

# GEOSCIENCES

<b>Graduate Program Head</b>	Mark Patzkowsky
<b>Program Code</b>	GEOSC
<b>Campus(es)</b>	University Park (Ph.D., M.S.)
<b>Degrees Conferred</b>	Doctor of Philosophy (Ph.D.) Master of Science (M.S.) Dual-Title Ph.D. in Geosciences and Astrobiology Dual-Title Ph.D. in Geosciences and Biogeochemistry Dual-Title Ph.D. and M.S. in Geosciences and Operations Research Integrated B.S in Geosciences and M.S. in Geosciences
<b>The Graduate Faculty</b>	View ( <a href="https://secure.gradsch.psu.edu/gpms/index.cfm?searchType=fac&amp;prog=GEOSC">https://secure.gradsch.psu.edu/gpms/index.cfm?searchType=fac&amp;prog=GEOSC</a> )

The Department of Geosciences offers M.S. and Ph.D. degree programs that provide students with a broad background in any of the major areas of geological sciences and intensive research experiences culminating in the preparation of a formal thesis. The goal of the programs is to prepare students for scientific careers in academia, government, or industry. A wide range of faculty interests and exceptional laboratory and other support facilities provide an extensive variety of areas of specialization in which students may choose their course work and research topics, which include:

- aqueous geochemistry
- chemistry and physics of rocks and mineral
- geodynamics
- global change and earth history
- sedimentary geology and paleobiology
- solid earth and applied geophysics
- surficial processes

The research of faculty and students is facilitated through the Biogeochemical Research Initiative for Education (BRIE, an NSF-sponsored graduate program in microbial biogeochemistry), the Petroleum Geosystems Initiative (an industry-sponsored, team-based M.S. program) linking the Department of Geosciences and the Department of Energy and Geo-Environmental Engineering and the Penn State Astrobiology Research Center (PSARC, an NSF-sponsored interdisciplinary program in the origin and evolution of life in the universe, aimed at understanding the connections between the environment and the biota on Earth, especially during the stages of its evolution) as well as the Environment Institute of the College of Earth and Mineral Sciences, including the Earth System Science Center, and the Center for Environmental Chemistry and Geochemistry.

In addition to extensive computing and supercomputing facilities developed in association with the Earth System Science Center, students have access to a wealth of analytical, experimental, and field equipment. State-of-the-art analytical equipment is maintained by the department and the Material Characterization Laboratory. The Department of

Geography and the Office for Remote Sensing of Environmental Resources have remote sensing facilities.

## Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<http://gradschool.psu.edu/prospective-students/how-to-apply>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<http://gradschool.psu.edu/graduate-education-policies>).

Scores from the Graduate Record Examinations (GRE) are normally required for admission. Exceptions must be approved by the department.

For admission, applicants generally are expected to have a bachelor's degree in some branch of the natural or physical sciences, engineering, or mathematics. An applicant also is expected to have completed standard introductory courses in geosciences, chemistry, physics, and mathematics through integral calculus, plus 15 credits of intermediate-level work in one or a combination of these subjects. Greater than minimal preparation in chemistry, geology, biology, mathematics, or physics may be required for particular subdisciplines. Applicants who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

Students with special backgrounds, abilities, and interests whose undergraduate grade-point average in courses pertinent to geosciences is below a 3.00 (on a 4.00 scale) will be considered for admission only when there are strong indications that a 3.00 average can be maintained at the graduate level.

Students are admitted both to the M.S. and Ph.D. degree programs. A student may work toward a Ph.D. degree without first earning a master's degree. If this option is desired, the student must arrange the scheduling of a qualifying evaluation no later than the end of the third semester of residence at Penn State.

## Degree Requirements

### Master of Science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies>)

Upon arrival, students will be advised initially by a committee appointed by the associate head for graduate program and research. The committee in turn will designate an interim adviser. Before the end of the first academic year of residence, the student is expected to develop specific academic and research interests so that an appropriate permanent academic adviser and research supervisor may be chosen. The academic adviser and research supervisor are usually the same person, except when the research supervisor is not a member of the geosciences Graduate Faculty. In such a case, a geosciences program family member serves as the academic adviser.

Master's degree students are required to take 30 credits at the 400, 500, 600, and 800 level, including at least 18 credits at the 500 to 600 level, combined. The 12 to 16 common degree credits described below satisfy the Graduate School minimum of at least 12 credits in course work in the major program.

As part of the M.S. program, each student is required to complete a thesis. The thesis must be defended in an oral examination administered

by an M.S. committee. The thesis must be accepted by the advisers and/or committee members, the head of the graduate program, and the Graduate School.

All graduate students in geosciences are expected to acquire breadth of knowledge in the geosciences, a fundamental and advanced knowledge of their subdiscipline, and skills in the areas of data collection and quantitative analysis. Toward that end, all graduate students must select one of the approved courses in each of the following areas:

1. Geosciences Breadth – 3-4 credits
2. Disciplinary Fundamentals – 3-4 credits
3. Data Gathering – 3–4 credits
4. Quantitative Analysis – 3-4 credits

Code	Title	Credits
<b>Required Courses</b>		
GEOSC 500	Issues in Geosciences	3
<i>Disciplinary Fundamentals</i>		
Select 3-4 credits from the following:		3-4
GEOSC 488	An Introduction to Seismology	
GEOSC 489	Dynamics of the Earth	
GEOSC 502	Evolution of the Biosphere	
GEOSC 518	Stable Isotope Geochemistry	
GEOSC 519	Mineral Equilibria	
GEOSC 533	Principles of Geochemistry	
GEOSC 542	Quantitative Methods in Hydrogeology	
GEOSC 548	Surface Processes	
GEOSC 585	Sedimentary Geology	
<i>Data Gathering and Interpretation</i>		
Select 3-4 credits from the following:		3-4
GEOSC 410	Marine Biogeochemistry	
GEOSC 413	Techniques in Environmental Geochemistry	
GEOSC 483	Environmental Geophysics	
GEOSC 508	Mechanics of Earthquakes and Faulting	
GEOSC 558	Multi-channel Seismic Processing and Interpretation	
GEOSC 565	Tectonic Geomorphology	
GEOSC 572	Field Stratigraphy	
<i>Quantitative Analysis</i>		
Select 3-4 credits from the following:		3-4
EMCH 524A	Mathematical Methods in Engineering	
GEOSC 514	Data Inversion in the Earth Sciences	
GEOSC 560	Kinetics of Geological Processes	
GEOSC 561	Mathematical Modeling in the Geosciences	
PNG 425	Principles of Well Testing and Evaluation	
GEOSC 597	Special Topics (either Multivariate Analyses in Geosciences OR Data Analysis in the Earth Sciences)	
<b>Electives</b>		12
<b>Culminating Experience</b>		
GEOSC 600	Thesis Research	6
	or GEOSC 610 Thesis Research Off Campus	
<b>Total Credits</b>		<b>30</b>

A current list of approved courses is maintained by the program office.

## Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<http://gradschool.psu.edu/graduate-education-policies>)

Upon arrival, students will be advised initially by a committee appointed by the associate head for graduate program and research. The committee in turn will designate an interim adviser. Before the end of the first academic year of residence, the student is expected to develop specific academic and research interests so that an appropriate permanent academic adviser and research supervisor may be chosen. The academic adviser and research supervisor are usually the same person, except when the research supervisor is not a member of the geosciences Graduate Faculty. In such a case, a geosciences program family member serves as the academic adviser.

Continuation in the Ph.D. program is determined by an oral qualifying examination before a qualifying examination committee. Preparation and defense of two research proposals will serve as one means of assessing the student's ability. At least one of these proposals should represent original work by the student, but the other may be an actual dissertation proposal and involve limited initial input from the adviser or others.

Course work in addition to the degree requirements described below will be selected by the student in consultation with his/her committee.

The comprehensive examination is both oral and written. It is administered by the Ph.D. committee after the student has essentially completed course work and after a foreign language requirement (if required by the committee) is fulfilled. A final oral defense of the dissertation is required.

All graduate students in geosciences are expected to acquire breadth of knowledge in the geosciences, a fundamental and advanced knowledge of their subdiscipline, and skills in the areas of data collection and quantitative analysis. Toward that end, all graduate students must select one of the approved courses in each of the following areas:

1. Geosciences Breadth – 3-4 credits
2. Disciplinary Fundamentals – 3-4 credits
3. Data Gathering – 3–4 credits
4. Quantitative Analysis – 3-4 credits

Code	Title	Credits
<b>Required Courses</b>		
GEOSC 500	Issues in Geosciences	3
<i>Disciplinary Fundamentals</i>		
Select 3-4 credits from the following:		3-4
GEOSC 488	An Introduction to Seismology	
GEOSC 489	Dynamics of the Earth	
GEOSC 502	Evolution of the Biosphere	
GEOSC 518	Stable Isotope Geochemistry	
GEOSC 519	Mineral Equilibria	
GEOSC 533	Principles of Geochemistry	
GEOSC 542	Quantitative Methods in Hydrogeology	
GEOSC 548	Surface Processes	
GEOSC 585	Sedimentary Geology	
<i>Data Gathering and Interpretation</i>		

Select 3-4 credits from the following:		3-4
GEOSC 410	Marine Biogeochemistry	
GEOSC 413	Techniques in Environmental Geochemistry	
GEOSC 483	Environmental Geophysics	
GEOSC 508	Mechanics of Earthquakes and Faulting	
GEOSC 558	Multi-channel Seismic Processing and Interpretation	
GEOSC 565	Tectonic Geomorphology	
GEOSC 572	Field Stratigraphy	

#### *Quantitative Analysis*

Select 3-4 credits from the following:		3-4
EMCH 524A	Mathematical Methods in Engineering	
GEOSC 514	Data Inversion in the Earth Sciences	
GEOSC 560	Kinetics of Geological Processes	
GEOSC 561	Mathematical Modeling in the Geosciences	
PNG 425	Principles of Well Testing and Evaluation (either Multivariate Analyses in Geosciences OR Data Analysis in the Earth Sciences)	
GEOG 597	Special Topics (either Multivariate Analyses in Geosciences OR Data Analysis in the Earth Sciences)	

A current list of approved courses is maintained by the program office.

## Dual-Titles

### Dual-title Ph.D. in Geosciences and Astrobiology

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs>).

#### Admission Requirements

Students must apply and be admitted to the graduate program in Geosciences and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the Astrobiology dual-title program. Refer to the Admission Requirements section of the Astrobiology Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/astrobiology>). Doctoral students must be admitted into the dual-title degree program in Astrobiology prior to taking the qualifying examination in their primary graduate program.

#### Degree Requirements

To qualify for the dual-title degree, students must satisfy the degree requirements for the degree they are enrolled in Geosciences, listed in the Degree Requirements section. In addition, students must complete the degree requirements for the dual-title in Astrobiology, listed on the Astrobiology Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/astrobiology>).

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from Geosciences and must include at least one Graduate Faculty member from the Astrobiology program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. There will be a single qualifying examination, containing elements of both Geosciences and Astrobiology. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying

examination may be delayed one semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation>), the Ph.D. committee of a Geosciences and Astrobiology dual-title Ph.D. student must include at least one member of the Astrobiology Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Astrobiology, the member of the committee representing Astrobiology must be appointed as co-chair. The Astrobiology representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Geosciences and Astrobiology. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

### Dual-title Ph.D. in Geosciences and Biogeochemistry

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs>).

#### Admission Requirements

Graduate students with research and educational interests in biogeochemistry may apply to the Biogeochemistry Dual-Title Degree Program. Students must apply and be admitted to the graduate program in Geosciences and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the Biogeochemistry dual-title program. Refer to the Admission Requirements section of the Biogeochemistry Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/biogeochemistry>). Doctoral students must be admitted into the dual-title degree program in Biogeochemistry prior to taking the qualifying examination in their primary graduate program. Students in the Biogeochemistry Dual Title program are required to have two advisers from separate disciplines: one individual serving as a primary adviser in their major degree program and a secondary adviser in an area within a field covered by the dual-title program and a member of the Biogeochemistry faculty.

#### Degree Requirements

To qualify for the dual-title degree, students must satisfy the degree requirements for the degree they are enrolled in Geosciences, listed in the Degree Requirements section. In addition, students must complete the degree requirements for the dual-title in Biogeochemistry, listed on the Biogeochemistry Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/biogeochemistry>). Additional course work from an approved list of courses is required.

All students must pass a qualifying examination that includes an assessment of their potential in the field of biogeochemistry. A single qualifying examination that includes biogeochemistry will be administered for admission into the student's Ph.D. program, as well as

the Biogeochemistry dual-title. The structure and timing of this exam will be determined jointly by the dual-title and major program. The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from Geosciences and must include at least one Graduate Faculty member from the Biogeochemistry program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation>), the Ph.D. committee of a Geosciences and Biogeochemistry dual-title Ph.D. student must include at least one member of the Biogeochemistry Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Biogeochemistry, the member of the committee representing Biogeochemistry must be appointed as co-chair. The Biogeochemistry representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Geosciences and Biogeochemistry. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

## Dual-title Ph.D. and M.S. in Geosciences and Operations Research

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-title-graduate-degree-programs>).

### Admission Requirements

Students must apply and be admitted to the graduate program in Geosciences and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the Operations Research dual-title program. Refer to the Admission Requirements section of the Operations Research Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research>). Doctoral students must be admitted into the dual-title degree program in Operations Research prior to taking the qualifying examination in their primary graduate program.

### Degree Requirements

To qualify for the dual-title degree, students must satisfy the degree requirements for the degree they are enrolled in Geosciences, listed in the Degree Requirements section. In addition, students must complete the degree requirements for the dual-title in Operations Research, listed on the Operations Research Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research>).

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from Geosciences and must include at least one Graduate Faculty member from the Operations Research

program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. There will be a single qualifying examination, containing elements of both Geosciences and Operations Research. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed one semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation>), the Ph.D. committee of a Geosciences and Operations Research dual-title Ph.D. student must include at least one member of the Operations Research Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in Operations Research, the member of the committee representing Operations Research must be appointed as co-chair. The Operations Research representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in Geosciences and Operations Research. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

## Integrated Undergrad-Grad Programs Integrated B.S in Geosciences and M.S. in Geosciences

Requirements listed here are in addition to requirements listed in GCAC-210 Integrated Undergraduate-Graduate (IUG) Degree Programs (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-210-integrated-undergraduate-graduate-degree-programs>).

The Department of Geosciences offers an integrated B.S./MS. Program that is designed to allow academically superior students to obtain both the B.S. and the M.S. degree in Geosciences within 5 years of study. Students who wish to complete the Integrated B.S./M.S. Program in Geosciences must apply for admission to the Graduate School and the Integrated B.S./M.S program by the end of their junior year

During the first three years, the student follows the course scheduling of one of the options in Geosciences (see the Undergraduate Bulletin (<http://bulletins.psu.edu/undergraduate>)); however, if a student intends to enter the Integrated B.S./M.S. program, he/she would be encouraged to take, wherever appropriate, upper level classes. By the end of the junior year, the student normally would apply for admission to the program. A decision of acceptance would be made prior to the beginning of the senior year and a M.S. Advising Committee would be appointed. During the senior year, the student would follow the scheduling of the B.S. Geosciences option he/she has selected, with an emphasis on completing 500-level course work wherever appropriate. During the senior year, the student will start work on a thesis designed to meet the departmental requirements of a M.S. thesis. During the fifth year, the student will take courses fulfilling the departmental M.S. degree requirements and complete the M.S. thesis.

## Admission Requirements

Students who wish to complete the Integrated B.S./M.S. Program in Geosciences must apply for admission via the Graduate School application for admission (<http://www.gradschool.psu.edu/prospective-students/how-to-apply>), and must meet all the admission requirements of the Graduate School and the Geosciences graduate program for the Master of Science degree, listed in the Admission Requirements section, by the end of their junior year. Typical test scores of students admitted to the Geosciences Graduate Program are: GPA 3.5, and GRE's Verbal 570, and Quantitative 700. Three letters of recommendation by faculty members for admission to graduate studies are required. The applications are reviewed by the Admissions Committee of the Geosciences Graduate Program and acted upon by the Associate Head for Graduate Programs.

In consultation with an adviser, students must prepare a plan of study appropriate to this integrated program, and must present their plan of study in person to the head of the graduate program or the appropriate committee overseeing the integrated program prior to being admitted to the program. The plan should cover the entire time period of the integrated program, and it should be reviewed periodically with an adviser as the student advances through the program.

## Degree Requirements

Students must fulfill all degree requirements for each degree in order to be awarded that degree, subject to the double-counting of credits as outlined below. Degree requirements for the Bachelor of Science in Geosciences are listed in the Undergraduate Bulletin (<http://bulletins.psu.edu/undergraduate>). Degree requirements for the Master of Science in Geosciences degree are listed on the Degree Requirements tab. Students must sequence their courses so all undergraduate degree requirements are fulfilled before taking courses to count solely towards the graduate degree. If students accepted into the IUG program are unable to complete the M.S. degree, they are still eligible to receive their undergraduate degree if all the undergraduate degree requirements have been satisfied.

Up to 12 credits may be double-counted towards the degree requirements for both the graduate and undergraduate degrees; a minimum of 50% of the double-counted courses must be at the 500 or 800 level. Credits associated with the culminating experience for the graduate degree cannot be double-counted.

## Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<http://gradschool.psu.edu/graduate-funding>) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<http://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants>) set by The Graduate School.

In addition, several graduate fellowships are available for students within the Department of Geosciences.

Programs of study are planned to require no more than two years for the M.S. degree and three additional years, or five years total, for the Ph.D. degree. A student transferring to the department with the M.S. degree should plan on four additional years. Financial support from teaching or research assistantships or from fellowships is available to students in good standing, but not awarded beyond these limits except in unusual cases.

## Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Geosciences (GEOSC) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/geosc>)

## Learning Outcomes

### Master of Science (M.S.)

1. **KNOW:** Students will develop and demonstrate advanced knowledge of a sub-specialty of geosciences, including understanding of, for example, historical and cutting-edge concepts, approaches, and techniques used in the field.
2. **ANALYZE & CREATE:** Students will demonstrate the ability to contextualize the results of data collection and analysis.
3. **RESEARCH IMPLEMENTATION:** Students will demonstrate the ability to develop and implement scientific approaches, utilizing data collection, analysis, or numerical models, to address a question or hypothesis.
4. **COMMUNICATE:** Students will develop the ability to communicate their research findings to an audience of their peers in both written and oral form.
5. **QUANTIFY:** Students will develop the ability to incorporate quantitative analysis of data to support interpretations.
6. **CRITICAL THINKING:** Graduates will be able to critically analyze and assess work by others in their field of specialty.
7. **PROFESSIONAL PRACTICE:** Students will demonstrate knowledge of ethical standards in research and scholarship, and the ability to collaborate in a collegial and ethical manner with other professionals within their field or with diverse scientific backgrounds.

### Doctor of Philosophy (Ph.D.)

1. **KNOW:** Students will develop and demonstrate advanced knowledge of a sub-specialty of geosciences, including understanding of, for example, historical and cutting-edge concepts, approaches, and techniques used in the field.
2. **ANALYZE & CREATE:** Students will demonstrate the ability to independently conceive a research hypothesis or question, and to contextualize the results of data collection and analysis.
3. **RESEARCH IMPLEMENTATION:** Students will demonstrate the ability to develop and implement scientific approaches, utilizing data collection, analysis, or numerical models, to address a question or hypothesis.
4. **COMMUNICATE:** Students will develop the ability to communicate their research findings to an audience of their peers in both written and oral form.
5. **QUANTIFY:** Students will develop the ability to incorporate quantitative analysis of data to support interpretations.
6. **CRITICAL THINKING:** Graduates will be able to critically analyze and assess work by others in their field of specialty.
7. **PROFESSIONAL PRACTICE:** Students will demonstrate knowledge of ethical standards in research and scholarship, and the ability to

collaborate in a collegial and ethical manner with other professionals within their field or with diverse scientific backgrounds.

## **Contact**

<b>Campus</b>	University Park
<b>Graduate Program Head</b>	Mark E Patzkowsky
<b>Director of Graduate Studies (DGS) or Professor-in-Charge (PIC)</b>	Mark E Patzkowsky
<b>Program Contact</b>	Angela Packer 507 Deike Building University Park PA 16802 amp13@psu.edu (814) 865-7394
<b>Program Website</b>	View ( <a href="http://www.geosc.psu.edu">http://www.geosc.psu.edu</a> )