graduate handbook
2018-2019
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GRADUATE COMMITTEE
The Graduate Committee is responsible for administration of admissions, academics, and other advisory issues for graduate students in the Department. The committee acts on applications for associate instructorships, fellowships, and summer research support and monitors academic progress of students. The committee consists of faculty members chosen to represent a range of disciplines and research fields in the department. The committee is assisted in its work by the Graduate Services Coordinator.

2018-19 GRADUATE COMMITTEE MEMBERS

Dr. Simon Brassell- Director of Graduate Studies  
( simon@indiana.edu)

Professor Michael Hamburger (Graduate Student Affairs)

Professor Claudia Johnson (Graduate Student Affairs)

Assistant Professor Chanh Kieu (Graduate Student Recruitment)

Assistant Professor Brian Yanites (Graduate Student Recruitment)

Graduate Services Coordinator Chelle Filippelli (ctabram@indiana.edu)
LINKS PROVIDED IN THIS HANDBOOK


University Graduate School: https://graduate.indiana.edu/index.html

IU Graduation Ceremony: http://universityevents.iu.edu/

Graduate Student Annual Review Forms: https://graduate.indiana.edu/forms/

Graduate Student Theses Deadlines: https://graduate.indiana.edu/thesis-dissertation/deadlines.html


EAS Graduate Student Handbook: http://earth.indiana.edu/education/handbook.html
**GENERAL INFORMATION FOR ALL GRADUATE STUDENTS**

*Degrees Offered*

The following graduate degrees are offered in the Department of Earth and Atmospheric Sciences: M.S. Geological Sciences, M.S. Geological Sciences-Atmospheric Sciences, Ph.D. Geological Sciences, Ph.D. Geological Sciences-Atmospheric Sciences.

*Residency*

All graduate students must complete at least 30 hours of graduate credits in residence at the IU Bloomington campus. Ph.D. students must be in residence at the Bloomington campus for at least two consecutive semesters during the degree program.

*IUB College Information*

The websites for the College and the Graduate School (https://graduate.indiana.edu/index.html) provide links on the College Graduate Office page to submit requests (Extensions of Incomplete, Family and Medical Leave), to apply for funding (College Travel Awards, College of Arts and Sciences Dissertation Year Research Fellowships), and to appoint your Doctoral Advisory Committee.

*Selection of Advisors and Research Committee*

The Graduate Committee advises graduate students on course selection until a primary advisor is selected. Students should choose a primary advisor with graduate faculty status (Appendix 1) from the Department of Earth and Atmospheric Sciences or the Indiana Geological and Water Survey (IGWS https://igws.indiana.edu/index.cfm). A co-advisor from the Department is required (Appendix 1) if the primary advisor is from the IGWS. In addition, all Ph.D. committees must be chaired by a member of the tenure-track faculty (Appendix 1).

A Research Committee will oversee the student’s academic and research progress toward the degree. For all degrees, a majority of members of the research committee must be selected from the Department of Earth and Atmospheric Sciences. The fields of expertise of both the primary advisor and the research committee should reflect the topic of research chosen by the student.

*Communication with Research Committee*

Students must keep members of their Research Committee informed of their research progress and fulfillment of academic requirements on a regular basis, both through individual or group meetings and by e-mail. Research meetings should occur in every semester of the academic year (Spring and Fall), although students are strongly encouraged to meet more frequently with their committee members on an informal basis.

*Annual Review*

An Annual Review of academic and research progress is required of all graduate students in the department, who should submit the completed Annual Review forms by March 15 following instructions and procedures on the departmental website. The Graduate Committee may require and notify individual students to submit forms earlier than the March 15 deadline in specific instances. The M.S. and Ph.D. Annual Review forms are available on the departmental website as interactive PDF forms under the Education tab and by the following link to the Graduate Handbook Appendices: http://earth.indiana.edu/education/handbook.html

To activate the fillable forms, click on "open in another program" and choose "open in Adobe PDF."

The Annual Review requires all students to meet with their research committee, and completion of the forms including signatures from all committee members and the student. The procedure also requires students to scan all pages of the review, including the signed forms, and submit them as a single composite PDF to the Graduate Service Coordinator. Students who fail to complete their annual review may lose departmental support fol-
lowing a review by the Graduate Studies Commit-
tee and the Chair.

Annual reviews will normally consist of three com-
ponents:

1. An oral presentation by the student that sum-
marizes academic and research progress with a
detailed plan for degree completion that includes
coursework and research.

2. An in-depth discussion with the research
committee to evaluate the student’s prog-
ress objectively and advise the student on
critical aspects of future plans to advance
his/her research.

3. Individual, independent grading of student
progress by the research committee. The
grading scale, form, and the submission pro-
cess will be determined each year by the
Graduate Studies Committee focusing on
ranking of accomplishments and research
progress (e.g. excellent, good, satisfactory,
poor).

The annual review process is the primary mecha-
nism used by the Department to gauge student
research performance and evaluate whether or not
a student should continue to receive departmental
support and continue in their degree program. It
also assists the Graduate Studies Committee in
evaluating student accomplishments for awards.
Based on the annual review a research commit-
tee can specify requirements that must be met
(e.g., revising a research proposal) for progress
to be deemed satisfactory. Those students whose
performance is judged unsatisfactory by their re-
search committee will be subject to departmental
summer probation, which behooves them to dem-
strate improved performance in their research
and/or coursework. Students in this category can
be required to undergo a second review by an ex-
tended committee (henceforth referred to as the
evaluation committee) consisting of the student’s
research committee and one or more represen-
tatives of the Graduate Studies Committee. This
review must take place in August prior to the start
of the fall semester. If performance is still judged
unsatisfactory the student will be placed on formal
academic probation with the Graduate School for
the fall semester. Students in probation are afforded
a final opportunity to show progress in research
based on a third review session administered by
the evaluation committee before the end of the
fall semester.

Sources of Funding

The Department of Earth and Atmospheric Sci-
ences awards AI, RA, and Fellowship support, as
well as summer research funds, on a competitive
basis. AI support encompasses responsibilities
in preparing and/or teaching laboratory courses,
among other duties. RA support is dependent on
the availability of specific research funds procured
by individual faculty members through externally-
funded grant proposals. Fellowships and summer
research support are available from assets allocated
to general or specific departmental accounts.

Diplomas

Degrees are granted every month of the year. The
University Graduate School requires receipt of an
electronic copy of the thesis/dissertation prior to
the 15th day of the month for which the degree is
to be granted; if received after the 15th the degree
will be granted the next month. However, the tim-
ing of degree awards for the months of May and
December when graduate ceremonies are held
is different. In both instances the date is moved
forward to April 30 and November 30, respectively.
Each degree diploma is mailed to a student’s home
address two to three months after the degree is
conferred. Diplomas are sent by third-class mail
(Printed Matter) through the US Postal Service.
Please be aware that items sent third-class are not
forwarded to a new address. Hence, students must
verify that their correct permanent home address is
on file with the Registrar to ensure that the degree
is mailed to the appropriate address. Please see
the Graduate Services Coordinator if you are an international student requiring special arrangements for receipt of the diploma. The Graduate Services Coordinator can instruct you on how to have the diploma sent from the University Graduate School to the EAS Graduate Office (GY107). Our department will then send the diploma by airmail to your international address. Duplicate diplomas may be obtained through the Registrar for an additional fee.

**Transfer of credit**

Up to 8 credit hours of graduate classes can be transferred from another institution, provided the classes meet the requirements of equivalency of graduate classes offered at IU and a grade of ‘B’ or higher was achieved. Pass/Fail or ‘S’ graded classes cannot be transferred. Requests for transfer of credit hours originate with the student and advisor. Students are required to highlight the specific courses they request for transfer on a copy of their transcript and submit that annotated transcript to the Graduate Office GY107. Transfers require approval by the University Graduate School and courses must have been completed within 5 calendar years after entering the Masters degree program.

**Minimum Grade Point Average**

All Masters students must maintain a 3.0 (B) grade point average. Students with a GPA less than 3.0 can be placed on academic probation until the student’s GPA increases to above 3.0. While on academic probation, our departmental policies preclude the student from being supported as an AI, RA, or Fellow. If the student’s GPA does not reach 3.0 after two semesters of probation, he/she will be dismissed from the graduate program.

**Primary Advisor**

An advisor (and co-advisor if necessary; see page 4) should be chosen during the first semester and no later than March 1 of the first year in the degree program.

**Research Committee**

A three-person research committee must be formed for each Masters student, consisting of the primary advisor and two other members. Two of the members of this committee must be tenure-track or non-tenure-track faculty of the Department (see Appendix 1). The composition of the research committee and signatures from each of the members must be filed with the Departmental Graduate Office by March 1 of the first year of the
degree program. Any change in committee membership must be communicated immediately to the Graduate Office.

**Completion of Written Thesis**

The thesis should be prepared in a form that is essentially ready to submit for publication in an appropriate journal(s). Publication and public presentation of research results is strongly encouraged but not required. The format of the thesis must conform to the University’s official policy on the production of theses (Appendix 2).

**Timeframe**

Master’s degrees must be completed within five years of enrollment, or six years for Dual Masters degrees. Students who exceed this time frame must revalidate their coursework.

**M.S. Requirements**

Students in the M.S. degree program who apply successfully for admission into the Ph.D. program in our Department must complete all formal requirements for the degree no later than one semester after entering the Ph.D. program.

**Application for Advanced Degree Form**

This form is on the Graduate School website (https://graduate.indiana.edu/forms), and must be completed and submitted a minimum of 60 days prior to the desired graduation date, regardless of whether you will attend the commencement ceremony.

**Commencement ceremony**

If you wish to attend the commencement ceremony, necessary forms must be filled out in advance. To attend the December commencement, the forms must be completed around mid-September; for the May commencement, they must be completed around mid-February. Further information can be found at the Indiana University Ceremonies website (http://universityevents.iu.edu/). Consult with the Department Graduate Office GY107 for further information.

**M.S. Thesis Presentation**

Students are encouraged to present their final M.S. research results at a regional or national meeting (e.g., AGU, GSA, AAPG, etc.). A departmental defense is not formally required but is strongly recommended and the open presentation should be announced to the department by the student’s advisor giving the title, date, time and location.

**MASTER OF SCIENCE ‘REPORT OPTION’ OVERVIEW**

This degree option is not recommended for most students because it may limit future educational and professional goals. Consequently, any student’s decision to follow this route needs to be taken in consultation with their advisor and research committee. One instance where this plan is appropriate is for those students who plan to continue in the Ph.D. program in our Department, building directly on research begun in the M.S. program. In such circumstances the report route can streamline that transition when appropriate but the formal decision to pursue this option should only be taken after admission to the Ph.D.

The degree requirements include:

**Total of 30 credit hours**

- 27 of the 30 hours must be graduate-level courses; the remaining 3 can be G810. 400-level courses from the Department of Earth and Atmospheric Sciences that can be taken for graduate credit are listed in Appendix 6. 500- to 700-level Earth and Atmospheric Sciences courses, and lower-level courses from other departments that count toward graduate credit can be found in the University Graduate School Academic Bulletin (see the section entitled “Graduate Credit-General” in the Academic Regulations section of the University Graduate School Academic Bulletin).
- 20 of the 27 hours must be from the Department of Earth and Atmospheric Sciences.
• At least three 3-credit hour courses of 500 level or above must be taken from the Department of Earth and Atmospheric Sciences.
• Selection of courses to be taken should be discussed with the primary advisor and research committee.

Transfer of credit
As above in M.S. overview.

Minimum Grade Point Average
As above in M.S. overview.

Report
The precise format and content of the report are determined in collaboration with the student’s advisor and research committee. The report must be signed by the entire research committee. It is recommended that the report should be prepared in a format suitable for publishing, but is not required.

Primary Advisor
An advisor (and co-advisor if necessary; as above in M.S. overview) should be selected no later than March 1 of the first year in the degree.

Research Committee
As above in M.S. overview.

Timeframe
As above in M.S. overview.

Application for Advanced Degree Form
As above in M.S. overview.

Commencement Ceremony
As above in M.S. overview.

M.S. Report Option Presentation
Students are encouraged to present their final M.S. research results at a regional or national meeting (e.g., AGU, GSA, AAPG, etc.) or as a departmental defense with title, date, time and location announced to the department.

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Example credit hour distribution for an M.S. student

<table>
<thead>
<tr>
<th>Classes</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAS G583 Isotopic Systematics</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G572 Basin Analysis and Hydrocarbons</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G601 Clay Mineralogy</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G571 Principles of Petroleum Geology</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G451 Hydrogeology</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G554 Fundamentals of Plate Tectonics</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G590 The Art of Geological Sciences</td>
<td>1.0</td>
</tr>
<tr>
<td>EAS G637 Seminar in Tectonics (taken twice)</td>
<td>2.0</td>
</tr>
<tr>
<td>A597 Introduction to Programming 1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Total: 24.0

Research Hours:
EAS G810 Research Hours: 6.0
Total: 30.0

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MASTER OF SCIENCE DEGREE: GEOLOGICAL SCIENCE-ATMOSPHERIC SCIENCES

Admission Requirements
Undergraduate major in earth sciences, Atmospheric Science, mathematics, physics, chemistry, biology, or equivalent. Applicants not meeting this requirement may be expected to complete additional coursework.

FIELD OF STUDY - ATMOSPHERIC SCIENCES

Course Requirements
Requirements are the same as the M.S. degree (thesis or report option) with one additional requirement. At least 12 credit hours must be from the list of courses specific to Atmospheric Sciences defined by the Department of Earth and Atmospheric Sciences

M.S./M.S.E.S.

Master of Science in Earth & Atmospheric Sciences

Master of Science in Environmental Science

This degree program is appropriate for students from a wide range of undergraduate science programs interested in a career in environmental sciences. This dual masters’ program is a 51-credit hour (two year) program that gives the student greater depth and breadth than is possible in a single degree.
Admission Requirements

A student must apply to and be accepted by both the Department of Earth and Atmospheric Sciences and the School of Public and Environmental Affairs (SPEA).

Course Requirements

- Course requirements are a minimum of 21 credits from each program distributed as follows:
  - Earth and Atmospheric Sciences core (12 cr.)
  - Environmental Science core (12 cr.)
  - Courses in economics, policy, and law competencies (6 cr.)
  - A tool skill (3 cr.)
  - Other Earth and Atmospheric Sciences or SPEA courses recommended by advisory committee and
  - 9 Credits of research divided between Earth and Atmospheric Sciences and SPEA.

The distribution of credits across these requirements can be modified with the approval of the research committee. This committee, with a minimum of three members, will supervise the student’s research program. At least one member of the committee must have a primary affiliation with the Department of Earth and Atmospheric Sciences and at least one member must have a primary affiliation with SPEA. Two members of the advisory committee must be named as co-advisors with one advisor from each program.

Courses that satisfy the 12 credit hour requirement:
EAS G532 Physical Meteorology and Climatology
EAS G531 Dynamic Meteorology
EAS G533 Advanced Synoptic Meteorology and Climatology
EAS G534 Air Pollution Meteorology
EAS G555 Wind Power Meteorology
EAS G562 Dynamic Meteorology: Boundary-Layer Meteorology
EAS G570 Micrometeorology
EAS G575 Climate Change Science
DOCTOR OF PHILOSOPHY DEGREE OVERVIEW

The requirements are:

**Total of 90 credit hours**

- 35 of the 90 hours must be graduate-level courses.
- 20 of the 35 hours of coursework must be in Earth and Atmospheric Sciences. The remaining credit hours may include electives and coursework required to fulfill the minor.
- 12 of these 35 hours must be graduate courses from the Indiana University Department of Earth and Atmospheric Sciences. In exceptional cases (e.g., when a student enters the Ph.D. program with a strong background in earth sciences from another university and finds few courses in the department that will support their doctoral research program), a candidate may petition the Graduate Studies Committee in writing to waive this requirement.
- Up to 30 credit hours of graduate classes can be transferred from another institution, providing a grade of ‘B’ or higher was earned. Pass/Fail or ‘S’ graded classes cannot be transferred without a letter of clarification from the instructor that a B or higher equivalent would have been awarded. Courses to be transferred must be approved by the University Graduate School and must have been completed within the 7 calendar years prior to passing the Qualifying Exam.

**Minimum Grade Point Average**

All Ph.D. students must maintain a 3.0 (B) grade point average.

**EAS G901 Advanced Research**

Dissertation credits as EAS G901 can be taken when the student has fulfilled all the course requirements detailed above, and completed 90 credit hours of graduate-level coursework. A maximum of 6 semesters of G901 is permitted.

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**Example credit hour distribution for a Ph.D. student**

<table>
<thead>
<tr>
<th>Classes:</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EAS G513 Seismology</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G583 Isotopic Systematics</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G514 Geophysical Signal Analysis</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G612 Inverse Methods in Geophysics</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G572 Basin Analysis and Hydrocarbons</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G601 Clay Mineralogy</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G571 Principles of Petroleum Geology</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G451 Hydrogeology</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G554 Fundamentals of Plate Tectonics</td>
<td>3.0</td>
</tr>
<tr>
<td>EAS G589 Geomicrobiology</td>
<td>3.0</td>
</tr>
<tr>
<td><em>Total</em></td>
<td><em>30.0</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minor:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A597 Introduction to Programming I</td>
<td>3.0</td>
</tr>
<tr>
<td>A598 Introduction to Programming II</td>
<td>3.0</td>
</tr>
<tr>
<td>P573 Scientific Computing</td>
<td>3.0</td>
</tr>
<tr>
<td>P673 Advanced Scientific Computing</td>
<td>3.0</td>
</tr>
<tr>
<td><em>Total</em></td>
<td><em>12.0</em></td>
</tr>
</tbody>
</table>

| Total all Graduate Courses:                          | *42.0*       |

<table>
<thead>
<tr>
<th>Research Hours:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>EAS G810 Research Hours</td>
<td>48.0</td>
</tr>
<tr>
<td><em>Total</em></td>
<td><em>90.0</em></td>
</tr>
</tbody>
</table>

G901 is currently 6 credit hours offered in spring and fall semesters. Summer enrollment is not required unless the student intends to receive the degree during summer, which necessitates enrollment in 1 credit of EAS G810.

**Primary Advisor**

A primary advisor (and co-advisor if necessary; see page 4) should be selected and agree to fulfill this role no later than December 1 of the first year of the degree.

**Advisory Committee**

The advisory committee shall approve the student’s program of study and counsel the student until he/she has passed the Qualifying Exam. The advisory committee must include at least two members from the major area and one from the minor. The name of the primary advisor and two other members of the committee must be confirmed in a signed letter to the Graduate Services Coordinator.
Research Committee

Following the qualifying exam, a research committee must be selected, consisting of the primary advisor and 3-4 other members. The research committee can include all of the members of the Advisory Committee, supplemented by other IU faculty or individuals from other institutions connected to the research. Three of the members of this committee must be tenure-track or non-tenure track faculty in the Department. In addition, the University Graduate School requires that at least two members of the research committee must be eligible to chair the committee (i.e., they must be tenure-track faculty). The composition of the research committee and signatures from each of the members must be provided on the annual review form; any change must be communicated to the Graduate Office promptly.

Selection of a Minor

Selection of a Minor is also a requirement for the degree. Minors in allied science and mathematics are intended to broaden a student’s background. The minor can also be in an area within the geosciences but distinct from the chosen major. Formal external and internal minors are approved by the University Graduate School (http://bulletins.iu.edu/iu/gradschool/2017-2018/requirements/index.shtml).

Minors typically require between 6 and 12 credit hours of coursework. Courses taken for the minor can count toward the requirement of 35 credit hours of graduate course work. The precise requirements and courses needed will be determined by the Minor Advisor, who must be a faculty member in the minor department. However, minors in some units (e.g., SPEA) required a specified number of credit hours. The minor advisor normally becomes a member of the student’s research committee (see below).

Students electing an internal minor must complete a minimum of 6 credit hours of course work in an area of earth or atmospheric sciences distinct from their major research area. Students planning an internal minor must have their study plan approved by their advisory committee and the Director of Graduate Studies to ensure that it conforms to the aim of broadening their background. (This option for a student-selected internal minor should not be confused with the individualized minor – see below).

An individualized minor option with a minimum of 12 credit hours from at least two different Departments is also possible through petition to the University Graduate School. An individualized internal minor, which also requires coursework from at least two Departments, must be approved by the Graduate Committee and by the Graduate School Dean’s office prior to completing the proposed course work.

In all instances it is strongly recommended that Ph.D. students consult with the Graduate Services Coordinator to ensure that their selection of courses to meet the minor requirement does indeed conform to the regulations established by the University Graduate School. Early action to verify course selections for the minor helps ensure timely progression to the qualifying examination and graduation and guard against taking redundant course options.

ADMISSION

Students are admitted to the Ph.D. program through one of three mechanisms:

• Direct admission to the Ph.D. program following completion of an undergraduate degree program. (Students who enter the Ph.D. program with a baccalaureate degree will be encouraged to complete an M.S. degree.)
• Admission after completion of an M.S. degree at another institution.
• Current Indiana University students enrolled in our M.S. program can apply for admission to the Ph.D. program early in their second year of graduate study.
The early review process is used to evaluate a student’s suitability for the Ph.D. program and preparedness to achieve the degree goal.

The expectations of progress toward the Ph.D. degree and the timelines for review of student progress, as described below, are different for each of these groups (Figure 1).

**EARLY REVIEW**

**Objectives**

The early review is an extension of the department annual review process. The specific purpose of this requirement is to provide an early stage assessment of each student’s level of preparation to complete the Ph.D. degree. The aim is to (i) ensure that students are actively developing a viable research project with appropriate advisors, and (ii) identify aspects of students’ academic background that need strengthening early in their course of study.

**Administration and Timetable**

The Graduate Studies Committee administers this review procedure. Figure 1 (page 16) is a graphical representation of the timeline for this review for the three different groups outlined above. A key aspect of this process is that students entering the program with a baccalaureate degree are required to go through this process in the fall of their second year of residence, whereas students entering the program with an M.S. degree will be reviewed in the spring semester of their first year. Students will be notified of the schedule for the various steps in the process at least two months in advance of their early review.

**Step 1: Study Plan**

As illustrated by the timelines in Figure 1, students are required to complete and submit a preliminary Ph.D. research and study plan comprised of three parts:

- **Research Statement**
  A brief (less than one page) summary of a student’s research plan written for a non-specialist. For example, a format comparable to the “Intellectual Merit” section of the project summary for a standard proposal to the National Science Foundation.

- **Personal Statement**
  An assessment by the student of their perception of specific strengths and weaknesses pertinent to their research field and degree goals. This should address three areas:
  1. Academic background (e.g. coursework and field experiences)
  2. Research skills (e.g. talents in writing, mathematics, computing, laboratory work, etc.)
  3. Personality characteristics important to professional success (e.g. tenacity, flexibility, commitment, ability to work in a team, etc.).

- **Intellectual Development**
  A bulleted list of specific targets in academic preparation and research skills that require strengthening in order to complete the Ph.D. in a timely manner.

**Step 2: Feedback and Review of Study Plan**

The graduate committee and the student’s advisor will provide feedback to the student as a written response sent via an email message according to the established schedule, typically about two weeks after submission of the study plan. This response will be in the form of a review that the
student should use as a guide in preparation for the oral exam. The review will focus on topics that will constitute the principal points for discussion in the oral exam, especially areas that students identify as strengths, rather than weaknesses.

**Step 3: Oral Exam**

The Graduate Studies Committee will schedule an oral exam for individual students. The examination committee will consist of two or members of the graduate committee, the student’s advisor, and (optionally) one or more members of the student’s research committee. Question topics will focus on areas of knowledge described in the individual review guide given to each student and centered on their strengths. Students should recognize, however, that the broad objective of the exam is to identify areas that need strengthening; hence, the committee may ask questions regarding any aspect of geosciences.

**Step 4: Results of Early Review**

There are three possible outcomes of this exam:

**Unconditional Pass**

This pass recognizes that a student has a background without deficiencies, a viable research plan, and is suitably prepared for success in the Ph.D. program.

**Deferred Decision**

When a student’s self-evaluation or the early review process reveals a need to augment their academic background there may be a requirement to complete one or more courses, or fulfill other specific conditions, as determined by the committee and advisor. The result of the exam may be deferred pending the student’s fulfillment of the conditions imposed by the committee, which may relate to aspects of coursework or research tasks. Students in this category are required to demonstrate significant progress by their annual review or they may enter the probation process described above in the description of the annual review process.

**Fail**

A student can fail this exam. The primary reason for failure will be a student’s inability to convince the committee that he/she can successfully complete the Ph.D. program. For example:

- An inability to provide coherent answers during the oral exam,
- The absence of a viable research plan, or likelihood of developing one,
- Evidence of a lack of commitment to the profession or to the Ph.D. program.

There is no possibility for retaking the exam for students who fail. For students entering the program with an outside M.S. degree (as designated above) the ‘fail’ result is generally reserved for those exceptional circumstances when a student is disengaged from their intended research program.

**QUALIFYING EXAMINATION**

This is a three-stage process and can be undertaken only after the minimum course requirements have been fulfilled. It should be normally taken no later than the 6th semester in the program:

1. The candidate will prepare a research proposal with figures of approximately 15 pages excluding references. The proposal will be reviewed by the student’s advisory committee and used as part of the exam assessment. The proposal must demonstrate that the proposed research consists of a suitable topic in terms of feasibility and importance. Hence, a set of preliminary results and familiarity with the field and literature are normally necessary before writing the proposal. Once revisions are made and the proposal is accepted by the advisory committee, the second stage can be initiated.

2. A written examination based on the research proposal is prepared by the advisory committee with each member of the committee providing questions coordinated by the
primary advisor. This is a normally a closed-book examination taken on a day agreed by the student and advisor and spans approximately 3 hours in the morning and 3 hours in the afternoon. The examination aims (i) to evaluate familiarity with the chosen research area, (ii) to assess the relation of this field of research to others in the geosciences, and (iii) to alert the student to potential weaknesses in the research proposal. The advisory committee will collectively evaluate responses to the examination questions. If responses are deemed sufficient and satisfactory, then the process proceeds to the third part. Students deemed to have failed the written examination will be required to retake the examination, or to complete specified remedial classes within 6 months of the examination date, or can be asked to leave the graduate program at the end of the semester.

3. The oral portion of the exam typically takes place one to two weeks after the written exam, and is scheduled in consultation with the research committee. It is the student’s responsibility to arrange for a room and reserve presentation equipment (see the Office Assistant in GY129). The format normally consists of an oral presentation of the research proposal by the student to their advisory committee, and responses to committee members’ questions regarding both the proposal and answers to the written examination. The oral examination usually takes 2-3 hours. Possible outcomes of this exam are:

- Pass and admission to formal Ph.D. Candidate status, pending Graduate School approval.
- Conditional pass whereby the candidate may need to satisfy some requirements set by the committee, which may involve further classes or research.
- Fail with permission to retake the exam.
- Fail without permission to retake the exam, which leads to dismissal from the graduate program.

Nomination to Candidacy

The Nomination to Candidacy form must be completed online at https://graduate.indiana.edu/forms/ prior to the Qualifying Examination. If a candidate passes, all committee members must sign the form on the day of the Qualifying Examination. This form is then sent to the University Graduate School for acceptance of the examinee to become a formal Ph.D. candidate. After approval by the Graduate School, the candidate must complete the form for nomination of their research committee, which is on the University Graduate School’s website (https://graduate.indiana.edu/index.html).

Completion of Written Dissertation

The dissertation should be prepared in a form that is essentially ready to submit for publication in appropriate journals. Publication of results is strongly encouraged and ideally dissertations contain chapters that have already been published in the peer-reviewed literature. The format of the dissertation must conform to the University’s official policy on the production of theses.

Dissertation Defense

The defense should be timed to ensure that at least eight months will elapse between passing the Qualifying Examination and the date the Ph.D. degree is awarded. The primary advisor and every member of the research committee must all be in agreement that the dissertation is ready for the defense to be scheduled, based on review and approval of drafts of the dissertation submitted by the student.

An Announcement of Defense must be submitted to the University Graduate School at least 30 days prior to the defense date. An example of the format required is included in Appendix 2. A copy of the dissertation for public perusal must be provided to
the department office at least two weeks prior to the defense. The defense itself consists of a public presentation of the dissertation research open to all faculty and students, followed by questions and discussion. The student’s research committee then conducts a rigorous oral examination of the student in closed session to determine whether the work submitted merits the Ph.D. degree.

The result of the defense is determined as (i) a pass, (ii) a conditional pass, which means that the research committee requires specific revisions of the dissertation to satisfy their recommendations, (iii) a deferred decision, which indicates that the opinion of the research committee was not unanimous – a circumstance that requires reports from the research committee detailing the differing opinions to the Dean of the Graduate School, or (iv) a failure without the option to retake.

After a successful defense, the Graduate Office needs to receive (i) one signed copy of the dissertation abstract, and (ii) one signed dissertation. Students should plan to submit the final version of their dissertation electronically to the University Graduate School as soon as possible.

**Timeframe**

The Ph.D. dissertation must be approved and signed by the student’s research committee and a copy must be submitted to the University Graduate School within seven years of passing the Qualifying Examination. Failure to meet this schedule will result in termination of Ph.D. candidacy. Reinstatement of candidacy is possible and involves obtaining permission of the department chairperson, fulfilling any reinstatement requirements from the Department, passing the Qualifying Examination again, and then requesting reinstatement from the Dean. Once reinstated, the degree must be completed within three years.

**Ph.D. Commencement Participation Application**

Paperwork must be completed in advance to attend commencement, and graduates should liaise with their advisors regarding the hooding ceremony. To attend the December commencement, forms must be completed in mid-September; for the May commencement, forms must be completed in mid-February. Commencement information can be found at the Indiana University Ceremonies website [http://universityevents.iu.edu/](http://universityevents.iu.edu/). Further information can be obtained from the Graduate Services Office.

**EXTENDED DEPARTMENTAL SUPPORT**

There is an opportunity each spring semester for Ph.D. students in their final year of guaranteed funding to apply for extended AI support. The application process requires the following:

1. Submission of a 3-5 page proposal by November 1 that includes: (i) a brief summary of the scientific topics addressed in the dissertation research, (ii) a concise review of research progress, (iii) an outline of research activities and dissertation chapters that remain to be completed, (iv) a proposed timeline for review and submission of the dissertation and a target defense date, (v) a statement about other potential sources of funding, and (vi) a brief summary of past teaching experience with examples of how students have accomplished specific learning outcomes.

2. Proposals are circulated to student research committees with each member of the research committee being asked to provide an independent evaluation of the document.

3. The student’s advisor will be required to submit a more extensive evaluation of the student’s research status and achievements and his/her previous teaching experience and effectiveness that includes a recommendation regarding support.

4. Each student will meet separately with the Graduate Affairs Committee, giving an oral presentation and responding to questions in a manner similar to the annual review process.
The Graduate Affairs committee will evaluate the information from the review process, placing students in one of four categories based on the following criteria:

1. Evidence of research progress and past productivity coupled with current momentum and recent accomplishments.
2. Objectivity and viability of plan for completion of dissertation, including comments from advisory committee.
3. Consideration of evidence of teaching effectiveness.

On the basis of this evaluation the committee will make one of four recommendations:

1. Priority funding – students in this category will receive an immediate extension of their guaranteed support package.
2. Fund if possible – final decisions for continuing support of students in this category will be made in combination with assessment of new student applications.
3. Fund only if late support becomes available – unplanned AI support sometimes emerges when the award of grant funds releases another student from an AI position. Students in this category will be eligible for support on a semester-by-semester basis in such instances.
4. Do not fund

Students in categories 1 and 2 are required to provide a formal acceptance or rejection of any offer by the April 15 national commitment date to mesh this process with recruiting new graduate students, although an earlier response is requested, whenever possible, to best enable recruitment of new graduate students.

**DOCTOR OF PHILOSOPHY DEGREE: GEOLOGICAL SCIENCE-ATMOSPHERIC SCIENCES**

**Course Requirements**

Requirements are the same as the regular Ph.D. degree with one additional requirement. At least 12 credit hours from a list of courses specific to Atmospheric Sciences defined by the Department of Earth and Atmospheric Sciences.

**DOCTOR OF PHILOSOPHY DEGREE WITHOUT PRIOR M.S.C. DEGREE IN GEOLOGICAL SCIENCES**

The requirements below presume that the student begins the program having completed a Bachelors degree. The requirements include:

**Total of 90 credit hours**

- 35 of the 90 hours must be graduate-level courses.
- 20 of these 35 hours must be graduate courses related to the students major research area
- 12 credits must be taken in the Indiana University Department of Earth and Atmospheric Sciences
- Credits for the minor count toward the 35 total hours of coursework
- Transfer of credit - as specified for Ph.D.

**Courses that satisfy the 12 credit hour requirement:**

- EAS G532 Physical Meteorology and Climatology
- EAS G531 Dynamic Meteorology
- EAS G533 Advanced Synoptic Meteorology and Climatology
- EAS G534 Air Pollution Meteorology
- EAS G555 Wind Power Meteorology
- EAS G562 Dynamic Meteorology: Boundary-Layer Meteorology
- EAS G570 Micrometeorology
- EAS G575 Climate Change Science
The following items have the same requirements as those specified in the Ph.D. Overview:

- A 3.0 (B) grade point average
- EAS G901 Advanced Research
- Primary Advisor
- Research Committee
- Selection of a Minor
- Ph.D. students are subject to annual and early review procedures described above
- Qualifying Examination
- Completion of Written Dissertation
- Dissertation Defense

*All IU students review fall of 3rd semester. External M.S. review start of 2nd semester*

Figure 1: Illustrates a timeline for completing Ph.D. and M.S. degrees in Geological Sciences at IU.
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<td>24</td>
</tr>
<tr>
<td>Appendix 4: 400-Level Courses Applied Toward Graduate Credit</td>
<td>27</td>
</tr>
</tbody>
</table>
APPENDIX 1

FACULTY DIRECTORY 2018-2019
## APPENDIX 1: TEACHING FACULTY, EMERITUS, AND ADJUNCT FACULTY

### Tenure-Track Faculty:  
(The following faculty can hair Ph.D. research committees, supervise Ph.D./Masters students and serve on research committees)

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Specialty</th>
<th>Phone</th>
<th>Room</th>
<th>Email</th>
<th>Dept.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor</td>
<td>Simon Brassell</td>
<td>Biogeochemistry, Organic Geochemistry</td>
<td>5-3786</td>
<td>MSBII 404</td>
<td>simon</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>James Brophy</td>
<td>Igneous Petrology, Geochemistry</td>
<td>5-6417</td>
<td>GY309</td>
<td>brophy</td>
<td>EAS</td>
</tr>
<tr>
<td>Assoc. Professor</td>
<td>Douglas Edmonds</td>
<td>Sedimentary Geology</td>
<td>5-4512</td>
<td>GY425</td>
<td>edmondsd</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>Michael Hamburger</td>
<td>Geophysics, Seisimology and Tectonics</td>
<td>5-2934</td>
<td>GY415</td>
<td>hamburg</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>Claudia Johnson</td>
<td>Geobiology</td>
<td>5-0646</td>
<td>GY501</td>
<td>claudia</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>Kaj Johnson</td>
<td>Geophysics</td>
<td>5-3612</td>
<td>GY401</td>
<td>kajohns</td>
<td>EAS</td>
</tr>
<tr>
<td>Asst. Professor</td>
<td>Chanh Kieu</td>
<td>Atmospheric Science</td>
<td>6-5704</td>
<td>GY428a</td>
<td>ckieu</td>
<td>EAS</td>
</tr>
<tr>
<td>Assoc. Professor</td>
<td>Jackson Njau</td>
<td>Geoanthropology</td>
<td>6-3170</td>
<td>GY513</td>
<td>jknjau</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>David Polly</td>
<td>Geobiology</td>
<td>5-7994</td>
<td>GY524a</td>
<td>pdpolly</td>
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<tr>
<td>Professor</td>
<td>Ed Ripley</td>
<td>Isotope Geochemistry</td>
<td>5-1196</td>
<td>GY329</td>
<td>ripley</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>Juergen Schieber</td>
<td>Sedimentary Geology</td>
<td>5-5322</td>
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<td>jschiebe</td>
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<tr>
<td>Asst. Professor</td>
<td>Paul Staten</td>
<td>Atmospheric Science</td>
<td>6-5135</td>
<td>GY424a</td>
<td>pwstaten</td>
<td>EAS</td>
</tr>
<tr>
<td>Asst. Professor</td>
<td>Brian Yanites</td>
<td>Geomorphology, Surface Processes, Geophysics</td>
<td>5-6109</td>
<td>GY429</td>
<td>byanites</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor</td>
<td>Chen Zhu</td>
<td>Hydrogeology, Mass Transport, Water-Rock-Gas-Microbe Interactions</td>
<td>6-1884</td>
<td>MSBII 424</td>
<td>czhu</td>
<td>EAS</td>
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</tbody>
</table>

### Non-Tenure-Track Teaching & Research Faculty:  
(These faculty can serve on research committees, and the Senior Scientists can supervise Ph.D./Masters students)

<table>
<thead>
<tr>
<th>Title</th>
<th>Name</th>
<th>Specialty</th>
<th>Phone</th>
<th>Room</th>
<th>Email</th>
<th>Dept.</th>
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</thead>
<tbody>
<tr>
<td>Senior Lecturer</td>
<td>Bruce Douglas</td>
<td>Tectons and Structural Geology</td>
<td>5-3848</td>
<td>GY423</td>
<td>douglasb</td>
<td>EAS</td>
</tr>
<tr>
<td>Senior Lecturer</td>
<td>Erika Elswick</td>
<td>Geochemistry, Sedimentology, Sedimentary Ore Deposits</td>
<td>5-2493</td>
<td>MSBII 428</td>
<td>eelswick</td>
<td>EAS</td>
</tr>
<tr>
<td>Professor of Practice</td>
<td>Jim Handschy</td>
<td>Petroleum Geology, Structural Geology, Seismic Interpretation</td>
<td></td>
<td></td>
<td><a href="mailto:jwhandsch@iu.edu">jwhandsch@iu.edu</a></td>
<td>EAS</td>
</tr>
<tr>
<td>Research Scientist</td>
<td>Ed Herrmann</td>
<td>Geoarchaeology</td>
<td>6-0587</td>
<td>GY417</td>
<td>edherrma</td>
<td>EAS</td>
</tr>
<tr>
<td>Lecturer</td>
<td>Cody Kirkpatrick</td>
<td>Atmospheric Science</td>
<td>5-3481</td>
<td>GY405</td>
<td>codykirk</td>
<td>EAS</td>
</tr>
<tr>
<td>Senior Scientist</td>
<td>Chusi Li</td>
<td>Petrology, Geochemistry, Mineral Deposits</td>
<td>5-1558</td>
<td>GY217</td>
<td>cli</td>
<td>EAS</td>
</tr>
<tr>
<td>Research Scientist</td>
<td>Peter Sauer</td>
<td>Biogeochemistry, Paleoclimateology</td>
<td>5-6591</td>
<td>MSBII 410</td>
<td>pesauer</td>
<td>EAS</td>
</tr>
<tr>
<td>Senior Scientist</td>
<td>Arndt Schimmelmann</td>
<td>Organic Geochemistry, Chemical Oceanography</td>
<td>5-7645</td>
<td>GY321</td>
<td>aschimme</td>
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</tr>
</tbody>
</table>
## Emeritus Faculty

<table>
<thead>
<tr>
<th>Name</th>
<th>Research Area</th>
<th>Phone</th>
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<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abhijit Basu</td>
<td>Sedimentary and Planetary Petrology</td>
<td>5-6654</td>
<td>GY507</td>
<td>basu</td>
<td>EAS</td>
</tr>
<tr>
<td>David Bish</td>
<td>Clay Mineralogy, Mineralogy</td>
<td>5-2039</td>
<td>GY209</td>
<td>bish</td>
<td>EAS</td>
</tr>
<tr>
<td>David L. Dilcher</td>
<td>Geobiology</td>
<td>6-0618</td>
<td>S209</td>
<td>dilcher</td>
<td>EAS</td>
</tr>
<tr>
<td>J. Robert Dodd</td>
<td>Geobiology</td>
<td>5-4957</td>
<td>GY119</td>
<td>dodd</td>
<td>EAS</td>
</tr>
<tr>
<td>Jeremy Dunning</td>
<td>Structural Geology</td>
<td></td>
<td></td>
<td>dunning</td>
<td></td>
</tr>
<tr>
<td>Henk Haitjema</td>
<td>Hydrology</td>
<td>5-0731</td>
<td>SPEA439</td>
<td>haitjema</td>
<td>SPEA</td>
</tr>
<tr>
<td>Brian Keith</td>
<td>Sedimentology, Stratigraphy</td>
<td>5-4213</td>
<td>S117</td>
<td>keithb</td>
<td>IGS</td>
</tr>
<tr>
<td>Enrique Merino</td>
<td>Geochemistry and Petrology</td>
<td>5-5088</td>
<td>GY117</td>
<td>merino</td>
<td>EAS</td>
</tr>
<tr>
<td>Greg Olyphant</td>
<td>Hydrogeology, Quaternary Geology</td>
<td>5-1351</td>
<td>S423</td>
<td>olyphant</td>
<td>EAS</td>
</tr>
<tr>
<td>Gary Pavlis</td>
<td>Geophysics</td>
<td>5-5141</td>
<td>GY409</td>
<td>pavlis</td>
<td>EAS</td>
</tr>
<tr>
<td>Lisa Pratt</td>
<td>Planetary Protection Officer, NASA</td>
<td>5-2149</td>
<td>MSBII 416</td>
<td>prattl</td>
<td>EAS</td>
</tr>
<tr>
<td>Lee J. Suttner</td>
<td>Sedimentology and Stratigraphy</td>
<td>5-4957</td>
<td>GY119</td>
<td>suttner</td>
<td>EAS</td>
</tr>
<tr>
<td>Robert Wintsch</td>
<td>Petrology, Tectonics</td>
<td></td>
<td></td>
<td>wintsch</td>
<td>EAS</td>
</tr>
</tbody>
</table>

## Adjunct Faculty

Adjunct Faculty: (These faculty can supervise a Ph.D./Masters student, but require a co-advisor from the Tenure or Non-Tenure-track Faculty. They can also serve on research committees)

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Research Area</th>
<th>Phone</th>
<th>Room</th>
<th>Initials</th>
<th>Department</th>
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</thead>
<tbody>
<tr>
<td>Professor</td>
<td>Chris Craft</td>
<td>Wetland Ecology</td>
<td>5-5971</td>
<td>MSBII 408</td>
<td>ccraft</td>
<td>SPEA</td>
</tr>
<tr>
<td>Research Scientist</td>
<td>Sally Letsinger</td>
<td>Hydrogeology, GIS</td>
<td>5-1356</td>
<td>S427</td>
<td>sletsing</td>
<td>IGS</td>
</tr>
<tr>
<td>Assoc. Professor</td>
<td>Adam Maltese</td>
<td>Science Education/Adjunct Faculty</td>
<td>6-8069</td>
<td>Wright Ed Bldg 3054</td>
<td>amaltese</td>
<td>School of Education</td>
</tr>
<tr>
<td></td>
<td>Maria Mastalerz</td>
<td>Coal Petrology, Coal Geochemistry, Coalbed Gas</td>
<td>5-9416</td>
<td>S225</td>
<td>mmastale</td>
<td>IGS</td>
</tr>
<tr>
<td>Research Scientist</td>
<td>Pat McLaughlin</td>
<td>Adjunct Faculty</td>
<td>5-1350</td>
<td>S319</td>
<td><a href="mailto:pimclaug@iu.edu">pimclaug@iu.edu</a></td>
<td></td>
</tr>
<tr>
<td>Distinguished Professor</td>
<td>Peter Ortoleva</td>
<td>Geochemistry</td>
<td>5-2717</td>
<td>CH203E</td>
<td>ortoleva</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Professor</td>
<td>Jeff White</td>
<td>Geochemistry</td>
<td>5-0731</td>
<td>MSBII 412</td>
<td>whitej</td>
<td>SPEA</td>
</tr>
</tbody>
</table>

1 Only the listed phone number is needed when calling from on-campus; add 85 to the front to reach them from off-campus locations.

Please note that this list changes every year – please consult the updated directory information placed in student mailboxes at the beginning of the fall semester.
APPENDIX 2
FORMS REQUIRED BY THE UNIVERSITY GRADUATE SCHOOL

The University Graduate School has a comprehensive website informing students on the requirements for preparing theses and dissertations. Please review materials provided for completion of the research degree at: https://graduate.indiana.edu/index.html

These forms are available online:

M.S. APPLICATION FOR ADVANCED DEGREE

Ph.D. NOMINATION OF RESEARCH COMMITTEE

Ph.D. NOMINATION TO CANDIDACY

Ph.D. SCHEDULE AND ANNOUNCEMENT OF FINAL EXAMINATION (on OneIU)

Ph.D. COMMENCEMENT PARTICIPATION APPLICATION (on OneIU)

A GUIDE TO THE PREPARATION OF THESES AND DISSERTATIONS (on Graduate School website)

INSTRUCTIONS: Go to the Graduate School website to complete and submit the required forms.

https://graduate.indiana.edu/forms/

AND

https://graduate.indiana.edu/thesis-dissertation/deadlines.html
The Partridge River Intrusion (PRI) is one of several large, tholeiitic bodies that occur along the Western portion of the Duluth Complex in northern Minnesota. Mafic magmatism developed in response to intercontinental rifting at approximately 1.1 Ga. The intrusion is host to several Cu-Ni sulfide deposits that are found near the basal contact with metapelitic footwall (the Proterozoic Virginia Formation). The upper portion of the PRI is characterized by thick, unlayered, monotonous sequences of troctolite and augite troctolite. Thin (usually less than 5 meters in thickness) layers of melatroctolite and picrite occur at irregular intervals. Cu-Ni mineralization, and iron-rich units of ferrogabbro occur near the base of intrusion. The ferrogabbro units are also enriched in incompatible elements (P, Y, Ti), and are intercalated with troctolite.

Previous researchers have suggested genetic mechanisms to explain the chemical variations in the PRI that range from differentiation of a single magmatic pulse, to multiple inputs of chemically distinct magma. This study was conducted to evaluate and model the magmatic process involved during the emplacement of the PRI. Samples were selected from a drillcore located to the northwest of the major Cu-Ni sulfide body at the Babbitt deposit. The site was chosen to avoid discontinuities caused by the presence of metapelitic xenoliths of the Virginia Formation, which are common in the vicinity of the mineralization.

Ferrogabbro at the bottom of the intrusion was derived from an evolved melt of ferrodioritic composition, emplaced early in the history of the PRI. A later, more primitive troctolitic melt intruded the ferrogabbro. The main massive Cu-Ni mineralization is distinct, isotopically and compositionally, from the overlying disseminated mineralization, and was emplaced as a separate body, also early in the history of the PRI. Both the differentiated, ferrogabbroic melt and the sulfide melt which formed the massive mineralization evolved in one or more staging chambers in the shallow crust.
APPENDIX 3

OUTSIDE COURSES APPLICABLE TO THE DEGREES
### Outside Courses

(Note: This is not an exhaustive list, other subjects may be taken with permission of the Graduate Committee and the Graduate School. All students are advised to consult the Director of Graduate Studies if you want a course at the 400 level or below to count for graduate credit.)

<table>
<thead>
<tr>
<th>Applied Mathematics</th>
<th>Cr hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>M301 Linear Algebra and Applications</td>
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</tr>
<tr>
<td>M303 Linear Algebra for Undergraduates</td>
<td>3.0</td>
</tr>
<tr>
<td>M311 Calculus 3</td>
<td>3.0</td>
</tr>
<tr>
<td>M312 Calculus 4</td>
<td>3.0</td>
</tr>
<tr>
<td>M343 Introduction to Differential Equations w. Applications 1</td>
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<tr>
<td>M344 Introduction to Differential Equations w. Applications 2</td>
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<tr>
<td>M415 Elementary Complex Variables w. Applications</td>
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<td>M441 Introduction to Partial Differential Equations w. Applications 1</td>
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## Appendix 3: Outside Courses

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<td>C317  Equilibria and Electrochemistry</td>
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<td>G532  Physical Climatology</td>
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APPENDIX 4

400-LEVEL COURSES THAT CAN BE APPLIED TOWARD GRADUATE CREDIT

400-Level courses that count for graduate credit within the Department of Earth and Atmospheric Sciences

- EAS E404, Geobiology
- EAS E406, Introduction to Geochemistry
- EAS E411, Invertebrate Paleontology
- EAS E413, Introduction to Earth Physics
- EAS E415, Geomorphology
- EAS E416, Economic Geology
- EAS E417, Optical Mineralogy
- EAS E418, Igneous and Metamorphic Petrology
- EAS X420, Regional Geology Field Trip
- EAS E423, Methods in Applied Geophysics
- EAS E427, Introduction to X-Ray Mineralogy
- EAS X429, Field Geology in the Rocky Mountains
- EAS E451, Hydrogeology