

# Earth Sciences

This section presents the requirements for programs in:

- **M.Sc. Earth Sciences**
- **M.Sc. Earth Sciences with Collaborative Specialization in Chemical and Environmental Toxicology**
- **Ph.D. Earth Sciences**
- **Ph.D. Earth Sciences with Collaborative Specialization in Chemical and Environmental Toxicology**

## Program Requirements

### M.Sc. Earth Sciences (5.0 credits)

#### Requirements:

1. **1.5 credit** in course work, 0.5 credit of which may be at the senior undergraduate level **1.5**

2. **3.5 credits in:** **3.5**

ERTH 5909 [3.5] M.Sc. Thesis (defended at an oral examination)

3. A pre-defence public lecture, preceding the oral examination, based on the thesis research

4. **0.0 credit in:** participation in the OCGC Seminar Series. Each student gives a presentation of one lecture (open to all members of the OCGC) describing the candidate's research study within 16 months of the candidate's registration in the M.Sc. program.

**Total Credits** **5.0**

### M.Sc. Earth Sciences with Collaborative Specialization in Chemical and Environmental Toxicology (5.0 credits)

#### Requirements:

1. **0.5 credit in:** **0.5**

BIOL 6402/ Principles of Toxicology  
CHEM 5708 [0.5]  
or BIOL 6403 [0.5] Ecotoxicology  
or CHEM 5705 [0.5] Ecotoxicology

2. **0.5 credit in:** **0.5**

BIOL 6405/ Seminar in Toxicology  
CHEM 5805 [0.5]

3. **0.5 credit in** additional course work **0.5**

4. **3.5 credits in:** **3.5**

ERTH 5909 [3.5] M.Sc. Thesis (in the specialization)

5. A pre-defence public lecture, preceding the oral examination, based on the thesis research

6. **0.0 credit:** participation in the OCGC Seminar Series. Each student gives a presentation of one lecture (open to all members of the OCGC) describing the candidate's research study within 16 months of the candidate's registration in the M.Sc. program.

**Total Credits** **5.0**

### Ph.D. Earth Sciences (1.0 credit)

#### Requirements:

1. **1.0 credit of course work at the graduate level.** **1.0**  
Additional courses may be prescribed by the thesis advisory committee

ERTH 6908 [0.0] Ph.D. Comprehensive Examination (Conducted by the thesis advisory committee. Includes the presentation of a thesis proposal and involves three areas of geoscience specialization chosen by the student's advisory committee and approved by the Director of the Ottawa-Carleton Geoscience Centre)

2. **0.0 credits in:** **0.0**

ERTH 6909 [0.0] Ph.D. Thesis (defended at an oral examination before an examination board that includes an external examiner)

3. **A pre-defence public lecture, preceding the oral examination, based on the thesis research** **0.0**

4. **0.0 credit in:** participation in the OCGC Seminar Series. Each student gives a presentation of one lecture (open to all members of the OCGC) describing the candidate's research study within 16 months of the candidate's registration in the Ph.D. program. **0.0**

5. **Fulfilment of residence requirement: at least four terms of full-time study** **0.0**

**Total Credits** **1.0**

### Ph.D. Earth Sciences with Collaborative Specialization in Chemical and Environmental Toxicology (1.0 credit)

#### Requirements:

1. **0.0 credits in:**

ERTH 6909 [0.0] Ph.D. Thesis (a research thesis on a topic in toxicology supervised by a faculty member of the Collaborative Program in Chemical and Environmental Toxicology, defended at an oral examination before an examination board that includes an external examiner)

2. **A pre-defence public lecture, preceding the oral examination, based on the thesis research**

3. **1.0 credit in:** **1.0**

BIOL 6402 [0.5] Principles of Toxicology  
or CHEM 5708 [0.5] Principles of Toxicology  
BIOL 6405 [0.5] Seminar in Toxicology  
or CHEM 5805 [0.5] Seminar in Toxicology

4. **0.0 credit in:** **0.0**

ERTH 6908 [0.0] Ph.D. Comprehensive Examination (Conducted by the thesis advisory committee. Includes the presentation of a thesis proposal)

5. **0.0 credit in:** participation in the OCGC Seminar Series. Each student gives a presentation of one lecture (open to all members of the OCGC) describing the candidate's research study within 16 months of the candidate's registration in the Ph.D. program. **0.0**

6. **Fulfilment of residence requirement: at least four terms of full-time study** **0.0**

**Total Credits** **1.0**

## Regulations

See the General Regulations section of this Calendar.

A grade of B- or higher is required for each course counted towards the Master's degree.

### Regulations

See the General Regulations section of this Calendar.

### Doctoral Candidacy

For students in the Ph.D. Earth Sciences, completion of the pre-defence public lecture is not a pre-requisite for achieving doctoral candidacy as defined in Section 13.3 of the Graduate General Regulations.

### Admission

The requirement for admission to the program is an Honours B.Sc. degree, with at least high honours standing, in geology or a related discipline.

### Accelerated Pathway

The accelerated pathway in the Department of Earth Sciences is a flexible and individualized plan of graduate study. Students in the final year of the B.Sc. Honours degree in Earth Sciences may apply with the agreement of their B.Sc. Honours supervisor, within the deadline of January 15th of the year the B.Sc.H. will be completed.

Students may receive advanced standing with transfer of up to 1.0 credit which will reduce their time to completion.

The M.Sc. thesis may include results from the honours thesis but must contain significant additional research.

### Accelerated Pathway Requirements

1. 1.0 credit in EARTH courses at the 5000-level with a grade of B+ or higher.
2. Minimum overall and Major CGPA of A-.

### Admission

1. Admission with master's degree: the normal requirement for admission into the Ph.D. program is a master's degree with a minimum GPA of 9.0.
2. Admission with bachelor's degree: exceptional applicants holding a bachelor's degree, with demonstrated potential for independent thought and advanced research, with a minimum GPA of 9.00 in the final two years may be directly admitted to the Ph.D. program.
3. Fast-track: students who have been admitted to the thesis master's program may be permitted to transfer into the Ph.D. program if they demonstrate (a) outstanding academic performance in completing their course work, and (b) significant promise for advanced research and the ability to defend their Ph.D. proposal in the first year of their Ph.D. program.

## Earth Sciences (ERTH) Courses

### ERTH 5001 [0.5 credit] (GEO 5301)

#### Seminars in Earth Sciences I

One-term modular courses 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. Course complements EARTH 5002.

Precludes additional credit for Students may not take a module for credit that is offered by their supervisor, but may do so with the permission of the OCGC Director.

A minimum of four modules offered per term, three must be completed to obtain course credit. Choice of modules must be approved by the OCGC Director.

### ERTH 5002 [0.5 credit] (GEO 5302)

#### Seminars in Earth Sciences II

One-term modular courses 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. Course complements EARTH 5001.

Precludes additional credit for Students may not take a module for credit that is offered by their supervisor, but may do so with the permission of the OCGC Director.

A minimum of four modules offered per term, three must be completed to obtain course credit. Choice of modules must be approved by the OCGC Director.

### ERTH 5104 [0.5 credit] (GEO 5114)

#### Mineralogy

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.

### ERTH 5105 [0.5 credit] (GEO 5115)

#### Thermodynamics, Kinetic Theory, and Metamorphic Petrology

Phase equilibria, phase diagrams, and the kinetics of mineral reactions; mass transfer; regional and global aspects of metamorphic petrogenesis. Course may include one or two weeks of field-based instruction with costs borne by students.

Includes: Experiential Learning Activity

### ERTH 5202 [0.5 credit] (GEO 5122)

#### Advanced Igneous Petrology

Integrates physical and chemical processes with the dynamics of magmatic systems to understand igneous processes. Course may involve a field trip with costs to be paid by students.

Includes: Experiential Learning Activity

**ERTH 5204 [0.5 credit] (GEO 5124)****Geology and Geochemistry of Ore Deposits**

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.

Includes: Experiential Learning Activity

**ERTH 5206 [0.5 credit] (GEO 5306)****Hydrothermal Ore Deposits**

Advanced economic geology course on hydrothermal ore deposits including geology and geochemistry, physical and chemical controls on mineralization, recognition and characterization of ore-fluid reservoirs, nature of large-scale fluid flow and alteration, and applications to exploration.

**ERTH 5207 [0.5 credit]****Advanced Contaminant and Remediation Hydrogeology**

Geochemical and physical principles controlling contaminant release, migration, and fate in subsurface systems, including application of geochemical and reactive transport models for quantification of contaminant source terms and mitigation and remediation processes. Examples related to mining and industrial wastes and natural groundwater systems.

Includes: Experiential Learning Activity

Prerequisite(s): ERTH 3205.

Also offered at the undergraduate level, with different requirements, as ERTH 4206., for which additional credit is precluded.

Lecture three hours per week, a laboratory two hours per week.

**ERTH 5215 [0.5 credit] (GEO 5125)****Natural Hazards in Canada - Risk and Impact**

Overview of natural hazards and severe weather phenomena in Canada. Notions of risk, return period, and probability of occurrence of natural disasters. Impact on society and infrastructure. Mitigation policies and strategies.

Also listed as IPIS 5505.

Also offered at the undergraduate level, with different requirements, as ERTH 4815, for which additional credit is precluded.

**ERTH 5301 [0.5 credit] (GEO 5131)****Siliciclastic Sedimentology**

Origin and significance of physical 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.

Includes: Experiential Learning Activity

**ERTH 5302 [0.5 credit]****Frozen Earth: Unveiling the Snowball Earth Catastrophe**

Discover how icy cataclysms shaped our planet through Earth's most extreme climate event: Snowball Earth!

We will explore this theory's origins, examine compelling geologic and geochemical evidence, and dive into topics such as glacial sedimentology, the carbon cycle, evolution, and more on this thrilling adventure.

Includes: Experiential Learning Activity

Also offered at the undergraduate level, with different requirements, as ERTH 4302, for which additional credit is precluded.

Lectures three hours per week.

**ERTH 5305 [0.5 credit] (GEO 5135)****Carbonate Sedimentology**

Aspects of modern depositional systems, dynamic facies models, sequence stratigraphy, mineralogy, and diagenesis of carbonate sediments. The 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).

Includes: Experiential Learning Activity

**ERTH 5306 [0.5 credit] (GEO 5136)****Paleobiology**

Extinctions, micro- and macro-evolutionary processes, long-term trends and cycles in the Phanerozoic; functional morphology; application of invertebrates to biostratigraphy, paleoceanography and paleolimnology. May include one or two weeks of field-based instruction with costs borne by the student.

**ERTH 5307 [0.5 credit] (GEO 5137)****Evolutionary Developmental Biology**

This course explores the mechanistic basis of organismic evolution from genetic, morphogenetic and epigenetic perspectives, within a phylogenetic context of living and extinct vertebrates.

Includes: Experiential Learning Activity

**ERTH 5308 [0.5 credit] (GEO 5138)****Advanced Micropaleontology**

Paleobiology, biostratigraphy and paleoecology of microfossils in the context of paleoceanography, paleolimnology and paleoclimatology. Course may involve a field trip with costs to be paid by students.

Includes: Experiential Learning Activity

**ERTH 5403 [0.5 credit] (GEO 5143)**  
**Environmental Isotopes and Groundwater Geochemistry**

Isotope applications in environmental and Earth sciences. Emphasis is placed current and novel environmental applications including contaminant tracing, hydrogeological studies, and (bio)geochemical cycling of elements. Mechanisms of stable isotope fractionation and analysis are presented. Student-led projects will explore the broad realm of isotope studies.

Also offered at the undergraduate level, with different requirements, as EARTH 4207 and ENSC 4207, for which additional credit is precluded.

**ERTH 5405 [0.5 credit] (GEO 5145)**  
**Radioisotope Geochemistry Methods**

Overview of the basic principles of radiochemistry and examination of the occurrence, sources and production of radionuclides in the earth system that have been used extensively in environmental and geochemical studies. Discussion of and practice using the key methods of radionuclide detection.

**ERTH 5407 [0.5 credit] (GEO 5147)**  
**Aqueous Inorganic Geochemistry and Modelling**  
Covers concepts in aqueous geochemistry including ion hydration and hydrolysis, aqueous activity, complexation, mineral solubility, carbonate system, redox, adsorption/surface complexation and reaction kinetics. Bi-weekly assignments provide an introduction to equilibrium geochemical modelling.

**ERTH 5409 [0.5 credit]**  
**Reactive Transport Modelling**  
Introduction to the theory of numerical models and application of reactive transport models in hydrogeology. Focus will be on development of appropriate conceptual models of flow, transport and bio- and geochemical reactions and simulation of these conceptual models using reactive transport codes.

**ERTH 5414 [0.5 credit] (GEO 5144)**  
**Isotope Mapping and Provenance Applications**  
Isotopes are used to trace provenance of organic and inorganic materials. This course will discuss how traditional isotope systems vary in the environment at different spatiotemporal scales and how mapping their variations can solve problems in hydrology, climatology, ecology, and archeology.  
Includes: Experiential Learning Activity

**ERTH 5501 [0.5 credit] (GEO 5151)**  
**Precambrian Geology**  
Geology of the main Archean cratons and Proterozoic belts with emphasis on North America. Formation of the Earth, composition and evolution of the crust and mantle during the first 4 billion years of Earth's history, from its formation to the end of the Proterozoic.  
Includes: Experiential Learning Activity

**ERTH 5503 [0.5 credit] (GEO 5153)**  
**Computer Techniques in the Earth Sciences**  
A practical course for mapping; quantitative analysis, integration and modeling of spatial data related to geosciences and engineering applications using a combination of GIS, statistical and geostatistical analysis techniques.  
Includes: Experiential Learning Activity  
Prerequisite(s): permission of the Department.

**ERTH 5505 [0.5 credit] (GEO 5155)**  
**Climate Change**  
Considers climate changes and their driving mechanisms over a broad range of timescales based on observations from geological archives and more recent instrumented evidence. Future climate projections and their accuracy are also considered.  
Includes: Experiential Learning Activity

**ERTH 5507 [0.5 credit] (GEO 5157)**  
**Tectonic Processes Emphasizing Geochronology and Metamorphism**  
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.

**ERTH 5600 [0.5 credit] (GEO 5160)**  
**Chemistry of the Earth**  
An examination of 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 areas.

**ERTH 5603 [0.5 credit] (GEO 5163)**  
**Stable Isotope Geochemistry**  
Mechanisms of isotope fractionation in nature; physical and chemical isotope fractionation, kinetic isotope effects. Variation of stable isotope ratios (hydrogen/carbon/oxygen/sulphur) in nature. Preparation techniques of natural samples for isotope analysis. Applications of stable isotopes to study magma genesis, ore genesis, nature.

**ERTH 5609 [0.5 credit] (GEO 5169)****Radiogenic Isotope Geochemistry**

Radiogenic isotope systematics applied to the solid Earth and their use to understand various geological processes. Evolution of large-scale isotopic reservoirs throughout Earth's history. Application of different radiometric dating techniques, assessment of geochronological data, models and interpretations.

**ERTH 5701 [0.5 credit] (GEO 5171)****Physics of the Earth**

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.

Also offered at the undergraduate level, with different requirements, as EARTH 4801, for which additional credit is precluded.

**ERTH 5703 [0.5 credit] (GEO 5173)****Structural Geology**

Deformation processes and the analysis of geological structures at all scales.

**ERTH 5704 [0.5 credit] (GEO 5174)****Tectonics**

Dynamic and geological aspects of plate tectonics throughout Earth history.

**ERTH 5707 [0.5 credit] (GEO 5177)****Engineering Seismology**

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 domain.

**ERTH 5708 [0.5 credit] (GEO 5178)****Earthquake Signal Processing**

Theoretical and practical aspects of earthquake signal processing, seismic instrumentation, instrument response and application of spectral analysis and response spectra.

**ERTH 5901 [0.5 credit] (GEO 5191)****Research Topics in Earth Sciences**

Directed reading/field/laboratory studies unrelated to thesis research, under the guidance of directors other than the thesis supervisor. A written proposal including research plan, deliverables, and evaluation, must be submitted for departmental approval prior to registration. Written report required.

Includes: Experiential Learning Activity

**ERTH 5903 [0.5 credit] (GEO 5193)****Field Studies**

Field investigations of geological problems, unrelated to thesis research, under the guidance of directors other than the thesis supervisor. Minimum of fifteen days field work. A written proposal including research plan, deliverables, and evaluation must be submitted for departmental approval prior to registration.

Includes: Experiential Learning Activity

**ERTH 5906 [0.0 credit] (GEO 5193)****M.Sc. Geoscience Seminar**

Participation in the Geoscience Seminar Series.

**ERTH 5907 [0.0 credit] (GEO 5193)****Ph.D. Geoscience Seminar**

Participation in the Geoscience Seminar Series.

**ERTH 5909 [3.5 credits] (GEO 7999)****M.Sc. Thesis**

A thesis proposal must be approved by the research advisory committee by the end of the first year of registration.

Includes: Experiential Learning Activity

**ERTH 6908 [0.0 credit] (GEO 9998)****Ph.D. Comprehensive Examination**

The Comprehensive Examination involves a thesis proposal and oral examination in three different areas of specialization. Students will receive a grade of Satisfactory or Unsatisfactory. This exam is taken within the first twelve months of registration in the program.

**ERTH 6909 [0.0 credit] (GEO 9999)****Ph.D. Thesis**

A thesis proposal must be approved by the research advisory committee by the end of the first year of registration.

Includes: Experiential Learning Activity