basement Complex and of younger supracrustal origin. The oldest rocks are a mix of polydeformed granitic to tonalitic plutons that are gneissic and/or migmatitic. In the southwest part of the map area basement granites are overlain by the ca. 2.9 Ga Central Slave Cover Group and ca. 2.7 Ga volcanic rocks of the northern-most Beaulieu River Volcanic Belt. These volcanic rocks are dominated by massive and pillowed basaltic flows with minor amounts of rhyolite, basaltic pillow breccia, and mafic and felsic volcanoclastic deposits. In addition, the area has been intruded by post-volcanic belt granites and mafic Lac de Gras (?) dykes. The nature and timing of thermotectonic events both prior and subsequent to volcanic belt deposition was studied. A protracted history of regional folding and shearing along the N-S Beniah Fault Zone is preserved in the various aged rock in the study area.

PERMAFROST AND TERRAIN RESEARCH FOR THE DEMPSTER AND INUVIK-TUKTOYAKTUK HIGHWAY INFRASTRUCTURE CORRIDORS

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Permafrost thaw and climate change are major stressors on northern infrastructure. Societal consequences of permafrost thaw in the rapidly warming Beaufort Delta region are significant because the area hosts the greatest density of Arctic communities, historic northern oil and gas exploration infrastructure, and the longest road network constructed on ice-rich permafrost in Canada. The Dempster and Inuvik to Tuktoyaktuk Highways (ITH) connect the Beaufort Delta region with southern Canada and comprise a 400 km-long corridor within NWT. This corridor transitions from warm (0 to -2 °C) to cold (<-4 °C) permafrost, traverses glaciated and unglaciated terrain with varying ice contents, and intersects a range of hydrological and ecological environments. The diverse range of geologic, climatic, and ecologic conditions yield gradients that facilitate research on permafrost variability and Arctic change, while at the same time presenting challenges to developing and maintaining northern infrastructure. The objective of this presentation is to summarize recent scientific research results conducted along the Dempster-ITH corridor with focus on: A) Spatial heterogeneity in ground temperatures in natural settings and along infrastructure; B) Terrain mapping and ground ice distribution, and; C) Integrating field observations with new remote sensing and modeling techniques to document permafrost dynamics in natural and built environments. These summaries provide context for part two of the presentation which pertains to the need for a regional research strategy related to terrain, permafrost, and infrastructure.

The Dempster-ITH road corridor provides a unique opportunity to develop a societally-relevant, northern-driven permafrost research network to support planning and maintenance of infrastructure, regulation, monitoring of climate change impacts, and informed adaptation. A network with a corridor focal point encourages collaboration and pure and applied studies that engage stakeholders, community participation, and support northern interests. Successful implementation requires leadership and institutional support from the Government of the Northwest Territories and Inuvialuit and Gwich'in landowners, and coordination between research organizations including NWT Geological Survey, Aurora Research Institute, Geological Survey of Canada, and universities to define key research priorities, human and financial resources to undertake studies, and protocols to manage data collection and reporting. The development of resilient researcher-stakeholder-community relationships is also necessary for the scientific and research initiatives to reach their potential. Ongoing efforts along the

Dempster-ITH corridor include: A) Consolidation and dissemination of existing datasets; B) Monitoring conditions at disturbances including quarries; C) Monitoring thermal evolution of permafrost across climate and ecological gradients and testing effects of snow manipulation to inform infrastructure management; D) Study of permafrost hydrology and road interactions, and; E) Monitoring terrain and roadbed stability and interaction with geohazards across different permafrost environments. The GNWT is working with partners to implement these studies. However, as the effects of climate change on the northern environment rapidly increase, a deficit in northern scientific capacity to support informed decision making, climate change adaptation, and risk management becomes more apparent.

TOP 5 DEVELOPMENTS IN INDIGENOUS, ENVIRONMENTAL AND REGULATORY LAW IN THE NORTHWEST TERRITORIES IN 2018

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This session will highlight some of the Top 5 Developments in Indigenous, Environmental and Regulatory law in the Northwest Territories in 2018.

1. Implementation of Modern Treaties: The Supreme Court of Canada's decision in the Peel River case, First Nation of Nacho Nyak Dun v. Yukon

2. Remember Species at Risk: The Federal Court of Appeal's decision on the Trans Mountain Pipeline Expansion Project, Tsleil-Waututh Nation v. Canada

3. Amendments to the federal Metal and Diamond Mining Effluent Regulations

4. The Return of the HADD: Restoring the express prohibitions against the harmful alteration, disruption or destruction of fish habitat, Canada's Proposed Amendments to the Fisheries Act

5. The North Slave Métis Alliance and consultation on the Northwest Territory Métis Nation Land and Resources Agreement-in-Principle, Enge v. Canada

TRUSTING THE LAND AGAIN: COMBINING WESTERN SCIENCE AND TRADITIONAL KNOWLEDGE TO UNDERSTAND LAKES IN THE AREA OF THE FORMER RAYROCK URANIUM MINE, NT

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The former Rayrock Uranium Mine site is located approximately 145 kilometres northwest of Yellowknife, Northwest Territories, on the western edge of the Marian River fault. The site is located within Tłı̨chǫ lands as per the Tłı̨chǫ Land Claim Agreement. During operation of the mine, 207,754 kilograms of Uranium yellowcake was produced from the mine. This produced 70,903 tonnes of un-neutralized (pH 2.5-3.0) tailings that were discharged across two areas that are now referred to as the north and south tailing piles.

Around the time of mining operations, the Tłı̨chǫ noted that materials in the tailing piles were contaminating the surrounding area. They observed how these tailings killed the trees and fish. Consequently, the Tłı̨chǫ avoided the Rayrock area, adding it to an exclusion zone that delineates areas that are not safe for harvesting. Furthermore, they believed that dead animals and plants down-stream from Rayrock were caused by the spread of the "poison" spilled into the water at Rayrock.

The tailings piles at the Rayrock Uranium Site were covered in 1996 as part of a remediation program and were then monitored for several years. Nonetheless, the Tłı̨chǫ continued to be concerned with the lakes and waterways in the area. Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) subsequently commissioned assessments to address these concerns. The results determined that all but one lake on site were safe for fish.

In order to address on-going Tłı̨chǫ concerns with the site, CIRNAC organized a multiple day tour of the area. Elders and youth from Tłı̨chǫ, communities were invited to stay at the site, where they observed the health of the wildlife and plants and complete a fish palatability test of fish from Sherman Lake. Characteristics considered were: physical condition, colour and appearance of organs, firmness of flesh, odours during cooking, and taste. Test results indicated no adverse effects on fish quality.

Pieces of the fish flesh were also tested using a mobile X-Ray Fluorescence tester. This showed low concentrations of metals of concern in the flesh of the fish prior to consumption. Laboratory analysis of the flesh was also performed.

In summary, community involvement was essential to begin concrete discussions on the health of the land around the former Rayrock Uranium Site. Tests conducted onsite drew on Traditional Knowledge as well as Western science. Both frameworks demonstrated that the fish sampled were not affected by former mining operations. This will go a long way to establish trust in the land and in remediation activities conducted by the Government of Canada.

APPLYING CHEMOSTRATIGRAPHIC DATA TO ESTABLISH A SEQUENCE STRATIGRAPHIC FRAMEWORK: AN EXAMPLE FROM THE DEVONIAN CANOL FORMATION

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Sequence stratigraphy is a useful method for understanding lateral and vertical heterogeneity in sedimentary successions. Predicting this variability is essential to understanding organic-rich mudstone resource plays, which have become increasingly important in recent years. However, making sequence stratigraphic interpretations in mudstone successions is challenging, because sedimentological variations are typically subtle, wireline logs can be ambiguous, and seismic or biostratigraphic datasets are commonly of limited use. As a result, researchers have started incorporating chemostratigraphic datasets to establish sequence stratigraphic frameworks in these intervals. The

chemostratigraphic proxies most commonly used are elements that reflect abundance of continental input including Al, Fe, K, Ti, and Zr, and proxies that can be used to infer the proportion of biogenic silica relative to detrital silica such as Si/Al, Si/Zr and Si-Al cross plots. Paleoredox proxies (e.g. Mo, Ni, Th/U, V) that give information about basin isolation and water column stratification can also be useful. However, the use of elemental proxies can be limited by the possibility of element migration during diagenesis or from surface weathering. Furthermore, chemostratigraphic datasets are most suited to the interpretation of trends which typically limits sequence stratigraphic inferences to longer term transgressive-regressive cycles unless supported by sedimentological data.

This presentation reviews existing work on the use of chemostratigraphy to establish a sequence stratigraphic framework, and provides local context by using data from the resource-rich Middle to Late Devonian Canol Formation as a case study. High-resolution elemental data have been collected from the Canol Formation in the Mackenzie Mountains and the Central Mackenzie Valley, Northwest Territories, using a portable x-ray fluorescence analyzer. Preliminary results suggest that it is possible to identify transgressive-regressive sequences and important sequence stratigraphic surfaces from these elemental proxies. Upon completion, this project will serve as a guide to the usefulness of geochemical proxies for sequence stratigraphy, which will facilitate the development of sequence stratigraphic frameworks to map variations in shale reservoir quality.

TWENTY YEARS AT THE EKATI DIAMOND MINE: CORPORATE SOCIAL RESPONSIBILITY IN ACTION

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The Ekati Diamond Mine in the Northwest Territories is owned and operated by Dominion Diamond Mines, the largest Canadian independent diamond producer. The Ekati mine was the first diamond mine in Canada, and started production in October 1998. In 2018 the operation is celebrating its twenty year anniversary. In the presentation, we will look back on some of the milestones and achievements of the last two decades. We will also discuss the commitment of the company to make a positive difference in the North through Corporate Social Responsibility initiatives, including support for education, training, community development, business opportunities and respect for the environment. Some examples include:

Community: Whether mining in northern Canada or sorting diamonds in India, we firmly believe that we can – and should – contribute to the social and economic well-being of the communities near our operations. Dominion's Indigenous partners and business operations are important stakeholders and we respect and value their rights, Traditional Knowledge (TK), and cultural heritage.

Hiring, Training and Development: Dominion Diamond Mines is committed to ensuring that the Ekati mine is a welcoming workplace for all employees and that we remain an employer of choice, particularly among northerners and northern Indigenous

communities. The company has a number of initiatives and policies to encourage northerners, representatives from Indigenous groups, and women to enter the mining industry.

Environment: Throughout the mining process, Dominion Diamond keeps the land and water of the Ekati mine clean and safe for people, plants, and animals. We understand the importance of the Arctic tundra environment and we are committed to mining in the safest, most environmentally responsible way.

APPLICATION OF DIURNAL PHASE LAG ANALYSIS TO CALCULATING THERMAL DIFFUSIVITY SERIES AND EARLY AND LATE WINTER N-FACTORS

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Improvements to temperature logging instrumentation have facilitated an increase in the collection of air and ground surface temperature series in permafrost areas. Analyzing these data improves our understanding of how permafrost is affected by increasing temperatures and other observed changes in climate conditions, especially in the Arctic. Essential to this understanding is transfer theory, particularly thermal diffusivity, which summarizes the heat transfer rate directly in the heat equation.

Since the thermal diffusivity is the ratio of the thermal conductivity to the specific heat capacity, a field measurement of the thermal diffusivity requires both of these values. They are often taken from nearby soil pits (as disturbing the ground near the logger changes the soil's thermal properties) and can only reflect the location's thermal diffusivity at that particular snapshot in time. Given that the harmonic solution to the heat equation relates the thermal diffusivity directly to each of the amplitude damping and the phase lag of the conduction wave as it travels between temperature sensors (e.g., an air and a ground surface sensor), a phase lag or amplitude series can provide a means to generate a thermal diffusivity series over time. However, existing analysis methods often use only temperature magnitudes for analysis (e.g., when calculating mean values or n-factors) or, if considering the phase lag and amplitude of the temperature sinusoid, will tend to look at the annual scale where there is little variation from year to year compared to the diurnal scale. In contrast to using the heat equation, n-factors are a commonly used technique for summarizing a seasonal air-surface temperature relationship. However, previous work has shown that seasonal winter n-factors are overestimates when considering only the early winter temperature values, and underestimates if only considering the later temperature values. Partitioning the winter n-factor may better capture seasonal variability.

This presentation will demonstrate a means to calculate diurnal amplitude and phase lag series of a coupled air-surface temperature series and some results thereof. It will begin with a brief discussion of the geographical context of heat transfer in permafrost areas based on the surface energy balance along with a description of the influences of snow, vegetation, and topography. A breakdown of how the diurnal phase lag and amplitude series are calculated will lead into a look at the underlying mathematical relationships of phase lag and amplitude to thermal diffusivity calculations (and, transitively, to one another) via the harmonic solution to the heat equation.

In the results section, diffusivity series will be calculated from the amplitude and phase lag series over the summer and winter seasons and compared to field values both in terms of spatial and temporal variation. Following this, an amplitude damping filter will be demonstrated that can separate early and late winter temperatures for partitioning freezing n-factors into early and late winter n-factors to see if this can better capture seasonal variability. The presentation will close with a summary and suggestions for future research.

2018 KIMBERLITE DISCOVERIES AT THE LOKI (LAC DE GRAS, NT) AND MEL (MELVILLE PENINSULA, NU) DIAMOND PROJECTS

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Details will be provided on the recent kimberlite discoveries at North Arrow's Loki (NT) and Mel (NU) diamond projects.

In April of this year, North Arrow announced the discovery of a new kimberlite at its Loki Diamond Project in the Northwest Territories. The Project is located in the Lac de Gras region, approximately 30 km southwest, and 24 km west of the Ekati and Diavik diamond mines, respectively. The Loki claims are contiguous to the south and east of the diamondiferous Monument kimberlite cluster. The project hosts several prospective exploration targets, as well as five known kimberlites: EG-01, EG-02, EG-05 and EG-130.

At the beginning of March 2018, North Arrow commenced drilling to test the EG-05 kimberlite, as well as other priority targets. On April 5th, intersections of the first new kimberlite (465) discovered at Lac de Gras in over five years were announced, along with new drilling of kimberlite EG-05.

The Mel Diamond Project is located on the Melville Peninsula (NU), approximately 140 km south of the community of Hall Beach, and 210 km northeast of the community of Naujaat (formerly Repulse Bay).

A prospecting program conducted in late 2017 focused on discovery of potential kimberlite bedrock sources to a well-defined kimberlite indicator mineral train in the north part of the project area. Kimberlite float and subcrop was found in two areas, including a surface exposure of the ML8 kimberlite. A 62.1 kg sample of ML8 yielded 23 diamonds larger than the 0.106 mm sieve size, including a single, colourless diamond larger than the 0.85 mm sieve size.

The 2018 exploration program included 778 m of exploration drilling leading to the discovery of a new kimberlite (ML345) and defining the ML8 kimberlite over a 170 m strike length. In addition, 447 till samples were collected to better define existing and new targets within the project area, 14 magnetic ground survey grids were completed, and over 200 kg of kimberlite was collected from surface at ML8 for further microdiamond analysis.

THE TRANSFORMATION OF DE BEERS CANADA

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Over the past two years, De Beers Canada has undergone a transformation. This has included:

- opening the world's largest new diamond mine (Gahcho Kué Mine);
- relocating its operational support centre to Calgary from Toronto, and refocusing the Calgary organization to ensure it provides support services to our remote operations rather than acting as a “head office”;
- improving partnerships with local communities;
- preparing to close the highly successful Victor Mine in Northern Ontario; and,
- looking for opportunities to grow the company in Canada.

The De Beers Canada of 2018 is a dramatically different company, one that has become a solid contributor to the De Beers Group, is a national leader in safety and has its focus on developing the first diamond mine on Baffin Island.

Our presentation will provide an update on the activities of De Beers Canada since 2016 and a look ahead at where our company is going in the future.

SUSTAINABLE DEVELOPMENT FOR NORTHERN CANADA BASED ON ENHANCED AND INTEGRATED GEOTHERMAL SYSTEMS

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Sustainability is a dynamic concept involving direct and non-direct relations among humans, the ecology, the Earth's resources, seeking positive outcomes. “Sustainable Development” (SD) entails society development within the context of sustainability, meaning maintaining or re-establishing a critical level of natural capital that entails resources of various kinds such as soil, water and air; minerals; natural products (wood, fish…); and appropriate energy sources. Providing energy and establishing the sustainability of energy sources is a major natural capital concept which needs to be considered in Canada's northern territories (NT, YK, NU, and northern parts of seven provinces) in order to achieve SD. Energy is the engine of development; a reliable and robust operating engine consuming dominantly renewable energy is necessary for SD. This article revisits some statistical data of the northern territories to find the current situation in the context of population, influx and industrial activity as indices of development. Enhanced geothermal systems (EGS) are introduced as part of a possible solution to provide renewable, green and cheap (hopefully) power and heat for remote communities to meet energy needs to allow an acceptable standard of living compared to other provinces in Canada. Energy price and its delivery problems are already known to be major basic obstacles to SD in the north, and investments in EGS in the north may help in the progress toward implementation of “power plant scale” systems in both the north and the south of Canada.

SEDIMENTOLOGY AND STRATIGRAPHY OF THE HUSKY CREEK FORMATION, NUNAVUT, CANADA

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The Mesoproterozoic Husky Creek Formation lies within the gently, northward-dipping Coppermine Homocline, 30-60 km south of the hamlet of Kugluktuk, Nunuvut. Across northwestern Canada, thick Mesoproterozoic-Neoproterozoic sedimentary and volcanic successions record the amalgamation and break-up of supercontinent Rodinia. These rocks are subdivided, from oldest to youngest, into three-unconformity bounded successions: A, B, and C. The boundary between successions A and B is exposed in the Coppermine Homocline, where rocks of the Rae Group (Succession B; <1151 ± 13 Ma, U/Pb detrital zircon) unconformably overlie the Husky Creek Formation of the Coppermine River Group (Succession A; <1230 ± 15 Ma, U/Pb detrital zircon). Exceptional exposures of the Husky Creek Formation occur along steep-walled canyons of the Coppermine River and its tributaries, which make it suitable for the 3D depositional architectural analysis. It has a composite thickness of ca. 1900 m and is dominated by planar and cross-stratified red sandstone and siltstone that is interlayered with 20-100 m thick basalt flows. The Husky Creek Formation overlies the Copper Creek Formation, a ca. 2.5 km thick, regionally extensive basaltic plateau linked to the 1.27 Ga Mackenzie Igneous Event. Petrographic analysis indicates that sandstones are dominated by mafic lithic detritus, suggesting provenance mainly from the basalts. Planar and cross-bedded sandstones with abundant desiccation cracks, adhesion structures and pedogenic nodules indicate a temperate to arid terrestrial paleo-environment that includes fluvial channel belts and floodplains subject to local eolian winnowing. U/Pb dating of detrital zircon grains collected from four stratigraphic levels (base to top) of the Husky Creek Formation reveal three main age groupings: (i) a 1270 Ma peak attributed to the Mackenzie Igneous Event; (ii) 1750 Ma -2700 Ma zircons, possibly recycled from the Hornby Bay Group, which underlies the Coppermine River Group and is exposed to the south; and (iii) >2700 Ma zircons attributed to the Archean Slave Province. An up-section decrease in ca. 1270 Ma zircon grains and a relative increase in Paleoproterozoic and Archean grains is interpreted to reflect expansion of the drainage basin as the Husky Creek Formation was being deposited. Paleoflow patterns indicate dominant south-southwestward transport, which is from the direction of the interpreted focal point of the Mackenzie Igneous Event. We conclude that the Husky Creek Formation was deposited in the waning stages of the Mackenzie Igneous Event by rivers flowing in a geographically restricted, possibly endorheic basin, carved into an extensive mafic volcanic plateau.

LARGE SCALE INDUSTRY COLLABORATION TO EVALUATE THE STATUS OF GRIZZLY BEAR POPULATIONS IN THE SLAVE GEOLOGICAL PROVINCE

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The Ekati Diamond Mine and Diavik Diamond Mine are located in the Slave Geological Province (SGP) of the Northwest Territories, approximately 300 km northeast of Yellowknife. Potential impacts to grizzly bears in the SGP associated with mining activities were predicted to be minimal

during the respective environmental assessments for these mines, but without detailed information about population status, testing this prediction is difficult. Regulators, monitoring agencies, and community members recommended that the mining industry collaborate on a large scale regional grizzly bear program to assess population status and monitor trends over time. In response, the Ekati and Diavik Diamond Mines agreed to work together on a large scale grizzly bear mark-recapture study surrounding their mine properties in the central barrens of the Northwest Territories. Technical and community workshops concluded that an important objective for grizzly bear monitoring was to determine the abundance and distribution of grizzly bears in a larger regional context and establish a baseline for long-term regional monitoring.
A DNA mark-recapture design was the best approach to meet this objective. The regional DNA study area is centred on the Ekati and Diavik Diamond Mines and contains 113 cells (12 km by 12 km) used for sampling grizzly bear hair in 2012, 2013, and 2017, for a total study area of approximately 16,000 km^2. In 2012, 112 grizzly bear individuals were identified through DNA hair analysis, including 42 males and 70 females. During the 2013 field program, a total of 136 grizzly bears were identified (60 males and 76 females), including 39 that had no previous detections in the regional database (22 males and 17 females). In 2017, 136 grizzly bears were identified (55 males and 81 females), including 62 with no previous detections in the regional database (33 males and 29 females).

Based on Spatially Explicit Capture Recapture (SECR) analysis of the individuals detected, female density was estimated as 3.6/1,000 km^2 (95% CI 2.9 to 4.6) in 2012 and 4/1,000 km^2 (95% CI 3.2 to 5) in 2013. Male density was estimated as 2/1,000 km^2 (95% CI 1.4 to 2.7) in 2012 and 2.9/1,000 km^2 (95% CI 2.2 to 3.7) in 2013. The 2017 density of both males (3/1,000 km^2) and females (4.7/1,000 km^2) continued to show an increasing trend in comparison to the previous monitoring years. The results of this regional study indicate a stable to growing population in the central barrens of the Northwest Territories relative to estimates for the Slave Geological Province in the late 1990's.

SUSTAINABLY ADVANCING RESOURCE DEVELOPMENT PROJECTS IN CANADA

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Seabridge Gold is a Canadian based resource exploration company. The company has 100 percent ownership of the Courageous Lake Project in the Northwest Territories, as well as the KSM and Iskut Projects located in Northwest British Columbia.

The Courageous Lake Project is a gold exploration project located approximately 240 km northeast of Yellowknife, NWT. Although the Project was not active for several years, exploration activities to grow the estimated resource base and improve the overall project economics have resumed at the project site.

At its core, Seabridge believes in responsible resource development, with community engagement and environmental sustainability among the top priorities.

Some of the implemented and ongoing initiatives by Seabridge at its KSM and Iskut Projects include:

- Signed a Benefits Agreement with the Nisga'a Nation.

- Signed an Environmental Agreement with the Gitanyow Nation.
- During the EA process, established a wildlife working group with the Tahltan, Nisga'a and the Gitanyow Nations, Seabridge, BC Forests Land and Natural Resources Operations to collaboratively resolve wildlife concerns.
- Made significant design changes to the KSM Project to accommodate community needs, adding in excess of $500M to the overall project capital costs.
- Building a workforce in northwest BC through education and trades training. Seabridge participates in many events through sponsorships, donations and offers bi-annual bursary programs to students; donated approximately $550,000 to date.
- Funds opportunities for local Indigenous community members to attend conferences and training programs to encourage and enable meaningful participation.
- Commits to the implementation of rigorous scientific, environmental and social management practices and assessments to assure high standards during operations.
- Conducts comprehensive environmental studies including fish and aquatic resources, wildlife and wildlife habitat, hydrology, hydrogeology, geochemistry, geohazards, atmospherics, terrestrial ecology, wetlands, noise, country foods, archaeology, traditional use and knowledge, land use, social and economics.
- Supports initiatives by Indigenous groups and local communities that seek to advance traditional ecological knowledge.

As responsible stewards of sustainable development, Seabridge is applying the learnings and best practices gathered from its KSM and Iskut Projects at the Courageous Lake Project. Seabridge has already planned and implemented various measures to ensure environmental and wildlife protection at its Courageous Lake Project including:

- Collaborated with Tłı̨chǫ to host a week long on site traditional knowledge workshop led by Tłı̨chǫ researcher and members that culminated in a TK report.
- Discussing opportunities with other Indigenous groups for the development of other TK studies.
- Implemented a wildlife protection plan that includes specific caribou protection measures when caribou are present in the area, such as monitoring and operational protocols for helicopter and drilling activities.
- Established a wildlife camera monitoring program to understand wildlife use of the area, with over seven years of data.
- Working with qualified local businesses that buy locally and hire local workers.
- Working with community liaisons to identify a range of engagement activities in preparation for Seabridge's plans to submit a new land use permit application next fall.
- Initiating discussions with development corporations to identify possible business and job opportunities.
- Working with community members to build relationships.

ARSENIC MOBILITY IN LAKE SEDIMENTS DURING LATE-HOLOCENE CLIMATE WARMING: IMPLICATIONS FOR GEOCHEMICAL BASELINES AND CONTAMINANT STABILITY IN A CHANGING NORTHERN CLIMATE

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Climate change is influencing the biogeochemistry of high northern latitude lake systems. These changes may have implications for the mobility of naturally occurring metal(loid)s and anthropogenic contaminants. Arsenic (As) mobility is highly susceptible to limnologic changes, seasonal fluctuations, and increases in organic matter due to its redox behaviour. However, the influence of regional climate change on long-term As stability in lake environments is poorly understood. Lake sediments provide archives of past climate changes and are widely used to reconstruct biogeochemical responses to regional climate trends. Through the examination of changes in sediment and porewater As speciation during mid- to late-Holocene (5,000 yr cal BP to present) regional warming cycles, this study provides insight as to how climate warming affects sedimentary As concentrations. This information is important for interpretation of metal(loid) concentrations in modern-day sediments, especially in areas disturbed by mining activities. Arsenic geochemistry is combined with multivariate analysis of paleoclimate proxies (particle size, organic matter type and quantity) and radiometric dating (^{14}C and ^{210}Pb) to determine the influence of climate warming on the distribution of As in lake sediment. Sediment cores were collected from four lakes in the Courageous Lake Greenstone Belt, central NT, in proximity to the former Tundra gold mine. Paleoclimate reconstructions of two of these lakes document increases in As concentrations in both sediments and porewater coincident with known periods of regional climate warming. During the Medieval Warm Period (ca. 5,000 to ca. 4,000 yrs BP; 110 yr/cm) sediment As concentrations are significantly ($r_s = 0.75$, $p < 0.05$, $n = 15$) related to the labile organic matter fraction (S2 as determined by Rock Eval® pyrolysis); conversely, a significant ($p < 0.05$) but negative ($r_s = -0.8$) relationship between sedimentary As concentrations and labile organic matter is evident over the shorter duration warming event centred at ca. 2,040 yrs BP (47 yrs/cm). These data suggest that changes in primary productivity may affect the remobilization and sequestration of As in lake sediment; however the effects on As mobility vary between lakes. The prevalence of both arsenopyrite and secondary, authigenic As-bearing pyrite (as determined by SEM, EMPA and bulk XANES) during these regional climate warming intervals provides evidence to support the interpretation that active remobilization of geogenic As occurred in lake sediments. However, in mining-impacted sediment, the relationship between labile organic matter and sedimentary As is not consistent in the four lakes studied. This study demonstrates that past regional warming cycles have played a role in influencing As mobility in sub-Arctic mineralized regions and thus provide a useful tool to better predict future geochemical change.

COBALT FROM THE DRC: POTENTIALS, RISKS AND SIGNIFICANCE FOR THE GLOBAL MARKETS AND THE POTENTIAL OF AN INCREASE IN CANADIAN COBALT PRODUCTION

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While cobalt demand and its relevance for emerging technologies and battery production are continuously increasing, mine supply is currently limited to few countries with the DRC representing the main producer of cobalt ore and China the dominant producer of refined cobalt metal. This constellation implies increasing supply and price risks for cobalt. From 2010 to 2015 global cobalt demand increased from 65,000 t to more than 90,000 t per year. Over the same period the mean compound annual growth rate for cobalt demand was 7.5 % while the demand for cobalt-based chemicals increased at an even steeper rate of 10.6. It is estimated that by the year 2026 the demand will more than double to 226,000 t.

Additionally, planning the future supply is affected by the fact that the DRC's cobalt mine production partly originates from artisanal and small scale mining (ASM) sources, in addition to industrial mines. In recent years, there has been repeated criticism of Child labor and unacceptable working conditions by civil society regarding the circumstances of ASM cobalt production and trade in the DRC. International cobalt supply chain stakeholders sourcing from the DRC were requested to step up their due diligence efforts in order to manage these conditions.

This talk serves to illustrate relevant facts on cobalt production and trade in the DRC on the background of the global cobalt market with a projection up to the year 2026. The possibility of an increased Canadian cobalt production using the examples of several existing and new projects (NICO, Dumont, Raglan, Sudbury, Thompson and Voiseys Bay) is also discussed.

PRELIMINARY RESULTS OF RECONNAISSANCE-SCALE BEDROCK MAPPING AND U-PB GEOCHRONOLOGY IN THE NONACHO LAKE AREA (NTS 75F), SOUTH RAE CRATON, NORTHWEST TERRITORIES

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In the Nonacho Lake area, the ca. 1.91-1.82 Ga Nonacho Group (NG) consists of breccia, conglomerate, sandstone, mudstone and rare volcanic rocks deposited in a complex system of braided stream, lacustrine, and alluvial fan environments. These rocks are polydeformed and unconformably overlie Archean to Paleoproterozoic gneisses and granitic rocks of the Rae craton. The basal unconformity of the NG has been the target of significant uranium exploration. In addition to U and REE, previous exploration discovered

several polymetallic (Cu-Au-Ag) showings hosted in both basement and NG rocks. The stratigraphy and structural geology of the NG has not been investigated in detail since the original mapping of Aspler (1985). Questions remain regarding the depositional setting and regional correlation of this Paleoproterozoic basin. The basement rocks remain un-mapped, although detrital zircon U-Pb dates from the NG suggest that the basement records a protracted Eoarchean to Paleoproterozoic history. The Nonacho Lake region currently lacks the geological framework necessary to facilitate mineral potential assessment and scientific work. Reconnaissance investigations conducted in 2018 will be followed by detailed studies in 2019 and 2020, with the goal to resolve the tectonometamorphic history and assess the economic potential of this underexplored region.

Basement rocks in the Sparrow Bay-Stewart River area comprise foliated granodiorite, dioritic to granitic injection gneiss with abundant ultramafic inclusions, local biotite-sillimanite paragneiss, and cross-cutting weakly foliated to undeformed granites. Preliminary U-Pb zircon geochronology reveals a spread of ages typical of the Rae craton, Queen Maud block, and Arrowsmith orogeny. Two foliated granodiorites yielded ages of ca. 2.60 and 2.50 Ga, a dioritic component of the injection gneiss is ca. 2.43 Ga, and the cross-cutting granites are ca. 2.35 to 2.28 Ga. Mapping at Hjalmar Lake revealed a unique body of carbonate-bearing hornblendite (carbonatite?) and NW-trending feldspar-phyric, calcite-amygdule-bearing dykes. The latter are undated but intrude the NG and were previously considered coeval with the 1.83 Ga Sparrow Dyke swarm. They bear a resemblance to ultrapotassic rocks of the ca. 1.83-1.75 Ga Baker Lake Group.

Evidence of two regionally extensive and likely distinct mineralizing systems has been observed: (1) an unconformity-related uranium mineralizing event with showings in basement and NG rocks; and (2) polymetallic sulphide mineralization associated with carbonate-fluorite veins at numerous showings in basement and NG rocks. The interpretation that most of the polymetallic showings are genetically related is based on similarities in metal tenor, alteration and emplacement characteristics.

Future work will include: 1) U-Pb geochronology to understand the major episodes of magmatism and metamorphism in the basement; 2) Lu-Hf tracing of magmatic rocks to constrain the age and isotopic character of their source, and to test for their interaction with the ancient crust that contributed ca. 3.9-3.0 Ga detrital zircons to the NG; 3) Ar-Ar thermochronology to delineate crustal-scale boundaries and constrain the timing of basement uplifts; 4) investigation into the source of mineralizing fluids in polymetallic sulphide-carbonate-fluorite bearing veins; 5) geochemistry, geochronology and economic significance of the carbonate-bearing hornblendite; and 6) detailed sequence stratigraphy and detrital zircon geochronology of the NG.

TRANSPORTATION CORRIDORS AND ACCESS TO RESOURCES IN THE NORTHWEST TERRITORIES

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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.

SPARKING THE INTEREST OF YOUNG NORTHERN WOMEN FOR NORTHERN CAREERS IN GEOLOGY, ENGINEERING AND MINING

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Research has shown young women have decided against careers in Science, Technology, Engineering and Math (STEM) related fields by age 14. It is our goal to increase the number of northern women in geology, engineering, and mining related fields by developing and offering programs specifically for northern girls age 12-17. By engaging them at a younger age in the industry that so shapes our lives we hope to bring more diversity and innovation to this traditionally male dominated field. Partnering with TerraX Minerals, Girl Guides of Canada, Mining Matters, and hopefully others, we are looking for industry, government, indigenous and private sector support in achieving our goal of increasing the presence of women in our northern workplaces. This talk will share the planning and design phases of this evolving northern based program primarily lead by female professionals and executives living in the North.

GEOCHEMICAL AND SM/ND ISOTOPIC CHARACTERIZATION OF POST-TECTONIC GRANITOIDS OF BOOTHIA PENINSULA, NU: IMPLICATIONS FOR THE EXTENT OF THE HUDSON GRANITES

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Bedrock mapping on Boothia Peninsula in 2017 as part of Natural Resource Canada's GEM-2 program, has revealed extensive 2.50-2.56 Ga tonalite-granodiorite to garnet monzogranite basement rocks, which are interfolded with widespread granulite-facies metasedimentary rocks. In southeast Boothia Peninsula, these metasedimentary rocks are cut by 1.84 -1.82 Ga weakly foliated to massive biotite-orthopyroxene monzogranite (charnockite) and hornblende-biotite quartz syenite to syenogranite. Although the weak fabric in this younger granitoid suite coincides with the general SW-striking regional fabric seen in eastern Boothia

Peninsula, the low degree of strain implies late-stage emplacement with respect to regional deformation.

The 1.84-1.82 Ga granitoids have an A- and I-type major-element composition, which is dominantly ferroan with variable SiO_2 (55 – 78%). The trace-element discrimination diagrams classify these rocks as transitional between within-plate and collisional granites. LREEs, however, are more enriched in the syenogranites compared to the charnockites. This difference combined with a larger negative Eu anomaly suggests the syenogranites are more evolved than the charnockites. We have investigated the Sm/Nd isotopic compositions of both suites on Boothia Peninsula to access the degree of interaction with Archean crust, therefore furthering our understanding of the granitoids origin and tectonic setting.

The $\varepsilon Nd_{1.83\ Ga}$ values (-7.0 to -8.0) obtained for 1.84-1.82 Ga granitoid rocks of Boothia Peninsula suggest two distinct crustal sources in their genesis: the hornblende-biotite syenogranite suite ($\varepsilon Nd_{1.83\ Ga}$ = -7.0 to -7.1, τDM = ~ 2.5-2.6 Ga) and the charnockite suite ($\varepsilon Nd_{1.83\ Ga}$ = -7.3 to -8.0, τDM = ~ 2.8 Ga). The Nd data for the charnockite suite can be explained by partial melting of late Mesoarchean to early Neoarchean basement rocks, which is typical of Rae craton. The less negative $\varepsilon Nd_{1.83\ Ga}$ values and younger model ages of the syenogranite suite suggest either derivation from a comparatively younger late Neoarchean crustal source or is a result of contributions from both typical Rae Basement and a slightly more juvenile source.

Geochemically, the 1.84-1.82 Ga granitoids on Boothia Peninsula are broadly comparable to other 1.85-1.80 Ga post-tectonic granites, the Hudson suite, which are widespread across the mainland Rae and Hearne cratons. Elsewhere in the Rae craton, this 1.85-1.80 Ga magmatism has been linked to Au/Cu base metal and uranium mineralization[1]. If correlative, the 1.82-1.84 Ga granitoids of Boothia Peninsula would mark the northernmost occurrence of Hudson granitoids, highlighting a distribution over nearly 1000 km. Revealing the extent of the Hudson granites may have larger implications for understanding the tectonic settings behind the extensive reworking of Rae and Hearne Cratons during the Paleoproterozoic.

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INVENTORY OF DONATED HISTORICAL NORTHWEST TERRITORIES EXPLORATION AND MINING RECORDS

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The Northwest Territories Geological Survey (NTGS) has an inventory of donated geological records from past exploration projects and closed mines. This inventory represents millions of dollars of exploration and mining information and contains original data, such as field notes and maps, air photos, drill logs, assay results, onion skin drawings, linen maps, photographs, annual reports, news clippings, and press releases. Although the majority of the records are from the 1970s and 1980s, some information dates back to the mid-1930s. Over the years the NTGS has stored these donated hardcopy files in a warehouse, which is not ideal for long-term preservation or client accessibility. In 2015,

the NTGS initiated the development of a database so that the information in the exploration archives could be easily accessed to support future geoscience research and exploration in the Northwest Territories (NWT). Currently, the whole collection has been scanned and catalogued within a spreadsheet. Plans include incorporating this database into the existing suite of NTGS Web applications.

Donations to this collection have come from many sources. However, some of the larger portions of the collection consist of reasonably complete records from major NWT mining companies including Cominco, Giant, Westmin, and Echo Bay. The donated materials from these companies include detailed mapping of mine workings and onsite brownfields exploration drilling. Perhaps the most exciting is the inclusion of exploration reports and evaluations from company geologists evaluating prospects and properties presumably offered for option, or under company exploration. The data consist of all manner of exploration work including geophysics, geochemistry, prospecting, and mapping on a remarkable number of NWT prospects, some with familiar names, others less so. Much of the work focuses on gold (Au), lead-zinc (Pb-Zn), silver (Ag), and uranium (U), however, there are entries describing work done looking for nickel (Ni), cobalt (Co), tantalum (Ta), beryllium (Be), lithium (Li) and many other commodities. Most of this collection was never filed for assessment work, and this release constitutes the first time this data has been publicly accessible. For project generators, it is an enormous archive of geological data and insights with the potential to provide a historical leg up for a modern exploration program.

THE MOBILITY OF ARSENIC IN THE WATERSHED OF A SMALL SUBARCTIC LAKE IMPACTED BY MINING POLLUTION: WHAT DOES THIS MEAN FOR THE LONG-TERM FATE OF ARSENIC IN THE YELLOWKNIFE AREA?

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The early years of historical mining activities in the Yellowknife region resulted in the release of large amounts of arsenic, antimony, and metals to the surrounding area. Sixty years after the bulk of these emissions were deposited large amounts of arsenic and antimony remain in lake sediments and soils in the region, and surface waters of many small lakes continue to exhibit elevated concentrations of these metalloids. Understanding the chemical recovery of small lakes from mining pollution in the region requires the consideration of processes occurring within lakes and their surrounding catchment. Studies that integrate these processes provide important information on the long-term fate of arsenic in impacted subarctic environments.

This presentation will draw on results from year-round sampling in the watershed of a small shallow lake (1.2 km^2; < 3 m maximum

depth) to discuss the various fluxes of arsenic in a landscape impacted by 50 years of mining pollution. Hydrologic inputs and outputs of arsenic from the lake were measured by combining bi-weekly chemical sampling and continuous flow measurements at the lake inflow and outflow. The flux of arsenic between lake sediments and the overlying water column was measured using a combination of porewater extraction techniques and experimental field incubations of lake sediments. The contribution of arsenic from surface runoff from the surrounding catchment was estimated in a small subcatchment by measuring discharge volume and chemistry. Contemporary atmospheric loading of arsenic to the watershed was measured by collecting rain and snow for chemical analyses.

Seasonality is an important feature of subarctic environments and early results from this study show that the mobility of arsenic varies across landscape units and is seasonally dependent. Lake sediments were a small source of arsenic to overlying water during the open-water season when lake water is well-oxygenated. These sediments became a substantial source of arsenic by mid-winter once anoxic conditions developed at the sediment boundary, and water column arsenic concentrations increased almost three-fold compared with late summer measurements (September: 50 µg/L - April: 141 µg/L). In spring, lake water arsenic concentrations decreased rapidly to less than 40 µg/L once snowmelt entered the lake but prior to the loss of ice cover and peak freshet at the lake outlet. Terrestrial contributions of arsenic to the lake via surface runoff were isolated to the snowmelt period in early May and during record precipitation periods in June and July. Loading estimates during these periods indicate that substantial amounts of arsenic continue to be transported from the terrestrial to aquatic environment.

These observations highlight the importance of considering environmental processes across seasons in evaluating the long-term fate of arsenic in shallow lakes in the region. The annual remobilization of sediment As into overlying waters under ice may be a significant process inhibiting the long-term recovery of mine-impacted lakes since it does not typically coincide with periods of high flow at lake outlets. Large winter increases in lake water arsenic also suggest that winter processes should be considered when evaluating exposure of aquatic life to arsenic.

BRIDGING THE GAP THROUGH CARE AND COLLABORATION: BEFORE CLOSURE AND AFTER PRODUCTION

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Wikipedia defines “Care and Maintenance” as a term used in the mining industry to describe processes and conditions on a closed mine site where there is potential to recommence operations at a later date. During a care and maintenance phase, production is stopped but the site is managed to ensure it remains in a safe and stable condition.

De Beers Canada Inc. - Snap Lake Mine entered the Care and Maintenance phase after production ceased in December 2015. The partnership with Det'on Cho Corporation provides for a sustainable execution of care and maintenance activities, taking into consideration approved work plans, mine

health and safety considerations and emergency response plans. The mine is currently in its third year of care and maintenance. After exploring the potential sale of the asset and assessing the possibility of reopening the mine, the decision to proceed toward closure was taken in December 2017, ushering Snap Lake into a period of extended care and maintenance (ECM) while a closure plan is developed and finalized.

Activities during ECM include monitoring of water quality and other environmental parameters, collecting/treating effluent and making sure that water leaving the site meets water license compliance. Physical infrastructure such as the airstrip, roads, buildings, processed kimberlite containment facilities and associated surface water infrastructure such as sumps, pumps and channels need to be kept in a safe and operable condition. Camp infrastructure such as generators and machinery and equipment are also part of the Care and Maintenance program. Collaboration between the De Beers Canada owner's team and Det'on Cho Corporation resulted in the safe execution of the 2018 work plan which included freshet operations, continued progressive reclamation work, monitoring and maintenance activities. After a trial-run of reduced camp occupancy in the winter of 2017, the site was fully winterized and demobilized in September 2018 to allow for monthly site visits for the duration of the winter and planning for a spring 2019 start-up.

LAND USE PLANNING IN WEK'ÈEZHÌI: AN UPDATE

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Land use planning is a process of making informed decisions about the future use of lands, waters, and other resources. Land use plans ensure better and more effective management of lands and resources, and create certainty for where and how development can take place.

Regional land use planning is an ongoing process in the Northwest Territories (NWT). To date, land use planning in the Mackenzie Valley has occurred on a regional basis according to settlement region boundaries. While a land use plan exists for Tłı̨chǫ lands, no land use plan has been developed for public lands in Wek'èezhìi, an area in the Bear and Slave geological provinces of the NWT. The Government of the Northwest Territories, Tłı̨chǫ Government and the Government of Canada are working collaboratively towards a land use plan for public lands in the region.

This talk will review the status and next steps for land use planning in Wek'èezhìi.

THE GEOTHERMAL POTENTIAL OF REMOTE REGIONS: A CASE STUDY OF ANTICOSTI ISLAND, QUÉBEC (CANADA)

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Anticosti Island is located in the Gulf of St. Lawrence and, like most remote regions of Canada, relies entirely on fossil fuels for both electricity and heat production. As an effort to diversify energy sources and reduce greenhouse gas emissions, a geothermal resource assessment of this sedimentary basin was achieved, developing a 3D geological model that was used as a basis to simulate conductive heat transfer and evaluate temperature distribution at depth.

The Anticosti sedimentary basin consists of a lower Ordovician to lower Silurian carbonate platform, which unconformably overlies the Precambrian basement. The 3D geological model of the basin, which integrates data from 24 oil and gas exploration wells and public seismic lines, encloses eight distinct geological units mainly composed of limestone and shale, with dolostone at the base of the sequence, and more sandstone in the eastern part. The thermal conductivity and the internal heat generation rate of each geological unit were evaluated from stratigraphic records and geophysical well logs. The undisturbed ground temperature near surface, used as a first type boundary condition for the 3D numerical model, was calculated from meteorological data. A constant heat flow of 15 $mW \cdot m^2$ was imposed at the base of the model at 40.5 km (Moho depth) as a second type boundary condition, while vertical side boundaries were considered adiabatic. Available bottom-hole temperature data were corrected for drilling disturbance and for paleoclimate effects. Terrestrial heat flow and a heat generation of the Precambrian basement were calculated analytically at the location of the 24 wells, according to 1D temperature profiles. Basement heat generation values were interpolated in 2D and included in the corresponding layers of 3D model.

The 3D heat conduction model was solved in steady state with the finite element method using FEFLOW. Results show that a temperature of 120 °C, which is considered the lower limit for efficient electricity production with a binary geothermal power plant, can be reached between 4 and 5.4 km depth in the Precambrian basement. The most promising temperature anomaly is located in the southeast of the island, reaching 120 °C at 4 km depth. However, the potential for the development of a geothermal plant in the near future is almost inexistent since the area is barely populated. The most populated area of the island is the locality of Port-Menier, in the northwest, with a population of 218 inhabitants. A temperature of 120 °C is reached at a depth of about 5 km below this locality. Direct geothermal energy use to heat building appears more feasible, with temperature of 57 °C reached at a depth of 2.1 km. Dolostones of the Romaine Formation having a relatively high permeability, reaching more than 10 mD, are present at this depth at the base of the sedimentary sequence. Future work perspectives include laboratory analysis to measure thermal properties of rock samples from all geological units to improve the numerical model defining geothermal resources and reducing uncertainty in temperature evaluation at depth.

TRACING THE FORMATION AND ABUNDANCE OF SUPERDEEP DIAMONDS

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Super-deep diamonds from the transition zone and lower mantle are valuable targets for mining, as they are often large, gem-quality[1] or ultra-valuable type IIb stones[2]. Hence, in mine prospects, it may become important to determine the various populations of sub-lithospheric diamonds. Unambiguously identifying a diamond's depth of formation is difficult as some minerals can be indicative of various depth regimes (e.g., ferropericlase, Ca-walstromite, enstatite, clinopyroxene, coesite). Here, we use the oxygen isotope compositions of inclusions in Kankan diamonds from Guinea to distinguish between the various diamond-forming processes that happen at lithospheric, asthenospheric to transition zone, and lower mantle depths. In this way, we hope to establish a process by which isotope geochemistry can better constrain the populations of superdeep diamonds in kimberlites, and can assist in estimating a pipe's propensity for large, valuable stones.

Oxygen isotopic analysis by secondary ion mass spectrometry (SIMS) is a high-precision technique that can track hydrothermal alteration that occurred at or close below the ocean floor. Our analyses of inclusions from Kankan diamonds demonstrate that garnets with 3-3.03 Si cations (pfu) have $\delta^{18}O$ that are well-constrained within the normal values expected for peridotitic and eclogitic inclusions, but that garnets with ≥3.04 Si cations (pfu) have consistently high $\delta^{18}O$ (median: 10‰) that slightly decreases with increasing Cr_2O_3. We interpret this signal as the reaction between a melted carbonate-rich oceanic slab and normal convecting asthenosphere[3]. In contrast, retrogressed, or former, bridgmanite has $\delta^{18}O$ values similar to primitive mantle, suggesting little involvement of slab melts.

In contrast to the worldwide suite of lithospheric inclusions of eclogitic paragenesis (median $\delta^{18}O$ of 7.03‰)[4,5], diamonds derived from ~250 to 500 km have inclusions with consistent, extremely high oxygen isotopes (median: 9.32‰)[6,7], due to the melting of extremely enriched carbonated oceanic crust. Diamonds from the lower mantle, however, have inclusions with primitive mantle oxygen isotopes, suggesting a different formation process. The clear distinction in inclusion $\delta^{18}O$ between lithospheric, asthenospheric to transition zone, and lower mantle diamond populations is useful in informing the depth regime of a suite of stones, especially those with inclusions of ambiguous depths (e.g., clinopyroxene, coesite, Ca-walstromite, enstatite, ferropericlase, etc.). For instance, we are currently searching for exotic oxygen isotopes in ferropericlase that indicate asthenospheric diamond growth, rather than the primitive mantle values expected for lower mantle ferropericlase. In conclusion, oxygen isotopic analyses of diamond inclusions can identify various sublithsopheric diamond populations, and may benefit the assessment of a mine's potential for large gem-quality, or type IIb diamonds.

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NEW AGE CONSTRAINTS ON CRUST FORMATION, PROVENANCE AND TIMING OF SEDIMENTATION, BOOTHIA PENINSULA-SOMERSET ISLAND, NUNAVUT, CANADA

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One of the major geological features of the Canadian Arctic is the "˜Boothia Uplift', an outlier of Precambrian basement exposed for > 900 km from Taloyoak to northwestern Somerset Island. This under-explored frontier region was last mapped in 1962 (Blackadar, 1967, GSC Bulletin 151) and 1986-1992 (Frisch, 2011, OF 6051, https://doi.org/10.4095/287896). In order to improve the geoscience knowledge base of this region and assess its mineral potential, detailed bedrock mapping supported by new high-resolution aeromagnetic data was conducted in 2017 and 2018 as part of the Geomapping for Energy and Minerals (GEM2) program.

Preliminary results reveal that the oldest basement rocks of Boothia Peninsula are voluminous upper-amphibolite to granulite-facies biotite-garnet K-feldspar porphyroclastic quartz monzonite, and lesser tonalite-trondjhemite gneiss with crystallization ages of ca. 2.56 Ga and 2.53 Ga, respectively.

Metasedimentary rocks across Boothia Peninsula yield detrital zircon that indicate the presence of at least two distinct clastic sequences. Widespread garnet-sillimanite semipelite to inhomogeneous diatexite have a maximum depositional age of ca. 2.50 Ga (Sequence I) with a prominent mode at ca. 2.52 Ga and lack detrital zircon older than 2.55 Ga. Lesser garnet-bearing psammite, quartzite and marble, exposed on northwestern Boothia Peninsula, have a maximum depositional age of ca. 1.95 Ga (Sequence II) with prominent modes at 1.963 Ga, 1.975 Ga, and 1.992 Ga with a minor mode at ca. 2.50 Ga, and no detritus older than 2.53 Ga. The detrital zircon U-Pb data suggest Boothia basement rocks are a likely source for Sequence I, while a prominent source for Sequence II appears to be the Thelon magmatic arc, which, according to the aeromagnetic data, may be 200 km west of Boothia Peninsula. Sequence I is cut by a voluminous intermediate to mafic plutonic suite dominated by diorite and quartz diorite with crystallization ages of ca. 2.49-2.48 Ga, establishing a minimum depositional age for this sedimentary package.

Fieldwork in 2018 on Somerset Island revealed that high-grade tonalitic to granodioritic rocks, associated with minor diorite, are more abundant than supracrustal rocks, the latter comprising clastic rocks often associated with tectonically thinned metacarbonate. It is not yet known if the clastic sequence associated with metacarbonate rocks on Somerset Island is correlative with Sequence I or Sequence II.

In summary, the new results indicate that (i) felsic and intermediate plutonic basement rocks of Boothia-Somerset formed between 2.56-2.48 Ga, a period that historically is not represented in Rae craton evolution; (ii) Neoarchean-Early Paleoproterozoic clastic Sequence I is not sourced from 2.6-2.97 Ga

crust of the Rae craton, and (iii) Thelon magmatic arc rocks are not exposed on Boothia Peninsula, as previously suggested, but may constitute Sequence II clastics. Collectively, GEM2 data are revealing an absence of rocks typical of Rae craton throughout the Boothia-Somerset region, suggesting the "Boothia uplift" may be an exotic terrane accreted to the Rae, or a ca. 2.56-2.48 Ga magmatic arc complex built on thinned Rae crust. It also reveals that mineral exploration strategies for Rae craton may not be applicable to the Boothia-Somerset region.

RAMPING UP FROM CONSTRUCTION TO OPERATIONS: LESSONS LEARNED AT GAHCHO KUÉ DIAMOND MINE

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Gahcho Kué Mine is a success story. Discovered in 1995, the mine's joint venture partners (De Beers Canada – 51%, the operator; Mountain Province Diamonds – 49%) successfully brought the world's largest new diamond mine into commercial production in early 2017. Located in the Northwest Territories, 280 km northeast of Yellowknife, the mine was built ahead of time and on budget. In its first year, the mine recovered 5.9 million carats of diamonds and is poised to do even better in 2018. The mine's safety performance continues to improve and is delivering on its socio-economic commitments to the Northwest Territories. Along the way, Gahcho Kué has received numerous awards and recognition, including national and international awards for project management, the Hatch-CIM Project Safety Award, Yellowknife Chamber of Commerce Workplace Safety Award and others.

This presentation will provide insight into:

- The ramp-up from construction into operations;
- Lessons learned along the way; and,
- The current status of the mine.

ORPHAN AND ELUSIVE GLACIAL DISPERSAL TRAINS FROM KIMBERLITES IN THE LAC DE GRAS AREA

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Numerous glacial dispersal trains, spatially and compositionally associated to kimberlites, have been characterized and mapped in the Lac de Gras region, Northwest Territories (NT). However, a small number of these trains have yet to be associated with a source. Additionally, a number of known sub-cropping kimberlites do not have well-defined, spatially associated, trains of indicator minerals. These issues suggest that local factors may be important in controlling the occurrence, shape, and strength of a dispersal pattern and its spatial association with a kimberlite. Identifying these factors and understanding their effect on the dispersion of indicator minerals could provide a road map for finding additional diamondiferous kimberlites in the NT and elsewhere.

Here we examine contrasting dispersal trains from south and southwest of Lac de Gras, as well as situations where the source of known dispersal trains (e.g., Coppermine Train) continue to elude exploration geologists. Using both surface and subsurface datasets, we find that the bedrock geology and topography of the source area, as well as those of the dispersal area, are potential key controls on the type and shape of dispersal patterns. Even across discontinuous drift and subdued shield relief we find that bedrock topography and lithology modulated the effect of glacial dynamics on till production and provenance. These 'bedrock factors' have interacted in various ways during Quaternary glaciations, in combinations unique to each case, to generate complex dispersal patterns in three dimensions. Accounting for these factors, using both surface and subsurface data, could enhance the success of drift exploration programs and improve their outcome in the glaciated shield terrains of northern Canada.

RE-THINKING DIAMOND EXPLORATION TACTICS IN THE SLAVE PROVINCE: A SURFICIAL GEOLOGY PERSPECTIVE

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It took several decades to develop the necessary understanding of glaciation, geochemistry and mineralogy to refine exploration strategies and find the first kimberlite in the Northwest Territories, Canada. These fundamental drift prospecting strategies followed by geophysics and drilling have been used to locate many kimberlite occurrences over the years. Indicator minerals in surface sediments are still the primary datasets used to identify kimberlite exploration targets; however, many of the kimberlite sources for the well-defined indicator mineral dispersals have been identified. Exploration must now focus on regions with more complex surficial geology where primary dispersal patterns in till are obscured by post-depositional modification. These patterns are largely defined using data from historical "˜till' surveys that often failed to properly scrutinize the sample media; reworked tills and other surficial materials were commonly collected. The regional surficial geology maps (e.g., 1:50,000 to 1:250,000) typically published by geological surveys to stimulate reconnaissance exploration in new areas are generally incapable of providing sufficient resolution to determine the genesis and post-glacial alteration of sample media or reconcile complex dispersal patterns. Furthermore, advances in analytical methods have yielded compiled datasets with results from multiple methods that are not always comparable. Without a new, more detailed and systematic approach to evaluating surface sediment data, exploration in areas with complex glacial, deglacial and post-glacial histories will be challenged to discover kimberlite.

The accessibility, quality and variety of high-resolution aerial or satellite imagery and topographic data has improved significantly over the years, affording a more detailed interpretation of the surficial environment. These detailed interpretations have allowed us to evaluate historical data with a new perspective and target the collection of new, high-quality data. Throughout the Slave Province, we have tailored surficial

interpretations to distinguish in-situ till from reworked till and other materials, which have altered dispersion and indicator mineral concentrations. Using examples from the Lac de Gras area, this presentation demonstrates how a detailed surficial framework, combined with an understanding of the varied analytical methods, is applied to historical datasets to refine indicator dispersal patterns and identify new exploration targets. By standardizing the data based on sediment genesis and transport mechanisms, the dataset becomes more suitable for statistical evaluation and anomaly threshold determinations that are unique to specific data subpopulations. As a result, anomaly contrasts are improved, and complex dispersals can be unravelled. In addition, areas with insufficient data coverage are identified and the necessary framework to complete informed, efficient infill or new sampling is provided. The examples we share highlight that there is no replacement for project-scale understanding of surficial geology and its varied effects on mineral dispersals in the development and interpretation of a surface sediment dataset used to identify kimberlite exploration targets.

STRUCTURAL SETTING OF THE CANTUNG W-CU-AU DEPOSIT: AN INTERACTION BETWEEN REGIONAL DEFORMATION AND PLUTON EMPLACEMENT

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The Cantung W-Cu-Au skarn hosts one of the most significant sources of tungsten in the world. Since 1962, ~7.68 Mt of ore has been extracted at a grade of ~1.4 % WO_3. Cantung is located within the Selwyn basin of the Canadian Cordillera, in the southwest corner of the NWT. The deposit is hosted in the folded sequence of carbonate units belonging to the Cambrian Sekwi Formation and is spatially and genetically associated with 94 to 98 Ma monzogranite intrusions of the Tungsten plutonic suite. The E-Zone underground orebody is developed along the lower, overturned, limb of a large near-recumbent antiform (the "Mine Fold"), which exerts a first-order control on the distribution and grade of mineralization. This fold has a strongly curved hinge line, which is largely oblique to the regional NW-SE structural trend, suggesting a complex deformation history.

Beyond the immediate surrounds of the Cantung deposit and the Mine Stock, the lithological units are macroscopically folded as part of a regional NW-SE trending fold event thought to be related to the Cordilleran Orogeny. This regional set of upright F1 folds and corresponding axial planar S1 foliation are a product of a major crustal shortening event, D1. Geological mapping in the area around Cantung has not identified any correlative structures to the curvilinear, near-recumbent, Mine Fold antiform. An interpretation is that the Mine fold formed from sub-vertical shortening and northward flow of Vampire and Sekwi Formation rocks during emplacement and upward "ballooning" of the Mine Stock. This would have allowed thermal weakening to localize shortening but only within the contact metamorphic aureole. The presence of limestone units immediately above the Mine Stock also favoured ductile flow. The development of a gently dipping S2 crenulation cleavage suggests that shortening

may have been initiated by emplacement of the larger parent magma body prior to final emplacement of Mine Stock.

The apparent lack of macroscopic F1 folds in the zone above the Mine Stock at Cantung indicates that emplacement of the intrusion might have initiated during D1, with the region above the stock forming a D1 strain shadow. The switch to sub-vertical D2 shortening reflected a local change in the strain field associated with pluton emplacement, and may not be associated with any change in the far-field kinematic reference frame. Similar sub-vertical shortening appears to have occurred in the thermal aureoles of other Cretaceous intrusions in the region. Post-D2 cooling of the aureole may have facilitated the formation of steep brittle fractures and faults that focused the emplacement of late dykes and the upward flow of late magmatically-derived hydrothermal ore-fluids.

A DIFFERENT APPROACH INTERPRETING THE GEOLOGICAL STRUCTURES CONTROLLING GOLD AT THE CABIN LAKE PROJECT, NWT, CANADA

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The Cabin Lake Project is located 110 km NW of Yellowknife (NWT). In 1945-47, a total of seven mineralized zones were discovered, 65 trenches excavated, a 340 ft. open cut was excavated in the promising No.2 zone (later referred as the Andrew Zone) and 7,406 ft in a total of 38 diamond drill holes, delineating a gold mineralized zone in the northern part of the property. The southern portion of the zone averaged 0.09 oz/ton Au across 11.6 ft., including a 318 ft. strike length averaging 0.15 oz/ton across 5.8 ft. (based on trenching). The northern part of the Andrew Zone returned a strike length of 400 ft., averaging 0.15 oz/ton Au across an average width of 8.7 ft., at a drilled depth of 100 ft. Both these zones remained open to depth and the northern zone was also open to the south. In 1986 Aber Resources continued geological mapping, and between1986 and 1987 completed 3,174 m of diamond drilling in the Bugow (Cabin Lake) leases. A new mineralized zone called the “Cabin Lake Zone” was discovered with a strike length of 100 m and a depth of 70 m establishing a mineral inventory of 70,000 tons grading 0.3 opt Au at the Cabin Lake zone.

The regional geology is mainly represented by two large areas or granitic intrusions of Proterozoic age, one to the north of Russell Lake and one southeast of Slemon Lake, and Russell Lake Archean belt assigned to the Archean Yellowknife Group, narrows to a 6.5 km width between these two granitic batholiths and extends 70 km to the north and 50 km to the east of the property.

The amphibolitic iron formations are the most reliable marker beds defining the contacts of the various metagreywacke units, and are also defining areas of potential economic value. The Bugow Iron Formation is repeated several times across the property as a result of isoclinal folding. It is found as a massive unit of banded amphibolite, quartz, occasional garnet, hornblende and chlorite. Metallic minerals such as magnetite and pyrite are common in the amphibolite, with lesser amounts of pyrrhotite and arsenopyrite.

The structural interpretation done back in the day shows evidence of three phases of Archean folding. In the past, geological thinking at Cabin Lake (Bugow) has been

severely limited by the lack of apparent correlation between gold values and fold hinge structures. The Andrew and Cabin Lake gold zones within the property indicate that none of them contain fold hinges. It is also demonstrated that the property shows half a dozen perfectly developed fold hinges, not one of which has responded positively to definitive prospecting, trenching, or in some cases, drilling. Clearly some other factors are involved, and that is likely bound up with the source of the gold in the property. It is also described by the geologists that worked the area that the auriferous parts of the amphibolite usually contain hornblende as opposed to the more usual grunerite. Magnetite is common in both mineralized and unmineralized amphibolite, with or without gold values.

FORTUNE MINERALS LIMITED NICO PROJECT UPDATE

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This presentation provides an overall update on the Fortune Minerals (Fortune Minerals) Limited NICO Cobalt-Gold-Bismuth-Copper development ("NICO Project") with emphasis on recent changes to project planning, development timelines and company activities. Fortune Minerals has received successful results of metallurgical test work verifying that it can produce an upgraded and essentially arsenic-free cobalt concentrate for the NICO Project. Gold can also be recovered by Fortune from its metal concentrates at the mine site allowing the Company to control the gold revenue stream, while producing separate cobalt and bismuth concentrates for sale to third party processors after arsenic that is typically penalized is removed. The 100% owned NICO Project is a development stage primary cobalt asset with significant gold and bismuth by-products. Fortune engaged Dundee Sustainable Technologies Inc. to conduct a metallurgical test work program to assess the application of its "Pyrolysis Roast" and "Arsenic Stabilization" processes on metal concentrates produced from the NICO Project.

The objective of this work was to demonstrate that Fortune can remove the arsenic and create metal concentrates that are more attractive to the market and can be processed in existing metal recovery circuits operating around the world. Fortune is evaluating the merits and conducting cost-benefit analysis of building a lower capital cost project that would produce concentrates vs. a higher capital cost project that would produce value added cobalt chemicals in a purpose-built refinery. The Company will evaluate the best development option in consultation with potential strategic partners and in consideration of their downstream product and commercial objectives. A technical report will be prepared to document the most commercially attractive project. Fortune has more than 35 confidentiality agreements with companies interested in strategic partnerships to build and operate the NICO Project.

On the socio-economic front, Fortune is a co-sponsor, together with the NWT government, and other industry, community and education partners, in delivering the Prospectors and Developers Association of Canada Mining Matters program to elementary schools in the NWT. The Company is also announcing funding for two educational awards for Tłı̨chǫ students to participate in post-secondary studies in programs related to the resource industry.

CONTROLS ON THE SPATIAL DISTRIBUTION OF ARSENIC CONCENTRATION AND SOLID-PHASE SPECIATION IN LONG LAKE SEDIMENTS

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Sediment arsenic concentrations in Long Lake, Yellowknife, Canada, which is used for recreational purposes, are elevated relative to Canadian and regional guidelines and exceed 3000 mg/kg in selected samples. This degree of arsenic enrichment can be largely attributed to the aerial deposition of arsenic trioxide from legacy stack emissions at Giant Mine and other former gold-mining operations in the Yellowknife area. Arsenic has persisted in lake sediments as arsenic trioxide for more than 60 years after peak mining emissions, but there is also evidence that arsenic trioxide has geochemically transformed to less bioaccessible arsenic-hosting phases such as arsenic sulphides.

Forty-seven sediment cores were collected in July 2016 as part of a spatial survey to elucidate the physical and geochemical controls on the distribution of arsenic in Long Lake sediments. High-resolution profiles of dissolved arsenic in bottom water and porewater were also collected to determine arsenic remobilization and diffusion rates across the sediment-water interface. Linear regression was used to explore the relationships between arsenic, other relevant geochemical variables, and water depth in all sediment depth intervals.

Arsenic concentrations and solid-phase speciation in Long Lake sediments exhibit considerable lateral and vertical variation. Two distinct types of sediment arsenic concentration profiles were identified and are interpreted to represent areas of sediment erosion and deposition. Multiple linear regression indicates that water depth, as a proxy for sediment texture, is the best predictor of arsenic concentrations in near-surface sediments but is a weaker predictor of arsenic concentrations in deeper sediment layers due to the existence of the two types of arsenic profiles identified in this study. Iron concentration, as an indicator of arsenic, iron, and sulphur co-diagenesis, is a better predictor of arsenic concentration at greater sediment depths.

Sediments are a source of arsenic to surface waters through diffusion-controlled release to bottom water; rates of arsenic release into the water column vary spatially with changes in sediment texture and porosity. In areas of sediment accumulation, rates of solid-phase As burial may exceed diffusion rates. The observed variations in the distribution and mobility of arsenic are interpreted to reflect the interplay between sediment-focusing processes and redox reactions.

The spatial heterogeneity of arsenic distribution observed in this study emphasizes the advantages of a multi-station approach for capturing whole-lake accumulation trends. Understanding the depositional patterns of atmospherically deposited arsenic in sediments is also important in the context of risk assessment, as it highlights areas of lakes where humans may be exposed to high sediment arsenic concentrations and more bioaccessible arsenic-hosting solid phases.

NUNAVUT MINERAL EXPLORATION & MINING OVERVIEW 2018

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In 2018, Nunavut is continuing its shift from primarily exploration-stage projects to more producing mines and advanced stage projects. The territory has two operating gold mines, Agnico Eagle's Meadowbank and TMAC Resources' Doris, as well as the Mary River iron mine owned by Baffinland Iron Mines. Although production from Meadowbank is scheduled to cease in 2019, Agnico Eagle is bringing the Whale Tail satellite deposit online to replace it, and will also initiate production from Meliadine next year.

Spending intentions for mineral exploration and deposit appraisal have declined to $110 million in 2018, down from $169 million in 2017, according to the statistics released by Natural Resources Canada. This places Nunavut sixth in Canada for mineral exploration spending. Consistent with the last several years, exploration for gold accounts for most of that total, with lesser amount spent on base metals, diamonds, iron, and uranium.

However, Nunavut saw an increase in the total value of mineral production in 2017, amounting to $844 million, of which $594 million was gold and $249 million was iron, placing the territory fifth in Canada. With two new mines approaching production, Nunavut has also seen an increase in mine complex development and capital assets spending.

Significant advances were made at Sabina Gold and Silver Corp.'s Back River gold project in 2018. The company obtained its Type B water license for completion of pre-construction infrastructure work and received a positive recommendation for issuance of its Type A license. The marine laydown area and landing were completed, paving the way for re-supply through sealifts. Drilling identified the new Nuvuak high-grade gold target. Sabina also finalized its Inuit Impact Benefit Agreement and Long Term Land Tenure Agreement with the Kitikmeot Inuit Association.

Several other gold projects were active in 2018: Auryn Resources Inc. continued exploring the Committee Bay project, conducting diamond and rotary air-blast drilling, as well as till sampling. Solstice Gold Corporation, spun off from Dunnedin Ventures Inc. in 2017 to explore the gold potential at its Kahuna diamond project, conducted prospecting, geological mapping, and till sampling over high priority areas. Silver Range Resources Ltd. conducted exploration for Pilbara-style gold mineralization at its Tree River property.

De Beers Canada Inc. purchased Peregrine Diamonds Ltd., acquiring the Chidliak diamond project and several other projects in Nunavut and Northwest Territories. North Arrow Minerals Inc. discovered a second kimberlite, ML345, on its Mel property to follow-up the diamondiferous ML8 discovery in 2017. Dunnedin Ventures also discovered a new kimberlite at Kahuna.

Aston Bay Holdings Ltd. completed 3,100 metres of drilling at its Storm Copper and Seal Zinc projects on Somerset Island.

Nunavut is continuing to draw interest in its mineral potential and it is encouraging to see an increase in the metals produced and the number of producing mines.

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

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During 2018 TerraX completed 6,118 metres of diamond drilling in 16 NQ drill holes. The majority of this drilling was completed on the Mispickel, Sam Otto and Daves Pond targets with 4,948 metres in twelve drill holes. The remainder of the drilling was completed on the Crestaurum Zone with four drill holes totaling 1170 metres. Gold mineralization was intersected in all targets. The most significant gold mineralization was intersected at the Sam Otto, Sam Otto South and Crestarum zones.

The 1,315 metres in the three holes drilled on the Sam Otto zone extended the depth of the zone to 350 metres vertical. This zone consists of quartz veins hosted in intermediate and felsic tuffs of the Banting Group. The best intersection was 0.85 Au g/t over 62.24 metres, including 2.04 g/t over 13.95 metres in TSO18-032. Three holes totaling 1,118 that were drilled on the Sam Otto South zone were the most significant as these three holes extended Sam Otto style gold mineralization an additional 1500 metres, south. The most significant intersections were:

- 2.16 g/t Au over 27.16 m, including 23.10 g/t Au over 1.0 m and 7.99 g/t Au over 2.44 m in hole TSO18-035
- 1.92 g/t Au over 11.52 m, including 2.89 g/t Au over 3.64 m in hole TSO18-037

The Crestaurum Zone drilling was designed to test the main mineralized shear/quartz vein system to 300 metres depth. Previous drilling had outlined discrete high-grade shoots to vertical depths of 100 – 150 metres. The four holes totaling 1170 metre intersected the high-grade shoots to depths of 300 vertical metres. The most significant intersections were:

- 5.38 g/t Au over 0.63 m in hole TCR18-076
- 5.57 g/t Au over 2.06 m in hole TSO17-078
- 4.41 g/t Au over 0.80 m in hole TSO17-079

In addition, all drill holes intersected a hanging wall shear/quartz vein system to a vertical depth of 50 to 75 metres. The most significant intersections were:

- 8.84 g/t Au over 2.49 m in hole TCR18-076
- 3.08 g/t Au over 2.80 m in hole TSO17-077
- 13.30 g/t Au over 1.24 m in hole TSO17-079

This hanging wall zone presents the possibility of two ore bearing sub-parallel structures at Crestaurum zone.

PASSIVE MONITORING FOR WILDLIFE: LESSONS LEARNED FROM 10 YEARS OF CAMERA MONITORING

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Collecting accurate wildlife data is important for environmental monitoring and environmental assessments. Some monitoring methods, such as low-level aerial surveys, can disturb wildlife. Passive monitoring using wildlife cameras offers a solution that provides good quality data with limited disturbance to wildlife. We report on our use of wildlife cameras during the last 10 years in NWT and Nunavut at seven mining projects. We discuss best practices for camera use and lessons learned. Key challenges include: 1) identifying hypotheses that can be tested using cameras, 2) appropriate experimental/monitoring design, 3) addressing low encounter rate, 4) measuring effort, 5) the use of machine learning, and 6) appropriate statistical tests to evaluate the hypotheses. Used appropriately, wildlife cameras can be a powerful tool for monitoring wildlife populations, but due consideration of their limitations are required well in advance of their deployment to make effective use of this monitoring technique.

METAL EARTH PROJECT; PROGRESS TO DATE

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Metal Earth is a seven-year, $104M research program led by the Mineral Exploration Research Centre, at Laurentian University. It is funded by the Canada First Research Excellence Fund, Laurentian University and Federal, Provincial, Territorial, Academic and Industry partners. Metal Earth is the largest mineral exploration research project ever conducted in Canada. It will focus on the Archean era, which represents about 80% of Earth history, 30% of Canada's Far North rock exposure, and almost 50% of Canada's metal wealth. Metal Earth will image entire ore and non-ore systems at full crust-mantle scale to determine the process responsible for Earth's differential metal endowment. It will transform our understanding if Earth's early history and how we explore for metals.

In Canada, and similar jurisdictions, mineral resources are increasingly difficult and expensive to discover and develop. This is a function of established mining camps becoming increasingly mature which pushes exploration and development activities into, remote and covered areas, or deep exploration in mature camps. The end result of this global trend is fewer discoveries and increased discovery costs on a per ounce basis. To slow and reverse this trend, the research community and the minerals industry need to collaboratively develop predictive tools to increase exploration success both in mature mining camps and new districts. Inherent in this research will be an improved understanding of the processes that result in Earth's differential metal endowment across geologic time and how we explore for metals.

Metal Earth has completed its second full field season with over 50 geoscientists conducting targeted mapping in 2018 and completion of 1,000 km of reflection seismic, magnetotelluric and gravity surveys across variably endowed fault systems and volcanic centers of the Abitibi and Wabigoon subprovinces. This presentation will focus on

progress to date and future plans for the project.

CONTAMINANT EXPOSURE HISTORY OF YELLOWKNIFE BAY FISH FROM OTOLITH MICROCHEMISTRY ANALYSIS

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The talk will review results from a study on otolith microchemistry of slimy sculpin, burbot, and lake whitefish from Yellowknife Bay, Northwest Territories, in relation to the Giant Mine Remediation Project. Otoliths are small “earbones” in fish that have been gaining attention in recent years as they can provide a detailed and permanent chronological record of trace element exposure over the life of a fish. The objective of the study was to assess pre-remediation patterns of trace elements in the fish otoliths to evaluate if signatures of contaminant exposure are present as a result of current and historic operations at Giant Mine. Trace elements analyzed in the study included arsenic, the mine's primary contaminant of concern, as well as antimony, copper, lead, strontium, and zinc.

SHORT HOLD TIME PARAMETERS

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It is well known that it is very difficult to transport samples from remote locations to the laboratory and allow sufficient time to commence analysis within the prescribed short hold times for certain parameters. Also, the majority of published hold times are based on legacy as opposed to hard science.

In an attempt to determine the validity of specific short hold times, a joint study between Diavik and Maxxam was undertaken. The purpose was to determine the stability of short hold time parameters over time using real samples from Diavik sites. Data from two sites will be presented. The first from the Diavik mine water treatment plant influent, which had relatively high levels of the target analytes. The second from a lake water sample with lower native levels of the target analytes. The parameters studied were ammonia (preserved and unpreserved), total nitrogen, nitrite, nitrate, phosphate, total phosphorus and turbidity. All target parameters have a prescribed 3-day hold time.[1] pH was also monitored.

Samples were collected by Diavik personnel in one-litre containers and extraordinary logistical measures were taken to get them to Maxxam's Burnaby laboratory as soon as possible. On receipt, they were immediately subsampled into appropriate containers. Each parameter (except pH and turbidity) was split into three containers: 1) as received; 2) low level spike added and 3) medium level spike added. All samples were analyzed within 3

days of sampling and subsequently analyzed at approximately 3-day intervals thereafter for a period of two weeks.

[1] Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment – Volume 4 Analytical Methods.

THE CANADIAN MINERALS AND METALS PLAN

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The purpose of the Canadian Minerals and Metals Plan is to re-establish Canada as the foremost mining nation in the world. The Energy and Mines Ministers Conference launched this initiative in August 2017 and federal, provincial and territorial governments have led the development of the Plan, including analytical work and extensive engagement across all jurisdictions.

This presentation will bring mining sector players up-to-date following feedback from federal, provincial and territorial mines ministers on the Plan outline presented to them in August 2018. Discussion to date has focused on six priority areas: Unlocking Canada's Resource Potential; Igniting Innovation; Providing Regulatory Certainty; Realizing Community Benefits and Supporting a Diverse Workforce; Advancing the Participation of Indigenous Peoples; and Capitalizing on Canadian Leadership in a Global Market. Engagement sessions with stakeholders will help validate the Plan elements and inform their development. The goal is to finalize the Plan in early 2019.

KEY AQUATIC PRIMARY PRODUCERS TRACK THE IMPACTS OF METAL POLLUTION AND LOCAL LAND-USE CHANGES IN CLIMATICALLY SENSITIVE SUBARCTIC LAKES AROUND THE CITY OF YELLOWKNIFE

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Very little long-term environmental monitoring information is available on the ecological impacts of anthropogenic activities on climatically-sensitive northern aquatic environments. Fortunately, lake sediments preserve the remains of many sensitive biological and geochemical indicators that can be used to hindcast past environmental conditions. We are using the paleolimnological approach to understand the long-term biological consequences of 20th century gold mining activities around the City of Yellowknife. Specifically, we aim to 1) establish the pre-disturbance biological conditions (i.e. prior to mining activities), 2) examine the response to metal pollution and local land-use changes, and 3) determine if biological recovery has occurred since the cessation of gold mining activities. To achieve these goals, we examined sedimentary diatom (microscopic siliceous algae) assemblages in radiometrically dated sediment cores from a suite of lakes around Yellowknife. Our data provide strong evidence that the primary producers from lakes around Yellowknife have been altered

by mining operations, as well as local land-use changes, over the past ~100 years. Despite the closure of the mining activities, the biota of these lakes have not returned to pre-disturbance conditions, as the contaminant concentrations are still high at some sites. The timing and nature of the biological changes in these lakes affected by multiple environmental stressors highlight the interactive effects of industrial contaminants, local land-use changes, and climate warming on the algal assemblages in climatically-sensitive subarctic regions.

NEW INSIGHTS INTO BARREN AND AU-MINERALIZED INTRUSIONS USING WHOLE ROCK AND TRACE ELEMENT GEOCHEMISTRY FROM THE YELLOWKNIFE GREENSTONE BELT, NWT

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The Yellowknife greenstone belt (YGB) consists of a homoclinal sequence of mafic and felsic metavolcanic rocks that young to the southeast and are cross-cut by at least three generations of felsic to intermediate dykes. Early mappers identified these dykes as porphyritic quartz-feldspar and feldspar-quartz intrusions and grouped together as the #9 dykes, despite their relative timing and textural differences. Narrow aplitic and granitic dykes were also observed and appear to be the youngest dykes in the belt. There has been limited work regarding the whole-rock and trace-element geochemistry of the YGB, and no studies have focused on the cross-cutting porphyritic dykes. This study aims to shed light on the genesis of these dykes by analyzing a larger data set from across the YGB and using immobile elements to characterize each lithology, complimenting isotope work, age dating, and field relationships.

Representative samples from the lithologies of interest were pulverized and made in to pressed pellets for analysis by micro-X-Ray Fluorescence (µXRF) and fused in to glass beads for Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). Quantitative µXRF data was gathered to use for internal standardization during LA-ICP-MS. This combination of analytical techniques has allowed for the complete geochemical characterization of the intrusions. Previous geochemistry studies of the Yellowknife region have focused on the Kam and Banting metavolcanic groups. However, this work used classification diagrams that compared elements, such as Fe, Mg, Na, Ca, and K, which are potentially mobile during even low degrees of hydrothermal alteration. This type of weak to intense alteration is nearly pervasive throughout the YGB, therefore any classifications done using these elements could give misleading results and warrants verification using more appropriate immobile high field strength elements, such as those involving alteration indices and immobile trace elements and applicable discrimination diagrams. By evaluating data in this manner, we can assess mass elemental losses and gains, and which trends may relate to mineralization.

HYDROTHERMAL FLUID SOURCES AND PATHWAYS IN A WORLD CLASS MISSISSIPPI VALLEY-TYPE LEAD-ZINC DISTRICT: PINE POINT

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Pine Point is a world class carbonate-hosted lead-zinc district, comprising at least 100 known occurrences of lead-zinc mineralization, spanning over 1600 km^2. Lead-zinc mineralization at Pine Point is hosted in Devonian reefal carbonate rocks. The district constitutes a major fraction of Canada's total lead and zinc potential, and accounted for a significant proportion of the total lead and zinc produced in Canada during its production years. The mineralizing system at Pine Point is thought to reflect regional-scale flux of sedimentary-derived brines. However, several key questions remain as to the ultimate sources of fluids, metals and sulfur, and the fluid pathways that led to focusing at Pine Point.

The Pine Point district contains two main types of mineralization: "tabular" bodies, which are stratabound and karstic, and "prismatic" bodies, which are cross-cutting, chimney-like pipes with breccia features. The spatial and genetic relationships between these two types are not entirely clear, as some of the prismatics are apparently rooted in tabular karst, whereas others are not. The geometries and spatial relationships between these two types give rise to the interpretation that mineralizing fluids derived from a common source variably made use of both stratabound karstic horizons and structurally controlled breccia pipes along their flow path. Nevertheless, questions remain as to whether regional fluid flux primarily followed the host carbonate package, or involved deeper circulation that may have accessed the carbonate section via discordant fluid pathways, perhaps represented in part by the prismatics. Available data indicate multiple fluid sources represented in different paragenetic stages, which may imply a role of fluid mixing in sulfide deposition. In addition, lead-zinc mineralization tends to be spatially associated with marcasite, although questions remain as to the paragentic relationship between marcasite and lead-zinc sulfides.

This presentation will provide a summary of the geologic context and hydrothermal features of the Pine Point District, and an overview of our ongoing geochemical studies of mineralizing fluid systems and paragenesis in both tabular- and prismatic-style mineralization. The presentation will highlight some of the interesting mineralogical and geochemical features of Pine Point and provide some preliminary hypotheses on the physical and chemical processes governing lead-zinc mineralization here and in general.

BOOTS ON THE GROUND – CARIBOU MONITORING

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The Boots on the Ground traditional knowledge caribou monitoring program completed its third installment this summer at Kokètì (Contwoyto Lake), which sits on the NWT/NU border. Two teams spend 3 weeks each out on the land observing the Bathurst caribou in their natural habitat. Tłı̨chǫ/Inuit Elders, field guides, wildlife monitors and researchers make up a 5-6 person team. By staying small scale the team is able to easily move across the land or use a boat on the lake to follow the caribou. The program created the "we watch everything" methodology; observations about vegetation, caribou behavior, caribou health and migration routes are recorded along with information on predators, other wildlife and the weather. Of note this year is how a changing climate is bringing new predators to the area, which further increases pressures on caribou. The presentation will explain the program and information gathered.

REMEDIATION APPROACHES AT KWETĮ̀ʔAÀ (RAYROCK) MINE

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The Tłı̨chǫ Government has worked in collaboration with the Crown-Indigenous Relations and Northern Affairs Canada - Contaminants and Remediation Division to remediate the Colomac and Rayrock mines. In 2017, Tłı̨chǫ Elders identified areas that they avoid due to historic contamination. Using western and indigenous science, the parties have worked to understand options for cleaning up the mine site, and prepared an action plan. On the ground monitoring by Tłı̨chǫ BEAHR (Building environmental aboriginal human resources) monitoring graduates is allowing the Tłı̨chǫ Government to attain a strong understanding of the health of the land in the region. The Tłı̨chǫ Government led an environmental monitoring program that aims to collect traditional knowledge about the safety of water, land and animals at the Kwetı̨ı̨ʔaà mine site. This information is designed to better understand the safety of the mine site, priorities for remediation, and to communicate to community members and the Tłı̨chǫ Government the findings of the work.

TŁĮCHǪ CONSULTATION AND ENGAGEMENT GUIDELINES

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The Tłı̨chǫ Government is preparing guidelines to formalize the procedures for community engagement on proposals for development in Mowhì Gogha De Nı̨ı̨tlèè. The guidelines recognize that engagement and information requirements will vary depending on the type and scale of development. Our presentation will review enabling legislation, the guideline applications, the goals, and guiding principles. These guiding principles are set based in Tłı̨chǫ way of life, such as respect, coexistence, and inclusiveness. The draft guidelines will be released at Geoscience, and feedback and questions will be welcomed. Our intent is to build transparent and coherent guidelines that align with other guidelines and policies the north.

CROSSING GREAT SLAVE LAKE – EXAMINING THE POTENTIAL FOR SUBMARINE CABLES AND HVDC TECHNOLOGY

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The Government of the Northwest Territories (GNWT) wants to expand the Taltson hydroelectric system in the territory's South Slave Region, and connect it to the North Slave Region's hydroelectric system. Connecting the two hydro systems would create a secure, reliable, green power grid that could supply almost 75% of the NWT's community power demands.

This expanded and connected grid could also supply territorial resource development projects with clean energy. Despite a lack of roads, electrical transmission lines and communication corridors to support it, the mining sector is the backbone of the NWT economy. Accessible hydroelectricity would dramatically reduce the mining industry's carbon emissions as well as their operational costs.

The Taltson River system has the potential to support 200 Megawatts (MW) of electricity generation capacity. The existing 18 MW hydro plant on the Taltson River could be accompanied by a new 60 MW plant utilizing existing water storage with no new flooding, and could deliver green energy to market within five to ten years.

The GNWT is currently undertaking a study to examine using High Voltage Direct Current (HVDC) and submarine cables to link the South Slave Region - which is rich in hydro resources - to the mineral-rich and high-load North Slave Region, where there is heavy resource development. The idea of connecting these two areas is not new. A Western Great Slave Lake Transmission Line and various AC submarine and overhead cabling routes were studied in the past, but today, using HVDC could provide superior performance and lower costs.

Most transmission lines are High Voltage Alternating Current (AC), which is generally the lowest cost option. Although HVDC transmission has superior technical properties, it can be more expensive. To interface with the AC grid, expensive converter stations are needed to convert electricity from AC to Direct Current (DC) and back again. Historically, HVDC was only economic for large power transfers over a long distance, or used where a long underwater cable was required. However, technological advances in recent years have created new HVDC solutions targeting smaller installations, although many of these installations are still in the hundreds-of-megawatts range.

For this project, an HVDC connection would reduce the overall cable size and the number of submarine cables needed (two vs. three). Lighter cables, with a greater length per cable reel means fewer cable joints. Cable joints are a potential point of failure in submarine cables, and represent a significant cost in labour and materials. Other challenges this study will examine include how to get cable-laying equipment to the location (traditional cable-laying vessels are not able to travel down the Mackenzie River), and the limited installation period due to the annual ice-up on Great Slave Lake.

Future work will include community engagement, environmental assessment, commercial prospects, and technical elements such as bathymetric studies. If

feasible, an HVDC submarine cable route could enable connection to remote mine sites that are dependent on diesel fuel for electrical generation, resulting in significant economic and greenhouse gas reduction benefits.

SURFACE AND SUBSURFACE TILL CHARACTERISTICS IN A DRUMLIN FIELD SOUTH OF LAC DE GRAS, NT; IMPLICATIONS FOR DRIFT PROSPECTING

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Successful diamond exploration is becoming increasingly challenging as the best expressed targets have been found. Areas of variable drift thickness and heterogeneous surficial deposits present several challenges to exploration. One particular aspect that is poorly understood is the effect of well-developed drumlin fields on the surface expression of dispersal trains. Our study focuses on drumlin fields and their potential effects in the expression of a dispersal pattern. Because drumlins are often stratified we hypothesize that multiple till layers of contrasting provenance, representing multiple ice-flow directions, can occur at the surface across drumlin fields due to erosional processes. This has the potential to affect analysis and interpretation of surficial till dispersion data.

To test this hypothesis, we examined data from a large RC drilling dataset donated by Dominion Diamond Ekati Corp. and North Arrow Minerals Inc. and complemented it with field-based surficial geology observations and analysis of additional surficial till samples across targeted drumlins. The surficial samples were collected at the top and on the sides of drumlins to test whether any glacial stratigraphy is expressed, especially in areas where post-glacial erosion may have exposed internal drumlin stratigraphy. Based on the RC data and available maps drift thickness within the drumlin field ranges from 1 meter in the swales between drumlins to about 20 meters on the top of the highest amplitude drumlins. Locally measured ice-flow indicators (n=11) show three distinct ice-flow directions from older to youngest: 260, 290, 305 degrees. Preliminary analysis of textural and compositional data shows variations within the till at depth as well as across the drumlin field. Ongoing work focuses on determining the relationship (or lack thereof) between till characteristics, drumlins, and ice flow history (till provenance), as well as on three-dimensional dispersal patterns of kimberlite indicator minerals and related geochemical pathfinders. This work will highlight landform feature considerations by using multiple parameters to analyze sample data in areas with complex glacial geology and high diamond potential.

UPDATE ON THE PROPOSAL FOR A NORTHWEST TERRITORIES MINERAL RESOURCES ACT

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The Government of the Northwest Territories committed to developing a Northwest Territories Mineral Resources Act. In accordance with strategic policy directives

and under the mandate of the 18th Legislative Assembly, the Department of Industry Tourism and Investment (ITI) has taken the lead in preparing this legislative project. From August to December 2017, ITI conducted 120 days of public engagement across the NWT guided by a discussion paper organized around nine broad topics. A high-level summary of directions and recommendations received was published in a What We Heard Report in January 2018.

This presentation will provide an overview of this legislative initiative as it is now completing the policy development phase and moving towards receiving direction to begin legislative drafting.

THE APPLICATION OF PALEOLIMNOLOGICAL METHODS AND GEOCHEMICAL NORMALIZATION TO ESTABLISH BASELINE CONDITIONS FOR METAL CONTAMINANTS IN ADVANCE OF PROPOSED MINING, MARIAN WATERSHED, NORTHWEST TERRITORIES, CANADA

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The Marian Watershed Stewardship Program (MWSP), a community-driven aquatic ecosystem monitoring program, was developed by the Tłı̨chǫ Government to address concerns regarding the cumulative impacts of multiple potential stressors. In particular, the MWSP aims to develop methods that will be effective for detecting potential pollution from the proposed cobalt-gold-copper-bismuth NICO mine within Tłı̨chǫ Lands. In collaboration with the MWSP, we are using paleolimnological methods and geochemical normalization to establish pre-mine baselines of lake sediment metals concentrations across the Marian Watershed prior to mine development, which can be used to assess for pollution from surficial sediment once the mine becomes operational. Here we present stratigraphic sediment metal concentration results from four lakes normalized to lithogenic and biogenic elements (Al, Ti, OM, C_{org}). The application of normalizing techniques to metals within the stratigraphic record aims to account for natural variation as a result of (bio) geophysical processes that may affect sediment metals concentrations. Our application of this method results in a set of lake and metal specific baselines established for the four lakes. Results show metal concentrations are substantially higher in lakes on or adjacent to the ore body compared to lakes located in the surrounding granitic bedrock terrane. Temporal variations in the concentrations of many metals of concern are small, which provide values that can effectively serve as baselines for ongoing monitoring. An exception is arsenic, a metalloid of major concern, which increases variably in the latter half of the 20th century. There are multiple possible explanations for this trend, including far-field atmospheric emissions, increase in erosion of arsenic-bearing sources in the lake catchments, and/or post-depositional diagenetic mobilization in the lake sediment profile. Notably, increases in arsenic concentrations also occur in the early part of the past millennium likely indicating the potential for variation in the catchment-derived supply of arsenic to these lakes. Additional studies are

required to further characterize processes that cause arsenic variations in these lake sediment records. Variation in sediment metals concentrations on both temporal and spatial scales in this region demonstrate the need for lake-specific baselines for accurate interpretation of contemporary sediment monitoring data. This paleolimnological approach may be may be expanded to other lakes in the region for additional monitoring. This unique opportunity allows for the development of a well-informed and robust monitoring program which applies a scientific approach to meet the needs of a northern community initiative.

SHALE BASIN EVOLUTION PROJECT – SUMMARY OF RESULTS OF THE 2016 AND 2018 FIELD SEASONS

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The Shale Basin Evolution Project was initiated by the Northwest Territories Geological Survey (NTGS) in 2014. The primary purpose of the project was to extend the recently completed NTGS source rock characterization studies of the Devonian age shales of the Bluefish Member of the Hare Indian Formation and Canol Formation from the Mackenzie Plain toward the north and west into the Peel Plain and Plateau areas of the Northwest Territories, respectively. NTGS expanded the scope of this study in 2016 to include a rigorous scientific assessment of all of the shales of the Devonian age Horn River Group, now including the Bell Creek Member of the Hare Indian Formation as well as the Bluefish and Canol shales into the study. Outcrop, subsurface core, and chip sample studies have been conducted annually since 2014. This talk focuses on the Middle to Late Devonian stratigraphy of the Horn River Group, and highlights the scientific results from the 2014 and 2016 field seasons in a regional context. Preliminary results from the 2018 season are also discussed.

The Givetian-Frasnian aged Horn River Group comprises the Hare Indian (Bluefish and Bell Creek members), Ramparts, and Canol formations. It overlies the regionally extensive carbonates of the Hume Formation, and is in turn overlain by shales and sandstones of the Imperial Formation. The Hare Indian Formation and Canol Formation, although variable in thickness, are present throughout the study area and comprise organic poor to organic-rich shales. Conversely, the Ramparts Formation is restricted to parts of the northern Mackenzie Plain and southern Peel Plain and Peel Plateau areas and comprises carbonate lithologies. The Kee Scarp Member of the Ramparts Formation produces Canol Formation sourced oil from a conventional oil pool at Norman Wells.

The Bluefish Member of the Hare Indian Formation comprises organic-rich shales with generally good, but regionally variable TOC content, also indicated by consistently high uranium concentration. Silica content in the Bluefish Member is moderate and variable, resulting in lower brittleness of the rock, which was also observed in the field. Terrestrial input, based on geochemical indicators, is generally low, but increases upward in stratigraphy. Palaeoredox indicators suggest deposition under at least partly anoxic conditions. The Bell Creek Member has generally low TOC content and low uranium concentration. Silica content is also low with an elevated terrestrial input signature. Palaeoredox indicators suggest sustained oxic conditions. The Canol

Formation has a variable, but generally elevated TOC content. Silica content is the highest of these formations, resulting in brittle fracturing noted in the field. Terrigenous input is low through Canol Formation deposition. Palaeoredox indicators suggest variable conditions during deposition. Source-rock and vitrinite reflectance analyses indicate a regionally variable trend of rock maturity, with generally increasing maturity toward the western part of the study area. Available conodont and stable isotope analysis results aid in delineating the chronostratigraphy of these strata. These results, in conjunction with forthcoming results of the 2018 field work, well sampling, and available seismic data, will be used in a regional basin modelling effort.

"MADE IN THE NORTH": USING ADAPTIVE APPROACHES TO MANAGE REMEDIATION PROJECTS IN DYNAMIC NORTHERN ENVIRONMENTS AT THE BULLMOOSE-RUTH REMEDIATION PROJECT

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Working in the Northwest Territories can present challenges; both in the biophysical aspects of remediation and in the necessary engagement with impacted communities. The Bullmoose-Ruth Remediation Project was a complex undertaking. The project involved seven Indigenous partner communities, seven abandoned mines in a remote part of the North Slave region, construction of around 270 km of winter access roads, multiple stakeholders with competing interests, and engineering undertaken in extreme climatic conditions. This presentation will explain how adaptive decision making was used to create solutions to emerging problems that fit the structural constraints in the human and biophysical environment.

The seven sites within the Bullmoose-Ruth Remediation Project are all abandoned gold mines or exploration sites; namely, Bullmoose Mine, Ruth Mine, Spectrum Mine, Beaulieu Mine, Joon Mine, and the Chipp and Storm exploration sites. These sites were active between the 1940s and 1980s and are located around 90 km northeast of Yellowknife, NT. Between March 2016 and July 2018, the Bullmoose-Ruth Remediation Project covered, closed, or filled 13 mine openings, removed 11,618 m^3 of metal-impacted soils, sediments, and tailings, treated 7,082 m^3 of hydrocarbon-impacted soils, and removed 2,231.1 m^3 of non-hazardous waste and 432.5 m^3 of hazardous waste. The project required the construction of two landfills, reconstruction of a length of Bullmoose Creek (32.4 m^2), installation of monitoring infrastructure and instrumentation, and construction of engineered hydrological controls. Although the remediation phase of the project is complete, monitoring will be ongoing for the foreseeable future.

By using adaptive decision making that allowed for change and modification based on field conditions, available resources, and close collaboration with team members and partners, the project team was able to find both engineering solutions and design optimization that allowed for the project to be completed a full year sooner than the planned schedule. The benefit of this early finish is a reduction in risk to people and the environment posed by the winter road, work activities, and human disturbance. These

benefits outweighed any risks associated with major changes to planned activities. This presentation will discuss these optimizations, and how the close collaboration with Indigenous partners allowed for a more efficient and successful Project completion.

AIRBORNE MAG/EM DATA INTEGRATION OF SLAVE PROVINCE KIMBERLITES, NWT

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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). This work focuses on the analysis of six horizontal gradient magnetic and frequency domain EM (FDEM) surveys that were flown from February to March 2017 (Munn Lake, Margaret Lake, Zyena Lake, Lac de Gras West, Big Blue and Mackay Lake). All surveys were acquired at 75 m line spacing with nominal terrain clearance of 60 m to maintain bird height of 25 m. They total 4,580 line-km. We use the FDEM data to locate areas of potential remanent magnetization, and thus additional areas that could be related to kimberlite bodies.

The area is part of the central Slave Craton, which is dominated by Archean granitoid rocks and Archean metasedimentary rocks. Heaman *et al.* (2013) identifies several distinct domains based on kimberlite ages in the area. Central Slave is characterized by Tertiary/Cretaceous age kimberlites, whereas the southern part exhibits kimberlites of Cambrian age. This have important implications for the orientation of the remanent magnetization vector.

The methodology involves the use of a homogeneous half-space model to invert the data for dielectric permittivity, relative magnetic permeability, apparent resistivity and magnetic susceptibility. Using this model, we calculated Conductivity-Depth-Images (CDIs) for all the EM data. The susceptibility distribution from the EM data (MagEM) is then plotted against an apparent susceptibility derived from the total field data for the main survey via standard FFT calculation (MagTMI). Major differences between both distributions are usually associated to remanence. Once we identify areas of potential remanent magnetization, we use Helbig analysis to estimate the direction of magnetization. The validity of this model is verified by comparison of the computed remanence direction with the appropriate Apparent Polar Wander Path (APWP). We find a good correlation of APWP directions with the estimated remanence, however, a viscous remanence component subparallel to the present's day Earth field is sometimes required.

Finally, we show the integration of these results with a structural interpretation of the aeromagnetic data and potential alteration zones derived from Aster imagery for all 6 blocks.

ARE WILDFIRES AN IMPORTANT SOURCE OF METAL CONTAMINATION OF BOREAL LAKES?

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Boreal forests accumulate metal contaminants in soils and biomass over time because of the strong association of these metals to organic matter. Wildfires contribute to the remobilization of previously deposited local and long-range pollution. Strong evidence suggests that the concentration of some metals (e.g., Pb and Hg) has increased ubiquitously in the boreal forest over the Anthropocene in response to global pollution. The role of wildfires in metal transport associated with catchment erosion is well documented. However, studies have also demonstrated that wildfire ashes, transported atmospherically, can be a pathway for the transport of metal(oids) such as arsenic, cadmium, lead and mercury. If forest metal concentrations have increased in the Anthropocene, is it possible that wildfires have become an increasingly important process for the deposition of metals across the landscape, including lakes?

We investigated metal accumulation in sub-Arctic boreal lakes located at close distances (0.5 to 10 km) from fire scars of various age in the Yellowknife area (NT, Canada). Charcoal particle accumulation rates were examined in relation with observational fire records since 1965 to determine the occurrence of fire events in the sedimentary records. Preliminary results demonstrated good agreement between observational fire records and fire history determined from charcoal accumulation in the lake sediments. Our preliminary analysis revealed that wildfire events were not associated with important increases in metal concentration. Correlations between charcoal accumulation rates and metal concentrations in the sediments will be tested. Subsequent analysis will examine (1) if subtle changes on lake metal cycling, such as short-term increases in metal accumulation rate, could be influenced by wildfires and (2) if there is a temporal trend in the relationship between wildfire and lake metal loading over the last century.

EVALUATING THE HYDROLOGY OF NORTHERN BOREAL LAKES NEAR YELLOWKNIFE, NORTHWEST TERRITORIES AND THEIR RESPONSE TO VARYING CATCHMENT AND CLIMATIC CONDITIONS

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Freshwater lakes are prominent features throughout northern boreal regions which provide important habitat for wildlife and resources for local communities. Increasingly, there have been concerns regarding 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, NT area over the past several years, and the influence on aquatic systems is not fully understood.

This research project integrates a number of analyses to identify the relative importance of climatic and catchment controls on the hydrology of 20 study lakes in the

Yellowknife region. The study lakes reflect a range of catchment characteristics, with lake surface areas ranging from 1.6 to 3,280 ha (median = 10.9 ha). Nine of the study lakes are situated within catchments that have experienced either full or partial burn since 2012. The 2017 and 2018 years of study reflect disparate, ice-free season (i.e., May to September) precipitation conditions. The 2017 ice-free season was indicative of relatively "dryer" conditions (i.e., total precip. = 148 mm), slightly below the seasonal average. The 2018 ice-free season reflected pronounced "wetter" conditions (i.e., total precip. = 259 mm), and the most seasonal rain experienced in Yellowknife since 1943 when climate records were first maintained.

Lake water isotope data, specifically d^2H and $d^{18}O$, were obtained twice (i.e., spring and late summer) during each of the 2017 and 2018 ice-free seasons, respectively. Study lake catchments were modeled in ESRI ArcMap 10.5 software using available 5-m and 10-m Digital Elevation Model (DEM) data, utilizing Spatial Analyst and ArcHydro extensions. Preliminary isotope data and lake catchment analyses indicate that the lakes exhibit strong hydrological variability. Basins with higher lake area to catchment area ratios appear to be more susceptible to drying compared to lakes with larger catchments. In-situ lake level monitoring was employed for 19 of the 20 study lakes using installed HOBO water level loggers, with relative depth changes derived via air/water pressure calibration. Net-average lake level changes were determined to be approximately -0.22 m (max = +0.02 m, min = -0.51 m) during the 2017 (i.e., dryer) ice-free season and +0.13 m (max = +0.42 m, min = -0.17 m) during the 2018 (i.e., wetter) ice-free season, respectively. Overall, lake level drawdown during periods of drought during summer months was more pronounced during 2017 compared to 2018. The influence of catchment properties including size, land cover and burn area on water isotope and lake level data continue to be investigated.

Lake sediment cores were obtained from three lakes spanning identified hydrological gradients. Historical records of hydrological conditions are being reconstructed using cellulose-inferred oxygen isotope ($d^{18}O$) analyses of the sediment cores. These data will be used to evaluate whether contemporary lake hydrological conditions are within the range of natural variability. The findings of this research program will enhance our knowledge of how warming northern climate and associated landscape changes are influencing lake hydrology. The work is part of a collaborative effort supported by the Government of NWT Cumulative Impact Monitoring Program (CIMP).

INDIN LAKE GOLD PROJECT – 2018 COLOMAC UPDATE

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Nighthawk Gold Corp. (NHK) is a Canadian based mineral exploration company currently focused on advancing its 100% owned, Indin Lake Gold Property, a 222,203-acre land package located 200 kilometres north of Yellowknife, Northwest Territories within the Indin Lake Gold Camp.

A 43-101 Inferred Mineral Resource estimate of 2.6 million ounces of gold (50.3 million tonnes at an average grade of 1.62 grams per tonne gold) is defined at the Colomac Gold Project. Approximately 50% of the mineralized Colomac and Goldcrest intrusions are captured by this 2018 estimate, leaving an underexplored and highly

prospective deposit that hosts several newly discovered high-grade gold zones, and broad domains of lower grade mineralization. In 2018 Nighthawk completed 124 holes for 32,504 metres, of which 55 holes for 14,952 metres were completed at Colomac.

Information will be presented for Nighthawk's model for gold mineralization for the Colomac sill, confirming Colomac's analogue to the Golden Mile Dolerite gold deposits, Kalgoorlie, Western Australia. Mineralization is hosted by a differentiated mafic sill of similar age with a sodic, siliceous, and brittle upper portion amenable to clean fracturing during regional structural deformation, fluid transport, and mineral deposition, and the preferential host for gold mineralization. Kalgoorlie is one of the world's largest gold deposits, exceeding 60 million ounces of production since 1893.

Nighthawk's 2018 drilling of Colomac was directed at high-grade Zones 1.5, and 3.5 as well as Zones 2.5 and 3.0. At Zone 3.5, last drilled during in 2012, results have detailed and confirmed its steep northern plunge, while recent drilling of high-grade Zone 1.5, discovered in 2014, has extended its dimensions to upwards of 300 metres in strike, to a vertical depth of 660 metres, and a true width of 30 to 60 metres in the near surface, and upwards of 155 metres at depth. Drill results for Zones 2.5 and 3.0 remain to be reported. Eleven holes for 2,367 metres were directed at the lesser known Grizzly Bear zone, located SW of the Colomac sill, following up on two maiden holes drilled in 2017. Results reveal significant near surface intercepts including (GB18-02) 6.25 metres of 4.04 gpt Au, and an undercut (GB18-02B) 17.25 metres of 2.00 gpt Au, including 4.50 metres of 5.13 gpt Au.

Nighthawk's 2018 campaign included the continuation and expansion of its regional exploration and drilling programs throughout the underexplored yet fertile Indin Lake gold camp. This included drilling 69 holes for 17,552 metres on the following prospects: Leta Arm properties, Treasure Island (last drilled in 2011), Damoti Lake (last drilled in 2010), and Swamp, a recent surface discovery of extensive alteration and mineralization. Available results are highlighted by Diversified hole DV18-08, which returned a new high-grade discovery 90 metres below surface that opened the deposit to the north with 17.50 metres (14.00 metre true width) of 5.81 gpt Au, including 9.25 metres of 9.65 gpt Au.

UPDATE ON THE CLAN LAKE GOLD PROJECT: EXPLORATION AROUND A 250,000 OUNCE GOLD RESOURCE

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Gold at Clan Lake was initiated by discoveries by the Earl-Jack syndicate in 1964. In the late 1960s, a 1,035 tonne bulk sample was processed, grading 14.59 gpt gold. Work by Noranda in the 1980's and by the Yellowknife Gold Syndicate in 1990's failed to materially expand the known showings. In 2008, Tyhee Gold Corp staked the property and quickly identified the Main Zone as containing 2.5 million tonnes grading 3.12 gpt gold for 254,000 ounces of gold as an Indicate Resources. Other showings such as the Morel, Bear, Cub and other gold zones saw only limited development. Recent examination has found the Morel Zone to be similar in size as the Main Zone, extending over 600 m in length and up to 100 m in width. Other zones have been found to have substantial potential.

UPDATE ON THE MON GOLD PROJECT: EXPLORATION AROUND A PAST PRODUCING GOLD MINE

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The Mon Gold Property was discovered by Cominco in 1936. In 1937 and 38, trenching and shaft sinking on a high-grade surface showing failed to provide encouraging results, however similarities to the Discovery Mine became apparent in 1948. In 1988 a structural solution to the high-grade showing was proposed, leading to the discovery of extensions to the mineralization. Between 1989 and 1997, small-scale mining confirmed the continuity of grade and widths of the A-Zone. Recently, property-wide prospecting was completed and two major gold-bearing trends referred to as the Western Mafic Trend (WMT) and Eastern Mafic Trend (EMT) were identified, containing virtually all gold showings. The WMT and the EMT can be traced for 3,300 m and 3,800 m across the property respectively, each up to 700 m wide. Five hundred and fifty grab and chip samples were collected, identifying fourteen zones with consistent elevated gold values. Five gold zones were selected for trenching and systematic sampling, exposing well mineralized chlorite + carbonate + quartz + sulphide + biotite schists. Concurrent with this work, spruce bark sampling was completed using ICP analysis on macerated samples, confirming and extending the known zones and identifying new trends.

TILL GEOCHEMISTRY AND LITHOGEOCHEMICAL EXPLORATION FOR A CONCEALED KIMBERLITE

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Research at the Kelvin kimberlite, NWT is defining surface exploration practices and developing new exploration tools based on host rock lithogeochemical alteration, that will result in reduced costs and improved discovery success. In regions where recent glaciation has buried kimberlites under glacial sediments, surface geochemical detection methods are best interpreted when coupled with a comprehension of the landscape formation processes. The glacial, post-glacial, and cryoturbation processes that have affected the landscape have, in turn, affected the dispersal of geochemical signatures in the till that can be detected and exploited by detailed surface mapping, sampling, and geochemical analysis. Additionally, the application of geochemical and hyperspectral data to country rock alteration core can aid in the detection of kimberlites during near-miss drilling campaigns.

The Kelvin kimberlite is located eight kilometers from the Gahcho Kué diamond mine in the Northwest Territories. The inclined pipe sub-crops beneath a lake and dips into gneiss country rock towards the northwest with a surface projection of more than 600 m long. Relative uniformity of surficial material (<6 m thick till veneer) allows for extensive b-horizon soil sampling

above the kimberlite, up-ice, and up to 1 km in the down-ice direction. Samples were sieved to -180 microns and analyzed by four acid digest ICP-MS and aqua-regia digest ICP-MS. Results indicate the soils to be very immature and identify the presence of a subtle Ni-Cr-Mg-Nb train originating from the lake side extending for >1km from source following the most recent ice direction to the west. The material for the train was abraded by the ice from the kimberlite, now sub-cropping beneath a lake, and would have provided additional support to drill what was initially targeted from geophysics.

Additional research is being carried out to detect alteration signatures in the country rock induced by the emplacement of the kimberlite. Lithogeochemical data from four drill holes aims to identify and quantify the metasomatic enrichment and depletion of elements sourced from the kimberlite while accounting for country-rock lithology variation. Hyperspectral imaging of the same drill core will aim to detect and quantify secondary mineralogy and subtle changes in mineral composition that otherwise cannot be detected visually. This data will be used to generate mineralogical and chemical vectors beneficial in near-miss situations when drilling kimberlites and defining diatreme geometries.

SAMMS: THE SUBARCTIC METAL MOBILITY STUDY

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SAMMS, supported by the Global Water Futures program, is a new research initiative. SAMMS aims to identify, quantify, and predict mobility of natural source and legacy mine-source metals in soil, wetlands, and lake sediments that extend from former, present, and planned mine sites currently and as climate change alters the quantity and quality of dissolved organic matter (DOM) produced and exported from vast organic stores in subarctic NWT watersheds. Special focus is to quantify the current and future mobility of legacy atmospheric-source contaminants, above naturally occurring levels, from the Giant Mine. Six work plans have been developed. These are designed to comprehensively trace the transport and behaviour of DOM and metals through terrestrial and aquatic ecosystems in headwater catchments between Giant Mine and Whatì. Work plans include: 1) terrestrial stores of historical metal deposition and

transport to aquatic ecosystems, 2) DOM quantity and quality, metal binding, and toxicology, 3) modelling of DOM quantity and quality in cold regions, 4) metal depositional history, pathways, and processes in lake sediments, 5) paleo-ecotoxicology and ecosystem structure, and 6) climate change effects including permafrost thaw. Findings will inform improved decision-making by multiple stakeholders in the NWT, including Indigenous peoples, about the both legacy of mining activities and implications of new mining developments on water quality in a changing environment.

This presentation will provide an introduction to SAMMS and highlight summer 2018 fieldwork activities, early results and describe our planned research direction over the next 12 to 24 months. Current research includes: 1) sediment cores collected in June within the annual regional prevailing airshed from Giant Mine from lakes each 10 km along an 80km transect extending northwest. Analysis of these lake sediment cores will aid in systematic identification of the extent of far-field atmospheric emissions of arsenic from Giant Mine. Paleohydrological analyses will be used to explore the role of climate on metal deposition in the lakes. 2) Fieldwork was also conducted at lakes northwest of Yellowknife along Highway 3, and included collection of lake sediment cores as well as soil, snow and lake water samples. Metal concentration and radiometric dating results from a sediment core retrieved from "˜Lake 10', located 57 km northwest of Yellowknife, displays down-core enrichment in arsenic (and antimony) concentration, consistent with some of our prior lake sediment core results adding further evidence for far-field emissions from Giant Mine. "˜Lake 10' is readily accessible from Highway 3 and will serve as a key intensive site to launch additional SAMMS terrestrial and aquatic ecosystem research.

Abstracts - Poster Presentations

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INCREASED RECOVERY OF DIAMONDS FROM ECLOGITE BY ELECTRICAL PULSE DISAGGREGATION

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It is well known that mechanical disaggregation, such as jaw crushing, can cause irreversible damage to valuable gemstones hosted in crystalline rocks. The SELFRAG Lab device uses electrical pulses at high voltages - typically between 150 and 200 kV - to separate material into individual grains along natural boundaries. The purpose of this research is to assess the viability of the SELFRAG as a tool to disaggregate diamond-bearing eclogites, and to assess if this method preserves grains that would otherwise be damaged through mechanical disaggregation.

In order to test the applicability of the SELFRAG to diamond recovery from mechanically strong diamond-bearing lithologies, we studied its effects on a diamondiferous eclogite, RV09, from Roberts Victor mine. The Roberts Victor mine is located in South Africa and is renowned for its unusually high abundance of mantle-derived eclogite xenoliths[1]. Before the eclogite was disaggregated, we bisected the sample and used a CT scan to determine its constituent minerals and the spatial distribution of diamond. One half of the sample was then placed into the SELFRAG, where it was subjected to ~100 shots of 200 kV electrical discharges that segregated the sample into individual grains of similar sizes. The other half was jaw crushed, using a steel jaw crusher which produced non-uniform composite grains and abundant fine material. The varying sizes and aggregate pieces made it difficult to pick diamonds, and after no diamonds were found, the jaw-crushed portion underwent further disaggregation in the SELFRAG.

After exerting the same time and effort picking through both portions of the RV09 sample, ten diamonds were recovered from the electronically disaggregated portion, while no diamonds were found in the conventionally disaggregated sample. The diamonds released from the SELFRAG were then imaged with a scanning electron microscope (SEM) to determine the extent to which the diamonds were damaged. Most of the released diamonds showed no evidence of breakage, but a few showed signs of damage that may have occurred prior to kimberlite eruption.

The dramatic disparity between the number of diamonds recovered with the SELFRAG and the lack of diamonds in the jaw crushed portion indicates that electrical disaggregation is a superior method compared to the conventional mechanical comminution technique. There are little to no signs of breakage in the SELFRAG-liberated diamonds, whereas, the damage caused by jaw crushing was extensive enough to produce small fragments not readily visible via optical microscopy. The SELFRAG is a promising alternative to conventional disaggregation and offers a practical solution

for lessening damage to valuable stones in rocks such as eclogites and kimberlites.

[1]MacGregor, I.D., Carter, J.L., 1970. Physics of the Earth and Planetary Interiors 3, 391–397.

CHARACTERIZATION OF POROSITY IN BLACK SHALES USING NITROGEN ADSORPTION EXPERIMENTS AND SCANNING ELECTRON MICROSCOPY. AN EXAMPLE FROM THE MIDDLE TO LATE DEVONIAN HORN RIVER GROUP, CENTRAL MACKENZIE VALLEY, NORTHWEST TERRITORIES

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Recently, organic-rich shales have become important unconventional reservoirs due to advances in technology that make it possible to exploit hydrocarbons trapped in the pores of these successions. In order to achieve an accurate assessment of the quality of the reservoir, understanding the porosity in these intervals is essential, however, as pores observed in black shales are microscopic, micro-imaging techniques are required to determine pore size, shape, distribution, and total pore volume.

This study focuses on the Middle to late Devonian Canol and Hare Indian formations, black shales of the Horn River Group located in Central Mackenzie Valley, Northwest Territories that have been identified as prospective unconventional resource candidates. Due to the remote location of these intervals, there is relatively few data gathered from the formations in the Horn River Group, and a detailed assessment of porosity has not yet been conducted.

For this project, scanning electron microscopy (SEM) and nitrogen adsorption-desorption experiments are used to characterize pores and determine pore volume. The dataset consists of four samples taken from the Husky Little Bear N-09 well: two from the Canol Formation at depths of 1727.05 m and 1718.95 m and two from the Hare Indian Formation at depths of 1810.0 m and 1825.0 m. Using the Barrett-Joyner-Halenda (BJH) model, nitrogen adsorption-desorption experiments suggests that the pore sizes in these samples ranged from 10 nm to 100 nm. The adsorption-desorption isotherms gathered from the same analysis also indicate that the pores are slit-shaped. The images from the SEM analysis indicate that the pores in these samples can be found in several sites including pyrite framboids, grain boundaries, microfractures, inside grains and in organic matter.

The results of this study contribute to our knowledge of the hydrocarbon storage capacity of the Hare Indian and Canol formations and increase our understanding of their potential as shale reservoirs.

SEISMIC DATA RESOLVE DEEP CRUSTAL EARTHQUAKES AND CRUSTAL VELOCITY STRUCTURE BENEATH THE BEAUFORT SEA, WESTERN CANADIAN ARCTIC

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The formation and evolution of the lithosphere in the western Canadian Arctic represent a long-standing tectonic puzzle. The eastern Beaufort Sea margin juxtaposes young (<150 Ma) Arctic Ocean lithosphere with Paleo-Proterozoic continental lithosphere of the Canadian Shield underlying Banks Island, over <200 km. The southern Beaufort Sea Mackenzie Delta margin represents a well-developed fold and thrust belt of Cretaceous to present age, but has only been recently recognized as likely active. A concentration of poorly constrained earthquakes within the Beaufort Sea are interpreted as due to flexure of the oceanic crust in response to margin thrusting or loading of thick Mackenzie Delta sediments. We use data from new land broadband seismic networks to investigate crustal structure and seismicity around the Beaufort Sea. Preliminary results from ambient seismic noise and receiver function analyses indicate a ~30 km deep Moho beneath the Beaufort Sea and Banks Island. We examine focal depths of selected Beaufort Sea earthquakes using teleseismic P-pP times and find focal depths of ~35 km. These results suggest that earthquakes occur on reactivated passive margin structures, possibly triggered by flexural loading.

LITHOSTRATIGRAPHY OF THE SUNSET RHYOLITE, CAMERON-BEAULIEU VOLCANIC BELTS, SLAVE PROVINCE

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The Sunset Lake area contains Neoarchean volcanic rocks of the Beaulieu belt, which occurs at the northeast margin of the ca. 2.8 Ga Sleepy Dragon Complex. The exact age and the stratigraphy of these volcanic rocks is not fully understood. As a result, volcanic rocks within the Beaulieu belt cannot be easily correlated. The focus of this study is the Sunset Rhyolite, a large rhyolitic body at the south end of Sunset Lake that was originally mapped as a single, coherent rhyolite dome, and to correlate it with a rhyolite dome and associated rhyolite fragmental rocks that host the Sunrise volcanogenic massive sulfide (VMS) deposit some 6 km to the north.

The objective of this study is to document the litho- and chemo-stratigraphy of the Sunset Rhyolite and compare it to that of the Sunrise deposit. During 2014, the Sunset Lake area experienced forest fires resulting in great outcrop exposure. Detailed mapping completed this past summer (2018) indicates the Sunset Rhyolite is not a single, coherent rhyolite body, but instead represents a much more complicated rhyolite flow/dome complex. The south Sunset Lake area is composed of basalt, andesite and rhyolite lavas with varying compositions of volcaniclastic rocks. The lithologies from oldest to youngest are as follow: 1) massive

to pillow flows that are basaltic to andesitic in composition (>200 m); 2) a dominantly coherent rhyolite that is weakly quartz-plagioclase porphyritic with local lobes and areas of in-situ breccia (50 – 100 m); 3) heterolithic volcaniclastic rocks (50 – 100 m) consisting of lapilli- to tuff-sized felsic (30 – 40%), mafic (10 – 15%), and andesite clasts (20 – 30%); 4) felsic volcaniclastic rocks ranging from tuff breccia to lapilli tuff with some tuff forming massive beds ~10-20 m thick with felsic volcaniclastic packages ~50-100 m thick. Felsic clasts share a similar composition to the coherent rhyolite.

The stratigraphy of the south Sunset Lake area is much more complicated than originally thought and does not represent a single coherent rhyolite lithofacies but instead is comprised of several different lithofacies. Detailed mapping of the area shows that volcaniclastic rocks make up 60-70% of the rhyolite in the area, the rest being massive. This has economic implications as the occurrence of a rhyolite dome indicates vent proximity and, along with the occurrence of volcaniclastic rocks, defining a topographic low that was filled with porous volcaniclastic debris, are key features needed for the formation of a VMS deposit. These lithofacies are also very similar to those observed at the Sunrise Deposit indicating they might represent the same stratigraphic horizon as that which hosts the VMS deposit.

ICHNOLOGICAL EXPRESSIONS OF LOW OXYGEN SETTINGS: AN INTEGRATED ICHNOLOGICAL AND SEDIMENTOLOGICAL ANALYSIS OF THE CANOL FORMATION, NORTHWEST TERRITORIES, CANADA

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The Canol Formation, part of the Horn River Group in the Northwest Territories, primarily consists of black shales deposited during the late Givetian to early Frasnian ages of the Middle and Late Devonian epochs. The Canol Formation is considered to represent distal basin fill accumulated in an anoxic to euxinic depositional setting, owing to the shale's organic-rich character, pyrite content, and lack of obvious biogenic reworking. The sediment transport processes resulting in the deposition of these shales have yet to be identified. This study aims to identify depositional processes and paleo-redox fluctuations within the Canol Formation via comprehensive integrated ichnological and sedimentological analyses and some integration with geochemical paleo-redox proxies.

Detailed ichnological and sedimentological petrographic analyses are carried out on thin sections taken from several cored Canol Formation intervals (MGM Shell East Mackay I-78, Husky Little Bear N-09 and H-64, and ConocoPhillips Mirror Lake N-20 and Loon Creek O-06) and outcrop localities

(Mountain River, Carcajou River, Dodo Canyon, Powell Creek, and Rumbly Creek). Initial investigation has led to the identification of biogenic-sedimentary structures (i.e., ichnofossils) throughout the Canol intervals. Identified traces are grouped into a morphological classification scheme based on characteristics such as orientation, structure fill and fill organization, and burrow linings. Six morphologically separate ichnofossils have been documented. Three morphotypes are classified as vertical burrows, and include relatively small sinuous vertical traces, inclined-to-vertical unlined meniscate-backfilled traces, and fugichnia. Three morphotypes display horizontal orientations, and include tubular lined traces with organized fill, tubular unlined traces with homogenized fill, and relatively small sinuous horizontal burrows. Bioturbation intensities range from unburrowed to heavily bioturbated, with sinuous vertical traces being the most commonly documented.

Primary sedimentary structures being evaluated include, but are not limited to, evidence of small-scale features such as bedding and lamination, and diagenetic features such as pyrite abundance and habit. Integration of geochemical data collected for paleo-redox analyses, such as molybdenum enrichment to indicate euxinic deposition, will help to define a link between the sedimentological and ichnological textural features and basin-wide depositional conditions. The data collected from this study will result in the identification of small-scale physio-chemical fluctuations within the basin during deposition of the Canol shales. This will ultimately lead to a deeper understanding of the large-scale geochemical and sequence stratigraphic trends occurring throughout the formation.

POST-FIRE ECOSYSTEM RESILIENCE AND CARBON DYNAMICS IN THE NORTHWESTERN BOREAL FOREST

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In northern boreal ecosystems, wildfire is the most important natural disturbance in controlling ecosystem structure and function. With recent increases in both the extent and severity of wildfires in some regions of boreal North America, the regional response of carbon pools to increased wildfire disturbance remains poorly understood. Here, we quantify the initial response and long-term recovery of aboveground and belowground carbon pools to wildfire in three distinct regions of the Northwest Territories, Canada, including the taiga plains (n=356), taiga shield (n=190), and Sahtu (n= 10) regions. We measured and analyzed carbon pools using a space-for-time substitution approach across approximately 1,270 km^2. Stand age ranged from 1 – 275 years since last fire, and stands were dominated either by black spruce (*Picea mariana*) or jack pine (*Pinus banksiana*). Our results show that mature stands in the shield on average have shallower organic soil depths (13.7±2.3 cm) compared to the plains (26.0±1.9 cm). In the plains ecoregion, fire reduced soil organic layer depths by 84% in

dry stands, 44% in intermediate stands, and 9% in wet stands. While wet stands lose less soil organic matter during combustion, they also recovered more quickly. By working across large environmental gradients of fire history, forest hydrology, and vegetation dominance, our field measurements will be helpful in validating remote sensing products related to wildfire as well as process-based modelling of both the short- and long-term consequences of wildfire for ecosystem carbon behaviour.

NEW TRENDS IN GOLD MINERALIZATION INVESTIGATED AT THE YELLOWKNIFE CITY GOLD PROJECT USING SYNCHROTRON X-RAY SPECTROSCOPY

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The Yellowknife City Gold Project (YCGP) encompasses 780 km^2 of contiguous land north, south and east of the city of Yellowknife. It lies in the prolific Archean north-south trending Yellowknife Greenstone Belt, a suite of mafic and felsic volcanics, and greywacke turbidites overlying a gneissic basement. Host rock alteration include chloritization, sericitization, and carbonatization, plus biotite alteration in wall rock. TerraX Minerals Inc. focuses its exploration and drilling efforts along 70 km of strike length on the southern and northern extensions of the mineralized shear zones and quartz veins associated with the past-producing, high-grade Con (6.1 Moz @ 16.1 g/t Au) and Giant (8.1 Moz @ 16.0 g/t Au) gold mines. Gold grades in core and surface rock samples related to this study range from 0.1 - ~200 g/t, with higher gold grades associated with mafic volcanic and greywacke hosts. Gold is associated with quartz veins and disseminated sulphides, including pyrite-arsenopyrite or sphalerite-galena in As-poor mineralization, and within sericite-chlorite.

Synchrotron analyses applied to mineral exploration can address industry-relevant questions and provide rapid solutions that add significant value using innovative, high-resolution analytical techniques. Synchrotron X-ray fluorescence (SR-XRF) spectroscopy is a nondestructive technique providing in-situ trace element analysis for ore mineral mapping and zonation. X-ray absorption near edge structure (XANES) spectroscopy can determine speciation of gold, arsenic and other trace elements, useful for geometallurgy and deleterious element characterization. Synchrotron X-ray diffraction (SR-XRD) is a rapid technique for mineralogical analysis, providing critical mineralogical information on altered and mineralized samples. Such methods can be performed on many types of materials without specialized sample preparation. We have developed novel, non-destructive SR-XRF techniques that can be performed directly on half-core samples or surface sample slabs and produce trace element maps >10 cm long by up to 5 cm wide. The technique provides critical trace-element associations in gold-bearing sulphide minerals that provide integral information regarding the nature of mineralizing fluids.

Synchrotron X-ray diffraction of 71 powdered samples, and X-ray fluorescence maps of 73 slabs and half cores reveal

similarities in mineralization styles between the Northbelt Property (i.e., Sam Otto, Crestaurum, Barney, Mispickel, and Homer Lake Zones) and the Con-Giant Mines, such as early pyrite-arsenopyrite mineralization overprinted by later sericite, quartz-carbonate, and sphalerite-galena, hinting that both locations are likely derived from a single mineralizing system. Our results suggest the timing of mineralization is similar throughout the Yellowknife City Gold Project. Overprinting relationships confirm findings from earlier studies that propose high-As sulphides formed first, followed by sericite-quartz-carbonate-chlorite alteration assemblages, and later low-As sulphides. The Yellowknife River Fault Zone and its splays likely act as conduits for fluid percolation and mineralization during metamorphism. Three main gold associations are present across the YCGP – gold+sulphide, gold+quartz-carbonate, and sericite-hosted gold, with the two latter due to later remobilization during syn-mineralization metamorphic processes. XANES analyses of samples where gold was identified by SR-XRF reveal the presence of only metallic Au within sulphides and quartz veins. No refractory gold associated with elevated arsenic levels has been observed suggesting gold may be easier to recover than previously thought.

CONTRASTING GROWTH CONDITIONS FOR SULPHIDE- AND GARNET-INCLUDED DIAMONDS FROM THE VICTOR MINE (ONTARIO)

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The Victor Diamond Mine, located in the Attawapiskat kimberlite field (Superior Craton), is known for its exceptional diamond quality. Here we study the chemical environment of formation of Victor diamonds. We imaged eight sulphide-included diamond plates from Victor using cathodoluminescence (CL). Then, along core-rim transects, we measured nitrogen content and aggregation state utilizing Fourier Transform Infrared (FTIR) spectroscopy, and the stable isotope compositions of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$), using a multi-collector ion microprobe (MC-SIMS). We compare the internal growth features and chemical characteristics of these sulphide inclusion-bearing diamonds with similar data on garnet inclusion-bearing diamonds from Victor (BSc thesis Galarneau).

Using this information, possible fractionation processes during diamond precipitation are considered and inferences on the speciation of the diamond forming fluid(s) are explored. Sulphide inclusion-bearing diamonds show much greater overall complexity in their internal growth features than garnet inclusion-bearing diamonds. Two of the sulphide-included samples have cores that represent an older generation of diamond

growth. Compared to garnet inclusion-bearing diamonds, the sulphide-included diamonds show very little intra-sample variation in both carbon and nitrogen isotopic composition; the inter-sample variations in carbon isotopic composition, however, are higher than in garnet included diamonds. For sulphide-included diamonds, $\delta^{13}C$ ranges from -3.4 to -17.5 and $\delta^{15}N$ ranges from -0.2 to -9.2. Garnet inclusion-bearing diamonds showed $\delta^{13}C$ values ranging from -4.6 to -6.0 and $\delta^{15}N$ ranging from -2.8 to -10.8. The observation of some ^{13}C depleted samples indicates that, unlike the lherzolitic garnet inclusion-bearing diamonds, the sulphide inclusion-bearing diamonds are likely both peridotitic and eclogitic in origin. The total range in N content across sulphide inclusion-bearing diamonds was 2 to 981 at ppm, similar to the garnet-included samples with a range of 5 to 944 at ppm.

The very limited variations in carbon and nitrogen isotopic signatures across growth layers indicate that sulphide-included Victor diamonds grew at comparatively high fluid:rock ratios. This is contrasted by the garnet inclusion-bearing diamonds that commonly show the effects of Rayleigh fractionation and hence grew under fluid-limited conditions.

BULK ORGANIC GEOCHEMISTRY AND U-PB ZIRCON GEOCHRONOLOGY OF THE WOMBAT SEDIMENTARY FILL

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The Wombat locality (64.73°N, 110.59°W) is a diamondiferous kimberlite in the Lac de Gras kimberlite field of Northwest Territories. Two drill cores, CH 93-29 and DDH 0-005, intersect the Wombat crater facies and include 195 m of well preserved, undisturbed lake sediment fill. Bulk sediment elemental analysis, C isotope composition, and Rock-Eval pyrolysis, together with inferences from microfossils, are used to characterize conditions of sedimentation and paleoenvironment in the maar lake. Bulk sediment C/N, hydrogen index (HI), and $\delta^{13}C$ indicate material derived from C_3 land plants dominates the sedimentary organic matter, with a minor algal contribution. The $\delta^{13}C$ values range from -25.3 ‰ to -30.2 ‰ (average -26.6 ‰) and are typical for C_3 land plants, with fluctuations in $\delta^{13}C$ likely related to shifts in the proportions of land-derived material and algal organic matter. An overall trend of higher $\delta^{13}C$ towards the top of the core suggests increasing autochthonous organic matter production. 18 samples analyzed by Rock-Eval pyrolysis all plot in the Type III kerogen field for HI vs. T_{max}, with average T_{max} values ~425 °C indicative of the low thermal maturity of organic matter. Total organic carbon (TOC) averages 3.6 wt.% and average total carbonate content is 14.1 wt.%, indicating bottom water anoxia

and substantial carbonate input from weathering of overlying carbonate cover rocks, respectively. Together with well-preserved freshwater microfossils (e.g. diatoms, chrysophytes, synurophytes), the results indicate deposition in a non-marine setting. The age of the Wombat maar lake sediments is determined using MC-LA-ICP-MS U-Pb zircon geochronology from two distal rhyolitic tephra beds found in the core DDH 0-005, yielding a date of 82.97±0.60 Ma (MSWD = 1.7, n=18 of 33 grains analyzed). This minimum age suggests that Wombat kimberlite pipe emplacement occurred during the Late Cretaceous, with sedimentation in the maar beginning shortly thereafter. Though our geochronology is preliminary at this point, our findings from the Wombat pipe post-eruptive lake sediment fill provide direct evidence for a non-marine environment in the Lac De Gras area during the Late Cretaceous. Furthermore, microfossils in the Wombat pipe sediment fill likely include the oldest-known occurrence of freshwater diatoms.

PETROLOGIC AND GEOCHEMICAL CHARACTERIZATION OF A CARBONATE-BEARING, AMPHIBOLE-PHYRIC INTRUSION AT HJALMAR LAKE, SOUTH RAE CRATON, NORTHWEST TERRITORIES: PRELIMINARY RESULTS

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The Nonacho lake area consists of Archean to Paleoproterozoic granites and gneisses unconformably overlain by the ca. 1.91-1.82 Ga alluvial-fluvial sequence of the Nonacho Group. The area was the site of extensive mineral exploration in the 1950-80s focused on unconformity associated uranium ± rare earth elements (REE) and polymetallic (Cu-Au-Ag) showings. Although previous research in the area has been largely directed towards the stratigraphy of the Nonacho Group, the geology of the basement rocks and mineralization potential of the area remain relatively understudied.

Reconnaissance mapping of the Nonacho Lake area in 2018 included an investigation of the Nonacho Group and basement rocks at Hjalmar Lake. The basal breccia and conglomerate member of the Hjalmar Formation, including a distinct cream-white, fine-grained, fluorite-bearing rhyolite, is well-exposed in unconformable contact with granitic basement. Mapping of the basement revealed an approximately 500 m by 1500 m, carbonate-bearing, amphibole-phyric intrusive body and associated dykes. The rock contains very coarse (up to 3 cm diameter), dark green to black, euhedral to subhedral amphibole crystals in a groundmass that varies from vitreous fine-grained greyish green (clinopyroxene) to leucocratic pink (feldspar) to white (carbonate) crystalline material. This body intrudes strongly foliated hornblende diorite and pink, highly altered, granite with amphibolite xenoliths. The intrusion is crosscut by a feldspar megacrystic granite and younger pegmatitic phases. Fluorite-calcite-sulphide bearing veins were observed in fine-grained mafic basement rocks ~100 m from the intrusion. The mineral assemblage in these veins is similar to that found in other veins in the region including those associated with the Crest (Cu-Ag-F) showing ~35 km to the northwest.

The spatial association between the carbonate-bearing intrusive rocks, the fluorite-bearing rhyolite, and fluorite-calcite-sulphide veins in the basement rocks raises questions regarding the intrusion's nature and relationship to hydrothermal mineralization in the region. The presence of interstitial carbonate in a mafic intrusive body suggests this intrusion may have a carbonatitic affinity. Carbonatites have a high potential for hosting multi-commodity mineralization and they are the main global sources of niobium and REE, critical metals used as alloys and catalysts in key economic sectors such as manufacturing.

Ongoing work includes: (1) petrological and geochemical analysis of amphibole and carbonate using microscopy, SEM, and electron microprobe to determine the origin of the minerals; and (2) U-Pb geochronology of potential U-Th-Pb-bearing accessory phases to determine the age of crystallization and provide insights on the tectonic environment during magmatism.

ISOTOPIC VARIATION OF VANADIUM IN SOIL, LAKE SEDIMENT AND BIOTA: AN INVESTIGATION OF A NOVEL GEOCHEMICAL TRACER

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With recent analytical advances, metal stable isotopes are increasingly being used as tools to trace the sources, transport and cycling of metal contamination in the environment. Coal, bitumen and crude oil are enriched in vanadium, and anthropogenic activities associated with fossil fuel production and use can release vanadium to the atmosphere, soil, and water. The objective of this study was to investigate vanadium as a potential isotopic tracer of metal contamination associated with fossil fuels. The first measurements of vanadium isotope ratios in geological materials by multi-collector inductively coupled mass spectrometer (MC-ICP-MS) were published less than a decade ago, and environmental variation of vanadium isotope ratios remains poorly characterized.

Vanadium isotope ratios were measured in environmental samples from the Oil Sands Region in northern Alberta and from Great Slave Lake in the Northwest Territories. Samples of soil, plant roots, lichen, and American marten liver (*Martes Americana*) were selected from monitoring programs in northern Alberta to cover a gradient in vanadium contamination (with varying distance from Oil Sands developments). A sediment core from a nearfield lake was examined for variation of vanadium isotope ratios among layers in the sediment depth profile. Additionally, samples of lake sediment and aquatic biota (benthic algae, plankton, and fish) were selected from a monitoring study in Great Slave Lake to track isotopic fractionation of vanadium associated with dietary transfer through an aquatic food web. Vanadium isotope ratios were measured on over 50 environmental samples following chemical isolation of vanadium and detection on a MC-ICP-MS at the Woods Hole Oceanographic Institute (Massachusetts, USA) using published methods.

Distinct vanadium isotope ratios (δ51V, reported relative to an Alfa Aesar standard) were measured in lichen (-0.89±0.12‰), lake sediment (-0.50±0.22), soil (-0.68±0.11‰),

and martin liver (-1.73±0.17‰) from northern Alberta. The vanadium isotope ratios of lichen, soil, and marten liver did not vary with their concentrations of vanadium or proximity to Oil Sands emissions. The δ51V profile in the lake sediment core was relatively homogenous (-0.52 to -0.69‰) between sediment layers of 2 to 14.5 cm depth. However, the surface layer (0-1 cm) had an enriched $\delta^{51}V$ value of -0.12‰. Plant roots showed heavier $\delta^{51}V$ values than the sediment they were growing in at four sites. The results of food web samples from Great Slave Lake (currently in progress) will also be presented. These observations indicate considerable variation of vanadium isotopes ratios in soil, lake sediment, and biota ($\delta^{51}V$ spanning ~2‰) that reflect complex processes of stable isotope fractionation in the environment.

ENVIRONMENTAL CHANGE AROUND NORTHERN COMMUNITIES: FROM BOREAL FOREST TO ARCTIC TUNDRA

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The communities of the Northwest Territories cover a huge range of climate, geology, permafrost, and land cover settings: they extend from Boreal forest to Arctic tundra, span 12 degrees of latitude, and transition all of the permafrost zones and geological settings from Precambrian Shield to Cordillera. Rapid climate warming in the Northwest Territories – at four times the rate of the global average – is driving significant environmental change, such as widespread permafrost thaw, shorter winters and longer summers, tundra shrubification, biome and wildfire regime shifts, and changes in water quality and aquatic health. Yet, the nature and magnitude of environmental changes affecting communities are not ubiquitous. This is because while these environmental changes are a response to climate warming, the different climate, geology, permafrost, and land cover settings dictate the types and trajectories of changes. However, currently we have either site-specific examples or broad-brush generalisations about the consequences of climate change, and therefore little understanding of how climate change-related stressors vary by setting. Here, we focus on the environmental changes affecting the Northwest Territories' 33 communities. Through a systematic review and meta-analysis of environmental studies conducted in or around each community, we investigate the environmental changes affecting each community. Then, using gridded climate data and remote sensing-derived indices of surface changes that are supplemented with site-specific data, we determine how different settings (geology, land cover, etc.) influence the nature and magnitude of those environmental changes and the occurrence of climate-related phenomena. We aim to determine the different factors that make a community vulnerable to environmental changes. This broad-scale and holistic approach is valuable for exploring interactions and feedbacks between climate forcing, landscape setting, and environmental responses. Ultimately, this study will provide insight on the variation in stressors and responses affecting communities across a wide range of climate and landscape settings encountered in the North. The outputs will be useful in the implementation of effective, community-specific climate change adaptation measures,

and can also be used to inform the development of broader climate change policies.

ALTERATION OF MN-ILMENITE IN HORTON AREA OF LENA WEST

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Mn-ilmenite was recognized as a kimberlite indicator mineral (KIM) in the Lena West diamond region of the Northwest Territories by Darnley Bay, Talmora and Sanatana. It includes compositions that match those found as inclusions in type IIa diamonds from Brazil and Venezuela that formed in the lower mantle. The recent determination that large, high value type IIa diamonds like the Cullinan, Koh-I-Nor, etc. also formed in the lower mantle increases the importance of Mn-ilmenites not only as a KIM resistant to tropical weathering but as a possible indicator of large high value stones. The Mn-ilmenite alteration products, pseudorutile ($Fe_2Ti_3O_9$) and ferropseudobrookite ($FeTi_2O_5$) may also be used as KIMs and provide useful additional information.

Mn-ilmenites found as inclusions in diamonds range from 51 wt.% TiO_2 (total wt.% 100) to 56 wt.% TiO_2 (total wt.% 95). The shortfall in wt.% of the high TiO_2 grains was ascribed by Kaminsky and Belasouva (2009) to some element not included in the analysis. The shortfall may also occur when some ferric iron is calculated as ferrous iron?

As most Lena West Mn-ilmenite analyses have high totals those with totals less than 96 wt.% have been considered an alteration product ("pseudorutile"). "Pseudorutile" is produced by the oxidation of FeO in ilmenite to Fe_2O_3 which results in an apparent loss of total weight percent when Fe is calculated as ferrous iron. A range of values approximating "ferropseudobrookite" with totals close to 100 wt.% is another alteration product of ilmenite with a loss of iron but without its oxidation to ferric iron.

The Horton area consists of a cluster of magnetic anomalies averaging ~ 200 m diameter east of a very large magnetic anomaly beneath Seahorse Lake. The Seahorse anomaly is at the focus of a train of kimberlite pathfinder elements coincident with a NNW trending KIM train characterised by Mn-ilmenite, picro-ilmenite and chromite. A parallel train of similar KIMs is focused on the cluster of smaller anomalies to the east.

"Pseudorutile" is found over the cluster of anomalies that lie within the Horton River drainage and in the area north towards Darnley Bay. It was especially abundant with some unaltered Mn-ilmenite grains in the cuttings of a Packsack drill hole that penetrated a few feet of rusty coloured clay coincident with one of the anomalies. It does not appear to travel far.

"Ferropseudobrookite" is found mostly west of the Horton River drainage, about 100 kilometers down-ice in the trains coming off the Seahorse anomaly and the cluster of smaller anomalies respectively. It represents the weathering of Mn-ilmenite in the upper part of anomalies that was carried furthest by glaciation indicating a resistance to mechanical wear.

Mn-ilmenite is a useful KIM in areas of tropical weathering and is also an indicator of rare large high value diamonds. The distribution of pseudorutile and ferropseudobrookite suggests that the initial alteration of Mn-ilmenite is to pseudorutile and then ferropseudobrookite. The presence

of one or the other is therefore a measure of the distance to the source.

FEASIBILITY STUDY OF ENHANCED GEOTHERMAL ENERGY SECONDARY APPLICATION FOR AGRICULTURAL PRODUCTION IN CANADIAN NORTHERN TERRITORIES

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In today's world, the role of energy in social welfare, economic growth, and sustainable development is crucial. In addition, reducing the fossil fuels consumption and using more green and renewable energy sources, combined with energy saving and energy conversion are mandatory in sustainable context. Geothermal energy, as a sustainable and renewable energy source, has certain advantages such as consistency, a massive amount of untapped potential, availability, and an extensive range of possible applications, which make it an interesting and practical solution for meeting the world's energy needs, particularly in cold weather regions such as northern Canada. Simultaneously, the use of geothermal energy diminishes greenhouse gas (GHG) emissions and environmental pollution (especially CO_2 emissions). In this paper, the feasibility of using enhanced geothermal energy (EGS) for production of agricultural products as a secondary application in Canada northern territories is investigated. The necessary water temperature to prepare the frosted soil for agricultural production is very lower than the temperature needed for electricity generation or heating/cooling of buildings; hence, geothermal energy systems (both shallow and deep) can supply the required water at the proper temperature range from the output water of systems. Providing the required water of the greenhouses in northern Canada using EGS has several advantages such as reduction of electrical energy use, eliminating transportation costs, creating job, increasing living standard which all leads the society toward a sustainable development.

ALL CREATURES GREAT AND SMALL: WILDLIFE BASELINE AT PINE POINT

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Many of the residents of the South Slave area have a strong interest in the region's wildlife. This interest was re-stated in listening sessions hosted by Pine Point Mining Limited in Hay River and Fort Resolution in late 2017. The Pine Point area is a popular hunting destination because it is readily accessible from the highway and has a network of on-site roads and cut-lines that make travel within the site fairly easy for humans and wildlife. The Pine Point area has a variety of land cover types ranging from relatively undisturbed swamps and forestlands to mine pits with constructed drainage ditches and cleared land that supported both an industrial park and townsite. These distinct areas are all used by wildlife in some way. Several different studies have been completed in recent years to measure wildlife species richness at Pine Point. The methods used to conduct these studies have included: ground surveys along transects, traditional knowledge studies, aerial surveys, continuous audio-recording at fixed locations, continuous monitoring with

wildlife cameras at fixed locations, and incidental observations. Results from the different studies have been compiled. They indicate that the different habitats at Pine Point support a fairly diverse assemblage of both migratory and resident animals.

DIAMOND POTENTIAL OF THE DEHCHO REGION

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Our knowledge of the diamond potential in the Dehcho region has progressed significantly in the past decade. We now recognize that the central Dehcho represents a world class diamond exploration district. Continued scientific and industry work in the area have clearly shown that the diamond potential of this area may be of the same magnitude as the Lac de Gras region, which hosts active diamond mines.

The evidence for high diamond potential in the Dehcho, includes abundant Kimberlite Indicator Minerals (KIM) from stream sediment sampling work, a diamond found in a stream sediment sample, 39 drilled kimberlites, some of which are diamondiferous, and numerous untested kimberlite-like geophysical anomalies from both government and industry data. Recent work at the University of Alberta has shown that deep Earth conditions in the area of the Horn Plateau may be as favorable for diamond generation and preservation as the Lac de Gras region and that there that there may be multiple generations of kimberlites present in the region. Given the relative paucity of exploration work and geoscience data in the Dehcho region, the available evidence is strongly suggestive of the possibility of the presence of diamond deposits.

UPPER MANTLE STRUCTURE UNDERLYING THE DIAMONDIFEROUS SLAVE CRATON FROM TELESEISMIC BODY-WAVE TOMOGRAPHY

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Cratons are, by definition, the most tectonically stable and oldest parts of the continental lithosphere on Earth. The Archean Slave craton is located in the northwestern part of the Canadian Shield. The propensity of diamondiferous kimberlite pipes in the central Slave craton raises many questions regarding their structural environment and source. Here, we provide the most robust teleseismic P and S body wave tomography models over the Slave craton region based on 20,547 P-wave delay times, 6,140 direct S-wave delay times and 3,381 SKS delay times. The P-wave model reveals an alternating pattern of relative positive and negative anomalies over a fine broad scale region within the central Slave craton. Furthermore, the P-wave model revealed two fine structures located in the lithosphere beneath the Lac de Gras kimberlite cluster, with relatively slow anomalies (B - C) that extend from 75 km to 350 km depths with an apparent dip to the north. These relatively slow P- and S-wave anomalies are associated with metasomatised regions within the lithosphere. The S-wave model displays a slow S-wave anomaly lying from 300 km depth to the transition zone beneath the central Slave craton. This anomaly is located beneath the Lac de Gras kimberlite cluster. We suggest that this anomaly is not the cause of the actual

kimberlites at the surface since last eruption occurred 75-45 Ma ago but may be related to a potential kimberlite magma ascent in the asthenosphere.

2018 GEOLOGICAL WORK IN THE CARIBOU PASS AREA, NTS 105P

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The western border of the Northwest Territories (NWT), within NTS map sheet 105P, both north and south of the Canol Heritage Trail, was mapped at 1:250,000 scale in the 1970's. Parts of northwestern 105P were re-visited as a part of the Northwest Territories Geological Survey (NTGS) Sekwi Project in 2006-2008. However, the geology of the region remains poorly understood, in part due to the predominance of shaley units with no marker horizons and the presence of extensive covered areas. Maps created by the Yukon Geological Survey west of the border provide a level of detail that is not matched on the NWT side. The Caribou Pass region has the potential to host intrusion-related mineral deposits including skarn (W, Au, Mo, and Cu) and Carlin-type gold, sedimentary-related phosphate and barite, and shale-dominated base metals deposits. Stream silt collected during geochemical reconnaissance in the early 2000s included 23 samples containing 13 to 93 ppb gold.

Rocks in the region were deposited as sediments in the Selwyn Basin on the western margin of Laurentia beginning in the Proterozoic. Paleozoic rocks record the development of: (1) the Misty Creek Embayment, an extensional sub-basin that developed along the eastern edge of the Selwyn Basin from the Cambrian until the Middle Devonian; (2) adjacent parts of the Mackenzie carbonate platform that encroached on the embayment beginning in the late Silurian; and (3) a widespread, unnamed basin in which mainly clastic strata were deposited from the Middle Devonian until the Mississippian. These three stratigraphic packages were folded, thrust eastward, and intruded by felsic plutons during a Cretaceous orogeny. Existing maps do not subdivide large areas of Cambrian to Devonian basinal strata.

Field mapping by the NTGS in 2018 was partially successful in subdividing the Cambrian to Devonian package of strata. A previously unidentified sandstone unit, probably volcanogenic, is exposed at the base of the Middle Cambrian Hess River Formation in two places. If this unit is in stratigraphic position, it may refine our understanding of magmatism within the Embayment. The Ordovician Rabbitkettle Formation is thin and poorly developed, in many places providing no clear demarcation between the shaley strata of Hess River Formation below and Duo Lake Formation above. The Early Devonian Hailstone Formation was identified above Duo Lake Formation in the heart of the Caribou syncline, whereas the platformal Silurian Cloudy and Devonian Tsetso formations were tentatively identified above Duo Lake Formation on the east limb of the syncline. A succession of dolostone reefs on the west limb of the syncline, including a thrombolite reef, are similar to Silurian reefs in Mount Kindle Formation to the north. The recent work also hints at structural complexities not shown on existing maps. A focus of future work will be determining which aspects of the stratigraphy and structure are related to prospectivity for Carlin-type gold. This will be addressed by mapping at 1:50,000 scale and detailed stratigraphic work.

COMMUNITY FOCUSED THERMOKARST MAPPING TO INFORM GEOHAZARD ASSESSMENTS AND FUTURE PERMAFROST THAW RISK

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The future impact of climate warming on communities and infrastructure is one of the most pressing issues facing northern Canada. Large areas of permafrost in Canada show signs of degradation and, with the Northwest Territories (NWT) warming ~4 times the rate of the global average, rates of permafrost thaw are expected to accelerate. Increasingly there is a need to consider the potential for thermokarst formation in community and land use planning. Current products that assess the distribution of thermokarst landscapes do so at the large, circumpolar scale, which is too coarse a scale to be useful for community or regional planning efforts. We aim to identify and predict – for a 50 km radius around six communities of the Northwest Territories – areas of the landscape that are susceptible to thermokarst formation. We identify and delineate thermokarst features in these focus areas using Sentinel remotely sensed imagery. These fine-scale community-focused datasets are then used to validate the current large-scale thermokarst probability maps (Olefeldt *et al*., 2016) and determine whether they can be downscaled for use in community land use planning and hazard assessment. Finally, our work seeks to understand the hierarchy of importance of landscape characteristics in determining a region's sensitivity to thermokarst formation. We will develop maps of subsurface predictor variables – such as surficial geology, ground ice content, land cover and slope – and use spatial multi-variate correlation analysis to determine the hierarchy of landscape controls on thermokarst formation. Overall, the objectives and outputs of this work seek to advance our ability to map permafrost geohazards and to help inform where and when to apply management and adaption efforts.

MINERALOGY, SCHEELITE LIBERATION AND SCHEELITE PARTICLE SIZE IN TAILINGS FROM THE CANTUNG TUNGSTEN MINE

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The objective of this study is to characterize the Cantung tailings using automated mineralogy to determine their potential economic value and environmental liability. The results will help to assess the feasibility of reprocessing the tailings to extract additional tungsten. Fifty samples were collected from surface to 30 m depth in four tailings ponds, and one bulk sample from the Flat River tailings, which had been released during the early stages of mining. 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.

We characterized the tungsten ore mineral, scheelite, with respect to concentration, grain size and liberation, evaluated the modal mineralogy, and calculated the relative amounts minerals that could generate acid

and those that could provide neutralization (e.g., acid-base accounting).

Scheelite was found to be the only tungsten mineral and was in concentrations up to 1% in the samples examined. Automated mineralogy provides the opportunity to determine grain size of a single mineral. To date, our results indicate that scheelite has a roughly bimodal distribution in size – about half the samples contain scheelite that is predominately 1-10 µm in size, and the other half of the samples have a wide range of coarser grains, up to 400 µm in size. The degree of liberation varies, most grains are partially liberated. Acid-base accounting (ABA) is a static test used to predict whether a sample will produce acidic drainage if the sulphide portion is exposed to oxygen and water. Conventionally, this is done using chemical tests but we have used a mineralogical method. The potential to produce acid was calculated from modal mineralogy by calculating the sulfur content of acid-generating minerals (Fe sulphides). Neutralization potential was calculated based on the abundance of carbonate minerals, while correcting for the presence of Fe and Mn carbonates which do not provide neutralization. Results to date indicate that most of the tailings are potentially acid-generated, consistent with chemical testing done on similar samples. However, these tests provide no information on the kinetic barriers to sulphide oxidation. Field observations indicate limited oxidation in the tailings ponds in contrast to extensive oxidation in the Flat River tails which have been exposed to weathering for decades. The Flat River tailings sample differs from the others in that weathering has oxidised almost all the pyrrhotite and replaced it with iron oxides and elemental sulfur. In contrast, pyrrhotite in samples from the impoundments exhibit limited weathering.

This project shows that automated mineralogy using SEM-MLA software can provide several kinds of quantitative information that is useful for assessing the potential for reprocessing the Cantung tailings, and redesigning the eventual storage of tailings (e.g., dry stack configuration). In particular, the concentration, grain size distribution and liberation of scheelite can be measured. Mineralogical variation can be assessed, and the potential for acid generation, based on static acid-base accounting, can be evaluated. Precious metals and bismuth particles, though rare, can be recognized and quantified using this method.

TRACKING LEGACY POLLUTION: ASSESSING SPATIOTEMPORAL PATTERNS OF ARSENIC AND OTHER METALS IN SUB-ARCTIC LAKES USING PALEOLIMNOLOGY

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Concerns persist about elevated concentrations of arsenic and other metals in the Northwest Territories due to legacy pollution from Giant Mine. While roasting operations ceased in the late 1990s, the possibility remains that lakes, wetlands, and soils have served as repositories, trapping much of the arsenic released in the 1950s via atmospheric deposition. Paleolimnological studies from far-field locations have shown evidence of arsenic enrichment that coincides with peak mine emissions, but systematic

studies are needed to determine the spatial extent of emissions from Giant Mine. As part of the Sub-Arctic Metal Mobility Study, temporal patterns of contaminant deposition and hydrological conditions will be reconstructed from sediment cores collected from eight lakes along an 80-km transect northwest of Yellowknife. Study lakes are located at 10-km increments following the prevailing wind direction. Lake sediment cores will be dated using radiometric methods (^{210}Pb, ^{137}Cs) and analyzed for metal concentrations and a suite of paleohydrological parameters. Objectives include to 1) define pre-industrial baselines of metal concentrations, 2) identify periods and extent of pollution from Giant Mine and other sources, and 3) discern if climate change affects metal transport to aquatic ecosystems.

FACTORS CONTROLLING TUNGSTEN MOBILITY IN CANTUNG MINE TAILINGS

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The Cantung Mine in the western Northwest Territories was a leading global producer of tungsten intermittently during the period of 1962 to 2015, and is currently owned by Crown Indigenous and Northern Affairs Canada (CINAC). The mine hosts five tailings ponds (~6.5 Mt total), as well as ~172,000 t of tailings that were deposited directly on the Flat River floodplain during its first three years of production. The tailings vary in terms of their mineralogy and degree of oxidation, which provides an excellent setting to study factors controlling low temperature tungsten mobility. As concerns about tungsten's potential toxicity have only recently emerged, there is an absence of literature on its fate and transport in the environment. In particular, few studies have addressed tungsten's mobility in mine tailings, which could act as a large point source of metal leaching.

In July 2018, eleven surface water samples, nine pore-water samples, and seventeen tailings samples were collected from the Cantung Mine's tailings. The tailings pore-water ranged from being acidic and oxidized (pH = 1.92, Eh = 0.83), to slightly alkaline and reducing (pH = 7.61, Eh = 0.17), and were sampled using suction lysimeters and by centrifuging tailings samples. Tailings samples were also collected from holes that were augered during lysimeter installation. Samples were transported to Queen's University in Kingston, Ontario, where the water samples have undergone elemental analysis by high resolution inductively coupled plasma mass spectrometry (HR-ICP-MS), and their anionic composition determined via ion chromatography (IC). Further analyses are planned, including O, H, S, and C stable isotopes, to address specific aspects of tungsten's behavior in the Cantung tailings. Tailings samples will have their modal mineralogy determined by SEM-MLA, and synchrotron micro-XRD analysis is planned to investigate phase specific adsorption. In addition, solid tailings and their co-existing pore-waters will be used to model water-mineral interactions by running simulations using PHREEQC.

RECONNAISSANCE SURFICIAL GEOLOGY, RIVIÈRE GRANDIN, NORTHWEST TERRITORIES, NTS 86-D

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The Rivière Grandin map area is characterized by three glacial terrains identified by different surficial sediments and landforms. In the northeast along and inland from the shores of Hottah Lake, glacial Lake McConnell deltas, beaches and offshore sediments occur between 180-350 m elevation. Farther west, in the Ortona Lake area and westward, terrain near or above 500-600 m elevation is defined by hummocky glaciofluvial sediments, a few morainal ridges, abundant radial meltwater channels, and an absence of ice-flow indicators, which may indicate local cold-based ice regimes. On the eastern edge of these highlands, rare drumlins trend northwestward, perpendicular to the flutings at lower elevations to the north and south. The remaining and most extensive map areas are generally covered by streamlined till with interspersed ridged till (minor moraines). Drumlins, crag-and-tails and drumlinoids record northwestward and southwestward topographically-deflected divergent and convergent ice flows. The area north, west and south of Rome Lake has a greater concentration of ridged till. Late during deglaciation, various minor ice-flow shifts occurred in the southwest map area, indicated by small, superimposed streamlined landforms.

DETERMINING EFFECTS OF CLIMATE CHANGE ON ARSENIC MOBILITY IN PEATLANDS: AN EXPERIMENTAL APPROACH

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Giant Mine, located in Yellowknife NWT, released a large amount of arsenic and other metals during the initial phase of its operation. These contaminants were then deposited on the landscape. Recent paleolimnological evidence has suggested that the pollution dispersed more than 100 km from the source. The landscape surrounding Yellowknife, like many subarctic systems, is dominated by peatlands with large quantities of organic matter that has built up over millennia. Peat and other forms of organic carbon can play important roles in the sequestration and mobility of arsenic, yet little is known about what controls these processes. Understanding these controls is important to anticipate the consequences of climate change on the release of pollutants to downstream ecosystems. Based on current paleolimnological research along an 80-km transect northwest of Yellowknife (see poster by Jasiak *et al.*), peat cores will be collected from locations of known arsenic pollution. The objectives of this project are to: (1) measure the concentration of metals in peat core samples and characterize the role of peat as a repository of metals, and (2) perform experimental manipulations that mimic wet-dry cycles and fire events to determine if these processes influence metal mobility

within peat profiles. This research will provide insight into the potential hazard that remobilized metals pose to ecosystems.

COMMUNITY SURFICIAL GEOLOGY AND GEOHAZARDS MAP SERIES, FORT MCPHERSON, NORTHWEST TERRITORIES, CANADA

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In many northern Canadian communities, buildings are supported in or on permafrost. Permafrost degradation due to climate warming can impact these building foundations, as well as nearby slopes whose stability depends on remaining frozen.

The community surficial geology and geohazards map series were compiled by Tetra Tech with the assistance and support of Ecology North, the Hamlet of Fort McPherson, and the Rat River Development Corporation Ltd., as one of several proposed adaptations to climate change in Fort McPherson that required geotechnical engineering and permafrost expertise. The map series were intended to be desktop-level maps that would accomplish the following tasks:

- Help the community better understand the soils, rock and permafrost around them;
- Provide a tool to assist land managers with land use and development: to determine the preferred areas for building; and
- Provide a baseline reference for monitoring potential future thaw or large-scale changes in the permafrost and/or slope stability, resulting from climate change and/or development.

A NEW GLACIAL LANDSCAPE MAP OF THE LAURENTIDE ICE SHEET IN CENTRAL NUNAVUT AND EASTERN NORTHWEST TERRITORIES

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A new glacial geomorphology map and database is in progress for the core region of the Keewatin Sector of the Laurentide Ice Sheet (LIS) in central mainland Nunavut and parts of eastern Northwest Territories. Keewatin is considered one of the last frontiers of the LIS where insufficient synthesized glacial histories restrict paleoglaciological reconstructions and glacial transport models, therefore hampering the effectiveness of surface mineral exploration methods. The new compilation will permit the identification and grouping of glacial features into coherent patterns, provide an update of the glacial history, and help evaluate glacial transport in areas of complex ice flow dynamics and changing basal ice thermal regimes. The map incorporates previous mapping (largely derived from air-photo interpretation with scattered fieldwork), recent field-based

mapping compilations, and new interpretation using ArcticDEM and LANDSAT8 imagery. To constrain the chronology of glacial and deglacial events, and document the nature and composition of glacial sediments in selected glacial terrains, targeted fieldwork was completed in 2017 and 2018. The final product will consist of a map (scalable) and GIS database of glacial features and landforms (individually mapped), an interpretation of glacial landscapes (georeferenced overlays), a bibliography of all published sources, and a nomenclature of the map features.

A preliminary map for the eastern sector of the project area covering ~400,000 km^2 in Nunavut is presented. The map comprises 43 complete/partial 1:250K scale NTS map sheets. Selected polygons, lines and point features of interest were extracted from a combined map geodatabase. The features were grouped into simplified shapefiles by theme. Information (metadata) is stored in attribute tables for each feature/field observation type regarding timing, mapper and nature of interpretation (e.g., error, duplication, shift, addition), and original data source. In total, 115,658 line features, 16,145 point features and 13,362 polygons are now included in the database, in addition to 5,753 ground and remote stations with field observations, ice-flow measurements and/or glacial sediment samples. This work is part of the Synthesis of Glacial History and Dynamics Rae Activity under the GEM-2 Program and is a collaboration between the Geological Survey of Canada, the Canada-Nunavut Geoscience Office and the Northwest Territories Geological Survey.

APPLICATION OF PASSIVE SEISMIC METHODOLOGIES TO THE DETERMINATION OF OVERBURDEN THICKNESS

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Diamond mining is central to the economic development of the Canadian North. Innovative methods are needed to identify new prospective targets, as many of them are hidden beneath a thick overburden of glacial sediments.

Passive seismics is an emerging method used to map the thickness of near-surface geological layers. Vibrations from distant earthquakes are used as a source of signal and data is processed to estimate the depth of the interface between the overburden and the underlying bedrock.

In July 2018, four Tromino seismographs were taken to a study site located approximately ten minutes driving north of Yellowknife. A total of 146 Tromino measurements and associated GPS elevation measurements were taken at 6 m intervals along a dirt road. Elevation measurements were averaged over the course of four days and the survey line was approximately 740 m long. Results indicated that depth to bedrock decreases near outcrops and increases in valleys however; another geophysical dataset is needed to validate the passive seismic data.

In addition, 36 repeatability measurements were taken at a borehole location to validate the Tromino's functionality and stability. Measurements were taken with 4 Trominos at the same location for 9 consecutive days to determine if data remains consistent even if the source signal changes each day. Each measurement yields a peak resonant frequency in (Hz). Key results from this study were that the average standard deviation of the peak resonant frequency associated with using the same instrument at the same location on different days was 0.07 Hz. This indicated that even if the source signal is different each day the standard deviation is very stable. Also, the average standard deviation of the peak resonant frequency associated with using different instruments at the same location on the same day was 0.05 Hz, which indicated that all instruments were performing well in terms of instrumental error.

A borehole study was conducted using two borehole locations. One was located at the repeatability study site and the other was approximately 65 m off the road, near a lake. To estimate the depth of the overburden-bedrock interface (Z) requires knowledge of the peak resonant frequency (F0) and shear wave velocity (Vs) in the near subsurface: Z = Vs/4*F0. Depth to bedrock was calculated using varying Vs values ranging from 200-500 m/s in steps of 25 m/s. The RMS error was calculated between borehole depths and calculated depths. The Vs value corresponding to the minimum RMS error value was 300 m/s, which was used to calculate depth to bedrock.

NORTHWEST TERRITORIES GEOLOGICAL SURVEY GEOPHYSICAL ACTIVITIES, 2018-2019

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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 magnetic, 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 NTGS Open Report in the near future.

The Banks Island aeromagnetic data submitted and donated by industry is being checked for errors, and enhanced by the addition of new interpretive grids such as vertical derivatives, analytical signal and magnetic susceptibility. Industry-standard geosoft formats are used, and in addition, new and original grids have been converted into georeferenced tiff images for the user's convenience. Geophysical interpretation of the Banks Island dataset is underway, and will be published as an NTGS Open File.

Areas of interest for new high-quality airborne geophysical projects are proposed

for information and discussion. The 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) completed a fixed wing aeromagnetic reconnaissance in the NWT Mackenzie Mountains, NTS 95M, 105P, 106A and parts of NTS 95N, 96D, 105I, O and 106B, C. The survey is designed with 800 metre line and 2400 metre tie line spacing. The nominal aircraft terrain clearance is 250 metres 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 reconnaissance aeromagnetic data can be used by multiple stakeholders to enhance geoscience knowledge, promote mineral exploration, and inform land use planning decisions.

MAPPING THAW SENSITIVE TERRAIN AND PERMAFROST DYNAMICS, DEMPSTER AND INUVIK-TUKTOYAKTUK HIGHWAY CORRIDOR REGION

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Knowledge of ground ice conditions and landscape thaw susceptibility provide the foundation to support resilient infrastructure in the north. Ground ice distribution, combined with terrain and climate factors, dictates landscape sensitivity of permafrost regions. Terrain, ground ice, and climate conditions across the 875 km Dempster and Inuvik-Tuktoyaktuk highway corridor vary to produce a natural laboratory where the factors that influence thaw sensitivity can be assessed. The Geological Surveys of Canada and the Northwest Territories are working together to develop robust methodology to identify, classify, and map permafrost, mass-wasting, and thermokarst features to provide baseline spatial information to support terrain studies and risk assessment along the corridor. Using a 3-D mapping approach that combines high-resolution satellite imagery and elevation data, geomorphological features related to periglacial, hydrological, and mass movement processes are identified and mapped within a 10 km-swath centred along the highway corridor. To ensure reproducibility and reliability of the results among mappers, the methods are tested by a number of technicians and include quality control/quality assurance measures. In addition to generating critical geoscience data for this region, the methods have been transferred to a stand-alone protocol, which can be applied in other fine-scale permafrost terrain or hazard mapping projects. Our overarching goal is to use the map data in conjunction with available geoscience data to develop better landscape system models. However, the maps also support other research projects such as the interpretation of local surface deformation patterns using satellite radar methods (DInSAR), provision of fine-scale data used to upscale terrain mapping efforts, and risk assessment along northern highways.

VOLCANIC STRATIGRAPHY AND ALTERATION OF THE SUNRISE VOLCANOGENIC MASSIVE SULFIDE DEPOSIT, BEAULIEU VOLCANIC BELT, NORTHWEST TERRITORIES

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The Sunrise deposit is a volcanogenic massive sulfide (VMS) deposit located within the Beaulieu volcanic belt (ca. 2.6 Ga) in the Slave craton, about 110 km east northeast of Yellowknife, Northwest Territories. The Beaulieu belt is part of the Yellowknife Supergroup, and is underlain by the ca. 2.8 Ga Sleepy Dragon Complex of the Central Slave Basement Complex. The belt is comprised of mafic volcanic flows with minor felsic volcanic rocks. The Sunrise deposit has a historic indicated resource of 1.52 Mt at 5.99% Zn, 2.39% Pb, 0.08% Cu, 262 g/t Ag, and 0.67 g/t Au. While the deposit has been explored since the late 1980s, the detailed volcanic stratigraphy and the nature of alteration associated with it remains poorly characterized.

The aim of this study is to characterize the rhyolite lapilli tuff hosting the VMS deposit, and the alteration associated with mineralisation, through detailed mapping (completed summer 2018), petrography, and lithogeochemistry (to be completed winter 2019). The deposit is spatially associated with a rhyolite flow-dome complex and associated felsic volcaniclastic rocks; however, the majority of the footwall stratigraphy consists of andesite and basalt pillow lavas. The ore is banded massive sulfide, hosted in a rhyolitic lapilli tuff that has been pervasively, strongly sericitized and silicified (predominantly composed of recrystallized K-feldspar and quartz, with lesser amounts of sericite and trace epidote in fractures). Ore is not exposed at surface, but the rhyolite lapilli tuff is pervasively Fe-stained from the weathering of disseminated pyrite, and locally contains sphalerite (<1 mm, <1%) and chalcopyrite (<1 mm). The lower contact of the rhyolite lapilli tuff is not exposed. The upper contact with pillow basalt of the hanging wall is marked by an ~1 m wide shear zone of intensely foliated basalt. Moderate carbonate and chlorite alteration and trace amount of pyrite and sphalerite (<1 mm, <1%, in pillow selvages) were observed in the basalt.

The Sunrise VMS deposit of the Beaulieu volcanic belt is hosted by a strongly silicified and sericitized rhyolite lapilli tuff with a maximum thickness of 40 m and strike length of 350 m as exposed at surface. The immediate hanging wall is composed of moderately carbonate and chlorite altered basalt that also contains trace pyrite and sphalerite, indicating the hydrothermal system was still active post-basalt eruption. Future work using whole rock geochemistry, and detailed mineralogy (X-ray diffraction) will allow us to quantify alteration zones within and petrogenesis of the rocks that host the Sunrise deposit; this new information will potentially aid in exploration for other VMS deposits in the Beaulieu belt.

CHOOSING AN APPROPRIATE DIGESTION PROTOCOL FOR ENVIRONMENTAL RISK ASSESSMENTS OF MINERALIZED EARTH MATERIALS

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Ecological and human health risk assessments at active and abandoned metal mines require accurate geochemical data for earth materials, including soils, sediments, dusts, and mine wastes. Reliable data on metal(loid) concentrations are also important for establishing geochemical baselines and to support environmental monitoring activities. However, the reported concentration for an element in a given sample can be affected by many factors, including mineralogy, grain size, laboratory digestion conditions (reagents, temperature, time), and the instrument(s) used for elemental analysis. In particular, aggressive multi-acid digestion methods used to provide "near-total" data for some metals of environmental interest (e.g., chromium (Cr)) may result in the loss of other elements (e.g., antimony (Sb), arsenic (As), sulfur (S)) through volatilization prior to analysis. When comparing data from different studies or sampling periods, it is crucial to ensure that the analytical protocols used are consistent and that changes in element concentrations over time are not simply due to variations in sample processing or laboratory procedures.

The purpose of this study is to compare common digestion protocols used in the analysis of geological materials and provide recommendations on the most appropriate techniques for use in environmental risk assessments. We analyzed samples of lake sediments, soils, and mine tailings collected at metal mine sites across Canada following digestion using two of the most commonly employed procedures in exploration and environmental geochemistry: modified aqua regia digestion (equal parts HNO_3:HCl:H_2O at 95°C for one hour) and a 4-acid digestion (HF-$HClO_4$-HNO_3 heated to fuming and taken to dryness; residue dissolved in HCl). All solutions were analyzed using ICP-ES/MS, and certified reference materials (CRMs) and duplicate samples were used to monitor analytical accuracy and precision. The concentration of elements (e.g., Cr) hosted in relatively insoluble mineral phases are consistently higher following 4-acid digestions as compared to digestions using aqua regia, but generally lower than total values in CRMs. In contrast, the concentrations of As are consistently higher in all samples following aqua regia digestions and in good agreement with certified values. The behaviour of other elements (e.g., Sb, copper (Cu), lead (Pb), S, zinc (Zn)) was more variable and for many samples, the results following 4-acid and aqua regia digestions were statistically indistinguishable. Variations in the mineralogy of different samples play a key role in determining the fraction of different metal(loid)s released by these digestion techniques. This presentation will highlight some of the advantages and disadvantages of using each of these digestion protocols for risk assessment and environmental monitoring purposes, and provide recommendations for using geochemical data to help guide environmental decision-making at both active and abandoned metal mines.

COSMOGENIC SURFACE EXPOSURE AGES FOR LAURENTIDE ICE SHEET DEGLACIATION IN THE WESTERN SLAVE CRATON

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The timing of northwest Laurentide ice sheet deglaciation is important for understanding how ice-sheet retreat, and associated meltwater discharge, may have been involved in abrupt climate change and rapid sea-level rise at the end of the last glaciation. However, the deglacial chronology across the western Canadian Shield is poorly understood, with only a handful of minimum-limiting ^{14}C dates constraining the timing and pattern of northwest Laurentide ice-sheet retreat. We use cosmogenic ^{10}Be surface exposure dating of glacial erratics, sampled opportunistically during bedrock mapping campaigns in the western Slave Craton, to directly date the timing of northwest Laurentide ice-sheet retreat during the last deglaciation. Five erratics sampled near the Acasta Gneiss "Discovery Site" have exposure ages between 12.8±0.6 and 12.2±0.6 thousand years ago (ka), with a weighted mean of 12.4±0.2 ka. Five erratics were also sampled 115 km to the east at Point Lake; four exposure ages are currently in-process, but one erratic from this site yielded an exposure age of 11.6±0.5 ka. When corrected for decreased atmospheric depth due to isostatic uplift since deglaciation, the data indicate that the Laurentide ice-sheet retreated through this western part of the Slave Craton ~13.7-12.8 ka, or ~1000 years earlier than inferred from the canonical compilation of minimum-limiting ^{14}C dates for deglaciation. Additional exposure ages on glacial erratics across the Slave Craton will allow comprehensive testing of hypotheses related to northwest Laurentide ice-sheet retreat and its potential forcing of abrupt deglacial sea-level rise and climate change events.

STRUCTURAL ANALYSIS AND CHARACTERIZATION OF AURIFEROUS QUARTZ VEINS OF THE PTARMIGAN AND TOM GOLD DEPOSITS, YELLOWKNIFE, NORTHWEST TERRITORIES, CANADA

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The Ptarmigan and Tom deposits comprise a series of echelon vein-type gold deposits hosted within deformed turbiditic rocks of the Archean Burwash Formation of the Slave Structural Province and are located approximately 10 km east of the Giant Deposit, which produced over 7 million oz. of gold. The Ptarmigan and Tom deposits are located within a 4 km wide metamorphic aureole of the Prosperous Granite to the west. The host rocks contain corderite porphyroblasts and several pegmatitic dykes.

Groundwork assessment of the structural controls of gold-bearing quartz veins of the Ptarmigan and Tom deposits was completed over the course of 15 days in the summer of 2018. Three generations of structures were identified, (D1) a bedding-parallel, weak spaced cleavage interpreted as S1, (D2) a

dominant foliation with variable intensity which ranges from spaced cleavage in greywacke to a schistosity within slate horizons, (D3) crenulation cleavage. In addition to the recognized structural generations, a sequence in style of quartz veins was observed. The sequence displays progressive deformation as follows; (A) Bedding parallel veins, ptygmatically folded and overprinted by porphyroblasts and refolded by outcrop-scale asymmetric folding. (B) Stratabound echelon veins folded by asymmetric F2 folds. (C) Ptarmigan style veins, sub-parallel to cleavage that locally cross-cut bedding, locally boudinaged, asymmetrically folded and crosscut by straight shear veins. (C*) Flat veins (extensional veins) that occur on both sides of the Ptarmigan and Tom Veins locally. (D) Cleavage parallel straight shear veins.

Based on field observations, a preliminary model involving oblique sinistral shearing along a high strain zone is proposed in order to explain relative timing of auriferous vein emplacement. (1) A syn-D2 emplacement of a series of echelon shear veins (preferentially along F2 fold axis); (2) Continued oblique-sinistral transpression generating curved-shaped geometry of the echelon veins.

CHARACTERIZATION OF APATITE WITHIN THE MACTUNG W (CU, AU) SKARN DEPOSIT, NORTHWEST TERRITORIES

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The Mactung W (Cu, Au) deposit, Northwest Territories, is a scheelite-rich, calc-silicate skarn (17 Mt total mineral resources grading 0.97% WO_3 and 0.078% Cu for a cutoff grade of 0.5%WO_3) hosted in two distinct packages of Cambrian to Silurian aged limestone with pelite, referred to as the upper (units 3D-F) and lower (unit 2B) ore zones, separated by a thick unit of hornfelsed pelite (unit 3C). Recent studies on the nearby Cantung deposit show that apatite in skarn record petrogenetic processes. In order to understand the evolution of the Mactung deposit, and constrain chemical signatures of mineralizing fluids, multiple generations of apatite were characterized using classical petrographic techniques, hot cathodoluminescence (CL), and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS).

Representative skarn samples were collected from each stratigraphic unit of the deposit and examined for apatite. Apatite was observed in skarn from all stratigraphic units, including the upper and lower ore zones and unit 3C. However, apatite was most commonly observed in skarn replaced, hornfelsed, phosphatic (collophane-rich) pelite, intercalated with limestone, in unit 3D. Apatite occurred in all skarn types studied,

including pyroxene-pyrrhotite, garnet-pyroxene, pyroxene, pyrrhotite and amphibole skarn. Textural evidence suggests that at least some apatite formed through the recrystallization of detrital collophane, as apatite were commonly distributed around partially dissolved phosphate nodules. Apatite was the earliest skarn phase within all skarn types, with the exception of some garnet-pyroxene and pyrrhotite skarn, where apatite and pyroxene appeared coeval. Scheelite and titanite (a minor skarn phase), likely formed coeval or immediately after apatite based on textural relationships.

Apatite exhibits five distinct fluorescence colours under CL, also distinguished by texture: i) irregular masses at the cores of oscillatory zoned apatite fluoresced light to dark grey, ii) the interior of oscillatory zoned apatite fluoresced blue, iii) the interior and/or rims of oscillatory zoned apatite fluoresced green (becoming lighter towards the rim), iv) the rims of oscillatory zoned apatite and entire unzoned crystals fluoresced yellow, and v) small patches of altered apatite rims fluoresced orange. Preliminary LA-ICP-MS data show that the different coloured florescent apatite have distinct rare earth element (REE) abundances. Dark grey apatite showed relatively low total REE contents (~590 ppm ΣREE, La-Lu), with relatively high $La_N/Yb_N = 33$ and negative Eu anomaly (Eu/Eu* = 0.4; where Eu* = $\sqrt{Sm_N*Gd_N}$). Green apatite contained moderate REE contents (average 1170 ± 180 ppm, 1σ; n = 14), with $La_N/Yb_N = 7$ (± 3, 1σ) and Eu/Eu* = 0.6 ± 0.1. Yellow apatite contained high REE contents (average 2130 ± 640, 1σ; n = 23), with $La_N/Yb_N = 4$ (± 2, 1σ) and Eu/Eu* = 0.4 ± 0.1. Orange apatite showed the highest concentration of REE (average 4040 ± 130 ppm, 1σ; n = 2), with $La_N/Yb_N = 1.83$ (± 1, 1σ) and Eu/Eu* = 0.1 ± 0.0. These preliminary results indicate that the breakdown of collophane likely influenced the HREE abundance of green apatite in unit 3D. As more data is collected, apatite compositions will be used to describe the evolution of skarn fluids.

NEW CONSTRAINTS ON CRUST AND MANTLE STRUCTURE SURROUNDING THE BEAUFORT SEA, WESTERN CANADIAN ARCTIC, FROM A NEW BROADBAND SEISMIC ARRAY

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The formation and evolution of the western Canadian Arctic Archipelago represents a long-standing tectonic puzzle. The eastern Beaufort Sea rifted margin juxtaposes young (<150 Ma) Arctic Ocean lithosphere with Paleo-Proterozoic continental lithosphere of the Canadian Shield underlying Banks Island. 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. Conversely, surface-wave based velocity models of North America indicate velocities at 100-150 km

depths similar to those beneath Canada's diamond mines in the central Slave craton. These results suggest Banks Island basement is part of the Canadian Shield and any kimberlites found thereon are promising diamond candidates. Furthermore, the southern Beaufort Sea Mackenzie Delta margin represents a well-developed fold and thrust belt of Cretaceous to present age but has only been recently recognized as likely active. This belt accommodates either slow thrusting of continental crust over the oceanic crust, or underthrusting of the oceanic crust beneath the margin.

We exploit data from new land broadband seismic networks to investigate crustal structure and seismicity around the Beaufort Sea. One of the key questions is how one can reconcile mantle structure typical of the Canadian Shield with crust typical of a rifted passive margin. Specifically, 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. Preliminary results of crust and mantle structure from dispersion analysis (ambient noise and teleseismic earthquakes), 1D inversion, and receiver function analyses, indicate a ~30 km deep Moho beneath the Beaufort Sea and Banks Island, with slight thinning northwards towards Prince Patrick and Melville Islands. Mantle velocities remain elevated, indicative of cooler lithosphere. Anisotropy orientations from SKS splitting indicate margin parallel fabrics, perpendicular to those expected for a tectonically extended margin; however, the source depth of these fabrics remains elusive.

CHARACTERIZING ARSENIC DEPOSITION AND MOBILITY IN TERRESTRIAL AND AQUATIC ECOSYSTEMS OF THE 'LAKE 10' CATCHMENT, NWT

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Abandoned mine sites in Canada's Northwest Territories prompt uncertainty regarding the extent of legacy metal pollution. Additionally, warming of subarctic regions is leading to changes in hydrology and dissolved organic matter (DOM), which can affect the fate, mobility, and toxicity of legacy mining pollutants. Here we focus on possible far-field arsenic pollution from Giant Mine. Laboratory analyses on a sediment core from “Lake 10”, located 57 km northwest of Yellowknife, has identified evidence of arsenic enrichment in the latter part of the 20th century consistent with the emission history of Giant Mine. These results provide the foundation to assess potential mechanisms that may mobilize arsenic from the landscape to the aquatic ecosystem. To characterize linkages of metal mobility between terrestrial and aquatic ecosystems, we will: (1) identify stores of metals in multiple terrain units and the aquatic ecosystems, (2) investigate the hydrological and biogeochemical pathways for metal mobility, and (3) probe for how climate change may alter these stores and processes.

RESORPTION FEATURES OF MACRO AND MICRO DIAMONDS FROM GAHCHO KUÉ

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Studies into the relationship between oxygen fugacity of mantle fluids/melts and etch features on diamond surfaces have shown specific fluid/melt compositions correspond to associated etch features. A classification scheme has been proposed to determine the fluid composition within a kimberlite by examining etch features associated with diamond surfaces as a proxy for fluid composition in an ascending diamondiferous kimberlite. A suite of 388 microdiamonds (defined as diamonds which pass through a 0.5 mm square mesh screen) and 88 macrodiamonds taken from various drill hole depths in the Hearne kimberlite and 88 inclusion-bearing macrodiamonds from the Gahcho Kué mine (NWT) were viewed under a secondary electron microscope for their surface features in accordance with this scheme. Two hundred and thirty specimens show shallow-depth etch features that can be easily classified: the main features observed were trigons and truncated trigons on the {111} faces and/or tetragons on the {100} faces (indicating etching by fluids of variable CO_2:H_2O ratios). Thirty-four specimens show deeper etched features that represent either extreme degrees of regular etching (such as deeply-etched tetragons), or corrosion type etching, wherein the diamond lattice is etched in a fluid-free melt. Variability between crystal habits exists between the size fractions studied, with cubic habits only being observed in the microdiamond population. This implies variable formation conditions for the two different diamond size fractions studied from Gahcho Kué. Among microdiamonds, surface textures associated with fluid-related etching are markedly more variable, with truncated trigons, tetragons, and both positive and negative trigons being observed. However, these often occur in combination with features showing a large variability in their depth to size ratio between samples, which is typically caused by mantle-related etching. These observations suggest repeated interaction of fluids/melts with the Gahcho Kué diamond population, with at least some of the fluids affecting the microdiamonds being more CO_2-rich than those that etched the macrodiamond fraction.

WINTER HYDRAULIC PRESSURES OBSERVED IN WATER BODIES AND RIPARIAN SETTINGS, NORTH SLAVE, SUBARCTIC CANADIAN SHIELD

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Ice and all-weather roads are critical lifelines for northern communities and resource development activities. Icings are sheet-like masses of layered ice that form on the surface during the winter by freezing of successive overflows of water. Icing development over ice and all-weather roads negatively impacts their performance, and there can be adverse effects on bridges and culverts. Consequently, icings are an ongoing maintenance and safety problem in northern regions. The mechanism controlling overflow timing and behaviour is poorly understood. Overflow timing and stream bed water pressures have been linked to air

temperature fluctuations in several regions, but the relation between these two signals is not well defined and the mechanism is unknown. The Shield region contains the highest density of resource development infrastructure in the Northwest Territories, much of which is supported by the Tibbitt to Contwoyto Winter Road (TCWR). The main operational difficulty faced by operators on the overland portions of the TCWR is overflow and icing. The objective of this work is to provide much needed geoscientific insight on the icing process, in order to reduce risks for land-based transportation infrastructure.

Overflows in the subarctic Canadian Shield may be controlled by periodic increases in hydraulic head during open-system freezing. Local observations at the TCWR Portage 23 (P23) overland section have shown that overflow occurs during the period of active-layer freezeback when it is likely hydrologically connected to the upstream lake. Based on our previous work at P23, we installed vertical series of pressure transducers and temperature data loggers to determine the relations between barometric pressure, air temperature, water/ice temperatures, and water/ice pressures during the freezing season. To examine variation in hydrological setting, replicate apparatus were installed in a shallow lake, the lake outlet, and in the riparian zone downstream of the outlet where icing has been observed.

Initial results suggest that during the freezing-season, high frequency fluctuation of absolute pressure in the lake is driven entirely by barometric pressure, with no detectable increase with snow loading. At the outlet, hydraulic pressures behaved similarly to lake pressures. Absolute pressures at the downstream sensors also fluctuated at high frequency with barometric pressure. However, in contrast to the lake and outlet sites, hydraulic pressure increased by up to 2.2 kPa over a two-week period that followed freezing onset. Hydraulic pressures gradually tapered off from peak values until freezing occurred at depth.

The static water level observed at the lake and outlet suggests that the lake is either an entirely open system with water entering and exiting the lake at the same rate over the winter, or alternatively, that the lake is entirely closed with respect to water flow. The latter is supported by our observation of decreasing hydraulic pressures at the downstream site. The initial increase in hydraulic pressures observed at the downstream site indicate the semi-confined nature of the freezing riparian area. Further signal analysis is being undertaken to investigate the effects of freezing front progression on hydraulic pressure at the downstream site.

PETROGRAPHIC ANALYSIS OF SYN- TO POST-TECTONIC GRANITIC DYKES IN THE YELLOWKNIFE GREENSTONE BELT, NWT: EVIDENCE FOR LATE-STAGE H_2O-RICH FLUIDS

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The Yellowknife greenstone belt (YGB) is located in the Archean Slave Province, in the Northwest Territories, Canada. It is host to the historic Con and Giant mines which have produced a total of 14.2 Moz gold at an average grade of 16 g/t. Historic and recent field work has documented narrow granitic dykes that were previously not the subject of

an academic study. To date these dykes have only been observed proximal to the Western Plutonic Suite in the amphibolite grade Chan Formation of the Kam Group, and not in the overlying greenschist grade Crestaurum, Townsite, or Yellowknife Bay formations. The granitic dykes are typically = 30 cm wide and up to 1 m, and often have a dark pink-red, earthy hematized colouring. The dykes have sharp contacts with no observable chill margins and an overall aplitic texture with occasional fine- to medium-grained white feldspars. The granitic dykes often have cm-scale quartz cores that are typically continuous along the length of the dyke, or occasionally occurring as discontinuous pods. The granitic dykes were found to cross-cut all lithologies in the map area, including feldspar-quartz porphyries, tonalites, granodiorites, and mafic flows, making them the youngest dykes based on relative timing relationships.

Petrographic analysis compliments field data by allowing for a more detailed study of microstructures. Microtextural analysis of granitic rocks has shown that there is a correlation between microstructures and metamorphic grade. Therefore, the examination of the various quartz and feldspar textures may lead to a better understanding of the relative timing of these syn- to post-tectonic dykes as they developed overprinting prograde to retrograde metamorphic and deformation textures. These relative timing relationships will be combined with U-Pb geochronology to establish the age of discrete deformation events.

GEOHERITAGE OF THE GREAT SLAVE LAKE SHEAR ZONE IN THE ŁUTSEL K'E DENE FIRST NATION TRADITIONAL TERRITORY – NORTHWEST TERRITORIES

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Geoheritage is a descriptive term applied to areas of geologic features with significant scientific, educational, cultural, or aesthetic value. Culturally significant geoheritage sites are places where geologic features played a role in cultural or historical events.

The Great Slave Shear Zone (also known as McDonald Fault or Tthe Lare´ in Dene Yati language) is a world-class scenic and geological wonder. It extends for more than 400 kilometers along the East Arm of the Great Slave Lake in the Northwest Territories and has been proposed as a continental transform fault which accommodated eastward motion of the Slave Craton as it impacted the western margin of the Churchill Province during the Lower Proterozoic.

Spectacular cliffs drop 100 meters into the Lake, making it one of the most clearly visible faults on the earth's crust. The prominence of the shear zone has resulted in numerous landforms in the East Arm, including islands, rivers, lakes, rocks and waterfalls coming to be regarded as sacred sites of the Łutsel K'e Dene First Nation, thereby adding the necessary cultural dimension to its visually appealing

geological landscape. For example, the eight-meter-high Parry Falls, on the Lockhart River (Tsa'kui Theda Deze´) at the east end of East Arm, is a sacred site. There, it is said that the Old Lady of the Falls (Tsa'kui theda) can be found, a medicine woman who has healing powers and sits in the waterfall. Every summer, the people of Łutsel K'e host an annual spiritual gathering, paying their respects, healing, and making offerings.

Tsa'kui Theda and other sacred places on the East Arm of Great Slave Lake are part of the rich cultural history of the Łutsel K'e Dene First Nation, who consider the area to be the "heart of their homeland". The sacred places and cultural significance of this region is greatly enhanced by the fascinating geology of the Great Slave Lake Shear Zone. The proposed Thaidene Nëné National Park and Reserve will serve an important function of protecting this geoheritage site for the future.

URANIUM-LEAD ZIRCON GEOCHRONOLOGY OF GRANITOIDS NEAR JOLLY LAKE, SLAVE CRATON, NORTHWEST TERRITORIES

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As part of a Northwest Territories Geological Survey 1:50 000-scale mapping program, we have undertaken a study of major granitoid bodies in the Jolly Lake area of the Slave Craton (~ 220 km NE of Yellowknife). Earlier work in this area has focused on the volcanic belts surrounding the granitoid bodies and consequently, relatively little information is available about the age and nature of plutonic units. Whereas the granitoids themselves are of little economic interest, a better understanding of these rocks could lead to more meaningful exploration of proximal volcanic belts and associated metal deposits. In addition, the granitoids can serve as probes of the Slave Craton lower crust and underlying lithospheric mantle from which the granitoid magmas were derived. Given the proximity of the study area to the Lac de Gras kimberlite field (~ 50 km to the NE), additional information on the nature and evolution of the Slave lithosphere through time may be useful in further diamond exploration.

Previous workers have subdivided the granitoids of the Jolly Lake area into younger, older, and undivided suites. The older suite comprises primarily granitoid gneisses and migmatites. There is uncertainty surrounding whether some of the rocks of this suite have granitoid or supracrustal protoliths. The younger suite of granitoids consists of little deformed to undeformed syenogranites, monzogranites and granodiorites. The undivided granitoid suite is characterized by deformational characteristics and emplacement ages intermediate between the older and younger suites. Monzogranites near Winter Lake and syenogranites near Courageous Lake have been dated at 2796-2855 Ma and 2613 Ma respectively, while the granites surrounding Jolly Lake remain undated.

Observations made during the 2018 field season generally agreed with the interpretations of earlier geologists in the context of unit age relationships. However, the finer scale of the present mapping allowed for more detailed and comprehensive lithological descriptions. In particular, we subdivided the basement complex in this area into at least four distinct types of gneisses, classified on the basis of their mafic mineral content and metamorphic texture.

The granitoid samples collected in the fieldwork are currently being processed for uranium-lead zircon geochronology. The isotopic analyses of zircon will be done in-situ in standard petrographic thin section by laser ablation, multi-collector, inductively coupled plasma mass spectrometry (LA-MC-ICPMS). The goal of the geochronological study is to firmly establish a sequence of emplacement for the various granitoid suites and clarify the origin of the older gneisses and foliated granites.

SALT DEPOSITS OF THE NORTHWEST TERRITORIES

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Salt (sodium chloride; NaCl) is one of the basic raw materials for various chemical processes and has been used to flavour and preserve food since Neolithic time. Worldwide salt production is over 200 million tonnes. Most of the production comes from sedimentary deposits that are either mined as rock salt or brines. Salt is also produced by evaporation of seawater in traditional solar ponds or using other heat sources including fire and waste heat from power generation.

Salt occurs in several areas of the Northwest Territories (NWT). These include subsurface and surface occurrences. Subsurface deposits occur in Cambrian to Devonian formations including the Saline River Formation, which is widely distributed in the Mackenzie and Franklin mountains as well as in the northern Interior Plains and has been encountered in wells drilled for petroleum exploration in the Fort Liard, Fort Smith, and Norman Wells areas. The Saline River occurrence has the potential for a large-scale solution mining.

Surface occurrences of salts in NWT include salt springs, which are widely distributed in the territory including the Salt Plains of the Wood Buffalo Park and the Fort Smith area. Historic annual production of about four tonnes of salts have been reported from these springs although the exact locations are unknown. Other surface occurrences include seawater along the Arctic Ocean coastline.

In May 2015, six water samples were collected from the Salt River in the Fort Smith area and analysed for sodium (Na), potassium (K), calcium (Ca), and chloride (Cl) among other elements. The samples returned up to 4120 mg/L Na and 7240 mg/L Cl. The concentration of Na and Cl in these samples has probably been diluted by an unknown quantity of fresh surface water. The salt concentration in the springs and water sources varies systematically during the year with spring runoff, rain, and snowfall contributing to lower levels and summer dry spells causing higher salt concentrations.

Although there is no current production of salt in the territory, there is potential for low volume, high value “artisanal or cottage” production in some areas. Any such production could take advantage of natural variations in weather to lower production costs and, leverage the territory's booming tourism sector to reach the wider national and international clientele.

GEOCHEMISTRY OF THE LUCKY LAKE W-ZN-PB SKARN DEPOSIT, NWT, CANADA: EPITHERMAL OVERPRINTING OF MAGMATIC HYDROTHERMAL SYSTEMS

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Lucky Lake is a granite-related tungsten-zinc-lead skarn deposit located ~ 60 km southeast of Cantung, one of the largest tungsten deposits in the world. Lucky Lake is unusual due to its base-metal enrichment relative to other tungsten deposits of the region. There is also the potential for gold and silver in its ores, as can be suspected by the deposit's location adjacent to the Hyland gold camp and the overlap of the Cretaceous tungsten belt and the Tintina gold-silver-bismuth province, which stretches across Alaska into northwestern Canada.

The goal of this research is to document the relative timing and pressure-temperature-geochemical conditions of tungsten and base-metal deposition. This study employs a variety of geochemical techniques to decipher the nature of the ores, including: petrographic, cathodoluminescent and ore microscopy of thin and polished sections; SEM analysis of ore and gangue mineralogy; and fluid inclusion microthermometry of ore-related minerals. Detailed SEM analysis of the ore minerals document the trace and minor element character of the Zn-Pb event and will permit us to test the idea of involvement of gold-bearing fluids in the hydrothermal system.

Reflected light and cathodoluminescence (CL) microscopy indicate that pyrite (FeS_2) and scheelite ($CaWO_4$) were deposited first, followed by pyrrhotite (Fe1-xS) ± chalcopyrite ($CuFeS_2$), and ultimately by sphalerite (ZnS) ± galena (PbS). Pyrite grain boundaries have ~ 120° interfacial angles characteristic of annealing during metamorphism driven by the adjacent granite. The early ore minerals (pyrite, scheelite, chalcopyrite and pyrrhotite) are associated with iron-rich carbonate gangue that exhibits a dull red-brown color in CL. In contrast, later sulfides (sphalerite and galena) are associated with bright yellow-orange CL, open-space-filling calcite cements, suggesting that Pb-Zn mineralization represents a distinct hydrothermal event from that which deposited tungsten and copper mineralization.

The tungsten ± copper mineralization was deposited from magmatic-related fluids similar to those at Cantung (~ 430 to 590°C). Fluid inclusions in later quartz (Th = 337 to 185°C) and sphalerite (Th = 153 to 155°C) suggest that zinc mineralization (followed closely by lead sulfide deposition) was the result of a later event(s) at lower temperatures, from fluids with salinities between 0.6 and 7.4 wt. % equivalent NaCl.

The Lucky Lake deposit's zinc and lead enrichments appear to be related to a later hydrothermal overprint not described in the world-class Cantung mine's ores. Recognition of this late-stage epithermal event may have implications for understanding the emplacement conditions of the tungsten skarns and regional exploration for zinc-lead ores elsewhere in the Mackenzie Mountains.