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Pillowed Volcanic Rocks with Quartz-Sericite-rich Rims
Yellowknife Supergroup, Snare River

Valerie Jackson, NWT Geoscience Office

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EKATI DIAMOND MINE: LONG LAKE CONTAINMENT FACILITY PORE WATER GEOCHEMISTRY

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In the Lac de Gras area, gem quality diamonds are hosted in Phanerozoic age kimberlites. Diamond mining at the Ekati Diamond Mine produces fine processed kimberlite (FPK) that is discharged during operations as a slurry into the Long Lake Containment Facility (LLCF). The FPK will remain stored in the LLCF during post-closure. The initial pore water chemistry of the LLCF is predominantly controlled by the quality of process plant discharge, which comprises FPK, and various liquid waste streams reporting to the LLCF. Pore water chemistry of the LLCF is further influenced by the dissolution of minerals in the FPK, which occurs through weathering processes and reactions, such as oxidation, that release ions into solution and control the geochemical equilibrium between the solid and aqueous phases. Once deposited in the LLCF, FPK pore water may undergo freezing or thawing, depending on the season, and permafrost aggradation with potential effects on pore water quality. The objectives of the study were to characterize the current pore water from frozen and unfrozen FPK within the LLCF and to increase understanding of how permafrost aggradation influences pore water quality in order to improve predictions of LLCF water quality in post-closure.

Seven drill holes were completed in Cell B of the LLCF in March 2013 for thermistor installation and pore water sample collection (BH-13-01 to BH-13-07). Pore water samples were collected from frozen and unfrozen FPK and isolated ice lenses observed at various depths. The majority of FPK samples collected from the LLCF were frozen, with the exception of two zones within the south east side of Cell B that were unfrozen at a depth of 5.9 m to 6.9 m in BH-13-06 and 1.9 m to 2.65 m in BH-13-05. Discrete samples of ice were collected in addition to frozen FPK samples collected from above and below the ice lenses.

The pH of pore water ranged from 5.6 to 10.9 throughout Cell B. The highest dissolved metal and anion concentrations were generally observed in the near surface samples (above 4.5 m), coinciding with the lowest pH values. Within this near surface zone, pore water concentrations were higher than process plant discharge water concentrations due to in situ weathering processes and solute expulsion during freezing.

Unfrozen FPK had lower concentrations than frozen FPK, and samples with a mix of ice and FPK had similar concentrations to the unfrozen FPK. The ice lenses had lower concentrations of Br^-, Cl^-, NO_3^-, SO_4^{2-}, Ca, Mg, Ni, and Sr than FPK material directly below the ice. The slight variation in concentrations may have been a result of solute expulsion during the formation of ice. This result suggests some expulsion of solutes may have occurred during the formation of the ice in the LLCF.

GEOCHEMISTRY OF THE ARCHEAN VOLCANIC ROCKS AROUND THE SLEEPY DRAGON COMPLEX, NORTHWEST TERRITORIES

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The late Archean Cameron and Beaulieu volcanic belts wrap around the Sleepy Dragon Complex, which is located about 100 km northeast of Yellowknife in the Slave craton. These Neoarchean belts comprise metavolcanic and metasedimentary rock that lay on top of a Paleo to Mesoarchean granite-gneiss complex and its Mesoarchean volcano-sedimentary cover. The Cameron-Beaulieu volcanic belts have been divided into subareas. Within the Tumpline subarea is Sharrie Lake and Turnback Lake volcanic belts. The volcanic belts at Sharrie and Turnback lakes are calc-alkaline and bimodal. Bedrock mapping and sampling in these two belts, as well as other locations in the Slave, took place during the 2012 and 2013 field seasons. The objective is to characterize the geochemical signature of the volcanic rocks around the Sleepy Dragon Complex, compare the geochemistry to other belts throughout the Slave, and to assess their potential for base-metal deposits. A summary of field work and preliminary data will be presented as well as a glimpse into future work.

In August 2012, field work was limited to reconnaissance sampling of mafic and felsic volcanic rocks across several Archean belts in the Slave craton. Preliminary results demonstrate that there are two distinct REE patterns in the felsic volcanic rocks: (1) No Eu anomaly with depleted heavy REE, and (2) Variable negative Eu anomaly with a flat heavy REE pattern. The mafic volcanic rocks share similar geochemical patterns amid the sampled belts. The focus in 2013 was detailed bedrock mapping and sampling at Sharrie Lake, and sampling along selected transects at Turnback Lake. Field relationships in both areas support submarine deposition with intermittent periods of quiescence or sedimentation, and a history of hydrothermal alteration. Further petrography, geochemistry and Nd-isotope analyses are in progress.

Sharrie Lake and Turnback Lake have numerous base-metal and sulphide showings. Their proximity and geochemical similarities to other known volcanic massive sulphide (VMS) deposits around the Sleepy Dragon Complex (namely Sunrise and Turnback/XL deposits) suggest that they too may host VMS deposits. Gossanous bodies bearing pyrite, pyrrhotite, sphalerite and galena are most commonly observed at felsic-sedimentary interfaces, and present near mafic-felsic volcanic contacts. Silicification and sericitization are common alteration features in both belts, while rusty felsic “millrock” occurs locally at Sharrie Lake. Geochemically, Sharrie Lake felsic volcanic rocks share a near identical REE pattern as those from Sunrise, BB and other VMS deposits in the Slave. Using the Superior classification, these are high FII rhyolites. While the FIII rhyolite pattern is characteristic of most VMS deposits in the Superior craton, the FII pattern may be the representative geochemical signature of VMS deposits in the Slave craton. Sharrie and Turnback Lake belts show promise but they still remain under-explored and warrant further examination for mineral potential.

KENNADY NORTH PROPERTY: POTENTIAL WITHIN THE COMPLEXITY

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The Kennady North Property is 100% controlled by Kennady Diamonds Inc. and is located approximately 300 km northeast of Yellowknife and approximately 10 km north of the Gahcho Kué Property.

The Faraday and Kelvin kimberlites were discovered in 1997 and 2000, respectively. With a limited number of drill hole intersections to evaluate, the historical interpretation of the Faraday kimberlite was a series of thin gently-dipping sheets. The Kelvin kimberlite had a similar interpretation but contained evidence to support a larger body. All work in this area was abandoned in 2003 under the assumption these bodies were too small to be economic. In 2012, Mountain Province Diamonds Inc. (49% owner in Gahcho Kue) created a new exploration company called Kennady Diamonds Inc. to conduct work on the ground surrounding Gahcho Kue.

Under contract to Kennady Diamonds Inc., Aurora Geosciences Ltd. has managed the ground geophysics and diamond drill program on the Kennady North Property since early 2012. During this time 3,168 line-km of airborne gravity, 248 line-km of HLEM, 2,786 ground gravity stations, 610 line-km of ground magnetics, and 29 line-km of capacitively coupled resistivity (Ohmmapper) geophysical surveys have been completed. Diamond drilling was initiated in July of 2012. A total of 11,138 meters in 64 holes targeting two known kimberlite bodies and many newly identified targets has been completed. This work has defined a potentially economic kimberlite body within the Kelvin kimberlite sheet complex. There are a number of other targets still to be explored.

3D modeling of newly acquired Ohmmapper data and conductivity depth imaging of historic Dighem data over and around the Kelvin kimberlite guided the 2013 drill program to successfully intersect a small kimberlite body within the sheet complex. This new data and the remodeling of historic data supports the interpretation that the Kelvin kimberlite body does indeed consist of an irregular shaped body and a sheet complex. Several new targets have been identified and considerable work will be required to delineate the extent and the economic potential of the Kelvin kimberlite. Recent work conducted on the Faraday kimberlite is limited to HLEM, ground gravity geophysics and ten diamond drill holes. In 2014, KDI plans to apply the approach used to delineate the Kelvin kimberlite at the Faraday kimberlite.

Micro diamond results from 2012 and early 2013 indicate encouraging micro and macro diamond counts from both the Kelvin and Faraday kimberlites. A new approach to exploration and a fresh look at historical data collected in the area has refreshed the potential for the under-explored Kennady North Property.

THE NORTHWEST TERRITORIES GEOSCIENCE OFFICE - 2013 ACTIVITY OVERVIEW

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The Northwest Territories Geoscience Office (NTGO) carries out government geological survey activities for the Northwest Territories. NTGO activities include geological mapping, non-renewable resource assessments, geochemical and geophysical surveys, outreach and education, data management and distribution, and administering technical report review under the Northwest Territories and Nunavut Mining Regulations. This year the NTGO added a Permafrost Scientist to our research team.

2013-14 is very much a transitional year for the organization. The Devolution agreement between the Federal and Territorial government will necessitate a new model for the NTGO. A joint Federal - Territorial Partnership, the Devolution agreement will see existing federal staff brought on as territorial employees, and the development of a new NTGO organization.

Despite reduced funding, the NTGO carried out a number of field-based research programs. On the minerals side, mapping continued in the Mackenzie Mountains (106B), the Howards Pass area (105I), and on Banting-equivalent volcanic rocks in the Slave Structural Province (86I and throughout the province). Industrial minerals research included projects looking at high quality silica sand, and high-Ca limestone resources. Petroleum activities include field work supporting a continuing study of the Horn River Basin petroleum potential. Research commenced on several programs intended to aid the Canol Oil Shale development including a compilation of industry ground water data, and a seismic monitoring program in the central Mackenzie Valley. Several Permafrost research programs continued in the Territory, including work on the Inuvik - Tuktoyaktok highway corridor.

NTGO field programs provide excellent opportunities for hands-on training of university geology students. This year the NTGO supported at least 20 students working on a diverse suite of research projects.

Outreach activities at the NTGO are designed to increase awareness of geology and mineral exploration within NWT communities as well as inform the public of NTGO research around their communities. Activities run the spectrum from short school visits and rock walks to the annual NTGO - University of Alberta fourth year field school which this year was held in the Simpson Island area of the East Arm.

The NTGO continues to host an excellent Earth Science library and to upgrade its web presence for client discovery and data dissemination. Our growing online collections contain more than four terabytes of data. This past fiscal year, our clients downloaded well over a terabyte of data from our servers.

EXPLORATION OF THE NORTHBELT PROPERTY, YELLOWKNIFE GREENSTONE BELT

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TerraX Minerals Inc. acquired the Northbelt property in February, 2013. The property covers 35.6 km^2, commencing 10 km north of Yellowknife and including 13 strike km of the Yellowknife Greenstone Belt. The volcanic belt consists predominantly mafic rocks of the Archean Kam Group, which is the host unit for the past-producing Giant

and Con gold deposits. The property has been intermittently explored by a number of companies, including Giant Yellowknife Mines Limited, since the 1940's, but has remained dormant since 1997. Previous exploration partially delineated the Crestaurum gold deposit, and identified a number of gold-bearing structures in the southern part of the property, as well as base/precious metal-rich structures in the north.

TerraX has compiled all available property data to create a comprehensive GIS database, including records of >450 holes drilled on the property. Collars for >250 holes have been found in the field and the core from nearly 200 holes has been acquired. TerraX also commissioned a property-wide, 520 line-km airborne magnetic/electromagnetic/radiometric survey, field checked a number of the metalliferous structures, and is relogging/resampling certain historical drill holes. This work has delineated four major target areas and numerous subsidiary targets.

The Crestaurum Shear hosts the Crestaurum deposit, drilled over a strike length of 1.4 km, but only to a vertical depth of <120 m. TerraX's re-assays of historical core have produced intersections as high as 5 m @ 62.9 g/t Au and have confirmed the continuity of the mineralized structure over its strike length. In the case of a second shear zone with historical gold intersections, the Barney Shear, TerraX's re-assays have yielded intersections including 20.86 m @ 3.79 g/t Au. The shear has been drill tested over 600 m, but has a strike length of 4.5 km. The Homer Lake polymetallic target in the northern part of the property contains historical drill intersections such as 6.10 m @ 2.54 g/t Au, 204.3 g/t Ag, 10.82% Pb and 6.03% Zn, as well as TerraX chip samples from trenches of 7 m @ 0.50 g/t Au, 90.2 g/t Ag, 4.25% Pb and 0.89% Zn, all in discrete structures. A strong conductor, completely untested by previous drilling, was identified by TerraX's electromagnetic survey in the vicinity. The Pinto shear structure was delineated in historical trenches over a 160 m strike length in the central part of the property. This target, also untested by previous drilling, returned grab samples as high as 49.3 g/t Au and 55.2 g/t Ag, as well as a chip sample of 2 m @ 7.15 g/t Au and 5.6 g/t Ag.

All mineralization noted to date is hosted by north to northeast trending structures, most of which are traceable for in excess of 1 km, none of which have been adequately explored. Many of these structures are evident in the new magnetic and radiometric data, as are untested targets. TerraX plans to drill the four major targets and two or three lesser targets in the upcoming winter drill season.

NOT JUST TALK: GUIDELINES FOR ENGAGEMENT IN THE MACKENZIE VALLEY

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On June 1, 2013, a new Engagement and Consultation Policy became effective for projects requiring water licences and land use permits in the Mackenzie Valley. The Policy and supporting Guidelines outline the Land and Water Board's expectations for proponents and stakeholders, both during the application phase and during the life of the project. The Guidelines incorporate best practices and assist proponents in carrying out effective engagement which contributes

to a more efficient and effective regulatory process.

CULTIVATING NEW EXPLORATION OPPORTUNITIES IN NUNAVUT

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Nunavut Resources Corp. (NRC) is an Inuit-owned corporation that was founded in 2010 by the Kitikmeot Inuit Association (KIA) to diversify and develop the economy of Nunavut by attracting investment capital to the region. In March of 2012, Transition Metals entered into a 5 year strategic alliance with NRC to work together to generate new exploration projects and to attract investment to Nunavut. The intent of the alliance is to combine the experience and track record of Transition's capable technical team with NRC's long term vision for Nunavut and social licence to operate. Working together, the Alliance seeks to find creative ways to fund and encourage exploration and development in Nunavut.

Transition's award-winning exploration team strives to apply proven and emerging technology to develop interpretive techniques that are integrated into custom-built digital compilations and advanced 3D geoscience models to facilitate effective and rigorous fieldwork. An example through a funding partnership with LOOKNorth that seeks to utilize the application of new remote sensing technology to gold exploration in the Slave Province will be introduced along with a review of exploration activities and opportunities at two key projects; Article 41 (Diamonds), and Itchen Lake (Gold).

In spite of a difficult investment environment over the last year and a half, the Alliance continues to persevere, and has assembled an encouraging and expanding portfolio of exploration projects. Transition is working hard with NRC to identify the next generation of discoveries in Nunavut.

THE LAST 9,000 YEARS IN LAKE RECORDS FROM THE NWT: TIME CONSTRAINTS FROM ^{14}C DATING, AGE-DEPTH MODELING, AND A NEW OCCURRENCE OF THE WHITE RIVER ASH

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As part of a multidisciplinary paleoclimate project aimed at assessing the future viability of the Tibbitt to Contwoyto Winter Road (TCWR) in the central Northwest Territories, we examined late Holocene sedimentary records from lake cores transecting boreal forest, treeline, and tundra zones. Before undertaking paleoclimate and paleoenvironmental studies on the cores, radiocarbon based age-depth models were constructed to ensure that the sedimentary record covers at least the last 3,500 years and that there are no major hiatuses in deposition.

A solid chronological framework is fundamental to interpreting the timing and

rates of past environmental changes. Significant advancements have been made during the last decade in the methods of age-depth modeling and the calibration of radiocarbon dates. Traditionally, linear regression linear interpolation models were used to estimate the ages of depths between a few dated horizons. While the classic approach is sufficient at a coarse scale, our study required much higher precision in order to resolve paleoclimate shifts on a multi-decadal scale. In addition to improving the dating resolution by adding more ^{14}C dates than have been traditionally used for cores in the region, the age-depth models for sedimentary successions retrieved as part of this study are constructed using a probabilistic/Bayesian approach involving multiple simulations. Such chronologies are essential in high-resolution paleoclimate and paleoenvironmental studies.

Thus far, over 130 ^{14}C dates have been obtained, primarily on bulk sediment, from 19 sediment cores obtained from 11 lakes along a latitudinal gradient spanning from the boreal forest near Yellowknife to tundra sites near Lac de Gras. There are between four to twenty-five ^{14}C dates per core, some of which have chronologies that extend back as far as 9,000 years before present. In two sediment cores obtained from Pocket Lake near Yellowknife, a visible tephra has been geochemically fingerprinted as the White River Ash (WRA). The WRA is from a Plinian-type eruption of Mount Churchill in Alaska that occurred ca. 1,200 years ago. The timing of the eruption is best constrained by radiocarbon dates from the outer rings of trees that were buried in coarse tephra and a pyroclastic flow near the source vents (Clague et al., 1995). The occurrence of the WRA in the Pocket Lake cores is, to the best of our knowledge, the furthest east it is recognized as a visible tephra. Because the timing of the WRA is well constrained, its occurrence in Pocket Lake was incorporated into the age-depth models for cores obtained from this site. This important marker has provided an important validation of the ^{14}C based age-depth models developed for Pocket Lake.

ADVANCES IN USING CLINOPYROXENE AS AN INDICATOR MINERAL IN DIAMOND EXPLORATION

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Garnet has long been the most sought after mineral in diamond exploration programmes. The focus on garnet is understandable given that its major-element composition can reveal information about the host rock mineralogy and diamond potential. The latest temperature and minimum pressure of equilibration can be calculated from the trace Ni, and Ca and Cr concentrations, respectively. Due to discrepancies between Ni-in-garnet temperatures and two-mineral exchange thermometry coupled with the fact that, typically, only minimum pressures can be determined from garnet, xenocrysts rarely provide geothermal gradients that correspond with xenolith-based geotherms. This limits the utility of garnet xenocrysts in diamond exploration for determining the depth to, and thickness of, the diamond stability window.

Clinopyroxene xenocrysts can derive from lherzolite, websterite and eclogite. The chemical composition of clinopyroxene xenocrysts is not as sensitive an indicator of source rock bulk composition as is garnet given that harzburgitic sources are excluded

by definition. Nevertheless, they do retain valuable information regarding their state of last equilibration.

Single-crystal thermobarometry of clinopyroxene xenocrysts derived from garnet peridotite is useful for establishing a mantle geotherm in order to predict the diamond potential of a given volume of lithospheric mantle. A major obstacle in using clinopyroxene xenocrysts for establishing mantle geotherms is interferences from clinopyroxene xenocrysts from spinel peridotites, and clinopyroxenes from bulk compositions significantly different from the thermobarometer calibration e.g. from strongly metasomatized peridotites. We have developed a series of discrimination plots that can be used to filter large datasets to remove invalid clinopyroxene xenocrysts and extract the most information possible from exploration data. In this presentation, we will illustrate the success of the discrimination plots on various publicly available datasets.

UNIQUE MODEL OF STEM EDUCATION OUTREACH FOR INUIT YOUTH IS KEY TO BUILDING SUPPORT FOR INDUSTRY AND DEVELOPING A SKILLED NORTHERN WORKFORCE

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Actua's unique for-youth-by-youth model of community-based, culturally relevant STEM education outreach program for Inuit youth is an effective strategy for inspiring youth to a) understand and appreciate the value of Canada's mining industry; thus contributing to the development of informed community leaders and decision-makers that support the industry; and b) stay in school and pursue higher education; thus contributing to the development of a skilled workforce for industry.

SOURCE OF LENA WEST KIMS & DIAMONDS - HORTON RIVER AREA?

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In the Horton River area on the east side of the Lena West diamond region of the Northwest Territories Talmora Diamond Inc. has numerous untested magnetic targets that have characteristics of kimberlite pipes. Kimberlite indicator minerals (KIMs) with good diamond association chemistry and 18 diamonds have been found in field samples widespread across the region. The source of these KIMs and diamonds has not been found but evidence points to a source that lies to the east in the direction of the Talmora property and a source that predates the Cretaceous rocks that cover much of the area. The Talmora claims lie outside the Cretaceous basin in the right location.

The Lena West KIMs are very different to those of the diamondiferous Darnley Bay kimberlites 120 km north of Talmora but match those of the Talmora property and of the very diamondiferous Dharma kimberlite 180 km SE of Talmora. The Dharma KIMs cover only part of the range of KIM compositions found in the Talmora and the general Lena West areas so cannot be the entire source of either area. The Talmora mineral chemistry matches the mineral chemistry of the favourable Dharma kimberlite but in matching the whole range of the Lena West mineral chemistry qualifies as the probable source of the latter.

Spinels in samples down-ice of individual magnetic anomalies on the Talmora property show distinct Mg/Fe plots or crystallization trend lines indicating a number of different sources. However, spinels from the many magnetic anomalies plotted together match those of all Lena West.

An attempt was made in 2012 to test several of the magnetic targets with a small Packsack drill. In three of five holes the drill just penetrated through the glacial overburden and ended in rusty coloured clay. A small piece of clay trapped in the core barrel was recovered but most was lost as suspended fines. The clay was assayed and cuttings were examined for KIMs.

Cuttings from the three holes that reached clay contained KIMs. From one hole 14 spinels, 1 picroilmenite (10.23% MgO; 3.24% Cr_2O_3) and 7 Mn-ilmenites (similar to those found as diamond inclusions) were recovered. The spinels have compositions that lie on a very narrow Fe/Mg crystallization trend line indicating a single population and nearby source.

The climatic setting of the Talmora property was similar to that of Sierra Leone at about 55 Ma. Diagenetic destruction of garnet and chrome diopside in Sierra Leone is more extreme and weathering is deeper than it probably was on the Talmora property. Still, the chemical composition of the Talmora clay is similar to the weathered kimberlites of Sierra Leone from depths of the water table to 24' beneath the water table.

There is a strong possibility that Talmora holds the source area of the Lena West KIMs and diamonds and this source area having the same mineral chemistry as Dharma has the potential of being very diamondiferous. A larger drill is required to obtain fresh kimberlite for microdiamond analysis.

CLIMATE CHANGE AND MINING HAUL ROAD DESIGN

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Recent research we have undertaken on the climate in the western Canadian Arctic indicates that, as others have found, the average annual temperature is increasing at the rate of approximately 0.5°C per decade. Surprisingly, however, the open season for ice bridges, ice roads and winter roads is increasing in many cases. While the open season is obviously affected by climate factors, it is also affected by the way in which operators manage the infrastructure. Evidently they are adapting to climate change -- finding new ways to counter the change -- faster than the change itself is occurring.

This cannot go on forever, however. Eventually the effects of climate change will have to be accommodated with adaptations in the design of infrastructure, rather than just how it is operated. The land-based, all-season mining roads will be no exception. The presentation will outline the changes in design that can be considered, from route selection through road structure design.

A GEOPHYSICAL CASE HISTORY FOR KIMBERLITE EXPLORATION, KENNADY NORTH PROJECT, NT

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Airborne and ground geophysical techniques are commonly used in diamond exploration programs particularly in Northern Canada where many kimberlite occurrences are hidden beneath lakes or quaternary deposits.

Complementary geophysical methods are often required to detect kimberlite deposits as their complex nature can produce variable geophysical responses. Once an anomaly is detected, interpretation and modeling using 2D and 3D inversion algorithms are performed to visualize and delineate possible kimberlite bodies. The results are then used to evaluate whether the new discovery holds merit and should be advanced.

This case history will document the application of geophysical surveys in the identification and delineation of the Kelvin kimberlite on Kennady Diamonds Inc.'s Kennady North Property. The property is known to host diamondiferous kimberlites; however, previous operators considered the kimberlites to be dyke/sheet like and too small to be economic and exploration ceased in 2003.

Kennady Diamonds Inc. resumed exploration on the property in 2011 with the completion of an airborne gravity gradiometer survey. The survey produced numerous kimberlite targets which were followed up with ground based magnetic surveys. During this time, an examination of historical airborne magnetic and electromagnetic and ground-based magnetic, electromagnetic and gravity geophysical surveys results was undertaken. This study indicated that resistivity was most useful in detecting the known kimberlites. The study also showed that the sample density for the ground gravity surveys would have to be increased to detect and model the bodies.

In 2013, additional ground-based gravity and resistivity surveys were conducted to address these shortcomings. A 3D capacitively coupled resistivity survey (OhmMapper) was conducted over the Kelvin kimberlite. Capacitively coupled resistivity is a relatively new technique suited for Northern Canada as the survey can be towed in the winter with snow machine. This was a test to evaluate the survey's capability of resolving complicated resistivity sections and possibly delineate larger zones of lower resistivity material related to kimberlite emplacement. The data collected were modeled using 2D and 3D software and used to successfully drill test larger zones in the Kelvin kimberlite.

A description of the 2013 surveys and results are discussed in the presentation.

EXPLORATION IN THE NORTHWEST TERRITORIES: 2013

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The presentation will review industry activities in the Northwest Territories since the beginning of 2013. The year was extraordinary for an absence of activity in the north. Many companies were absent from the territory as they had trouble raising the necessary funds to sustain exploration spending, forcing them to scale back on fieldwork and defer new activities. Whereas in 2012, there was a "scaling back" of activities, this year the focus was on maintaining properties in good standing and

nothing else. By the end of the third quarter 2013, only 91 claims covering 57,000 ha have been recorded in contrast to the 832 claims containing 742,000 ha that lapsed. This activity level is a marked reduction from the 710 claims covering ca. 550,000 ha. that were staked in 2011. The causes for this situation are not simple and have been attributed to a complex mix of weakness in global markets, localized investing, and adjustments to the perceived versus real risk/return balance of the mining industry.

The outlook was not all negative and highlights for the Northwest Territories include the conclusion of the Ekati Diamond Mine sale to Harry Winston Diamond Corporation. Following the sale of the Harry Winston luxury brand diamond jewelry and timepiece division, the company reformed as Dominion Diamond Corporation and this NWT-focused company has vaulted to one of the top diamond producers in the world. The new company forecast the addition of three kimberlites (Lynx, Jay and Cardinal) to their mining plans and participated with North Arrow Minerals in a large till sampling program to look for additional pipes. Other success in diamond exploration were realized at the Debeers/Mountain Province Gaucho Kue project where the project passed another level of permitting approval and the adjacent exploration efforts by Kennady Diamonds were rewarded with new kimberlite intersections.

Permit and License approvals were also received by metal projects, with both Fortune Minerals NICO project and Canadian Zinc Prairie Creek mine receiving approvals, allowing the companies to move forward towards a production phase. The environmental assessment of Avalon Rare Earth Minerals' Nechelacho Project was also positively concluded allowing the project to move to the phase of development.

Creative approaches to exploration were also apparent, as companies were able to advance "brownfields" projects through the use of previously archived core. Both Nighthawk Gold at Colomac/Indin Lake and TerraX Minerals at Northbelt/Yellowknife were able to re-assay historic core to develop new exploration successes, outlining new resources and developing new drill targets for future work.

While predictions of the future of exploration in the Northwest Territories may be viewed as dependent on "Supercycle projections", Chinese supply and demand, fluctuating commodity prices and the scarcity of venture capital, it is clear that work to find and develop the minerals resources will continue.

NORTHWEST TERRITORIES GEOSCIENCE OFFICE (NTGO): 2013 PETROLEUM INDUSTRY ACTIVITY OVERVIEW AND PETROLEUM GEOSCIENCES GROUP ACTIVITY REPORT

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Oil and gas industry activity in the Northwest Territories covering the period October 2012 to October 2013 has been focused in the Central Mackenzie Valley (CMV) and in the Beaufort Sea. During this period, a total of 307 km of 2D and 3375 km^2 of 3D seismic reflection data were acquired. Most of this activity was in the Beaufort Sea, with the exception of 83 km of 2D seismic acquired in the CMV. Three exploration wells were drilled in the CMV

by ConocoPhillips (COPRC - 2 wells) and MGM (1 well). In addition, three well reentries occurred for this time frame. Husky reentered two wells on their CMV acreage and one well was reentered for operations at the Liard gas pool by Paramount Resources Ltd. Operators active in the CMV also drilled surface water wells to characterize baseline groundwater geochemistry of near surface fresh water aquifers. The water wells will be monitored on a periodic basis to evaluate baseline fluctuations in groundwater chemistry and possible changes in water chemistry subsequent to drilling and hydraulic fracturing operations in the Sahtu. Calls for bids on NWT lands during the reporting period included 6 parcels comprising 468,467 ha in the CMV region. A total of $19.2 million was bid for 2 parcels comprising 146,458 ha. Lastly, on May 6th, Lone Pine Resources announced that the National Energy Board had granted them a Commercial Discovery Declaration for natural gas resources tested during recompletion operations on Upper and Lower Besa River Formation shales from a well in the Pointed Mountain gas pool near Ft. Liard.

The Petroleum Geoscience Group is currently involved in two regional scale, multi-year research projects. These include a regional assessment of the hydrocarbon potential of the Mackenzie Plain, central NWT, and a multi-jurisdictional regional hydrocarbon assessment of Devonian to Carboniferous age shale units (Besa River to Golata Formations) covering the Liard Basin of the Northwest Territories, Yukon, and British Columbia. The Petroleum Group's focus from October 2012 to present has been to continue analytical work for the 2012 and 2013 summer field seasons in the Liard Basin and Mackenzie Plain and to report on that work at conferences such as the Canadian Society of Petroleum Geologists annual convention in Calgary and the Unconventional Gas Technical Forum held annually in British Columbia. This is the final year of the Mackenzie Plain Project so we are also devoting time to interpret four years of data to create a regional synthesis volume. The NTGO also recently agreed to collaborate with industry on their shallow fresh water aquifer drilling programs in the CMV. In the near term, the Petroleum Group will compile and release the initial baseline data collected by individual operators in one or more NWT Open Reports so that this information is made publicly available. Also, the NTGO is currently collaborating with the Geological Survey of Canada on enhancing seismic monitoring capacity in the CMV. Among other things, this program will provide information on pre-development, natural background seismicity that is characteristic of the CMV region.

MISTY CREEK EMBAYMENT, SELWYN AND MACKENZIE MOUNTAINS, NWT - AN UNDER-EXPLORED MINERAL DISTRICT

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A small multi-year project to examine the basinal strata of the Bonnet Plume map area and their economic potential is winding up this winter after a final week of spot-mapping in July, 2013. Field work for the project comprised a short reconnaissance in 2009, a 4-week single-team season in 2011, and a helicopter-supported, 7-week program with two mapping teams in 2012.

Building on 1970's reconnaissance bedrock

mapping and 1980's stratigraphic work of the Geological Survey of Canada (GSC), we have refined the bedrock map of parts of National Topographic System (NTS) mapsheet 106B. A draft is in publication; a final map and report incorporating 2013 data are in preparation. The map compiles new observations with re-interpretation of pre-existing GSC and industry data. Subdivision of basinal strata is aiding the emerging structural interpretation and highlighting areas where further work is needed.

NTGO conducted water, silt and heavy-minerals analyses of primary streams throughout the Mackenzie Mountains (from 2005 to 2011), and a combined magnetic and radiometric airborne survey of parts of 106B (Source Peaks area, 2011). The new mapping, new and old mineral deposit models, geophysical and geochemical data are combined to highlight the types of mineral deposits that should be targeted in this region.

Features that commend the area for Carlin-like and other deposits include:

- the presence of deep lithospheric faults that were active (re-activated?) during Early Paleozoic creation of the Misty Creek embayment;
- a long-lived continental margin that allowed deposition of the variety of rocks (platformal, slope and basinal, volcanic and intrusive) necessary for permeability contrasts;
- the presence of carbonaceous sediments that globally are spatially associated with gold (auriferous exhalative, orogenic, and Carlin-like), and of fault-bounded sub-basins associated with sedex base metals;
- a protracted tectonic history involving contractional orogenesis and possibly localized later extension/transtension;
- the abundance of potential antiformal metal traps in the hangingwalls of normally reactivated reverse faults and of intersecting structures, both of which are key to localizing gold in Carlin-type deposits; and
- a thick, underlying pile of Neoproterozoic rift-related clastic and evaporitic rocks that may have sourced metals and sulfur to undiscovered deposits.

The presence of locally thick, heavily altered, mafic-volcanic successions indicates the existence of hydrothermal and magmatic fluids, though the extents of these systems are uncertain. The platformal carbonate successions host numerous MVT prospects and one gold showing, but the basinal and slope successions are largely unexplored.

ICE COVERS AND RISK MANAGEMENT: ADVANCING THE STATE OF PRACTICE

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Ice roads (and winter roads) remain a vital transportation link in northern and arctic regions of Canada for remote communities and industrial sites. Ice road transportation can be reliable and safe when built and operated using effective risk management principles. Many remote communities and industry rely on winter roads each year to provide an affordable link for bringing in bulk supplies, fuel and equipment.

Ice roads are experiencing an increase in operational demands while climate change is having an adverse impact on the ice road-

operating season. Increased demands occur in the form of heavier trucks hauling larger payloads as mining and construction equipment has grown along with the scale of site development. Furthermore, there appears to be a greater variability in winter temperatures and snow cover from one year to the next. A strong industrial safety culture and increased operational demands are causing ice cover operators to examine more closely the safety margins and control measures present in ice cover operations.

In previous years, the state of practice relied upon by operators for determining allowable loads was based on ice capacity equations developed by Lorne Gold. Two significant developments have taken place since then: (i) Ground Penetrating Radar (GPR) ice profiling and (ii) stress analysis for ice bearing capacity. GPR profiling can efficiently characterize/quantify the distribution of the thickness of an ice road/platform to details not envisioned when Gold's empirical approach was developed. Stress analysis of ice plates supporting loads is a deliberate approach to accounting for ice strength, load configuration and other operational variables that are not considered explicitly in Gold's equations. Although the current state of practice has been successful in previous years, it does not take advantage of the GPR ice-profiling data and it is not as flexible as the stress analysis approach.

NOR-EX has been developing a Risk Management Framework to update the state of practice for ice road design. Initial development of the Risk Management Framework took place over the past 6 years on the Tibbitt to Contwoyto Winter Road. During that period, this framework has proven very successful, even during seasons with well above normal average temperatures. NOR-EX believes the Risk Management Framework can further incorporate the contemporary developments in GPR ice profiling and stress analysis to advance the state of practice for ice design and safety.

NOR-EX is conducting a field investigation to validate the concept of using the ice information obtained from GPR ice profiling together with stress analysis to characterize the performance of an ice sheet under load. The expectation is to update the state of practice and start applying it to industry practice in the next 12-30 months. We believe this will enable ice road operators to safely and confidently optimize the season available for transportation and exploration, resulting in longer seasons, more payloads, and less costs.

HOLOCENE INVESTIGATIONS OF THREE LAKES IN THE CENTRAL NORTHWEST TERRITORIES: CLIMATE CHANGE ACROSS ECOTONE GRADIENTS AND IMPLICATIONS FOR FUTURE CHANGE

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The continued success of the natural resource based economy of the Northwest Territories depends on the use of winter roads. A 568 km long winter road, the Tibbitt to Contwoyto Winter Road (TCWR), is the only ground transportation route that services mines in the central NWT, including the Ekati Diamond Mine, the Snap Lake Mine, and the Diavik Diamond Mine. Cold winter temperatures are necessary for the continued viability of the TCWR because 87% of its length is built over frozen lakes. Changing ice stability, thickness, and duration of cover associated with recent climate variability have impacted the use of the road.

The purpose of this project is to analyze lake sediments, natural archives of past climate change, to better understand climate variability and terrestrial ecosystems response to those changes. This information may be used by stakeholders in adaption planning for current and forecasted climate change. Three lakes were studied along the latitudinal gradient of the TCWR. Waite Lake is located 75 km northeast of Yellowknife and within boreal forest. The late freezing and early ice breakup of this lake is a concern for winter road operation. Danny's Lake is located 30 km south of treeline and Horseshoe Lake is located 60 km north of treeline.

Sediments were obtained from the lakes using a freeze-coring device and analyzed for palynomorphs and microscopic charcoal at 2-cm intervals. Age-depth relationships of the sediments show decreasing sedimentation rates northward. Based on AMS ^{14}C dating, the Waite Lake record extends to ~2500 BP and is analyzed at a ~30-yr resolution, the Danny's Lake record extends to ~8610 BP and is analyzed at a ~160-yr resolution, and the Horseshoe Lake record extends to ~8866 BP and is analyzed at a ~ 215 to ~860-yr resolution. The longer Danny's and Horseshoe lake records capture a warming event at ~7000 BP when *Picea* (spruce) replaced shrub tundra and tundra vegetation. The frequency and severity of regional fires decreased at this time, suggesting climate also became moister. At ~1730 BP fires increased and warmer temperatures resulted in the expansion of *Pinus* (probably jack pine) at Danny's and Horseshoe lakes. *Picea glauca* (white spruce) and Cupressaceae (probably juniper) expanded at this time at Waite Lake. Palynomorph abundances in Waite Lake document additional variability at ~1300 BP and ~120 BP, using the higher resolution analysis that was possible with this core.

Time series analyses of the accumulation rate of charcoal in the Waite Lake core show a significant (>95% C.I.) ~99-yr periodicity between ~1500 and ~1720 BP and between ~2050 and ~2350 BP. In the Danny's Lake record, significant ~430-yr and ~2610-yr (>90% C.I.) and ~980-yr (>95% C.I.) signals are present in the frequency of charcoal. The ~430-yr signal is significant between~4950 and ~5550 BP, the ~980-yr signal between ~3850 and ~6650 BP and the ~2610-yr signal is significant throughout the record. These signals suggest that solar variability may have influenced regional fire regimes in the NWT at various times in the Holocene.

A HIGH-RESOLUTION HOLOCENE AND RECENT PALEOCLIMATE RECONSTRUCTION USING C AND N ISOTOPES,

NORTHWEST TERRITORIES, CANADA

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The Tibbitt-to-Contwoyto Winter Road (TCWR) is the sole overland route servicing diamond mines north of Yellowknife, Northwest Territories (NWT), Canada. However, as this road is only operational during winter, the length of its season is strongly influenced by climate. This was exemplified in 2006, when an El Niño event caused an unusually short ice road season and resulted in a costly reduction of shipments to the mines. For future use and development of the TCWR, a comprehensive understanding of past regional climate variability is required.

This study is an integral component of a larger-scale study designed to develop a comprehensive database of high-resolution paleoclimate data for the NWT, using a variety of proxies. As part of the larger study, freeze cores were taken from the sediments of numerous lakes along the TCWR and sliced at 1-mm intervals using a custom-designed sledge microtome. Bulk ^{13}C and ^{15}N isotope analysis was completed at a 1-cm interval through the core of a lake just below the tree line. Results from this analysis show clear trends with distinct transitions occurring at 6900, 3900, and 726 BP. These transitions are interpreted to have been the result of changes in climate from warm and dry conditions in the Early Holocene to cooler and wetter conditions in the Late Holocene.

Additionally, time-series analysis of the most recent 800 years at a 2.5 mm resolution has provided a clearer understanding of short-term climate cycles which may still be affecting the region. Cross-wavelet analysis with tree-ring records from North America and China indicates a strong influence of the Pacific Decadal Oscillation on the region at least as far back as 500 BP.

HIGH PRECISION TRACE ELEMENT ANALYSIS OF DEEP-WATER, VENT-RELATED DOLOSTONE IN THE BORDEN BASIN, NUNAVUT

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The Mesoproterozoic Borden Basin (Nunavut; Nanisivik Zn-Pb district) contains unusual, deep-water dolostone mounds (Ikpiarjuk Formation) that formed during fluid-venting along subaqueous faults. Mounds are hundreds of metres thick, extend for kilometres along mapped faults, and consist of featureless pelagic dolomudstone and benthic clotted dolostone. The faults along which mounds nucleated were active during mound accumulation and may have delimited several subaqueous sub-basins.

Mound dolostone was analysed for trace elements using in situ laser ablation and solution ICP-MS. Results from benthic and pelagic phases from all mounds but one show REE + Y patterns that are typical of Proterozoic seawater, indicating that the carbonate formed from seawater. Positive Ce anomalies indicate that mounds formed in anoxic water (base of stratified water column). An unusual Eu anomaly in most samples is interpreted to indicate a restricted basin in which local weathering-derived solutes influenced REE composition. Although the REE + Y patterns are

interpreted as generally seawater-derived, differences in the magnitude of various anomalies and the overall slope of the REE + Y patterns cannot be attributed to detrital impurities incorporated during deposition of the dolostone, or to diagenetic alteration. The differences in REE + Y patterns suggest (a) that although mound dolostone was derived from seawater, vent fluid composition varied subtly by location, and (b) that there was little mixing of bottom-water between sub-basins.

Black shale (Arctic Bay Fm.) and geographically limited shallow-water benthic carbonate strata (Iqqittuq Fm.) accumulated at the same time as the Ikpiarjuk Formation The black shale contains layers that are enriched in the redox-sensitive metals V, Mo, and U. Enrichment may have been via a dolomite particle shuttle that exported dissolved metals from the upper, oxidised part of the water column to the sea floor, or by sub-seafloor remobilisation into dolomite. Ikpiarjuk Formation enrichment in these trace metals is best developed in clotted, benthic dolostone, which formed under an anoxic water mass and is therefore unrelated to the particle shuttle. Pelagic dolomudstone of the mounds does not exhibit significant enrichment in redox-sensitive metals; it is probably neither the hypothesised particle shuttle, nor a sediment that received preferential early intrastratal redistribution of metals. Water-column precipitation of vent-related carbonate mudstone did not take place in the upper water column, but below the redoxcline and photic zone, and was not involved in the concentration of redox-sensitive metals in the black shale. Any dolomite particle shuttle or sub-seafloor dolomite recipient of remobilised metals must, therefore, have originated regionally in the upper water-column: it was not related to mounds or to the contemporaneous shallow-water carbonate system.

Trace metal enrichment in both black shale and Ikpiarjuk Formation benthic carbonate indicates that bottom water was anoxic. Redox stratification in a basin undergoing extension is a prerequisite for SEDEX/CD deposits. Although mound-related vent fluid composition remains unclear, the distribution and composition of Ikpiarjuk Formation mounds indicate that fluids were locally and voluminously expelled during black shale deposition.

THE BANDED IRON FORMATION OF THE CENTRAL SLAVE COVER GROUP: SEAWATER CHEMISTRY AT 2.85 GA

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Banded iron formations (BIFs) are metamorphosed chemical sediments that initially precipitated from Precambrian ocean water. Here we present new field, petrographic, and geochemical data from the ~2.85 Ga BIF from the Central Slave Cover Group (CSCG). The bulk of the CSCG is composed of lower amphibolite grade oxide- and silicate-facies BIF underlain by grey to greenish fuchsitic quartzite and quartzarenite. The best preserved BIF exposures are found in the lower part of the stratigraphic section at Dwyer Lake and Bell Lake. Here the BIF contains mesobands of microcrystalline quartz interbedded with micro- and mesobands of magnetite with green Fe-amphiboles at the quartz-magnetite

interface. Up stratigraphic section, the BIF becomes mixed with terrigenous material, as evident from beds of semi-pelite with coarse-grained mica and garnet. From the BIF, seven silica-rich bands (~88 wt.% SiO_2) and seven iron-rich bands (~75 wt.% Fe_2O_3) have been separated for geochemical analysis. All bands show low input of insoluble alumina (<1% wt.% Al_2O_3). Rare earth and Yttrium (REY) systematics reveal a modern seawater pattern with enrichment of heavy rare earth elements (HREE/LREE>>1) and an Yttrium anomaly. However, the iron bands show a systematic deviation from modern seawater pattern with more elevated LREE than the silica bands. The abundances of insoluble detrital components such as Al_2O_3, Ti, Zr, Th and Nb are elevated in the iron bands relative to the silica bands pointing towards a larger terrigenous input during precipitation of the iron. However, a consistent and distinct Europium anomaly is found in all of the BIF bands suggesting a constant influence on the marine chemistry from subaqueous hydrothermal activity, possibly in relation to early continental rifting of the underlying Central Slave Basement Complex. It therefore appears as though the BIFs are composed of both a hydrothermal and continental component.

DEEP SUBSURFACE SALINE AQUIFER CHARACTERIZATION, DEH CHO AREA, NORTHWEST TERRITORIES

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The Deh Cho territory in southern Northwest Territories is prospective for both conventional and unconventional oil and gas production. Shales of the Devonian Horn River Formation are particularly prospective, although activity to date has been focused to the south in Horn River Basin, and to the north in Central Mackenzie Valley.

In "tight" • (low-permeability) reservoirs, a major challenge facing operators is to induce sufficient permeability to support economic flow rates and cumulative recoveries. Horizontal wells in the target formation stimulated by multiple induced hydraulic fracture jobs has proved successful in many tight plays. This process poses two major environmental challenges, however - it requires large amounts of water for injection into the wells, and smaller amounts of contaminated water that are flowed back require safe disposal.

One of the most successful strategies in mitigating these challenges has been to use deep saline subsurface aquifers both as frac water sources and as disposal zones. This strategy preserves surface and shallow subsurface fresh water for other users, and eliminates the potential for contamination of surface fresh water supplies by drilling and completion fluids. As an example, in the Devonian shale gas play of Horn River Basin of northeastern British Columbia, operators Encana and Apache drilled water source and disposal wells, built a water treatment plant, and developed the capacity to produce more than 10,000 m^3 water per day from the Debolt Formation saline aquifer at depths of up to 500 metres. This is now the source more than 95% of their frac waters, and also serves as a disposal zone for spent frac waters.

This study was undertaken with two specific objectives:

1. Identify and characterize deep subsurface aquifers in Deh Cho territory, capable of

supplying the large water volumes required for fracture stimulations supporting shale oil and gas development;
2. Identify formations which have the capacity to safely accept contaminated drilling and completion fluids.

Ten stratigraphic units with potential to be subsurface water source and disposal zones were mapped in the Deh Cho territory. They cannot be ranked absolutely, as their distribution and quality is highly variable; however, sufficient mapping and characterization was done to guide operators in selecting the best aquifer candidates at particular locations. This presentation will review three of the aquifers - the Mount Kindle, Slave Point, and Mattson formations - to illustrate the range of deep saline aquifer potential across this immense territory.

BIOENGINEERING TECHNIQUES FOR REVEGETATION OF RIPARIAN AREAS AT THE COLOMAC MINE, NT

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Factors such as nutrient poor soils, harsh climactic conditions, remote locations and high costs often make revegetating disturbed areas in northern environments a challenge. In Canada's Northwest Territories, many abandoned mine sites are under federal responsibility and require remediation. In 2010, work at Colomac Mine, an abandoned gold mine 220 km northwest of Yellowknife, employed novel bioengineering and project planning techniques to re-vegetate impacted riparian areas. An expert in bioengineering techniques for land and riparian restoration was engaged to explore options and recommend revegetation methods. The revegetation plan focused on methods to establish pioneer species. Natural plant recovery and succession were facilitated by the "rough and loose" • technique where a checkerboard of small holes and hills was created with an excavator to allow the soil to capture and retain moisture, trap windborne seed, promote easy root penetration and prevent erosion. Manual revegetation methods consisted of harvesting and planting local willow cuttings, alder seeds and sedge plugs to ensure that the new vegetation at these sites was adapted to local growing conditions and therefore compatible with surrounding undisturbed areas. Onsite training for capacity building was provided to ensure the project personnel understood how to implement the techniques. A multi-year monitoring plan including vegetation counts and photographic documentation was undertaken. Initial results (2011, 2012 and 2013) have shown success rates of 60-100% plant survival on the majority of areas where bioengineering techniques were used. In contrast, poor re-vegetation success rates of 8-33% plant survival were experienced in areas where techniques were either used incorrectly or implemented too late in the season. Some lessons learned from this project include the importance of considering restoration requirements and revegetation techniques at the conceptual stage of remediation design and planning; the effectiveness of the "rough and loose" • method and use of local pioneer species; and the need to support bioengineering training and capacity building for personnel undertaking the work. Success of the revegetation effort is measured by monitoring and is incorporated into the long-term monitoring program for the site. The

bioengineering techniques implemented at Colomac Mine provided a successful, cost effective, and local approach to revegetation in a northern environment.

NECHALACHO RARE METALS PROJECT - DESIGNED FOR CLOSURE

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Avalon Rare Metals Inc. ('Avalon') is a publicly traded company engaged in the exploration and development of rare metal deposits in Canada. Avalon proposes to mine, mill and produce a rare earth carbonate and oxides, zirconium, niobium and tantalum oxides from the Nechalacho deposit located at Thor Lake. The proposed development is referred to as the Nechalacho Project.

The Nechalacho Project has two proposed site components: an underground mine and flotation plant (Nechalacho Mine and Flotation Plant site), to be located at Thor Lake, and a hydrometallurgical plant (Hydrometallurgical Plant site) to be located at the existing brownfields site of the former Pine Point Mine.

Avalon's Conceptual Closure and Reclamation Plan is based on a "design for closure" • approach, with the ultimate goal being a "walkaway" • design. The closure and reclamation of all Nechalacho Project site facilities will be conducted in accordance with the terms and conditions of the anticipated MVLWB Land Use Permit and Water Licence, and consistent with the Mine Site Reclamation Guidelines for the Northwest Territories (INAC 2007), and the draft Guidelines for the Closure and Reclamation of Advanced Mineral Exploration and Mine Sites in the Northwest Territories (MVLWB/AANDC 2013).

The Plan is a living document that will be updated throughout the life of the Project to adapt to and incorporate any changes (both in terms of the Project or available technologies) that may arise. This will also include ongoing discussions with its Aboriginal partners, the local communities and other interested stakeholders.

A NEW TOOL FOR ACID ROCK DRAINAGE PREDICTION AND RISK ASSESSMENT

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Prediction of the likelihood of mine tailings to produce acidic drainage or to represent a human health risk if accidentally ingested is conventionally based on chemical testing of bulk samples rather than mineralogical characterization. These risks, however, actually depend on the identity, particle size, relative proportion and degree of weathering of minerals in the sample. We have used automated mineralogy to predict acid drainage based on the relative proportion and degree of liberation of sulfide and carbonate minerals present in each sample. We have also applied this tool to explain why Pb from some tailings samples is more bioaccessible than from other samples, a result applicable to human health risk assessment. Mineral Liberation Analysis (MLA), allows for the collection of particle-by-particle quantitative information on chemical composition, particle size, and shape based on scanning electron

microscopy (SEM). Specific phases of interest or size fractions can be targeted, and relative percentages of mineral phases present can be determined.

Acid rock drainage and metal leaching is considered the largest environmental problem facing the mining industry. Acid-base accounting is a test used to predict whether a sample will produce acid drainage if exposed to the atmosphere by evaluating the balance between acid-generating sulfide minerals and acid-neutralizing carbonate minerals. Instead of measuring total sulfide and inorganic carbon, we have used MLA to calculate the relative proportion of sulfide and carbonate grains. This has allowed us to adjust for the presence of iron and manganese carbonate minerals, which can contribute acidity, and the iron sulfide component of sulfide minerals such as sphalerite and chalcopyrite. This approach has been applied to tailings samples from several sites, including some in the NWT. Results indicate the MLA-based prediction of neutralization potential ratio is similar to the values from conventional acid-base accounting.

Bioaccessibility refers to the degree to which a potentially toxic metal will be leached by bodily fluids if ingested or inhaled. This depends on particle size, mineral host and liberation of the metal-hosting particle from other minerals, all parameters which can be evaluated using MLA. Gastric Pb bioaccessibility testing performed on Pb-Zn tailings indicated that Pb bioaccessibility was not directly correlated with the total Pb concentration. This suggested that there were mineralogical or physical controls on bioaccessibility. MLA was used to quantify the relative proportions of cerussite, a highly bioaccessible Pb carbonate, and galena, a less bioaccessible Pb sulfide. Liberation and particle size were also analyzed as controls on bioaccessibility. The sample with the highest Pb bioaccessibility has the highest ratio of cerussite to galena, the smallest particle size, and the most liberated Pb-bearing particles.

The fundamental processes that control whether potentially toxic elements are released or seques-tered from mine waste involve mineral-water interaction and it is important to characterize the reactive minerals present. MLA offers that opportunity and can provide answers to various mineralogical questions with the same test. Detailed mineralogy remains a non-routine tool for mine drainage prediction but these new tools have potential to provide critical information in complex or controversial cases.

AN OVERVIEW OF THE NATIONAL ENERGY BOARD'S FILING REQUIREMENTS FOR ONSHORE DRILLING OPERATIONS INVOLVING HYDRAULIC FRACTURING

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On September 12, 2013 the National Energy Board (the NEB or the Board) released it Filing Requirements for Onshore Drilling Operations Involving Hydraulic Fracturing. These Filing Requirements address the unique aspects of hydraulic fracturing within the NEB's mandate under the Canada Oil and Gas Operations Act (COGOA) to promote safety, environmental protection, and the conservation of oil and gas resources for onshore drilling and production in the North. In drafting these Filing Requirements the Board has undertaken extensive

engagement in the North on its regulation of hydraulic fracturing. This included meeting with communities, land claim organizations, elders, youth, legislators, federal and territorial government departments and regulated companies. The Filing Requirements seek to address specific concerns that were heard as a part of this engagement.

3D TILL SAMPLING: A COMMITTED STRATEGY FOR THE HIDDEN KIMBERLITE

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Dominion Diamonds Corporation (DDC) holds a land package totaling 123,000 hectares south of the Ekati and Diavik Diamond Mines some 275km northeast of Yellowknife, NT. A total of 91,000 hectares are owned 100% by DDC and 32,000 hectares are under a joint venture agreement between DDC and North Arrow Minerals Inc.

Geophysical targets ("shooting fish in a barrel") have come and gone and now industry needs to be evaluating efficient ways of trying to find covered kimberlites with little to no geophysical response. Significant work has been completed over the last two decades to evolve grassroots exploration techniques to evaluate kimberlite indicator mineral trains. Certainly the most important of these tools is till sampling. Until this recent program by DDC, it was common to use manual labour to excavate pits down 0.3-0.5m below surface and obtain a minimum 20kg representative sample from a specific horizon of the regional till column. In 2013, DDC used a small reverse circulation drill to quickly and systematically test the full till column underlying the entire property. A reconnaissance-scale drill pattern was established using 1km spaced holes along 3km spaced lines. A total of 758 holes were completed in 89 days averaging over 8 holes and 8 moves on a daily basis. Till samples were taken at 0.5m intervals and/or at changes in till horizons. Approximately 0.5m of bedrock was sampled at each station.

A compilation of the current programs' kimberlite indicator mineral data will be shown along with historical data for the area to support the need for an expeditious format of analyzing the entire till column. Dominion Diamond Corporation believes they are on the right path to unearth hidden and inconspicuous kimberlites.

LIDAR-BASED ASSESSMENT OF VEGETATION DENSITY AT DIFFERENT HEIGHTS ON SEISMIC LINES IN THE NORTHWEST TERRITORIES, CANADA

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Seismic lines are narrow linear disturbance features created during oil and gas exploration and often factor heavily in wildlife and land management decisions in northern Canadian. Numerous studies show that seismic lines trigger changes in expected behaviors (e.g., behavioral responses) in a number of bird and mammal

species, but that those behavioral responses can dissipate with line recovery. Unfortunately, line recovery is poorly understood and highly variable both within and among geographic regions making accurate estimates of the current recovery state of a given line difficult. This hinders effective management decisions, especially in jurisdictions where decisions are based on a land-surface disturbance metric, because it is not possible to differentiate between those seismic lines that may function as disturbance features and those that may not.

Applications of remotely sensed data often offer invaluable insights about vegetation dynamics and have numerous advantages over traditional methods of vegetation mapping. Light Detection and Ranging (LiDAR) is a remote sensing technology that measures vegetation height at very fine spatial scales and provides detailed 3-dimensional (3D) spatial patterns of vegetation density and distribution. This research utilizes LiDAR data to examine spatial patterns of vegetation density at various heights on seismic lines in forest ecosystems in the Northwest Territories. The research goal is to develop a method to characterize structural attributes of vegetation on seismic lines in the Northwest Territories.

The main research question is: Can the LiDAR point cloud data be used to estimate the current vegetation state of an existing seismic line? The specific objectives are as follows:

1. Assess the capability of LiDAR data to accurately estimate vegetation density at different heights on seismic lines
2. Detect and classify the existing vegetation density in three geometric planes: along the seismic lines, across the seismic lines, and vertically with height classes being stacked on top of each other
3. Develop a method to compare visibility through the vegetation on seismic lines and undisturbed forested areas as a function of vegetation density at different heights

LiDAR data was used to classify the 3-dimensional vegetation density using 2m x 2m rectangular cuboids of various heights selected to represent values of interest. Five vegetation height breaks from a visibility and wildlife habitat perspective were identified. These height breaks along with the LiDAR point cloud were translated into five Height Classes to classify forest vegetation from the ground to crown tops in the disturbed (seismic) and undisturbed (forested) areas of interest. The 3D vegetation density patterns in these areas were then analyzed, compared, and ranked using a moving window analysis.

The developed method can be applied to classify the current 3D state of vegetation on seismic lines across the landscape and compare it to the surrounding undisturbed forest. The developed metrics demonstrate how these data can be used to rank visibility along seismic lines for determining the value for wildlife cover. The information and approach offered by this research will help to more fully integrate ecological data in land use planning and management decisions across boreal Canada.

USING PALEOLIMNOLOGY TO EXTEND BASELINE DATA FOR EVALUATION OF POTENTIAL MINE IMPACTS ON WATER QUALITY IN ARCTIC LAKES

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Arctic lakes are changing due to climate warming, and a few years of baseline monitoring data that is typical for pre-mining impact studies may not be sufficient to track these changes or to assess natural variability in water quality. The lack of long-term baseline water quality data therefore can hamper the ability to tease apart the potential response of lakes to mine activities from that of climate change and natural variability. A paleolimnological investigation was used to extend the time horizon of baseline water quality monitoring activities to provide a longer-term context for future assessment of lake water quality in Arctic lakes.

Sediment cores were retrieved from Izok Lake, Itchen Lake and a nearby reference lake in the central Canadian Arctic. The sediments were dated using ^{210}Pb and diatom algae preserved in the sediment cores were used as biological indicators to assess water quality changes over time. A diatom-based model was applied to quantitatively reconstruct lake water pH from the fossil diatom assemblages in each of the cores.

The diatom assemblages from the study lakes were similar and reflected the deep, nutrient-poor, cold and circumneutral conditions that have persisted in the lakes over the last several centuries. A prominent change in the diatom records occurred near the turn of the 20th century indicating a shift to warmer conditions with potentially stronger water column stability and increased lake productivity and benthic habitat availability. The timing of this change is consistent with the onset of warming trends that occurred between ~100 and 150 years ago as inferred from paleoecological records in Arctic regions throughout the northern Hemisphere. Only subtle changes in the fossil diatom communities occurred in the more recent times since ~1900, indicating that water quality conditions fluctuated over that time period over that time period. Changes in pH were estimated to have varied naturally in the study lakes by up to ~1 pH unit on decadal timescales and have displayed an overall increasing trend over the last ~50-60 years at Izok and Itchen lakes. Fluctuations in pH closely matched regional precipitation records from Yellowknife. This historic natural variability and increasing trend in pH could only be revealed using paleolimnological assessments and must be considered in the evaluation of future water quality monitoring data to differentiate between the local effect of mining activities and regional-scale responses to precipitation.

REGIONAL INVESTIGATION OF THE ACASTA GNEISS COMPLEX, WESTERN SLAVE CRATON

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An ongoing Ph.D thesis study of the Acasta Gneiss discovery area, where 4.0 Ga rocks were first identified more than two decades ago, provides an opportunity to examine the regional context of Earth's most ancient crust. During the summer of 2013, two projects were initiated to better understand the Acasta Gneiss Complex (AGC) at a regional scale.

The first project extends bedrock mapping within the Acasta River Structural Dome where the discovery area is located. Traverses were conducted across lithologic and structural strike both north and south of this area. It is evident from our field observations that (i) several map units can be traced regionally, and (ii) some of these map units are best characterized as 'gneiss associations' - that is, assemblages of different rock types that are spatially associated, cannot be broken out individually at a regional scale, and collectively form distinctive rock packages. The Acasta gneiss associations may or may not have structural contacts with adjacent map units.

The second project involved spot-checks of AGC outcrops located east, west, and north of the Acasta River Dome. Approximately 30 helicopter landings were made with the farthest located 22 km from the discovery area. At each landing site, approximately one hour was spent investigating lithology, structure, contact relationships, etc., and collecting sample suites for geochemical and isotopic analysis. Although a significant number of landings were on deformed homogeneous granite of probable Neoarchean age, the dominant rock types at several localities were clearly older, polydeformed tonalite, granodiorite, and gabbro gneiss.

Based on characteristics of older Acasta rocks within the discovery area, it is tempting to speculate that similarly-ancient rocks were sampled during both of the regional projects described above. The ages of the most intriguing sampled units will be investigated initially by reconnaissance U-Pb geochronological dating at the University of Alberta.

DIVERSE INDICATOR MINERAL AND GEOCHEMICAL DISPERSAL PLUMES IN TILL AND ESKER SAMPLES: EAST ARM OF GREAT SLAVE LAKE TO THE THELON RIVER, NT

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We present results from till geochemistry and indicator mineral studies in surficial sediments from an extensive region (~36,000 km^2) of the southeastern part of the Northwest Territories. This region encompasses parts of five distinct geological domains: southeast Slave, Taltson-Thelon magmatic tectonic zone, East Arm basin, Thelon basin, Rae domain (Queen Maud correlatives and Nonacho basin). Compilation of >500 known mineral occurrences suggests the following potential styles of mineralization: VMS, MVT, SEDEX, IOCG, lode gold, magmatic sulphide, vein copper, peralkaline syenite rare metal, granitic pegmatite rare metal, kimberlite-hosted diamond, 5-element vein, sandstone-hosted uranium, vein uranium, chromite. Due to the wide variety of deposit types, and thus a diverse suite of pathfinder elements, three different analytical procedures (aqua regia, 4-acid, fusion) were undertaken to provide a robust till geochemical survey. In conjunction a heavy mineral study was undertaken utilizing both till and esker samples.

A number of diverse till geochemical anomalies are observed, including gold, silver, platinum, base metals, and Cr-Ni-Co. These geochemical anomalies are not always co-incident with, or correlate with the indicator mineral anomalies. Indicator mineral grains (and anomalous concentrations of these grains) recovered include gold, PGM's, chalcopyrite, gahnite, loellingite, arsenopyrite, chromite, olivine and low Cr-diopside. Importantly, all types of mineral grains were recovered from both till and esker samples. A significant, previously unknown plume of olivine + chromite + low Cr-diopside mineral grains and extends south-westward >100 km down-flow from a source area in the vicinity of Williams Lake where ultramafic and mafic boulders and cobbles are observed. In the Williams Lake area the till has high concentrations of Ni, Cr and Cu. To the west of the Thelon basin, previously un-recognized outliers of Thelon sandstone occur, based on till geochemistry (e.g. >90wt% SiO_2 and high Zr), which has potential importance for unconformity U mineralization.

TO THE APPLICATION OF LIDAR TO MAP SURFICIAL GEOLOGY AND AGGREGATE POTENTIAL IN NORTHWEST TERRITORIES AND YUKON

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LiDAR digital elevation models have been proven to be an effective tool for aggregate mapping in Northwest Territories (NWT) and Yukon. This region is generally characterized by low topographic relief and landforms masked by vegetation. High resolution LiDAR data provides a level of detail not achievable by other digital terrain modelling techniques, whether extracted from aerial photography or low-resolution topographic contour maps from satellite imageries.

The project area is located approximately 160 km northern Dempster Highway, crossing Yukon and NWT. The LiDAR flight was designed to acquire high density data with 1.5 points per square meter using a 200 KHz multipulse system. Aerial photos were captured simultaneously with LiDAR to support the quality control. High-resolution digital elevation models (DEMs) have been derived from LiDAR data for this area, and analyzed for aggregate potential mapping

The LiDAR provided adequate resolution to identify several potential aggregate deposits. The finding was compared with the published maps from lithostratigraphic information by the seismic shothole drillers' log database (GSC Open File 6833). This study suggests that for areas with glacial landforms covered by forest and low relief, the LiDAR DEM can efficiently assist in identifying the aggregate potential mapping for infrastructure development, upgrade, and maintenance in northern regions.

VARIABILITY IN DIAMOND POPULATION CHARACTERISTICS ACROSS THE SIZE RANGE 0.2 - 2.4 MM - A CASE STUDY BASED ON DIAMONDS FROM MISERY (EKATI MINE)

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In diamond exploration size frequency distributions are widely used for predicting the macro-diamond grade of new kimberlite discoveries. The purpose of this study is to investigate the relationship between the different diamond size fractions extracted from a single caustic fusion sample used for grade evaluation of the Misery kimberlite; this will allow us to assess the validity of this approach.

Of an initial representative suite of 1627 diamonds, ranging in size from 0.075 to 2.38 mm, 558 diamonds were sub-sampled (ranging in size from 0.212 to 2.38 mm) and analyzed for their nitrogen characteristics using FTIR spectroscopy. Of this sub-suite, a random sample of ~ 50% was taken for determination of carbon isotope ($\delta^{13}C$) systematics by secondary ion mass spectrometry (SIMS).

The acquired nitrogen data are very variable, ranging in concentration from below the limit of detection (< 5-10 at.ppm; Type II) to over 2500 at.ppm with a median abundance of ~ 860 at.ppm (n = 476). Preliminary analysis shows a slight decrease in median N abundance with increasing size fraction. While the diamonds of sieve classes < 0.85 mm show median values between 845 and 900 at.ppm the coarser diamonds have a median of 690 at.ppm.

The interrelationship between N abundance and aggregation state allows the calculation of time averaged mantle residence temperatures (TN) based on an assumed residence time (3 Ga). Misery diamonds show two distinct subpopulations in TN, one = 1125 °C and a second = 1175 °C. Projected on a central Slave geotherm, the two temperature groups correspond to diamonds coming from depth less than about 160 km and greater than about 170 km, respectively. This bimodal distribution, including the gap between the two subpopulations, is visible in all size fractions. The relative proportion of 'shallow' to 'deep' diamonds, however, decreases with sieve size (with the fraction < 0.3 mm showing a particularly low ratio 'deep'/'shallow').

Carbon isotopic ($\delta^{13}C$) characteristics have to date been determined for 188 diamonds (453 spots analyzed). Our preliminary results show that 95% of the data have $\delta^{13}C$ values in the range between -7.5 to -2.6‰ with a symmetrical distribution and a median of -4.3‰. Distinct subpopulations exist within interval, but no discernible differences between the individual size fractions are immediately apparent.

Overall the initial results indicate no major differences between the evaluated diamond size fractions, but further analysis is required to test for more subtle distinctions.

GREAT SLAVE LAKE PROJECT - COMMUNITY ENGAGEMENT AND CAPACITY BUILDING STRATEGY

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The Great Slave Lake Project consists of three (3) abandoned mine sites within the East Arm basin of Great Slave Lake, NT. Gold, copper, and tungsten were mined at

the Outpost Island Mine site (1941-42 and 1951-52); cobalt and nickel at the Blanchet Island Mine site (1950s and 1970s); and nickel at the Copper Pass site (late 1960s).

The Great Slave Lake Project Community Engagement Plan was developed in late Fiscal Year 2012-13 and the stakeholder groups were invited to project update meetings intended to provide an introduction to the new PMT; an update on work completed to date and a description of next steps for the project. The meetings also provided a forum for the communities to share their knowledge of the sites, express their concerns and inform the PMT how they would like to be engaged on the project. Through the meetings, it was determined that the communities possessed solid knowledge of the sites and had built some capacity through earlier cleanup efforts, mine remediation/monitoring training sessions and more recent community-based monitoring programs.

Follow-up meetings were held with LKDFN, DKFN and FRMC Executive Councils in April to respond to questions received by email and raised during the project update sessions, discuss socio-economic opportunities and map out next steps for the project. Coming out of these meetings, it was determined that the communities preferred that the GSL Options Analysis workout be held in Fort Resolution to bring the communities together for a collaborative approach. Engagement activities following the Executive update meetings included:

- Traditional Knowledge Study in May. The TK Study included a mapping exercise, aerial site reconnaissance via helicopter and community-based questionnaire);
- GSL Options Analysis Workout in June. The two day options analysis workout included presentations by the Crown with participation by community-selected Elders and Technical Advisors. Engineering and environmental science information was exchanged with Traditional Knowledge of the sites, surrounding areas and historic access routes Technical reviews by the community's Technical Advisors prior to the workout helped facilitate preferred options selection achieved through round table consensus.
- Elders and Water Board Site Tour in July. The preferred options from the Options Analysis workout were further discussed and the site tour proved effective in "ground-truthing" • the workout discussions.
- Copper Pass brush clearing program in September. Completed in advance of the Bidders Tour, the historic access road at Copper Pass was opened up by a community-based forestry crew to provide safe site access.

The Great Slave Lake Project Community Engagement and Capacity Building Strategy required considerable effort but has paid off with strong stakeholder support and enhanced community capacity. Beyond the remediation planning phase, the communities will be actively involved through the remediation, closure and monitoring phases

BEHAVIOR OF ICE COVERS UNDER MOVING LOADS - THE DRIVING MECHANISM

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A field program was completed in 2012, where the response of the ice cover and water was measured under a loaded vehicle travelling at various speeds, and in various water depths.

The results indicate that a "deflection bowl" • is created in the ice cover under the weight of the vehicle. This bowl, which travels with the vehicle, behaves like a vessel that is carrying the vehicle over the water surface. Because the ice cover is flexible the shape of the bowl changes as the forces acting on it change with speed.

The experimental results further suggest that the increased deflection occurring near critical speed (i.e. the speed where the deflection bowl reaches maximum depth) is predicted by the Bernoulli Principle. The effect of the Bernoulli Principle is sensitive to water depth. As water depth decreases and interference from the bottom starts to occur, critical speed occurs at a lower velocity.

Failure of an ice cover under a moving load will occur as a result of excessive bending within the ice cover. Minimum deflection (i.e. minimum bending) occurs when travelling either slower than approximately 0.5 of critical speed, or faster than 2 times the critical speed.

The results of the study suggest that current speed limits are not effective at keeping operations outside of the critical speed range wherever water depths are less than approximately 15 metres.

Opportunities for reducing the cost and improving the safety of transportation on ice covers have been identified as a result of this study. Additional field observations are required to confirm the effectiveness of the measures that have been identified.

Re-Os ARSENOPYRITE AND U-Pb DETRITAL ZIRCON GEOCHRONOLOGY AT THE MELIADINE GOLD DISTRICT, NUNAVUT: IMPLICATIONS FOR THE GEOLOGIC SETTING AND AGE OF THE TIRIGANIAQ DEPOSIT

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The Meliadine Gold District (MGD) is located in the western Churchill Province and contains an estimated 3 Moz of contained gold (13.3 million tonnes at 7.0 g/t[1]) in proven and probable resources within a larger mineral resource. The majority of gold deposits within the MGD are spatially related to the WNW-ESE trending Pyke fault zone, which cuts Archean amphibolite-greenschist facies supracrustal rock packages of the Rankin Inlet Group. Tiriganiaq is the largest of the known deposits within the MGD and occurs along an E-W trending and steeply north-dipping fault interpreted as a splay of the

Pyke fault. Gold is concentrated within a series of structurally controlled and stacked lodes that are hosted by an interbedded sequence of Banded Iron Formation (BIF), chloritic mudstone, and siltstone-greywacke (Upper Oxide Formation). This mineralized sedimentary Formation is coincident with the Pyke fault splay and separates the Sam (siltstone-greywacke) and Wesmeg (mafic volcanic-volcaniclastic-greywacke) formations, which represent the hanging wall and footwall of the Tiriganiaq deposit, respectively.

New U-Pb detrital zircon ages reveal that the Sam and Wesmeg Formations were deposited at ≤2.66 Ga and are thus consistent with the interpreted ca. 2.66 Ga age for the Rankin Inlet Group. The latter is traditionally grouped with Neoarchean greenstone belts comprising the Hearne Craton; however, disparately older Mesoproterozoic detrital zircon ages (2.9-2.8 Ga) from the Sam and Wesmeg Formations are significantly older than the expected age of the central Hearne sub-domain to which the Rankin Inlet Group is traditionally assigned and share more similarities with Mesoarchean rocks comprising the Chesterfield block to the north. These new detrital zircon results highlight the possibility that the crustal-scale Pyke fault zone may also represent a major terrane boundary.

At Tiriganiaq, gold occurs as inclusions within arsenopyrite and is also observed filling idioblastic arsenopyrite fractures along with pyrrhotite and lesser galena ± chalcopyrite. Arsenopyrite from a suite of auriferous BIF and quartz vein samples yield a Re-Os isochron age at ca. 1931 ± 40 Ma (MSWD = 7.7; $^{187}Os/^{188}Os_{initial}$ = 2.3 ± 2.7; n = 8). This isochron age is within analytical uncertainty at 2σ with a weighted average Re-Os model age (1899 ± 6 Ma; MSWD = 0.5; n = 3) obtained from replicate analyses of a highly-radiogenic arsenopyrite sample. Both Re-Os arsenopyrite age determinations are expected to constrain the timing of gold, but are ostensibly older than previously reported U-Pb hydrothermal monazite ages for the same deposit (ca. 1.85 Ga[2]). Despite the age difference, both geochronometers suggest that gold was introduced, at least locally, during Paleoproterozoic re-working of the Archean host rocks. Determining the precise age of the Archean host rocks and gold mineralization and unravelling the Paleoproterozoic metallogenic history of the MGD represent key elements of on-going research as part of the Lode Gold project of the Targeted Geoscience Initiative-4 program.

[1]www.agnico-eagle.com

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FISH COMMUNITY DYNAMICS AND ENVIRONMENTAL ASSOCIATION: IMPLICATIONS FOR DECISION MAKING FOR SUSTAINABLE FISHERIES IN GREAT SLAVE LAKE, NORTHWEST TERRITORIES (NWT)

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An ecosystem-based fisheries management (EBFM) framework for decision making

requires the development of ecological indicators that allow anthropogenic impacts on fish and fisheries to be detected and managed against the background of natural variation. Great Slave Lake (GSL) connects two of the largest river systems in the NWT, Slave and Mackenzie, and its environmental productivity is largely influenced by water regulation at the Bennett Dam at the headwater of the Peace River, arctic climate variability, and the activity of commercial, aboriginal and recreational (CRA) fisheries. Combined with environmental and fishery production information, the GSL species-specific biomass-per-unit-effort (BPUE) metrics of fish communities are potentially useful indicators because of their theoretical foundation and practical utility.

To evaluate the fish community dynamics and environmental associations, we explored BPUE datasets from surveys in the main basin of the lake during July-August, 2012-2013. A total of 121 effective gillnet samples were taken by using pelagic (49 sets in 5 m below the surface), mid-water (15 sets in 20 m deep) and benthic sets (57 sets in the bottom), which covered the commercial fisheries administrative areas IW, IE, II and III at water depths from 2.5 to ~73.8 m. By using a combination of multivariate analyses, site depth ($F=16.66$, $p<0.001$), gear depth ($F=6.41$, $p<0.001$), temperature ($F=4.43$, $p<0.001$) and turbidity ($F=3.78$, $p<0.001$) were identified as driving environmental variables differentiating the spatial distribution of fish communities dominated by Lake Whitefish (32%) and Ciscoes (14%) over the studied areas. Of 23 fish taxa identified, the prey-predator pairs of fish communities were spatially assembled by the four forcing variables mentioned above, suggesting that environmental modification generally has had a stronger effect on the structures and functions of fish communities than shifts in the level of commercial harvest alone. Monitoring anthropogenic impacts on structuring fish communities have implications for ensuring the fish community diversity and sustainability of fish production in the northern larger lacustrine ecosystems.

AN ASSESSMENT OF THE STRUCTURE, CONTENT, AND USABILITY OF THE KIMBERLITE INDICATOR AND DIAMOND DATABASE (KIDD)

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The Kimberlite Indicator Diamond Database (KIDD) is a database initiated and developed by NTGO to archive kimberlite indicator mineral (KIM) grain counts reported within assessment reports of mining activity in the Northwest Territories. Despite its widespread use since its inception nearly 25 years ago, there has yet to be a formal assessment of the KIDD data structure, content and usability of this data archive. This presentation reports on these elements of KIDD and highlights that the data content is quite robust, in terms of the transfer of information from assessment reports to the database. However, we note there are some limitations and provide caveats on data usage, as well as suggestions on potential improvements to KIDD.

KIDD archives four main types of sample data and metadata: 1) Sample and site descriptions (general sample attributes: sample number, location, etc.); 2) Information on KIM (grain count data from suites of KIM); 3) Analytical information (processing techniques, processed size fractions, etc.); 4) Comments (mixed array of site attributes, analytical information, KIM information). The completeness and accuracy of reported KIM grain counts is variable. Only ~34% of all archived samples report total KIM grain count information. Individual KIM grain count reporting varies between ~0.02% (diamonds) to ~16% (garnets). Despite some limitations in grain count reporting, the data contained within KIDD are of high quality and integrity: over 87% of data reported within assessment reports are faithfully and accurately reported within KIDD. Moreover, data allow for delineation and recognition of dispersal patterns at the scale of individual surveys/properties.

Some limitations to the use of KIDD result from irregular reporting and non-standardized reporting formats. This is the case for sample weights and sampling site attributes which are highly valuable data when using KIDD as an archival or data mining source. These limitations result not from an absence of data but from the database structure itself that does not contain proper fields for standardized reporting of these attributes.

Overall, KIDD offers a useable archival dataset of high data quality. However, numerous caveats and limitations in data reporting require careful data evaluation by the user.

NUNAVUT PROSPECTORS PROGRAM (NPP) AND INTRODUCTION TO PROSPECTING COURSE (IPC)

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Implemented: 1999 (Territory inception) to present; and ongoing.

Description/rationale: At the time of the territorial partition of Nunavut (1999), there was effectively no prospectors' program in Nunavut as programming and prospectors working in what became Nunavut had worked through the NWT office. Following the ideas of the NWT 'Grubstake Program', the Nunavut Prospectors Program (NPP) was introduced with the combined objectives of increasing resident technical and entrepreneurial skills, and adding to Nunavut's mineral occurrence and knowledge databases.

The NPP consists of two components:
(1) training and support for prospectors, and (2) funding assistance for prospectors to prospect their land. Up to $8000 in project-expense funding is available annually to qualified prospectors.

The Introduction to Prospecting Course (IPC) covers background prospecting and geological information that introduces basic prospecting methods. The course is offered in each Nunavut community every three to four years as an evening class for five nights and one full day in the field. The IPC combines both a classroom and experiential science regime. Course participants are introduced to hands-on learning with rocks and minerals and to prospecting skills during the evenings and the one-day outdoors

prospecting. Participants who successfully complete the IPC are eligible to apply for funding to assist with a prospecting field program on an area where the prospector chooses. Both the NPP funding program and the introductory prospecting course are delivered and administered by the Government of Nunavut's two Resident Geologists and two Community Mining Advisors based in Cambridge Bay and Arviat. These professionals also provide ongoing technical support to NPP prospectors.

Results: Typically 10-20 community-based prospectors receive NPP-project funding each year. Many of these prospectors apply for funds annually for continuing prospecting field programs. The profile of funding recipients closely matches Nunavut's demographics in that 80-90% of NPP-funded prospectors are Inuit and the majority of NPP-supported prospectors reside and work in the smaller and more isolated communities as opposed to the larger, regional centers.

In the 15 years that the Nunavut community-delivered Introductory Prospecting Course (IPC) has been offered, over 900 Nunavummiut have taken the course. The NPP and IPC are successfully serving as a vehicle for (1) capacity building community education and awareness, and (2) building skills and understanding of prospecting, mineral tenure and the mineral exploration industry in general. The 2013 season certified 90 people who completed the IPC. Interested participants have applied to the GN-NPP for funding for small field programs undertaken this year.

LAKE MUD: A TOOL TO IDENTIFY GLOBAL TELECONNECTIONS AND QUANTIFY THE RANGE OF ENVIRONMENTAL RESPONSES TO CLIMATE VARIABILITY IN THE NORTHWEST TERRITORIES, CANADA

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Recent climate changes affecting the Canadian Subarctic have prompted policy planners to seek a better understanding of regional climate variability and the range of associated environmental responses. A key concern is the viability of current infrastructure and the necessity to invest in more permanent overland routes. The dearth of consistent long-term records of regional climate has greatly hindered and even precludes the accurate modeling of future climate in the region. Previous studies have tracked coarse temporal scale changes in treeline movement but not at the temporal resolution necessary to identify the oscillatory nature of global teleconnections which contribute to regional climate variability. Also missing is the range of associated environmental responses to historical climate variability. Only when this response is understood can future scenarios of climate models be put into terms of environmental impact.

Global teleconnections, such as the El Niño/Southern Oscillation, are the result of large scale oceanic and atmospheric circulatory processes. They temporally fluctuate at specific frequencies and thus

environmental processes they affect, whether directly or indirectly, will record a similar fluctuation within their paleorecords. The varying nature of particle size distributions of mud deposited into lakes represents variability in the energy of the surrounding catchment. This energy can be modulated by sediment availability, changes in snowpack, presence or absence of vegetation, and average precipitation. These all in turn are modulated by regional climate variability which is the result of the forcing behaviour of global teleconnections. Sediment freeze cores were collected from two boreal subarctic lakes - Waite Lake and Danny's Lake - in the Northwest Territories, Canada and were subsampled at millimeter intervals utilizing a custom-designed freeze core microtome. Time series analysis of the grain size distributions identified periodicities equivalent to those seen in records of the El Niño/Southern Oscillation, the Pacific Decadal Oscillation and the Gleissberg Cycle. These results help to clarify which teleconnections are associated with the regional climate variability of the Canadian Subarctic.

Biotic proxies are an important tool for tracking historical environmental changes due to climatic variability. Arcellacea are a freshwater protist living on the mud of the lake bottom, which undergo rapid generation times, are resistant to dissolution and are numerous. A suite of geochemical and sedimentological analysis of mud collected from fifty six lakes spanning North from Yellowknife into the southern arctic ecozone of the Northwest Territories were used to characterize lakes and the arcellacean populations they contain. This information coupled with downcore studies of ancient arcellacean populations can be used to reconstruct an environmental history for the region. These results help to identify important climate events, possible analogue scenarios and define the range of expected environmental response to natural climatic variability.

Altogether these results will provide policy makers and climate modelers with the required information to project possible future climate scenarios and to assess the viability of present and future infrastructure in the Canadian Subarctic.

CANADA-NUNAVUT GEOSCIENCE OFFICE 2013 ACTIVITIES

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The Canada-Nunavut Geoscience Office (CNGO) is a partnership between the Government of Nunavut, Natural Resources Canada and Aboriginal Affairs and Northern Development Canada. Nunavut Tunngavik Incorporated also sits on the management board as a non-voting member. CNGO's mandate is to provide accessible geoscience information and expertise for responsible economic development, protecting communities and infrastructure, capacity building and training and data dissemination. CNGO delivers a diverse suite of geoscience activities in collaboration with universities, industry, other government organizations and NRCan's Geo-Mapping for Energy and Minerals (GEM) program.

In 2013 CNGO activities included regional geoscience mapping on Hall Peninsula east of Iqaluit, mineral deposit studies in Borden Basin, targeted mapping at the Korok Inlet carving stone deposit (Nunavut's largest quarry), climate change adaptation research on land-based and and coastal infrastructure,

exploration for industrial limestone resources on Southampton Island and the land of a new geoscience field school for Nunavummiut. The intent of this presentation is to provide an overview of the activities noted above and discuss ideas for future geoscience work in the territory.

HACKETT RIVER PROJECT: AG RICH VMS DEPOSIT

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The Hackett River Project is located 480 km Northeast of Yellowknife in the Kitikmeot region of Nunavut. Glencore Canada Corporation's Hackett River property spans over 100 km within the Hackett River Archean (2.8Ga) Greenstone Belt of the Slave Province. This advanced exploration project is host to four important polymetallic VMS deposits (Zn-Ag-Cu-Pb-Au) highly enriched in silver. The Hackett River Belt has been folded by three phases of deformation and is metamorphosed from lower - upper amphibolite facies. Over the last 2 years, Glencore has completed over 90,000 m of diamond drilling across the property and also performed a variety of geophysical, geochemical and structural studies.

The presentation will highlight the main lithological, geochemical and structural features of the Hackett River VMS deposits that can be used to target future exploration work.

ARCELLACEANS (TESTATE LOBOSE AMOEBAE) AS PROXIES FOR ARSENIC AND HEAVY METAL CONTAMINATION IN THE BAKER CREEK WATERSHED, NORTHWEST TERRITORIES, CANADA.

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The Baker Creek Watershed (BCW) near Yellowknife, NT is known to be contaminated by arsenic and other contaminants derived from the adjacent Giant Mine. This mining operation drove a post-WWII economic boom for the territory, but left behind a legacy of arsenic contamination, both on site and within the adjacent BCW; enough to cause serious environmental concern. While mine on-site arsenic trioxide sequestration is currently the focus of a massive remediation project, the impact on the surrounding BCW is less well understood. Arcellaceans (testate lobose amoebae) are benthic protist primary consumers that have been previously shown to respond to a variety of contaminants (e.g. As, Hg and various heavy metals) associated with mining activities. The aim of this study is to utilize arcellaceans as biological proxies of arsenic and heavy metal contamination in the BCW, and to contribute to the quantification of the environmental impact of the Giant Mine on the BCW.

Arcellaceans were analyzed in sediment-water interface samples from sixty-one lakes across the region surrounding the Giant

Mine. Samples were also analyzed for other proxies (e.g. geochemical, micropaleontological and sedimentological). Q and R cluster analyses of arcellacean results were used to group samples with similar species distribution, and to determine which species or strains tend to co-occur. Redundancy analysis (RDA) was also performed to determine species-environment relationships, and to provide a better understanding of the observed clustering. Tentative results indicate that there is a close correlation between environmental variables of concern (e.g. As, Pb) and the distribution of arcellacean species. Samples from these contaminated lake stations were characterized by a relatively low Shannon Diversity Index (SDI=1.5 -1.8) and were dominated by faunas that are known to reflect environmental stress (e.g. Centropyxis constricta "aerophila"• and Centropyxis constricta "constricta").

The preliminary results of this ongoing research suggest that arcellaceans will prove to be reliable proxies for recognizing contamination associated with mining activities. They will be particularly useful in the examination of cores from lakes in the BCW where they will be used to determine pre-mining baseline environmental conditions, the response of lakes to mining impact and for gauging the success of post-mining remediation. These results will provide valuable insight into the impact of Giant Mine on the BCW that will be of use to policy makers and planners when evaluating the merit of various remediation programs.

PRELIMINARY PETROGRAPHY, GEOCHEMISTRY, STABLE ISOTOPES, AND FLUID INCLUSION SYSTEMATICS OF THE CARIBOU LAKE MAFIC-ULTRAMAFIC INTRUSION, NWT

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The Caribou Lake Intrusion (CLI) comprises the western intrusive suite of the Early Proterozoic Blachford Lake Intrusive Complex, which intrudes Archean Morose granite and sedimentary rocks of the Archean Yellowknife Supergroup. The CLI is approximately 90 km southeast of Yellowknife, NWT on the north shore of Great Slave Lake and has a strike length of approximately 12 km north-south and up to 1 km wide. The most recent exploration from 2004-2007 had focused on Ni-Cu-PGE showings in the area following exploration dating back to 1937 that was focused on Fe and Ti deposits. Several intersections of massive to heavily disseminated pyrrhotite ± chalcopyrite ± pentlandite were encountered during a diamond drill program in 2006.

This study is examining the petrology and mineralization within the CLI. The methods used will provide insight into primary processes of sulfide formation and metal enrichment as well as secondary processes (magmatic volatile activity, hydrothermal alteration and metamorphism) that have influenced the metal tenor and mineralogy of the system. The overall goal is to develop a model for the mineralization and to compare this system to other mineralized and barren tholeiitic layered and multi-phase mafic-ultramafic intrusions globally (e.g., Duluth, Muskox, Lac Des Iles).

Detailed petrography characterized the mineralogy of the base metal and PGE mineralization as well as the silicate mineralogy and alteration, revealing that pyrrhotite (Po) is the dominant sulfide present with chalcopyrite occurring in close proximity. Cobalt-rich pentlandite ((Co, Ni, Fe) 9S8) is the dominant Ni-bearing phase present and occurs as thin exsolution lamellae within Po grains. Vanadium-rich oxide (magnetite) mineralization is abundant throughout the intrusion, with some magnetite containing up to several wt% vanadium (V).

Generally, trace element plots show the rocks are slightly enriched in LREE compared to HREE, and exhibit a positive Eu anomaly; together with the unusually high V content of the associated oxide phases, these characteristics are consistent with plagioclase-rich cumulate rocks crystallizing over a relatively narrow range in fO_2 close to NNO. Sulfur isotopes will be helpful in determining if contamination occurred from the surrounding host rocks. Preliminary $\delta^{34}S$ have an average value of 0.3 ± 0.5 ‰ (n = 7), suggesting a primary magmatic sulfur source with little contamination from Archean sedimentary host rocks.

First stages of fluid inclusion work have shown numerous inclusion types hosted within apatite and quartz, ranging from polyphase brines heterogeneously trapped with a carbonic fluid phase to lower salinity aqueous-carbonic fluids. Similarities exist between fluid inclusion types in the CLI and in other large mafic-ultramafic intrusions (e.g. Stillwater, Duluth) in which high temperature, late magmatic volatiles have interacted with mineralized cumulates and have modified ore tenors.
Petrographic, geochemical, and fluid/melt inclusion work is only in the preliminary stages and ongoing. As the work progresses it will aid in: (i) the understanding of ore forming processes involved during the formation of CLI, (ii) identify host sites for PGE minerals and other discrete metal phases (e.g. As, Ag, Au), and (iii) constrain types of fluids (magmatic, meteoric, metamorphic) involved in metal remobilization and alteration.

GEOLOGICAL COMPILATION OF THE WESTERN MAINLAND AND SOUTHERN ARCTIC ISLANDS REGIONS, NORTHWEST TERRITORIES

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The compilation of existing geological data for the western NWT in a Geographic Information System is nearing completion. The compilation will be first released digitally as seven seamless maps within a geodatabase; shapefiles will be included as an option. Eventually, a series of regional maps, complete with a standard map legend, will be available in hardcopy format.

Current efforts are focusing on mainland NWT and adjacent parts of Yukon Territory and Nunavut, and have begun integrating the geology of the Arctic Islands. Work is also utilizing all published maps and reports up to 2012. Provision of recently completed but unpublished maps is gratefully acknowledged, as is the exchange of ideas with several geologists with valuable first-hand knowledge.

Data for the compilation were originally assembled as AutoCAD maps and Excel

spreadsheets. The AutoCAD files were then disassembled, managed and thematically reconstructed in accordance with standard geological practices into a geodatabase within ArcGIS. Topology was rigorously tested and maintained throughout the process. The spreadsheets are a continually evolving, comprehensive legend that includes data from the compiled maps, correlation charts, subsurface, and supplementary information in government and industry reports and academic publications. From these spreadsheets, standard unique unit labeling and colouring, hierarchical naming, and lithological and age descriptions of some 500 units are also managed and maintained within the geodatabase.

The bedrock geology of the regions has been mapped and compiled at a variety of scales and degrees of detail. Previous compilations and synthesis have resolved many of the inconsistencies among the individual representations of the geology in each map. However, several factors result in an ever-changing and evolving database. These include differing and evolving nomenclature of stratigraphic units and structures, details not represented on maps but available only in reports and areas where new information has altered geological details and interpretations.

The bulk of the present compilation process is therefore the development of a new synthesis of the geology. This involves the inclusion of map and other data at a much broader range of data densities (equivalent to scales from 1:1 000 000 and up to 1:10 000 in rare instances) than used in previous compilations, resolving, as much as possible, all inconsistencies and extending new data and local changes as appropriate to broader regions. This compilation also embraces areas adjacent to western and eastern NWT, including offshore areas where well and seismic data are available. These are required to make the map and database seamless and internally and externally consistent.

Geodatabases can contain a higher density of information than is usually included on traditionally published regional maps. Such information includes paleontological and radiometric ages, rock unit descriptions, locations of measured sections, well core and seismic data, mineral occurrence data, etc., essential for comprehensive synthesis of all geological information. The ultimate goal is to provide a comprehensive bedrock map as a base upon which as much geological and other data as possible may be layered, in turn assisting further synthesis of the geological evolution.

A CRITICAL RE-EVALUATION OF THE NEOARCHEAN BANTING GROUP

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The overall stratigraphic nomenclature of the Archean Slave craton is relatively straightforward. A Hadean through Mesoarchean basement complex (Central Slave Basement Complex; CSBC) is unconformably overlain by the ca. 2850 Ma Central Slave Cover Group (CSCG), a sequence of quartzite ± banded iron

formation ± felsic and mafic volcanic rocks. Overlying the CSCG is the Yellowknife Supergroup, the base of this being the >2730 Ma to 2700 Ma Kam Group that is best preserved in the Yellowknife greenstone belt. Kam Group occurrences generally coincide with the preservation of CSBC and/or CSCG throughout the central and western part of the craton, with the easternmost occurrences in the Courageous Lake belt (Cycle 1). Farther east it is likely that the ca. 2708 Ma Innerring Sequence of the Back River volcanic complex and the ca. 2716 to 2697 Ma Flake Lake suite in the Hope Bay belt are correlative with the Kam Group. The ca. 2690 Ma Raquette Lake Formation of the Ross Lake Group contains felsic volcanic rocks and overlying carbonate-cemented sedimentary mass waste aprons. New precise age data from the Cameron River belt indicate that the volcanic rocks associated with the Raquette Lake Formation are indistinguishable from the Thlewycho sequence in the Back River complex (2692 ± 2 Ma), and the Square Lake suite in the Hope Bay belt (ca. 2690 Ma), suggesting that these units form a distinctive pan-Slave marker horizon both on- and off-basement. This diminishes the need for craton-internal Neoarchean terrane boundaries.

At its type locality, the Banting Group consists of minor ca. 2663 Ma felsic volcanic rocks with interbedded greywacke-mudstone horizons. This is highly dissimilar to vast, typically bimodal volcanic belts across the craton that have yielded older crystallization ages between ca. 2685 and 2667 Ma. A number of these belts host volcanogenic massive sulphide deposits and numerous gold prospects, but most are not equivalent to the Banting Group as currently defined. All volcanic belts are unconformably overlain by either ca. 2661 Ma (Package I) or <2630 Ma (Package II) greywacke-mudstone turbidites. The Banting Group volcanic rocks are only slightly older than the 2661 Ma rhyolite tuffs in the Duncan Lake Group (Burwash Formation) turbidites. Based on this, it would seem more likely that the Banting Group rocks and their age equivalents, such as at Clan Lake, Russell Lake and elsewhere, in fact occur at the base of the Duncan Lake Group. The volcanic rocks between 2685 and 2667 Ma that exist across the craton require re-evaluation to thoroughly test the stratigraphic relationships between volcanic belts. Regardless, each volcanic belt appears to contain between 1 and 3 pieces of the (at least) 4-piece volcano-stratigraphic puzzle outlined above. While each belt may have evolved in differing petrogentic environments, the general pan-Slave similarities, including post-volcanic history, indicate the volcanic units need not have formed in an exotic sense to the CSBC.

THE INTERNAL ZONE OF WOPMAY OROGEN: THE ATTENUATED AND IMBRICATED WESTERN MARGIN OF THE ARCHEAN SLAVE CRATON

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The Paleoproterozoic Wopmay orogen is bisected by the N-S Wopmay fault zone; to the west is the 1.97-1.89 Ga Hottah terrane and 1.87-1.85 Ga Great Bear magmatic zone and to the east lies the Slave craton and the

overlying Coronation Supergroup. Between Wopmay fault zone and the Slave craton (sensu stricto) there are highly deformed and gneissic Archean rocks that are unconformably overlain by thin Paleoproterozoic siliciclastic and carbonate strata ranging from greenschist to granulite facies. Collectively these rocks have been assigned to the metamorphic internal zone of the orogen. An alternative interpretation is that these rocks are part of the Hottah terrane, formed exotic to the Slave craton, and are preserved as a klippe ("Turmoil klippe") that was obducted on the Slave margin during ca. 1.88 Ga Calderian collision of the Hottah terrane and Slave craton.

We have tested the above hypotheses in the southern Wopmay orogen (between 63°N and 66°N latitude) using bedrock mapping, combined with U-Pb geochronology and Nd isotope data on the Archean basement, and U-Pb detrital zircon data from unconformably overlying sedimentary strata. Bedrock mapping and isotopic data of the Archean rocks demonstrate they can be tied directly to the western Slave craton; this includes Mesoarchean and Neoarchean plutonic rocks and supracrustal rocks derived from the Yellowknife Supergroup, and numerous Paleoproterozoic dyke swarms. However, unlike the neighbouring Slave craton, these rocks (and intrusive dyke swarms) underwent ductile deformation prior to and after deposition of the overlying strata. Bedrock mapping demonstrates that sedimentary units unconformably overlie both Meso and Neoarchean basement in the area. Post-deposition, these were extensively deformed together such that basement-cover relationships are now preserved across a series of domes and basins. The detrital zircon data from quartzites, which are between 1 and 20 metres unconformably above the Meso- and Neoarchean basement, indicate provenance from the adjacent Slave craton, with the addition of ca. 2030 Ma detritus. As such, we interpret these strata to be the lowest part of the Epworth Group deposited on Slave-derived basement.

The results demonstrate the Archean rocks between the Wopmay fault and Slave craton, including the type section of the Turmoil klippe, were originally part of the Slave craton but were deformed pre, syn, and post the 1.88 Ga Calderian orogeny. This deformation included rifting and later basement involved folding and thrusting that helped shape the current architecture of the area. A detail remaining to be resolved is the stratigraphic/tectonic position of the ca. 1.89 Ga Grant subgroup marginal basin volcanic sequence. These greenschist facies rocks are preserved adjacent to high-grade Archean gneiss and it is uncertain if they were erupted directly on this Archean basement or thrust from the west during arrival of the peri-cratonic Hottah terrane.

PALEOCLIMATOLOGICAL ASSESSMENT OF THE CENTRAL NORTHWEST TERRITORIES AND IMPLICATIONS FOR THE LONG-TERM VIABILITY OF THE TIBBITT TO CONTWOYTO WINTER ICE ROAD: A PROJECT OVERVIEW

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Our multi-disciplinary research on a series of cores collected along, and adjacent to, the length of the TCWR was mandated to provide high-resolution information on climate variability and its effects on aquatic and terrestrial environments in the central NWT and NU. Our methodology has permitted us to recognize cycles and trends that have impacted climate change at annual to centennial scales through not only the mandated past 3500 years, but for much of the Holocene. In addition to analysis of the instrumental record that exists from 1942 onward for the region, several other climate sensitive proxies were utilized at varying temporal resolutions: dendrochronology (annual), grain-size analysis (subdecadal), chironomids (decadal), isotopic analysis (decadal), diatoms (decadal), palynology (decadal), arcellaceans (decadal). Through use of time series analysis techniques on our multi-proxy data set we have been able to identify the influences of well-known teleconnections such as; the El Niño-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), and solar cycles on the natural climate variability of this region. Their influence has been cyclic and follows predictable patterns. The overarching influence has been solar cycles of varying periods, which seem to have influenced both the phase and magnitude of Pacific Decadal Oscillations, which in turn influence the penetration of ENSO events into the north. Solar peaks generally result in warmer conditions, particularly at the most northerly latitudes. In the past positive PDOs have been associated with warmer winters and negative PDOs cooler winter conditions. For example, following the great PDO regime shift of 1976-77 there was a significant step-wise increase in winter temperatures in the NWT. El Niño events coupled with PDO+ events generally result in particularly warm winters.

With the recent shift to PDO- conditions and a projection of very weak solar activity for the next few decades winter conditions should on average be colder than in recent years, resulting in conditions ideal for ice road construction. However, possible offsets for this overall cooling trend is the impact of periodic ENSO events as has recently occurred in 2006 and 2010, as well as possible anthropogenic influence. Our results will be of interest to stakeholders (e.g., industry, government, non-government organizations, and First Nations groups) as they strive to strategically manage northern ecosystems and inform policy makers and planners of potential climatic conditions that may prevail in the coming decades.

CANADA'S ARCTIC CRATONS: HOW MANY, HOW OLD, HOW COME?

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The discovery of diamonds in the NWT sparked a Canada-wide exploration effort that led to the discovery of hundreds of kimberlites, many containing diamonds, all over Canada's North. While few of the subsequent finds have proved to be economic the mantle xenolith cargo that some of these kimberlites brought to surface is a unique record of the mantle root that underpins the region. As part of a long-term research program aimed at characterizing the deep roots of Arctic Canada we report new geochronology results for mantle peridotites from central Victoria Island, Parry Peninsula, Repulse Bay and Pelly Bay. Some of these locations lie beneath regions recognized as having cratonic surficial rocks, while others lie on proposed extensions of existing cratons or on newly suggested cratonic areas. For most suites we have obtained bulk compositions, mineral chemistry and Re-Os isotope data allowing both their composition and age to be related to known cratonic peridotites, e.g., the those from the Central Slave kimberlite field. In all cases, bulk compositions and olivine mg-numbers overlap those for cratonic peridotites and suggest that the lithospheric roots in these locations formed as a result of high degrees of mantle melting, akin to processes that formed Archean mantle roots. In contrast, Re depletion age spectra are much more diverse.

The Victoria Island kimberlites are thought to erupt through a possible northerly extension of the Slave craton. Peridotite TRD ages range up to 2.5 Ga but with a pronounced age mode at 1.8 to 2 Ga, suggestive of new mantle addition at this time. The composition and age spectra are distinct from the Central Slave Craton and suggest that the region is under-pinned by early Proterozoic mantle. Parry Peninsula peridotites are shallow spinel to garnet-spinel facies and also show a pronounced age mode at 1.8 to 2 Ga, also indicative to a Proterozoic rather than Archean mantle root beneath this region. At Repulse Bay we find ages extending back to 2.7 Ga (n=1) but with a mode at circa 2.3 Ga, coincident with the Arrowsmith orogeny. Only at Pelly Pay do we find clear evidence of Archean residual mantle, yet even here there is a complete continuum of ages through the Proterozoic. We interpret the majority of these findings in terms of extensive melting during Proterozoic orogenic events, that produced highly depleted mantle, with melting extents approaching those seen in the Archean, producing residual mantle columns that were thickened during collision and subduction. The significance of these findings in terms of diamond potential is unclear as major Proterozoic re-setting and new mantle generation took place in the centre of the Kaapvaal craton, beneath the Cullinan Mine, a location which has produced some of the world's most valuable diamonds.

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A COMPLICATED NEIGHBOURHOOD: NEW RESULTS FROM THE WESTERN RAE AND THELON TECTONIC ZONE FROM GEO-MAPPING FRONTIERS

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As part of the Geological Survey of Canada's Geo-mapping Frontiers GEM-1 project, reconnaissance geological studies were undertaken across the northwestern Rae craton and adjacent Thelon tectonic zone (TTZ). The study involved compilation and synthesis of archival data, surficial geology interpretation (CGM-113, 131, 143) a two week helicopter mapping transect, acquisition of high-resolution aeromagnetic (OF 7211-7226; 7268-7275), stream sediment (OF 7471) and till geochemical surveys (OF 7418). In support of the study thirty new U-Pb zircon and monazite ages were obtained from archival and newly collected samples (OF, in prep). Integration of these results with new field observations and published literature has enabled delineation of four regionally extensive crustal domains. Stretching from the Queen Maud Gulf coast to the Thelon game sanctuary, they comprise, from west to east, the 2.0-1.9 Ga TTZ, a 3.2-2.9 Ga Mesoarchean block, the 2.5-2.45 Ga Queen Maud granitoid belt,, and the 2.45-2.40 Ga Sherman basin. New metamorphic zircon and monazite ages attest to the effects of the 2.4-2.35 Ga Arrowsmith orogeny across the Mesoarchean block. A major early (2.03-1.99 Ga) pulse of TTZ magmatism and metamorphism is recognized, and reaches farther east than previous models. In addition, Mesoarchean crust extends west into the TTZ, and appears to be both intruded by TTZ magmatic rocks and structurally intercalated with them. Geochemical anomalies in the southern Mesoarchean block may be related to the Ni-Cu-PGE-bearing Parry River mafic suite. A major thermal event at 1.905 Ga affected the western Mesoarchean block and the TTZ, along with a metamorphic overprint at ca. 1.88 Ga. Intriguingly, these two Paleoproterozoic thermal events occur adjacent to part of the Slave province characterized by west-vergent, polyphase, thick-skinned thrusting involving Slave basement and the Kilohigok basin. Major north-south mylonite zones, evident in the aeromagnetic and archival data, appear to offset late Paleoproterozoic mafic dykes and involve the Mesoproterozoic Elu basin. These observations and co-located U and REE stream sediment anomalies, raise the potential for unconformity uranium mineralization in the area.

Recent compilations have interpreted the TTZ as intrusive into the western margin of the Rae craton, assigning widespread metasedimentary and orthogneissic rocks to the Rae. Our synthesis of archival data shows that enigmatic low grade greenstone belts and associated subvolcanic intrusions occur within the TTZ, separated from the Slave craton by Thelon plutonic rocks. These belts, reportedly underlain by pillowed mafic-intermediate volcanic and volcaniclastic rocks, including iron formations, are associated with significant stream sediment geochemical anomalies (Cu, Pb, Zn, Ag) and sulphides in heavy mineral separates (sphalerite, chalcopyrite, and arsenopyrite-loellingite). Analysis of their known extent and geophysical expression shows that they lie along strike of rocks assigned to the Slave craton, and new geochronology supports this interpretation. These relationships underscore ambiguities in the zone's setting and evolution (e.g. subduction polarity, structural interleaving, intraplate magmatism?), and may help resolve long-standing uncertainty regarding the location and nature of the TTZ. The more complex cratonic architecture recognized herein and new stream sediment data highlight greatly

increased mineral potential for this underexplored area.

CONTROLS ON RARE EARTH ELEMENT MOBILITY FROM NECHALACHO TAILINGS, THOR LAKE, NWT

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The Nechalacho rare earth element (REE) deposit, owned by Avalon Rare Metal Inc., is located approximately 100 km east of Yellowknife. The deposit is hosted within a hydrothermally altered layered nepheline-sodalite syenite in the peralkaline Blatchford Lake complex. The main REE ore minerals are zircon, fergusonite, allanite, monazite, bastnäsite, and synchysite/parasite. This research investigates the mechanism of REE mobility in waters that have interacted with pilot plant tailings from the Nechalacho deposit, Northwest Territories. In aqueous environments, REEs are known to be transported by complexation to inorganic and organic ligands, as colloids (of REE minerals due to fine grinding of ore), and through sorption to colloids or suspended particles. Metal toxicity is thought to be greater in aqueous environments when metals occur as free ions rather than complexes, and the speciation can also impact the treatment technologies utilized to reduce metal concentrations. A series of shake flask tests were designed to simulate the interaction of tailings with leach water to identify soluble phases and mobile elements. Nechalacho pilot plant tailings were mixed 3 to 1 by weight with 3 different waters: distilled deionized water (pH 5, ionic strength $I = 0$), lake water (pH 8, $I = 0.005$), and water from the pilot plant processing (pH 8, $I = 0.05$). The flasks were gently agitated on an orbital shaker at 150 rpm for 24 h at both 25°C and 4°C. The decants from the shake flask tests were first filtered at 0.45 µm then at 10 nm, with the total REEs in the two filtrates varying between the three water types: DI water (12 µg/L; 0.8 µg/L), lake water (3 µg/L; 1 µg/L), and water from pilot plant processing (5.5 µg/L; 4 µg/L). The [REE] in the colloidal phase ($[REE]_{colloids} = [REE]_{0.45} - [REE]_{0.01}$) increased with decreasing ionic strength, while the [REE] in the dissolved fraction (10 nm filtrate) increased with increasing ionic strength. Additionally there was a greater [REE] mobilized at 4°C than 25°C, and also with a greater proportion of the REEs being in the colloidal phase at the lower temperature. Of the REEs that do occur in the dissolved phase, aqueous speciation modelling indicates that only a small fraction (< 1%) will occur as free ions.

LITHOGEOCHEMICAL CHARACTERIZATION AND CORRELATION OF THE DEVONIAN HORN RIVER GROUP IN CENTRAL MACKENZIE VALLEY, NWT

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Evaluation of shale oil and gas potential of the Devonian Horn River Group (Hare Indian, Ramparts, and Canol formations) is the main focus of the Mackenzie Plain Petroleum Project (2009-2014) being conducted through the Northwest Territories Geoscience Office. The study area lies within Mackenzie Plain, a petroleum producing and exploration area located in the Central Mackenzie Valley, flanked by the Mackenzie Mountains to the south and west and Franklin Mountains to the north and east. The conventional oil field at

Norman Wells, one of Canada's largest fields, has produced more than 250 million barrels of oil from a Middle Devonian reef within the Ramparts Formation. Mackenzie Plain remains lightly explored for oil and gas resources. The goal of the project is to update, expand, and improve petroleum geoscience data and interpretation for this exploration area, with emphasis on characterizing potential shale reservoirs.

Correlation and lithogeochemical characterization of the Horn River Group is being refined through study of more than 25 outcrop localities within Mackenzie Plain and its adjacent mountain ranges. The field program focused on measuring and describing sections and taking spectral gamma ray measurements at outcrop. Chip samples were collected for source rock evaluation (through Rock-Eval and reflectance analyses), mineralogy (semi-quantitatively, using X-ray diffraction, XRD) and whole rock geochemistry. Similar analyses were conducted on samples from 26 exploration wells to correlate organic-rich subunits and compare trends in mineralogical and lithogeochemistry profiles (major oxides and trace elements) from outcrop to wells.

Analytical results indicate the Canol Formation and basal Bluefish Member of the Hare Indian Formation both have excellent source rock potential (average TOC contents greater than 5%). XRD results indicate these units are also quartz-rich (Bluefish Member >60%, Canol Formation >80%), which may enhance their ability to be fractured hydraulically as shale reservoirs. In contrast, the upper Hare Indian Formation is typically a poor source rock (<1% TOC), with the exception of "atypical"• dark grey upper Hare Indian Formation with TOC contents >6%. The Carcajou member within the carbonate-dominated Ramparts Formation contains some rich source rocks (average 4% TOC). Where the upper Hare Indian and Canol formations are visually similar in outcrop, the former is characterized by a higher concentration of light rare earth elements and its kaolinite plus chlorite content. These distinct signatures establish a basis for lithogeochemical correlation, particularly where Horn River Group strata remain undivided, and an "atypical"• upper Hare Indian Formation may be present, such as in the southwestern part of the study area.

In both Horn River Group outcrop and well samples, dominantly Type II kerogen (oil prone) is suggested, with a contribution from Type III kerogen (gas prone). Tmax values and vitrinite reflectance data indicate samples are within the oil window. A regional trend of increasing maturity from northeast to west and south across Mackenzie Plain is suggested.

USE OF MULTICOMPONENT SEISMIC DATA TO IDENTIFY THE CANOL SHALES

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This paper will show the use of converted waves (PS) from multicomponent seismic to identify the Canol Shales in Northwest Territories, Canada.

The elastic properties of these shales make it difficult to identify them on the PP waves but not on the PS waves. The response for the Middle Canol has a strong shear wave reflectivity that shows as a strong reflection on PS seismic data. This allows the mapping of the thickness of the Canol Interval with confidence.

The paper will describe the acquisition and processing of the multicomponent seismic data. Examples of the multicomponent data will be compared with synthetic modeling results. The benefits of joint PP/PS inversion for elastic attributes will also be presented.

AN ICELAND-LIKE SETTING FOR GENERATION OF EARTH'S EARLIEST KNOWN CONTINENTAL CRUST

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The Acasta Gneiss Complex (AGC) contains the oldest known continental rocks on Earth with U-Pb zircon ages indicating crust formation between 3.6-4.03 Ga [1-3]. These complex rocks hold a wealth of information regarding early Earth evolution. Here we report whole rock geochemistry along with SIMS U-Pb, trace element, and O-isotope compositions of zircon from a >4.0 Ga tonalite unit identified during detailed mapping of the AGC over the past three years.

Unlike typical Archean TTG magmatism [4], this unit is characterized by moderate silica contents (58-62 wt % SiO2), strong Fe-enrichment (12-15 wt% FeO), and low Mg numbers (13-18). REE patterns have relatively little fractionation of the heavy REE from the light REE (La/YbN ~2.5) and contain a significant negative Eu anomaly. These features strongly suggest that, unlike deep-seated Archean TTG magmas [4], the evolution of this AGC tonalite was dominated by shallow-level fractionation processes involving plagioclase.

Zircons from this well preserved unit document complex morphological patterns, very similar to previously described pre-4.0 Ga zircons from the AGC [1]. Two phases of igneous zircon growth, centers and mantles, are compositionally distinct but record indistinguishable U-Pb ages >4.01 Ga. Oxygen isotopic compositions from zircon centers and mantles document a decrease in $\delta^{18}O$ from a mean of 5.6±0.1‰ to a mean of 4.7±0.1‰. This center to mantle decrease in magmatic $\delta^{18}O$ can be explained by late-stage assimilation of hydrothermally altered crust. Also, variations in trace element abundances from igneous zircon growth zones are consistent with this process.

Collectively, these data for the >4.0 Ga AGC tonalite are strikingly similar to those reported for intermediate rocks from Iceland (e.g., icelandites), which are thought to have formed by a combination of shallow-level basaltic magma fractionation and assimilation of surface-water altered crust [e.g., 5]. Thus, Iceland may serve as a suitable analogue for the generation of Earth's earliest proto-continental crust.

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GOLATA AND BESA RIVER FORMATION STRATIGRAPHY; SHEAF CREEK AND SOUTH NAHANNI RIVER, NTS 95F/2, NORTHWEST TERRITORIES

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The hydrocarbon potential of late Devonian to Mississippian fine-grained sediments in the Liard Basin of Northwest Territories, Yukon, and British Columbia is the focus of a combined field-based and subsurface project spanning three jurisdictions. This ongoing multi-year project was initiated in 2012 by the Northwest Territories Geoscience Office, Yukon Geological Survey, and the Oil and Gas Division of the British Columbia Ministry of Energy, Mines, and Natural Gas. While the BC portion of the Liard Basin is an area of current shale gas exploration and production, north of 60 its unconventional resource potential is underexplored. The principal goals of the project are to: 1) categorize the shale gas potential of the Besa River Formation and its stratigraphic equivalents; and 2) improve regional stratigraphic correlations between the jurisdictions involved.

Two stratigraphic sections within the boundaries of Nahanni National Park were measured, described, and sampled by the Petroleum Group of the Northwest Territories Geoscience Office during the 2013 field season. These include a 78 m Carboniferous age Golata Formation section at Sheaf Creek (61°12'23"N, 124°33'32"W) and a 49 m Late Devonian to Early Mississippian age Besa River section at South Nahanni River (61°15'19"N, 124°37'14"W). The Golata Formation at Sheaf Creek is characterized by a sharp conformable contact with the underlying Flett Formation and a transitional conformable upper contact with the overlying sandstones, siltstones and shales of the Mattson Formation. This section consists of shale and mudstone (50%), siltstone (35%), minor dolostone (10%) and sandstone (5%). Although no regional contacts were present at the South Nahanni River Besa River section, it is estimated to be approximately 300 m above the nearby outcropping Devonian age Nahanni River carbonate. The Besa River Formation at this locality consists primarily of shale (80%) with minor mudstone (20%). Spectral gamma ray measurements were taken at 1 m intervals and chip samples were collected over 2 m intervals at each section. The chip samples will be analyzed for: 1) evaluation of source rock potential (Rock-Eval, total organic carbon, vitrinite reflectance); 2) mineralogy (X-ray diffraction); and 3) whole rock geochemistry to record changes in the abundance of major and trace elements throughout each section. Samples were also taken for microfossil biostratigraphy and for producing thin sections.

Initial petrographic analysis of Golata Formation siltstones has shown that they are composed mainly of quartz grains (approximately 80%) and clay minerals (approximately 15%). The quartz is mostly present as monocrystalline grains with rare polycrystalline grains showing sutured boundaries. Clay minerals are present within discrete laminations at macroscopic scale and along grain boundaries. Heavily altered feldspar grains and muscovite are present in trace amounts. Porosity was visually estimated at approximately 5%.

NUNAVUT 2013: FINDING EXPLORATION SUCCESS

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Mining and mineral exploration companies continued to be active in Nunavut in 2013, at both established projects and several new ones. Spending intentions for mineral exploration and deposit appraisal exceeded $300 million, but actual expenditures are

expected to be lower as several operators reduced their exploration budgets or cancelled planned programs.

Gold continues to be the commodity of chief interest in the territory, accounting for more than half of all exploration expenditures. Agnico-Eagle's Meadowbank gold mine produced 173,691 ounces of gold in the first half of 2013. Approximately 80,000 m of drilling was completed at that company's Meliadine gold project, mostly focused on resource conversion and exploration within known deposits. Sabina Gold & Silver completed a substantial drill program at its Back River gold project and received the results of the preliminary feasibility study for the project. TMAC Resources acquired the Hope Bay gold project from Newmont Mining Corporation and conducted an exploration program at site. Other gold projects that were active in 2013 include the Itchen Lake project (Transition Metals Corp), the Pistol Bay project (Northquest Ltd.) and the Kiyuk project (Prosperity Goldfields Corp.).

The project certificate for Baffinland's Mary River iron project was issued in late 2012. The company plans to proceed with an "early revenue phase"• for the project. Baffinland also recently signed an Inuit Impact Benefit Agreement with the Qikiqtani Inuit Association, and announced a positive construction decision for Mary River.

The most advanced base metal projects in the territory are both located in the Kitikmeot region (western Nunavut). Glencore Xstrata Plc completed a significant drill program at its Hackett River zinc-silver project, while MMG Limited carried out regional target identification at its Izok Corridor zinc-copper project. Other active base metal projects include Anconia Resources' polymetallic ATLAS-1 in the Kivalliq region, Aston Bay Holding's Storm copper project in the High Arctic and Vale's West Melville nickel project on the Melville Peninsula.

Work was completed at two uranium projects in 2013, both located in the Kivalliq Region. AREVA Resources is advancing its Kiggavik project through the regulatory process. The next step is the submittal of the Final Environmental Impact Statement for the project, expected by September, 2014. Kivalliq Energy Corporation completed diamond drilling and geochemical surveys at its Angilak uranium project. Additionally, the company acquired the Baker Basin Property, northeast of Angilak, from Pacific Ridge Exploration Ltd.

Peregrine Diamonds collected a bulk sample from the CH-6 kimberlite at its Chidliak diamond project. Under an option agreement, De Beers also completed an exploration program on the property that resulted in the discovery of two new kimberlites. De Beers announced in October that it does not intend to exercise its right to enter into a joint venture on the property.

Nunavut continues to have healthy levels of mineral exploration in 2013. Diverse commodities are being explored for across the territory, including gold, base metals, uranium and iron. There is also a mix of advanced, established and early stage projects that suggests that Nunavut remains an attractive destination for explorers.

THE BACK RIVER PROJECT - A PROJECT STATUS AND GEOLOGICAL UPDATE

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The Back River Project in the West Kitikmeot region of Nunavut consists of a number of gold deposits hosted within complexly folded banded iron formation. Sabina Gold and Silver Corp., 100% owner of the Back River Project, has recently released a positive pre-feasibility study and announced combined measured and indicated resources of 23.6Mt grading 6.0g/t Au, and additional inferred resources of 7.3Mt grading 8.0g/t Au. These resources are found predominantly in 3 deposits (Goose Main, Umwelt and Llama) in the Goose district and in 6 smaller deposits (Locale 1 & 2, LCP North & South, GH and Slave) in the George area, a satellite project area some 65km NW of Goose.

The pre-feasibility study presents an 8.4 year mine life commencing in Q4, 2017, with a total of 15.0 million tonnes to be mined at an average grade of 5.69 g/t Au. With the completion of the PFS, Sabina has commenced with its plan to complete a full feasibility study. The company is also well advanced in the preparation of a Draft Environmental Impact Statement, which is expected to be filed in early 2014. Since acquiring the Back River Project in 2009, Sabina has carried out aggressive annual exploration programs and discovered significant new resources, the Umwelt and Llama deposits being particularly noteworthy.

During the 2012 and 2013 field seasons, the company completed approximately 147,000m of diamond drilling, divided between resource expansion and definition, as well as brownfields and greenfields exploration and geotechnical investigations. Simultaneously, company geologists carried out 1:5,000 to 1:50,000 scale regional mapping programs to unify historical geological and structural reports covering the different properties composing the Back River project.

The project area is underlain by the largely turbiditic Archaean sediments of the Beechey Lake Group of the eastern Slave province, which hosts four multi-km scale occurrences of iron formation. The northern portion of the project area is occupied by clastic sediments and carbonates of the Proterozoic Goulburn Group.

Overall structural trends and styles conform well to the overall eastern Slave context, with three Archaean and two Proterozoic phases of deformation recognized. Most of the gold mineralization in the Back River Project properties is associated with quartz veins, silicification and high strain zones within the stratigraphically lower part of the oxide iron formation, and, to a lesser extent, within meta-sedimentary rocks and silicate iron formation of the greywacke unit underlying the iron formation. Sulphides include pyrite, pyrrhotite, and arsenopyrite, with accessory alteration assemblage of chlorite, carbonate, hornblende and grunerite. Visible gold is locally present, especially where sulphides are greater than 10% and where coarse-grained arsenopyrite is present.

Gold mineralization is thought to have occurred during the waning stages of D_1, or in a post-D_1/pre-D_2 time. Early S_1 fabric parallel quartz veinlet swarms are the most likely vector of this initial gold endowment. Subsequently felsic dykes exploited the silicified pathways formed by the veinlet swarms, resulting in the development of locally significant gold remobilization during D_2 deformation.

NEW GEOLOGIC MAPPING AND ASSOCIATED ECONOMIC POTENTIAL ON NORTHERN HALL PENINSULA, BAFFIN ISLAND, NUNAVUT

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This presentation reports on field observations, initial interpretations, and early implications of six-weeks of geological investigation on the northern Hall Peninsula of southern Baffin Island, Nunavut. As part of the Canada-Nunavut Geoscience Office's 2012-14 Hall Peninsula Integrated Geoscience Program, the 2013 field work was focused on furthering geoscience knowledge and documenting the economic potential of the area. Observations suggest that the geology underlying Hall Peninsula represents a transition from an orogenic foreland to hinterland, related to terminal collision of the Paleoproterozoic Trans-Hudson Orogen. Three associated phases of deformation were documented, as well as an east-to-west increase in metamorphic grade. Regional-scale east-verging folds and thrust imbricates have structurally thickened Archean basement and Paleoproterozoic supracrustal units on Hall Peninsula.

Bedrock mapping has identified several localities with potential economic interest. Two large layered mafic/ultramafic intrusions identified in the northern and southwestern portions of the peninsula show potential for Ni-Cu-PGE mineralization. The geological setting of the layered intrusions appears comparable to that reported for the higher-level Raglan-type deposits in the Cape Smith Belt of northern Quebec. Several ultramafic intrusions on the eastern side of the northern Hall Peninsula exhibit post-emplacement hydration alteration features and assemblages. Hydrated ultramafic rock is the most common type of carving stone used in Nunavut, and is a valuable commodity that is currently in high demand as the traditional art form expands to reach new global markets. Other economically interesting discoveries on northern Hall Peninsula include silicified pyrite- and pyrrhotite-bearing gossans, granitic pegmatites, and a semi-precious fluorapatite showing.

COMMUNITY STEWARDSHIP AND LOW-FLOW CHANNELS FOR AN ARCTIC CHAR RUN IN NUNAVUT, CANADA

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New climate trends may pose a risk to domestic fisheries in the Canadian Arctic. We studied a historically significant Arctic char run in Nulahugyuk Creek where local knowledge refers to a recent decline, possibly in response to lower flows. In 2012, we partnered with the Inuit community of Kugluktuk, Nunavut, with the following objectives: i) to better understand the fish migration and current state of the run; and ii) to create experimental low-flow channels for fish passage using traditional rock weir and watercourse engineering principles. Over the 18-d study period the char run peaked early when flows were highest: 95 adults captured July 5, versus two adults captured July 21 when flows had decreased by 50%. Mortality from stranding in the lower section of the creek was high (>8% tagged

fish) and only a small percentage of tagged fish successfully moved upstream. Data-logging antennae arrays recorded surprisingly low speeds during migration (1.3km/d). The data suggest challenging conditions including warm, shallow water and many barriers. In response we identified five problem locations in the creek where boulders were removed by hand and placed to direct flows and fish. Post-manipulation, water levels increased 70% and upstream movements of fish were observed. The community-based approach provides a novel solution for a changing north, including off-site habitat compensation for losses incurred by mining.

THE TIBBITT TO CONTWOYTO WINTER ROAD: PAST AND FUTURE CLIMATE CHANGE

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The area around Yellowknife has experienced a significant warming trend in every season since the 1940s. However, the greatest warming occurred during the winter months with an average temperature of -26.0°C for 1943-1976 and an average of -23.3°C for 1977-2009. In addition, there has been a major increase in precipitation since the 1940s.

In this presentation we present an overview of new proxy data for Holocene climate change in this region and link these to the instrumental record to put the recent climatic changes into a long-term context. It is clear that recent warming in this region has been very rapid. The major increase in warming and precipitation occurs after the 1976 phase shift of the Pacific Decadal Oscillation (PDO).

We use a series of global climate models to produce an ensemble of future climate scenarios for the Northwest Territories and develop site-specific future temperature and precipitation estimates based on an established statistical downscaling approach. Our results suggest that changes to the operation of the Tibbitt to Contwoyto winter road system will have to be developed for continuing viability.

INTEGRATING SURFACE AND SUB-SURFACE DATA TO OPTIMIZE LAND USE PLANNING

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Effectively balancing environmental and economic sustainability around land use issues requires the ability to make informed decisions on trades-offs and cost-benefit analyses. Across western Canada land use planning has been employed in various capacities to balance industrial development and ecosystem conservation. Such plans typically divide a landscape into zones in which different types and amounts of land uses are permitted. However, the decision-making metrics that underpin such planning processes often lack sufficiently detailed information on economic interests, particularly detailed sub-surface data for oil and gas potential. Because environmental data are easy and cost effective to obtain

relative to sub-surface data, environmental data are often over represented in decision-making processes. This is problematic where land use planning strives to incorporate multiple and often competing land uses in that incomplete information precludes informed discussions around trades-offs and cost-benefits and may unintentionally bias resulting zoning and permitted uses within a landscape.

The objective of this paper was to compare how land use planning decisions may differ relative to different data inputs and different land use values. Using the emerging Canol Shale play in the Central Mackenzie Valley (CMV) in the Northwest Territories (NWT) as a case-study, we created a series of integrated maps based on both wildlife and hydrocarbon data. First we used data on caribou winter range and moose and furbearer distribution and density collected during environmental monitoring on two winter seismic operations to identify habitats and regions within the CMV of high value to wildlife. Next we used a sub-surface model developed from existing seismic and well log data and new 2D seismic data acquired in 2011/12 and 2013 to identify likely oil and gas windows and estimated shale thicknesses within the CMV. Lastly, we integrated those data and compared how decisions may differ first by withholding portions of the whole dataset and next across a continuum of development-conservation values.

This work moves the discussion around land use planning forward in two important ways. First, we show that by including additional layers of data, decision making around trade-offs can be more completely contextualized. Second, we demonstrate that even with additional data, choices around trade-offs are complex. While market forces efficiently adjudicate commodity values in measureable ways, those forces are not equipped to similarly adjudicate ecological values. Rather, ecological values are measured by individuals and are therefore subjective. Further thought is required around how much weight different values carry in decision making, however, we believe that integrating a suite of relevant surface and sub-surface data, even as these data relate to competing interests, can better reflect the complex set of values around managing energy development in the CMV among rights- and stake-holders.

TŁĮCHO AQUATIC ECOSYSTEM MONITORING PROGRAM (TAEMP) OVERVIEW

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The Tłįcho Aquatic Ecosystem Monitoring Program (TAEMP) has been active for four years in the Tłįcho region in the NWT, most recently in the community of Gametì in September 2013. The purpose of the TAEMP is to implement an aquatic ecosystem monitoring program based on Tłįcho and scientific knowledge to determine whether fish health, water, and sediment quality is changing over time at locations near each of the four Tłįcho communities. The program centres around a five-day out-on-the-land camp which allows elders and scientists to share knowledge, and provides opportunities for the participation and training of youth. The use of Tłįcho and scientific knowledge further provides the foundation for an approach to long-term monitoring, and contributes to the overall Marian Lake Watershed Stewardship program. The TAEMP is led by two wildlife management authorities in the Tłįcho

region: the Wek'èezhìi Renewable Resources Board (WRRB) and the Tłı̨cho Government, and is further supported by staff from the Wek'èezhìi Land and Water Board (WLWB), the Department of Fisheries and Oceans (DFO), and Golder Associates. This program will contribute to cumulative effects monitoring by providing baseline and monitoring of water quality, sediments and fish health trends through time. These data, combined with monitoring information from communities, mineral exploration projects, abandoned mines, and long-term water quality monitoring stations, will help detect ecosystem changes. The presentation will summarize insights gained on successful community engagement and data collection through use of standardized protocols with examples provided from previous years.

USING RADARSAT-2 DATA TO SUPPORT CUMULATIVE IMPACT MONITORING OF WATER RESOURCES IN THE NORTHWEST TERRITORIES

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Resource development is accelerating in the Northwest Territories (NWT), particularly mineral resources in the North Slave region and oil and gas in the Central Mackenzie Valley. The territorial and federal governments are working together to develop and implement a cumulative impact monitoring program (CIMP), which requires environmental baseline information and effective approaches for monitoring. The resource industry is also interested in effective approaches to gather information prior to exploration and development activities.

The presentation will introduce a new initiative to use satellite remote sensing to support understanding of baseline conditions and monitor and detect environmental change across large areas. These remote sensing tools include radar, which provides the unique ability to provide information on lake and river ice conditions. Using a combination of radar and optical satellite images, the "*Earth Observation for Cumulative Impact Monitoring*" project will supply environmental baseline data for northern water bodies, specifically information on lake ice conditions, surface water extent, wetland types, and submerged aquatic vegetation.

Mapping areas where lake ice has frozen to the bottom helps to indicate the suitability of lakes as fish overwintering habitat. It can also act as a proxy for water depth as shallower lakes will have higher proportion of grounded ice. This information may be valuable for industry to help plan potential use of certain lakes as part of resource development and transportation corridors. Lake freeze-up and the expansion grounded ice can be monitoring using radar images, such as RADARSAT-2.

The extent of surface water and trends in water availability are of interest for water resource management. Seasonal, annual, and decadal trends may be assessed using an extensive archive of RADARSAT data, since water body extent can be extracted from radar images. Functional wetland types can also be extracted from remotely sensed

data, especially with a combination of radar and optical satellite data such as RADARSAT and RapidEye.

The use of satellite remote sensing will be an important tool for cumulative impact monitoring, including community and industry partners. State-of-the-art regional environment monitoring programs are increasingly looking to apply remote sensing technologies to support field-based methods. The use of satellite remote sensing can be an important tool to monitor and collect environmental data for northern water bodies and help study cumulative impacts.

The presentation will introduce the project, technologies, and the opportunities for participation.

MARIAN WATERSHED COMMUNITY-BASED AQUATIC EFFECTS MONITORING PROGRAM

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

Tłįcho Lands have been under Moratorium since the signing of the Tłįcho Agreement in 2005 and on June 1, 2013, the Moratorium was lifted as the Tłįcho Wenek'e or Land Use Plan came into force. With the potential for future development of Tłįcho Lands, the Tłįcho people have expressed concern about impacts on the water and wildlife they are so dependent upon. The Marian Watershed Monitoring Program is being established to start collecting baseline information about the water and fish on Tłįcho lands and in locations the Tłįcho feel are the most important, prior to any major development pressure, 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 Hyslop Lake this fall. This area was chosen by community members due to its close proximity to the proposed Fortune Minerals NICO project. This is an area that is of utmost concern to Tłįcho history and modern day life. One elder and 5 community monitors previously trained by the Department of Culture and Lands Protection (DCLP) participated in the study gaining further hands on training. The program will expand each year to ensure further monitoring of Tłįcho waters by Tłįcho people, with communication back to community members being a key component of the program.

BATHURST CARIBOU INTERACTION WITH WINTER ROADS IN THE NORTH-CENTRAL NORTHWEST TERRITORIES

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Concerns over the interaction between caribou and winter roads were raised during the Environmental Impact Review process for both the De Beers Gahcho Kué Project and Fortune Minerals NICO Project. Mortality from harvest and collisions with vehicles and changes in migratory movements and behaviour were concerns related to effects from roads on caribou. Movement data of Bathurst caribou cows equipped with satellite and global positioning system (GPS) collars were used to estimate the frequency of encounters and residency times within a 5 km buffer around the Tibbit-to-Contwoyto Winter Road (TCWR), Tłı̨cho Road Route (TRR) and Gahcho Kué Project winter access road during 1996 to 2010 in a Geographic Information System (GIS) platform. The seasonal movements of collared caribou indicated that the Bathurst herd reach their wintering areas below the treeline no later than December and remain there until May. During the operational period of winter roads, which is January to April, caribou daily movement is much lower than other seasons. The potential for interactions with vehicles and roads will partially depend on the winter distribution of animals, and the correspondent distance to roads. For the TCWR and TRR which traverse or occur below the treeline, encounter rates and residency times have been generally low during the study period. During the same period, recorded caribou mortality from vehicles was low, and would result in a negligible change to caribou abundance. The Bathurst herd begins to migrate towards the calving grounds in May when winter roads are not in operation and snow berms are deteriorating, which suggests that winter roads likely have little influence on caribou migration routes. However, the effect of winter roads on caribou harvest levels is uncertain, and requires the collection of appropriate and sufficient data and analysis.

SATELLITE REMOTE SENSING OF FOREST TREE SPECIES DISTRIBUTION IN THE NORTHWEST TERRITORIES

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Natural resource management in northern forested areas requires land cover and tree species identification for improved decision making for sustainable resource development. For example, the NWT Biomass Energy Strategy and Boreal Woodland Caribou Action Plan require detailed forest resources information, from which resource inventory and maps of wildlife habitat, landscape disturbance, and vegetation cover can be produced. These are important for industry sectors through policy compliance and permits for exploration, and for government monitoring and inventory. However, the acquisition of forest information is often time-consuming and expensive due to the large areas, remoteness, and inaccessibility of northern boreal forests. Therefore, satellite-based remote sensing is increasingly used to derive these products over large areas. Although information regarding the distribution of tree species has been obtained using remote sensing in forest regions in southern Canada, these approaches are either untested or not

suitable for higher-latitude, more open forest stands of the NWT. Because satellite signals are highly mixed due to the presence of tree shadows and understory vegetation in lower density open forests, spectral mixture analysis (SMA) based on analysis of sub-pixel scale components was considered appropriate for investigation. In this study, a satellite land cover map had already been generated, however, information about forest tree species distribution was not available. SMA was used to identify leading tree species near Fort Providence NWT using Landsat Thematic Mapper imagery as a new attribute for the land cover map. A preliminary accuracy of 81% was achieved for four species based on 48 ground plots using SMA of multiple-date imagery acquired at different stages of the growing season. Work is continuing to further improve these results and to collect independent information for validation.

Abstracts - Poster Presentations

GEOCHEMICAL CHARACTERIZATION OF ARSENIC-RICH SUBAQUEOUS TAILINGS AT TERRA MINE, NWT

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The mobility of arsenic (As) in subaqueous environments depends on redox conditions and pH of the water, as well as the mineralogical form in which the As is held. Arsenic has been identified as the primary element of concern at the abandoned Terra Mine Site. Terra, which closed in 1985 after 16 years of mining, is located 10km from the southeast shore of Great Bear Lake. Mined for silver, copper and bismuth, the deposit contains a complex mineral assemblage with the ore hosted in structurally controlled hydrothermal veins within the calcareous mudstone of the Terra Formation in the Bear province.

It is estimated that roughly 500,000 tons of tailings produced from the milling and processing plant were deposited in Ho-Hum Lake during the life of the mine. This is the single largest source of As to the local environment from the mine site. The surface water of Ho-Hum Lake is of circumneutral pH, and contains As concentrations between 50 and 80µg/L, which is significantly higher than the maximum of 5µg/L recommended for aquatic life.

Arsenic was hosted in arsenopyrite (FeAsS) in the ore, but sulfide oxidation may have led to release of As to water and the partial attenuation of As by Fe oxides. Previous work has shown that these As-hosting Fe oxides are susceptible to reductive dissolution leading to further release of As to water and the transformation of the mineralogical hosts for As from Fe oxides to As-S precipitates such as realgar. Thus, depending on redox conditions, sediments can act as either a source or a sink for As. Understanding As mineralogy is critical for predicting long-term stability of Ho-Hum lake sediments.

Two field programs were conducted in 2013, during which surface water, pore water, sediment and mineral precipitates were collected. Water samples will be analysed for metals, metalloids, anions as well as As speciation. Solid samples will be analyzed for bulk geochemistry, and subsamples will be selected for detailed mineralogical work.

The purpose of this study is to characterize the subaqueous mine tailings in Ho-Hum Lake. This will be done by determining the minerals hosting As, what processes are controlling arsenic release or sequestration within the mine tailings, and how these processes vary spatially and with depth. This information can potentially be used to modify the design of the remediation planned for the site.

REGIONAL METALLOGENY PATTERNS AS REVEALED BY STREAM SEDIMENTS FROM THE MACKENZIE MOUNTAINS, NWT.

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The Mackenzie Mountains, Northwest Territories, Canada, are the northern extent of the Cordilleran thrust belt of the Cordilleran orogen and have evolved over the last billion years. Neoproterozoic siliciclastic and carbonate sedimentary rocks, with minor igneous rocks, are related to the break-up of the Supercontinent Rodinia. Paleozoic sedimentary rocks record an evolving passive margin on the northwestern edge of Laurentia. Mesozoic (Cretaceous) post-collisional granitoid intrusions resulted from accretionary tectonics on the western edge of North America. Laramide-related thrusting and folding that overprints earlier synsedimentary deformation, is responsible for the current architecture of the region. This diverse and extensive tectonic evolution has resulted in an equally diverse collection of >300 documented mineral deposits and prospects.

The mineral deposit types can be arranged chronologically. In the Neoproterozoic these include stratiform/stratabound Kupfersheifer-type Cu-Ag hosted in the rift-related Coates Lake Group. The Coates Lake deposit being the largest, contains a historical resource estimate of 33.4 million tonnes @ 3.92% Cu and 10.3g/t Ag. The second deposit type is stratiform Fe occurring as part of hematite-jasper iron formation in the rift-related glacio-marine Rapitan Group with a historical resource estimate of 5.6 billion tonnes @ 47.5% Fe. Phanerozoic mineralization styles include sedimentary exhalative (SEDEX) Zn-Pb that deposited synchronously with deep-water shales in the Cambrian through Devonian of the Selwyn Basin. The Ordovician-Silurian Howard's Pass region contains 185.6 million tonnes @ 5.20 Zn% & 1.79% Pb of shale-hosted mineralization and is considered one of the largest undeveloped zinc deposits in the world. Greater than 200 mineral occurrences belong to the carbonate-hosted Zn-Pb (+base-metals) type, found in the carbonate Mackenzie Platform. Mineralization styles are variable in this deposit type and potentially four sub-types exist. The best example is at Prairie Creek, hosted by Paleozoic sedimentary rocks and Laramide-related faults and containing 11.7 million tonnes @ >20% combined Pb-Zn and 229g/t Ag. Cretaceous intrusion-related W-skarn (proximal to intrusions), base-metal skarn (distal from intrusions), rare-metals and semi-precious tourmaline related to pegmatites, and vein-hosted emeralds, occur throughout the southwestern Mackenzie Mountains. Cantung Mine and the Mactung deposit are the western world's largest W-deposits, containing 2.9 million tonnes @ 1.21% WO3 and 33 million tonnes @ 0.88% WO3 respectively.

Regional stream sediment surveys have an excellent record for guiding exploration efforts and have been carried out over much of the Canadian Cordillera using the National Geochemical Reconnaissance (NGR) methodology. Since 2003, a silt, water, and bulk stream sediment survey has been conducted throughout the Mackenzie Mountains by the Northwest Territories Geoscience Office and the Geological Survey of Canada, collecting material and observations from over 9000 sites, including nearly 1300 HMC samples. These surveys are based on a grab sample of silt-sized stream sediment, and a corresponding water sample, collected at a density of one sample per 13 km^2. The collection of coarser-grained and volumetrically-larger samples for heavy indicator minerals has been assessed at a lesser density. The results largely demonstrate agreement with the established regional metallogeny, but there

is evidence for other potential mineral deposit types yet to be found.

SYNTHESIS OF COASTAL GEOSCIENCE DATA FOR DEVELOPMENT IN THE BEAUFORT REGION

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The southeastern coastline of the Beaufort Sea, from the Alaska/Yukon border to Cape Dalhousie on the Tuktoyaktuk Peninsula, NT, is a transgressive coast in ice-rich unlithified deposits susceptible to rapid erosion and morphologic change. Oil and gas activity in the Beaufort Sea is reliant on the coast for access to supplies, services, shelter, and other shore-based facilities. Baseline coastal geoscience information at existing and potential port sites and harbours of refuge is critical for future environmental assessments in this sensitive area. The Geological Survey of Canada has been funded as part of the Beaufort Regional Environmental Assessment (BREA) to compile and synthesize information on coastal and nearshore seabed conditions critical to the planning, site selection, regulation and management of potential harbour facilities. This project is providing an inventory, synthesis and analysis of geoscience knowledge for the coastal zone of the Canadian Beaufort Sea. Industrial and community stakeholders have expressed interest in this type of information, in particular nearshore bathymetry, coastal classification, and shore-zone change assessment data.

Here, we provide an overview of the coastal geoscience information assembled for the entire region with a more detailed examination of data acquired for the existing critical port at Tuktoyaktuk and other potential port sites at McKinley Bay, NT, and King Point, YT. Repeat coastal surveys, combined with analysis of historical air photos and satellite imagery, provide information on rates of coastal change for Tuktoyaktuk Harbour and vicinity, including rapid shrinking of Tuktoyaktuk Island in the harbour mouth. Nearshore, sub-bottom data combined with bathymetric charts and more recent multibeam surveys provide information on shoaling of the harbour and its approaches. Preliminary evidence suggests significant infilling of a channel just inside the eastern harbour entrance with sediment eroded from the front of Tuktoyaktuk Island. At McKinley Bay, repeat multibeam bathymetric surveys were used to assess infilling of the dredged entrance channel. Wave and current data at Atkinson Point provide a basis for quantifying longshore sediment transport toward the harbour mouth. Repeat surveys at monitoring sites on the coast provide a measure of coastal change between 1988 and 2013. At the historic harbour of King Point, used for the 1905-1906 overwintering of the Gjøa in the first transit of the Northwest Passage, the entrance to the lagoon, open in the 1950s, was closed by spit extension before 1970. Our analysis of coastal change at this site is based on historical air photos and a repeat survey of coastal monitoring sites in 2012. Despite the challenges of combining several decades of data derived from different sources and equipment, this on-going activity has successfully helped to identify data gaps and will contribute to an improved knowledge of

coastal processes for the Beaufort Sea region.

LOW OCCURRENCE AND DIVERSITY OF POLLEN OF DICOTYLEDENOUS FLOWERING PLANTS IN THE LATE ALBIAN-AGED HASSEL FORMATION ON ELLESMERE ISLAND, SVERDRUP BASIN

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Rare tricolpate pollen of dicotyledonous flowing plants, an important biostratigraphic marker, is first documented in the Sverdrup Basin of the Canadian Arctic in the Albian (Lower Cretaceous). At more southern latitudes in Canada and even at high latitudes in Asia, this pollen type appears much earlier in the rock record and with greater diversity than is documented in Arctic Canada. Biostratigraphic age determinations in the less studied rocks of the Canadian Arctic are made by correlation to better-dated strata elsewhere in the world. The apparent latitudinal diachroneity in Canada, and temporal discrepancies to other parts of northern hemisphere of the first appearance of pollen from dicotyledonous flowering plants warrant further research. Angiosperms are thought to have evolved as a stream-margin pioneer flora, and so the wide-spread Hassel Formation's Late Albian to Early Cenomanian fluvial-deltaic sediments represent ideal depositional system to sample for early dicotyledonous angiosperm pollen. We analyzed 54 palynological samples from six sections of Hassel Formation exposed on Ellesmere Island to document the occurrence and diversity of angiosperm pollen to compare with previous studies of Hassel Formation and equivalent strata at other sites in the Canadian Arctic. Similar to previous studies from the central Sverdrup Basin and Baffin Bay Basin, few tricolpate angiosperm pollen are documented. We show that angiosperms were present in the central Canadian High Arctic by at least the Albian. Our findings also support previous interpretations of angiosperms being present in Hassel Formation deltaic/fluvial settings as pioneer flora and we demonstrate that a paucity and low diversity of early angiosperms was a widespread phenomenon in the Sverdrup Basin.

PRELIMINARY PETROGRAPHY AND GEOCHEMISTRY OF THE DUDLEY LAKE AREA (NTS 106B/6&7) VOLCANIC ROCKS, MARMOT FORMATION

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The Misty Creek Embayment (Mackenzie and Selwyn Mountains, NWT) was an Early Paleozoic rift-related depocenter for basinal sediments and alkaline magmatism. Marmot Formation mafic volcanic and intrusive rocks are unusually thick in a rugged 6x4km area near Dudley Lake. They overlie Ordovician Rabbitkettle Formation silty limestone and underlie Ordovician-Silurian Duo Lake Formation shale and siltstone. The Dudley area was chosen for its thick pile of unexamined Marmot Formation, and because the Selma bedrock mapping project provided a framework within which to interpret the sampled rocks. The

volcanic/intrusive rocks were chosen for a focused petrographic study whose ultimate aim is to reveal any characteristics relating to mineralization and economic potential.

An ENE-striking thrust fault in the target area places Marmot Formation on top of a stratigraphic succession of Marmot Formation overlain by black shaley limestone of Duo Lake(?) Formation. A NW-trending, linear, low-amplitude magnetic high, and coincident sharp gradient in potassium content (2011 NTGO Source Peaks survey), are at least eight kilometres long. The north end of the magnetic anomaly coincides with a circular gossan about 400 metres in diameter, which is one of three areas examined in 2012. The Ridge Area, north of the Gossan, is within the thickened volcanic/intrusive exposure, and the Valley Area is south of the thrust.

Hyaloclastite is present in the Ridge Area, where also clinopyroxene (augite?) and biotite-phlogopite phenocrysts are well preserved in relatively fresh rock. Clinopyroxene is zoned, with a reabsorbed core and a euhedral rim. Completely altered olivine and partially altered glomero-plagioclase phenocrysts are present in some samples. The matrix ranges from palagonitic to devitified to trachytic in texture. Amygdules have varying abundance, shape and size distribution, and zoning. Some breccias are pseudobreccias created by alteration. A "lava lamp-like" • outcrop may be a peperite formed by lava in ash. Angular, lava-armoured fragments are mostly pelletal lapilli(?), but range up to bomb size. Magnetic minerals were not discovered in the Gossan Area to explain the magnetic anomaly, although both magnetic and non-magnetic disseminated pyrrhotites are present in the Ridge Area.

In the Valley Area, amygdaloidal - phenocrystic flows are overlain by volcanic flow and pyroclastic breccias, which are overlain by volcaniclastic conglomerate grading up to sandstone-siltstone with graded bedding and cross-bedding.

Sulphide minerals and textures include primary chalcopyrite, pentlandite exsolution flames in pyrrhotite, and pyrrhotite with an apparent affinity for plagioclase phenocrysts. The pyrrhotite is variably altered with incipient to pervasive "birdseye" • texture. Pyrite-marcasite is present as disseminations, stringers and carbonate(?) replacements. In the Gossan Area, pyrite is common as disseminations and in stylolites, as are carbonate veins with wallrock alteration and patchy zones of pervasive alteration. A sample of broken rock taken downslope from the circular gossan returned 1190 ppm Zn, 124 ppm Cu and 239 ppm Pb from 35-element ICP. In this sample sphalerite stringers have exsolved chalcopyrite blebs.

Additional petrography and microprobe analyses are planned for 2014, to identify the chemistry of the primary and secondary silicate, oxide and sulphide mineralogy, with focus on the economic potential.

ESTABLISHING A PRECISE CHRONOLOGY OF VOLCANOGENIC MASSIVE SULPHIDE BASE AND PRECIOUS-METAL DEPOSITS IN THE ARCHEAN SLAVE CRATON

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The Banting VMS project is investigating volcanic belts throughout the Archean Slave craton in the Northwest Territories for their potential to host volcanogenic massive sulphide (VMS) base and precious-metal deposits. A number of major deposits are known and currently being explored in Nunavut, including IZOK Lake, High Lake, Hood, and Hackett River. Historically known deposits in the NWT include DEB in the Courageous Lake volcanic belt, BB in the Indian Mountain volcanic belt, Sunrise in the Beaulieu River volcanic belt and a number of smaller prospects. A key objective is to establish the time of formation for known deposits across the craton and compare this to the timing of volcanic belts that appear to have VMS deposit potential. The project aims to produce 30 new high-precision ages from across the craton and this presentation will provide an insight into the preliminary dataset.

To establish the timing of VMS deposit formation we are targeting deposit-hosting footwall or hangingwall rhyolite or dacite flows or tuffs and employing high-precision U-Pb zircon dating by chemical-abrasion thermal ionization mass spectrometry (CA-TIMS). Once the known deposits are precisely dated, they can be compared on a deposit to deposit and volcanic belt to volcanic belt scale across the craton. For example, historic and new data indicates at least two time-frames of VMS deposit formation. From historic data, it appears the High Lake and DEB deposits formed around ca. 2700 Ma in felsic volcanic rocks near the top of the Kam Group. The second time interval appears to be around ca. 2670 Ma. The host-rock ages will be complemented by high-precision εHf_{zircon} and $\varepsilon Nd_{whole\text{-}rock}$ tracer isotopic studies. These results will be compared with the pattern of historic Pb_{galena} isotopic data from Slave VMS deposits to allow a more refined estimate of the role of ancient Archean crust in their formation.

NWT FIELD SCHOOL: BEDROCK MAPPING IN THE YELLOWKNIFE GREENSTONE BELT

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Since 2003 the Northwest Territories Geoscience Office (NTGO) has partnered with the University of Alberta to conduct a unique advanced fourth-year field school in the Northwest Territories. The field school delivers a two-week bedrock mapping course at the end of August and exposes six 4th-year undergraduate students to the challenges and rewards of conducting field work in the North. A new locality is chosen each summer where the general geologic setting is known but the existing maps need upgrading. This results in an undergraduate research project driven by independent observations and critical thinking, making a real contribution to the NTGO's knowledge base. This is contrasted with most other field schools in which the same localities have been visited for 40+ years, resulting in cut-and-paste "cookbook" • exercises.

Over the course of 10 days, bedrock mapping was undertaken on a series of islands located in Yellowknife Bay on Great Slave Lake. The main objective was to characterize and map a portion of the

Yellowknife Greenstone Belt, an Archean aged unit (2700 Ma) located in the Slave Province. Mapping was facilitated by inflatable Zodiac watercraft to allow access to several islands located within the study area. A wide range of rock types were encountered during the mapping project: volcaniclastic rocks, tholeiitic basalts, gabbroic sills, and three varieties of dyke intrusions. Mapping observations indicated two distinct zones within the mapping area based on the abundance of supracrustal material present. Igneous dykes comprised three different types, indicating the possibility for multiple dyke swarms. Overall, field observations indicate a complex interplay between volcanic activity, sediment transport and deposition, and post-deposition/emplacement igneous intrusion.

THE BANTING GROUP VMS PROJECT: RESULTS FROM BEDROCK MAPPING IN 2013

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The Banting Group VMS (volcanogenic massive sulfide) project aims to test the VMS prospectivity of ca. 2690-2660 Ma volcanic rocks from select greenstone belts of the Slave craton within the NWT (see also Ootes et al., this volume). In 2013, bedrock mapping was carried out at 1:7500 scale at Sharrie Lake, Indin Lake and at the Snare River. At Sharrie Lake, mapping focused on refining contacts defined in 2012 and extending the limit of mapping to incorporate VMS-style mineral showings reported in NORMIN.db. The "Devore" showings occur along basalt-rhyolite contacts in the highly strained SE part of this bimodal belt. A sample from one of the Devore trenches yielded >5000 ppm Pb, 36500 ppm Zn, 199 ppb Au, 294 ppm Ag, and 442 ppm Cu. Ongoing geochemical studies will augment the characterization of the main volcanic units and alteration styles (see Berger et al. and McGoldrick et al., this volume). A preliminary age of the Sharrie Lake rhyolite indicates it erupted at ca. 2680 Ma, considerably older than expected.

The volcanic rocks exposed along the Snare River near Wijinnedi Lake are divided into northern and southern belts. The northern belt is characterized by abundant mafic and intermediate lavas and volcaniclastics, gossans along flow contacts and at the sediment interface, and extensive areas dominated by features suggestive of volcanic-sediment interaction (e.g. basaltic pillows within a sandy groundmass). In contrast, south of Snare River dacite-rhyolite predominates, exposures of coherent lava are subordinate to volcaniclastics, and sulfide mineralization is generally restricted to the felsic volcanic-sediment contact. A submarine depositional environment is likely for both belts, however local cross-bedded sandstones may indicate a near wave-base environment was achieved during buildup of the southern dacite-rhyolite centre. Forthcoming geochronology and geochemistry will attempt to resolve whether the northern predominantly mafic-intermediate belt is genetically and temporally related to the southern felsic centre (see Williams et al. and Ootes et al., this volume). A preliminary crystallization age of 2674.7 ± 0.8 Ma was obtained from rhyolite exposed south of the Snare River.

At Indin Lake, a 4 km^2 area of the Burnt Inlet volcanic belt was examined. Mafic-

intermediate volcanic rocks (Leta Arm group) dominate, with thin, discontinuously traced felsic volcanic units and enigmatic quartz-rich (± amphibole, garnet, staurolite, andalusite) rocks occurring near the interface with overlying greywacke-mudstone turbidites that contain staurolite, garnet, andalusite, cordierite and fibrolite. All volcanic rocks are variably metasomatised as evidenced by the near total (and locally complete?) obliteration of features such as pillow selvages in mafic flows and presence of staurolite and andalusite in amphibole-bearing rocks. Preliminary analyses of a sample of highly strained and variably altered rhyolite has yielded two zircon fractions with ages of ca. 2700 and 2670 Ma. As in the Snare River area, evidence of coincident volcanism and sedimentation is widespread and extensive gossan zones locally mark the sediment-volcanic contact. Two samples, one each from the overlying sulfidic slates at Snare River and Indin Lake, yielded slightly elevated Au (15, 28 ppb), Cu (334, 256 ppm), and Zn (536, 739 ppm).

REMOTE PREDICTIVE SURFICIAL MATERIALS AND SURFICIAL GEOLOGY MAPPING: MARIAN RIVER, NTS 85-N, NWT

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Despite the relatively detailed knowledge of bedrock geology in the high mineral potential southern Bear-Slave region, our understanding of surficial sediments, permafrost extent, and geotechnical conditions is still limited in many areas. This lack of basic geoscience information hinders the understanding of present and future terrain risks to roads and other infrastructure, which are vital for sustainable northern economic development.

The remote predictive surficial materials map for the Marian River NTS Map Sheet 85-N was derived using Landsat 7 imagery (normalized bands 2, 3, 4, 5 and 7), a digital elevation model and forest fire history, with limited integrated SPOT5 satellite imagery and topographic characteristics calculated from CDED data to improve mapping capabilities and accuracy. The spectral signatures associated with bedrock, silty clay, diamicton, sand, modern lacustrine and organic units were established using "training areas" • determined from traditional airphoto interpretation and limited field validation data. A high level of statistical separation between the training area classes indicates that sufficient spectral differences exist for each surficial unit and a reasonable model can be built to map this region.

The central and eastern parts of the predictive map indicate silty clay infilling bedrock depressions and topographic lows between 157 m (current elevation of Great Slave Lake) and about 220 m asl. At elevations above 220 m, silty clay is less extensive, and isolated occurrences of diamicton in the form of reworked till veneer and unmodified blanket exist. The high spatial density of silty clay below 220 m contributes to the reconstruction of glacial Lake McConnell (estimated maximum elevation of 280-300 m) and identifies the distribution of thaw-sensitive silty clay terrain. Both exposed and vegetated outcrops in the Bear and Slave terrains were also identified, although distinguishing

potential bedrock of the Interior Platform was more problematical.
Remote predictive materials maps provide a first order assessment of surficial sediments, which can guide traditional surficial geology mapping efforts and offer regional information for geological interpretations and decision making processes related to infrastructure development, exploration and land use management. Surficial geology maps at 125K scale are derived from these predictive maps, based on conversion of materials to geology using expert regional knowledge, airphoto interpretation and landform assessment, field validation and data (striation measurements). The methodology used here builds on the success of the predictive surficial geology maps for the Yellowknife area, NTS 85-J (Geological Survey of Canada Open File 7108) and the Hearne Lake area, NTS 85-I (Geological Survey of Canada Open File 7233).

SUSTAINABLE MANAGEMENT OF THE TRI TERRITORIAL SURFICIAL GEOLOGY DATABASE: FACILITATING MORE EFFECTIVE EXPLORATION AND RESOURCE DEVELOPMENT

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The Tri-Territorial surficial geoscience database provides access to multi-scale surficial geoscience data in support of northern exploration and economic development. This is accomplished through a digital compilation and queriable geodatabase of new and existing surficial geology maps of Northwest Territories, Nunavut, and Yukon. The project also supports Geo-mapping for Energy and Minerals (GEM) mapping activities in Wager Bay, Cumberland Peninsula, and Victoria Island, as well as Climate Change remote predictive mapping (RPM) initiatives in the Marian River area (NTS 85-N).

The surficial database consists of 704 published maps, of which 477 (68%) were selected for digital compilation. Legacy publications include 241 maps from the Northwest Territories (106 maps in digital format) and 303 maps from Nunavut (211 in digital format). Approximately 160 maps from the Yukon are in digital format, and compiled by the Yukon Geological Survey. An additional 60 new GEM surficial maps and 50 unpublished manuscript maps will be added to the database. Within the Northwest Territories, the compilation includes a wide variety of maps, from detailed 50K-125K scales, to reconnaissance maps at 125K-1M scales with little or no field work.

The Geological Survey of Canada (GSC) recently developed a standard surficial geology legend, known as the Surficial Data Model (SDM) published in Open File 7003 (Version 1.2). This ensures the implementation of common map units and symbols, and facilitates new Quaternary geology mapping and correlation of map units at all scales. Conversion of legacy map units to the new legend is ongoing and will provide more indepth database queriability. The science language for the SDM will be updated regularly (Version 2.0 and beyond) to ensure that new map units and symbols requested by surficial geology mappers and map users are consistently implemented. The language allows mappers to archive information about earth materials in a manner that is consistent, uniform, and

flexible. The next phase in the project is to parse legacy knowledge terminology (map unit legend descriptions) and transfer it into the new corporate database, maintaining archival terminology where appropriate. A parsed, standardized science language will increase usability, queriability and comparability of geoscience knowledge of proven interest and value to stakeholders.

Currently, a preliminary compilation of published Northwest Territories surficial geology maps can be viewed at the NTGO website: www.nwtgeoscience.ca/google_earth/. An interactive, queriable web-based portal is being developed from which the complete GEM Tri-Territorial Surficial database will eventually be accessed, providing an effective dissemination tool for exploration industry, land-use planners and policy-makers.

TOWARD AN IMPROVED PROCESS UNDERSTANDING OF INDICATOR MINERAL DISPERSAL IN GLACIATED TERRAIN: A PROGRESS REPORT

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A significant amount of data has been collected for mineral exploration in glaciated terrain of northern Canada. A largely emperical approach has been utilized during the past 20 years with respect to understanding indicator mineral (IM) dispersal, which has lacked integration of modern process based research on glacial dynamics, landforms and landscapes. The Targeted Geoscience Initiative (Phase 4) (TGI-4) Indicator Mineral Dispersal Study is focussed on understanding of dispersal in glaciated terrains. The objective is to improve the interpretation of dispersal patterns by integration within a landscape context and through understanding of glacier processes for continental ice-sheets. In the past year work has focused on four components: i) formulating a process-based glacial dispersal model, ii) assessment of the Kimberlite Indicator Diamond Dataset (KIDD), iii) investigation of IM communition, and iv) variation of IMs in esker sedimentary facies.

i) The role of a subglacial thermal regime in the erosion, entrainment and deposition of debris beneath ice sheets was reviewed by Hooke et al. (2013). With this framework in place, they then presented a process-based model for the generation of ore plumes in till.

ii) An investigation of the structure and content of KIDD and comparison with a random selection of assessment reports identified some limitations in grain count reporting; however, > 87% of data in assessment reports are accurately reported within KIDD (in most instances the reporting accuracy is higher). Non-standardized reporting of sample weights and sampling site attributes places limitations on the use of KIDD. These limitations are not from an absence of data, but from the original database structure, which could be modified. KIDD offers a highly useable archival dataset; however, careful data evaluation by the user is required.

iii) A tumbling mill experiment using three

IMs was undertaken. In the experiments, pyrope garnet grains lost mass the fastest, followed by chrome diopside grains, and ilmenite grains, which lost very little mass. The pyrope grains lost mass as a result of grain fracturing into tens to hundreds of angular fragments, producing abundant sand-sized particles, in addition to abundant mud (i.e. silt and clay). The experiment highlights the importance of considering IM mass rather than just IM grain counts.

iv) The IM sampling protocol of glacifluvial sediments (especially eskers) on the generally untested assumption that fluvial and glacifluvial systems operate in similar manners. A test on IM concentration in various sedimentary facies of an esker was completed. Contrary to common belief, sandy esker facies commonly contained more IMs per unit weight than gravelly facies. This brings into question the common practice of targeting gravelly esker facies when sampling for IMs. It also suggests sandy esker facies could potentially provide equal or superior data.

Further investigation is being completed on each of the above items to refine the results, and to enhance the integration with field sampling protocols, laboratory analysis, and data interpretation.

PERMAFROST - INFRASTRUCTURE RESEARCH: GREAT SLAVE REGION, NORTHWEST TERRITORIES, CANADA

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Community and industry infrastructure is continually expanding throughout the extensive discontinuous permafrost zone of the Great Slave Region. Permafrost conditions strongly influence the type of infrastructure suited to northern environments, but few data exist to indicate where climatically-sensitive permafrost terrain occurs in this region. Permafrost and infrastructure are integral components of Transportation Risk in the Arctic to Climate Sensitivity (TRACS), which is a collaborative research network between Natural Resources Canada, Northwest Territories Geoscience Office, and Northwest Territories Centre for Geomatics. As a component of TRACS, a network of sites regarding the range of permafrost conditions has been established. This robust dataset includes air, near-surface and deep ground temperatures, snow and active-layer depths, geotechnical data, and automated digital imagery, located in a variety of ecological settings. In addition to ground-based investigations, remote sensing techniques are used to map locations of icing (a.k.a. aufeis, "glaciations"•, kw'oo) development, as their formation can affect the integrity of overland portions of winter roads and routing of steam flow during spring freshet. A 30-year data set is being developed to determine their total distribution and return frequency. Complimentary data at several overland winter road sites define local thermal and hydrological controls on icing development. The network also investigates long-term ground subsidence with interferometric satellite radar data, and permafrost thermal evolution through modelling, validation and field experimentation. Additionally, four maps of the local surficial geology, which strongly influences permafrost conditions, are complete. Established in partnership, this science network will continue to provide essential information on permafrost

conditions in this region, and will contribute to the understanding of permafrost changes with a warming climate.

PETROLOGY AND GEOCHEMISTRY OF CA. 2680 MA PILLOW LAVAS AT SHARRIE LAKE, SOUTHERN SLAVE PROVINCE, NWT

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Circa 2680 Ma volcanics in the Tumpline Lake subarea of the Cameron River - Beaulieu River volcanic belt in the southern Slave craton are being assessed by the NWT Geoscience Office to determine their potential as a prospective Volcanogenic-hosted Massive Sulphide (VMS) environment. Bedrock mapping, geochronology, petrology, geochemistry, and isotopic studies are being employed in this evaluation. Bedrock mapping at Sharrie Lake in the Tumpline Lake subarea, located approximately 70 km ENE of Yellowknife, was completed at 1:7500 scale in 2012 and 2013. Two types of pillowed flows were selected for further study from this strongly bimodal subarea in which the mafic constituents are the Tumpline basalt flows including basalt, andesite and dacite members. In addition to some true pillowed basalts, many flows have basalt-like textures yet appear to be dacitic to rhyolitic. The VMS-potential of these pillowed lava flows will be assessed by characterizing the alteration and constraining the timing of alteration and deformation relative to metamorphism. A petrographic study will be complemented by whole-rock major, trace and rare earth element data from 23 samples and electron microprobe analyses of selected minerals. Metamorphic assemblages and P-T conditions will be documented in order to assess the effects of post-alteration processes.

The flows sampled for this study were mapped as mafic or intermediate based on consistent field criteria, although some were previously mapped as felsic volcanic rocks. A detailed petrographic and geochemical study will be undertaken to determine their primary compositions (e.g., basalt or dacite) and the effects of alteration. Primary volcanic features, including pillows, are variably preserved at Sharrie Lake despite heterogeneous strain and greenschist to lower amphibolite facies metamorphism. Distinctive but heterogeneous outcrop-scale alteration textures indicate possible silicification and sericitization which could be associated with a VMS-potential environment. In thin section, disseminated groundmass carbonate is common and ovoid aggregates of quartz and carbonate, interpreted in the field as deformed amygdules, display textures indicating recrystallisation during regional metamorphism. The origin of sigma- and delta-type porphyroclasts of recrystallised quartz is enigmatic but they are hypothesized to be amygdules. Heterogeneous strain at thin section scale is shown by sigmoidal quartz and plagioclase porphyroclast morphologies and a variably developed foliation defined by the alignment of biotite and amphibole. Peak metamorphism was syn- to post-kinematic based on syn- to post-folation hornblende growth and post- foliation garnet growth. The relative timing of carbonate and quartz alteration is ambiguous owing to the effects of heterogeneous strain; sericitization is spatially associated with cross-cutting veins and is interpreted to be late.

GEOLOGICAL COMPILATION OF THE WESTERN MAINLAND AND SOUTHERN ARCTIC ISLANDS REGIONS, NORTHWEST TERRITORIES

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The compilation of existing geological data for the western NWT in a Geographic Information System is nearing completion. The compilation will be first released digitally as seven seamless maps within a geodatabase; shapefiles will be included as an option. Eventually, a series of regional maps, complete with a standard map legend, will be available in hardcopy format.

Current efforts are focusing on mainland NWT and adjacent parts of Yukon Territory and Nunavut, and have begun integrating the geology of the Arctic Islands. Work is also utilizing all published maps and reports up to 2012. Provision of recently completed but unpublished maps is gratefully acknowledged, as is the exchange of ideas with several geologists with valuable first-hand knowledge.

Data for the compilation were originally assembled as AutoCAD maps and Excel spreadsheets. The AutoCAD files were then disassembled, managed and thematically reconstructed in accordance with standard geological practices into a geodatabase within ArcGIS. Topology was rigorously tested and maintained throughout the process. The spreadsheets are a continually evolving, comprehensive legend that includes data from the compiled maps, correlation charts, subsurface, and supplementary information in government and industry reports and academic publications. From these spreadsheets, standard unique unit labeling and colouring, hierarchical naming, and lithological and age descriptions of some 500 units are also managed and maintained within the geodatabase.

The bedrock geology of the regions has been mapped and compiled at a variety of scales and degrees of detail. Previous compilations and synthesis have resolved many of the inconsistencies among the individual representations of the geology in each map. However, several factors result in an ever-changing and evolving database. These include differing and evolving nomenclature of stratigraphic units and structures, details not represented on maps but available only in reports and areas where new information has altered geological details and interpretations.

The bulk of the present compilation process is therefore the development of a new synthesis of the geology. This involves the inclusion of map and other data at a much broader range of data densities (equivalent to scales from 1:1 000 000 and up to 1:10 000 in rare instances) than used in previous compilations, resolving, as much as possible, all inconsistencies and extending new data and local changes as appropriate to broader regions. This compilation also embraces areas adjacent to western and eastern NWT, including offshore areas where well and seismic data are available. These are required to make the map and database seamless and internally and externally consistent.

Geodatabases can contain a higher density of information than is usually included on traditionally published regional maps. Such information includes paleontological and

radiometric ages, rock unit descriptions, locations of measured sections, well core and seismic data, mineral occurrence data, etc., essential for comprehensive synthesis of all geological information. The ultimate goal is to provide a comprehensive bedrock map as a base upon which as much geological and other data as possible may be layered, in turn assisting further synthesis of the geological evolution.

IS THE NEOPROTEROZOIC RAPITAN IRON FORMATION A CONTINENTALLY SOURCED DEPOSIT?

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Neoproterozoic iron formations (IFs) have been traditionally considered as being deposited in either restricted rift basins, or on reactivated continental margins and sourced from variously diluted hydrothermal vent fluids. Both the depositional environment and the source of these deposits are crucial to understanding their origin and for reconstructing the oceanic paleoredox conditions during their sedimentation. In this regard, the return of IFs after a billion year hiatus has been used as evidence to support widespread ferruginous deep-ocean conditions prior to deep ocean ventilation in the latest Neoproterozoic. However, there are still a number of questions regarding the source (hydrothermal vs. continental) and restriction of the depositional basin (closed vs. connected to the open ocean). Here, we present the trace element and Nd isotope geochemistry of the ca. 715 million year old Rapitan IF, Northwest Territories, to better understand the sediment and solute sources, depositional setting, and redox chemisty of the water column at the time of the IFs deposition.

The Rapitan IF is characterized by the lack of positive Eu anomaly and a relatively weak fractionation of Sm and Yb, which indicate that neither high nor low-temperature hydrothermal input significantly contributed to the chemistry of the basinal waters. Furthermore, the absence of statistically significant Ce anomalies suggests that the basin had a water column redoxcline above which seawater was poorly oxygenated; i.e., dissolved Mn(II) was unlikely to have been oxidized, thereby limiting oxidation of Ce(III). Importantly, anoxic to weakly oxygenated conditions as those present in the Rapitan basin favour that Eu remains soluble and travels long distances, whereas it co-precipitates with Fe- and Mn-oxyhydroxides relatively close to the source under oxic conditions. Thus, if hydrothermal activity existed somewhere in the open ocean, and the Rapitan basin was connected to it, this should be reflected in these Fe-rich deposits. Sm-Nd isotope data indicate that the chemistry of basinal waters was mainly controlled by solutes sourced from weathering of nearby continental crust. In this regard, negative εNd values shown by the Neoproterozoic Rapitan IF contrast with the typical positive mantle-like values of the Paleoproterozoic and Archean IF, which also have positive Eu anomalies. This indicates a different source is required (i.e., the latter have a strong contribution from hydrothermal vents). An alternative is that, iron and silica in the Rapitan IF could have been derived from weathering and erosion of exposed landmasses surrounding the basin. In summary, REY signatures, including Ce, Eu, and Sm-Nd data for the Rapitan IF are

better explained by deposition in an isolated fresh- or saltwater basin, and thus they cannot be used to reconstruct the geochemistry of the entire Neoproterozoic ocean, particularly its redox structure.

CHARACTERIZATION OF GOLD DISTRIBUTION IN THE CANTUNG W-SKARN DEPOSIT, NORTHWEST TERRITORIES

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The Cantung W-skarn deposit is located in the Northwest Territories just east of the Yukon border in the Flat River Valley. The tungsten mine is within the polymetallic W-Au Tintina Belt of the northern Canadian Cordillera and is currently operated by North American Tungsten Corporation Ltd. As of the end of 2009, Cantung had an estimated 6.21 Mt with an average recovered grade of 1.56% WO_3 despite multiple mine closures since its opening in 1962. A press release in October 2011 gives the most recent estimate of indicated mineral resources as 2.06 Mt grading 1.04% WO_3 with probable mineral reserves of 1.34 Mt grading 1.05% WO_3.

Tungsten has been mined through both an underground mine, from the E Zone, and through an open pit resource near the surface. Extensive W skarns were developed by a hydrothermal fluid that was predominantly hot, supercritical magmatic brine with homogenization temperatures that ranged from 270 to 500°C. Mineralization at the Cantung mine is comprised of calcic exoskarn replacements within the Ore Limestone and lower grade replacements in the Swiss Cheese Limestone, a calc-silicate/chert unit. Pyrrhotite is abundant in all skarn facies and is positively correlated to the W mineralization. Scheelite and chalcopyrite are dominant, although locally abundant sphalerite and anomalous Bi concentrations were also significant. While tungsten and copper are the main mine products, with the increase of its price, gold may become an appreciable by-product of the mine.

The purpose of this study is to characterize the distribution, mineralogy, and petrogenesis of Au found within this deposit. From the E Zone, five samples with bulk rock Au assay values greater than 0.5 ppm were examined petrographically. Using the bulk geochemical data (n = 48), Au correlates positively (Spearman's Rank, r') with Bi (0.76), Ag (0.70), Fe (64), Cu (0.64), and Mo (0.60). No free Au (electrum) has been identified optically or by SEM and FEG-SEM in analyses thus far. The hypothesis is that the Au is present as nano-inclusions within chalcopyrite or is lattice bound within Bi-minerals or related tellurides and selenides that occur in the interstices of the calc-silicate minerals that have been identified. The liquid bismuth collector model is tested using LA-ICP-MS analysis to determine the extent of lattice bound Au. This model involves Au scavenging from magmatic hydrothermal fluid by complex liquid Bi-sulphide phases saturating during W-Cu mineralization.

AN 8,500 YEAR HOLOCENE PALEOLIMNOLOGICAL RECORD FROM FRAME LAKE, YELLOWKNIFE, NT

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Frame Lake lies within the urban boundary of Yellowknife and is an important recreational area for the city, having a sandy beach and recreational area on its shore. The lake has an area of about 84 ha, with inflow and outflow being mainly from seepage. Frame Lake is quite shallow with a maximum depth of 6.5 m. Most of the shoreline is characterized by exposed bedrock although there are some weedy shore areas adjacent to shallow coves. High ionic concentrations and elevated biochemical oxygen demand levels are related to the close proximity of the lake to the urban core. The lake has additional unusual chemical characteristics that may be related to the winter ice surface being used as a snow dump.

To determine baseline environmental conditions for the lake three freeze cores and several sediment water interface samples were collected from the southern basin of the lake. Research on these lake sediments is still at a preliminary stage. To date eleven radiocarbon dates obtained from cores Frame-1FR and Frame-2FRF1 were used to chronologically constrain lake deposition and develop an age model for the >8500 year record of archived sediments. The basal part of the record is comprised of Lake McConnell glacial clays that grade upward into progressively darker gytja sediments. These darker sediments developed as the lake became isolated and more productive. Of particular interest is a dual band of grey-colored sediments less than one cm thick that was deposited ~1200 calendar year before present. Although this unit is approximately the same age as White River Ash deposits that we have observed in a core from nearby Pocket Lake, they do not appear to be comprised of tephra. Instead they seem to be made up of ash and charcoal fragments derived from a paleo-forest fire. Analysis of diatoms from the cores is at a preliminary stage, although floras seem to be well preserved. High-resolution analysis of additional proxy records at high temporal resolution (arcellaceans, grain size, LOI) will be carried out in the coming months.

REGIONAL GEOSCIENCE STUDIES AND PETROLEUM POTENTIAL OF MACKENZIE PLAIN AREA, CENTRAL NWT

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The Mackenzie Plain Petroleum Project was initiated by the Northwest Territories Geoscience Office in 2009 as a five-year study that couples field-based stratigraphic research with data from subsurface exploration wells. Mackenzie Plain is a petroleum producing and exploration area in the Central Mackenzie Valley that hosts the conventional oil field at Norman Wells. The objective of the project is to improve and expand petroleum geoscience data and interpretation for this exploration area to stimulate resource exploration and development. A main focus of the project is the characterization of hydrocarbon source rocks as potential shale reservoirs within the Devonian Horn River Group. Project results

will be compiled into a final volume in Spring 2014, with chapters devoted to hydrocarbon potential data from: 1) Cambrian outcrops; 2) Devonian Horn River Group outcrops and exploration wells; 3) other outcrops such as the Upper Devonian basal Imperial Formation, Cretaceous units, and "Root River reef"•; and 4) solvent extraction analyses from oil-stained Devonian units.

The Cambrian clastic play is a conceptual play for natural gas in Mackenzie Plain, focused stratigraphically on Mount Clark (reservoir) and Mount Cap (source, reservoir) formations. From outcrop studies, potential reservoir rocks are quartz sandstones and perhaps fractured quartzites of Mount Clark and Mount Cap formations and Proterozoic quartzite, in which porosities of 2-10% and permeabilities in the tens of millidarcies occur within gross reservoir thicknesses of 10-40 m. Potential source rocks for the play are black shale in Mount Cap and/or Saline River formations. One-quarter of shale samples analysed using Rock-Eval pyrolysis yielded greater than 1% total organic carbon (TOC), with a maximum of 7.08% TOC. Data suggest the Mount Cap Formation is overmature (wet to dry gas zone) where sampled adjacent to western Mackenzie Plain, and Type III (gas-prone) kerogen is dominant.

The Horn River Group contains potential shale reservoirs in the Hare Indian (Bluefish Member), Ramparts (Carcajou member), and Canol formations. Analytical results from both outcrop and exploration wells indicate excellent source rock potential within the Bluefish Member and Canol Formation, both with average TOC contents greater than 5%. These units are also quartz-rich (Bluefish Member >60%, Canol Formation >80%), which may enhance their ability to be fractured hydraulically as shale reservoirs. The Carcajou member within the carbonate-dominated Ramparts Formation contains some rich source rocks (average 4% TOC), as does the upper Hare Indian Formation where it contains dark grey shale (>6% TOC); however, across much of the study area, the upper Hare Indian Formation is more typically silty, greenish-grey shale and a poor source rock (<1% TOC). In Horn River Group samples, dominantly Type II kerogen (oil prone) is suggested, with a contribution from Type III kerogen (gas prone). Thermal maturation data suggest strata are within the oil window through much of Mackenzie Plain, with a regional trend of increasing maturity from northeast to west and south. Characterization of each unit based on its organic richness, mineralogy, and lithogeochemistry aids in differentiating shale-on-shale packages where the intervening Ramparts Formation is absent between the Hare Indian and Canol formations.

TRACE ELEMENT GEOCHEMISTRY OF OXIDE ORE AT THE PRAIRIE CREEK DEPOSIT, NWT

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The Prairie Creek Mine is a high grade Zn-Pb-Ag deposit in the southern Mackenzie Mountains of the Northwest Territories, confined within the boundaries of the Nahanni National Park and approximately 43 km upstream of the South Nahanni River. The deposit comprises two distinct types of carbonate-hosted mineralization that includes stratabound replacement massive

sulphides and quartz-carbonate-sulphide veins. The sulphide mineralization at Prairie Creek has undergone oxidation and alteration, forming high grade zones rich in smithsonite and cerussite. This weathered portion represents a significant resource and a potential component of mine waste material. Geochemical characterization of this mineralogically distinct component of the mineralization will play a critical role during and after mining to understanding the mines potential impacts on the environment. The current investigation attempts to gain an improved understanding of the oxide mineralization at Prairie Creek through the characterization of the geochemical and mineralogical controls on metal mobility, with particular attention to the metal carbonates as a host for trace elements and their role in sequestering those elements in paste backfill under saturated conditions. Surface, core and mine wall samples of the sulphides with varying intensities of oxidation have been collected. Mineralogical analyses of a number of surface samples using SEM, EMP, LA-ICP-MS, and synchrotron-based µXRD and µXRF have so far been performed.

The oxide mineralization consists primarily of smithsonite ($ZnCO_3$), cerussite ($PbCO_3$), quartz and variable amounts of galena, sphalerite, anglesite ($PbSO_4$), tennantite-tetrahedrite, calcite, dolomite, covellite, malachite and azurite. These primarily occur in the quartz-carbonate-sulphide veins as well as locally within the stratabound massive sulphides. Synchrotron-based µXRD has allowed the identification of a number of other minor alteration minerals, including various arsenates, Sb-oxides/hydroxides, and cinnabar (Hg sulfide). Quantitative electron microprobe analyses of multiple cerussite and smithsonite targets reveal variable concentrations of Zn (0-7850 ppm), Ca (55-1530 ppm), Cu (0-2135 ppm), Fe (0-390 ppm) and Cd (270-1060 ppm) in cerussite, while smithsonite commonly shows concentrations of Ca (150-14970 ppm), Cd (95-9510 ppm), Cu (0-27890 ppm), Fe (0-6525 ppm), Mg (0-81315 ppm), Mn (0-5030 ppm), and Pb (760-19090 ppm) as well as minor amounts of Sb (0-725 ppm) and As (0-730 ppm). The relatively low concentrations of Sb and As in the metal carbonates suggest these elements primarily occur in the separate mineral phases of the arsenate minerals, Sb-oxides/hydroxides and tennantite-tetrahedrite within the sulphide zones. Laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) analyses show similar trends, with the highest concentrations of As, Sb, Hg, Fe, Mn, Ag and Pb occurring where smithsonite contains abundant inclusions of the various mineral phases mentioned above. Further analytical work using similar methods will be carried out on the diamond drill hole core and underground samples collected in August 2013. Testing of simulated paste backfill under saturated conditions (i.e. similar to those expected underground) will also be conducted using bulk samples of the oxide ore component.

INFRARED SPECTROSCOPY AND CARBON ISOTOPIC ANALYSES OF VICTOR MINE DIAMONDS

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Located in the James Bay Lowlands of Ontario, the Victor Mine exploits two coalesced pipes containing pyroclastic and

hypabyssal-like kimberlite. Kimberlite emplacement occurred in the Jurassic. Situated in the Superior Province, Victor is Canada's first diamond mine located outside the Slave Craton. The Victor Mine produces diamonds of exceptional quality and value (average value of US$ 419 per carat) from a relatively low grade deposit (0.2 carats/ton).

Here we present the first analytical data set on Victor diamonds (gem quality, 2-3mm size range): nitrogen concentrations and aggregation states (via FTIR) and carbon isotopic compositions ($\delta^{13}C$, sealed tube combustion) were determined on cleavage chips of 0.5-2 mg mass. Based on the nitrogen data, Victor diamonds are dominantly Type IaAB (median value of 23 %B) and, compared to diamonds worldwide, relatively rich in nitrogen (median of 464 at.ppm). Using the relationship between platelet formation and nitrogen aggregation, Victor diamonds resided in a stable environment with a time averaged mantle temperature of 1100°C (derived from nitrogen concentration and aggregation data). The carbon isotopic data indicate a median $\delta^{13}C$ value of -5.3 ‰, with a few outliers towards strongly 13C depleted values (as low as -15.0‰). The occurrence of a few $\delta^{13}C$ values <-10‰ likely relates to diamonds of eclogitic or websteritic paragenesis. The strong dominance of mantle-like carbon isotopic compositions may indicate a peridotitic paragenesis for the bulk of Victor diamonds. However, diamonds with eclogitic mineral inclusions from the Kaapvaal Craton generally also show prominent modes in $\delta^{13}C$ about -5‰, implying that in the absence of inclusion data a dominant source paragenesis for Victor diamonds cannot be unequivocally identified. The nitrogen aggregation data allow placing an upper limit on the formation age of Victor diamonds. Likely related to a thermal pulse associated with the 1.1 Ga Midcontinent Rift, diamonds from the nearby T1 kimberlite (also ~ 1.1 Ga in age) show high nitrogen aggregation states and common platelet degradation. Overall poorly aggregated nitrogen and a regular relationship between platelets and nitrogen B centers strongly suggest that Victor diamonds formed subsequently, i.e. <1 Ga ago.

A GEOCHEMICAL COMPARISON OF VOLCANIC ROCKS FROM THE SNARE RIVER AND COURAGEOUS LAKE VOLCANIC BELTS IN THE SLAVE CRATON AND IMPLICATION FOR VMS EXPLORATION

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Detailed mapping and geochemical sampling occurred across three greenstone belts in the Slave craton (Northwest Territories) during the 2013 summer field season in conjunction with the NWT Geoscience Office's Banting VMS Project. The greenstone belts contain varying amounts of bimodal sequences of metavolcanic and metasedimentray rocks belonging to the Yellowknife Supergroup. Work focused on the Wijinnedi-Snare volcanic belt of the western Slave, the Courageous-MacKay Lake Greenstone Belt of the central Slave, and the Lac du Rocher volcanic belt of the south-central Slave. The petrology of these "Banting-aged" • Neoarchean volcanic rocks will help provide a basis to understand geochemical and geological features indicative of economic

mineralization, and to provide geochemical data to assist in the interpretation of the regional geology.

Ninety four rock grab samples were collected for petrology and lithogeochemical analysis. A select sample batch will be processed at Carleton University for neodymium (Nd) and sulfur (S) isotopes. Chondrite normalized REE patterns can be used to distinguish felsic metavolcanic rocks associated with base-metal sulphide deposits (FII and FIII types) from barren felsic metavolcanic rocks (FI type). Nd isotopes coupled with lithocemistry will determine crustal formation ages as well as identify reservoirs and processes involved in petrogenesis. The S isotope system can be used to evaluate the origins of sulphides and sulphates bearing fluids within a hydrothermal system, and constrain the mechanism for potential ore mineralization. This will be completed in order to identify economically prospective rhyolite horizons within greenstone belts in the Slave craton (NWT) and compared with known VMS-hosting environments in the Slave craton in Nunavut and in the VMS camps of Noranda and Kidd Creek, Superior craton. Analytical work will be completed throughout 2013-2014.

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