Carleton University

Office of the Vice-Provost
(Academic and Global Learning)

memorandum

DATE: October 24, 2025

TO: Senate

FROM: Dr. David Hornsby, Vice-Provost (Academic and Global Learning), and Chair, Senate Quality Assurance and Planning Committee

RE: Master's in Mineral Exploration and Resource Management
New Program Approval

SQAPC Motion

THAT SQAPC recommends to Senate the approval of the Master's in Mineral Exploration and Resource Management program as presented, to commence in Fall 2026.

Senate Motion

THAT Senate approve the proposed Master's in Mineral Exploration and Resource Management program as presented to commence in Fall 2026.

Background

The proposed full cost-recovery program is a fully online, course-based Master's in Mineral Exploration and Resource Management. It is designed to provide a concentrated and intensive course of study on the science and practice of mineral exploration. The curriculum comprises 8 mandatory graduate level courses. Key to this program is also the recognition of the importance of stakeholder engagement and consultation, with particular attention to the need to consult Indigenous peoples who may be affected by exploration or mining activities. This program will quickly elevate students anywhere in Canada and the world, to a standard of ability allowing them to step into middle management with confidence.

Attachments

Self-Study with Appendices (Volume I)
Discussant Report
Site Visit Schedule
External Reviewer Biographies
External Reviewers' Report
Unit response to the External Reviewers' Report and Implementation plan
Dean's response to the External Reviewers' Report
Courseleaf Entries
Faculty CV (Volume II)

Quality Assurance Framework and Carleton's Institutional Quality Assurance Process (IQAP)

Upon the above motion being passed by Senate, the required documentation will be submitted to the Ontario Universities' Council on Quality Assurance for approval. This approval is required before the program can commence.

Carleton University

Office of the Vice-Provost and
Associate Vice-President (Academic)

Institutional Quality Assurance Process

Master's in Mineral Exploration and Resource Management

New Program Approval Template

(Volume I)

September 2025

Approvals Table

This table will record that the brief has been approved by: 1) the program lead on behalf of the team; 2) the head of the academic unit or chair of the program committee (in the case of interdisciplinary programs not administered exclusively by one academic unit) on behalf of the unit or program committee; 3) the Faculty Dean(s).

James Mungall	March 12, 2025
Program Lead	**Date**
Tim Patterson	March 12, 2025
Chair/Director	**Date**
Maria DeRosa	March 21, 2025
Dean(s):	**Date**

Committees Reviews and Approvals

Vice-Presidents' Academic Research Committee (executive summary)	January 2025
Provost's Budget Working Group (executive summary)	January 2025
Curriculum Committee	April 2025
Faculty Board	May 2025
Senate Committee on Curriculum, Admissions on Studies Policy	
Senate Quality Assurance and Planning Committee	
Senate	
Quality Council	

Contents

A. The Program

A.1. Program overview

The technologies driving us into the future, such as electric vehicles, large capacity storage batteries, wind turbines, solar panels, nuclear reactors, and smart phones are all connected by one common thread: critical minerals. Critical minerals such as cobalt, silicon, uranium, lithium, nickel and others are minerals that are essential to Canada's economy, its national security (Canada, 2022), and they are key components for achieving a green and digital future in Canada and internationally (Natural Resources Canada, 2022). Consequently, Canada and Ontario are focusing on mineral exploration and extraction as part of their broader economic plans (Natural Resources and Forestry Ontario, 2022; Natural Resources Canada, 2022). Additionally, both governments recognize that partnering with Indigenous communities is critical to the success of this economic push (Natural Resources and Forestry Ontario, 2022; Natural Resources Canada, 2022). Given the necessity for these minerals, there is a need for people who can ethically run complex mineral exploration and mineral resource management programs.

Current earth sciences training offered by Canadian universities sufficiently covers the knowledge requirements stipulated by provincial and territorial Geoscience associations such as the Association of Professional Geoscientists (PGO) in Ontario. This training partially prepares students to be fully accredited as a professional geoscientist (PGeo). However, even with the knowledge required to achieve professional status, early career geoscientists have relatively minimal exposure to courses in the geology of mineral resources and lack general knowledge of exploration methods or the management skills necessary to run large mineral exploration projects successfully. Furthermore, an undergraduate Earth Science education does not provide coverage of the subjects of professionalism, professional ethics, the legal system, and the regulatory framework of professional geoscience practice needed to pass the PGO's Professional Practice Examination. The usual approach to professional advancement is to learn on the job. However, few jobs provide a well-rounded education and there is consequently a shortage of early-career people capable of running the complex mineral exploration or mineral resource management programs necessary to find and extract critical minerals. Of the ten globally available Master's programs[1], none span the breadth of the technical engineering, earth sciences, or management background necessary to run a minerals exploration project (Appendix 4. Supplementary Tables). The only program that is close to meeting all three, the Queen's University Master of Earth and Energy Resources Leadership is effectively

[1] University of Pennsylvania: Online Master of Science in Applied Geoscience; Heriot Watt: The Applied Petroleum Geoscience MSc; University of Arizona: Master of Engineering in Mining, Geological, and Geophysical Engineering; University of Ottawa: Master of Engineering Management; Colorado School of Mines: Professional Master's Mining Industry Management; Colorado School of Mines: Professional Masters Degree in Mineral Exploration; Laurentian University: MSc Geology – Applied Mineral Exploration; Queen's University: Master of Earth and Energy Resources Leadership; University of Toronto: Mining Industry Management Program; CODES Tasmania: Master of Economic Geology.

an MBA with a hybrid modular online/residential format and little coverage of the technical skills. The proposed program differs from all these others in that it spans the gamut of skill development with equal emphasis on geoscience knowledge, exploration, mining methodology, and training in finance, business, and management.

Early in 2024, Prof. Maria DeRosa, Dean of the Faculty of Science, suggested that the Department of Earth Sciences could look into developing an online, course-based Master's program. In response, Prof. Tim Patterson, Chair of the Department of Earth Sciences, recognized the needs summarized above and drafted a curriculum outline that Prof. James Mungall expanded upon utilizing his extensive industry experience and pre-existing course offerings. This led to the proposed Master's in Mineral Exploration and Resource Management. During the summer of 2024, Prof. Mungall approached a number of industry and academic partners to seek assistance in building out the proposed curriculum's technical aspects related to mineral exploration. These partners enthusiastically offered their support as a program such as this meets current personnel and training needs in the mineral exploration industry.

The proposed full cost-recovery program is a fully online, course-based Master's in Mineral Exploration and Resource Management (MMERM). It is designed to provide a concentrated and intensive course of study on the science and practice of mineral exploration. The curriculum comprises 8 mandatory graduate level courses divided among Geoscience (2), Methods in Exploration and Mining (3), and Ethics, Finance and Management (3). Graduates will learn the mineral systems models for a large array of major mineral deposit types. They will learn best practices in exploration to find and characterize such deposits in safe, ethical and cost-effective ways. Graduates will be able to make preliminary estimates of the value and likely market potential of mineralization ranging from early-stage exploration projects to mineral resources at the feasibility study stage. Furthermore, they will have significant understanding of the legal, social, ethical, and financial context in which private and public companies operate. The knowledge provided in these courses will greatly exceed those tested by the formal Professional Practice and Ethics examinations required by professional bodies, such as the PGO. For example, they will learn about the functioning of corporations and public sector agencies and governments, as well as the legal and ethical framework in which exploration activities are carried out. Key to this program is also the recognition of the importance of stakeholder engagement and consultation, with particular attention to the need to consult Indigenous peoples who may be affected by exploration or mining activities. This program consolidates all what was learned with a capstone project wherein they will apply the above knowledge to create a detailed plan for a mock exploration program. Overall, this program will quickly elevate students anywhere in Canada and the world, to a standard of ability allowing them to step into middle management with confidence. We plan to start the program in September 2026.

A.2. Mission and strategic directions

The MMERM aligns well with Carleton's Strategic Integrated Plan (Carleton University, 2020). The program will share knowledge and shape the future by dramatically enhancing employment opportunities for graduates while serving to mobilize highly interdisciplinary streams of knowledge on a national and international stage. It will employ exciting, new pedagogical avenues. By going online to reach our

audience where they live, we will make maximum use of Carleton University resources in the most sustainable possible manner.

The program will serve Ottawa and serve the world by opening Carleton's resources to a global audience. The program will be built around strongly integrated partnerships with academic and industry experts and companies from Ontario, the rest of Canada, and the world. Welcoming students from around the world will advance Carleton's international standing and support the development of ethical and responsible exploration geologists everywhere.

The online aspect of the degree aligns the program with Carleton's Equity, Diversity and Inclusion Action Plan (Carleton University Department of Equity and Inclusive Communities, 2023; Carleton University Equity and Inclusive Communities Advisory Group, 2021). Attracting a diverse student cohort to an in-person Master's program is challenging because people with careers and young families are effectively barred from participation, as may be international students who cannot afford to move to another country. The MMERM will completely remove these barriers to access. In doing so we will make our campus, country, and our world accessible to all.

There are a several aspects of this program that work towards aligning it with the Kinàmàgawin (Learning Together) Report's Calls to Action and Progress Reports (2024; 2020, 2022). Within the budget, we have allocated funding to compensate Indigenous Knowledge Keepers and community members for any expertise they may provide (Call to Action 16). We are also planning to embed material on Indigenous history and culture into "Best Practice in Mineral Exploration" (MERM 5007; Call to Action 21). Environmental sustainability will be a component of the "Best Practice in Mineral Exploration" course (MERM 5007; Call to Action 30). We are in discussions with Office of the Associate Vice-President Indigenous Teaching, Learning and Research about utilizing the Collaborative Indigenous Learning Bundles or another approach as recommended. Although this program is not developed for a specific Indigenous community, by having the coursework be provided asynchronously and fully online, we believe students that wish to remain in their communities will be able to complete this program (Call to Action 22).

A.3. Relationship to other academic programs at Carleton

The MMERM program does not overlap with any existing Carleton programs and should have no impact on any other academic units. We have approached the Sprott School of Business, and they have indicated their support for the program (Appendix 5. Letters of Support).

There will be an impact on the other programs within Earth Sciences because of the need to supply teaching and administrative personnel to support the MMERM program, as described in the Resources section below. However, by hiring a full-time program coordinator and two term fulltime equivalent (FTE) assistant professors, teaching stream, this burden can be reduced to the supervisory role to be played by the Program Director, who must be a faculty member of the Department of Earth Sciences.

Students in the proposed program may also consider taking the Masters Certificate in Project Management or the Mini-MBA for Science, Technology & Engineering Professionals (STEPs), but these other programs should be considered complementary rather than duplicative of the MMERM program.

B. Program Learning Outcomes and Assessment

B.1 Program learning outcomes

Table B.1: Learning outcomes

Learning Outcomes
1. Graduates are able to describe and recognize the essential geological characteristics and mechanisms of formation of all the major mineral deposit types.
2. Graduates are able to describe and recommend methods that would be best suited to obtain the information that is required to fully characterize selected exploration targets.
3. Graduates are able to describe methods of mining, beneficiation, refining and waste management and then apply this knowledge to set constraints on feasibility of hypothetical mining developments on exploration targets.
4. Graduates are able to determine the potential market value of a mineral asset.
5. Graduates are able to describe the workings of financial systems and apply this knowledge to support decision-making in the raising of funding for mineral exploration activities.
6. Graduates are able to act within the general ethical and legal framework governing mineral exploration.
7. Graduates are able to plan fully costed programs designed to test exploration hypotheses based on mineral systems science and taking into account logistical constraints, risk management, and compliance with relevant laws and regulations.

B2: MAPPING LEARNING OUTCOMES TO PROVINCIAL DEGREE-LEVEL EXPECTATIONS (DLEs)

The Council of Ontario Universities has established a framework of Degree Level Expectations (DLEs) that specify what students should know, and be able to do, after successfully completing degree program, list each program's learning outcomes and how these ensure that the appropriate degree level expectations are met.

Graduate DLEs

1. Depth and breadth of knowledge
2. Research and scholarship
3. Level of application of knowledge
4. Level of communication skills
5. Awareness of the limits of knowledge
6. Professional capacity/autonomy
7. Experiential Learning

Table B.2: Learning outcomes and degree level expectations

Learning Outcomes	Degree Level Expectations Met[2]
1. Graduates are able to describe and recognize the essential geological characteristics and mechanisms of formation of all the major mineral deposit types.	1, 2, 4, 5, 7
2. Graduates are able to describe and recommend methods that would be best suited to obtain the information that is required to fully characterize selected exploration targets.	1, 2, 3, 4, 5, 7
3. Graduates are able to describe methods of mining, beneficiation, refining and waste management and then apply this knowledge to set constraints on feasibility of hypothetical mining developments on exploration targets.	1, 3, 4, 5, 7
4. Graduates are able to determine the potential market value of a mineral asset.	1, 3, 4, 5, 7
5. Graduates are able to describe the workings of financial systems and apply this knowledge to support decision-making in the raising of funding for mineral exploration activities.	1, 3, 4, 5, 6, 7
6. Graduates are able to act within the general ethical and legal framework governing mineral exploration.	1, 3, 4, 6, 7
7. Graduates are able to plan fully costed programs designed to test exploration hypotheses based on mineral systems science and taking into account logistical constraints, risk management, and compliance with relevant laws and regulations.	1, 2, 3, 4, 5, 6, 7

[2]Additional information on the DLEs can be found at: https://oucqa.ca/framework/appendix-1/

B.3 Program structure and curriculum map

a. Program structure

The courses will be delivered asynchronously, online, through professionally produced video lectures and assignments. The materials will be produced with the assistance of industry or academic leaders, separately from the teaching of the courses. Each course will contain approximately 20-40 hours of instruction and approximately 10 significant assignments (Appendix 1. Program Requirements). Student engagement will be monitored by tracking their access to the online course materials, their engagement with other class members on online discussion boards, and their timely completion of marked assignments. The teaching and monitoring of the prepared course materials will be completed by term faculty.

The curriculum comprises 8 mandatory graduate level courses divided among Geoscience (2), Methods in Exploration and Mining (3), and Ethics, Finance and Management (3). First, the program will give a summary of the characteristics of mineral deposits of all economically significant types couched in a conceptual framework called the mineral systems model (MERM 5001, MERM 5002; See Appendix 2. Course Descriptions). Each deposit type will be described in terms of both their physical attributes and what is known about the physical and chemical processes in the Earth that have created them. The goal of teaching this overview of mineral systems will be to give students the capacity to recognize deposits if they encounter them, to propose characteristics they might expect to be able to use to detect and classify them and, above all, to learn to see deposits not as postage stamps to describe and collect but as complex products of key processes that will manifest themselves differently in every individual instance. The mental agility to synthesize general knowledge of mineral systems with field observations is critically important to successful exploration.

Second, the program will show students the entire range of tools and methods in common use to detect and characterize mineral deposits of all types, equipping them to choose the best and most cost-effective approaches to mineral exploration (MERM 5003, MERM 5004, MERM 5005; Appendix 2). Knowledge of exploration methodologies will be supplemented by practical instruction in the geostatistical methods required to define the physical extents and commodity grades in sufficient detail to allow full assessment of the economic value of a deposit to be performed. In addition to their training in the detection and characterization of ore bodies, the students will also receive a broad training in the myriad techniques used to transform ore into finished products, including mining, beneficiation and mineral separation, smelting and refining, for all the major commodities.

Proper determination of economic value depends on a broad array of factors including metal prices and price forecasting, operation of capital markets, fundamentals of business and economic planning including assessment of net present value of assets by accounting for capital expenditures, operational expenditures and revenues in the context of discounted future earnings (MERM 5006; Appendix 2). The proposed program will educate students in all these subjects sufficiently to permit them to communicate effectively with their financial officers, to read and understand feasibility studies, and to

perform preliminary feasibility analyses themselves as exploration programs develop in real time. Coursework will also guide students through the legal and ethical frameworks that surround mineral extraction projects (MERM 5007). Students will gain a strong understanding of corporate governance, social licence and the function of public sector agencies and governments. Additionally, there is a strong focus on community engagement and consultation, particularly focusing on the need to form mutually respectful relationships with Indigenous peoples when undertaking exploration or mining activities. This coursework will be consolidated with a capstone project (MERM 5008; Appendix 2) whereby students will work in groups to create a complete plan for a mock exploration program using a real case study. Students will apply their geoscience, exploration and mining methods, as well as the ethical, financial and regulatory knowledge to create a plan that takes into account the practical, financial, and regulatory constraints and supports environmental stewardship and stakeholder engagement. See below for a semester-by-semester breakdown of the coursework and how the Program Learning Outcomes (PLO) map to this coursework (Table B.3.).

Fall semester

Geoscience

1. MERM 5001. Magmatic Mineral Systems: 0.5 credit
2. MERM 5002. Fluid-dominated Mineral Systems: 0.5 credit

Methods in Exploration and Mining

3. MERM 5003. Exploration Methods: 0.5 credit
4. MERM 5004. Mining, Beneficiation, and Waste Management: 0.5 credit

Winter semester

Methods in Exploration and Mining (continued)

5. MERM 5005. Mineral Resource Estimation: 0.5 credit

Ethics, Finance and Management

6. MERM 5006. Mineral Exploration Finance and Economics: 0.5 credit
7. MERM 5007. Best Practice in Mineral Exploration: 0.5 credit
8. MERM 5008. Program Management and Logistics: 0.5 credit

Program curriculum map

Table B.3: Program curriculum map summary

Learning Outcomes	Year(s) to be Assessed[1]	Program Components[3]	Level[4] (I, R, M)	Activities and Artifacts[5]
1. Graduates are able to describe and recognize the essential geological characteristics and mechanisms of formation of all the major mineral deposit types.	2026/2027	MERM 5001 Magmatic Mineral Systems Models	I	Knowledge checks Discussion boards Quizzes Group projects Case studies
		MERM 5002 Fluid-dominated Mineral Systems Models	I	Knowledge checks Discussion boards Quizzes Group projects Case studies
		MERM 5003 Exploration Methods	R	Quizzes Experiential projects Case studies
		MERM 5008 Program Management and Logistics	M	Capstone project

[1] The year the learning outcome will be assessed, with each learning outcome assessed a minimum of two times.
[3] Program components should include those core courses, elective courses, options (co-op, internship, mention Français, international experience), and other program requirements (language requirement, international experience) which contribute most directly to the achievement of the particular learning outcome.
[4] Level of delivery of each program component related to the particular learning outcome: I = introductory; R = Reinforcement; M = Mastery (relevant to the expected outcome at the degree level).
[5] Activities can include presentations, group work, performance, role play, etc. Artifacts can include exams, papers, reports, portfolios, cases, etc.

2. Graduates are able to describe and recommend methods that would be best suited to obtain the information that is required to fully characterize selected exploration targets	2026/2027	MERM 5003 Exploration Methods	I	Knowledge checks Discussion boards Quizzes Experiential projects Case studies
		MERM 5005 Mineral Resource Estimation	R	Experiential projects
		MERM 5008 Program Management and Logistics	M	Capstone project
3. Graduates are able to describe methods of mining, beneficiation, refining and waste management and then apply this knowledge to set constraints on feasibility of hypothetical mining developments on exploration targets.	2026/2027	MERM 5004 Mining, Beneficiation and Waste Management	I, R	Knowledge checks Discussion boards Quizzes Experiential projects Case studies
		MERM 5005 Mineral Resource Estimation	R	Experiential projects
		MERM 5006 Mineral Exploration Finance and Economics	R	Experiential projects

		MERM 5008 Program Management and Logistics	M	Capstone project
4. Graduates are able to determine the potential market value of a mineral asset.		MERM 5005 Mineral Resource Estimation	I	Knowledge checks Discussion boards Quizzes Experiential projects Case studies
		MERM 5006 Mineral Exploration Finance and Economics	R	Experiential projects
		MERM 5008 Program Management and Logistics	M	Capstone project
5. Graduates are able to describe the workings of financial systems and apply this knowledge to support decision-making in the raising of funding for mineral exploration activities.	2026/2027	MERM 5006 Mineral Exploration Finance and Economics	I, R	Knowledge checks Discussion boards Quizzes Experiential projects Case studies

		MERM 5007 Best Practice in Mineral Exploration	R	Experiential projects
		MERM 5008 Program Management and Logistics	M	Capstone project
6. Graduates are able to act within the general ethical and legal framework governing mineral exploration.	2026/2027	MERM 5005 Mineral Resource Estimation	R	Case studies
		MERM 5006 Mineral Exploration Finance and Economics	R	Case studies
		MERM 5007 Best Practice in Mineral Exploration	I	Knowledge checks Discussion boards Quizzes Test Experiential projects Case studies
		MERM 5008 Program Management and Logistics	M	Capstone project

7. Graduates are able to plan fully costed programs designed to test exploration hypotheses based on mineral systems science and taking into account logistical constraints, risk management, and compliance with relevant laws and regulations.	2026/2027	MERM 5001 Magmatic Mineral Systems Models	I	Case studies
		MERM 5002 Fluid-dominated Mineral Systems Models	I	Case studies Case studies
		MERM 5003 Exploration Methods	I	Case studies
		MERM 5006 Mineral Exploration Finance and Economics	R	Experiential projects
		MERM 5007 Best Practice in Mineral Exploration	R	Experiential projects
		MERM 5008 Program Management and Logistics	M	Capstone project

B.4 Program learning outcomes assessment plan

At the start of the program, the Program Director, Prof. James Mungall, and Daphne Uras, in collaboration with Maristela Petrovic-Dzerdz, have developed the assessment methodologies and are conducting program-level learning outcome assessments. Detailed course maps are being designed to the level of approximately weekly modules, each of which contains several sub-modules with pre-defined contents. In each sub-module there is an explicit list of activities, learning materials, ungraded assessments (knowledge checks), multiple choice tests, and both formative and summative written assignments. All assessments are crosslinked to course-level learning outcomes (CLO)s and all CLOs are linked to PLOs; all CLOs are tested at least once at the formative level and also in summative assignments. There will be a weekly discussion board on which students will be encouraged to comment on a weekly

question or discussion point with a small mark component dedicated to rewarding frequent posting of thoughtful comments.

While the programming is running, the Program Director and the contract instructors will review the results of the program learning outcome assessments. Table B.3. above will be used as a checklist to ensure each entry matches to at least one assessment at the appropriate level. The assignments from the courses will be cross-referenced and applied to the assessment of program and course-level learning outcomes. This worksheet will be presented alongside a summary report semi-annually to the Earth Sciences Department Chair, and the Provost's Office. Any potential changes proposed during this will be approved and completed by the Program Director before bringing them to Science Committee on Academic Planning – Graduate (SCAP-G) and other curriculum bodies.

B.5 Program Essential Requirements

PREAMBLE

Program essential requirements are defined by the Ontario Human Rights Commission as "the knowledge and skills that must be acquired or demonstrated in order for a student to successfully meet the learning objectives of that… program." The program essential requirements are components that contribute to the achievement of the learning outcomes of the program.

"An appropriate accommodation at the post-secondary level would enable a student to successfully meet the essential requirements of the program, with no alteration in bona fide standards or outcomes, although the way the student demonstrates mastery, knowledge and skills may be altered."

-Ontario Human Rights Commission's Policy on Accessible Education for Students with Disabilities (2018)

The aim of accommodation in a post-secondary context is to provide equal opportunities to all students to enjoy the same level of benefits and privileges and meet the requirements for acquiring an education. Based on these principles, an accommodation will be considered appropriate where it will result in equal opportunity for an otherwise qualified student with a disability to attain the same level of performance or enjoy the same level of benefits and privileges experienced by others, without compromising bona fide academic requirements.

Paul Menton Centre For Students with Disabilities (PMC)

"The Paul Menton Centre is responsible for assessing requests for academic accommodation of students with disabilities through evaluations that are carried out on an individual basis, in accordance with human rights legislation and University policy, and with the support of relevant, professional/medical documentation. Students will only receive academic accommodation if the functional limitations of their disability impact directly on their academic performance."

The program essential requirements of the Master's in Mineral Exploration and Resource Management have been reviewed in consultation with the Paul Menton Centre to ensure capacity for reasonable academic accommodation of students with disabilities, in accordance with the Carleton University

Academic Accommodation Policy. The learning outcomes can be attained as outlined in the program description with the use of appropriate academic accommodations.

C. Governance

The program will be housed in the Department of Earth Sciences. Prof. James Mungall will start as the Program Director. The Program Director will oversee curriculum development, learning outcome assessments, and program changes. Two term assistant professor, teaching stream faculty will teach the pre-existing materials, manage the courses, and grade materials. They can provide the Program Director with comments on the curriculum, but changes are ultimately approved by the Program Director. Currently, Prof. James Mungall is the Program Director. Continuity of governance is assured by the current hiring process of a new faculty member, outside of this program's creation, in Critical Minerals research and teaching. This new faculty member will provide redundancy in the event that the Director is unable to continue to fulfill his role. One semester before the program launches, an administrative assistant will also be hired to act as the Program Administrator and assist with administering non-academic student issues, contracting, and other aspects of the program.

D. The Faculty

D.1. Faculty appointed to the unit or program.

The program's teaching materials are being created by Prof. Jim Mungall who is acting as Program Director. Resources have been allocated to complete Prof. Mungall's normal teaching load. The new hire in Critical Minerals will be able to assist with the program and could act as the Program Director, if necessary, in the long term. Two term teaching stream faculty will be hired on three-year contracts to teach some of the materials. However, ownership and management of teaching materials and thus ensuring program quality and continuity will be the Program Director's responsibility.

Table D.1: Core program faculty

Faculty Name	Rank	Appointment Status	Percentage Appointment	Supervision Privileges*	Area of Specialization/Field Affiliations
James Mungall	Professor, Director of MMERM	Tenured, full-time	100	D	Mineral Exploration, Mineral Deposits, Geochemistry, Petrology
TBA	Assistant Professor	Tenure-track	100	D	Critical Minerals and Structural Geology

*D=full privileges; M=full privileges at Master's level only; CD=co-supervision privileges at doctoral level, full privileges at Master's level; CDM=co-supervision privileges only at both doctoral and Master's level; CM=co-supervision privileges at Master's level, no privileges at doctoral level

D.2. Faculty research funding.

As this program is a course-based Master's, faculty member's funding will not be utilized to support student learning nor the delivery of the academic program.

D.3. Distribution of thesis supervision.

There is no thesis component in this program. Therefore, there is no need for thesis supervisors. The Program Director's thesis supervision capacity will be affected to some extent, which will be mitigated by his release from 1.0 full course equivalent of the normal 1.5 credit teaching commitment. The Program Director will be able to continue to supervise graduate students unrelated to the MMERM program.

Table D.3: Distribution of thesis supervision since 2017

Faculty Name	**Rank**	**Completed**				**Current**			
		Undergraduate	**Master's**	**PhD**	**PDF**	**Undergraduate**	**Master's**	**PhD**	**PDF**
James Mungall	Full Professor	11	6	6	4	1	0	1	1

D.4. Current teaching assignments

The Program Director, Prof. James Mungall, is a tenured Full Professor in the Department of Earth Sciences. He has taught 1.5 FCE in the Earth Sciences department each year since 2017. Starting in 2025 and continuing during the development and after the launch of the program, he will be relieved of 1.0 teaching credits through contract instructor replacements but will continue to teach "Mineral Exploration Field Geology" (ERTH 4209) for two weeks every summer term. Prof. Mungall will oversee the delivery of all eight courses as Program Director, but the two term assistant professors, teaching stream will be responsible for day-to-day delivery and grading of the courses. Each teaching stream professor will teach two 0.5 credit courses related to the program in each of the Fall and Winter semesters.

Table D.4: Distribution of Teaching Assignments

Faculty Name	Courses Taught			Notes
	2024-25	2023-24	2022-23	
James Mungall	ERTH 3806 ERTH 4209 Plus 1.0 FCE of teaching release from ERTH 3204 and ERTH 4303	ERTH 3204 ERTH 4303	ERTH 3204 ERTH 4209 ERTH 4303	

D.5. Contract instructors

The program will be taught by the Program Director, and two term, FTE assistant professors, teaching stream. As the course materials will be prepared before the courses are offered, these two assistant professors will teach from the pre-existing course materials. We will also hire two contract instructors to teach the Program Director's undergraduate courseload. As the course work is online, we will be able to hire from the large talent pool across Ontario and Canada.

E. Program Admission and Enrolment

E.1. Admissions requirements

The basic level of preparation required for entry to the program will be completion of an undergraduate degree program in Earth Sciences approximately equivalent to the Honours Bachelor of Science in Earth Sciences at Carleton University. Like other Canadian Earth Sciences programs, Carleton's Honours BSc has been designed to meet and exceed the knowledge requirements of the PGO (Professional Geoscientists of Ontario). Although individual programs in Canada are not accredited like Engineering programs, the PGO and other provincial professional bodies do require that applicants meet the knowledge requirements, which have been harmonized nation-wide. We will therefore use the knowledge requirements document published by the PGO as our guideline to assess preparedness for the MMERM program. For students from Canadian programs with known curricula, simple possession of the Hons BSc degree with high honours standing will suffice, but in case of uncertainty for international applicants the PGO knowledge requirements will be applied. In all cases the Director will reserve the

authority to accept or reject applications in full consideration of transcripts and related professional experience (Appendix 3. Admission Requirements).

E.2. Class sizes and course and program capacity

As the courses will be asynchronous and online, the class sizes can be scaled as necessary. These courses will be made specifically for this degree and will not be attended by students outside of the MMERM program. Care is being taken to create rigorous but easily scalable assessments through the use of carefully designed multiple choice tests, testing to level 5 of Bloom's taxonomy, and a limited number of summative assignments (e.g., two major assignments per course). The initial goal is to be able to accommodate 50 students in each class.

E.3. Projected enrolment

The pool of potential applicants is global in extent. Even in North America there are estimated to be approximately 50,000 working geoscientists (Bureau of Labor Statistics & U.S. Department of Labor, 2024; Geoscientists Canada, 2024; Geoscientists of Canada & Canadian Federation of Earth Sciences, 2018). If only 10% of these were at a career stage where the MMERM program could improve their qualifications and half of those were interested in mineral resources, the North American pool would number 2,500. The program only needs to attract 0.1% of North American geoscientists (50/50,000) each year to bring in 50 students. UNESCO estimates that there are 400,000 geoscientists worldwide (Capello, et al., 2023). Therefore, we believe we will have a steady enrolment of 50 students per year. Additionally, the program is sustainable with an enrolment of approximately 14 students a year. We will reach these qualified candidates by utilizing targeted advertising through our network of research and industry partners. We believe good advertising should create more demand than can be accommodated.

F. Student Experience and Satisfaction

F.1. Student orientation, advising, and mentoring

The Program Administrator will be responsible for front-line communications with prospective and incoming students. The Program Administrator will be provided with documents and videos designed to welcome students and train them in effective use of the online course materials. Students will receive guidelines for appropriate standards of behaviour in group settings and academic standards for plagiarism, use of AI, and other academic matters. Each course will open with further introductory videos and clear descriptions of expectations for student work, assessments, and mechanisms for asking questions, raising concerns, or lodging complaints.

The Program Administrator and Program Director will advise and mentor students on progressing through the program. Furthermore, the Program Director will make available their industry contacts to provide guidance and mentorship to the students as well.

F.2. Career paths of graduates

Discovery, definition, and development of mineral resources will be of central importance to the ongoing transition to an electrified economy here and around the world. There is a need for highly trained professionals to run the exploration programs and supervise the mining developments that the world will depend upon to complete the green transition. Canadian mining and downstream companies will need to hire between 100,000 and 200,000 people over the next decade (Mining Industry Human Resources Council, 2023); these will include over 25,000 professionals and supervisors. Although graduates of Master's programs in Earth Sciences are knowledgeable scientists, they generally lack operational knowledge and have limited managerial experience. Graduates of the MMERM program will become professional geoscientists poised to move into management roles in the mineral exploration or extractive industries. These people will not become engineers or financial professionals, but they will be a rare breed of geoscientist who understands engineers and accountants well enough to collaborate with them on their own terms, providing crucial understanding of the entire exploration and development process from the point of view of the geoscience professional. These industries are highly globalized, and geoscientists may find themselves working in multiple countries over the course of a career.

The MMERM will accelerate the transition from geoscientist into operations manager and ensure the race to find and develop critical metal deposits is done by people who understand the science and practice of exploration and resource definition. Importantly, it will ensure these graduates are trained to do so in an ethical and responsible manner. Typical job descriptions for graduates in an approximate sequence of growing responsibility will be Project Geologist, Exploration Manager, Vice-President Exploration, President/CEO. These roles will be held within companies ranging from small private junior exploration companies to publicly listed juniors, up to major mineral producers.

G. Resources

Personnel requirements after course development will comprise a Program Director taken from the full-time tenure-stream faculty complement of the Department of Earth Sciences, one Program Administrator staff position and two term, FTE assistant professors, teaching-stream to teach the prepared materials, monitor and contribute to discussion boards, and correct the assignments. The Program Director is a tenured or tenure-track professor specializing in mineral deposits who will receive partial relief from normal teaching responsibilities.

G.1. Support and technical staff

A Program Administrator will manage outreach and marketing, front-line communication with students regarding non-academic issues, liaise with students and instructors, work with service providers for software licences, troubleshoot software issues, maintain the courses records, and communicate with

the Registrar's Office, SCAP-G, the Office of the Dean of Science, the Provost's Office, and Teaching and Learning Services.

Additional support will be provided on an as-needed basis through Teaching and Learning Services. However, the amount of support needed will be front-loaded to the program development stage and should be minimal once delivery has begun. As with any course there will be a need for ongoing technical support for the teaching software Brightspace and Mediaspace.

G.2. Space

a. Laboratory facilities

As this program is completely online, laboratory facilities are not necessary.

b. Unit/program and affiliated research facilities

As this is not a research degree, research facilities will not be necessary.

c. University and unit/program computer facilities and computing resources

As the program is online, students will be required to provide their own computer and internet access.

G.3. Library Resources

An analysis of Carleton University Library's information resources and services in support of the MMERM demonstrates that the Library does not require any additional funds to support it

PREAMBLE

The Library report is prepared by the librarian or subject specialist responsible for the subject area(s) covered by the program, using a common template developed from guidelines established by the Ontario Council of University Libraries. The main purpose of the report is to specify whether any new resources or services are necessary in order to support the program, for example, whether the Library needs to purchase new books or subscribe to new journals or electronic resources.

The librarians and subject specialists preparing the reports rely on their own professional experience with collecting resources in the subject areas in order to make assessments about whether there are gaps in the collection that need to be filled in order to provide the appropriate teaching and research support for new, modified, or reviewed programs. They consult various sources for information about published resources in the subject area, including the database maintained by the Library's main monographs vendor, publishers' lists and websites, handbooks and guides to the literature, the library collections of universities that offer the program, various specialized sites relevant to the subject from professional societies and organizations, as well as basic information available in tools such as Google

Scholar or generally on the web. They also generally consult faculty members (e.g., the Library representative or the department chair) to discuss their assessment of the strengths and gaps. The Library makes a clear distinction between those resources which are essential to the program and those which are simply "nice to have." Generally speaking, the reports list only the essential resources, with costing obtained from the vendors or agents from which the Library would obtain the materials: each item is listed and costed individually and the total amount is recorded in the report.

The report also provides context by providing information about the following, when possible or applicable: percentage of top-ranked journals which the Library subscribes to in the subject area(s); how much funds have been spent in the past fiscal year on e-resources, journals, and printed books in support of the subjects covered by the program; how much funds have been spent in the past 8 years on printed monographs for the program; specialized collections in archives, maps, data, and government information; instruction, teaching, and practicums carried out by Library staff in the classroom or in the Library; highlights from the Library website (e.g., links for subject and course guides and to online tutorials); research partnerships between the Library and the department or program; research consultations; help desk visits; and selected detailed statistical information about the Library.

H. Development of the Self-Study

The Volumes 1,2, and 3 were prepared by:

- Prof. James Mungall, Professor, Department of Earth Sciences, Director of MMERM

- Prof. Maria DeRosa, Dean of Science, Faculty of Science

- Prof. Matthias Neufang, Associate Dean, Graduate Affairs, Faculty of Science.

- Prof. Tim Patterson, Chair, Department of Earth Sciences.

- Dr. Ethan Hermer, Professional Programs Officer, Faculty of Science.

Prof. Mungall was chosen to develop the program due to his lifelong involvement in teaching, research and practice of mineral exploration. He is drawing on a global network of professional contacts to enrich and refine the content of the program. Once the online courses are ready in draft form, they will be shared with selected specialists in the mineral exploration industry for Beta-testing and detailed feedback prior to finalization of content. As the Dean of Science, Prof. DeRosa, and as Associate Dean, Graduate Affairs Prof. Neufang are responsible for ensuring that the program meets the needs of students of the Faculty of Science. As Department Chair, Prof. Patterson is responsible for aligning the program with the goals and needs of the Earth Sciences Department. Dr. Hermer is responsible for overseeing the development and adoption of new graduate-level professional programs for the Faculty of Science. Daphne Uras (Life-long Learning Program Coordinator, Centre for Initiatives in Education), Maristela Petrovic-Dzerdz (Educational Developer, Course Design, Teaching and Learning Services), and Dr. Lizzie Yan (Program Assessment Specialist, Office of Academic Programs and Strategic Initiatives) collaborated on the development of the assessment methodologies and are conducting program-level learning outcome

assessments with Prof. Mungall. Christina Noja (Director, Office of Academic Programs and Strategic Initiatives) and Valentina Leon (Program Officer, Office of Academic Programs and Strategic Initiatives) provided guidance through the quality assurance process.

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Appendix 1. Program Requirements

Requirements:

1. 4.0 credits in:		**4.0**
MERM 5001 [0.5]	Magmatic Mineral Systems	
MERM 5002 [0.5]	Fluid-dominated Mineral Systems	
MERM 5003 [0.5]	Exploration Methods	
MERM 5004 [0.5]	Mining, Beneficiation, and Waste Management	
MERM 5005 [0.5]	Mineral Resource Estimation	
MERM 5006 [0.5]	Mineral Exploration Finance and Economics	
MERM 5007 [0.5]	Best Practice in Mineral Exploration	
MERM 5008 [0.5]	Program Management and Logistics	
Total Credits:		**4.0**

Appendix 2. Course Descriptions

New Courses

MERM 5001 [0.5 credit]

Magmatic Mineral Systems

Systematic review of source, generation, concentration, migration, separation, enrichment and preservation of major magmatic and derived orthomagmatic hydrothermal ore deposit types including base metal sulfide, precious metal sulfide, porphyry Cu, vein-hosted Sn, Ag, W, etc., chromitite, Fe-Ti oxide, kimberlite-hosted diamond, rare metals, carbonatites.

MERM 5002 [0.5 credit]

Fluid-dominated Mineral Systems

Systematic review of source, generation, concentration, migration, separation, enrichment and preservation of major fluid-generated ore deposit types including Carlin-type and orogenic gold, IOCG, VMS, MVT-Irish Type, SEDEX, IOCG, unconformity and roll-front U, sediment-hosted Cu-Co, residual soil deposits (e.g., laterite), chemical sediments (e.g., iron formation).

MERM 5003 [0.5 credit]

Exploration Methods

Methods overview including application of mineral systems framework, data synthesis, GIS, methods and synthesis of geophysical, remote sensing, mapping, geochemical, drilling, assay and geometallurgy. Target selection at all scales from regional to deposit. Cost-benefit analysis for data collection (e.g., mapping vs drilling, operations efficiencies).

MERM 5004 [0.5 credit]

Mining, Beneficiation, and Waste Management

Methods and environmental burdens of open cast and underground mining, geometallurgy, comminution, mineral separation, concentration, refining and smelting of major and minor commodities; waste rock and tailings management, impoundment stability and environmental geochemistry.

MERM 5005 [0.5 credit]

Mineral Resource Estimation

Data types and QAQC, geological modeling and domaining, implicit modeling for wireframing (theory and practice), statistics, compositing, capping and declustering, variograms, block modeling, estimation theory and examples, validation and classification, mineral reserves and reporting.

MERM 5006 **[0.5 credit]**

Mineral Exploration Finance and Economics

Sources of funding for mineral exploration and development, corporate structure and financing, balance sheets, commodity markets, net present value, and reconciliation of projected and realized profits.

MERM 5007 [0.5 credit]

Best Practice in Mineral Exploration

Professionalism, ethics, professional practice, law for professional practice, corporate governance, social license, Indigenous relations, labor relations, corporate and operational risk management, environmental stewardship, responsibility to shareholders.

MERM 5008 [0.5 credit]

Program Management and Logistics

Capstone course where groups of students use a real case study to plan a fully costed exploration program, including a detailed mineral system analysis, which fully considers operational and corporate risk management, economic and financial constraints, environmental stewardship, and stakeholder engagement.

Appendix 3. Admission Requirements

The normal requirement for admission to the program is an Honours B.Sc. degree, with at least high Honours standing, in geology or a related discipline, and which meets the Professional Geoscientists of Ontario knowledge requirements for an undergraduate degree. Applicants judged to be generally acceptable but deficient in some aspect of preparation may be asked to complete coursework in addition to the program requirements.

Appendix 4. Supplementary Tables

Table 1. Global offerings in Master's professional programs in resource geology and engineering

Institution	Program name	Eng[1]	ES[2]	Man[3]	Mode	Fees (CAD)
U Pennsylvania	Online Master of Science in Applied Geosciences		X		online	-
Heriot Watt (UK/Dubai)	The Applied Petroleum Geoscience MSc	X	X		online	$24,000
U Arizona	Master of Engineering in Mining, Geological and Geophysical Engineering	X		X	online	-
U Ottawa	Master of Engineering Management	X		X	online	ON*
Colorado School of Mines	Professional Master's Mining Industry Management	X		X	mixed	$32,000
Colorado School of Mines	Professional Masters Degree in Mineral Exploration		X		in-person	$32,000
Laurentian U	MSc Geology - Applied Mineral Exploration		X		in-person modular	ON*
Queen's U	Master of Earth and Energy Resources Leadership	X	X	X	in-person	$41,000
U Toronto	Mining Industry Management Program	X		X	mixed	ON*
CODES Tasmania	Master of Economic Geology		X		mixed	$71,600

[1]Engineering

[2]Earth Sciences

[3]Management

ON* signifies normal institutional domestic and international tuition fees for Ontario graduate programs

Appendix 5. Letters of Support

STATEMENT OF SUPPORT FROM SISTER UNIT

RE: Carleton University is proposing a MSc Mineral Exploration and Resource Management housed in the Department of Earth Sciences.

[x] I support this change unconditionally.
[ ] I do not support this change.
[ ] I support this change, with the following reservations:

On behalf of the Sprott School of Business, I support the creation of a MSc. Mineral Exploration and Resource Management.

Signature:

Name: Emily Gray
Title: Associate Dean, Student Success and Recruitment, Professional Graduate Programs
Academic Unit: Sprott School of Business
Date: October 9, 2024
Notes:

Institutional Quality Assurance Process

Library Report for M.Sc. Mineral Exploration & Resource Management

New Program

Date: November 11, 2024

Compiled by: George Duimovich, Collections Librarian, Science, Engineering & Design

Submitted to: Christina Noja, Director, Academic Programs & Strategic Initiatives

cc Amber Lannon, University Librarian
Sarah Simpkin, Associate University Librarian, Academic Services
Edward Bilodeau, Associate University Librarian, Collection Services
Alana Skwarok, Acting Head, Collections & Assessment
Jennifer Browning, Acting Head of Electronic Resources & Acquisitions
Joel Rivard, Head of Research Support Services

Overview and Recommendations

An analysis of Carleton University Library's information resources and services in support of the program demonstrates that the Library does not require additional funds to support it.

Library Collections

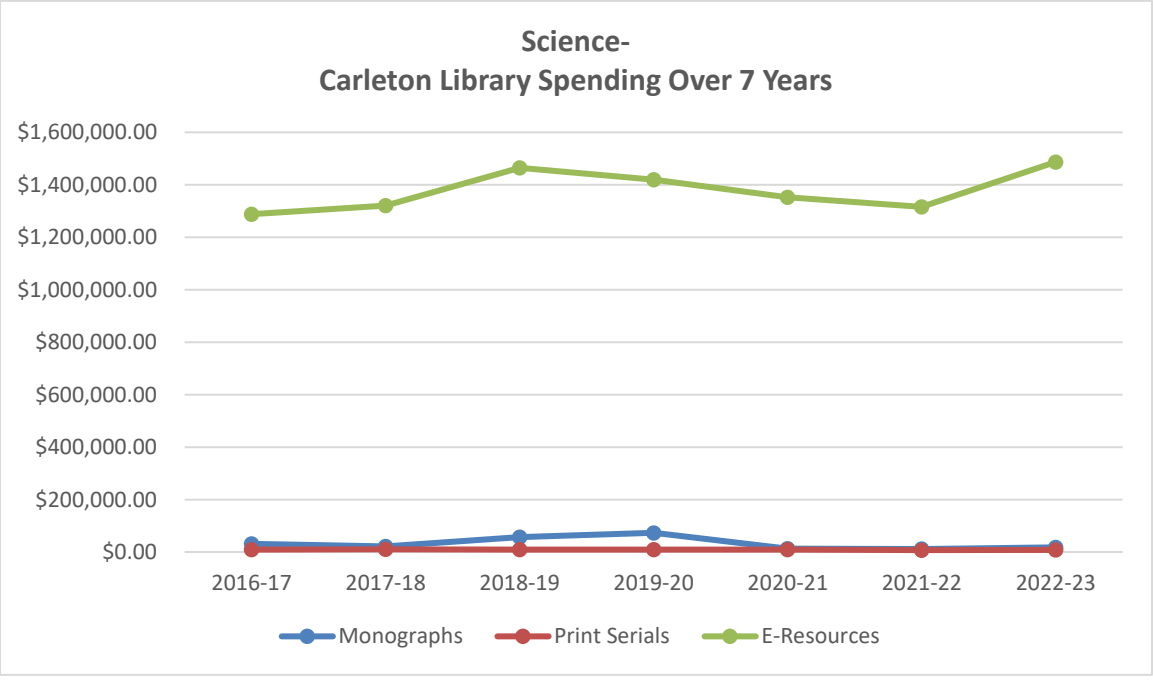
Subject Specific

The Library's collection includes specific resources to support the Mineral Exploration & Resource Management program. These include 25 of the top-ranked 25 journals in *Journal Citation Reports* classified under *each* of the distinct subject categories: Geosciences (Multidisciplinary), Mineralogy, Mining & Mineral Processing, and Remote Sensing.

In addition, the Library's collections of journals in related programs are also strong in Geography and Geomatics, Chemistry, and Environmental Sciences. Significant database coverage includes GeoRef, GEOBASE, GeoscienceWorld, Web of Science, Scopus and others. Collections and services also include GIS Resources & Consultations, Data Services, and a significant print and digital cartographic collection.

During the 2022-23 academic year, the Library's spending for collection in all areas was about $8.7 million. 88% of the entire collections budget is spent on electronic resources**.** Over $3.1 million was spent on general electronic resources which benefit all subject areas.

In addition to that amount, the following shows the amounts spent on electronic resources (databases, journals, eBook packages, indexes), print journals, and monographs (individual orders) related to Faculty of Science for the past seven years***:***



The policy for materials that the Library collects for the *Mineral Exploration & Resource Management* program includes:

- Earth & Geological Sciences
- Geography and Geomatics
- Environmental Science
- Chemistry

Teaching, Learning, and Research

Carleton Library is a vibrant and active partner in teaching, learning, and research across all disciplines of the university. Library staff take pride in supporting students to develop the skills required to locate, evaluate, use, and communicate information effectively and responsibly. Our programs and services are grounded in Ontario's Quality Assurance Framework.

The Subject Specialist works collaboratively with faculty to address students' information competencies in several ways, including:

Instruction, Teaching, and Practicums

A total of 469 in-class instruction sessions were provided by Library staff in all subject areas during 2022-23, and a total of 12,542 students attended those sessions. These sessions were also supplemented by the creation of over 200 videos with over 31.000 total views. The Subject Specialist designs and delivers instruction sessions and practicum opportunities to meet the needs of specific assignments and course requirements while addressing broad learning objectives.

The Library offers workshops for graduate students in research and writing through the Faculty of Graduate and Postdoctoral Affairs (FGPA). FGPA hosts Grad Navigate: a hub of graduate-specific workshops and services that assist graduate students in navigating different aspects of their graduate school experience and developing professional skills. Examples include (but are not limited to) workshops about copyright, citation management, research data management, NVIVO, scholarly journal writing, research impact, and data visualization.

Online Learning Support

The Library website (library.carleton.ca) guides students through each step of the research process: identifying, accessing, borrowing, evaluating, and citing resources. Google Analytics recorded almost 1 million visits to the Library website during 2022-23. Library users can conduct a comprehensive search of the entire collection using the Omni search interface. Recent enhancements to Omni allow Carleton users to easily request items from university libraries across Canada, the United States, and other countries.

Highlights of the subject guides available on the Library's website include:

- Earth Sciences
- Geology Maps and GIS Data
- Chemistry
- Environmental Science

Services

Individual Research Consultations

Library staff provided 2274 individual research consultations across all faculties in 2022-23. Consultations can be scheduled for discipline-based research support, as well as support for numeric and geospatial data, research data management, open access publishing, evidence synthesis, copyright, knowledge mobilization, and many related topics.

Research Help – Desks & Chat

Onsite research help is provided through two service points: a Research Help desk on the main floor of the Library and a help desk in Archives and Special Collections (ASC). These two service points had a total of 2685 visits in 2022-23. This service is supplemented by an extended online Ask a Librarian Chat service. A total of 1860 Carleton patron questions were answered via Ask a Librarian in 2022-23.

Results from recent user surveys show that the Library performs well in providing off-campus access to resources and services, and that these resources help people to be successful at university. It was noted that help is available from Library staff when needed. The Library also does well at providing accurate answers to questions and providing course reserves that help both faculty and students.

General Information about the Library

Carleton Library consists of five stories, totaling over 214 thousand square feet. Two floors are dedicated to silent study, while three others allow for quiet conversation. As of the Fall of 2019, the Library had a total of 2400 seats for students. This included 179 public computers and 41 bookable group study rooms. User surveys show the need for more group and silent spaces with outlets for power, and so renovations throughout the Library in the past few years continue to focus on new study space for students.

The Library has dedicated graduate study spaces assigned on a first come, first served basis. These include large carrels, desks in shared study rooms, and graduate lockers.

Thanks to $1 million in funding from the Government of Ontario's Training Equipment and Renewal Fund and a matching contribution from the university, the fourth floor of Carleton Library has been transformed into a newly designed space called the Future Learning Lab. This multi-purpose space can be adapted to suit a wide range of needs. It is envisioned as both a physical space and a set of programs designed to foster innovation and incentivize student-centred ways of teaching.

The New Sun Joy Maclaren Adaptive Technology Centre (JMC) provides students access to assistive technologies and accessible individual and group study rooms. Rooms are equipped with a variety of adjustable furniture, desks, and assistive technologies and hardware.

The Library's collection includes approximately 1.2 million print monographs, 2.8 million e-books, and over 277,000 e-journals in a wide range of subjects and disciplines. In addition, the Library has substantial collections of government documents and other resources, maps, data, rare books and other special research collections, printed journals, archives, theses, multimedia resources (audio, DVD, streaming video), musical scores, as well as licensed access to full-text and indexing databases in a broad range of subjects.

Members of the Library's Collections & Assessment Department build and maintain the Library's collection by developing collection policies that guide the systematic selection of materials. The Library welcomes purchase suggestions from members of the Carleton community. A purchase suggestion form is available on the Library's website to gather suggestions.

In order to enhance its purchasing power (particularly for electronic resources), the Library is an active member of two major cooperative partnerships: the Ontario Council of University Libraries (OCUL), a consortium of the 21 academic libraries in the province; and the Canadian Research Knowledge Network (CRKN), a consortium of 75 academic libraries across the country. Carleton Library is also a member of HathiTrust, a not-for-profit collaborative of academic and research libraries which gives students, staff, and faculty access to a digital repository of millions of books, serials, and other materials from research institutions and libraries from around the world.

The Library's annual acquisitions budget for the 2023-24 fiscal year is $8.6 million, and its staffing and operating budget is $14.4 million.

The Library acquisitions budget is not protected from inflation, exchange rates, or cuts, which often challenges the Library's ability to provide all the necessary resources in support of teaching, learning, and research at Carleton. Consideration of the funds necessary for the Library's acquisitions budget is part of the academic planning and Quality Assurance processes for new programs. The Library is dedicated to regular assessment of its resources and services. Staff use an assortment of qualitative and quantitative techniques to evaluate collections and services in order to make sound decisions within budget parameters.

The Library strongly supports the principles and practices of open access (OA). The University's institutional repository was established in 2011 and is maintained by the Library. It includes a growing archive of the broad intellectual output of the University, as well as digitized versions of most of the theses accepted at Carleton since 1955. The Library contributes to CURIE, the University's program to provide funding for faculty and researchers who are publishing in open access journals, and has also entered into a number of agreements with publishers that offer no-charge open access publishing or discounts. The Library's journal hosting service allows Carleton-affiliated scholars to publish open access journals as a means of increasing availability of scholarly research and writing, as well as to increase involvement in disciplinary discourse. For more information about the Library's support for open access and research dissemination, please see our website.

AT A GLANCE: CARLETON UNIVERSITY LIBRARY

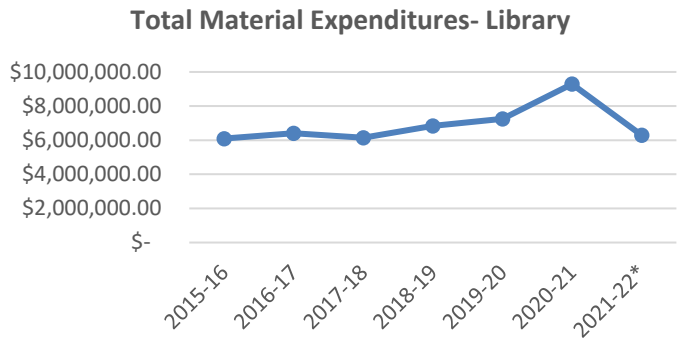
Statistics as of May 1, 2023 except where indicated. Labour disruption, new system implementation & effects of the pandemic** including an entire year online *** has affected some numbers*

Research Highlights

- Carleton's Institutional Repository
- Open Access- Funding for Faculty, Staff, & Students; Open Access Awards for Graduate Students
- Research Data Management Training
- Professional Skills Training for Graduate Students

Collection Spending:

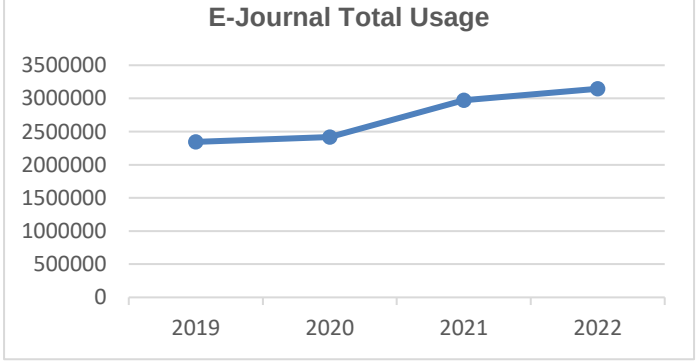
- $8.7 million; 88% of the entire collections budget spent on electronic resources
- $3.1 million spent on general electronic resources which benefit all subject areas

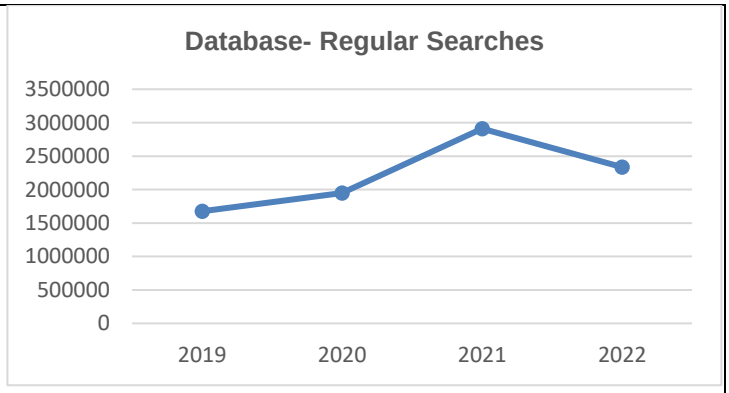


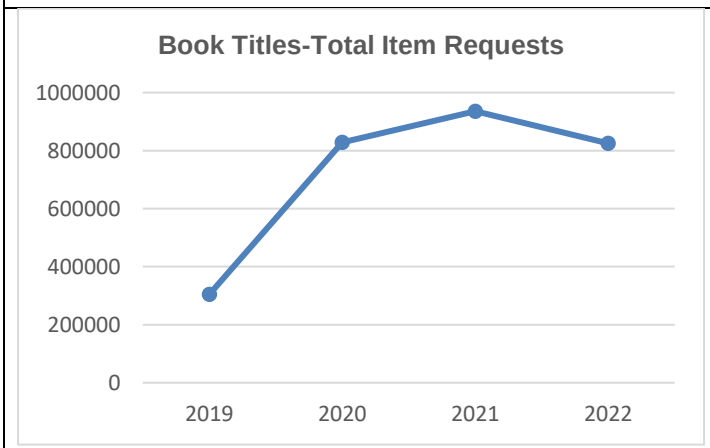
**2020-21- purchased a lot of one-time material to support the switch to online learning which did not have to be paid for again. Annual cost increases for subscriptions were lower than usual due to ongoing pandemic, & a favourable exchange rate lowered our overall spend as most of our invoices are paid in USD.*

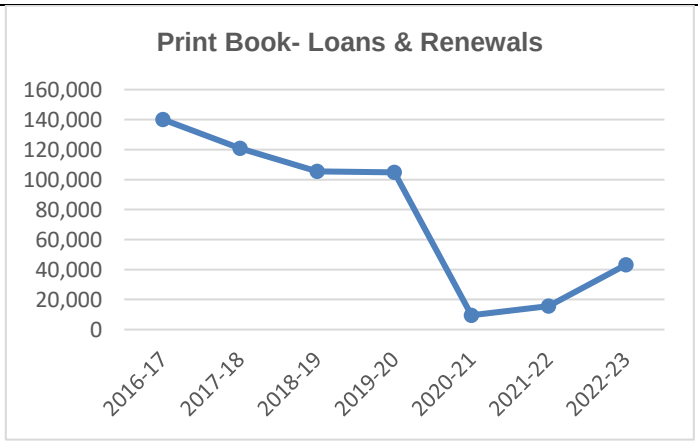
Collections- Usage

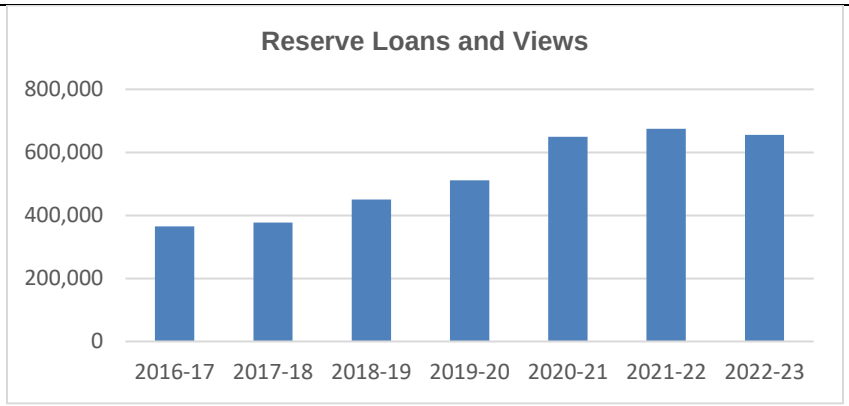
COUNTER 5-compliant data from a selection of major e-publishers/vendors (2019 onward only)



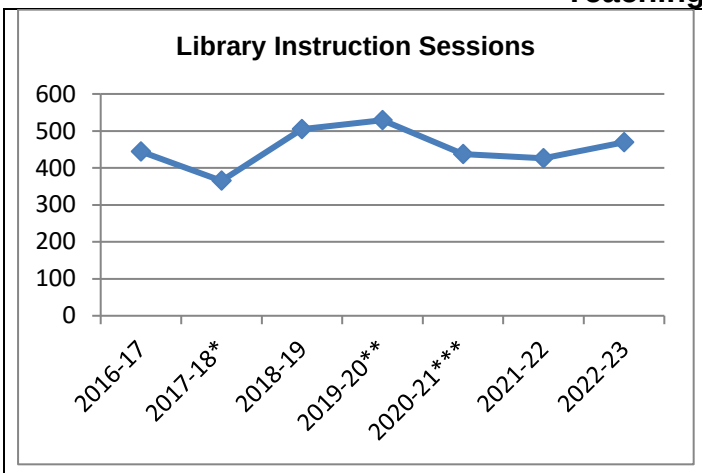


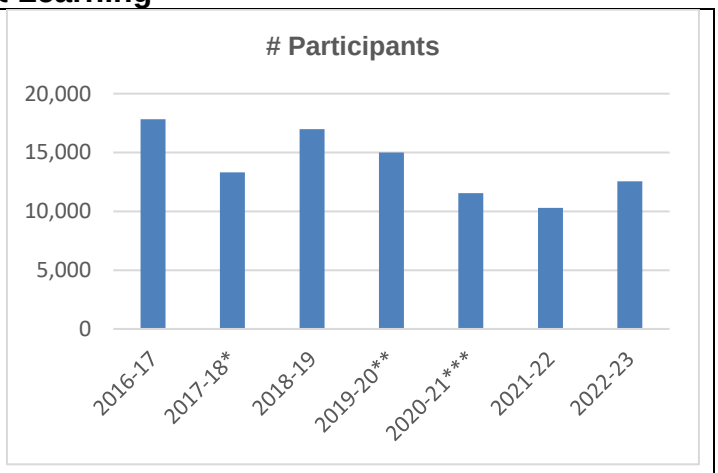






Teaching & Learning





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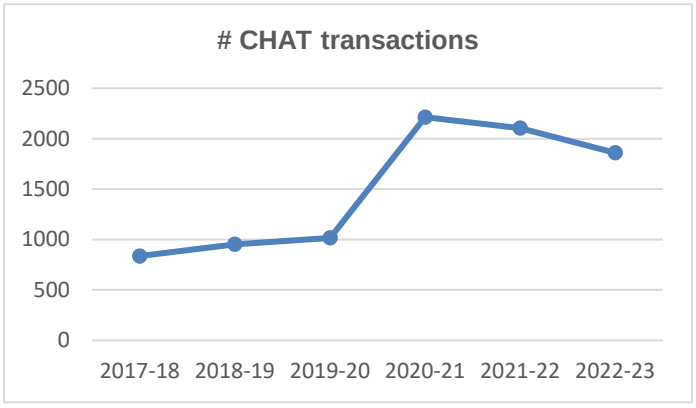

Highlights for 2022-23:

- 469 instruction sessions; 12,542 students attending
- 2274 individual research consultations in 2022-23 for all faculties
- 2685 research help questions answered on site
- 1860 Carleton patron questions answered (CHAT)
- Over 200 instruction videos created with over 31,000 total views

Space

Almost 1 million visits to Library website in a year
Future Learning Lab
Adaptive Technology Centre
Innovative Study areas
Group & graduate study rooms
Book Arts Lab, an experiential learning space

Discussant Report
New Program Review

Name: Hashmat Khan

Program(s) being reviewed: MSc Mineral Exploration and Resource Management (MMERM)

Date of report: August 18, 2025

Your discussant report along with the self-study, external reviewers' report, unit response and implementation plan and Dean's response will all be forwarded to SQAPC for review and consideration. This report is circulated only to SQAPC and is not made public however, it can be subject to FIPPA requests.

Review of self-study (Volume I)

The self-study provides a good rationale for launching the new MMERM, full-cost recovery, course-based online program. The learning outcomes are clearly specified and mapped to the DLEs. Given the asynchronous delivery of the program, the assessment in the courses is planned in a variety of ways: knowledge checks, discussion boards, quizzes, case studies, experiential projects, and a capstone project. MMERM program is envisioned as a Fall-Winter (two term) program which I think presents some challenges (as also noted by the External Reviewers). Overall, I have no concerns to highlight with the self-study.

Review of External Reviewer's Report

The External Reviewer's Report is quite detailed and reflects a thorough review of the proposed program. Based on that, they have made seven recommendations. There are four concerns that cover admissions (especially English language requirement), assessments (AI concerns), course content development, and a succession plan. The reviewers have explicitly noted that maintaining the quality of the courses (and therefore the program) will require resources towards a succession plan.

Review of Unit Response and Implementation Plan

The unit response is in strong agreement with the recommendations, with six being agreed to unconditionally. I found the responses adequate with clear action items to implement the recommendations.

Unit Response and Implementation Plan: Summary of Recommendations

No revisions are required.

External Reviewer Recommendation	Discussant's concern	Discussant Recommendation

Recommendation of program outcome

Recommended to commence

Additional comments

The title of MERM 5006 is “Mineral Exploration, Finance and Economics”. However, from the course description and the description on page 9 on the self-study, it is evident that the course content is about Finance and Accounting topics and not about fundamentals of Economics. My suggestion, therefore, is the consider the course name change to “Mineral Exploration, Finance and Accounting”.

Site Visit Schedule for the New Graduate Programs in Mineral Exploration and Resource Management May 7th, 2025

External Reviewers: Dr. Daniel J. Kontak and Dr. John Francis Hugh Thompson

Internal Reviewer: Dr. Veronic Bezaire, Institute of Biochemistry

All meetings can be accessed at:

https://us06web.zoom.us/j/86326231807?pwd=1BiqCIHn5hN6Bb1OpqOAoSD8Ywxf3s.1

EST	May 7, 2025	(PDT)
9:30-9:45	Meet and Greet Dr. Kontak, Dr. Thompson and Dr. Veronic Bezaire	6:30-6:45
9:45-10:30	Meeting with Dr. Richard Amos, Acting Department Chair of Earth Science.	6:45-7:30
10:30-12:00	Meeting with Dr. James Mungull, Program Lead	7:30-9:00
12:00-1:00	LUNCH	9:00-10:00
1:00-1:30	Meeting with Sheila Thayer, Department and Graduate Administrator	10:00-10:30
1:30-2:15	Meeting with Dr. Dan Siddiqi, Vice Provost Graduate Studies	10:30-11:15
2:15-3:00	BREAK	11:15:12:00
3:00-3:30	Meeting with Dr. Maria DeRosa, Dean, Faculty of Science	12:00-12:30
3:30-4:00	Closing Meeting with Hashmat Khan, Associate Vice-President (Academic Programs and Strategic Initiatives)	12:30-1:00
4:00-4:30	Meeting for External Reviewers to prepare report	1:00-1:30
4:30-4:45	Additional time (only if needed for technical issues)	1:30-1:45

Daniel j. Kontak

Dr. Kontak born and raised in Antigonish, Nova Scotia, attended St. F.X. for his BSc. (Hons) in geology before leaving pursuing graduate studies elsewhere in Canada. This work was in the area of ore deposit research and focused on large scale met allogenic problems, uranium in Labrador (MSc) and granite-hosted Sn-W granites in the Peruvian Andes (PhD); He has continued this broad approach to ore deposit studies for many decades. After a post-doc stint at Memorial University (1985), he moved to Nova Scotia and worked for the provincial survey (1986-2006) on many ore deposit systems (Sn W, Au, Pb-Zn, Ba, aggregates, zeolites) across a very beautiful province. In 2006 he moved to Laurentian University to assume an academic career where he enjoys the Canadian Shield experience in all respects, both during the hot summers and chilly winters.

Education

- Post-doc 1986 - Memorial University, St. John's, NFLD
- Ph.D. 1979-1984 - Queen's University, Kingston, ON
- M.Sc.1976-1979 - University of Alberta, Edmonton, AB
- B.Sc. 1972-1976 - St. Francis Xavier, Antigonish, NS

Academic Appointments

Full Proffessor 2009-present

Associate Professor, Laurentian 2006-2009

Dan's research program aims to fully characterize a variety of magmatic and hydrothermal ore systems using both traditional and novel approaches. This work incorporates field studies supported by a large range of follow-up geochronologic (Re-Os, Ar-Ar, TIMS and LA U-Pb), petrologic and mineral-fluid chemical work that utilizes state-of-the-art analytical facilities at Laurentian and collaborating institutions. The work is financed through a wide variety of granting agencies that include the Federal Government (NSERC DG and CRD grants), Geological Survey of Canada, provincial surveys and many exploration and mining companies.

Dr. John F.H. Thompson

Thompson was the first Wold Family Professor in Environmental Balance for Human Sustainability at Cornell. Thompson has a BA from Oxford University and M.Sc. and Ph.D. degrees from the University of Toronto. In 1982, he joined the BP Minerals group (Rio Tinto) initially in Australia, followed by positions in the UK and Salt Lake. In 1991, Thompson became Director of the Mineral Deposit Research Unit (MDRU) at the University of British Columbia managing exploration-related research for over twenty companies. He returned to industry in 1998 as Chief Geoscientist for Teck, and then Vice President Technology and Development. In the latter role he managed technology and innovation programs and was involved in corporate development including resource and technology-related transactions. He left Teck in 2012 and became the Principal for PetraScience Consultants based in Vancouver, an exploration, development and technology consultancy. Thompson is a Director (past-Chair and founder) of Geoscience BC, a member of the Global Agenda Council on the Future of Mining and Metals with the World Economic Forum, and a board member of Genome BC. He was a co-founder and President of the Canada Mining Innovation Council and President of the Society of Economic Geologists (SEG). He has board and advisory positions with public and private companies and other organizations.

Research Interests

Battery Research and Technology, Carbon Footprint, Climate Change, Earth Resources, Economic Development, Energy, Energy Efficiency, Energy Storage, Environment, Geothermal, Innovation, Metals, Natural Resources, Renewable Energy, Solar Energy, Technology, Water Management, Wind Energy

- Earth System Science
- Geochemistry, Petrology and Volcanology
- Energy, Mineral and Water Resources
- Geophysics and Seismology
- Tectonics and Structural Geology

Teaching Interests

Thompson’s teaching focuses on Earth resources; distribution, availability, responsible mining and, processing, and energy, water and environmental management. He also discusses the use of metals, new technologies and the implications for demand.

Carleton University | Office of the Vice-Provost and Associate Vice-President (Academic)

External Reviewer Report Template – Cyclical Program Review

are to be held anonymous on the report.

Recommendations

The most important part of the report from the point of view of the university will be the recommendations made for program improvement (a minimum of 3 are required). We therefore request that all recommendations be clearly listed under 3 main categories:

- **Weakness:** Remedial action is recommended to strengthen compliance with program quality standards.
- **Concern:** Potential risk to future quality that should be considered.
- **Opportunity:** Recommendation for future enhancements

Program(s) being reviewed:	Mineral Exploration and Resource Management
Date of review:	May 7, 2025
Names and Emails of External Reviewers:	John FH Thompson jfhthompson@gmail.com Daniel Kontak dkontak@laurentian.ca
Date of Report:	May 2025

Program Objectives

- In general – absolutely –and in particular is noted for the inclusiveness of potential future applicants.
- The format – asynchronous, virtual, dominantly instructed/evaluated by contract instructors, full cost recovery – is unusual for geosciences, but not without precedent for other programs (e.g., business), and therefore each part will need to be carefully monitored, assessed and adjusted as necessary to make sure that it meets the institutions missions and plans, and brings credit to Carlton University.

Program Requirements

- Considerable effort and thought have gone into creating a program that meets objective and learning outcomes.
- The essential goal is to give students a strong framework in which to design and implement exploration programs, assess results, and understand opportunities, challenges and risks that may result from these programs. The students will not advance their specialist knowledge in any particular area, but will have the capability to operate effectively across a wide range of activities.
- While lacking the depth of some current graduate programs, the program offers training in areas generally lacking in undergraduate and graduate delivery – mineral resources and

economics, financing, regulatory, ore processing, and more.

- Given the changing demands in exploration, the course will need to adapt frequently to remain current and effective.
- The program is innovative, and highly accessible, but will be challenging to deliver consistently.

Program Requirements for graduate programs only

- The program is designed for delivery in one year, but students who are also working are likely to need at least two years to complete the course. This will require management in terms of numbers and assessment to limit likely bottlenecking as student enrolment overlaps.
- The generalist/framework nature of the course is not suited to undergraduates, and in fact ideal students would probably be a few years out of their undergraduate degree with some industry experience recommended.
- The program is designed for delivery at the graduate level. It does not include a research project but the final course is a capstone that effectively requires research, design, planning, budgeting, and risk assessment.

Assessment of Teaching and Learning

- Assessing students in the asynchronous, online format will be challenging. Currently, the plan includes multiple choice testing as a significant method of assessment, but this can be challenging for students, as well as difficult to determine individual efforts. Similarly, written material may present challenges for global students and will be potentially open to abuse with ChatGPT etc. Considerable thought and care will have to go into the final assessment process and perhaps an oral format might be considered as part of the assessment (note: DK found this to be effective and fair during COVID).
- There is no plan to include live on-line or in person components in the program. It is strongly recommended that at least a one-hour instructor-student interview is included in the program to monitor performance, provide advice and collect real-time feedback on the course.

Admission Requirements

- Effective assessment of applicants will require careful evaluation of global undergraduate programs (which vary greatly) and related institutional grading (which also differs greatly from Canada), and individual performance.
- Assessment will be much easier if the supporting employer documents the record and potential of the student; this may be the case for the majority of applicants. A well-designed template would assist in this matter.
- Use of short personal videos and written statements could help assess applicants.
- Language proficiency is not critical, at least in comparison to in person graduate students who may be involved in teaching. Adapted requirements will be needed. However, comprehension and "translation" of science may be an issue where English is not a 1st language and should be monitored.

Resources

- The course has been largely designed by Prof. Jim Mungall, and the video lectures will be delivered by him with material input from others. Jim's involvement is critical but also a concern

when he decides to step back. The addition of a new faculty member focused on critical minerals is important and could help to maintain the quality of the course in the future.

- Contract instructors will introduce and provide support for the video lectures and will provide the assessment of students. Candidates for the positions are expected to be in Ottawa, potentially from the GSC-NRCan. The quality of the instructors will be important, as well as their ability to adapt to the online format.
- The global and online nature of the course will present many challenges, and the proposed staff management position will play a vital role. Again, this person must be able to handle global challenges – communication, language, culture.
- The potential for elective in-person field trips as part of the program, once established, would be a significant enhancement. In person involvement and collaboration would build cohorts adding to the value of the program and improving performance assessment.

Resources for graduate programs only

- Prof. Jim Mungall has an excellent and relevant research record, and he has also led mineral exploration programs. Jim has been involved with large international companies and has a network of contacts that will support the program, likely provide students, and provide critical feedback.
- Succession planning is essential given the one-person delivery format/management and that Jim is approaching retirement.

Quality and other indicators

- Carlton has a small but strong faculty in the Department of Earth Science, but with the exception of Prof. Jim Mungall, the university does not have a recognized reputation in mineral exploration. Building and marketing the program will be important.
- If faculty renewal presents an opportunity, an additional relevant instructor should be considered.
- A low initial enrolment that is manageable but large enough to ensure it is at least revenue-neutral ensures quality control as it grows and expands internationally.

Additional Comments:

Comments below are the basis for the recommendations that follow:

- **Concern**: Think carefully about numbers – minimum 14, maximum 30-50? How do you manage varying completion rates (which is expected)?
    - E.g., first year ~20-25, 5-10 complete and 10-15 carry over to the second year – how many new students? How is that managed between different courses, and especially the capstone course.
- **Concern:** Admissions – use of videos and written statements
- **Weakness:** QA/QC of admissions and student performance in the asynchronous online setting is challenging – add an interview per semester?
- **Concern:** The program will rely initially on Dr. Jim Mungall who is nearing retirement, thus succession planning is critical to ensure continue success of the program.
- **Opportunity:** Employing high-quality instructors will be vital
- **Concern:** Is the current plan of 2 program components sufficient for the ore-deposit component? Once the syllabi are done this might be revisited.
- **Opportunity:** For Course 4, consider using Ore Body Knowledge as the framework for considering mining and recovery methods, environmental performance etc.
- **Opportunity:** For Course 5, consider the "due diligence" task as a framework for understanding and evaluating resources and reserves, and other critical factors; link to Course 6 – due diligence to full evaluation.
- **Opportunity:** Introduce data science in Course 3, 4, 5 and 7 – as a range of tools; exploration professionals will need to be able to talk to data scientists.

Summary of Recommendations/Program Enhancements

Use the chart below to summarize your overall recommendations for the program and suggested program enhancements. If possible, it would be beneficial to the university for the recommendations to be prioritized.

Recommendation	**Category** *(Weakness, Concern, Opportunity)*
1) Plan the admissions and enrollment process carefully	Weakness/concern
2) Use an oral element for assessment and engagement	Concern/opportunity
3) Build the best instructional team and plan for succession	Concern – this will be the core of the course
4) Balance of course content (e.g. ore deposit knowledge) needs consideration and continual assessment. It is important to develop a full syllabus to see how it	Concern/opportunity

will work and consider testing through a few lectures and/or seeking additional feedback.	
5) Maintain flexibility and adapt to changing industry methodologies and personnel requirements	Opportunity
6) Add an elective field component	Opportunity
7) Build the program-Carleton brand based on quality delivery and industry interaction.	Opportunity

Master's of Mineral Exploration and Resource Management
Unit Response to External Reviewers' Report & Implementation Plan
Programs Being Reviewed: Graduate Programs

Note: This document is forwarded to Senate, the Quality Council and posted on the Vice- Provost's external website.

Introduction & General Comments

Please include any general comments regarding the External Reviewers' Report.

The Department of Earth Sciences was pleased to receive the very positive External Reviewers' report on June 4, 2025. This report was shared with the Director of the new program. We are happy to note that the ER's comments align very closely with our existing plans and priorities, and the implementation of the recommendations is entirely feasible without requiring any significant alterations to existing plans. This document contains both a Unit Response and Implementation Plan, created in consultation with Dr. Maria DeRosa, the Dean of Science, where we provide detailed plans to implement the recommended actions.

For each recommendation one of the following responses must be selected:

Agreed to unconditionally: used when the unit agrees to and is able to take action on the recommendation without further consultation with any other parties internal or external to the unit.
Agreed to if additional resources permit: used when the unit agrees with the recommendation, however action can only be taken if additional resources are made available. Units must describe the resources needed to implement the recommendation and provide an explanation demonstrating how they plan to obtain those resources. In these cases, discussions with the Deans will normally be required and therefore identified as an action item.
Agreed to in principle: used when the unit agrees with the recommendation, however action is dependent on something other than resources. Units must describe these dependencies and determine what actions, if any, will be taken.
Not agreed to: used when the unit does not agree with the recommendation and therefore will not be taking further action. A rationale must be provided to indicate why the unit does not agree (no action should be associated with this response).

Calendar Changes

If any of the action items you intend to implement will result in calendar changes, please describe what those changes will be. To submit a formal calendar change, please do so using the Courseleaf system.

UNIT RESPONSE AND IMPLEMENTATION PLAN **Programs Being Reviewed: Master's of Mineral Exploration and Resource Management** **Prepared by (name/position/unit/date): Dr. James Mungall/Professor, Director of MMERM/ Department of Earth Sciences, June 9, 2025**					
External Reviewer Recommendation & Categorization	**Unit Response:** **1- Agreed to unconditionally** **2- Agreed to if additional resources permit (describe resources)** **3- Agreed to in principle** **4- Not agreed to** **Rationales are required for categories 2, 3 & 4**	**Action Item**	**Owner**	**Timeline**	**Will the action described require calendar changes? (Y or N)**
1. Weakness/Concern: Plan the admissions and enrollment process carefully	*1. Agreed to unconditionally*	*Admissions for this asynchronous, fully online program must allow for the likelihood that many applicants may be graduates of foreign universities where English was not the primary language of study. We will follow "Section 3.6 Proficiency in English" of the Graduate Calendar to ensure an applicant's English proficiency using minimum English proficiency scores (e.g., CAEL, IELTS, TOEFL) for admission into our graduate program.* *The knowledge requirements for admission to the MMERM program follow the knowledge requirements for professional geoscientists (PGO) in Canada. Only candidates whose training would make them eligible for PGO status will be considered for admission to MMERM. To ensure candidates meet this requirement, we will request World Education Service (WES) grade equivalencies. Furthermore, if an applicant does not meet the PGO standard,*	*Director of the MMERM*	*Recruitment will begin late Fall 2025. The standards and approaches will be reviewed after the first applicants start in Fall 2026.*	*Y, if changes to the admissions process occur in the future.*

		we will recommend they complete the requisite courses before acceptance into the program. All candidates will be required to sit for a brief video interview to ensure that the applicant is the person who has written the application and that their English aptitude is sufficient. Standards and approaches will be reviewed after the first round of applications.			
2. Concern/Opportunity: Use an oral element for assessment and engagement.	*1. Agreed to unconditionally*	*In light of the burgeoning and increasingly sophisticated uses of Artificial Intelligence (AI) in education and in the workplace, we recognize the inevitability that AI will be widely used by students. In response, we will teach students about the legitimate use of AI as a tool and will educate them on the hazards of inaccuracy in AI products and the absolute necessity of rewriting and fact-checking all AI products based on a thorough understanding of primary sources. To ensure that students have intellectual ownership of their work, we will require oral/video defenses of all major written assignments. Fact-checking and cross-checking of cited references will be key to the detection of unedited and unexamined AI products in student submissions.* *Oral assessments will build students' sense of connection to the human element in this asynchronous online program and give students opportunities to ask questions and engage more fully with instructors.*	*Director of the MMERM, Term-appointed teaching faculty*	*Oral assessments will begin in the middle of the first semester (Fall 2026) and will be conducted at least twice each semester, for each student in each course.*	*N*

3. Concern: Build the best instructional team and plan for succession	*1. Agreed to unconditionally*	*New hires of the term-appointed teaching stream faculty members and of the full-time program manager will be conducted through the normal search process.* *A succession plan is predicated on the assumption that the program will be successful and self-sustaining. In these circumstances, if the Director retires or unable to fill their role, the Dean of Science, in consultation with the Chair of the Department of Earth Sciences would support the immediate replacement of the current Director in a timely fashion to ensure continuity of service. Potentially, the newly hired Professor of Critical Minerals and Structural Geology (appointed July 1, 2025) could be placed in charge of the MMERM while a successor is being found.*	*The Director of the MMERM* *Chair of Earth Sciences* *Dean of Science*	*Recruiting for the term-appointed teaching stream faculty members and the program manager will begin in late 2025 with the aim of having them appointed by July 1, 2026.*	*N*
4. Concern/Opportunity: Balance of course content (e.g. ore deposit knowledge) needs consideration and continual assessment. It is important to develop a full syllabus to see how it will work and consider testing through a few lectures and/or seeking additional feedback.	*1. Agreed to unconditionally*	*Course syllabi already exist as one-page summaries of key topics. These have been reviewed by industry professionals for scope and relevance, and the feedback has been used to make ongoing adaptations.* *Once course materials have been prepared, each course will be reviewed in its entirety (all presentation materials, readings, and assessments) at a high level by industry leaders. Then each course will be beta-tested by small teams of industry personnel including both seasoned professionals and junior-level staff, a cohort similar to the target audience. Feedback will be used to modify course content,*	*The Director of the MMERM*	*Courses are being developed in a staggered plan culminating in completion of all courses in draft form by early winter 2026. Beta testing is currently planned to*	*Y, if changes to course content affect the course descriptions.*

		assessment tools, and overall structure as necessary.		*begin in mid-summer 2025.*	
5. Opportunity: Maintain flexibility and adapt to changing industry methodologies and personnel requirements.	*1. Agreed to unconditionally*	*Feedback from students and their employers will be used to guide ongoing adjustments to the scope and delivery of course materials. Questionnaires will be issued to all students after each course and to all graduating students.* The proposed program budget includes annual expenditures in support of revising existing courses. If there is a strong need for a new course (e.g., adding an elective field component), and enrolment permits, changes to the program will occur through Carleton University's usual processes. *The courses are being designed in close collaboration with TLS staff to ensure that they are "future-proofed". This means that, for example, lecture videos do not contain direct references to assessments, dates, etc., so that these course elements can easily be changed from year to year without necessitating rerecording of entire courses. All video lectures are recorded using Camtasia, which enables each individual slide to be rerecorded separately and easily spliced back into the deck.* *Transcripts are being created for all lecture materials, so that course instructors will be able*	*The Director of the MMERM*	*Annual review of each course will begin after each semester is completed, starting January 2027.*	*Y, possibly if new courses are needed*

		to rerecord videos in whole or in part, as necessary.			
6. Opportunity: Add an elective field component.	*2.* Agreed to if additional resources permit	*The program, as currently envisioned, is asynchronous and entirely online, which precludes any field or residential component. However, we recognize the tremendous cohort-building potential of group activities like field schools or lab courses, which also offer invaluable hands-on learning experiences. Offering field programs or a short residential program on campus at Carleton University for citizens of numerous countries would represent a major planning challenge but could be very rewarding. If financial and personnel constraints permit, we will investigate the creation of optional field or residential courses. For example, field trips to key mining districts or a 2-week on-campus course with emphasis on hands-on examination of rare rock collections could offer unparalleled enrichment to the program.*	*The Director of the MMERM*	*We will start exploring this possibility in Fall 2027.*	*Y, if new courses are added or changes to existing courses are made.*
7. Opportunity: Build the program-Carleton brand based on quality delivery and industry interaction.	*1. Agreed to unconditionally*	*The Earth Sciences Department is planning an ambitious program of growth in teaching and research over the coming years, and the MMERM program is key to promoting global recognition of Carleton University as a center of Critical Minerals teaching and research on the*	*The Director of the MMERM*	*Growth and improvement will be supported continuously, with annual internal*	*N*

		global stage, in alignment with provincial and federal needs. *Close interaction with TLS at every stage ensures that the program is produced to the highest standard of quality of content and delivery. The ongoing activity of close interaction and feedback with industry will ensure continuing relevance and utility of the program to the students and their employers.*		*program reviews and debriefs.*	

Master's of Mineral Exploration and Resource Management
Dean's Response
Program Being Reviewed: Graduate Program
Date: June 30, 2025
Version: 1

Instruction
The table below has been pre-populated with the external reviewer recommendations. Please complete the Dean's Response column by providing a separate response to each of the external reviewers' recommendations, as required by the QAF (5.3.1).

Dean's Response **Programs Being Reviewed: Master's of Mineral Exploration and Resource Management** **Prepared by: Dr. Maria DeRosa, Dean of the Faculty of Science**	
External Reviewer Recommendation & Categorization	**Dean's response** **A response is required for each recommendation listed.**
1. **Weakness/Concern**: Plan the admissions and enrollment process carefully	*I wholeheartedly support utilizing the planned admission process, as outlined in the unit's response.*
2. **Concern/Opportunity**: Use an oral element for assessment and engagement.	*I fully support the use of oral examination elements to support teaching and learning, with particular attention to AI tools, in order to increase student engagement with the material and the instructors.*
3. **Concern:** Build the best instructional team and plan for succession	*I fully support the hiring plan that has been proposed for this new program, and I will advocate for the corresponding pre-approved resources through the yearly budget allocation process concomitant with the program reaching its expected enrolment targets.*
4. **Concern/Opportunity**: Balance of course content (e.g. ore deposit knowledge) needs consideration and continual assessment. It is important to develop a full syllabus to see how it will work and consider testing through a few lectures and/or seeking additional feedback.	*I support the Department of Earth Sciences' plan to consult with industry and beta test the courses before the program starts.*

5. **Opportunity:** Maintain flexibility and adapt to changing industry methodologies and personnel requirements.	*"Futureproofing" this program is very important given the rapidly evolving landscape of Mineral Exploration and Resource Management. I support the modular approach based on user and industry feedback to ensure the course material is adapted to current trends in Mineral Exploration and Resource Management. As in Recommendation Three, I will advocate for the corresponding pre-approved resources through the yearly budget allocation process concomitant with the program reaching its expected enrolment targets.*
6. **Opportunity:** Add an elective field component.	*The possibility of adding an elective field component and increasing the hands-on learning experiences of our students is of great interest to the Faculty of Science. Such an addition aligns with our Strategic Integrated Plan: "To enhance student employability outcomes, we will: Increase experiential learning opportunities (e.g., research, industry, museums, government, hospitals, NGOs, or community members)". We will explore the opportunity to increase the enriching and practical aspects of the planned program while maintaining the benefits of online delivery that accommodates many different types of learners.*
7. **Opportunity:** Build the program-Carleton brand based on quality delivery and industry interaction.	*In alignment with our Strategic Integration Plan, I support any activity wherein we "dedicate resources for outreach activities to foster partnerships in research, and training with government, hospitals, NGO's, industry, embassies, museums and others." Mineral Exploration and Resource Management is a key component to a green and prosperous future in Ontario and Canada, and so I support the Department of Earth Sciences' intention to utilize this program and the connections built during its creation to grow in this area.*

New Program Proposal

Date Submitted: 09/08/25 1:45 pm

Viewing: MMERM : M. MERM Mineral Exploration and Resource Management

Last edit: 09/08/25 1:45 pm

Last modified by: ethanhermer

Changes proposed by: ethanhermer

In Workflow

1. **ERTH ChairDir GR**
2. **SCI Dean**
3. **SCI GFCC**
4. **SCI JFBoard**
5. **PRE SCCASP**
6. SCCASP
7. SQAPC
8. Senate
9. CalEditor

Approval Path

1. 09/08/25 4:37 pm Fred Gaidies (fredgaidies): Approved for ERTH ChairDir GR
2. 09/09/25 2:15 pm Matthias Neufang (matthiasneufang): Approved for SCI Dean
3. 09/09/25 2:18 pm Matthias Neufang (matthiasneufang): Approved for SCI GFCC
4. 09/09/25 2:19 pm Matthias Neufang (matthiasneufang): Approved for SCI JFBoard

Effective Date	2026-27
Workflow	majormod
Program Code	MMERM
Level	Graduate
Faculty	Faculty of Science
Academic Unit	Department of Earth Sciences
Degree	
Title	M. MERM Mineral Exploration and Resource Management

Program Requirements

M. Mineral Exploration and Resource Management (4.0 credits)

Requirements:

1. 4.0 credits in:		4.0
MERM 5001 [0.0]	Magmatic Mineral Systems	
MERM 5002 [0.0]	Fluid-Dominated Mineral Systems	
MERM 5003 [0.0]	Exploration Methods	
MERM 5004 [0.0]	Mining, Beneficiation, and Waste Management	
MERM 5005 [0.0]	Mineral Resource Estimation	
MERM 5006 [0.0]	Mineral Exploration Finance and Economics	
MERM 5007 [0.0]	Best Practice in Mineral Exploration	
MERM 5008 [0.0]	Program Management and Logistics	
Total Credits		4.0

New Resources	No New Resources
Summary	This is the course sequence for the new Masters in Mineral Exploration and Resource Management professional masters.
Rationale	The Master's in Mineral Exploration and Resource Management has been created to the meet the need for people who can ethically run complex mineral exploration and mineral resource management programs.
Transition/Implementation	This program is set to start in Fall 2026.
Program reviewer comments	

Key: 2331

New Program Proposal

Date Submitted: 09/08/25 1:46 pm

Viewing: TBD-2330 : R-ADM-Program-Master's in Mineral Exploration and Resource Management

Last edit: 09/08/25 1:46 pm

Last modified by: ethanhermer

Changes proposed by: ethanhermer

In Workflow

1. **ERTH ChairDir GR**
2. **SCI Dean**
3. **SCI GFCC**
4. **SCI JFBoard**
5. **PRE SCCASP**
6. SCCASP
7. SQAPC
8. Senate
9. CalEditor

Approval Path

1. 09/08/25 4:37 pm Fred Gaidies (fredgaidies): Approved for ERTH ChairDir GR
2. 09/09/25 2:15 pm Matthias Neufang (matthiasneufang): Approved for SCI Dean
3. 09/09/25 2:18 pm Matthias Neufang (matthiasneufang): Approved for SCI GFCC
4. 09/09/25 2:20 pm Matthias Neufang (matthiasneufang): Approved for SCI JFBoard

Effective Date	2026-27
Workflow	majormod
Program Code	TBD-2330
Level	Graduate
Faculty	Faculty of Science
Academic Unit	Department of Earth Sciences
Degree	
Title	R-ADM-Program-Master's in Mineral Exploration and Resource Management

Program Requirements

Admissions Information

The normal requirement for admission to the program is an Honours B.Sc. degree, with at least high Honours standing, in geology or a related discipline, and which meets the Professional Geoscientists of Ontario knowledge requirements for an undergraduate degree. Applicants judged to be generally acceptable but deficient in some aspect of preparation may be asked to complete coursework in addition to the program requirements.

New Resources	No New Resources
Summary	The admission requirements are being added as it is a part of the new Masters in Mineral Exploration and Resource Management professional masters.
Rationale	The admission requirements are being added as it is a part of the new Masters in Mineral Exploration and Resource Management professional masters.
Transition/Implementation	This will have no effect on current students as it is a new program.
Program reviewer comments	

Key: 2330

Associated Minors

Course Code	Course Name	Action
MERM 5001	Magmatic Mineral Systems	Added
MERM 5002	Fluid-Dominated Mineral Systems	Added
MERM 5003	Exploration Methods	Added
MERM 5004	Mining, Beneficiation, and Waste Management	Added
MERM 5005	Mineral Resource Estimation	Added
MERM 5006	Mineral Exploration Finance and Economics	Added
MERM 5007	Best Practice in Mineral Exploration	Added
MERM 5008	Program Management and Logistics	Added

Carleton University

Office of the Vice-Provost and
Associate Vice-President (Academic)

Institutional Quality Assurance Process

Master's in Mineral Exploration and Resource Management

New Program Approval Template

(Volume II)

March 2025

Contents

PERSONAL INFORMATION

James E Mungall

Professor

Department of Earth Sciences, Carleton University

DEGREES

1987	BSc	Geology	University of Waterloo
1989	MSc	Geology	McGill University
1993	PhD	Geology	McGill University

EMPLOYMENT HISTORY

2017-present	Professor	Department of Earth Sciences, Carleton University
2023-present	President and CEO	Bronzite Exploration Corp
2015-2017	Professor	Department of Earth Sciences, University of Toronto
2009-2015	Associate Professor	Department of Earth Sciences, University of Toronto
2008-2009	Chief Geologist	Noront Resources Ltd, Toronto
2004-2008	Associate Professor	Department of Earth Sciences, University of Toronto
1999-2004	Assistant Professor	Department of Earth Sciences, University of Toronto

PUBLICATIONS

Life-time summary:	Books or monographs authored	0
	Books edited	1
	Chapters in books	5

Papers in peer-reviewed journals	85 (42 since 2018)
Abstracts or papers presented	> 100

Chapters in books:

Mungall, J.E., 2015. Physical controls of nucleation, growth and migration of vapor bubbles in partially molten cumulates. Chapter 8 (invited) in the book Layered Intrusions, Eds. B Charlier, O. Namur, R. Latypov and C. Tegner, Springer p. 331-378.

Mungall, J.E., 2014. Magmatic Ores *in* Treatise on Geochemistry, Vol 13: Geochemistry of Mineral Deposits. (revised from the chapter published on-line only in 2007).

Mungall, J.E., Harvey, J.D., Balch, S.J., *Azar, B.*, Atkinson, J., Hamilton, M.A., 2010. Eagle's Nest: a magmatic Ni-Cu-PGE deposit in the James Bay Lowlands, Ontario, Canada. SEG Spec. Pub. 15, 539-557.

Balch, S.J., Mungall, J.E., Niemi, J., 2010. Present and future geophysical methods for Ni-Cu-PGE exploration: Lessons from McFaulds Lake, Northern Ontario. SEG Spec. Pub. 15, 559-572.

Papers in peer-reviewed journals:

Smith, W.D., Fay, L., Mungall, J.E., Shahabi Far M., Djon L., 2025. Olivine compositions reveal an andesitic parent magme for the Archean palladium-mineralized Lac Des Iles Complex of Ontario, Canada. Mineralium Deposita 60, 375-399.

Smith, W.D., Albrechtsen, B., Maier, W.D., Mungall, J.E., 2024. Petrogenesis and Ni-Cu-(PGE) prospectivity of the Mt Ayliff Complex in the Karoo Igneous Province: new insights from the Ingeli and Horseshoe lobes. Journal of the Geological Society of London Special Issue.

Li, Z., Mungall, J.E., Georgiatou, A.A., Wang, H., Dong, Y., Chen, L., Chu, F., Li, X., 2024. Magmatic sulfide oxidation links crustal PGE mobilization and hydrothermal mineralization. Geochimica et Cosmochimica Acta 378, 114-126.

Shawwa, N.A., *McLoughlin-Coleman, T.R.*, Babechuk, M.G., Shahabi Far, M., Mungall, J.E., Rainbird, R.H., 2024. Earth's oldest terrestrial red beds as direct evidence for the Great Oxidation Event ca. 2.3 Ga. Precambrian Research 409, 107-123.

Boucher, B.M., *Robb, S.J.,* Hanley, J.J., Kerr, M.J., Mungall, J.E., 2023. Platinum-group elements (PGE) in the New Afton alkalic Cu-Au porphyry deposit, Canadian Cordillera: I: Relationships between PGE, accessory metals and sulfur isotopes in pyrite. Frontiers in Earth Science 10.3389/feart.2023.8

Robb, S.J., Boucher, B.M., Mungall, J.E., Hanley, J.J., 2023. Platinum-group elements (PGE) in the New Afton alkalic Cu-Au porphyry deposit, Canadian Cordillera, II: PGE distribution and models for the hydrothermal coprecipitation of Co-Ni-Pd-Pt in pyrite. Frontiers in Earth Science 10.3389/feart.2023.8

Bacha, R.R.B., Mungall, J.E., Ernst, R.E., 2023. Petrogenesis of the Katangan mafic rocks, Zambia and the Democratic Republic of Congo: Insights from lithogeochemistry, LIP classification, and petrological modeling. Results in Geochemistry doi.org/10.1016/j.ringeo.2023.100027.12.

Wang, Y., Mungall, J.E., Liu, J., 2023. Osmium isotope heterogeneity of the upper mantle: Evidence from the Bay of Islands ophiolite complex. Journal of Geophysical Research - Solid Earth doi 10.1029/2023JB026789

Augustin, C.T., Mungall, J.E., Schutesky, M.E., Chamberlain, K.R., Ernst, R., Garcia, V.B., 2023. U-Pb in-situ SIMS baddeleyite and zircon dates and thermodynamic modeling of the Mangabal Complex: Indications of asthenospheric mantle influence in the formation of layered intrusions of the Brasilia orogen. Gondwana Research 122, 93-111.

Zhang, X, Maciag, B.J., Brenan, J.M., Mungall, J.E., 2022. Experimental study of the partitioning of some platinum group elements (Pd and Ir) between orthopyroxene and melt. Geochimica et Cosmochimica Acta 339, 127-138.

Augustin, C., Mungall, J.M., Schutesky, M.E., et al., 2022. Petrological and geochemical characteristics of the mafic-ultramafic Americano do Brasil Complex, central Brazil, and the implications for its genesis. Ore Geology Reviews 150, 105126.

Jenkins, M.C., Mungall, J.E., Zientek, M.L., et al., 2022. The geochemical and textural transition between the Reef Package and its hanging wall, Stillwater Complex, Montana, USA. Journal of Petrology 63(7).

Li, Y.Z., Mungall, J.E., 2022. Chalcophile element heterogeneity in Ni-Cu-(Platinum Group Element) orebodies of the Raglan Horizon in Cape Smith Belt: Implications for ore-forming processes. Economic Geology 117, 1131-1148.

Laudadio, A.B., Schetselaar, E.M., Mungall, J.E., Houle, M.G., 2022. 3D modeling of the Esker Intrusive Complex, Ring of Fire Intrusive Suite, McFaulds Lake greenstone belt, Superior Province: Implication for mineral exploration. Ore Geology Reviews article 104866

Yao, Z-S, Mungall, J.E., 2022. Magnetite layer formation in the Bushveld Complex of South Africa. Nature Communications 13(1), 1-11.

Yao, Z-S., Mungall, J.E., 2022. Transport and deposition of immiscible sulfide liquid during lateral magma flow. Earth Science Reviews article 103964.

Yao, Z-S, 2021, Mungall, JE. Kinetic controls on the sulphide mineralization of komatiite-associated Ni-Cu-(PGE) deposits. Geochimica et Cosmochimica Acta 305, 185-211.

Yao, Z-S, Mungall, JE *Jenkins, CM*. (2021). The Rustenburg Layered Suite formed as a stack of mush with transient magma chambers. Nature Communications doi 10.1038/s41467-020-20778-w.

Jenkins, M.C, Mungall, J.E., Zientek, M.L., Costin, G., *Yao, Z-S.*, 2021. Origin of the J-M Reef and Lower Banded Series, Stillwater Complex, Montana, USA. Precambrian Research 367, article 106457.

Bacha, R.F.B., Toledo, C.L.B., Silva, A.M., Mungall, J.E., 2021. Alkali element mobility as a vector for gold mineralization: An example from Central Brazil. Geochemistry 81(4) article 125808.

Waterton, P., Mungall, J.E., Pearson, D.G., 2021. The komatiite-mantle platinum-group element paradox. Geochimica et Cosmochimica Acta 313, 214-242.

Yao, Z-S, 2021. Mungall, JE. Linking the Siberian flood basalts and giant Ni-Cu-PGE sulfide deposits at Norilsk. Journal of Geophysical Research: Solid Earth. http://dx.doi.org/10.1029/2020JB020823 In Press

Yao, Z-S, Mungall, JE *Jenkins, CM*. (2021). The Rustenburg Layered Suite formed as a stack of mush with transient magma chambers. Nature Communications. http://dx.doi.org/10.1038/s41467-020-20778-w

Robb S.J., Mungall J.E. (2020). Conductive vs convective thermal modeling of the Bushveld Complex: time to decide. A reply to the comment by Cawthorn on Robb and Mungall

(2020) [Earth Planet. Sci. Lett. 534, 116084]. Earth and Planetary Science Letters. 549: 116477.

Robb, S.J., Mungall, J.E., 2020. Testing emplacement models for the Rustenburg Layered Suite of the Bushveld Complex with numerical heat-flow models and plagioclase geospeedometry. Earth and Planetary Science Letters 534, Article 116084, 11 pp.

Wang, Z., Jin, Z.J., Mungall, J.E., Xiao, X., 2020. Transport of Ni-Cu sulfide liquid and silicate melt in partially molten peridotite. Earth and Planetary Science Letters 536, Article 116162, 13 pp.

Brown, J.L., *Dyer, S.*, Mungall, J.E., Ellis, D.J., Christy, A.G., 2020. High pressure Cu-Fe-S phase equilibria: some experimental and theoretical constraints on sulfides in subduction zones and the lithospheric mantle. Journal of Petrology doi.org/10.1093/petrology/egaa043

Mungall, J.E., *Jenkins, M.C., Robb, S.J., Yao, Z.,* Brenan, J.M., 2020. Upgrading of magmatic sulfides, revisited. Economic Geology 115, 1827-1833.

Kastek, N., Mungall, J.E., Ernst, R.E., Cousens, B.L., 2020. Roberts Lake syncline magmas: a proposed extension of the Cape Smith belt. Lithos 366, 10554.

Jenkins, M.C., Mungall, J.E., Zientek, M.L., Holick, P., Butak, K., 2020. Composition of the J-M Reef, Stillwater Complex, MT, USA. Economic Geology 115, 1799-1826.

Yao, Z., Mungall, J.E., Qin, K., 2020, A preliminary model for the migration of sulfide droplets in a magmatic conduit and the significance of volatiles. Journal of Petrology 60, egaa005.

Yao, Z., Mungall, J.E., 2020. Flotation mechanism of sulphide melt on vapour bubbles in partially molten magmatic systems. Earth and Planetary Science Letters 542, 116298.

Brenan, J.M., Mungall, J.E., Bennet, N.R., 2019. Abundance of highly siderophile elements in lunar basalts controlled by iron sulfide melt. Nature Geoscience 12, 701-706.

Jenkins, M.C., Mungall, J.E., 2018. Genesis of the peridotite zone, Stillwater Complex, Montana, USA. Journal of Petrology 59, 2157-2190.

Barnes, S.J., Mungall, J.E., 2018. Blade-shaped dikes and nickel sulfide deposits: a model for the emplacement of ore-bearing small intrusions. Economic Geology 113, 789-798.

Mungall, J.E., Brenan, J.M., *Long, K., Smythe, D.,* Naslund, H.R., 2018. Immiscible shoshonitic and Fe-P-oxide melts preserved in unconsolidated tephra at El Laco volcano, Chile. Geology, 255-258.

Yao, Z., Qin, K., Mungall, J.E., 2018. Tectonic controls on Ni and Cu contents of primary mantle-derived magmas. American Mineralogist 103, 1545-1567.

Le Vaillant, M., Barnes, S.J., Mungall, J.E., Mungall, E.L., 2017. Role of degassing of the Noril'sk nickel deposits in the Permian-Triassic mass extinction event. PNAS 114, 2485-2490.

Mungall, J.E., Kamo, S., McQuade, S., 2016. U-Pb geochronology documents out-of-sequence emplacement of ultramafic layers, Bushveld Igneous Complex, South Africa. Nature Communications DOI: 10.1038/ncomms13385.

Barnes, S.J., Mungall, J.E., Le Vaillant, M., Godel, B., Lesher, C.M., Holwell, D., Lightfoot, P.C., Krivolutskaya, N., Wei, B., 2016. Sulfide-silicate textures in magmatic Ni-Cu-PGE sulfide ore deposits. 1. Disseminated and net-textured ores. American Mineralogist 102, 473-506. (invited contribution).

Liu, Y., Mungall, J.E., Ames, D.E., 2016. Hydrothermal alteration and local enrichment of platinum group elements in the Tootoo and Mequillon magmatic sulfide deposits, South Raglan Trend, Cape Smith Belt, New Quebec. Economic Geology 111, 467-485.

Kamenetsky, V.S., Park, J.-W., Mungall, J.E., Pushkarev, E.V., Ivanov, A.V., Kamenetsky, M.B., Yaxley, G.M., 2015. Crystallization of platinum-group elements from silicate melts: evidence from Cr-spinel-hosted inclusions in volcanic rocks. Geology 43, 903-906.

Barnes, S.J., Mungall, J.E., Maier, W.D., 2015. Platinum group elements in mantle melts and mantle samples. Lithos 232, 395-417.

Aulbach, S., Mungall, J.E., Pearson, D.G., 2015. Distribution and processing of highly siderophile elements in cratonic mantle lithosphere. Higher Siderophile and Strongly Chalcophile Elements in High Temperature Geochemistry and Cosmochemistry, Reviews in Geochemistry and Mineralogy, 81, 239-304.

Sciortino, M., Mungall, J.E., 2015. Generation of high-Ni sulfide and alloy phases during serpentinization of the Dumont Dunite, Quebec. Economic Geology, 110, 733-761.

Mungall, J.E., Brenan, J.M., Godel, B., Barnes, S.J., Gaillard, F., 2015. Transport of metals and sulphur in magmas by flotation of sulphide melt on vapour bubbles. Nature Geoscience DOI: 10.1038/NGEO2373.

Mungall, J.E., Brenan, J.M. 2014. Partitioning of platinum-group elements and Au between sulfide liquid and basalt and the origins of mantle-crust fractionation of the chalcophile elements. Geochimica et Cosmochimica Acta 125, 265-289.

Guo, K., Mungall, J.E., Smith, R.S. 2013. The ratio of B-field and dB/dt time constants from time-domain electromagnetic data: a new tool for estimating size and conductivity of mineral deposits. Exploration Geophysics, 44, 238-244.

Botcharnikov, R.E., Holz, F., Mungall, J.E., Beermann, O., Linnen, R., Garbe-Schonberg, D. 2013. Behavior of gold in a magma at sulfide-sulfate transition: revisited. The American Mineralogist, 98, 1459-1464.

Bi, X., Ruizhong, H., Hanley, J.J., Mungall, J.E., Jiantang, P., Linbo, S., Kaixing, W., Yan, S., Hongli, L., and Xiaoyan, H., 2009. Crystallization conditions (T, P, fO2) from mineral chemistry of Cu- and Au- mineralized alkaline intrusions in the Red River-Jinshajiang alkaline igneous belt, western Yunan Province, China. Mineralogy and Petrology, 96, 43-58.

Chung, H.-Y. and Mungall, J.E., 2009: Physical constraints on the migration of immiscible fluids through partially molten silicates, with special reference to magmatic sulfide ores. Earth and Planetary Science Letters, 286, 14–22.

Mungall, J.E., and Naldrett, A.J., 2008: Ore deposits of the platinum-group elements Elements, 4, 253–258.

Finnigan, C.S., Brenan, J.M., Mungall, J.E., and McDonough, W.F. 2008: Experiments and models bearing on the role of chromite as a collector of platinum group minerals by local reduction. Journal of Petrology, 49, 1647–1665.

Hanley, J.J., Mungall, J.E., Pettke, T., and Spooner, E.T.C. 2008: Fluid and halide melt inclusions of magmatic origin in the ultramafic and lower banded series, Stillwater Complex, Montana, USA: Journal of Petrology, 49, 1133–1160.

Mungall, J.E., 2007: Crystallization of magmatic sulfide ores: An empirical model and application to Sudbury ores. Geochimica et Cosmochimica Acta, 71, 2809–2819.

Mungall, J.E., 2007: Crustal contamination of picritic magmas during transport through dikes: the Expo Intrusive Suite, Cape Smith fold belt, New Quebec. Journal of Petrology, 48, 1021–1039.

Mungall, J.E., *Hanley, J.J*., Arndt, N.T., and *Debecdelievre, A.*, 2006: Evidence from meimechites and other low-degree mantle melts for redox controls on mantle-crust fractionation of platinum-group elements. Proceedings of the National Academy of Sciences, 103, 12695–12700.

Mungall, J.E., Andrews, D.R., Cabri, L., Sylvester, P.J., and Tubrett, M., 2005: Partitioning of Cu, Ni, Au and Platinum Group Elements between monosulfide solid solution and sulfide melt under controlled oxygen and sulfur fugacities. Geochimica et Cosmochimica Acta, 69, 4349–4360.

Mungall, J.E. and *Su, S*., 2005: Interfacial tension between magmatic sulfide and silicate liquids: constraints on kinetics of sulfide liquation and sulfide migration through silicate rocks. Earth and Planetary Science Letters, 234, 135–149.

Mungall, J.E., 2005: Magmatic geochemistry of the platinum-group elements *In* Exploration for Platinum-Group Element Deposits, (J.E. Mungall, Ed.), Mineralogical Association of Canada Short Course Vol. 35, 1–34.

Hanley, J.J., Mungall, J.E., Pettke, T., Bray, C.J., and Spooner, E.T.C., 2005: Ore metal redistribution by hydrocarbon-brine and hydrocarbon-halide melt mixtures, North Range footwall of the Sudbury Igneous Complex, Ontario, Canada. Mineralium Deposita, Vol. 40, 237–256.

Hanley, J.J., Pettke, T., Mungall, J.E., and Spooner, E.T.C., 2005: Investigations of the behaviour and distribution of platinum and gold in silicate melt-brine mixtures at 1.5 kbar, 600 to 800ºC using synthetic fluid inclusions methods: a laser ablation ICP-MS pilot study. Geochimica et Cosmochimica Acta, 69, 2593–2611.

McDonald, A.M., Cabri, L.J., Stanley, C.J., Rudashevsky, N.S., Poirier, G., Ross, K.C., Mungall, J.E., Durham, B.R., and Rudashevsky, V.N., 2005: Ungavaite, Pd_4Sb_3, a new intermetallic mineral from the Mesamax Northwest deposit, Ungava region, Québec, Canada: description and genetic implications. Canadian Mineralogist, 43, 1735–1744.

Cabri, L.J., McDonald, A.M., Stanley, C.J., Rudashevsky, N.S., Poirier, G., Durham, B.R., Mungall, J.E., and Rudashevsky, V.N., 2005: Naldrettite, Pd_2Sb, a new intermetallic mineral from the Mesamax Northwest deposit, Ungava region, Québec, Canada. Mineralogical Magazine, 69, 839–847.

Mungall, J.E., 2004: Magmatic Ores. Invited contribution to The Encyclopedia of Geology, Elsevier Press. 637-645.

Hanley, J.J., Mungall, J.E., Bray, C.J., and Spooner, E.T.C., 2004: The origin of bulk rock and water-soluble Cl and Br enrichments in footwall Cu-Ni-PGE ore-hosting Sudbury Breccia in the Fraser Copper Zone, Strathcona Embayment, Sudbury, Ontario, Canada; Canadian Mineralogist, 42, 1777–1798.**]**

Mungall, J.E., Ames, D.E., *Hanley, J.J*., 2004: Geochemical evidence from the Sudbury Structure for crustal redistribution during large bolide impacts. Nature 429, 546–548.

Giuli, G., Paris, E., Mungall, J.E., Romano, C. and Dingwell, D.B., 2004: V oxidation state and coordination number in synthetic silicate glasses by XAS. The American Mineralogist 89, p. 1640–1646.

Mungall, J.E., & *Hanley, J.J.*, 2004: Origins of outliers of the Huronian Supergroup within the Sudbury Structure. Journal of Geology, 112, 59–70.

Hanley, J.J., & Mungall, J.E., 2003: Chlorine enrichment and hydrous alteration of Sudbury Breccia hosting footwall Cu-Ni-PGE mineralization at the Fraser Mine, Sudbury, Ontario, Canada. The Canadian Mineralogist, 41, 857–881.

Mungall, J.E., & Brenan, J., 2003: Experimental evidence for the chalcophile behaviour of the halogens. The Canadian Mineralogist 41, 207–220.

Mungall, J.E., 2002: Roasting the mantle: slab melting and the genesis of major Au and Au-rich Cu deposits. Geology 30, 915–918.

Mungall, J.E., 2002: Kinetic Controls on the Partitioning of Trace Elements Between Silicate and Sulphide Liquids. Journal of Petrology, 43, 749–768.

Mungall, J.E. 2002: Late-stage sulfide liquid mobility in the Main Mass of the Sudbury Igneous Complex; examples from the Victor Deep, McCreedy East and Trillabelle deposits. Economic Geology, 97, 1563–1576.

Mungall, J.E., 2002: Empirical models relating viscosity and tracer diffusion in magmatic silicate melts. Geochimica et Cosmochimica Acta, 66, 125–143.

Mungall, J.E., & Dingwell, D.B., 1999: Chemical diffusivities of 18 trace elements in granitoid melts. Geochimica et Cosmochimica Acta, 63, 2599–2610.

Mungall, J.E., Romano, C., & Dingwell, D.B., 1998: Multicomponent diffusion in the molten system K_2O-Na_2O-Al_2O_3-SiO_2-H_2O. American Mineralogist, 83, 685–699.

Mungall, J.E., & Dingwell, D.B., 1997: Actinide Diffusion in a Haplogranitic Melt: Effects of Temperature, Water Content and Pressure. Geochimica et Cosmochimica Acta, 61, 2237–2246.

Mungall, J.E., Bagdassarov, N., Romano, C., & Dingwell, D.B., 1996: Numerical modelling of stress generation and microfracturing of vesicle walls in glassy rocks. Journal of Volcanology and Geothermal Research, 73, 33–46.

Mungall, J.E., & Martin, R.F., 1996: Extreme differentiation of peralkaline rhyolite, Terceira, Azores: a modern analogue for Strange Lake, Labrador? The Canadian Mineralogist, 34, 769–777.

Romano, C., Mungall, J.E., Bagdassarov, N., & Dingwell, D.B., 1996: Tensile strengths of vesicular glasses using synthetic fluid inclusions. American Mineralogist, 81, 1148–1154.

Mungall, J.E., & Martin, R.F., 1995: Petrogenesis of basalt-comendite and basalt-pantellerite suites, Terceira, Azores, and some implications for the origin of ocean-island rhyolites. Contributions to Mineralogy and Petrology 119, 43–55.

Mungall, J.E.:, 1994 Interfacial tension in miscible two-fluid systems with linear viscoelastic rheology. Physical Review Letters 73, 288–291.

Mungall, J.E. & Martin, R.F.:, 1994 Severe leaching alteration of trachytic glass without devitrification, Terceira, Azores. Geochimica et Cosmochimica Acta 58, 75–83.

Mungall, J.E., Frape, S.K., Gibson, I.L. & Kamineni, D.C., 1987: Rare earth abundances in host granitic rocks and fracture-filling gypsum associated with saline groundwaters from a deep bore-hole, Atikokan, Ontario. Canadian Mineralogist 25, 539–543.

COURSES TAUGHT IN PAST 7 YEARS

Undergraduate (at Carleton University)

2024	ERTH3204 Mineral Deposits	0.5 credit
2024	ERTH4303 Resources of the Earth	0.5 credit
2024	ERTH3806 Structural Geology	0.5 credit
2023	ERTH3204 Mineral Deposits	0.5 credit
2023	ERTH4303 Resources of the Earth	0.5 credit
2023	ERTH4209 Mineral Exploration Field Geology	0.5 credit
2022	ERTH3204 Mineral Deposits	0.5 credit
2022	ERTH4303 Resources of the Earth	0.5 credit
2020	ERTH3204 Mineral Deposits	0.5 credit
2020	ERTH4303 Resources of the Earth	0.5 credit
2019	ERTH3209 Mineral Exploration Field Geology	0.5 credit

2019	ERTH3204 Mineral Deposits	0.5 credit
2019	ERTH4303 Resources of the Earth	0.5 credit
2018	ERTH3209 Mineral Exploration Field Geology	0.5 credit
2018	ERTH3204 Mineral Deposits	0.5 credit

Graduate (at Carleton University)

2019	ERTH5202 Advanced Igneous Petrology	0.5 credit

GRADUATE STUDENTS SUPERVISED

Lifetime summary:	Master's thesis	23 completed
	Doctoral	7 completed 1 in progress
	Post-doctoral	4 completed 1 in progress

Students supervised:

Karim El Ghawi, PhD thesis, Geometallurgy of the crust: 2025-present

Thomas McLoughlin-Coleman, MSc thesis, Application of machine learning and pyrite geochemistry to the identification of paleoplacer gold sources at Pardo, Ontario, Canada: 2022-2024

Karim El Ghawi, MSc thesis, Application of FactSage to model the compositional variability of the Ni-Cu-PGE mineralization at the Main Zone of the Tamarack Intrusive Complex: 2023-2024

Claudia Augustin, PhD thesis (cotutelle with U Brasilia), Age and petrogenesis of the Americano do Brasil Intrusion, Brazil: 2020-2023

Rafael Bacha, PhD thesis (co-supervised), Influence of LIP magmatism on the Zambian Cu Belt: 2019-2023

Yingzhou Li, PhD thesis, Origins and Significance of Globular Sulfide Ores at Raglan and Norilsk: 2019-2023

Nabil Shawwa, PhD thesis (co-supervised), Timing of the Great Oxygenation Event in the Huronian Supergroup, Ontario: 2018-2024

Chris Jenkins, PhD thesis, Petrology and Petrogenesis of Mineralization in the Banded Series of the Stillwater Complex, Montana: 2017-2022

Sam Robb, MSc thesis, PGE Mineralization at the New Afton Porphyry Deposit, BC: 2018-2020

Alex Laudadio, MSc thesis (co-supervised), 3D Geological Modelling of the Double Eagle – Black Thor Intrusive Complexes, McFaulds Lake Greenstone Belt, Ontario, Canada: 2016-2019.

Konrad Chrzastowski, MSc thesis, Contact Relations of the J-M Reef, Stillwater Complex, Montana: 2016-2017

Chris Jenkins, MSc thesis, Genesis of the Peridotite Zone, Stillwater Complex, Montana: 2016-2017.

Stephanie Skitch, MSc research project, Distribution and Genesis of Gold Mineralization in the Pine Tree-Josephine deposit of the Mother Lode District, California: 2014-2015

Kirill Kompaniets, MSc thesis, A reversal in the crystallization sequence in the Sudbury Igneous Complex: 2014-2015

Mariea Kartick, MSc thesis, Sources of Elevated Ra Emissions from U Mine Tailings in the Elliot Lake District, Ontario: 2014-2015

Volodymyr Andrienko, MSc thesis, Base Metal Sulfide Mineralogy of the Upper Critical Zone, Rustenburg Layered Suite, South Africa: 2014-2015

Quincy Poon, MSc thesis, Thermogravitational Convection in Silicate Magmas: 2014-2015

Julien Mailloux, MSc thesis, The Genesis of Pd Mineralization at the Mesamax Deposit, Nunavik Ni, New Quebec: 2015-2015

Shawn Vandekerkhove, MSc thesis, Interfacial Energies of Sulfide-Silicate Systems: 2014-2014

Yakun Liu, MSc thesis, Remobilization of Pd by Metamorphic Fluids at the Mequillon and Tootoo Deposits, Nunavik, Quebec: 2013-2014

Michelle Sciortino, MSc thesis, Generation of High-Ni Sulfide and Alloy Phases During Serpentinization of the Dumont Dunite, Quebec: 2012-2014

Caitlin Beland, MSc thesis, The Magmatic-Hydrothermal Transition in Peralkaline Rhyolite Magma, Terceira, Azores: 2012-2013ff

Christopher White. PhD thesis, Low-sulfide PGE-Ni-Cu mineralization from five prospects within the footwall of the Sudbury Igneous Complex. 2005-2012.

Bronwyn Azar. MSc thesis, The Blackbird Chromitite Deposit, Ontario. 09/2009 to 12/2010

Laura Karrei. MSc thesis, Platinum-group element geochemistry in arc and back-arc magmas, Tonga Arc. 09/2007 to 08/2008.

Angela Escolme. MSc thesis, Controls on Platinum-Group Element Geochemistry in Sea-Floor lavas from Explorer Ridge and the Manus Basin. MPhil at Manchester University, UK (I was principal supervisor) 06/06 to 04/07.

William Randall, MSc thesis, U-Pb Geochronology of the Expo Igneous Suite, Cape Smith Belt and the Kyak Bay Intrusion, New Quebec Orogen: Implications for the Tectonic Evolution of the Northeastern Trans-Hudson Orogen. 09/2004 to 06/2005

Ellen Choi, MSc thesis, Multicomponent Diffusion in the System K_2O-Na_2O-CaO-FeO-MgO-TiO_2-P_2O_5-Al_2O_3-SiO_2. 09/2001 to 09/2004

Jacob Hanley, MSc thesis. Halogen pathfinders to footwall Cu-PGE deposits, Strathcona Mine, Sudbury. 09/1999 to 10/2001

Clayton Capes, MSc thesis. A Petrological Investigation of the Copper Cliff Embayment Structure Sudbury Ontario. 09/1999 to 09/2001.

EXTERNAL RESEARCH FUNDING

2024-2030 Creating the next generation of mineral deposits, NSERC DG, 5 years at $80,350 per year

2023-2025 Primary controls on Cu sulfide mineralogy in Mid-Continent Rift ore deposits, NRCAN TGI grant, 2 years at $50,000 per year

2021-2024 Targeted U-Pb dating of mafic-ultramafic intrusions, NSERC Alliance Grant, 4 years at $50,000 per year (received 25%)

2022-2024 Petrogenesis and structure of the Tamarack Ni-Cu-Co-PGE deposit, NSERC Alliance Grant, 2 years at $84,267 per year

2020-2022 Origins of Chonoliths, NSERC Alliance Grant, 4 years at $50,000 per year, postdoctoral research in origins of mineral deposits

2019-2020 Investigating mineralizing processes in layered mafic intrusions using SEM-based microtextural and chemical analysis, CFI JELF grant, 1 year at $60,000 per year, funds to purchase research equipment

2019-2020 Investigating mineralizing processes in layered mafic intrusions using SEM-based microtextural and chemical analysis, ORF grant, 1 year at $60,000 per year, funds to purchase research equipment

2019-2019 PGE distribution in the New Afton Cu-Au porphyry deposit, NSERC Engage grant, 1 year at $25,000 per year, funds to support analytical work as part of a MSc thesis project

2018-2023 Developing the full potential of the large igneous province (LIP) record for multi-commodity, multi-scale exploration targeting, NSERC CRD grant, 5 years at $200,000 per year (Co-PI with Richard Ernst and Brian Cousens)

2018-2023 Origins of layers in layered intrusions, NSERC DG, 5 years at $36,000 per year, operating funds

2018-2021 Platinum-group element composition of the Tethyan depleted mantle reservoir, China University of Geosciences Open Research Project, 3 years at ~$40,000 per year

2018-2020 Transport and deposition of sulfide liquid: vectors to ore accumulations, Natural Resources Canada Targeted Geosciences Initiative V grant, 2 years at $45,000 per year

2018-2020 Origin of chromitites in the Ring of Fire Part II: trace element fingerprinting of contaminants, Natural Resources Canada Targeted Geosciences Initiative V grant, 2 years at $39,000 per year (co-PI with James Brenan)

2016-2018 Experimental investigation of the role of magma contamination in the genesis of chromitite in the Ring of Fire, Ontario, Natural Resources Canada Targeted Geosciences Initiative IV grant, 2 years at $41,000 per year (co-PI with James Brenan)

2014-2015 Origin of Pd-rich mineralization at Mesamax and Expo Ungava deposits, Nunavik Ni, Canadian Royalties Inc, 1 year at $15,000 per year

2014-2015 Sources of elevated Ra emissions from U mine tailings in the Elliot Lake district, Canadian Nuclear Safety Commission, 1 year at $15,000 per year

2009-2018 Field and experimental constraints on petrogenesis of Cr-Ni-PGE deposits, NSERC DG 8 years at $40,000 per year

2008-2017 Norman Keevil Chair in Ore Genesis, Research Chair, University of Toronto, $10,000 per year