The Ottawa-Carleton Geoscience Centre

Tory Bldg. 320

The Centre

The centre, established in 1982, represents the combined research strengths of Carleton University and the University of Ottawa. Research facilities are shared between the two campuses and graduate students are enrolled in the university where their faculty supervisors hold appointments. Programs are available leading to the degrees of M.Sc. and Ph.D. in most areas of geoscience. Six areas of research are emphasized, each involving a major component of field work: Precambrian studies, tectonics, resource geology, northern studies, environmental geoscience, and geochemistry. The Derry/Rust Research Group for Sedimentary Resources and the Geotechnical Science Laboratories are research units in the centre.

All thesis, seminar and examination requirements in the centre may be met either in French or English. Courses are offered in French wherever appropriate.

Members of the Centre

F.P. Agterberg, *Geomathematics; Evaluation of Nonrenewable Resources; Automated Stratigraphic Correlation*

R.W. Arnott, *Clastic Sedimentology; Experimental Sedimentology*

G.E. Bauer, *Geotechnical Engineering; Groundwater Flow; Soil Mechanics*

Keith Bell, *Isotope Studies; Petrology of Alkaline Rocks and Carbonatites; Geochronology*

Keith Benn, *Structural Geology, Structural Petrology; Anisotropy of Magnetic Susceptibility; Basement Tectonics*

John Blenkinsop, *Mass Spectrometry; Geochronology; Isotope Geochemistry*

G.F.Bonham-Carter, *Spatial Information Systems; Spatial Data Modeling*

A.C. Brown, *Sedimentary Mineral Deposits*

R.L. Brown, Tectonics and Structural Geology

E.M. Cameron, *Precambrian Geochemistry; Genesis of Gold Deposits; Exploration Geochemistry*

S.D. Carr, *Cordilleran and Grenville Tectonics, U-Pb Geochronology*

G.Y. Chao, *Mineralogy; Crystallography*

I.D. Clark, *Hydrogeology; Environmental Isotope Geochemistry*

André Desrochers, *Carbonate Sedimentology and Diagenesis; Canadian Arctic*

O.A. Dixon, *Invertebrate Paleontology; Stratigraphy; Canadian Arctic*

J.A. Donaldson, *Precambrian Stratigraphy and Sedimentology*

M.J. Drury, *Geothermics and Borehole Geophysics*

C.R. Duguay, *Remote Sensing; Geographic Information Systems*

A.D. Fowler, *Geochemistry; Archean Metavolcanic Belts; Non-linear Dynamics*

J.M. Franklin, *Ore Deposits; Hydrothermal Alteration; Sea Floor Hydrothermal Activity*

H.M. French, *Permafrost and Periglacial Phenomena*

W.K. Fyson, *Structural Analyses in Metamorphic Terrains*

M.-A. Geurts, *Palynology and Geomorphology; Travertine*

W.D. Goodfellow, *Geochemistry of Modern and Ancient Sediment-hosted Deposits; Mass Extinction*

S.K. Hanmer, *Shear Zones; Progressive Strain; Grenville Problems*

Keiko Hattori, *Isotope Geochemistry; Mineral Deposits; Archean Geology*

P.F. Hoffman, *Global Tectonics; Precambrian Earth History*

D.D. Hogarth, *Mineralogy: Igneous and Metamorphic Petrology; Alkalic Rocks*

C.W. Jefferson, *Sediment-hosted Ore Deposits; Resource Assessment; Exploration Geochemistry*

J.P. Johnson, *Glacial and Periglacial Geomorphology; Glaciology; Remote Sensing*

P.G. Johnson, *Glacial Geomorphology; Slope Mass Movements, Glacier Hydrology*

I.R. Jonasson, *Geochemistry; Ore Deposits*

Ralph Kretz, *Mineral Chemistry; Metamorphism; Environmental Studies*

Jarmila Kukalova-Peck, *Paleontology; Fossil Insects*

A.E. Lalonde, *Petrology and Mineralogy of Plutonic Rocks*

B.M. Lauriol, *Geomorphology*

Joyce Lundberg, *Karst; Quaternary Studies; Geochronology*

D.J. McLaren, *Geological Time; Event Stratigraphy*

F.A. Michel, *Isotope Geochemistry; Groundwater and Permafrost Studies*

R.R. Parrish, *Geochronology, Tectonics; Cordilleran Geology*

R.T. Patterson, *Micropaleontology Specializing in Foraminifera*

Giorgio Ranalli, *Rheology of the Earth; Geodynamics; Plate Tectonics*

D.G. Rancourt, *Mössbauer Spectrometry; Mineralogy; Geobarometry; Geothermometry; Micas*
M.J. Robin, *Contaminant Hydrogeology; Geostatistics; Geomathematics*
D.A. Russell, *Vertebrate Paleontology*
D.F. Sangster, *Sediment-hosted Mineral Deposits; Geochemistry; Stable Isotopes*
A.P.S. Selvadurai, *Geomechanics; Geotechnical Engineering*
W.W. Shilts, *Quaternary Geology; Glacial Sedimentology; Mineral Exploration in Glaciated Terrains; Environmental Geochemistry*
G.B. Skippen, *Metamorphic Petrology; Aqueous Geochemistry*
M.W. Smith, *Permafrost; Microclimate; Soil Freezing*
B.E. Taylor, *Stable Isotope Geochemistry; Crystal Fluids; Igneous/Metamorphic Processes; Mineral Deposits*
R.P. Taylor, *Fluid-rock Systems; Mineral Deposits*
J.K. Torrance, *Soil Chemistry; Clays, Oxide Minerals and Geotechnical Problems*
Jan Veizer, *Sedimentary Geochemistry; Carbonates; Diagenesis; Ores; Precambrian Sedimentology*
D.H. Watkinson, *Metallic Mineral Deposits*
P.J. Williams, *Soil Freezing and Geotechnical Problems; Cold Region Pipelines*
R.W. Yole, *Stratigraphy and Sedimentology; Petroleum Geology*

Research Associate

J.W. Card, *Radiogenic Isotope Geochemistry*

Postdoctoral Fellow

R.J. Rice, *Precambrian Sedimentology*

Master of Science

Admission Requirements

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

Program Requirements

- A research thesis, which will be defended at an oral examination
- The equivalent of two full courses, one of which may be at the senior undergraduate level
- Participation in the geoscience seminar series and presentation of a seminar

Academic Standing

A grade of B- or better must normally be received in each course counted towards the master's degree.

Doctor of Philosophy

Admission Requirements

The normal requirement for admission to the Ph.D. program is an M.Sc. degree in geology or a related discipline. Students who show outstanding academic performance and research promise while in the M.Sc. program may be permitted to transfer to the Ph.D. program without completing the M.Sc.

Program Requirements

- A research thesis, to be defended orally before an examination board which will include an external examiner
- A comprehensive examination, with emphasis on areas chosen by the student's advisory committee. The examination is normally taken within the first twelve months of study
- Two graduate full courses
- Participation in the geoscience seminar series and presentation of a seminar

Residence Requirement

The normal residence requirement for the Ph.D. degree is at least four terms of full-time study.

Graduate Courses

- Geology 67.511 (GEO5111)

Crystallography
Principles and techniques of X-ray crystallography; interpretation of X-ray photographs and application to the study of minerals.
G.Y. Chao.

- Geology 67.512 (GEO5112)

Rock-Forming Minerals
Recent work on structure, chemistry and interrelationships of igneous and metamorphic rock-forming minerals.
(To alternate with 67.513/GEO5113 or GEO5713)
D.D. Hogarth.

- Geology 67.513 (GEO5113)

Mineralogy of Plutonic Rocks
A seminar course reviewing the applications of mineralogical studies to the petrogenesis of felsic and mafic plutonic rocks. Topics include: structural state of feldspar minerals, applications to granitic rocks; chemical evolution of mica, pyroxene and amphibole minerals in plutonic bodies; phase relationships; review of the mineralogy of specific plutonic rock-types (e.g. anorthosites, syenites and hyperaluminous granites). (To alternate with 67.512/G
EO5112)

A.E. Lalonde.

- Geology 67.513 (GEO5713)

Minéralogie des Suites Plutoniques
Un cours ayant pour but d'accentuer la contribution des études minéralogiques détaillées à l'élaboration de la pétrogénèse des roches plutoniques mafiques ou felsiques. Parmi les sujets couverts figurent: la mise en ordre des feldspaths, son évaluation et ses applications à l'étude des granites, l'évolution chimique des micas, pyroxènes et amphiboles, relations de phases ainsi qu'une revue de la minéralogie de suites plutoniques spécifiques telles que les anorthosites, les syénites et les granites hyperalumineux.
A.E. Lalonde.

- Geology 67.521 (GEO5121)

Igneous Petrogenesis
Concentration on one or more of: origin and differentiation of basaltic magma; origin of granites; computer modeling of partial melting and fractional crystallization; magmatism in time and space. Laboratory and lecture material linked together in project form.
(Also offered as GEO5721)
A.D. Fowler, R.P. Taylor, A.E. Lalonde.

- Geology 67.521 (GEO5721)

Pétrogenèse Ignée
Un cours basé sur un (ou plusieurs) des thèmes suivants: origine et différenciation de magma basaltique; origine de granites; simulation par ordinateur de fusion partielle et cristallisation fractionnée; magmatisme en temps et en espace. Laboratoire et cours qui s'enchainent sous forme d'un projet.
A.D. Fowler, A.E. Lalonde.

- Geology 67.522 (GEO5122)

Physical Volcanology
The distribution, classification and physical characteristics of volcanos and other volcanic land- forms; lava flows, tephra, breccias, and other rocks formed through volcanic activity. Volcanic environments; recognition of ancient volcanic features; case histories.

- Geology 67.523 (GEO5123)

Metamorphic Petrology
Thermodynamics and kinetics of mineral reactions; metamorphic zones and isograds; mass transfer; regional and global aspects of metamorphism.
Ralph Kretz, G.B. Skippen.

- Geology 67.524 (GEO5124)

Metallic Mineral Deposits
Relationships of some metallic mineral deposits to igneous rocks: topics range from oxides and sulfides in and around intrusions to stratiform volcanogenic deposits. Course concludes with a field trip to northern Ontario and Quebec at end of winter term.
D.H. Watkinson.

- Geology 67.527 (GEO5127)

Physical Processes in Igneous Petrology
Lecture, reading and seminar course dealing with the physical processes responsible for generation, ascent, crystallization and cooling of igneous rocks. Topics covered include partial melting in the upper mantle and separation of the liquid; magma properties, structure, viscos-ity, temperature, density, and heat; magma pro-cesses, intrusion, extrusion, diffusion, convec- tion types, assimilation, nucleation, and crystal growth; cooling of magmas, conduction, convection, permeability, vapor phase exsolution, met-eoric water, development of spinifex, spheru- lites. These processes will be related to field
examples wherever possible.
A.D. Fowler.

- Geology 67.527 (GEO5727)

Les Processus Physiques en Pétrologie Ignée
Les processus responsables directement à la génération, l'ascension, la croissance et le refroidissement des roches ignées seront présentés dans les cours, les colloques et dans la discussion de la littérature récente. Les sujets suivants seront traités; fusion dans le manteau et la séparation du liquide; propriétés des magmas, la structure, la viscosité, la température, la densité et la chaleur; les processus magmatiques, l'intrusion, l'extrusion, la diffusion, la convection, la perméabilité, l'exsolution d'une vapeur, l'eau météorique, le développement de spinifex et les sphérulites. Les processus seront étudiés à l'aide d'exemples de terrain chaque fois que ça sera possible.
A.D. Fowler.

- Geology 67.528 (GEO5128)

Ores in Sediments
Ore-forming processes in sediments and sedimentary rocks. The generation, transport and deposition of ore elements relative to processes such as redox traps, basin water expulsion, dir-ect precipitation from seawater, and placer sedimentation are discussed in seminar format. All major sedimentary deposit-types are included.
Prerequisite: An undergraduate course in miner-al deposits.
D.F. Sangster, A.C. Brown.

- Geology 67.530 (GEO5130)

Dynamics of Sedimentary Systems
Weathering, rivers, ocean and atmosphere, sedi-

mentation and tectonism, basins and their sediments, P-T evolution, compaction, diagenesis, brines and fluid dynamics, mineralization, rock cycle and evolution through geologic time.
Jan Veizer.

- Geology 67.531 (GEO5131)
Sedimentology and Stratigraphy
Selected problems in sedimentary geology, emphasizing sedimentary structures, facies models and diagenesis. The application of modern techniques of stratigraphic, petrologic and statistical analysis.
J.A. Donaldson.

- Geology 67.532 (GEO5132)
Paleoecology
Emphasis on marine fossils as paleoenvironmental indicators: effects of substrate type, energy conditions, light, temperature, biotic associates and other environmental factors on the occurrence and distribution of organisms and their
fossil remains.
O.A. Dixon, R.T. Patterson.

- Geology 67.533 (GEO5133)
Advanced Micropaleontology
Selected topics in micropaleontology covered in greater detail than in introductory micropaleontology. Areas addressed include the paleoecology, biogeography and biology of foraminifers and other microfossil groups, as well as their application to biostratigraphy and paleoceanography.
R.T. Patterson.

- Geology 67.534 (GEO5134)
Fossil Fuels
Petroleum, natural gas, coal and unconventional fossil fuels; their origin, occurrence, and evaluation in the light of current geological thought.
R.W. Yole.

- Geology 67.536 (GEO5136)
Paleobiology
Selected topics in paleobiology of marine fossils. Topics include extinctions, micro- and macro-evolutionary processes, long-term trends and cycles in the Phanerozoic, and functional morpho-logy.
R.T. Patterson.

- Geology 67.541 (GEO5141)
Permafrost Hydrology and Investigative Methods
An examination of groundwater flow in perma-frost regions. The importance of ground-water in the formation of various types of ground ice, and the effect of groundwater flow on permafrost distribution.
F.A. Michel.

- Geology 67.542 (GEO5142)
Environmental Geoscience
A study-seminar course in which students will examine, in depth, certain environmental prob-lems, including geological hazards, mineral and energy consumption and environmental degrad-ation. 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.
Ralph Kretz.

- Geology 67.543 (GEO5143)
Environmental Isotopes and Groundwater Geochemistry
Stable environmental isotopes ($^{18}0$, ^{2}H, ^{13}C, ^{34}S, ^{15}N) in studies of groundwater origin and flow, and geothermal studies. Groundwater dating techniques involving tritium and radio-carbon, and exotic radioisotopes (e.g. ^{36}Cl, ^{39}Ar, ^{85}Kr). Low temperature aqueous geochemistry and mineral solubility with emphasis on the carbon-ate system. Some application to paleoclimatology will be discussed.
Prerequisite: Fourth-year hydrogeology (67.420 or GEO4192) or equivalent.
I.D. Clark, F.A. Michel.

- Geology 67.544 (GEO5144)
Groundwater Resources
Advanced topics in the exploration and development of groundwater resources, including detailed aquifer response analysis. Examination of hydrogeology in arid and undeveloped regions will also be included.
Prerequisite: Fourth-year hydrogeology (67.420 or GEO4192) or equivalent.
F.A. Michel, I.D. Clark.

- Geology 67.545 (GEO5145)
Contaminant Hydrogeology
A theoretical and applied course examining sources of groundwater contamination and mechanisms of transport. Inorganic, radioactive, and organic, biological contaminant behavior will be discussed as well as regulations, monitoring methodologies, aquifer restoration and fundamental questions of high-level radioactive-waste disposal and municipal landfills.
Prerequisite: Fourth-year geochemistry or equivalent, or permission of instructor.
M.J. Robin, I.D. Clark.

- Geology 67.546 (GEO5146)
Numerical Methods in Hydrogeology
Application of numerical methods in hydrogeological problem solving, including a review of governing equations, initial and boundary

conditions, and both finite element and finite difference methods. Additional topics to be explored include particle tracking, Laplace and Fourier transforms, and stochastic methods.
Prerequisite: Fourth-year hydrogeology, or permission of instructor.
M.J. Robin.

- Geology 67.547 (GEO5147)
Geochemistry of Natural Waters
Aqueous speciation, solubility of metals, minerals and gas, reaction kinetics and equilibria. Chemi-stry and dynamics of groundwaters and hydrothermal fluids.
Keiko Hattori, I.D. Clark.

- Geology 67.551 (GEO5151)
Precambrian Geology
Problems of Precambrian geology, emphasizing classical and current studies in North America; comparative study of the Canadian Shield and other Precambrian shields; research projects, field trips and petrologic studies of representative rock suites.
J.A. Donaldson.

- Geology 67.552 (GEO5152)
Geology of Arctic Canada
Origins and development of the principal geological regions of the Canadian Arctic. Emphasis on the Phanerozoic record but other topics or problems may be included.
O.A. Dixon.

- Geology 67.553(GEO5153)
Applications of Spatial Information Systems to Geology
This is a practical course in the application of PC-based geographic information systems to the analysis of regional geoscientific data. Spatial data capture, spatial data structures, spatial data analysis and modeling will be reviewed with reference to applications in mineral exploration, envir-onmental and other problems. Students will undertake assignments and projects involving the use of a PC-based system.
G.F. Bonham-Carter.

- Geology 67.560 (GEO5160)
Chemistry of the Earth
An investigation of the geochemical constitution of the Earth and how the Earth has evolved. Topics will include meteorites and the early history of the Earth; chemical and isotopic constraints on the geochemical evolution of the crust and mantle; Earth models and their limitations.
John Blenkinsop.

- Geology 67.562 (GEO5162)
Physical Geochemistry
Application of thermodynamics to geologic problems. Experimental study of mineral equilibria.
G.B. Skippen.

- Geology 67.563 (GEO5163)
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 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.

- Geology 67.566 (GEO5166)
Exploration Geochemistry
Selected topics in applied geochemistry including: biogeochemical exploration; element mobilities in the surface environment; recent developments in data interpretation; quality control of geochemical data. Special attention to the use of geochemical methods for gold exploration and possible applications of stable and radiogenic isotopes to mineral exploration.
E.M. Cameron.

- Geology 67.567 (GEO5167)
Hydrothermal Fluids
Liquids, vapors, supercritical fluids as the agents of rock-water interaction and mass transfer in the crust. Phase relations in systems such as NaCl-H_2O-CO_2 and thermodynamic constraints on geological fluids. Applications to mineral equilibria and the microscopic study of fluid inclusions.
G.B. Skippen.

- Geology 67.568 (GEO5168)
Mineralized Hydrothermal Systems
Geology of active geothermal systems, generation of hydrothermal fluids, geochemistry of hydrothermal fluids, stability and solubility of minerals in base-metal and precious-metal mineralization, interpretation of fluid inclusion data.

- Geology 67.569 (GEO5169)
Radioisotope Geochemistry
Nucleosynthesis; chemical differentiation of the Earth. Evolution of large scale reservoirs. Isotopic tracers ($^{143}Nd/^{144}Nd$, $^{87}Sr/^{86}Sr$, common Pb). Geochronology; fundamentals and application of Sm/Nd, Rb/Sr, U/Pb, K/Ar and Lu/Hf methods. Evolution of the solid Earth from the isotopic perspective.
Keith Bell.

(Before 1992-93 listed as Geology 67.565/ GEO5165)

- Geology 67.571 (GEO5171)

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.
Giorgio Ranalli.

- Geology 67.572 (GEO5172)

Tectonophysics
The physics of deformation; continuum mechanics approach (elasticity, strength, plasti-city, viscosity), and micro-rheological approach (diffusion, dislocations, and flow mechanisms). Applications to tectonic processes.
Giorgio Ranalli.

- Geology 67.573 (GEO5173)

Structural Geology
Selected problems in structural geology treated in seminar and laboratory sessions. Emphasis on interpretation of fabrics developed during synmetamorphic strain. Students investigate and report on individual projects.
R.L. Brown, W.K. Fyson.

- Geology 67.574 (GEO5174)

Tectonics
An investigation of the structural style of mountain belts and their tectonic setting; tectonics of Precambrian deformed belts.
R.L. Brown, W.K. Fyson.

- Geology 67.575 (GEO5175)

Neotectonics
An investigation of present day geological processes in a variety of plate boundary and intraplate settings. Topics will include analysis of island arcs, currently active mountain ranges in convergent plate boundary settings, and rift systems in both continental and oceanic settings. Consideration will be given to depositional basins, structure, magmatism, metamorphism and mineralization in these various settings.
R.L. Brown.

- Geology 67.576 (GEO5176)

Rock Microfabric Analysis
An overview of rock fabric studies. Specific topics will include shape and lattice-preferred orientations of minerals, anisotropy of magnetic susceptibility fabrics, mode of development and evolution of fabrics with progressive deformation, fabric asymmetries, and textural and petro-fabric criteria for determination of deform- ational mechanisms. The course will include a review of measurement techniques (U-stage,
x-ray, anisotropy of magnetic susceptibility, image analysis), and of methods of statistical analysis (vector averaging, pole and inverse pole diagrams, orientation distribution function). Tectonic implications of fabric type distributions and fabric development will be stressed. The relationship between petrofabrics and seismic anisotropy will be discussed. The course may include one or more of the following; student seminars, reports based on bibliographic research or personal research, work on fabric of selected samples.
Keith Benn.

- Geology 67.576 (GEO5776)

L'Analyse des Microfabriques
Un regard sur l'étude de la fabrique des roches à l'échelle microscopique. Les sujets abordés comprendront: les orientations préférentielles de résaux et de forme des minéraux, les fabriques d'anisotropie de susceptibilité magnétique, les modes de développement et d'évolution des fabriques lors de la déformation progressive, les asymmétries entre fabriques et sous-fabriques, et les critères pétrographiques pour détermin-ation des mechanismes de déformation. Les techniques de mesure des fabriques (platine universelle, anisotropie de susceptibilité magnétique, rayons-X, analyse d'image) et les méthodes d'analyse statistique des données directionnelles (moyennes vectorielles, projections de pôles, diagrammes de densité, fonction de la distribution des orientations) seront discutées. La signification tectonique du développement et de la distribution spatiale des différents types de fabriques sera mise en évidence. Les relations entre pétrofabrique et anisotropie sismique seront aussi abordées. Ce cours comprendra un ou plus des travaux dirigés suivants: séminaires, rapports écrits basés sur une recherche bibliographique ou basés sur un travail personnel, mesures et analyses des fabriques des échantillons sélectionnés.
Keith Benn.

- Geology 67.590 (GEO5190)

Directed Studies
Directed reading and/or laboratory studies for full-credit course, under the guidance of selected extramural or intramural directors. A written description of the project must be submitted for departmental approval prior to registration.

- Geology 67.591 (GEO5191)

Directed Studies
Directed reading and/or laboratory studies for half-credit course, under the guidance of selected extramural or intramural directors. A written description of the project must be submitted for departmental approval prior to registration.

- Geology 67.593 (GEO5193)
Field Studies
Systematic investigations of geological problems, based on a minimum of fifteen days field work plus related library research and laboratory projects. Written report required.

- Geology 67.594 (GEO5294)
Problems in Historical Geology and Geological Time
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 evi-dence 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 human-ity. Half-course given during fall and winter terms.
D.J. McLaren.

- Geology 67.599 (GEO7999)
M.Sc. Thesis
A thesis proposal must be approved by the research advisory committee by the end of the first year of registration.

- Geology 67.699 (GEO9999)
Ph.D. Thesis
A thesis proposal must be approved by the research advisory committee by the end of the first year of registration.

The following Geography courses are included in the centre's program:

Department of Geography,
Carleton University:

- Geography 45.530W1
Soil Thermal and Hydrologic Regimes
Characteristics of soil regimes, particularly in freezing soils, role of soil properties; analytical and numerical methods, including computer simulation.
M.W. Smith.

- Geography 45.532F1
Soil Thermal and Hydrologic Properties
Instrumental techniques for investigation of hydrological and thermal processes near the Earth's surface, laboratory instrumentation and analysis of laboratory and field procedures in geotechnical science.
P.J. Williams.

- Geography 45.533W1
Periglacial Geomorphology
Permafrost, its distribution and significance, seasonal ground freezing, ground thermal regime, physical, thermodynamic, and geotechnical properties of freezing and thawing soils, terrain features ascribable to frost action, and soli- fluction and patterned ground.
P.J. Williams.

- Geography 45.534W1
Aspects of Clay Mineralogy and Soil Chemistry
The role of clay minerals in soils will be considered from a geotechnical and/or biological per-spective.
J.K. Torrance.

Department of Geography,
University of Ottawa:

- GEG 5001
Seminar: Earth Sciences (full-credit course)

- GEG 5303
Process in Geomorphology: Physics of Media, Mechanics of Movement and Topographic Expression
Discussion of the physics of medium deformation as the basis of landscape-forming processes (ice, water, and Earth surface materials), the mechanics and effects of movement on the Earth's surface, and concepts of landscape evolution due to the spatial and temporal variations of these processes.

- GEG 5703
Concepts Climatiques en Paléogéographie de l'Holocène dans le Nord du Canada
Le cours examine: 1) les causes et les mécanismes des variations climatiques de la fin du pléistocène et de l'holocène et leur impact sur les paysages; et 2) les méthodes d'acquisition et d'interprétation des données indirectes (palynologie, géomorphologie, analyses isotopiques).

- GEG 7905
Pleistocene Periglacial Problems
The

*F,W,S indicates term of offering. Courses offered in the fall *and* winter will be followed by T.

The number following the letter indicates the credit weight of the course: 1 denotes a half-course credit, 2 denotes a full-course credit, etc.

course will consist of a series of seminars which will focus upon the problems of Pleistocene paleogeographic reconstruction in the mid-latitudes. The various lines of geomorphic and stratigraphic evidence which are used to infer cold non-glacial (i.e. periglacial) conditions in the Pleistocene will be critically examined in the light of our understanding of present day periglacial landforms and processes.
H.M. French.