

Geology

Faculty

Chair and professor

C.M. Leshner, B.Sc., M.A. (Indiana), Ph.D.
(Western Australia)

Professors

H.L. Gibson, B.Sc. (Queen's), M.Sc. Ph.D.
(Carleton), MERC director
B.S. Kamber, B.Sc., M.Sc., Ph.D. (Bern), Canada
Research Chair in Precambrian Geology
D.G.F. Long, B.Sc. (Leicester), M.Sc., Ph.D.
(Western Ontario), M.Sc. and Ph.D.
(*graduate coordinator until December 31, 2006*)
A.M. McDonald, BSc (Toronto), M.Sc., Ph.D.
(Carleton)
D.A.B. Pearson, B.Sc. (Durham), Ph.D.
(London) DIC

Associate professors

E.A. Gallie, B.Sc. (Queen's), Ph.D. (UBC),
ENES program coordinator
B. Lafrance, BSc (Montréal), PhD (New
Brunswick) (*graduate coordinator starting
January 1, 2007*)
S.J. Piercey, B.Sc. M.Sc. (Memorial), Ph.D.
(UBC), Applied M.Sc. program coordinator
G.A. Spiers, B.Sc. (Waikato), M.Sc., Ph.D.
(Alberta), Research Chair in Environmental
Monitoring

Assistant professors

P. Jugo, B.Sc. (V. Central de Venezuela), M.Sc.
(Maryland), Ph.D. (Alberta)
D.K. Tinkham, B.Sc. (Rocky Mountain), M.Sc.
(Illinois), Ph.D. (Alabama)
E.C. Turner, B.A., B.Sc. (Toronto), Ph.D.
(Queen's), B.A. Earth Science and B.Sc.
Geology program coordinator

Affiliate professor

P.C. Thurston, A.B. (Rutgers), M.A. (Bryn
Mawr), Ph.D. (Western Ontario)

Emeritus professors

A.E. Beswick, B.Sc., Ph.D. (London) DIC
P. Copper, B.A., M.A. (Saskatchewan), Ph.D.
(London), DIC
J.F. Davies, B.Sc., M.Sc. (Manitoba), Ph.D.
(Toronto)
R.S. James, B.Sc., M.Sc. (McMaster), Ph.D.
(Manchester)
R.R. Keays, B.Sc. (Queen's), Ph.D. (McMaster)
D.H. Rousell, B.Sc. (Manitoba), M.Sc. (UBC),
Ph.D. (Manitoba)
R.E. Whitehead, B.Sc. (Mount Allison), Ph.D.
(New Brunswick)

Adjunct professors

D. Ames, B.Sc. (Waterloo), M.Sc., Ph.D.
(Carleton)
N. Arndt, B.Sc. (Hons) (Australian National),
Ph.D. (Toronto)
J.A. Ayer, B.Sc., M.Sc. (Carleton), Ph.D.
(Ottawa)
A. Bailes, B.Sc. (McGill), M.Sc., Ph.D.
(Manitoba)
P.J. Barnett, B.Sc. (Brock), M.Sc., Ph.D.
(Waterloo)
G. Beakhouse, B.Sc., M.Sc. (Manitoba), Ph.D.
(McMaster)
A. Cheburkin, B.Sc. (Kiev), Ph.D. (Ukraine)
M.J. Easton, B.Sc. (Western Ontario), M.Sc.
(Hawaii), Ph.D. (Memorial)
C.E.G. Farrow, B.Sc. (Mount Allison), M.Sc.
(Acadia), Ph.D. (Carleton)
J.S. Fedorowich, B.A. (Toronto), M.Sc., Ph.D.
(Saskatchewan)
J.M. Franklin, B.Sc., M.Sc. (Carleton), Ph.D.
(Western Ontario)
A.G. Galley, BSc (Carleton), MSc (Western
Ontario), PhD (Carleton)
J.P. Golithly, B.Sc. Ph.D. (McGill)
R.A.F. Grieve, B.Sc. (Aberdeen), M.Sc. Ph.D.
(Toronto)
M.D. Hannington, B.Sc. (Queen's), M.Sc. Ph.D.
(Toronto)

T.E. Lane, B.A. (Franklin and Marshall), M.Sc. (Dalhousie), Ph.D. (Memorial)
 P.C. Lightfoot, B.A. (Oxon), M.Sc. (Toronto), Ph.D. (Open)
 W.A. Morris, B.Sc. (Leeds), Ph.D. (Open)
 E.F. Pattison, B.Sc., M.Sc. (McGill)
 J.M. Peter, B.Sc. (UBC), M.Sc., Ph.D. (Toronto)
 F. Santaguida, B.Sc. (McMaster), M.Sc. (Waterloo), Ph.D. (Carleton)
 G.M. Stott, B.Sc. (McMaster), M.Sc. (Waterloo), Ph.D. (Toronto)
 O. Tavchandjian, B.Sc., M.Sc. (d'Aix-Marseille), Ph.D. (UQAC)

Research scientists

S. Hem, B.Sc., M.Sc., Ph.D. (Copenhagen)
 K. Ross, B.Sc., M.Sc. (Lakehead)

Technologists

J.M. Byron, B.Sc. (Acadia), GIS Dipl. (COGS)
 W. Desjardins, Dipl. (Cambrian College)
 N. Tardif, B.Sc., M.Sc. (Laurentian)

Secretaries

Edda Bozzato, Dipl. (Marymount College)
 Roxanne Mehes, Dipl. (Collège André-Grasset), Dipl. (Collège Notre-Dame)

Mineral Exploration Research Centre

MERC is a semi-autonomous research centre within the Department of Earth Sciences, and is an affiliated centre of the Mining Innovation, Remediation, and Applied Research Corporation (MIRARCO). The objectives of MERC are to:

- 1) initiate, promote and conduct independent and collaborative university-government-industry research on mineral deposits and Precambrian geology worldwide
- 2) pursue a fundamental understanding of mineral deposits and their geological settings
- 3) aid the Canadian mining industry in the discovery of ore deposits
- 4) train geoscientists in mineral exploration research techniques
- 5) raise awareness of the importance of mineral exploration research for regional and national economic development

The functions of MERC are to:

- 1) undertake fundamental and applied research on mineral deposits and Precambrian geology
- 2) characterize mineral deposits and their host rocks, country rocks, and alteration haloes at regional, district, and local scales using modern geological, geophysical, and geochemical methods
- 3) develop geological, geophysical, and geochemical tools to aid industry in area selection, district selection, and deposit location
- 4) develop improved geological and genetic models for mineral deposits in order to better understand their origin and distribution
- 5) communicate research findings to industry, government, and the scientific community
- 6) contribute to the training of academic and industry researchers and students through teaching programs in the Department of Earth Sciences and through workshops and short courses
- 7) administer and manage mineral exploration research programs involving government, industry, and academic partners
- 8) provide geological, geophysical, mineralogical, and geochemical services to government and the mineral industry

Program

Laurentian University is located in one of the most richly mineralized areas of Precambrian rocks in the world and the Department of Earth Sciences (DES) is ideally located to support both field and laboratory-based teaching and research in the areas of mineral deposits and Precambrian geology. The department offers a thesis-based Ph.D. in Mineral Deposits and Precambrian Geology, a thesis-based M.Sc. in Geology, and a coursework-based Applied M.Sc. in Mineral Exploration. Students interested in developing field skills may apply to participate in the joint Laurentian-OGS M.Sc. Mapping School Program. The department, along with MERC, the Centre for Environmental Monitoring (CEM), the

Solid Phase Section of Laurentian's Central Analytical Facility, the Ontario Geological Survey, the Ontario Geoscience Laboratories, the Ontario Mines Library, and the Ministry of Northern Development and Mines are located in the Willet Green Miller Mineral and Mining Research Centre (WGMC) on the Laurentian University campus. The proximity to world-class ore deposits at Sudbury (Ni-Cu-PGE), Kidd Creek (Cu-Zn), Timmins (Au), Rouyn-Noranda (Cu-Zn), and Val d'Or (Au) permits a level of field-based education and research in ore deposits that is not easily duplicated anywhere else in the world. The close interaction of MERC and DES with major national and international mining companies (e.g., BHP-Billiton-WMC, Cameco, Falconbridge, GoldCorp, Inco, Outokumpu, Placer Dome, Teck-Cominco) and numerous local junior exploration companies provides collaborative research projects that provide our students with unparalleled opportunities to obtain hands-on training in mineral exploration. MERC and DES researchers are currently working in Australia, Brazil, China, Mexico, Morocco, Oman, Turkey, and the United States, as well as in most Canadian provinces and territories. The department supervises the Solid Phase Section of Laurentian's Central Analytical Facility, which houses several analytical electron microscopes and X-ray diffractometers. It is a partner in the CEM Analytical Centre for the Environmental Sciences (ACCESS), which houses AAS, ICP-AES, and IPC-MS instrumentation, and is in the process of building a state-of-the-art laser ablation ICP-MS analytical laboratory. The department has a special access agreement with the Ontario Geoscience Laboratories, which contain a comprehensive range of other electron optical, X-ray diffraction, X-ray fluorescence, X-ray emission, and mass spectrometric analytical equipment essential to conducting fundamental research in the earth sciences.

Program requirements

Ph.D. in Mineral Deposits and Precambrian Geology

The Ph.D. program requires the completion of six one-term graduate level course equivalents beyond the B.Sc. or four one-term graduate-level courses beyond the M.Sc. In either case, one of the courses shall be the Ph.D. Graduate Seminar (GEOL 6007). In addition, candidates must prepare a Ph.D. research proposal within 9 months of registration, must pass an oral Ph.D. qualifying examination within 12 (full-time students) or 18 (part-time students) months of registration, and must successfully defend a Ph.D. Thesis (GEOL 6000). Admission requirements: Applicants for admission to the Ph.D. program must normally possess a master's degree or equivalent in Geoscience from a recognized university with a minimum average grade of B+. Applicants must provide evidence of suitable educational background and potential for advanced research in their discipline. Letters from referees, professional experience, and publication records are additional criteria that may be taken into consideration for admission. Students with B.Sc. Honours degrees will not normally be admitted directly into the Ph.D. program; M.Sc. students wishing to transfer to the Ph.D. program without completing an M.Sc. thesis must first obtain a recommendation from their M.Sc. Advisory Committee. The department evaluates each application on a case-by-case basis, taking into account the performance of the student in graduate courses and research. Residency requirements: A minimum of two full academic terms (fall and/or winter) of full-time residence is required for all Ph.D. students within their first two years of study. The minimum period of study is two years (full-time) for candidates holding a M.Sc. degree or three years (full-time) for candidates entering the program with a B.Sc. Honours degree.

M.Sc. in Geology – Thesis-based option

The M.Sc. program normally consists of four one-term GEOL graduate courses, plus a thesis (GEOL 5000). The department may recommend that in individual cases, other suitable fourth-year undergraduate courses may be taken in addition to the normal graduate load. Admission requirements: B.Sc. Honours degree with a minimum B average.

M.Sc. in Geology – Mineral exploration option

The Applied M.Sc. in Mineral Exploration degree is designed for industry geologists who wish to upgrade their skills. The program involves six 2-week course modules (listed below, no options) and an Applied Research Project (GEOL 5055). The courses are normally offered three per year (September, December and April) on a two-year cycle; students may enter the program at any time. The courses are taught by members of the Department of Earth Sciences, MERC researchers and outside experts. The scope and topic of the applied research project will be determined in consultation with the faculty supervisor and will focus on a problem of interest to the candidate's employer, typically in one of their active exploration or mining areas. Required courses:

- GEOL 5055 Applied research project
- GEOL 5307 Structure, tectonics and mineral exploration*
- GEOL 5326 Mineral exploration in volcanic terrains*
- GEOL 5606 Exploration for magmatic ore deposits
- GEOL 5607 Exploration for hydrothermal ore deposits
- GEOL 5806 Exploration geochemistry
- GEOL 5956 Exploration geophysics

* *field-based modules*

Admission requirements

Entrance to the Applied M.Sc. in Mineral Exploration program is restricted to geoscientists holding a B.Sc. Honours degree in the earth

sciences (minimum B average) with at least two years of industrial or equivalent experience. Admission is competitive and applicants will be evaluated on the same criteria as the thesis-based option (marks, references and evaluation by faculty in the program). Enrolment and residency requirements: Students in the Applied M.Sc. in Mineral Exploration program who are employed in the mineral exploration industry and maintain continuous enrolment are considered full-time students and will pay normal full-time graduate registration fees. Students who do not take the courses on a continuous basis will be classified as part-time.

Laurentian-OGS Mapping School Option

Geological mapping is a critical and essential component of many graduate research projects. In order to train students in regional mapping and to promote collaborative research activities, the Department of Earth Sciences and the Ontario Geological Survey have developed a mapping school program option within the regular thesis-based M.Sc. and Ph.D. degrees in which highly-qualified applicants are co-supervised by OGS geoscientists (many of whom are adjunct professors in the department) and hired by the OGS for a minimum of three months to work on projects of mutual interest containing a significant field component. As senior field assistants, the candidates will have access to all of the computer map production facilities required to carry out their mapping and will be expected to contribute to maps and texts for OGS Open File Reports. Access to and acquisition of data from the Ontario Geoscience Laboratories can also be expected to contribute to the database for the laboratory component of the thesis project. Admission to this program is highly competitive; applicants interested in this option should advise the graduate coordinator when they apply for admission and apply for summer employment with the OGS well before the deadline, which is normally at the end of February.

Faculty research

Faculty research interests and specialties are listed below and at: www.laurentian.ca/geology

Gallie, E.A., Hyperspectral remote sensing of minerals, rocks, sulphide ore grade, and oil sand characteristics; use of remote sensing for land cover change; remote sensing of water quality.

Gibson, H.L., Physical volcanology and igneous geochemistry; VMS and hydrothermal ore deposits.

Jugo, P., Igneous geology, petrology and geochemistry.

Kamber, B., Precambrian geology, isotope and trace element geochemistry, geochronology

LaFrance, B., Structural geology and ore deposits; gold deposits, microstructures and deformational processes.

Leshner, C.M., Geology and genesis of magmatic Ni-Cu-(PGE) sulfide deposits; geochemistry and alteration of volcanic rocks associated with massive Cu-Zn-Pb sulphide deposits and mesothermal gold deposits; physical volcanology, geochemistry, and petrogenesis of komatiites.

Long, D.G.F., Precambrian sedimentology, stratigraphy and basin analysis; fluvial and marine processes; mixed carbonate – siliciclastic storm-dominated sequences; molar-tooth carbonates; placer gold, uranium, and industrial minerals.

McDonald, A.M., Mineralogy of alkaline rocks, crystal chemistry, crystallography.

Pearson, D.A.B., Environmental studies and science communication.

Piercy, S.J., Exploration and igneous geochemistry, geology of Phanerozoic and Archean terrains, architecture and crust-mantle evolution of orogenic belts.

Spier, G.A., Clay mineralogy, pedology, environmental and low-temperature geochemistry, applications of atomic spectroscopy.

Tinkham, D.K., Metamorphic petrology, geochronology, structural and thermal evolution of orogenic belts.

Turner, E.C., Precambrian and Paleozoic carbonate sedimentology, stratigraphy, and paleontology; microbial paleobiology; carbonate-hosted base metal deposits.

Thurston, P.C., Igneous geochemistry, evolution and structure of Archean greenstone belts, and Archean ore deposits.

Course descriptions

GEOL 5000 E – M.Sc. Thesis cr 6

GEOL 5006 E – Research Techniques in Geology

This course is designed to train students at the graduate level in a wide variety of techniques commonly used to collect standard types of data used in geological research. These techniques include x-ray diffraction; X-ray fluorescence; wet chemical techniques for dissolving silicate rock materials; atomic absorption spectrophotometry; H₂O and CO₂ analysis; U-stage optical techniques; and methods of storing, retrieving and analyzing data using the department's interactive computer terminal. Other techniques to be added as they become available. In the lecture portion of this course, the theoretical basis for each technique will be discussed. Practical applications of each technique to geological problems will be strongly emphasized. Students will be required to show competence in each of the techniques to successfully complete the course. cr 3

GEOL 5007 E – Research Seminar in Geology

Students will present four seminars, only one of which may be on a topic in a field of research directly related to their thesis. Topics will be chosen by the student in consultation with their thesis supervisor(s). Students are expected to attend all seminars. Lecturers in this course will address all aspects of seminar preparation and presentation at a standard appropriate for professional meetings. One meeting per week during the fall and winter terms, normally for four terms or upon thesis submission. cr 3

GEOL 5055 E – Applied Research Project

This course is required for and limited to students enrolled in the coursework master's option in Geology. Students will register for the course each semester that they are enrolled in the program. They will select a research topic in consultation with a faculty advisor during the first course module, prepare a research proposal for evaluation at the second course module, present short seminars during successive course modules, and submit the results of their research in a written format. It is expected that full-time students will complete the research project course within two and one-half years after the date of initial enrolment. cr 6

GEOL 5107 E – Advanced Mineralogy

A lecture-seminar course on the structure, crystal chemistry, phase equilibria, and natural occurrences of the more common rock-forming minerals. Prerequisite to the course is an adequate undergraduate background in mineralogy, igneous and metamorphic petrology, and economic geology. cr 3

GEOL 5206 E – Topics in Igneous Petrology

This is a lecture-seminar course covering selected topics in igneous petrogenesis. Students will also undertake a major term project selected in consultation with the professor. cr 3

GEOL 5207 E – Topics in Metamorphic Geology

This course covers selected topics in metamorphic petrology and geochemistry. Current periodical literature will normally form the basis of discussion topics. Lectures, student seminars and field excursions are included. cr 3

GEOL 5216 E – Advanced Sedimentology

Physical and chemical processes of the sedimentary cycle; various continental and marine sedimentary environments; facies relationships as controlled by tectonism. Other topics considered to suit individual needs. cr 3

GEOL 5217 E – Applied Sedimentology

Use of facies models in the interpretation of the structural, stratigraphic and sedimentary framework of depositional basins. Application of sedimentary facies models to hydrocarbon exploration and exploitation. cr 3

GEOL 5246 E Carbonate Facies

This lecture-seminar course addresses the diversity of carbonate lithofacies and their spatial and temporal distribution. Topics span the full geographic range of carbonate depositional environments, including peritidal, shallow-marine, reefal, slope, pelagic and terrestrial (lacustrine, tufa, travertine, speleothemic carbonates) settings, and associated evaporitic lithofacies. The evolution of carbonate depositional systems is traced through time, following the geochemical evolution of the atmosphere/hydrosphere and the evolutionary addition of new biological groups to the carbonate-sediment-generating system (lec 3, sem 3, cr 3).

GEOL 5306 E – Structural Controls on Ore Deposits

A lecture-seminar course on strain and kinematics of shear zones and transpression zones, the development of vein-fracture systems, stress and fluid pressure cycling during ore genesis, and deformation and recrystallization processes in sulphide minerals. Structural controls on the development of mineral deposits will be emphasized. Other topics tailored to individual student's research needs will be considered. cr 3

GEOL 5307 E – Structure, Tectonics, and Mineral Exploration

This course will address the tectonic and structural controls on the localization and genesis of mineral deposits. It will examine regional tectonic settings, regional structural controls, and local structural controls, using the lode Au deposits in Northern Ontario as a case study. The course is normally given in a field trip mode and will include evening lectures and field/underground mapping exercises. All field costs will be borne by the student. cr 3

GEOL 5317 E - Topics in Applied Remote Sensing

Topics covered in this course will be selected from applications of remote sensing to geological, land cover and water quality mapping. cr 3

GEOL 5326 E – Mineral Exploration in Volcanic Terrains

This course will focus on: a) the products and deposits formed by volcanic eruptions; b) eruptive processes and styles; c) mechanisms of emplacement, and d) landforms produced. Special emphasis will be placed on mineralisation and alteration processes associated with hydrothermal systems in both submarine and subaerial environments and the application of information gained from these systems to exploration. The course is normally given during a 10-12 day field trip. All field costs to be borne by the student. cr 3

GEOL 5406 E – Paleocology of Ancient Environments

The application of paleoecological principles and theory to the analysis of ancient environments. The distribution of major ecosystems in time and space: paleobiogeography of the Phanerozoic. Terrestrial paleoecosystems: fossil faunas and floras of upland to lowland environments, equatorial and polar latitudes; lacustrine and fluvial settings. Coastal paleoenvironments: estuaries, deltas, supratidal and intratidal settings. Marine paleoenvironments: shelf settings, siliciclastic and carbonate, the slope, reefs. The deep sea and its fossil record: refugia during mass extinctions. cr 3

GEOL 5407 E – Precambrian and Paleozoic Paleontology

This lecture-seminar course covers selected topics in the early evolution of life. Special emphasis is placed on the appearance, taphonomy, evolution and utility of prokaryotic organisms as recorded in Precambrian and Phanerozoic microbialites and organic-walled microfossils, the early fossil record of protists and algae, fossil evidence of the Precambrian-

Phanerozoic transition, and selected aspects of Paleozoic marine invertebrate paleontology. (lec 3, Sem/lab 3) cr 3

GEOL 5416 E – Global Change: The Geologic Record

This course will examine the long-term record of global change as reflected in sedimentary rocks, fossil faunas and floras and low-temperature isotope geochemistry. Topics to be considered will include: major changes in biogeochemical cycling processes of carbon, phosphorus, nitrogen, and sulphur through geologic time; lithosphere-ocean-atmosphere interactions; sedimentary suites as paleoclimatic keys; siliciclastics, tillites, paleosols, carbonates, evaporites, laterites, phosphorites, coals; sedimentary processes related to global change: e.g. sea level changes, storm events, climate cycles; fossils as paleoclimatic keys: reefs and reef organisms, stromatolites, coralline fossils, shelly fossils, paleobotany and palynology; plate tectonic models and mountain-building as forcing mechanisms for climatic change, extraterrestrial forcing (e.g. Milankovic cycles, impacts, etc.). cr 3

GEOL 5606 E – Exploration for Magmatic Ore Deposits

This course will focus on the geology and petrogenesis of magmatic ore deposits. Deposit types will include Ni-Cu-PGE sulphide, chromite, magnetite and ilmenite deposits. Emphasis will be placed on the processes responsible for their formation and the features pertinent to exploration. cr 3

GEOL 5607 E – Exploration for Hydrothermal Ore Deposits

This course will focus on the geology, alteration and origin of hydrothermal ore deposits. Deposit types will include epithermal and mesothermal precious metal, porphyry Cu and Cu-Au, and VMS deposits. Emphasis will be placed on the processes responsible for their formation, the recognition of alteration halos, and the features pertinent to exploration. cr 3

GEOL 5806 E – Exploration Geochemistry

This course will address the principles and methods of geochemical exploration, including planning, sampling, geochemical analysis, data handling and interpretation. It will include case histories of stratiform PGE deposits in layered intrusions, magmatic Fe-Ni-Cu-(PGE) sulphide deposits in ultramafic lavas, porphyry Cu deposits, volcanic-associated Cu-Zn-(Pb) deposits, Archean lode gold deposits, sedimentary-exhalative Pb-Zn-Cu deposits, and diamond exploration. cr 3

GEOL 5906 E – Topics in Shield Geology

The scope of this course includes concepts of Precambrian crustal evolution; the synthesis of wide-ranging geological data in modeling the evolution of Precambrian cratons, as well as discussion of the most recent field work in the Canadian Shield, especially in Ontario. cr 3

GEOL 5956 E - Exploration Geophysics

This course will focus on the application of magnetic, gravity and electrical techniques in mineral exploration, including remote sensing, image processing and geographic information system (GIS) management. cr 3

GEOL 6000 E – Ph.D. Thesis cr 6

GEOL 6007 E – Ph.D. Research Seminar in Geology

Full-time students registered in the Ph.D. program will present a one-hour seminar, once per term, to a maximum of 6 terms (2 per year). Topics will be chosen in consultation with their thesis supervisor and will alternate between thesis-related material and topics of active, current interest in the earth sciences. Part-time Ph.D. students must present one seminar in each year of their Ph.D. studies to a maximum of 6 seminars. cr 3

GEOL 6506 – Directed Studies in Geology

An independent study course on a topic in geology that is not covered in another graduate course in the department. cr 3