DOCTORATE IN PHILOSOPHY
EARTH SCIENCES
SPECIALIZATION
IN CHEMICAL AND
ENVIRONMENTAL
TOXICOLOGY

Summary
- Degree offered: Doctorate in Philosophy (PhD)
- Registration status option: Full-time
- Language of instruction: English
- Primary program: PhD in Earth Sciences
- Collaborative specialization: Chemical and Environmental Toxicology
- Program option (expected duration of the program):
  - with thesis (16 full-time terms; 64 consecutive months)
- Academic units: Faculty of Science (http://science.uottawa.ca), Department of Earth and Environmental Sciences (http://science.uottawa.ca/earth), Ottawa-Carleton Geoscience Centre (http://science.uottawa.ca/earth/ocgc-institute).

Program Description
Ottawa-Carleton Geoscience Centre

Established in 1982, the Ottawa-Carleton Geoscience Centre (OCGC) combines the research strengths of the University of Ottawa and Carleton University. The Centre offers graduate programs leading to the master's (MSc) and doctoral (PhD) degrees in Earth sciences.

Research facilities are shared between the two campuses. Students have access to the professors, courses and facilities at both universities; however, they must enroll at the “home university” of the thesis supervisor.

The Centre is one of the participating units in the collaborative program in chemical and environmental toxicology (at the master’s and doctoral levels) and in environmental sustainability (at master’s level).

Collaborative Program Description
Toxicology is the study of effects of toxic substances on living systems. These toxic substances can either be organic or inorganic, synthetic or natural materials. Environmental toxicology further extends to aspects of chemical transport, fate, persistence and biological accumulation of toxic substances and their effects at the population and community levels. While individual researchers usually specialize in a particular area, toxicologists today must be able to appreciate significant research in other fields and therefore require an understanding of the basic principles of other disciplines. To meet this challenge the University of Ottawa and Carleton University offer a joint collaborative program leading to a master of science or a PhD degree with specialization in chemical and environmental toxicology.

Main Areas of Research
- Environmental geoscience
- Geochemistry
- Petrology
- Geomathematics
- Geomatics
- Mineral resources studies
- Sedimentary systems
- Tectonics
- Geophysics

Other Programs Offered Within the Same Discipline or in a Related Area
- Master of Science Earth Sciences (MSc)
- Master of Science Earth Sciences Specialization in Chemical and Environmental Toxicology (MSc)
- Master of Science Earth Sciences Specialization in Environmental Sustainability (MSc)
- Master of Science Earth Sciences Specialization in Science, Society and Policy (MSc)
- Doctorate in Philosophy Earth Sciences (PhD)

Fees and Funding
- Program fees:
  The estimated amount for university fees (https://www.uottawa.ca/university-fees) associated with this program are available under the section Finance your studies (http://www.uottawa.ca/graduate-studies/programs-admission/finance-studies).

  International students enrolled in a French-language program of study may be eligible for a differential tuition fee exemption (https://www.uottawa.ca/university-fees/differential-tuition-fee-exemption).

  To learn about possibilities for financing your graduate studies, consult the Awards and financial support (https://www.uottawa.ca/graduate-studies/students/awards) section.

Notes
- Programs are governed by the general regulations (http://www.uottawa.ca/graduate-studies/students/general-regulations) in effect for graduate studies at each of the two universities.
- In accordance with the University of Ottawa regulation, students have the right to complete their assignments, examinations, research papers, and theses in French or in English. Research activities can be conducted either in English, French or both, depending on the language used by the professor and the members of his or her research group.
Program Contact Information  
Graduate Studies Office, Faculty of Science (https://science.uottawa.ca/en/faculty-services/graduate-studies)  
30 Marie-Curie Street, Gendron Hall, Room 181  
Ottawa, Ontario, Canada  
K1N 6N5  

Tel.: 613-562-5800 x3145  
Email: gradsci@uOttawa.ca  

Twitter | Faculty of Science (https://twitter.com/uOttawaScience?lang=en)  
Facebook | Faculty of Science (https://www.facebook.com/uOttawaScience)  

Admission Requirements  
For the most accurate and up to date information on application deadlines, language tests and other admission requirements, please visit the specific requirements (http://www.uottawa.ca/graduate-studies/programs-admission/apply/specific-requirements) webpage.  

To be eligible, candidates must:  
• Have a master’s degree in earth sciences (or equivalent) with a minimum average of 75% (B+).  

Note: International candidates must check the admission equivalencies (https://www.uottawa.ca/graduate-studies/international/study-uottawa/admission-equivalencies) for the diploma they received in their country of origin.  

• Demonstrate a good academic performance in previous studies as shown by official transcripts, research reports, abstracts or any other documents demonstrating research skills.  

• Meet the funding requirements.  

Note: International students must provide proof of financial support: i.e., a stipend provided by a supervisor as well as a combination of awards and/or trust funds.  

• Identify at least one professor who is willing to supervise your research and thesis.  

• We recommend that you contact potential thesis supervisors as soon as possible.  
• To register, you need to have been accepted by a thesis supervisor.  
• The supervisor’s name is required at the time of application.  
• The choice of supervisor will determine the primary campus location of the student. It will also determine which university awards the degree.  

• Be sponsored into the collaborative specialization by a faculty member of the collaborative program, normally the thesis supervisor, who must be appointed, cross-appointed or stand as an adjunct at the primary program.  
• Meet the following additional requirements:  
  • Complete a relevant introductory course in toxicology, either:  
    • Prior to admission to the collaborative program in chemical and environmental toxicology; or  
    • While enrolled in the program by taking one of the two introductory courses (TOX 8156 or TOX 9104).  

Language Requirements  
Applicants must be able to understand, write and fluently speak the language of instruction (English) in the program to which they are applying. Proof of linguistic proficiency may be required.  

Applicants whose first language is neither French nor English must provide proof of proficiency in the language of instruction.  

Note: Candidates are responsible for any fees associated with the language tests.  

Notes  
• The admission requirements listed above are minimum requirements and do not guarantee admission to the program.  
• Admissions are governed by the general regulations (http://www.uottawa.ca/graduate-studies/students/general-regulations) in place for graduate studies and by the general regulations of the Ottawa-Carleton Geoscience Centre (OCGC).  
• Candidates must apply to the primary program and indicate in their application for admission to the PhD program in Earth Sciences that they wish to be accepted into the collaborative specialization in Chemical and Environmental Toxicology. To be admitted to the collaborative program, candidates must also be accepted in the primary program.  

Fast-Track from Master’s to PhD  
Students enrolled in the master’s program in Earth Sciences at the University of Ottawa may be eligible to fast-track directly into the doctoral program without writing a master’s thesis, provided the following conditions are met:  
• Achievement of an A- average in the last two years of undergraduate studies;  
• Completion of two graduate courses (six units) with a grade of A- or better in each;  
• Satisfactory progress in the research program;  
• Written recommendation by the supervisor and the advisory committee;  
• Approval by the graduate studies committee.

The passing grade in all courses is B.

Minimum Requirements
The passing grade in all courses is B.

Notes:
• The transfer to the PhD must take place within sixteen months of initial enrollment in the master’s.
• Following the transfer, all the requirements of the doctoral program must be met: six units of coursework in addition to the six already completed, the comprehensive exam (to be completed within 12 months of transfer), participation in the geoscience seminar series, and the thesis.

Program Requirements
Doctorate with Collaborative Specialization
The Department may require students to take additional courses, depending on their backgrounds. The units completed for the specialization count also towards the primary program.

Students must meet the following requirements for the doctorate with collaborative specialization:

Compulsory Courses:
3 course units from:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOX 8156 Principles of Toxicology</td>
<td>3</td>
</tr>
<tr>
<td>TOX 9104 Ecotoxicology</td>
<td></td>
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</tbody>
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3 optional course units in Earth sciences (GEO) at the graduate level ¹

Seminar:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>TOX 9105 Seminar in Toxicology ², ³</td>
<td>3</td>
</tr>
</tbody>
</table>

Comprehensive Examination:

<table>
<thead>
<tr>
<th>Course</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO 9998 Comprehensive Examination (Ph.D.) ⁴</td>
<td>0</td>
</tr>
</tbody>
</table>

Thesis:

<table>
<thead>
<tr>
<th>Course</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>THD 9999 Doctoral Thesis ⁵, ⁶</td>
<td>0</td>
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</tbody>
</table>

Note(s)
¹ The optional course units may also be selected from related disciplines approved by the Department of Earth Sciences.
² Students who completed the seminar course TOX 9105 for the master’s specialization are exempted from this requirement.
³ The seminar course in toxicology involves the presentation of a seminar, and regular attendance at the seminars presented by the Department.
⁴ The comprehensive examination must be successfully completed within twelve months of the initial admission into the program.
⁵ Presentation and defense of a thesis in toxicology based on an original research carried out under the supervision of a faculty member participating in the chemical and environmental toxicology collaborative program.
⁶ Students are responsible for ensuring they have met all of the thesis requirements (http://www.uottawa.ca/graduate-studies/students/theses).

Students who fail two courses (equivalent to 6 units), the thesis proposal, or the comprehensive exam or whose research progress is deemed unsatisfactory are required to withdraw.

Research
Research Fields & Facilities
Located in the heart of Canada’s capital, a few steps away from Parliament Hill, the University of Ottawa is among Canada’s top 10 research universities.

uOttawa focuses research strengths and efforts in four Strategic Areas of Development in Research (SADRs):
• Canada and the World
• Health
• e-Society
• Molecular and Environmental Sciences

With cutting-edge research, our graduate students, researchers and educators strongly influence national and international priorities.

Research at the Faculty of Science
The Faculty of Science has become a true centre of excellence in research through its world-class professors as well as its programs and infrastructure in Biology, Chemistry, Earth Sciences, Mathematics and Statistics, and Physics.

The research accomplished by its 140 internationally recognized professors, its approximately 400 graduate students and its dozens of postdoctoral researchers and visiting scientists has positioned the Faculty of Science as one of the most research intensive science faculties in Canada. Our professors have received many international and national awards including three NSERC Gerhard Herzberg Gold Medal winners and numerous Fellows of the Royal Society of Canada.

The Faculty of Science, through its strategic use of infrastructure programs, hosts world-class Core Facilities and is at the leading edge for the study of Catalysis, Experimental and Computational Chemistry, Environmental Toxins, Nuclear Magnetic Resonance, Isotope Analysis, Molecular Biology and Genomics, X-Ray Spectrometry/Diffractionmetry, Geochemistry, Mass Spectrometry, Physiology and Genetics of Aquatic Organisms, and Photonics. The Faculty is also associated with the Fields Institute for research in mathematical science and the Centre de recherche mathématiques (CRM) at the Université de Montréal, providing a unique setting for mathematical research.

For more information, refer to the list of faculty members and their research fields on Uniweb.

IMPORTANT: Candidates and students looking for professors to supervise their thesis or research project can also consult the website of the faculty or department (https://www.uottawa.ca/graduate-studies/students/academic-unit-contact-information) of their program of choice. Uniweb does not list all professors authorized to supervise research projects at the University of Ottawa.

Courses
Not all of the listed courses are given each year. The course is offered in the language in which it is described.
A 3-unit course at the University of Ottawa is equivalent to a 0.5-unit course at Carleton University.

**GEO 5114 Mineralogy (3 units)**
An advanced course covering selected topics in mineralogy, such as crystallography, crystal chemistry, crystal structure, mineralogy of rock-forming mineral groups, and instrumental methods in mineralogical research, such as use of electronic optical instruments, spectroscopy, and X-ray crystallography; seminar presentations and practical exercises included. This course is equivalent to ERTH 5104 at Carleton University.

**Course Component:** Lecture

**GEO 5122 Advanced Igneous Petrology (3 units)**
The course focuses on particular aspects of the discipline and integrates physical and chemical processes with the dynamics of magmatic systems to understand igneous processes. This course is equivalent to ERTH 5202 at Carleton University.

**Course Component:** Lecture

**GEO 5124 Geology and Geochemistry of Ore Deposits (3 units)**
An advanced course in ore deposits examining aspects of their geology, geochemistry, and exploration. Topics will be selected from a range of different deposit types, including hydrothermal and magmatic ore deposits, as well as laboratory and field examination of different ores and their host rocks. This course is equivalent to ERTH 5204 at Carleton University.

**Course Component:** Lecture

**GEO 5131 Siliciclastic Sedimentology (3 units)**
Origin and significance of physical and sedimentary processes and structures. Analysis of ancient siliciclastic depositional environments in a facies model and sequence stratigraphic framework. Course involves lectures, seminars and field excursions. This course is equivalent to ERTH 5301 at Carleton University.

**Course Component:** Lecture

**GEO 5135 Carbonate Sedimentology (3 units)**
Lectures and seminars will cover aspects of modern depositional systems, dynamic facies models, sequence stratigraphy, mineralogy, and diagenesis of carbonate sediments. Practical part of the course will consist of a field-laboratory project that integrates various techniques in carbonate sedimentology (mapping, petrography, staining, cathodoluminescence, fluorescence, SEM). This course is equivalent to ERTH 5305 at Carleton University.

**Course Component:** Lecture

**GEO 5136 Paleobiology (3 units)**
Selected topics in paleobiology of micro- and macro-invertebrates and vertebrates. Topics include extinctions, micro- and macro-evolutionary processes, long-term trends and cycles in the Phanerozoic, and functional morphology, as well as application of invertebrates to biostratigraphy, paleoceanography and paleoecology. This course is equivalent to ERTH 5306 at Carleton University.

**Course Component:** Lecture

**GEO 5139 Glacial and Periglacial Geology (3 units)**
An examination of various sedimentary environments associated with glacial and periglacial processes and their significance for mineral exploration and environmental geochemistry. Study of cold climate non-glacial conditions and the development of permafrost and permafrost-related features, including the effect of groundwater flow on permafrost distribution. This course is equivalent to ERTH 5309 at Carleton University.

**Course Component:** Lecture

**GEO 5142 Environmental Geoscience (3 units)**
A study-seminar course in which students will examine, in depth, certain environmental problems, including geological hazards, mineral and energy consumption and environmental degradation. The relation between development and the environment will be considered. Students will prepare a report and present a seminar on a subject of their choice, and will participate in a research project centered in the Ottawa area. This course is equivalent to ERTH 5402 at Carleton University.

**Course Component:** Lecture

**GEO 5143 Environmental Isotopes and Groundwater Geochemistry (3 units)**
A practical course in the application of computer techniques in the evaluation of groundwater resources and their vulnerabilities. Topics include governing groundwater flow equations and solute transport equations from first principles, and application of principles in case studies. Topics: forces and potentials, fluids, geological materials, transport equations from first principles, and application of principles in case studies. Students will prepare a report and present a seminar on a subject of their choice, and will participate in a research project centered in the Ottawa area. This course is equivalent to ERTH 5402 at Carleton University.

**Course Component:** Lecture

**GEO 5144 Environmental Geoscience (3 units)**
A study-seminar course in which students will examine, in depth, certain environmental problems, including geological hazards, mineral and energy consumption and environmental degradation. The relation between development and the environment will be considered. Students will prepare a report and present a seminar on a subject of their choice, and will participate in a research project centered in the Ottawa area. This course is equivalent to ERTH 5402 at Carleton University.

**Course Component:** Lecture

**GEO 5146 Techniques of Groundwater Resources Evaluation (3 units)**
Governing groundwater flow equations, initial and boundary conditions; simple numerical solutions (spreadsheets); complex numerical solutions (commercial software); and analytical solutions. Applications: aquifer response test analysis, capture zone analysis, groundwater flow modeling, water budgeting, and aquifer vulnerability assessment.

**Course Component:** Lecture

**GEO 5147 Geochemistry of Natural Waters (3 units)**
Aqueous speciation, solubility of metals, minerals and gas, reaction kinetics and equilibria. Chemistry and dynamics of groundwaters and hydrothermal fluids. This course is equivalent to ERTH 5407 at Carleton University.

**Course Component:** Lecture

**GEO 5148 Theory of Flow and Contaminant Transport in Geological Materials (3 units)**
Development of governing groundwater flow equations and solute transport equations from first principles, and application of principles in case studies. Topics: forces and potentials, fluids, geological materials, contaminants, case studies.

**Course Component:** Lecture

Prerequisite: undergraduate hydrogeology. Permission of the Department is required.

**GEO 5151 Precambrian Geology (3 units)**
Geology and tectonic history of the Canadian Shield, emphasizing modern four-dimensional interpretations (map, depth, time); comparison and correlation with other Precambrian shields; global Precambrian tectonic evolution through review of continental reconstructions; Precambrian mineral deposits; field trips and research projects. This course is equivalent to ERTH 5501 at Carleton University.

**Course Component:** Lecture

**GEO 5153 Computer Techniques in the Earth Sciences (3 units)**
A practical course in the application of computer techniques in the acquisition and interpretation of geoscientific data. Topics will be selected from the following: remote sensing and geographic information systems; geostatistical analysis techniques; analysis and modelling of geoscientific data. This course is equivalent to ERTH 5503 at Carleton University.

**Course Component:** Lecture

Permission of the Department is required.
GEO 5157 Tectonic Processes Emphasizing Geochronology and Metamorphism (3 units)
Applications of empirical, analytical and quantitative techniques to problems in regional geology and crustal tectonics; orogenic processes; heat and metamorphism; isotopic geochronology as applied to thermal history. This course is equivalent to ERTH 5507 at Carleton University.
Course Component: Lecture

GEO 5160 Chemistry of the Earth (3 units)
Examine the composition of the mantle and crust in selected tectonic settings, such as subduction zones and hot spots. Topics may include how geochemical data constrain geodynamic settings of study area. This course is equivalent to ERTH 5600 at Carleton University.
Course Component: Lecture

GEO 5163 Stable Isotope Geochemistry (3 units)
Mechanisms of isotope fractionation, fractionation in nature; physical and chemical isotope fractionation, kinetic isotope effects. Variations of stable isotope ratios (hydrogen, carbon, oxygen and sulphur) in nature. Preparation techniques of natural samples for isotope analysis. Applications of stable isotopes to study magma genesis, ore genesis, nature of water and formation fluids and sedimentary environments. This course is equivalent to ERTH 5603 at Carleton University.
Course Component: Lecture

GEO 5169 Radioisotope Geochemistry (3 units)
Course Component: Lecture

GEO 5171 Physics of the Earth (3 units)
The physics and dynamics of the solid Earth: seismology; gravitational and magnetic fields; thermal state. Geophysical constraints on the structure and composition of the interior. Geodynamic processes. This course is equivalent to ERTH 5701 at Carleton University.
Course Component: Lecture

GEO 5173 Structural Geology (3 units)
Deformation processes and the analysis of geological structures at all scales. This course is equivalent to ERTH 5703 at Carleton University.
Course Component: Lecture

GEO 5174 Tectonics (3 units)
Dynamical and geological aspects of plate tectonics throughout Earth history. This course is equivalent to ERTH 5704 at Carleton University.
Course Component: Lecture

GEO 5177 Engineering Seismology (3 units)
Seismological topics with engineering applications. Characterization of seismicity and seismic sources (areas and faults). Seismic hazard analysis. Empirical and theoretical modeling of strong ground motion in time and frequency domains. This course is equivalent to ERTH 5707 at Carleton University.
Course Component: Lecture

GEO 5178 Geophysical Signal Processing (3 units)
Practical aspects of earthquake and other geophysical signal process; focus on application of Fourier analysis, digital filters, instrument response. This course is equivalent to ERTH 5708 at Carleton University.
Course Component: Lecture

GEO 5193 Field Studies (3 units)
Systematic investigations of geological problems, based on a minimum of 15 days field work plus related library research and laboratory projects. Written report required. This course is equivalent to ERTH 5903 at Carleton University.
Course Component: Research

GEO 5294 Problems in Historical Geology and Geological Time (3 units)
Controversial ideas concerning the Earth and time: historical development of thought on the physical and biological evolution of the Earth. Understanding the stratigraphic column in regard to duration, age and correlation, including evidence from paleontology and sedimentology, particularly gaps in the succession and rhythmic or episodic events. Origin and nature of life, relationship between crustal events and evolution, including extinctions. Concepts and models in geology; responsibility of the geologist to humanity. Half-course given during Fall and Winter sessions.
Course Component: Lecture

GEO 5301 Seminars in Earth Sciences I (3 units)
One-session modular course covering a spectrum of Earth science topics and current research problems, ranging from the geology and geophysics of the solid Earth, to its surface environment and crustal resources. A minimum of 4 modules is offered per session; 3 must be completed to obtain unit for a course. Students may not normally obtain units for modules that are offered by their supervisors. The choice of modules must be approved by the Director of the Geoscience Centre or a designate. This course complements GEO 5302 (ERTH 5002). This course is equivalent to ERTH 5001 at Carleton University.
Course Component: Lecture

GEO 5302 Seminars in Earth Sciences II (3 units)
One-session modular course covering a spectrum of Earth science topics and current research problems, ranging from the geology and geophysics of the solid Earth, to its surface environment and crustal resources. A minimum of 4 modules is offered per session; 3 must be completed to obtain unit for a course. Students may not normally obtain units for modules that are offered by their supervisors. The choice of modules must be approved by the Director of the Geoscience Centre or a designate. This course complements GEO 5301 (ERTH 5001). This course is equivalent to ERTH 5002 at Carleton University.
Course Component: Lecture

GEO 5306 Hydrothermal Ore Deposits (3 units)
An advanced course in economic geology related to hydrothermal ore deposits, including their geology and geochemistry, physical and chemical controls on hydrothermal mineralization, the recognition and characterization of ore-fluid reservoirs, and the nature of large-scale fluid flow and alteration, with an emphasis on applications to exploration. This course is equivalent to ERTH 5206 at Carleton University.
Course Component: Lecture

GEO 5998 Examen de synthèse (doctorat) / Comprehensive Examination (Ph.D.)
Ce cours est équivalent à ERTH 6908 à la Carleton University. / This course is equivalent to ERTH 6908 at Carleton University.
Volet / Course Component: Recherche / Research

TOX 8156 Principles of Toxicology (3 units)
The basic theorems of toxicology with examples of current research problems. The concepts of exposure, hazard and risk assessment will be defined and illustrated with experimental material from some of the more dynamic areas of modern research. This course is equivalent to BIOL 6402 at Carleton University.
Course Component: Lecture

This is a copy of the 2018-2019 catalog.
TOX 8157 Chemical Toxicology (3 units)
Advanced course in chemical toxicology dealing with both chemical hazards and exposure. Overview of empirical data relating to the toxicity of various classes of chemicals for test organisms, followed by study of toxicity at the cellular level, including studies of interactions between toxic substances and enzymatic systems. Data applicable to the interpretation and monitoring of WHMIS health regulations. Initial events in enzyme induction and mutagenesis. Study of predictive capabilities in the areas of structure-activity relationships and mechanisms of enzyme induction, followed by assessment of mechanisms of exposure to toxic chemicals.
Course Component: Lecture

TOX 9104 Ecotoxicology (3 units)
Selected topics and advances in ecotoxicology with emphasis on the biological effects of contaminants. The potential for biotic perturbation resulting from chronic and acute exposure of ecosystems to selected toxicants will be covered along with the methods pesticide, herbicide and pollutant residue analysis and the concept of bound residues. This course is equivalent to BIOL 6403 at Carleton University.
Course Component: Lecture

TOX 9105 Seminar in Toxicology (3 units)
A one-session course in seminar format highlighting current topics in toxicology. The student will present a seminar and submit a report on the seminar topic. Student, faculty and invited seminar speakers.
Course Component: Seminar

TOX 9106 Genetic Toxicology (3 units)
Topics in mutagenesis and DNA repair, including spontaneous and induced mutagenesis, genetic toxicology testing, the genetics and biochemistry of replication, DNA repair and recombination, and the role of mutagens in the development of genetic disease and cancer. This course is equivalent to BIOL 6406 at Carleton University.
Course Component: Lecture