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Critical Minerals Geoscience and Data: list of proposed sub-activities for 2023–2024

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Critical Minerals Geoscience and Data

The Geological Survey of Canada's (GSC) Critical Minerals Geoscience and Data (CMGD) initiative is one part of the Government of Canada's strategy to strengthen the supply chains of critical minerals that are needed for a green and digital economy. The initiative will focus on 14 critical minerals on Canada's critical minerals list (cobalt, copper, germanium, graphite, indium, lithium, nickel, niobium, rare earth elements, scandium, tellurium, tungsten, vanadium and zinc) that are essential to sustainable economic development, but may, in some cases, be subject to a limited domestic supply and/or at risk of supply chain disruptions on a global scale.. These minerals are vital to a range of industries including technology, energy, defence, and infrastructure, and are essential to produce a wide range of products, including batteries, electronics, and infrastructure materials. Results from the initiative will provide baseline information for decisions related to resource development and investment, while supporting the growth of Canadian industries reliant on these critical mineral resources.

CMGD Program Objectives

Overarching Program Objective:

- To provide world class geoscience for the public good to reduce risk for public and private sector investment decisions and increase Canada's competitiveness in developing its critical mineral resources.

Detailed Program Objectives:

- Enhanced data assets and modelling of Canada's critical mineral resources to delineate economic and ESG pathways and value chains.
- Improved economic benefit to northern and isolated communities through access to accurate, up-to -date data for decision making on critical mineral exploration and mining infrastructure projects.
- Comprehensive geo-environmental characterization of critical mineral resources guided by ESG principles.
- Increased awareness of critical mineral opportunities for mineral processors.
- Improved understanding of the value of critical minerals in mine waste as a potential source of critical minerals.

Expected Program Outcomes:

- Develop and improve critical mineral expertise within Canada to decrease reliance of supply on other nations.
- Accelerated access to national and international markets for key Canadian critical minerals.
- Improved access to markets with model supply scenarios that will link critical mineral resource and mining data with market analysis to optimize responsiveness to market changes.

- Reduced risk for public and private sector investment decisions and increased Canadian competitiveness in developing its critical mineral resources through the provision of world-class geoscience to the public.

CMGD Project and Activity Descriptions (2023 – 2028)

SOLUTION 1: CRITICAL MINERAL KNOWLEDGE BASE

Description: A comprehensive sampling and analysis program to characterize critical mineral contents and associations within Canada's mineral deposits and derivative products (ores, concentrates, minerals, tailings, and wastes). This key information is necessary to estimate critical mineral resources, inform potential value and supply options, provide geoscience data for tracing critical minerals through supply chains, and conduct robust economic modelling. All data generated will be freely available to the public.

Activities

Critical Mineral Resources (Activity lead: Michael Parsons, GSC-Atlantic)
Description: A comprehensive sampling and analysis program to determine critical mineral contents and associations within Canada's mineral deposits and derivative products (ores, concentrates, minerals, tailings, and wastes).

Critical Mineral Analytical Methods (Activity lead: Duane Petts, GSC-Ottawa)
Description: Development of cutting-edge analytical tools and/or methodologies to accurately quantify critical mineral contents and associations within Canada's mineral deposits and derivative products (ores, concentrates, minerals, tailings, and wastes).

SOLUTION 2: CRITICAL MINERAL SYSTEM STUDIES

Description: Thematic geoscience research focused on conventional as well as new, emerging, or unconventional sources of the 14 priority critical minerals (Annex 2). This information will be used to inform mineral potential modelling and will be considered together with environmental assessment and ESG information (see Solution 3). This research is necessary to have a complete understanding of the critical mineral potential across Canada, with the goal of maximizing value from new and existing critical mineral resource streams, both of which are necessary to meet the forecasted demand. The proposed research will focus on new sources that have the greatest potential to rapidly go into production with low environmental impact. This will position Canada as a global leader in critical mineral deposit discovery, development, and production.

Activities

Conventional Sources (Activity lead: Anne-Aurélie Sappin, GSC-Quebec)
Description: Thematic geoscience research focused on conventional sources of the 14 CMDG priority critical minerals (Annex 2).

Unconventional Sources (Activity leaders: Wouter Bleeker and Jan Peter, GSC-Ottawa)
Description: Thematic geoscience research focused on new, emerging, or unconventional sources of the 14 CMDG priority critical minerals (Annex 2). Examples of new and emerging critical mineral systems include (but are not limited to): brines, clays/muds, seawater, waste rocks, evaporites, phosphates, gas fields (hydrogen, helium), coal ash, coal clays, etc.

SOLUTION 3: ADVANCED PREDICTIVE GEOSCIENCE

Description: Advanced analytics to support robust "green" critical mineral exploration, production, and marketing decision-making. The goal is to deliver assessments of geological potential, together with projected economic feasibility factors and ESG considerations early in the exploration cycle to reduce risk in mineral exploration and accelerate project development. Mineral intelligence will be based on geology, geochemistry, and geophysics data, together with production information, capital and operating costs, and infrastructure access (roads, rail, power, shipping). Presently, the data needed for sound decision-making are fragmented and hosted across multiple government departments and agencies, as well as other data providers, and in myriad of formats. Where needed, datasets will be populated, or newly created. For example, datasets and new knowledge arising from Solutions 1 and 2 provide vital information on possible co- and by-product critical minerals that could positively impact the feasibility of a particular deposit and accelerate production. These datasets will be trusted, discoverable, and interoperable, and made publicly available for query and analysis.

Activities

AI and Deep Learning (Activity lead: Mohammad Parsasadr, GSC-Ottawa)
Description: Development of artificial intelligence tools and methodologies to consider geological prospectivity, economic feasibility/return on investment (e.g., considering commodity pricing, operating costs, among others, at varying deposit sizes and grades, royalties) and Environmental, Social, and Governance issues (e.g., species at risk, freshwater resources, carbon storage, and climate risks) to focus exploration efforts, reduce risk, and support sustainable development.

Environmental, Social and Governance (ESG) (Activity lead: Christopher Lawley, GSC-Ottawa)
Description: Development of tools and methodologies for considering environmental, social and governance (ESG) criteria in a critical mineral context. Research proposals that integrate mineral system knowledge to improve ESG performance are particularly encouraged. New validation methods are also needed to measure ESG performance across multiple international standards.

SOLUTION 4: MARKET ASSESSMENTS

Description: Consumer and supplier mineral criticality assessments for Canada. These critical commodity assessments will compile production, export, import, consumption, and dependency on external sources for critical minerals. The assessments will be robust, updatable, and conducted from the perspective of Canadian consumers and suppliers. They will enhance Canada's ability to maximize future potential in the global critical mineral economy. The criticality assessments will build on results from Solutions 1-3 and incorporate market intelligence and commodity forecasts.

Activities

Commodity Assessments (led by Policy & Economics, and Hazards, Adaptation and Operations branches)
Description: Not applicable

International Collaborations (Activity Lead: Michael Gadd, GSC-Calgary)
Description: Collaborations under the Critical Mineral Mapping Initiative (CMMI), including development of new geoscience collaborations related to the 14 priority critical minerals with national geological surveys.

CMGD Logic Model

Short-Term Outcomes:

- A program focused on geoscience of critical minerals from conventional (base and precious metal deposits hosted within bedrock that have historically had an important role in the economic development of Canada) and unconventional sources (e.g., waste rock, tailings, oil field brines) in Canada with a focus on public data delivery and applications of artificial intelligence and deep learning.

Medium-Term Outcomes:

- Enhanced data assets and modelling of Canada's critical mineral resources to delineate economic and ESG pathways and value chains.
- Improved economic benefit to northern and isolated communities through access to accurate, up-to-date data for decision making on critical mineral exploration and mining infrastructure projects.
- Comprehensive geo-environmental and ESG characterization of critical mineral resources
- Increased awareness of critical mineral opportunities for mineral processors.
- Improved understanding of the value of critical minerals in mine waste as a potential source of critical minerals.

Long Term Outcomes:

- Robust critical minerals expertise within Canada to decrease reliance of supply from other nations.
- Accelerated access to national and international markets for key Canadian critical minerals.
- Improved access to markets with model supply scenarios that will link critical mineral resource and mining data with market analysis to optimize responsiveness to market changes.
- This goal will be accomplished by providing world-class geoscience for the public good to reduce risk for public and private sector investment decisions and increase Canada's competitiveness in developing its critical mineral resources.

Outputs:

- Geoscience knowledge products including expert advice, syntheses, data, information, peer-reviewed papers, national mineral potential maps, predictive models, databases, atlases, and tools will be developed and made publicly available.
- Train and mentor the next generation of highly qualified geoscience professionals.

Proposed CMGD Sub-Activities (2023 – 2024)

Solution 1: Critical Mineral Knowledge Base

Activity 1.1: Critical Mineral Resources

Sub-Activity Title	Principle Investigator	Sub-Activity Descriptions
Critical Mineral Resources in Tailings from the Former Saint Lawrence Columbium Mine, Oka, Québec	Desbarats, Alexandre	This sub-activity will deliver an Open File report and datasets characterizing the mineralogy, geochemistry and granulometry of critical mineral resources in tailings at the former Saint Lawrence Columbium (SLC) mine in Oka, Québec. The critical minerals of interest are Nb, hosted in unrecovered pyrochlore, and REE and P, hosted in apatite. The study will also provide resource estimates (non-NI 43-101 compliant) and a characterization of deleterious minerals (sulfides, clays) that could affect recovery of critical minerals during tailings reprocessing.
Sample Management System API	Quat, Marianne	The Sample Management System needs to modernize in order to properly share data with other applications and investigations in CMGD. The first and critical step is to create API between the web application and Oracle database. This API will allow many other systems to use the data and allow the SMS to increase functionality and eventual migration out of Oracle and an on-premise aging server to a cloud solution. Other enhancements (dictionaries and interface) may also be made to incorporate the workflow of CMGD field studies, AI and deep learning activities.
Apatite, the forgotten critical mineral: a potential P and REE tailings bonanza	Kjarsgaard, Bruce	The sub-activity will mainly focus on characterizing the REE and P content of apatite; a subordinate focus will be on the Nb content of pyrochlore (and potentially also of fersmite, Nb-perovksite) in tailings at the former Saint Lawrence Columbium (SLC) mine in Oka, Québec. As a proof of concept, it is proposed to collect a 200 kg tailings sample of tailings, to be sent to the Saskatchewan Research Council (SRC) for the separation and recovery of apatite (and pyrochlore). The recovered apatite will undergo hydrometallurgy at SRC to produce a high purity (< 1ppm Th, U) mixed REE carbonate. This high purity REE carbonate can then be used in downstream processing to produce individual rare earth element separates.

Activity 1.2: Critical Mineral Analytical Methods

Sub-Activity Title	Principle Investigator	Sub-Activity Descriptions
N/A	N/A	N/A

Solution 2: Critical Mineral System Studies

Activity 2.1: Conventional Sources

Sub-Activity Title	Principle Investigator	Sub-Activity Descriptions
Controls on the distribution and morphology of rare metal pegmatites	Cawood, Tarryn	Rare metal pegmatites host three of the 14 priority critical minerals (lithium, niobium, and REEs), as well as other critical minerals (cesium, tantalum, bismuth, fluorspar, tin, titanium, and uranium). However, exploration for rare metal pegmatites is hampered by the lack of a robust mineral system model, which is necessary for predicting their distribution

		at a regional scale, and assessing whether an area may host a rare metal pegmatite or pegmatite group with a size and geometry (morphology) that would allow them to be mined economically. This project will therefore investigate the regional-scale geologic controls on rare metal pegmatite distribution, and the regional- to deposit-scale controls on rare metal pegmatite size and geometry, by 1) creating and interrogating an updated inventory of rare metal pegmatites in Canada; 2) conducting detailed case studies of key pegmatite groups; and 3) leveraging the current global surge in research into Li-bearing pegmatites by integrating published studies from across the globe.
Carbonatite-hosted Critical Minerals	Kjarsgaard, Bruce	Carbonatites host key critical mineral mines and deposits (REE, Nb, P, plus others); at present, exploration models consist of 'find a carbonatite', and/or, 'this is how to find a carbonatite'. Multiple, distinct carbonatite-hosted critical mineral ore deposit models are required for (1) REE, (2) Nb, (3) P and this project will address these issues by undertaking modern geochronology plus tracer and stable isotopic research on well characterized Canadian carbonatite mines and deposits, complimented by experimental studies of REE, Nb, P solubility and critical mineral (e.g. bastnaesite, pyrochlore, apatite) stability in melts and fluids. The outcome will be robust ore deposit models for critical minerals in carbonatites, to enhance exploration success.
Rare-earth and high field-strength element potential and controls in magnetite-apatite deposits	Kjarsgaard, Bruce	This project will explore the concentrations of several critical minerals to Canada, including rare earth elements (REE) plus phosphorus (P) in apatite from magnetite-apatite ores from the Great Bear Magmatic Zone (Northwest Territories), as well as allied niobium (Nb) and uranium (U) mineralization. The key geologic controls on how these elements can be concentrated in these rocks will be determined. Preliminary studies of other similar magnetite-apatite ores have shown that these rocks have untapped potential for hosting these critical minerals, and this research will provide a foundation for understanding the key processes and factors that generate anomalous concentrations of these elements that are key to new green energy and infrastructure technologies.
Reappraisal of sediment-hosted stratabound copper mineralization in New Brunswick and Nova Scotia after 30 years of scientific dormancy	Pinet, Nicolas	Over the past 30 years, very few studies have investigated the numerous sediment-hosted stratabound copper (SSC) occurrences of New Brunswick and Nova Scotia. This project will update our knowledge of this type of mineralization by addressing knowledge gaps in the context of recent geological models of basin evolution and new approaches/methods.

Activity 2.2: Unconventional Sources

Sub-Activity Title	Principle Investigator	Sub-Activity Descriptions
Unconventional mechanisms for Zn-V enrichment after organic matter degradation	Cesar Colmenares, Jaime	This sub-activity will study the mechanisms behind Zn-V enrichment after biodegradation of organic molecules in the subsurface. The mechanism is completely new and might be unique to the Western Canadian Sedimentary Basin. The project takes advantage of petroleum systems knowledge and transfers it to critical mineral prospecting.
Resources and Sources of Lithium in Oilfield Brines from Western Canada	Jiang, Chunqing	The proposed sub-activity is to assess the resources and origins or genesis of lithium in oilfield brines associated with past and current oil and gas production in Western Canada. Resource assessment will be carried out by (1) mapping the geographical and stratigraphical distributions of the currently produced oilfield brines using data from various regulatory agencies; (2) establishing models for predicting potential brine resources via integration of geophysical well logs along with the abundant water chemistry data obtained previously on formation water samples collected from drill stem tests (DST) and oil/gas productions; (3) acquiring new

		oilfield brine samples from operators and measuring their chemical properties including lithium content to expand the lithium brine geochemistry database; (4) identifying proxies for lithium contents based on available water chemistry data, and finally (5) mapping the distribution of lithium brine resources. Investigation of the source(s) of lithium in the brines will be conducted by (1) interpreting water and rock geochemistry in geological frameworks to elucidate the sources of lithium and other critical minerals; and (2) integrating laboratory leaching/digestion experiments on lithium-rich rocks with geochemical modeling to understand water-rock interactions and aqueous fluid and mineral transport and accumulation in the subsurface.
Critical Mineral Distribution and Resource Potential in Historical Mine Wastes from the Maritime Provinces	Parsons, Michael	This project will examine the critical minerals present in historical tailings from base metal mines in the Maritime Provinces, focusing on both primary commodities (e.g. copper, nickel, zinc) and by-product elements (e.g. germanium, indium, tellurium). The main goal is to characterize the effects of long-term weathering on the spatial distribution and mineral hosts of these elements in the mine wastes and to study the most effective methods of reprocessing for critical mineral recovery. This knowledge is essential for assessing the potential value of critical minerals in mine wastes and the environmental impacts of future reprocessing activities.
Distribution, precipitation, and endowment of critical minerals in the Grenville Province and their link with alkaline ultrapotassic-potassic magmatic systems	Soltanmohammadi, Azam	This project aims at evaluating the distribution of critical minerals, like Li and REEs, in the potassic and ultrapotassic magmatic systems of the Grenville Province as new unexplored potential critical minerals reservoir in the country. The team will define the spatial and temporal distribution of critical minerals in the intrusions and the related host rocks and how they form in relation to the architecture and the chemical composition of the lithosphere and the crust. Through an extensive multi-disciplinary approach, the team will assess the critical physical and chemical parameters controlling Li and REEs enrichment of primary magmas, from their mantle source to their emplacement site. It will also address how these critical minerals can be further enriched during differentiation and hydrothermal mobilization when potassic-rich fluid/melt systems interact and redistribute in the host metasedimentary and metaigneous rocks.
Characterization of critical metal content and mineralogy in Canadian tailings deposits.	Smith, Jennifer	Historic tailings across Canada represent a possible significant source of unrecovered metals. At present however, the metal content and future potential of mine waste is not well constrained. This project will begin to evaluate the critical mineral potential of the Hemlo gold mine tailings in Ontario, which with its complex mineralogy is host to a diverse range of priority metals, including V, W, Te, Mo and Sb. The main goal is to characterize the critical metals present and evaluate what metals are of potentially economic significance. This project will also constrain how these metals reside (i.e. host mineralogy) and are spatially distributed within the tailings.
Feasibility study of critical metal enrichment utilizing metal fractionation on different sizes of particulates in waters	Zheng, James	Utilizing fractionation of critical metals on different sizes of colloids dispersed into waters from mining activities and tailings, those metals in mining effluent can potentially be recovered from the water and therefore reduced in the treated water using tangential flow filtration methodology. Testing of this technique at selected mine sites aims to evaluate the recovery of dispersed critical metals in treated and untreated water from mining and processing activities. The final goal of this study aims to produce critical metals from the waters from mining and processing activities.

Solution 3: Advanced Predictive Geoscience

Activity 3.1: AI and Deep Learning

Sub-Activity Title	Principle Investigator	Sub-Activity Descriptions
Canada Geological Map Compilation	Lawley, Chris	Accurate, reliable, and high-resolution geological maps are essential for assessing Canada's potential to discover new critical mineral deposits. However, the most recent digital compilation of Canada's bedrock geology was completed in 1996 and is missing all of the advances in geoscientific knowledge, techniques, and data that have been acquired over the last ~30 years. The Canada Geological Map Compilation (CGMC) will leverage natural language processing with the best available bedrock geological maps to provide complete coverage of Canada's land and offshore areas to address that knowledge gap.
Data In, Uncertainty Out – De-risking Exploration Through Uncertainty Analysis	Zhang, Steven	Reliable and data-driven prospectivity maps are one of the priorities of the National Geological Surveys Committee (NGSC) and a key desirable outcome to enable timely and efficacious exploration of Canada's Critical Minerals. However, uncertainty associated with geological prospectivity is largely unknown and the lack of uncertainties represents a technical barrier to the adoption of any prospectivity map for either land-use decisions or further exploration. We propose a series of investigations into effective methods that could determine uncertainty associated with prospectivity with a focus on Canada's priority critical mineral commodities.
Multiscale prospectivity modeling of Canada's priority critical minerals	Parsasadr, Mohammad	Multiscale geological prospectivity models are one of the priorities of the National Geological Surveys Committee (NGSC). These also contribute to the Geological Survey of Canada's geoscience priorities, namely land-use management and risk reduction. Geological prospectivity models coupled with their quantified uncertainties are central to decision-making for critical mineral exploration campaigns, helping de-risk the exploration surveys. Herein, a multistage adaptive exploration targeting system is proposed and applied to multiscale geological prospectivity and uncertainty modeling of a suite of Canada's priority critical minerals.
Modernizing our collections and data: the Surficial Section air photo inventory	Paulen, Roger and McMartin, Isabelle	Currently, in several rooms throughout the GSC (e.g., G70, 283, personal offices) lie annotated air photos that have been used by GSC research programs from the 1960s until present day. The goal of this sub-activity is to modernize the collection by properly documenting and archiving where the GSC has mapped the surficial geology in Canada. Properly archiving this valuable collection of air photos is important as it will make a valuable reference resource accessible for future work at the GSC, NRCan, other government departments (e.g., CNGO), and external stakeholders.
Geophysical imaging of lithospheric structure to guide predictive modelling of critical mineral systems	Lee, Ben and Tschirhart, Victoria	The proposed research will address the gap in deep-seeing geophysical datasets in the four corners region comprising the boundary between northern Saskatchewan, northern Manitoba, southeastern Northwest Territories, and southern Nunavut. By expanding the magnetotelluric (MT) coverage in this area, which is host to numerous critical mineral and metal occurrences and deposits (e.g. Cu, Ni, REE and others), the proposed research will improve the accuracy of AI-guided prospectivity mapping across all of Canada. The results of this study will provide valuable insights into the lithospheric structure controlling mineral endowment in this region and inform the modelling of the lithospheric structure on a national scale, thereby advancing our understanding of Canada's 3D mineral prospectivity.
Development of deep learning methodologies to improve mineral prospectivity mapping for critical minerals	Bellefleur, Gilles	The proposed sub-activity aims to develop deep learning approaches to improve mineral prospectivity mapping by leveraging disparate, multi-resolution datasets. The research will address several knowledge gaps in mineral prospectivity mapping, including preserving contextual information by extracting powerful latent representations of input data, mitigating biases, using positive-only labels, and finding an improved evaluation metric. The proposed work will build on previous research and

		welcome collaboration with other sub-activities focusing on mineral prospectivity mapping for comparison and improvement of methodologies to produce better critical mineral prospective maps across Canada.
Ice stream paradigm and search for critical minerals in Canada: exploiting the power of automated geospatial mapping techniques	Paulen, Roger	Both western Nova Scotia and the southern Canadian Shield are of national strategic importance to Canadians as a source of domestic critical minerals needed for the green economy. These landscapes have been extensively modified by glacial scouring under the continental-size Laurentide Ice Sheet (LIS) and obscured by complex glacial sediments and landforms creating challenges that no other country faces in prospecting for and developing its critical mineral resources. The advent of very high-resolution LiDAR digital data and other topographic data is a game changer since it has promoted the development of automated (machine learning) mapping methods. Large areas of glaciated terrain can now be mapped quickly using geospatial analytical techniques and hierarchical and unsupervised machine learning-based data clustering to recognize pathways of former ice streams.
Regional lake geochemistry to support critical mineral exploration	McClenaghan, Beth	The GSC has conducted regional-scale lake bottom sediment surveys in the glaciated Precambrian Shield terrain of Canada for more than 50 years, however, few of these GSC datasets for northern Canada have been interpreted using modern state-of-the-art machine learning techniques to assess mineral potential. Factors that control lake sediment geochemistry in Arctic lakes are not fully understood and these unknowns can affect interpretations of these large lake sediment datasets. This proposed activity will focus two subactivities: i) conducting a mineral prospectivity assessment for critical mineral exploration for the northern Bear-Slave corridor region (160,000 km2) using new reanalysis lake sediment geochemical data recently generated by the GEM GeoNorth Program, and ii) lab-based research to address questions and unknowns about critical element mobility in northern lake sediments that will increase the understanding and efficacy of lake sediment mineral potential modelling and environmental assessment.
AI-based 3D geological modelling for critical mineral systems	Hillier, Michael	AI-based 3D geological modelling method development for critical mineral systems. Includes predictive deep learning for spatial estimation, uncertainty characterization, and knowledge representation, to generate large and complex geological models that will be used as a geological framework supporting downstream 3D critical mineral prospectivity mapping.
National fault inventory for critical mineral systems	de Kemp, Eric	To compile, update, harmonize and attribute a publicly accessible geospatial database of Canada's most significant bedrock faults, shear zones and deformation corridors. To provide an essential evidence layer for critical mineral potential studies, and to act as a guide for focused 3D structural and stratigraphic modelling in zones identified as having high critical mineral occurrence and/or potential.
3D structural characterization and anisotropy modelling using multidisciplinary geophysical and geological data	de Kemp, Eric	This project intends to improve the accuracy of local to national scale 3D earth models by deriving structural constraints for subsurface geology from multidisciplinary geophysical and geological data. We will develop and implement this new technology to enhance the predictability and interpretation practice for mapping lithospheric architectures. These advancements will better support direct ore targeting and also give us a clearer vision of how critical mineral systems operate, with a more robust characterization of the deeper, potentially controlling, structures.
Developing Machine Learning Techniques for Geology Prediction in Areas with Limited Outcrops	Bellefleur, Gilles	GSC and KIGAM are establishing a collaboration on critical minerals, which in part aims to develop machine learning techniques to improve the prediction of geology from geophysical data in areas with limited or no outcrops. This will be done using deep learning techniques and generating synthetic data to find relationships between geology, physical rock properties, and geophysical data. A test site in Canada (Flin Flon Glennie Complex) is proposed to validate the usefulness of the methodologies. An

		airborne survey is also proposed to acquire gravity gradiometer data to support accurate predictions.
Prospectivity mapping of critical minerals in VMS deposits in Canada using deep learning	Tirdad, Shiva	Artificial intelligence, specifically deep learning methods allow for the integration of geological, geophysical and geochemical data to create comprehensive models for critical mineral prospectivity mapping. The models can be trained to predict the likelihood of finding critical minerals such as copper and zinc in Volcanogenic Massive Sulfide deposits. We can also estimate the stochastic uncertainty associated with the model predictions and mitigate the risk in exploration activities.

Activity 3.2: Environmental, Social, and Governance (ESG)

Sub-Activity Title	Principle Investigator	Sub-Activity Descriptions
Green economic pathways	Lawley, Chris	Reporting standards in Canada (NI-43-10), Australia (JORC), and across the world (UNFC) are planning to include Environmental, Social, and Governance (ESG) principles into the formal definition of a mineral resource, which will improve risk disclosure and be used to guide investment. However, reporting and managing ESG performance at the project level is incomplete unless all of the situated risks that are associated with critical mineral development are placed into a regional, national, and global context. This study will develop and validate new methods for combining public ESG datasets to improve pre-competitive, data-driven natural resource management strategies at multiple spatial scales to address that knowledge gap.