May 29, 2003

Professor Carolyn Tuohy
Vice-President, Policy Development
and Associate Provost
Room 206, Simcoe Hall
27 King's College Circle
University of Toronto

Dear Professor Tuohy:

At its meeting of May 27, 2003, the Council of the School of Graduate Studies approved the following motion:

> **THAT** SGS Council approve the proposal for a Collaborative Master of Science Program in Geology and Physics, effective September 2003. The new collaborative program will be housed within Division III for administrative purposes.

The proposal, executive summary and memorandum of agreement attached. The Division III Executive Committee approved this proposal at its meeting of May 6, 2003.

On behalf of the Council of the School of Graduate Studies, I am presenting this item to Governing Council committees, for information.

Yours sincerely,

Jane Alderdice
Secretary to SGS Council
and Coordinator of Policy, Program and Liaison

Encl.
/smr

c.c.	D. Bailey	D. Coombs	R. Desai	H. Van Driel
	C. Johnston	S. Rosatone	S. Scott	L. Yee

H:Council/FollowUp/2002-2003/May 27/Geology – Physics Collaborative Program

Motion

School of Graduate Studies Council
Tuesday, May 27, 2003

Item 7.1.

MOTION (/) **THAT** SGS Council approve the proposal for a Collaborative Master of Science Program in Geology and Physics, effective September 2003. The new collaborative program will be housed within Division III for administrative purposes.

See the proposal, executive summary and memorandum of agreement attached.

NOTE:
The Division III Executive Committee at its meeting of May 6, 2003 approved this proposal.

With SGS Council's approval this item will go to Governing Council committees for information, and to the Ontario Council on Graduate Studies for a standard appraisal.

BRIEF FOR THE STANDARD APPRAISAL OF THE

COLLABORATIVE M.SC. PROGRAM IN GEOLOGY AND PHYSICS

March/April, 2003

Executive Summary

A formal collaborative program in Geology and Physics is proposed, with two goals in mind: (1) to formalize some of the ad hoc arrangements which have been used to deliver graduate education in the overlap area ("geophysics") between geology and physics, and (2) to make visible to potential graduate students a program which is available in reality but has little public visibility because it does not exist formally.

Although education in this overlap area is normally delivered world-wide in combined departments of Earth Science, the University of Toronto is almost unique (U. of Alberta being the other example in Canada) in that geophysics here is done primarily in the Physics Department. This has advantages and disadvantages. Certainly geophysics has fared very well in the Physics Department at the University of Toronto, its significant impacts on the field beginning well before J. Tuzo Wilson's seminal contributions to the theory of plate tectonics. Nevertheless, there are two significant problems with the present arrangement that, as noted above, this proposal addresses.

The creation of this collaborative program is straightforward, since it simply gives structure to existing *ad hoc* arrangements. Briefly, the Collaborative Program and home department requirements taken together require that students fulfill half their lecture course requirements in each of the two home Departments, do a research project with report and oral examination according to the requirements of the home department, require advisory committee input from both departments, complete an additional half-course which is a core course for the program, and participate in the graduate seminar series of both departments. No additional resources are required to implement the Program. Courses already exist, faculty in one department have supervised and advised students in the other department, graduate students from one department regularly use research resources in the other. It might well be asked why a proposal like this was not implemented years ago. The answer lies in the new funding scheme recently introduced by the Faculty of Arts and Science. This has enforced homogenization of M.Sc. programs (in terms of duration and thus course and thesis requirements); the M.Sc. requirements of the two Departments now have essentially the same structure, and merging them into a collaborative program is straightforward.

Table of Contents

Proposal

1. Rationale and Description:

The overlap area of Geology and Physics is often summarized by the term geophysics. More precisely, geophysics is the application of the principles and methods of physics to problems of earth science. This field includes both long-studied but still important research problems (e.g. the age of the Earth, plate tectonics, earthquakes, methods of underground imaging) and emergent interdisciplinary fields (such as climate change, evolution of the planets, methane hydrates).

At most universities, research and teaching in geophysics are handled by Departments of Geology or of Earth Science. The University of Toronto and the University of Alberta are unique in Canada, and certainly unusual in the world, in that geophysics is done by faculty members primarily in Physics Departments. This has advantages and disadvantages. Certainly geophysics has fared very well in the Physics Department at the University of Toronto, its significant contributions beginning well before J. Tuzo Wilson's seminal contributions to the theory of plate tectonics.

There are compensating disadvantages, however. Most graduate student applicants interested in geophysics come from universities that combine geology and geophysics in a single department. These students cannot find a suitable home here at the University of Toronto in which to study and do research in certain types of geology-related geophysics. They do not have the undergraduate background overtly suitable for admission to a Physics graduate program, nor, if they have concentrated on geophysics at the undergraduate level, do they have a full suite of geology courses expected in a geology student. Because of the flexibility of the graduate admissions process at the University of Toronto, we have managed to admit such students anyway, and they have generally done very well.

However, there are two problems with this approach. The first is that such students rely on unofficial voluntary cooperation of faculty in the two Departments in order to assemble a suitable program of courses and research straddling both departments. This has worked on an *ad hoc* basis, but it would be much preferable to codify the rules by which this occurs in a Collaborative Program.

The second problem with the existing unofficial approach is that we in some sense already run a collaborative program but without any external visibility. Although we successfully accommodate students who do apply in this field, most students graduating in Canada and world-wide simply

do not apply to the University of Toronto because they do not see, in our publicity material, a formal program which fits both their background and their cross-disciplinary research interests. We almost certainly lose a huge number of potentially excellent graduate students, in both Departments, even before the application stage. These students are actually of two types: the first has been described above: the graduate of a geophysics program in the more usual combined Earth Science department. There is a second group of students that we are also missing: graduates of a physics program who have decided to apply their skills in Earth Sciences normally look for a program that will convince future employers that they have made the transition successfully. The prospect of a second degree in Physics offers no convincing assurance to students or their future employers that this is the case (even if it is, in fact).

The proposed collaborative program will rectify both problems. The participating home departments will be Geology and Physics. The program structure will be very simple. The lecture course requirements are that students take 1.0 FCE in each of the two home Departments. The research topic will be one that straddles the interests of the home departments; there will be a requirement that the student's advisory committee have faculty from both home departments. The other important aspect of the proposed Collaborative Program will address graduate admissions. By making the Program Director, or his/her delegate, a member of the graduate admissions committees of both departments, students with mixed geology/geophysics backgrounds, not quite conventional for either of the home departments, can be admitted to either department on the advice of the program director. Note that the proposed program builds on strength: the last OCGS appraisal of both home programs resulted in a classification of "Good Quality".

In the first instance, a Collaborative Program at the M.Sc. level is proposed. (Both home departments offer Ph.D. degrees as well, but participation at the Ph.D. level, although a logical following step, is not proposed at this time.) The start date is as soon as possible: September 2003.

2. Demand and Enrolment

Currently, yearly graduate admissions to geology and geophysics (a fraction of physics) together total about 15. Of these, probably only one or two would enroll in the Collaborative Program if it were available. However, as noted above, most of the enrollment growth would be expected to come from students who currently go to other universities.

Using data compiled by the Council of Chairs of Canadian Earth Science Departments (available at http://www.uwo.ca/earth/cddgc/cccesd02.html) there were 102 M.Sc. and 78 Ph.D. students registered in geophysics programs across the country in the academic year 2001-2002. Although it is not obvious from the data exactly how many of these are in the more geological style of geophysics program not currently offered at U of T, it is reasonable to assume that the vast majority are. If the proposed Collaborative program were in place at U of T, a simple per capita calculation (assuming that U of T should on average capture 10% of the nation's graduate students) indicates that up to 10 M.Sc. students could be enrolled in it at any one time. This estimate does not presume that these graduate students are all Canadian; we would hope to attract a significant number of students from elsewhere once the program was visible.

This suggests a potential demand of about 10 students per year for the Collaborative Program, once it has been visible for a while. This assumes, of course, that Departmental graduate enrolment quotas recently introduced by the Faculty of Arts and Science do not seriously hamper its growth as a separate program. It also assumes that all these students are of a calibre suitable for admission to the program.

3. Core Faculty:

The definition of core faculty used here is those faculty who are eligible and committed to teach and supervise in the proposed Collaborative program. These are the faculty who teach the existing graduate courses in each home department that are of special interest to students enrolling in the proposed program. This does not mean that each core member will have a registered graduate student in the proposed program at all times; indeed, the number of core faculty is comparable with the projected enrolment, and they will also have graduate students registered solely in the home department.

It is proposed that all tenured/tenure-stream faculty members of the geophysics group (somewhat loosely defined within the Physics Department) be core faculty for this program. This is currently Bailey, Dunlop, Edwards, Jellinek (a new appointment), Milkereit, Mitrovica and Peltier.

From Geology, core faculty are those of the structural geology/tectonics/geophysics group: Cruden, Halls, Pysklywec, and Robin.

From the Lassonde Institute in Engineering (as a cross-appointee to both Geology and Physics): Paul Young.

Each of the above Faculty members is a member of the Graduate School. An appendix with brief CV's and samples of relevant publications is attached (as Appendix 3).

4. Collaborative Program Requirements:

Admission Requirements:

All students must apply to and be accepted by both the home degree program, either Geology or Physics in this case, and the Collaborative Program. The admission requirements for the Collaborative Program are in addition to those of the home department. For the Collaborative Program, students must possess an undergraduate degree in one of the disciplines relevant to the Collaborative Program. Such an undergraduate program should include a mixture of the courses appropriate to the degree programs in Geology and Physics. This undergraduate program must be, in the judgement of both the Program Director and the home department, suitable preparation for the lecture course requirements of the Collaborative Program. Typical students might come from (a) a joint Physics/Geology undergraduate program, or (b) a Physics or Engineering Science program, with some introductory earth science, or (c) the geophysics stream of a combined Earth Science department that includes, for example, math and physics to the level of partial differential equations, classical mechanics and electromagnetic theory.

Program Requirements:

A student must:

1) take 1.0 full lecture course equivalents at the graduate level in the home Department (see Appendix 4 for a list of currently available courses);
2) take at least 1.0 full lecture course equivalents at the graduate level in the other participating Department (see Appendix 4 for a list of currently available courses);
3) complete supervised research in the subject area of the Collaborative program (the intellectual overlap area between Geology and Physics), equivalent in load to 3 full time courses, producing a thesis or report

on it as part of the home department requirements, and undergo an oral examination on it in accordance with the usual M.Sc. requirements of the home department (see Appendix 2 for home department requirements);

4) take the program core course GLG1101H (Seminars in Geology); although given by the Geology Department, this is a wide-ranging course spanning the gamut of the Earth Sciences. In this course, each student is required to make two seminar presentations during the course, and to lead the questioning at two of the seminars presented by other students; the topics are assigned by the course coordinator, and are deliberately chosen to be outside the area of the student's research; attendance at every class is mandatory; the pass/fail assessment for this course is by a team of several faculty members led by the course coordinator.

Note that students enrolled in Option I in Physics or in the course-only option in Geology (see Appendix 2 for details of M.Sc. programs in the two departments) are not eligible to enrol in the Collaborative Program.

5. Other Common Intellectual Activities:

Both Geology and the geophysics group within Physics run two sets of seminars (in the sense of a talk with questions and discussion afterward, not a discussion group *per se*). The first set comprises more formal ones, usually involving speakers invited from outside the University. The second set is in each case a series given by the graduate students themselves, in Geology given the name "Rockfest" on Friday afternoons. Students in the program are expected, in each department, to attend the first series in both Departments, and both attend and make a presentation in the second series in both Departments.

6. Administration:

The Program Committee:
The Collaborative Program will be administered by a program committee consisting of one graduate faculty member from each participating home program (recommended by each Chair). The Program Committee shall be chaired by the Program Director. The Program Committee shall meet at least twice a year, and as required.

The Program Committee shall be responsible for the following activities:

a) review of all applications and admissions to the collaborative program,

b) nomination of a new Director from amongst its membership, as required,
c) assisting the Director in the fulfilment of his/her duties as described above (see (c) and (d) below).

The Director:
The Director of the program will be recommended by Program Committee in consultation with the Chairs of the two home departments; the appointment will be made by the Dean of the SGS. The term of appointment will initially be three years with subsequent terms normally up to five years. The Office of the Collaborative Program will be that of the Director of the Collaborative Program. The Director:

a) administers the collaborative program including applications, admissions, record-keeping, and budget,
b) maintains appropriate content of program entry in the SGS Calendar, the website, and any other promotional material,
c) in conjunction with the Program Committee, approves individual admissions to the collaborative program, and attends (or delegates attendance at) those meetings of the graduate admission committees of the two home departments that deal with admissions of students aiming for the Collaborative program,
d) in conjunction with the Program Committee, approves individual student programs in conformity with the standards of the collaborative program and ensures that students registered in the program have supervisory arrangements in accordance with the program's requirements; monitors the progress of students in the program; ensures that appropriate academic advising is available to students in the program,
e) ensures that a collaborative program core faculty member is a member of a student's thesis examination committee,
f) certifies completion of collaborative program requirements for each student enrolled in the program,
g) reports to the SGS any changes to the administration or program requirements, and any other academic issues,
h) ensures full and appropriate communication with the heads of participating graduate units with respect to the collaborative program,
i) provides reports to SGS on the program's activities, including registration and graduation figures, when required for review or appraisal, or as requested,
j) chairs the Program Committee.

7. Budget:

No budget is proposed, since no budget is required. No additional faculty, administrative, or technical staff are associated with the program. All facilities required by students in the program are already provided by the two home departments. Financial and administrative procedures for students will be those of the home department in which the student is registered. Publicity costs will be small; the program can be promoted in the publicity material that each home department already undertakes to produce. The Program Director/Committee may elect to produce independent publicity material for the Program itself for distribution at conferences and meetings of special interest to the Program; each unit must pay its share of the appropriate expenses, provided such expenses are approved in advance by the home departments.

School of Graduate Studies
University of Toronto

COLLABORATIVE M.SC. PROGRAM IN GEOLOGY AND PHYSICS

MEMORANDUM OF AGREEMENT

MARCH, 2003

Memorandum of Agreement concerning a Collaborative Graduate Program in Geology and Physics between the Department of Geology and the Department of Physics.

1. Rationale

The need for this program arises out of the multidepartmental and multidisciplinary distribution of Earth Science education and research at the University of Toronto.

2. Objectives

In order to develop cooperative and multidisciplinary graduate education and research in the overlap area of Geology and Physics, the Department of Geology and the Department of Physics agree to participate in a Collaborative Program at the M.Sc. level.

3. Registration and Program Completion

Each graduate student in the Program shall be enrolled in a participating degree program in one of the two participating departments (known as the home department). The student shall meet the admission requirements of both the Collaborative Program and of the home department for this program. The student shall register in the School of Graduate Studies through the home graduate unit and shall:

a) meet all respective degree requirements of the School of Graduate Studies and the participating graduate unit; and

b) meet the requirements of the Collaborative Program. (see Proposal, Section 4).

Note that students enrolled in Option I in Physics or in the course-only option in Geology (see Appendix 2 for details of M.Sc. programs in the two departments) are not eligible to enrol in the Collaborative Program.

With the approval of the Collaborative Program Director, the designation “Completed the Collaborative Program in Geology and Physics” shall be shown on the transcript, upon certification that all requirements of the Collaborative Program in Geology and Physics have been fulfilled.

4. Role of Participating Graduate Units

Each participating graduate unit shall retain its statutory control over admissions and home program requirements, and its statutory duty to provide adequate research supervision by a member of the graduate faculty in the unit. The home graduate unit shall recommend the granting of the degree. Students in the Collaborative Program normally shall be supervised by a member of the Collaborative Program's core faculty, or have a core faculty member as a member of the supervisory committee. Participating graduate units will include reference to the Collaborative Program in the SGS Calendar entry, on the department website, and in other related advertising of the home program. Core faculty members shall remain available to contribute to the collaborative program through teaching of the relevant courses and participating in the delivery of seminar series and other common learning elements. Not all faculty members participate each year and, in many cases, may simply remain available to interested students. Faculty will teach courses in the subject area of the collaborative program in the home program. Although specific course in the subject area may change, and not all such courses may be available every year, it is intended that each participating Department will continue to provide sufficient courses (at least one full course equivalent) appropriate for Program students enrolled in the other Department.

5. Program Director

The Program Committee initiates and recommends the appointment of a new Director to the Dean of SGS, after consultation with chairs/directors of participating graduate units and with the current collaborative program director. The Dean of the School of Graduate Studies approves appointments of Directors of Collaborative Programs. The initial term normally is three years, with subsequent terms normally up to five years. An appointment is renewable upon recommendation of the Program Committee in consultation with the chairs/directors of participating graduate units, and approval of the Dean of SGS.

The Director:

- administers the collaborative program including applications, admissions, record-keeping, and budget,
- maintains appropriate content of program entry in the SGS Calendar, the website, and any other promotional material,
- in conjunction with the Program committee, approves individual admissions to the collaborative program, and attends (or delegates attendance at) those meetings of the graduate admission committees of the two home departments that deal with admissions of students aiming for the Collaborative program,
- in conjunction with the Program committee, approves individual student programs in conformity with the standards of the collaborative program and ensures that students registered in the program have supervisory arrangements in accordance with the program's requirements; monitors the progress of students in the program; ensures that appropriate academic advising is available to students in the program,

- ensures that a collaborative program core faculty member is a member of a student's thesis examination committee,
- certifies completion of collaborative program requirements for each student enrolled in the program,
- reports to the SGS any changes to the administration or program requirements, and any other academic issues,
- ensures full and appropriate communication with the heads of participating graduate units with respect to the collaborative program,
- provides reports to SGS on the program's activities, including registration and graduation figures, when required for review or appraisal, or as requested,
- chairs the Program Committee.

6. Program Committee

It is agreed that the Collaborative Program shall be administered by a program committee consisting of one graduate faculty member from each participating home program (recommended by each Chair). The Program Committee shall be chaired by the Program Director. The Program Committee shall meet at least twice a year, and as required.

The Program Committee shall be responsible for the following activities:

a) review of all applications and admissions to the collaborative program
b) nomination of a new Director from amongst its membership, as required
c) assisting the Director in the fulfilment of his/her duties as described above.

7. Resource Issues

No budget is proposed, since no budget is required. No additional faculty, administrative, or technical staff are associated with the program. All facilities required by students in the program are already provided by the two home departments. Financial and administrative procedures for students will be those of the home department in which the student is registered. Publicity costs will be small; the program can be promoted in the publicity material that each home department already undertakes to produce. The Program Director/Committee may elect to produce independent publicity material for the Program itself for distribution at conferences and meetings of special interest to the Program; each unit must pay its share of the appropriate expenses, provided such expenses are approved in advance by the home departments.

School of Graduate Studies
University of Toronto

COLLABORATIVE M.SC. PROGRAM IN
GEOLOGY AND PHYSICS MEMORANDUM OF AGREEMENT
MARCH, 2003

SIGNATURE PAGE
UNIT AGREES TO PARTICIPATE IN ACCORDANCE WITH ALL TERMS OUTLINED IN THIS MEMORANDUM OF AGREEMENT

Participating Graduate Units:

_____ *Date:* _____
Professor Henry Van Driel, Chair
Department of Physics

_____ *Date:* _____
Professor Steven Scott, Chair
Department of Geology

School of Graduate Studies

_____ *Date:* _____
Professor Michael R. Marrus, Dean
School of Graduate Studies

_____ *Date:* _____
Professor Donald E. Cormack, Vice-Dean
School of Graduate Studies

APPENDIX 1
SGS Calendar Entry

Geology and Physics (Collaborative Program)

Program Committee
R.C. Bailey, PhD/Geology and Physics ***(Director)***
A.R. Cruden, BSc, PhD/Geology
J. R. Drummond, BA, MA, DPhil

Participating Faculty
R. C. Bailey, BSc, PhD/Geology and Physics
A. R. Cruden, BSc, PhD/Geology
D. J. Dunlop, MA, PhD/Physics
R. N. Edwards, BSc, PhD, ARCS/Physics
H. C. Halls, BSc, MSc, PhD/Geology
M. Jellinek, BSc, PhD/Physics
B. Milkereit, Professor, Teck Chair of Exploration Geophysics, Department of Physics
J. X. Mitrovica, BASc, MSc, PhD/Physics
W. R. Peltier, BSc, MSc, PhD, FRSC, University Professor/Physics
R. N. Pysklywec, BSc, PhD/Geology
P.-Y. F. Robin, BSc, MSc, PhD/Geology
P. Young, BSc, PhD/Civil

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The graduate units of Geology and Physics participate in the Collaborative M.Sc. Program in Geology and Physics. This program fosters graduate education in those areas of study that overlap traditional departmental boundaries.

Admission Requirements
Application for admission to the Collaborative M.Sc. Program in Geology and Physics must be made through one of the two participating home departments, this being either Geology or Physics. Note that students enrolled in Option I in Physics or in the course-only option in Geology are not eligible to enrol in the Collaborative Program. In addition, the applicant must submit a supplementary brief application form to the Collaborative Program Director (available from either home department or the Collaborative Program office). Normal deadlines for application to the School of Graduate Studies apply. Students who have already been admitted to one of the two home departments may apply to the Collaborative Program until October 1.

Program Requirements

Students must meet all respective degree requirements of the School of Graduate Studies, the home department, and of the Collaborative Program. This will normally require work equivalent to eleven half-courses as follows:

- the core half-course GLG1101H
- two half lecture courses in Geology
- two half lecture courses in Physics
- a supervised research project in the field of geophysics or the overlap area of physics and geology, equivalent in load to six half courses

The supervised research project and associated report or thesis will be completed under the regulations of the home department In addition, the student is expected to attend the regular seminar series of both the Geology Department and of the Geophyics Lab in the Department of Physics, and to participate in the graduate student seminar programs of both Geology Department and of the Geophysics Lab. Program requirements are normally completed within twelve months of entry to the program. Students who successfully complete the requirements of the Collaborative Program will receive the notation "Completed Collaborative Program in Geology and Physics" on their transcript.

APPENDIX 2
Home Department Requirements

Collaborative Program requirements are such as to exclude registration for either the Option 1 M.Sc. in Physics or the Course M.Sc. in Geology.

Physics:

M.Sc. Program	Option 1 M.Sc.	Option 2 M.Sc.	Option 3 M.Sc.
Lecture Courses	*4.0 FCE*	*2.0 FCE**	*2.0 FCE**
Research Course		*1.0 FCE*	
Report	*1.0 FCE*	*2.0 FCE*	
Thesis			*3.0 FCE*

Geology:

M.Sc. Program	Course M.Sc.	Research M.Sc.
Lecture Courses	*5.0 FCE*	*2.0 FCE**
Research Course		
Report		*3.0 FCE*
Thesis		

* Up to 50% of this requirement may be taken outside the Department.

APPENDIX 3
Core Faculty

R. Bailey, Professor,
Departments of Geology and Physics
Brief CV*:* B.Sc., Dalhousie (1965); Ph.D., Cambridge (1970
Research Interests*:* Physical processes in the deep crust; Electromagnetic sounding of the Earth's crust and mantle; Inverse theory in Geophysics.
Some recent relevant publications*:*

- Bailey, R.C., *Gravity-driven continental overflow and Archaean tectonics*. Nature, **398**, p. 413-415. 1999.
- Bailey, R.C *The Initiation Of Orogenic Margin Reverse Faulting*, Geophysical Research Letters **29**, 2001

S. Cruden, Professor,
Department of Geology
Brief CV*:* B.Sc., 1984, Dundee University, Scotland, Ph.D., 1989, Hans Ramberg Tectonic Laboratory, Uppsala, Sweden
Research Interests*:* Ascent and emplacement of magma, Precambrian tectonics, Analogue modelling of lithospheric deformation, Structural controls on ore, Tectonic history and stability of continental interiors.
Some recent relevant publications*:*

- Petford, N., Cruden, A.R., McCaffrey, K.J.W., & Vigneresse, J.-L. 2000. *Dynamics of granitic magma formation, transport and emplacement in the Earth's crust*. Nature, 408, 669-673.
- Cruden, A. R., Tobisch, O.T. & Launeau, P. 1999. *Magnetic fabric evidence for conduit-fed emplacement of a tabular granite: Dinkey Creek Pluton, central Sierra Nevada Batholith, California.* Journal of Geophysical Research, 104 (B5), 10,511-10,531.

D. Dunlop, Professor
Department of Physics
Brief CV*:* B.A.Sc., Toronto (1963); M.A., Toronto, (1964); Ph.D., Toronto (1968).
Research Interests*:* Geomagnetisim and Tectonics: Fundamental magnetic properties and domain structures of ferromagnetic oxides; chemical overprinting magnetization in the laboratory and in nature; ocean floor ophiolite magnetism; seafloor spreading; paleomagnetism of orogenic belts; thermal uplift histories.
Some recent relevant publications*:*

- Carvallo, C., and D. J. Dunlop*, Archeomagnetism of potsherds from Grand Banks, Ontario: A test of low paleointensities in Ontario around A.D. 1000,* Earth Planet. Sci. Lett. 186, 437-450 (2001)
- Yu, Y. J., and D. J. Dunlop, *Multivectorial paleointensity determination from the Cordova Gabbro, southern Ontario,* Earth Planet. Sci. Lett. 203, 983-998 (2002)

R. N. Edwards, Professor,
Department of Physics
Brief CV*:* ARCS, Imperial College (1966); BSc(Special), London (1966); PhD, Cambridge (1970)
Research Interests*:* Development of theory and methodology of novel techniques to map the physical properties of the Earth's near-economic zone, its crust and upper mantle, particularly beneath the oceans and shallow shelf seas.
Some recent relevant publications*:*

- E.C. Willoughby and R.N. Edwards, *Shear Velocities in Cascadia From Seafloor Compliance Measurements*, Geophysical Research Letters, 27, 1021-1024, 2000.
- Jianwen Yang, K. Latychev and R.N. Edwards*, Numerical computation of hydrothermal fluid circulation in fractured earth structures*, Geophysical Journal International, 135, 627-650, 1998.

M. Jellinek, Assistant Professor (as of July, 2003),
Department of Physics
Brief CV: B.Sc., Hamilton (1990), M.Sc. Idaho (1994), Ph.D. A.N.U. (1999)
Research Interests*:* Physical volcanology and petrology, Geodynamics, and Planetary science.
Some recent relevant publications*:*

- Jellinek, A.M. and M. Manga, 2002. *The influence of a chemical boundary layer on the fixity and lifetime of mantle plumes*, Nature, 418, 760-763.
- Stegman, D.R., A.M. Jellinek, S. Zatman, M.A. Richards, and J.R. Baumgardner 2001*, Lunar core dynamo driven by thermochemical mantle convection*, Nature,421, 143-147, 2003.

H. Halls, Professor,
Department of Geology
Brief CV: B.Sc., Sheffield, M.Sc. Durham, Ph.D. Toronto. (1970)
Research Interests*:* Paleomagnetic, rock-magnetic and potential field studies of dikes and the geology and geophysics of the Lake Superior Basin, the Kapuskasing Structural Zone and the Snowbird Tectonic Zone.
Some recent relevant publications*:*

- Nitescu, B. and Halls, H.C. 2002. *A gravity profile across southern Saganash Lake fault: implications for the origin of the Kapuskasing Structural Zone.* Canadian Journal of Earth Science 39:469-480.
- Halls, H.C. and Zhang, B. 2003. *Crustal uplift in the southern Superior Province, Canada, revealed by paleomagnetism.* Tectonophysics 32: 123-136.

B. Milkereit, Professor, Teck Chair of Exploration Geophysics,
Department of Physics
Brief CV: Diplom, Kiel (1981); Ph.D., Kiel. (1984)
Research Interests*:* Exploration geophysics, 3-D seismic imaging, continental deep drilling, meteorite impact craters.
Some recent relevant publications*:*

- Bernd Milkereit, E.K. Berrer, Alan R. King, Anthony H. Watts, B. Roberts, Erick Adam, David W. Eaton, Jianjun Wu and Matthew H. Salisbury (2000), *Development of 3-D seismic exploration technology for deep nickel-copper deposits – A case history from the Sudbury basin, Canada*, Geophysics, 65, pp.1890-1899.
- Christopher A. Scholz, Tobias Karp, Keely M. Brooks, Bernd Milkereit, Philip Y.O. Amoako, Justice A. Arko (2002) *Pronounced central uplift identified in the Bosumtwi impact structure, Ghana, using multichannel seismic reflection data,* Geology, 30, p. 939-942.

J.Mitrovica, Professor
Department of Physics
Brief CV: B.A.Sc., Toronto (1983); M.Sc., Toronto (1985); Ph.D., Toronto (1991)
Research Interests*:* Space-geodetic measurement techniques (very-long- interferometry; Global Positioning System surveying); global regional scale geodynamics; glacial isostatic adjustment; solid (body) tides; Earth rotation and gravity field; plate tectonics and mantle convection.
Some recent relevant publications*:*

- Clark, P.U., J.X. Mitrovica, G. Milne and M. Tamisiea, *Sea-Level Fingerprinting as a Direct Test for the Source of Global Meltwater Pulse IA*, Science, 295, 2438-2441, 2002.
- Mitrovica, J.X. and G.A. Milne, *On the Origin of Late Holocene Highstands Within Equatorial Ocean Basins,* Quat. Sci. Rev., 21, 2179-2190, 2002.

R. Peltier, University Professor
Department of Physics
Brief CV: B.Sc., U.B.C. (1967); M.Sc., Toronto (1969); Ph.D., Toronto (1971).
Research Interests*:* Stability of stratified rotating flows; nonlinear hydrodynamic waves in the atmosphere and oceans; physics of planetary interiors; mantle convection and continental drift; glacial isostasy and the dynamics of the ice-age earth; paleoclimatology and global change; magnetohydrodynamic processes in the earth's core; computational fluid dynamics with supercomputers
Some recent relevant publications*:*

- Butler SL, Peltier WR, *Thermal evolution of Earth: Models with time-dependent layering of mantle convection which satisfy the Urey ratio constraint*, J GEOPHYS RES-SOL EA **107** (B6), 2002
- Crowley TJ, Hyde WT, Peltier WR,*CO2 levels required for deglaciation of a "Near-Snowball" Earth,* GEOPHYS RES LETT **28** (2): 283-286 JAN 15 2001

R. Pysklywec, Assistant Professor,
Department of Geology
Brief CV: B.A.Sc., Queens (1993); M.Sc., Toronto (1994); Ph.D., Toronto (1998).
Research Interests*:* Study of geodynamic processes and Earth- evolution. Application of numerical methods to geological problems. Coupled mantle-lithosphere dynamics; global and regional mechanisms of tectonic processes--orogenesis, basin GPS and active tectonics, structural geology; mantle convection.
Some recent relevant publications*:*

- Pysklywec, R. N., C. Beaumont, P. Fullsack*, Lithospheric deformation during the early stages of continental collision: numerical experiments and comparison with South Island, New Zealand,* J. Geophys. Res., 107(B7), ETG 3 1-19, 2002.
- Pysklywec, R. N., C. Beaumont, and P. Fullsack, *Modeling the behaviour of the continental mantle lithosphere during plate convergence,* Geology, 28(7), 655-658, 2000.

P-Y. Robin, Professor
Department of Geology
Brief CV: Civil and Mining Engineer, Ecole Nationale Supérieure de Métallurgie et de l'Industrie des Mines, Nancy (1965); M.Sc., Toronto (1968); Ph.D. M.I.T. (1974).
Research Interests*:* Physics and chemistry of deformation and phase transitions Minerals and of polymineralic rocks; measurement of large paleostrains and rock fabrics.
Some recent relevant publications*:*

- Fueten, F., P.-Y. F. Robin, and M. Schweinberger (2002) *Finite element modelling of the evolution of pressure solution cleavage.* J. of Structural Geology 24, 1055-1064
- Riller, Ulrich, W. M. Schwerdtner, and P.-Y. F. Robin (1998) *Low-temperature deformation mechanisms at a lithotectonic interface near the Sudbury Basin, Eastern Penokean Orogen, Canada*. Tectonophysics 287, 59-75

P. Young, BSc, Professor
Lassonde Institute
Brief CV: B.Sc.London (1973), M.Sc., Newcastle (1974); Ph.D. (1981), Sunderland
Research Interests*:* Rock fracture dynamics, induced seismicity, earthquake and fault mechanics, and rock damage.
Some recent relevant publications*:*

- Young, RP, Hazzard, JF and Pettitt, WS, 2000. *Seismic and Micromechanical Studies of Rock Fracture*, Geophys. Res. Lett., **27**,1767-1770.
- Young, R.P. and Collins, D.C, 2001. *Seismic studies of rock fracture at the Underground Research Laboratory, Canada*, International, Journal of Rock Mechanics & Mining Sciences, special issue on geophysics in rock mechanics, **38**, 787 – 799

APPENDIX 4
Available Courses

Together, the Departments of Geology and Physics teach many graduate courses. Because students may come from somewhat different backgrounds, the most appropriate mix will depend on the student. The following is a list of Geology and Physics courses, taken from the SGS 2002-2003 calendar (not all are given every year), which have geophysical or related content, or to which geophysics is relevant. Some of the connections may not be obvious (for example, atmospheric physics and the study of geological records such as glacial sediments converge in the study of climate change and the paleoenvironment; the utility of many geophysical methods in mineral exploration is strongly dependent on the geological nature of the particular mineral deposit); a broad selection of such courses is necessary in order not to limit the ability of the program to track future research developments.

GLG 1220H Fractures and Faults in the Earth
GLG 1222H Rheology and Tectonics
GLG 1442H Introductory Mineral Deposits I
GLG 1443H Introductory Mineral Deposits II
GLG 2302H Mineral Deposits Geology
GLG 2602H Regional Precambrian Geophysics
GLG 2603H Geochronology
GLG 2605H Sedimentary Basin Analysis I
GLG 2606H Sedimentary Basin Analysis II
GLG 2608H Advanced Glacial Sedimentology*/N. Eyles*
GLG 2705H Techniques in Paleoenvironmental Research
PHY 2107H Experimental Methods in Physics
PHY 1840H Foundation Course in Geophysics
PHY 2601H Special Topics in Geophysics I
PHY 2602H Special Topics in Geophysics II
PHY 2603H Inverse Theory
PHY 2604H Rock Magnetism
PHY 2605H Advanced Seismology
PHY 2606H Advanced Geodynamics
PHY 2607H Advanced Electromagnetic Methods in Geophysics
JGP 4170H Geotectonics
PHY 1830H Foundation Course in Atmospheric Physics
PHY 2509H Special Topics in Atmospheric Physics I
PHY 2510H Special Topics in Atmospheric Physics II