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Cover photographs, clockwise from top left:

Kikerk Formation (slate) of the Recluse Group - Morel Lake;
Luke Ootes, NWT Geoscience Office

Students (Ryley, Steph, Jeff) from the University of Alberta Field School - Yellowknife Bay;
John Ketchum, NWT Geoscience Office

Upper Devonian Trout River Formation (limestome) - Sambaa K'e Falls;
David Watson, NWT Geoscience Office

Silicified Pillowed Volcanic Rocks - Sharrie Lake;
Valerie Jackson, NWT Geoscience Office

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GEOLOGY, GEOCHEMISTRY, AND TRACE ELEMENTS IN SULFIDES AND GOLD DISTRIBUTION AT THE POLYMETALLIC NICO (AU-CO-BI±CU-W) DEPOSIT, NORTHWEST TERRITORIES, CANADA

ACOSTA-GONGORA*, P.[1], GLEESON, S.A.[1], SAMSON, I.M.[2], OOTES, L.[3], CORRIVEAU, L.[4] AND TAYLOR, B.E.[5]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) UNIVERSITY OF WINDSOR, WINDSOR, ON
(3) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(4) GEOLOGICAL SURVEY OF CANADA, QUEBEC CITY, QC
(5) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON

The Great Bear Magmatic zone (GBmz) in the Northwest Territories is host to the NICO (Au-Bi-Co±Cu-W) deposit and other smaller iron-oxide dominated polymetallic systems. Many of these systems have analogous alteration and mineralization styles and tectonic environments to the Iron-Oxide Copper Gold (IOCG) deposits in Chile and Australia (e.g. Olympic Dam, La Candelaria, Raúl-Condestable). The NICO deposit is located is located in the southern GBmz. This deposit hosts economic Au-Co-Bi (±Cu-W) mainly in magnetite-amphibole rich rocks of the Treasure Lake group, with some late-stage mineralized veins in the strongly potassic-altered felsic volcanics of the Faber group. The polymetallic mineralization is concentrated in the Bowl Zone, with 43-101 compliant reserves of 33 Mt @ 1.02 g/t Au, 0.112% Co, 0.14% Bi, 0.04 % Cu (Fortune Minerals Ltd. press release, July 5th, 2012).

The early ore stage (M1) is represented by the precipitation of arsenopyrite, cobaltite, loellingite, scheelite and pyrrhotite, with gangue minerals such as magnetite and pyrite and variable amounts of amphibole, biotite, quartz, potassic feldspar and fluorite. The Co-As-Fe sulphides are recognized to occur in four principal styles: i) veins (1mm to 20cm thick); ii) disseminated along the bedding planes; iii) randomly disseminated within wallrock; and iv) as massive mineral aggregates. The late ore assemblage (M2) consists of native Bi, bismuthinite, emplectite, whittichenite, and chalcopyrite, with minor amounts of molybdenite. Associated with the ore minerals are chloro-potassichastingsite, hematite, quartz and variable amounts of amphibole, magnetite, fluorite, and potassic feldspar. Locally, M2 mineral assemblages are variable and three have been identified: i) magnetite-native Bi-bismuthinite (±quartz-chloro-potassichastingsite); ii) chloro-potassichastingsite-bismuthinite-chalcopyrite-emplectite-whittichenite-hematite-native Au-tellurides (±chlorite,fluorite); and iii) actinolite-chalcopyrite-molybdenite-(±bismuthinite).
These late ore fluids likely resulted in partial arsenopyrite re-crystallization and during this process multiple inclusions of native Bi, Bi-Cu sulphides and silicates could have been incorporated to the arsenopyrite crystals.

LA-ICP-MS raster analysis was carried out on arsenopyrite-rich samples pyrite, cobaltite and loellingite. No major geochemical differences were identified with a specific arsenopyrite mineralization style, but some slight differences in Ni, Se, Sb, and Pb concentrations between the sulphide phases were found. In addition, it was confirmed that native gold (Au) is present mainly as inclusions. The richest Au inclusions (4752 ppm) are also associated with high Te and Bi (as defined by spectral peaks). Only one analysis showed the presence of Au evenly distributed in the crystal lattice of an arsenopyrite grain; however, its overall concentration is very low (3 ppm). Petrographic and trace element studies indicate the occurrence of Au as inclusions in arsenopyrite is closely related to the emplacement of the late Bi- and Bi-Cu sulphides and hematite, indicating that Au is post-dating the Co-As-Fe sulphides.

THE SNOWBIRD NICKEL PROJECT, NWT/SK INCLUDING THE NICKEL KING DEPOSIT

ARMSTRONG, K.A.
STRONGBOW EXPLORATION INC., VANCOUVER, BC
KARMSTRONG@STRONGBOWEXPLORATION.COM

During the period from 2006 through 2010, Strongbow Exploration actively pursued an exploration strategy focused on investigating the potential of the southern Snowbird Tectonic Zone ("STZ") to host magmatic Ni-Cu-Co deposits. The STZ is a major crustal scale structure that can be traced for over 2,800 km from the Rocky Mountains in southern Alberta to Hudson Bay in Nunavut and represents an underexplored region prospective for magmatic nickel sulphide deposits. Strongbow's Snowbird nickel project presently incorporates approximately 39,000 ha of mineral claims and mining leases located along a 100 km strike length of the southern STZ, straddling the Saskatchewan-Northwest Territories border. Exploration work has confirmed that numerous mafic-ultramafic intrusions are located along this section of the STZ. Some of these intrusions are known to host nickel-copper mineralization, including the Nickel King deposit, Northwest Territories, as well as the Dumas, Heel, Breynat and Opescal Lake areas.

The Nickel King deposit is located near the north end of Selwyn lake, approximately 30 km north of the NWT/Saskatchewan border. Mineralization has been traced over a strike length of 2,600 m and is hosted within two arcuate, stacked south dipping norite sills. The sills range from a minimum of about 10 m to 100 m or greater in thickness and are currently interpreted as two limbs of a westerly plunging synform. Mineralization consists of pyrrhotite with lesser amounts of chalcopyrite and pentlandite. Sulphide minerals typically comprise less than 5% in the upper sill but locally exceed 20%. In the better-mineralized portions of the lower sill, the sulphide content typically ranges from 5% to 15%, occasionally reaching 30% over short intervals (typically less than 1 m). Petrographic work indicates that pentlandite is the primary Ni-bearing sulphide mineral, occurring typically as discrete grains and veinlets and only rarely as exsolution lamellae or flames in pyrrhotite. Initial metallurgical studies indicate the deposit is amenable to traditional processing techniques and capable of producing a final concentrate with grades of 16.5% Ni, 4.2% Cu and 0.74% Co at recoveries of 78.4% (Ni), 89.1% (Cu) and 63.5% (Co).

Nickel King hosts a NI 43-101 compliant resource of 11.11 million tonnes grading 0.4% Ni, 0.10% Cu and 0.018% Co in the indicated category and 33.06 million tonnes grading 0.36% Ni, 0.09% Cu and 0.018% Co in the inferred category (PEG Mining Consultants. June 2, 2010. A NI 43-101 technical report on the Nickel King project is available for download and viewing from Strongbow's website at www.strongbowexploration.com). Significant potential remains to expand the current Nickel King resource estimate through infill and step out drilling, and to also discover new Ni-Cu deposits within the Nickel King area and further to the south within the Snowbird project area. The STZ is a highly prospective area with potential to define a new belt of nickel deposits in central Canada.

THE FRANKLIN LARGE IGNEOUS PROVINCE ON VICTORIA ISLAND, LINKAGES BETWEEN THE PLUMBING SYSTEM AND THE LAVAS

BÉDARD*, J.H.[1], DELL'ORO, T.[2], WEIS, D.[2], SCOATES, J.[2], BEARD, C.[2,3], WILLIAMSON, N.[4], COUSENS, B.[4], HRYCIUK, M.[5], WING, B.[5], HAYES, B.[6], RAINBIRD, R.[7] AND OOTES, L.[8]
(1) GEOLOGICAL SURVEY OF CANADA, QUÉBEC, QC
(2) UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER BC
(3) UNIVERSITY OF BRISTOL, BRISTOL, UK
(4) CARLETON UNIVERSITY, OTTAWA, ON
(5) MCGILL UNIVERSITY, MONTRÉAL, QC
(6) CARDIFF UNIVERSITY, CARDIFF, UK
(7) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(8) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT

The Neoproterozoic Minto Inlier of Victoria Island comprises a 4-km thick succession of

sedimentary rocks (Shaler Supergroup) capped by Natkusiak Fm. Flood basalts, and intruded by coeval diabasic sills (ca720 Ma Franklin event). The Natkusiak basalts outcrop as 2 erosional remnants (NE & SW lobes). The lowermost lavas (<100 m) are valley-filling primitive basalts (≤11 wt% MgO) erupted from multiple vents, with the earliest deposits interbedded with underlying fluvial sandstones. The unit is characterized by LREE-LILE-enrichment, high L/HREE, high $^{87/86}Sr_i$ (≤0.70791), intermediate εNd (4.0-8.1) and εHf (0.03-6.7), high $^{208/204}Pb$ (≤39.136), high $^{207/204}Pb$ (≤15.686), and high $^{206/204}Pb$ (≤18.978). After a hiatus marked by reworking of lavas, at least 1 km of basalt erupted as two differentiation cycles (10-6% MgO). Only a truncated section of cycle 1 basalts are preserved in the SW, however. The flood lavas in the SW have higher εNd (7.7-9.6), lower $^{87/86}Sr_i$ (0.70251-0.70605), higher εHf (4.1-9.7), lower $^{208/204}Pb$ (36.196-37.623), lower $^{206/204}Pb$ (16.147-17. 787), and lower $^{207/204}Pb$ (15.383-15.605) than basal basalts. Cycle 2 lavas from the NE are even more depleted, suggesting that the source became more depleted with time. Although the volcano-stratigraphy can be correlated throughout the area, NE lobe lavas have systematically higher εNd values (by about 4-5 units) than SW lobe lavas, suggesting compartmentalization of the plumbing system, with an eruptive facies change somewhere within the NE lobe.

The plumbing system is dominated by sills with localized dykes. Younger diabasic sills have trace element signatures matching the sheet flow lavas, whilst older sills, some with olivine-rich bases, match the basal lavas. Data so far implies that most of the sills in the W Minto Inlier flowed towards the SW, presumably from a feeder zone located east of the head of Minto Inlet. All of the sills examined, including some that directly underlie the SW lobe lavas, have isotopic signatures that match the NE lobe lavas, not the overlying SW lobe lavas. The plumbing system from which the SW lobe lavas erupted has yet to be discovered.

Most sills have $\delta^{34}S$ signatures that are systematically higher (+2 to +4) than depleted mantle values (ca. +0), suggesting that most of the magmas have acquired crustal sulfur during passage through the crust, possibly by interacting with carbonate rocks. Many calc-silicate skarns generated by reaction between basalt and carbonate hosts have enriched $\delta^{34}S$ signatures between +8 and +10. Small-scale sulfide immiscibility has been observed in fault-hosted dyke tips, and S-isotopic signatures imply that some gypsum-hosted sills ($\delta^{34}S$ +11 to +13) have assimilated sulfate-rich sediments ($\delta^{34}S$ ca +15). Mixing calculations indicate that assimilation of up to 0.7% host sulfate can reproduce the intra-sill $\delta^{34}S$ signatures, but less than half the sulfur required by the isotopic data is still present in these contaminated sills. This suggests that the sills lost S after mixing, either by extensive S-degassing, or by loss of an immiscible sulfide phase upstream of the point of sampling.

NUNAVUT 2012: MOVING FORWARD WITH A DIVERSE COMMODITY BASE

BIGIO, A.
ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT CANADA, NUNAVUT REGIONAL OFFICE, IQALUIT, NU
WWW.AANDC-AADNC.GC.CA/NUNAVUT

Exploration expenditures in Nunavut for 2012 are expected to be in the $400 to $420 million range, slightly above the five year average of $396 million. The Meadowbank mine produced 177,804 oz of gold in the first half of 2012, with a record 98,403 oz produced in the second quarter.

Gold exploration activities constituted the largest portion of exploration expenditures. The Meliadine project near Rankin Inlet reported encouraging results from exploration and deposit delineation drilling. Sabina Gold and Silver Corp. completed a positive Preliminary Economic Assessment on their Back River gold project in May and filed a project description with the Nunavut Impact Review Board (NIRB) to begin the environmental assessment process. Newmont Mining Corporation announced in

January that their Hope Bay operation would be put into care and maintenance status beginning in October 2012

Interest in iron remained strong with exploration progressing at the Roche Bay – Tuktu and Haig Inlet projects. A final decision report was issued in September by NIRB for the proposed Mary River high grade iron ore project, recommending the proposed mine development and related infrastructure construction proceed to the regulatory phase.

Uranium exploration was limited to the Kivalliq region. A Draft Environmental Impact Statement (DEIS) was submitted to NIRB in January by AREVA Resources Canada Inc. for the Kiggavik project. Cameco Corporation and Kivalliq Energy Corporation completed drill programs on their respective properties.

Much of Nunavut's 2012 exploration spending on base metals was concentrated in the Kitikmeot region. Xstrata Zinc Canada continued exploration on the Hackett River silver-zinc-copper property, and advised regulators of their intention to re-engage the environmental assessment process with the submission of a revised DEIS for Hackett River in 2013. MMG Resources Inc. conducted an extensive drill program at Izok Lake and announced its intention to proceed with the Izok Corridor project, the proposed mining of zinc-copper deposits at Izok and High Lake.

Shear Diamonds Ltd. reprocessed stockpiled kimberlite at the Jericho mine, recovering 47,500 carats of diamonds before halting activity in September. Peregrine Diamonds Ltd. continued exploration at its Chidliak property, and announced in September an agreement with De Beers Canada Inc. whereby De Beers would have exclusive rights to enter into a joint venture agreement on the project.

With a portfolio that includes gold, base metal, uranium and iron projects advancing through the regulatory process, Nunavut's exploration and mining sector continues to move towards becoming a mining district with a diverse commodity base.

A REGIONAL-SCALE GEOLOGICAL MAP DATABASE FOR CANADA'S THREE NORTHERN TERRITORIES

BRODARIC, B., HARRISON*, J.C., PAUL, D., ST-ONGE, M.R. AND TELLA, S.
GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON

More than three years in the making, staff of the Geological Survey of Canada (in cooperation with the Yukon Geological Survey, the Northwest Territories Geoscience Office and the Canada-Nunavut Geoscience Office) have been constructing a regional-scale geoscience map database for the three northern territories. The purpose of this presentation is to provide an overview of database components and capabilities for access and retrieval of a wide range of geoscience information as might be used for mineral and energy exploration across the region.

Components of the database include tools for data entry, data storage and data retrieval. Types of data include polygon and line spatial objects covering the three territories. Linear features include faults of various types. Primary polygon attributes include lithologies of formally and informally named units, plutonic and volcanic settings and environments of sedimentary deposition, maximum and minimum age, degree of metamorphism, map labels, unit descriptions as provided by source map legends, and data source references. Secondary polygon attributes include diagnostic features ranging from grain-size and bedding thickness of stratified units to metamorphic mineral assemblages and timing of thermal events (tagged with publication references). All attributes are documented using a best-practice, internally-consistent science language and hierarchical schema developed by the project team.

Protocols for public access to the database are still being worked out. However, release of derivative compilation maps with accompanying geodatabases is planned for 2013, including for

the Baffin Island region, the shield west of Hudson Bay, and the Arctic Islands (scale 1: 1,500,000).

THE NORTHWEST TERRITORIES GEOSCIENCE OFFICE – 2012 ACTIVITY OVERVIEW

CAIRNS*, S. AND KETCHUM, J.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
SCOTT_CAIRNS@GOV.NT.CA

The Northwest Territories Geoscience Office (NTGO) carries out geological survey activities for the Northwest Territories. This year marks the 10th anniversary of the C.S. Lord Building, where Government of the Northwest Territories and Aboriginal Affairs and Northern Development Canada employees jointly staff the NTGO. NTGO activities include geological mapping, non-renewable resource assessments, geochemical and geophysical surveys, outreach and education, data management and distribution, and administering portions of the Northwest Territories Mining Regulations.

In 2012, the NTGO carried out a number of field-based research programs. On the minerals side, mapping was carried out in the Mackenzie Mountains (106B), and on Banting-equivalent volcanic rocks in the Slave Structural Province (86I and throughout the province). Regional geochemical projects were carried out in the Mackenzie Mountains (106M), Colville Lake area (96N) of the Interior Platform, as well as the Jean Marie River Area (95H). Petroleum activities included a final year of fieldwork for the Mackenzie Plain Project, a reconnaissance study of the Horn River Basin (joint with Yukon and BC government geologists), and a deep aquifers study of the western Dehcho Region.

NTGO field programs provide excellent opportunities for hands-on training of university geology students. This year the NTGO supported 29 students on a diversity of projects ranging from rare earth deposit mineralogy, through investigating the sedimentological record, to understand past responses to variable climates.

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.

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.

GEOHERITAGE: FOUNDATION FOR EDUCATION AND OUTREACH

CALDER, J.H.
NOVA SCOTIA DEPARTMENT OF NATURAL RESOURCES, HALIFAX, NS
JHCALDER@GOV.NS.CA

The concept of Geoheritage, the recognition of geologic sites that inform humanity of our common bond with the Earth, is gaining momentum globally. If undertaken as a thoughtful, systematic strategy involving experienced geoscientists, the recognition of geoheritage can form a powerful basis for engaging the public. As for UNESCO World Heritage, both natural (classic geological) sites and cultural sites can be recognized. Cultural sites are those where human history is intimately associated with a geological site, examples being sacred sites and mining areas that have shaped a region's history. A carefully established geoheritage list can be used to launch publications, geological highway maps, guide EdGeo workshops and school, university and public field trips, and can help guide a successful geotourism industry. Less tangibly, but perhaps most importantly, a formal recognition of geoheritage creates awareness of

Earth history, and engages geoscientists in sharing their insight with their fellow citizens.

A challenge in developing a geoheritage list is to establish a minimum level of significance – 'setting the bar' - to avoid devaluing significance and creating a bureaucratic quagmire. Three levels of significance that can be employed are: i) globally unique; ii) globally significant; and iii) exceptional examples. It is important to recognize that scientific significance does not in all cases translate into high interpretive potential and a positive visitor experience. Scientific obscurity, issues of access, and vulnerability of a site in absence of salaried or community stewards may render a site unsuitable for geotourism, and for general education and outreach. These cautions aside, a carefully crafted geoheritage list can and should become the focus of celebrating our common heritage on Earth. Perhaps most importantly, it invites geoscientists to become engaged in helping others read the pages of the Big Volume of Earth history, as we look to our shared and as yet unwritten future on this planet.

A REASSESSMENT OF OIL AND GAS RESOURCE POTENTIAL IN THE BEAUFORT-MACKENZIE BASIN

CHEN*, Z., DIETRICH, J., ISSLER, D., LI, M., OSADETZ, K., DIXON, J. AND HU, K.
GEOLOGICAL SURVEY OF CANADA, CALGARY, AB,
ZCHEN@NRCAN.GC.CA

The Geological Survey of Canada (GSC) has recently completed a new oil and gas resource assessment for the Beaufort-Mackenzie Basin under the Earth Sciences Sector Geo-mapping for Energy and Minerals (GEM) Program. This assessment is based on recent project outputs that include: 1) quality-assessed compilations of multi-disciplinary geoscience datasets, 2) improved petroleum systems models, 3) a revised assessment methodology, and 4) improved oil recovery analogues.

In the past twelve years, the GSC has conducted multiple government and government-industry funded research projects on petroleum systems with emphasis on essential geological elements that control petroleum formation and occurrence in the Beaufort-Mackenzie Basin. New organic geochemical evidence suggests that marine Upper Cretaceous organic-rich shale could be the major source for many of the oil accumulations in the basin rather than Paleogene shale dominated by terrestrially-derived organic matter as published previously. The oil-prone marine source rocks may be far more extensive than previously thought and likely generated large amounts of liquid petroleum that could have been trapped in shelf and deeper water areas of the basin. Petroleum system modelling and seismic data inversion have generated scenarios that provide additional constraints for play risk evaluation. Improved thermal history modelling and mapping using quality assessed legacy and new geothermal data provide better constraints for understanding the petroleum generation, migration and accumulation histories throughout the basin. In addition, the GSC has tackled some of the existing problems in assessment methodology. The inter-dependencies of volumetric parameters and correlations in resource aggregation can be addressed adequately now by the revised methodology. The new data and petroleum models improved our understanding of the petroleum systems and resulted in a substantial increase in the estimates of oil resource endowment in the basin.

This talk will present the results of the new oil and gas resource assessment in the Beaufort-Mackenzie Basin with examples showing evidence and new findings relevant to the assessment, the implementation of the revised assessment methodology, and rationales and justifications for some of the key input parameters used in the new resource assessment.

ENVIRONMENTAL SITE ASSESSMENT (ESA) OF ABANDONED MINES AT GORDON LAKE, NT

COEDY, W.
CONTAMINANTS & REMEDIATION DIRECTORATE, ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT CANADA, YELLOWKNIFE, NT
BILL.COEDY@AANDC-AADNC.GC.CA

Several abandoned gold mine sites in the Gordon Lake area (85 km NE of Yellowknife) have recently been investigated by AANDC for contaminants of concern under the Federal Contaminated Sites Action Plan protocol. Six sites have been designated Class 1 which implies that they are a high priority for further characterization, risk management and remediation. Currently, a Phase III ESA is underway at Camlaren, Burnt Island, Goodrock, Kidney Pond/Knight Bay and Treacy mine sites. Another mine site in the vicinity, Old Parr/Liten Mine, was designated Class 1 in 2009. Old Parr/Liten Mine also had the distinction of requiring an archaeological survey. As a result of this work, many artifacts were recorded and hand tools were collected for the Northwest Territories Mining Heritage Society.

The Phase III ESA field work was conducted in September 2012 to confirm the presence of contaminants above Canadian Council of Ministers of the Environment (CCME) guidelines and the extent of contamination through vertical and horizontal delineation. Although clean-up of the sites occurred in the late 1980's, petroleum hydrocarbon and metals exceedances above CCME guidelines were detected during this investigation. Further investigations will also examine the hydrological pathways, determine background levels for the Gordon Lake watershed and evaluate acid rock drainage and the potential for metal leaching from the blast rock, ore, tailings and mine workings.

Gordon Lake is a remote area with ecological, mineral and historical significance. Prospector cabins and exploration camps (c.1939) associated with the mine sites were included in the assessment and their historical significance to mining heritage will be discussed. Tourists frequent the sites to discover the rich mining history during fishing trips in the summer. In winter, the Tibbet-Contwoyto ice road provides easy access to sport fishing and recreational hunters. A number of hazards have been identified for each site and represent a human safety concern.

The Phase III report will confirm classification and provide strategies and rough cost estimates to remediate the sites to acceptable environmental and human health and safety standards. Based on the background levels of the Gordon Lake area, strategies may consider a combination of remediation, risk management and long term monitoring. Next steps for Class 1 sites include public engagement and the consideration of human health and ecological risk assessments.

LATE HOLOCENE CYCLICAL PATTERNS OF DIATOM POPULATIONS IN SUB-BOREAL NORTHWEST TERRITORIES, CANADA

DALTON*, A.S.[1], VERMAIRE, J.C.[2], MACUMBER, A.L.[1], PATTERSON, R.T.[1], ROE, H.M.[3], CRANN, C.[1], SWINDLES, G.T.[4], GALLOWAY, J.M.[5] AND FALCK,H.[6]
(1) OTTAWA-CARLETON GEOSCIENCE CENTRE, CARLETON UNIVERSITY, OTTAWA, ON
(2) CARLETON UNIVERSITY PALEOECOLOGICAL LABORATORY, OTTAWA, ON
(3) SCHOOL OF GEOGRAPHY, ARCHAEOLOGY AND PALEOECOLOGY - QUEEN'S UNIVERSITY, BELFAST, UK
(4) SCHOOL OF GEOGRAPHY, UNIVERSITY OF LEEDS, LEEDS, UK
(5) NATURAL RESOURCES CANADA, GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
(6) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
ASDALTON@CONNECT.CARLETON.CA

The Tibbitt to Contwoyto Winter Road (TCWR) is a vital transportation route for mine supplies. The winter road begins near Yellowknife and stretches 600 kilometres northward into Nunavut. Recent climatic variability, particularly the El Nino of 2006, which shortened the transportation season significantly, has sparked interest in determining the future viability of this road. The goal of this research is to study the nature of climate cycles impacting this region over the past ~3500 years, and to investigate

whether warming conditions over the past several decades could be attributed to natural causes.

Diatoms are single-celled protists found worldwide in many lacustrine environments. In arctic ecosystems, certain benthic taxa (*Fragilaria spp.*) flourish under ice-covered conditions where light penetration is significantly reduced, while planktic species (*Aulacoseira spp.*) thrive under ice-free conditions, where photosynthesis is optimal. Past ice cover can be inferred by studying the ratio of benthic to planktic diatoms contained in a sediment core. This information is of great interest to TCWR policy makers and planners.

Many researchers study diatoms, but few look at diatoms in the Northwest Territories (NWT) and even fewer carry out time series analysis on the resulting data. Our paleoclimate reconstruction reveals decadal to centennial-scale cycles in *Aulacoseira spp*. and *Fragilaria spp.* abundance, corresponding to warm and cool cycles over the past 3500 years. The ~68 year climate cycle detected in both *Aulacoseira spp.* and *Fragilaria spp.* suggests that climate in the NWT is affected by the Pacific Decadal Oscillation, which operates at approximately the same length. As a result, perceived recent warming in the region may in part be attributed to natural climate cyclicity.

EXPERIENTIAL SCIENCE

DANIEL, S.
EDUCATION, CULTURE AND EMPLOYMENT, GOVERNMENT OF THE NWT, YELLOWKNIFE, NT

The Department of Education, Culture and Employment, for the NWT, has developed a new pathway for high school science education called Experiential Science. These courses, offered at grades 10, 11 and 12 respectively, are designed to engage students in hands-on learning while applying scientific knowledge, processes and protocols in a context based learning environment. The program of studies is designed to appeal to a wide variety of students by providing learning opportunities that engage their own learning style. The curriculum for Experiential Science integrates Western science and Aboriginal knowledge and principles through field and laboratory experiences and applications. The program of studies investigates ecology and geology through the systems approach. Each course has a specific focus: Grade 10 - Arctic and Subarctic Terrestrial Systems; Grade 11 - Arctic and Subarctic Marine Systems; and Grade 12 - Arctic and Subarctic Freshwater Systems. A balance between classroom and field investigations allows students to learn in a dynamic environment, which fosters a better understanding of ecological and geological principles and processes. The presentation will focus on the three student textbook, its implementation in schools, ongoing teacher inservice and the use of a private label wiki for sharing students' generated data and teacher inservice. This update will discuss the current status of the project and new initiatives to enhance student learning experiences.

OCEANIC CORE COMPLEXES AS SITES OF SEAFLOOR HYDROTHERMAL DISCHARGE: APPLICATIONS TO THE GEOLOGICAL RECORD

DUKE, N.A.
DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF WESTERN ONTARIO, LONDON, ON
NDUKE@UWO.CA

The recognition of oceanic core complexes (OCCs) along slow spreading ridges is a recent contribution from the Deep Sea Drilling Program. When spreading rates are slow, seawater ingress of normal faults penetrates to the mantle causing serpentinization. Buoyant rise of oceanic crust over serpentinized mantle is accommodated by crustal scale detachment faults. OCCs lack the sheeted dykes and pillow basalt members of typical ophiolite sequences, exposing basal serpentinite-gabbro complexes at surface. Detachments comprise a brittle/ductile interface that is a ready conduit for hydrothermal discharge and account for some of the largest seafloor hydrothermal vents discovered to date. Studies of such fields demonstrate these differ

significantly from typical black smoker settings, lacking well defined discharge pipes, form carbonate/sulphate mounds as well as sulphide deposits, and have associated hydrothermally altered footwall serpentinite and gabbro.

Seafloor detachment-related mineralization is likely to prove more broadly represented in the geological record than currently realized. The hybrid VMS/SEDEX Greens Creek Deposit on north Admiralty Island is a prime Upper Triassic example. The high grade polymetallic sulphide ore occurs at the base of Carnian/Norian pyritic-graphitic argillite overlying serpentinite-gabbro plumbed Devono-Mississippian greenstone. Footwall greenstone is pervasively altered to tan sericite, serpentinite to green barian mariposite and manganiferous carbonate, and gabbro to pumpellyite. Talc-chlorite-carbonate shears bound the serpentinite/gabbro bodies. High-Ag barite replacement ores form footwall to laminated Pb-Zn-Ag exhalite and overlying bedded pyrite. Detachment fault controlled hydrothermal discharge accounts for a fundamental structural break between host argillite and underlying transpositional hydrothermal phyllonite. Hydrothermal breccia-conglomerate, sourced in footwall phyllonite, marks the ore horizon away from the site of mineralization and is contemporaneous with a major Permo-Triassic unconformity in regional stratigraphy. This Greens Creek example supplies several elements likely to be common to detachment controlled hydrothermal sites on ancient seafloors -in particular, bedded exhalative ores overlying ductile deformed footwall hydrothermal alteration. Perhaps the extensive chloritites giving rise to alumino-silicate rich porphyroblastic schist units at such Archean VMS camps as Manitouwadge and Snow Lake relate to hydrothermally altered detachments. The occurrence of footwall gabbro and stratiform talc schist rather than a copper-rich chlorite pipe zone at Matagami Lake might also indicate detachment-fault control.

The recognition of oceanic core complexes adds new complexity to our understanding of the make-up of oceanic crust and supplies a new seafloor setting for focused hydrothermal discharge. Although best studied on slow spreading ridge segments, such complexes are also known to develop during initial continental break-up, accounting for OCCs in the continental margin rifts formed during opening of the North Atlantic. One might also consider extensional arc settings, such as at Greens Creek, prime for OCC development. Detachment fault controlled hydrothermal discharge may therefore accompany a wide variety of ancient seafloor settings and likely to have operated at some SEDEX as well as VMS environments. Exploration should focus where euxenic sediment covers ductile deformed and hydrothermally altered strata with contemporaneous serpentinite-gabbro injections.

GEOPHYSICAL DESCRIPTION OF THE CANOL AND BLUEFISH SHALES, NWT, CANADA

ENACHESCU*, M.[1], KIERULF, F.[1], PRICE, P.[1] AND CHÂTENAY, A.[2]
(1)MGM ENERGY CORP., CALGARY, AB
(2) EXPLOR, CALGARY, AB

The oil shale play of the Central Mackenzie Valley (CMV) started first as an idea developed by several industry and government geoscientists who realized that the Western Canadian Basin organic rich shale fairway extended into the Northwest Territory. Long known as the source rock for the Norman Wells light oil accumulation, the Canol Formation was previously studied as a source rock and captured in geological surface and subsurface maps used to explore for additional conventional reservoirs. Based on preliminary geochemical studies of the rock outcrops, cores and cuttings both the Canol Shale and the older Bluefish Shale look like potential lucrative unconventional plays. The next investigative phase for these unconventional plays was to evaluate their thickness, regional distribution and predictability using seismic data.

Geophysical investigations of the Middle to Late Devonian shales were performed in parallel with geological and geochemical studies. The first

step was to identify the organic shale intervals on the gamma ray logs recorded in all post-1970s exploration wells and correlate the intervals into the sonic and density log displays. The main play - Canol Shale- varies in in thickness from 0 m (when truncated by the Base Cretaceous Unconformity) to more than 120 m (in distal basinal locations). In places the top Canol Formation has a clear seismic impedance contrast and can be effectively tracked on superior quality seismic lines. In other locations, the Canol can only be ghosted within the Devonian clastic succession overlying the Hume Formation. The top of Hume is marked by a very strong, widespread amplitude reflector which can be used to 1) mark the bottom of shale prospective sequence and 2) indicate a lower parallel surface to both Base Canol and Top Bluefish formations separated by the roughly constant thickness Hare Indian inorganic shale. Once tied to all usable wells in the area, the variable quality seismic horizon Top Canol can be regionally mapped, converted to depth and isopached using the seismic regional grid in order to evaluate the potential volume of unconventional reservoir. A similar technique can be used to map and isopach the Middle Devonian Bluefish Member (6-25 m log thickness).

Better quantification of the prospective Devonian shale oil volume can be done using the high resolution seismic 2D regional program recently acquired by Explor. This high resolution Three-Component (3C) vibroseis and dynamite source program is Canadian Arctic's most advanced seismic data set allowing for: 1) correct ties to the shale oil intervals, 2) a further examination of lateral shale properties and 3) more accurate planning of future directional drilling.

EXPLORATION IN THE NORTHWEST TERRITORIES: 2012

FALCK*, H., CAIRNS, S. AND GOCHNAUER, K.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
HENDRIK_FALCK@GOV.NT.CA

The presentation will review industry activities in the Northwest Territories since the beginning of 2012. The year started on an optimistic note with many exploration plans being announced. However, the pace of exploration financings was impacted by a shift in the global economic climate that started as early as late 2011. Many junior companies had trouble raising the necessary funds to sustain exploration spending in 2012, forcing them to scale back on fieldwork and defer new activities.

The result of this "scaling back" is immediately apparent upon examining claim-staking statistics. By the end of the third quarter 2012, only 45 claims totaling 31,000 ha. have been staked in the Northwest Territories, many of those covering recently-lapsed, older claims. This is in stark contrast to the 710 claims covering ca. 550,000 ha. staked in 2011, when staking had expanded into in new regions of the NWT and returned to areas in which it had been absent for over 20 years. In regions where large portions of crown lands are tied up in land-claim withdrawals, very few option agreements and exchanges of ownership of grandfathered claims occurred this year.

More advanced projects with previously emplaced financings were relatively active this year. The established properties were all busy with multiple drills turning. Efforts by project operators to define or replace reserves by increasing their exploration allocations in 2012 resulted in a continuation of drilling programs. Companies moving properties through the feasibility stage of exploration continued to expend large efforts to upgrade reserve estimates in order to meet securities exchange compliance standards. These efforts were not restricted to a single commodity but represent lead, zinc, gold, diamonds and rare earth minerals.

No new mines were opened in 2012, but existing diamond and tungsten mines have reported stable to modestly-increased productions levels compared to the last year. These increases in many cases can be attribute to recent development and infrastructure expenditures, and were complimented in several cases by

increases in "on-property" exploration efforts. While the Northwest Territories seemed like a quiet place in 2012, it may not have been alone, as the causes appear to be global in nature.

CAMBRIAN TECTONISM OF THE EASTERN MACKENZIE MOUNTAINS

FALLAS*, K.M. AND MACNAUGHTON, R.B.
GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
KAREN.FALLAS@NRCAN.GC.CA

Petroleum exploration in the central Mackenzie Corridor has historically targeted strata from the Cambrian to the Cretaceous. Bedrock mapping activities within the Geo-mapping for Energy and Minerals (GEM) Program of the Geological Survey of Canada is preparing new bedrock geology maps for the Mackenzie Plain and adjacent areas. This work has increased the documentation of geological features which improve our understanding of the tectono-stratigraphic history of the region. An aspect of particular focus for this presentation is the relationship between the Cambrian-aged Mackenzie Arch and Mackenzie Trough.

The Cambrian extensional history of the Mackenzie Trough, preserved beneath the Mackenzie Plain and Franklin Mountains, has been previously documented by others. Our examination of Cambrian exposures in the eastern Mackenzie Mountains has provided information to constrain the relationships on the southwest margin of the Mackenzie Trough. Data gathered during this project show that the Mackenzie Arch influenced not only the preservational patterns of formations but also the distribution of lithofacies within formations. Along the eastern flank of the Mackenzie Arch, Early to Middle Cambrian sedimentation is recorded by a basal package of cross-bedded, bioturbated quartz arenite, assigned to the Mount Clark Formation, overlain by a shale-dominated succession mapped as Mount Cap Formation. Farther east, in the MacDougal Anticline (i.e., toward the Mackenzie Trough), the Mount Cap Formation is well-developed but the Mount Clark Formation passes into a heterolithic succession (shale, carbonate, and sandstone) better treated as a basal member of the Mount Cap Formation. The Middle to Late Cambrian Saline River Formation shows similar facies trends. In the easternmost Mackenzie Mountains, a typical, thick succession of mudrocks and evaporites is well developed. However, these strata pass south-westward (toward the Mackenzie Arch) into a succession that lacks evaporites, contains abundant quartz sandstone, and locally contains conglomerate. Late Cambrian influence of the Mackenzie Arch is also seen in the basal beds of the dolostone-dominated Franklin Mountain Formation. Along the Arch, these strata include beds of sandy dolostone and quartz sandstone. North-eastward, in the Mackenzie Trough and Franklin Mountains, the basal Franklin Mountain Formation is rich in shale and siltstone. This evidence indicates that the Mackenzie Arch was a positive feature on the southwest margin of the Mackenzie Trough, and was likely exposed above sea-level for some time during the Cambrian.

In addition to the facies variations, Cambrian tectonism is also recorded by stratigraphic thickness changes across normal faults found along the north-eastern flank of the Mackenzie Arch. These thickness changes occur within strata correlated with the Saline River Formation, but do not involve overlying Franklin Mountain Formation strata. Conglomeratic beds within this unit suggest these faults may have been active during deposition of this interval. These faults constitute part of a NNW-striking set of normal faults, preserved within Proterozoic strata, which were active during Cambrian extension affecting both the Mackenzie Trough and Mackenzie Arch.

NTGO PETROLEUM GROUP 2012 – NEW FACES, CHALLENGES AND BEGINNINGS

FIESS, K.M.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
KATHRYN_FIESS@GOV.NT.CA

During 2012, the Northwest Territories Geoscience Office (NTGO) successfully

recruited a new Manager of Petroleum Geosciences, Kathryn Fiess, and a Petroleum Geologist, a Master's graduate from the University of Ottawa named Jonathan Rocheleau. Kathryn brings twenty five years of subsurface petroleum exploration and development experience and has extensive knowledge of the oil and gas industry. Jonathan has a solid background in field geology, sedimentology and a tremendous enthusiasm for adding to his experience base and skill sets. The Petroleum Group is currently working on the Mackenzie Plain Project and has initiated new research on unconventional resource assessments this summer in the Liard Plateau area of the Northwest Territories.

The Mackenzie Plain Petroleum Project was initiated in 2009 by the Petroleum Group. The study area spans about 180,000 square kilometers from 63 degrees 30 minutes north to 66 degrees 30 minutes north latitude and 124 degrees west to 130 degrees west longitude. One of the key objectives of this study is to evaluate the hydrocarbon resource potential of the Mackenzie Plain area with a special focus on the Devonian Horn River Group. Four field seasons have been successfully completed. Rock chip samples from both outcrop and core and cuttings have been analyzed for source rock potential, thermal maturity, mineralogy, and whole rock geochemistry. Data has been released publicly each year in the form of open reports uploaded to NTGO's website. Field studies were completed this summer and the year of 2013 will be spent synthesizing and interpreting all the previous year's work. Our objective is to deliver a final synthesis paper and digital atlas for the project.

The Liard Basin Project is a collaborative geoscientific effort involving NTGO, the Yukon Geological Survey, and the Oil and Gas Division of British Columbia's Ministry of Energy, Mines and Natural Gas. The Liard Basin spans the southwest corner of NWT, southeast corner of Yukon, and into northeast BC. It is of interest to all three jurisdictions because it contains strata equivalent to that BC's Horn River Basin. The purpose of this work is to evaluate the resource potential of the Devonian-Carboniferous package, including the Besa River Formation shale and to establish time stratigraphic correlations between these three regions. Field methods and analytical techniques are similar to those used for the Mackenzie Plain study. Field reconnaissance in 2012 involved helicopter-supported work on outcrops of the Golata and Besa River formations including detailed measurement, description, and sampling. The results of each field season's analytical work will be reported upon annually at geological conferences and uploaded to the NTGO website. The Petroleum Group intends to produce geoscience that will further our understanding of the hydrocarbon resource potential of the NWT and facilitate timely economic development of these resources in our region.

NTGO'S BONNET PLUME MAPPING PROJECT - 2012 UPDATE

FISCHER*, B. AND GOCHNAUER, K.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
BETH_FISCHER@GOV.NT.CA

Published maps of NTS map sheet 106B are preliminary drafts from 1974 that predate modern stratigraphic knowledge. The basinal rocks of this region are prospective for shale-hosted Zn-Pb deposits. The slope and platformal rocks host showings of carbonate-hosted Zn-Pb±Cu (eg. Gayna River; Dap) and silicified carbonate breccia containing up to 0.38 oz/T gold (Ris). Recent stream-sediment geochemistry has revealed numerous metal anomalies.

Watershed mapping in 2009 and 1:40,000-scale mapping near Dudley Lake in 2011 was followed this year by mapping at 1:250,000 to 1:60,000 scale of 400 km^2, mainly in NTS 106B/SE. The project supported two B.Sc. theses (below) and an M.Sc. (see poster by Chevrier and Turner).

The Mid-Cambrian to Early Devonian "Road River Group" in 106B/SE was subdivided into five formations that were originally identified by

stratigraphic studies in 1982. Mafic volcanic rocks of the Ordovican-Silurian Marmot Formation in 106B/SE (Porter Puddle complex; see poster by Williams et al.) and at Dudley Lake (106B/6,7) consist of fragmental rocks and subordinate flows (phenocrystic, amygdular, pillowed, and massive varieties). A linear magnetic anomaly in the same area remains unexplained by the known stratigraphy and may represent a buried intrusion, with implications for mineral exploration. Mapping supports interpretation of the Porter Puddle complex as a volcanic center. Large-scale cross-stratification suggests rapid deposition of volcaniclastic debris. A skeletal rudstone interval that pinches out laterally probably developed as a submarine reef encircling the volcanic island. Later periods of volcanic quiescence and intermittent gravitational disturbance are recorded by convolute-laminated sandstone, and channels of conglomerate in shale.

The Ordovician-Silurian Cloudy Formation in the eastern map area is a resistant skeletal rudstone/floatstone, which represents a significant departure from the type slope lithofacies. Another departure is the sandstone member, present not only in 106B/SE but also 70 km northwest in 106B/5,6, which suggests widespread shallowing and terrestrial influence prior to Hailstone Formation deposition. The Early/Mid-Devonian slope-facies Hailstone Formation is laterally equivalent to platformal limestone of the Grizzly Bear Formation (see poster by Knowlton et al.). A thick succession of Early Devonian(?) platformal carbonate rock in the eastern part of the map area, apparently has no basin-ward equivalent. The youngest strata, mapped previously as Earn Group, were divided into five siliciclastic units of the Mid-Late Devonian Earn and Mississippian Tsichu groups.

In the southern map area, recessive Earn-Tsichu strata strike southeast and are folded into tight, NE-verging anticlines with Hailstone and Grizzly Bear formations exposed in their cores. Two steep, SW-side-down faults cut the central map area. A north-trending break is postulated to explain an apparent sense reversal in the northern fault. Northeast of these faults, a structural dome exposes the Porter Puddle volcanic edifice, which was a paleo-topographic anomaly that probably localized strain during later tectonic events.

Samples have been submitted for biostratigraphic analysis. Burial history is being studied in collaboration with GSC-Calgary (GEM project EGM003). A draft map will be available by spring.

PROPOSED CONSTRUCTED WETLAND TREATMENT SYSTEM FOR WATER TREATMENT AT THE NICO PROJECT, NWT

HAAKENSEN*, M.[1], SCHRYER, R.[2], CASTLE, J.[3] AND RODGERS, J.[3]
(1)CONTANGO STRATEGIES LTD. SASKATOON, SK
(2)FORTUNE MINERALS LIMITED, LONDON, ON
(3)CLEMSON UNIVERSITY, SOUTH CAROLINA, USA

Fortune Minerals Limited is proposing to implement a Constructed Wetland Treatment System (CWTS) at the NICO Project site to treat water at closure generated from either seepage from the co-disposal facility or overflow from the open pit. The CWTS is a passive treatment system that will require virtually no maintenance and is a "walk-away" solution for water treatment at the NICO site.

To design the CWTS, Fortune has engaged the services of Contango Strategies Limited (CSL) in conjunction with their partners at Native Plant Solutions (a division of Ducks Unlimited Canada) and Drs. John Rodgers and James Castle (of Clemson, South Carolina). This team has prepared a work plan to design and undertake a series of feasibility studies to confirm the performance of a CWTS for removal of constituents of concern (COCs) from the water. Every CWTS they design and implement is created on a case-by-case basis, tailored to the specific water needing renovation and site-specific requirements. The team has reviewed the post-closure water quality predictions for the site and based on their

experience in dealing with similar situations, will design and implement a CWTS for treatment of water post-closure at the NICO site.

Wetlands offer natural environments harboring unique biogeochemical reactions. A CWTS can be designed to allow required reactions to take place for treatment of targeted constituents in waters needing renovation. Some metals (e.g., As) are removed from the water by binding to organic detritus, followed by decomposition resulting in negative redox conditions and metal-sulfide precipitation in the presence of reduced sulfur. Other metals (e.g., Al, Fe) can be removed by oxidation processes, while yet others (e.g., S, Se) can be directly targeted through microbial reduction in anaerobic conditions.

Through characterization of the water to be treated, a site-specific, custom CWTS is designed that can naturally clean all of the COCs from the water. Pilot-scale systems are then constructed with a unique combination of sediments, plants, size, water depth, and nutrients for the microbes to produce conditions that promote the preferred biogeochemical pathways to treat the COCs (e.g., biotransformation, oxidation, reduction, sorption). Explanatory parameters (e.g., pH, redox potential, dissolved oxygen, temperature) are monitored during pilot-scale confirmatory testing and optimization of cold-climate performance using pilot facilities at CSL in Saskatoon, Sk.

Design of the CWTS for the NICO Project will go through four phases of design including indoor and outdoor pilot tests, a demonstration model and full scale prototype at the mine site. The objective is to demonstrate the effectiveness of this treatment technology early in the mine life so that a fully proven system will be in place at closure.

The site-specific design strategy for CWTSs, based in fundamental biogeochemistry of natural wetlands, represents a novel approach for renovating impaired waters by converting constituents to less bioavailable and less toxic forms by sequestering them in mineralized forms in the sediments. Often having improved performance over time as the CWTS establishes itself over years, the CWTS can clean water as a long-term sustainable passive water treatment solution.

DEEP-WATER VENT-RELATED CARBONATE MOUNDS: EVIDENCE FOR A REDOX-STRATIFIED WATER COLUMN IN THE MESOPROTEROZOIC BORDEN BASIN, NU

HAHN*, K.E. AND TURNER, E.C.
DEPARTMENT OF EARTH SCIENCES, LAURENTIAN UNIVERSITY, SUDBURY, ON
KX_HAHN@LAURENTIAN.CA

The Mesoproterozoic Borden Basin (Nunavut), host of the carbonate-hosted Nanisivik Zn-Pb deposit, is one of the tectonostratigraphically complex Bylot Basins and remains economically under-explored. Isolated carbonate mounds of the Ikpiarjuk Formation in the lower part of the basin-filling Bylot Supergroup in the Milne Inlet Graben are kilometres in diameter, hundreds of metres thick, enclosed by black shale (Arctic Bay Formation), and centred on and elongate parallel to basin-scale, syndepositionally active faults. A new depositional date for the Arctic Bay Formation (~1.1 Ga) indicates that syndepositional extension early in the basin's depositional history was associated with tectonic stresses during the assembly of Rodinia.

The carbonate mounds are characterised by an unusual clotted texture and lack the features generally associated with Mesoproterozoic reefs (i.e., stromatolites). Mounds accumulated below storm wave-base and below the photic zone. Recent work showed that black shale of the Arctic Bay Formation was deposited in anoxic and at times euxinic bottom water, which suggests that the Borden Basin had a pronounced chemocline. Preliminary results of REE analyses of samples from the Ikpiarjuk Formation mounds show positive Ce anomalies which indicate that anoxic conditions persisted throughout deposition of the mounds. There are

no other documented carbonate mounds in the Proterozoic that were deposited in such deep-water, sub-photic, anoxic conditions.

The Ikpiarjuk Formation mounds are interpreted to represent fossilized cold seeps that accumulated where groundwater entered seawater through seafloor fissures associated with active faults. A redox-stratified water column in a basin undergoing syndepositional extensional faulting is a depositional setting associated with the formation of SEDEX/CD deposits. There is currently no evidence for SEDEX-type venting in this under-explored basin, but the pronounced local venting of subsurface fluid to produce the Ikpiarjuk Formation mounds indicates that low-temperature fluids were locally expelled at line- or point-sources on the basin floor during black shale deposition.

Although the Mesoproterozoic seems to have been a global nadir in sediment-hosted Zn-Pb deposits, the presence of the carbonate-hosted Nanisivik deposit (recently dated at ~1.1 Ga) in the Borden Basin illustrates that Zn-Pb-carrying fluids were produced and circulated close to the time of sediment deposition. The basin clearly had most of the prerequisites for SEDEX/CD deposits, but its potential in this regard remains unknown. Study of the products of venting in the Ikpiarjuk Formation may elucidate the geochemical evolution of vent fluids and shed light on the economic potential of the Arctic Bay and Ikpiarjuk formations.

MULTI-SOURCE VEGETATION INVENTORY – RESEARCH FINDINGS AND NEXT STEPS

HALL, R.J.[1], SKAKUN, R.S.[1], FILIATRAULT, M.[1], GARTRELL, M.[1], VOICU, M.[1], LAKUSTA, T.[2], SMITH, L.[2], AND GROENEWEGEN*, K.[2]

(1)CANADIAN FOREST SERVICE, NRCAN, EDMONTON, AB

(2)FOREST MANAGEMENT / FOREST RESOURCES, GNWT, HAY RIVER, NT

Managing the NWT landscape is an increasing challenge driven by changing demands against the relative lack of consistent, up-to-date, and detailed forest and vegetation inventory data. As a result, the ability to track and manage cumulative impacts, forest sustainability, wildlife and habitat security, and land cover change, is limited. Meeting these needs requires a data and knowledge integration approach that supports the analysis of associations between forest structural attributes and the range of resource values needed by the Government of NWT. There is also a fundamental need to determine the contribution of NWT forests to the state of forests in Canada, changes in carbon stock and contribution to greenhouse gas emissions.

Across the NWT, there exists a continuous 30m pixel resolution land cover map, the Earth Observation for Sustainable Development (EOSD c.2000) which was updated to 2007 over an approximate 200,000 km^2 region within the southern Taiga Plains Ecozone. The EOSD land cover map describes the broad distribution of forest and vegetation land cover across the NWT. With very limited attribute information, however, the product in itself has relatively limited utility for supporting resource management decisions. To effectively manage the forest resource, managers need to know answers to questions such as how tall and old forest stands are, how much volume and biomass they contain, how dense the stands are, what are the species composition characteristics, how the forest land is being used by people and wildlife, and how is the forest changing as a result of natural disturbance and a changing climate.

To address some of these questions, a partnership research-based program between Natural Resources Canada Canadian Forest Service (NRCan-CFS) and the Government of the Northwest Territories (GNWT) has been ongoing since 2006. The focus of this program has been to develop and evaluate remote sensing techniques to derive inventory products that estimate forest structure, stand volume, aboveground biomass and age as value-added attributes to the land cover map. A data and modeling integration approach has been

developed to scale field data, LiDAR and satellite optical imagery into a Multisource Vegetation Inventory product conducive for spatial analysis. This presentation will provide an overview of the program, its components, status and current activities.

OIL AND GAS POTENTIAL AND THE KA'A'GEE TU CANDIDATE NATIONAL WILDLIFE AREA

HAMRE, K.
NWT PROTECTED AREAS STRATEGY, YELLOWKNIFE, NT
PASMANAGINGDIRECTOR@NORTHWESTEL.NET

The Ka'a'gee Tu candidate National Wildlife Area is located in the Dehcho region of the Northwest Territories, centred around Kakisa and Tathlina Lakes. It is bordered along its south side by the Cameron Hills.

The area has national ecological significance and cultural significance to the community of Kakisa and the whole Dehcho region. In 2006, the Ka'a'gee Tu First Nation began the process of moving the Ka'a'gee Tu area forward through the Northwest Territories Protected Areas Strategy (PAS) process. The First Nation originally identified an area of approximately 8,670 km² for consideration and study.

The Ka'a'gee Tu First Nation excluded the Cameron Hills from their proposal, as they were interested in maintaining access to the high oil and gas potential of the Cameron Hills. In other words, areas known to have high non-renewable resource potential were specifically excluded in order to balance the need for economic opportunities and growth with the need for protection.

As part of the eight-step PAS process, the First Nation's proposal was discussed with the surrounding communities and Environment Canada - Canadian Wildlife Service (CWS). In 2009, CWS determined that Ka'a'gee Tu contained nationally significant ecological values that fell within its legislative mandate. Hence CWS agreed to work toward creating the Ka'a'gee Tu National Wildlife Area through the PAS process. The surrounding communities asked that the original study area be expanded to encompass 9,607 km², but their request did not create an overlap with the area of high oil and gas potential.

Part of the PAS process involves doing assessments on the areas values: ecological, cultural and economic. Clearly some early information was known about those values, because they guided the original proposal and CWS's agreement to sponsor the area. However, more detailed studies are required in the PAS process to better evaluate suitable land administration, boundaries and management regime.

The oil and gas potential in the area was assessed by Morrow (2007), referencing previous estimates of the hydrocarbon potential of the NWT and the Dehcho region by the National Energy Board, the Canadian Gas Potential Committee, the Northwest Territories Geoscience Office, and Drummond Consulting. Morrow noted that new quantitative hydrocarbon play assessments for the NWT were underway by Geological Survey of Canada at the time of his Ka'a'gee Tu assessment.

To ensure stakeholders had up to date information, the PAS contracted Drummond (2011) to provide revised estimates of hydrocarbon potential in the Ka'a'gee Tu study area. He concluded that while the Ka'a'gee Tu study area covers 5.5% of the Dehcho region, it contains an estimated 3.4% of the undiscovered recoverable gas and 10.8% of the undiscovered recoverable oil. Drummond notes that the greatest oil potential is along the southern boundary near the Cameron Hills, where other hydrocarbon discoveries have been made.

This information will be used by the working group established through the PAS process to make recommendations on the

area's land administration, boundaries and management regime.

OXYGEN ISOTOPE AND LITHOGEOCHEMICAL STUDIES OF GOLD MINERALIZATION OF ORMSBY AND CLAN LAKE, YELLOWKNIFE GREENSTONE BELT

HANSEN*, E.[1], SHELTON, K.L.[1], GOMEZ, F.[1], FALCK, H.[2] AND PRATICO, V.[3]
(1) DEPARTMENT OF GEOLOGICAL SCIENCES, UNIVERSITY OF MISSOURI, COLUMBIA, MO USA
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(3) TYHEE GOLD CORP., VANCOUVER, BC
EGHANSEN@MAIL.MIZZOU.EDU

Ormsby and Clan Lake are areas of active gold exploration in the north end of the Yellowknife greenstone belt. Gold occurs principally within silicified and sulfidized metavolcanic rocks of the Archean Banting Group (2.69-2.66 Ga). Ormsby is hosted within a narrow, elongate mafic unit, which is surrounded by voluminous metasedimentary rocks. Clan Lake is hosted in a larger, intermediate to felsic, metavolcanic-volcaniclastic complex. Mineralization in both areas is characterized by arsenopyrite followed by pyrrhotite ± native gold. The deposits occur along a N-NE trend associated with regional faulting and present an opportunity to determine if their ores are related to similar hydrothermal systems whose chemistries differ as a function of host lithology, or instead indicate chemically distinct hydrothermal systems. In summer 2011, one hundred fifty-three samples were collected to reflect the spatial distribution of quartz veins, sulfides, wall rocks, and alteration.

Quartz veins from Ormsby have $\delta^{18}O$ values of 13.0-15.1‰ V-SMOW (n=10), which are interpreted to reflect dominance of metasedimentary-derived fluids that reacted with the mafic metavolcanic host rocks. In contrast, Clan Lake's quartz veins and wall rocks have $\delta^{18}O$ values of 11.3-15.2‰ (n=19) and 8.2-12.8‰ (n=14), respectively, interpreted to indicate both metavolcanic and metasedimentary fluid sources. Similar influence of both metavolcanic and metasedimentary fluid sources has been documented in the hydrothermal system responsible for the world-class gold deposits of the Giant mine at the southern end of the greenstone belt.

Tyhee Gold Corporation's large lithogeochemical data set for 150 drill cores from Clan Lake permits us to link $\delta^{18}O$ values with host rock chemistry. 3-D modeling of the spatial distribution of $\delta^{18}O$ values defines a volume of rock with higher values that coincides with elevated gold concentrations. Therefore, $\delta^{18}O$ values may be useful in defining the size of the Clan Lake mineralizing system and may be helpful as an exploration tool and ore guide. By this reasoning, based on drilling to date, we have defined a northern edge of an economically mineralized portion of the alteration zone. To the south-southwest, the high-$\delta^{18}O$, high-gold trend appears to continue, indicating a potential vector for future exploration efforts.

Lithogeochemical data were also used to reconstruct volcanic protoliths at Clan Lake and to determine if there is a preferred ore-hosting chemistry or lithology. Immobile element ratios (Zr/Ti and Cr/Al) of altered rocks at Clan Lake reflect dominantly intermediate composition protoliths, with a minor felsic component. Samples that we suspected were mafic have immobile element ratios more consistent with intermediate rock protoliths. A plot of gold grade versus Zr/Ti ratios (ppm/percent) suggests that there is a preferred chemistry of intermediate rocks associated with gold deposition, with Zr/Ti ratios between 350 and 560. Ongoing studies hope to determine if this chemistry corresponds to a preferred lithology with enhanced porosity and permeability during the gold mineralizing event or one whose chemistry was more reactive with the ore fluids, or a combination of both.

TECTONIC RECONSTRUCTION AND GEOPHYSICAL INVESTIGATIONS OF IOCG OCCURRENCES: GREAT BEAR MAGMATIC ZONE, NT

HAYWARD*, N.[1], CORRIVEAU, L.[2], ENKIN, R.[3] AND MONTREUIL, J.-F.[4]
(1) GEOLOGICAL SURVEY OF CANADA, VANCOUVER, BC
(2) GEOLOGICAL SURVEY OF CANADA, QUÉBEC, QC
(3) GEOLOGICAL SURVEY OF CANADA, SIDNEY, BC
(4) INRS-ETE, QUÉBEC, QC
NHAYWARD@NRCAN.GC.CA

The Geological Survey of Canada's (GSC) Geomapping for Energy and Minerals (GEM) Program is developing and applying new techniques to iron oxide-copper-gold (IOCG) mineral exploration. The Great Bear magmatic zone (GBmz) is the remnants of a Paleoproterozoic continental magmatic arc (ca. 1.872–1.843 Ga), which hosts IOCG mineralisation, including the (Au-Co-Bi-Cu) NICO deposit. The arc, which was built upon the Hottah terrane during eastward subduction prior to accretion of the Fort Simpson terrane, is dominated by granodiorites, with mafic and volcaniclastic rocks towards the margins. Coarse grained biotite granites (ca. 1.866 – 1.856 Ga) mark the final plutonic event, which was followed by extensive NE-striking brittle faulting, related to final accretion.

A tectonic reconstruction of the GBmz, based on the interpretation of a new compilation of high-resolution aeromagnetic data and geological maps, resets major fault offsets associated with final accretion. The reconstruction provides a snapshot of the geometry of the GBmz at the time of mineralisation (ca. 1.873 - >1.866 Ga), and a tectonic model for the late-stage setting and evolution of the arc, important in understanding the context of the mineralisation. The model suggests that the NE-striking faults were preceded by extension, localised along the western side of the arc in association with NNE-striking faults, perhaps driven by shifting plate motions and slab-rollback.

Geophysical target models developed for the NICO area, which integrate proprietary high-resolution magnetic and gravity data with GSC physical property data, extracted from 651 samples collected from NICO and other sites across the GBmz, clearly delineate the primary ore zone and the majority of the local mineral showings. Applied regionally, similar models accurately locate known magnetite-group IOCG deposits, including NICO and prospects such as Grouard, Fab, DeVries and Cole Lake, the magnetite to hematite-group systems of the Port Radium-Echo Bay district, and offer possible targets for future exploration.

"ELF" – A GROUND EQUIVALENT TO GEOTECHS ZTEM AIRBORNE SYSTEM

HILDES, D.
AURORA GEOSCIENCES LTD, YELLOWKNIFE, NT
DAVE.HILDES@AURORAGEOSCIENCES.COM

The extremely low frequency electromagnetic system (ELF) is a new ground geophysical technique, closely related to Geotech's ZTEM airborne system. The ELF unit is very portable and cut lines are not necessary. Daily production for a two-person crew is typically between two and four line-km depending on terrain, station spacing and geomagnetic conditions. The survey measures vertical and horizontal components of the natural time-varying geomagnetic field originating primarily from global lightning activity. The system calculates the tilt angle, or tipper, of the magnetic fields from 11 to 1440 Hz which are sensitive to 2D and 3D conductivity contrasts. The system is designed to image resistivity from depths of 10 metres to 2 kilometers dependant on the host conductivity structure. The ELF system offers a very cost-effective alternative to other deep imaging EM techniques such as MT / CSAMT / large-loop TEM.

The data can be automatically inverted in three dimensions to provide a full conductivity structure of the earth which can be efficiently integrated with other geological knowledge. The results can be useful in mapping both small shallow features and larger regional geological structures. The system is more sensitive to low-conductivity contrasts

than other active-source EM techniques. The depth of investigation is dependent on the local conductivity, with greater depth of investigation possible in resistive rocks.

A description of the system, field procedures and case studies are discussed in the presentation.

CLIMATE CHANGE IMPACT ON THE STATE OF PERMAFROST AT INUVIK, NWT

HOEVE, T.E.
EBA, A TETRA TECH COMPANY, YELLOWKNIFE, NT
EHOEVE@EBA.CA

Previous studies have identified northern Canada, in general, and the Mackenzie Valley in particular, as experiencing higher air temperature increases due to climate warming than within other parts of Canada. Consequently, infrastructure that is supported on permafrost, such as buildings, has been recognized as vulnerable. Inuvik, because of its size and location, has been identified as particularly vulnerable. But to-date, the impact of climate warming on the permafrost within the developed area of the community has not been defined.

Ground temperature monitoring cables were installed during the construction of the foundation of the Western Arctic Research Centre, in Inuvik, in 2010. Foundation performance relies on the integrity of the permafrost to be maintained. The monitoring cables permit the integrity of the permafrost to be monitored.

Initial data from this instrumentation is presented and clearly shows a heat flux from the ground surface downward. Climate data exhibits a warming trend and is interpreted to be the driver for this ground warming. The practical implications of this ground warming are described.

THE COMPLEX GROWTH OF NON-GEM DIAMONDS AT THE DIAVIK DIAMOND MINE, CANADA

HUNT*, L.[1], STACHEL, T.[1], PEARSON, D.G.[1], STERN, R.[1], MUEHLENBACHS, K.[1] AND MCLEAN, H.[2]
(1) CCIM, UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) RIO TINTO, DIAVIK DIAMOND MINES INC., YELLOWKNIFE, NT
LCHUNT@UALBERTA.CA

Diavik is located in the Cretaceous-Miocene Lac de Gras Kimberlite Field of the Central Slave craton. Whilst high value gem diamonds are abundant, fibrous/polycrystalline overgrowths of crystalline diamonds, opaque fibrous cubes and polycrystalline boart are also common, and are detrimental to production value.

Non-gem diamonds are valuable tracers of mantle metasomatism, trapping micro-inclusions of the melt/fluids which formed them and allowing direct analysis of the changing chemical environment in which they grew. We aim to establish the changes in physical and chemical conditions accompanying the transition from gem to non-gem diamond growth and how this affects the sub-cratonic lithospheric mantle (SCLM). This information will then be used to establish a chemical fingerprint for fibrous/polycrystalline diamond growth events that may be used to predict the presence of such a revenue-detrimental diamond component during exploration.

Cathodoluminescence of five sectioned non-gem diamonds (three coated diamonds and two hailstone boart) revealed fine scale complexities not observed in visible light that suggests multiple stages of growth.

Secondary Ion Mass Spectromotry was used to determine N content and $\delta^{13}C$ along transects perpendicular to diamond growth. Despite the visual complexities of the hailstone boart, little variation is observed in N content (960 to 1100ppm) or $\delta^{13}C$ (-6.5 to -6.0‰). The coated stones show more variation: The coats are generally higher in N content (average 1700ppm) with more negative $\delta^{13}C$ (-8 to -

5.5‰) than the associated cores (1300ppm and -4.5 to -5‰). The change from gem to non-gem growth appears visually sharp and may represent precipitation from two distinct fluids. However, a subtle shift in N content and $\delta^{13}C$ is already observed prior to the visible core-coat transition in two of the three coated stones. This suggests that a more continuous evolution of the diamond precipitating medium, possibly through mixing processes, may have prompted non-gem growth after a critical point of supersaturation was reached. The mantle-like $\delta^{13}C$values may suggest a melt/fluid derived from the asthenosphere.

Initial Fourier Transform Infrared (FTIR) spectroscopy indicates non-gem diamond growth by different diamond forming fluids. Peaks associated with carbonate are observed in a selection (Six to-date) of non-gem growth, whilst a further subset (Five to-date) display peaks associated with silicates. Klein-BenDavid et al. (2007) suggested, through analysis of micro-inclusions in fibrous diamonds, that non-gem diamonds grow from carbonatitic fluid which evolves to more silicic and saline compositions. This may explain the textural, elemental and isotopic variations observed in this sample set. Mantle residence temperatures, determined from nitrogen content and aggregation state, indicate multiple growth events throughout the entire lithospheric mantle.

THE BANTING GROUP VMS PROJECT: RESULTS AND SPECULATIONS FROM 2012 (SHARRIE LAKE, NTS 85I)

JACKSON*, V.A. AND OOTES, L.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
VALERIE_JACKSON@GOV.NT.CA

The 2690-2660 Ma bimodal Banting Group volcanic rocks of the Slave craton are known to host volcanogenic massive sulfide (VMS) deposits. In Nunavut, some deposits are in advanced exploration stages (e.g. Hackett River, IZOK), while in the NWT many prospective volcanic belts have not been thoroughly investigated for their VMS potential. The NWT Geoscience Office and partners have initiated a project to test the prospectivity of such volcanic belts in the NWT. The project applies a targeted multi-disciplinary approach, using volcanology, alteration, U-Pb geochronology, and isotopic studies to augment detailed bedrock mapping and map compilation. A variety of related outstanding questions can thus be addressed, such as: which belts are potential hosts to VMS deposits and which are not; what characterizes belts with deposits or deposit-potential versus those without; what are the tectonic settings of the belts, and; how do the belts compare within the Slave and globally to other Archean VMS camps?

As a first step in the project, four areas containing Banting Group-equivalent volcanic rocks were identified for detailed bedrock mapping: Sharrie, Indin, and Fenton lakes and Snare River-Wijinnedi Lake. In 2012, 15 days were spent mapping at Sharrie Lake, within a strongly bimodal part of the Beaulieu River volcanic belt at the south end of the Sleepy Dragon complex. The area was mapped by Lambert in 1972 and 1973 at 1:50,000 scale and his map was used as a base for our 1:7,500 scale efforts. Highlights from the more detailed study are provided below; predictably this study has resulted in a more complex geological map.

Volcanic rocks at Sharrie Lake are disposed in a steeply overturned, northwest-plunging antiform, display a penetrative regional foliation and an intense subvertical stretching lineation, and have undergone greenschist to lower amphibolite facies metamorphism. Fortunately, deformation was sufficiently heterogenous that many primary volcanic textures are preserved. Dark green to black, chlorite-amphibole-rich basaltic pillows have thin selvages and little interstitial material; many basalt flows show signs of significant syn-volcanic alteration. Intermediate flows are grey, biotite±garnet-bearing, typically highly vesicular, and pillows have thick selvages and/or abundant interstitial material; many intermediate flows may represent altered basalts. Rhyolite and smaller amounts of dacite vary from massive (subvolcanic intrusions

or rhyolite domes?) to volcaniclastic rocks with ash, lapilli and block-sized fragments. The felsic rocks are concentrated towards the nose of the antiform, along the southwestern limb, and in the core of the structure. Elsewhere, interlayering with mafic-intermediate flows is evident at meso- and macro-scales. Slightly younger gabbroic intrusions, some with polygonal cooling fractures, and ultramafic dykes cross the volcanic rocks. Local zones of silicification, sericitization, and Al-enrichment in felsic rocks and spotty alteration in pillowed flows are documented, but widespread alteration may only be evident through geochemical studies. Sulphidic gossans are common at flow contacts and are prominent in pillowed flows along the southern contact with the overlying Burwash Formation greywacke-mudstones.

A number of other belts were examined during reconnaissance, including Lac du Roche, Mackay-Courageous, and Cameron River. Forthcoming U-Pb crystallization ages and tracer isotope studies (Sm-Nd) on both rhyolites and basalts will shed light on their temporal and petrological evolution.

TRI TERRITORIAL SURFICIAL GEOLOGY DATABASE: SUPPORTING MORE EFFECTIVE EXPLORATION AND RESOURCE DEVELOPMENT

KERR*, D.E. AND EAGLES, S.
GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
DKERR@NRCAN.GC.CA

The objective of the Tri-Territorial Surficial Database Project is to provide an accessible regional-scale surficial geoscience knowledge database to support northern exploration and economic development. This is accomplished through a digital compilation and queriable surficial database of new and existing surficial geology maps of Northwest Territories, Nunavut, and Yukon. The Project coordinates with ongoing Geo-mapping for Energy and Minerals (GEM) field mapping activities on Victoria Island, Wager Bay, Cumberland Peninsula, as well as other GEM and Climate Change Remote Predictive Mapping (RPM) initiatives in the Yellowknife/Hearne Lake area (NTS 85J, 85I), Hall Peninsula, and MacKay Lake (NTS 75M).

The surficial database identified 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), 303 maps from Nunavut (211 in digital format), and 160 maps from the Yukon, all in digital format, compiled by the Yukon Geological Survey. An additional 58 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 500K-1M scales with little or no field work.

A new Geological Survey of Canada (GSC) Surficial Data Model (SDM) has recently been developed (Open File 7003, version 1.2) to ensure the implementation of standard map units and symbols, and thus facilitates new Quaternary geology mapping and correlation of map units at local, regional and national scales. Conversion of legacy map units to the new legend is ongoing and will provide significant queriable advantages to the database. The science language for the SDM will be updated (version 2.0 and beyond), to ensure that new map units and symbols requested by surficial geology mappers found on published maps are consistently implemented. The language allows geological mappers to archive information about earth materials in a manner that is consistent, uniform, and flexible. The next step will be to parse legacy knowledge terminology (map unit legend descriptions) and bring it into new corporate databases, maintaining archival terminology where appropriate. A parsed, standardized science language will increase the usability, queriability and comparability of geoscience knowledge of proven interest and value to stakeholders contained in surficial framework databases.

Currently, a 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 communication tool for exploration industry, land-use planners and policy-makers.

PERMAFROST LANDFORM STATUS, SELWYN/MACKENZIE MOUNTAINS, NORTHWEST TERRITORIES

KERSHAW*, G.P.[1], MAMET, S.D.[2] AND KERSHAW, G.G.L.[3]

(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) UNIVERSITY OF SASKATCHEWAN, SASKATOON, SK
(3) DALHOUSIE UNIVERSITY, HALIFAX, NS

Palsas and peat plateaus are common permafrost landforms in the discontinuous permafrost zone. These landforms consist of a surface cover of peat which thermally isolates a mineral sediment core. The mineral sediments contain excess ice which gives the features their height. These landforms are often used to delineate the southernmost extent of permafrost.

Current information on the evolution of permafrost landforms rarely covers more than the last several decades. The Selwyn/Mackenzie Mountains study area is unusual since aerial photography and field studies started in 1943-4. In addition, dendroclimatological studies have been used to develop a proxy climate record spanning 1750 to the present day. Consequently, there is a rare opportunity to evaluate the role of recent climate warming on permafrost landforms in this region.

The proxy climate record shows that from ~1800 to 1850, cooler conditions prevailed. From ~1850 to 1900 there was warming followed by cooling until ~1930 when warmer conditions persisted for ~20 years. The cooler period between ~1960 and 1980 was followed by warming to the present day.

The aerial photography of 1943 and 1944 captured the condition of the features at the end of the 1900-1930 cool period. Ground level photos at one palsa field in Macmillan Pass also provide a basis for comparison. At this time there was evidence of thawing expressed by thermokarst and post-palsa ponds with raised rims. Several features apparent on 1944 images have completely thawed and others have significantly decreased in their areal extent. The greatest changes have occurred along the perimeter of features whereby they have receded and subsided to produce thermokarst ponds at their margins. Some larger peat plateaus enclose thermokarst depressions, but most features degrade from their perimeter.

Since 1990 several palsas and peat plateaus have been monitored by thaw depth surveys and automated microclimate stations. Despite cooling of mean annual air temperatures over the past 5-6 years, near-surface permafrost is warming. Mean annual permafrost temperature ranges from ~−2.0 to −0.2°C depending on the site. In general the low elevation sites have colder permafrost than those at higher elevation despite expected adiabatic cooling. The majority of features have had stable active layers, despite perimeter recession. Two have experienced deeper active layers and one of these has had an extreme reduction in size (90% loss of its 1944 area).

Warming trends in the near-surface permafrost and evidence of areal reductions in the size of all features suggest that palsas and peat plateaus will continue to thaw and disappear from the Selwyn/Mackenzie Mountains study area. The current trend was initiated in the late 1930's to early 1940's. Many of the features likely originated prior to 1850 and probably before extant trees colonized the region in the mid-1700's.

TUNDRA PLANT RESPONSES TO 70-YEAR-OLD CANOL CRUDE-OIL SPILLS, NORTHWEST TERRITORIES

KERSHAW*, G.P.[1], KERSHAW, L.J.[1], KERSHAW, E.S.[2], KERSHAW, J.M.[2] AND KERSHAW, G.G.L.[3]
(1) ARCTIC AND ALPINE ENVIRONMENTAL CONSULTING SERVICES, SHERWOOD PARK, AB
(2) WOLFVILLE, NS
(3) DALHOUSIE UNIVERSITY, HALIFAX, NS
PETER.KERSHAW@UALBERTA.CA

During the Second World War, the CANOL No. 1 Project was completed. It included a 10-cm diameter crude-oil pipeline and tote road through the Mackenzie Mountains to connect oil production at Norman Wells, NT with oil refining in Whitehorse, YT. Oil was first received at Whitehorse on 16 April 1944 and pipeline shutdown and abandonment occurred by 13 March 1945 when drain-back was taken in at each pump station. A total of 9,864 kL (60,275 imp bbl) was left in the line or in surge tanks at the pump stations. In the NT section there would have been ~1,800 kL (11,000 imp bbl) in storage tanks (excluding the Camp Canol tank farm) and ~3,000 kL (18,330 imp bbl) in the pipe. Between 1948 and 1953, the bulk of the NT section of the pipeline was salvaged. To retrieve pipe sections, a low point was selected and punctured to drain the oil, which was sometimes burned.

Of the 372 km in the NT, 117 km traverse tundra ecosystems. These were the focus of fieldwork conducted in 1977-79, 1997-8 and 2012 (approximately 35, 50 and 70 growing seasons after the initial disturbance). Subsampling was conducted when variations in site characteristics (e.g., change in slope, change in dominant plant cover) warranted.

Each sampling time, permanently marked vegetation quadrats were assessed. For each quadrat, cover was estimated for vascular plant taxa in four vertical strata: 0-30 cm, 30-100 cm, 100-200 cm, and >200 cm. Nonvascular plants were often difficult to identify in the field and some species had to be grouped (e.g., miscellaneous acrocarpous mosses, biotic soil crusts, *Cladonia* spp.). Cover estimates were also made for abiotic components, including exposed mineral substrate, organic matter/litter and anthropogenic material. The 1970s quadrat photos and two permanent marker pegs were used to relocate quadrats for resampling in 1997-8 when an additional 15 randomly located plots were installed and assessed. The permanent markers consisting of nails and aluminum numbered tags were relocated for the 2012 resurvey using a metal detector.

Nine oil spill sites were found, varying in size from 6 to 4,460 m^2. Historical records include three of the sites which resulted from releases of 1.6 to 212.8 kL (10 to 1300 imp bbls), while the remainder were assumed to have resulted from construction or salvage operations. Spill soils were warmer and hydrocarbon degradation decreased with depth in the 0 to 25 cm range. Little evidence of hydrocarbons was observed below this depth. Plant community characteristics differed greatly between crude-oil contaminated sites and adjacent undisturbed vegetation. After 70 years, species richness, diversity, and cover remain low on contaminated sites, but all indices indicate continued recovery. A number of vascular plants and non-vascular taxa have been identified as successful colonizers of crude-oil spills after 70 years of natural recovery.

ICE WEDGE DEVELOPMENT AND DEGRADATION ACROSS THE LOW ARCTIC TREELINE TRANSITION: A LANDSCAPE PARADOX

KOKELJ*, S.V.[1], LANTZ, T.C.[2], WOLFE, S.[3], KANIGAN, J.C.[1], PALMER, M.[1], IRWIN, D.[4] AND BURN, C.R.[5]
(1) CUMULATIVE IMPACT MONITORING PROGRAM, ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT, YELLOWKNIFE, NT
(2) SCHOOL OF ENVIRONMENTAL STUDIES, UNIVERSITY OF VICTORIA, VICTORIA, BC
(3) GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA, OTTAWA, ON
(4) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(5) DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES, CARLETON UNIVERSITY, OTTAWA, ON

The nature of ground ice and the thermal regime of permafrost dictate the response of periglacial landscapes to disturbance or climate warming. Polygonal terrain is widespread in areas of continuous permafrost and the underlying wedge ice constitutes a dominant near-surface ground ice type in many northern landscapes. In this research we used remote sensing and a regional network of ground-temperature and ground-ice observations to investigate controls on the distribution and size of ice wedges, and terrain sensitivity across the low Arctic treeline transition. Our study area includes an existing natural gas pipeline, the proposed Mackenzie Gas Project and the planned Inuvik-Tuktoyaktuk road. To examine spatial variation in factors controlling ice-wedge development we examined snow, ground thermal and ice-wedge cracking conditions at sites with fine-grained mineral and organic soils across this ecological gradient. For comparison, the regional distribution of ice wedges were assessed by mapping polygonal terrain using aerial photographs, and ice-wedge characteristics were determined at over 40 permafrost exposures in mineral soils and by shallow drilling at several peatlands across the study region. To relate the long-term integrity of infrastructure with broad-scale patterns of ice-wedge characteristics we also assessed the nature and magnitude of thermokarst subsidence at over 100 anthropogenically disturbed sites from across the region using aerial photographs and field assessments.

The density and the size of ice wedges decreased southward across the treeline transition with increasing ground temperatures. Polygons and large ice-wedges characterized much of the terrain in the northern dwarf shrub tundra region. Ground temperature observations at sites across the study area show that thermal-contraction cracking thresholds were crossed more frequently in peatlands than in fine-grained hummocky uplands. Regional scale mapping also revealed an abrupt latitudinal decline in wedge ice through the tall shrub transition zone, which was consistent with latitudinal changes in ground thermal conditions.

In subarctic boreal forests, relict wedge-ice was confined to peatlands indicating that thermal-contraction cracking and ice-wedge growth occurred during periods with colder winter temperatures or lower snow cover. The present climate and snow conditions of the subarctic boreal zone are insufficient to freezeback a saturated organic active layer. This condition can initiate the degradation of polygonal peatlands while subarctic forested sites underlain by mineral soils remain stable. The inherent physical- and thermal-sensitivity of polygonal peatlands make these ecosystems focal points of change in a warming low Arctic environment.

The sensitivity of this terrain is also indicated by the magnitude of surface subsidence at sites of historical infrastructure, which follows closely the regional patterns in ice-wedge characteristics. A summary of the research results, including interactive maps will be disseminated via the Decision Makers Atlas. This pilot project is intended to provide environmental information to regulatory boards and planners in an accessible and understandable web-based format.

THE NUCLEAR BATTERY - A ZERO EMISSIONS SOURCE OF SAFE, LOW-COST ELECTRICITY AND PROCESS STEAM IN REMOTE LOCATIONS

LANG, P.M.
DUNEDIN ENERGY SYSTEMS LTD., HAWKSTONE, ON
PLANG@DUNEDINENERGY.CA

Overview

In a resource hungry world, Canada's arctic frontier has seen a major increase in mineral exploration and mining development activity. With a near total lack of in-place infrastructure to support these activities, vast quantities of diesel fuel are being used to meet the electricity, process steam, and space heating requirements of these energy intensive operations. While this has proved to be a satisfactory solution in the past, the evolving dynamics of security of supply, fuel logistics, costs, and environmental concerns has cast serious doubt on the future

viability of this energy source as the prime mover of large industrial projects in the north.

Cost

Even with the European and US economies at or near zero growth rates, the price of oil remains punishingly high. Energy costs are becoming the gatekeeper on some resource development projects.

> *"There are lots of resources up there, but a lot of those are not currently on mine plans because of operating costs. And that's mainly linked to energy cost. Once you've solved that, you've got diamond mines for the next 50 years easily"*
> Ricus Grimbeek, former president of Ekati diamond mine Globe and Mail, April 9, 2010, "The North Scrapes Bottom"

Security of supply

With the closing of several east coast refineries the security of supply of ultra low sulphur diesel with a -40^0 pour point is becoming increasingly problematic. Some mines are down to a single supplier.

The Nuclear Battery – a possible solution to the diesel dilemma.

The term "nuclear battery" is a generic term used to describe any small, low power, integral design, long-life nuclear power plant in which there is no on-site refuelling or spent fuel storage operations. Nuclear batteries have a typical fuel life of 10 to 20 years. When the fuel in the reactor core is exhausted, the entire reactor module is removed from the plant as a sealed unit and shipped to a fuel processing facility for recycling into fresh fuel. A new replacement core module with fresh fuel is installed in its place, invoking the notion of battery replacement. The sealed core vessel does not permit operator access to the fuel during its operational life thereby eliminating the risk of proliferation.

The nuclear battery under development by Dunedin Energy Systems Ltd. is a 5 MWe (25 MWt) inherently safe power plant that requires no external source of water. It emits no SOx, NOx, VOCs, GHGs or particulates and can operate in the all electric or co-generation mode producing electricity and high-grade steam heat.

A single Dunedin Energy nuclear battery will displace over 180 million litres of diesel fuel and eliminate the production of up to 500,000 tons of CO_2

In remote locations the nuclear battery can be highly competitive with diesel generation in cost, security of supply, logistical effort and environmental risk. This technology will be a key enabler of sustainable development in the north. It is a national strategic technology that Canada must possess.

YUKON ROCKS: EARTH SCIENCE ENGAGEMENT IN THE YUKON

LAXTON, C.S.
YUKON GEOLOGICAL SURVEY, WHITEHORSE, YT
SARAH.LAXTON@GOV.NT.CA

There are a number of Earth Science engagement initiatives underway across Yukon. These activities are implemented to promote public engagement and understanding of the geology of the region. The Yukon Geological Survey is actively collaborating with local agencies including the Yukon Chamber of Mines, Department of Education, Yukon Parks, and Environment Yukon to deliver dynamic, captivating, hands-on learning opportunities in a fun setting. Key events include Mining Week, Geoscience Forum, and the Yukon Teachers' Workshop – these provide venues for the Yukon Geological Survey to connect with the public and increase the accessibility of our products and staff.

Yukon has a number of communities spread across the territory making it difficult for those residents and students to participate in Whitehorse based activities. The Yukon Permafrost Outreach Program in partnership

with Kenji Yoshikawa, University of Alaska Fairbanks, visits schools involved with frost tube monitoring at the start of every school year. This program reaches six communities across the territory and gets students excited about taking frost tube measurements and for many students, is the first introduction to a geologist in the class room. Other endeavours being pursued at the Yukon Geological Survey include the finalization of the Yukon geology highway map series, increased web presence, and the development of a regional pamphlet series that can be used by both the interested public and teachers in the classroom.

REGIONAL BEDROCK MAPPING, HALL PENINSULA, NUNAVUT

MACHADO*, G.[1], BILODEAU, C.[1], TAKPANIE, R.[1], ST-ONGE, M.[2], RAYNER, N.[2], SKIPTON, D.[3], FROM, R.[4], MACKAY, C.[4], YOUNG, M.[5], CREASON, G.[5] AND BRADEN, Z.[5]

(1) CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(3) UNIVERSITY OF OTTAWA, OTTAWA, ON
(4) UNIVERSITY OF SASKATCHEWAN, SASKATOON, SK
(5) DALHOUSIE UNIVERSITY, HALIFAX, NS
GMACHADO@NRCAN.GC.CA

In 2012, the Canada-Nunavut Geoscience Office (CNGO) initiated a targeted regional bedrock mapping project (1:250 000 scale) on Hall Peninsula, southern Baffin Island, (NTS sheets 25I, part of 25J, 25O, 25P, 26A and 26B) as part of the office's long-term objective to upgrade the geoscientific knowledge base for Nunavut. The field project was preceded in 2009 by an aeromagnetic survey flown by the Geological Survey of Canada (GSC).

The geology of Hall Peninsula remains poorly known, even though the first geological observations go back to Frobisher's 1576 voyage. It has only been mapped once, at reconnaissance scale, during the GSC's Operation Amadjuak in the 1960's and sampled for geochronology in the 1990's by the CNGO. This information was incorporated into a compilation map published in 2006 (GSC Open File 4931) dividing the Peninsula into three crustal entities: the Cumberland Batholith; the Lake Harbour Group and the Hall Peninsula block. The mineral potential of this region is largely unknown, except for recent discoveries of diamond-bearing kimberlites.

In 2012, six weeks were spent mapping the southern portion of the peninsula (NTS sheets 25P, 25I, parts of 25O and parts of 25J) covering approximately 20 000 km^2. Mapping defined more precisely the three crustal entities listed above, revealed at least two other episodes of granitic magmatism and also some supracrustal packages with volcanic rocks. Some rock units in the area record at least three phases of deformation, were initially metamorphosed to granulite facies, and then retrograded to upper amphibolite facies. Thematic studies focussing on regional tectonics, metamorphism, structure and possible volcanism associated with sedimentary packages have been initiated by university partners.

Considering the overall geological context of Hall Peninsula, the potential to find new mineralization is multifaceted. The discovery of ultramafic rocks within supracrustal packages points to possibly interesting new sources of carving stone and these may have potential for nickel-copper-PGE mineralization. The large area underlain by Archean basement could be host to more diamond-bearing kimberlites similar to the ones found in the northern portion of the peninsula. Also, the marble belonging to the Lake Harbour Group has potential to host gemstones as is the case in the Kimmirut area. Based on the reported geology, other types of mineralization can also be considered, namely gold associated with iron-formation and VMS deposits associated with supracrustal packages.

IMPACTS OF RETROGRESSIVE THAW SLUMPS ON THE GEOCHEMISTRY OF PERIGLACIAL STREAMS: IDENTIFYING A GEOCHEMICAL TRACER OF SLUMP RUNOFF AT THE WATERSHED-SCALE

MALONE*, L.[1,2], LACELLE, D.[3], KOKELJ, S.[4] AND CLARK, I.[1]
(1) DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF OTTAWA, ON
(2) CURRENT ADDRESS: SRK CONSULTING, YELLOWKNIFE, NT
(3) DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF OTTAWA, OTTAWA, ON
(4) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
LMALONE@SRK.COM

Across the circumpolar Arctic, the most abrupt impacts to freshwater ecosystems result from degrading permafrost (i.e. active deepening, thermokarst disturbance, lake drainage). The recent thawing of near-surface permafrost has been shown to increase ionic concentrations in nearby streams. Further, local-scale studies (up to ~ 1 km^2) indicate that suspended sediment and solute concentrations in streams situated immediately downstream of active layer detachment slides, which are isolated thermokarst events, are orders of magnitude greater than concentrations from the adjacent landscape. These results suggest that even if a thermokarst disturbance is localized, the potential for downstream aquatic impacts can be significant.

Retrogressive thaw slumps are one of the most dramatic thermokarst landforms in periglacial regions. Several slumps on the Peel Plateau near Fort McPherson (NWT) were visited in the summers of 2010 and 2011 as part of a program to assess their cumulative impacts on surface water quality in the Stony Creek drainage basin and the Peel River. Considering that the hamlet of Fort McPherson is located only 30 km north-east of an area undergoing extensive permafrost degradation, investigating the cause of thermokarst disturbances and its environmental effects (including water quality of nearby streams) is needed to assess its impact on the fish habitats and water quality of the Peel River.

In this study, we characterized the chemistry of runoff from two large thaw slumps and associated mudflows to investigate their impact on the water quality of the Stony Creek watershed and of the Peel River downstream of Stony Creek. Field measurements (pH, electrical conductivity, total suspended sediment) and sampling for geochemical analysis were used to characterize the composition of slump runoff, unaffected surface waters and surface waters affected by slump runoff. Slump runoff is characterized by high suspended sediments (911 g/L), high conductivity (2700 µS/cm), and high SO_4^{2-} (max. 2078 ppm). Slump runoff originates as a solute rich meltwater at the headwall. As the runoff travels along the mudflow, it leaches and re-dissolves material in the mudflow, resulting in an increase in the conductivity of the runoff until it receives contribution from unaffected waters, diluting the slump runoff signal.

SEM imaging and XRD analysis on the suspended sediments were used to determine the source of the high SO_4^{2-} concentrations. Framboidal and euhedral pyrite were observed under the SEM, but no evidence of pyrite oxidation was found. This suggests that the high SO_4^{2-} concentrations in the runoff are a result of the re-dissolution and leaching of sulfate minerals within the mudflow. Although concentrations of SO_4^{2-} and suspended sediment decrease with distance from the slump headwall through dilution, the concentrations 26 km downstream in the Peel River remain well above levels in undisturbed streams.

CANADA-NUNAVUT GEOSCIENCE OFFICE 2012 ACTIVITIES

MATE, D.
CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
DMATE@NRCAN.GC.CA

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 to support responsible resource exploration and development, geoscience capacity building, education, training, geoscience awareness and outreach. 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 the 2012 field season geoscience activities included regional geoscience mapping on Hall Peninsula east of Iqaluit, mineral deposit studies in Borden Basin, carvingstone deposit resource assessment on Baffin Island and climate change adaptation research on key land-based and coastal infrastructure. 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.

LODESTAR – AN ENVIRONMENTAL DATA MANAGEMENT TOOL

MCCARTHY, C.[1], COEDY*, W.[2] AND JACKSON, J.[3]
(1)WILDROSE CONSULTING LTD. PORTLAND, OREGON, USA
(2)CONTAMINANTS & REMEDIATION DIRECTORATE (CARD), ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT CANADA, YELLOWKNIFE, NT
(3)INFORMATICS, ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT CANADA, YELLOWKNIFE, NT
BILL.COEDY@AANDC-AADNC.GC.CA

This year Aboriginal Affairs and Northern Development Canada (AANDC) rolled out LodeStar, a web-accessible Oracle-Apex database, to provide a unified approach to their environmental data management across the Northwest Territories. The database was developed to provide AANDC consistent and long-range approach to managing environmental data collected for site remediation and environmental monitoring. It handles laboratory analytical results from water, sediment, and air samples. The application supports project requirements for defined data handling and long-term data archival.

LodeStar was initially developed to manage monitoring data from several CARD remediation projects. The application stores data from multiple sites in separate data "silos" that are independent but share a consistent yet flexible data management approach. A LodeStar Working Group was established to invite other database managers to collaborate on standardizing best practices, establish development priorities, and cost share contractual services. As a result, participants are developing new sites and migrating their data to LodeStar and contributing to new enhancements. LodeStar allows simultaneous users to logon from anywhere at anytime using an Internet browser. AANDC's Informatics Group administers the application and it meets their standards for data security. Users are granted access to one or more sites depending on their project roles. Roles are established for site administrators and for users who have responsibility for entering sample records and for uploading, tracking, validating, screening, and reporting laboratory results. Once users have been trained to use LodeStar on one site, they will be familiar with the application for work on any number of sites.

At the heart of the LodeStar database is a flexible and intuitive search engine that allows users to set selection criteria for retrieving and naming data sets for validation, screening, and reporting. Recent enhancements have focused on automating data validation functions and documenting validation outcomes. This will allow users to evaluate whether selected data sets are appropriate for an intended use. The application currently screens results against regulatory guidelines and water license criteria. It also easily interfaces with other software programs, such as statistical modeling packages and GIS.

A demonstration of the application can be arranged.

GLACIAL HISTORY AND DISPERSAL PATTERNS NORTH OF WAGER BAY, NUNAVUT

MCMARTIN*, I.[1], CAMPBELL, J.E.[1], DREDGE, L.A.[1], CORRIGAN, D.[1] AND HUNTLEY, D.[2]
(1) NATURAL RESOURCES CANADA, GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) NATURAL RESOURCES CANADA, GEOLOGICAL SURVEY OF CANADA, VANCOUVER, BC
IMCMARTI@NRCAN.GC.CA

New 1:100 000 scale surficial geological mapping across a large region (31 000 km^2) north of Wager Bay, Nunavut, together with regional-scale till sampling (10-km spacing), provide new data and improved understanding of the glacial history in support of mineral exploration, sustainable resource development and land-use management. Conspicuous northward-trending crag-and-tail and other streamlined landforms over a large part of the study area indicate a prevailing northward direction of ice flow from a centre of outflow lying south of, or along Wager Bay. Prominent north-flowing meltwater corridors containing a succession of subglacial, supraglacial and proglacial sediments occur in the northern part of the study area and indicate southward ice retreat. Southwest of Repulse Bay, southeastward and eastward ice-flow indicators overprint the dominant northward flows and are associated with opening of Repulse Bay during deglaciation, followed by radial flow from a remnant ice mass. East-flowing meltwater corridors characterized by complex sediment-landform assemblages and eroded tills indicate a westward retreating ice margin in this area. Both the northward and eastward meltwater corridors have their heads close to topographic drainage divides (Committee Bay and Wager Bay) and are replaced farther inland (up-ice) by bedrock-controlled subglacial channels and esker sediments, nested ice-marginal meltwater channels, or continuous proglacial channels and small outwash pads. These late, more subtle channels and sediments formed as the ice mass receded and vanished into the highlands north of Wager Bay. A small area within these highlands shows evidence of pre-Late Wisconsinan relict, weathered till and bedrock surfaces, presumably reflecting cold-based conditions and preservation under a remnant ice mass. A late sequence of east-southeastward ice flows into Wager Bay is found along the northern shores of Wager Bay and reflects the opening of Roes Welcome Sound, drawdown into Wager Bay, and separation of remnant ice centres on either side of Wager Bay.

To date, 306 till samples have been collected for provenance, geochemistry, various indicator minerals and gold grain counts. A number of significant dispersal patterns are recognized from the 2010 and 2011 analytical results and 2012 field work. A major sand-sized fluorite grain anomaly forming a 20-km long fan-shaped dispersal train oriented NNE is found in the Stewart Lake area indicating a source within local intrusions of unknown age (Nueltin?). A multi-element geochemical signature (Al_2O_3-Co-Cr-Cr_2O_3-Cu-Fe_2O_3-Ga-Sc±Cd±Ni±Sn) is present in till (<63 µm) collected in a large area southwest of Repulse Bay which may be associated with previously unknown slices of supracrustal rocks including metasediments and BIF found during 2012 joint bedrock and surficial mapping activities. Two ultramafic boulder dispersal trains and possible up-ice (south) sources were also identified in 2012. One of the boulder trains may be linked to a north-trending ultramafic geochemical dispersal train (Cr-Ni-Co) previously reported north of the study area within the Committee Bay TGI project area. Till pebble lithology analysis and results from 2012 sampling will further refine the characteristics and significance of glacial transport in the area. This research is part of the Wager Bay surficial mapping activity under the GEM Melville Peninsula Project.

MICRO- AND MACRO-DIAMOND CHARACTERISTICS FROM THE PANDA KIMBERLITE

MELTON*, G.L.[1], STACHEL, T.[1], STERN, R. A.[1], CARLSON, J.[2] AND HARRIS, J.W.[3]
(1)UNIVERSITY OF ALBERTA, EDMONTON, AB
(2)BHP BILLITON DIAMONDS INC., KELOWNA, BC
(3)UNIVERSITY OF GLASGOW, GLASGOW, UK

The Panda kimberlite (53 Ma) is part of the Ekati Mine, located in the Central Slave Craton, about 25 kilometers north of Lac de Gras. To better understand the diamond forming environments below the Central Slave Craton we combined data from 90 macro-diamonds previously studied by us with new FTIR and SIMS data from 121 micro-diamonds from the Panda kimberlite.

The dominant micro-diamond morphology is octahedral (43%), followed by dodecahedral (26%), cubic (17%) and minor irregular and aggregated forms. Fifty-two percent of micro-diamonds are cloudy/fibrous (inclusion rich, translucent) and 45% are clear ("gem-quality", inclusion free, transparent). The cloudy/fibrous samples are grey (68%), brown (29%) and yellow (3%). The gem-quality samples are colorless (74%), brown (23%), grey (2%) and yellow (2%). Macro-diamonds selected for a previous inclusion study are dominantly clear octahedra or dodecahedroids.

Nitrogen concentration in gem-quality micro-diamonds ranges from below detection (< 10 at. ppm, two samples) to 1688 at. ppm (average = 794 at. ppm); The median value of nitrogen aggregation is 17% B-center. Cloudy/fibrous micro-diamonds range from 366 to 1696 at. ppm nitrogen and have a mean aggregation of 28%. Macro-diamonds range from below detection (five samples) to 1260 at. ppm (median = 187), and have a median aggregation of 26%. Overall, nitrogen concentrations and $\delta^{13}C$ values of Panda micro-diamonds are distinctly higher than for macro-diamonds from the same mine and from other diamond deposits (A154, DO27) in the Central Slave Craton. Platelet peaks occur in similar proportions in gem-quality micro- and macro-diamonds (84% and 79%, respectively) but are nearly absent in cloudy/fibrous micro-diamonds (6%). Platelet peak areas form a linear correlation with concentration of nitrogen in B centers and hence classify as "regular". While hydrogen peaks are prevalent in all three diamond groups, peak areas at 3107 cm^{-1} in cloudy micro-diamonds are, in general, larger. Average carbon isotope compositions in gem-quality and fibrous/cloudy micro-diamonds are identical (-4.1‰) and are significantly higher than the macro-diamond average (-5.4‰). The lack of isotopically light samples in micro-diamonds, typically associated with an eclogitic paragenesis, is a significant observation.

Time averaged mantle residence temperatures (calculated for a mantle residence of 3.5 Ga) indicate a range in temperatures that is most likely a result of the growth of samples at variable depths in the mantle. An absence of samples originating from 155 km to 165 km depth may be associated with the transition from the upper, more depleted lithosphere to the less depleted lower lithosphere (c.f. Griffin et al. 1999). An overall trend of increasing $\delta^{13}C$ values with decreasing temperature (representing a proxy for decreasing depth) is observed for diamonds of all studied size classes from Panda. This trend of increasing $\delta^{13}C$ with decreasing depth may reflect progressive isotopic fractionation of an upward percolating carbonate-bearing diamond forming fluid/melt.

GEOCHEMISTRY OF THE HOOD VOLCANOGENIC MASSIVE SULFIDE (VMS) DEPOSIT, NUNAVUT, CANADA

MILLS*, H.[1], PIERCEY, S.[1] AND TOOLE, P.[2]
(1) MEMORIAL UNIVERSITY OF NEWFOUNDLAND, ST. JOHN'S, NL
(2) MINERALS AND METALS GROUP, VANCOUVER, BC
HKMILLS@MUN.CA

The Hood volcanogenic massive sulfide (VMS) deposit is located ~400 km north of Yellowknife, NWT in the Hanikahimajuk Lake area, Nunavut and is estimated to contain 3.2 Mt at 3.6% Zn and 2.6% Cu[1]. The deposit is one of many undeveloped and underexplored mineral deposits in the Slave Craton. The Hood deposit consists of a cluster of three main mineralized lenses and several other mineral occurrences proximal to a felsic volcanic center in the late Archean Amoogabooga volcanic belt. Mineralization in the main lenses is sub-seafloor replacement-style and is hosted in a bimodal volcanic sequence of basaltic/andesitic and rhyolitic flows with minor tuff. The

mineralization consists of massive and semi-massive pyrite-pyrrhotite-sphalerite-chalcopyrite zones and stringer sulfide. The deposit structure and the relationship between lenses remain enigmatic.

Lithogeochemistry of the Hood deposit volcanic rocks illustrate they are subalkaline with calc-akaline to transitional magmatic affinity. Felsic volcanic rocks are FII -type rhyolites based on $(La/Yb)_{cn}$ vs Yb_{cn} ratios. Primitive-mantle-normalized multi-element plots indicate felsic rocks are enriched in light rare earth elements (LREE) and have flat heavy rare earth element (HREE) patterns. They have strong negative Eu and Ti anomalies and moderate positive Zr and Hf anomalies. These signatures are similar to felsic rocks of the Kam group in the southern Slave craton. Mafic rocks are similar to enriched mid-ocean ridge basalts (E-MORB) but with a slightly stronger enrichment of LREE. However, unlike typical E-MORB, the mafic Hood volcanic rocks have negative Nb anomalies. The primary geochemistry of the Hood deposit volcanic rocks suggests the deposit formed in a back-arc basin tectonic setting. Alteration indexes, mass change calculations and principal component analyses identify alteration trends. Mafic rocks are dominantly chlorite altered, whereas felsic rocks are variably chlorite and quartz-sericite altered. Mafic rocks have typically undergone SiO_2 loss. Intensity of alteration does not change dramatically between the hangingwall and the footwall of the deposit supporting sub-seafloor replacement as the method of mineralization.

HIGHLY ACCURATE STEREO SATELLITE ELEVATION MAPPING IN THE ARCTIC

MITCHELL, G. AND RUSSELL*, M.
PHOTOSAT, VANCOUVER, BC
MEGAN@PHOTOSAT.CA

Topographic mapping accurate to better than 50cm in elevation can now be produced for most areas within 50 km of the coastline of the Arctic Ocean. A high resolution stereo satellite acquisition program of the Arctic coastline employing the WorldView-1 and WorldView-2 satellites started on June 1, 2012. These two satellites acquired high resolution stereo photos of the Arctic coastline throughout the summer. With this new stereo satellite photo archive many Arctic elevation mapping projects can now be undertaken during the winter planning season. Over the past few years PhotoSat has carried out several highly accurate stereo satellite elevation mapping projects in the Arctic. These mapping projects have included studies for mine site exploration and development, watersheds, transportation corridor planning and permafrost changes. From September to May each year we have been unable to fulfill requests for highly accurate elevation mapping in the Arctic due to the absence of high resolution stereo satellite photos. Projects that could wait for new satellite photos to be acquired have been postponed until the following summer. Other projects have been cancelled. We will show examples of stereo satellite elevation mapping projects, accurate to better than 50cm in elevation, for Ellesmere Island, Baffin Island, Melville Island, and various locations in mainland Arctic Canada.

PRINCIPLE OF COMPONENTS GEOCHRONOLOGY OF THE CA. 3920 MA ACASTA GNEISS

MOJZSIS*, S.J.[1,2,3], CATES, N.L.[1], CARO, G.[4], BLEEKER, W.[5], HOPKINS, M.D.[1], GUITREAU, M.[2,6], BLICHERT-TOFT, J.[2], TRAIL, D.[7] AND ABRAMOV, O.[1,8]
(1) DEPARTMENT OF GEOLOGICAL SCIENCES AND NASA LUNAR SCIENCE INSTITUTE, UNIVERSITY OF COLORADO, BOULDER, COLORADO, USA
(2) LABORATOIRE DE GEOLOGIE DE LYON, ECOLE NORMALE SUPERIEURE DE LYON AND UNIVERSITE CLAUDE BERNARD LYON 1, LYON, FRANCE
(3) HUNGARIAN ACADEMY OF SCIENCES, INSTITUTE OF GEOLOGY AND GEOCHEMISTRY, BUDAPEST, HUNGARY
(4) CENTRE DE RECHERCHE PETROGRAPHIQUE ET GEOCHIMIQUE (CRPG), CNRS, VANDEOUVRE-LES-NANCY, FRANCE
(5) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(6) DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF NEW HAMPSHIRE, DURHAM, NEW HAMPSHIRE, USA
(7) DEPARTMENT OF EARTH & ENVIRONMENTAL SCIENCES AND NEW YORK CENTER FOR ASTROBIOLOGY, RENSSELAER POLYTECHNIC INSTITUTE, TROY, NEW YORK, USA
(8) ASTROGEOLOGY RESEARCH PROGRAM, UNITED STATES GEOLOGICAL SURVEY, FLAGSTAFF, ARIZONA, USA

Compiled U-Pb zircon ages of the oldest components of the Acasta Gneiss Complex (AGC) in the Archean Slave craton (Northwest Territories, Canada) span about 4050-3850 Ma (Stern and Bleeker, 1998); yet older 4200 Ma xenocrystic U-Pb zircon ages have also been reported for this terrane (Iizuka et al., 2006). The AGC has at least 50 km^2 of exposure, but only a small subset has been documented in the detail required to investigate a complex history. To better understand this history, ion microprobe U-Th-Pb zircon geochronology was combined with zircon rare earth elements (+Y; $[REE+Y]_{zirc}$) and Ti-in-zircon thermometry (Ti^{xln}) measured in petrographic thin sections and mineral separates extracted from a sub-divided ~60 cm^2 slab of banded gneisses. Micro-sampling by this method reveals domains with distinctive $[Th/U]_{zirc}$ vs. Ti^{xln} and $[REE+Y]_{zirc}$ correlative with different zircon age populations and rock compositions, but not Sm-Nd isotope systematics. Lattice-strain theory used to model $D_{WR}^{zircon}[REE+Y]$ reconciles the zircon geochronology within the individual components. The AGC preserves a legacy older than about 4000 Ma, but analysis shows that this derives from assimilation of older crust. Magmatic incursions at ca. 3920 Ma in the Acasta gneisses are contemporaneous with the Late Heavy Bombardment of the solar system. Later superimposed Eoarchean events (3850-3720 Ma) are reminiscent of emplacement times for the Itsaq Gneiss Complex in West Greenland (Nutman et al., 1996), Nuvvuagittuq Supracrustal Belt in northern Québec (Cates and Mojzsis, 2009), and Manfred Complex in Western Australia (Kinny et al., 1990). Equilibration of Sm-Nd occurred at the scale of individual components over the course of one or more of these events.

FORMATION OF THE FAYALITE-BEARING RIM SYENITE OF THE BLATCHFORD LAKE INTRUSIVE SUITE: REMNANTS OF AN ERODED RING DYKE?

MUMFORD, T.R.[1], COUSENS, B.L.[1] AND FALCK, H.[2]
(1) CARLETON UNIVERSITY, OTTAWA, ON
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
TMUMFORD@CARLETON.CONNECT.CA

The peralkaline eastern lobe of the Blatchford Lake intrusive suite comprises alkali-feldspar granite (Grace Lake granite) that inwardly decreases in quartz content, grading into alkali-feldspar syenite (Thor Lake syenite) at its core. Underlying the Thor Lake syenite is the silica undersaturated Nechalacho layered suite that hosts Nechalacho rare-earth element (REE) deposit. A prominent concentric ridge with a corresponding magnetic high coincides with the transition between the Grace Lake granite and Thor Lake syenite; the ridge and magnetic high are related to a narrow, mineralogically distinct, arcuate phase termed the "rim syenite".

At surface the rim syenite is fine- to coarse-grained and composed of subhedral poikilitic perthitic alkali feldspar, poikilitic arfvedsonite, apatite, magnetite, euhedral to subhedral aegirine, interstitial quartz, with rare primary euhedral calcite and anhedral to rounded fayalite. Fayalite is distinctly absent in both the Grace Lake granite and Thor Lake syenite. While the presence of fayalitic olivine in syenites has been documented in alkaline rocks, its localized arcuate distribution within the Blatchford Lake intrusive suite is unusual. Worldwide, fayalite-bearing syenite bodies generally occur as small plutons, e.g. Panxi Region, China, or as ring dykes, e.g. Tibchi anorogenic ring-complex, Nigeria.

We believe the resistive weathering of the rim syenite is related to the variation in mineralogy and the decreased grain-size relative to the Grace Lake granite and the Thor Lake syenite. New U-Pb zircon dates suggest that the Grace Lake granite and Thor Lake syenite are coeval, in contrast to previous work that suggested a

difference of ~90 Ma. Diamond drilling by Avalon Rare Metals Inc. has identified the presence of a texturally distinct cumulitic fayalite syenite at a depth of ~ 300 m at the margin of the rim syenite. Gradational contacts, isotopic and chemical trends between the rim syenite and fayalite syenite suggest that the two units form a mineralogical continuum.

We propose that the rim syenite represents the basal remnants of an eroded ring dyke, formed by central caldera collapse, and that the Grace Lake granite and Thor Lake syenite represent the source chamber. The emplacement of magma into higher stratigraphic levels would act as a conduit for fluid flow, thereby depressurizing the residual system. In highly evolved granitic systems such as this, a pressure drop would likely initiate volatile exsolution. If the exsolved volatile phase was dominated by anionic species (i.e. CO^-, OH^-, F^-), as is typical in evolved A-type granites, it could significantly decrease the oxygen fugacity in the system, favoring a mineral assemblage that includes fayalite. The focused fluid flow, and subsequent (temporary) pressure loss localized along a ring structure may explain the restriction of fayalite to the rim syenite. Given the control of volatile species (i.e. CO_2, F, Cl) on mobilization of REE, the volatile loss associated with the ring dyke emplacement could destabilize REE-complexing ligands and spawn precipitation of REE-bearing mineral phases.

CONTINUING GEOLOGICAL COMPILATION OF THE MAINLAND REGION, NORTHWEST TERRITORIES

OKULITCH*, A.V.[1] AND IRWIN, D.[2]
(1) GEOLOGICAL SURVEY OF CANADA, VANCOUVER, BC
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
ANDREWVLADIMIR.OKULITCH@NRCAN-RNCAN.GC.CA

The aim is to use existing geological data to assemble and compile a representation of the bedrock geology of the NWT for inclusion in a Geographic Information System. Data are compiled as maps in AutoCAD and as tables in Excel spreadsheets. AutoCAD files are then dissembled, managed and thematically reconstructed in accordance with standard geological practices in ArcGIS. Topology is rigorously tested and maintained throughout the process. The spreadsheet is a continually evolving, comprehensive legend that will include data from the compiled map, correlation charts, subsurface, and supplementary information in government and industry reports. From this spreadsheet, standard unique unit labeling and colouring, hierarchical naming, and lithological and age descriptions of some 500 units are also managed and maintained within ArcGIS. Current work is focusing on mainland NWT and adjacent parts of Yukon Territory; subsequent work will concentrate on the Arctic Islands to complete the database.

The bedrock geology of the mainland region 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. In most cases, the new, local interpretations have not been utilized to revise surrounding regions and their older maps. 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 1:20 000 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 the western

NWT, required to make the map and database seamless and internally consistent.

Map database files 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 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 data as possible may be layered, in turn improving the synthesis of the geological evolution.

Current work is utilizing all published maps and reports. Provision of recently completed but unpublished maps is gratefully acknowledged, as is the exchange of ideas with several geologists with valuable first-hand knowledge. The product will be available as data files containing all information and eventually published as a series of regional maps.

EVOLUTION OF THE ARCHEAN SLAVE CRATON AS RECORDED BY DETRITAL ZIRCONS FROM THREE CHRONOLOGICALLY DISTINCT SEDIMENTARY BASINS

OOTES*, L.[1], MISKOVIC, A.[1,2], HEAMAN, L.[3] AND HEWTON, M.[4]
(1) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(2) MDRU, UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC
(3) UNIVERSITY OF ALBERTA, EDMONTON, AB
(4) SIMON FRASER UNIVERSITY, BURNABY, BC
LUKE_OOTES@GOV.NT.CA

The growth of a craton is recorded by episodes of juvenile magmatism. The reworking and destruction of cratonic material through time may be preserved as detritus in sedimentary basins. As detrital zircon U-Pb dating and Lu-Hf isotopic tracing have become the 'fossil' record of Precambrian environments, key stratigraphic horizons and their zircons can enable the decoding of Archean lithospheric evolution. Presented here is previously reported and unpublished detrital zircon in situ U-Pb ages (SHRIMP and ICPMS) from three distinct sedimentary sequences within and on the Archean Slave craton, forming a dataset in excess of 5000 individual analyses. The oldest unit is quartzite from the ca. 2820 Ma Central Slave Cover Group (CSCG) that rests unconformably on Mesoarchean basement throughout the central and western part of the craton. The second is the ca. 2660 and <2640 Ma Package I and II greywacke-mudstone turbidites that are ubiquitous throughout the Slave craton. The <2600 Ma conglomerates (e.g., Jackson Lake, Keskarrah formations) are important stratigraphic horizons in the craton, but currently there is only limited U-Pb detrital zircon data available. The third horizon is Paleoproterozoic Coronation margin quartzite preserved unconformably on Archean basement at the eastern edge of the Wopmay orogen.

We have screened our detrital zircon dataset to only include data with concordance between +15% and -5%, errors <50 Ma (1σ) and ages older than their constrained depositional age. We do not include detrital zircon ID-TIMS ages as these tend to bias probability curves, because of the low analytical errors by this methodology. The major peaks in zircon crystallization ages recorded by the CSCG occur between 3.65-3.20 Ga, 3.18-3.16, 2.98-2.94, 2.90, and 2.85-2.82 Ga, Within the Package I-II turbidites the major zircon populations are at 2.74 Ga, 2.72-2.70, 2.68-2.66, and 2.64-2.63 Ga. The Coronation margin quartzite contains significant zircon populations at 2.63 Ga, 2.61, 2.60-2.59, and 2.57 Ga. The largest populations in the Mesoarchean data are at 3.15 Ga and 2.94 Ga and in the Neoarchean at 2.70 Ga, 2.68-2.66 Ga, and 2.59 Ga. Within our assigned parameters, only three grains older than 3.90 Ga have been identified.

THE HOTTAH – GREAT BEAR STRATIGRAPHIC CONTINUUM: IMPLICATIONS FOR IOCG MINERALIZATION AND PLATE INTERACTIONS IN THE WESTERN CANADIAN SHIELD

OOTES*, L.[1], DAVIS, W.[2], JACKSON, V.A.[1], NEWTON, L.[3], ACOSTA-GONGORA, P.[4] AND SHAKOTKO, P.[5]

(1) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(3) MEMORIAL UNIVERSITY OF NEWFOUNDLAND, ST. JOHN'S, NF
(4) UNIVERSITY OF ALBERTA, EDMONTON, AB
(5) UNIVERSITY OF SASKATCHEWAN, SASKATOON, SK

The Hottah – Great Bear volcano-plutonic continuum is the westernmost exposed domain of the Precambrian Shield. The 1873-1855 Ma Great Bear magmatic zone has been well-studied and is now recognized to host iron oxide copper-gold (IOCG) mineralization, in addition to historically known uranium and other precious and base-metal styles of mineralization. The basement upon which the magmatic zone was constructed, the Hottah terrane, remains poorly understood. The evolution of the Hottah basement and its stratigraphic reconstruction is critical not only to the development of a tectonic model and the understanding of large-scale controls on IOCG mineralization, but also to how the Hottah terrane may relate to other domains in the western Canadian Shield.

The oldest preserved bedrock in the Hottah terrane is the younger than 1970 Ma Holly Lake metamorphic complex, a mix of pelitic and volcanic rocks that underwent high temperature, low pressure metamorphism prior to ca. 1930 Ma. Detrital zircon U-Pb ages reveal source ages of ca. 2.63, 2.45-2.30, 2.1, 1.97 Ga. (Davis et al 2011 YK forum). The complex is intruded by 1930 and 1915 Ma granitoids that were unroofed by ca. 1905 Ma, when bimodal rift-related Zebulon Formation volcanic rocks were deposited directly on these granitoids. The ca. 1900 Ma Conjuror Bay Formation marginal marine quartz arenite unconformably blankets this stratigraphy and has detrital sources similar to the Holly Lake metamorphic complex, with the addition of a 1.93 Ga zircon population. Stratigraphically overlying the Conjuror Bay Formation are the 1895 Ma Bloom Basalts that are correlated with 1895 Ma Grant Group basalts to the east. From about ca. 1915 Ma, the preserved stratigraphy is indicative of an evolving extensional regime from initial rift to marginal back-arc basin. The platform-like Treasure Lake Group sits atop this stratigraphy and its detrital zircons indicate it was sourced from the Slave craton and the ca. 1.89 Ga Hepburn intrusive suite. All of the above units were deformed prior to the onset of LaBine Group andesitic volcanism at 1873 Ma and rhyolitic 1869 Ma Faber Group volcanism. Both the LaBine and Faber volcanic sequences sit unconformably on the Treasure Lake Group and are coincident with the timing of IOCG mineralization, such as at Sue-Dianne and NICO. Circa 1865-1855 Ma post-orogenic plutonism dominates the preserved bedrock in the Hottah – Great Bear domain. εNd^T data on all of the Hottah and Great Bear volcano-plutonic units indicate interaction/derivation from a 2.5 to 2.2 Ga basement.

Collectively the Hottah – Great Bear continuum records 120 million years of volcano-plutonic evolution. The detrital zircon and εNd^T data demonstrate that Hottah may have a basement or source domain similar to Buffalo Head, or the Queen Maud domains and shares similar ages with Thelon-Taltson magmatic zones. Some of the Hottah – Great Bear age data are coincident with chronological events recorded elsewhere in the western Canadian Shield. While the Hottah terrane may not share petrologic features with other terranes, the age similarities can be taken to indicate that it was exposed to the same tectonic events, possibly a result of subduction zone maturation and plate interactions to the west.

INDICATOR MINERAL RESEARCH AND METHOD DEVELOPMENT IN GLACIATED TERRAIN: RESULTS FROM THE GEM TRI-TERRITORIAL INDICATOR MINERAL PROJECT (2008-2013)

PAULEN*, R.C.[1], MCCLENAGHAN, M.B.[1], ADCOCK, S.W.[1], SPIRITO, W.A.[1], JEFFERSON, C.[1], MCCURDY, M.[1], MCNEIL, R.[1], PARADIS, S.[2], HICKIN, A.[3], ROBINSON, S.[3], LAYTON-MATTHEWS, D.[3], OVIATT, N.M.[4], GLEESON, S.[4], RICE, J.[5] AND MENZIES, J.[5]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, SIDNEY, BC
(3) DEPARTMENT OF GEOLOGICAL SCIENCES, QUEEN'S UNIVERSITY, ON
(4) DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES, UNIVERSITY OF ALBERTA, AB
(5) DEPARTMENT OF EARTH SCIENCES, BROCK UNIVERSITY, ON
ROPAULEN@NRCAN.GC.CA

To assist mineral exploration in northern Canada, several indicator mineral research activities were undertaken at the Geological Survey of Canada as part of the Geomapping for Energy and Minerals (GEM) Program (2008-2013). Project goals included: 1) the compilation/database population of heavy mineral data collected from surficial sediments in Canada's north, 2) improving and publishing a till sampling protocol for till geochemistry and heavy minerals, and 3) methodology development to demonstrate how indicator minerals can be used to explore for various commodities.

Information about indicator mineral data is continually being acquired from published government reports, assessment files, unpublished reports, and private exploration company holdings. These data will complement the KIDD-KIMC and till geochemistry data sets provided by territorial partners, and include indicator minerals of all commodities. The information is captured in the Canadian Database of Geochemical Surveys (CDoGS), which accommodates the comprehensive metadata required for all varieties of geochemical and indicator mineral surveys. The CDoGS web portal (http://geochem.nrcan.gc.ca) exposes these surveys in query-able fashion so that those of interest can be identified for further examination. The results of various indicator mineral commodity types are displayed using Google Earth™, where instant linkages and interpretations can be made from seeing the data plotted in association with regional glacial landforms.

Drift prospecting research, in collaboration with industry and academic partners, was initiated at the Izok Lake Zn-Cu-Pb-Ag VMS deposit and Kiggavik uranium deposit in Nunavut and the Pine Point Pb-Zn MVT district in the Northwest Territories. These study areas are located in regions either affected by multiple ice flow trajectories, ice divide migration, or thicker glacial drift. Landforms, striae, clast dispersal, till stratigraphy, till geochemistry, till micromorphology and indicator minerals provide records of simple to complex net transport. Preliminary results, from GSC Open Files published and/or in press are presented and provide the exploration industry with a proven methodology for mineral exploration in the glaciated terrain of northern Canada.

OPERATION GEM SOUTH RAE: RECONNAISSANCE GEOLOGY OF THE MOST POORLY KNOWN PART OF THE CHURCHILL PROVINCE, NORTHWEST TERRITORIES AND NUNAVUT

PEHRSSON*, S.J., PERCIVAL, J.A., KJARSGAARD, B.K., DAVIS, W.J, BERMAN, R.G., HILLARY, E.M., MACKINNON, A., JEFFERSON, C.W. AND KISS, F.

GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
PEHRSSON@NRCAN.GC.CA

The Geo-mapping for Energy and Minerals Program undertook research in 2012 on the South Rae area of the Churchill Province to provide knowledge on a region last mapped in 1955 at 1:million scale during Operation Thelon. Field studies were undertaken in two transect areas, supported by remote predictive mapping, re-analysis of archival materials and a new high-resolution aeromagnetic survey.

Integrated surficial and bedrock geology investigations were undertaken over two weeks in July 2012 in the northern transect, the region between Mary Frances, Whitefish, Eyeberry and Beaverhill Lakes (parts of NTS 75O, 75P, 75I and 75J), parts of which have been the subject of a lake sediment sampling program by NTGO. The bedrock geology, from west to east, consists of Archean rocks of the Rae subdomain, a thin strip of sedimentary and volcanic rocks of inferred Paleoproterozoic age, and sandstones of the Thelon Basin. 109 till samples and 72 esker samples were taken for heavy mineral analysis, with geochemistry studies in progress on the till samples. Bedrock sampling and observations at 90 sites complimented the surficial studies. Although the area was originally believed to be outcrop-poor due to the extensive and monotonous surficial cover, there is in fact enough exposed bedrock to permit possible future mapping at 1:250K scale.

The southern transect area straddles the region between the Thelon and Athabasca basins in SE NWT, and has been subdivided into 9 domains based on new U-Pb age results on archival samples, field investigation and interpretation of the aeromagnetic survey. From west to east these comprise: 1) the Porter domain, including Paleoproterozoic Nonacho basin, basement granitoids and high grade supracrustal rocks; 2) the Howard Lake shear zone, a west-dipping shear zone showing evidence for brittle reactivation; 3) the Penylan domain comprising ca. 2.04 Ga gabbro-diorite-anorthosite complexes and granitic rocks with ca. 1.85 Ga metamorphism; 4) the McCann granulite domain, consisting of diatexite, charnockite and metatexite, with a pervasive 2.47-2.3 Ga Arrowsmith metamorphism; 5) the Black Bay fault, a west-dipping, east-vergent ductile thrust; 6) the Rennie-Abitau domain of intensely folded amphibolite- to granulite-facies ortho-and paragneisses; 7) the Firedrake domain of shallow-dipping, variably deformed diorite-quartz-diorite-tonalite complexes with younger monzodiorite and leucogranite phases; 8) the Boyd domain of 2.6 Ga granodiorite-tonalite and related mafic to intermediate supracrustal rocks intruded ca. 1.84 Ga monzogranites, and 9) the Snowbird Tectonic zone, at this latitude a ductile thrust intruded by ca. 1.74 Ga Nueltin granite, but also reactivated as a steeply-dipping younger brittle fault.

A number of mafic dyke and sill swarms were discovered, the oldest of which, the metamorphosed Orpheus sheets, are distinctly layered mafic-ultramafic bodies with gossanous ultramafic phases. A southeast-trending swarm that transects the area may be correlative with ca. 1.7 Ga Tyrrel Arm dykes to the east. Gossans were also noted with early mafic-ultramafic phases of the 2.0 Ga Penylan suite which may be correlative with the Ni-bearing Parry River intrusions of the Queen Maud block. Follow-up work will include geochronology, as well as analysis of gossans and till samples to test economic potential.

OPERATION GEM: RECONNAISSANCE GEOLOGY OF SOME POORLY KNOWN PARTS OF MAINLAND NUNAVUT AND NORTHWEST TERRITORIES

PERCIVAL*, J.A.[1], NADEAU, L.[2], WODICKA, N.[1], BERMAN, R.G.[1], BETHUNE, K.M.[3], DAVIS, W.J.[1], GIRARD, E.[2], HARRIS, J.R.[1], HILLARY, E.M.[1], JEFFERSON, C.W.[1], KELLETT, D.[1] AND PEHRSSON, S.J.[1]

(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, QUEBEC, QC
(3) DEPT. OF GEOLOGY, UNIVERSITY OF REGINA, REGINA, SK
JOPERCIV@NRCAN.GC.CA

In the final phase of the Geo-mapping for Energy and Minerals Program, work is underway to provide some knowledge on areas that have not received attention since helicopter reconnaissance missions of the 1950's and 60's. The Chantrey, Tehery and South Rae areas were selected for further investigation on the basis of their coarse scale of mapping and lack of understanding of lithology, age, structure and mineral potential. Remote predictive maps were constructed for the each area prior to fieldwork using existing maps and imagery, re-analysis of archival materials and new high-resolution aeromagnetic surveys.

The Chantrey area flanks the Queen Maud Bird Sanctuary on the east and south, providing a transect of the NNW-striking Archean and Paleoproterozoic units of the northwestern Rae Province and Thelon magmatic zone. Ten major domains are recognized from aeromagnetic patterns, a previous coastal transect (Schultz et al. Geology 35, 2007; Tersmette, U Alberta MSc 2012), new SHRIMP zircon ages on archival samples, and 2012 reconnaissance field observations. From east to west these domains comprise: 1) high-grade metamorphic equivalents of Archean Woodburn Lake group supracrustal rocks and enveloping gneisses; 2) Amer mylonite zone; 3) a broad zone dominated by ca. 2.6 Ga K-feldspar megacrystic granitoid rocks, diatexite and sparse supracrustal remnants; 4) the Paleoproterozoic Montressor metasedimentary belt; 5) the Chantrey fault zone; 6) a belt of ca. 2.7-2.6 Ga magnetic, well foliated granitoid rocks; 7) migmatitic metasedimentary rocks of the ca. 2.45-2.40 Ga Sherman basin; 8) a belt of highly magnetic, ca. 2.5-2.45 Ga granitoid rocks; 9) a heterogeneous domain of Mesoarchean granitoid and gneissic rocks, some of supracrustal parentage; and 10) the Thelon magmatic zone of 2.0-1.9 Ga granitoid rocks with minor paragneiss. Reworking at ca. 2.5–2.3 and 1.91 Ga is evident in domains 6-9. Exposures of supracrustal rocks are rare west of the Chantrey fault, possibly an artefact of peneplaned topography and extensive glacial cover.

The Tehery area north of Chesterfield Inlet consists mainly of amphibolite facies or higher-grade Archean granitic gneiss and plutonic rocks, several supracrustal assemblages of uncertain age, and local Paleoproterozoic intrusions. Field activities in summer 2012 included targeted bedrock mapping with coincident till sampling, stream sediment sampling, and ground truthing for surficial geology. Within the central portion of the map area (NTS 56B and southern part of 56G), the new mapping confirmed the presence of a folded supracrustal assemblage previously identified on the basis of remote predictive mapping. This assemblage comprises quartzite, iron formation, mafic gneiss potentially derived from metavolcanic rocks, and dismembered ultramafic sills or flows. Further northwest in NTS 56F and 56G, supracrustal rocks occur in northeast-trending infolds along strike of the Paleoproterozoic Ketyet River Group and are dominated by thick white quartzite and psammite to pelite.

Follow-up work in both the Chantrey and Tehery areas will include geochronology to test long-range correlations and orogenic history, as well as analysis of gossans, till and stream sediment samples, to evaluate economic potential.

DETRITAL ZIRCON (U-TH)/HE THERMOCHRONOMETRY FROM THE MACKENZIE MOUNTAINS & MACKENZIE CORRIDOR, NWT: INSIGHTS INTO BURIAL & EXHUMATION OF THE NORTHERN CORDILLERA

POWELL*, J.[1], SCHNEIDER, D.A.[1] AND ISSLER, D.[2]
(1) DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF OTTAWA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
IPOWE068@UOTTAWA.CA

The Mackenzie River corridor of the Northwest Territories has experienced a protracted burial and unroofing history throughout the Phanerozoic with little quantitative constraints on the amount of deposition or erosion occurring between the Carboniferous and Early Cretaceous. We are using innovative and complementary approaches to resolve the timing of maximum burial and onset of hydrocarbon generation, and its relationship with the formation of structural traps. Detrital thermochronometry provides a powerful tool to aid in our understanding of hydrocarbon formation and migration, as these geochronological systems detail the temperature-time histories of sedimentary basins and provide critical insight into the magnitude and extent of major thermal events.

Samples for detrital zircon (U-Th)/He thermochronology were collected along a transect extending approximately 150 km from the northern Mackenzie fold-thrust belt into the adjacent Mackenzie River corridor. Sampling targeted clastic Neoproterozoic strata exposed in the core of anticlines and from the hanging wall and footwall of the Plateau Fault, the eastern-most crustal-scale Laramide thrust fault that places Neoproterozic strata on top of Paleozoic rocks, as well as younger clastic strata in order to resolve the timing of maximum burial. Since helium is only retained in the crystal structure of zircon at temperatures below ~180°C, ages recorded by the thermochronometer indicate when the zircon cooled through this temperature. The challenge will be to resolve the tectonic implications (basin deepening, thrusting, hydrothermal fluids) for our cooling age pattern.

Of the samples collected, single grain (U-Th)/He thermochronology has been performed on Neoproterozoic quartzites, Cambrian sandstones and Cretaceous units. The He systematics of zircons from the Neoproterozoic units have been thermally reset since deposition and consequently record Late Cretaceous cooling. Moreover, a subset of these samples serve to resolve the timing of movement on the Plateau Fault to be post-Cenomanian. In the Cambrian and Cretaceous samples, zircons preserve cooling ages older than the stratigraphic age of the units, indicating that burial has not been significant enough to achieve the temperatures necessary to reset the thermochronometer. Instead, the zircon (U-Th)/He ages for these samples detail cooling in their source regions. Cooling ages recorded in our Cretaceous samples show fluctuations from Tertiary and Permian to Carboniferous cooling, supporting the hypothesis of fluctuating source terranes throughout the Cretaceous.

Our preliminary dataset of zircon (U-Th)/He cooling ages provide insight into the timing of recent regional tectonics within the Mackenzie Corridor and appear to correspond with the late Albian-early Cenomanian erosional event modeled by Issler et al. (2005). While the Cambrian and Cretaceous units have not been heated above 180°C to reset the post-deposition (U-Th)/He systematics, these data do help constrain the upper boundary of temperatures reached during burial and detail the timing of uplift in varying Cretaceous source terranes. Ultimately, the increased risks and costs associated with hydrocarbon exploration in frontier regions necessitate the synthesis of all varieties of geological data. This study aims to aid in this endeavor by modernizing the ways in which thermochronological methods are applied to sedimentary basin analysis.

THE YELLOWKNIFE GOLD PROJECT

PRATICO, V.
TYHEE GOLD CORP., VANCOUVER, BC
VAL@TYHEE.COM

Tyhee Gold Corp. continued the development of its wholly-owned Yellowknife Gold Project (YGP) with a Feasibility Study (FS) conducted by a team lead by SRK Consulting and consisting of Lyntek Incorporated, Knight Piésold & Co. and EBA. The Mackenzie Valley Environmental Impact Review Board has moved the environmental assessment of the project to the Information Request phase.

Positive economic results of the FS were published August 15, 2012 and the company will proceed to final engineering design. Tyhee will commence licensing for construction and operation following completion of the environmental assessment process.

SRK conducted a mineral resource estimate for the YGP including the data acquired during the 2011 diamond drilling program. The mineral resources for the YGP have been estimated by SRK at 27,115,000 tonnes grading an average of 1.97 grams per tonne gold classified as Measured and Indicated resources. Inferred mineral resources are estimated at an additional 5,744,000 tonnes grading an average of 2.62 grams per tonne. The mineral resources are reported in accordance with NI 43-101 standards with an effective date of July 1, 2012.

The potential for development of additional resource exists for the Ormsby, Nicholas Lake, Goodwin Lake and Clan Lake properties. The deposits are open laterally or vertically and additional diamond drilling has the potential to develop significant new gold resource. The resource potential of the Ormsby deposit is limited laterally but unbounded vertically. Diamond drilling limits the lateral extent of the Nicholas Lake deposit but the deposit is unbounded below the bottom of Nicholas Lake resource. The Goodwin Lake property has some potential for diamond drilling to expand the Vad Zone resource and the property hosts a prospective metavolcanic unit with historical gold showings. The Clan Lake Main Zone gold deposit is unbounded both laterally and vertically. The Clan Lake property hosts numerous gold showings in highly prospective metavolcanic units over a 7 km north-south extent. All of the showings have geological and mineralogical similarities to the Clan Lake gold deposit.

The FS analyzed a combination of open pit and underground operations. The mining plan anticipates open pit operations at the Ormsby, Bruce and Clan Lake deposits and underground operations at the Ormsby and Nicholas Lake deposits.

SRK estimated total Proven and Probable mineral reserves inclusive of mineral resources at 20,433,000 tonnes grading an average of 2.03 grams per tonne. SRK confirmed there are no periods of negative cash flow in the economic model and project economics are favourable at the three year moving average price of US$ 1,400 per ounce gold. A mill feed schedule based on the mineral reserves estimated a 15 year mine life producing a total of 1,207,000 ounces of gold. Production will average 104,000 ounces gold per year for years 2 to 9.

Tyhee Gold Corp. is committed to working with all stakeholders in a socially responsible manner using the company's Social Responsibility Statement as a foundation. The YGP will provide employment and business opportunities to First Nations people and other residents of the NWT.

THE MIDDLE TO LATE DEVONIAN OIL SHALE PLAY IN THE CENTRAL MACKENZIE VALLEY: REGIONAL GEOLOGICAL AND GEOCHEMICAL CHARACTERIZATION

PRICE*, P.R., COOPER, M., ENACHESCU, M.E. AND KIERULF, F.
MGM ENERGY CORP, CALGARY, AB

The June 2011 Federal Petroleum Land Sale within the Central Mackenzie Valley (CMV) saw 11 parcels, totalling almost 900,000 ha (2.2 million acres or 96 Alberta townships) awarded to five companies for a combined work commitments in excess of $534 million. In June 2012 an additional 2 parcels, totalling just over 154,000 ha (~17 Alberta townships) were awarded to two companies for a combined work commitments in excess of $92 million.

What then created the excitement within the CMV that resulted in $625 million dollars of work commitments in the CMV? Underlying the majority of the recent sale blocks is an organic-rich world class shale basin. Two middle to late Devonian shale intervals within this basin, the Canol and Bluefish, show significant potential for Shale Oil Resource. Geochemical, petrographic and sedimentologic analysis of the subsurface and outcrop combined with regional seismic interpretation have allowed for a comprehensive evaluation of the exploration potential of these shales and for comparison to other shale basins currently being explored.

Since that initial 2011 land sale, two new wells (currently confidential) have tested and cored the shale intervals and a large amount of new modern 2D and 3D seismic data has been shot. Further plans are now under way by the some of the interest owners for drilling of up to four additional exploration wells during the upcoming 2012-2013 winter season. With encouragement from drilling and potential

testing of these world-class shale formations an exciting future may be in the cards for the CMV and neighbouring communities.

MACKENZIE PLAIN PETROLEUM PROJECT: SHALE OIL AND SHALE GAS POTENTIAL IN THE DEVONIAN HORN RIVER GROUP

PYLE*, L.J.[1], GAL, L.P.[1] AND FIESS, K.M.[2]
(1) VI GEOSCIENCE SERVICES LTD., BRENTWOOD BAY, BC
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
LPYLE@VIGEOSCIENCE.COM

Shale oil and gas potential of the Devonian Horn River Group in Mackenzie Plain is the focus of a five-year (2009-2014), field-based and subsurface project being conducted through the Northwest Territories Geoscience Office. Mackenzie Plain is a petroleum producing and exploration area in the Central Mackenzie Valley that contains the conventional oil field at Norman Wells. The main goal of the project is to characterize the source rock and unconventional petroleum potential of the Horn River Group.

The 2012 field program focused on measuring, describing, and sampling a proposed reference section for the Horn River Group, located on a tributary to the Mountain River. Above the Hume Formation carbonate, the section includes Hare Indian Formation (with basal Bluefish Member), Ramparts Formation (including Carcajou member), and Canol Formation and exposes most unit contacts. Data collected include spectral gamma ray measurements at outcrop, and chip sampling for the following analyses: 1) evaluation of organic rich shale for source rock potential (Rock-Eval, total organic carbon, kerogen type, thermal maturity, and reflectance); 2) mineralogy (semi-quantitatively, using X-ray diffraction, XRD); and 3) whole rock geochemistry. Six additional sections were examined and sampled within Mackenzie Plain in 2012, which will complement the datasets from 29 outcrop sections and stations within the study area.

Chip samples from 26 exploration wells that penetrate the Horn River Group have undergone the same analyses as outcrop samples. The selected wells are arranged in five roughly east-west transects that span the Mackenzie Plain from north to south. Correlation of organic-rich subunits between the wells and outcrops is underway through integration of the trends in lithogeochemistry profiles (major oxides and trace elements), outcrop scintillometer profiles and available gamma logs, and total organic carbon trends.

From initial datasets, outcrop Rock-Eval and total organic carbon (TOC) analyses indicate the Canol Formation (average TOC 5.02%), part of the Ramparts Formation (average TOC 4.24%), and Bluefish Member (average TOC 5.39%) are excellent source rocks, while the upper portion of the Hare Indian Formation is a poor source rock (average TOC 0.13%). Well cuttings samples similarly indicate fair to excellent quality source rock, particularly in the Canol Formation and Bluefish Member. From both Horn River Group outcrop and well samples, mainly Type II kerogen is present with a contribution from Type III kerogen. Both T_{max} values and vitrinite reflectance data indicate samples analysed from wells and outcrop are within the oil window through much of Mackenzie Plain, with a regional trend suggesting increasing maturity from northeast to west and south. XRD results suggest the Canol Formation in outcrop contains 82-90% average modal quartz, Ramparts and Hare Indian formations have variable amounts of quartz and calcite as dominant minerals, and Bluefish Member samples have significant to abundant quartz. XRD analyses on subsurface samples indicate the Canol Formation and Bluefish Member samples are quartz-rich, averaging 73% and 66%, respectively. Clay minerals account for about 15% in both units.

FIELD RELATIONS OF THE ACASTA GNEISS COMPLEX

REIMINK*, J.R.[1], CHACKO, T.[1], STERN, R.A.[2] AND HEAMAN, L.M.[1]
(1) DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES, UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) CANADIAN CENTRE FOR ISOTOPIC MICROANALYSIS, UNIVERSITY OF ALBERTA, EDMONTON, AB
REIMINK@UALBERTA.CA

The Acasta Gneiss Complex (AGC) has long been known to contain rock units with crystallization ages close to or in excess of 4.0 Ga making them the oldest known felsic rock units in the world. However, the AGC has experienced a long and complex history with multiple periods of igneous intrusion, deformation and metamorphism. Indeed, previous workers have demonstrated that orthogneisses within the AGC have crystallization ages ranging from ~4.03 to ~3.4 Ga. This large age range of rock units gives us the opportunity to investigate the evolution of Earth's earliest known continental crust through a period of greater than 600 million years. Due to the polyphase nature of these rocks, much of the previous work has focused on high-resolution geochronology to interpret the complex field relationships. Here we present results of the past field season where an approximately 1 x 1 km area of relatively low strain was mapped at a 1:1000 scale. Our goal is to delineate mappable rock units in these complex gneisses and then use field relationships and in-situ geochronology to unravel the geological history of the area. The mapping revealed the presence of four main rock units:

- The dominant unit is a grey to pinkish, biotite-bearing granodiorite gneiss. Preliminary U-Pb dating of zircon [4, and our work] by in-situ laser-ablation inductively coupled plasma mass spectrometry (LA-MC-ICP-MS) suggests a crystallization age of between ~3.7-3.55 Ga for this unit.
- The second unit is a coarse grained and relatively undeformed metagabbro unit. Preliminary LA-ICP-MS dating of this unit in our lab and work by previous workers [4] suggest a crystallization age of ~3.75 Ga for this unit.
- The third unit is an amphibolite gneiss, which is locally garnet bearing. It is unclear whether this unit is a more strongly deformed version of the metagabbro or an earlier-formed unit intruded by the gabbro.
- We refer to the fourth unit as the layered tonalite. It comprises bands of lighter colored biotite tonalite gneiss alternating with melanocratic hornblende-biotite tonalite gneiss. Our initial work suggests that some components of this layered tonalite unit may be older than 3.9 Ga.

Work is currently underway to refine the ages of these units through in-situ U-Pb dating by LA-MC-ICP-MS and Cameca ims1280 ion microprobe. These geochronological data will be evaluated in light of the field relationships documented in the mapping.

AURORA COLLEGE GEOSCIENCE FIELD ASSISTANT TRAINING PROGRAM

ROBINSON, K.A.
AURORA COLLEGE, FORT SMITH, NT
KROBINSON@AURORACOLLEGE.CA

Aurora College, with the support of the NWT and Nunavut Chamber of Mines, and the NWT Geoscience Office, is developing a five week (150 hour) Geoscience Field Assistant Training Program. The program will provide participants with the skills and knowledge required to function as productive field assistants in the Geoscience and Mineral Exploration sectors.

The need for geoscience field assistant training was confirmed through a needs assessment conducted by TAIT Communications. There were 33 respondents to the needs assessment survey, and the findings confirmed that (1) there was a significant demand for geoscience field assistants in the NWT and Nunavut, and (2) that companies in the NWT and Nunavut would be

interested in hiring Aurora College graduates of a Geoscience Field Assistant Training Program. Based on the detailed findings of the needs assessment, Aurora College and the Geoscience Field Assistant Training Program Steering Committee worked to develop and refine a program outline.

Core courses in the program are listed below:

999-101 Introduction to the Role of Field Assistant (6 hours)
999-102 Communications and Team Work (6 hours)
999-103 Introduction to Orienteering (12 hours)
999-104 Applied Computer and Technology Skills (12 hours)
999-105 Basic Geology (24 hours)
999-106 Sampling (9 hours)
999-107 Prospecting (12 hours)
999-108 Claim Staking/Mineral Rights (6 hours)
999-109 Geophysical Surveying and Grids (6 hours)
999-110 Introduction to Mineral Exploration (6 hours)
999-121 Wilderness First Aid (24 hours)
999-122 Helicopter and Fixed Wing Aircraft Safety (3 hours)
999-131 Field Camp Skills (12 hours)
999-111 Problem Solving and Decision making (6 hours)
999-112 Document use and Data Entry (6 hours)

The program also has section of optional courses so that the delivery can be tailored to specific industry and/or community clients.

On October 8, 2012 a Request for Proposals (RFP) was issued for the development of courses in the program. It is expected that development will be completed by February 16, 2013.

DETAILED GEOCHEMICAL STUDIES OF LAC DE GRAS KIMBERLITES – REDEFINING THE 'DIAMOND AGE WINDOW'?

SARKAR*, C., HEAMAN, L. AND PEARSON, D.G.
DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES, UNIVERSITY OF ALBERTA, EDMONTON, AB
CIRANJEEB.SARKAR@UALBERTA.CA

The Lac de Gras (LDG) kimberlite field, within the central Slave craton, Canada hosts more than 270 kimberlites, which including the Ekati and Diavik properties, making it one of the most economic kimberlite fields in the world.

Establishing the emplacement ages of the LDG kimberlites and their distribution pattern has been a key aspect of exploration. A total of 50 kimberlites have been radiometrically dated, yielding ages between 45 and 75 Ma. Based on high precision Rb-Sr macrocrystal phlogopite dating (40 kimberlites) and U-Pb groundmass perovskite dating (10 kimberlites), five distinct episodes of kimberlite magmatism have been proposed in this area: (1) the Mark array (47.8 $\pm$ 0.3 Ma), (2) Panda array (53.2 $\pm$ 0.3 Ma), (3) A154 array (55.3 $\pm$ 0.3 Ma), (4) the Cobra array (59.0 $\pm$ 0.7 Ma) and (5) "Mid-sixties" kimberlites (64-75 Ma). One of the most compelling features of the published age distribution is that only the Eocene kimberlites (45 to 56 Ma) appear to be of economic significance, even though older and younger kimberlites erupt in relatively close (km to sub-km) proximity.

This 'diamond age window' is mainly defined by Rb-Sr isochron and model ages of a small number of kimberlites (<20%) dated so far. Although eruption ages determined by Rb-Sr phlogopite and U-Pb perovskite methods agree for a number of kimberlites we have determined that some of the samples previously dated by the Rb-Sr technique have slightly different U-Pb ages (by up to 6 Ma). Rb-Sr mineral isochrons typically define precise ages, however, Rb-Sr model ages are often affected by progressive crustal contamination and variation in assumed initial Sr isotope compositions. In addition,

mica from a number of desirable targets is altered; preventing meaningful application of the Rb-Sr technique. Our objective, in a renewed study, is to refine the age distribution of LDG kimberlites using a single geochronometer - the perovskite U-Pb technique ($^{206}Pb/^{238}U$ ages), to create an internally consistent database. Besides geochronology, we are also investigating in more detail the notion of a diamond age window and adding tracer information (Sr and Nd isotope ratios) to investigate the source characteristics of highly diamondiferous versus diamond-absent kimberlites. We have selected several kimberlites of unknown age as well as some previously dated pipes for this study.

Initial results from 17 kimberlites, including 3 undated pipes, are consistent with the age range previously proposed for kimberlite emplacement in the LDG area. However, it also indicates that the distribution of highly diamondiferous LDG kimberlites may not be restricted within the Eocene period, with some economically significant kimberlites having Cretaceous ages. This modifies the established model of episodic kimberlite emplacement and there is a possibility of finding more than one 'diamond window' in the LDG area. We are developing a more precise U-Pb dating technique by improving the mineral separation method and chemistry followed by analyses via multi-ion counting TIMS. This will allow us to precisely analyze smaller sample sizes, allowing dating of samples where perovskite is very scarce. We are exploring the possibility of higher precision U-Pb perovskite dates by analyzing co-crystallized oxides to constrain the initial common Pb of the magma. We will use statistical techniques to identify age clustering and hope to more quantitatively relate kimberlite age to diamond grade. A more detailed and extensive picture of the age distribution of kimberlites in the LDG area should help future exploration efforts.

CLOSURE PLAN AND PERMITTING UPDATE FOR THE NICO GOLD-COBALT-BISMUTH-COPPER DEPOSIT, NORTHWEST TERRITORIES

SCHRYER*, R., GOAD, R., DE CARLO, M., MOLONEY, P. AND SHEPARD, B.
FORTUNE MINERALS LIMITED, LONDON, ON
INFO@FORTUNEMINERALS.COM

This presentation will detail the progress of the NICO Project in the permitting process. Fortune has also made several refinements to its closure plans that have addressed concerns brought forward by various Parties during the environmental review process.

The following was assumed in the development of the revised closure plans:

1. Seepage/run-off from the co-disposal facility (CDF) will require treatment prior to release into Nico Lake;
2. A Constructed Wetland Treatment System (CWTS) will be built to passively treat this water;
3. The open pit will be actively flooded with water from the Marina River so that a final closure condition can be reached within 10-14 years after operations have ceased; and
4. Overflow from the open pit will be approximately167,000 m^3/year.

The seepage/run-off from the CDF may require a moderate amount of treatment to achieve Site Specific Water Quality Objectives (SSWQOs) levels. This level of treatment can easily be achieved with a purposely built CWTS which will occur early during operations. This would be a passive treatment system that will function without maintenance once established.

It is calculated that between 10 and 14 years of active pumping (during the summer) would be required to achieve overflow. Pumping will be halted 2 years prior to overflow to allow time for

the water to settle and to test the water quality profile in the open pit to determine if in-pit treatment should be undertaken. The open pit water quality predictions show that predicted steady state total arsenic levels are only 35% higher than naturally occurring levels. This is well below the level of treatment observed in the natural wetland and in other established CWTS systems. The CTWS would not have to operate at a high level of efficiency in order to meet SSWQO's but it will be designed to exceed expectations.

The updated closure plan demonstrates a clear "walk-away" solution to potential water quality issues at the NICO Mine. The CDF CWTS will be built according to a vigorous study plan that can only move forward based on the success of previous pilot-scale studies and the on-site demonstration CWTS. This CWTS will have performed for years prior to closure and will provide the basis of design for the open pit CWTS. The open pit will be actively filled if in-pit treatment solutions cannot be found that would ensure acceptable water quality under a passive filling scenario. CWTS will be built should it be required. However, the new calculations on open pit water quality and quantity show that the potential for changes to water quality in the Marian River, with or without CWTS treatment, are negligible.

The public hearings were completed on October 11th, 2012. The public registry was closed on October 22nd. The Mackenzie Valley Review Board is currently preparing its report of Environmental Assessment in which it will make its recommendation to the Minister.

THE ~1.9 GA REGOLITH AT BEAVERLODGE LAKE, NORTHWEST TERRITORIES: IMPLICATIONS FOR ATMOSPHERIC OXYGEN AND UNCONFORMITY-TYPE (?) URANIUM MINERALIZATION

SHAKOTKO*, P.[1], OOTES, L.,[2] AND PAN, Y.[1]
(1) GEOLOGICAL SCIENCES, UNIVERSITY OF SASKATCHEWAN, SASKATOON, SK
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
PHS090@MAIL.USASK.CA

Paleoweathering, alteration events, and uranium mineralization are often preserved along unconformities. At Beaverlodge Lake, south of the Great Bear Lake, NWT, an 18 km long ridge has at least two unconformities preserved and has been mapped. At the base of Beaverlodge ridge, ca. 1931 Ma quartz-feldspar porphyry of rhyodacitic composition is unconformably overlain by ca. 1905 Ma bimodal volcanic rocks of the Zebulon Formation. Overlying both of these is a ca. 1900 Ma quartz arenite of the Conjuror Bay Formation. Elsewhere are ca. 1892 Ma Bloom Basalts that overlie the Conjuror Bay Formation. Relevant to this study is a location along the ridge where the porphyry underlies the quartz arenite, with a well-preserved regolith and a coincident past-producing uranium occurrence.

In 2011, fieldwork was conducted in the Beaverlodge Lake area and consisted of detailed traverses and sampling across the unconformity. Whole-rock geochemical analyses were undertaken to investigate the mobility of elements relative to the unconformity. The following trends were observed: while Si, Fe, K, Ca, and Ti display an upward increase towards the unconformity, Na and Mg have been removed from the profile. Aluminum, Mn, and P remain relatively constant throughout the profile. These major element trends are consistent with other Paleoproterozoic regoliths as well as those of modern-day dacite weathering profiles. The maximum values of the alteration index (AI) and plagioclase index of alteration (PIA) at 77 and 96, respectively, indicate a tropical weathering profile during the formation of the Beaverlodge Ridge regolith.

Electron microprobe analysis and back-scattered electron imaging have identified several accessory minerals in the porphyry including allanite, zircon, fluoroapatite, magnetite, and rutile. Zircon, allanite, and fluoroapatite in the Beaverlodge Ridge regolith are well-preserved, whereas Fe and Ti oxides such as magnetite and rutile often display evidence of surface weathering such as dissolution, etching and pitting. Further quantitative work was undertaken to analyze the chemistry of the chlorites. Three distinctive groups of chlorite were identified forming a continuum with a range of Mg number values. X-ray powder diffraction (XRPD) analyses of the most altered porphyry samples have identified muscovite, illite and kaolinite as the primary clay constituents. Elevated levels of potassium observed in the geochemistry, although not unheard of in paleosols, are best explained by late K-metasomatism.

In 2012, fieldwork was undertaken to sample across the unconformity between the Zebulon and Conjuror Bay formations. Whole-rock geochemical and mineralogical analyses are underway to compare the alteration observed in the porphyry to that of the Zebulon Formation. Additional work is being conducted to date the uraninite mineralization and analyze REE's and other trace elements in uraninite and compare these results with other uranium showings in the Great Bear magmatic zone.

THE GRYPHON™ MULTI-PARAMETER AIRBORNE PLATFORM: A POWERFUL REGIONAL EXPLORATION TOOL

SHALES, A.
FUGRO AIRBORNE SURVEYS
ASHALES@FUGROAIRBORNE.COM

Airborne geophysical methods are extremely useful tools in exploration and mapping programs. There are many different types of airborne geophysical systems and each type measures a different physical parameter which in turn provides different information about the subsurface of an area of interest. Regardless of the type of target or targets being sought, in order for a given target to be detected by geophysical methods, a contrast in a given physical parameter must exist between the target and the surrounding host rock. Some targets may have a contrast in one or more parameters but not in another. Therefore it is important to select the most appropriate geophysical method that captures the parameter exhibiting the most contrast. In areas where limited previous information exists, this can pose a problem as often one may not know what target types are present and therefore which survey method is most appropriate.

However this dilemma changes with the introduction of the GRYPHON™ Multi-Parameter Platform which is the only system to combine the full suite of airborne geophysical measurements onto a single platform. The simultaneous collection of: electromagnetic, magnetic, gravity, radiometric, LiDAR and digital video data by the GRYPHON™ system provides a cost-effective and time-efficient way to obtain unparalleled information on an area's geophysical signature. Integrating this information together provides a fuller understanding of an area's geology and ensures information on all possible parameters is measured thereby reducing the chance of missing a target. Details on this exciting new technology along with examples will be discussed.

EVIDENCE OF PHYSICAL AND CHEMICAL WEATHERING IN THE PRAIRIE CREEK MINE AREA, SOUTHERN MACKENZIE MOUNTAINS, NWT

SKERIES*, K.[1], JAMIESON, H.[1], FALCK, H.[2], DAY, S.[3] AND PARADIS, S.[4]
(1) DEPARTMENT OF GEOLOGICAL SCIENCES AND GEOLOGICAL ENGINEERING, QUEEN'S UNIVERSITY, KINGSTON, ON
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(3) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(4) GEOLOGICAL SURVEY OF CANADA, SIDNEY, BC
SKERIES@GEOLADM.GEOL.QUEENSU.CA

The recently completed Mineral and Energy Resource Assessment (MERA) of the Nahanni National Park expansion has recognized many mineral occurrences in the Greater Nahanni Ecosystem of the Northern Cordillera, Northwest Territories. One of the sediment-hosted sulphide occurrences has been broadly categorized as 'carbonate fault' type. Members of this deposit type, including the Prairie Creek deposit, tend to produce muted surficial geochemical signatures which are easily missed against the natural backgrounds. In carbonate-dominated watersheds, chemical analyses of stream water and sediments do not return anomalously high elemental concentration results, even in areas where the rocks are known to contain Zn-Pb-Ag (± Cu) sulphide mineralization. The purpose of this study is to determine the mineralogical and geochemical controls on weathering and mobilization of the sulphide mineralization hosted within carbonate rocks in the Prairie Creek area.

The Prairie Creek property, located in the Mackenzie Mountains of the Northwest Territories, contains Lower Paleozoic carbonate-hosted sulphide deposits that consist of Zn, Pb, Ag (± Cu)- sulphide vein systems and stratabound zinc sulphide lenses. Galena, sphalerite, pyrite, and tennantite-tetrahedrite are present as massive-lenses to disseminated sulphides in the vein system; however, much of the uppermost portions of the deposit are highly oxidized, with smithsonite (zinc carbonate) and cerussite (lead carbonate) being the predominant minerals. In addition to the vein-hosted mineralization are showings best described as Mississippi Valley-type mineralization, also containing galena and sphalerite.

In the field season of 2011, 41 stream water and stream sediment samples from four proximal streams were obtained. Additionally, 10 sieved (< 177 µm) ore-pile and waste rock pile samples, and vadose zone water samples from both these piles were collected. Chemical analyses of all media were subsequently acquired (ICP-MS, ICP-ES, as well as INAA on solid media). Results have shown that elements of interest (Pb, Zn, Ag, Cu, Sb, As, Cd, Se) are present in both filtered (< 0.45 µm) and unfiltered water fractions, indicating that both physical and chemical weathering processes are occurring. Thin sections of solid samples were also analyzed using Scanning Electron Microscopy, as well as synchrotron-based µ-XRF (trace element mapping) and µ-XRD (X-ray diffraction) methods.

Mineralogical analysis of stream sediments suggests that a large proportion of the elements of interest are being adsorbed to iron oxides/oxyhydroxides (goethite and hematite). Within the ore stock pile and waste rock pile, adsorption of the elements of interest onto iron oxides/oxyhydroxides, as well as clay particles, may be occurring. Evidence of secondary mineral growth, such as needle-like cerussite and hydrocerussite, is also present within the ore stock pile and waste rock pile and shows the presence of trace metals, indicating that metals are released and reprecipitated within the ore stock pile and waste rock pile.

3-D STRUCTURAL MODEL OF THE SLAVE CRATON MANTLE LITHOSPHERE, NORTHWEST TERRITORIES

SNYDER*, D.B., HILLIER, M. AND KJARSGAARD, B.A.
GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON

After over ten years of acquiring and analyzing geophysical, geochemical and geological observations, we are able to compile a fully 3-dimensional model of the subcontinental mantle lithosphere of the Slave craton. This model incorporates several knowledge layers that include:

- continuous (3D) seismic P- and S-wave velocities, conductivity;
- local or discrete observations (1D) of seismic anisotropy or discontinuities, rock type from xenoliths and xenocrysts, paleogeotherms; and
- surface maps (2D) of elevation, gravity, magnetics and geology.

Many of these products are derived from recent GEM program activities within Natural Resources Canada.

The primary focus of the analysis to date has been depth correlation of major regional discontinuities, such as the Moho or mid-lithosphere discontinuity, with significant gradients in seismic velocities or conductivity. Intriguing corrugated structure on these deep discontinuity surfaces is observed and possibly correlates with NE-SW seismic anisotropy polarizations or mapped regional D2 crustal fold structures and orogenic trends along the margins of the Slave craton. Broad-scale lateral changes in mantle geochemical and geophysical properties appear to match mapped surface geology domain boundaries, such as the limits of the Central Slave Basement Complex or edges of the Slave craton.

LITHALSA DISTRIBUTION, MORPHOLOGY AND LANDSCAPE ASSOCIATIONS IN THE GREAT SLAVE LOWLANDS, NORTHWEST TERRITORIES

STEVENS, C.W.[1] AND WOLFE, S.A.[2]
(1) FORMERLY: GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA, OTTAWA, ON. PRESENTLY: SRK CONSULTING (US) INC., ANCHORAGE, ALASKA, USA
(2) GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA, OTTAWA, ON, AND DEPARTMENT OF GEOGRAPHY, CARLETON UNIVERSITY, OTTAWA, ON

The distribution of ice-rich terrain is an important geotechnical consideration for the engineering of northern infrastructure. Within the Great Slave Lowlands, Northwest Territories, fine-grained silts and clays deposited by glacial Lake McConnell (ca. 13 to 9.5 cal ka BP) and ancestral Great Slave Lake (post 9.5 cal ka BP) are widely distributed across discontinuous permafrost terrain. Whereas these sediments are known to contain excess ice attributable to permafrost aggradation and ice segregation, little is known about the distribution of ice-rich terrain in this region.

Mineral lithalsas are permafrost mounds, caused by the formation of segregate ice when the permafrost aggrades into the ground, and are most commonly encountered within fine-grained (lacustrine, glaciolacustrine or marine) sediments in discontinuous permafrost terrain. Lithalsas, like ice-wedges and pingos, represent a form of ice-rich permafrost terrain that can be readily identified on the basis of surface geomorphology. A total of 1,777 ice-rich mineral lithalsas have been mapped over 3,680 km^2 using monochromatic stereo-pair aerial photographs, across the Great Slave Lowlands and Uplands. Drill cores indicate lithalsas in this region consist of ice-rich silt and clay, with segregated ice lenses up to 10 cm thick. Three distinct morphologies are recognized including: i) circular, ii) linear and (iii) crescentic shapes, exhibiting conical and ridge-like forms up to 8 m in height and more than 100 m in width. A linear correlation between lithalsa height and width suggests that 1 cm of vertical growth is accompanied by about 15 cm of lateral growth at the peripheral edge. Lithalsa distribution is skewed towards lower-elevation terrain, with 97.7% located within the Great Slave Lowlands, and most of these within 10-15 m above present-day level of Great Slave Lake (~156 m asl). This proximity to present-day lake level suggests that many lithalsas in the region are late Holocene in age. These features predominately occur adjacent to water bodies and follow the regional distribution of frost susceptible silt and clay, particularly within former streams, embayments and structurally-controlled bedrock valleys. Landscape associations suggest lithalsa formation is controlled by sedimentological, thermal and hydrological conditions.

The thermal and physical disturbance of lithalsa features in the Great Slave Lowlands can result in substantial terrain subsidence. Analysis of historical aerial photographs has identified lake expansion caused by the recent degradation of lithalsa. In addition, road surface subsidence on the order of 85 cm in the last decade along a section of Highway 3 at Boundary Creek is likely the result of permafrost degradation within a mineral lithalsa following road construction.

PRAIRIE CREEK MINE; A LIGHT AT THE END OF THE TUNNEL?

TAYLOR, A.
CANADIAN ZINC CORPORATION, VANCOUVER, BC

The Prairie Creek Mine is located in the Mackenzie Mountains, 200 kilometres west of Fort Simpson in the Northwest Territories. In 1982, Prairie Creek mine was fully permitted and mine infrastructure was built, however, the mine never achieved production. Canadian Zinc has, through exploration over many years, successfully expanded and defined a significant Pb, Zn, Ag, Cu Mineral Resource to a threshold where future operations could be confidently based upon a minimum of 10 years. Necessary regulatory applications were submitted in June 2008.

SNC-Lavalin Engineering completed a Preliminary Feasibility Study in June 2012 based on a Proven and Probable Reserve of 5.2m tonnes grading 9.4% Zn, 9.5% Pb and 151gpt Ag which was derived from a Measured and Indicated Mineral Resource, estimated by AMC Mining, to contain further potential of 6.3m tonnes of Inferred Resource grading 14.5% Zn, 11.5% Pb, 229 gpt Ag and 0.57% Cu. The P & P Mineral Reserve alone is sufficient to base mine economics on an 11 year life with high potential of converting the Inferred Resource to additional Reserves through further definition drilling. The PFS projected favorable mine economics of 40.4% IRR with a 3 year pay-back and a $160m capital cost to upgrade the existing facility.

At the Prairie Creek Mine high-grade base metal mineralization occurs within vein and stratabound-type geological settings. The high-grade vein is located within a steeply dipping fault zone that cross-cuts carbonate sedimentary sequences in close proximity to the axial plane of a regional doubly plunging antiform. Diamond drill exploration in 2012, continued from previous years, included further exploration at 1.6 kilometre step-out deep hole drillpad to test for the down plunge extent of the known resource hosted in the vein-type structure.

The proposed underground mine plan includes mining rates of 1,300 tpd and milling rates of 1,000 tpd to produce lead and zinc concentrates to be trucked out via a winter road. The proximity of Nahanni National Park Reserve and similar eco-sensitivities arising from local concerns has led to some innovative approaches to mitigate environmental concerns from the proposed project. Significant enhancements to the operation include installation of a new dense media separation plant, paste backfill plant, diesel generators and a new water management system that includes a new storage pond, water treatment plant and exfiltration system.

Formal socio-economic agreements have been signed with key players in the region in order to further benefit northern participation. Furthermore, the Company has entered into significant training programs funded, via the Mine Training Society, through Federal grants in order to prepare a more qualified workforce in the region to participate in future employment opportunities at the mine.

Operating applications for the Prairie Creek Mine were submitted to the Mackenzie Valley Land and Water Board in June 2008 and an Environmental Assessment under the Mackenzie Valley Review Board was completed in December 2011. The applications are now proceeding through the final phase of permitting with the regulatory authorities.

BORDEN BASIN ZN-PB DISTRICT (NU) THEMATIC STUDIES: 2011-2012

TURNER*, E.C.[1], KAMBER, B.S.[2], KONTAK, D.J.[1], LONG, D.G.F.[1], HNATYSHIN, D.[3], CREASER, R.[3], MORDEN, R.[1] AND HAHN, K.[1]
(1)DEPARTMENT OF EARTH SCIENCES, LAURENTIAN UNIVERSITY, SUDBURY, ON
(2)SCHOOL OF NATURAL SCIENCES, TRINITY COLLEGE DUBLIN, DUBLIN, IRELAND
(3)DEPARTMENT OF EARTH AND ATMOSPHERIC SCIENCES, UNIVERSITY OF ALBERTA, EDMONTON, AB
ETURNER@LAURENTIAN.CA

The Borden Basin project consists of multi-year field-dominant research that encompasses a suite of investigations aimed at understanding the evolution and economic potential of this proven but poorly understood Zn district (Nanisivik mine; 1976-2002). Recent work in this project established the regional architecture of the thick and areally extensive Mesoproterozoic carbonate units that host known base-metal mineralisation (Zn, Pb, Cu +/- Ag); this foundation then contextualised focused research on known carbonate-hosted sulphide bodies. Since the end of the 2011 field season, field and analytical advances have resulted in the publication of results from five thematic studies focused on the basin's economic potential. (1) A field-based study mapped and characterised the many known Zn-Pb+/-Cu showings in the 250 x 100 km Milne Inlet Graben (main zone of mineralisation), identified the structural and stratigraphic controls on the spatial distribution of three showing types, and highlighted two geographic zones of elevated economic potential. (2) A field-based and analytical study of a thick (>100 m) and unexplored black shale unit showed that geochemical and geologic conditions in the basin during shale accumulation would have been appropriate for the deposition of SEDEX-type sulphides if local vent sources had been present (currently unknown). This work also yielded the first direct date for the depositional age of the Bylot Supergroup (~1092+/-59 Ma; U-Th-Pb whole-rock on black shale), which is considerably younger than the previous, assumed depositional age and coincides with the Grenvillian orogeny and assembly of Rodinia. (3) A fluid inclusion study of the Nanisivik ore body showed that ore-forming fluids were Na-rich and comparatively low-temperature (<100°C; in striking contrast to ≤200-250°C results of earlier studies), with increasing temperature towards the "mine dyke", a Franklin-aged (~720 Ma) intrusion that cross-cut the ore-body and locally modified the fluid inclusions (i.e., to higher Th values). (4) Re-Os dating of pyrite from the Nanisivik ore-body and the Hawker Creek group of showings provide for the first time a direct date for the mineralising event: ~1100 Ma. This date refutes recent work that indicated a Phanerozoic age for the mineralising event and refocuses the economic potential of the event to Proterozoic host rocks only. The results also suggest that fluid movement post-dated sediment deposition by only a brief time, and may have been driven by tectonic events associated with the amalgamation of Rodinia. (5) Study of the clastic basal rocks of the Mesoproterozoic succession showed that the potential for unconformity-type U deposits in this basin is low. Field work in 2012 focused on understanding vent-related deep-water carbonate mounds that were deposited during accumulation of black shale (PhD student project), and on outlining the tectonic evolution of the basin using sediment provenance; the analytical phases of these two projects are the focus of laboratory-based work for fall and winter 2012.

THE COREGONID FISHES OF BLUEFISH LAKE, NT

VECSEI*, P. AND PANAYI, D.
GOLDER ASSOCIATES LTD., YELLOWKNIFE, NT
PVECSEI@GOLDER.COM

The diversity of Coregonid fishes (including whitefish, cisco and inconnu) in the Great Slave Lake watershed is poorly understood. A recent fishery survey in Bluefish Lake, NT on the Yellowknife River has identified coregonid species and morphs that are either unknown or that have not yet been identified in the Great Slave Lake watershed. We collected ciscoes from a deep water location in Bluefish Lake between September 26 and 30, 2012. We employed a traditional taxonomic approach to identify and compare these three unique ciscos. We identified 3 cisco morphs; a large-eyed, slim-bodied morph; a short-headed, large-bodied morph, and third morph with in-between features. These morphs can be distinguished using a suite of meristic and morphometric traits. We also captured and identified pygmy whitefish during our survey. The presence of this species in the Great Slave Lake watershed is an important discovery and is among the most

significant range extension for a coregonid in recent times.

THE MON GOLD MINE, AN EXAMPLE OF AN ARCHEAN DISCORDANT STRATABOUND GOLD DEPOSIT

WEBB, D.R.
NEW DISCOVERY MINES LTD., VANCOUVER, BC
DAVE@DRWGCL.COM

The Mon Gold Mine is located within the Yellowknife Greenstone Belt, 50 km north of the City of Yellowknife, NWT. Production in 1989 and again in 1991-1994 is reported to have been 3,141 ounces from 7,117 tonnes of ore for an average grade of 13.7 gpt. Production figures for 1964 and after 1994 have not been reported.

The Mon Gold Mine is an example of a Discordant Stratabound Gold Deposit (DSGD) and is hosted within a thickly bedded amphibolite-facies belonging to the Burwash Formation meta-argillite adjacent to a stratiform amphibolite unit. Gold mineralization occurs within and adjacent to a 1 to 3 meter wide zone comprising quartz veins and silicified argillite disposed in a horseshoe-shaped antiform with a 20 meter interlimb distance plunging moderately to the southeast. Gold is associated with sulphides that typically occur proximal to inclusions and quartz vein margins and include <1% galena and sphalerite and minor to rare arsenopyrite, pyrite, pyrrhotite, and chalcopyrite. Intense alteration of the argillite into a mottled grey and reddish-pink hematized unit occurs up to 4 metres away tangentially from the gold mineralization and tens of metres away laterally from the quartz veins. The ore is free-milling with high-levels of gravity recoverable gold and very low levels of deleterious elements.

Mineralization similar to that which occurs at the Mon Gold Mine can be found at the Discovery Mine 40 km to the north where a steeply-plunging quartz vein system occurs within a thick meta-argillite member of the Burwash Formation adjacent to an amphibolitic unit. Here past production accounted for 1 million ounces of gold from 900,000 tonnes of ore.

The DSGD contrast to the better known Concordant Stratiform Gold Deposit (CSGD or saddle reef-type) in that the DSGD is constrained to a thickly-bedded favourable stratigraphic unit and is clearly discordant to the strata and is typically folded within that unit. Metasomatism is much more apparent in the DSGD than in the CSGD.

OCCURRENCE AND ENVIRONMENTAL IMPACT OF OXIDE-SULPHIDE GOSSANS AND THEIR REACTIVE ZONES IN PERMAFROST

WILLIAMSON*, M.-C.[1], HARRIS, J.[1], PERCIVAL, J.B.[1], BÉDARD, J.[2], FROOME, J.[3], PETERSON, R.C.[3] AND RAINBIRD, R.[1]
(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, QUÉBEC, QC
(3) DEPARTMENT OF GEOLOGICAL SCIENCES, QUEEN'S UNIVERSITY, KINGSTON, ON
MWILLIAM@NRCAN.GC.CA

The bioavailability of potentially toxic trace elements, such as As, Cd, Co, Cr, Cu, Hg, Ni, and Pb, is strongly related to their mineral chemistry and oxidation state in the environment. Environmental assessments of future mine sites in the North require knowledge of the conditions under which trace metals released during oxidation of sulphides are subsequently concentrated and contained in permafrost, or dissolved in fluids and released from it. Previous investigations of base metal gossans in arctic regions suggested a complex acid rock generation process in which freeze–thaw cycles promote the chemical weathering of sulphide-rich rocks accompanied by the production of reactive gossanous soil.

We report the results of a collaborative activity based on the following scientific hypothesis: *Arctic gossans constitute analogues of how mine waste would behave in a permafrost environment.* The objectives of the activity in Years 1 and 2 were to: (1) locate gossans in

central Victoria Island using satellite imagery; (2) measure the spectral signatures of surficial materials at key locations to improve the accuracy of remote predictive maps; (3) map and sample surface materials of alteration zones ; (4) determine the stratigraphy, mineralogy, and geochemistry of deposits to document facies and origin. Our results show that remote predictive mapping of oxide-sulphide gossans is best achieved using a combination of Landsat-7 and Worldview-2 images; and that the results obtained from *in situ* surface spectral analyses are robust, and validate or improve the maps. The mineralogy of gossans at two different localities on Victoria Island consists predominantly of gypsum, jarosite and goethite, implying an important role for sulphate-evaporite rocks of the Kilian Formation in the genesis of these deposits. In addition, frozen pore waters in gossan pyrite sands at one locality are extremely acidic, with a pH of 2, confirming our working hypothesis that the gossans constitute analogues of mine waste in permafrost, and provide natural laboratories for the study of oxidation reactions, their environmental impact, and remediation. Finally, the long-term persistence of pyrite encased within the acidic permafrost indicates that oxidation and dissolution reactions are very slow in these sensitive environments. The development of acid-generating, reactive zones in permafrost associated with oxide-sulphide gossans requires close attention and further study as global temperatures rise and potentially impact the depth of the active layer.

TUNDRA SCIENCE AND CULTURAL CAMP

YUILL, S.M.
ENVIRONMENT AND NATURAL RESOURCES, GOVERNMENT OF THE NORTHWEST TERRITORIES,YELLOWKNIFE, NT
STEPHANIE_YUILL@GOV.NT.CA

Imagine a program that emphasizes learning from the land; one that takes students into the classroom then into the field – every day; one that is fun yet educational and emotive; one that connects scientific study and traditional knowledge.

Welcome to The Department of Environment and Natural Resources' Tundra Science and Cultural Camp – a ten-day environmental education program for high school students and teachers in the Northwest Territories. Located 300 kilometres north of Yellowknife at the Department's Tundra Ecosystem Research Station at Daring Lake, the camp takes students out of their comfort zone and onto the tundra and challenges them with incredible learning opportunities.

Participants work closely with a variety of instructors including educators, scientists, on-site university researchers and Dene elders. Topics covered include geology, wildlife ecology, ornithology, plant ecology, archaeology, and human history. Traditional knowledge is an integral part of this cross-cultural education program.

Since 1995, more than 250 students and teachers have participated in the program, which has inspired young people, both aboriginal and non-aboriginal, to embrace science by providing insight into the nature of science, its methodologies and applications in resource management. Bringing students, scientists and educators together with elders gives everyone involved the opportunity to improve communication skills, understand different cultures and bridge the gap between western science and traditional Dene knowledge.

This contact has proven to motivate students, helping them refine their interests in science and traditional knowledge. It provides teachers with the skills and knowledge to make their science courses in the classroom more relevant. Participants also learn about decision-making, resource management and development issues in this diamond mining region of the Northwest Territories.

Graduates often comment that the camp had a profound effect on the way they view science, traditional knowledge and the environment. Many of them have continued with post-

secondary education in the sciences and are returning to the North to be employed in the private and public sectors.

ABSTRACTS - POSTER PRESENTATIONS

PALEOGEOGRAPHIC, STRATIGRAPHIC, AND GEOCHEMICAL EVIDENCE FOR CONFIGURATION AND SEDIMENTOLOGY OF RAPITAN GROUP BASINS (NWT AND YT)

BALDWIN, G.J.[1], TURNER*, E.C.[1] AND KAMBER, B.S.[2]
(1)DEPARTMENT OF EARTH SCIENCES, LAURENTIAN UNIVERSITY, SUDBURY, ON
(2)DEPARTMENT OF GEOLOGY, TRINITY COLLEGE DUBLIN, DUBLIN, IRELAND
GEOFF.I.BALDWIN@GMAIL.COM

The Rapitan iron formation contains one of the largest undeveloped iron deposits on Earth. Deposited in a rift basin during the Neoproterozoic "snowball Earth" glacial episode (ca. 711 Ma), this hematite-jasper iron formation is stratigraphically associated with glacioclastic turbidites and diamictites. The Rapitan Group overlies the rift-related Coates Lake Group and is widespread in the Mackenzie and Wernecke Mountains (NWT and YT). Iron formation of significant thickness is limited to the Snake River area, which straddles the territorial border. The limited geographic extent of the iron formation within the Rapitan Group remains unexplained, a problem that is further compounded by the geographically discontinuous nature of the entire group's exposure. Exposures of the Rapitan Group appear to define two sub-basins: the Snake River basin (YT and NWT), which contains thick iron formation (locally >100 m thick), and the Mountain-Keele-Redstone River (MKRR) basin (NWT), in which the iron formation is much thinner (local maximum 35 m). Iron formation and glacioclastics in the two sub-basins have distinct sedimentological characteristics. In the Snake River basin, the iron formation is generally hematite-rich and a significant proportion of the jasper is nodular; in the MKRR sub-basin the iron formation is generally poorer in hematite and is dominated by bedded and locally silty jasper. Glacioclastic turbiditic rocks of the Sayunei Formation, which underlies the iron formation, consist of siliceous, hematitic mudstone and siltstone, with thin intervals of coarser clastic material in the MKRR, whereas much sandier and clast-rich material dominates in the Snake River sub-basin. Geochemically, iron formation samples from the MKRR sub-basin show evidence for subtle siliciclastic contamination, in sharp contrast with the much more minor contamination in Snake River basin. This phenomenon is best illustrated by Fe/Al ratios and the rare earth elements, which suggest that the deposition of thick iron formation required clastic input to be minimal. Geographically, the margins of the two sub-basins correspond to crustal-scale basin-bounding faults previously defined in underlying successions. This distribution suggests that the sub-basins were the only areas where the Rapitan Group was deposited, and that differentiation into two sub-basins was depositional, rather than erosional or structural. This interpretation is supported by the locally abrupt pinch-outs of the entire Rapitan Group. Thus, basin architecture and the supply of clastic material are the major controls on both the character and distribution of the Rapitan iron formation and the Rapitan Group as a whole

RECOGNIZING OPTIMUM BANDED IRON FORMATION-HOSTED GOLD ENVIRONMENTS IN ANCIENT, DEFORMED AND METAMORPHOSED TERRANES: PRELIMINARY RESULTS FROM THE MEADOWBANK DEPOSIT, NUNAVUT

CASTONGUAY*, S.[1], JANVIER, V.[2], MERCIER-LANGEVIN, P.[1], DUBÉ, B.[1], MCNICOLL, V.[3], MALO, M.[2], PEHRSSON, S.[3], AND BÉCU, V.[1]
(1) GEOLOGICAL SURVEY OF CANADA, QUEBEC CITY, QC
(2) INSTITUT NATIONAL DE LA RECHERCHE SCIENTIFIQUE-ETE, QUEBEC CITY, QC
(3) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
SEBASTIEN.CASTONGUAY@RNCAN-NRCAN.GC.CA

The Meadowbank project is part of the Lode Gold Project of NRCan's TGI-4 Program that aims at improving geological exploration models where gaps exist in our understanding of Canada's major gold systems with respect to footprint, vectoring and fertility as indicators for hidden/buried deposits. The Lode Gold Project investigates a selected group of deposits in various settings, with some emphasis on underexplored styles/types of mineralization, including Banded Iron Formation (BIF)-hosted gold deposits, which represent prime exploration targets in northern Canada. The BIF-hosted gold deposits theme consists of a systematic investigation of the proximal and distal geological and hydrothermal signatures or footprints, structural controls and timing of the mineralization with respect to the overall geologic evolution of their host rocks and camp-scale settings. Such research is underway at the Musselwhite mine and Hardrock deposit in Ontario, and at the Meadowbank mine in Nunavut.

Agnico-Eagle Mines' Meadowbank mine is located in the Kavallik region of Nunavut, 70 km north of the community of Baker Lake. The deposit is hosted in the Neoarchean Woodburn Lake Group, in the Rae domain of the Western Churchill geological province. Ongoing research and data acquisition to date have mostly been concentrated on the Portage and Goose orebodies, which now represent a ca. 3 km-long open-pit operation. The lithologic sequence of the deposit consists of, from east to west, intermediate to felsic volcaniclastic rocks, banded iron formation, ultramafic rocks, locally interlayered with the BIF, and quartzite. The predominant gold mineralization found at the Portage and Goose orebodies is associated with pyrrhotite and pyrite, which have replaced magnetite or that occur as narrow stringers of disseminated sulphides. The ore zones are typically 6-7 m wide (5 up to 40 g/t) and hosted in the BIF, predominantly along the contacts with ultramafic rocks. Gold also is found in high-grade quartz veins (up to 300 g/t) crosscutting the BIF and adjacent volcaniclastic rocks. At least four phases of regional deformation affect the host rocks of the Meadowbank deposit, which have been metamorphosed to mid-greenschist through amphibolite facies. Regionally, the main phase of deformation (D2) consists of tight to isoclinal folds, axial planar foliation and shear zones, although mesoscopic F2 folds are rare in the mine area. Regional D3 (shallow-inclined open to closed folds and axial planar crenulation cleavage) and D4 (SW-plunging, steeply inclined cross-folds) deformation also affect the mine sequence and the mineralization. Although the geometry of the Portage orebodies is typically portrayed as an isoclinal F2 fold, preliminary new mapping suggests that mine sequence is also fault imbricated by two late-D2 shear zones preferentially developed within the ultramafic units. These shear zones appear to truncate the ore zones, and possibly control their distribution. Targeted geochronology, structural analysis, petrographic and geochemical analyses of roughly 400 samples along selected sections of the Portage and Goose orebodies are underway to characterize the proximal and distal alteration associated with the mineralization and ultimately establish its hydrothermal footprint, the timing of gold introduction and structural controls.

LITHOSTRATIGRAPHY OF THE CENTRAL MISTY CREEK EMBAYMENT, NWT

CHEVRIER, T.S. AND TURNER*, E.C.
DEPARTMENT OF EARTH SCIENCES, LAURENTIAN UNIVERSITY, SUDBURY, ON
TS_CHEVRIER@LAURENTIAN.CA

The Misty Creek Embayment (MCE) is a deep-water embayment (100 x 150 km) within the SEDEX-hosting early Paleozoic Selwyn Basin (NWT and YT). It is defined by lateral transitions from shallow-water to deep-water lithofacies. The stratigraphic succession consists of four formations (Hess River, Rabbitkettle, Duo Lake, and Cloudy formations), interfingered with an alkalic basalt unit (Marmot Formation). The Misty Creek Embayment is understood to have formed as a result of an

enigmatic extensional event and has unknown economic potential.

A single, almost complete, composite stratigraphic section was documented and sampled through 2920 m of strata in the basin's centre [west-central NTS 106B; Hess (part), Rabbitkettle, Duo Lake, and Cloudy (part) formations]. A refined description of the basin's lithostratigraphic units will aid in mapping and correlation. A subsequent analytical program will refine the understanding of the basin's tectonostratigraphic history, depositional environments and time constraints, and identify stratigraphic units with potential to host elevated concentrations of base metals. This poster highlights lithostratigraphic information relevant to regional mapping.

At the study location, from a distance MCE formations are distinguished only by subtle differences in bed thickness and colour. At outcrop-scale, the Hess River Formation (1370 m) consists of alternating decimetre- to metre-scale beds of recessive, medium grey-weathering siltstone in sharp contact with resistant, pale brown-weathering calcareous siltstone and silty limestone with distinctive, intermittent, pale orange-brown-weathering laminae of very fine- to fine-grained graded calcareous and slightly pyritic quartz sandstone. Approximately 50 m of recessive shale and siltstone are present near the base of the exposure; the base of the formation is not exposed. Rare fossils include trilobite fragments, brachiopods, and sponge spicules. The transition between the Hess River and Rabbitkettle formations is gradational. The Rabbitkettle Formation (805 m) is characterised by monotonous intervals of pale grey- to brown-weathering, graded, millimetre- to decimetre-thick beds of quartz sandstone, calcareous siltstone, and limestone. Sedimentary structures including slump-folds, creep-folds, scour marks, cross-lamination, and limestone nodules are common. The contact between the Rabbitkettle and Duo Lake formations is gradational. The Duo Lake Formation (220 m) is divided in two by the volcanic Marmot Formation (295 m). The Duo Lake Formation is dominated by dark grey-weathering, thinly bedded shale and variably calcareous, generally graptolitic siltstone. The contact of the Duo Lake and Cloudy formations is marked by the appearance of laminated lime mudstone interbedded with calcareous siltstone or shale. In this section, a significant proportion of the Cloudy Formation interval measured (230 m; incomplete) is interpreted as an olistostrome (175 m). Above the olistostrome the succession consists of thinly bedded siltstone, chert, and minor limestone, with rare graptolites.

The Hess River Formation was deposited in deep-water, on a subtle slope, and is locally turbiditic; the Rabbitkettle Formation contains conspicuous evidence of deposition on a slope; The Duo Lake Formation was not deposited on a substrate with a significant gradient.

BROADENING MINERAL EXPLORATION TARGETS IN TERRAINS PROSPECTIVE FOR IOCG DEPOSITS: EXAMPLES FROM THE GREAT BEAR MAGMATIC ZONE

CORRIVEAU, L.[1], MONTREUIL, J.-F.[2], HAYWARD*, N.[3], MCMARTIN, I.[4], POTTER, E.[4], ENKIN, R.[5], DAVIS W.[4] AND CRAVEN, J.[4]
(1) GEOLOGICAL SURVEY OF CANADA, QUÉBEC, QC
(2)INRS-ETE, QUÉBEC, QC
(3) GEOLOGICAL SURVEY OF CANADA, VANCOUVER, BC
(4) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(5) GEOLOGICAL SURVEY OF CANADA, VICTORIA, BC
NHAYWARD@NRCAN.GC.CA

Unexpected new mineral exploration targets arise from the geological characterization and the geophysical delineation of a N-S trending iron oxide-copper-gold (IOCG) belt at circa 1.87 Ga in the Great Bear magmatic zone (GBmz) prior to its dissection by NE-trending transcurrent faulting. These targets provide unparalleled perspectives for exploring multiple metal deposits in the GBmz and other prospective terrains of Canada's North. The knowledge is also being used by federal, territorial and First Nations governments and Northerners for land-use planning and development of resources in the North.

In greenfield areas of the belt, next to known deposits and within footprints of the historic silver and uranium mines along the NE shore of Great Bear Lake, the GEM project has demonstrated metal endowment in magnetite-, magnetite-hematite and hematite-group IOCG deposits. Affiliated deposit types developed within a continuum from IOCG to porphyry and epithermal deposit types. They include iron oxide±apatite deposits, base metal-poor multiple-metal deposits, and albitite-hosted uranium deposits. As such, potential untapped resources in GBmz include base metals (Fe, Cu, Pb, Zn, Ni), precious metals (Au, Ag and platinum-group elements), strategic metals (Bi, Co, Mo, V, Nb, Ta and rare earth elements) and nuclear metals (U and Th). This wide diversity in the metal signature of the GBmz mineralized zones is a fundamental consequence of the geological processes that lead to IOCG deposits. Vectors to mineralization based on the geological, chemical, mineralogical and rock physical property signatures of the mineralizing systems are furthered by processing the project multivariate IOCG data with adapted statistical methods and through the development of new geophysical models that highlight potential targets. Potential metal endowment below the surface can be modelled by geophysics or tested by examining undervalued legacy drill core collections across the GBmz. Vectors to mineralization developed under the project can also be applied to archived GBmz and Canada-wide lake sediment, till, and bedrock samples, through their re-analysis with geochemical methods suitable to process IOCG-type material. In addition, environmental impacts in northern weather conditions of future IOCG mine tailings can be addressed by studying historic workings and tailings in the Camsell River and Port Radium-Echo districts, such studies would aid environmentally responsible development of northern IOCG resources. The GBmz also has existing infrastructure and logistical hubs to facilitate access to key areas and lower costs of future mineral resources exploration and development activities.

LIARD BASIN PETROLEUM PROJECT: SHALE GAS POTENTIAL OF DEVONIAN-CARBONIFEROUS STRATA IN YUKON, NORTHWEST TERRITORIES, AND NORTHEAST BRITISH COLUMBIA

FERRI, F.[1], FIESS, K.[2], FRASER, T.[3] AND PYLE*, L.[4]
(1) OIL AND GAS DIVISION, BC MINISTRY OF ENERGY, MINES AND NATURAL GAS, VICTORIA, BC
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(3) YUKON GEOLOGICAL SURVEY, WHITEHORSE, YT
(4) VI GEOSCIENCE SERVICES, VICTORIA, BC
TIFFANI.FRASER@GOV.YK.CA

The British Columbia Ministry of Energy, Mines and Natural Gas, Northwest Territories Geoscience Office, Yukon Geological Survey and Geological Survey of Canada are collaborating to provide geoscience information on the petroleum potential of Devonian-Mississippian shale units in Liard Basin. The study, known as the Liard Basin Petroleum Project, was initiated in 2011 so as to: a) pool government resources and expertise within a multi-jurisdictional basin; and b) to build on increased industry activity in neighbouring Horn River Basin which contains similar Devonian-Missisippian stratigraphy to Liard Basin. The study will comprise new measured sections from different parts of the basin and will sample shale for organic geochemistry, biostratigraphy and mineralogy. This poster introduces the project and reports on reconnaissance fieldwork in the Liard region in summer 2012.

Liard Basin is a relatively underexplored region straddling the boundaries of Yukon and Northwest Territories and the province of British Columbia. Historically, exploration and production in the region have focused on conventional targets, specifically Lower-Middle Devonian carbonate and Cretaceous siliciclastic reservoirs. The unconventional hydrocarbon potential of the basin has not yet been assessed.

Upper Devonian – Middle Mississippian strata of the Besa River Formation represents a westward shale-out of carbonate rocks spanning the Upper Keg River/Pine Point to the Debolt/Flett formations. Besa River sections

also contain western equivalents to the Horn River, Fort Simpson, Golata and other eastern shale successions. East of the Yukon-NWT border, the upper Besa River Formation grades into mudstone, shale and lesser carbonate of the Middle Mississippian Golata Formation. Both the Besa River and Golata formations in the region are overlain by sandstones of the Mississippian Mattson Formation. In the study area, Mattson Formation sandstone forms steep, resistant cliffs, in contrast to the recessive, often obscured shale and mudstone outcrops found stratigraphically below.

Fieldwork based out of Ft. Liard, NWT, in July 2012 led to the identification and measuring of several Devonian-Mississippian Besa River Formation and Mississippian Golata Formation shale outcrops in northern and western Liard Basin. Although the recessive nature of the units posed challenges in finding a complete section, several sections were examined and included: 1) lower Golata Formation in NWT, 2) middle Besa River Formation in Yukon, and 3) lower to middle Besa River Formation in BC. In conjunction with detailed lithologic descriptions, a hand-held gamma ray spectrometer collected data at 1 m intervals. In addition, shale chip samples were collected at 2 metre intervals for Rock-Eval/TOC, vitrinite reflectance, ICP-ES and ICP-MS lithogeochemistry, XRD mineralogy, and conodont and radiolarian biostratigraphy. Despite the fine-grained nature of these formations, detailed section descriptions show that outcrops are highly variable in nature in terms of color, weathering characteristics, diagenetic features and gamma-ray counts. Correlation of these sections to existing subsurface and outcrop logs and assessment of petroleum potential is the focus of continuing research.

SATELLITE-BASED ANALYSIS OF SURFACE CHANGES WITHIN SLAVE GEOLOGICAL PROVINCE

FRASER*, R.H.[1], DESCHAMPS, A.[1], OLTHOF, I.[1] AND WOLFE, S.[2]
(1) CANADA CENTRE FOR REMOTE SENSING, NATURAL RESOURCES CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA, OTTAWA, ON

Mineral resources located in the Slave Geological Province north of Yellowknife, NWT are a primary driver for economic development in Canada's North. Ground-based transportation infrastructure is becoming increasingly important to the region, with mines and communities requiring all-weather road access across discontinuous permafrost and winter-road access primarily across frozen lakes. Discontinuous permafrost, unstable ground, and climate represent hazards to infrastructure across a vast and otherwise inaccessible terrain. The Great Slave – TRACS project is a multi-agency collaboration that aims to reduce the costs and risk of transportation infrastructure in this resource-rich area.

Satellite-based mapping and modeling of permafrost terrain represents an efficient means of providing geoscience information over large areas for critical infrastructure and development. By integrating satellite-based maps with surficial geological information and knowledge of permafrost and climate conditions, TRACS will conduct a terrain-climatic sensitivity analysis within a 15,000 km^2 portion of the Slave Province lying within NWT. This area includes the discontinuous-to-continuous permafrost region and the first 150 km of the Tibbitt-Contwoyto winter road that provides access to several mines.

One TRACS activity involves detecting surface changes within the study region using the historical (1985-present) archive of 30 m resolution Landsat TM/ETM+ satellite imagery. The change-detection approach is examining long-term reflectance trends using a stack of 102 growing-season Landsat images. Trends will then be related to changes in fractional

vegetation and land cover using regression tree models trained with plot and high resolution satellite data. It is anticipated that the resulting change information will:

(a) Identify any long-term vegetation trends, such as shifts in treeline, burn frequency, and wetland or shrub distribution that, if continued, could impact future permafrost thermal conditions and the integrity of transportation routes;
(b) Provide a means of studying the trajectory of previous disturbances in the area, such as those related to the removal of permafrost-insulating vegetation for road construction; and
(c) Provide an indictor of areas subject to permafrost degradation, as this alters surface drainage and wetness that is often reflected in vegetation change (e.g. thermokarst tranformating spruce forest into wetlands).

Initial results from the reflectance-trend products indicate a wide range of surface changes, including wildfire, mining developing and regeneration of abandoned mines, changes in water level and wetland vegetation, new municipal developments, and changes related to the old and new Yellowknife Highway.

NON-RENEWABLE RESOURCE RESEARCH AND THE NWT PROTECTED AREAS STRATEGY

HAMRE, K.
NWT PROTECTED AREAS STRATEGY, YELLOWKNIFE, NT
PASMANAGINGDIRECTOR@NORTHWESTEL.NET

The NWT Protected Areas Strategy (PAS) is one of the main processes for identifying and establishing protected areas in the NWT. The PAS recognizes the need for economic activity and environmental sustainability and seeks a balanced approach to protection. As part of the 8-step PAS process, a comprehensive evaluation of each study area is conducted, including ecological, cultural, non-renewable and renewable resources, and socio-economic information to inform decisions and management.

Non-renewable resource research has two main parts: mineral potential, and oil and gas potential. Since the PAS was signed by the Government of the NWT and federal government in 1999, 30 non-renewable resource assessments are underway or have be published and posted on the PAS website www.nwtpas.ca. The assessment process is consistent with the principles and goals of the NWT-PAS and the Minerals and Metals Policy of the Government of Canada. Assessment studies are based on quality, peer-reviewed geoscience work.

Mineral assessment reports are generally done in two phases. Phase I reports compile existing data on the candidate protected areas. The reports identify mineral deposit types and identify gaps in the geoscience information coverage. Phase II reports are based on new data collection and evaluation. This typically involves collection and analysis of heavy mineral concentrate samples, glacial till samples, stream silt samples and stream water samples. Data are reviewed to determine the highest mineral potential within the candidate areas. Most of the mineral assessment reports have been done by NWT Geoscience Office geologists.

Oil and gas studies are more likely to be combined in one report, as field work for oil and gas discoveries is outside the scope of the PAS process. The reports are a comparative and qualitative assessment based on a number of geological factors, such as the number of overlapping petroleum plays, the presence of established plays and (or) known hydrocarbon for any given area. Most of the hydrocarbon assessment reports have been done by GSC staff in Yellowknife or Calgary.

Non-renewable resource assessment reports deal only with geological potential; geological potential does not necessarily equate to economic development potential. For economic

potential, the PAS process uses a socio-economic assessment. This combines several aspects of economic potential, as well as incorporating cultural, social and environmental information.

Not all protected areas are the same. Throughout the process, various options for legal designation and management of an area are undertaken. Non-renewable resource assessments help determine the most suitable designation, land administration and management regime. Where possible, areas of high development potential will be avoided, and the process takes into account land and water access to potential and existing third party interests.

The integration of traditional knowledge is an important aspect of all PAS, and very much part of the consideration in establishment and management recommendations.

Some of the results and uses of the non-renewable resource data will be shown on the poster.

TOWARD IMPROVED GEOLOGICAL MAPS OF NORTHERN CANADA: REMOTE PREDICTIVE MAPPING CONTRIBUTIONS TO OPERATION GEM

HARRIS, J.R.[1], PERCIVAL*, J.A.[1], HILLARY, E.M.[1], MACLEOD, R.[2], JOSEPH, J.[2], WAGNER, C.[2], BROWN, N.[1], BERMAN, R.G.[1], PEHRSSON, S.[1], WODICKA, N.[1] AND DAVIS, B.[1]
(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, PACIFIC, BC
HARRIS@NRCAN.GC.CA

A major component of the Operation GEM project involves the integration of legacy field data with predictions of bedrock structure and lithology made from a variety of geoscience data sets including geophysical (regional and high-resolution magnetics and gamma ray) and remotely sensed data. During Operation GEM, archival materials dating from the 1950s-1960s helicopter reconnaissance operations were geo-located and re-analyzed for magnetic susceptibility, composition and in some cases, zircon geochronology (data mining) to enhance the bedrock database. This information contributed to pre-field interpretations that were then tested through targeted field visits in 2012.

This poster summarizes the Remote Predictive Mapping (PRM) protocols developed during GEM and their application in producing predictive maps for a large portion of the Churchill Province west of Hudson Bay. Predictive maps for the Tehery, Chantrey and South Rae transect areas will illustrate how the maps were constructed and demonstrate how they can be interpreted and used to guide fieldwork as well as the next generation of improved geological maps of northern Canada.

REMOTE PREDICTIVE MAPPING – PROGRESS IN MAPPING CANADA'S NORTH

HARRIS, J.R., ERNST, R., BUCHAN, K., WAGNER, C., JOESPH, J., BROWN, N., MACLEOD, R., HAYWARD, N., SCHETSELAAR, E., GUNSKY, E., HARRISON, C*., ST-ONGE, M., RUSSELL, H., PARKINSON,W., LESSMAN, J., HILLARY, B., BUENVIAJA, R. AND SHARPE, D.
GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
HARRIS@NRCAN.GC.CA

Remote Predictive Mapping (RPM), part of the GEM program, deals with the production of predictive bedrock and surficial geology maps derived from the integration of a variety of geoscience data including geophysical, geological, geochemical and remotely sensed. These predictive maps can be used to assist and focus regional mapping activities as well as providing first-order geologic information in "white-space" areas. RPM has directly contributed to northern mapping campaigns in a number of ways:

- providing a complete compilation of existing and interpretation of new dykes (from airborne magnetic, LANDSAT and DEM data) for the entire area north of 60°,

- providing a complete compilation and new interpretation of geologic form lines, faults, and lineaments for north of 60°,
- providing methods and techniques for extracting geologic information from a variety of geoscience data for both bedrock and surficial mapping, and
- providing predictive bedrock and structural maps for the Operation GEM project of a large area west of Hudson Bay.

The dyke and form-line compilations will be directly used in the Tri-territorial Bedrock and Surficial Geology Integration (TRI-T) compilation project. This poster will present these four RPM outputs as well as summarize the protocols used to produce these predictive maps.

FACIES CONTROLS ON RESOURCE DISTRIBUTION IN THE MCMURRAY FORMATION - NORTHERN ALBERTA

HERBERS*, D.[1], BOBEY, B.[1], HARRIS, C.[2] AND GINGRAS, M.[1]
(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) SOUTHERN PACIFIC RESOURCE CORP., CALGARY, AB
HERBERS@UALBERTA.CA

Of Canada's heavy oil and bitumen resources, the Athabasca oil sands are the largest accumulation, with an estimated 1.3 trillion bitumen barrels of ultra-heavy oil in place. Ongoing development of the resource has shown notable variability in ultra-heavy oil distribution. The anisotropic and heterogeneous distribution of resource in the McMurray Formation reflect: (1) uneven saturation of ultra-heavy oil laterally and vertically; (2) the presence of a very uneven oil-water contact; and (3) the presence of local water-saturated, depleted gas zones. We use three outcrop analogues (Saprae Creek, Daphne Island and Steepbank River) of the McMurray Formation to determine the influence lithology has on resource distribution.

Outcrop characterization at Saprae Creek and Daphne Island aim to characterize reservoir heterogeneity with attention directed towards the distribution of bitumen in McMurray Formation sandstones. To quantify bitumen saturation across the sections, three methodologies were employed: (1) direct current resistivity profiling equipment was used to measure changes in pore fluid content; (2) petrographical data were used to characterize oil lean-zones and resource disparity; and (3) oil and water saturations were quantified using bitumen loss on ignition.

Thin section and outcrop observations revealed three main morphologies of oil disparity, each displaying a strong relationship between grain size and bitumen saturation. At Saprae Creek, grain size ranged from 1.0 to 0.5 Phi. The average oil content in the lean sandstones is 6 weight %, compared to 12 weight % for the highest measurements from the outcrop. The heaviest bitumen saturations are associated with the 1 Phi fractions. One explanation for the association of oil with the finer fraction is that during oil biodegradation (which happened in the subsurface), capillarity immobilized the heavy oil in finer-grained laminae, protecting the resource for subsequent water washing. At Daphne Island similar grain-size trends are seen, but a courser grained channel (grain size (phi - 1.0) is also present. At Daphne, heavy-oil locally exceeds 12 weight % in the coarser grained sands, which may be explained by the lower volume of irreducible water associated with coarse-grained reservoirs.

Finally, exposures of the McMurray Formation along the Steepbank River display the oil-water contact. Carefully measured sections show that the relief on the oil-water contact can be as much as 4 meters over 20 lateral meters. No lithological control could be associated with this topography, and so other effects, such as oil-loss during biodegradation or ground-water head distributions must be considered.

Although this study is aimed at understanding the local resource distribution in the McMurray Formation, it has relevance to conventional reservoirs. If the oil-water contact is prone to perturbation by groundwater flow, then reserve

estimates should account for this behavior. Moreover, are lean zones in the McMurray the result of biodegradation, or were original oil distributions (i.e. before biodegradation) antecedent of the distributions observed today?

FINGERPRINTING GLACIAL PROCESSES FOR DIAMOND EXPLORATION ON BAFFIN ISLAND

JOHNSON, C.L.[1], ROSS, M.[1], GRUNSKY, E.[2] AND HODDER, T.J.[1]
(1) UNIVERSITY OF WATERLOO, WATERLOO, ON
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON

Drift prospecting is a widely applied exploration method, especially for diamondiferous kimberlites in glaciated areas like Canada. Drift prospecting involves searching for distinct mineral assemblages (such as kimberlite indicator minerals or KIMs) or geochemical pathfinders in glacial sediments and tracing them back to their source using information gleaned from the glacial geologic record and geophysical properties of potential bedrock source areas. In order to use this method effectively, it is essential to understand the regional past glacial dynamics and subtleties of glacial erosion, sediment production, transportation and deposition. North-central Hall Peninsula, Baffin Island, is highly prospective for diamonds with 64 kimberlites (61 on Peregrine Diamond's Chidliak property and 3 on their adjacent Qilaq property) found to date. A research project was undertaken in this region to improve understanding of the glacial record and develop a glacial dynamics evolution model.

An innovative multi-faceted approach was used which involves mapping glacial landforms through remote sensing (Landsat and DEM) and targeted fieldwork (meso- to micro- scale paleo flow features), as well as analysis of various subglacial erosion intensity proxies (Chemical Index of Alteration, streamlined landform elongation, and lake density).

Five distinct Glacial Terrain Zones (GTZs) were recognized based on this multi-faceted approach. The degree of landscape inheritance and overprint varies across GTZs, each recording a portion of the glacial dynamics history. The geochemical composition of the till was also studied using a principal component analysis (PCA) in an attempt to gain insight into how bedrock influences the chemical composition of the till, and to see if the GTZs had a chemical signature. To determine if the GTZs could be predicted by the till geochemistry, a linear discriminant analysis was subsequently applied to the data. Initial results indicate that GTZ prediction varies from 58 to 89% accuracy, with an overall accuracy of prediction of 82%.

This type of mosaic landscape explains the dramatically different dispersal trains across the study area, and is the basis for developing a predictive tool.

THE HAILSTONE FORMATION: A LOOK AT ITS PALEOENVIRONMENT AND DEPOSITIONAL SETTING

KNOWLTON*, D.[1], HUBBARD, S.[1] AND FISCHER, B.J.[2]
(1)UNIVERSITY OF CALGARY, CALGARY, AB
(2)NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT

The principles of uniformitarianism and catastrophism are used to interpret the paleoenvironment of the Early to Middle Devonian Hailstone Formation in the northern Mackenzie Mountains, Northwest Territories (NTS sheet 106B).

A Neoproterozoic rifting event separated Laurentia from the Rodinia supercontinent, and a passive margin developed along its western boundary. This is preserved today in the Mackenzie Mountains. Even though it was, in tectonic terms, a passive margin, it was quite active tectonically. During the Cambrian, an embayment formed along part of the margin in response to thinning and stretching of the mantle. The Misty Creek Embayment (MCE) was subject to a number of different extensional events from the Cambrian until the Ordovician.

Published maps of the area are of draft quality, and don't incorporate more recent reconnaissance stratigraphic studies of the MCE that divide the Lower Paleozoic map unit into five separate formations. The current study is part of an initiative by the NTGO to address some of the knowledge gaps.

The youngest of the Lower Paleozoic units are the slope-facies Hailstone Formation and its lateral, platformal equivalent, the Grizzly Bear Formation. Two sections were measured through the Hailstone Formation, one at the type section and one at a location where the slope facies seemed to shoal upward into near-platformal facies. These locations were chosen to allow study of the transition from a proximal platform setting to a more distal slope/basin setting. Numerous samples and photographs document the variety of lithofacies in both sections.

The Hailstone Formation in its type section has a covered base. It consists of thinly bedded, graded skeletal rudstone-packstone with thinly interbedded calcareous shale and/or shaly lime mudstone, and is overlain without apparent disconformity by shale of the Canol Formation. The Hailstone Formation here is of a distal, toe-of-slope facies. The second section was measured in the core of a tight anticline in Earn Group shales, and consists of thinly to thickly bedded lime mudstone and calcareous sandstone, suggestive of a more-proximal-slope environment, changing upward into medium to thick beds of coral-crinoid rudstone and bafflestone interlayered with calcareous siltstone, that are interpreted to be platform-edge reefs. The succession is slightly displaced by a fault, underlain under cover by Cloudy(?) Formation and overlain under cover by Canol Formation. Northwest of the measured sections, a meters-thick breccia at least 7km long defines the base of the formation. The presence of this distinctive unit in some locations and not in others is under consideration.

This study will provide the first detailed sedimentological description of the Hailstone Formation and thus will build on previous work and add to the knowledge base. It also has implications for gold exploration, since the tight anticline of permeable grainstone overlain by shale is a possible structural trap for metal-bearing fluids, and the black mudstones are a possible metal source.

FLUID INCLUSION STUDY TO TRACK EVOLUTION OF PALEOZOIC DIAGENETIC FLUIDS ON VICTORIA ISLAND, NWT

MATHIEU, J., KONTAK, D.J. AND TURNER*, E.C.
DEPARTMENT OF EARTH SCIENCES, LAURENTIAN UNIVERSITY, SUDBURY, ON
JY_MATHIEU@LAURENTIAN.CA

Understanding the movement and evolution of diagenetic fluid in a sedimentary basin allows for a better assessment of the economic potential (base metals; hydrocarbons) of a basin. Victoria Island in Canada's Arctic archipelago remains largely unmapped and explored despite the presence of known economic resources on surrounding islands. The purpose of this project is to investigate the evolution of diagenetic fluids in the Proterozoic Shaler Supergroup and in the western part of the Franklinian basin, as recorded by fluid inclusions in diagenetic cements, with a view to enhancing the understanding of the basin's economic potential. Standard petrography integrated with microthermometry and evaporate mound analysis using SEM-EDS were used to track the thermal and compositional changes of diagenetic fluids in two stratigraphically distinct carbonate host rocks from the vicinity of Minto Inlet: the Neoproterozoic Wynniatt Formation and lower Paleozoic "map-unit 10b".

The Wynniatt Formation hosts three cement phases: saddle dolomite, brown dolomite, and calcite (in chronological order). Petrographic evidence indicates that all phases post-date deposition of Cambrian sandstone. Two diagenetic cements are hosted in dolostone of map unit 10b: quartz and calcite. Associated with primary growth zones in the quartz cement are pyrite framboids; this indicates the presence of reducing fluid during quartz precipitation.

Secondary petroleum fluid inclusion assemblages (FIAs) in the quartz cement fluoresce pale green under UV light (385 nm), which indicates (sub)mature petroleum. Petroleum FIAs are absent from the calcite cement and therefore must have migrated through the area in the time between precipitation of the two cements.

Based on regional stratigraphy (~1 km thick), the trapping temperatures of the FIAs (115° to 125°C) are much higher than what could have been locally derived. This indicates that the fluids were "hydrothermal" (i.e., temperature above that dictated by geothermal gradient and therefore sourced from a hotter zone elsewhere).

Two distinct hydrothermal fluids are recorded in the FIAs of the Wynniatt Formation: an evolved saline fluid and a meteoric fluid. The KCl-rich saline fluid (Na/K of 0.2) experienced a progressive change towards a hotter and more NaCl-rich fluid (Na/K of 5) due to fluid-rock interaction. No amount of mixing or evolution can account for a 0 wt. % NaCl equiv. fluid and therefore a second fluid must have been introduced during the last increment (calcite) of cement growth.

The fluid responsible for cements in map unit 10b experienced three different compositions: a Na (Ca)-rich composition that transported heavy metals (Cu, Zn, and Pb), a saline composition that accompanied petroleum, and a Na-K-rich composition. Petroleum maturation suggests that the basin remained within the oil window and therefore did not exceed a burial depth of 5 km, which agrees with the inferred overlying stratigraphic thickness (~1 km). The fluid inclusion evidence indicates that map unit 10b has the potential to host both base-metal and petroleum resources.

DIAMOND SOURCES BENEATH THE HALL PENINSULA, NUNAVUT: A PRELIMINARY ASSESSMENT BASED ON MICRO-DIAMONDS

NICHOLS*, K.[1], STACHEL, T.[1], PELL, J.[2] AND MATE, D.[3]
(1) UNIVERSITY OF ALBERTA, EDMONTON, AB
(2) PEREGRINE DIAMONDS, VANCOUVER, BC
(3) CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
HOGBERG@UALBERTA.CA

The Chidliak kimberlites, 120km northeast of Iqaluit on the Hall Peninsula Southern Baffin Island, Nunavut, tap mantle sources of unknown paragenesis, age and history; many of the recently discovered kimberlites have proven to be diamondiferous. Micro-diamonds (≤600 μm) and macro-diamonds (≥600 μm) were recovered during initial kimberlite sampling. Of the 44 kimberlites (out of 62) tested for diamonds, commercial sized diamonds were recovered for 41% of the kimberlites. Micro-diamond studies are a powerful tool to characterize the mantle sources of cratonic roots and to gain insights into conditions of diamond formation and preservation beneath the Hall Peninsula.

Approximately 740 lithospheric micro-diamonds have been provided by Peregrine Diamonds Ltd., of which 210 micro-diamonds within the size range of 210 to 600 μm will be utilized for geochemical analyses. Lithospheric diamonds form in the subcontinental lithospheric mantle (SCLM) and are associated with mantle source rocks including peridotites, eclogites and sometimes pyroxenites. Morphological characteristics, carbon isotopic compositions, and nitrogen characteristics of Chidliak diamond will be used to constrain upper mantle sources, mantle residence times and conditions of diamond formation.

Since carbon and nitrogen have a similar ionic radius, nitrogen can substitute and bond strongly with carbon in the diamond crystal structure. Nitrogen is by far the most abundant substitutional impurity in diamond, with values as high as 0.55%. Nitrogen concentrations can be used to obtain broad constraints on possible

upper mantle diamond sources; the median nitrogen content for a peridotitic source is 70 ppm and for an eclogitic source it is 370 ppm. Using Fourier Transform Infrared (FTIR) spectroscopy, it is observed that Chidliak micro-diamonds have nitrogen contents ranging from below the limit of detection (~10 at.ppm) to 3356 at.ppm, with an average nitrogen concentration of 1237 at.ppm. Assuming a mantle residence time (e.g., 3 Ga or 1 Ga), it is possible to use the measured nitrogen abundance and aggregation to calculate time averaged mantle residence temperatures. Only high quality infrared spectra are used in determining temperature; the Chidliak micro-diamonds show a range in temperature from ~960 to 1260°C. For micro-diamonds that are pure IaA (0% nitrogen in the B centre), an assumed value of 0.5% B was used for the temperature calculations (i.e., calculated temperatures for these diamonds represent a maximum value).

The benefits of this study will lie in providing a first order assessment as to what the likely mantle sources of these diamonds are and how they are situated in a world-wide context. It will result in the first direct constraints on diamond sources in the deep lithosphere beneath what possibly represents a previously unrecognized small Archean cratonic block, aid in the modern interpretation and understanding of diamond mantle sources beneath the Hall Peninsula, and ultimately contribute to the economic development of Nunavut's mineral resources.

DETECTING MASSIVE ICE USING GROUND-PENETRATING RADAR IN THE NORTHWEST TERRITORIES

ODELL*, D.E.[1], MOORMAN, B.J.[1] AND SMITH, I.R.[2]
(1) DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF CALGARY, CALGARY, AB
(2) GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
DODELL@UCALGARY.CA

Massive ice and related thaw subsidence present a significant challenge to the geotechnical engineering and design of infrastructure such as roads, pipelines and buildings in permafrost regions. Development in these areas requires an understanding of the distribution of massive ice and the establishment of effective methods for its quantification at a local scale. The research discussed here demonstrates the application of Ground-Penetrating Radar (GPR), seismic shothole drillers' lithostratigraphic logs, and other complementary data in the identification of massive ice along recent seismic cutlines at Little Chicago and Lac des Bois, central Northwest Territories.

Three occurrences of massive ice along 58 km of ground traverses were identified using 100 MHz GPR data, velocity analysis, shothole drillers' logs and air photos. At Little Chicago (120 km north of Fort Good Hope), an ice body measuring 55 m in lateral extent and having a maximum thickness of 2.6 m was identified. Inverse modeling of the propagation velocity from a hyperbolic return below the ice yielded a calculated velocity of 0.16 m/ns, supporting the conclusion of massive ice. A second example of massive ice, measuring 90 m in lateral extent, was also identified at Little Chicago using data interpreted from 2008 drillers` logs in conjunction with GPR facies analysis. In the Lac des Bois, Colville Hills area, massive ice measuring 50 m horizontally and with a maximum thickness of 1.7 m was detected in an area of active thermokarst.

The successful identification of massive ice at three sites from two different field areas highlights the effectiveness of GPR in detecting and mapping such occurrences, while emphasizing the importance of complementary data in studies using GPR as a primary methodology.

APPLICATION OF SCIENCE AND LOCAL INUIT KNOWLEDGE TO IMPROVE FISH PASSAGE IN A NUNAVUT STREAM

O'NEIL, J.[1], STEVENS, C.[1], POPOWICH, R.[1], SWIFT*, D.[1] AND ADJUN, B.[2]
(1)GOLDER ASSOCIATES LTD., EDMONTON, AB
(2)KUGLUKTUK HUNTERS AND TRAPPERS ORGANIZATION, KUGLUKTUK, NU
CAMERON_STEVENS@GOLDER.COM

To what degree salmonid species can tolerate climate changes in the north remains unknown. One species of traditional importance is Arctic char (*Salvelinus alpinus*), a salmonid that migrates between freshwater and marine environments many times over its life. Evidence suggests that critical connecting watercourses have already experienced change including decreased flows which make passage more difficult. To explore this in greater detail, representatives from the Kugluktuk Hunters and Trappers Organization, the Nunavut Department of Environment, the University of Alberta, and Golder Associates, are studying the movement behaviour of Arctic char from the Hingittok Lake - Nulahugyuk Creek system, Nunavut.

Over 100 Arctic char in the creek were studied using PIT tag monitoring arrays and visual observations. The migratory life cycle of Arctic char in the creek (between the lake and ocean) was monitored relative to flow regimes. Previous work identified areas with dispersed flows through boulder gardens where the potential for migratory barriers is high. Sections of the channel were manually manipulated by local Inuit volunteers to potentially improve passage for fish, and movements though these areas were evaluated.

Results from a successful first field season indicate that existing conditions for successful migration by Arctic char are poor. The movement window closes quickly and movement by successful migrants is much earlier and slower than expected. Water temperatures are higher than anticipated and represent a physiological stressor to migrating Arctic char, and natural mortality by stranding and natural predation was prevalent. We intend on continuing this work in 2013 and into the future to determine if mitigation options are available to help conserve this culturally important species in similar systems in the north.

For the mining industry, this type of project represents an opportunity for community involvement, hiring opportunities, and No-Net-Loss compensation options under the regulatory permit approval process. Findings may be applied to assist in the maintenance and recovery of other fish stocks that are of cultural and subsistence value to the Inuit people.

SLAVE CRATON VMS POTENTIAL AND EVALUATION OF THE BANTING GROUP

OOTES*, L.[1], JACKSON, V.A.[1], HAMILTON, M.A.[2], COUSENS, B.C.[3], COVELLO, L.[4] AND BERGER, A.[3]

(1) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
(2) DEPARTMENT OF EARTH SCIENCES, UNIVERSITY OF TORONTO, TORONTO, ON
(3) DEPARTMENT OF EARTH SCIENCES, CARLETON UNIVERSITY, OTTAWA, ON
(4) AURORA GEOSCIENCES, YELLOWKNIFE, NT
LUKE_OOTES@GOV.NT.CA

2.69-2.66 Ga bimodal metavolcanic belts are preserved throughout the Slave craton; these are commonly referred to as Banting Group. Many localities contain known and previously explored volcanogenic massive sulphide (VMS) base-metal deposits. However, advanced exploration activity is currently focused entirely in Nunavut (High Lake, Hackett River, IZOK Lake), and while there are some known VMS deposits in the NWT (e.g., BB, Sunrise), prospective volcanic belts remain under-evaluated for their VMS potential. Through a targeted approach the VMS prospectivity of each of these belts will be tested through bedrock mapping, major and trace element geochemistry, tracer isotope studies (Sm-Nd; Lu-Hf), and highly precise U-Pb zircon dating. Contemporaneously, the breadth of the use of the term Banting Group is tested; does the Banting Group as defined in the Yellowknife volcanic belt really correspond to other similar belts across the craton? For example, in Yellowknife the best available ages for Banting volcanic rocks indicate they erupted at ca. 2662 Ma, but intrusive rocks with ca. 2671 Ma ages are also known. In other Banting-equivalent belts, older ages are more common, ranging from ca. 2690 to 2670 Ma (clustering near 2675 Ma), although ca. 2662 Ma volcanic rocks are also known to be dispersed across the craton. A first-order objective of this project is to define

the age domains of the various volcanic belts and then establish a geochemical and tracer isotope baseline across which areas can be independently compared.

Four areas have been identified for bedrock mapping and include Sharrie Lake (see Jackson and Ootes, this volume), Fenton Lake/Cameron River, Wijinnedi Lake/Snare River, and west Indin Lake south of Leta Arm. All these areas have received 1:50 000 scale or better bedrock mapping, however recent forest fires have left pristinely exposed bedrock where the detail of bedrock mapping can be significantly improved. Other identified areas have received bedrock mapping and base geology that is more than adequate for targeted geochronology and geochemical profiles. During 2012, 20+ samples were collected for U-Pb zircon geochronology by chemical abrasion isotope dilution thermal ionization mass spectrometry from over 10 different belts, including the footwall and/or hanging wall of the Sunrise, BB (Indian Mountain), DEB, Lark, and Inc 10 VMS deposits, in addition to areas that contain distal exhalites, or where VMS potential remains unknown. All samples will have corresponding tracer isotope constraints and where areas are bimodal, samples of both mafic and felsic volcanic rocks will be analyzed and compared.

The outcome of this study will permit the comparison of prospective VMS belts in the NWT with those that are being actively explored in Nunavut. Positive results should delineate which belts are most prospective for yet undiscovered deposits and encourage further exploration for VMS deposits. The long-standing question of 'what is' and 'what is not' Banting Group will be thoroughly tested across the west, south, and eastern portion of the craton and the timing, environment, and evolution of these volcanic belts will be constrained.

TABLETS: A PEEK INTO THE FUTURE OF FIELD DATA COLLECTION

PIERCE*, K.L., RENTMEISTER, K. AND FALCK, H.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT
KELLY_PIERCE@GOV.NT.CA

Since 2001, the Northwest Territories Geoscience Office (NTGO) has utilized Pocket PCs (PPC) with ESRI's ArcPad software to collect field data. However, PPCs are no longer at the forefront of technology and have become largely obsolete. Tablets seem to be the next evolutionary step for field data collection. To test their suitability in the field, a pilot project was undertaken to increase data entry efficiency in a stream and lake sediment sampling program. For several years, the NTGO, in partnership with the Geological Survey of Canada (GSC), have been conducting this sampling using basic analog field data collection. The results of this project have highlighted some of the advantages and hurdles in implementing new technology.

Despite the seeming abundance of hardware choices, notably Android devices, Windows tablets, and iOS tablets; the decision was to use the Apple iPad. Battery life and mature software application options were primary deciding factors; other contributing factors were screen size, available accessories, operating system stability, and ease of use. The software application (app) had to include a customizable data entry form with GIS and/or GPS capability that functioned offline, could import/export data (shapefiles, imagery, and waypoint files), and change symbology. An appropriate application with all these capabilities could not be found, instead a few apps were used together to meet the required specifications.

FileMaker Pro software was selected for field data collection, as it specializes in the construction of customized databases and data entry forms. The entry form databases, which are based on the paper forms used by the GSC in their National Geochemical Reconnaissance program, were transferred to the iPad and used

with the FileMaker Go app. In addition to site observations, and *in situ* chemical property readings, the form collects location coordinates and database-embedded photos from the iPads' GPS and camera, respectively. The FileMaker database can later be converted to a shapefile or Google Earth kml file and viewed spatially, with each sample location linked to its accompanying photos. Finding a GIS or GPS app with the necessary requirements was more challenging. Ultimately two applications were chosen, with differing success, GlobalScout for the GPS app and iGIS for the GIS app. While GlobalScout worked well in most respects, the unintuitive interface and lack of waypoint functionality of iGIS made it of limited use.

The final hardware setup included two iPads, each encased in an Otterbox for protection in the field. Two battery power packs were used to charge the tablets when remote from a power source. An external keyboard was also utilized. With the proper protection, the iPad proved to be a reliable and efficient tool in the field. While FileMaker and GlobalScout worked well, the search will continue for better, more suitable, applications. The next experiment will be to implement tablets for NTGO bedrock mapping projects, which have long used PPCs to collect field data. iPads or the upcoming Windows 8 tablets could provide an appropriate and superior replacement, but appropriate GIS apps need to catch up to the hardware.

NEW BEDROCK GEOSCIENCE MAPS OF THE WESTERN MINTO INLIER OF VICTORIA ISLAND

RAINBIRD, R.[1], BÉDARD, J.H.[2] AND GIRARD, E.[2]
(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) GEOLOGICAL SURVEY OF CANADA, QUÉBEC, QC

The GEM-Minerals mapping project on Victoria Island has covered a large portion of the Neoproterozoic western Minto Inlier and Paleozoic platform rocks to the north. Mapping in summers of 2010 and 2011 with a party of 15-20 geologists yielded a wealth of data and samples. Preliminary versions of the first bedrock map products will be presented, including sheets 87H12 (Minto Inlet) and 87H05 (Qiqittiivik). Although coverage in the field was on a 100,000 scale, interpolation using remote imagery allows 50,000 scale maps to be produced from these data where coverage was best. The maps represent a major upgrade in the quality of bedrock coverage in these areas. Previously undivided Paleozoic rocks have been mapped on the Formation level, whereas several of the Shaler Supergroup Formations are represented on the member level. Neoproterozoic rocks located to the north of Minto Inlet, previously only represented on the Group level, are now shown on the Formation level. Igneous rocks that were previously only schematically represented north of Minto Inlet, now occupy a significant portion of the map area. Once the 50,000 scale maps are completed, a series of thematic and regional scale maps will be developed.

DEVELOPING AN IMPROVED KNOWLEDGE FRAMEWORK FOR INDICATOR MINERAL INTERPRETATION

RUSSELL, H.A.J., KJARSGAARD, B.A., LESEMANN, J.-E. AND SHARPE, D.R.
GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
HRUSSELL@NRCAN.GC.CA

New methods development is needed to develop an improved framework for IM survey design and interpretation in order to enhance exploration effectiveness. To date, glacial geological mapping has focused mainly on surficial sediments, landform recognition, and evidence of bedrock erosion (e.g. striae) to provide a paleoglaciological context for IM interpretation.

Increasing recognition of the importance of regional erosional events in glacial landscape genesis raises the possibility that, in some settings, sediment transport processes and directions may differ from erosional processes responsible for landform development. Mapped dispersal plumes record sediment transport vectors and they may be examined independently of landforms (and landforming

processes) used to reconstruct ice flow directions. Therefore, the proposed approach aims to differentiate sediment production and transport processes from land forming processes. This may better focus attention on the subglacial processes responsible for dispersal plume development.

With a few exceptions, little work has been directed toward understanding the geometry of indicator plumes across a geological region, or for specific ice-sheet flow lines. A multi-stepped approach will be used to examine dispersal plume characteristics.

First, dispersal plumes will be mapped at a region – system scale relying on a wealth of legacy IM data (government, industry). Associations of dispersal trains with known IM sources will provide a first-order interpretive framework for dispersal plume patterns and transport distances in a region.

Second, landscape elements such as streamlined landforms, glaciofluvial landforms, and the type and distribution of sediments will be used to refine the local geomorphic and sedimentologic context of dispersal plumes. These data will further constrain plume mapping and allow assessment of complex flow paths, mechanisms and possible palimpsest relationships.

Third, recent advances on understanding of subglacial sediment production, entrainment, and deposition processes will be integrated within the evolving interpretive framework to refine interpretation of dispersal plumes.

Lastly, numerical modeling will attempt to quantify the key variables controlling dispersal plume development in various geologic terrains.

CONTROLS ON PERMAFROST DISTRIBUTION WITHIN THE NEAR-SHORE ZONE OF THE MACKENZIE DELTA

STEVENS, C.W.[1] AND MOORMAN*, B.J.[2]
(1) SRK CONSULTING (US) INC., ANCHORAGE, AK
(2) DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF CALGARY, CALGARY, AB
MOORMAN@UCALGARY.CA

Permafrost presents a significant challenge to proposed oil and gas development in the Mackenzie Delta, due to its influence on the stability of linear infrastructure and foundation conditions. Environmentally safe and economically sustainable development in this region requires an understanding of the spatial variability of ground temperatures and the response of permafrost to natural and human-induced changes of the environment. Recent research conducted by the University of Calgary and the Geological Survey of Canada has investigated permafrost beneath shallow-water environments seaward of the modern delta front.

The findings of this study indicate that ground temperatures are mainly controlled by the presence of liquid water or ice at the sediment bed. Where ice freezes to the sediment bed surface (i.e. becomes bottom-fast), conductive transfer between cold air temperatures and relatively warmer underlying sediments leads to heat loss throughout the winter. Interannual variability in ground temperatures results from changes in on-ice snow thickness, which modifies the duration of bottom-fast ice and subsequent heat loss from the ground. Thermal modeling indicates that the critical ice contact time for sustaining permafrost beneath near-shore zones of bottom-fast ice is 142 days. The integration of this finding with a time-series of synthetic aperture radar images, which defines the timing of BFI across the near-shore zone, was used to produce the first map of shallow-water permafrost for the outer Mackenzie Delta. Permafrost was mapped beneath 393.8 km^2 of BFI. These locations typically represent areas where sediment supply exceeds present-day sea level rise. As hydrocarbon exploration and development proceeds in the Mackenzie Delta, the recent advancements in monitoring

permafrost beneath shallow water and ice will become critical to the planning and the regulation of development in this dynamic and climatically sensitive environment.

REMOTE PREDICTIVE SURFICIAL MATERIALS AND SURFICIAL GEOLOGY MAPPING USING LANDSAT 7, HEARNE LAKE, NTS 85I, NWT

STEVENS, C.W.[1], KERR*, D.E.[2], EAGLES, S.[2] AND WOLFE, S.A.[2]
(1) FORMERLY WITH GEOLOGICAL SURVEY OF CANADA, CURRENTLY WITH SRK CONSULTING (US) INC., ANCHORAGE, ALASKA, USA
(2) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
DKERR@NRCAN.GC.CA

Despite the relatively detailed knowledge of bedrock geology in the high mineral potential southern Slave region, knowledge of surficial sediments, permafrost, land cover, and geotechnical conditions is still rudimentary. This lack of basic geoscience information hinders the understanding of present and future terrain risks to roads and other infrastructure, which are vital to northern economic development.

The preliminary remote predictive surficial materials map for the Hearne Lake NTS Map Sheet 85I is derived using Landsat 7 imagery (normalized bands 2,3,4,5 and 7). The spectral signatures associated with bedrock, silty clay, diamicton, sand 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 spectral differences exist for each surficial unit and a reasonable model can be built to map this region.

The preliminary map indicates silty clay infilling bedrock depressions and topographic lows between 157 m (current elevation of Great Slave Lake) and about 205 m asl. At elevations above 205 m, clay is less extensive, and isolated occurrences of diamicton in the form of reworked till veneer exist, as well as till blanket further inland. The high spatial density of silty clay generally below 205 m contributes to the reconstruction of glacial Lake McConnell (estimated maximum elevation of 280-300 m) and identifies the distribution of thaw-sensitive clay terrain. Both exposed and vegetated sand and gravel deposits, representing glaciofluvial sediments, and potentially useful as granular resources, were also identified across previously unmapped terrain.

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. From these predictive maps, together with field data, surficial geology maps can be derived as an aid to mineral exploration. The methodology used here builds on the success of the predictive surficial geology map for the Yellowknife area, NTS 85J (Geological Survey of Canada Open File 7108). Additional selected adjacent NTS sheets (85P, 85O, 85N) will integrate SPOT5 satellite imagery and topographic characteristics calculated from CDED data to improve mapping capabilities and accuracy.

PALYNOLOGICAL ANALYSIS OF DANNY'S LAKE, CENTRAL NORTHWEST TERRITORIES

SULPHUR*, K.C.[1], GALLOWAY, J.M.[2], HILLS, L.V.[1], CRANN, C.[3], MACUMBER, A.[3], PATTERSON, R.T.[3] AND FALCK, H.[4]
(1) DEPARTMENT OF GEOSCIENCE, UNIVERSITY OF CALGARY, CALGARY, AB
(2) GEOLOGICAL SURVEY OF CANADA, CALGARY, AB
(3) DEPARTMENT OF EARTH SCIENCES, CARLETON UNIVERSITY, OTTAWA, ON
(4) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT

The Tibbitt to Contwoyto Winter Road (TCWR) is the critical link in the supply chain to northern diamond mines, including the Diavik Diamond Mine (Rio Tinto Group) and Ekati Diamond Mine (NHP Billiton Inc.). Use of the TCWR is limited to only a few months of the year because the road is built over frozen lakes; cold winter temperatures are required to maintain sufficient ice thickness. Northwest Canada has experienced some of the most rapid warming (on the order of 1.5 to 2° C per decade) in the Northern Hemisphere during the last few decades and climate models predict continued temperature increases for at least the next

century. Recent climate fluctuations have resulted in a reduction of ice cover duration and thickness along the route of the TCWR, which has substantial economic impact for northern industries. Understanding cyclic climate phenomena in the Northwest Territories will enhance our ability to predict future climate and the impact on the TCWR. However, instrumental climate records extend only to the 1940's in the Northwest Territories. To place recent climate change in a geologic perspective, proxy records must be used. Palynology, the study of pollen and spores, is one of the best means for reconstructing past climate.

Danny's Lake (64° 15' 26'' N, 110° 06' 03'' W) is the first lake to the north of the 49th land portage along the TCWR and is approximately 17 km south of Lac de Gras and the Diavik Diamond Mine. It is located near the important ecotone boundary of the transition from boreal forest to tundra and is thus situated in a sensitive recording area where past climate change can be determined. A 111-cm sediment core was taken from Danny's Lake in March, 2010. These lake sediments contain well-preserved pollen and spores and microscopic charcoal. Pollen and spores will be used to reconstruct how vegetation communities in the central Northwest Territories have changed over the past ~3500 years. These changes in plant communities have ecological implications that can be related to climate variations. In this way, a palynological study can be used as a proxy of climate, and thus document past climate cycles. These past climate cycles can then be used to predict future climate cycles, and therefore aid in predicting the future viability. Microscopic charcoal will also be analyzed in sediment core samples from Danny's Lake to investigate fire regimes in the study region, how fire regimes have been affected by climate change, and how vegetation communities have responded to fire disturbance. Understanding disturbance regimes, and community response to fire disturbance, is important because occurrences of fires are affected by weather variations, and long-term trends in climate. Lightning strikes are major sources of tundra fires. The variations in weather and length of the storm season are affected by long-term climatic changes. This palynological study will help reconstruct the climate history of the area, and aid in predicting future climate cycles that will affect the TCWR, and thus the natural resource development in the north.

SURFICIAL GEOLOGY COMPONENT OF THE 2012 HALL PENINSULA GEOSCIENCE PROJECT

TREMBLAY*, T.[1], ALLARD, M.[2], BUDKEWITSCH, P.[3], GOSSE, J.[4], LEBLANC, A.M.[5], PEYTON, P.[6], LEBLANC-DUMAS, J.[2] AND MATE, D.[1]

(1) CANADA-NUNAVUT GEOSCIENCE OFFICE, IQALUIT, NU
(2) DÉPARTMENT DE GÉOGRAPHIE, UNIVERSITÉ LAVAL, QUÉBEC, QC
(3) ABORIGINAL AFFAIRS AND NORTHERN DEVELOPMENT, IQALUIT, NU
(4) DEPARTMENT OF EARTH SCIENCES, DALHOUSIE UNIVERSITY, HALIFAX, NS
(5) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(6) ENVIRONMENTAL TECHNOLOGY PROGRAM, NUNAVUT ARCTIC COLLEGE, IQALUIT, NU
TREMBLAY.TOMMY@NRCAN.GC.CA

The surficial geology component of the Canada-Nunavut Geoscience Office Hall Peninsula Geoscience project (2011-2014) completed during field season 2012 will be presented, both in summary of the future work and as a preliminary overview of the Quaternary geology of the area. The 1:100 000 surficial geology mapping, glacio-dynamical setting and ice flow history of the area will be emphasized in this project. Permafrost studies will be undertaken to better understand the nature of frozen ground in various settings, around Iqaluit airport and on the Hall Peninsula plateau. Satellites images interpretation as an aid to surficial geology mapping will enhance the mapping methodology using Landsat, Spot, Worldview and Radarsat images and data. Uplift studies will help understand the chronology of relief formation and erosion. Traditional place-names geological study will aim at describing how the geological landscape is linked with traditional activities and landmarks.

A FORMAL STRATIGRAPHY FOR THE MACKENZIE MOUNTAINS SUPERGROUP IN NWT

TURNER*, E.C. AND LONG, D.G.F.
DEPARTMENT OF EARTH SCIENCES, LAURENTIAN UNIVERSITY, SUDBURY, ON
ETURNER@LAURENTIAN.CA

When the Mackenzie Mountains Supergroup was first envisioned in the 1970s, its stratigraphy and nomenclature were not formalised. Once the GSC regional mapping program in the Mackenzie Mountains (NWT) was complete, little impetus or opportunity remained for the detailed work of choosing and documenting type sections and establishing formation names. In many cases so little was known of the constituent units that no informed decisions could be made on divisions or lateral correlations. Results of the early work in the central Mackenzie Mountains have since been augmented by stratigraphic studies undertaken during NTGO's Sekwi Mountain project, and by focused thematic studies. This work now permits the informed selection of type sections and the establishment of formal stratigraphic units. The supergroup, as now formally established for the Mackenzie Mountains (NWT) in two GSC Open Files (in press), includes, in stratigraphic order: carbonate rocks of the Tabasco Formation (new; lowermost exposed unit in NWT); mudstones, sandstones and minor carbonate rocks of the Tsezotene Formation (previously formalised); sandstones, mudstones and carbonate rocks of the Katherine Group (previously named, with no type section); and carbonate rocks, evaporite rocks and mudstones of the Little Dal Group (previously named, with no type section). Descriptions and type sections are provided for the Katherine and Little Dal groups, along with fifteen new formations. These are the Tabasco Formation (formerly "H1 unit"), seven formations in the Katherine Group (Eduni, Tawu, Grafe River, Etagochile, Shattered Range, McClure, and Abraham Plains formations; formerly numbered, informal, formation-scale units) and seven formations in the Little Dal Group (Dodo Creek, Stone Knife, Silverberry, Gayna, Ten Stone, Snail Spring, and Ram Head formations; correspond approximately to former informally named formations). The establishment of a formal stratigraphic nomenclature and type sections for the Mackenzie Mountains Supergroup will facilitate mapping, regional and global correlation, and communication about these rocks.

PUBLICATION ACTIVITIES OF THE NORTHWEST TERRITORIES GEOSCIENCE OFFICE, 2012

WATSON, D.M.
NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT

Every year since its inception, the Northwest Territories Geoscience Office (NTGO) has published geoscience results authored by its staff, supported students, collaborating scientists of other institutions, and contractors. This year (2012) saw the continuation of that tradition. In addition to Open Files and Open Reports this year saw the introduction of a new format – the Special Volume, a format compiling multi-year work into one comprehensive report. The inaugural volume was Geology of the Central Mackenzie Mountains of the Northern Canadian Cordillera.

In addition to the Special Volume, this year to date has seen the publication of eleven Open Files as well as eight Open Reports. Geoscience Office scientists also published more than six contributions in journal publications such as the Canadian Journal of Earth Science and the American Mineralogist.

Subjects covered by publications released this year range from regional geophysics (South Rae, Source Peaks etc.) to petroleum potential (Horn River Group) and isotope geochemistry (Pb-U, and Sm-Nd), geological mapping (South Wopmay), and studies in support of the Protected Areas Strategy (Shúhtagot'ine néné).

Most of the Northwest Territories is represented in this year's publications. Concentrations of work are apparent both in the mountains to the west and the area north and east of Yellowknife.

Both of these areas correspond to areas of high interest from the private sector.

Geoscience Office publications are available as downloads from NTGO's web site (http://www.nwtgeoscience.ca/) through one of the applications (NT GoMap, NT GoData or Gateway). Copies on paper or CD may also be available on request.

PETROLOGY AND GEOCHEMISTRY OF THE PORTER PUDDLE COMPLEX,NORTHERN CANADIAN CORDILLERAN MIOGEOCLINE

WILLIAMS*, B.[1], PE-PIPER, G.[1] AND FISCHER, B.J.[2]
(1) SAINT MARY'S UNIVERSITY, HALIFAX, NS
(2) NWT GEOSCIENCE OFFICE, YELLOWKNIFE, NT

The Porter Puddle Complex is located in the southeastern Bonnet Plume map sheet (NTS 106B/SE) in the northern Canadian Cordillera (Northwest Territories). The region, according to published reconnaissance-scale maps, is underlain by the Lower Paleozoic Road River Group basinal strata, undivided Silurian to Devonian platformal carbonate rocks, and the Middle Devonian Earn Group turbiditic siltstone and sandstone. The Lower Paleozoic strata were deposited in the Misty Creek paleo-embayment, an embayment of the Selwyn Basin thought to have formed by incipient rifting. Ordovician-Silurian volcanic rocks of the Marmot Formation have been identified and their approximate extent mapped in several areas in southern NTS 106B.

The Porter Puddle complex was identified during a multi-year stratigraphic study of the Misty Creek embayment, carried out by the Geological Survey of Canada, which subdivided the Lower Paleozoic strata into a number of formation-level units and formally defined the Marmot Formation. The complex was interpreted as a submarine volcanic edifice that records shoaling and eventual subaerial erosion. It consists of potassic-ultrapotassic and alkalic volcanic rocks. Previous studies of the geochemistry of these rocks are limited, and were summarized by grouping the rocks according to geographic and not stratigraphic location. The recommended initial igneous petrographic studies were also omitted in favor of whole rock geochemistry.

New mapping, carried out as part of the NTGO's Bonnet Plume project during the 2009-2012 field seasons, has applied the newer stratigraphy to mapped areas, and better delineated the various horizons of the Porter Puddle complex. The purpose of this study is to expand the understanding of the Porter Puddle Complex, through detailed petrological, petrographic, and geochemical analyses, and to use these results to elucidate the primary composition, magma source, depositional conditions, and perhaps alteration of the rocks that form the complex, within the framework of the new, more detailed mapping.

Seventeen samples of mafic flows from various parts of the complex were collected, slabbed and prepared for polished-thin section and whole rock geochemical analysis. Initial examination of porphyritic, massive, amygdaloidal, and pillowed mafic rocks reveals subhedral-anhedral phenocrysts of pyroxene and biotite/phlogopite, set in an altered chloritic matrix. Local carbonate alteration of the groundmass may originate from late-stage quartz/calcite veining associated with orogeny, or from seawater-sourced fluids close to deposition. Analyses are expected by December and an initial petrological-geochemical analysis will be carried out early in the new year.

A VIRTUAL GEOLOGICAL FIELD TRIP ACROSS VICTORIA ISLAND, NORTHWEST TERRITORIES

WILLIAMSON, M.-C.[1], RAINBIRD*, R.[1], FROOME, J.[2] AND BROWN, O.[3]
(1) GEOLOGICAL SURVEY OF CANADA, OTTAWA, ON
(2) DEPARTMENT OF GEOLOGICAL SCIENCES, QUEEN'S UNIVERSITY, KINGSTON, ON
(3) OOLEEPEEKA CONSULTING LTD., VANCOUVER, BC
MWILLIAM@NRCAN.GC.CA

The Geo-mapping for Energy and Minerals (GEM) and Polar Continental Shelf Programs of

Natural Resources Canada provided support for geological field work on Victoria Island in 2010 and 2011. The operations were extensive and involved over 30 geologists and the community of Ulukhaktok each summer. In keeping with the GEM objective of *acquiring new information on northern resource potential,* the surveys targeted the production of geological maps required for base and precious metal exploration.

We present the results of a geoscience outreach project that was initiated in June 2012 to communicate the results of field work to the community of Ulukhaktok. The approach involved the production of a Google Earth software interface that enables users to navigate to key locations on Victoria Island. At each location, the physiography and geology are illustrated with a series of captioned photographs. A pilot outreach study was completed in 2011 for a GEM-Minerals project of comparable scope - the Cumberland Peninsula (Baffin Island) Integrated Geoscience Project. The results were impressive, and paved the way for other GEM projects to follow. The objectives of the GEM-Victoria Island outreach project are to: (1) introduce some aspects of the geoscience that could assist the community of Ulukhaktok on questions related to mineral exploration and resource development; (2) promote the GEM-Victoria Island project goals and showcase discoveries; (3) communicate the details on access, aircraft and logistics support, field safety protocols, mapping tools, technology, etc, that are required to conduct geological field work in Canada's North; (4) increase public awareness about career opportunities in the Earth Sciences; and (5) promote networking amongst GEM-Minerals stakeholders in northern communities, industry, territorial governments, universities, and colleges. First and foremost, the deliverable is a tangible way to thank the residents of Ulukhaktok for their support of the field campaigns since 2010.

The GEM-Victoria Island *Virtual Geological Field Trip* consists of 18 stops along a route that zigzags through the entire area targeted for geological mapping. The trip starts in Ulukhaktok and ends at the Prince Albert impact structure, discovered near Richard Collinson Inlet on NW Victoria Island. Along the way, users will become familiar with the daily routine at GSC base camps *Minto North* (2010) and *Minto South* (2011); fly through canyons, and along spectacular cliffs and waterfalls; navigate the Kuujjua River and the shores of Wynniatt Bay; explore ancient sandstone caves, lava flows, and a mysterious circular structure of unknown origin; and learn along the way about the geology and potential economic resources of the region. This interactive guide to the beautiful landscapes of Victoria Island also illustrates the challenges and rewards of geological field work in the Canadian Arctic. It is a legacy product for all our friends in Ulukhaktok, the GEM-Victoria Island project leaders, participants, and supporters, our many stakeholders, and all Canadians, to enjoy.