

# Status of the Geoscience Workforce

2018



**Carolyn Wilson**



connecting earth, science, and people



# Status of the Geoscience Workforce 2018

Carolyn Wilson

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Front cover: La Tortuga Island, Venezuela. Geophysical acquisition with conventional geoelectric methods for groundwater exploration along the runway of the island. Carianna Herrera for AGI's 2017 Life as a Geoscientist contest.

Back cover: A Sherpa mountain guide for the Khumbu Climbing Center in Phortse, Nepal, taking bearings off of peaks around Phortse in order to locate himself on a map. These skills, along with knowledge of how to recognize and avoid natural hazards, weather issues and the impacts of climate change, especially on the glaciers, is helping to improve the safety of mountain workers in Nepal. Photo by Rob Thomas for AGI's 2017 Life as a Geoscientist contest.

If you have any questions or comments related to this report, please contact:

Carolyn Wilson  
Geoscience Workforce Data Analyst  
American Geosciences Institute  
4220 King Street  
Alexandria, VA 22302  
<https://www.americangeosciences.org>  
Email: [cwilson@americangeosciences.org](mailto:cwilson@americangeosciences.org)  
Phone: (703) 379-2480 ext. 632



## Introduction

The *Status of the Geoscience Workforce* report provides a biennial comprehensive benchmark of the geoscience profession. This report is based on original data collected by the American Geosciences Institute and existing data from federal, industry, and professional membership organization sources. This report synthesizes all the recent, readily available and reliable data related to the geosciences from the education and training of new geoscientists, to the employment trends in the geoscience workforce, to the federal funding trends for the geosciences and economic trends of the major geoscience industries. The report is broken into 6 chapters:

**Chapter 1:** Trends in K-12 Geoscience Education – Preparing Students for College Geoscience Programs and Society

**Chapter 2:** Postsecondary Education Benchmarks

**Chapter 3:** Trends in Two-Year College Geoscience Programs

**Chapter 4:** Trends in Four-Year Institution Geoscience Programs

**Chapter 5:** Trends in Geoscience Employment – Examining Student Transitions and Workforce Dynamics

**Chapter 6:** Trends in Economic Metrics and Drivers of the Geoscience Workforce

Some highlights of this report include:

- The racial and ethnic diversity of geoscience graduates at all degree levels continues to be the lowest among science and engineering fields. The recruitment of diverse populations may be more effective through the recruitment of first-generation college students. However, in 2017, only 9% of bachelor's graduates, 5% of doctoral graduates, and 9% of doctoral graduates were first-generation college students. Future work in recruitment should consider targeting these students.
- Current geoscience employers and recent graduates strongly agree that new graduates are deficient in professional skills, such as writing, collaboration, project management, adaptability, and leadership, as they are exiting their degree. Many of these skills can be developed through professional internships open to geoscience students. Recent graduates also mentioned the need for more programming skills, as well as stronger quantitative and analytic skills.
- Over the past five years, participation in quantitative courses has not changed with 70%-80% of geoscience graduates completing Calculus II as their highest quantitative course. However, many employers want new hires to have experience in more advanced courses such as Linear Algebra and Differential Equations.
- Nearly all geoscience graduates participate in at least one research experience before graduation, and strong research skills are necessary for their professional development. However, the research skills gained can depend on a student's degree field because different methods tend to be used by different fields. For example, 50% of undergraduate and 80% of graduate atmospheric science students tend to conduct computer-based research, whereas 60% of undergraduate and nearly 90% of graduate geochemistry students tend to conduct lab-based research.
- Many of the collaboration and professional skills desired by employers can be developed by students through internship experiences, but internships are not experiences that most graduates participate in before completing their degree. Over the past five years, approximately 60%-65% of bachelor's graduates, 40%-50% of master's graduates, and 50%-65% of doctoral graduates did not participate in an internship experience.

- Over the past five years, recent geoscience graduate hiring has evolved with the economic changes that have impacted geoscience industries. In 2014, the oil and gas industry entered an economic downturn that led to layoffs. The hiring of recent graduates decreased from 2014-2016 in oil and gas at all degree levels in response to this downturn. The interest in jobs within that industry among recent graduates also decreased. The overall percentage of recent graduates that had secured employment at graduation over the past five years decreased as well from 15% to 10% of bachelor's graduates, 43% to 30% of master's graduates, and 70% to 37% of doctoral graduates.
- Female representation within the geoscience workforce has been steadily increasing each year. In 2017, 35% of environmental scientists and geoscientists were

women. Also, over 30% of two-year college faculty and 20% of four-year institution faculty are women. Among four-year institution faculty, that is an increase from 2010 when 15% of the faculty were women.

- There were approximately 312,000 geoscientists employed in the United States in 2016. Over the next decade, there is predicted to be an 11% growth in geoscience full-time equivalents (FTE), as well as a potential loss of 48% of the workforce as they reach retirement. Due to these changes, AGI predicts a shortage of 118,000 FTEs by 2026. While many of these positions will be filled by newly trained geoscientists, the workforce, in anticipation of these changes, has begun to implement new, innovative technologies to increase productivity and address the future shortage of FTEs in the geosciences.

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# Chapter 1: Trends in K–12 Geoscience Education — Preparing Students for College Geoscience Programs and Society

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With the national deployment of the Next Generation Science Standards, earth science in middle and high school curriculums continues to grow and develop. One of the recognized Disciplinary Core Ideas is Earth and Space Science, which makes earth science concepts equally represented with the other science disciplines within the standards. By the end of 2018, nineteen states and the District of Columbia have adopted the standards for their state science curriculums, and twenty-one additional states developed their own science standards that were influenced by the framework for the development of the Next Generation Science Standards<sup>1</sup>. These changes can be seen in the increased integration of geoscience and earth systems science concepts in the science requirements for graduation in multiple states. Forty-five states and the District of Columbia allow an earth science or environmental science course to count towards their science requirements for graduates. Among those states, six require an earth science course for graduation and three require a course that covers specific earth science concepts.

However, of the sciences, the earth sciences still have the fewest trained teachers at the elementary and secondary levels. According to the National Science Foundation, approximately 8 percent of elementary teachers hold a science, mathematics, or engineering degree, and among science, math, and engineering secondary teachers, approximately 40 percent held a science, math, or engineering degree, and only 3 percent held a geoscience degree.

Horizon Research released their Report of the 2018 National Survey of Science and Mathematics Education in December 2018. They found that 68 percent of middle school teachers and 58 percent of high school teachers had an introductory earth or space science course, but only

29 percent of middle school teachers and 24 percent of high school teachers took another earth or space science course beyond the introductory course. They also found that 5 percent of secondary education teachers held a degree in earth science<sup>2</sup>.

College readiness among students is often indicated through course selection of higher-level math and science courses, taking Advanced Placement (AP) courses, and SAT test scores. While there has been growth in the number of students taking science and math AP courses in high school over the past decade, there has been a decrease in mean SAT scores among students that took coursework in science. However, the SAT test-takers that have coursework in Biology, Chemistry, and Physics have mean SAT scores that are higher than the overall mean scores of all SAT test-takers. There has also been an increase in the percentage of high school students meeting the ACT College Readiness Benchmarks for science. Among all college-bound seniors that took the SAT, the master's degree became the most popular intended terminal postsecondary degree in 2016. These recent graduates are recognizing the need for a graduate degree in order to be successful in their future.

Since 2013, AGI has surveyed students graduating with a degree in the geosciences about their educational background in the geosciences. Consistently over the past five years, approximately half of the graduates had taken a formal earth science, environmental science, or geography course while in high school, which was a greater than expected. This indicates the utility of these courses to recruit students into geoscience majors during their postsecondary education, as well as reflects the increasing inclusion of earth science courses in the high school curriculum.

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<sup>1</sup> National Science Teachers Association. About the Next Generation Science Standards, Retrieved from <https://ngss.nsta.org/About.aspx>.

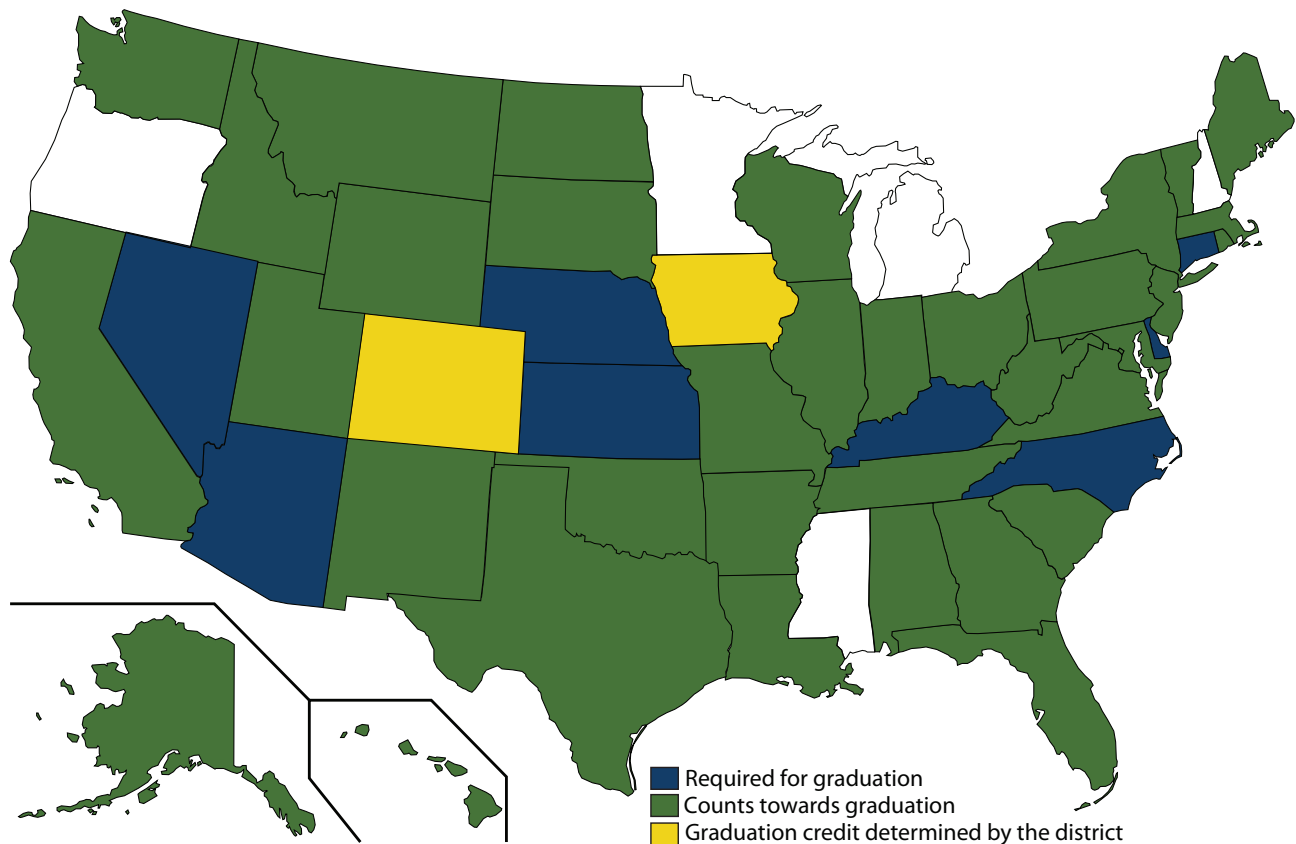
<sup>2</sup> Horizon Research, Inc. (2018) Report of the 2018 NSSME+. Retrieved from <http://horizon-research.com/NSSME/2018-nssme/research-products/reports/technical-report>.

## Earth Science Education

As the Next Generation Science Standards continue to influence state science curriculum, more states are incorporating earth science education concepts and courses into their secondary school curriculum. Figures 1.1 and 1.2 and Table 1.1 show the extent to which states recognize earth science courses within the middle and high school curriculum. Compared to 2016, three additional states require earth science for graduation, bringing the total to six. While most of these states require an earth or environmental science course for graduation, three states, Delaware,

Kentucky, and Nebraska, require a course that covers specific earth science concepts. These concepts are likely informed by the NGSS guidance, which identifies the core concepts in earth and space science that should be covered in K–12 education. Thirty-six states and the District of Columbia allow for, but do not require, an earth or environmental science course to count towards their science graduation requirement. Forty-eight states assess earth science concepts at least once either in middle school and/or high school through a standardized test.

**Figure 1.1: Earth Science Education Graduation Requirements in High School**



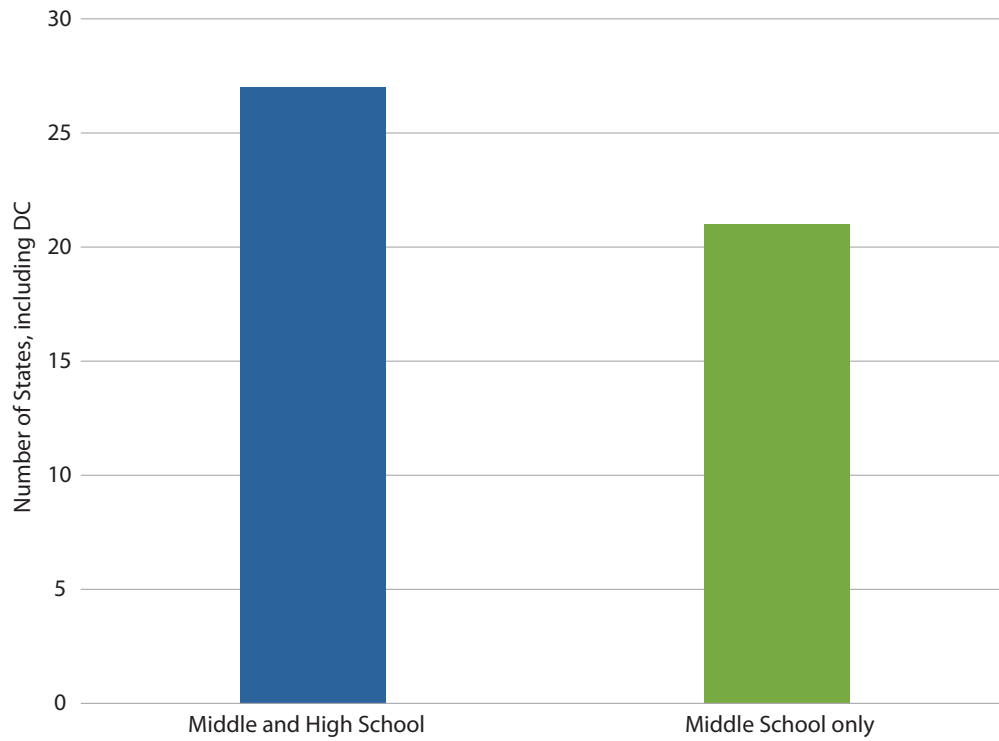
AGI Geoscience Workforce Program; Data derived from state Department of Education websites

**Table 1.1: State-Level Earth Science Requirements for Graduation**

Earth Science Credit for Graduation		Earth Science Credit for Graduation	
State	2018	State	2018
Alabama	Earth Science can count as the Physical Science credit	Nebraska	Course with Earth and Space concepts required for graduation
Alaska	Earth Science can count as the Physical Science credit	Nevada	Course with Earth and Space concepts required for graduation
Arizona	Earth Science required for graduation	New Hampshire	No
California	Earth Science can count as the Physical Science credit	New Jersey	Earth Science course can count for graduation
Colorado	Graduation requirements determined by districts	New Mexico	Earth Science course can count for graduation
Connecticut	Earth/Environmental Science required for graduation	New York	Earth Science course can count for graduation
Delaware	Course with Earth and Space concepts required for graduation	North Carolina	Earth/Environmental course required for graduation
District of Columbia	Earth Science course can count for graduation	North Dakota	Earth Science course can count for graduation
Florida	Earth Science course can count for graduation	Ohio	Earth Science course can count for graduation
Georgia	Earth Systems or Environmental Science course can count for graduation	Oklahoma	Earth Science course can count for graduation
Hawaii	Earth Science course can count for graduation	Oregon	Unknown
Idaho	Earth Science course can count for graduation	Pennsylvania	Earth Science course can count for graduation
Illinois	Earth Science course can count for graduation	Rhode Island	Earth Science course can count for graduation
Indiana	Earth and Space Science course can count for graduation	South Carolina	Earth Science course can count for graduation
Iowa	Graduation requirements determined by districts. Science is not required but is recommended.	South Dakota	Earth Science course can count for graduation
Kansas	Course with Earth and Space concepts required for graduation	Tennessee	Earth Science course can count for graduation
Kentucky	Course with Earth and Space concepts required for graduation	Texas	Earth Science course can count for graduation
Louisiana	Earth Science course can count for graduation	Utah	Earth Science course can count for graduation
Maine	Earth Science course can count for graduation	Vermont	Earth Science course can count for graduation
Maryland	Earth Science course can count for graduation	Virginia	Earth Science course can count for graduation
Massachusetts	Earth Science course can count for graduation	Washington	Earth Science course can count for graduation
Michigan	No	West Virginia	Earth Science course can count for graduation
Minnesota	No	Wisconsin	Earth Science course can count for graduation
Mississippi	Unknown	Wyoming	Earth Science course can count for graduation
Missouri	Earth Science Course can count for graduation		
Montana	Earth Science course can count for graduation		

AGI Geoscience Workforce Program; Data derived from state Department of Education websites

**Figure 1.2:** States that Assess Earth and Space Science Concepts in Middle and High School



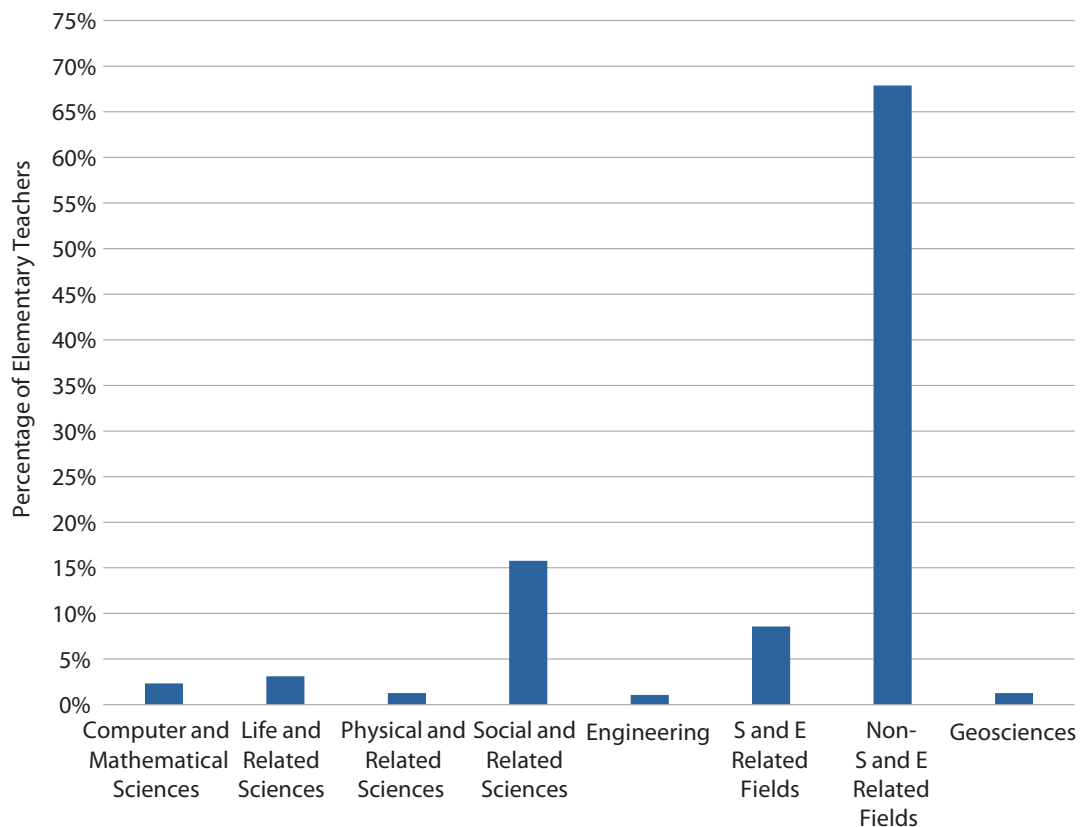
AGI Geoscience Workforce Program; Data derived from state Department of Education websites

## Teachers

The population of elementary school teachers represented in Figure 1.3 encompass all elementary school teachers, while Figure 1.4 represents only secondary school teachers who teach computer science, math, or science. The majority of elementary teachers hold degrees in non-science and engineering fields, such as the humanities or education, and this percentage has increased nearly 30 percentage points since 2013. Only 8% of elementary teachers hold a science, mathematics, or engineering degree—a decrease of 4 percentage points compared to elementary teachers in 2013. In 2015, as in 2013, only 1% of elementary teachers held a geoscience degree. Assuming this trend continues, there

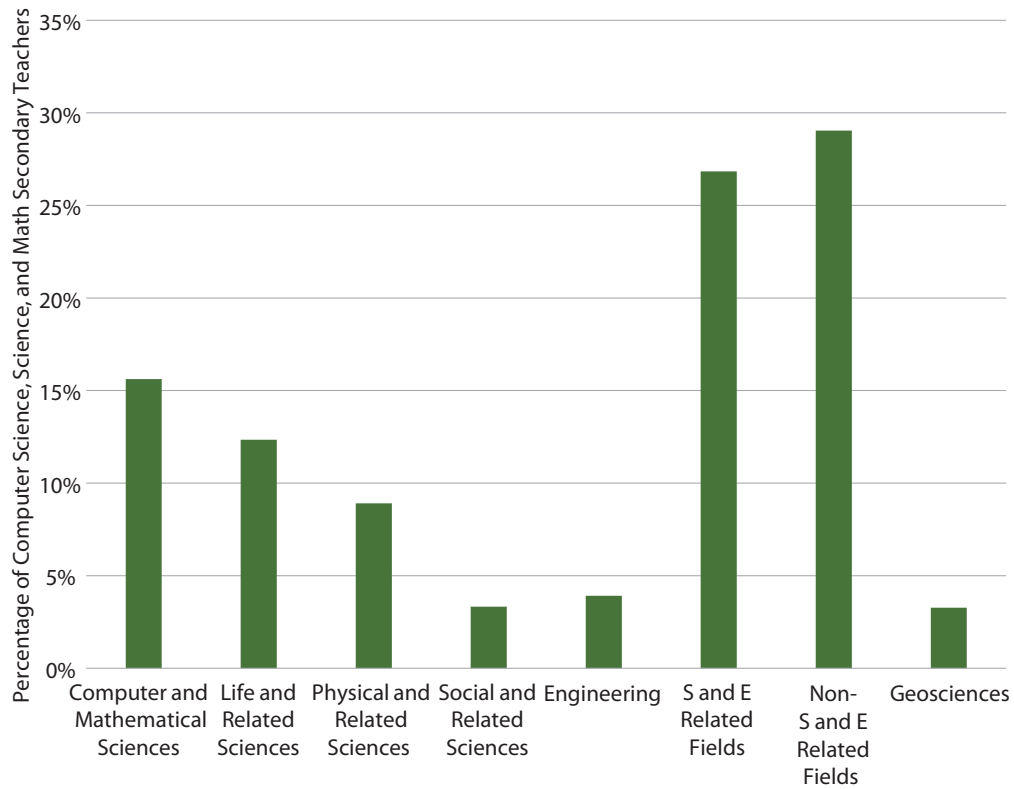
will be a diminishing pool of elementary teachers able to effectively provide the fundamental building blocks of STEM for their students. Over half of the secondary teachers teaching computer science, science, and math courses held degrees in non-science and engineering related fields and other science and engineering related fields, which include health science and science and mathematics teacher education. Approximately 41% of secondary teachers teaching computer science, math, or science classes in 2015 held a degree in computer and mathematical sciences, life sciences, physical sciences, and engineering, but only 3% of these secondary teachers held a degree in geoscience.

Figure 1.3: Degree Fields of Elementary School Teachers, 2015



AGI Geoscience Workforce Program; Data derived from NSF's National Survey of College Graduates 2015 public-use data files

**Figure 1.4: Degree Fields of STEM Secondary Teachers, 2015**



AGI Geoscience Workforce Program; Data derived from NSF's National Survey of College Graduates 2015 public-use data files

## Students

High school course selection in math and science and Advanced Placement (AP) course selection are both used as indicators of future college success by demonstrating students' ability to handle rigorous coursework. Over the past decade, Advanced Placement course participation in science and calculus has steadily increased in the United States. Calculus AB and BC AP courses tend to draw the most students each year. In 2017, the most popular science and mathematics AP courses were the AP Calculus courses, which enrolled more than 200,000 more students than the next most popular set of courses, AP Physics. This increase in participation in AP Physics from 2014 to 2015 was due to a redesign of the course. The algebra-based course was split into two courses allowing for students to take 2 years of algebra-based AP Physics. AP Environmental Science course enrollments have quickly grown over the past decade increasing by approximately 100,000 students and equaling the enrollment of the Chemistry AP course in 2016 and 2017. The growth in this course is encouraging for the recruitment of future geoscience students.

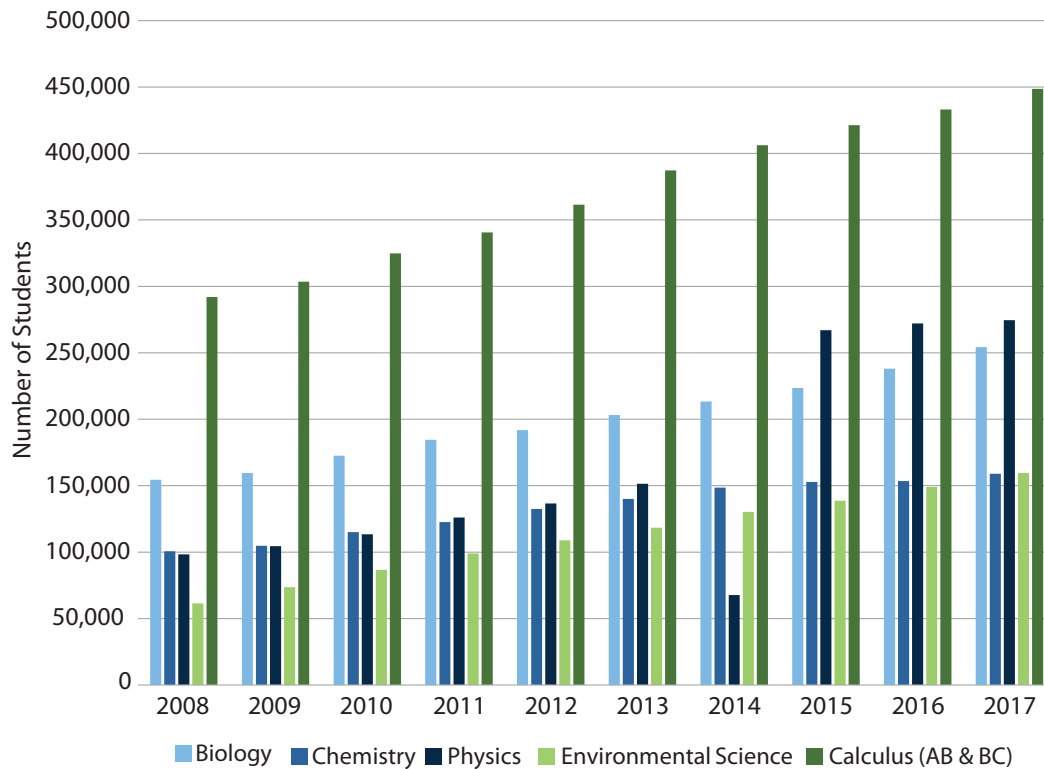
Figures 1.6–1.11 examine SAT test-takers with coursework in the sciences. Among these SAT test-takers, the mean math, writing, and critical reading scores have all decreased from 2007–2016 regardless of previous science coursework. Average SAT scores in all three areas appear to be the lowest for students that took geology, earth, or space science, which is also lower than the overall average scores

for all SAT test-takers. However, it is important to note that this course is typically considered a science elective for graduation in the United States, so it can tend more non-college bound students than other STEM courses. While average SAT scores have been decreasing, more of these students have shown increased interest in receiving graduate degrees as their terminal degree, particularly master's degrees. If the assumption that SAT scores indicate college success, this is a concerning trend for programs attempting to attract qualified graduate students.

Among ACT test-takers from 2008–2017, there has been a gradual increasing trend in college readiness benchmarks overall, but when these benchmarks are broken down by subject, college readiness in English, Mathematics, and Reading have decreased between 2008 and 2017.

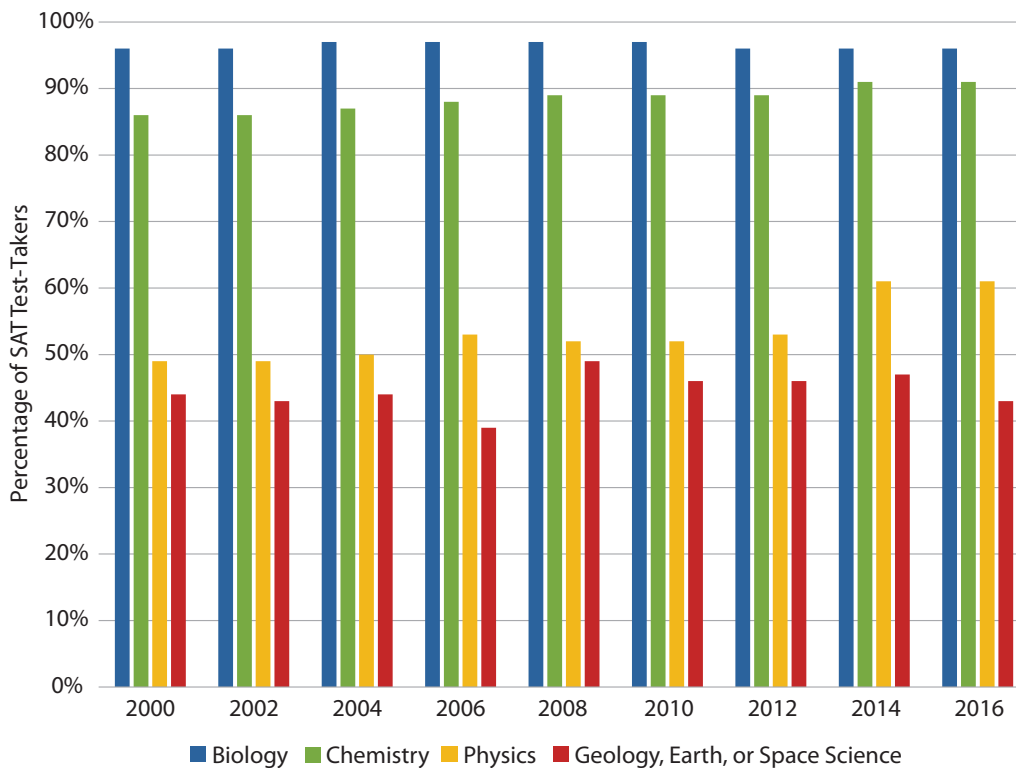
AGI's Geoscience Student Exit Survey has been used to collect data about recent graduates for the past five years. While the percentages vary somewhat from year to year, in general, approximately half of geoscience graduates, regardless of degree level, take an earth or environmental science course in high school (Figure 1.13). These high school courses continue to be important areas for the recruitment of future geoscience majors at the postsecondary level, but this also raises concerns relative to the quality of some of these recruits in light of the results of SAT scores of students who took a geology, earth, or space science course.

**Figure 1.5: Number of Students Taking AP Courses in Science and Math, 2008-2017**



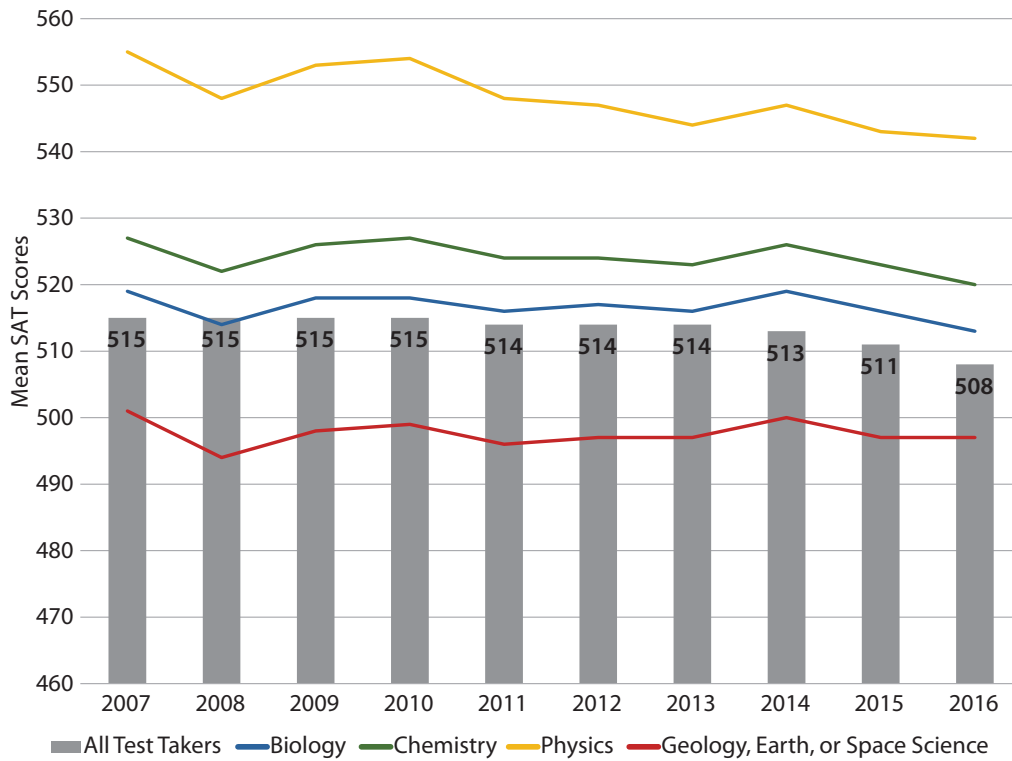
AGI Geoscience Workforce Program; Data derived from the College Board AP Data

**Figure 1.6: SAT Test-Takers with Coursework or Experience in Selected Sciences**



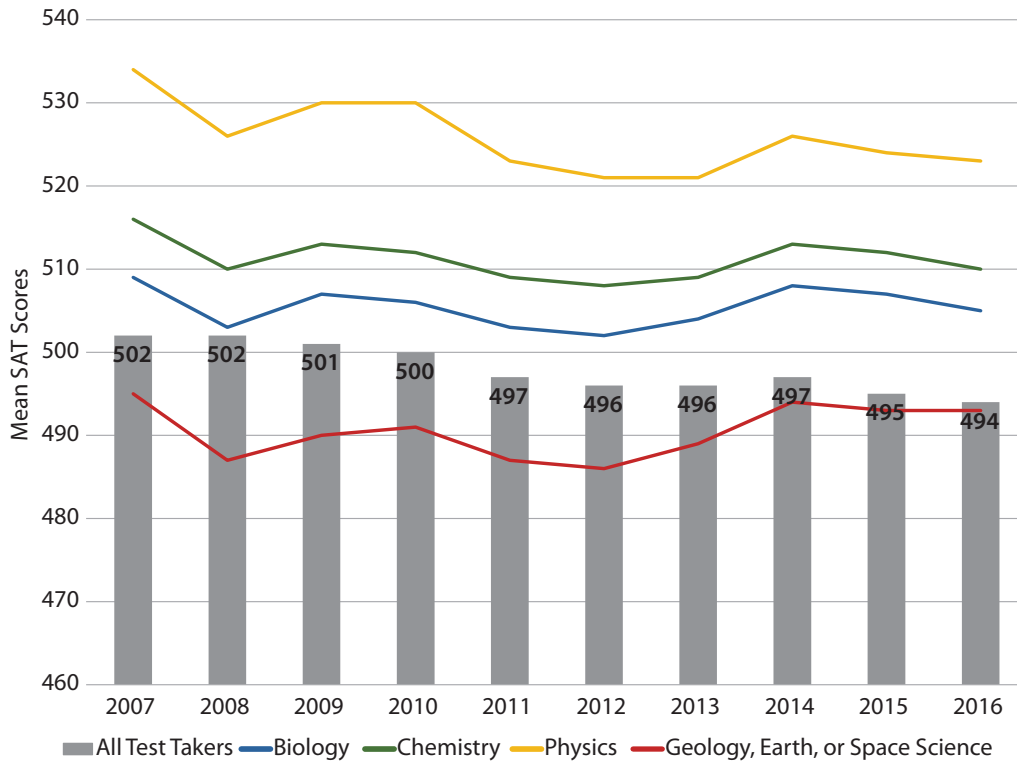
AGI Geoscience Workforce Program; Data derived from the College Board College-Bound Seniors, Total Group Report, 1996-2017

**Figure 1.7: Mean Math SAT Scores for Test-Takers with Coursework in Science**



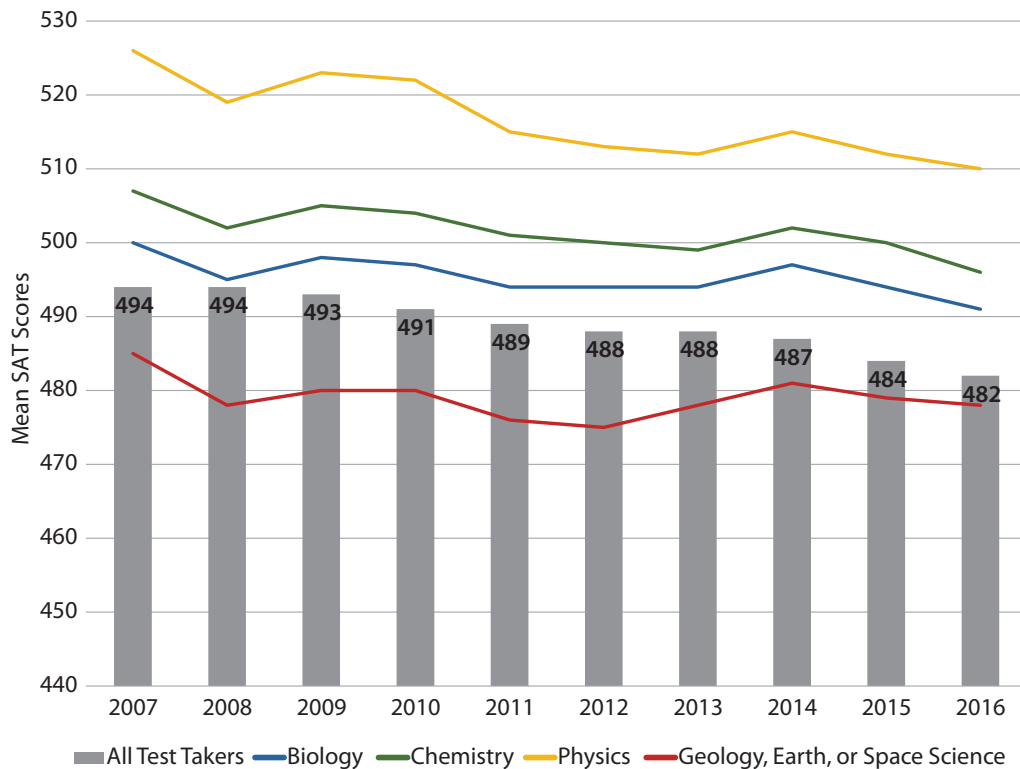
AGI Geoscience Workforce Program; Data derived from the College Board College-Bound Seniors, Total Group Report, 1996-2017

**Figure 1.8: Mean Critical Reading SAT Scores for Test-Takers with Coursework in Science**



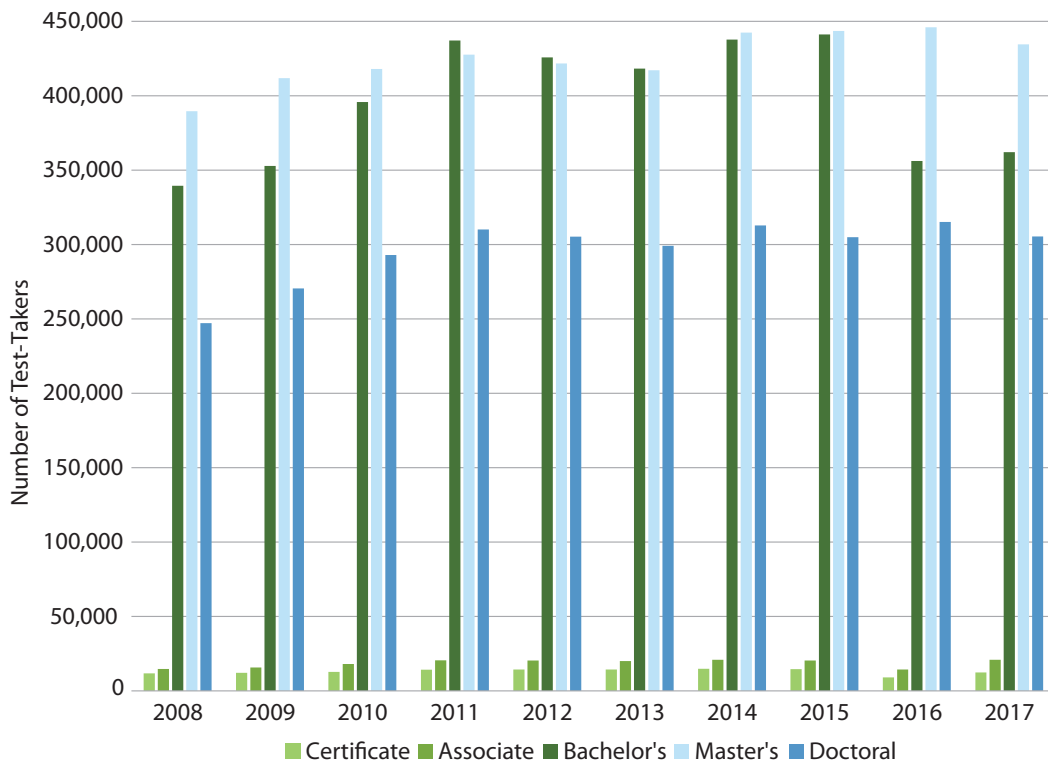
AGI Geoscience Workforce Program; Data derived from the College Board College-Bound Seniors, Total Group Report, 1996-2017

**Figure 1.9: Mean Writing SAT Scores for Test-Takers with Coursework in Science**



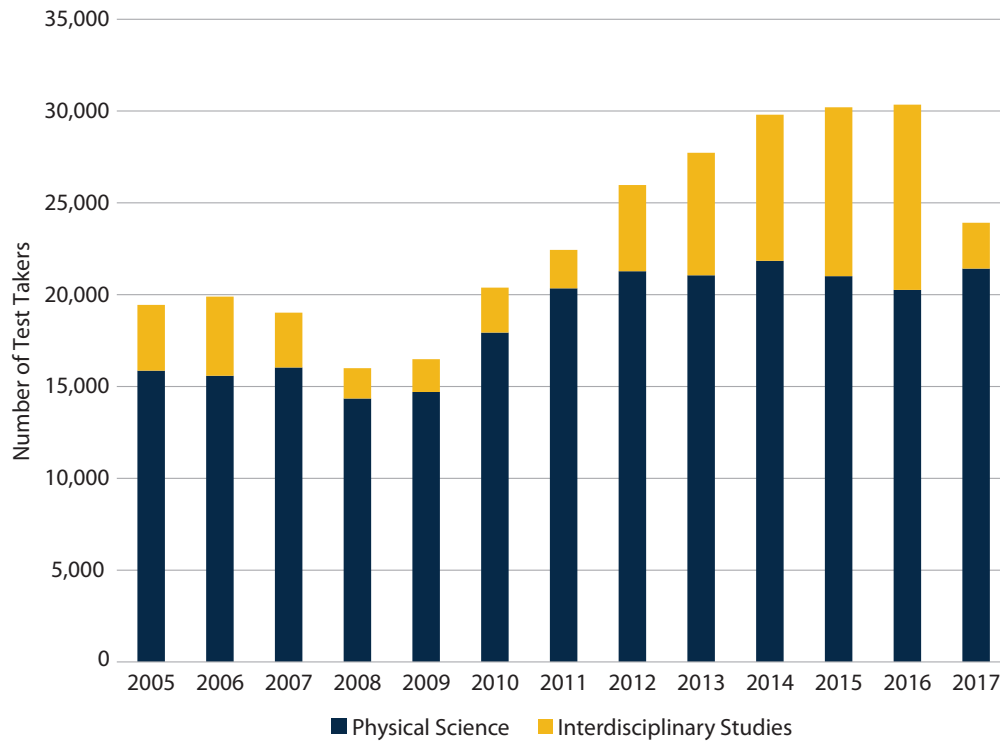
AGI Geoscience Workforce Program; Data derived from the College Board College-Bound Seniors, Total Group Report, 1996-2017

**Figure 1.10: Intended Terminal Degree Level of College-Bound High School Seniors that Took the SAT**



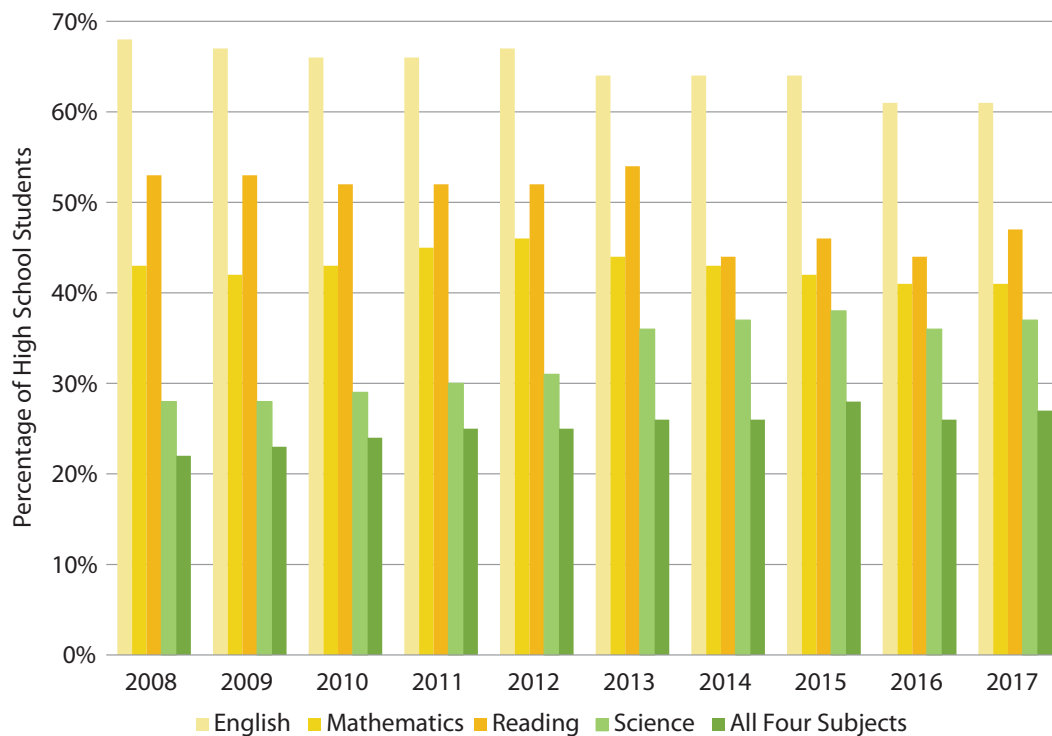
AGI Geoscience Workforce Program; Data derived from the College Board College-Bound Seniors, Total Group Report, 1996-2017

**Figure 1.11: SAT Test-Takers Intending College Degrees in Physical Sciences or Interdisciplinary Studies**



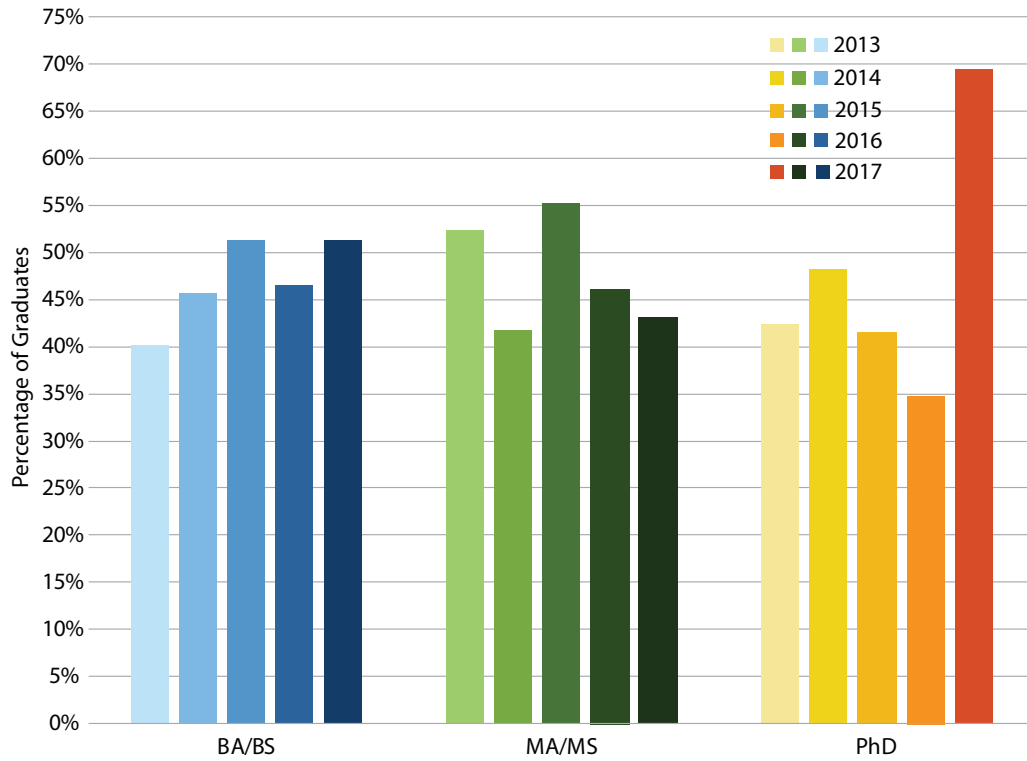
AGI Geoscience Workforce Program; Data derived from the College Board College-Bound Seniors, Total Group Report, 1996-2017

**Figure 1.12: High School Students Meeting ACT College Readiness Benchmarks**



AGI Geoscience Workforce Program; Data derived from ACT National Public Report, 2008-2017

**Figure 1.13:** Geoscience Postsecondary Graduates Who Took an Earth Science Course in High School, 2013–2017



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

## Chapter 2: Postsecondary Education Benchmarks

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This chapter benchmarks geoscience postsecondary education to the national postsecondary education population in the United States.

In the United States, the total number of postsecondary degrees continues to increase annually. While the rate of growth in total number of degrees awarded slowed from 2012–2015, a historical record of 3.85 million degrees were awarded in 2015 in the United States. Degrees awarded growth is projected to continue over the next decade, potentially reaching 4.5 million degrees. The majority of the awarded degrees in 2015 were bachelor's degrees, but the growth trends are evident at all degree levels. Even though degrees awarded are still increasing, enrollments at two-year colleges have been decreasing and enrollments at four-year institutions have been remaining steady since 2010. The increasing cost of college and structural changes in the economy may be impacting enrollment rates.

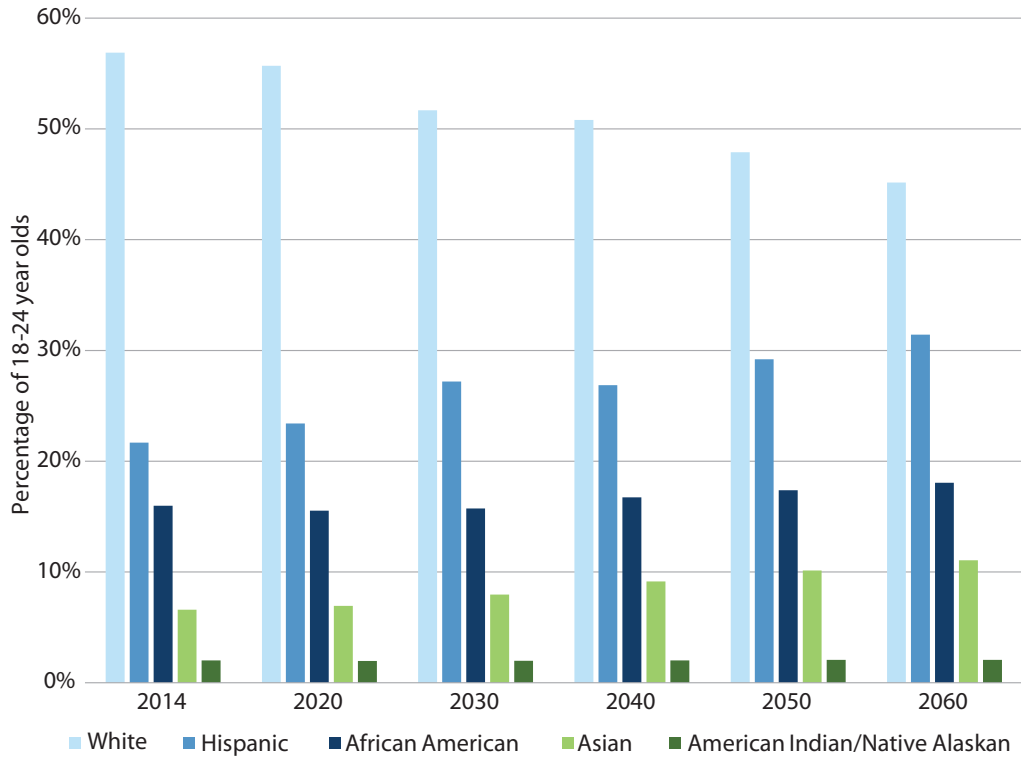
Changes in the general population highlights the ever-growing talent pool of college-age underrepresented minority groups, particularly Hispanics. By 2060, the Hispanic college-age population will be the fastest growing group within the total college-age population. The college-age Hispanic population is projected to grow to

within 14 percentage points of the Caucasian college-age population, and the Caucasian college-age population will decrease to below 50 percent of the total college-age population according to the U.S. Census Bureau.

At 2-year colleges, the total enrollment of underrepresented minorities reached 40 percent in 2015, and 33 percent of associate's degrees were awarded to underrepresented minority populations in that same year. Hispanic students have the largest percentage of enrollments and awarded associate's degrees among underrepresented minority groups. At four-year institutions, the total enrollments and degrees awarded for underrepresented minorities has also been steadily increasing, reaching 28 percent enrollment in 2015, and the degrees awarded to underrepresented minorities reached 22 percent of all bachelor's degrees, 20 percent of all master's degrees, and 14 percent of all doctoral degrees.

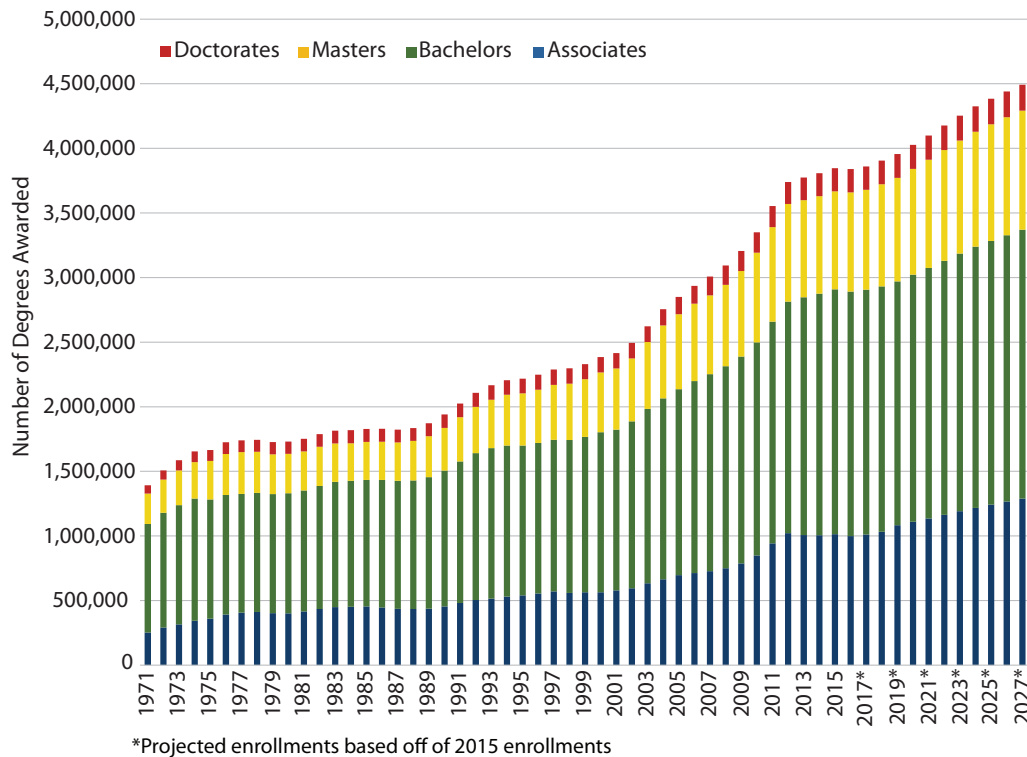
In 2016, 49 percent of the U.S. college-age population was female, and the majority of all degrees are awarded to women with no indication of any changes in this trend in the future. However, growth of female enrollment rates may be nearing a long-term balance as the enrollment rates has remained steady just under 60 percent since 2000.

**Figure 2.1: Race/Ethnicity of U.S. College-Age Population, 2014-2060**



AGI Geoscience Workforce Program; Data derived from US Census Bureau Population Estimates

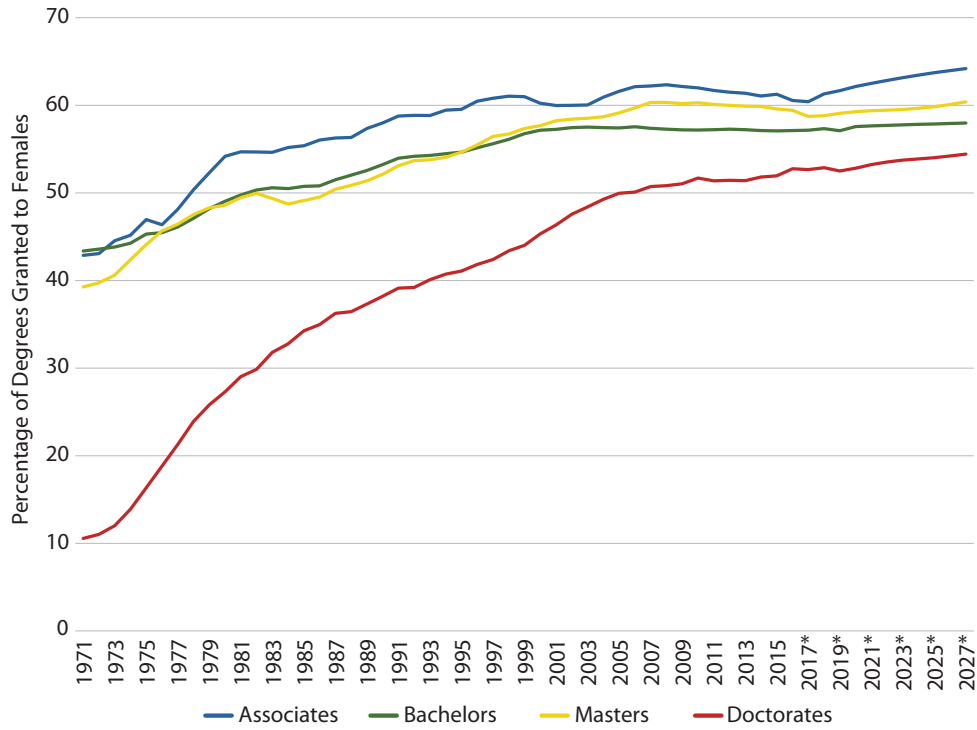
**Figure 2.2: Degrees Granted from U.S. Postsecondary Institutions**



\*Projected enrollments based off of 2015 enrollments

AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

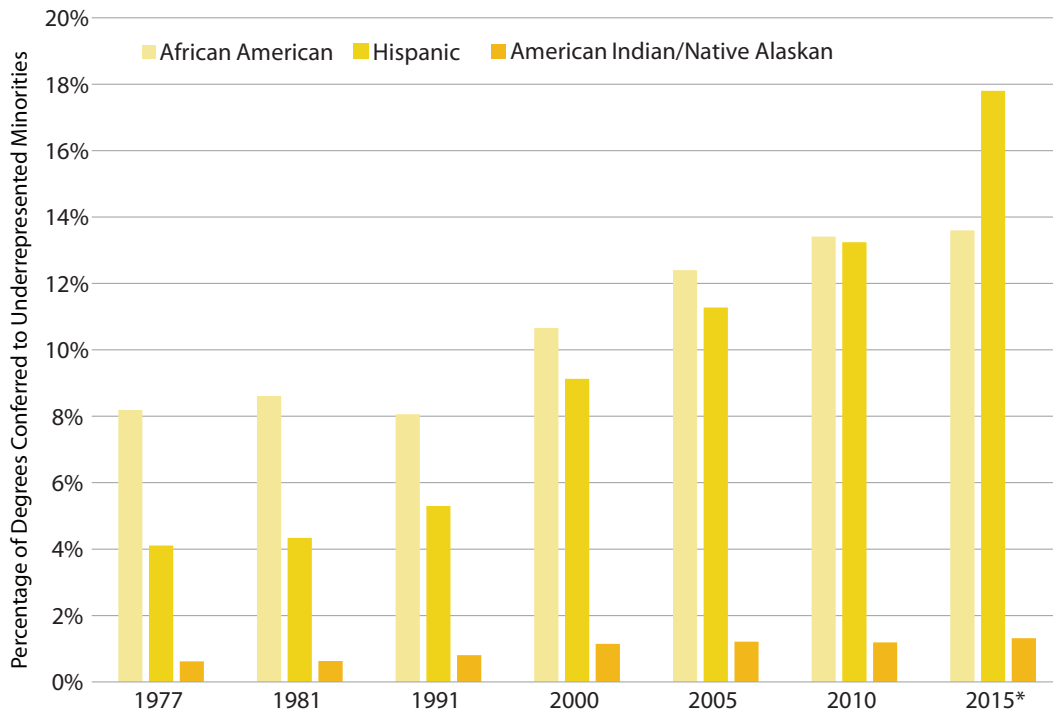
**Figure 2.3: Percentage of Degrees Granted to Women by Degree Level, All Majors**



\*Projected enrollments based off of 2015 enrollments

AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

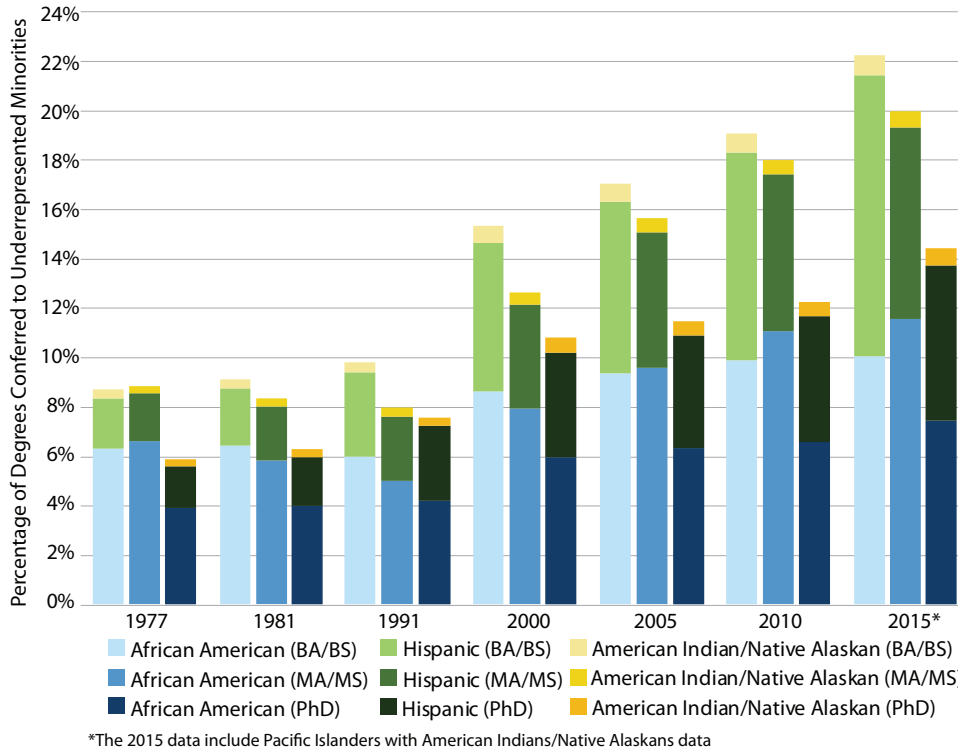
**Figure 2.4: Percentage of Associate's Degrees Awarded to Underrepresented Minorities, All Degree Fields**



\*The 2015 data include Pacific Islanders with American Indians/Native Alaskans data

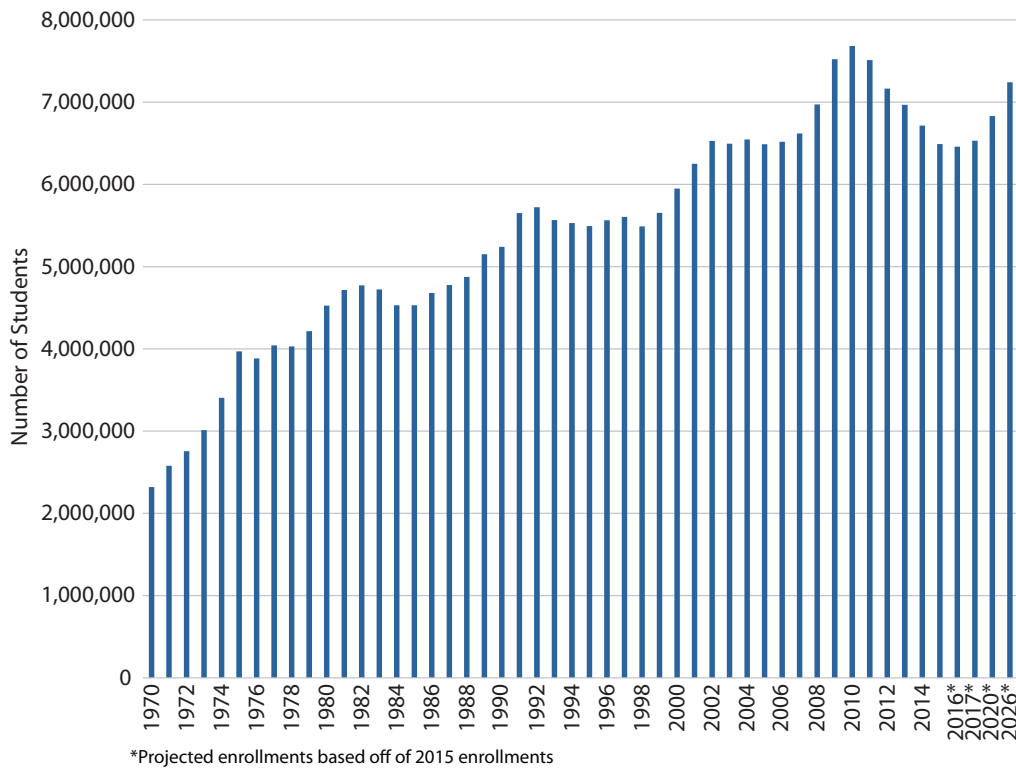
AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

**Figure 2.5: Percentage of Degrees Awarded to Underrepresented Minorities, All Majors**



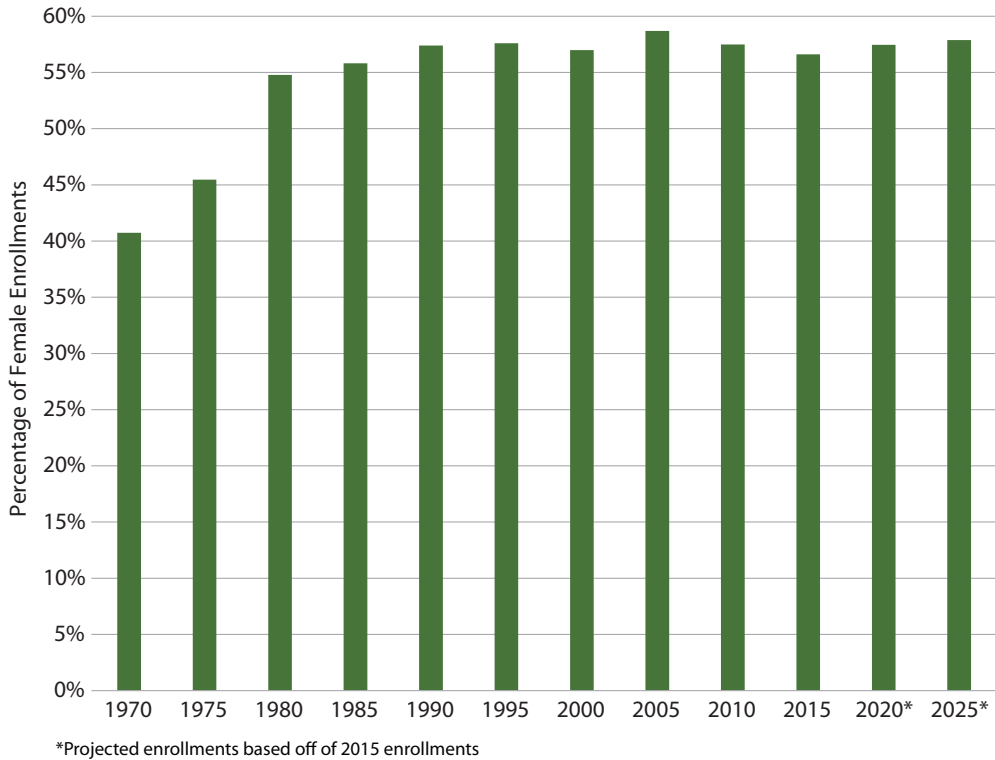
AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

**Figure 2.6: Fall Enrollments at U.S. Two-Year Colleges**



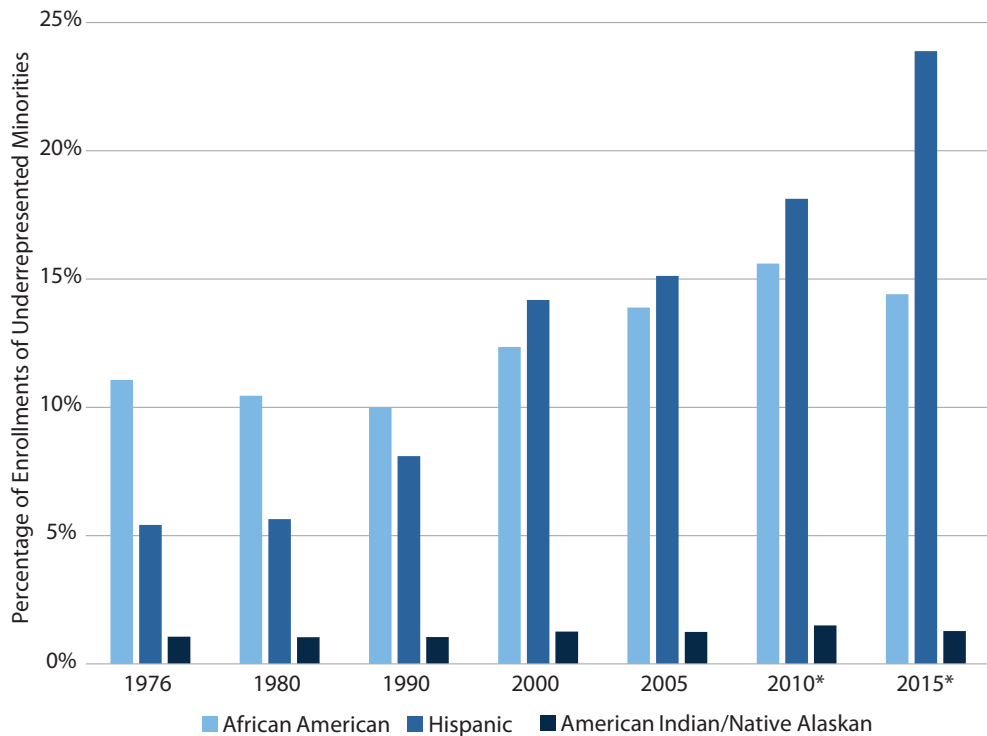
AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

**Figure 2.7: Participation of Women in Two-Year Colleges**



AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

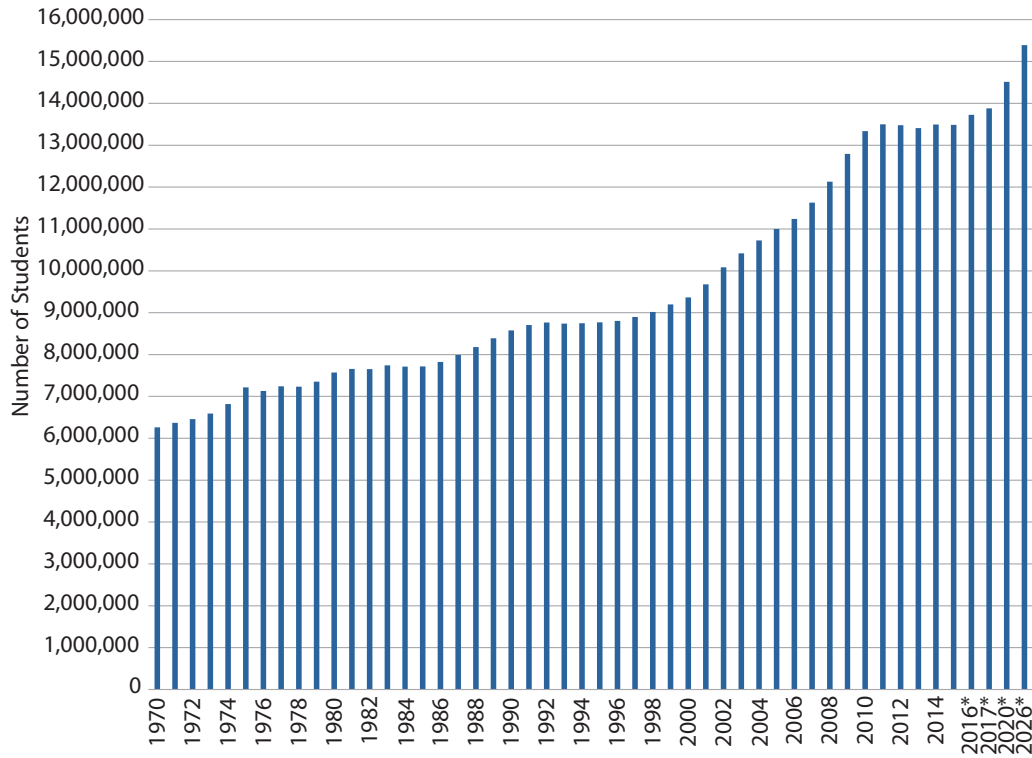
**Figure 2.8: Underrepresented Minority Enrollments at Two-Year Colleges**



\*The 2010 and 2015 data include Pacific Islanders with American Indians/Native Alaskans data

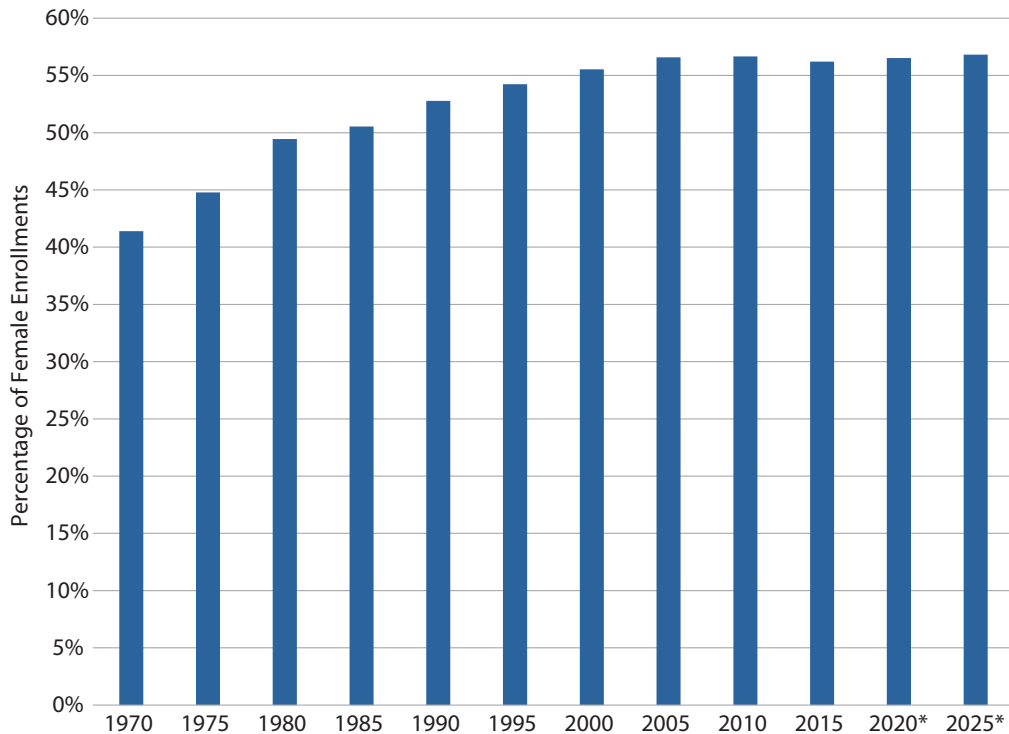
AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

**Figure 2.9: Fall Enrollments at Four-Year Institutions**



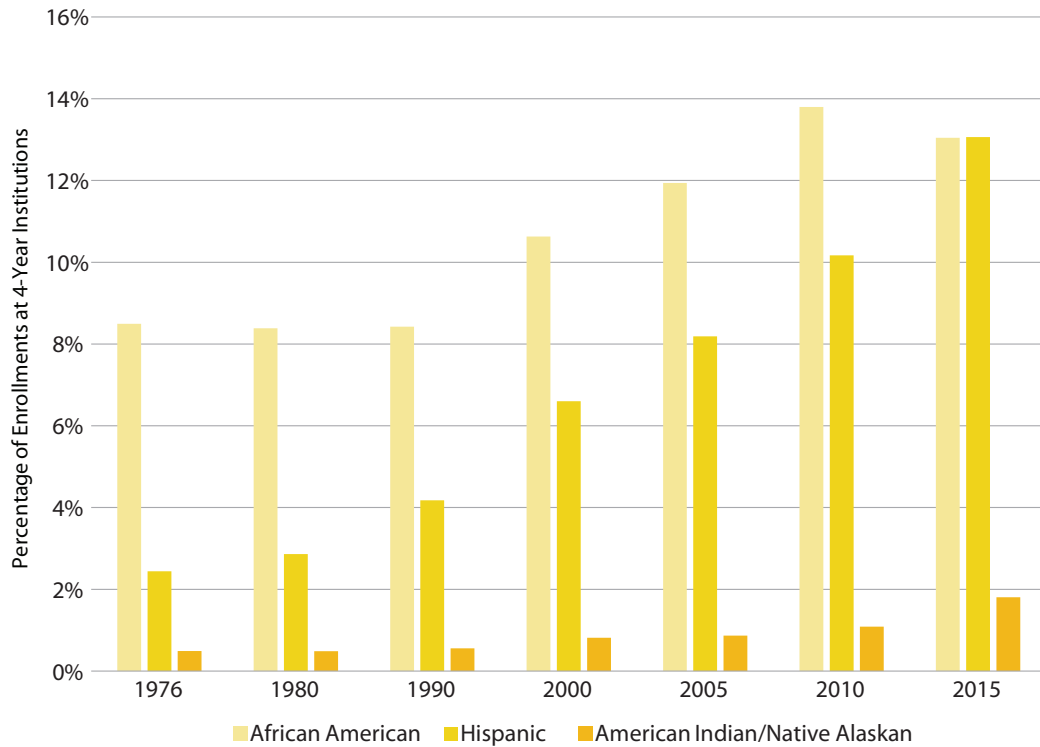
AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

**Figure 2.10: Female Enrollments at Four-Year Institutions**



AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016

**Figure 2.11: Underrepresented Minority Enrollments at Four-Year Institutions**



AGI Geoscience Workforce Program; Data derived from NCES Digest of Education Statistics, 2016



## Chapter 3: Trends in Two-Year College Geoscience Programs

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Approximately 21 percent of two-year colleges in the United States offer a geoscience program or course. Most of these two-year colleges offer a few geoscience courses, but a few have full geoscience programs that will associate degrees. These programs tend to exist where there is a strong regional connection to geoscience industries, such as Texas, California, Washington, Illinois, New York, and Arizona.

Most geoscience programs at two-year colleges have one or two faculty members slated to teach a geoscience course, and these faculty members tend to be within a natural sciences or physical sciences division. While approximately half of geoscience two-year college faculty are hired in non-tenure positions, many two-year colleges do have tenure-track positions for their faculty. The full-time geoscience faculty tend to be younger at two-year colleges than at four-year institutions, but the part-time two-year college faculty tend to be a little bit older than the full-time faculty. Two-year colleges also tend to have higher percentages of female faculty tenured or tenure-track than at four-year institutions.

Geoscience faculty teaching at two-year colleges have indicated that there is a growing interest in the geosciences among their students, particularly in states with strong geoscience industries, and they tend to encourage their students to transfer to four-year institutions to complete their geoscience degree. Thus, this student population is an ideal target for recruitment of geoscience majors at four-year institutions. Consistently, over the past five years, a quarter to a third of geoscience bachelor's

graduates spent at least one semester at a two-year college. Further development of relationships between two-year colleges and four-year institutions could increase the recruitment of students into geoscience majors.

Two-year colleges tend to have higher percentages of underrepresented minorities among their student population compared to the student population at four-year institutions, but the racial and ethnic makeup of transfer students that successfully complete a geoscience degree is similar to the racial and ethnic makeup of those geoscience graduates that began their post-secondary education at a four-year institution.

With growing evidence for more active recruitment of geoscience majors from two-year college transfers, AGI collaborated with two-year college faculty to investigate the factors that assist in effective transfer of two-year college students, as well as the challenges these students have faced after entering a geoscience program at a four-year institution. Over half of the two-year college transfers took a geoscience course while at their two-year college, which likely sparked their interest in the subject. As these transfer students were moving to the four-year institution, the majority of them indicated that their personal motivation for a bachelor's degree and the transferred coursework were the most impactful factors for a successful transfer and completion. The final results of this work are in the process of being published, particularly related to the challenges faced transfer students faced while working towards their bachelor's degree. Once this work is published, AGI will release more information and data about this study.

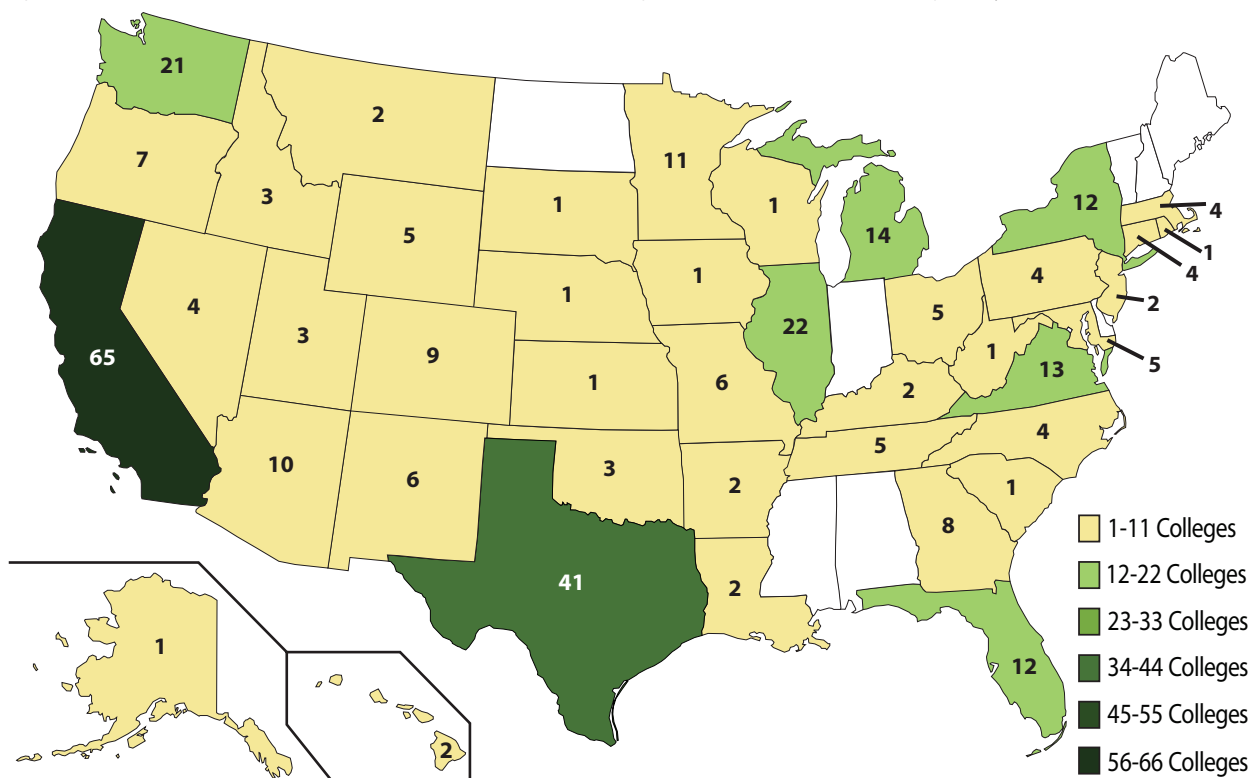
## Geoscience Departments and Faculty

There are 1,579 two-year colleges in the United States, according to the Department of Education, and 327 of these schools have a geoscience program or course available or students (Figure 3.1). Since 2016, Georgia, Pennsylvania, and Nebraska, each lost one geoscience program and Colorado gained one geoscience program. When comparing the geoscience programs at two-year colleges to the total number of two-year colleges in each state, California has the largest rate of two-year colleges having geoscience programs, followed by Texas and Illinois (Table 3.1).

However, most of these schools that provide geoscience courses have few faculty to teach these classes. Out of the 327 two-year colleges with geosciences, 60% have 5 or fewer faculty members that teach geoscience coursework and 28% have only one faculty member to represent the geosciences at their two-year college (Figure 3.2). These percentages have decreased since 2016 revealing an increase in the number of faculty members that teach geoscience courses within the two-year college system. Among these faculty members, approximately

half are instructors, lecturers, adjunct, or visiting faculty (Figure 3.3). While the majority of two-year college faculty specialize in geology for research and teaching, approximately 30% of them specialize in general earth sciences, earth science education, and physical geology—all of which are listed within the “Other” category of research specialties (Figure 3.5). When comparing the terminal degrees of these faculty members, most hold master’s degrees, and overall the percentage of terminal master’s degree holders increased between 2007 and 2017 from 59% to 61% (Figure 3.6). Thirty-one percent of geoscience faculty at two-year colleges are female compared to the 21% of four-year institution geoscience faculty (Figure 3.7 and 4.4). That is only a one percentage point increase in the female geoscience faculty at two-year colleges and a two percent increase in female geoscience faculty at four-year institutions compared to 2015. These percentages continue to slowly increase each year. The increased percentage of female faculty members at two-year colleges can be seen in growth of female Professors, Associate Professors, Instructor/Lecturers, and Adjunct/Visiting Professors.

**Figure 3.1: Number of Geoscience Departments/Programs at Two-Year Colleges by State**



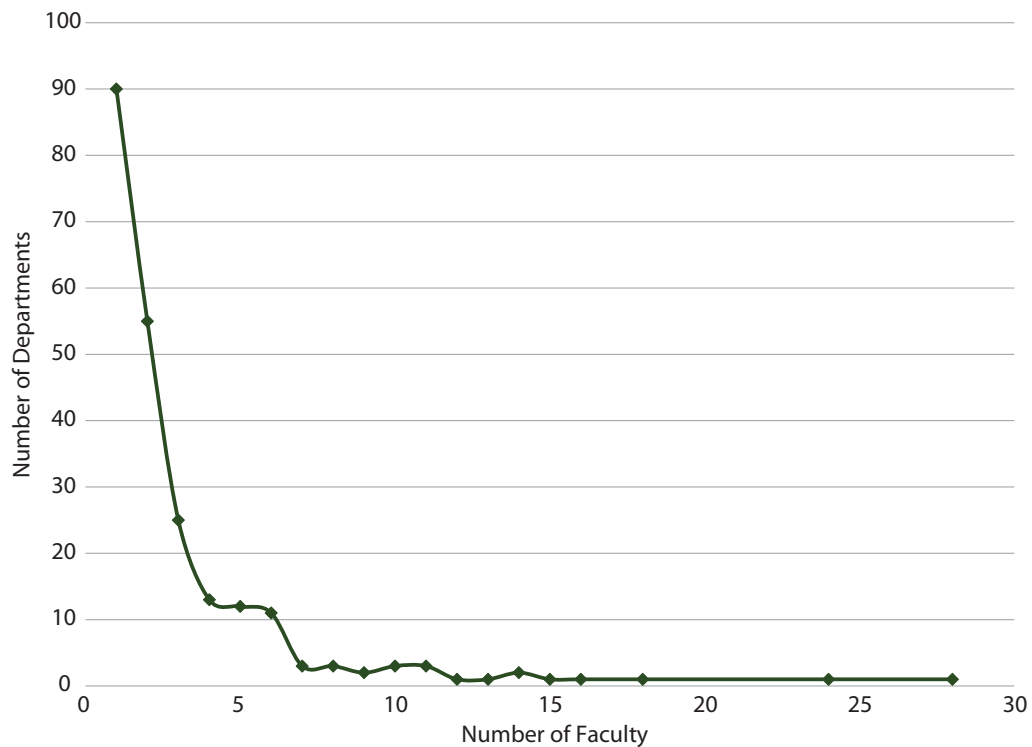
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Table 3.1:** Percentage of Two-Year Colleges with Geoscience Programs for Selected States

State	2-Year Colleges with Geoscience Programs	2-Year Colleges in the State	Percentages of 2-Year Colleges in the State with Geoscience Programs
California	65	186	35%
Texas	41	113	36%
Illinois	22	63	35%
Washington	21	29	72%
Michigan	14	28	50%
Virginia	13	46	28%
Florida	12	64	19%
New York	12	71	17%
Minnesota	11	32	34%
Arizona	10	33	30%

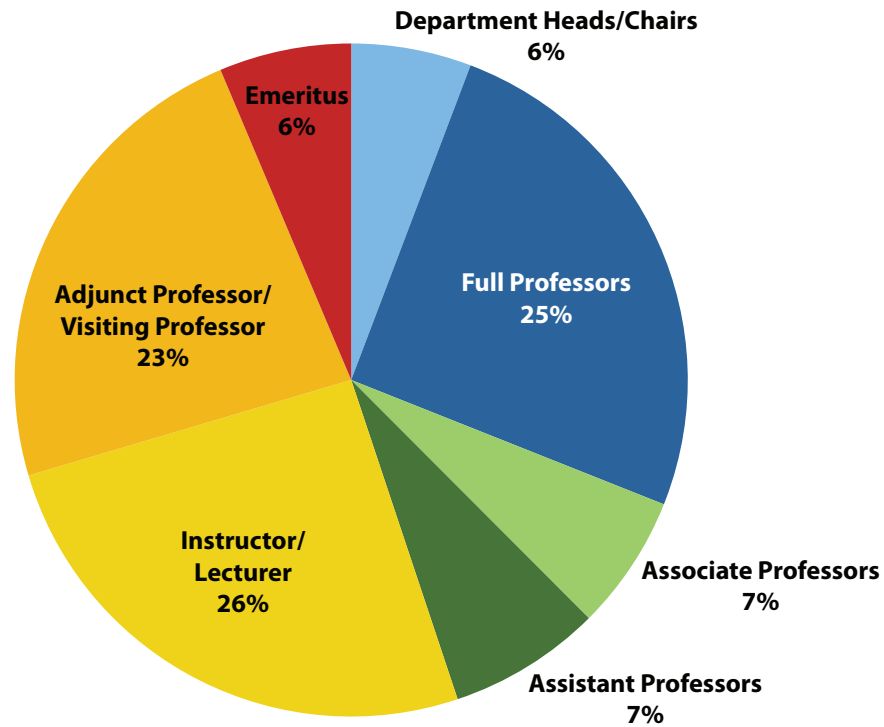
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database and Carnegie Classification of Institutions of Higher Education

**Figure 3.2:** Number of Faculty per Geoscience Department/Program at Two-Year Colleges



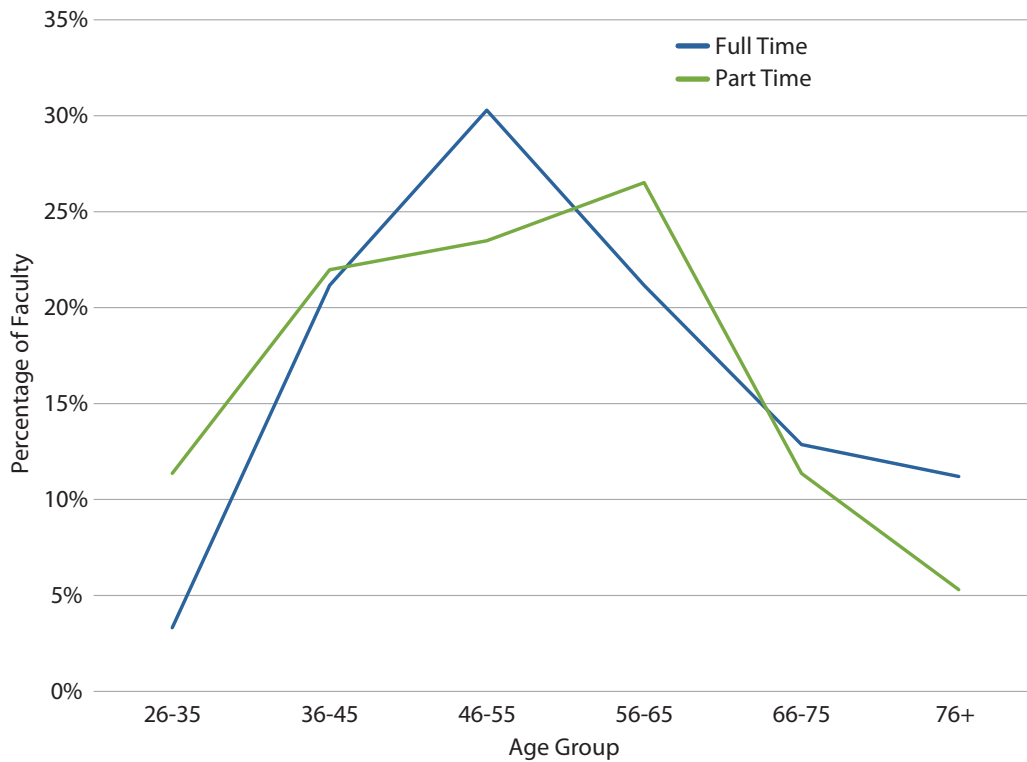
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 3.3: Percentage of Geoscience Faculty by Rank at Two-Year Colleges, 2017**



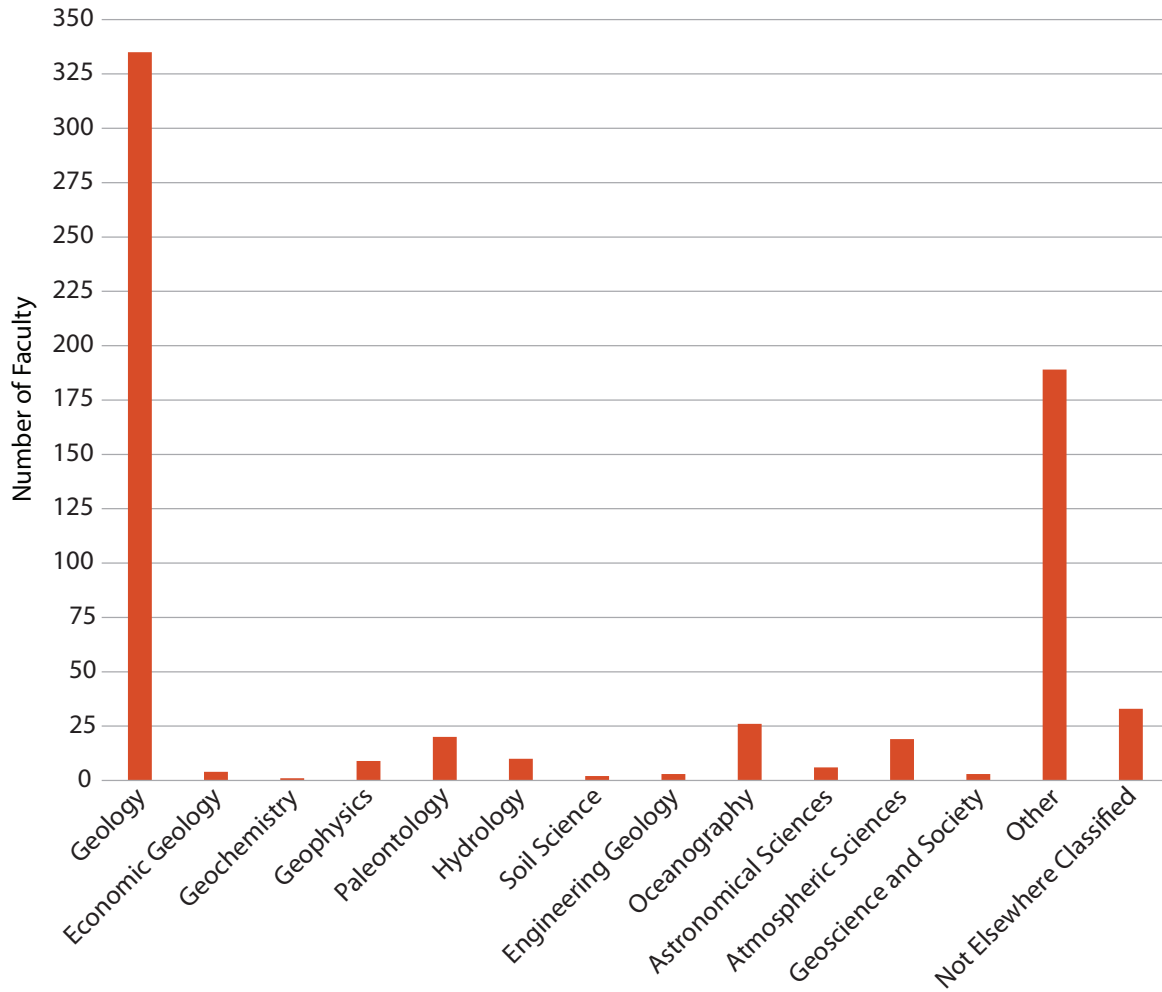
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 3.4: Age Demographics of Two-Year College Geoscience Faculty**



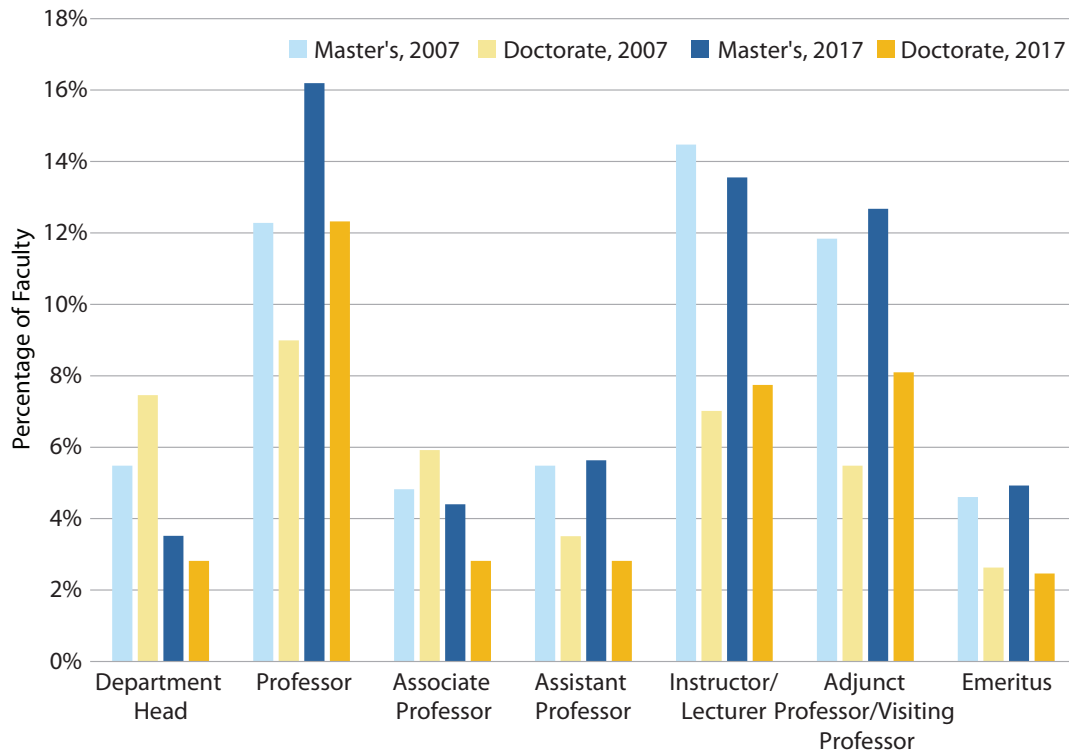
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 3.5:** Research Specialties of Two-Year College Faculty, 2017



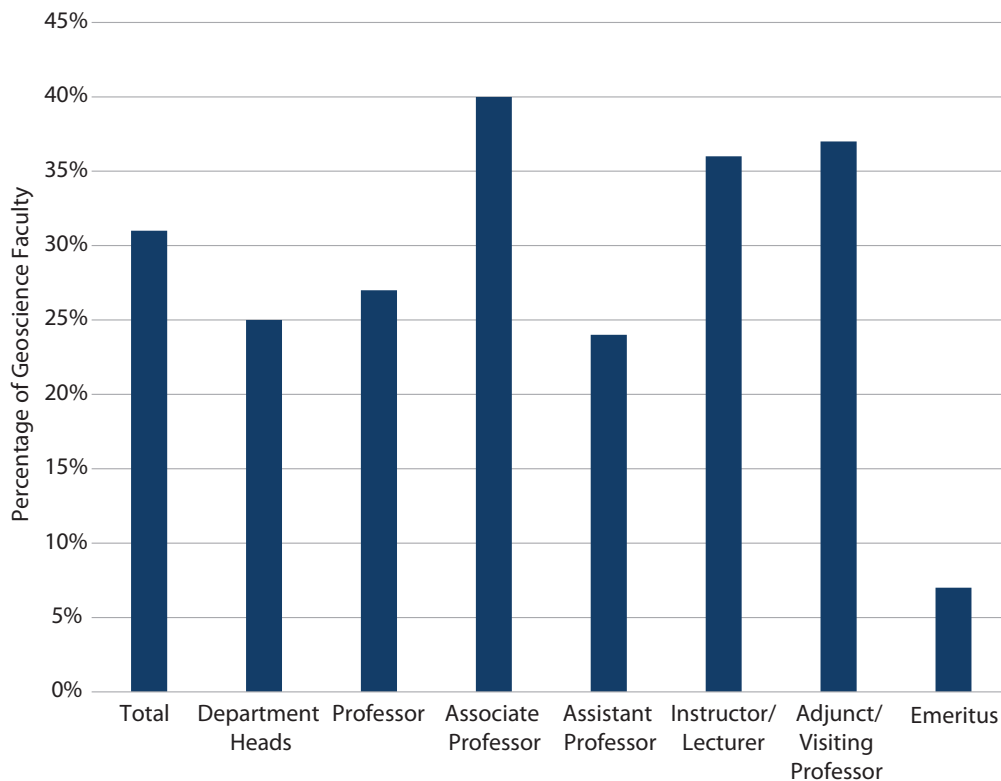
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 3.6: Terminal Degrees of Two-Year College Faculty, 2017**



AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 3.7: Percentage of Two-Year Geoscience Faculty Positions Held by Women**



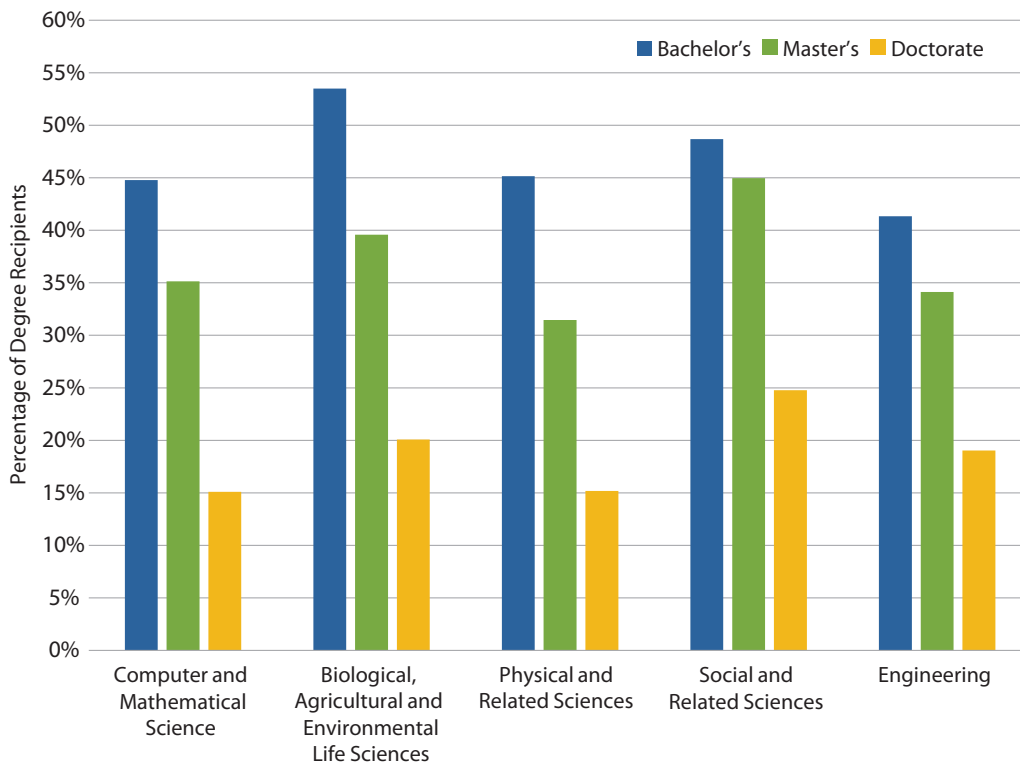
AGI's Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

## Geoscience Students

Many of the students that attend a two-year college transfer to four-year universities whether or not they complete an associate's degree, particularly in the sciences. According to the National Science Foundation, in 2015, 47% of bachelor's graduates, 38% of master's graduates, and 20% of doctoral graduates in science and engineering attended a two-year college (Figure 3.8). In the geosciences, in 2017, 27% of bachelor's graduates, 26% of master's graduates, and 14% of doctoral

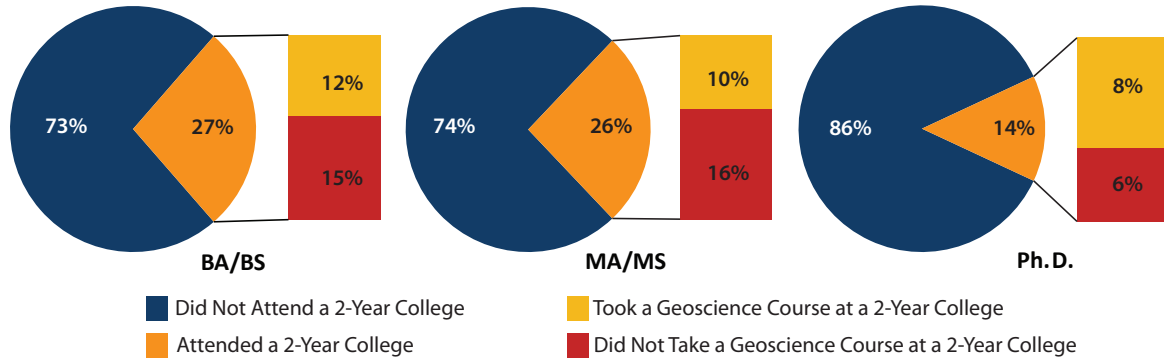
graduates spent at least one semester at a two-year college (Figure 3.9). These rates of two-year college experience have varied a little over the past five years, but in general, approximately a quarter of geoscience bachelor's graduates spent some time at a two-year college. Considering the higher racial and ethnic diversity found at two-year colleges, recruitment of future geoscience graduates should have a stronger focus at the two-year college level in order to make the student population more representative.

**Figure 3.8: Four-Year University Graduates by Degree Field Who Attended a Two-Year College, 2015**



AGI's Geoscience Workforce Program; Data derived from NSF's Survey of College Graduates 2015 public-use dataset

**Figure 3.9:** Geoscience Graduates with at Least One Semester at a Two-Year College, 2017



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

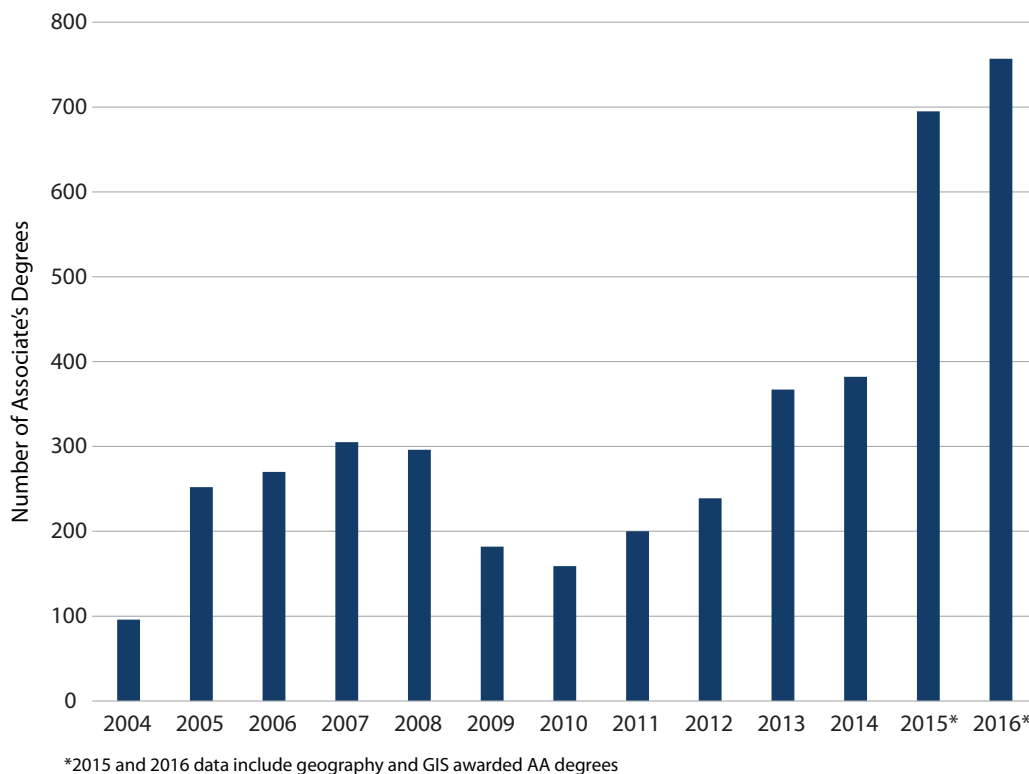
## Geoscience Associate's Degrees

While enrollments at two-year colleges have been decreasing and completions have seen only small growth over the past few years, the number of geoscience associate's degrees awarded has increased by 23% from 2014 to 2016 (Figure 3.10). One important note is that starting in 2015, the number of awarded geoscience associate's degrees began to include Geography and GIS/Cartography associate's degrees, which accounts for the large increase in Figure 3.10. These two degree fields share numerous skills and knowledge with the geosciences and are likely pathways for geoscience majors from two-year colleges. Of the geoscience associate's degrees awarded in 2016, 45% were awarded to women and 12% were awarded to under-represented minorities (Figures 3.11 and 3.12). Both of

these percentages are lower than the overall percentages of associate's degrees awarded to women and underrepresented minorities. While two-year colleges tend to be more diverse than four-year institutions, this diversity is not being reflected in two-year college geoscience programs that award associate's degrees.

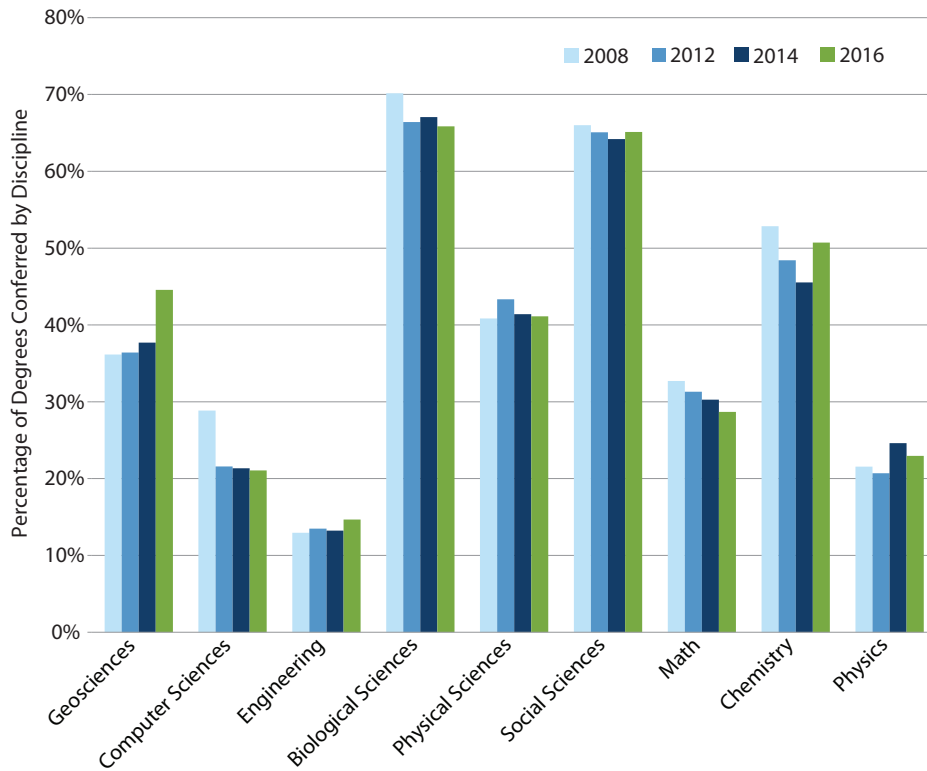
All three figures were derived from data provided by the Department of Education's Integrated Postsecondary Education Database System (IPEDS). It is important to remember that the information is self-reported by each institution's main administrative office and thus reflects main offices' definitions of geoscience and other fields. This may explain some of the change and variance in the number of geoscience associate's degrees awarded each year.

Figure 3.10: Geoscience Associate's Degrees Awarded Annually



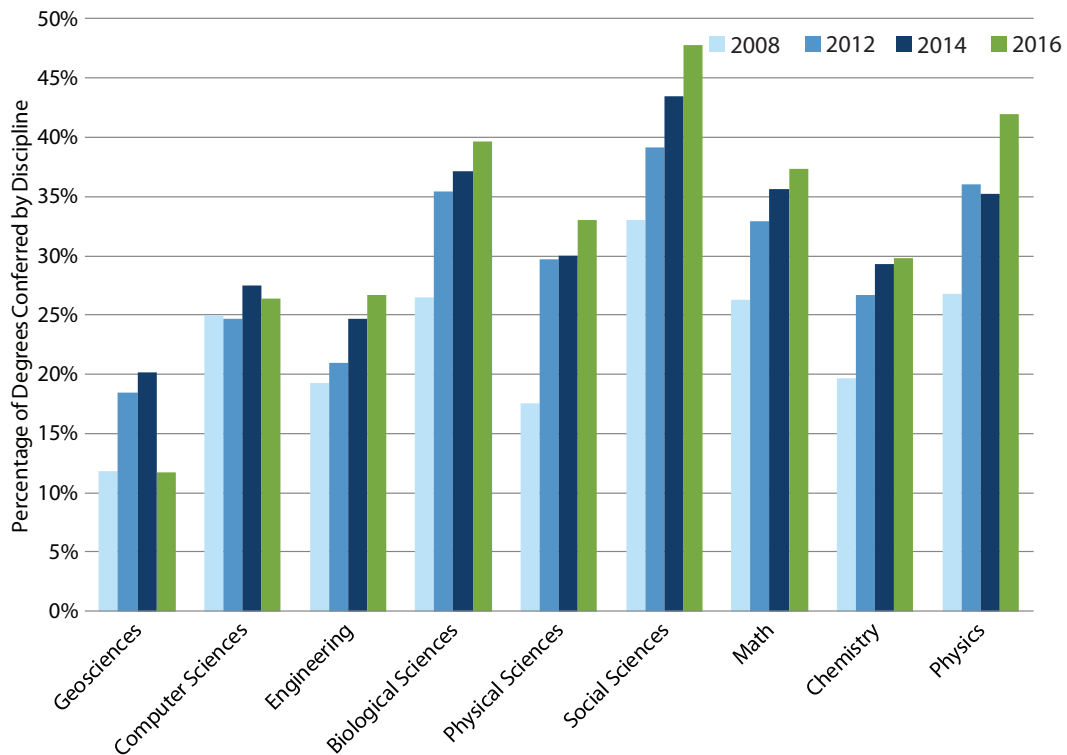
AGI Geoscience Workforce Program; Data derived from IPEDS

**Figure 3.11: Percentage of Associate's Degrees Awarded to Women by Discipline**



AGI Geoscience Workforce Program; Data derived from IPEDS

**Figure 3.12: Percentage of Associate's Degrees Awarded to Underrepresented Minorities by Discipline**



AGI Geoscience Workforce Program; Data derived from IPEDS

## Chapter 4: Trends in Four-Year Institution Geoscience Programs

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A degree from a four-year institution is essential for developing the necessary knowledge and technical skills to be successful in the geoscience workforce. The master's degree in the geosciences historically has been considered the degree of employment for private sector jobs in the geosciences. However, certain industries have been hiring more bachelor's graduates, and approximately half of doctoral graduates pursue careers outside of academia. Therefore, measuring the health of geoscience departments at four-year institutions is essential for tracking the future of the geoscience workforce.

Geoscience faculty at four-year institutions are trending older at all ranks compared to 2015. The average age of all faculty is 60 years old, and there have been decreases in the number of faculty under 36 and within the 36-40 years old range, indicating a slowing in hiring of new geoscience faculty. The percentage of female geoscience faculty has been slowly increasing over the past decade reaching 20 percent in 2017. These increases can be seen across nearly all ranks of faculty, with most of the growth among assistant professors, associate professors, and instructors or lecturers. This increase in female faculty is expected to continue because approximately 43 percent of doctoral graduates over the past decade have been women.

Undergraduate geoscience student enrollments increased from 2010-2015, but since 2015, enrollments have remained flat at approximately 32,000 students. However, departments have been raising concerns of decreasing enrollments among undergraduate students recently. While this is not evident in AGI's data, that may be due to the departments reporting their enrollments into online geoscience programs or departments, certificate program enrollments, or including their introductory geoscience course enrollments. In conjunction with the rising enrollments that started in 2010, the number of awarded bachelor's degrees has been increasing since 2014. Graduate student enrollments have continued to fluctuate around 10,000 students, and the number of awarded graduate degrees has stayed level, indicating that graduate programs have been at capacity for many years.

Female enrollments at all degree levels have been fluctuating between 38 and 45 percent since 2005, which is lower than that overall participation of women at four-year institutions. Students from underrepresented minorities are harder to track through enrollments; however, data collection efforts by AGI and NSF provide a better understanding of the graduation levels of minorities with geoscience degrees. It appears there has

been a small increase in the percentage of underrepresented minorities among geoscience bachelor's degree recipients since 2012, reaching 12 percent in 2016, but this trend is driven by an increase in Hispanic students in geoscience departments. The geosciences still tend to have the lowest participation rates from underrepresented minorities compared to all science disciplines according to NSF. While there are currently many efforts underway aimed at increasing the underrepresented population of students in the geosciences, there may also need to be more focus on encouraging women to major in the geosciences. An alternate consideration for the recruitment of diverse populations into the geosciences may be through a concerted effort of recruitment of first-generation college students. In 2017, among geoscience graduates, 9 percent of bachelor's graduates, 5 percent of master's graduates, and 9 percent of doctoral graduates were first-generation college students, which is indicative of low levels of participation by diverse communities among geoscience postsecondary students. First generation college students also tend to come from lesser economic means and could benefit from funding provided for recruitment of new majors.

Since 2013, with the start of AGI's Geoscience Student Exit Survey, AGI has noticed a need to further investigate the skills development of geoscience students in preparation for entering the geoscience workforce. Many of the necessary technical skills for geoscientists are developed outside of the classroom through field experiences, research experiences, and internships. Most field camps in the United States appear to be at capacity but participation rates of bachelor's graduates in field camps has been increasing since 2013, reaching 47 percent in 2017. Students recognize the importance of field experiences for developing those necessary field skills before entering the workforce, and those students that do not attend field camp are still participating in field courses and field experiences before graduation. Students are also regularly participating in research experiences, particularly graduate students.

Most employers hiring geoscience graduates find their applicants to be well versed in technical geoscience skills because of these experiences. However, these employers are concerned about the development of professional skills, as well as the students' lack of higher-level quantitative experience. Approximately 60 percent of bachelor's graduates and doctoral graduates do not participate in internships, and these kinds of experiences are vital to understanding the day to day working environment for a geoscientist in various industries. These experiences also help students develop and gain exposure to the

desired communication, management, and collaboration skills desired by all employers hiring geoscientists. When recent graduates were asked about the skills they wished they had developed before entering the workforce, many cited communication skills, business skills,

programming and scripting skills, and networking skills to name a few. It is essential that the geoscience community recognize these needs and work to help students develop these skills in order to be successful once they enter the workforce.

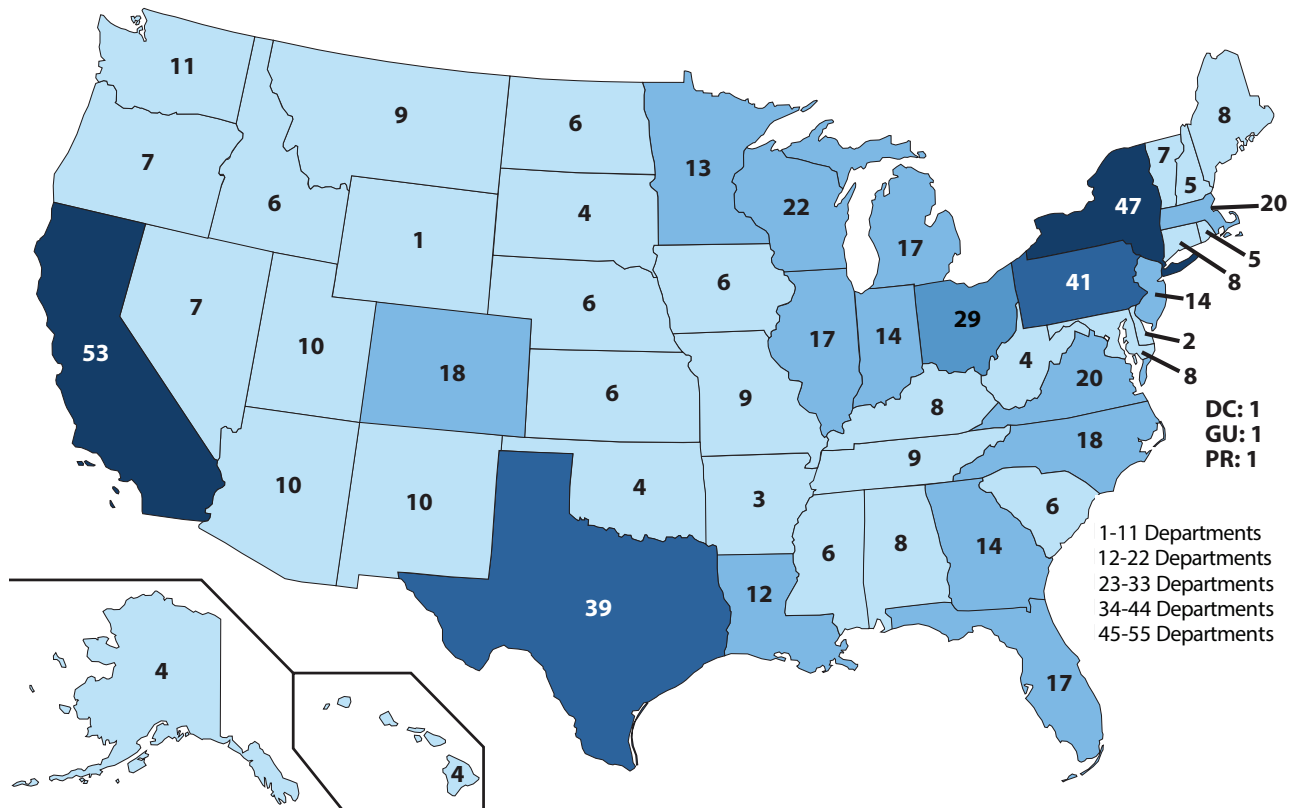
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## Geoscience Departments

According to AGI's Directory of Geoscience Departments, there are currently 635 geoscience departments at four-year universities (Figure 4.1). Since the 2016 report, the total number of departments decreased by three, mostly from sunsetting of departments as part of organizational restructuring or the merging of two or more departments into one larger geoscience department.

Within departments, the average number of tenure-track faculty is approximately 10 faculty members, and the average enrollment of undergraduate and graduate students within a department is 58 students. Texas continues to lead the nation in the number of geoscience undergraduate and graduate students enrolled with geoscience departments, followed by Massachusetts, Colorado, and California (Tables 4.1 and 4.2).

Figure 4.1: Number of Geoscience Departments by State



AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Table 4.1:** Percentage of All U.S. Geoscience Undergraduate Students Enrolled in 2016-2017

State	Percentage of All Undergraduate Geoscience Students
Texas	8.2%
Massachusetts	6.8%
Colorado	5.2%
California	5.2%
Pennsylvania	4.8%
New York	4.4%

AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Table 4.2:** Percentage of All U.S. Geoscience Graduate Students Enrolled in 2016-2017

State	Percentage of All Graduate Geoscience Students
Texas	12.5%
Massachusetts	7.7%
California	6.8%
Colorado	6.8%
Tennessee	4.7%
Illinois	4.5%

AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

## Geoscience Faculty

In 2017, there were 9,075 geoscience faculty and researchers employed in U.S. geoscience departments at four-year universities, compared to 10,048 in 2015. This decrease reflects a lack of hiring of new faculty to fill retiring tenured faculty, as well as removal of some faculty from the listing whose prior retirement had not been reported. Approximately 74% of the geoscience faculty are tenured and 14% are untenured but in tenure-track positions (Figure 4.2). This is a small increase of 2 percentage points of tenured faculty since 2015 and a decrease of 1 percentage point of untenured, tenure-track faculty since 2015.

The geoscience faculty are tracking older at all rankings. The age distribution of geoscience faculty has shifted to an average age of 60 years old in 2017 compared to the average age of 58 in 2015. The large fraction of faculty with the rank of Professor are within the 56-65 age range (Figure 4.3). The total number of faculty under 36 years old decreased from 344 in 2015 to 232 in 2017, and the total number of faculty within the 36-40 years old age range decreased from 633 in 2015 to 558 in 2017. Whereas, the total number of faculty within nearly every other age range increased between 2015 and 2017. This indicates a slowing in hiring of geoscience faculty at four-year institutions.

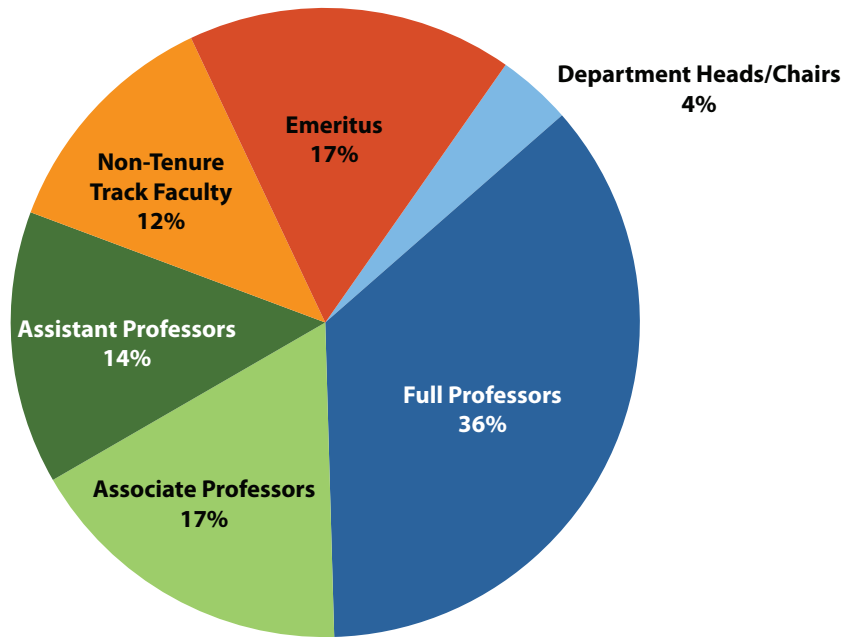
The overall percentage of women in geoscience faculty positions at four-year universities continues to slowly rise from 17% in 2015 to 20% in 2017. This percentage in women geoscience faculty has been consistently rising since 2008. The largest growth was seen among the

ranks of Associate Professor and Instructor/Lecturer (Figure 4.4).

According to AGI's GeoRef database, there has been an increase in the average number of geoscience publications per year over the past few decades from approximately 16,160 publications per year in the 1970s to approximately 29,400 publications per year from 2010-2015 (Figure 4.5). The research areas that geoscientists tend to focus their time and publications have changed over the decades with Geophysics, Environmental Geology, Geochemistry, Quaternary Geology and Petrology dominating the publications from 2010-2015 (Table 4.4). In 2017, publications rates within journals published by a few of AGI's member societies showed increases in the number of articles published in ocean science, climate science, space science, and geoscience education (Figure 4.6).

Since the publication of the last edition of this report, AGI's Workforce Program worked to update the list of research specialties to better represent the variety of work conducted in the geosciences by faculty. The changes included adding a category for public affairs research titled Geoscience and Society, as well as expanding options under most of the other category headings. The changes to the specialties list can be found in Table 4.5. Everything listed in bold is either new or was reassigned to a new category. For example, Atmospheric Sciences was moved from "Other" to its own category with new specific research areas added to this category. With the recognition of these changes, AGI hopes to see more faculty find their specific research fields represented.

**Figure 4.2:** Percentage of Geoscience Faculty by Rank at Four-Year Institutions, 2017



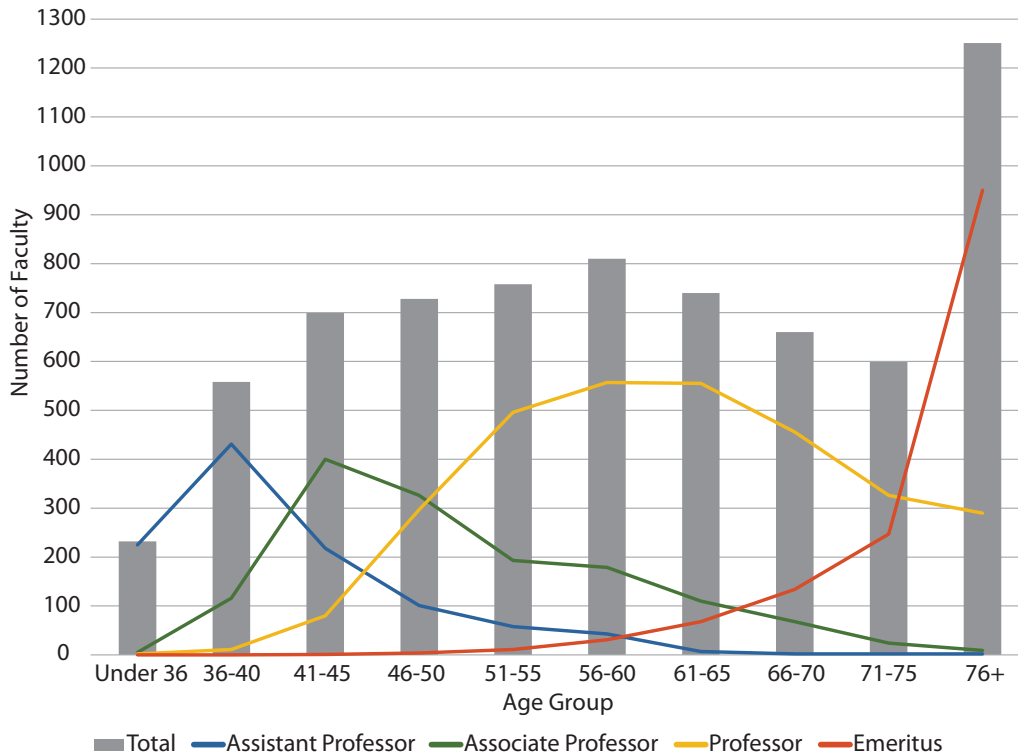
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Table 4.3:** Top Ten Degree Granting Institutions of U.S. Geoscience Tenure-Track or Tenured Faculty, 2015

School where Faculty Earned Highest Degree	Total Number of Tenure or Tenure-Track Faculty Graduates
Massachusetts Institute of Technology	304
University of California-Berkeley	237
University of Washington	231
University of Wisconsin-Madison	217
Stanford University	214
Columbia University	183
California Institute of Technology	180
Pennsylvania State University	173
Harvard University	168
University of Arizona	162

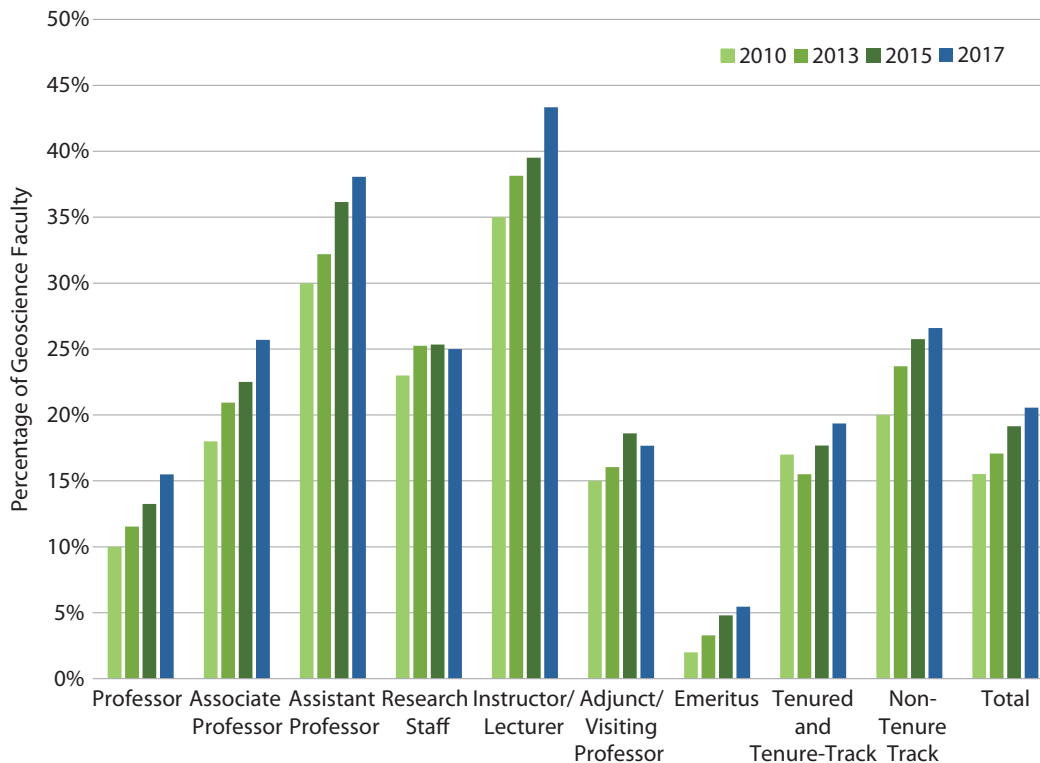
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 4.3: Number of Geoscience Faculty by Age Group and Rank, 2017**



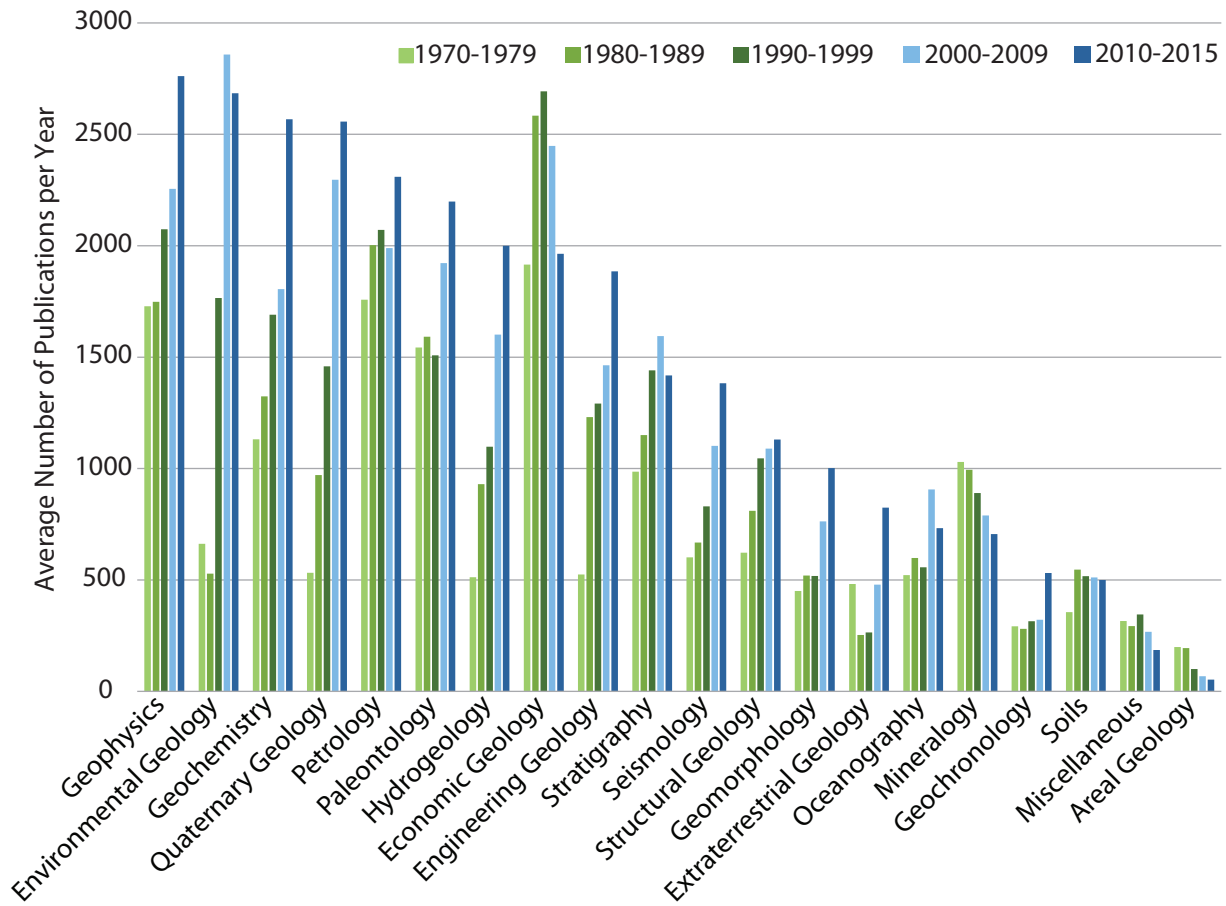
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 4.4: Percentage of Female Geoscience Faculty by Rank**



AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 4.5: Trends in Geoscience Publications**



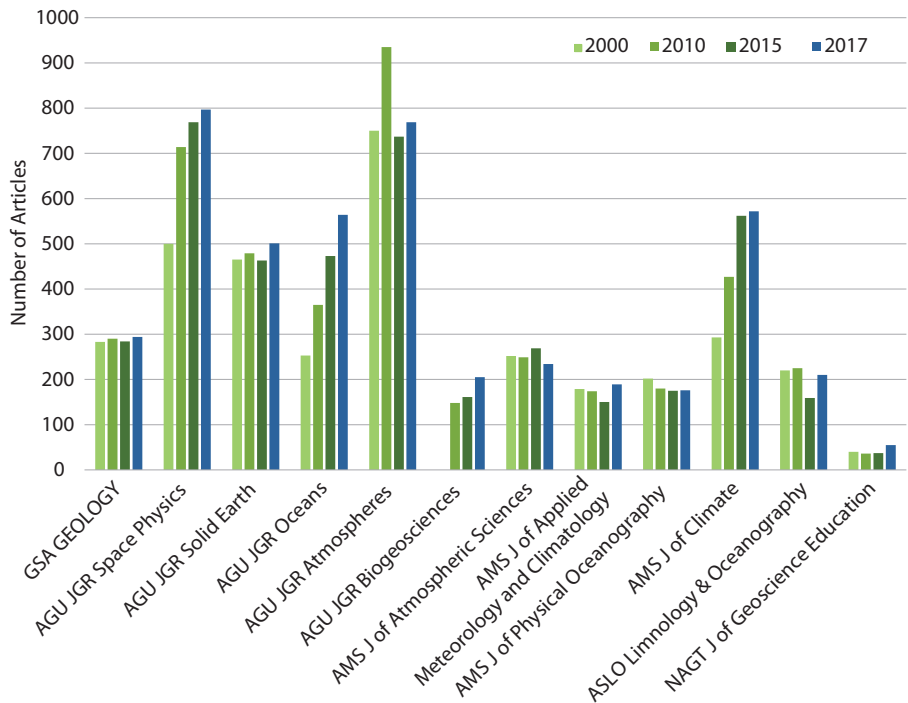
AGI Geoscience Workforce Program; Data derived from AGI's Georef database

**Table 4.4: Top Five Geoscience Publication Topics, 1970-2015**

1970-1979	1980-1989	1990-1999	2000-2009	2010-2015
Economic Geology	Economic Geology	Economic Geology	Environmental Geology	Geophysics
Petrology	Petrology	Geophysics	Economic Geology	Environmental Geology
Geophysics	Geophysics	Petrology	Quaternary Geology	Geochemistry
Paleontology	Paleontology	Environmental Geology	Geophysics	Quaternary Geology
Geochemistry	Geochemistry	Geochemistry	Petrology	Petrology

AGI Geoscience Workforce Program; Data derived from AGI's GeoRef database

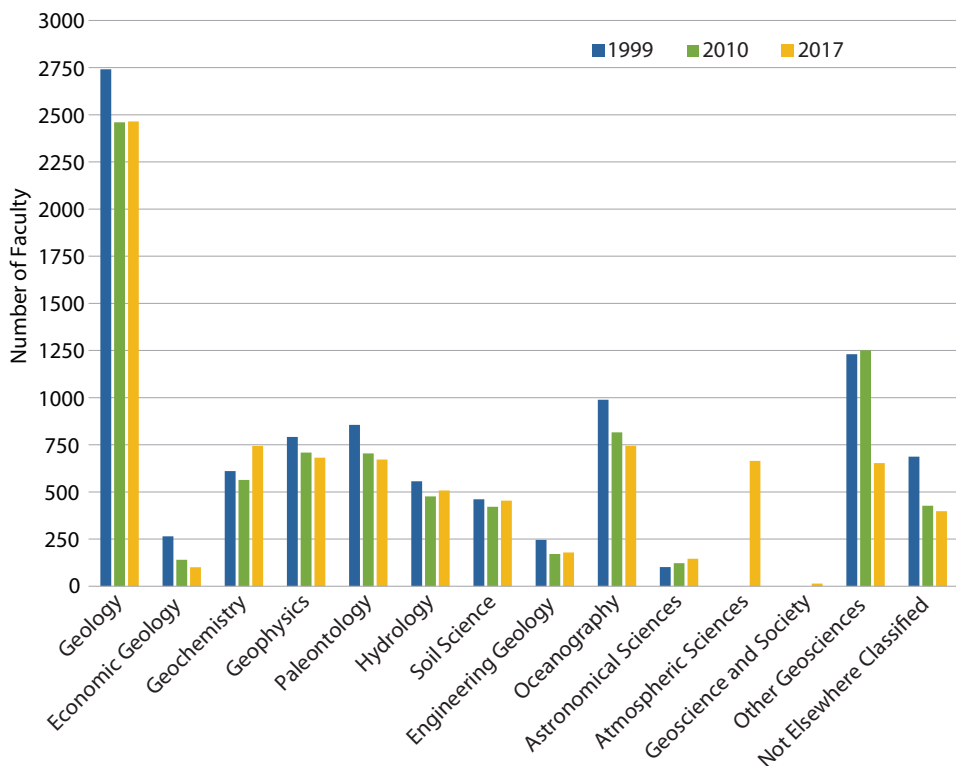
**Figure 4.6: Publication Trends in Selected Geoscience Journals**



Acronyms: Geological Society of American (GSA); American Geophysical Union (AGU) Journal of Geophysical Research (JGR); American Meteorological Union (AMS); Association for the Sciences of Limnology and Oceanography (ASLO); National Association of Geoscience Teachers (NAGT)

AGI Geoscience Workforce Program; Data derived from the AGU, AMS, ASLO, GSA, and NAGT journal publications websites

**Figure 4.7: Trends in Geoscience Faculty Research Specialties (1999-2017)**



AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Table 4.5: Research and Teaching Specialties of Geoscience Faculty, 2017**

Faculty Specialties	Faculty (2017)	Faculty Specialties	Faculty (2017)	Faculty Specialties	Faculty (2017)
<b>GEOLOGY</b>		<b>GEOPHYSICS</b>		Petroleum Engineering 22	
General Geology	211	General Geophysics	186	Rock Mechanics	29
Archaeological Geology	37	Experimental Geophysics	26	<b>Ocean Engineering/Mining</b>	<b>10</b>
Environmental Geology	113	Exploration Geophysics	73	<b>Geotechnical Engineering</b>	<b>0</b>
Geomorphology	250	Geodesy	28	<b>Geological Engineering</b>	<b>2</b>
Glaciology and Glacial Geology	111	Geomagnetism and Paleomagnetism	58	<b>OCEANOGRAPHY</b>	
Marine Geology	81	Gravity	4	General Oceanography	54
Mineralogy and Crystallography	135	Heat Flow	10	Biological Oceanography	242
Paleolimnology	19	Seismology	218	Chemical Oceanography	121
Petroleum Geology	54	Marine Geophysics	71	Geological Oceanography	73
General Petrology	74	<b>Nonlinear Geophysics</b>	<b>0</b>	Physical Oceanography	211
Igneous Petrology	225	<b>Near Surface Geophysics</b>	<b>7</b>	Shore and Nearshore Processes	43
Metamorphic Petrology	85	<b>PALEONTOLOGY</b>		<b>Paleoceanography</b>	<b>1</b>
Sedimentary Petrology	56	General Paleontology	192	<b>ASTRONOMICAL SCIENCES</b>	
Sedimentology	318	Paleostratigraphy	39	Cosmochemistry	24
Physical Stratigraphy	91	Micropaleontology	59	Planetary Geology	53
Structural Geology	324	Paleobotany	20	Extraterrestrial Geophysics	40
Tectonics	135	Palynology	18	Meteorites and Tektites	14
Volcanology	82	Quantitative Paleontology	4	<b>Astrophysics</b>	<b>11</b>
Mathematical Geology	21	Vertebrate Paleontology	106	<b>Heliophysics</b>	<b>0</b>
Mineral Physics	29	Invertebrate Paleontology	107	<b>Astrobiology</b>	<b>0</b>
<b>Medical Geology</b>	<b>6</b>	<b>Paleoecology</b>	<b>109</b>	<b>ATMOSPHERIC SCIENCES</b>	
Forensic Geology	0	<b>Paleoclimatology</b>	<b>10</b>	<b>Atmospheric Sciences</b>	<b>505</b>
<b>ECONOMIC GEOLOGY</b>		<b>Geomicrobiology</b>	<b>4</b>	<b>Meteorology</b>	<b>140</b>
General Economic Geology	45	<b>HYDROLOGY</b>		<b>Atmospheric Chemistry</b>	<b>4</b>
Coal	12	General Hydrology	117	<b>Atmospheric Physics</b>	<b>2</b>
Metallic Ore Deposits	29	Ground Water/Hydrogeology	264	<b>Climatology</b>	<b>14</b>
Industrial Minerals	3	Quantitative Hydrology	41	<b>GEOSCIENCE AND SOCIETY</b>	
<b>Ore Deposits (other)</b>	<b>1</b>	Surface Water	57	<b>Natural Hazards</b>	<b>3</b>
Oil and Gas	9	Geohydrology	29	<b>Manmade Hazards</b>	<b>1</b>
<b>Construction Materials (ssg)</b>	<b>0</b>	<b>Materials Transport</b>	<b>0</b>	<b>Water Quality/Use</b>	<b>3</b>
<b>GEOCHEMISTRY</b>		<b>SOIL SCIENCE</b>		<b>Geoscience Communications</b>	<b>1</b>
General Geochemistry	157	Soil Physics/Hydrology	64	<b>History of Geoscience</b>	<b>6</b>
Analytical Geochemistry	30	Soil Chemistry/Mineralogy	110	<b>OTHER</b>	
Experimental Petrology/Phase Equilibria	41	Pedology/Classification/Morphology	50	General Earth Sciences	100
Exploration Geochemistry	6	Forest Soils/Rangelands/Wetlands	29	Earth Science Education	84
Geochronology and Radioisotopes	93	Soil Biology/Biochemistry	55	Physical Geography	112
Low-Temperature Geochemistry	159	Paleopedology/Archeology	7	Remote Sensing	129
Marine Geochemistry	65	Other Soil Science	136	Material Science	18
Organic Geochemistry	61	<b>ENGINEERING GEOLOGY</b>		Land Use/Urban Geology	45
Stable Isotopes	91	General Engineering Geology	61	Geographic Information Systems	147
Trace Element Distribution	112	Earthquake Engineering	4	<b>Geoinformatics</b>	<b>3</b>
<b>Biogeochemistry</b>	<b>18</b>	Mining Tech/Extractive Metallurgy	14	<b>Global Change</b>	<b>11</b>
<b>High-Temperature Geochemistry</b>	<b>1</b>	Mining Engineering	37	<b>Nanogeoscience</b>	<b>0</b>
<b>Aqueous Geochemistry</b>	<b>6</b>			<b>Climate Modeling</b>	<b>3</b>
				Not Elsewhere Classified	398

AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Table 4.6: Top Geoscience Specialities with the Most Change in Faculty Since 2015**

Positive Change in Faculty	Negative Change in Faculty
<b>GEOLOGY</b>	
Glaciology and Glacial Geology	Sedimentary Petrology
Igneous Petrology	General Petrology
Tectonics	Structural Geology
<b>ECONOMIC GEOLOGY</b>	
Ore Deposits (other)	General Economic Geology
--	Metallic Ore Deposits
<b>GEOCHEMISTRY</b>	
Low-Temperature Geochemistry	Trace Element Distribution
Biogeochemistry	General Geochemistry
<b>GEOPHYSICS</b>	
Geodesy	General Geophysics
Geomagnetism & Paleomagnetism	Exploration Geophysics
<b>PALEONTOLOGY</b>	
General Paleontology	Paleobotany
Paleoclimatology	Palynology
<b>HYDROLOGY</b>	
General Hydrology	Geohydrology
Surface Waters	--
<b>SOIL SCIENCE</b>	
Other Soil Science	Soil Chemistry/Mineralogy
--	Pedology/Classification/Morphology
<b>ENGINEERING GEOLOGY</b>	
Geological Engineering	Mining Engineering
Ocean Engineering/Mining	Petroleum Engineering
<b>OCEANOGRAPHY</b>	
Physical Oceanography	Geological Oceanography
Biological Oceanography	Shore and Nearshore Processes
<b>ASTRONOMICAL SCIENCES</b>	
Astrophysics	Planetary Geology
Cosmochemistry	--
<b>OTHER GEOSCIENCES</b>	
General Earth Sciences	Physical Geography
Earth Science Education	Land Use/Urban Geology

AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

## Geoscience University Students

Since 2008, undergraduate and graduate enrollments in geoscience departments had been steadily increasing to 31,407 undergraduates in 2014 and 11,165 graduate students in 2012. Since then, the enrollments have remained steady with very small changes to those numbers (Figure 4.8). This appears to mirror the trend of overall enrollments of students in four-year universities (Figure 2.9). Geoscience graduation rates for bachelor's degrees have been increasing since 2014 reaching 4668 bachelor's graduates in 2017 (Figure 4.9). This increase corresponds to the increasing enrollments of undergraduates that started in 2009. In a few years, this increase should level out similarly to the enrollments. The number of master's graduates continue to hover just under 1500 graduates, but 2017 saw an increase in doctoral graduates from 690 in 2016 to 813 in 2017.

Figures 4.11–4.14 and Figure 4.17 show the percentage of science and geoscience degrees awarded to underrepresented minorities from three different sources—the National Science Foundation, the Department of Education's IPEDS database, and AGI's Geoscience Student Exit Survey. Accurate data on the enrollments and completions of underrepresented minorities in geoscience degree programs can be difficult to acquire, and all three sources have different methods for gathering this information. The National Science Foundation uses a combination of survey data provided by graduates and universities to provide graduation rates among science and engineering underrepresented minority students. In 2015, there were small increases in the percentage of science and engineering degrees awarded to individuals in underrepresented populations at all degree levels compared to 2013. Among geoscience graduates, bachelor's degrees conferred to underrepresented minorities increased from 9% to 11% from 2013–2015 (Figure 4.11). Master's degrees conferred stayed the same at 8% and doctoral degrees conferred decreased from 5% to 4% from 2013–2015.

Figures 4.12–4.14 show the data provided by the Department of Education. The Department of Education IPEDS database contains information received from the main administrative offices at universities, so their information comes from the forms filled out by the students upon entry into the university and any supplemental data provided by the departments. Similar to the NSF data, the percentage of bachelor's degrees awarded to underrepresented minorities increased to 12% in 2016, while the percentage of master's and doctoral degrees awarded stayed the same between 2015 and 2016 at 8% and 6% respectively.

AGI's Geoscience Student Exit Survey collects data directly from the recent graduates at the time of their graduation. This survey has run for the past five years, and the percentage of underrepresented minorities completing their geoscience degree has varied a bit over the past five years. Among bachelor's graduates, 7–11% were underrepresented minorities from 2013–2017. Among master's graduates 3–12% were underrepresented minorities, and among doctoral graduates, up to 8% were underrepresented minorities from 2013–2017 (Figure 4.17). With the small populations and varied data acquisition strategies, precise understanding of trends in underrepresented participation is difficult to ascertain. The one key consistent trend is that underrepresented populations in the geosciences remain extraordinarily low.

In 2017, the majority of geoscience students were U.S. citizens. Geoscience doctoral programs tend to have the highest percentage of foreign national students compared to the other degree levels (Figure 4.16).

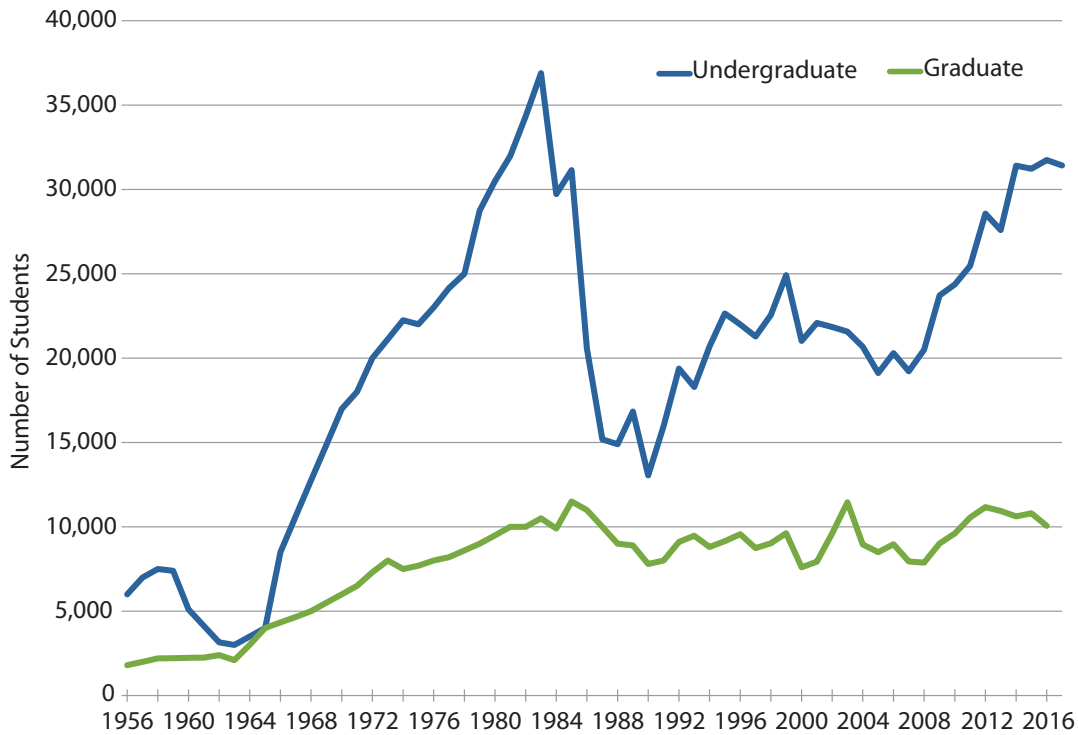
The diversity challenges faced by the geosciences has sparked questions about the trend of socioeconomic status of geoscience students, and one way to infer this is through the highest education level of the students' parents or guardians. In general, most geoscience graduates at all degree levels have at least one parent with a postsecondary degree, and the percentage of graduates with a parent holding a graduate or professional degree increases with the graduate's degree level. In 2017, the data indicated that 9% of bachelor's graduates, 5% of master's graduates, and 9% of doctoral graduates were first generation college students (Figure 4.15). These demographic trends have not changed much over the past five years.

AGI's Geoscience Student Exit Survey was developed to help geoscience departments to assess the educational experiences of graduating students, as well as for AGI to understand the trends of strengths and weaknesses of new graduates entering the workforce. This survey has been conducted tri-annually since 2013, and it is distributed to geoscience graduates in the United States at each traditional graduation period (at the end of fall, spring, and summer semester). This year, results from the Exit Survey will be presented as a five-year analysis, looking at recent trends among recent graduates related to demographics, skills development, co-curricular activities, and immediate plans after graduation.

Figures 4.18–4.20 show the participation in advanced quantitative courses by geoscience graduates over the past five years. Over this time period, approximately 80% of all geoscience graduates take Calculus I and 80% of graduate students take Calculus II during their postsecondary education. However, particularly among bachelor's graduates, the percentages of graduates that take higher level quantitative courses decreases dramatically. Students are receiving instruction in chemistry and physics during their geoscience degrees with approximately 90% of all graduates taking at least one chemistry course and at least one physics course (Figures 4.21–4.23).

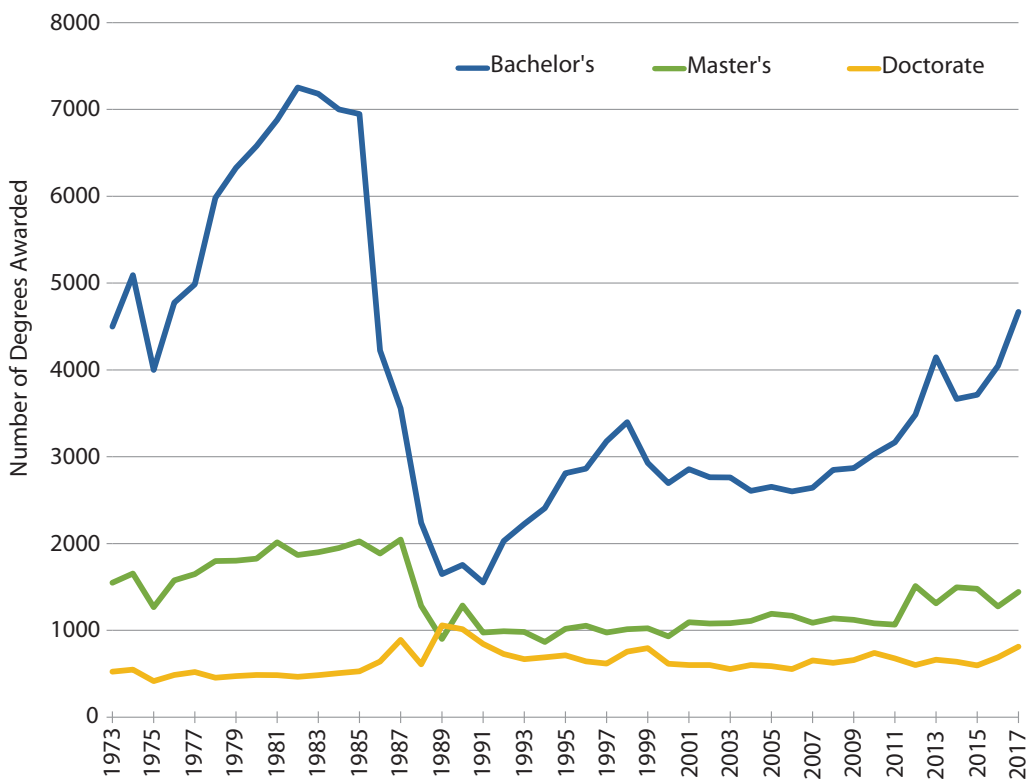
While the percentages vary from year to year, the majority of graduates at the bachelor's and master's degree levels chose to major in the geosciences at some point during their undergraduate education. This highlights the importance of undergraduate introductory geoscience courses as recruitment tools for future majors (Figures 4.24–4.26). Figure 4.27 shows the degree field choices of geoscience graduates over the past five years. This figure highlights the carried fields and interests that fall under the geosciences umbrella, particularly among master's and doctoral graduates.

**Figure 4.8:** Geoscience Enrollments at U.S. Four-Year Institutions, 1955-2017



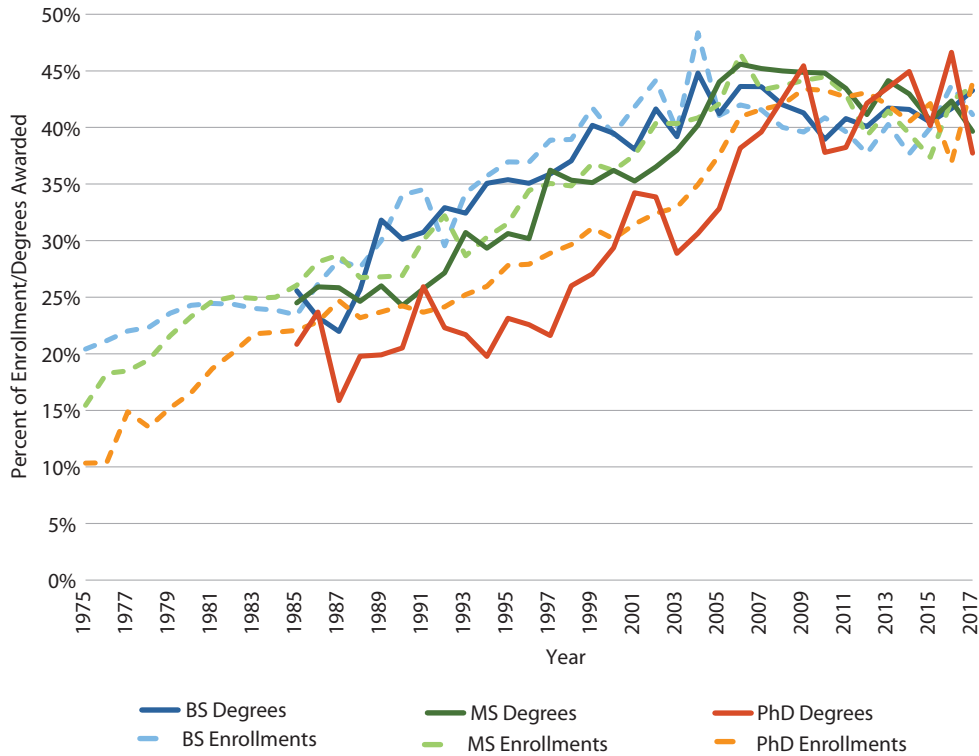
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 4.9:** Geoscience Degrees Awarded at U.S. Four-Year Institutions, 1973-2017



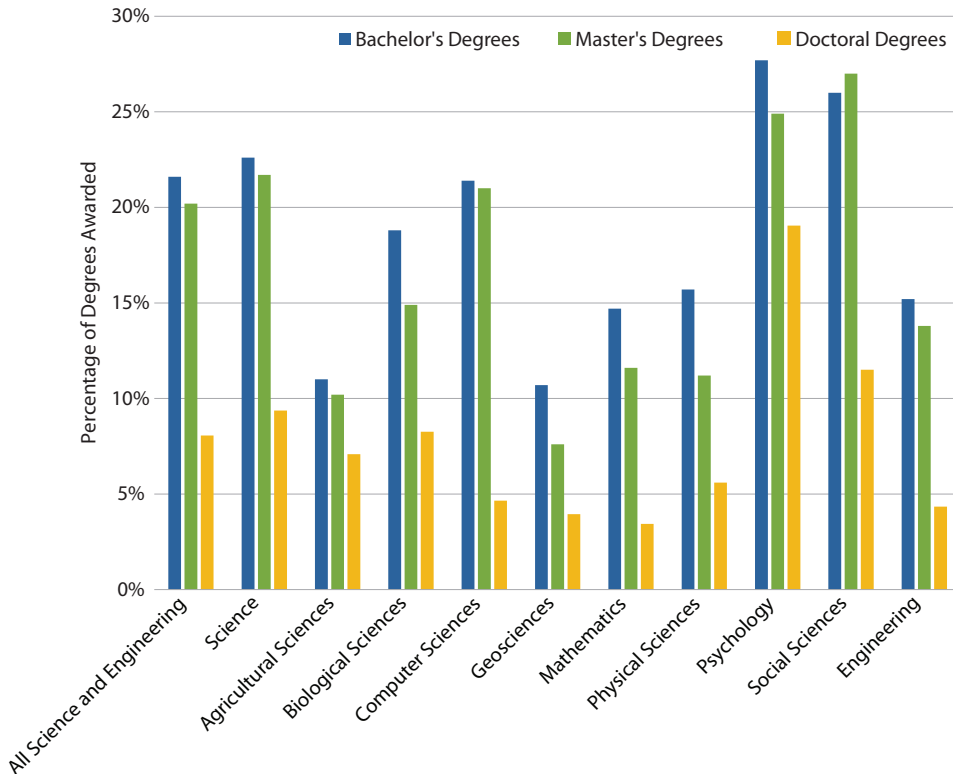
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 4.10: Participation of Women in Geoscience Programs**



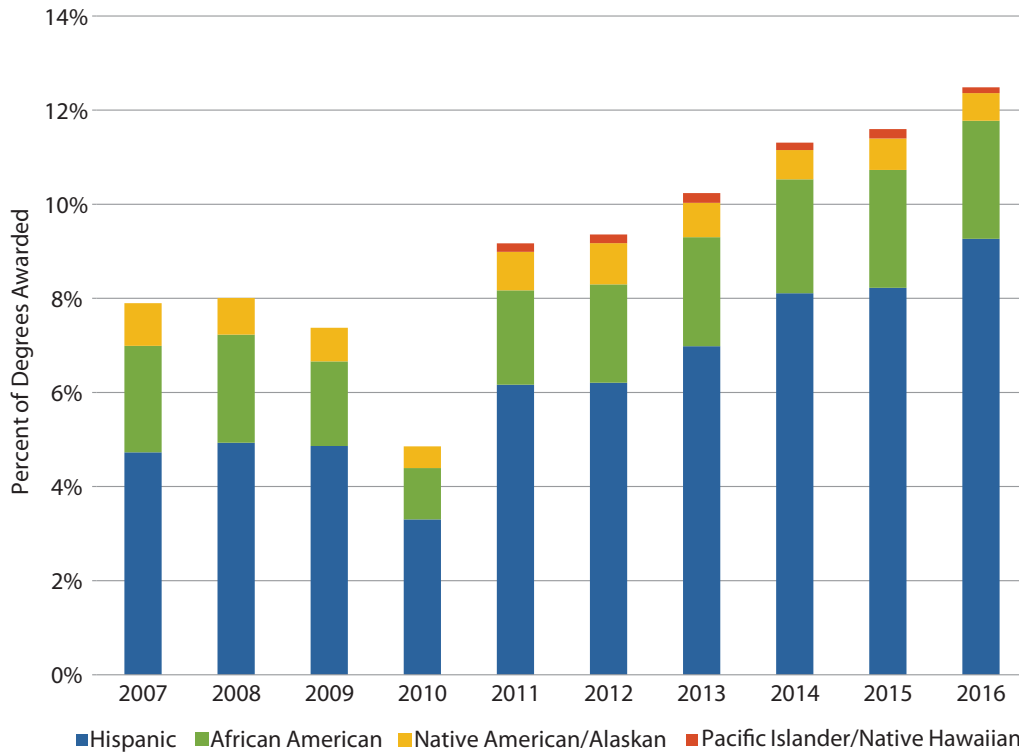
AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 4.11: Percentage of Science and Engineering Degrees Awarded to Underrepresented Minorities, 2015**



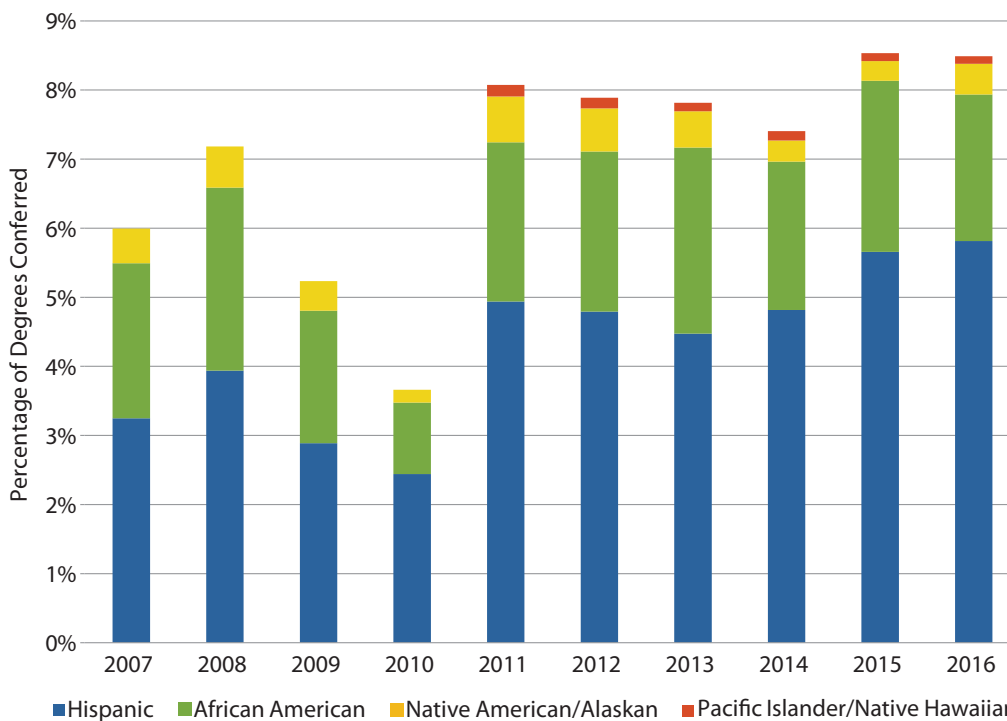
AGI Geoscience Workforce Program, Data derived from NSF's National Survey of College Graduates 2015 Public-use data files

**Figure 4.12: Percentage of Geoscience Bachelor's Degrees Awarded to Underrepresented Minorities**



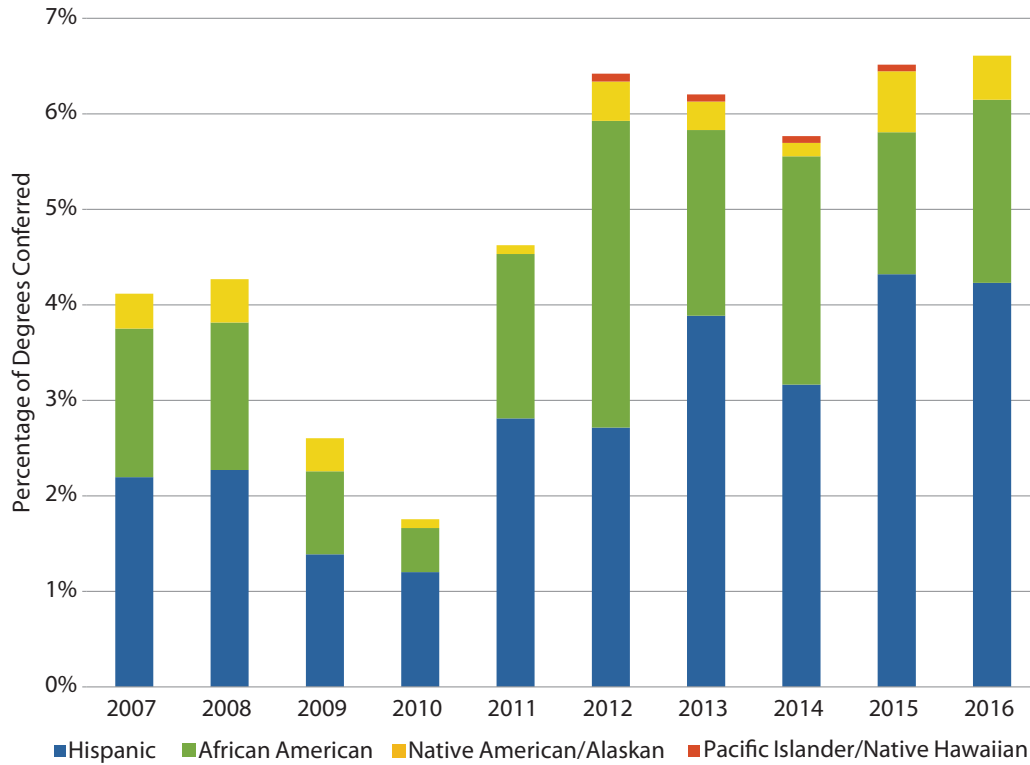
AGI Geoscience Workforce Program; Data derived from IPEDS

**Figure 4.13: Percentage of Geoscience Master's Degrees Awarded to Underrepresented Minorities**



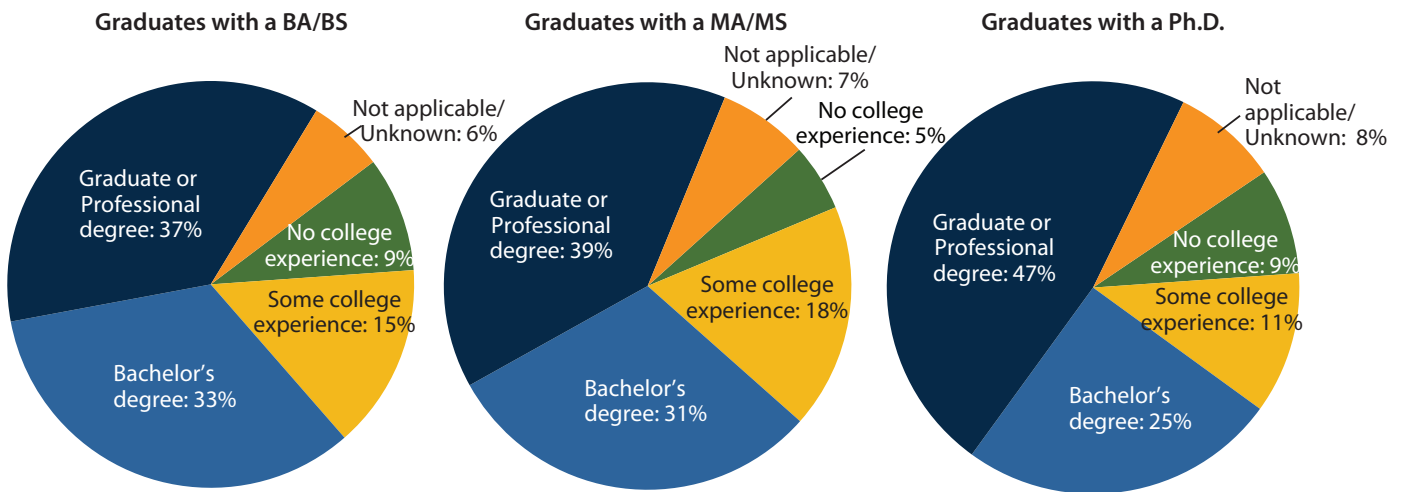
AGI Geoscience Workforce Program; Data derived from IPEDS

**Figure 4.14: Percentage of Geoscience Doctoral Degrees Awarded to Underrepresented Minorities**



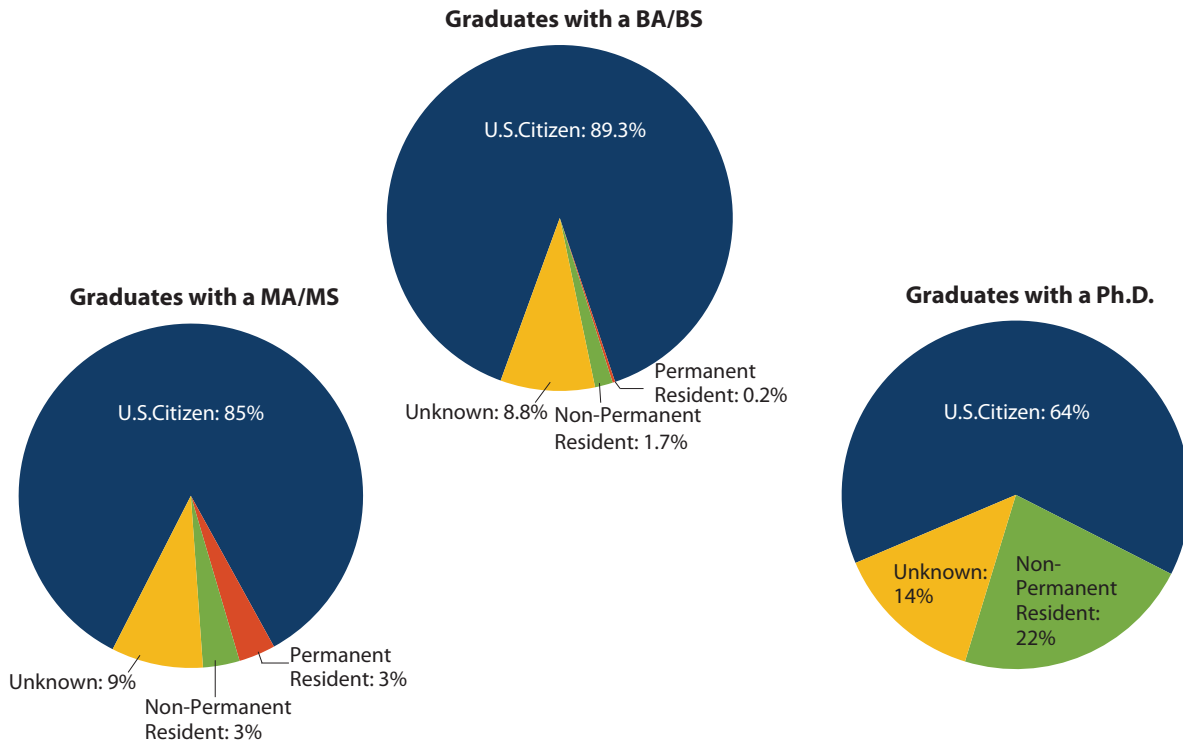
AGI Geoscience Workforce Program; Data derived from IPEDS

**Figure 4.15: Highest Level of Education of Parents of Geoscience Graduates, 2017**



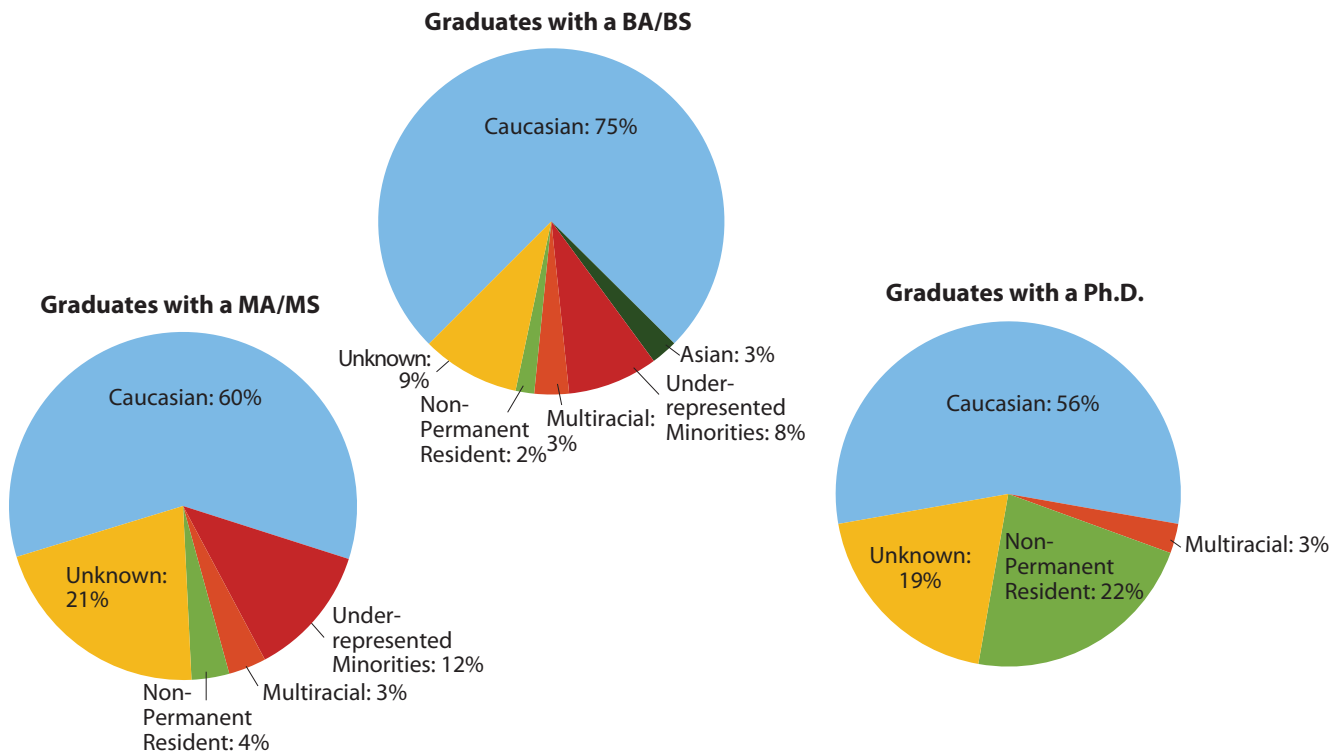
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.16: Citizenship of Geoscience Graduates, 2017**



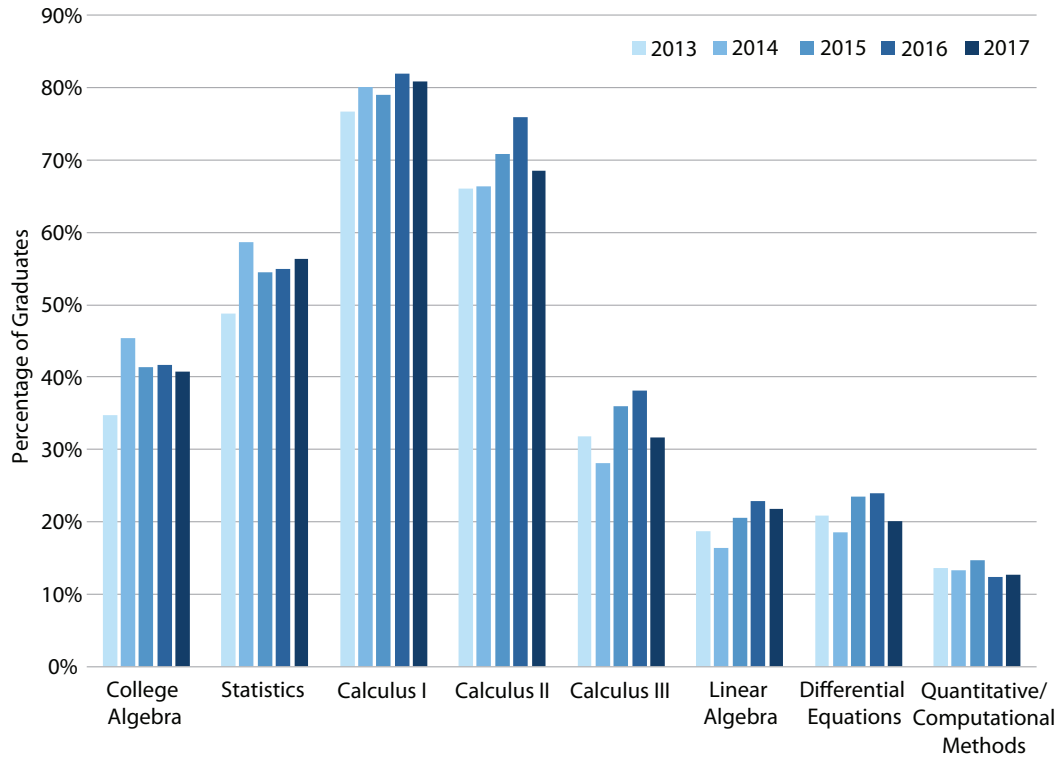
AGI Geoscience Workforce Program, Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.17: Race and Ethnicity of Geoscience Graduate Students, 2017**



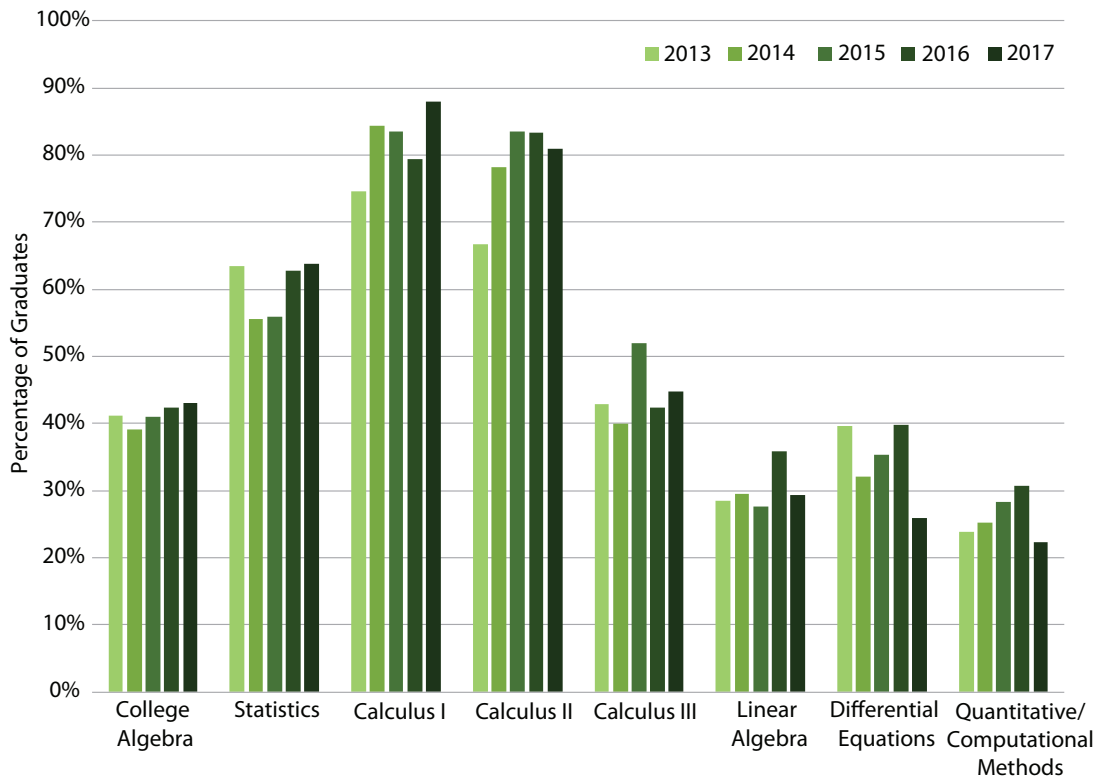
AGI Geoscience Workforce Program, Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.18: Quantitative Skills and Knowledge Gained by Bachelor's Graduates, 2013-2017**



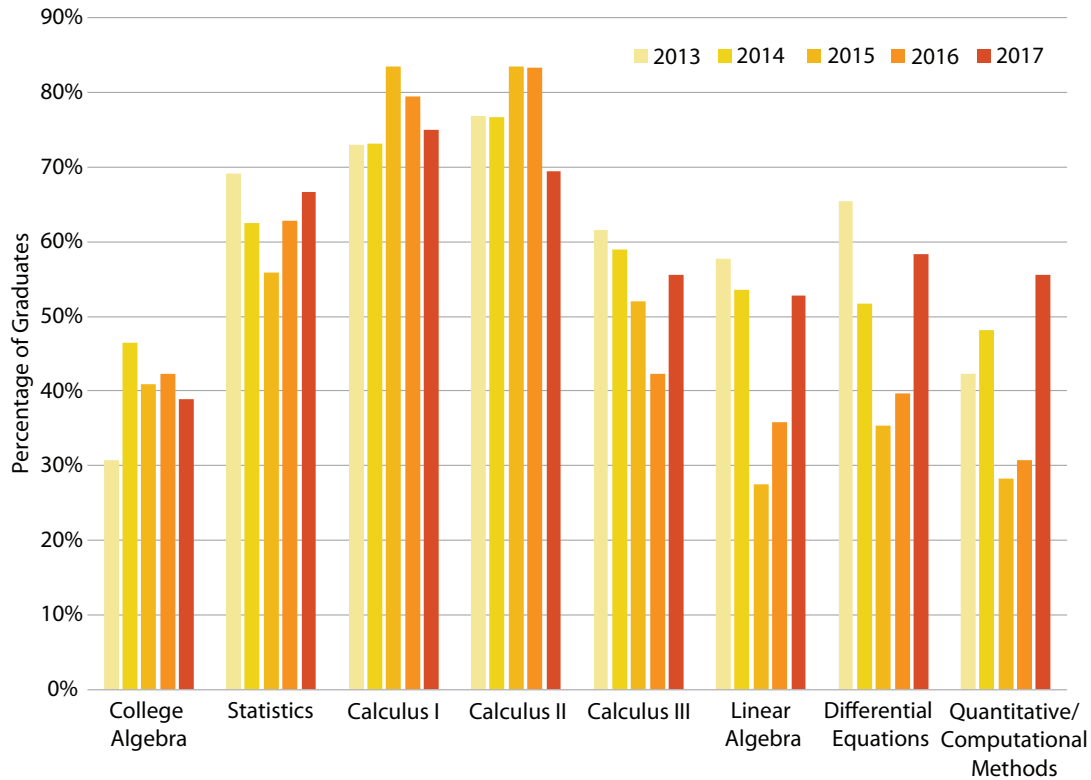
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.19: Quantitative Skills and Knowledge Gained by Master's Graduates, 2013-2017**



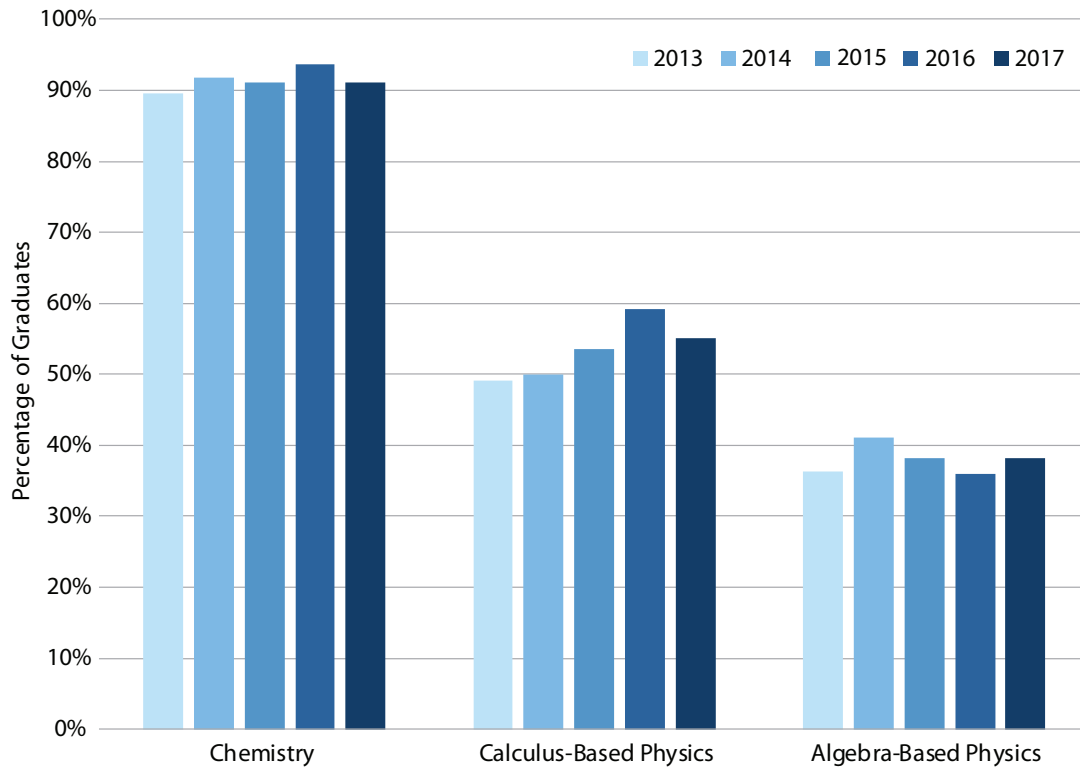
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.20: Quantitative Skills and Knowledge Gained by Doctoral Graduates, 2013-2017**



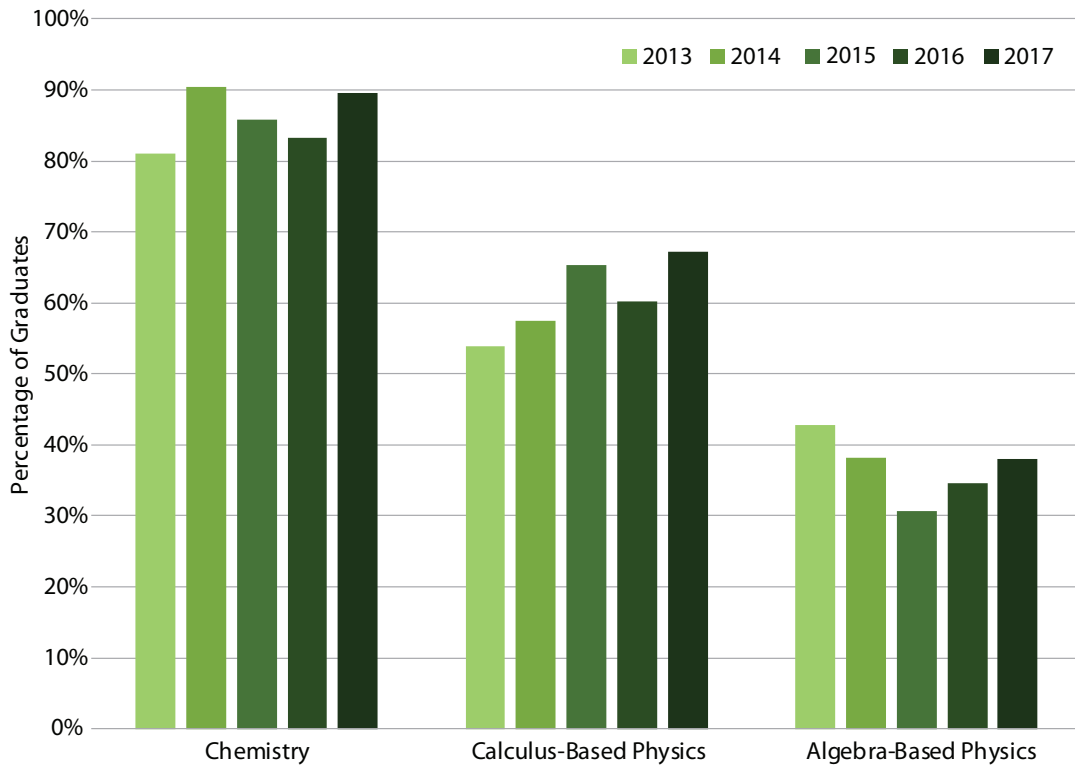
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.21: Supplemental Science Courses Taken by Bachelor's Graduates, 2013-2017**



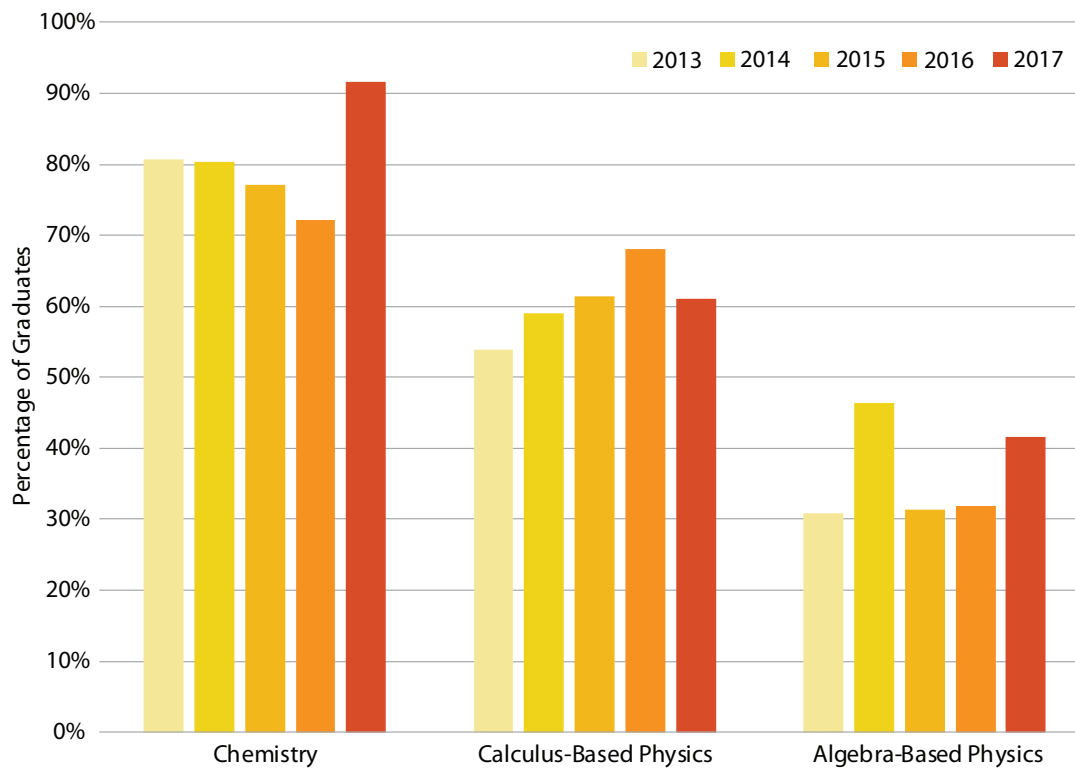
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.22: Supplemental Science Courses Taken by Master's Graduates, 2013-2017**



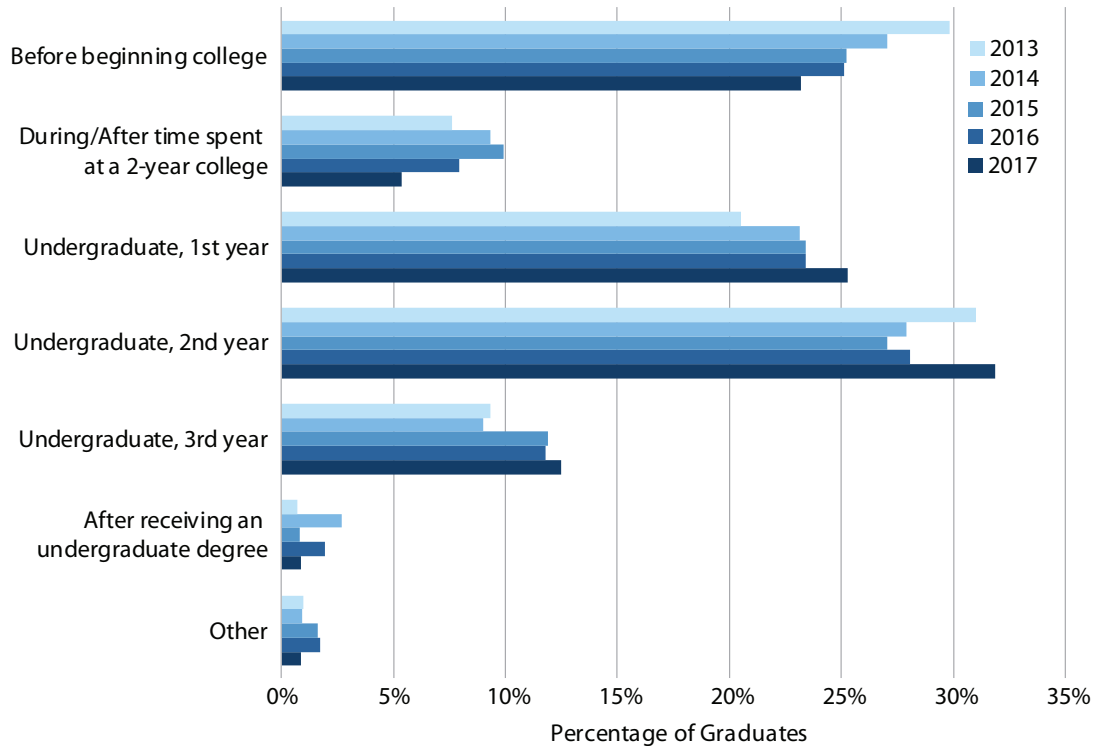
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.23: Supplemental Science Courses Taken by Doctoral Graduates, 2013-2017**



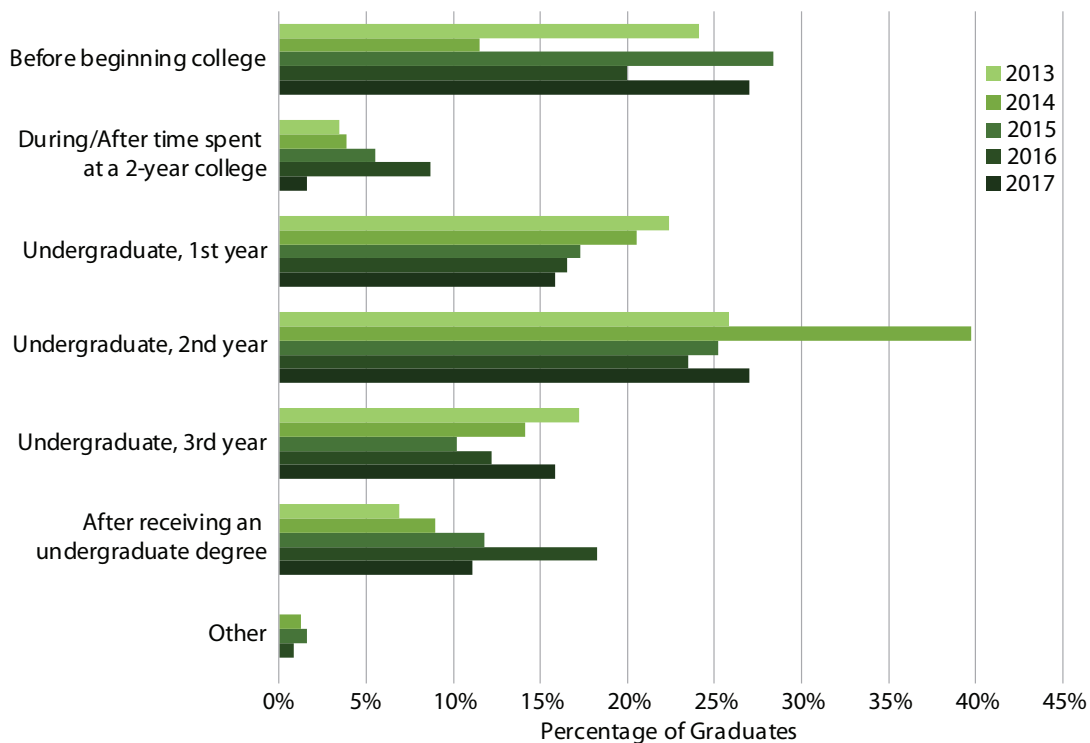
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.24:** The Point in Time When Bachelor's Graduates Decided to Major in the Geosciences, 2013-2017



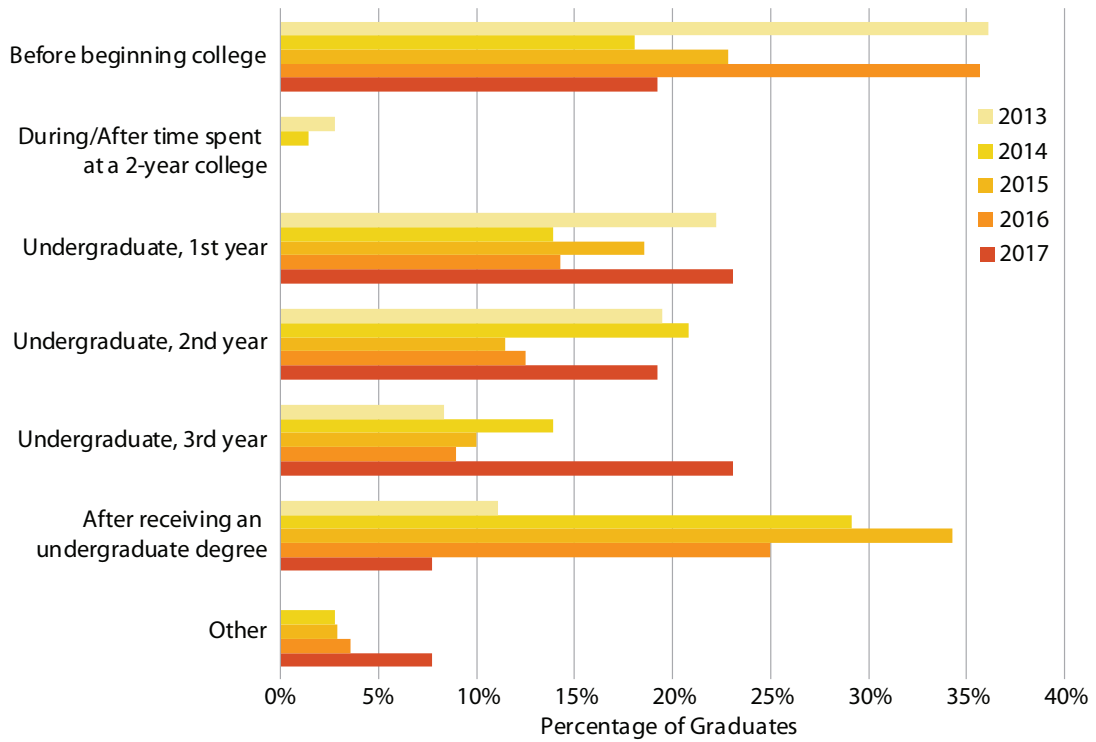
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.25:** The Point in Time When Master's Graduates Decided to Major in the Geosciences, 2013-2017



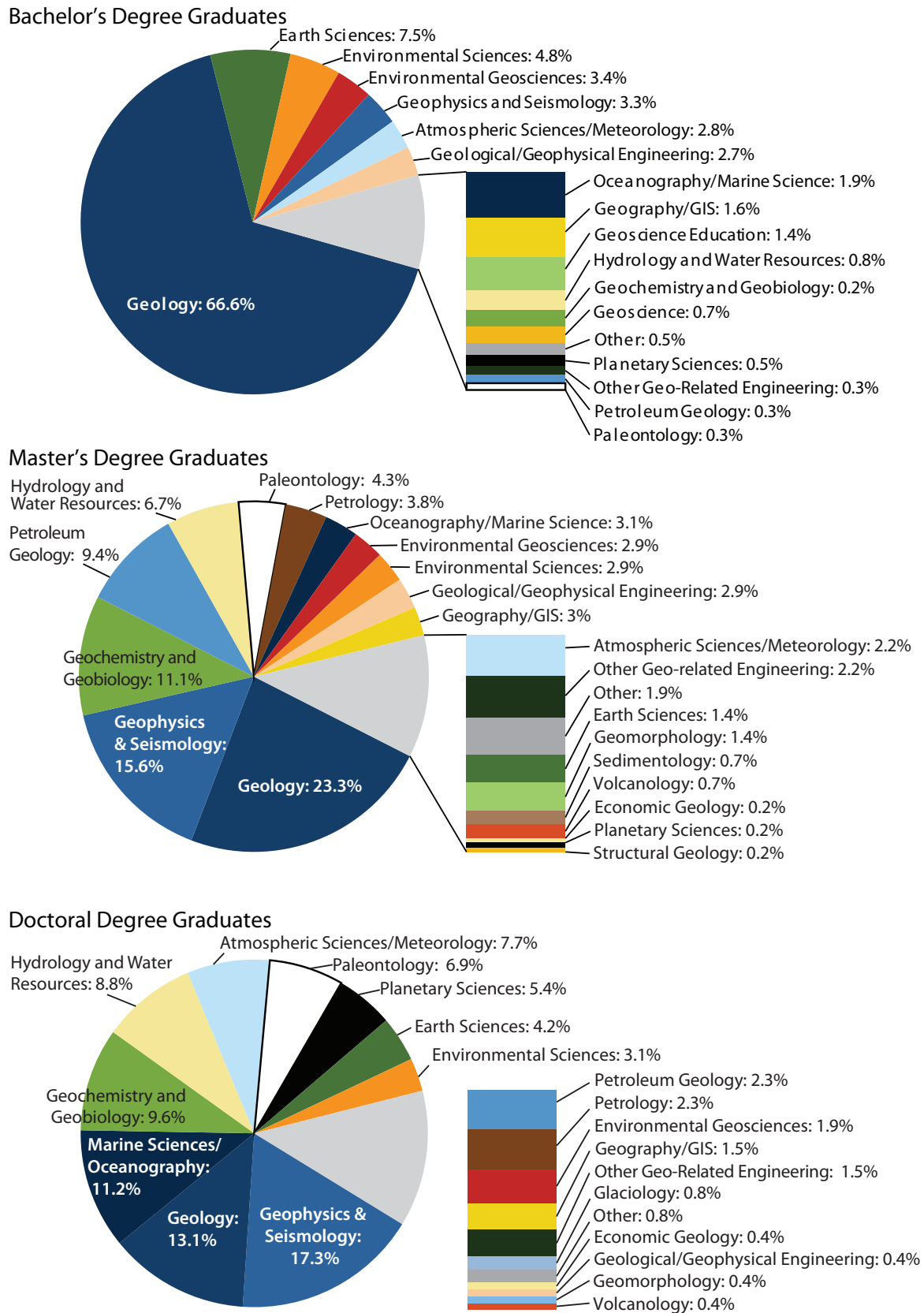
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.26:** The Point in Time When Doctoral Graduates Decided to Major in the Geosciences, 2013-2017



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

Figure 4.27: The Chosen Degree Fields of Geoscience Graduates, 2013-2017



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

## Co-Curricular Activities

Field camp attendance has been decreasing since 2014 when it peaked at 3,584 student participants. In 2017, there were 3,322 student participants (Figure 4.28). If this trend continues, then either the available field camps have reached their maximum capacity or the cost of attending field camp may be limiting participation among students. However, even though total enrollment has been decreasing, there has been an increase in the percentage of bachelor's graduates that attended field camp before graduation and a decrease in the percentage of bachelor's graduates that haven't participated yet but are planning to attend a field camp over the past five years (Figures 4.29–4.31). There has been an approximate 10 percentage point decrease in doctoral graduates that participated in field camp at some point during their postsecondary education.

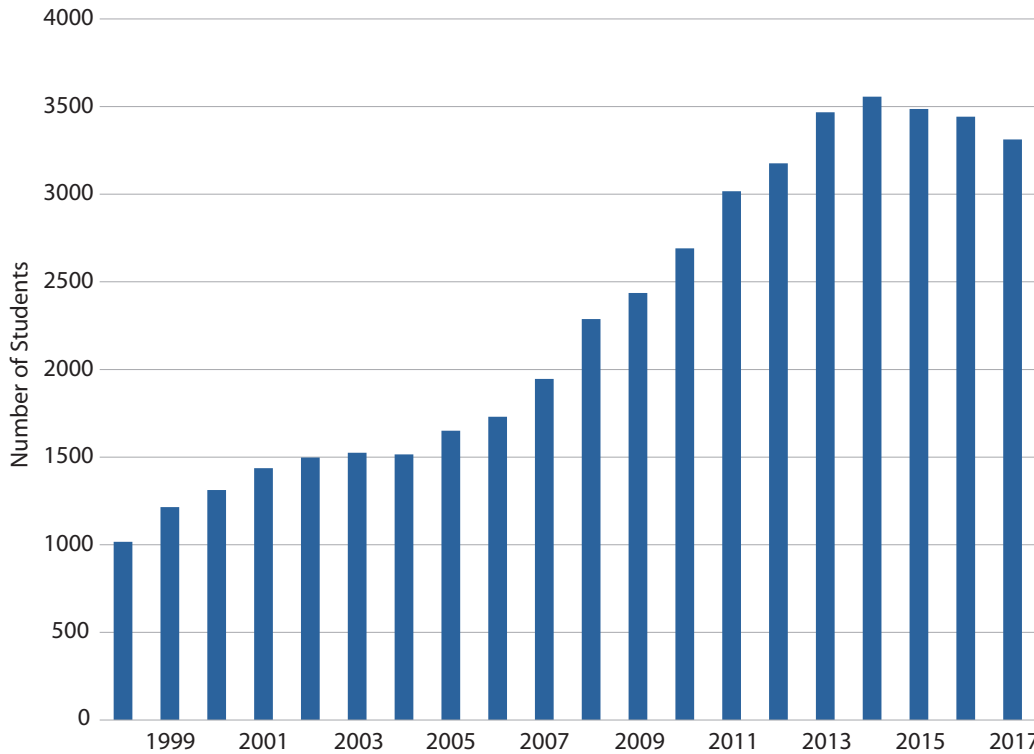
In the United States, at least 45 states have at least one university that hosts a field camp within their department (Table 4.7). Most these field camps are held in the western states of the United States, particularly Montana, Wyoming, Colorado, and New Mexico, but departments also offer field camps in seven different international locations as well (Figure 4.32). If a student did not participate in a field camp during their postsecondary education, it is highly likely that they received field experience through field courses in their curriculum and other experiences, such as field trips (Figures 4.33–4.38). Field experiences have become a hallmark of the geoscience postsecondary experience and skills developed through these experiences are expected by employers looking to hire recent graduates.

Research experiences have not been as common as field experiences among bachelor's graduates with between 20–26% of bachelor's graduates not participating in a research experience before graduation (Figures 4.39–4.41). However, employers consistently identify skills developed through research experiences as necessary for success in

the geoscience workforce. Figures 4.42–4.46 show the research methods used for individual research conducted by undergraduates and graduate students by their degree field. This series of figures demonstrate the research methods commonly used within certain degree fields, as well as indicates the skills development of these recent graduates based on the methods typically used for their field. For example, Atmospheric Science majors are more likely to conduct computer-based research, whereas Geochemistry majors are more likely to conduct lab-based research while working on their degree. These different methods can lead to the development of a different set of skills. Approximately 95% of master's graduates participate in at least one research experience, and from 2010–2015, 2,296 master's theses were written and catalogued by AGI's GeoRef Information Services (Figure 4.40 and Figure 4.49). GeoRef also catalogued 2,036 doctoral dissertations from 2010–2015 (Figure 4.50).

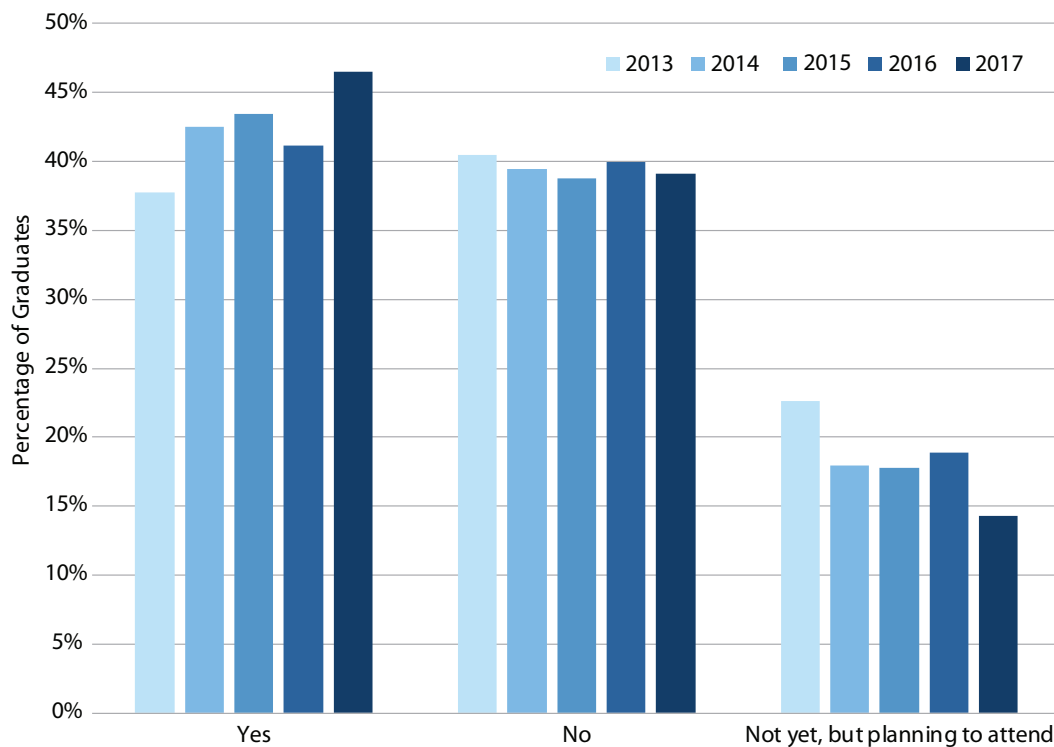
Internships are considered key experiences for anyone entering the geoscience workforce because they are recognized by many industries a good recruitment tool for future employees, as well as providing a clearer understanding of the everyday work and expectations of working geoscientists. Internships help students develop many of the needed professional skills, such as effective communication, collaboration, and networking, which may not be easily gained through their education program. However, participation in internships is surprisingly low, particularly among bachelor's and doctoral students. Over the past five years, 60% or more of bachelor's graduates did not participate in an internship, and approximately 55% of doctoral graduates did not participate in an internship (Figures 4.51 and 4.53). When graduates were asked about their internship participation, master's graduates tend to recognize the importance of these opportunities because they are more likely to submit multiple applications and use any resources available to them to find these opportunities.

**Figure 4.28: Field Camp Attendance, 1998-2017**



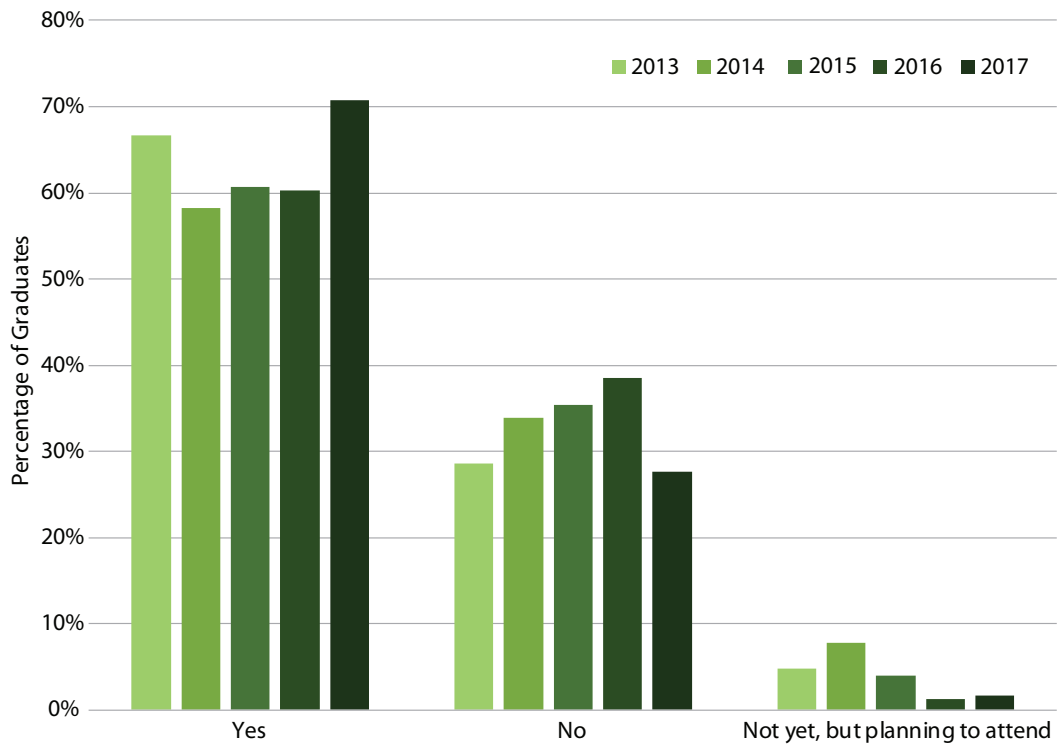
AGI Geoscience Workforce Program; Data derived from department field camp syllabi and data provided by Dr. Penelope Morton, UMN-Duluth

**Figure 4.29: Bachelor's Graduates that have Participated in a Field Camp, 2013-2017**



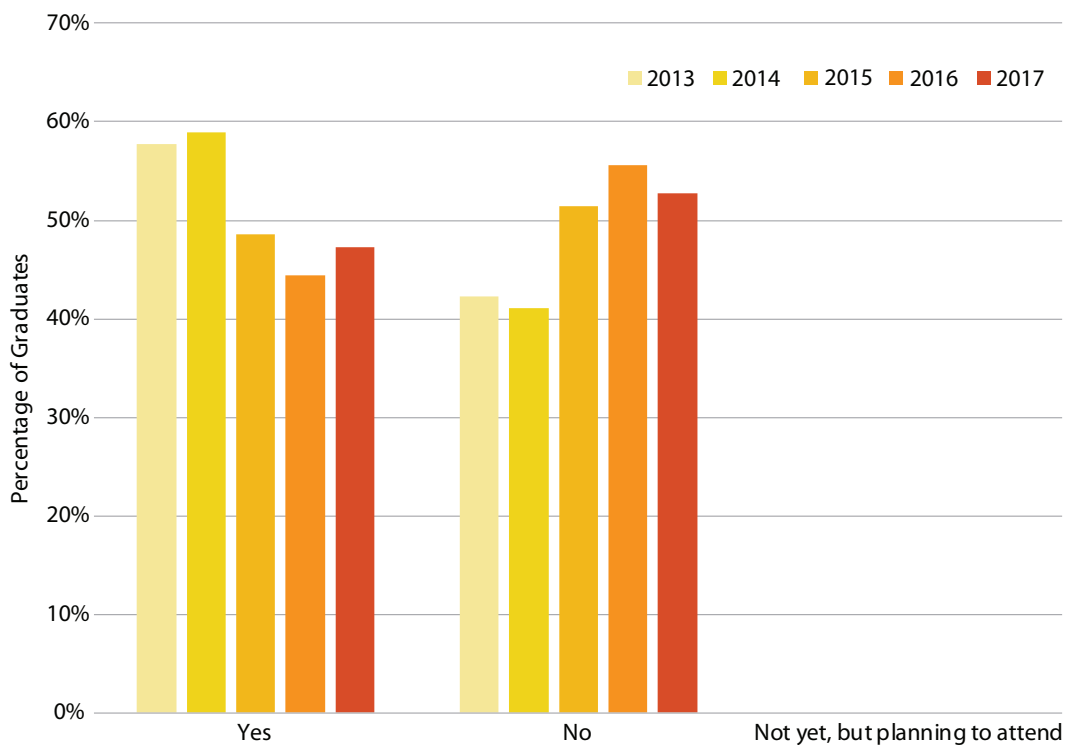
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.30: Master's Graduates that Have Participated in a Field Camp, 2013-2017**



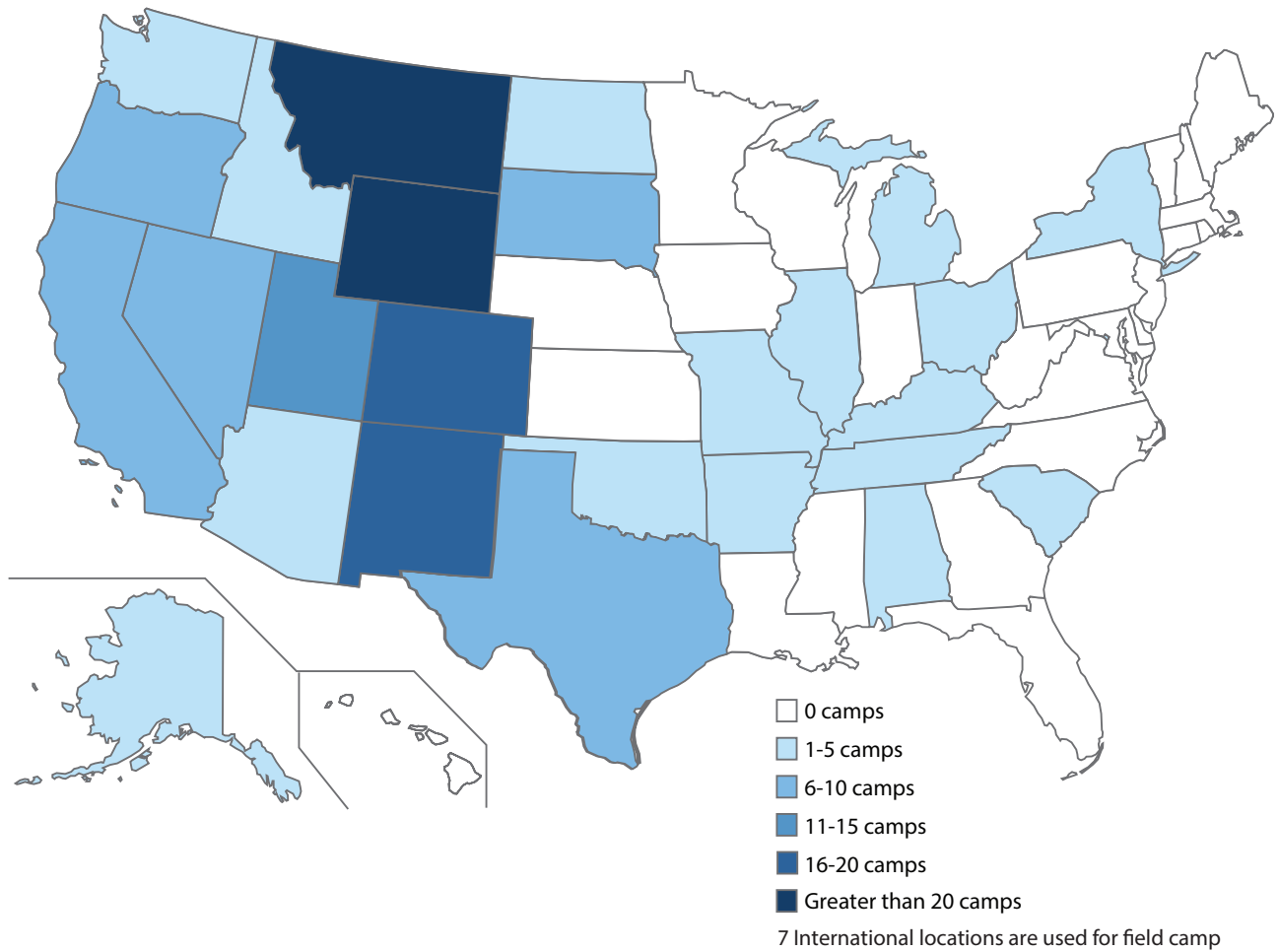
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.31: Doctoral Graduates that Have Participated in a Field Camp, 2013-2017**



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

Figure 4.32: Locations of Geoscience Field Camps by State, 2017



AGI Geoscience Workforce Program; Data derived from department field camp syllabi and data provided by Dr. Penelope Morton, UMN-Duluth

**Table 4.7: U.S. Universities Hosting Geoscience Field Camps, 2017**

University Hosting Field Camp	State	University Hosting Field Camp	State
University of Alaska-Anchorage	AK	Cornell College	IA
University of Alaska-Fairbanks	AK	Iowa State University	IA
Auburn University	AL	Boise State University	ID
University of Alabama	AL	Brigham Young University-Idaho	ID
University of South Alabama	AL	Idaho State University	ID
University of Arkansas	AR	University of Idaho	ID
Arizona State University	AZ	Illinois State University	IL
Northern Arizona University	AZ	Northern Illinois University	IL
University of Arizona	AZ	Southern Illinois University	IL
California State University-Chico	CA	University of Illinois-Urbana-Champaign	IL
California State University-Fullerton	CA	Western Illinois University	IL
California State University-Longbeach	CA	Wheaton College	IL
California State University-Los Angeles	CA	Ball State University	IN
California State University-Northridge	CA	Indiana University	IN
California State University-Sacramento	CA	Fort Hays State University	KS
California State University-Stanislaus	CA	University of Kansas	KS
Humboldt State University	CA	Wichita State University	KS
Sacramento State University	CA	University of Kentucky	KY
San Diego State University	CA	Western Kentucky University	KY
San Jose State University	CA	Louisiana State University	LA
Santa Monica College	CA	University of Louisiana at Lafayette	LA
University of California-Davis	CA	Massachusetts Institute of Technology	MA
University of California-Riverside	CA	Northeastern University	MA
University of California-Santa Barbara	CA	Salem State University	MA
University of California-Santa Cruz	CA	Albion College	MI
University of Southern California	CA	Michigan Technological University	MI
Adams State College	CO	University of Michigan	MI
Colorado Mesa University	CO	Western Michigan University	MI
Colorado School of Mines	CO	University of Minnesota-Duluth	MN
Colorado State University	CO	University of Minnesota-Twin Cities	MN
Fort Lewis College	CO	Missouri University of Science & Technology	MO
Western State College of Colorado	CO	University of Missouri -Columbia	MO
University of New Haven	CT	University of Missouri-Kansas City	MO
University of Delaware	DE	University of Mississippi	MS
Florida Atlantic University	FL	Montana State University	MT
Florida State University	FL	Montana Tech of the University of Montana	MT
University of Florida	FL	University of Montana	MT
Georgia State University	GA		
University of Georgia	GA		

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AGI Geoscience Workforce Program; Data derived from department field camp syllabi and data provided by Dr. Penelope Morton, UMN-Duluth

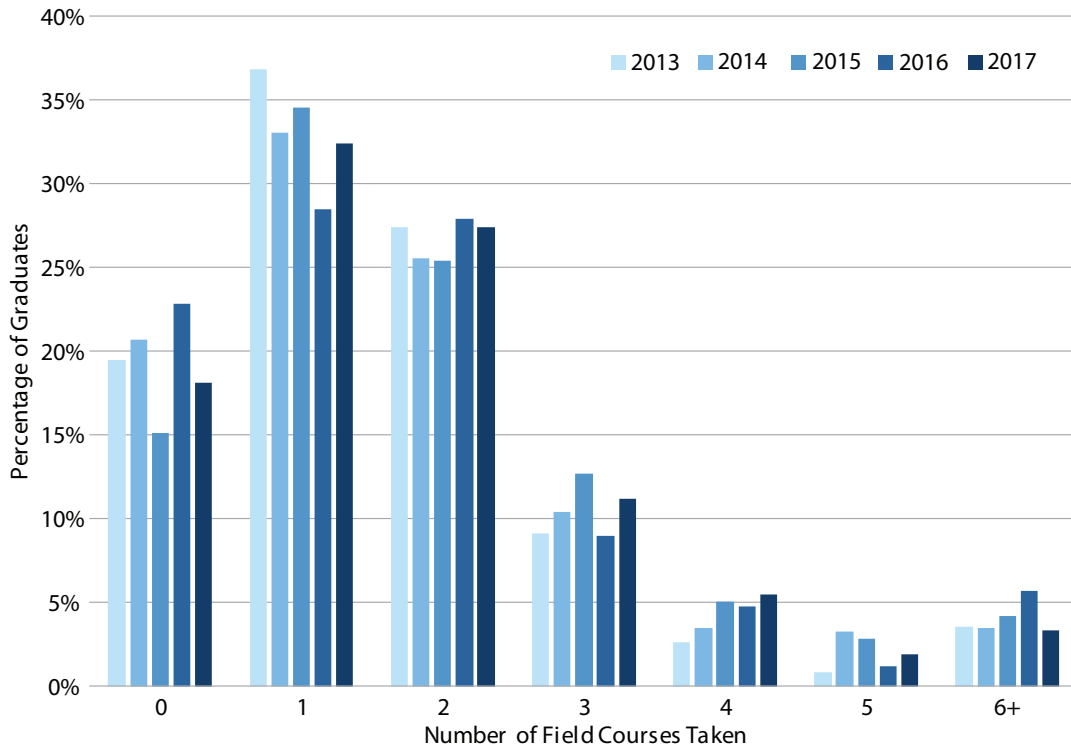
**U.S. Universities Hosting Geoscience Field Camps, 2017, continued**

University Hosting Field Camp	State
Appalachian State University	NC
East Carolina University	NC
North Carolina State University	NC
University of North Carolina-Wilmington	NC
Chadron State College	NE
University of Nebraska	NE
Dartmouth College	NH
Stockton University	NJ
New Mexico Institute of Mining and Technology	NM
New Mexico State University	NM
University of New Mexico	NM
University of Nevada-Las Vegas	NV
University of Nevada-Reno	NV
Colgate University	NY
Cornell University	NY
Hobart & William Smith Colleges	NY
State University of New York-Cortland	NY
State University of New York-Oswego	NY
University at Buffalo	NY
York College	NY
Bowling Green State University	OH
Kent State University	OH
Miami University	OH
Ohio State University	OH
Ohio University	OH
Shawnee State University	OH
University of Akron	OH
University of Dayton	OH
Wright State University	OH
Oklahoma State University	OK
University of Oklahoma	OK
Oregon State University	OR
University of Oregon	OR
Juniata College	PA
Lehigh University	PA
Penn State University	PA
Clemson University	SC
University of South Carolina	SC

University Hosting Field Camp	State
South Dakota School of Mines and Technology	SD
University of Memphis	TN
Angelo State University	TX
Baylor University	TX
Stephen F. Austin State University	TX
Sul Ross State University	TX
Texas A&M University	TX
Texas A&M University-Kingsville	TX
Texas Tech University	TX
University of Houston	TX
University of Texas-Arlington	TX
University of Texas-Austin	TX
University of Texas-Dallas	TX
University of Texas-El Paso	TX
Brigham Young University	UT
Southern Utah University	UT
University of Utah	UT
Utah State University	UT
Weber State University	UT
George Mason University	VA
James Madison University	VA
University of Mary Washington	VA
School of International Training	VT
Central Washington University	WA
Eastern Washington University	WA
University of Washington	WA
Washington State University	WA
Western Washington University	WA
Beloit College	WI
Northland College	WI
University of Wisconsin-Eau Claire	WI
University of Wisconsin-Madison	WI
University of Wisconsin-Oshkosh	WI
Concord University	WV
University of West Virginia	WV
University of Wyoming	WY

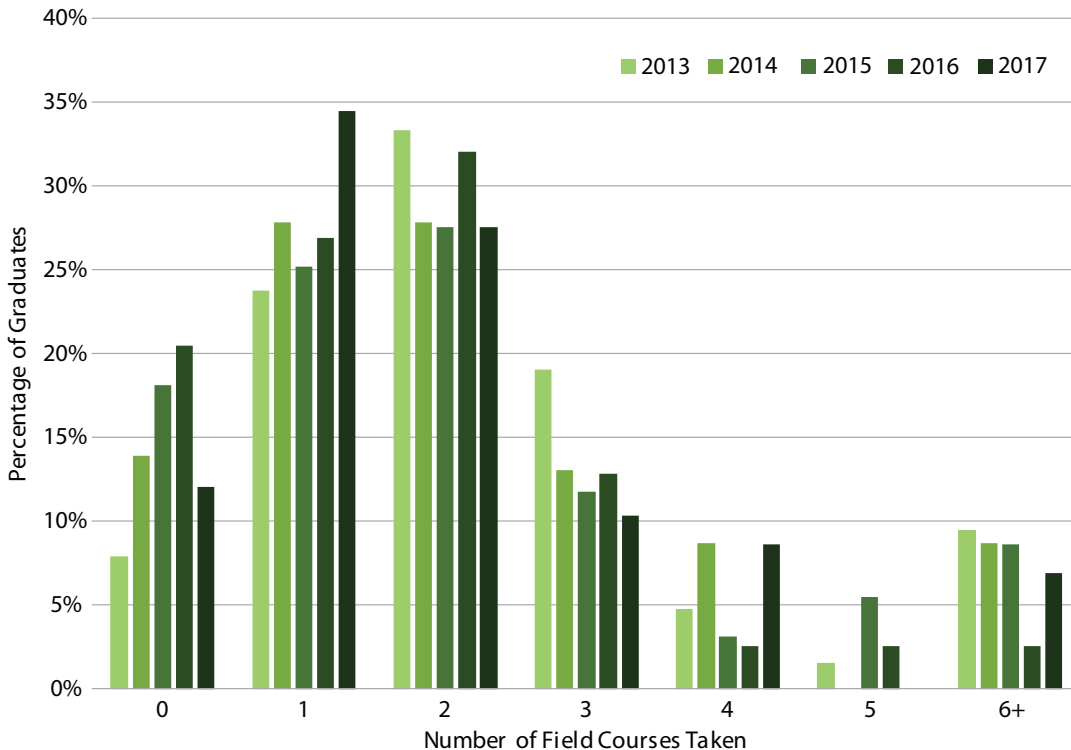
AGI Geoscience Workforce Program; Data derived from department field camp syllabi and data provided by Dr. Penelope Morton, UMN-Duluth

**Figure 4.33: Bachelor's Graduates that Have Taken One or More Field Courses, 2013-2017**



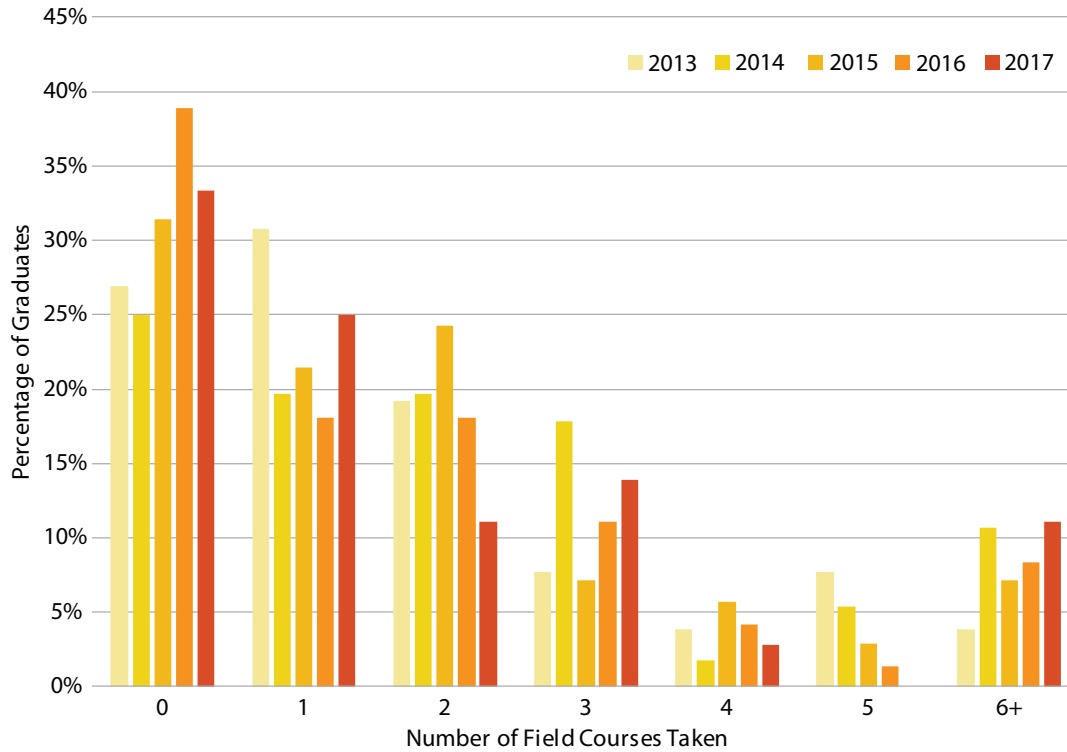
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.34: Master's Graduates that Have Taken One or More Field Courses, 2013-2017**



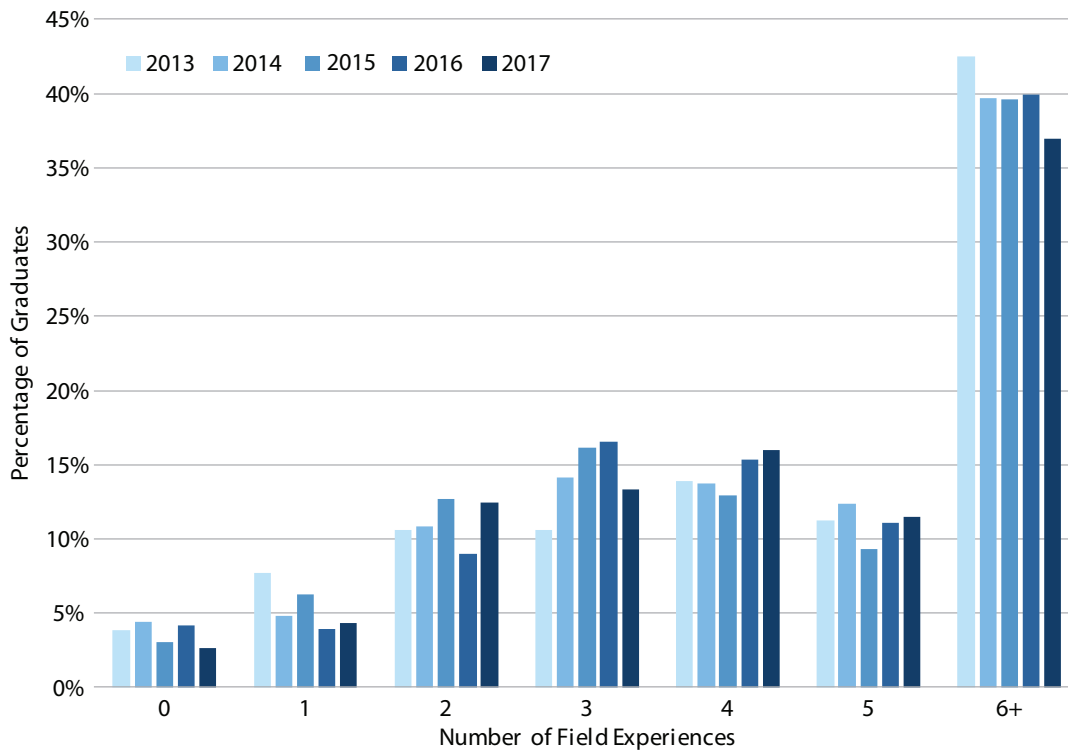
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.35: Doctoral Graduates that Have Taken One or More Field Courses, 2013-2017**



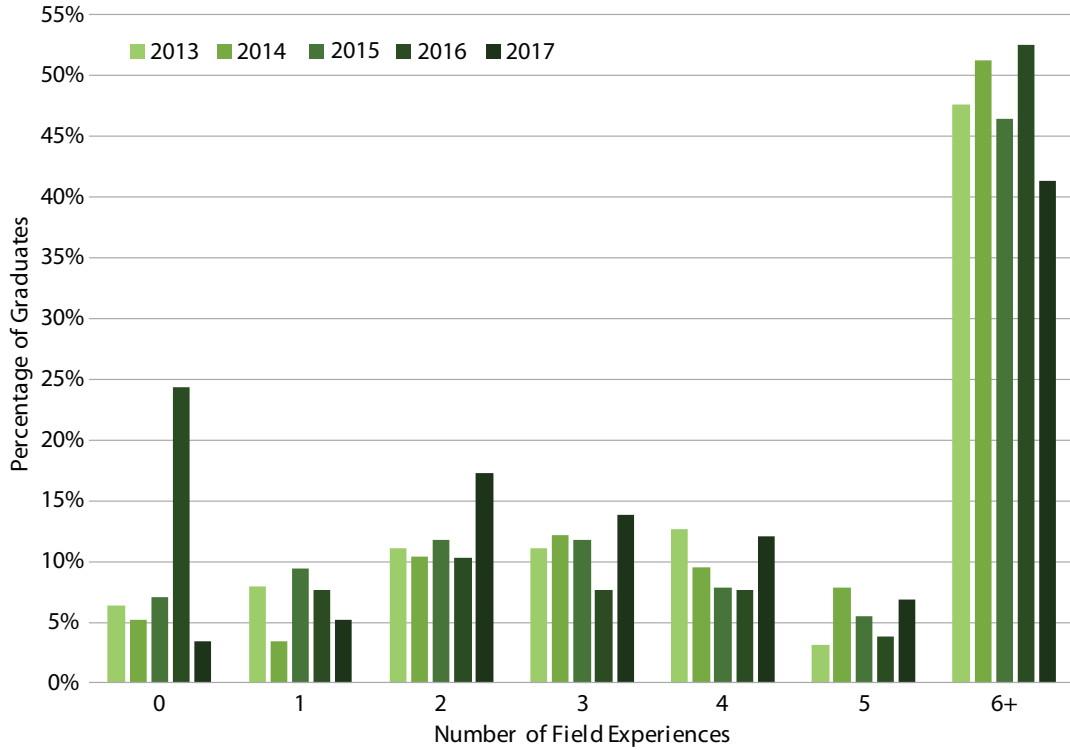
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.36: Bachelor's Graduates with One or More Field Experiences, 2013-2017**



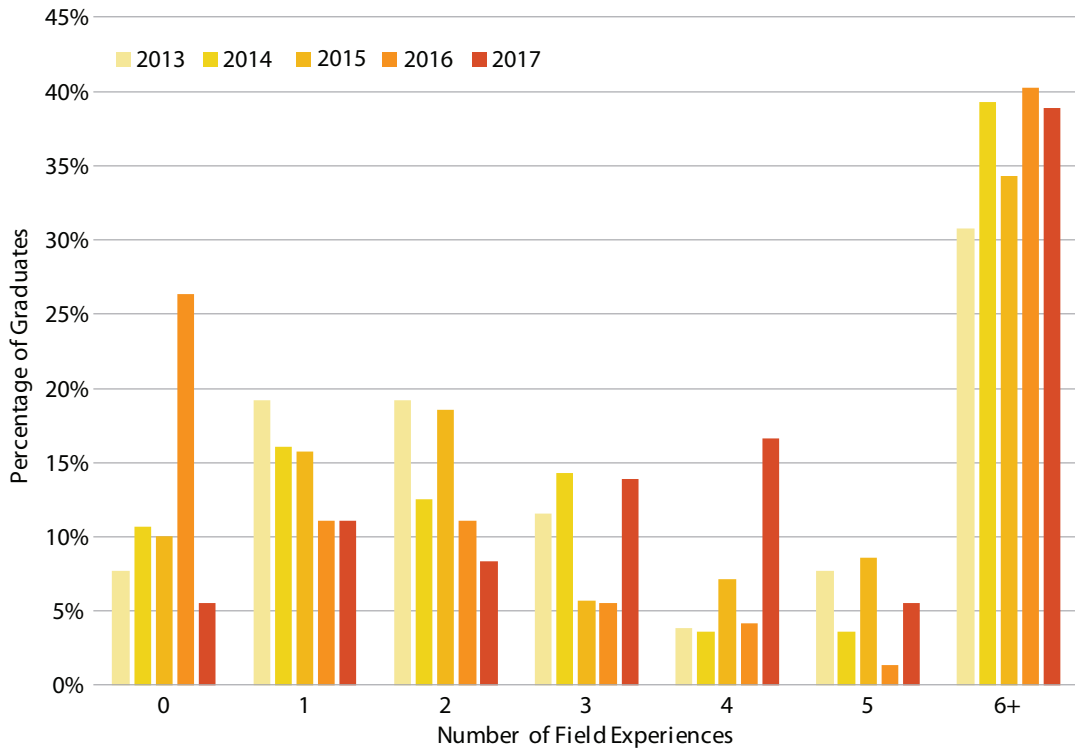
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.37: Master's Graduates with One or More Field Experiences, 2013-2017**



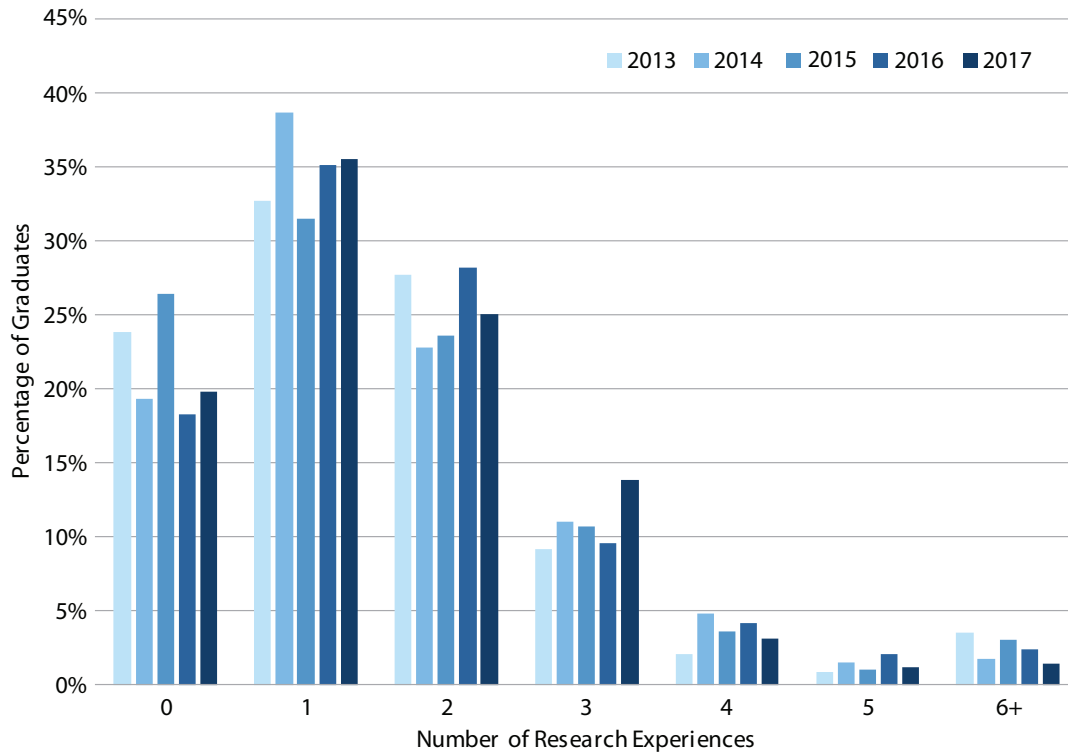
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.38: Doctoral Graduates with One or More Field Experiences, 2013-2017**



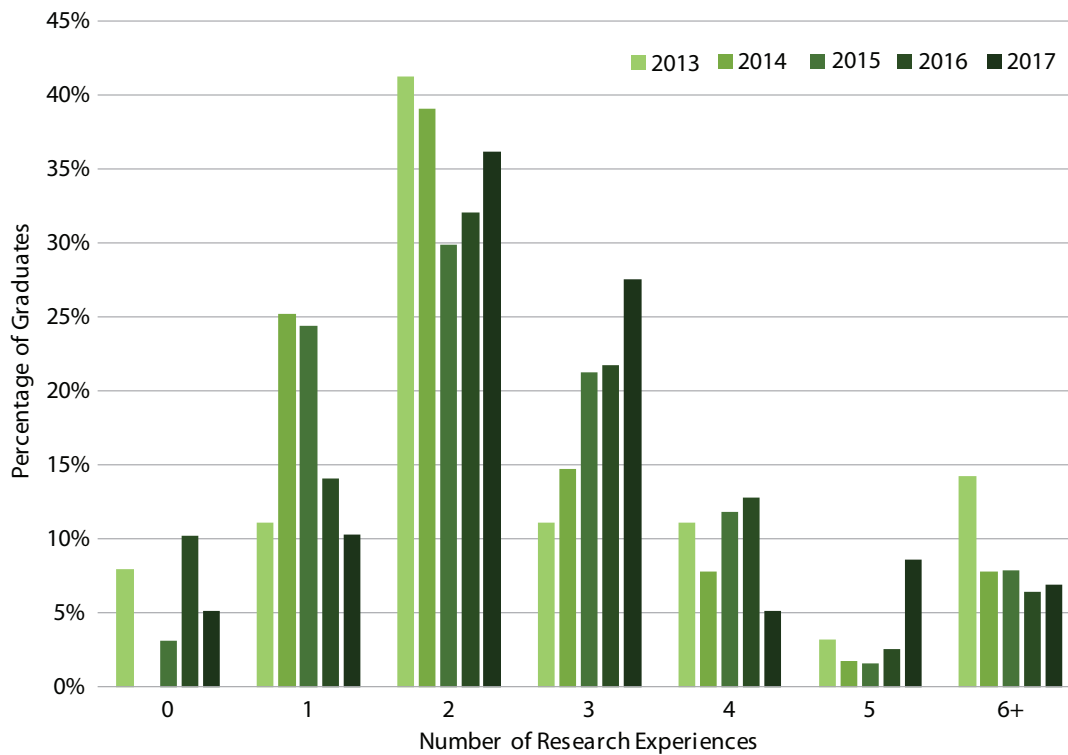
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.39: Bachelor's Graduates with One or More Research Experiences, 2013-2017**



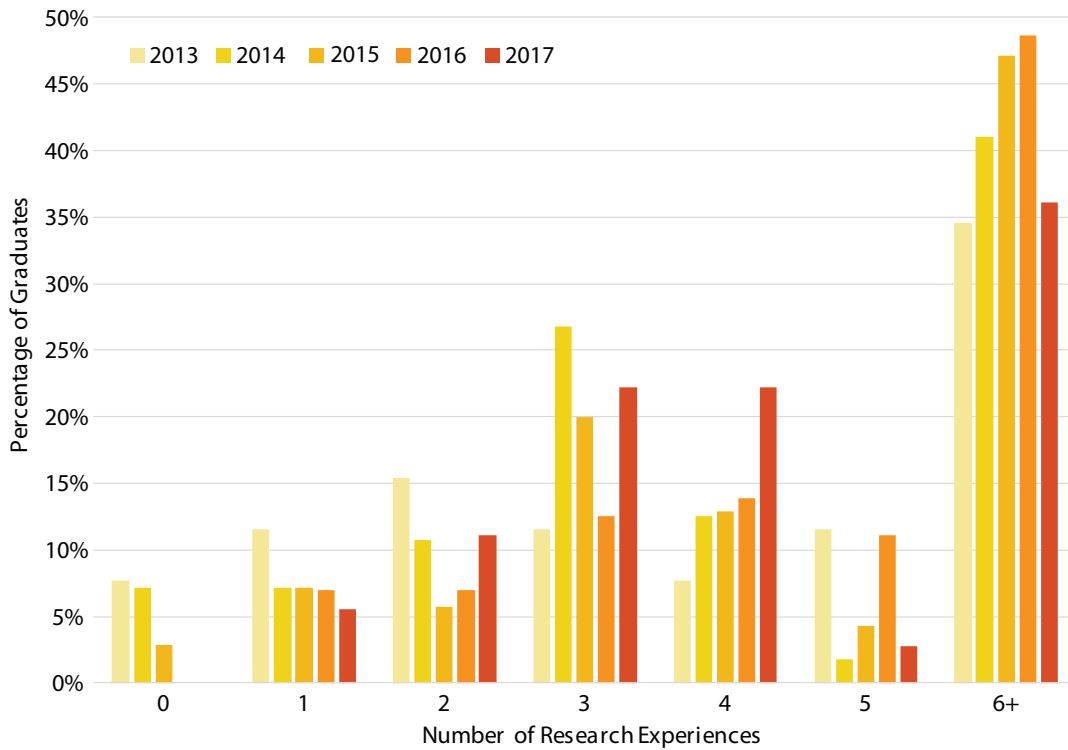
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.40: Master's Graduates with One or More Research Experiences, 2013-2017**



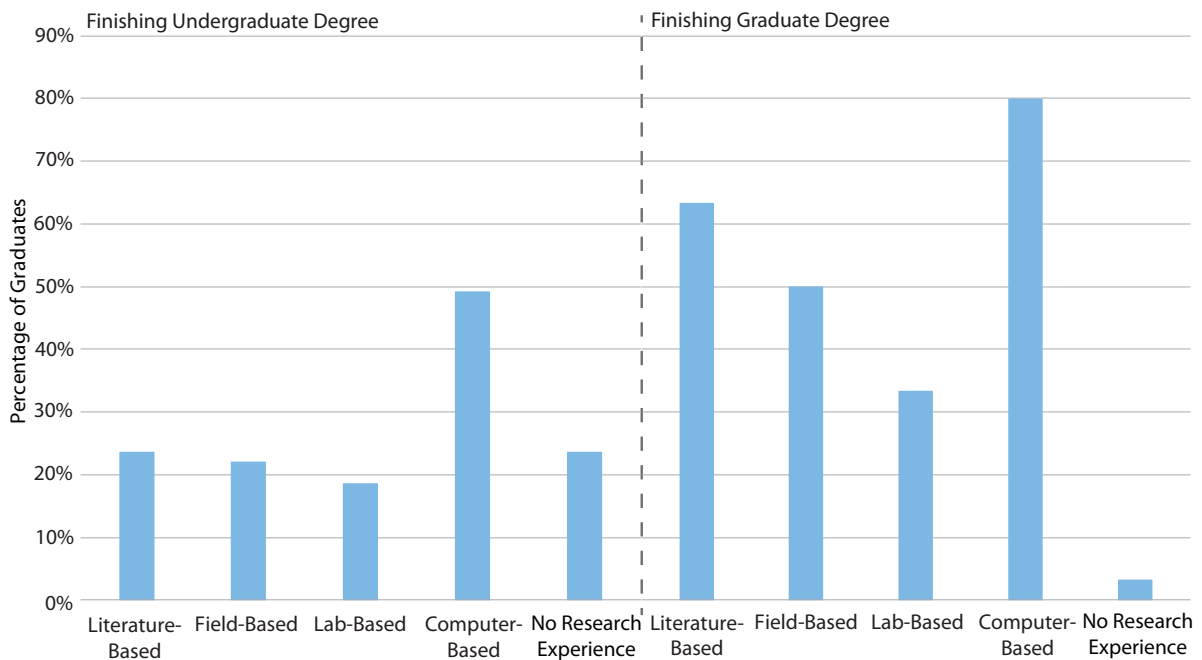
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.41: Doctoral Graduates with One or More Research Experiences, 2013-2017**



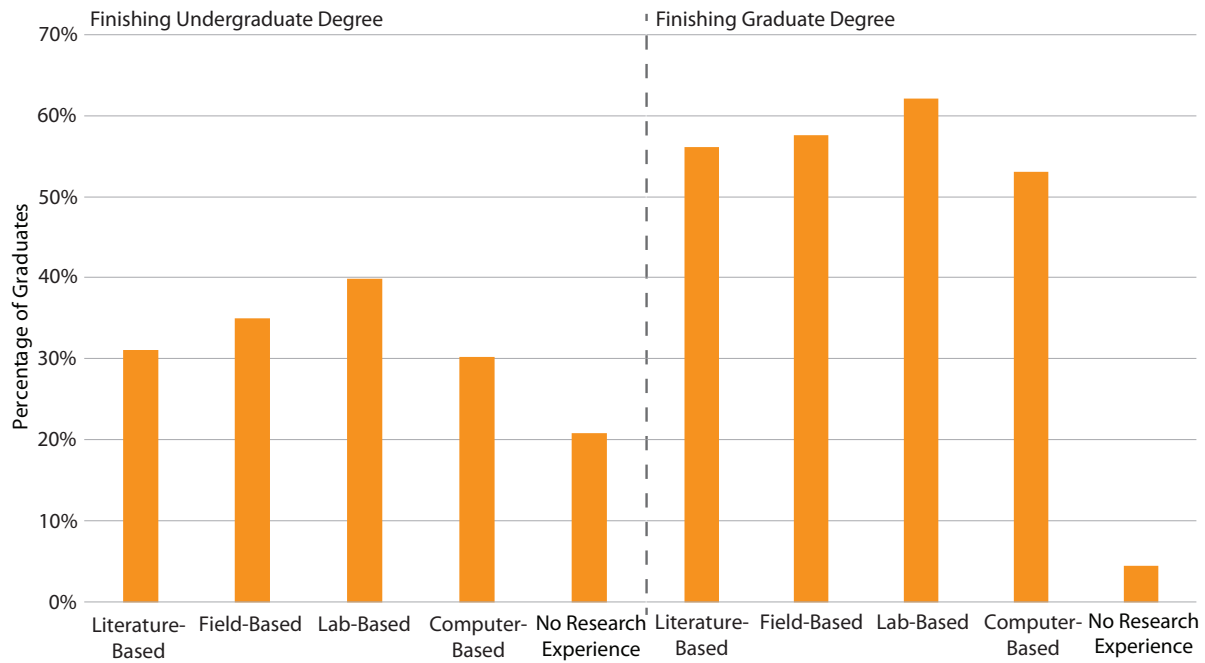
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.42: Research Methods Utilized by Atmospheric Science Majors for Their Individual Research Projects, 2013-2017**



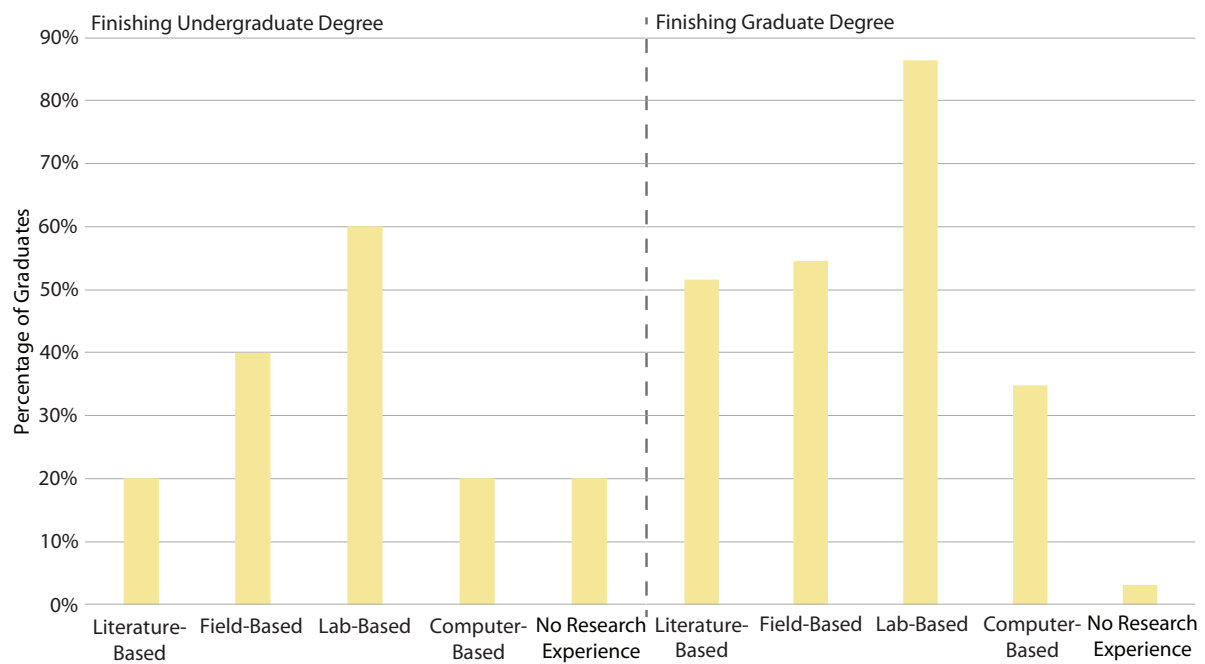
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.43:** Research Methods Utilized by Environmental Science Majors for Their Individual Research Projects, 2013-2017



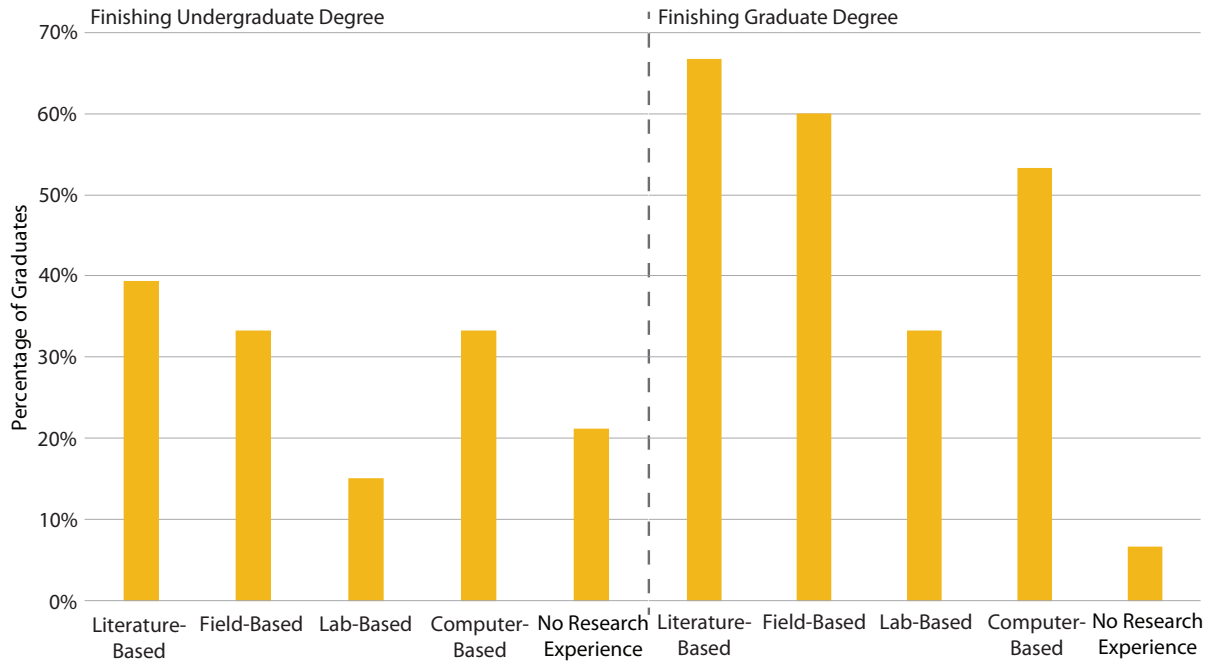
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.44:** Research Methods Utilized by Geochemistry Majors for Their Individual Research Projects, 2013-2017



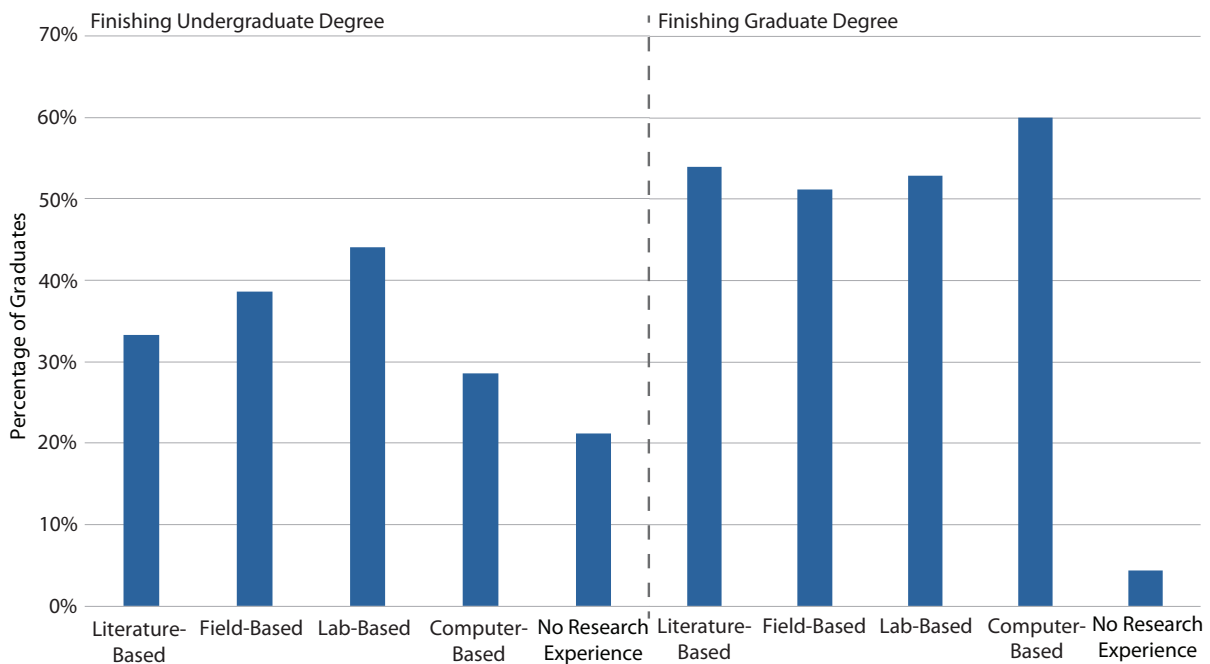
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.45:** Research Methods Utilized by Geography Majors for Their Individual Research Projects, 2013-2017



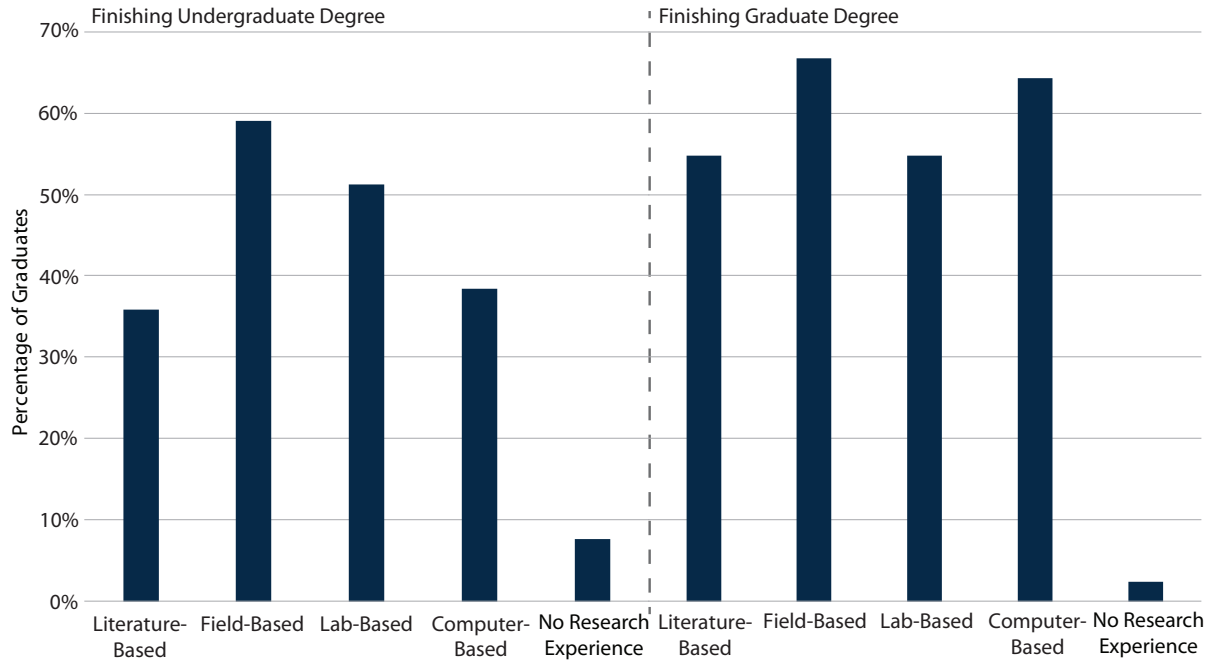
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.46:** Research Methods Utilized by Geology Majors for Their Individual Research Projects, 2013-2017



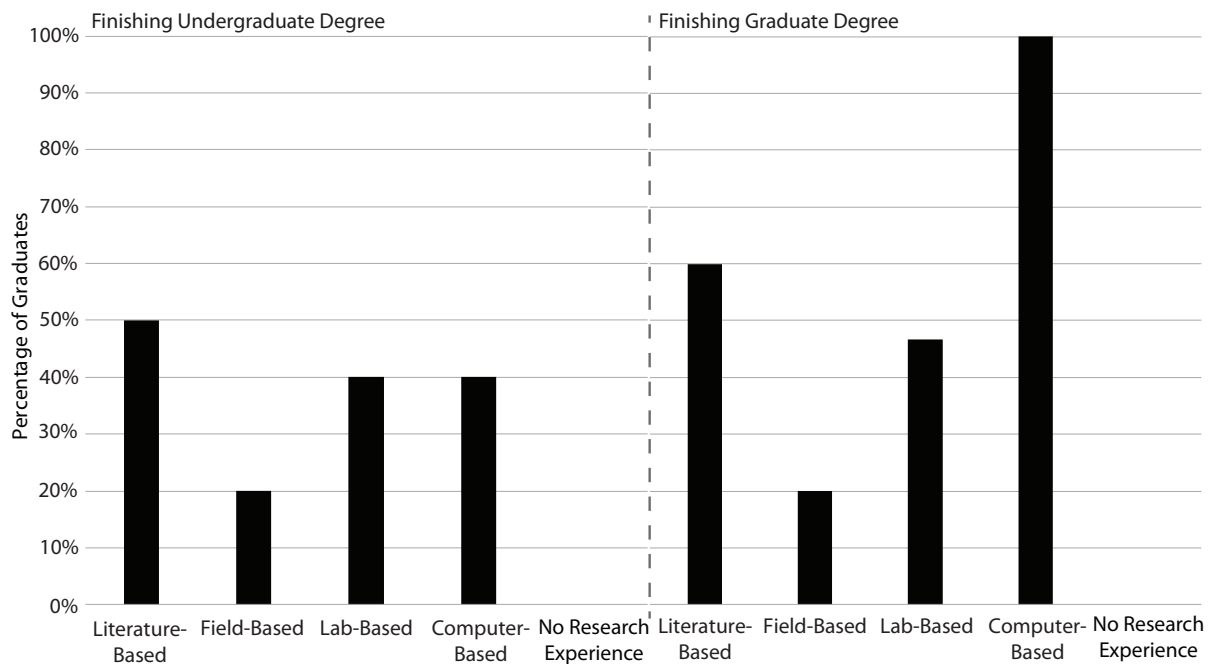
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.47:** Research Methods Utilized by Oceanography Majors for Their Individual Research Projects, 2013-2017



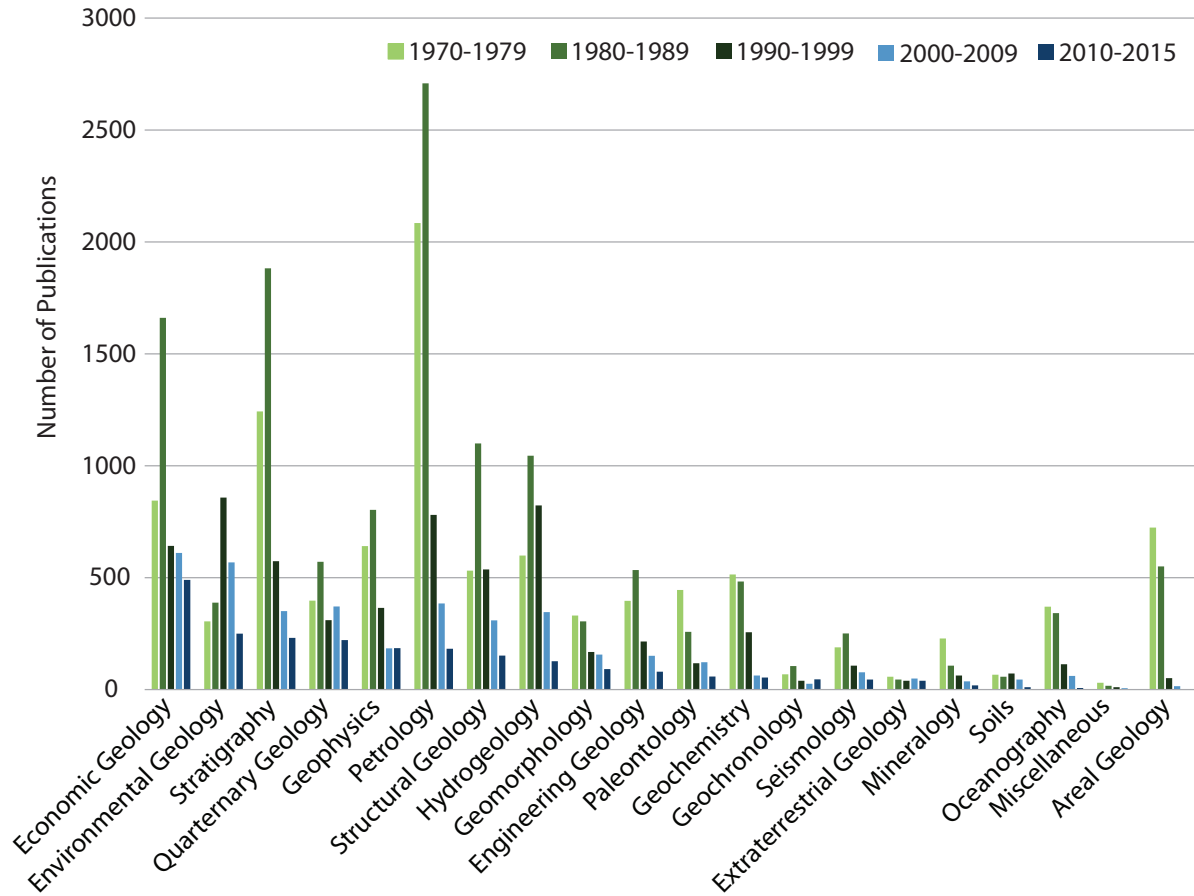
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.48:** Research Methods Utilized by Planetary Science Majors for Their Individual Research Projects, 2013-2017



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.49:** Trends in Geoscience Master's Thesis Topics



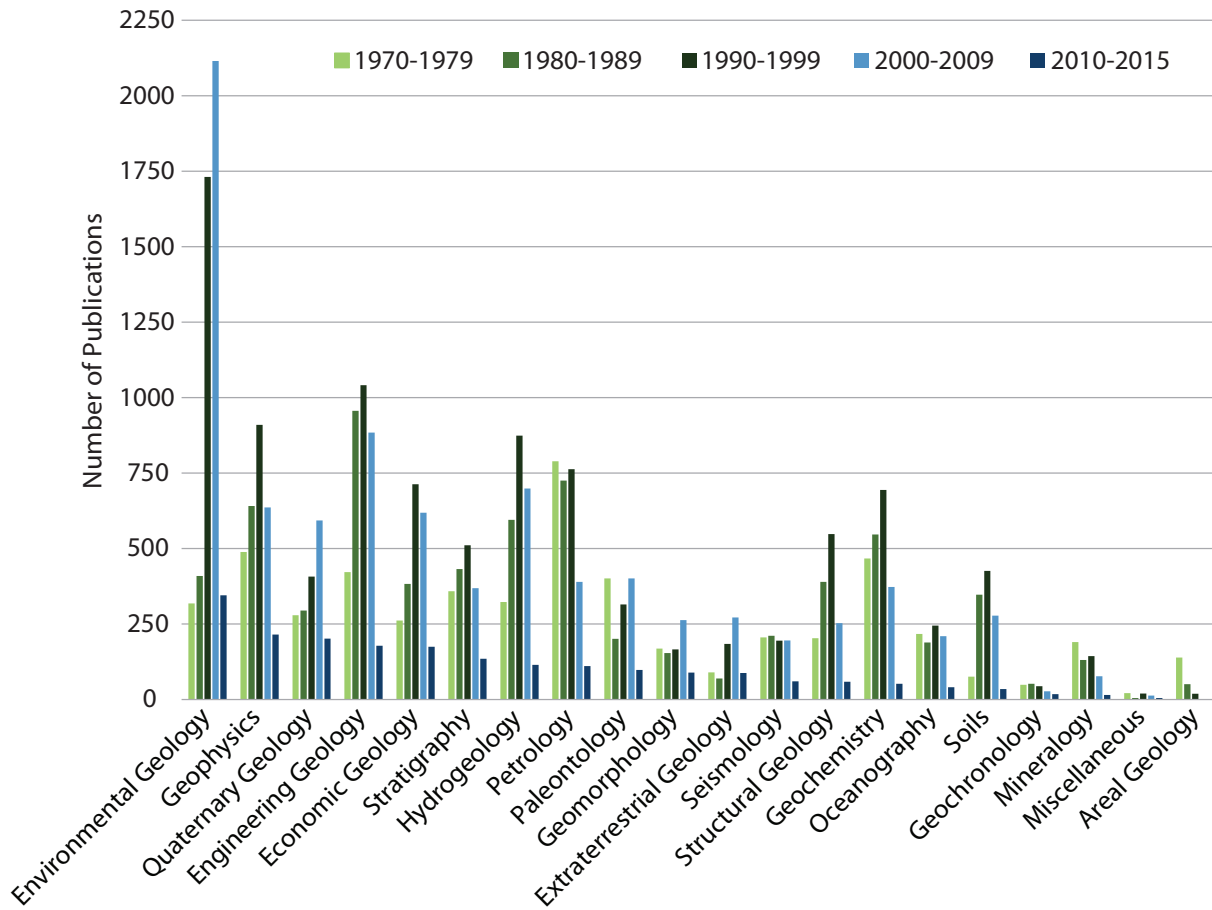
AGI Geoscience Workforce Program, Data derived from AGI's Georef database

**Table 4.8:** Top Five Geoscience Master's Theses Topics

1970-1979	1980-1989	1990-1999	2000-2009	2010-2015
Petrology	Petrology	Environmental Geology	Economic Geology	Economic Geology
Stratigraphy	Stratigraphy	Hydrogeology	Environmental Geology	Environmental Geology
Economic Geology	Economic Geology	Petrology	Petrology	Stratigraphy
Areal Geology	Structural Geology	Economic Geology	Quaternary Geology	Quaternary Geology
Geophysics	Hydrogeology	Stratigraphy	Stratigraphy	Geophysics

AGI Geoscience Workforce Program; Data derived from AGI's GeoRef database

**Figure 4.50: Trends in Geoscience Doctoral Dissertation Topics**



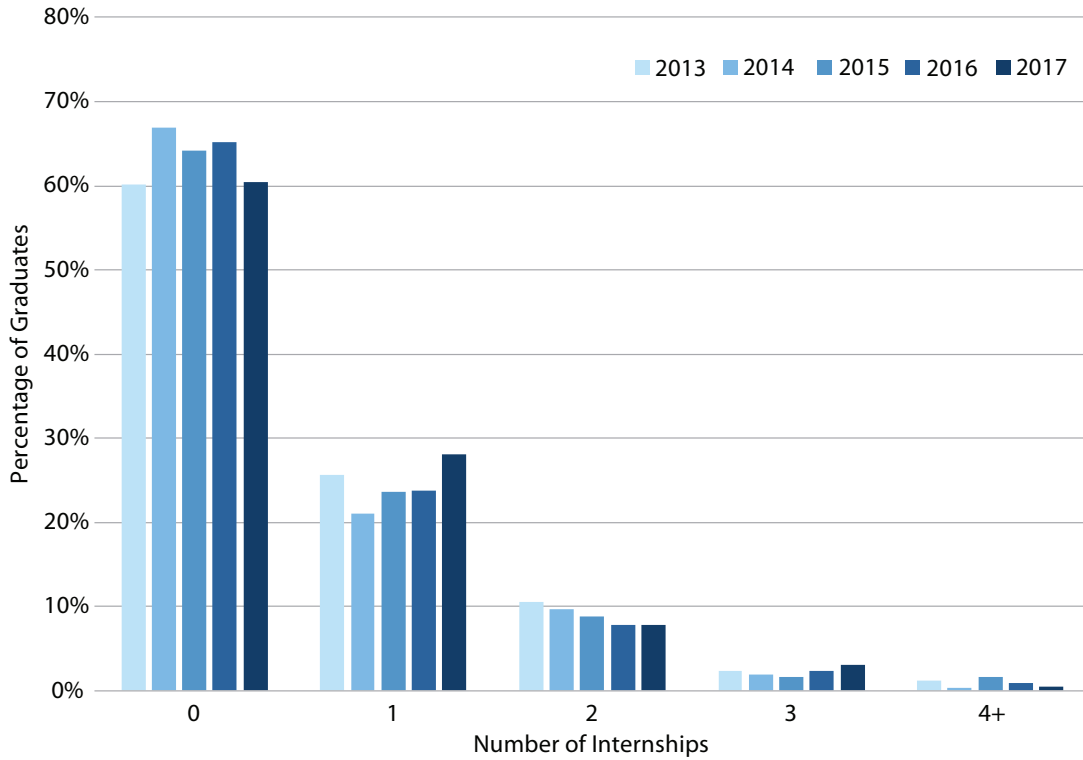
AGI Geoscience Workforce Program; Data derived from AGI's Georef database

**Table 4.9: Top Five Geoscience Doctoral Dissertation Topics**

1970-1979	1980-1989	1990-1999	2000-2009	2010-2015
Petrology	Engineering Geology	Environmental Geology	Environmental Geology	Environmental Geology
Geophysics	Petrology	Engineering Geology	Engineering Geology	Geophysics
Geochemistry	Geophysics	Geophysics	Hydrogeology	Quaternary Geology
Engineering Geology	Hydrogeology	Hydrogeology	Geophysics	Engineering Geology
Paleontology	Geochemistry	Petrology	Economic Geology	Economic Geology

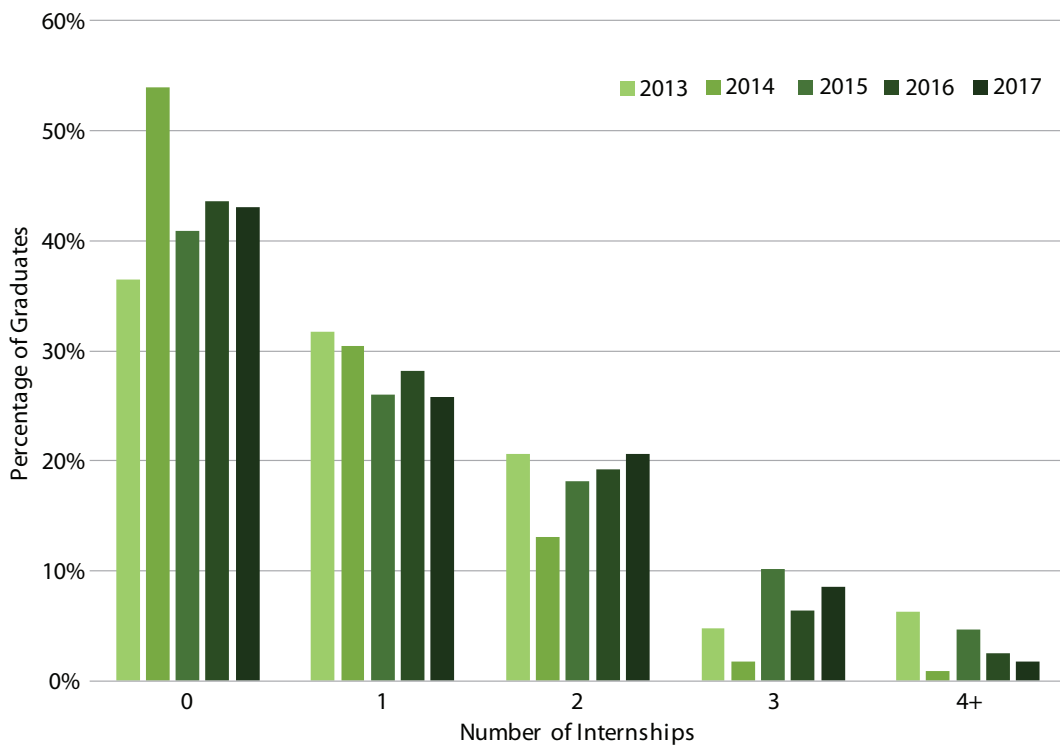
AGI Geoscience Workforce Program; Data derived from AGI's GeoRef database

**Figure 4.51: Number of Internships Held by Bachelor's Graduates, 2013-2017**



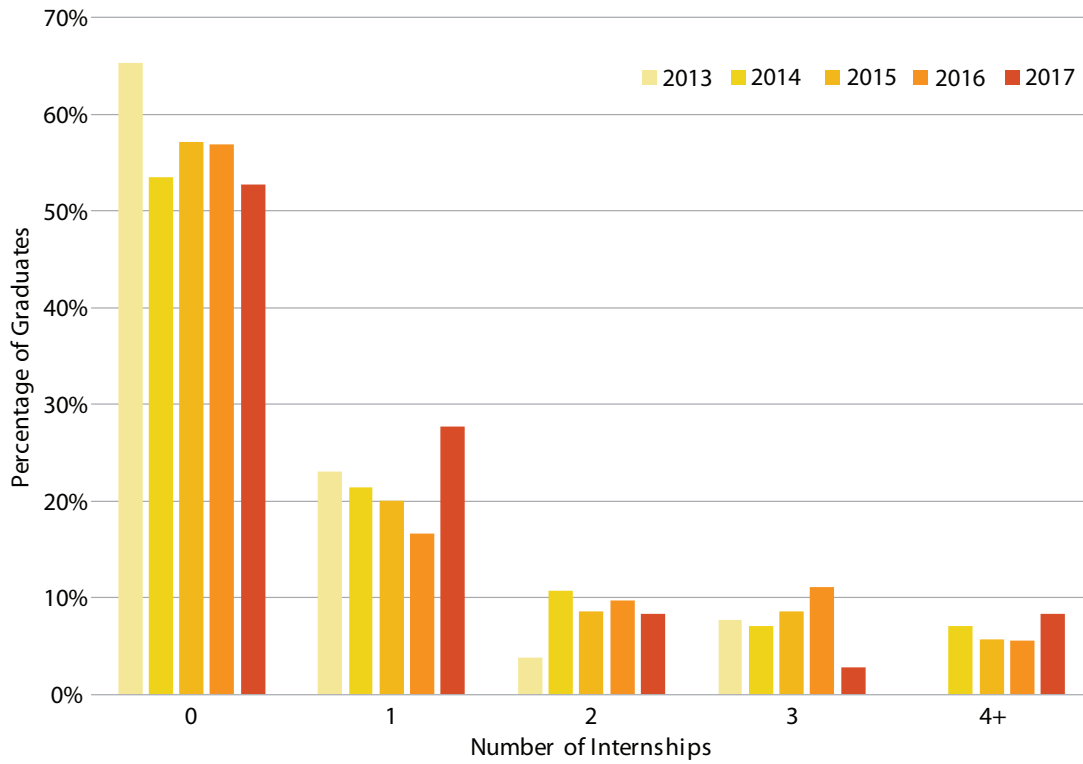
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.52: Number of Internships Held by Master's Graduates, 2013-2017**



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.53: Number of Internships Held by Doctoral Graduates, 2013-2017**



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

## Skills Development

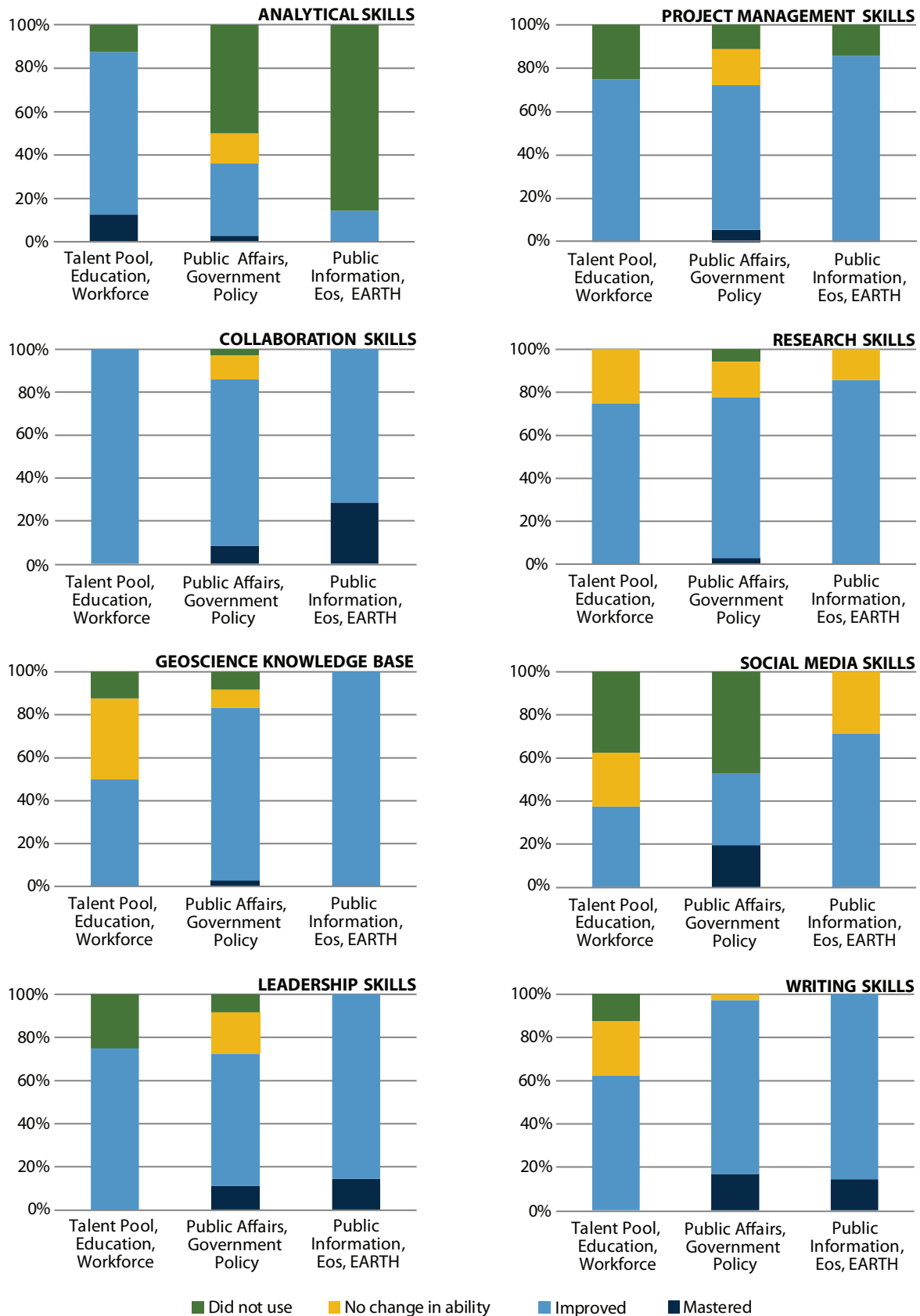
Over the past five years, conversations among industry, academic, government and society representatives have focused on the need for an increased focus on the development of appropriate technical and non-technical skills desired by employers. These conversations have led to new investigations by AGI's Workforce Program identifying these skills, their importance, and how they can be obtained. Former interns that worked at AGI and the American Geophysical Union were asked to rate their use and ability of skills identified by intern managers at AGI and AGU as important for their offered internships. Figure 4.54 shows how for each identified skill, the former interns' change in ability in each skill separated out by the type of program. While some skills, such as analytical skills, and social media skills, are variable in their use depending on the type of program sponsoring the internship, most former interns recognized an increase in their abilities while working in this position. These data stress the impact of internships on the professional development of students and recent graduates.

Another study, in collaboration with the American Association of Geographers and funded by the National Science Foundation, investigated the student preparation of identified technical and non-technical skills compared to the importance of these skills by a professional for terminal master's students in geology and geography

programs in the United States (Figure 4.55). The relative sizes of the circles can only be compared within the same category of either technical skills or non-technical skills. Skills selected for this graphic displayed statistically significant disparity between student preparation and rated importance, as indicated by the Geoscience Career Master's Survey data analysis. The blue circles indicate that professionals found these skills to be more important than the overall preparation of students when graduating from their master's program. The preparation of students was determined by aggregating data of student and faculty responses. To read more about this study, please do review the Geoscience Career Master's Preparation Survey Report written by Heather Houlton. This report is located on the AGI Workforce Program website (<https://www.americangeosciences.org/workforce/reports>).

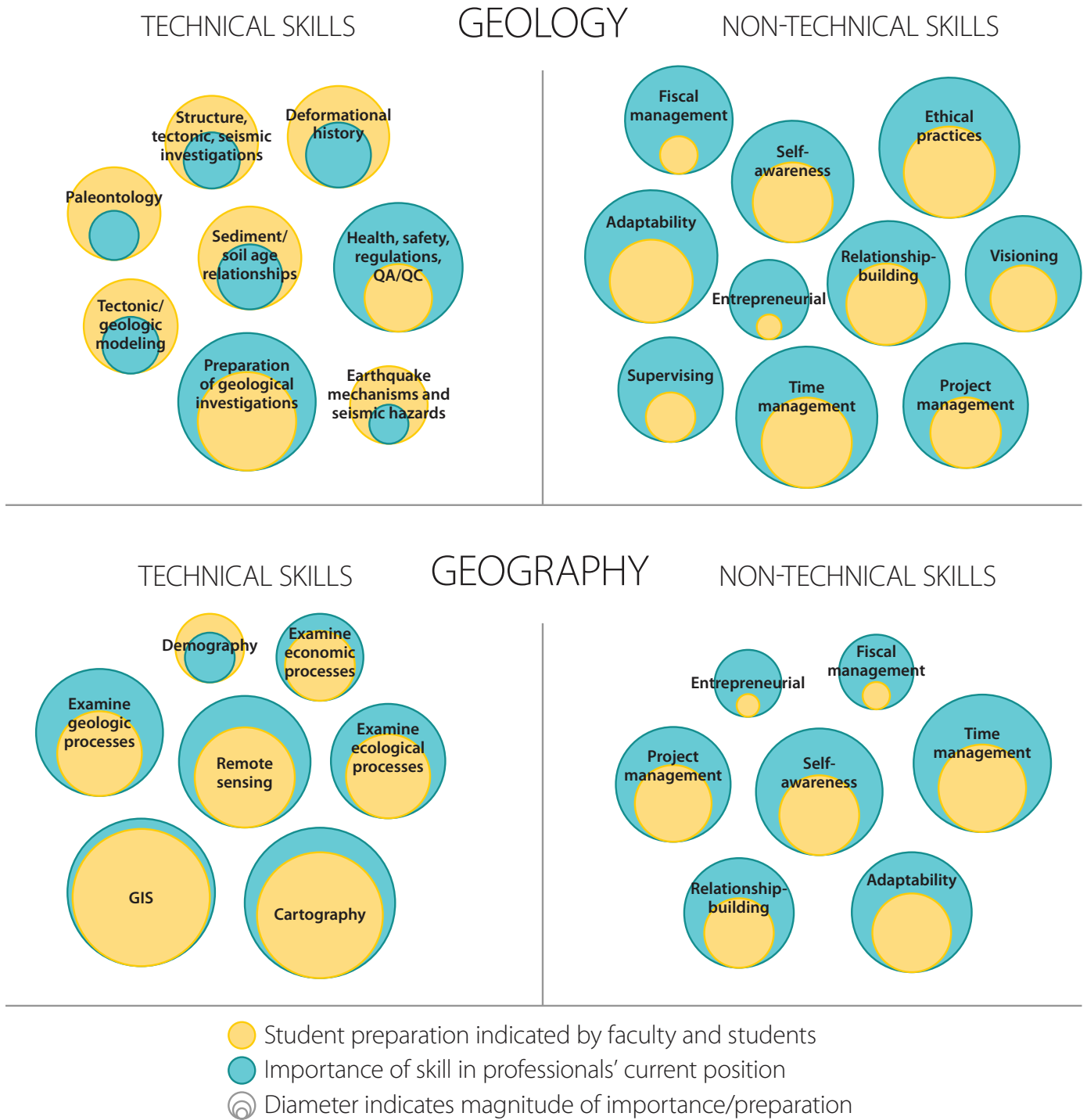
A third investigation into skills development came as part of a follow up survey with recent graduates that took AGI's Geoscience Student Exit Survey between 2013 and 2016. As a part of the survey, the participants were asked to list skills and knowledge they have gained since entering the workforce and any skills they wished had been covered before graduating with their terminal degree. Table 4.11 lists the responses received from those two open answer questions on the survey. Interestingly, these listed skills align well with skills employers have indicated as necessary to be successful in the geoscience workforce.

Figure 4.54: Skills Development Through Internships with AGU and AGI



AGI Geoscience Workforce Program; Data derived from a survey of former AGU and AGI interns

**Figure 4.55: Disparity Between Skill Appraisal and Student Preparation for Geology and Geography Terminal Master’s Students**



AGI Geoscience Workforce Program; Data provided as a collaboration between Heather Houlton, AGI, Jaimi Ricci, AGI, and Candice Leubbering, AAG and image designed by Kat Cantner, AGI

**Table 4.10: Skills and Knowledge Assessment by Early-Career Geoscientists**

Skills, Knowledge, and Certifications Gained After Entering the Workforce	
3D Modeling	Leadership
Business Management	Modelling
Classroom Management	Nuclear Gauge Testing Certification
Communication	OSHA Construction Certification
Computer Programming/Coding/Scripting	OSHA HASWOPER Certification
Curriculum Development	Professional Geologist License
Data Analysis Skills/Software	Program Management
Database Management	Science Communication
Economics	Seismic Interpretation
Environmental Science	Statistics
First Aid/AED/CPR	Teaching Skills/Certification
Geologist in Training Certification	Various Field Specific Software
Geotechnical Analysis	Various Field Specific Skills
GIS	Well Log Interpretation
Graphic Design	Wetland Delineation Training
Laboratory Skills/Equipment Training/Safety Training	Writing

Skills and Knowledge Graduates Wished They Knew Before Entering the Workforce	
Applied Geoscience Knowledge	Networking Skills
Broader Geoscience Knowledge	Program Management
Business Skills	Research Skills
Career Experiences/Internships	Science Communication
Computer Programming/Coding/Scripting	Statistics
Database Management	Teaching Experience
Environmental Policies/Regulations	Web Development
Field Skills	Writing
GIS	

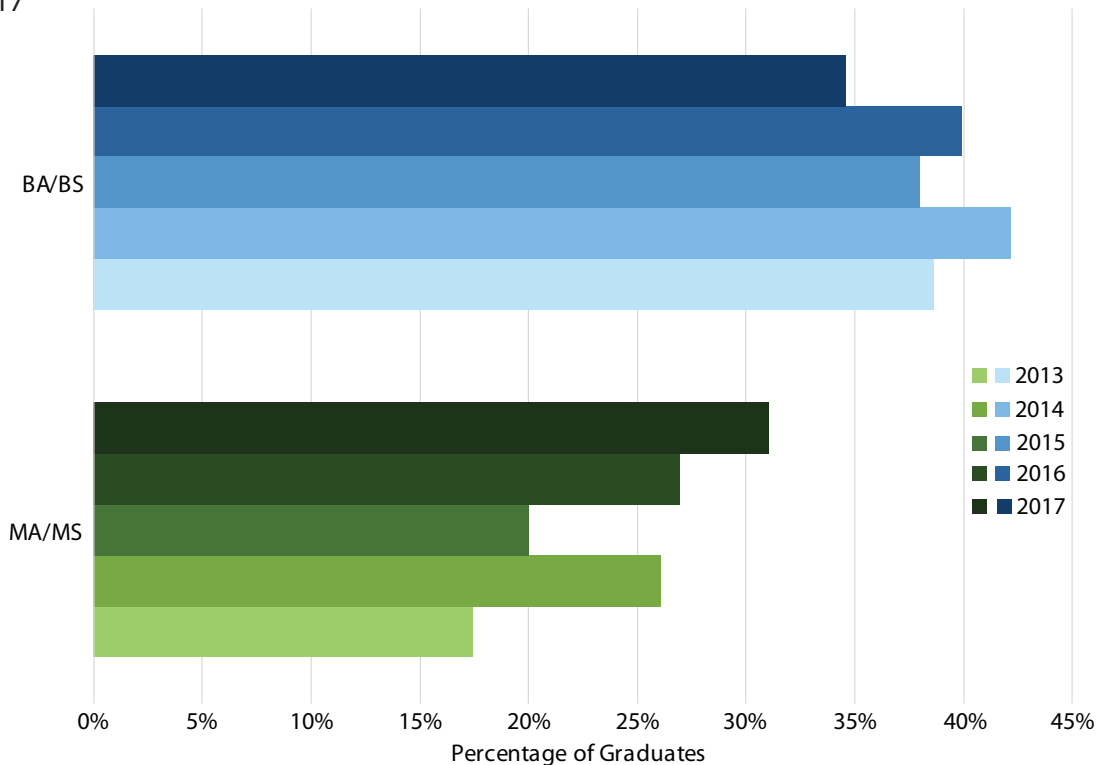
AGI Geoscience Workforce Program; Data derived from follow-up survey of previous participants in AGI's Geoscience Student Exit Survey, 2013-2017

## Student Plans for Graduate School

From 2013–2017, the percentage of master’s graduates that planned to attend graduate school after completing their master’s degree rose from 17% to 32%, but there was a decrease in the percentage of bachelor’s graduates that planned to attend graduate school from 43% in 2014 to 35% in 2017. Concerns have been raised that many of the geoscience graduate programs have reached

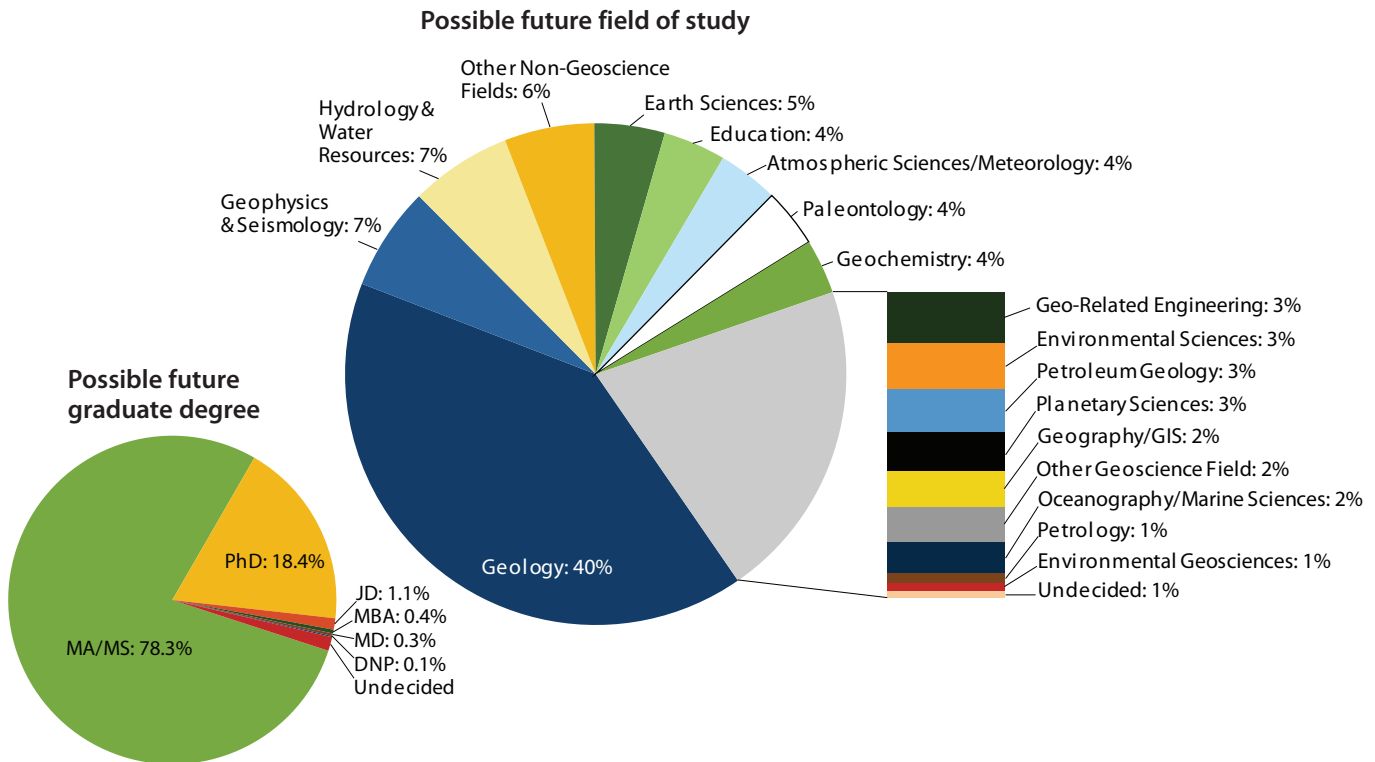
their capacity and cannot accept additional applicants to their programs, especially in light of the ongoing increase in bachelor’s degrees awarded. However, the increase in intent of master’s graduates to continue with another graduate degree instead of entering the workforce is likely due to the slow down in hiring of recent graduates starting in 2014, particularly in the energy and extractive industries.

**Figure 4.56:** Geoscience Students Planning to Attend Graduate School Immediately After Graduation, 2013–2017



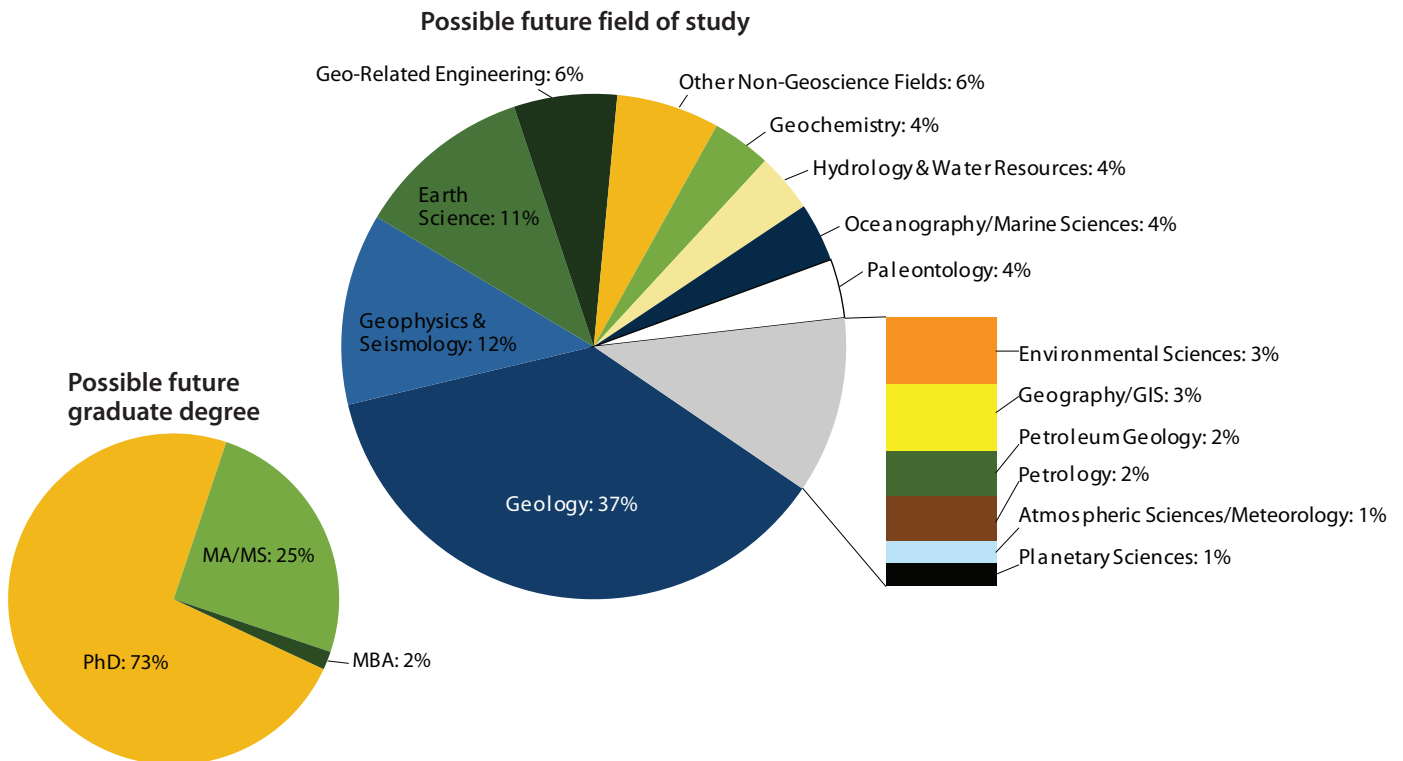
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.57: Geoscience Graduate Students Planning to Pursue Another Graduate Degree, 2013-2017**



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.58: Geoscience Undergraduate Students Planning to Pursue a Graduate Degree, 2013-2017**



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

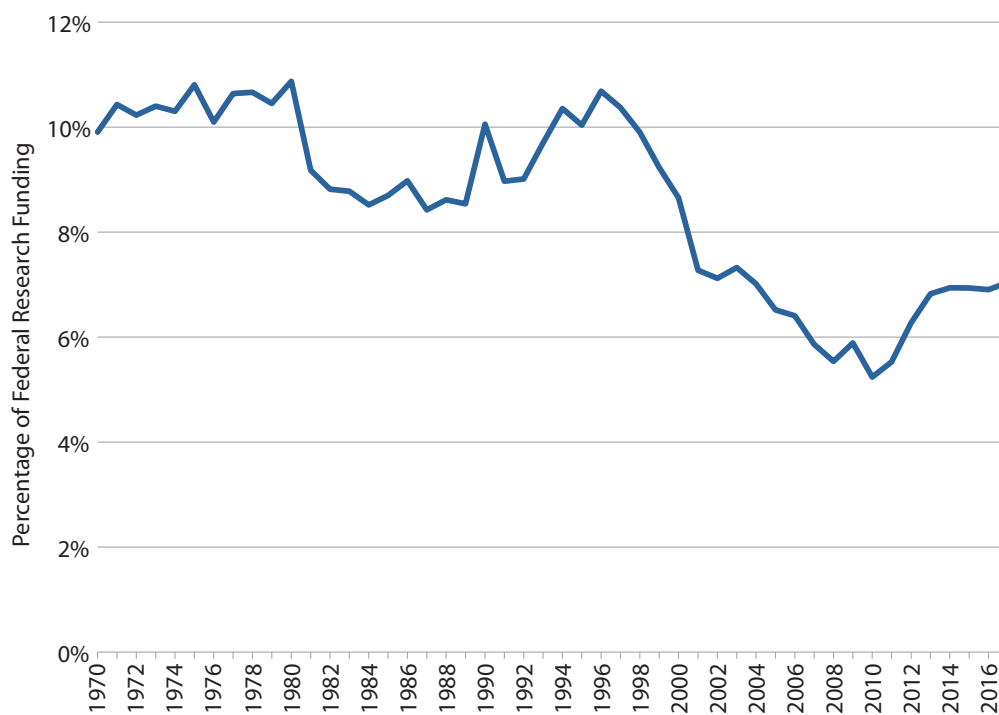
## Funding of the Geosciences at the University Level

The percentage of federal research funding applied to the geosciences had decreased from a high of 11% in 1996 to a low of 5% in 2010, but it seems to be holding steady around 7% through 2017 (Figure 4.59). However, the overall amount of federal research funds awarded to universities has steadily risen, which highlights the overall increases in total federal research funding since the 1970s (Figure 4.60). Most research funds for geoscience given to universities came from the National Science Foundation (NSF) reaching \$5.96 billion in 2015 (Figure 4.65).

At NSF, the funding rate was on a downward trend from 2009–2015, but it has increased since 2015 because the number of proposals submitted to NSF has been decreasing since 2013 (Figure 4.66). The recent increase in the funding rate can also be seen in the funding rate for the other divisions in the Geoscience Directorate

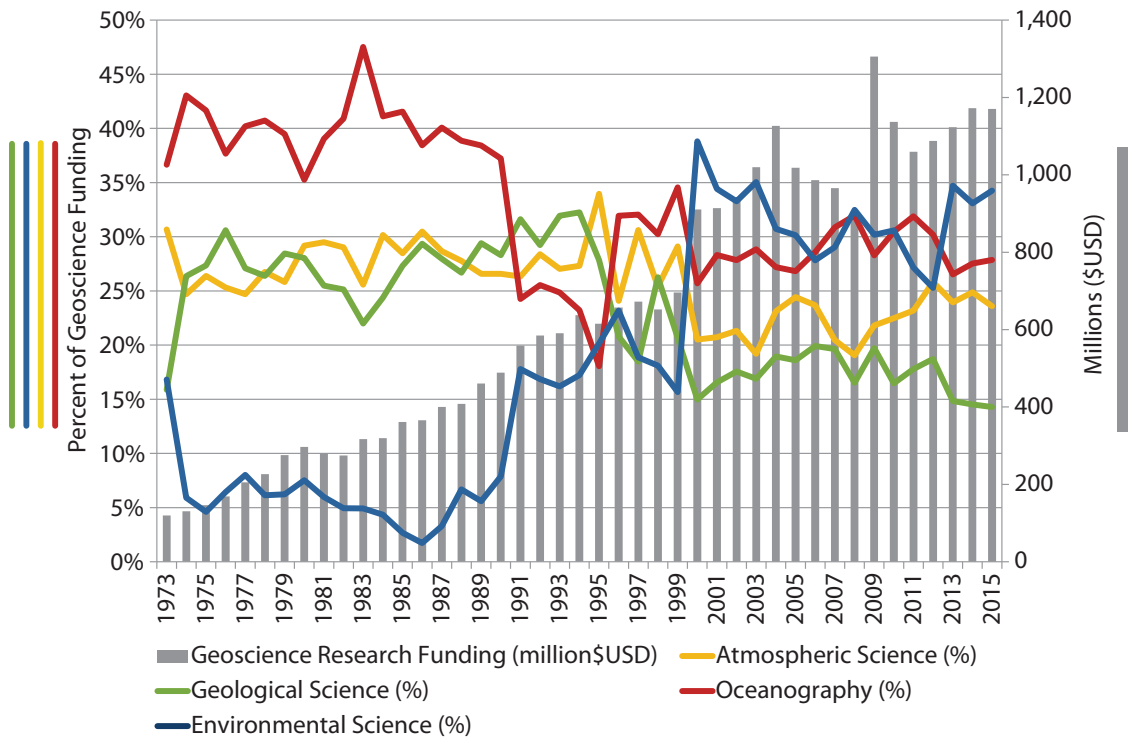
(Figure 4.67). The funding rate for the Atmospheric and Geospace Science Division is approaching the high funding rate of 50% previously reached in 2009 that was due to the American Recovery and Reinvestment Act (ARRA) introduced by the United States government in 2009. The rise in proposals submitted to NSF from 2009–2013 may have been driven by unrealistic expectations of funding on the part of proposal writers due to the ARRA funding. Therefore, the decrease in submitted proposals since 2013 may be a recalibration of funding expectations. Along with the increase in the funding rate from 2015–2017, there has also been an increase of approximately \$10,000 in the median annual size of geoscience awards (Figure 4.68). This increase in median annual size of funding of awards can be seen within all the division within the Geoscience Directorate, except for the Polar Programs Division.

**Figure 4.59:** Percentage of Total Federal Research Funding Applied to the Geosciences



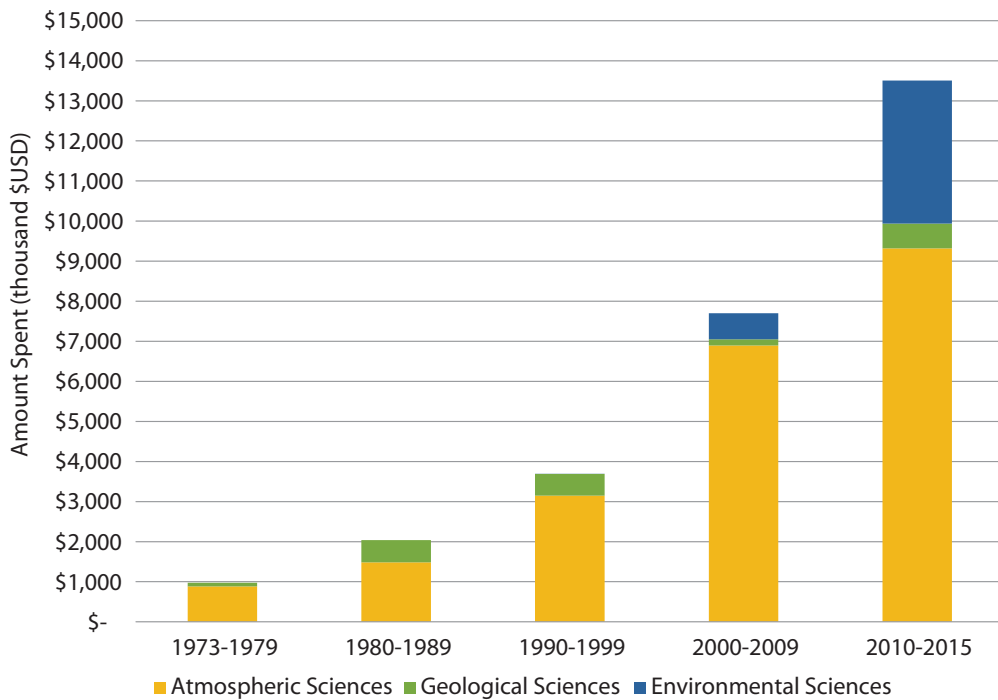
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.60:** Percentage of University Geoscience Research Funding per Subdiscipline from Selected Federal Agencies



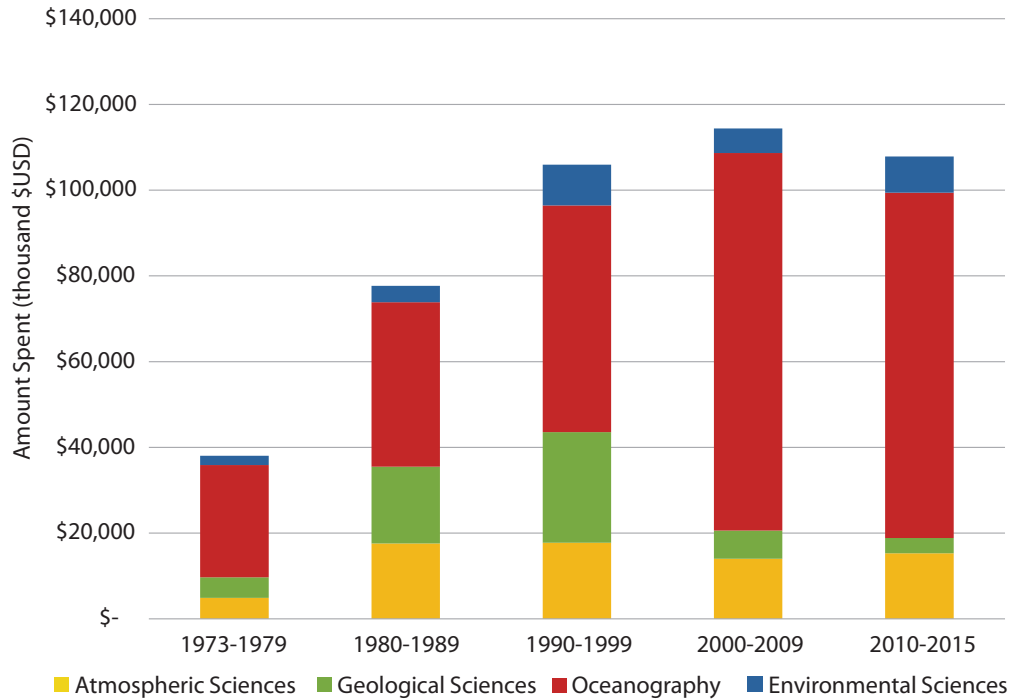
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.61:** Average Annual University Geoscience Research Funding by the Department of Agriculture



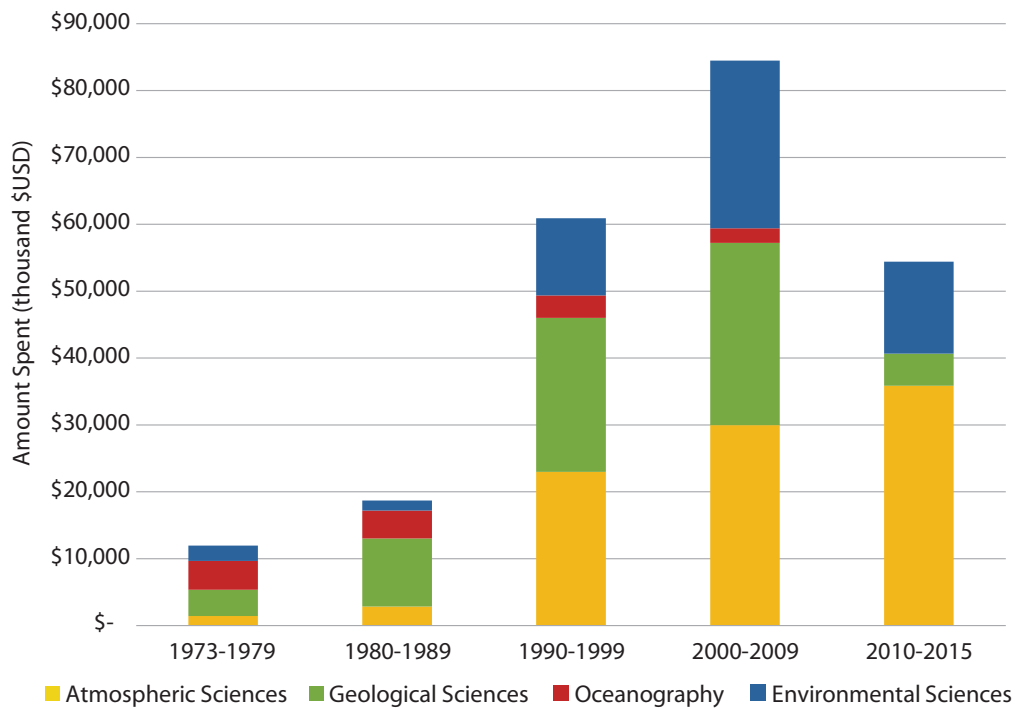
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.62: Average Annual Geoscience Research Funding by the Department of Defense**



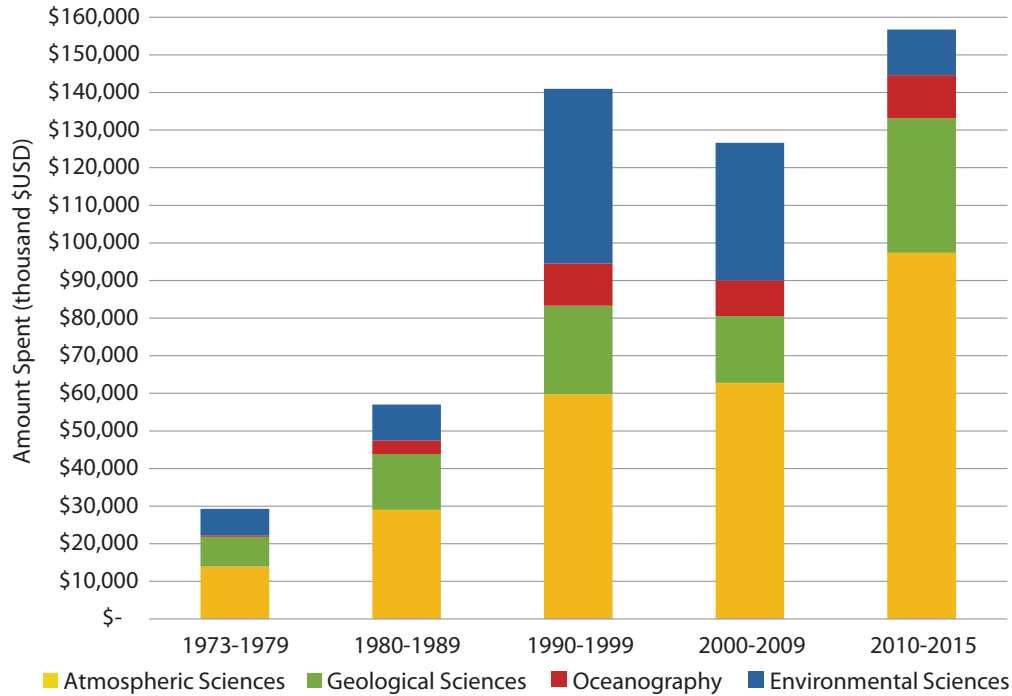
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.63: Average Annual University Geoscience Research Funding by the Department of Energy**



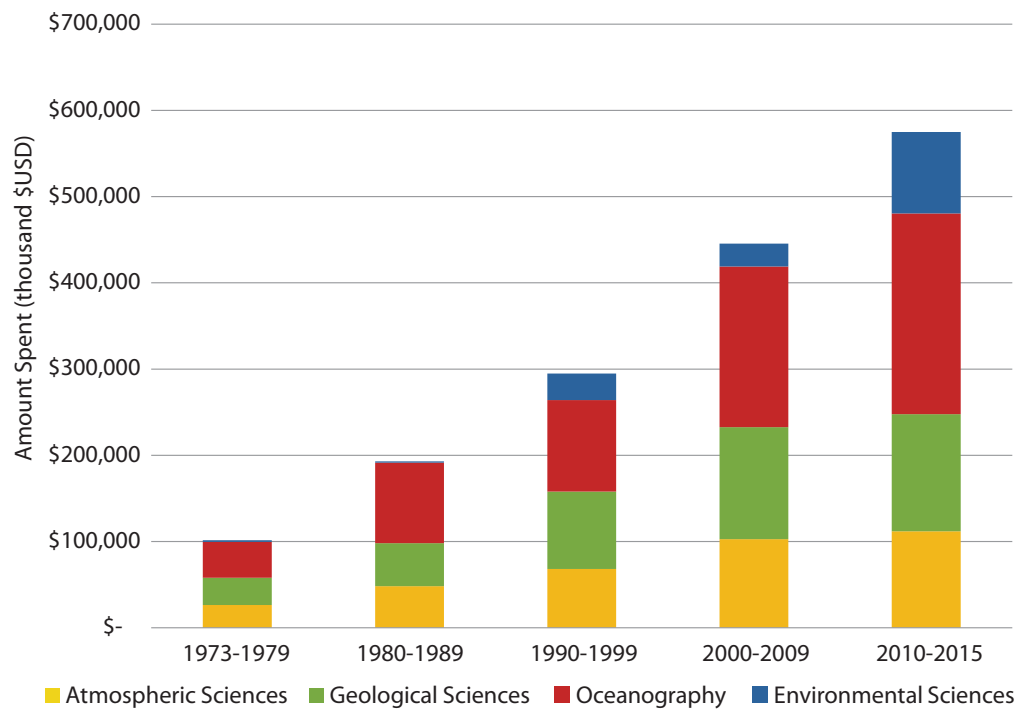
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.64:** Average Annual University Geoscience Research Funding by NASA



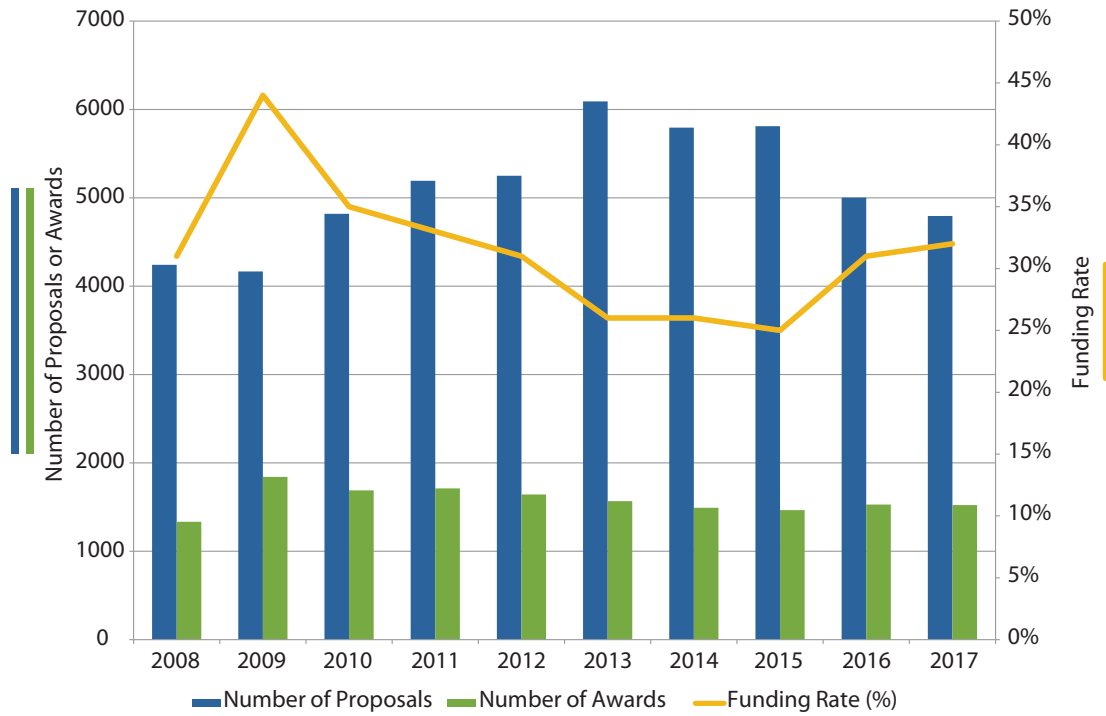
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.65:** Average Annual University Geoscience Research Funding by NSF



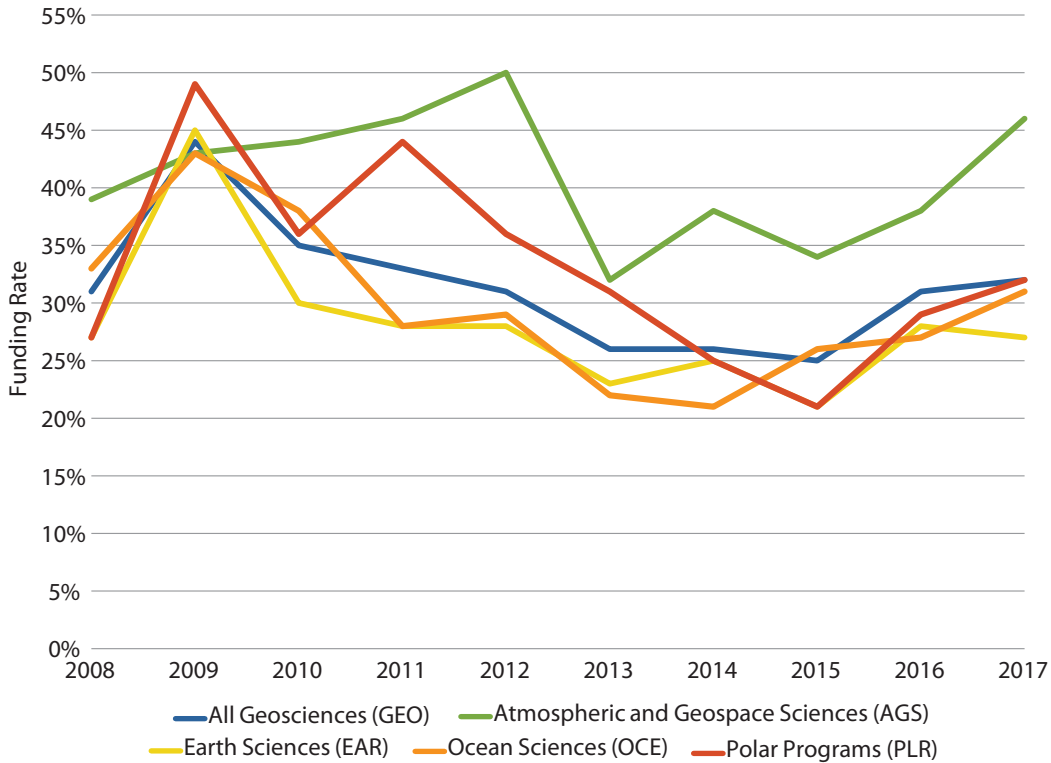
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 4.66: Funding of Geoscience Proposals at NSF**



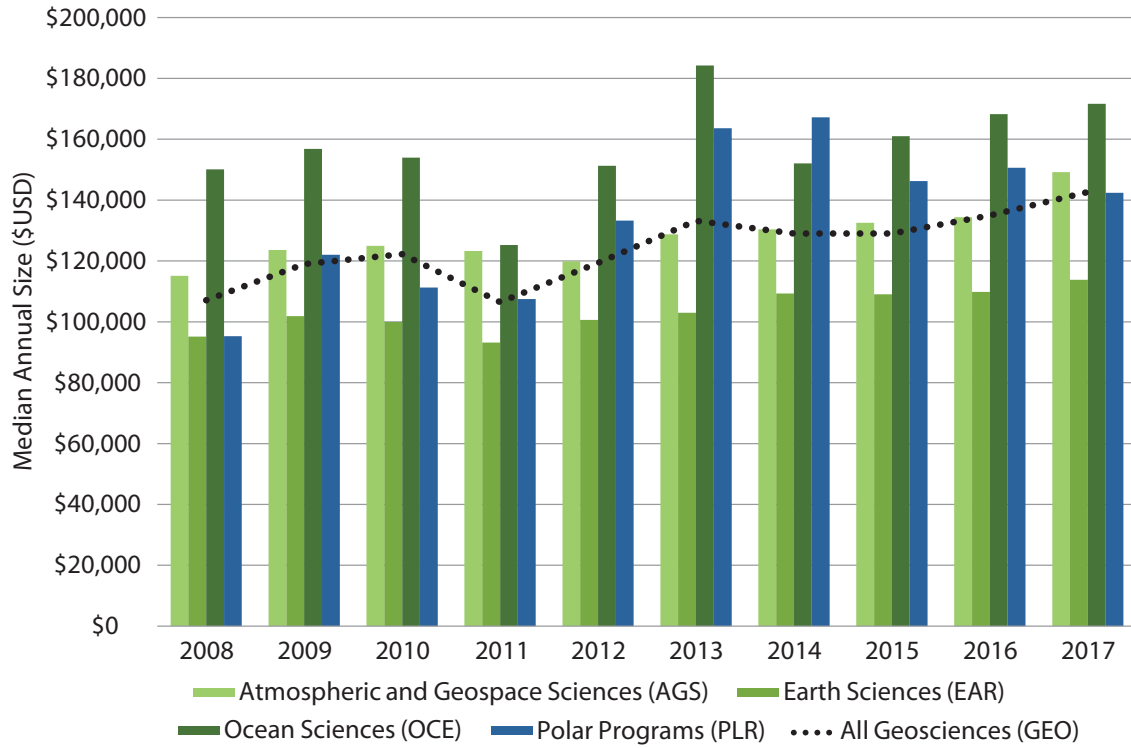
AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Figure 4.67: Funding Rates of Geoscience Proposals at NSF by GEO Division**



AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Figure 4.68:** Median Annual Size of Geoscience Awards at NSF by GEO Division



AGI Geoscience Workforce Program; Data derived from NSF's BILS Funding Trends database

**Table 4.11: Top 10 Universities Receiving NSF Atmospheric and Geospace Science (AGS) Awards Annually, 2008-2017 (Millions \$USD)**

Institution	State	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Colorado State University	CO	\$8.3	\$8.5	\$9.2	\$7.5	\$8.8	\$7.6	\$8.7	\$11.5	\$5.3	\$3.1
University of Wyoming	WY				\$3.3	\$3.6	\$4.9		\$2.5	\$3.0	\$2.9
University of Colorado-Boulder	CO	\$4.5	\$7.3	\$4.0	\$5.6	\$4.7	\$4.1	\$3.1	\$5.1	\$6.4	\$2.5
Massachusetts Institute of Technology	MA	\$2.7	\$4.6	\$4.3	\$4.1	\$4.2	\$2.7	\$4.0	\$4.2	\$4.4	\$2.3
University of Washington	WA	\$3.3	\$4.8		\$4.7	\$5.0	\$4.0	\$4.4		\$3.0	\$1.8
University of Alabama-Huntsville	AL										\$1.6
University of California-Irvine	CA										\$1.5
University of Texas-Austin	TX										\$1.4
University of Minnesota-Twin Cities	MN										\$1.2
University of Wisconsin-Madison	WI									\$3.4	
University of California-Los Angeles	CA	\$3.0			\$4.3	\$4.6		\$6.0	\$2.3	\$3.3	
Johns Hopkins University	MD	\$2.9	\$5.0					\$2.6		\$3.1	
Columbia University	NY			\$3.5	\$2.8	\$2.7	\$4.7			\$3.0	
Cornell University	NY	\$6.5		\$3.0	\$3.0					\$2.6	
University of Miami	FL	\$2.7					\$2.70			\$1.2	
University of Illinois-Urbana-Champaign	IL		\$4.5				\$2.7		\$4.3		
Carnegie-Mellon University	PA								\$2.7		
University of Oklahoma	OK	\$3.6					\$4.9		\$2.6		
University of Michigan	MI			\$5.1		\$2.5	\$3.1		\$2.6		
Pennsylvania State University - University Park	PA		\$4.4		\$3.1	\$2.7		\$3.1	\$2.3		
University of California - Berkeley	CA							\$2.8			
Colorado School of Mines	CO					\$2.3					
Boston University	MA	\$5.7	\$5.6	\$6.2	\$4.6						
New Jersey Institute of Technology	NJ			\$6.0							
Oregon State University	OR			\$5.4							
University of Hawaii	HI			\$3.1							
Virginia Polytechnic Institute and State University	VA		\$7.6								
George Mason University	VA		4.324								

AGI Geoscience Workforce Program; Data derived from NSF's BIIS Funding Trends database

**Table 4.12: Top 10 Universities Receiving NSF Earth Science (EAR) Awards Annually, 2008-2017 (Millions \$USD)**

Institution	State	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
University of New Mexico	NM									\$3.5	\$3.7
University of Illinois-Urbana-Champaign	IL			\$3.8	\$3.3	\$3.8	\$3.0	\$4.0	\$3.8		\$2.3
University of Wisconsin-Madison	WI			\$4.0			\$3.0	\$3.8			\$2.2
Oregon State University	OR								\$2.8	\$3.1	\$2.1
Arizona State University	AZ				\$3.6	\$4.0					\$2.0
University of California-Berkeley	CA								\$3.7	\$3.8	\$1.5
Duke University	NC										\$1.1
University of Colorado - Boulder	CO	\$3.2	\$4.9	\$4.0	\$5.2	\$4.1	\$5.0	\$5.0	\$4.8	\$5.0	\$1.0
University of New Hampshire	NH										\$1.0
Idaho State University	ID										\$0.8
University of Southern California	CA		\$7.2	\$5.8	\$5.1	\$5.6	\$5.1	\$4.1	\$5.4	\$5.4	
University of Minnesota-Twin Cities	MN	\$5.9	\$7.5	\$5.7	\$5.1	\$3.6	\$5.0	\$4.5	\$4.3	\$4.4	
Pennsylvania State University-University Park	PA	\$3.0	\$3.9	\$4.2			\$3.5				\$3.7
University of Arizona	AZ	\$5.4	\$11.6			\$3.2	\$4.4	\$4.2	\$3.0	\$3.5	
Columbia University	NY	\$3.8	\$4.4	\$3.6	\$3.1	\$3.5	\$8.2	\$4.2	\$6.7	\$2.9	
University of California-Davis	CA					\$3.7					\$2.9
University of Chicago	IL	\$2.7		\$3.6	\$3.2	\$5.2			\$3.1		
University of California-Los Angeles	CA							\$4.6	\$2.7		
California Institute of Technology	CA	\$4.0	\$5.1				\$3.1	\$3.2			
Indiana University	IN							\$2.9			
University of Texas-Austin	TX	\$2.7		\$3.8			\$3.0				
Woods Hole Oceanographic Institute	MA					\$3.1					
North Carolina State University	NC				\$3.0						
University of California-Merced	CA				\$3.0						
Massachusetts Institute of Technology	MA	\$3.1	\$4.9		\$3.0						
Scripps Institute of Oceanography	CA			\$3.1							
University of Pennsylvania	PA		\$4.8								
State University of New York-Stony Brook	NY	\$3.5	\$4.5								

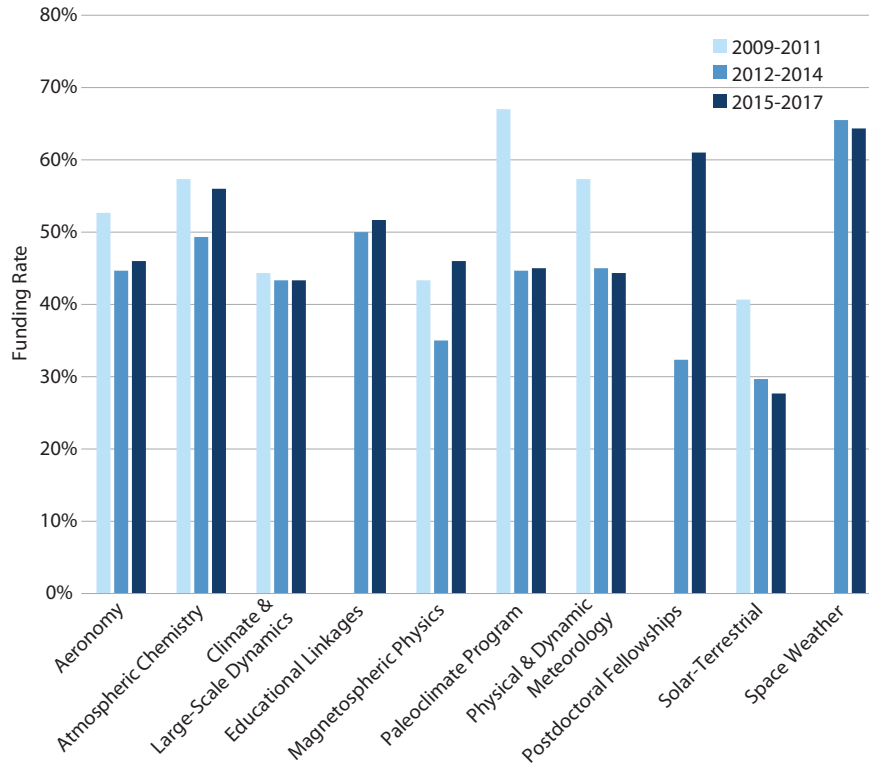
AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Table 4.13: Top 10 Universities Receiving NSF Ocean Sciences (OCE) Awards Annually, 2008-2017 (Millions \$USD)**

Institution	State	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Texas A&M University	TX								\$48.0	\$46.0	\$38.0
Woods Hole Oceanographic Institution	MA	\$53.6	\$74.0	\$63.5	\$59.6	\$50.8	\$55.7	\$50.2	\$42.0	\$52.2	\$23.1
Columbia University	NY	\$22.8	\$27.4	\$17.9	\$20.0	\$23.7	\$17.5	\$18.9		\$26.2	\$16.8
University of Hawaii	HI	\$12.3	\$13.8	\$17.3	\$7.6	\$12.1	\$13.3	\$10.9	\$13.5	\$13.1	\$11.2
Scripps Institute of Oceanographic Research	CA	\$24.4	\$36.0	\$23.5	\$25.7	\$31.1	\$21.0	\$21.7	\$21.8	\$16.8	\$9.9
University of Alaska - Fairbanks	AK		\$162.6	\$34.0				\$4.4		\$10.7	\$8.8
University of Washington	WA	\$15.8	\$21.4	\$13.6	\$14.2	\$20.2	\$9.5	\$11.4	\$17.4	\$12.9	\$8.3
University of Southern California	CA				\$8.5	\$6.1	\$9.1	\$6.9	\$6.5	\$8.7	\$8.1
Oregon State University	OR	\$10.6	\$12.3	\$7.4	\$12.7	\$9.4	\$11.8	\$14.5	\$10.8	\$14.4	\$5.0
University Rhode Island	RI	\$4.9	\$10.1	\$6.3	\$6.5	\$4.7		\$5.2		\$6.4	\$4.8
University of Miami	FL	\$6.6	\$9.9	\$7.1	\$6.4	\$5.2	\$5.6	\$4.2	\$7.0		
University of California-Santa Barbara	CA				\$5.0		\$5.4		\$6.8		
Oregon Health and Science University	OR	\$4.0					\$4.0				
University of California-Santa Cruz	CA					\$4.5					
University of Georgia	GA			\$4.8							
Georgia Institute of Technology	GA		\$4.5								
Massachusetts Institute of Technology	MA	\$4.1									

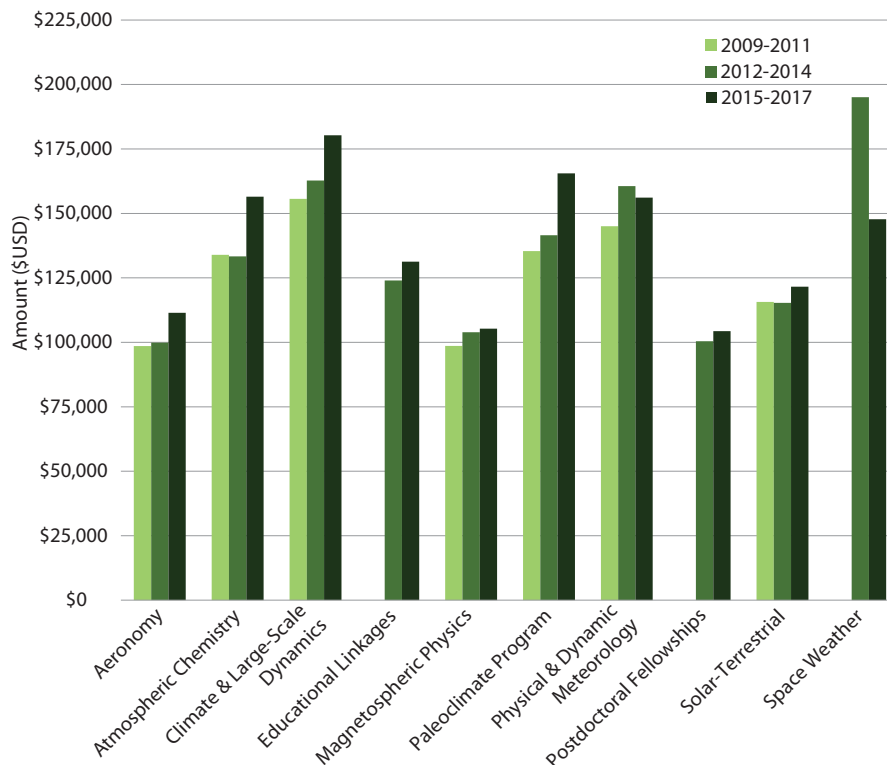
AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Figure 4.69:** Trends in NSF Atmospheric and Geospace Science Funding Rates by Subject



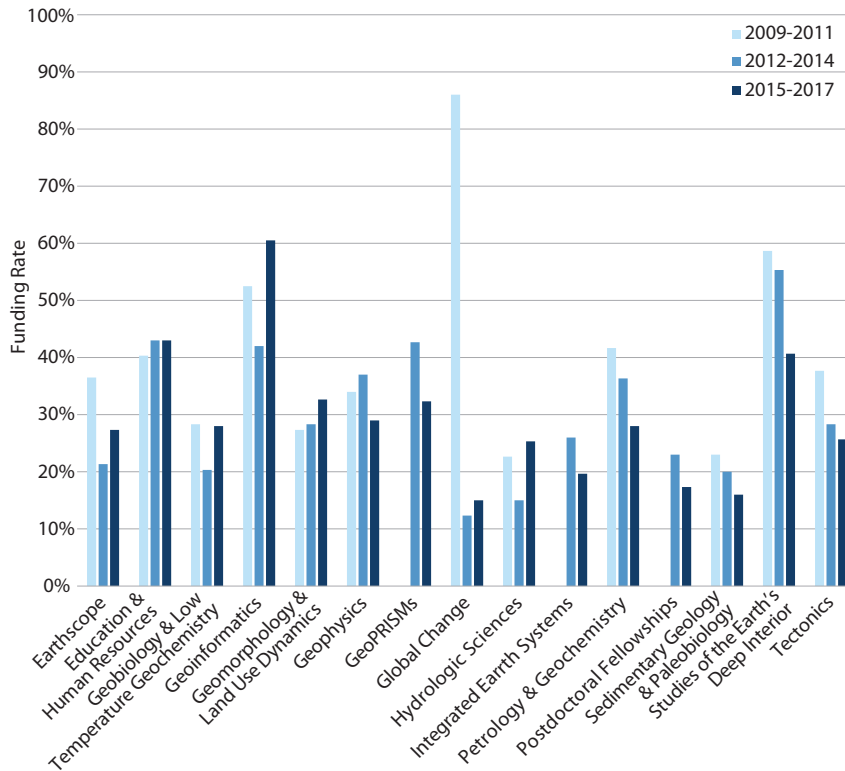
AGI Geoscience Workforce Program; Data derived from NSF's BIFS Funding Trends database

**Figure 4.70:** Trends in NSF Atmospheric and Geospace Sciences Award Size by Subject



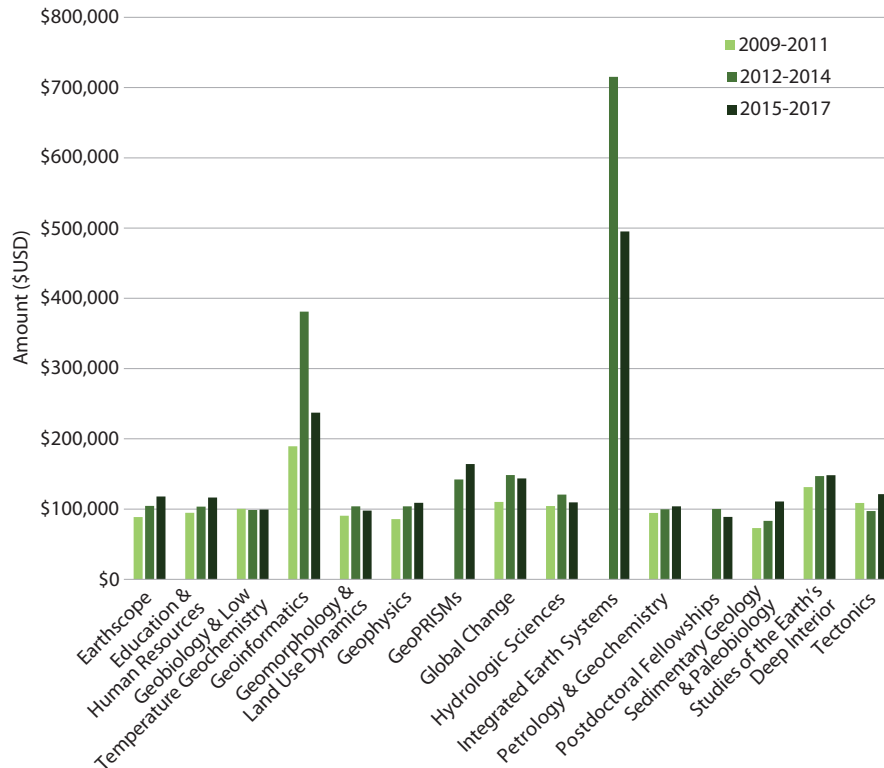
AGI Geoscience Workforce Program; Data derived from NSF's BIFS Funding Trends database

**Figure 4.71: Trends in NSF Earth Sciences Funding Rates by Subject**



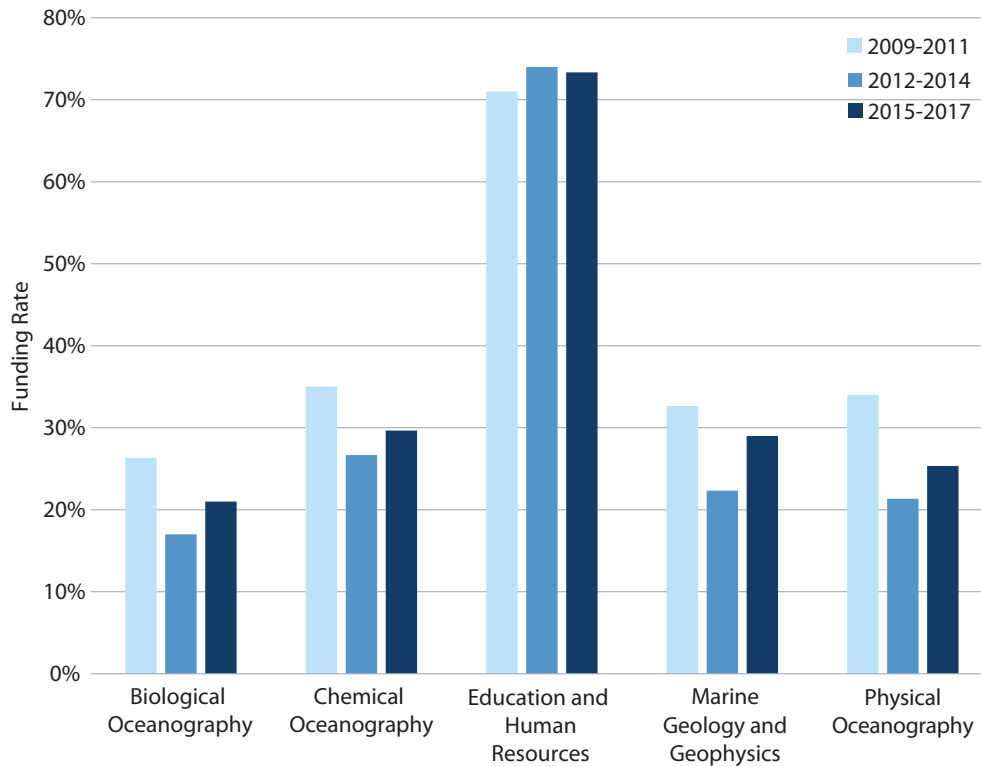
AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Figure 4.72: Trends in NSF Earth Sciences Award Size By Subject**



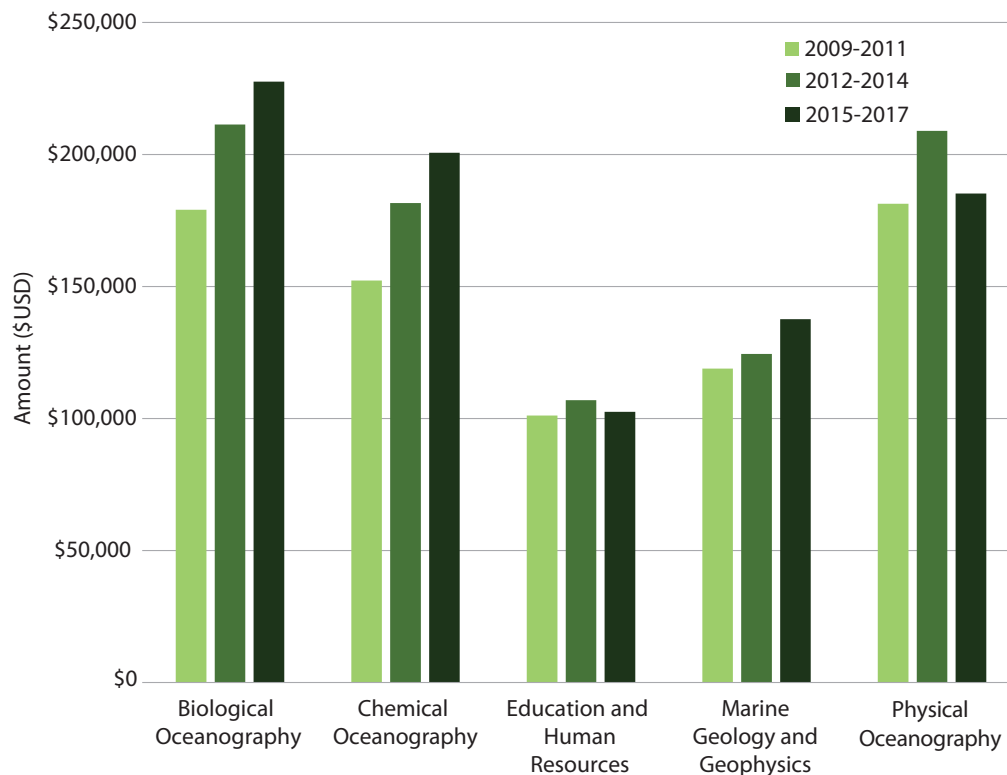
AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Figure 4.73: Trends in NSF Ocean Sciences Funding Rates by Subject**



AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

**Figure 4.74: Trends in NSF Ocean Sciences Award Size by Subject**



AGI Geoscience Workforce Program; Data derived from NSF's BUIS Funding Trends database

## Funding of Geoscience Students

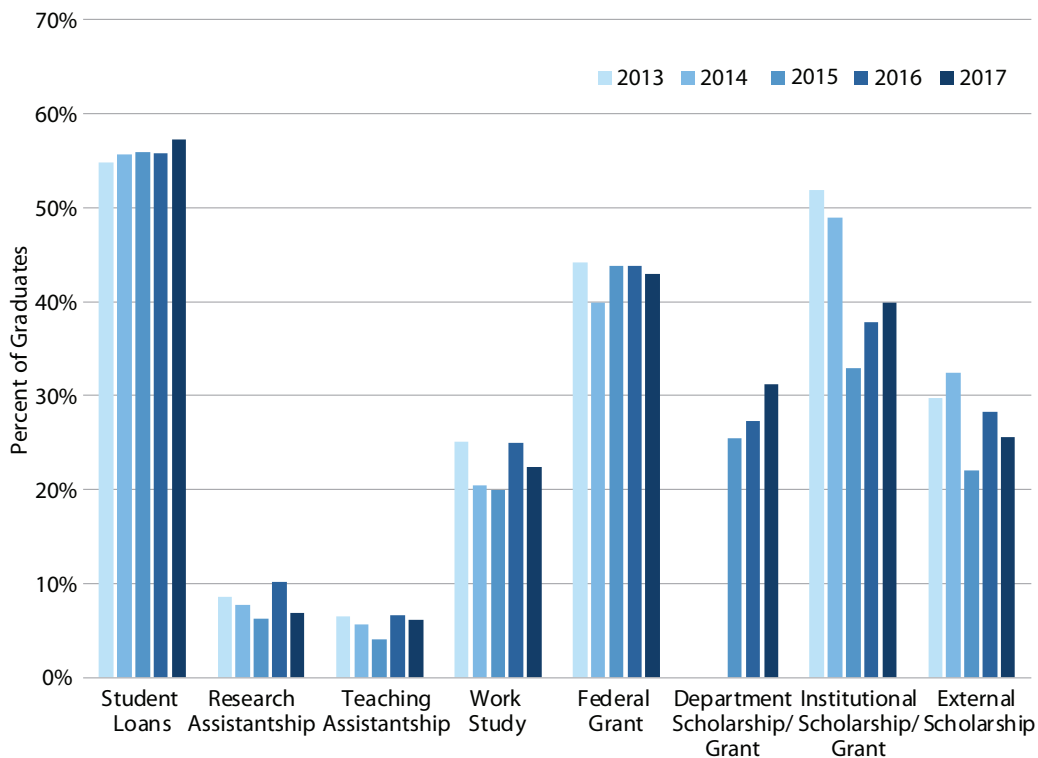
Geoscience students use a variety of funding sources to pay for their degree programs, including student loans, teaching assistantships, research assistantships, federal grants, and institutional scholarships. While many assume that students in geoscience graduate programs get tuition and fees covered by the institution, between 2013 and 2015, the percentage of master's graduates that took out student loans to help pay for their education increased from 32% to 38%, and approximately 16% of doctoral graduates during that same time period also used student loans to pay for their degree (Figures 4.75–4.77).

NSF's Graduate Research Fellowships are a prestigious and well-funded award for graduate students. The number of awards given to geoscience graduates has been increasing since 2008 to a high of 148 awards in 2015 totaling

\$6.5 million in award money (Figure 4.79). However, the number of geoscience awards dropped in 2018 to 118 awards totaling \$5.4 million. The rapid increase in the total number of graduate fellowships was initially due to the ARRA stimulus funding in 2009, but the continuing high number of awards and the increase in awarded amounts per funded fellowship since then was due to a focus by NSF to increase the quality of the future academic workforce.

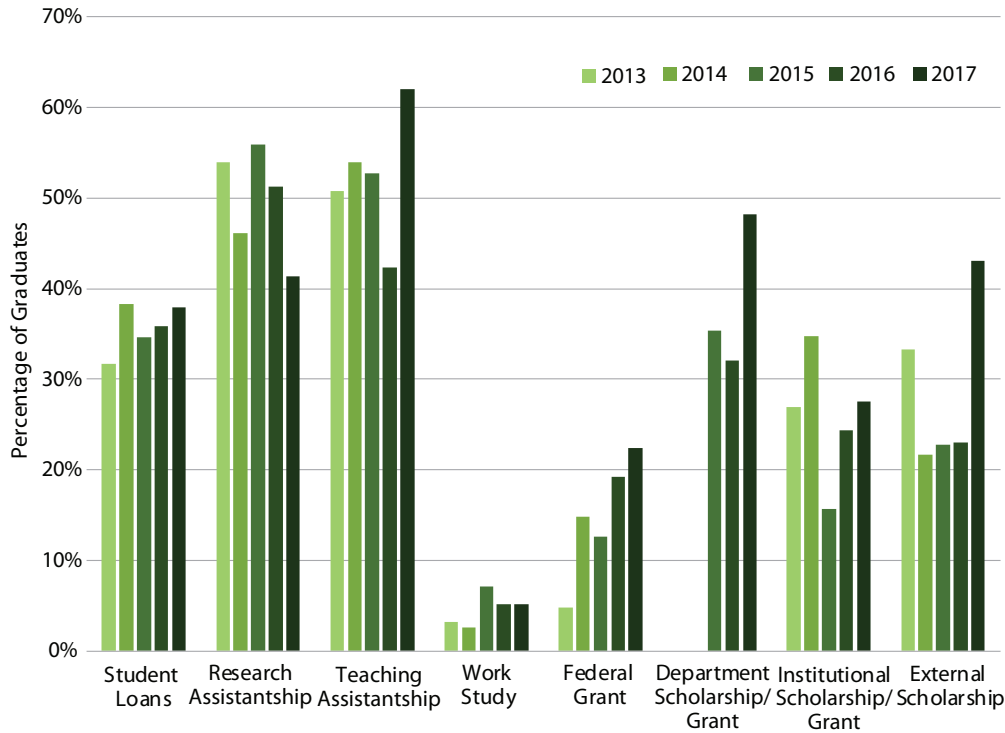
The fields of study for the geoscience graduate fellowship awards indicate the popular areas of study for geoscience graduate students. Over the past decade, there was a rapid increase in the number of awards in the geochemistry, paleoclimate, geophysics, marine biology, and biogeochemistry fields (Figure 4.80).

**Figure 4.75:** Types of Financial Aid Used by Bachelor's Graduates While Working Towards Their Degree, 2013-2017



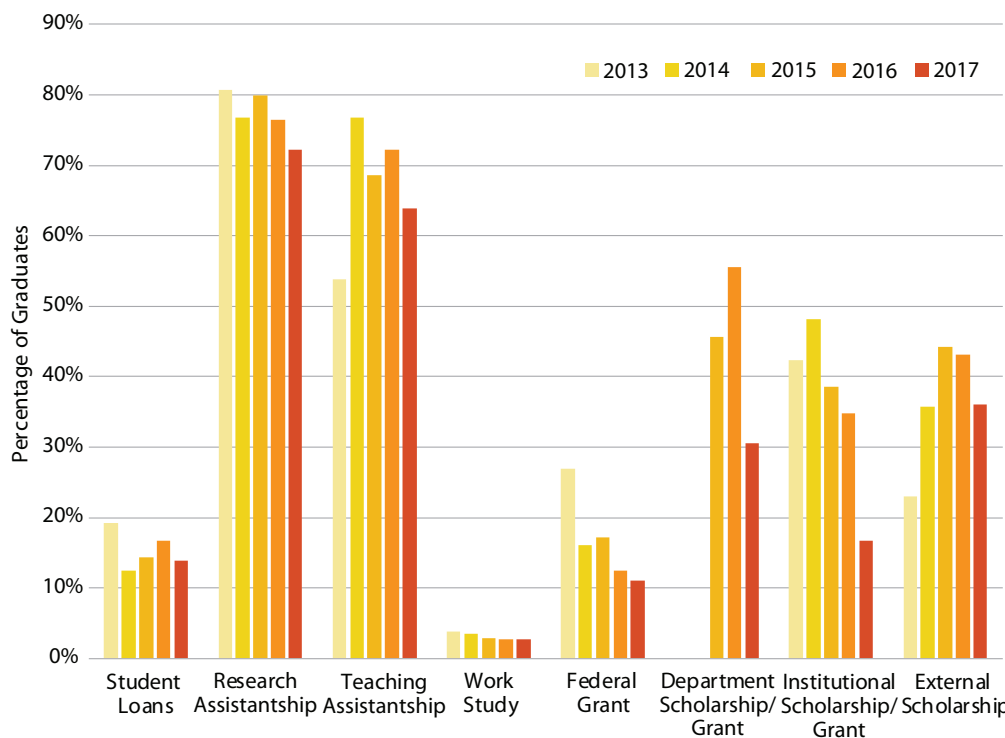
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.76:** Types of Financial Aid Used by Master’s Graduates While Working Toward Their Degree, 2013-2017



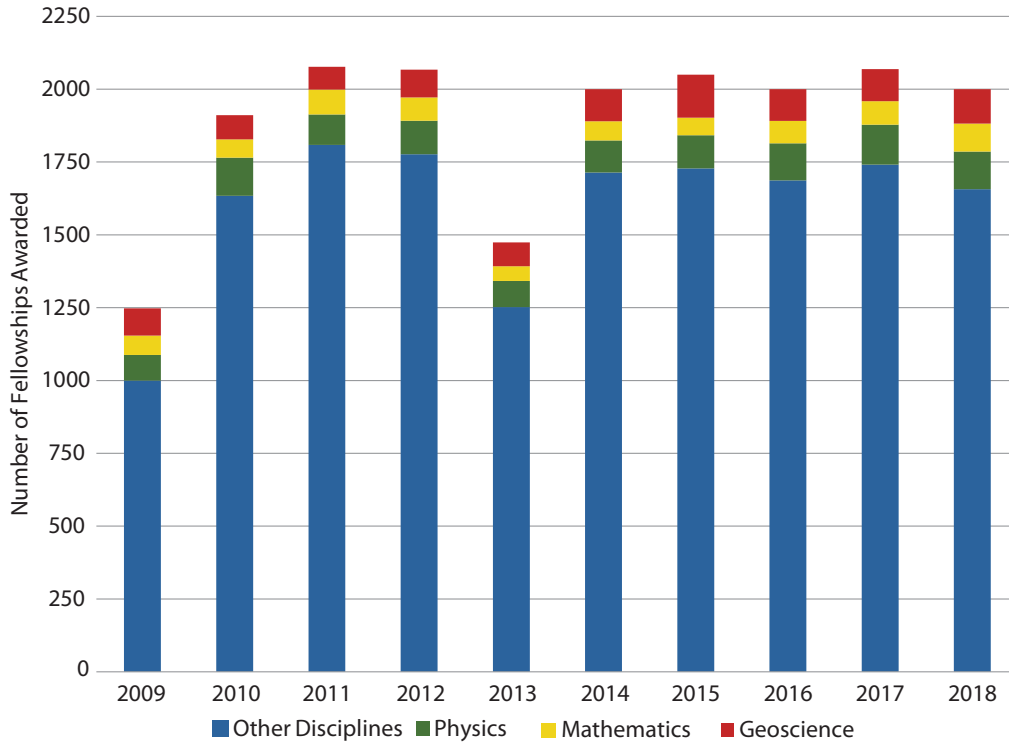
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.77:** Types of Financial Aid Used by Doctoral Graduates While Working Towards Their Degree, 2013-2017



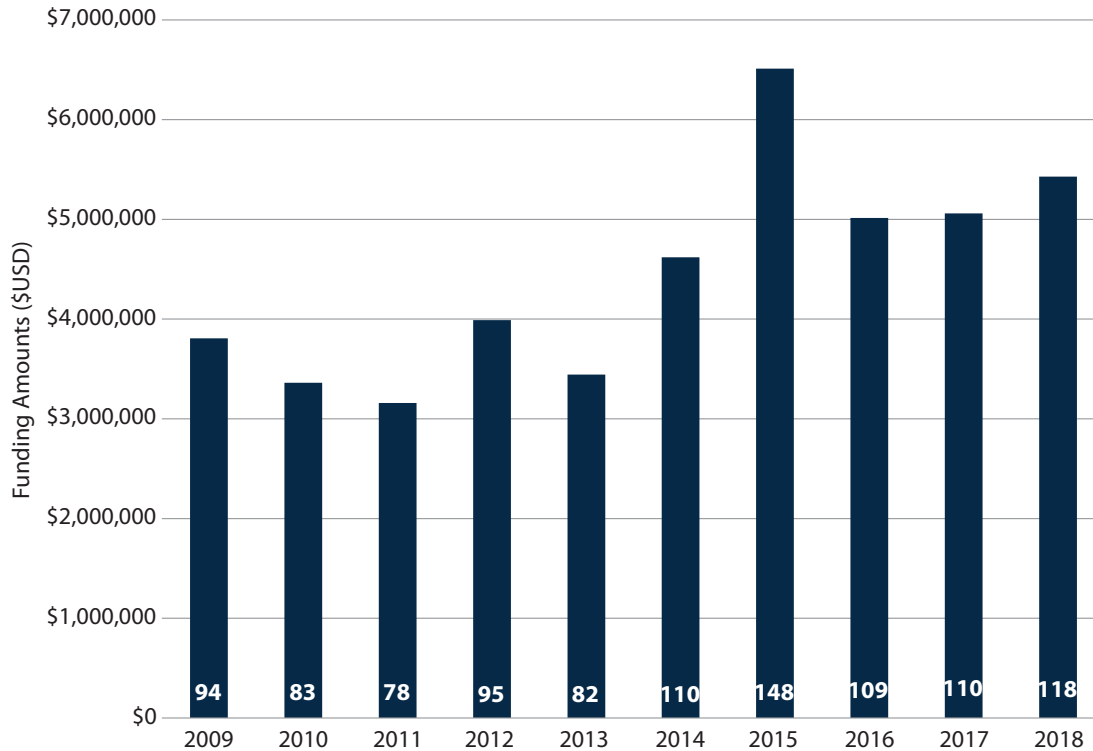
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 4.78: Number of NSF Graduate Fellowships Awarded, 2009-2018**



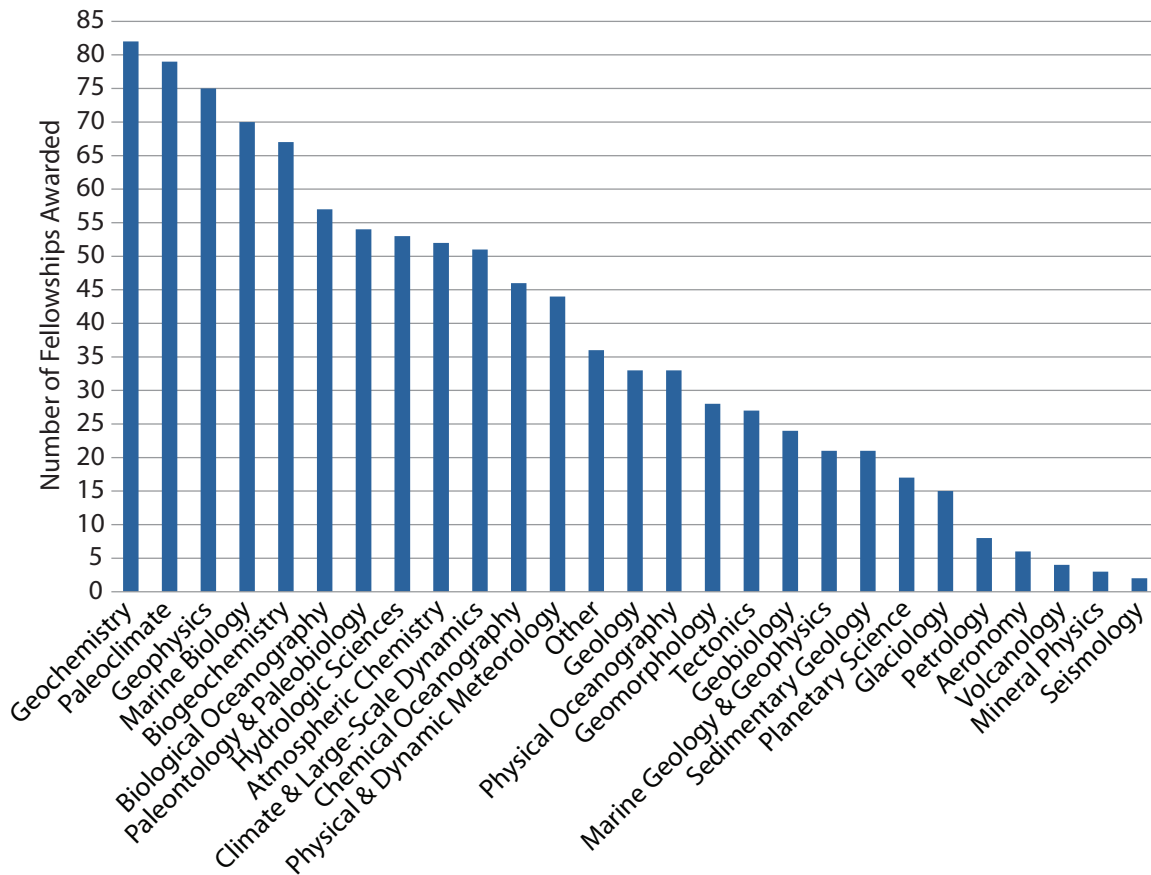
AGI Geoscience Workforce Program; Data derived from NSF Graduate Fellowship Program annual awards

**Figure 4.79: Total Funding of Geoscience NSF Graduate Fellowships**



AGI Geoscience Workforce Program; Data derived from NSF Graduate Fellowship Program annual awards

**Figure 4.80:** NSF Geoscience Graduate Fellowships by Field of Study, 2009-2018



AGI Geoscience Workforce Program; Data derived from NSF Graduate Fellowship Program annual awards

**Table 4.14:** Top 10 Baccalaureate Institutions Attended by NSF Geoscience Graduate Fellows (2009-2018)

Baccalaureate Institutions of Geoscience NSF Graduate Fellows	State	Number of Fellows (200-2018)
University of Washington	WA	33
Brown University	RI	27
Harvard University	MA	25
Stanford University	CA	19
Cornell University	NY	18
Massachusetts Institute of Technology	MA	17
University of Texas at Austin	TX	17
University of California-Berkeley	CA	16
Columbia University	NY	15
Yale University	CT	15

AGI Geoscience Workforce Program; Data derived from NSF Graduate Fellowship Program annual awards

**Table 4.15:** Top 10 Graduate Institutions Attended by NSF Geoscience Graduate Fellows (2009-2018)

Graduate Institutions of Geoscience NSF Graduate Fellows	State	Number of Fellows (200-2018)
University of Washington	WA	56
University of California-San Diego	CA	43
Columbia University	NY	39
Massachusetts Institute of Technology	MA	38
University of California-Berkeley	CA	36
Harvard University	MA	30
Stanford University	CA	30
University of Colorado at Boulder	CO	28
California Institute of Technology	CA	26
University of Arizona	AZ	25

AGI Geoscience Workforce Program; Data derived from NSF Graduate Fellowship Program annual awards

## Chapter 5: Trends in Geoscience Employment — Examining Student Transitions and Workforce Dynamics

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When discussing employment demand for the geosciences, the three major factors is the rate at which new talent transitions into geoscience professions, the rapid loss of experienced talent as they approach retirement, and the integration of new technology to increase productivity. This report focuses on the first two issues.

According to the Bureau of Labor Statistics (BLS), there were a total demand of 311,768 geoscience full-time equivalents (FTE) in 2016, and this number is expected to increase by 11 percent by 2026 to a total of 344,704 FTEs. Approximately 147,000 geoscientists are expected to retire by 2026, but over the next decade, approximately 62,000 students will be graduating with their bachelor's, master's, or doctoral degrees in the geosciences. Therefore, assuming minimal non-retirement attrition from the geoscience workforce, there is expected to be a deficit of approximately 118,000 geoscience FTEs by 2026.

It is critical to examine these numbers not as individuals but as FTEs because new technological advances have yielded measurable efficiency and productivity increases in the geoscience industries thus displacing people, but not necessarily total work per a benchmark level of effort. When BLS conducts their workforce predictions for the future decade, their analysis does not necessarily take into account the new innovations and technological advancements that will be in place within the workforce. While AGI predicts a shortage of the geoscience workforce over the next decade, we are confident that recent advances in the integration of data science and machine learning, particularly within the resource industries, will substantially absorb the deficit in actual individual geoscientists. In fact, the integration of new technologies will require future geoscientists to be skilled in new ways as the nature of work in the geosciences changes with these developments.

Over the past five years, there has been a decrease in hiring of recent graduates at all degree levels, and a shift in the proportion of graduates being hired by certain industries. For example, from 2014-2016, there was a decrease in hiring by oil and gas companies at all degree levels, which lead to a higher proportion of environmental companies hiring bachelor's graduates, the federal government hiring master's graduates, and research institutes

hiring doctoral graduates. During this time period, there was a steady downturn in the oil and gas industry, which led to an increase in layoffs and a shifting in needs assessed within the industry. However, while there has been a decrease in hiring of graduates immediately after graduation, on average, recent geoscience graduates were able to find a job within two months of graduation. With multiple years of AGI's Exit Survey data, the connections between the various degree fields within the geosciences to industries hiring these graduates are becoming clearer and highlighting the diversity of career options for geoscience graduates.

The percentage of women in environmental science and geoscience occupations has been steadily increasing since 2014, reaching 35 percent in 2017. The data are showing encouraging trends in the increased hiring of women in geoscience industries and within academia, and this trend should continue into the future. The percentage of underrepresented minorities in environmental and geoscience occupations has also been increasing since 2013 but at a much slower rate, reaching 10 percent in 2017. The engineering and manager occupations in the geosciences tend to have a higher percentage of underrepresented minorities than the scientist occupations. While good data showing the percentage of underrepresented minorities within academia is hard to find, the extremely low percentages of underrepresented minority populations in postdoctoral appointee positions provides an indication of the racial and ethnic representation among the faculty and staff in academia. While this report only provides data for the racial and ethnic representation of geoscience postdoctoral appointees, when the data was analyzed, it was clear that low racial and ethnic diversity is a systemic problem for all of science and engineering academia.

Future work at AGI will continue to focus on the skills gap between recent graduates and the future workforce needs. A better understanding is needed on how the industries and economy are changing with the development of new innovations, and how these changes are affecting the global workforce, as well as the geoscience workforce in the United States. The more we understand about the future workings of the workforce, the better we can help prepare the future workforce with the appropriate skills and knowledge to be successful.

## Early Career Workforce

Over the past five years, fewer new geoscience graduates are hired immediately upon completion of their degree at all degree levels. Between 2013 and 2017, immediate hiring of bachelor's graduates dropped from 15% to 10%; immediate hiring of master's graduates decreased from 43% to 30%, and immediate hiring of doctoral graduates decreased from 70% to 36% (Figures 5.1–5.3). This decrease in hiring of geoscience graduates at the point of graduation also led to an increase in graduates seeking employment in the geosciences, particularly among master's and doctoral graduates. Along with the changes in hiring rates from 2013–2017, there were also changes in the hiring patterns of various industries as well. Figures 5.4–5.6 show the percentage of new hires each year by industry for each degree. AGI's Exit Survey was the first quantitative dataset indicating the slowdown in hiring of new graduates in the oil and gas industry in 2015 and 2016 for all degree levels. As oil and gas hiring slowed among bachelors' graduates, higher percentages of graduates were hired within the environmental services industry and federal government. Bachelor's graduates also found jobs within a more diverse collection of industries compared to master's and doctoral graduates. The decrease in hiring of doctoral graduates in the oil and gas industry led to increases in hiring at 4-year universities and research institutes. The decrease in hiring of master's graduates into the oil and gas industry was not as drastic as among bachelor's and doctoral graduates, but there was an increase in hiring by the federal government as hiring decreased in the oil and gas industry.

Changes in hiring among various industries can also affect the interest in those industries by graduates seeking employment in the geosciences. Figures 5.7–5.9 are vector graphs showing the changes in interest of various industries by graduates seeking employment in the geosciences compared to hiring of graduates within those industries. For example, for the oil and gas industry, interest was higher while the industry was hiring recent graduates, and that interest in the industry decreased as hiring decreased. Interestingly, job interest in state or local government tended to remain much higher than the actual hiring within that industry.

Over the past five years, median starting salaries for recent graduates have decreased as hiring in the oil and gas industry slowed (Figures 5.10–5.12). All starting salaries

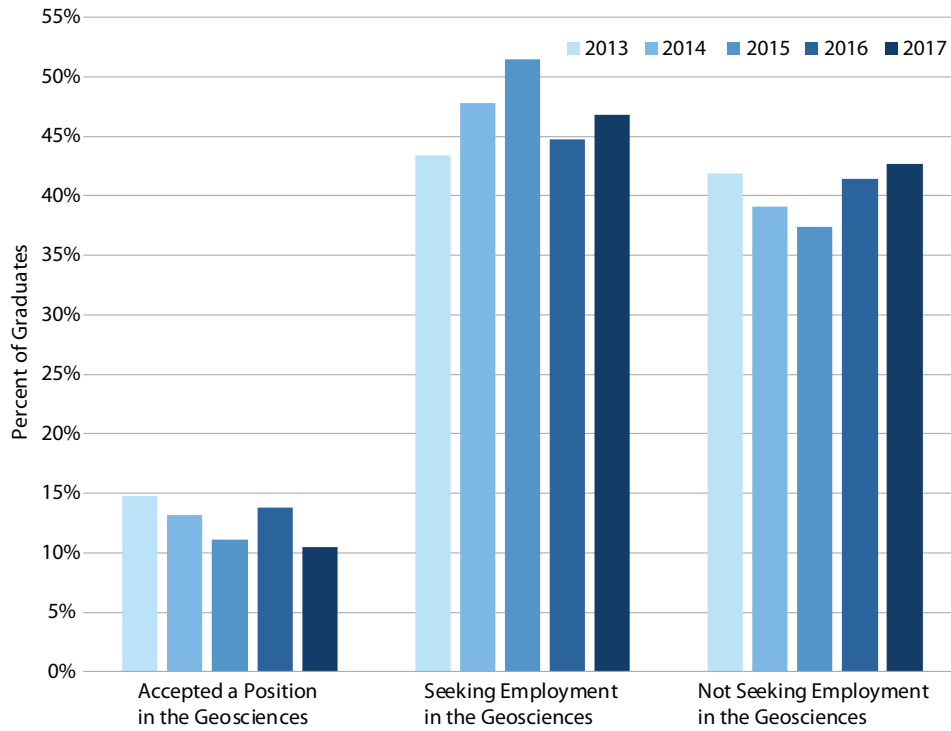
over \$90,000 corresponded to jobs within that industry. However, clear salary ranges can be seen for each degree level. Most hired bachelor's graduates received a salary between \$30,000 and \$50,000. Most hired master's graduates were given a starting salary between \$40,000 and \$60,000 or between \$90,000 and \$110,000 in the oil and gas industry. Most hired doctoral graduates were given a starting salary between \$40,000 and \$70,000. As seen in these figures, master's and doctoral graduates tend to be hired within similar starting salary ranges regardless of degree.

Figures 5.19–5.21 show the various resources graduates used to find their geoscience job from 2013–2017. While it varies somewhat by degree type, most graduates depended on personal contacts, internet searches, and faculty referrals to find their jobs. Master's graduates, in particular, tend to find the various campus recruiting events by industry representatives to be useful for securing employment.

The circular figure displays the connection between the degree fields of recent geoscience graduates from 2013–2017 (in color) to the industries where these geoscientists found their first job after graduation (in gray) (Figure 5.22). The size of the bars along the out edge of the circle represents the number of recent graduates that pursued a particular degree field and entered a particular industry. Each colored, inner ribbon connects a particular degree field with a job in a particular industry. This visualization shows the variety of industries available to graduates with a geoscience degree, as well as the complexity of the workforce and knowledge needed in the distinct industries.

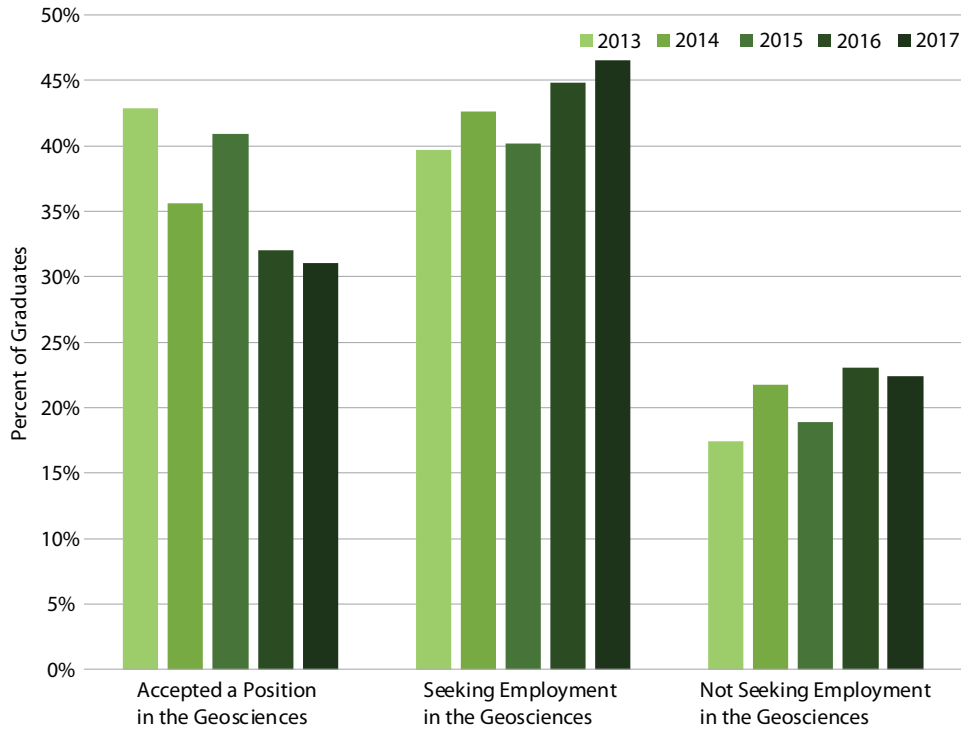
Doctoral graduates that tend to find employment at 4-year universities and research institutes are typically hired as post-doctorates. Figures 5.23–5.29 detail various demographic information and funding information of geoscience post-doctorates. In 2016, there were approximately 2000 geoscience post-doctorates making up 5.6% of all the science post-doctorates in the United States. Of these geoscience post-doctorates, 36% were female and 70% were white. Most geoscience post-doctorates are supported by funds from the federal government sources, particularly the National Science Foundation, but 38% of post-doctorates are supported by non-federal industry funding sources.

**Figure 5.1: Bachelor's Graduates Seeking or Have Accepted a Position within the Geosciences, 2013-2017**



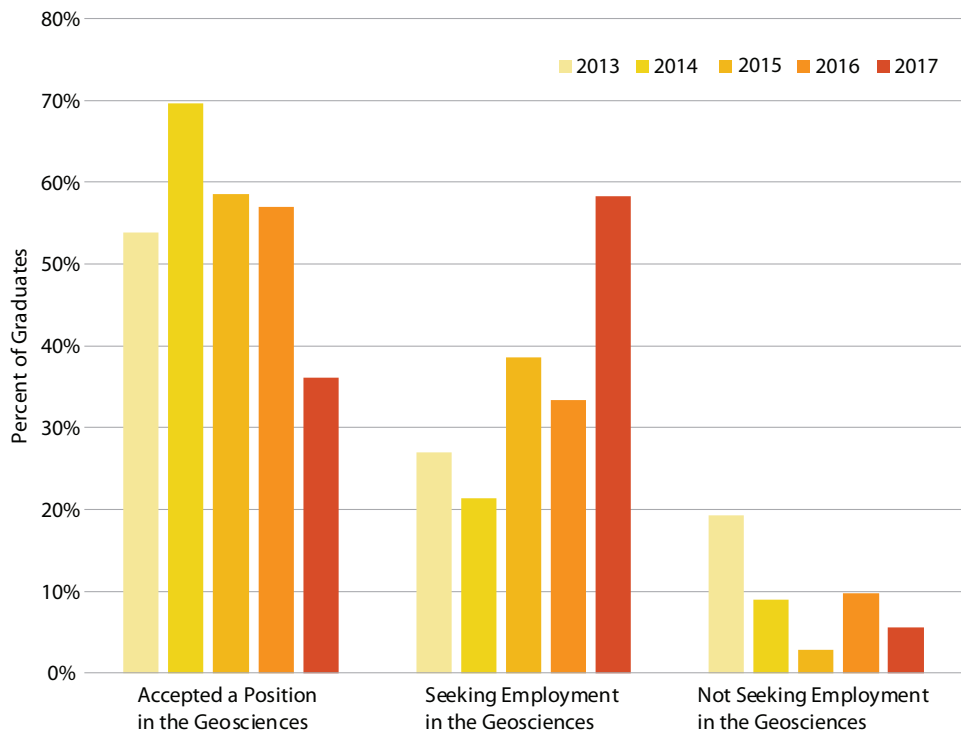
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.2: Master's Graduates Seeking or Have Accepted a Position within the Geosciences, 2013-2017**



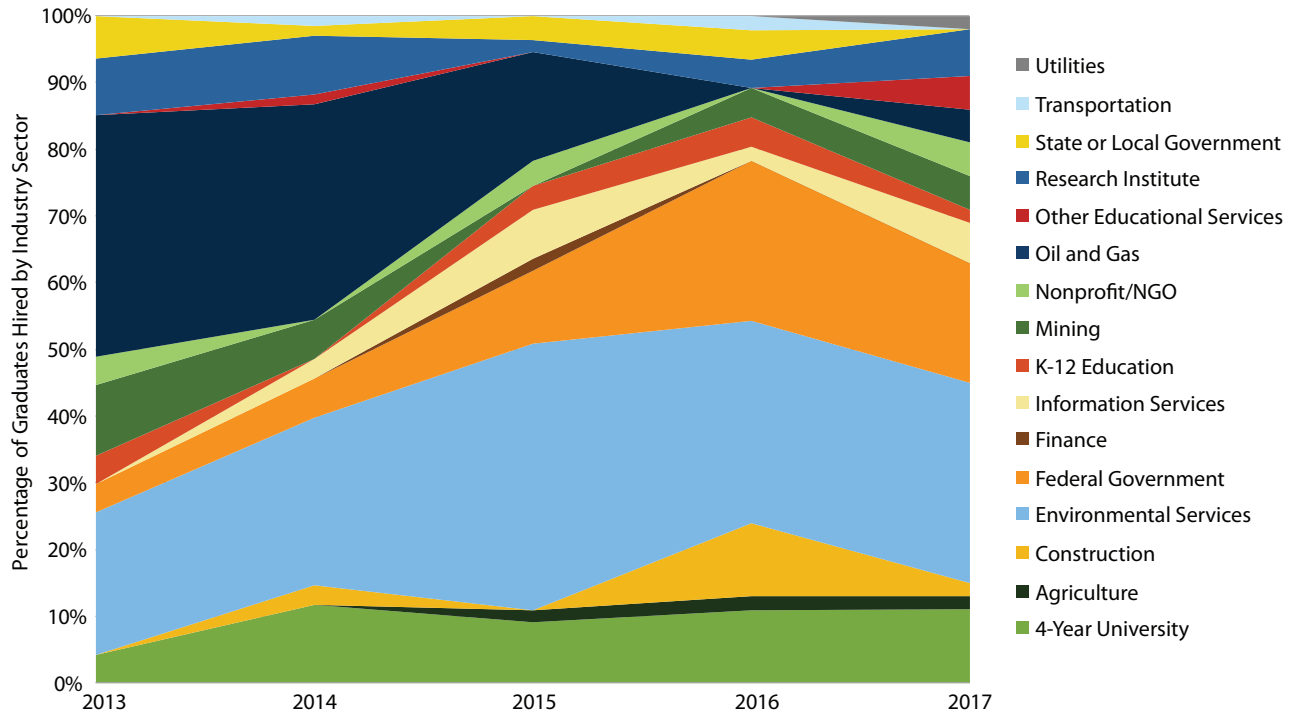
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.3: Doctoral Graduates Seeking or Have Accepted a Position within the Geosciences, 2013-2017**



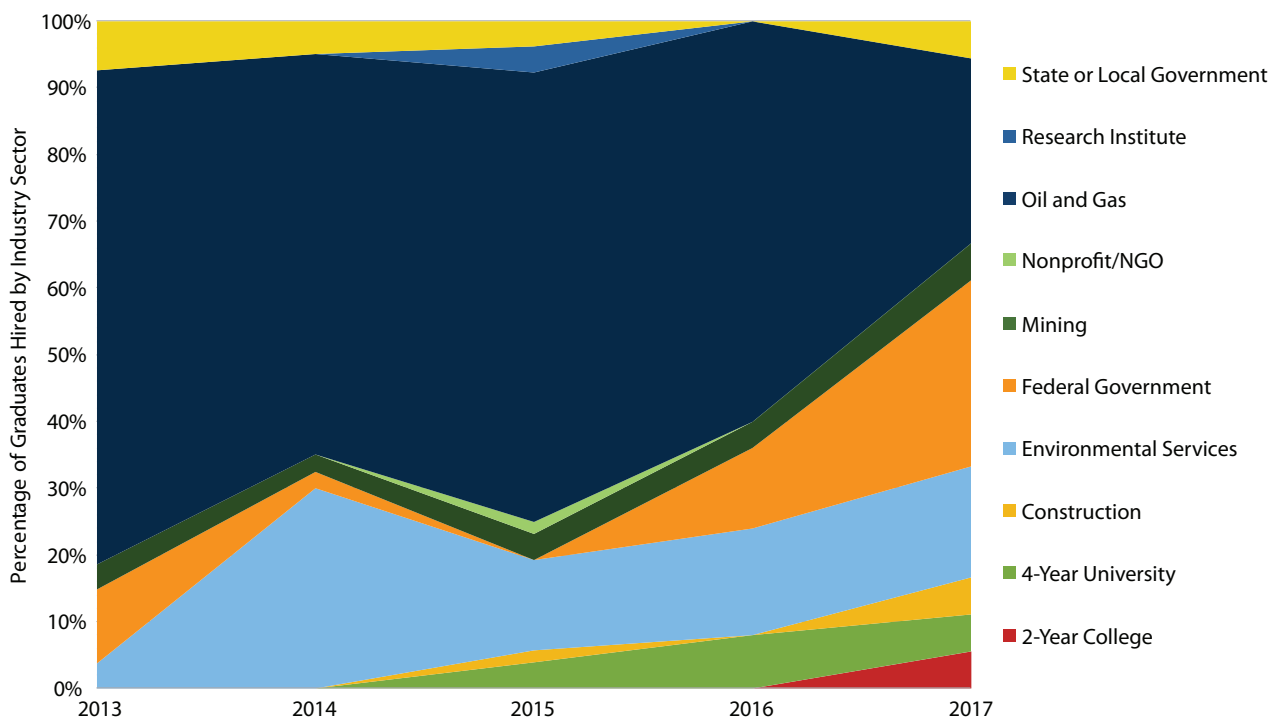
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.4: Industries Hiring Bachelor's Graduates, 2013-2017**



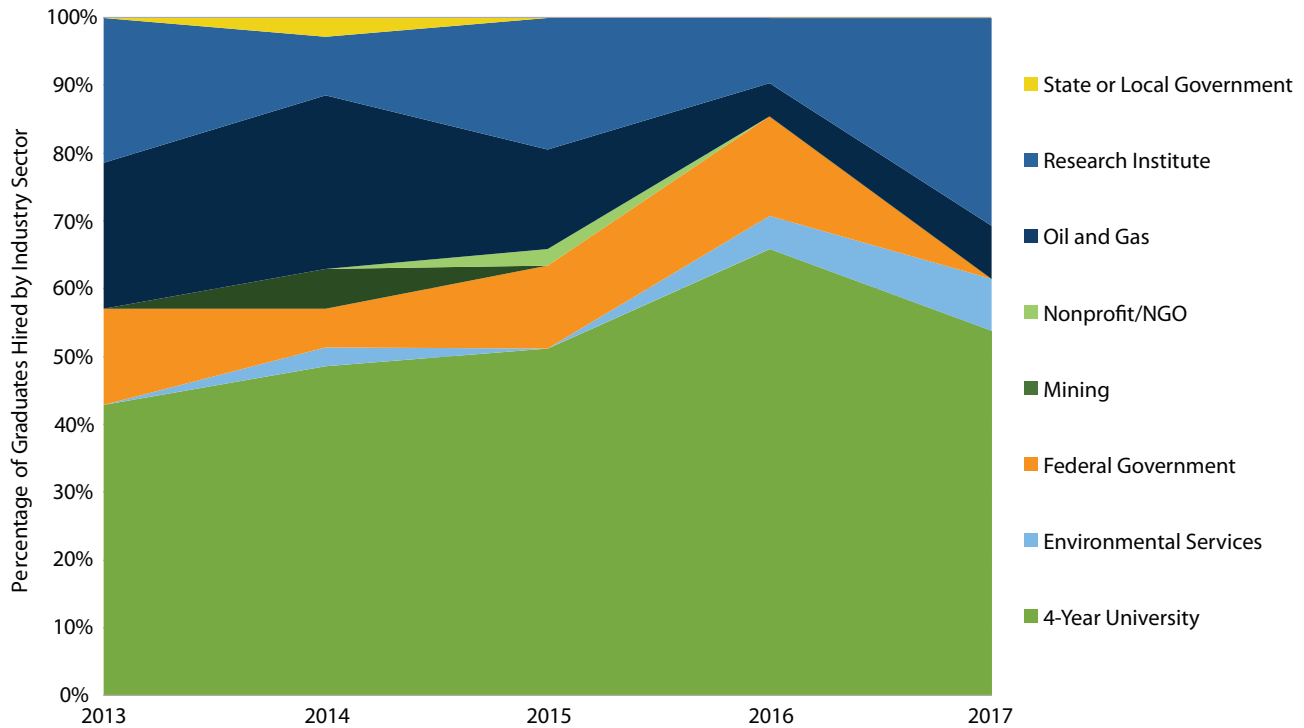
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.5: Industries Hiring Master's Graduates, 2013-2017**



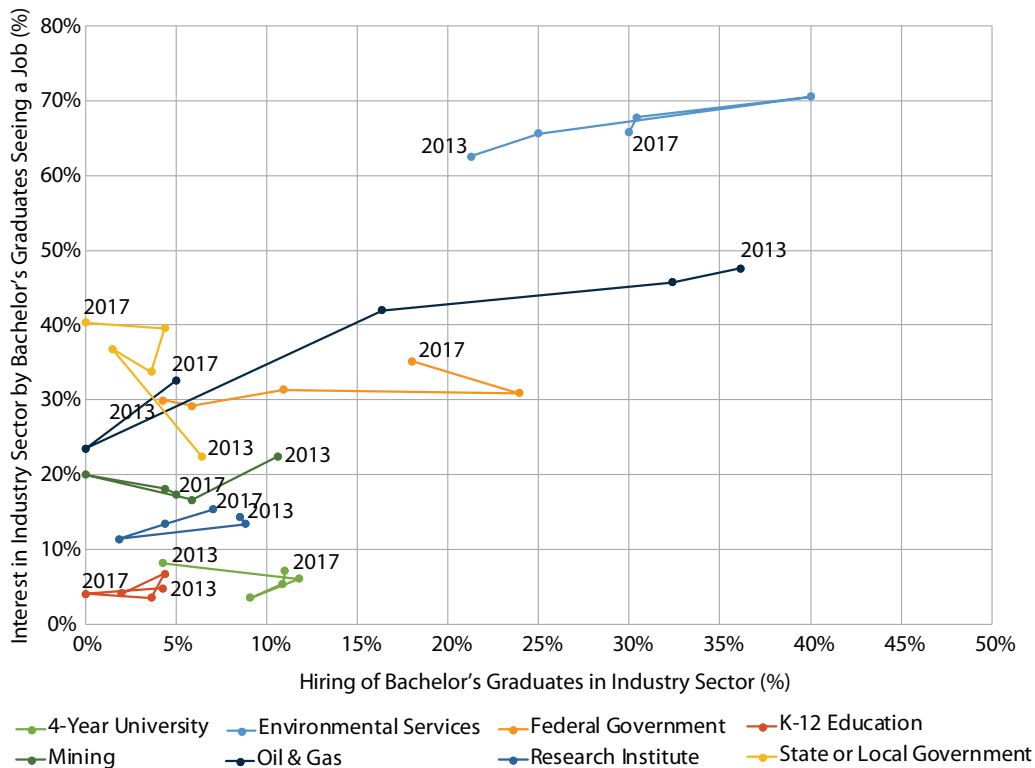
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.6: Industries Hiring Doctoral Graduates, 2013-2017**



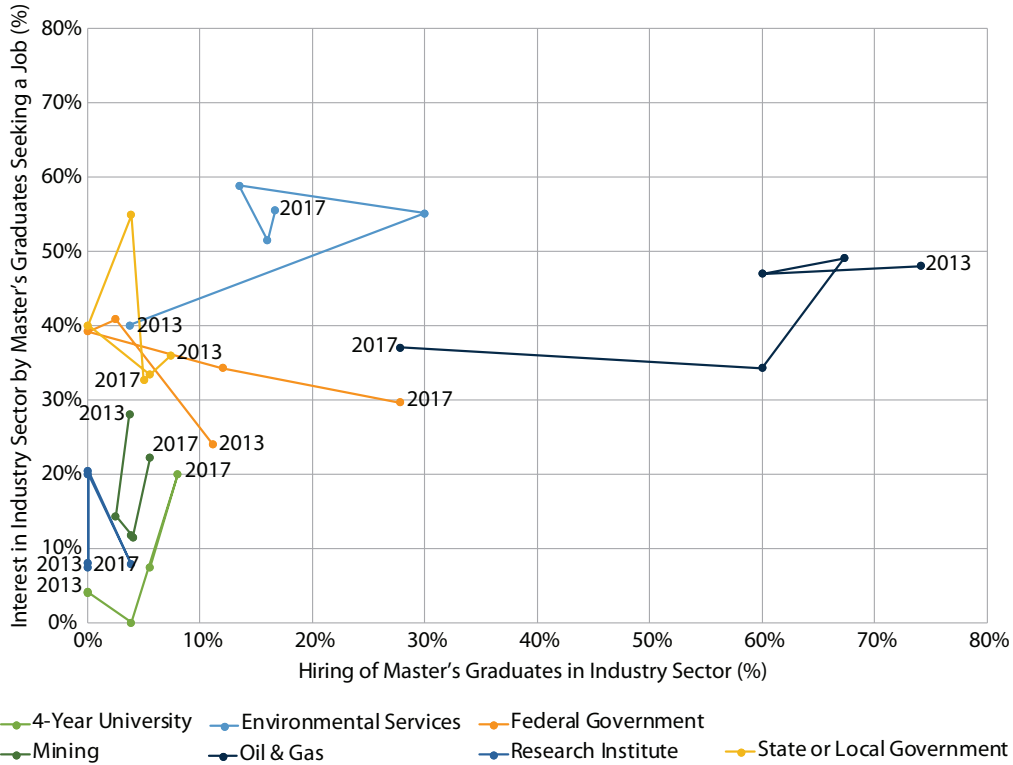
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.7: Changing Interest vs Hiring of Bachelor's Graduates Within Certain Industries, 2013-2017**



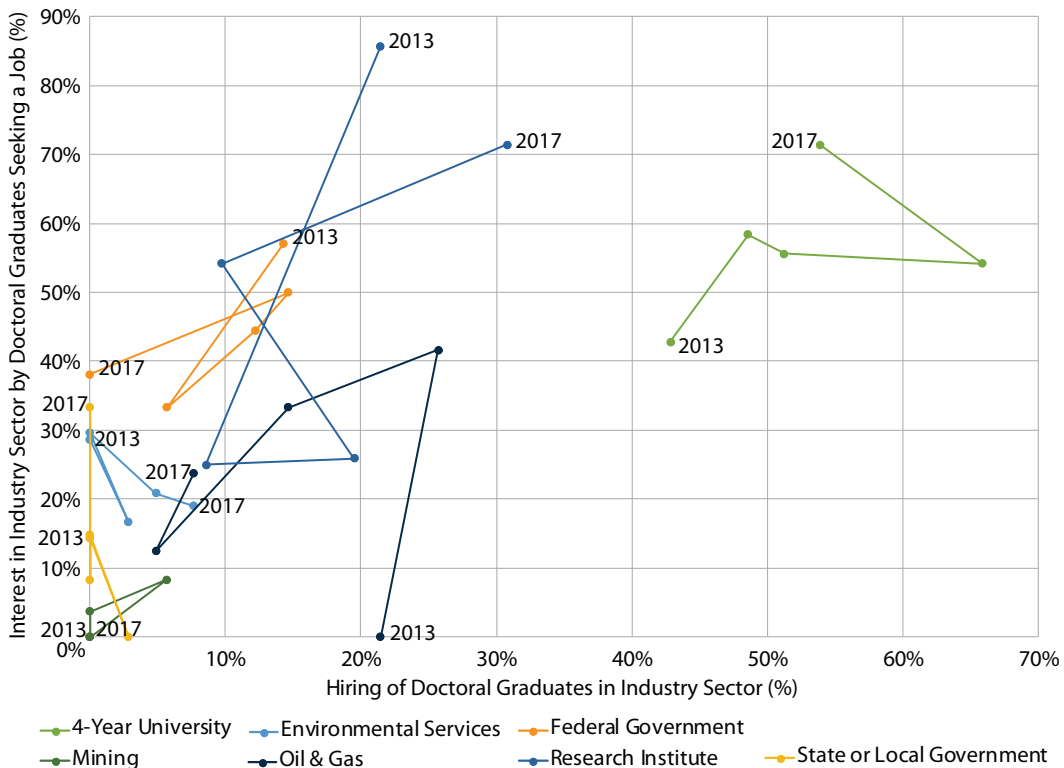
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.8: Changing Interest vs Hiring of Master's Graduates within Certain Industries, 2013-2017**



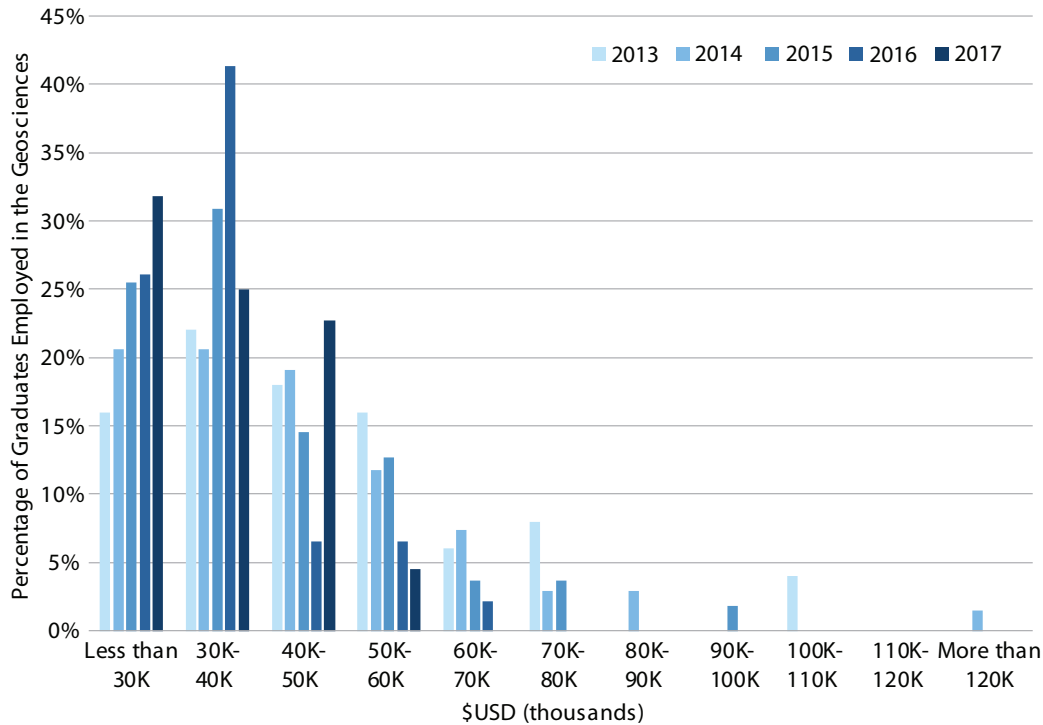
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.9: Changing Interest vs Hiring of Doctoral Graduates within Certain Industries, 2013-2017**



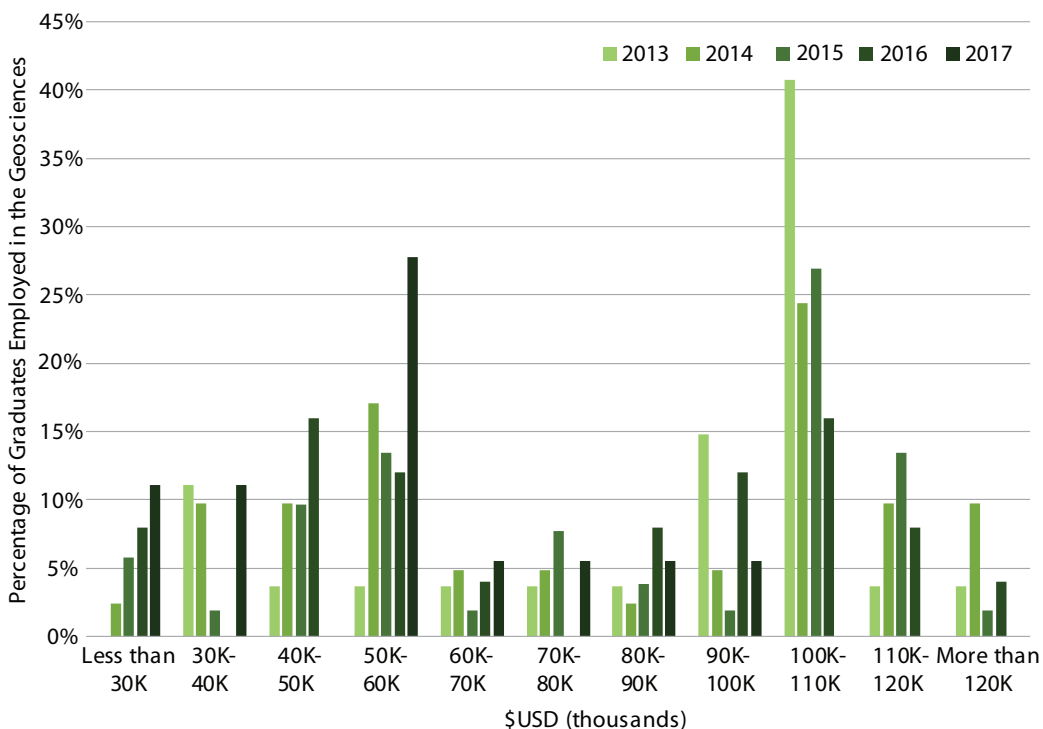
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.10: Starting Annual Salaries for Employed Bachelor's Graduates, 2013-2017**



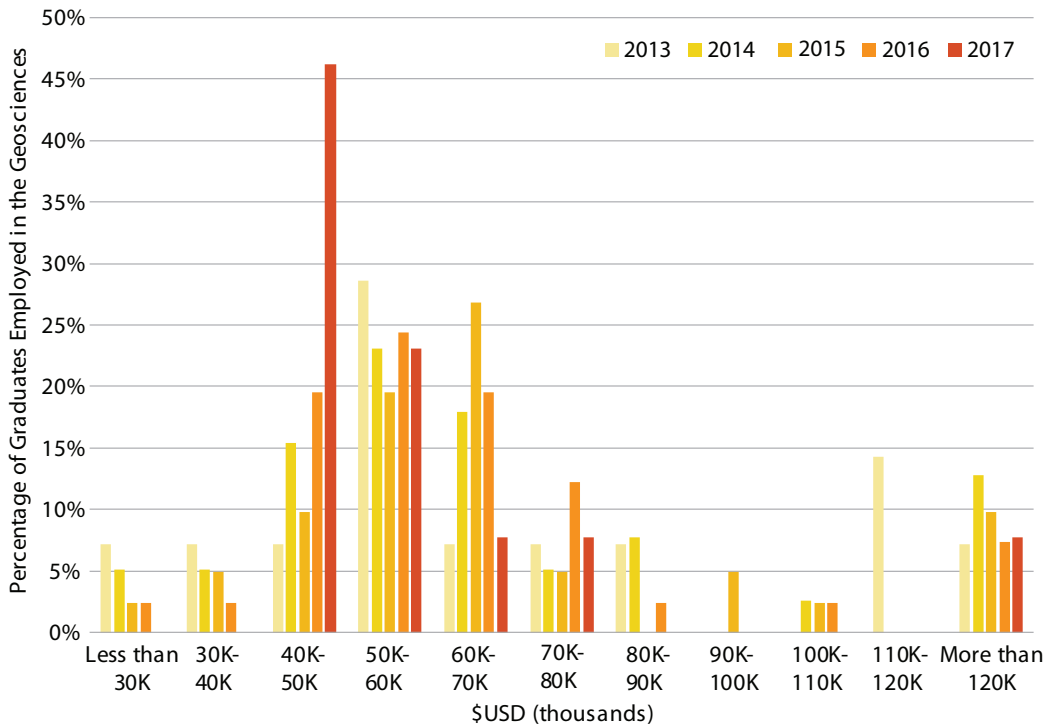
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.11: Starting Annual Salaries for Employed Master's Graduates, 2013-2017**



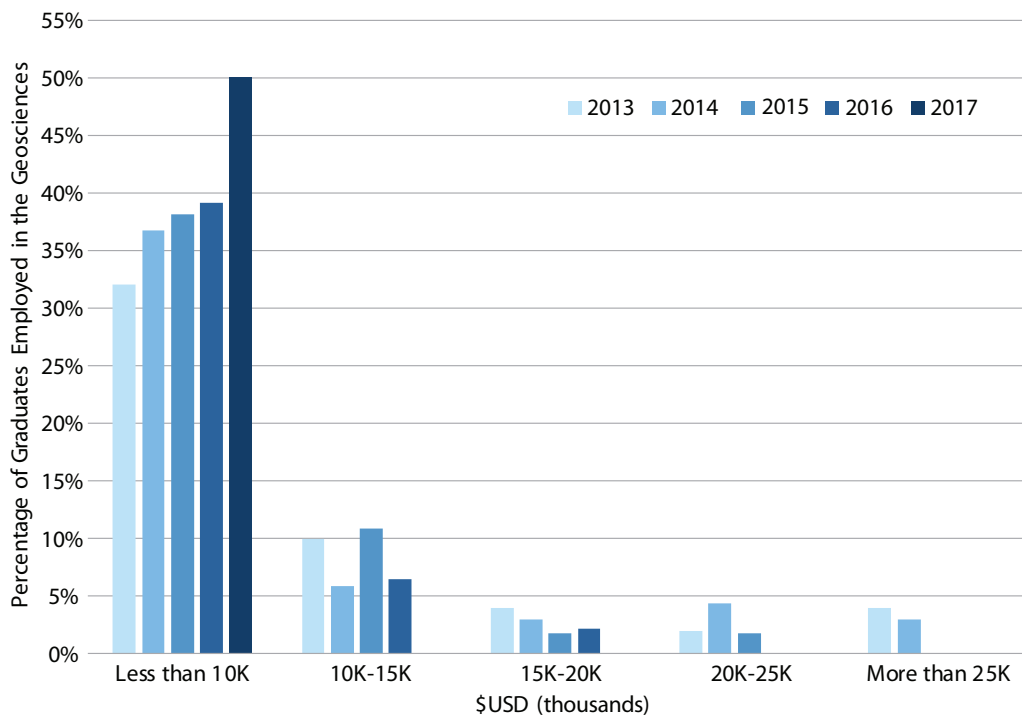
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.12: Starting Annual Salaries for Employed Doctoral Graduates, 2013-2017**



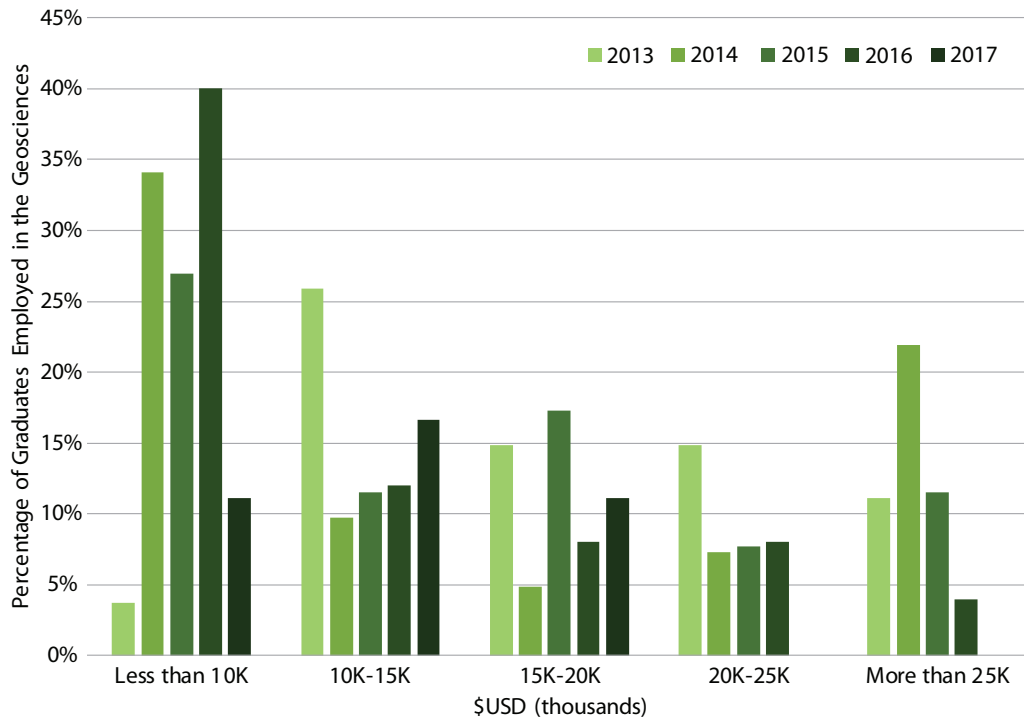
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.13: Additional Compensation Granted to Bachelor's Graduates with a Geoscience Job, 2013-2017**



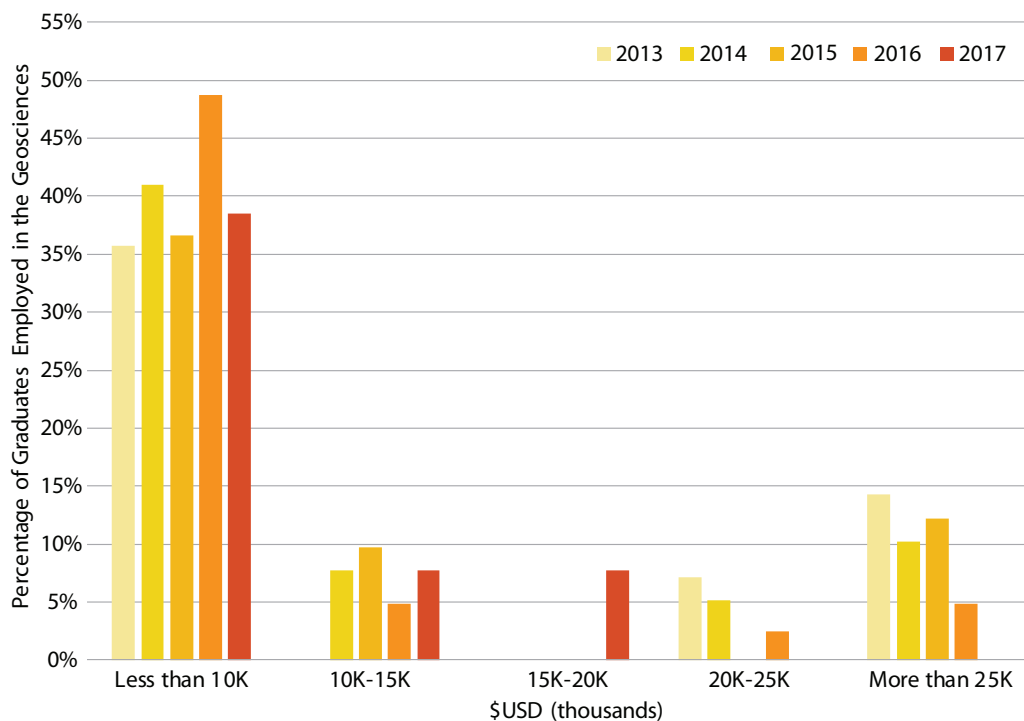
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.14:** Additional Compensation Granted to Master's Graduates with a Geoscience Job, 2013-2017



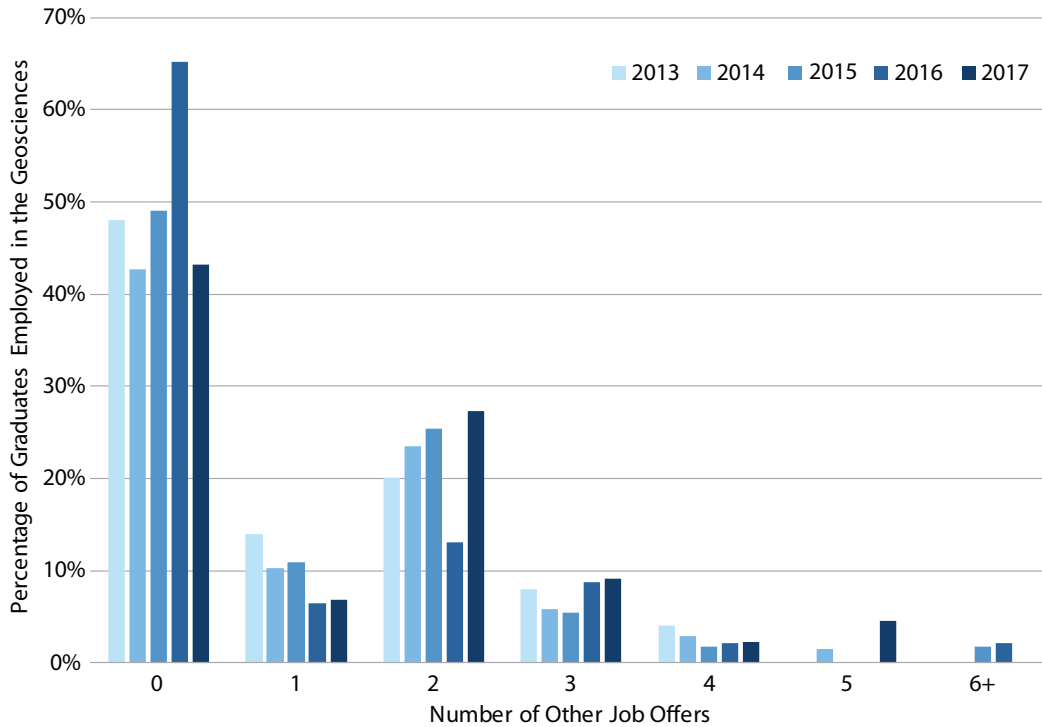
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.15:** Additional Compensation Granted to Doctoral Graduates with a Geoscience Job, 2013-2017



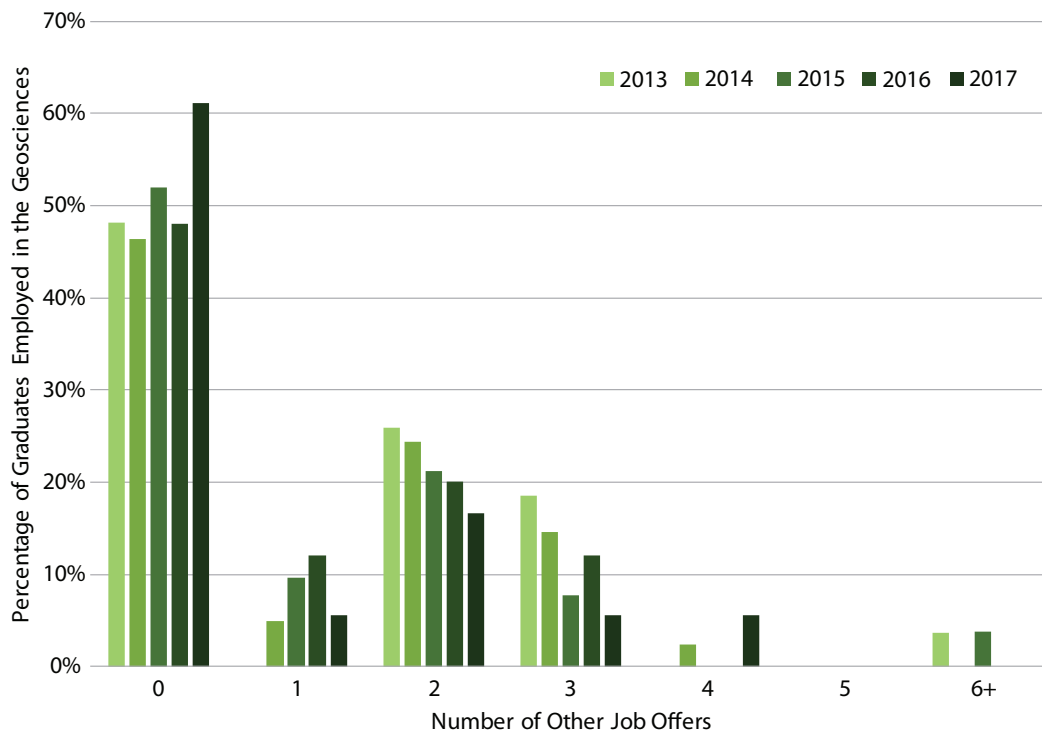
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.16: Other Geoscience Job Opportunities Offered to Employed Bachelor's Graduates, 2013-2017**



AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.17: Other Geoscience Job Opportunities Offered to Employed Master's Graduates, 2013-2017**



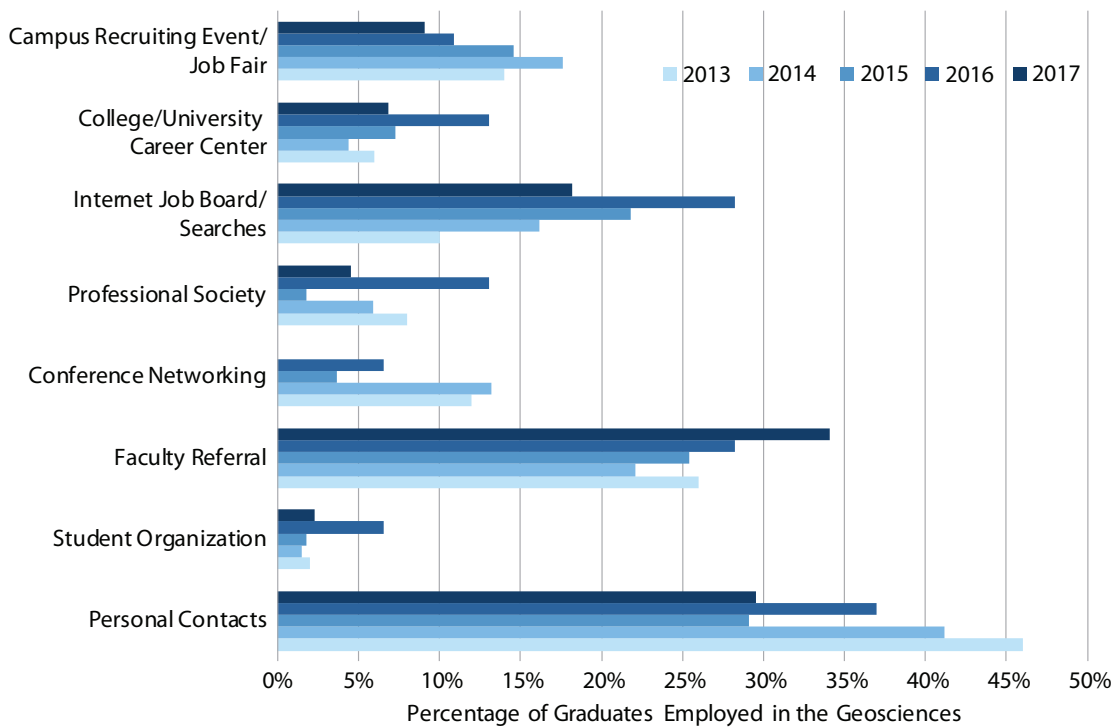
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.18: Other Geoscience Job Opportunities Offered to Doctoral Graduates, 2013-2017**



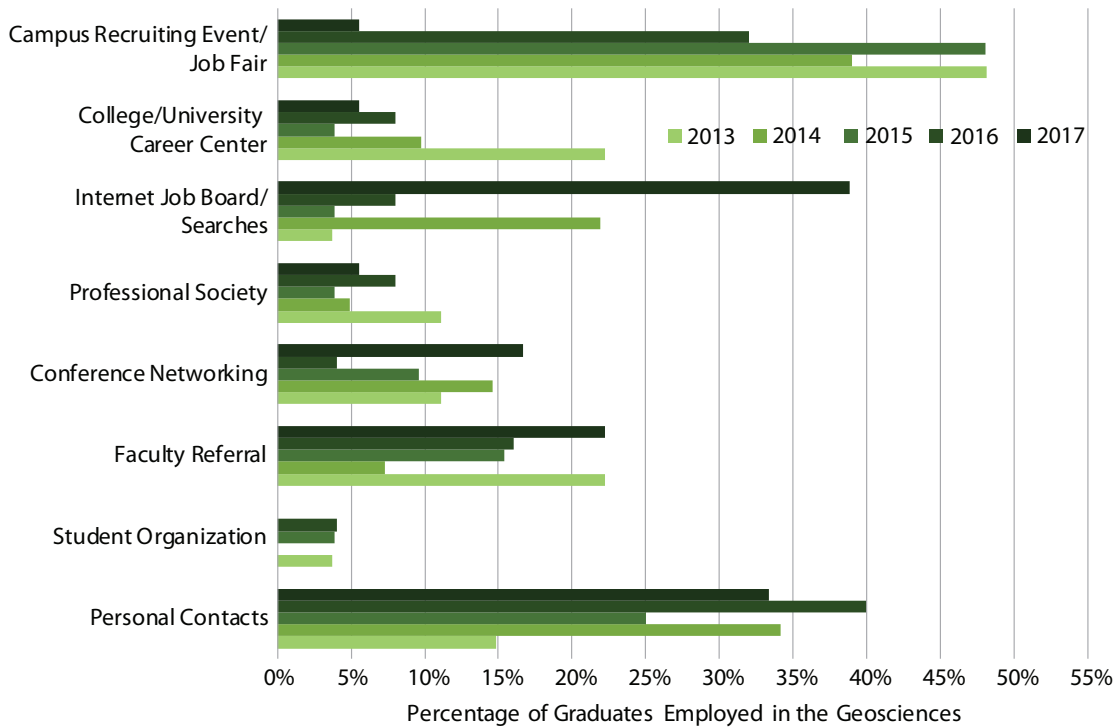
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.19: Useful Job Search Resources Used by Bachelor's Graduates, 2013-2017**



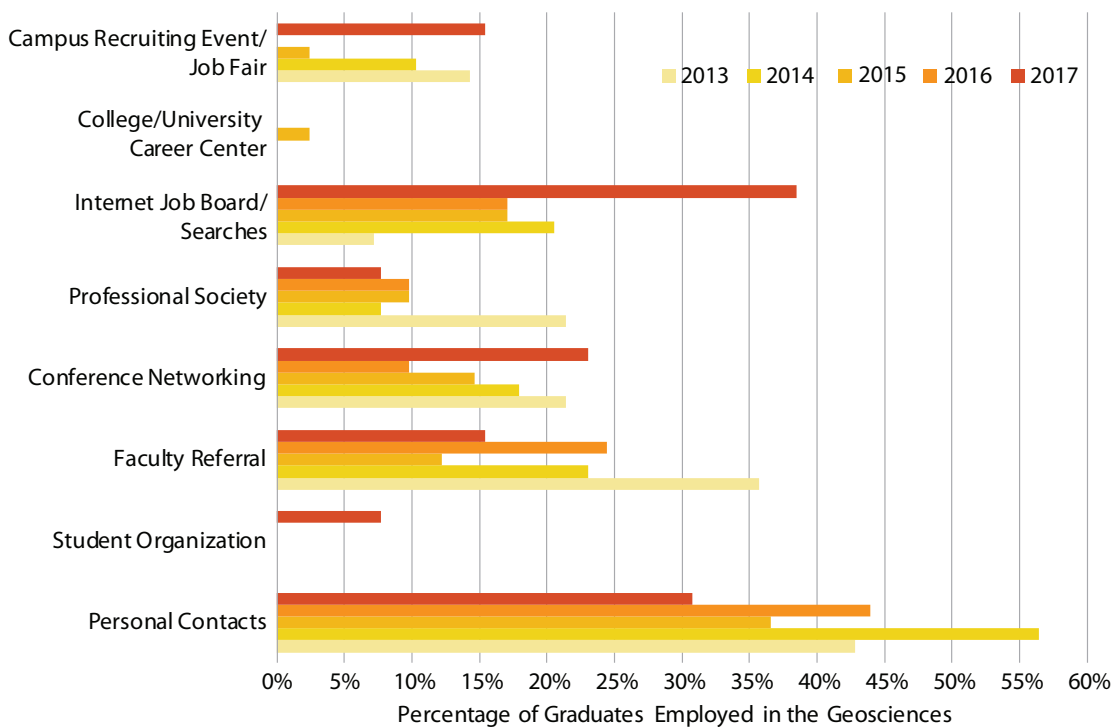
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.20: Useful Job Search Resources Used by Master's Graduates, 2013-2017**



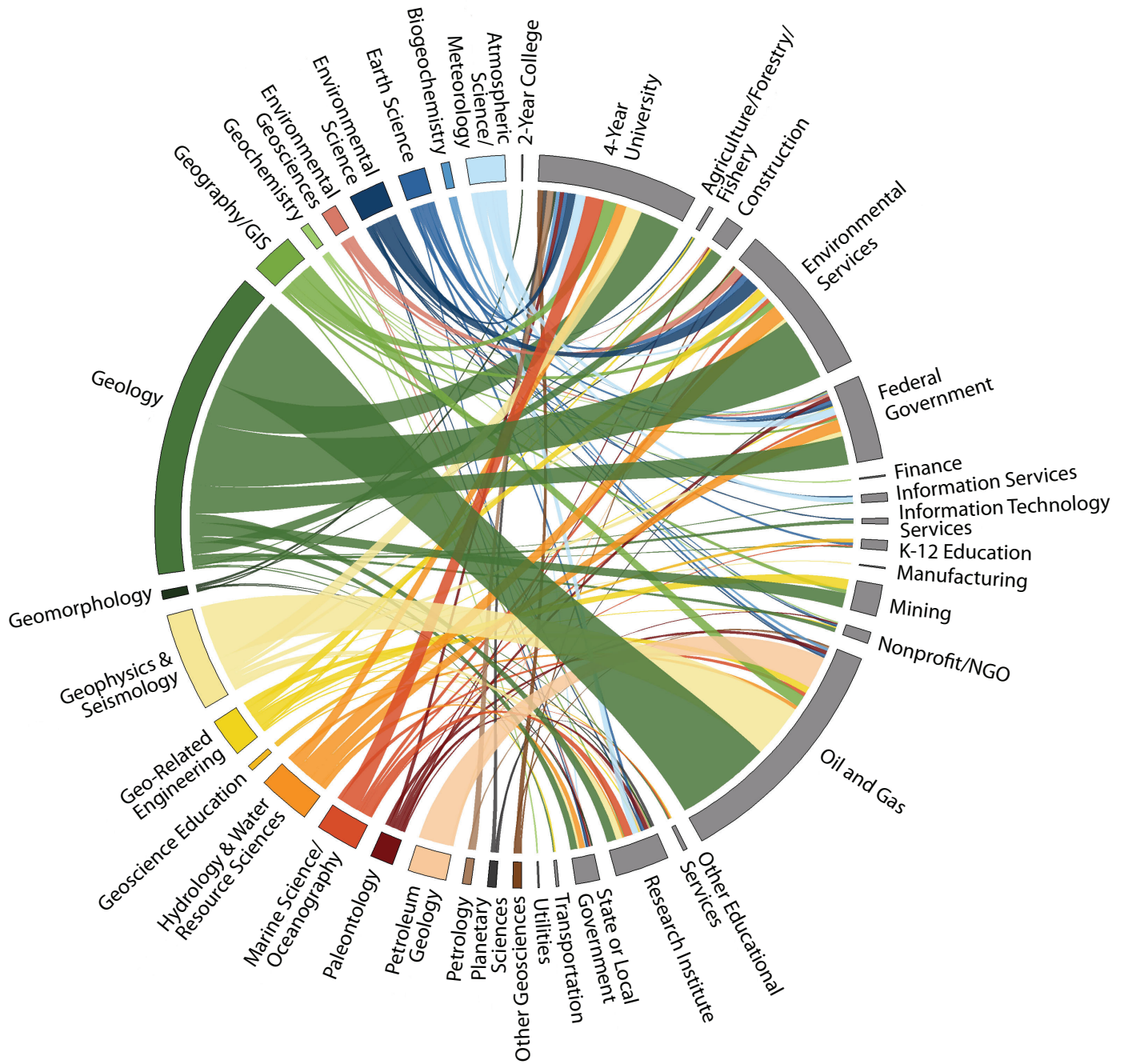
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.21: Useful Job Search Resources Used by Doctoral Graduates, 2013-2017**



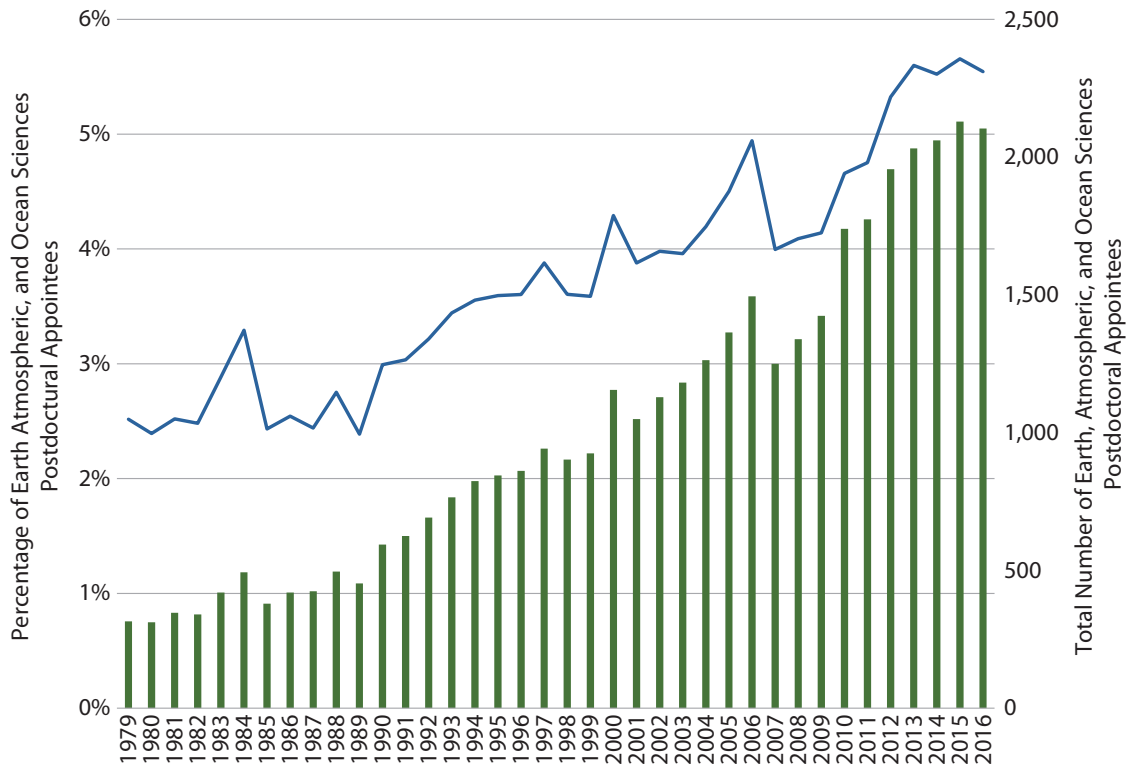
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.22: Industries of Geoscience Graduates' First Jobs by Degree Field (2013-2017)**



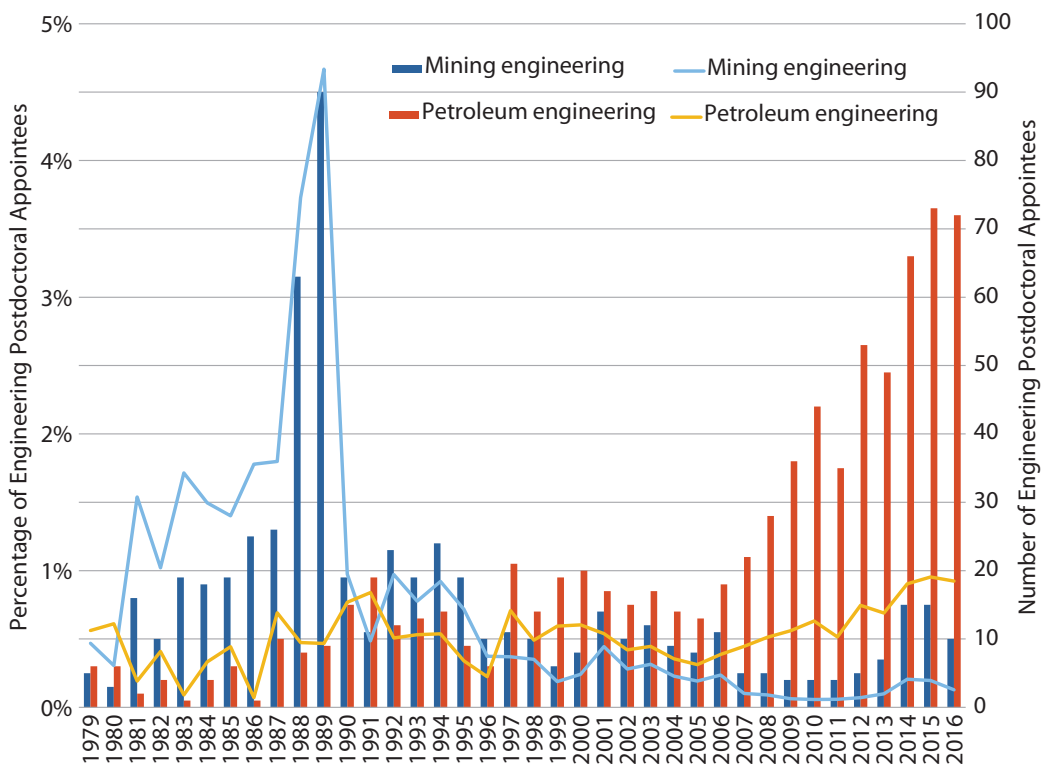
AGI Geoscience Workforce Program; Data derived from AGI's Geoscience Student Exit Survey

**Figure 5.23: Geoscience Postdoctoral Appointees, 1979-2016**



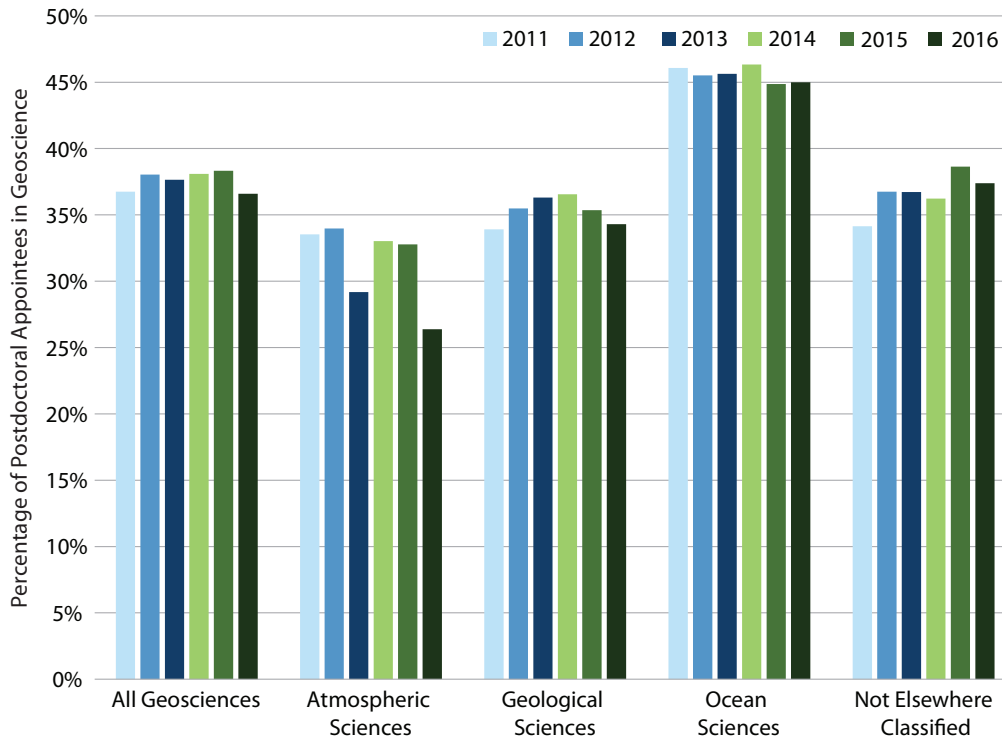
AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

**Figure 5.24: Mining and Petroleum Engineering Postdoctoral Appointees, 1979-2016**



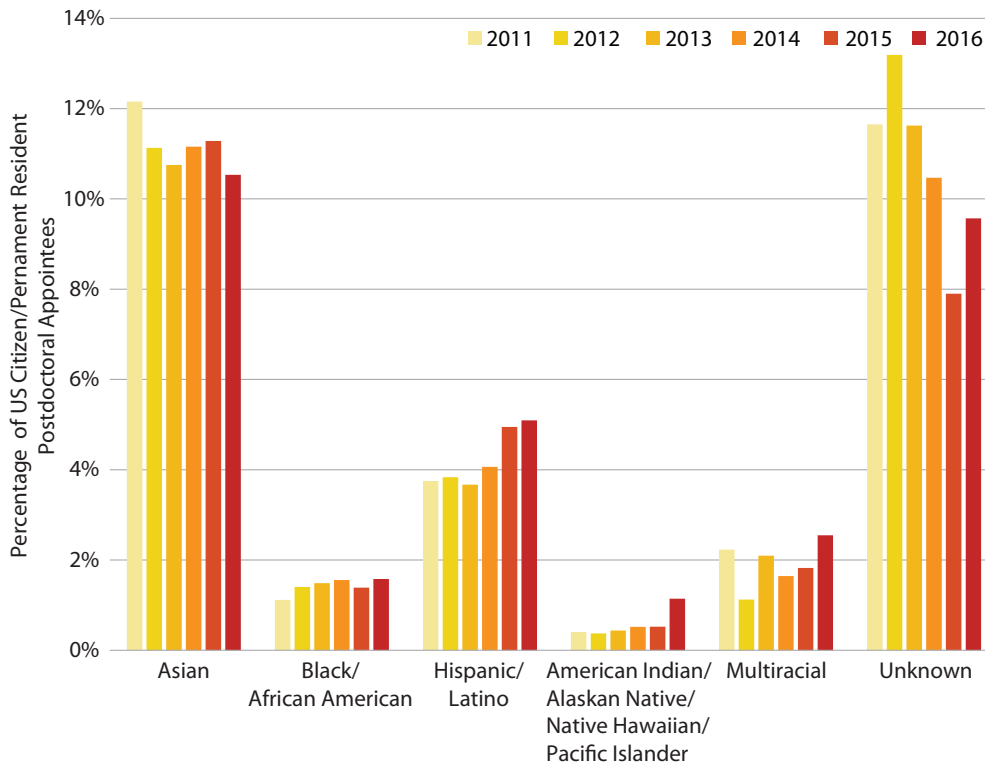
AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

**Figure 5.25: Percentage of Female Geoscience Postdoctoral Appointees**



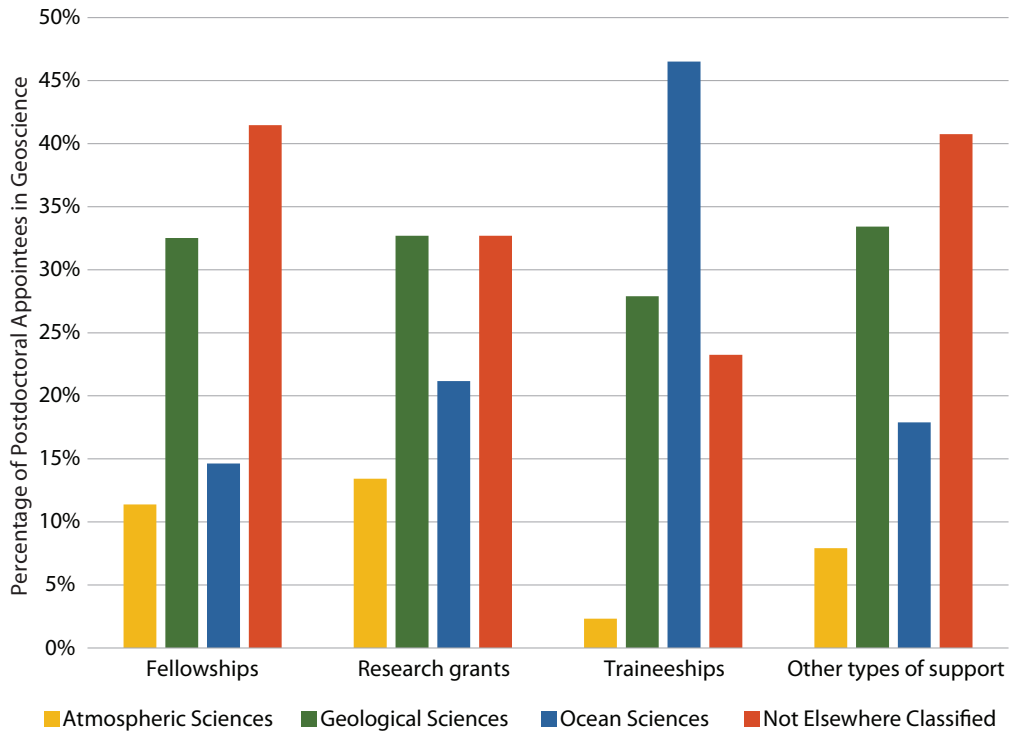
AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

**Figure 5.26: Race/Ethnicity of Geoscience Postdoctoral Appointees**



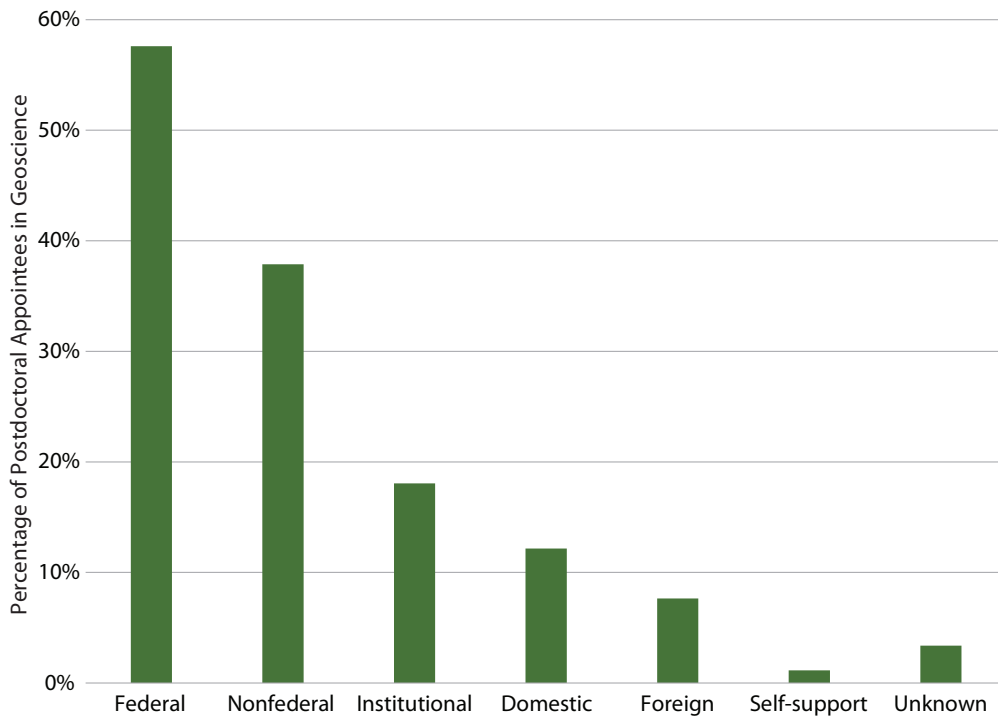
AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

**Figure 5.27: Mechanisms of Support for Geoscience Postdoctoral Appointees, 2016**



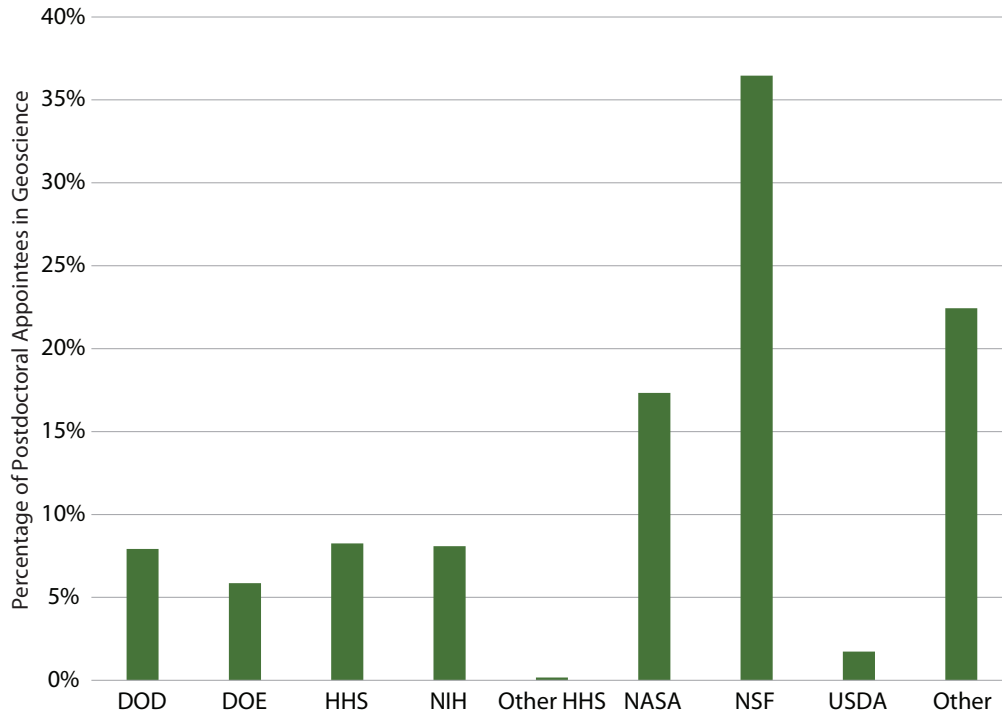
AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

**Figure 5.28: Primary Source of Funding for Geoscience Postdoctoral Appointees, 2016**



AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

**Figure 5.29:** Primary Source of Federal Funding for Geoscience Postdoctoral Appointees, 2016



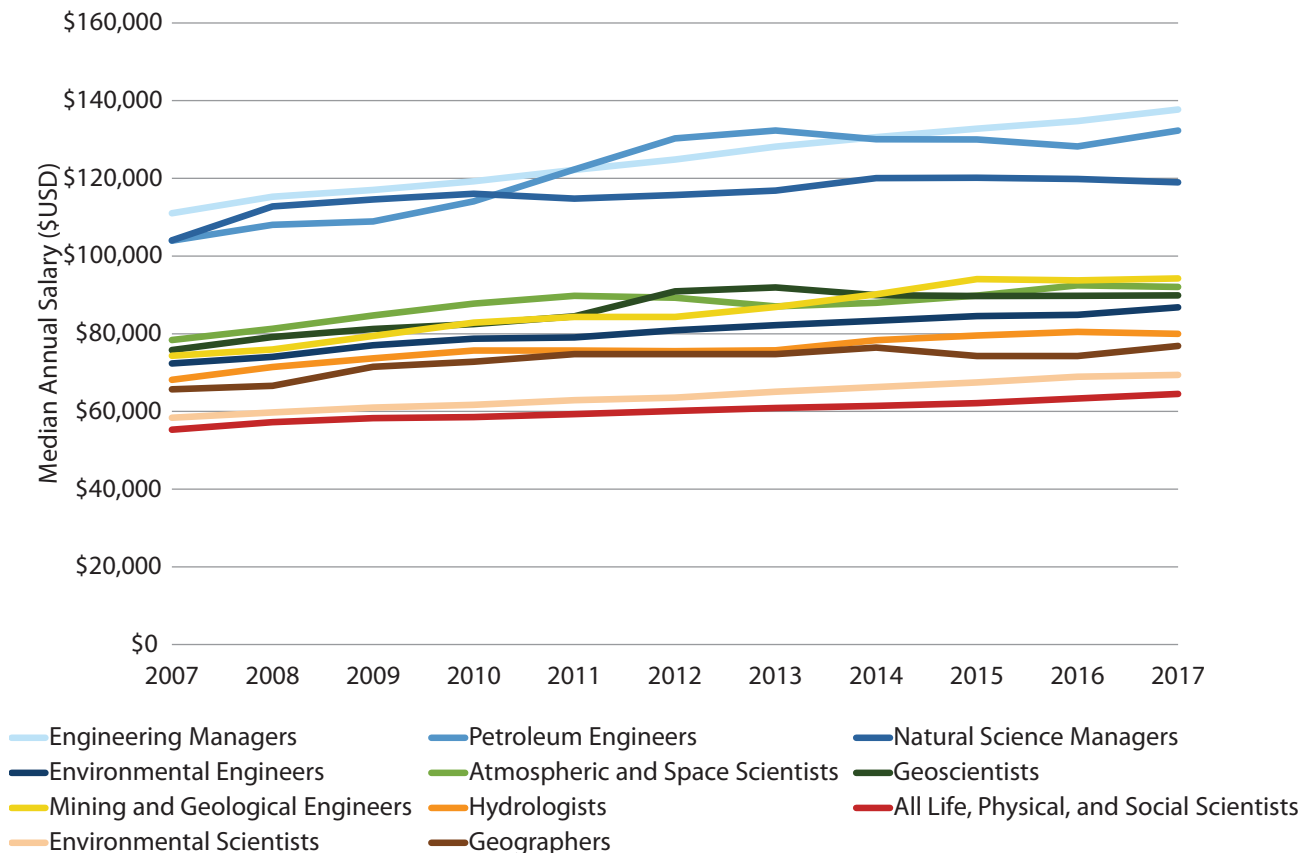
AGI Geoscience Workforce Program; Data derived from Survey of Graduate Students and Postdocs in Science and Engineering

## Salary Trends for Geoscience Occupations

Median occupation salaries present a more realistic typical salary for a particular occupation compared to mean salaries. Geoscience salaries have increased by 1.7% since 2015, which was lower than the growth seen in other science occupations (3.7%) and among all U.S. occupations (4%) (Figure 5.3). In 2017, the geoscience occupations with the highest median salaries were for engineering managers (\$137,720), petroleum

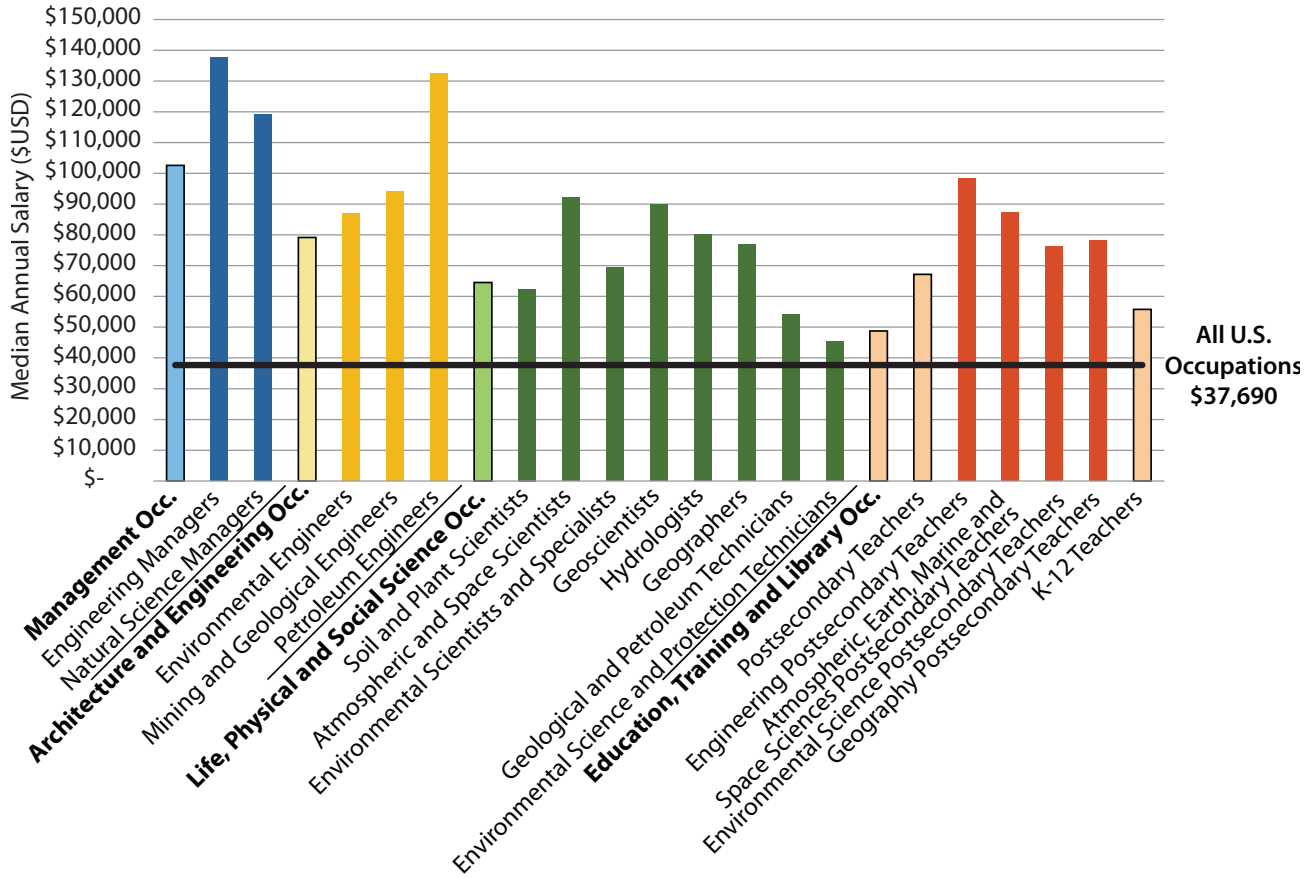
engineers (\$132,280), natural science managers (\$118,970), and mining and geological engineers (\$94,240). Figure 5.31 details the median salaries of geoscience occupations compared to larger groups of occupations for 2017. All geoscience occupations have a median salary above the overall national average salary of \$37,690 in the United States, which again reinforces that the geosciences often lead to a lucrative career field in the U.S.

**Figure 5.30: Median Annual Salaries of Geoscience Occupations (2007-2017)**



AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, National Occupational Employment and Wage Estimates

**Figure 5.31: Median Annual Salaries of Geoscience Occupations, 2017**



AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, National Occupational Employment and Wage Estimates

## Demographics of the Geoscience Profession

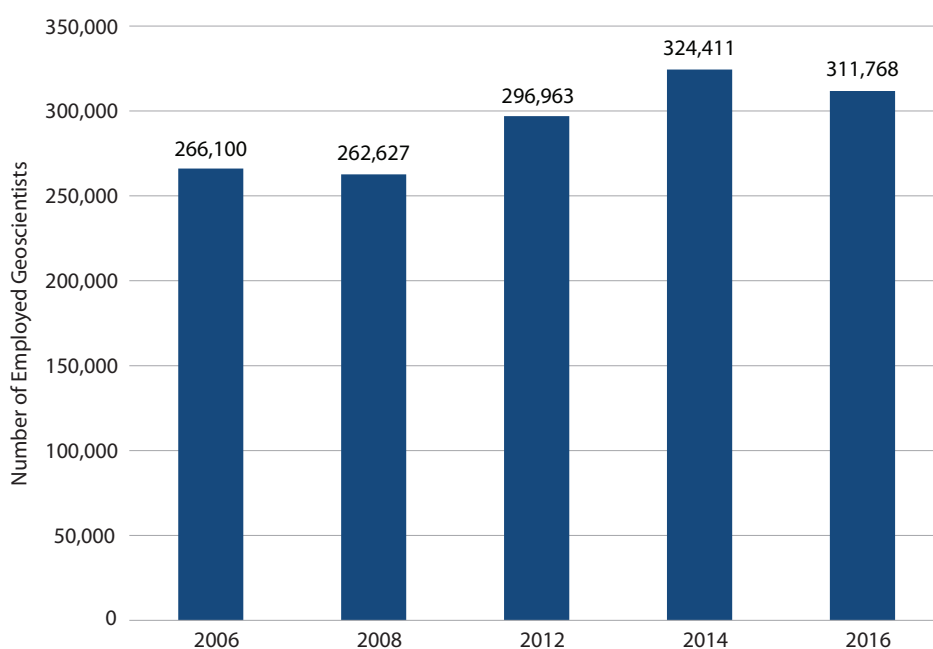
From 2014 to 2016 there was a slight decrease in the total number of geoscientists employed in the United States (Figure 5.32). For the 2016 edition of the report, the total number of geoscientists employed in 2014 included the number of postsecondary teachers in atmospheric sciences, earth sciences, marine sciences, space sciences, environmental sciences, and geography fields as counted by the Bureau of Labor Statistics. When reviewing the list of occupations by the Bureau of Labor Statistics, it became clear that these occupations should be included in the counts of total geoscientists. Considering that change, the total number of geoscientists employed in the United States have only seen small changes since 2012. A large majority of the geoscientists working in the U.S. have occupations within the professional, scientific, and technical services industry. This industry includes occupations related to research facilities, testing laboratories, and architectural engineering (Figure 5.33). When looking at the various occupations within the geoscience workforce, most geoscientists tend to fall into the environmental scientist and environmental engineer occupation categories (Figure 4.13). Between 2014 and 2016 there were small decreases in the number of geoscientists in nearly all the

occupation categories, except soil and plant scientists and conservation scientists.

Since 2008, the percentage of female geoscientists and environmental scientists fluctuated between 25% and 30%, but in 2017, this percentage increased to 35%. In previous editions of the report, data on female representation in the geoscience workforce from the National Science Foundation has also been included, but when reviewing the 2015 dataset for the Survey of College Graduates, the data showed quality issues when constrained to geoscientists.

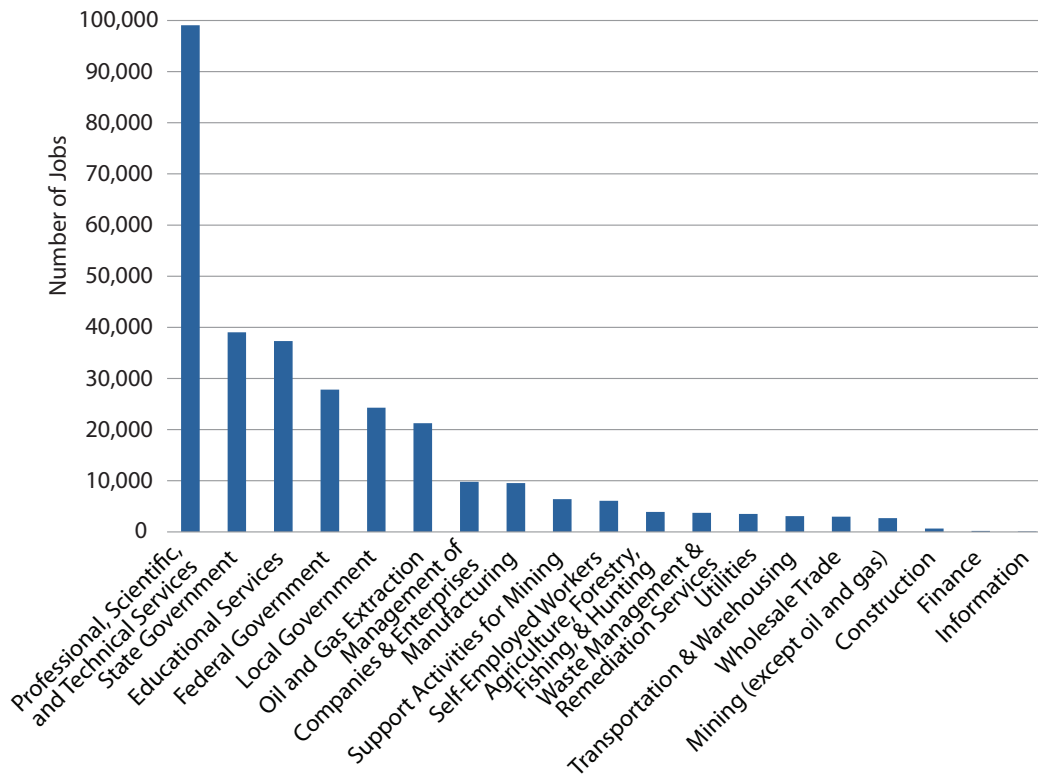
There is a discrepancy between the data on underrepresented minorities in the geoscience workforce from the Bureau of Labor Statistics and the National Science Foundation. According to the BLS, the percentage of underrepresented minority geoscientists increased to 10% in 2017 (Figure 5.36). However, the NSF reported that 14% of geoscientists were from underrepresented minority groups in 2015 (Figure 5.37). This discrepancy may be related to data collection methods or ongoing changes in accounting for multi-racial options in demographic surveys.

**Figure 5.32:** Total Number of Employed Geoscientists in the United States



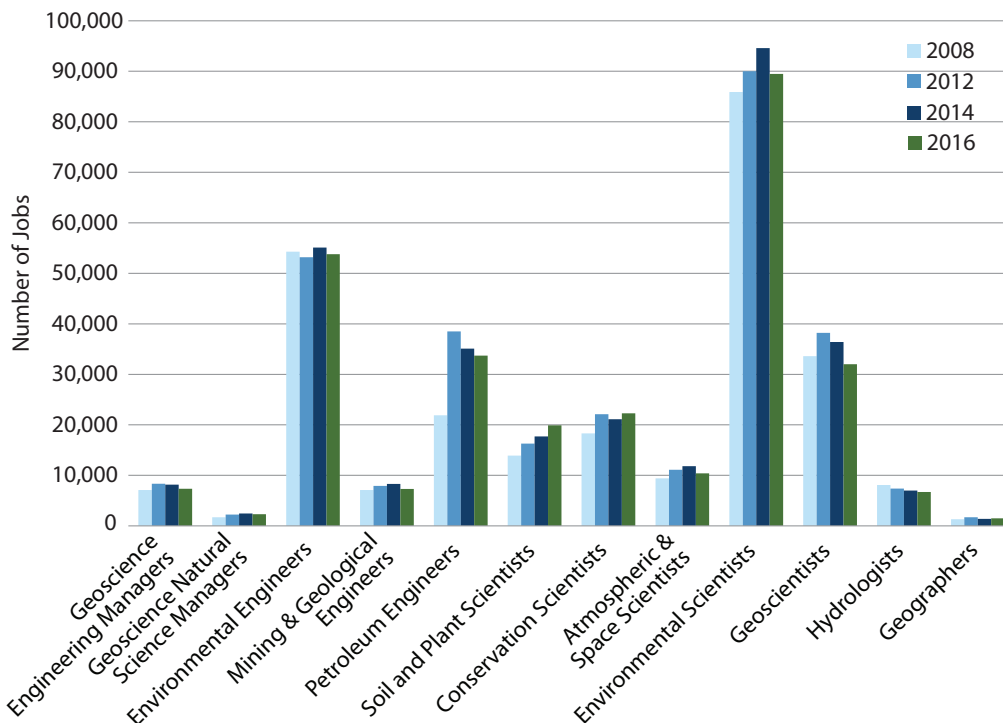
AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Employment Projections

**Figure 5.33: Number of Geosciences Jobs by Industry Sector in 2016**



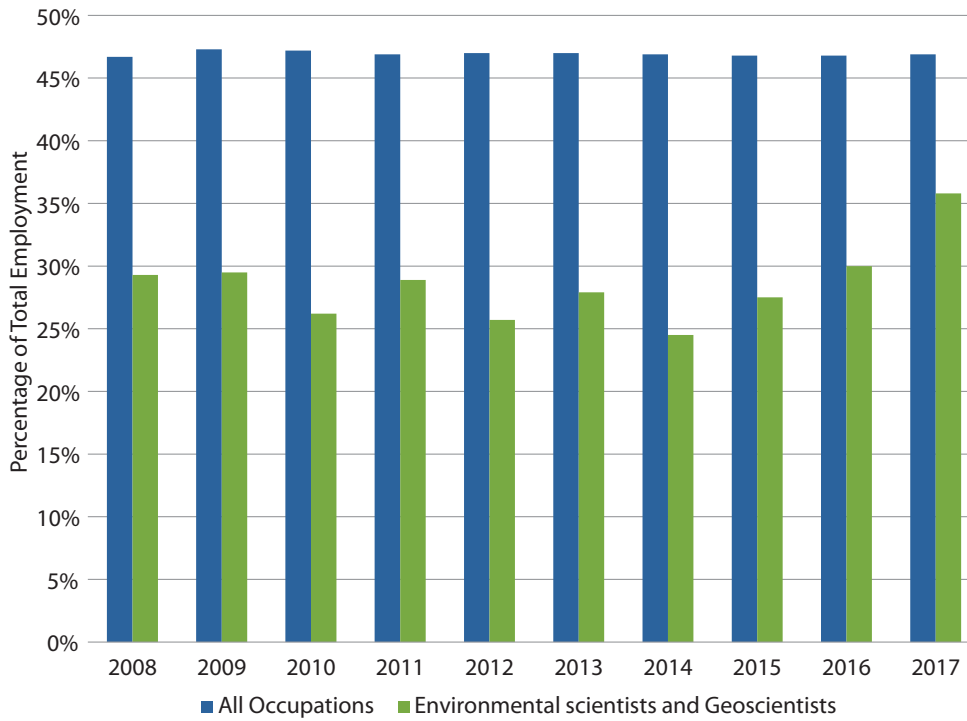
AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Employment Projections

**Figure 5.34: Current Employment for Detailed Geoscience Occupations (2008-2016)**



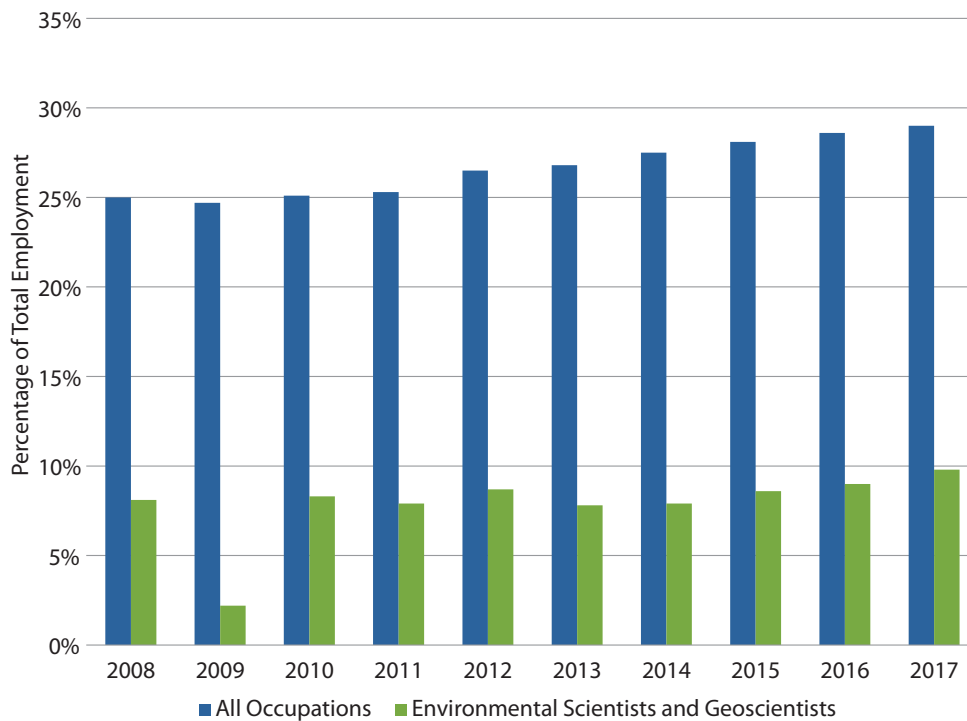
AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Employment Projections

**Figure 5.35: Percentage of Women in Environmental Science and Geoscience Occupations**



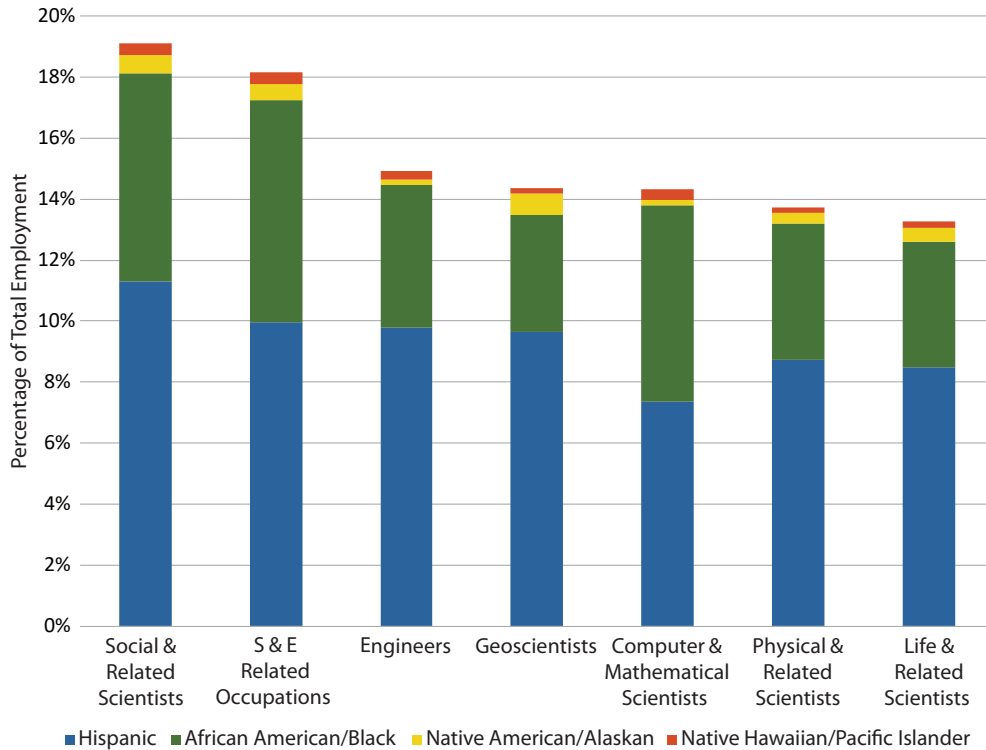
AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Current Population Survey

**Figure 5.36: Percentage of Underrepresented Minorities in Environmental Science and Geoscience Occupations**



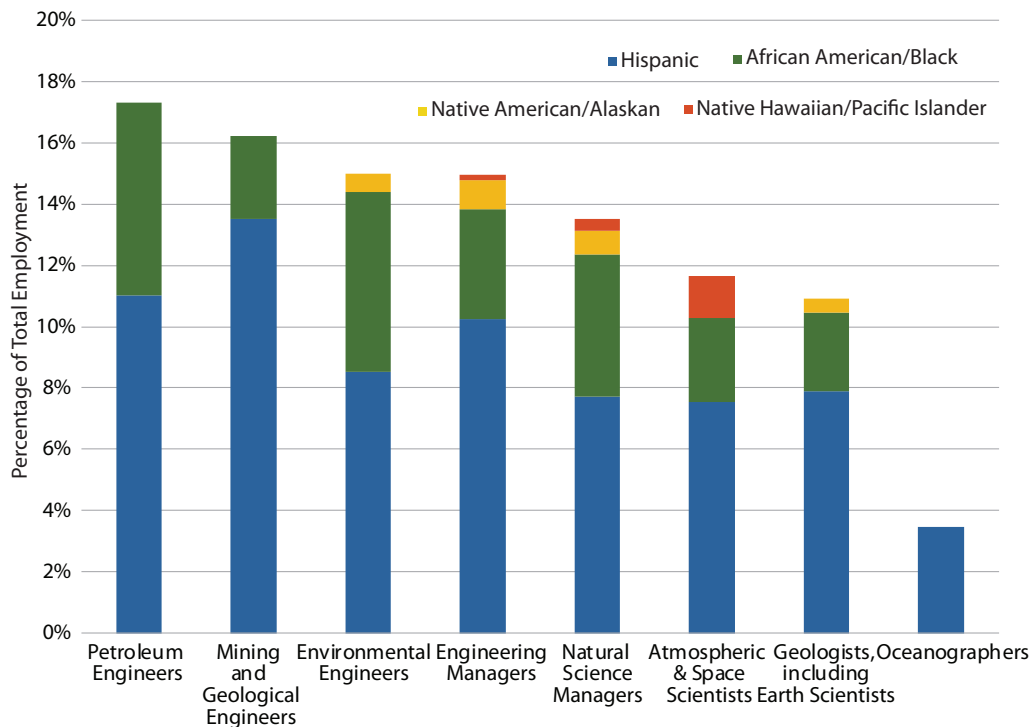
AGI Geoscience Workforce Programs; Data derived from the US Bureau of Labor Statistics, Current Populations Survey

**Figure 5.37: Percentage of Underrepresented Minorities in Geoscience and Other Science and Engineering Occupations, 2015**



AGI Geoscience Workforce Program; Data derived from NSF's Survey of College Graduates 2015 public-use data files

**Figure 5.38: Percentage of Underrepresented Minorities in Detailed Geoscience Occupations, 2015**



AGI Geoscience Workforce Program; Data derived from NSF's Survey of College Graduates 2015 public-use data files

## Workforce Age Demographics

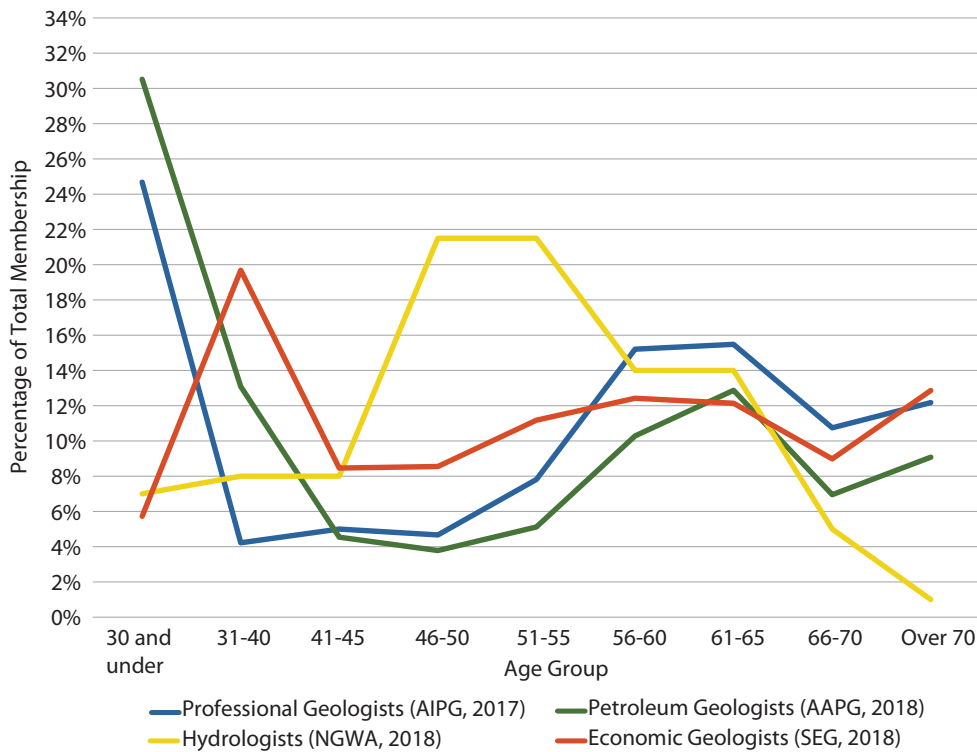
The age distribution of the members of professional societies, such as the American Association of Petroleum Geologists, the American Institute of Professional Geologists, the Society of Economic Geologists, and the National Groundwater Association, provide a representation of the general age distribution of the traditional geoscience workforce. Figures 5.39 and 5.40 present the same data, but Figure 5.39 shows the society membership that are ages 30 and under.

Many geoscience professional societies have actively tried to become more engaged with students and increase their student membership, and a few appear to be successful in this effort. When the student membership data is ignored, the majority of the traditional geoscience workforce is in their late 50s, except the majority of the hydrologists tend to be in their late 40s. The higher percentages seen for the age group 31–40 in Figure 5.40 may still have some artifact of student memberships, but it is also high because it covers 10 years, whereas most of the age groups in this Figure cover geoscientists in 5-year groups. The age distributions of geoscientists in the federal government are trending towards retirement age without clear signs of future replacements for the aging workforce (Figures 5.41–5.49). In fact, the overall employment of geoscientists in the federal government has decreased by 9% since 2009.

According to the National Mining Association, the mining industry continues to have had an influx of young geoscientists for all mining (except oil and gas extraction) and for support activities for mining and oil and gas (Figure 5.50–5.51). However, unlike the professional society distributions, the new entries into the mining industry do not seem to remain through their career. There is a steady decrease in the age of geoscientists in mining and in support activities of mining and oil and gas.

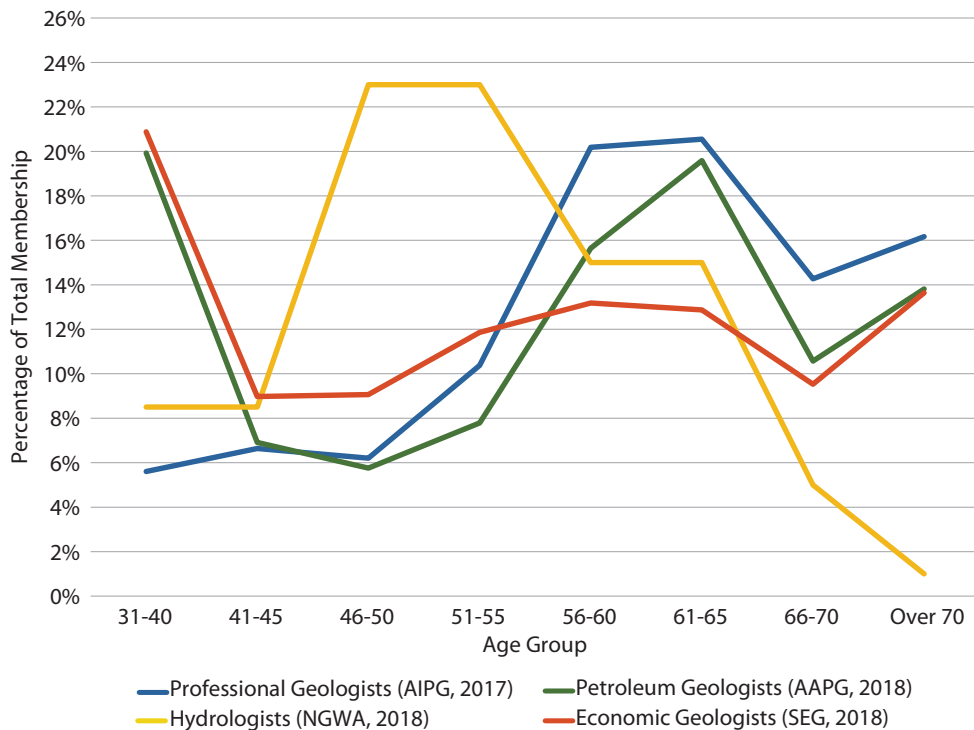
Between 2009 and 2017, there has been minimal change in the age distribution of faculty by rank (Figure 5.52). However, we have seen a small decrease in the age distribution of faculty in all ranks, except for Emeritus faculty and instructors and lecturers since 1990. It does appear that assistant professors in 2017 tended to be a bit younger than in 2015. In 2015, there appeared to be a small hiring gain since 2013, but in 2017, the number of assistant professors decreased by 56 faculty members compared to 2015, indicating slow hiring of new faculty since 2015. Most tenure-track faculty move steadily through the ranks to reach full professor between the ages of 46–50 on average. However, full professors tend to work later in their career, creating a crossover in the population of full professors and emeritus in their 70s.

**Figure 5.39: Geoscience Age Distribution by Member Society**



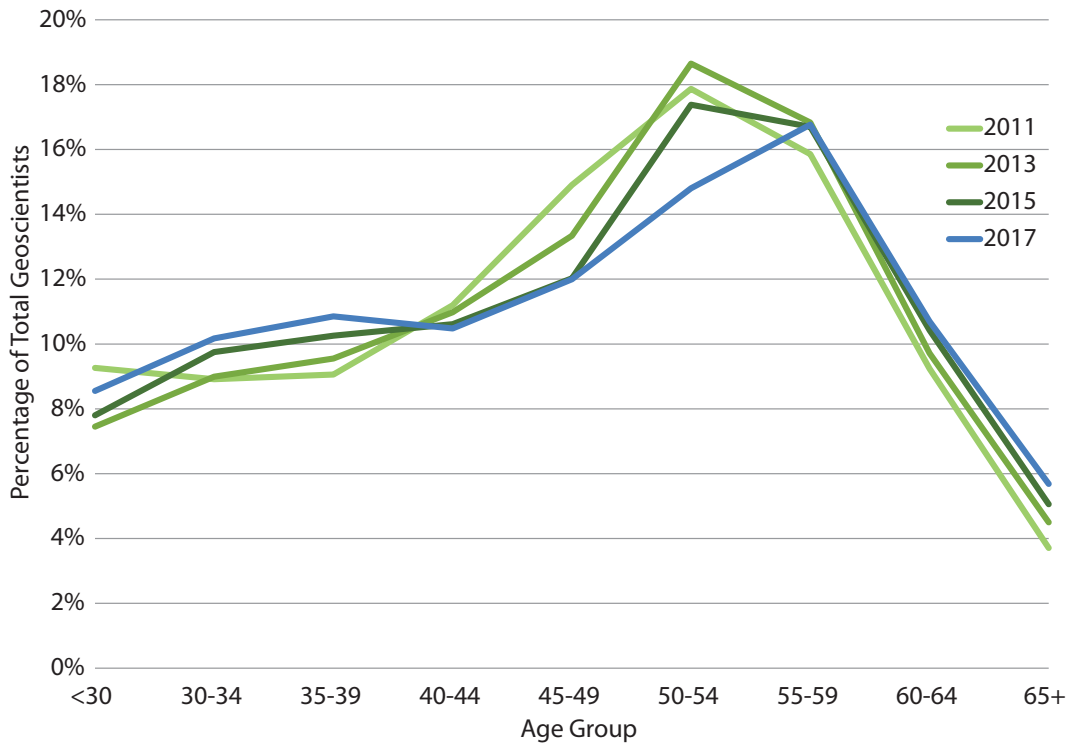
AGI Geoscience Workforce Program; Data provided by the American Institute of Professional Geologists, American Association of Petroleum Geologists, Society of Economic Geologists, and the National Groundwater Association

**Figure 5.40: Geoscience Age Distribution by Membership Society without Student Memberships**



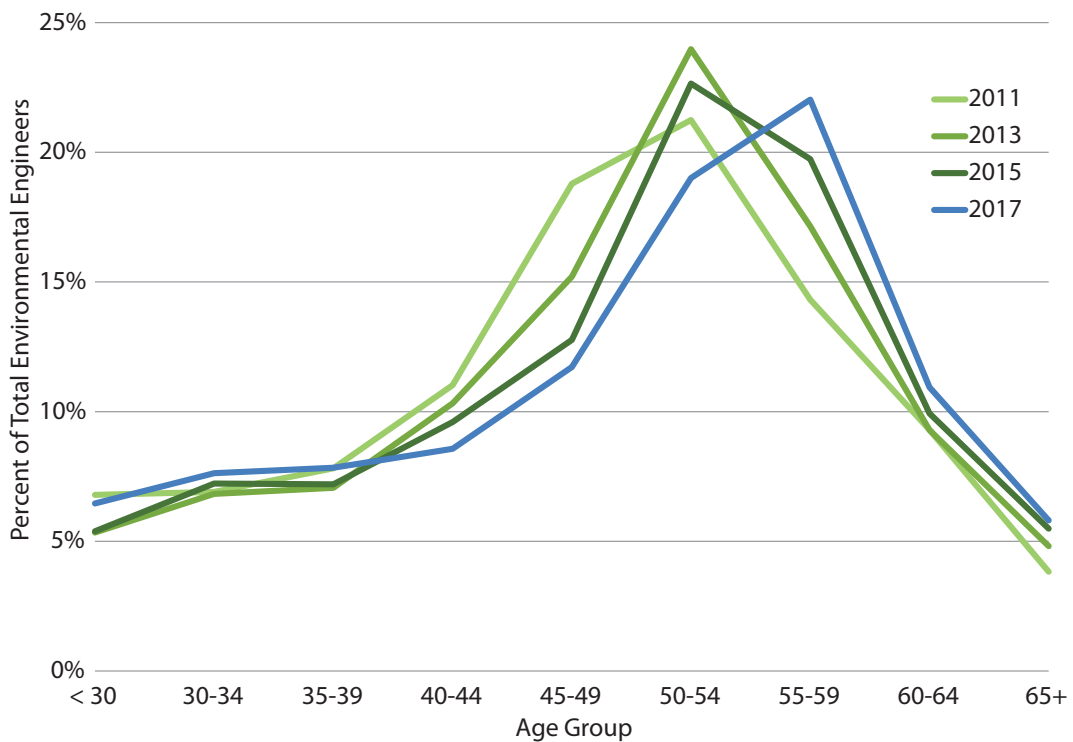
AGI Geoscience Workforce Program; Data provided by the American Institute of Professional Geologists, American Association of Petroleum Geologists, Society of Economic Geologists, and the National Groundwater Association

**Figure 5.41: Age Distribution of Geoscientists in the U.S. Government**



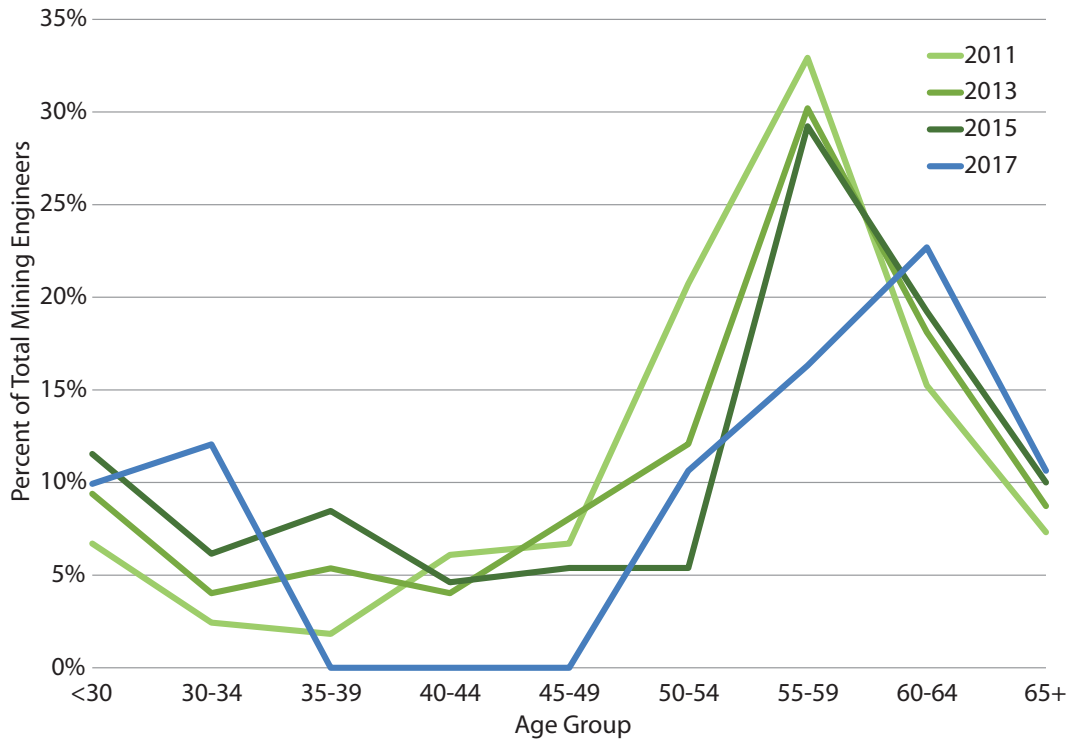
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.42: Age Distribution of Environmental Engineers in the U.S. Government**



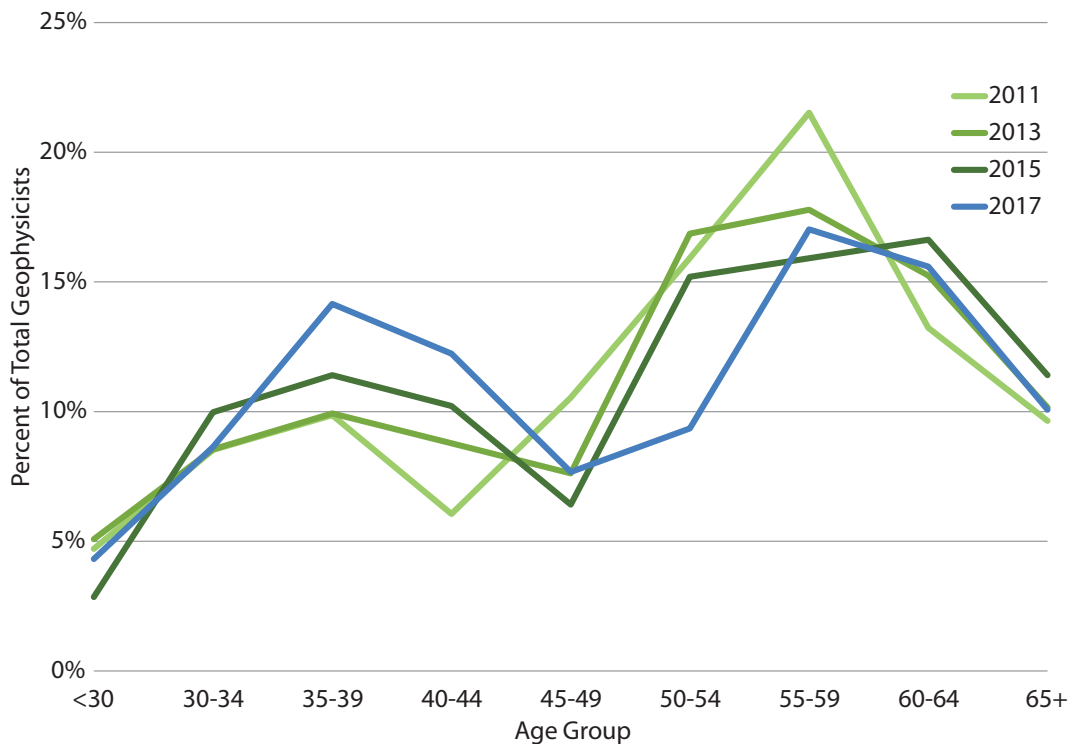
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.43: Age Distribution of Mining Engineers in the U.S. Government**



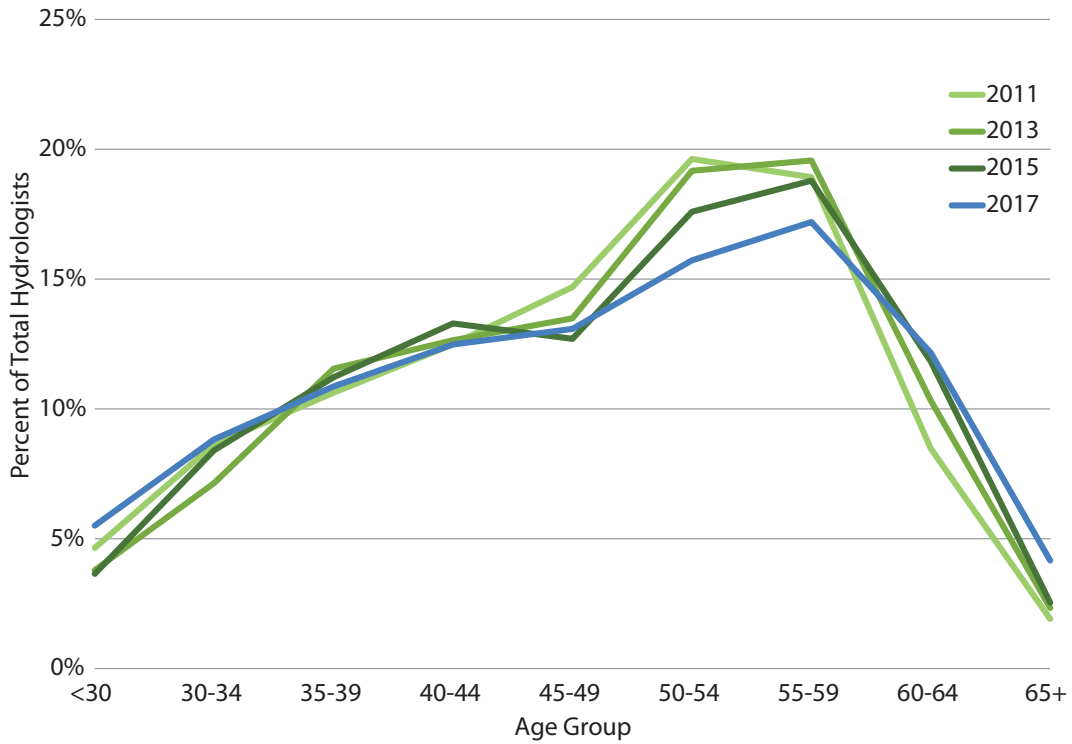
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.44: Age Distribution of Geophysicists in the U.S. Government**



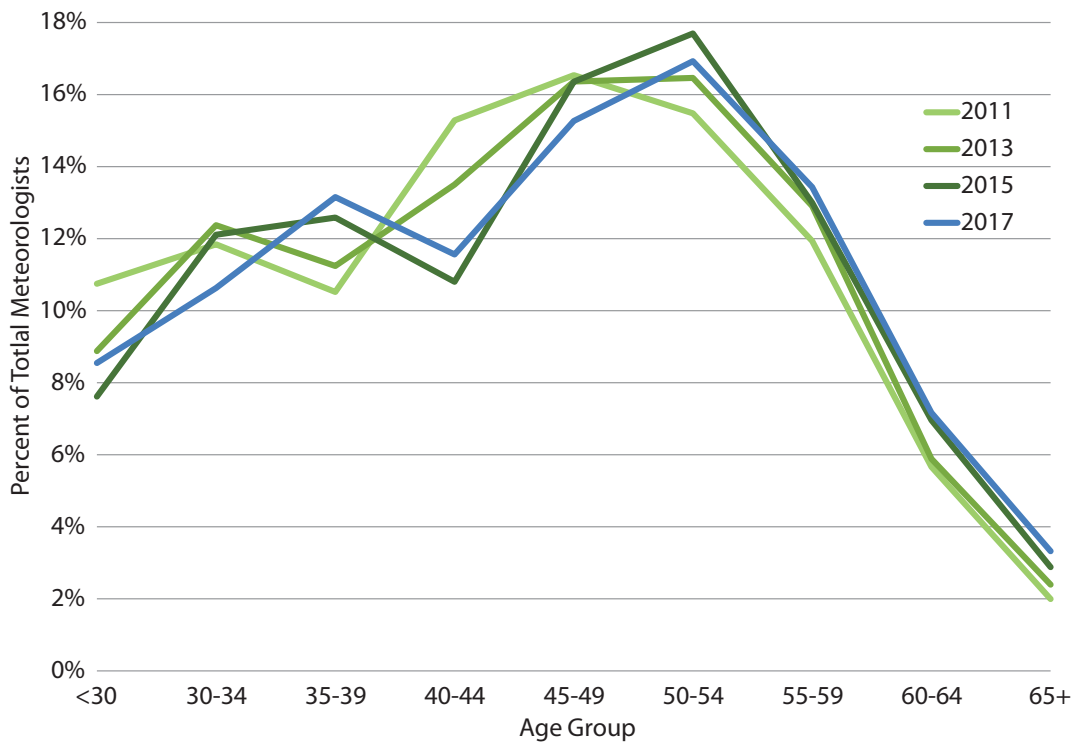
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.45: Age Distribution of Hydrologists in the U.S. Government**



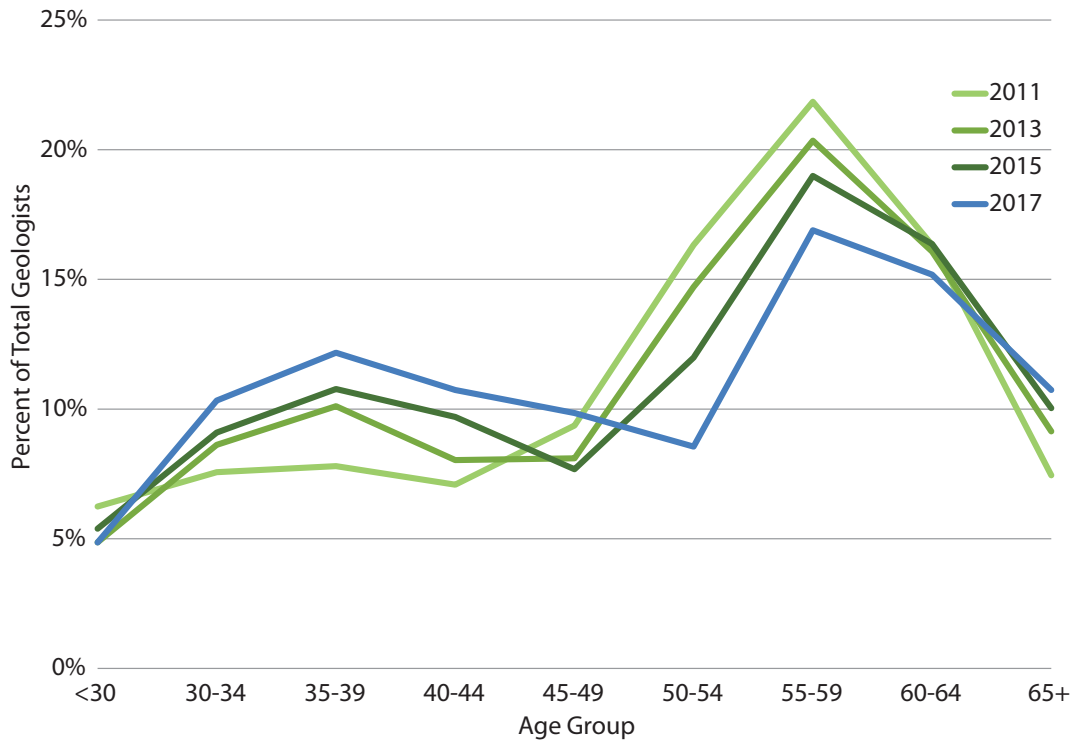
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.46: Age Distribution of Meteorologists in the U.S. Government**



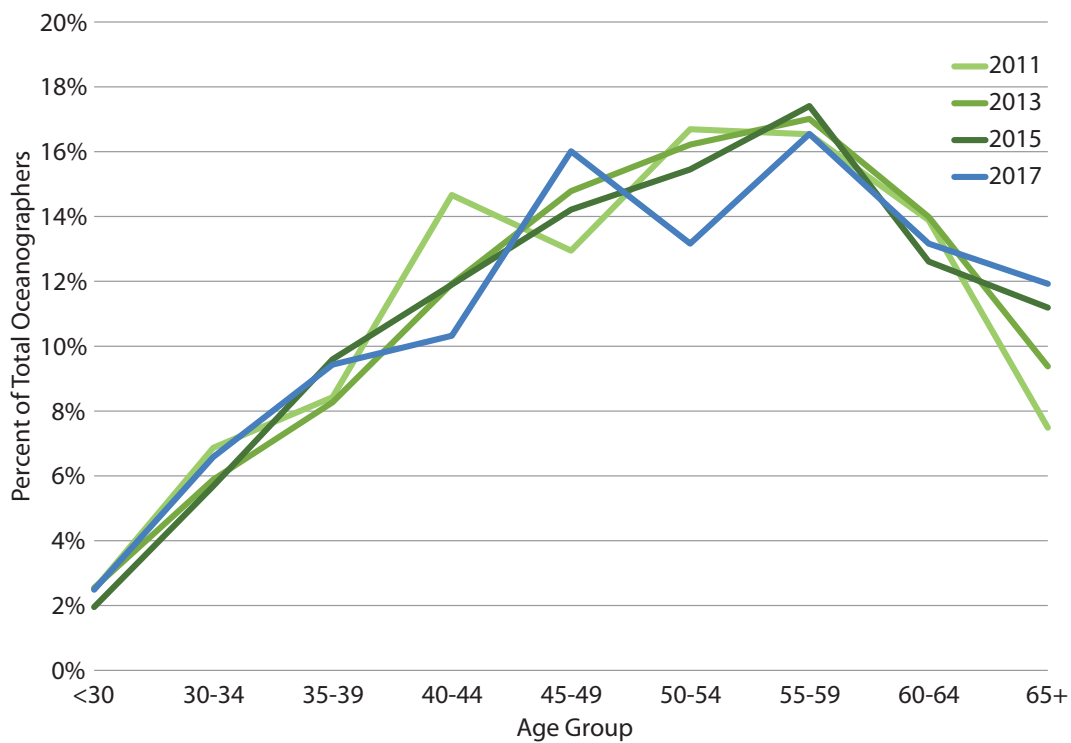
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.47: Age Distribution of Geologists in the U.S. Government**



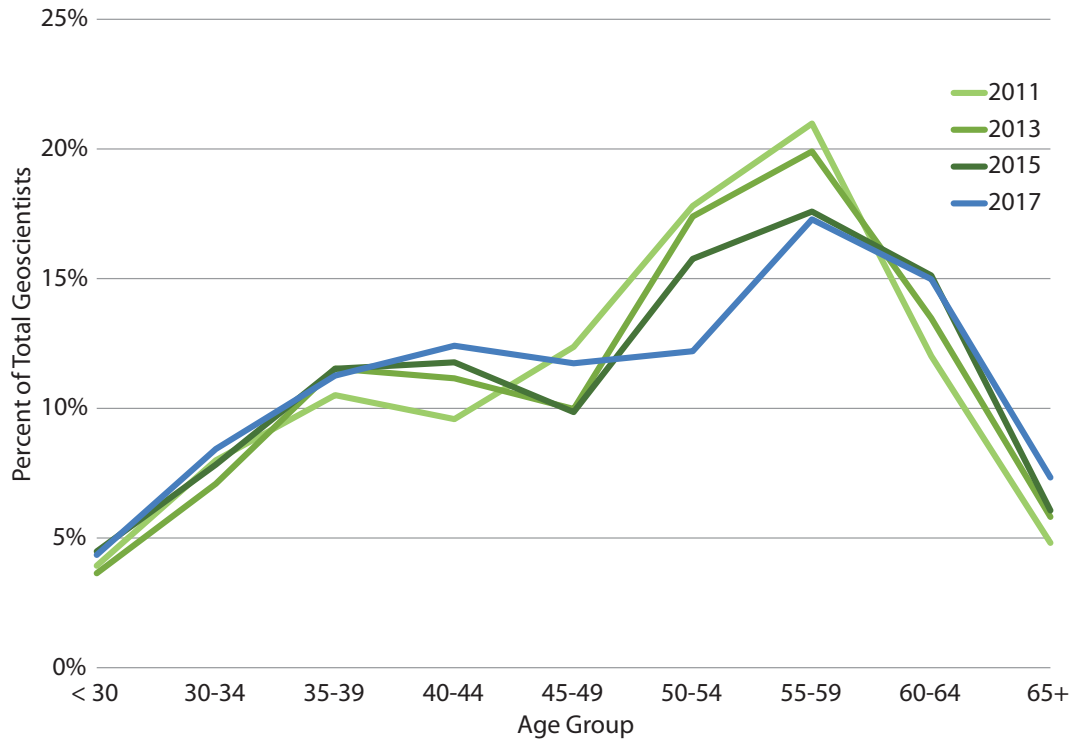
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.48: Age Distribution of Oceanographers in the U.S. Government**



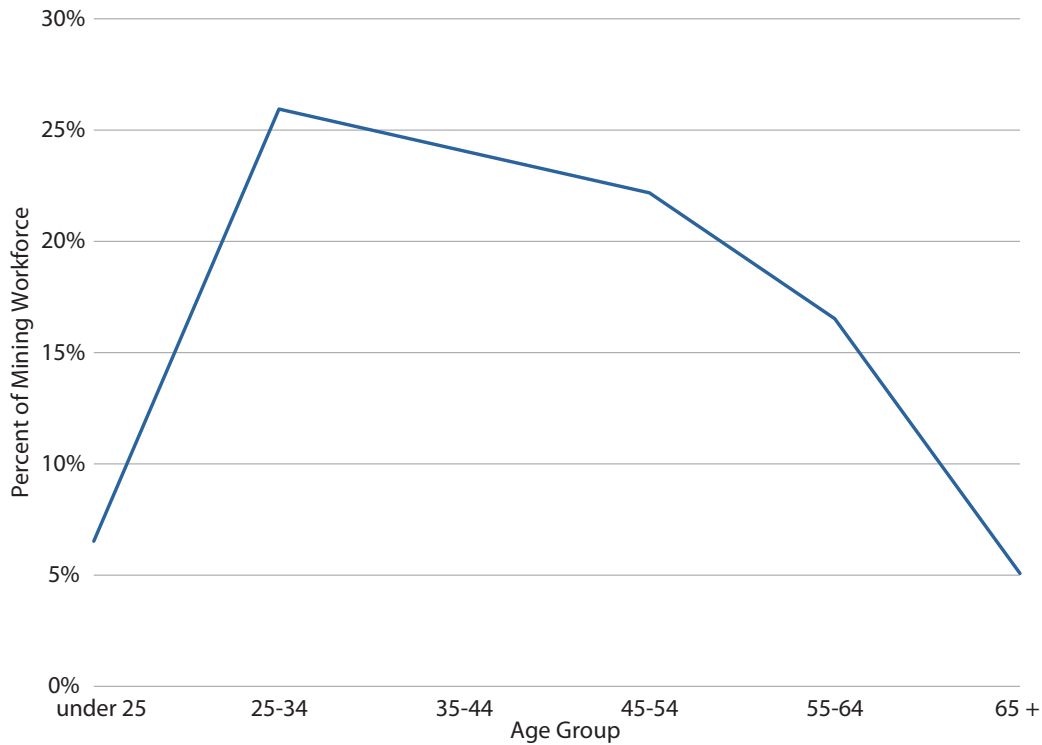
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.49: Age Distribution of Geoscientists in the U.S. Geological Survey**



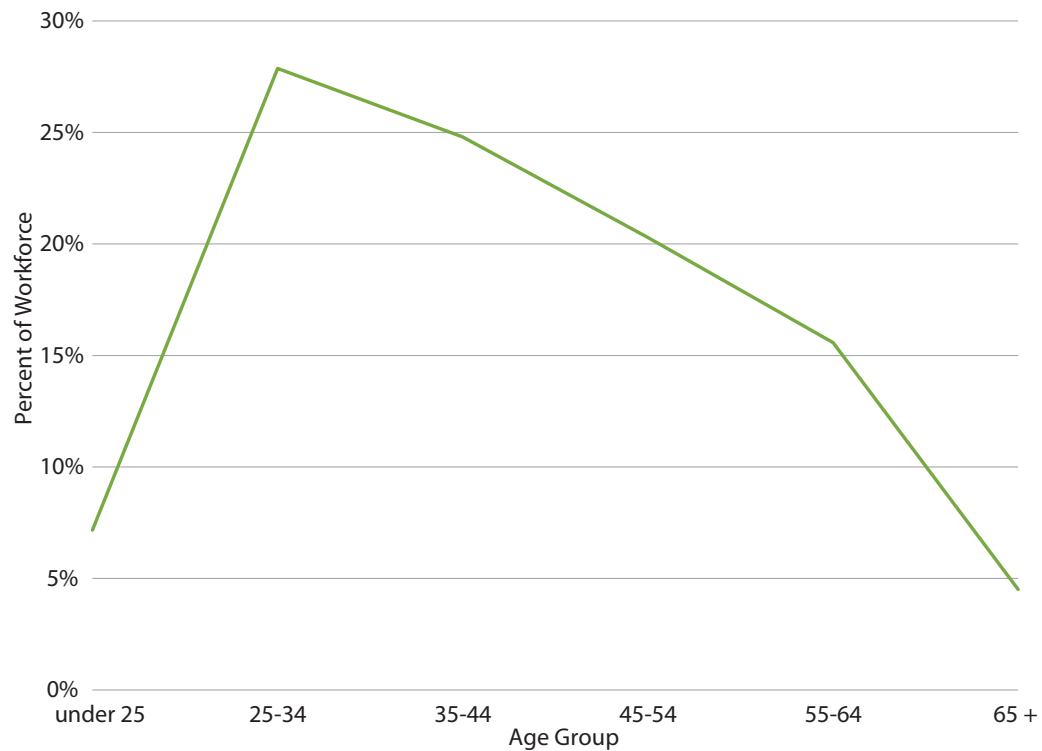
AGI Geoscience Workforce Program; Data derived from the Office of Personnel Management fedscope database

**Figure 5.50: Age Distribution of Geoscientists in Mining, 2016**



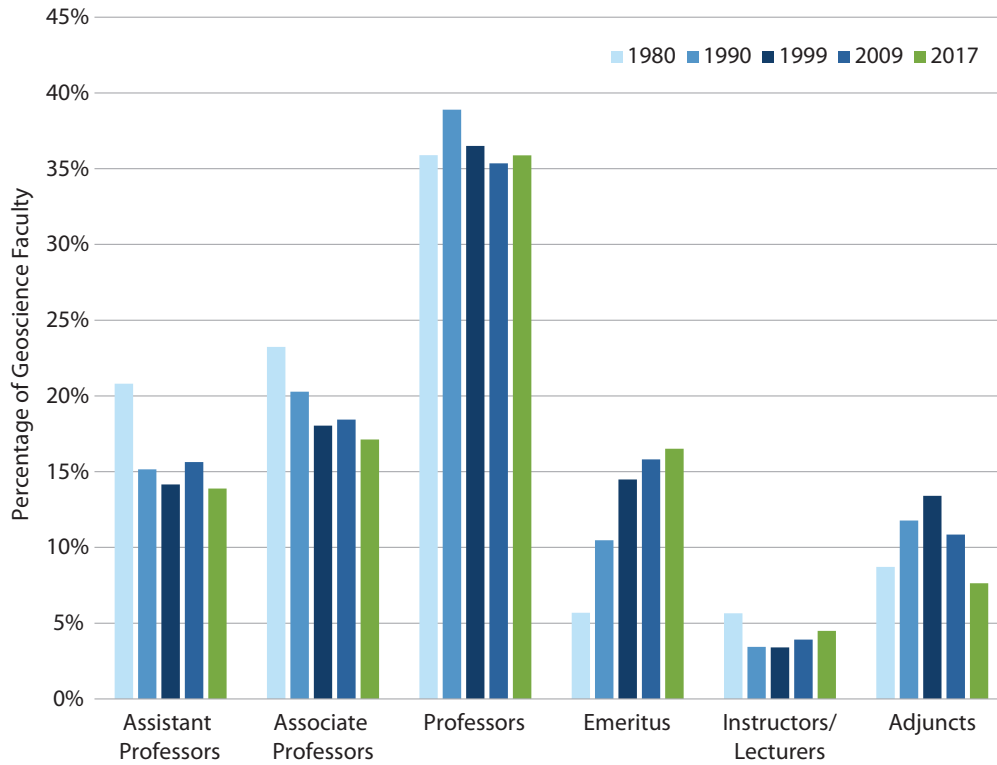
AGI Geoscience Workforce Program; Data provided by the National Mining Association

**Figure 5.51: Age Distribution of Geoscientists in Support Activities for Mining and Oil & Gas, 2016**



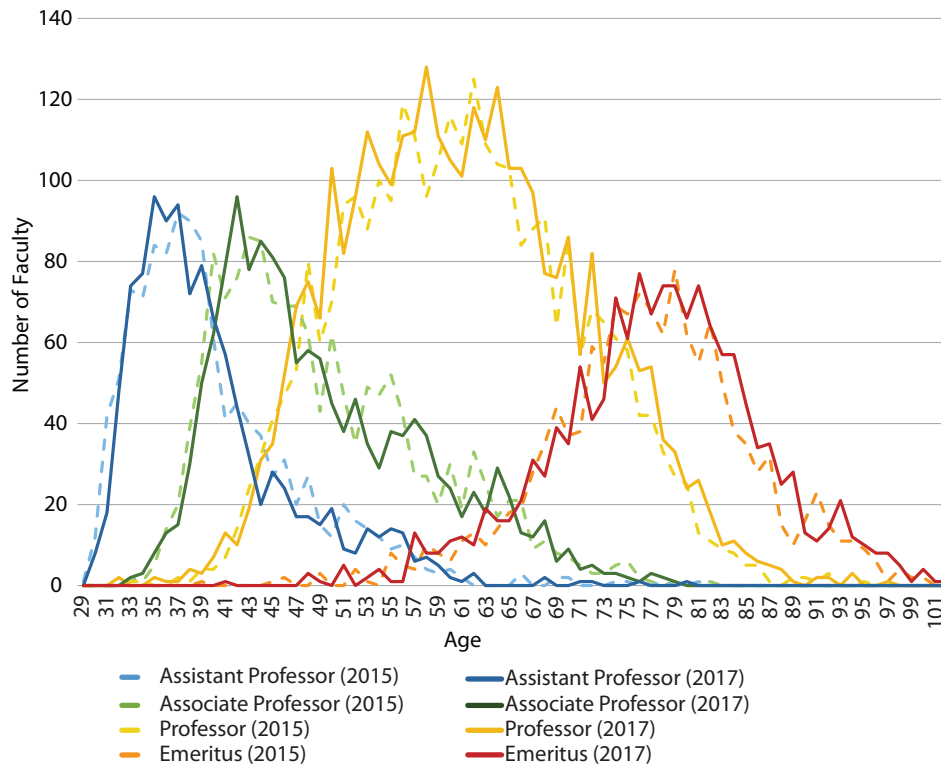
AGI Geoscience Workforce Program; Data provided by the National Mining Association

**Figure 5.52: Trends in Faculty Rank Distribution at Four-Year Institutions (1980-2017)**



AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

**Figure 5.53: Age Distribution of Geoscience Faculty Members**



AGI Geoscience Workforce Program; Data derived from AGI's Directory of Geoscience Departments database

## Geoscience Employment Projections 2016–2026

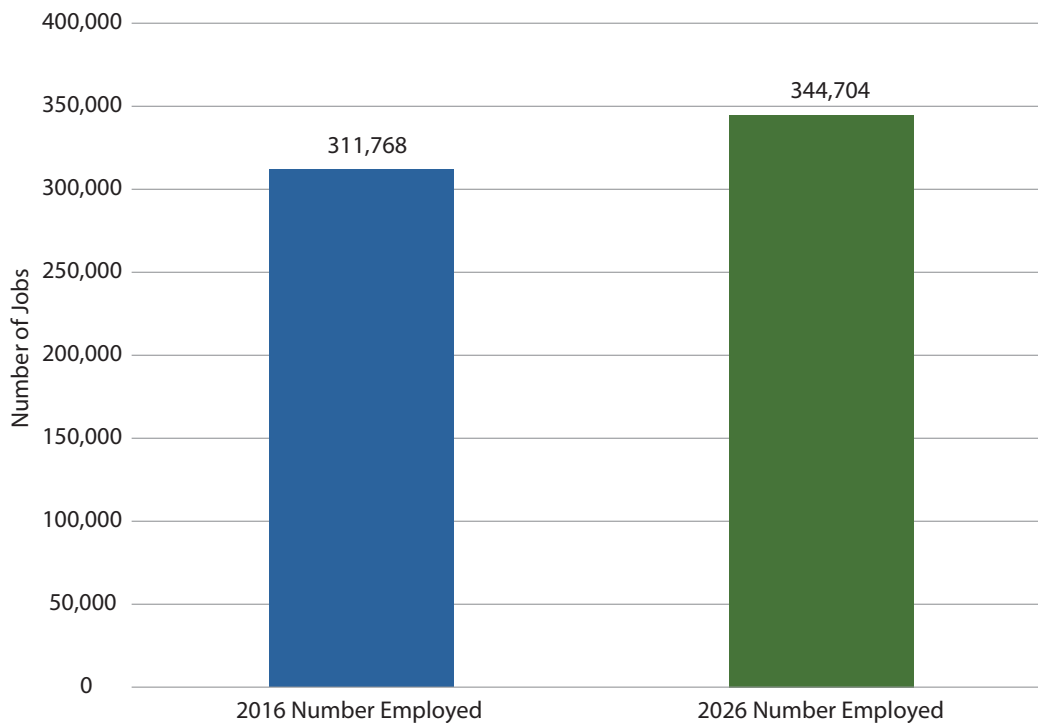
According to the U.S. Bureau of Labor Statistics, there were a total of 311,768 geoscientist jobs in 2016, and they are projecting job growth to 344,704 geoscientist jobs in 2026 — an 11% increase between 2016 and 2026 (Figure 5.54), which is slightly above the projected overall growth of the U.S. workforce in that time frame. This growth will be seen in all major industries hiring geoscientists, except for the mining (except oil and gas) industry (Figure 5.55).

The U.S. Bureau of Labor Statistics is projecting an 11% loss in jobs in the mining industry for geoscientists. Petroleum engineers, geoscientists, hydrologists, and atmospheric and space scientists are projected to have the highest percent change in the number of available

jobs by 2026 (Figure 5.56). It is important to note that the number of jobs in the future may not translate to the number of people. In this case, jobs actually mean “full-time equivalents (FTE)”. There has been significant growth in the use of technology to increase efficiency and replace some of the FTEs traditionally filled by individuals in all geoscience industries. This change is forcing the workforce to reevaluate the types of jobs that need to be filled with qualified and trained geoscientists.

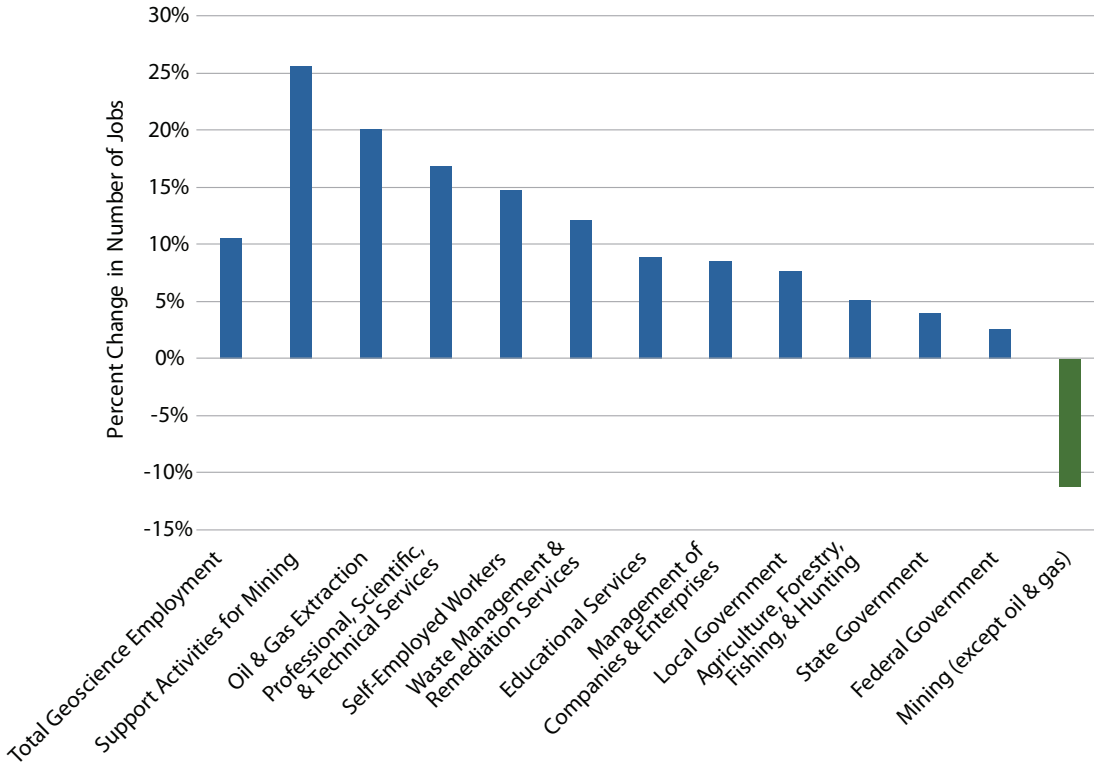
Table 5.1 documents the number of jobs in 2016 and projected for 2026 for different occupations within various industries known for hiring geoscientists, as well as the 2016 median annual salary for these occupations.

**Figure 5.54: Employment Projection for Geoscience Occupations (2016-2026)**



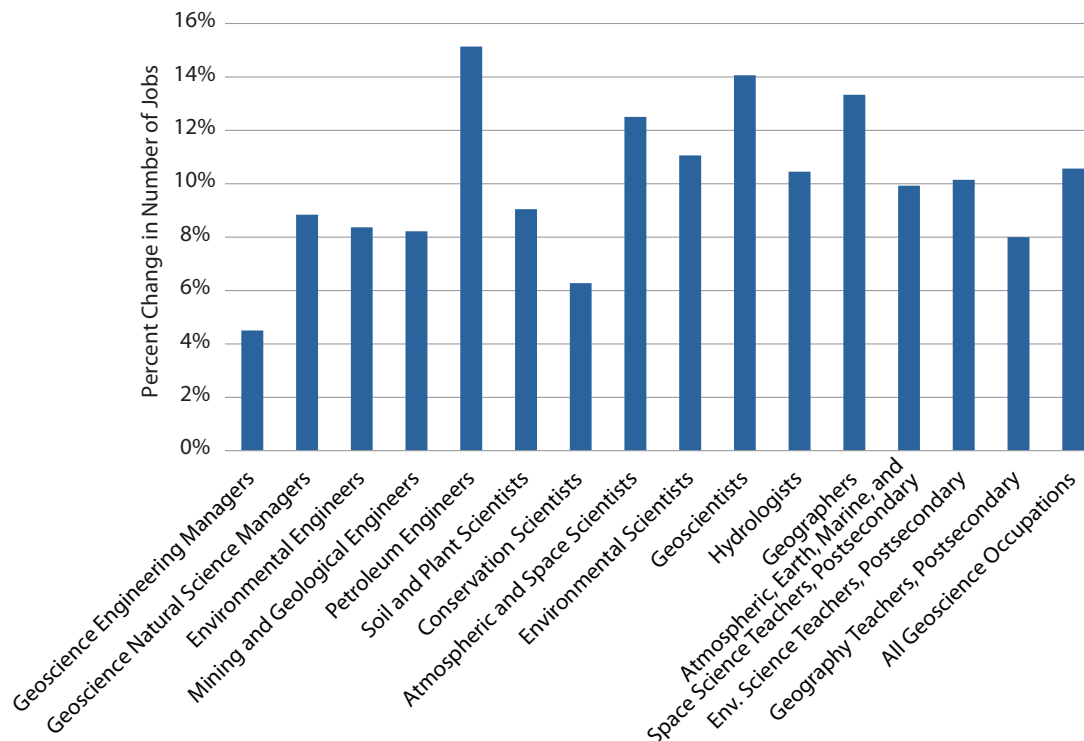
AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Employment Projections

**Figure 5.55: Employment Projections for All Geoscience Occupations by Industry Sector (2016-2026)**



AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Employment Projections

**Figure 5.56: Employment Projections for Detailed Geoscience Occupations (2016-2026)**



AGI Geoscience Workforce Program; Data derived from the US Bureau of Labor Statistics, Employment Projections

**Table 5.1: U.S. Bureau of Labor Statistics Current and Projected Geoscience Employment**

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Total Employment, All Workers</b>				
Engineering managers (*)	7,353	7,684	5%	\$134,730
Natural science managers (*)	2,315	2,520	9%	\$119,850
Environmental engineers	53,800	58,300	8%	\$84,890
Mining and geological engineers, including mining safety engineers	7,300	7,900	8%	\$93,720
Petroleum engineers	33,700	38,800	15%	\$128,230
Soil and plant scientists	19,900	21,700	9%	\$62,300
Conservation scientists	22,300	23,700	6%	\$61,810
Atmospheric and space scientists	10,400	11,700	13%	\$92,460
Environmental scientists	89,500	99,400	11%	\$68,910
Geoscientists, except hydrologists and geographers	32,000	36,500	14%	\$89,780
Hydrologists	6,700	7,400	10%	\$80,480
Geographers	1,500	1,700	13%	\$74,260
Atmospheric, earth, marine, and space science teachers, postsecondary	13,100	14,400	10%	\$85,410
Environmental science teachers, postsecondary	6,900	7,600	10%	\$78,340
Geography teachers, postsecondary	5,000	5,400	8%	\$76,810
<b>All Geoscience Occupations</b>	<b>311,768</b>	<b>344,704</b>	<b>11%</b>	
<b>Self-Employed Workers, All Jobs</b>				
Environmental engineers	200	300	50%	-
Mining and geological engineers, including mining safety engineers	400	500	25%	-
Petroleum engineers	1,200	1,600	33%	-
Soil and plant scientists	1,200	1,200	0%	-
Conservation scientists	400	400	0%	-
Environmental scientists	1,600	1,800	13%	-
Geoscientists, except hydrologists and geographers	900	1,000	11%	-
Hydrologists	100	100	0%	-
Geographers	100	100	0%	-
<b>All Geoscience Occupations</b>	<b>6,100</b>	<b>7,000</b>	<b>15%</b>	
<b>Agriculture, Forestry, Fishing, and Hunting</b>				
Soil and plant scientists	3,700	3,900	5%	\$66,380
Conservation scientists	200	200	0%	\$66,720
<b>All Geoscience Occupations</b>	<b>3,900</b>	<b>4,100</b>	<b>5%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Oil and Gas Extraction</b>				
Engineering managers (*)	844	1,008	19%	-
Natural science managers (*)	105	106	1%	\$131,480
Environmental engineers	500	600	20%	\$104,040
Mining and geological engineers, including mining safety engineers	900	1,000	11%	\$126,020
Petroleum engineers	12,000	14,500	21%	\$134,440
Environmental scientists	600	800	33%	\$86,750
Geoscientists, except hydrologists and geographers	6,300	7,500	19%	\$128,980
<b>All Geoscience Occupations</b>	<b>21,249</b>	<b>25,514</b>	<b>20%</b>	
<b>Mining (Except Oil and Gas)</b>				
Engineering managers (*)	91	88	-3%	\$122,000
Environmental engineers	300	200	-33%	\$82,370
Mining and geological engineers, including mining safety engineers	1,800	1,600	-11%	\$87,740
Environmental scientists	100	100	0%	\$72,960
Geoscientists, except hydrologists and geographers	400	400	0%	\$81,820
<b>All Geoscience Occupations</b>	<b>2,691</b>	<b>2,388</b>	<b>-11%</b>	
<b>Support Activities for Mining</b>				
Engineering managers (*)	160	200	25%	\$154,460
Natural science managers (*)	40	40	0%	\$107,110
Environmental engineers	100	100	0%	\$94,520
Mining and geological engineers, including mining safety engineers	300	400	33%	\$91,960
Petroleum engineers	4,600	5,900	28%	\$106,340
Environmental scientists	100	100	0%	\$72,160
Geoscientists, except hydrologists and geographers	1,100	1,300	18%	\$120,980
<b>All Geoscience Occupations</b>	<b>6,400</b>	<b>8,040</b>	<b>26%</b>	
<b>Utilities</b>				
Engineering managers (*)	203	206	1%	\$134,840
Natural science managers (*)	5	10	98%	\$114,780
Environmental engineers	900	900	0%	\$85,480
Petroleum engineers	600	600	0%	\$99,220
Conservation scientists	100	100	0%	\$80,560
Environmental scientists	1,400	1,400	0%	\$89,720
Geoscientists, except hydrologists and geographers	200	200	0%	\$79,230
Hydrologists	100	100	0%	\$91,420
<b>All Geoscience Occupations</b>	<b>3,508</b>	<b>3,516</b>	<b>0%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Construction</b>				
Engineering managers (*)	45	45	1%	\$124,100
Environmental engineers	200	200	0%	\$90,960
Petroleum engineers	100	100	0%	\$157,780
Environmental scientists	200	200	0%	\$74,100
Geoscientists, except hydrologists and geographers	100	100	0%	\$66,660
<b>All Geoscience Occupations</b>	<b>645</b>	<b>645</b>	<b>0%</b>	
<b>Manufacturing</b>				
Engineering managers (*)	589	562	-5%	\$135,380
Natural science managers (*)	58	56	-3%	\$124,070
Environmental engineers	2,900	2,800	-3%	\$94,490
Mining and geological engineers, including mining safety engineers	100	100	0%	\$87,200
Petroleum engineers	3,500	3,500	0%	\$124,000
Soil and plant scientists	300	200	-33%	\$59,300
Environmental scientists	1,900	1,900	0%	\$82,330
Geoscientists, except hydrologists and geographers	200	200	0%	\$98,840
<b>All Geoscience Occupations</b>	<b>9,547</b>	<b>9,318</b>	<b>-2%</b>	
<b>Wholesale Trade</b>				
Engineering managers (*)	51	51	1%	\$135,740
Natural science managers (*)	17	17	-2%	\$134,080
Environmental engineers	400	400	0%	\$91,750
Petroleum engineers	200	200	0%	\$111,780
Soil and plant scientists	2,200	2,100	-5%	\$61,350
Environmental scientists	100	200	100%	\$63,490
<b>All Geoscience Occupations</b>	<b>2,968</b>	<b>2,968</b>	<b>0%</b>	
<b>Transportation and Warehousing</b>				
Engineering managers (*)	80	82	3%	\$128,220
Environmental engineers	300	300	0%	\$93,860
Petroleum engineers	2,100	2,200	5%	\$116,870
Soil and plant scientists	-	-	-	\$53,820
Atmospheric and space scientists	-	-	-	\$107,710
Environmental scientists	600	600	0%	\$100,220
Geoscientists, except hydrologists and geographers	-	-	-	\$74,150
<b>All Geoscience Occupations</b>	<b>3,080</b>	<b>3,182</b>	<b>3%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Information</b>				
Engineering managers (*)	1	0	-15%	\$148,970
Atmospheric and space scientists	-	-	-	\$88,400
Geoscientists, except hydrologists and geographers	100	100	0%	-
<b>All Geoscience Occupations</b>	<b>101</b>	<b>100</b>	<b>0%</b>	
<b>Finance and Insurance</b>				
Natural science managers (*)	0	0	0%	\$120,630
Petroleum engineers	100	100	0%	\$167,210
Geoscientists, except hydrologists and geographers	100	100	0%	-
<b>All Geoscience Occupations</b>	<b>200</b>	<b>200</b>	<b>0%</b>	
<b>Professional, Scientific, and Technical Services</b>				
Engineering managers (*)	2,546	2,804	10%	\$136,730
Natural science managers (*)	933	1,066	14%	\$137,410
Environmental engineers	26,700	29,900	12%	\$82,560
Mining and geological engineers, including mining safety engineers	2,700	3,100	15%	\$90,640
Petroleum engineers	3,900	4,600	18%	\$133,370
Soil and plant scientists	5,500	6,600	20%	\$67,860
Conservation scientists	1,200	1,400	17%	\$66,120
Atmospheric and space scientists	4,500	5,500	22%	\$89,020
Environmental scientists	34,500	41,300	20%	\$68,110
Geoscientists, except hydrologists and geographers	13,800	16,100	17%	\$78,360
Hydrologists	2,500	3,000	20%	\$87,770
Geographers	300	400	33%	\$62,500
<b>All Geoscience Occupations</b>	<b>99,080</b>	<b>115,770</b>	<b>17%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Architectural, Engineering, and Related Services</b>				
Engineering managers (*)	3,370	3,566	6%	\$130,880
Natural science managers (*)	165	166	1%	\$109,200
Environmental engineers	14,400	15,400	7%	\$84,130
Mining and geological engineers, including mining safety engineers	2,100	2,400	14%	\$84,140
Petroleum engineers	2,000	2,200	10%	\$136,720
Soil and plant scientists	500	500	0%	\$57,930
Conservation scientists	200	200	0%	\$67,680
Atmospheric and space scientists	100	100	0%	\$93,400
Environmental scientists	10,400	11,400	10%	\$63,630
Geoscientists, except hydrologists and geographers	8,200	9,100	11%	\$80,220
Hydrologists	1,100	1,300	18%	\$88,410
Geographers	200	200	0%	\$54,630
<b>All Geoscience Occupations</b>	<b>42,735</b>	<b>46,532</b>	<b>9%</b>	
<b>Testing Laboratories</b>				
Engineering managers (*)	122	111	-11%	\$126,950
Natural science managers (*)	79	76	-4%	\$99,720
Environmental engineers	800	800	0%	\$77,090
Mining and geological engineers, including mining safety engineers	100	100	0%	\$76,070
Soil and plant scientists	400	400	0%	\$56,510
Environmental scientists	2,400	2,400	0%	\$53,410
Geoscientists, except hydrologists and geographers	500	400	-20%	\$62,900
<b>All Geoscience Occupations</b>	<b>4,401</b>	<b>4,288</b>	<b>-3%</b>	
<b>Computer Systems Design and Related Services</b>				
Engineering managers (*)	27	32	20%	\$150,970
Environmental engineers	200	200	0%	\$94,740
Atmospheric and space scientists	100	100	0%	\$103,590
Environmental scientists	200	200	0%	\$53,160
Geoscientists, except hydrologists and geographers	4,800	6,100	27%	\$123,370
<b>All Geoscience Occupations</b>	<b>5,328</b>	<b>6,633</b>	<b>25%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Management, Scientific, and Technical Consulting Services</b>				
Engineering managers (*)	671	815	21%	\$130,360
Natural science managers (*)	527	642	22%	\$123,660
Environmental engineers	10,700	12,600	18%	\$798,670
Mining and geological engineers, including mining safety engineers	300	400	33%	\$127,020
Petroleum engineers	1,200	1,500	25%	\$119,940
Soil and plant scientists	2,600	3,300	27%	\$61,930
Conservation scientists	600	700	17%	\$56,960
Atmospheric and space scientists	600	800	33%	\$69,860
Environmental scientists	20,900	26,200	25%	\$68,150
Geoscientists, except hydrologists and geographers	700	800	14%	\$74,890
Hydrologists	1,300	1,700	31%	\$87,250
Geographers	100	100	0%	\$65,680
<b>All Geoscience Occupations</b>	<b>40,198</b>	<b>49,557</b>	<b>23%</b>	
<b>Scientific Research and Development Services</b>				
Engineering managers (*)	306	361	18%	\$157,570
Natural science managers (*)	5554	651	18%	\$145,470
Environmental engineers	1,200	1,400	17%	\$94,190
Mining and geological engineers, including mining safety engineers	100	200	100%	\$123,410
Petroleum engineers	700	800	14%	\$152,520
Soil and plant scientists	2,300	2,700	17%	\$76,500
Conservation scientists	400	500	25%	\$83,730
Atmospheric and space scientists	2,500	2,900	16%	\$98,560
Environmental scientists	3,000	3,400	13%	\$86,730
Geoscientists, except hydrologists and geographers	11,100	12,800	15%	\$81,340
Hydrologists	100	100	0%	\$86,840
Geographers	100	100	0%	\$69,030
<b>All Geoscience Occupations</b>	<b>22,359</b>	<b>25,912</b>	<b>3%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Other Professional, Scientific, and Technical Services</b>				
Engineering managers (*)	8	13	50%	\$140,790
Natural science managers (*)	21	26	20%	\$119,520
Environmental engineers	200	300	50%	\$89,850
Atmospheric and space scientists	1,200	1,600	33%	\$68,430
Environmental scientists	100	100	0%	\$79,390
Geoscientists, except hydrologists and geographers	100	100	0%	\$68,960
<b>All Geoscience Occupations</b>	<b>1,630</b>	<b>2,138</b>	<b>31%</b>	
<b>Management of Companies and Enterprises</b>				
Engineering managers (*)	293	319	9%	\$141,280
Natural science managers (*)	97	102	6%	\$162,530
Environmental engineers	1,300	1,500	15%	\$94,050
Mining and geological engineers, including mining safety engineers	400	400	0%	\$105,290
Petroleum engineers	4,500	4,800	7%	\$153,320
Soil and plant scientists	300	400	33%	\$83,710
Atmospheric and space scientists	100	100	0%	\$94,770
Environmental scientists	1,100	1,200	9%	\$96,640
Geoscientists, except hydrologists and geographers	1,700	1,900	12%	\$141,970
<b>All Geoscience Occupations</b>	<b>9,790</b>	<b>10,621</b>	<b>8%</b>	
<b>Administrative and Support and Waste Management and Remediation Services</b>				
Engineering managers (*)	36	37	1%	\$135,990
Natural science managers (*)	5	5	-3%	\$121,360
Environmental engineers	3,100	3,400	10%	\$89,740
Mining and geological engineers, including mining safety engineers	-	-	-	\$136,870
Petroleum engineers	100	100	0%	\$142,970
Soil and plant scientists	300	300	0%	\$71,040
Environmental scientists	1,500	1,600	7%	\$69,440
Geoscientists, except hydrologists and geographers	300	300	0%	\$83,460
<b>All Geoscience Occupations</b>	<b>5,342</b>	<b>5,742</b>	<b>7%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Waste Management and Remediation Services</b>				
Engineering managers (*)	154	200	30%	\$140,430
Natural science managers (*)	61	67	9%	-
Environmental engineers	2,500	2,800	12%	\$88,440
Environmental scientists	800	900	13%	\$66,050
Geoscientists, except hydrologists and geographers	200	200	0%	\$80,830
<b>All Geoscience Occupations</b>	<b>3,715</b>	<b>4,167</b>	<b>12%</b>	
<b>Educational Services, Public and Private</b>				
Engineering managers (*)	68	75	11%	\$115,760
Natural science managers (*)	150	166	10%	\$85,670
Environmental engineers	300	400	33%	\$67,930
Petroleum engineers	100	100	0%	\$55,750
Soil and plant scientists	3,200	3,400	6%	\$52,360
Conservation scientists	900	900	0%	\$57,660
Atmospheric and space scientists	1,600	1,700	6%	\$82,910
Environmental scientists	3,800	4,200	11%	\$65,520
Geoscientists, except hydrologists and geographers	2,000	2,200	10%	\$62,270
Hydrologists	-	-	-	\$74,040
Geographers	200	200	0%	-
Atmospheric, earth, marine, and space science teachers, postsecondary	13,100	14,300	9%	\$85,250
Environmental science teachers, postsecondary	6,900	7,600	10%	\$78,330
Geography teachers, postsecondary	5,000	5,400	9%	\$76,770
<b>All Geoscience Occupations</b>	<b>37,318</b>	<b>40,641</b>	<b>9%</b>	
<b>Junior Colleges; State, Local, and Private</b>				
Atmospheric, earth, marine, and space science teachers, postsecondary	2,600	2,800	8%	\$72,930
Environmental science teachers, postsecondary	800	800	0%	\$67,150
Geography teachers, postsecondary	900	1,000	11%	\$73,010
<b>All Geoscience Occupations</b>	<b>4,300</b>	<b>4,600</b>	<b>7%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>Colleges, Universities, and Professional Schools; State, Local, and Private</b>				
Engineering managers (*)	77	87	13%	\$114,430
Natural science managers (*)	193	203	5%	\$84,810
Environmental engineers	300	300	0%	\$69,280
Petroleum engineers	100	100	0%	\$55,750
Soil and plant scientists	3,100	3,400	10%	\$52,390
Conservation scientists	800	900	13%	\$57,430
Atmospheric and space scientists	1,600	1,700	6%	\$82,910
Environmental scientists	3,700	4,000	8%	\$64,650
Geoscientists, except hydrologists and geographers	2,000	2,200	10%	\$62,270
Geographers	200	200	0%	\$43,920
Atmospheric, earth, marine, and space science teachers, postsecondary	10,500	11,500	10%	\$89,300
Environmental science teachers, postsecondary	6,100	6,700	10%	\$79,820
Geography teachers, postsecondary	4,100	4,500	10%	\$77,330
<b>All Geoscience Occupations</b>	<b>32,771</b>	<b>35,790</b>	<b>9%</b>	
<b>Federal Government, Excluding Postal Service</b>				
Engineering managers (*)	625	631	1%	\$133,410
Natural science managers (*)	794	807	2%	\$112,520
Environmental engineer	3,400	3,500	3%	\$102,280
Mining and geological engineers, including mining safety engineers	100	100	0%	\$86,170
Petroleum engineers	400	400	0%	\$103,200
Soil and plant scientists	1,400	1,500	7%	\$75,740
Conservation scientists	7,200	7,400	3%	\$73,380
Atmospheric and space scientists	3,100	3,100	0%	\$101,320
Environmental scientists	5,700	5,800	2%	\$100,690
Geoscientists, except hydrologists and geographers	2,400	2,400	0%	\$97,440
Hydrologists	1,900	2,000	5%	\$86,220
Geographers	800	900	13%	\$82,920
<b>All Geoscience Occupations</b>	<b>27,818</b>	<b>28,537</b>	<b>3%</b>	

Occupation	2016 Number Employed	2026 Number Employed	2016-2026 Percent Change	2016 Median Annual Salary (OES)
<b>State Government, Excluding Education and Hospitals</b>				
Engineering managers (*)	496	516	4%	\$99,930
Natural science managers (*)	620	641	3%	\$81,840
Environmental engineers	8,200	8,500	4%	\$74,730
Mining and geological engineers, including mining safety engineers	100	100	0%	\$96,750
Petroleum engineers	200	200	0%	-
Soil and plant scientists	500	500	0%	\$56,100
Conservation scientists	4,900	5,100	4%	\$54,070
Atmospheric and space scientists	100	100	0%	\$66,700
Environmental scientists	20,200	21,000	4%	\$62,110
Geoscientists, except hydrologists and geographers	2,300	2,400	4%	\$71,820
Hydrologists	1,300	1,400	8%	\$63,430
Geographers	100	100	0%	\$56,610
<b>All Geoscience Occupations</b>	<b>39,016</b>	<b>40,557</b>	<b>4%</b>	
<b>Local Government, Excluding Education and Hospitals</b>				
Engineering managers (*)	603	645	7%	\$120,960
Natural science managers (*)	183	194	6%	\$101,500
Environmental engineers	4,600	5,000	9%	\$84,000
Mining and geological engineers, including mining safety engineers	500	500	0%	-
Soil and plant scientists	1,000	1,100	10%	\$52,810
Conservation scientists	4,500	4,900	9%	\$49,700
Environmental scientists	12,100	13,000	7%	\$67,560
Geoscientists, except hydrologists and geographers	200	200	0%	\$121,180
Hydrologists	600	600	0%	\$76,350
<b>All Geoscience Occupations</b>	<b>24,287</b>	<b>26,139</b>	<b>8%</b>	

(\*): Engineering managers and Natural science manager employment numbers were estimated from the federal data by dividing the total non-manager geoscientists by the total number of non-manager S&E employees per industry and then multiplying this result by the total number of engineering (or natural science) managers per industry.



## Chapter 6: Trends in Economic Metrics and Drivers of the Geoscience Workforce

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Tracking the economic metrics related to the geoscience workforce can help indicate potential changes in the supply and demand for the future workforce, which in turn impacts students finishing geoscience degrees at four-year universities. Therefore, this chapter looks at the changes in federal funding for geoscience research, economic metrics in the resource industries, and the contribution of geoscience to the overall U.S. gross domestic product.

The percentage of federal research funding awarded to geoscience research declined over the years from 13 percent in 1970 to 7 percent in 2015, but the total dollar amount of federal geoscience research funding has increased steadily to nearly \$5 billion in 2017. However, the increase in spending has been targeted mainly to basic research spending, which increased to 9 percent of federal research funding applied to the geosciences. The increase in spending in basic research has been targeted at atmospheric science research and environmental science research primarily.

This chapter clearly captures the economic recession in 2009 and the economic downturn in the oil and gas industry starting at the end of 2014 through 2016 in data of geoscience economic activity. Some of the indicators show the beginning of the recovery from this recent economic downturn in oil and gas. The price of oil, the gross domestic product (GDP) contributed by geoscientists in

the oil and gas industry, and number of working oil rigs show a rapid decline from 2014-2016. The price of oil in US dollars and Euros per barrel reached its lowest point since 2002 in early 2016, and since that time, the price of oil has been increasing. The GDP contribution by geoscientists in the oil and gas industry in 2016 was nearly \$20 billion, down from \$53 billion in 2012. We expect this valuation to show a strong increase over the next few years, but it may not reach the high valuation in 2012. In 2016, the U.S. was operating only 35 percent of the drilling rigs worldwide, down from 52 percent in 2014. However, since 2016, over 200 crude oil rigs and 100 natural gas rigs have been brought back into active service.

Since the economic recession in the United States in 2009, the mining industry, particularly the mines yielding metal ore and industrial minerals have seen an increase in the material handled by these mines, as well as the value of these yields.

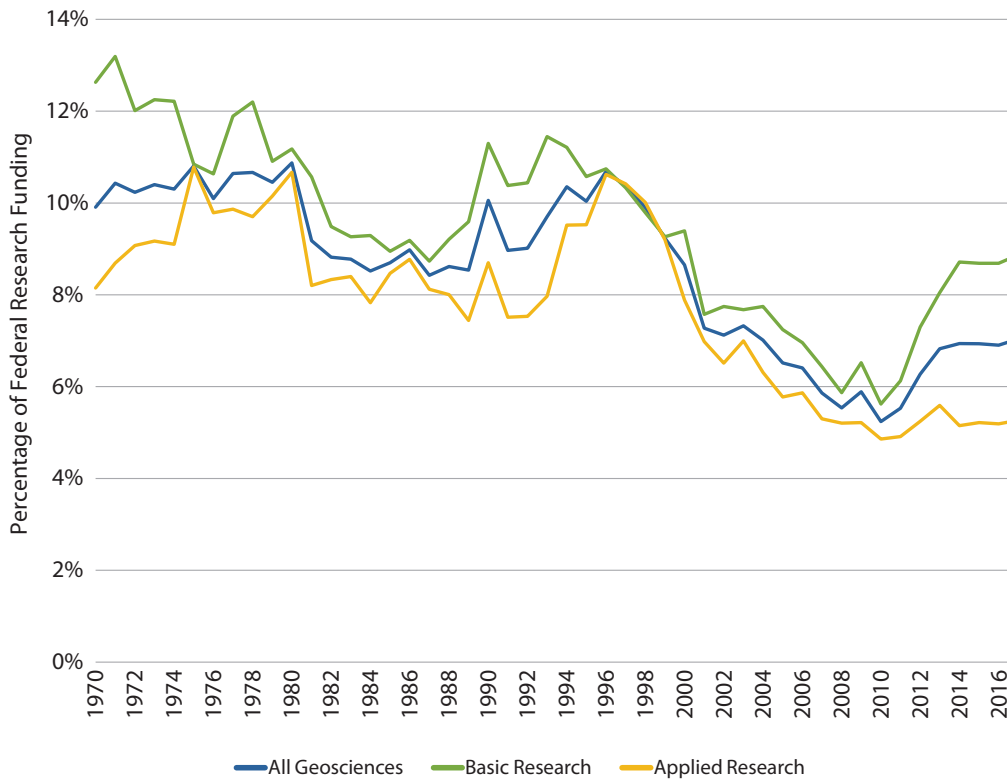
All major employment sectors that directly hire geoscientists currently make up approximately 0.35 percent of the total U.S. economy equaling \$64 billion of the U.S. gross domestic product. This is a decrease of approximately \$36 billion since 2012 due to the economic downturn in the oil and gas industry. The projected GDP contributed by geoscientists in 2026 is approximately \$80 billion. However, this projection will change as the U.S. oil and gas industry continues to rebound in the next few years.

## Federal Research Funding for the Geosciences

The percentage of federal funding for applied and basic research in the geosciences reached a low in 2012 of 6% for basic research and 5% for applied research (Figure 6.1). However, from 2012 to 2014, the percentage of basic geoscience research increased, while the percentage of applied geoscience research stayed the same. In 2017 the percentage of basic geoscience research increased to 9% and the percentage of applied geoscience

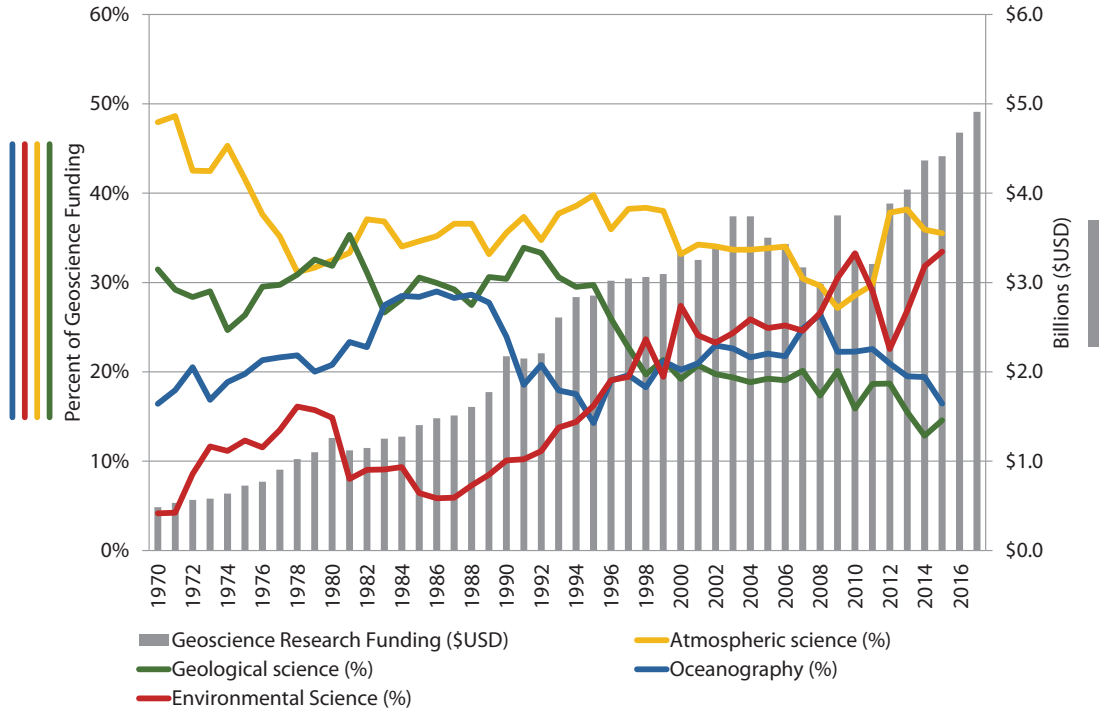
research remained at 5%. The overall amount of money spent on geoscience research by the federal government has been increasing since 2012, reaching a high of approximately \$5 billion in 2017, with most of that growth in funding going to basic research (Figure 6.2). This increase in federal funding for the geosciences since 2012 has also mainly been given to research in the environmental sciences and the atmospheric sciences (Figure 6.3 and 6.4).

**Figure 6.1:** Percentage of Federal Research Funding Applied to the Geosciences



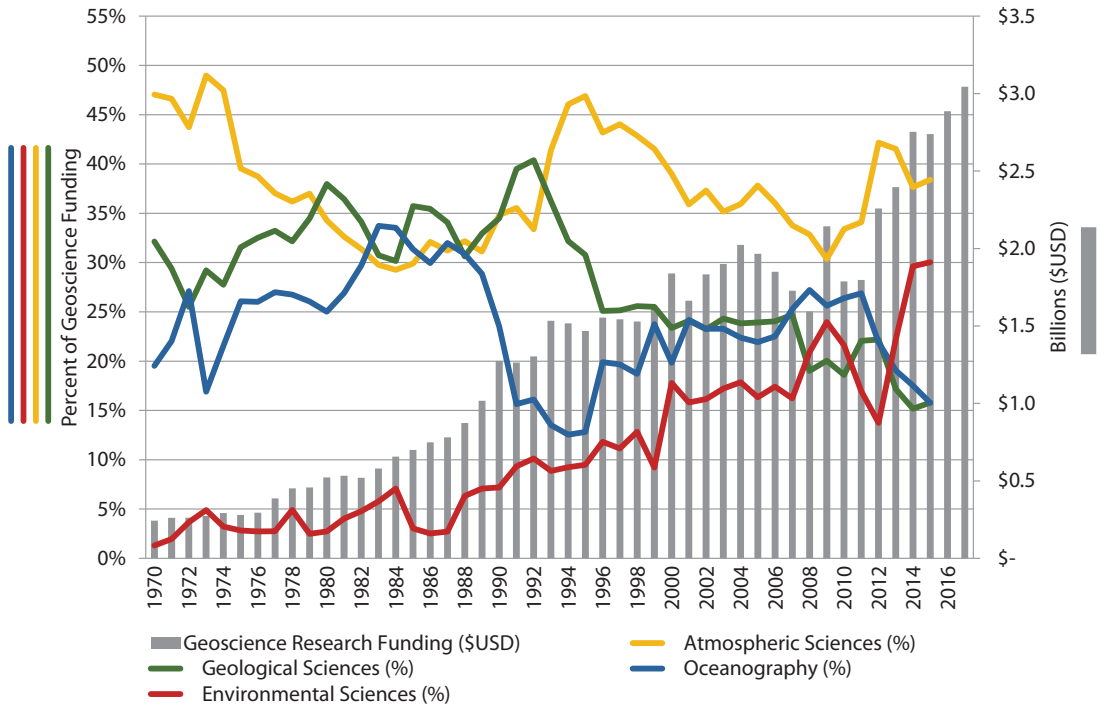
AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 6.2: Total Federal Research Funding of the Geosciences**



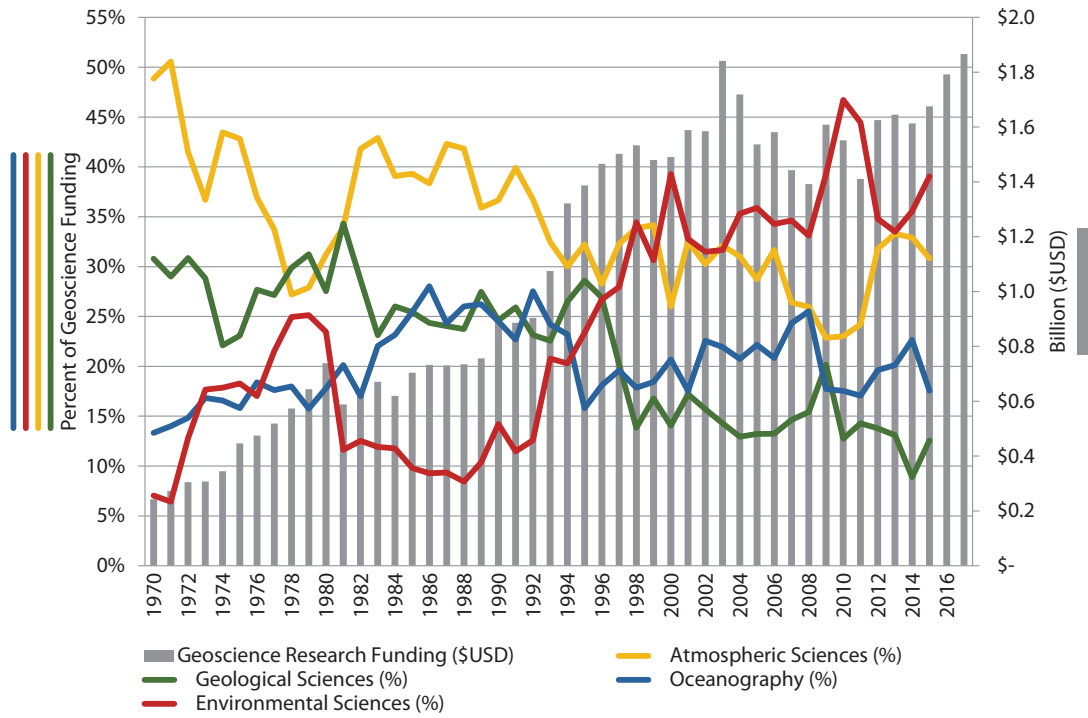
AGI Geoscience Workforce Program; Data derived from the NSF/SRS Survey of Federal Funds for Research & Development

**Figure 6.3: Federal Funding of Basic Research in the Geosciences**



AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

**Figure 6.4: Federal Funding of Applied Research in the Geosciences**



AGI Geoscience Workforce Program; Data derived from NSF/SRS Survey of Federal Funds for Research & Development

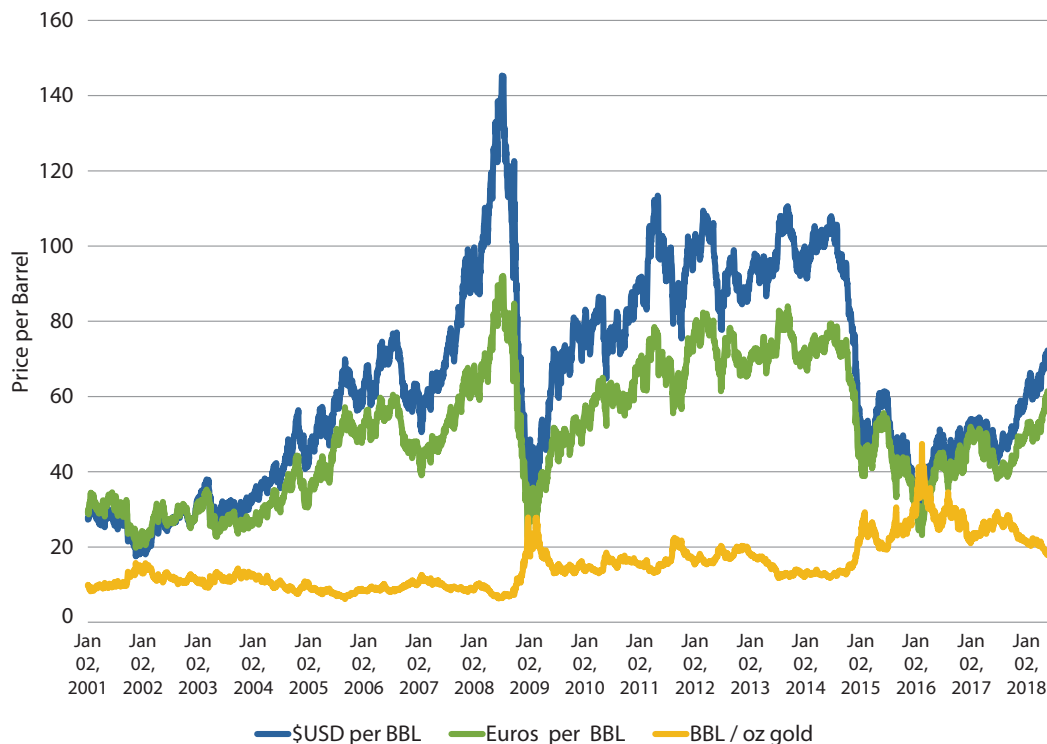
## Commodity Prices and Output

Figure 6.5 shows the changes in spot prices of crude oil per barrel (BBL) in U.S. dollars and in euros from 2001 to 2018, which covers the recent economic recession, subsequent recovery period, recent economic downturn in the petroleum industry, and the recent movements towards recovery. The graph also shows the number of barrels per troy ounce of gold. The price of oil, relative to the dollar, grew faster than it did relative to the euro through the recession and this trend is continuing through the more recent economic recovery to the present as the dollar/euro exchange rate continues to narrow. The price of oil by gold appears to take an opposite increasing trend during both the 2009 recession and the 2014 economic downturn compared to the dollar and euro. The total domestic commodity output data for the petroleum and mining industries shows a steady increase from 2002 to

2008, followed by a sharp decline in 2009 due to the economic recession (Figure 6.6). However, the industries were able to bounce back quickly during the economic recovery and into 2014. Because data is only available through 2014, the downturn in the petroleum industry is not seen in this graph or in the data for the gross operating surplus.

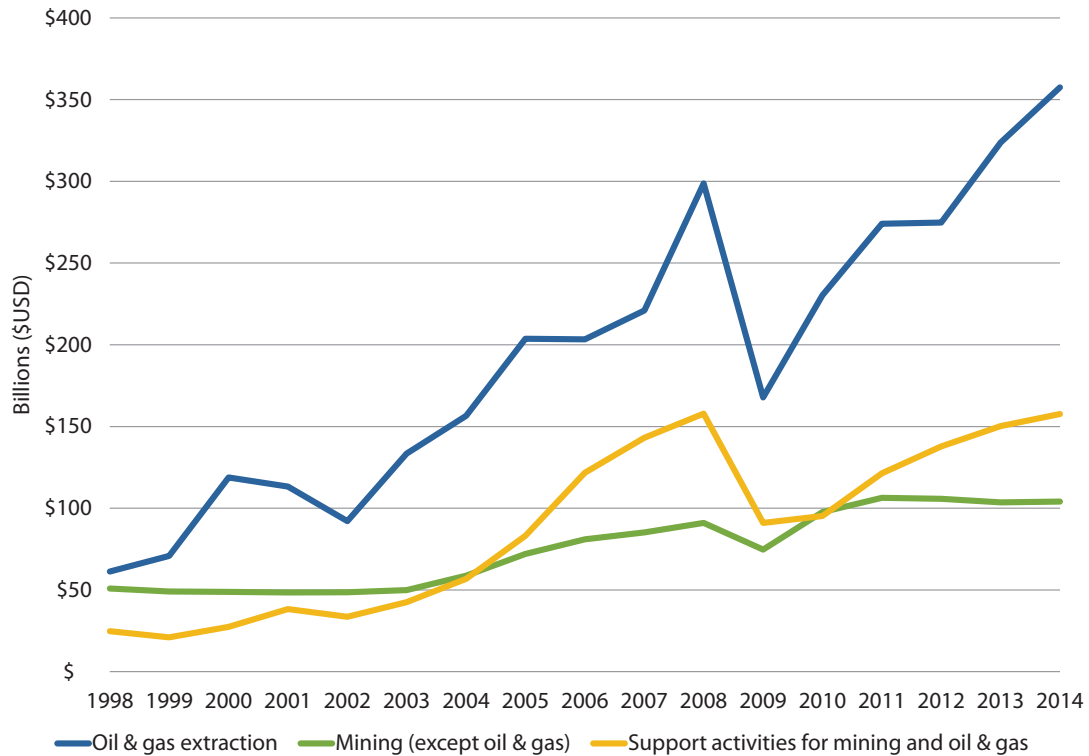
The gross operating surplus for the petroleum and mining industries grew steadily until 2008, after which only mining continued to increase (Figure 6.7). After the recession the oil and gas extraction industry rebounded and continued to increase into 2014. However, from 2014–2016, the gross operating surplus for oil and gas extraction decreased again. In the next edition of this report, the rebound from the economic downturn should be evident in the data.

Figure 6.5: Price of Oil by Currency and by Gold



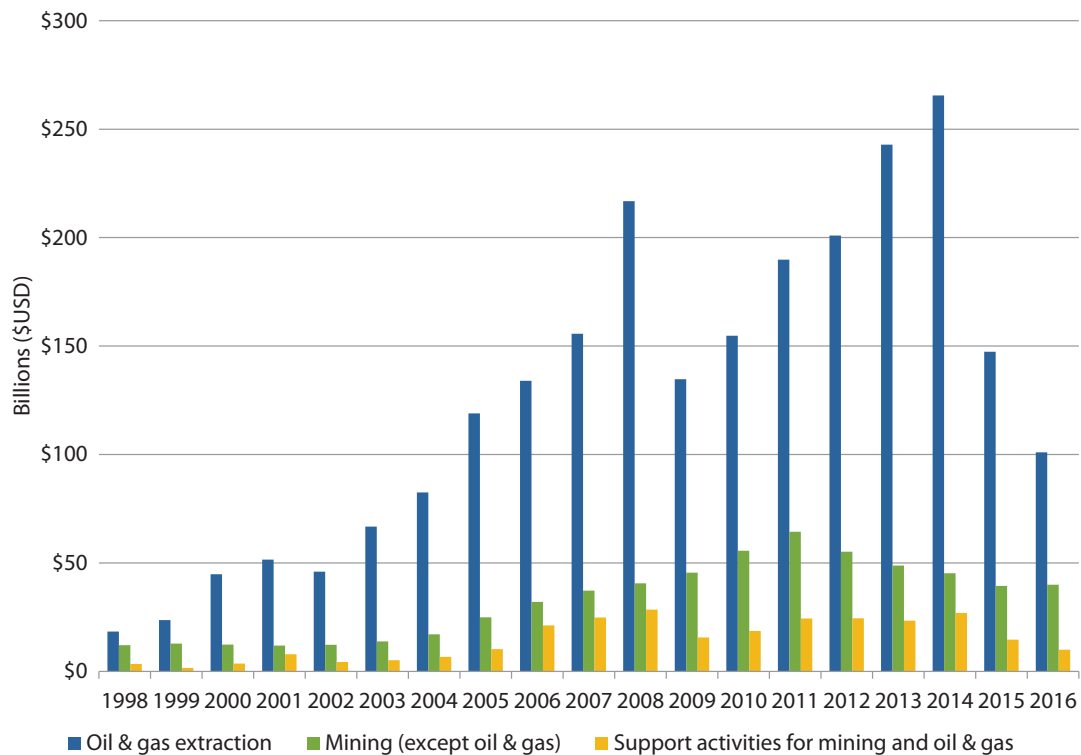
AGI Geoscience Workforce Program; Data derived from EIA, OFX, and World Gold Council

**Figure 6.6:** Commodity Output for the U.S. Mining, Oil and Gas Extraction, and Support Industries



AGI Geoscience Workforce Program; Data derived from the U.S. Bureau of Economic Analysis

**Figure 6.7:** Gross Operating Surplus for the U.S. Mining and Oil and Gas Extraction, and Support Industries



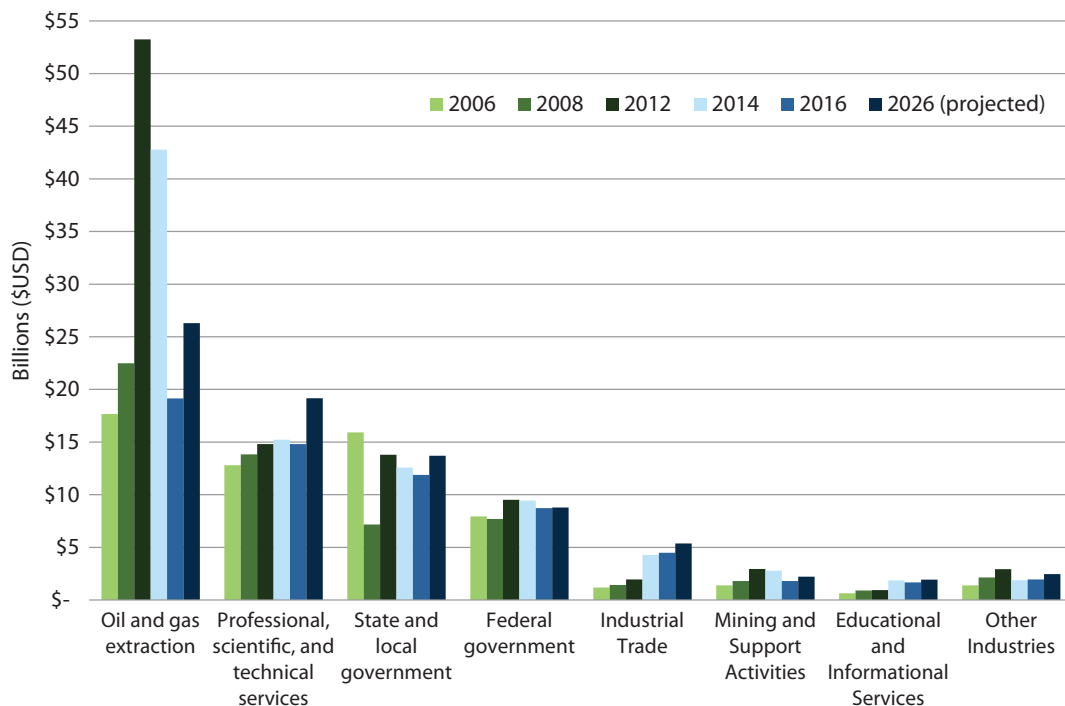
AGI Geoscience Workforce Program; Data derived from the U.S. Bureau of Economic Analysis

## Gross Domestic Product Contribution of Geosciences

The geoscience component of industry gross domestic product (GDP) represents the first order economic contribution of geoscientists to the U.S. economy. The geoscience component of industry GDP is calculated by multiplying the value added amount for a specific industry by the percentage of the industry's total employment that are geoscientists. Thus, the total geoscience component of industry GDP is usually less than an industry's domestic production. For example, for the oil and gas industry, the value added amount was \$162 billion in 2016. Geoscientists comprise 11.8% of the industry's employment. Therefore, the geoscience component of the oil and gas industry's GDP in 2016 was \$19.14 billion (Figure 6.8). In 2016, the

geoscience component of the oil and gas industry's GDP was nearly as low as it was 10 years previously due to the industry downturn that began in 2014. This downturn included layoffs within the industry, and this can be seen in the change in the calculated GDP contribution by geoscientists. The 10-year projection of the geoscience component of the oil and gas industry's GDP is nearly half of the 2024 projection presented in the 2016 edition of this report because of structural changes in the oil and gas industry. Therefore the 2026 projection is likely much lower than it should be because it is based on the lower employment numbers of 2016. As the industry recovers, the projections will likely increase.

Figure 6.8: Amount of Geoscience Industry GDP Contributed by Specific Industries



AGI Geoscience Workforce Program; Data derived from U.S. Bureau of Economic Analysis, U.S. Bureau of Labor Statistics, and AGI's Directory of Geoscience Departments database

## Productive Activity of Geoscience Industries

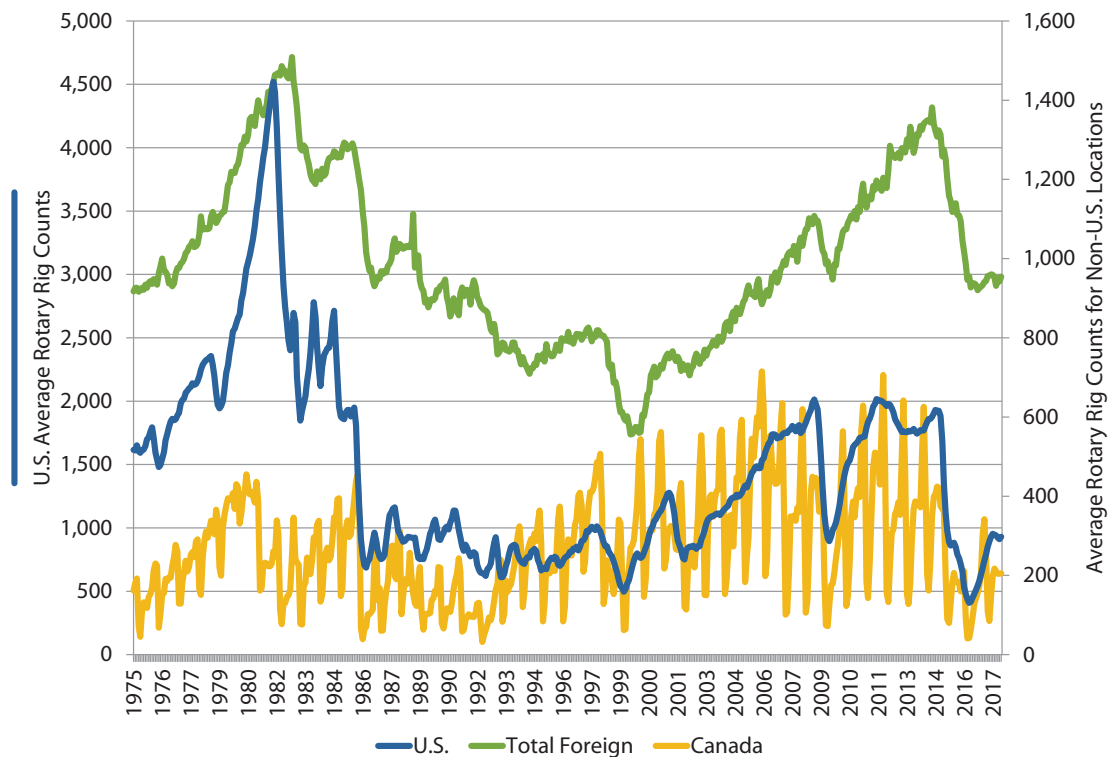
At the height of the petroleum industry in 2014, the U.S. was operating 52% of the drilling rigs in the world, but at the end of 2016, that percentage dropped to 35% due to an idling of 1291 rigs (Figure 6.9). U.S. drilling began recovering in 2017 by opening 216 rigs, thus operating 45% of the drilling rigs in the world. Most of the oil rigs that idled between 2014 and 2016 were onshore rigs, and near the end of 2016 the number of operating onshore and offshore rigs were nearly equal (Figure 6.11). The recent recovery in 2017 led to the activation of onshore rigs, but the number of offshore rigs has continued to slowly decrease through 2017.

Since the recession in 2009, there has been a rapid increase in crude oil wells and a rapid decrease in natural gas wells. However, the number of crude oil and natural gas rigs

decreased from 2014–2016 due to pressure from oil prices. As the industry recovers there have been over 200 crude oil rigs and approximately 100 natural gas rigs brought into active service through 2017. (Figure 6.12).

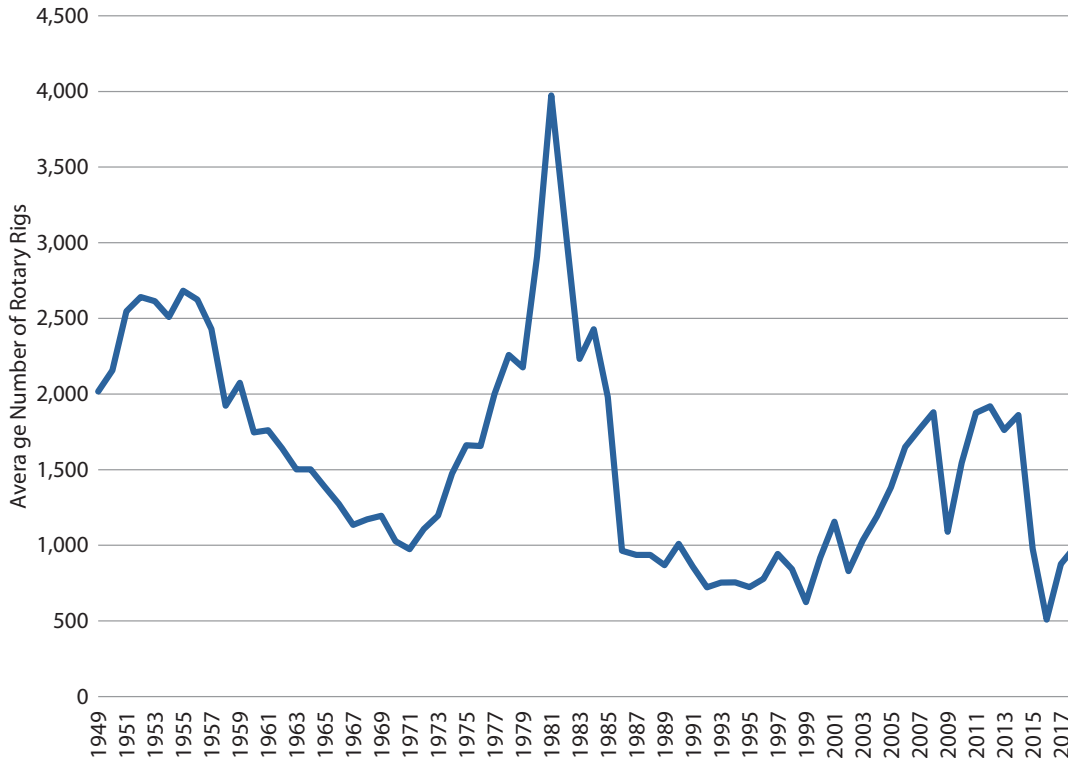
U.S. mines for industrial minerals and sand, gravel and stone appear to have been hard hit during the recession. While it appears the non-aggregate industrial minerals sector has bounced back some in 2012 and 2013, mines for sand, gravel, and stone saw a decrease in the material handled by the mines (Figure 6.15). In 2009 with the decrease in sand, gravel, and stone mines, metal ore became the raw material sector with the highest yield in metric tons since 2009. Along with higher yields of metal ore, the value of the metal ore has risen since 2009 reaching \$30 billion in 2014 (Figure 6.17).

Figure 6.9: Average Rotary Rig Counts by World Region



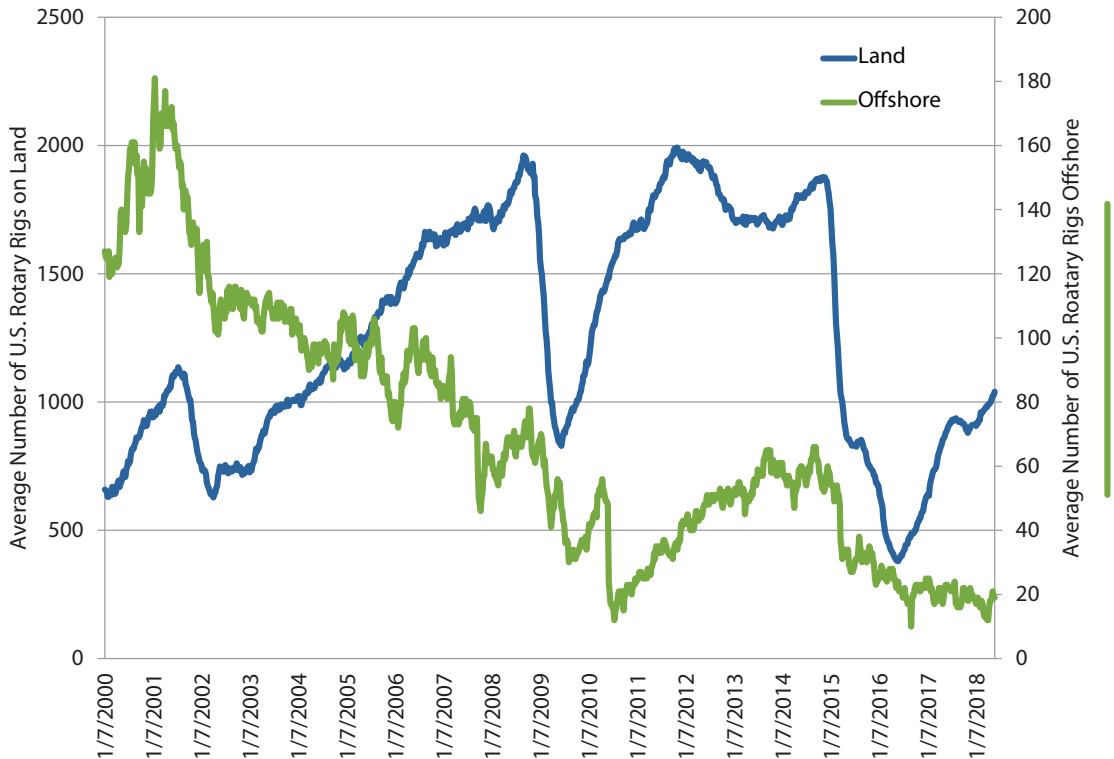
AGI Geoscience Workforce Program; Data derived from Baker Hughes

**Figure 6.10: U.S. Rotary Rig Counts**



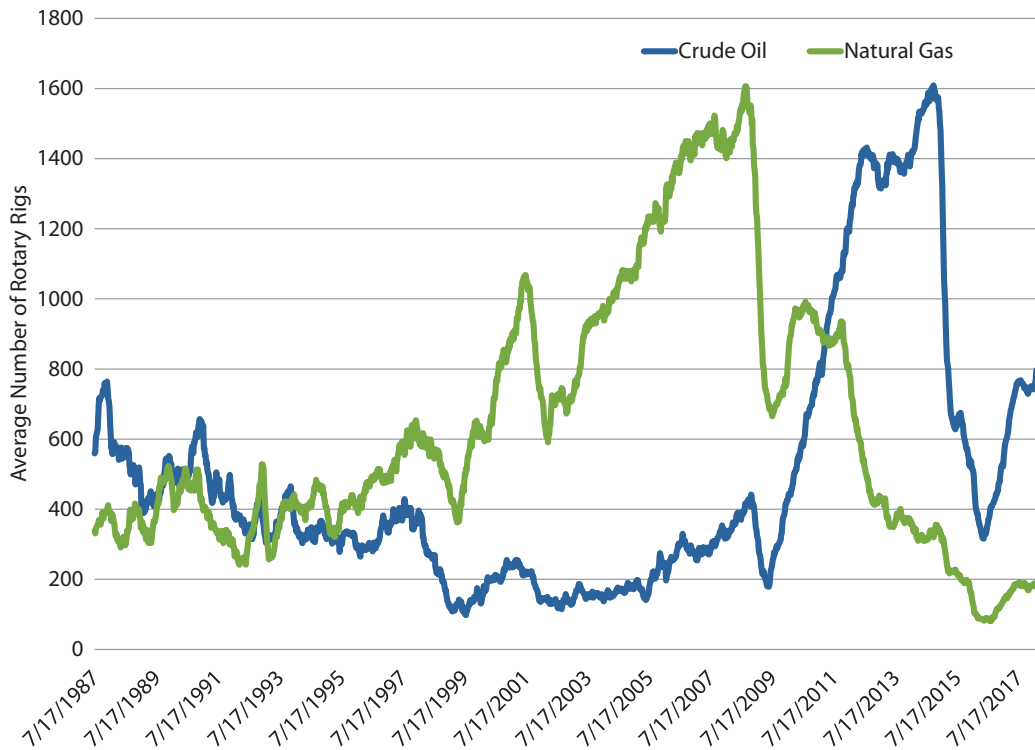
AGI Geoscience Workforce Program; Data derived from Baker Hughes

**Figure 6.11: U.S. Rotary Rigs by Location**



AGI Geoscience Workforce Program; Data derived by Baker Hughes

**Figure 6.12: U.S. Rigs by Type**



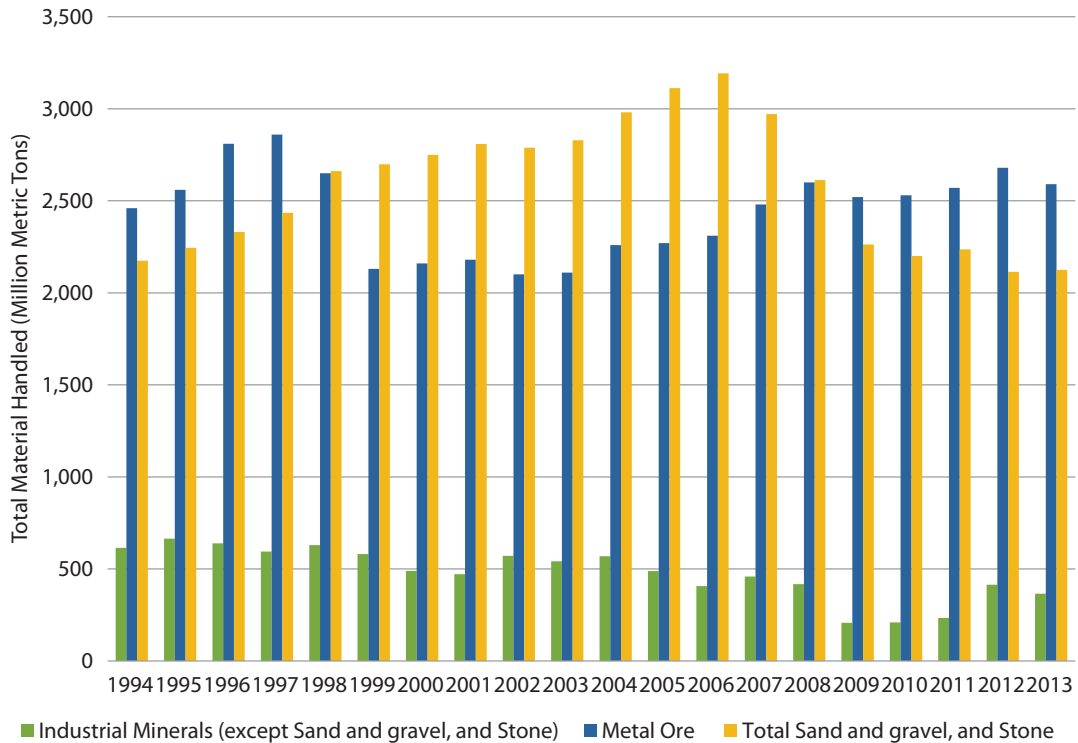
AGI Geoscience Workforce Program; Data derived from Baker Hughes

**Figure 6.13: Number of U.S. Mines**



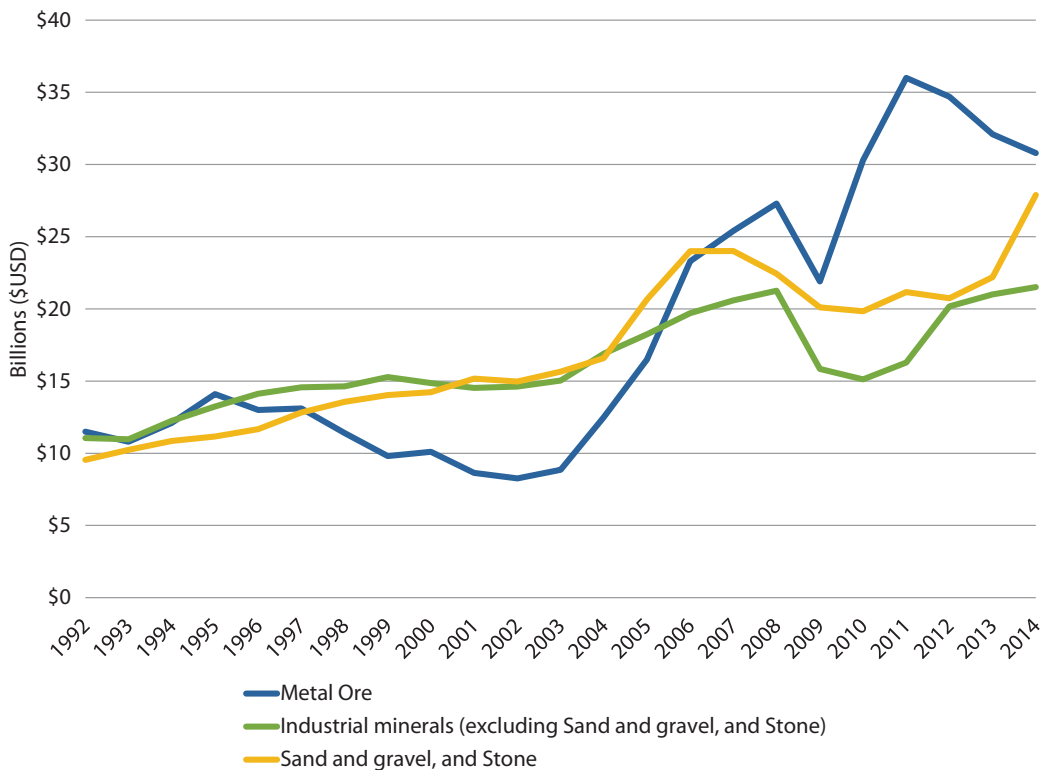
AGI Geoscience Workforce Program; Data derived from the USGS Mining and Quarrying Trends

**Figure 6.14: Material Handled at U.S. Mines**



AGI Geoscience Workforce Program; Data derived from the USGS Mining and Quarrying Trends

**Figure 6.15: Value of Non-Fuel Mineral Production from U.S. Mines**



AGI Geoscience Workforce Program; Data derived from USGS Minerals Yearbook



## Appendix A: Defining the Geosciences

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Given its complexity, the geoscience occupation is difficult to define under existing nomenclature. This is the result of varied educational pathways geoscientists pursue and because of the different industries in which geoscientists work. Additionally, each federal data source (U.S. Bureau of Labor Statistics, U.S. Census Bureau, National Center for Education Statistics, National Science Foundation, U.S. Bureau of Economic Analysis, Office of Personnel Management), professional society, and industry classifies geoscientists differently depending on the intent of data collection (national occupation trends, science and engineering trends, education vs. occupation, internal classification codes, etc.), the characteristics of the population surveyed, and the focus of the organization.

U.S. federal policy and funding is partially determined by the economic activity and employment trends of a given profession. Accurate measurement and analysis of the geoscience profession are central to successful decisions that support a robust geoscience profession in the U.S.

Unfortunately, the geosciences are not consistently defined across the myriad of data sources collected and used by federal government and professional societies. In many cases the issues of definition are related to splitting of disciplines, in some cases they are archaic artifacts of early labor policy, and in other, represent a lack of domain knowledge in the agencies setting the definitions. Though many federal agencies are attempting to improve their classification approach, the current diversity of definitions will continue for the foreseeable future. Unfortunately, the public statistics from this data are used by counselors and individuals seeking career

options, and the current state of geoscience workforce data usually severely under-represents the size of the profession and the breadth of opportunities.

To address this issue, AGI has established a working definition for the geoscience profession in order to improve comparability of data across sources and time periods, which is laid out in this section.

Many federal data sources use the Classification Instructional Programs (CIP) codes to classify educational programs, the Standard Occupational Classification (SOC) codes to classify occupations, and the North American Industry Classification System (NAICS) to classify industries. In this appendix we report how each data source defines a geoscientist. The CIP codes are managed by the U.S. Department of Education's National Center for Education Statistics. The SOC codes were developed by the U.S. Office of Management and Budget and are managed by the Standard Occupational Classification Revision Policy Committee. This committee consists of representatives from the U.S. Bureau of Labor Statistics, the U.S. Bureau of Census, the U.S. Department of Labor (Employment and Training Administration), the Office of Personnel Management, the Defense Manpower Data Center, the National Science Foundation, the National Occupational Information Coordinating Committee, and the Office of Management and Budget. The NAICS was developed under the guidance of the Office of Management and Budget by the U.S. Economic Classification Policy Committee, Statistics Canada, and Mexico's Instituto Nacional de Estadística, Geografía e Informática in order to allow for economic comparisons between North American countries.

## Educational Classifications

### Classification of Instructional Programs (CIP)

The National Science Foundation and the National Center for Education Statistics use the Classification of Instructional Programs (CIP) to classify educational programs including fields of study and program completions. The CIP website (<https://nces.ed.gov/ipeds/cip-code/browse.aspx?y=55>) also has an online application

that allows for the cross-referencing of instructional programs to the Standard Occupational Classification codes. For the 2018 report, the 2010 CIP codes were used, which includes the new categories of “Environmental Chemistry”, “Earth Science Teacher Education”, and “Environmental Education”.

**Appendix Table 1: CIP Codes that Refer to Geoscience Programs**

CIP Code	Title	Description
3.0104	Environmental Science	A program that focuses on the application of biological, chemical, and physical principles to the study of the physical environment and the solution of environmental problems, including subjects such as abating or controlling environmental pollution and degradation; the interaction between human society and the natural environment; and natural resources management. Including instruction in biology, chemistry, physics, geosciences, climatology, statistics, and mathematical modeling.
13.1337	Earth Science Teacher Education	A program that prepares individuals to teach earth science programs at various educational levels
13.1338	Environmental Education	A program that prepares individuals to teach environmental education at various educational levels as a K-12 classroom educator. Includes instruction in foundations of environmental education, instructional methods, and related content knowledge.
14.0802	Geotechnical Engineering	A program that prepares individuals to apply mathematical and scientific principles to the design, development, and operational evaluation of systems for manipulating and controlling surface and subsurface features at or incorporated into structural sites, including earth and rock moving and stabilization, land fills, structural use and environmental stabilization of wastes and by-products, underground construction, and groundwater and hazardous material containment.
14.1401	Environmental/ Environmental Health Engineering	A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of systems for controlling contained living environments and for monitoring and controlling factors in the external natural environment, including pollution control, waste and hazardous material disposal, health and safety protection, conservation, life support, and requirements for protection of special materials and related work environments.
14.2101	Mining and Mineral Engineering	A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of mineral extraction, processing and refining systems, including open pit and shaft mines, prospecting and site analysis equipment and instruments, environmental and safety systems, mine equipment and facilities, mineral processing and refining methods and systems, and logistics and communication systems.
14.2401	Ocean Engineering	A Program that prepares individuals to apply mathematical and scientific principles to the design, development, and operational evaluation of systems to monitor, control, manipulate, and operate within coastal or ocean environments, such as underwater platforms, flood control systems, dikes, hydroelectric power systems, tide and current control and warning systems, and communications equipment; the planning and design of total systems for working and functioning in water or underwater environments; and the analysis of related engineering problems such as the action of water properties and behavior on physical systems and people, tidal forces, current movements, and wave motion.
14.2501	Petroleum Engineering	A program that prepares individuals to apply mathematical and scientific principles to the design, development, and operational evaluation of systems for locating, extracting, processing and refining crude petroleum and natural gas, including prospecting instruments and equipment, mining and drilling systems, processing and refining systems and facilities, storage facilities, transportation systems, and related environmental and safety systems.
14.3901	Geological/ Geophysical Engineering	A program that prepares individuals to apply mathematical and geological principles to the analysis and evaluation of engineering problems, including the geological evaluation of construction sites, the analysis of geological forces acting on structures and systems, the analysis of potential natural resource recovery sites, and applied research on geological phenomena.

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CIP Code	Title	Description
26.1302	Marine Biology and Biological Oceanography	A program that focuses on the scientific study of the ecology and behavior of microbes, plants, and animals inhabiting oceans, coastal waters, and saltwater wetlands and their interactions with the physical environment. Includes instruction in chemical, physical, and geological oceanography; molecular, cellular, and biochemical studies; marine microbiology; marine botany; ichthyology; mammalogy; marine population dynamics and biodiversity; reproductive biology; studies of specific species, phyla, habitats, and ecosystems; marine paleoecology and paleontology; and applications to fields such as fisheries science and biotechnology.
40.0401	Atmospheric Sciences and Meteorology, General	A general program that focuses on the scientific study of the composition and behavior of the atmospheric envelopes surrounding the earth, the effect of earth's atmosphere on terrestrial weather, and related problems of environment and climate. Includes instruction in atmospheric chemistry and physics, atmospheric dynamics, climatology and climate change, weather simulation, weather forecasting, climate modeling and mathematical theory; and studies of specific phenomena such as clouds, weather systems, storms, and precipitation patterns.
40.0402	Atmospheric Chemistry and Climatology	A program that focuses on the scientific study of atmospheric constituents, reactions, measurement techniques, and processes in predictive, current, and historical contexts. Includes instruction in climate modeling, gases and aerosols, trace gases, aqueous phase chemistry, sinks, transport mechanisms, computer measurement, climate variability, paleoclimatology, climate diagnosis, numerical modeling and data analysis, ionization, recombination, photoemission, and plasma chemistry
40.0403	Atmospheric Physics and Dynamics	A program that focuses on the scientific study of the processes governing the interactions, movement, and behavior of atmospheric phenomena and related terrestrial and solar phenomena. Includes instruction in cloud and precipitation physics, solar radiation transfer, active and passive remote sensing, atmospheric electricity and acoustics, atmospheric wave phenomena, turbulence and boundary layers, solar wind, geomagnetic storms, coupling, natural plasma, and energization.
40.0404	Meteorology	A program that focuses on the scientific study of the prediction of atmospheric motion and climate change. Includes instruction in general circulation patterns, weather phenomena, atmospheric predictability, parameterization, numerical and statistical analysis, large- and mesoscale phenomena, kinematic structures, precipitation processes, and forecasting techniques.
40.0499	Atmospheric Sciences and Meteorology, Other	Any instructional program in atmospheric sciences and meteorology not listed above.
40.0509	Environmental Chemistry	A program that focuses on the scientific study of natural systems (air, water, and soil) through the use of chemical techniques and instrumentation, with an emphasis on the movement and fate of pollutants and chemical aspects of contaminant remediation. Includes instruction in analytical, inorganic, organic, and physical chemistry; aquatic, soil, and atmospheric chemistry; environmental engineering; environmental toxicology; and analytical methods
40.0601	Geology/Earth Sciences, General	A program that focuses on the scientific study of the earth; the forces acting upon it; and the behavior of the solids, liquids and gases comprising it. Includes instruction in historical geology, geomorphology and sedimentology, the chemistry of rocks and soils, stratigraphy, mineralogy, petrology, geostatistics, volcanology, glaciology, geophysical principles, and applications to research and industrial problems.
40.0602	Geochemistry	A program that focuses on the scientific study of the chemical properties and behavior of the silicates and other substances forming, and formed by geomorphological processes of the earth and other planets. Includes instruction in chemical thermodynamics, equilibrium in silicate systems, atomic bonding, isotopic fractionation, geochemical modeling, specimen analysis, and studies of specific organic and inorganic substances.
40.0603	Geophysics and Seismology	A program that focuses on the scientific study of the physics of solids and its application to the study of the earth and other planets. Includes instruction in gravimetric, seismology, earthquake forecasting, magnetometry, electrical properties of solid bodies, plate tectonics, active deformation, thermodynamics, remote sensing, geodesy, and laboratory simulations of geological processes.
40.0604	Paleontology	A program that focuses on the scientific study of extinct life forms and associated fossil remains, and the reconstruction and analysis of ancient forms, ecosystems, and geological processes. Includes instruction in sedimentation and fossilization processes, fossil chemistry, evolutionary biology, paleoecology, paleoclimatology, trace fossils, micropaleontology, invertebrate paleontology, vertebrate paleontology, paleobotany, field research methods, and laboratory research and conservation methods.
40.0605	Hydrology and Water Resources Science	A program that focuses on the scientific study of the occurrence, circulation, distribution, chemical and physical properties, and environmental interaction of surface and subsurface waters, including groundwater. Includes instruction in geophysics, thermodynamics, fluid mechanics, chemical physics, geomorphology, mathematical modeling, hydrologic analysis, continental water processes, global water balance, and environmental science.

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CIP Code	Title	Description
40.0606	Geochemistry and Petrology	A program that focuses on the scientific study of the igneous, metamorphic, and hydrothermal processes within the earth and the mineral, fluid, rock, and ore deposits resulting from them. Includes instruction in mineralogy, crystallography, petrology, volcanology, economic geology, meteoritics, geochemical reactions, deposition, compound transformation, core studies, theoretical geochemistry, computer applications, and laboratory studies.
40.0607	Oceanography, Chemical and Physical	A program that focuses on the scientific study of the chemical components, mechanisms, structure, and movement of ocean waters and their interaction with terrestrial and atmospheric phenomena. Includes instruction in material inputs and outputs, chemical and biochemical transformations in marine systems, equilibria studies, inorganic and organic ocean chemistry, oceanographic processes, sediment transport, zone processes, circulation, mixing, tidal movements, wave properties, and seawater properties.
40.0699	Geological and Earth Sciences/ Geosciences, Other	Any instructional program in geological and related sciences not listed above.
45.0701	Geography	A program that focuses on systematic study of the spatial distribution and interrelationships of people, natural resources, plant and animal life. Includes instruction in historical and political geography, cultural geography, economic and physical geography, regional science, cartographic methods, remote sensing, spatial analysis, and applications to areas such as land-use planning, development studies, and analyses of specific countries, regions, and resources.

## Occupational Classifications

### Standard Occupational Classification Codes

The U.S. Census Bureau of Labor Statistics and National Science Foundation (NSF) use the Standard Occupational Classification (SOC) codes (<https://www.bls.gov/soc/>) to classify geoscientists; however, each organization has a different focus for its surveying and data collection. While a new 2018 Standard Occupational Classification cod system has been released, this report uses the 2010 Standard Occupational Classification codes because much of the data was collected using that code system. The next edition of the report will likely use the 2018 SOC system.

Data from the U.S. Census Bureau, U.S. Bureau of Labor Statistics and the Office of Personnel Management are coarse because the first two agencies focus on national population trends and the third agency focuses on trends across all sectors of the federal government. Data from the National Science Foundation has a finer resolution because it is focused on specific data topics within the science and engineering fields. Data from all of these sources are too coarse to establish precise trends for geoscientists.

In data classified by the SOC codes, some geoscientists are grouped in categories with other non-geoscience scientists and engineers. For example, soil scientists

who study the chemical, physical, and mineralogical composition of soils are grouped with the Soil and Plant Scientists whose focus is on agriculture. Geotechnical engineers, who study the structural behavior of soil and rocks, perform soil investigations, design structure foundations, and provide field observations of foundation investigation and construction, are grouped with civil engineers who perform construction. Geoscientists at the professional or managerial level are grouped with either Engineering Managers or Natural Science Managers. Oceanographers do not have their own SOC code and are therefore categorized in various other codes. Geoscience teachers at post-secondary institutions are grouped in the Environmental Science Teacher, Atmospheric, Earth, Marine, and Space Science Teacher, Geography Teacher, or Engineering Teacher categories.

The National Science Foundation's classification of geoscientists provides better resolution than the SOC codes; however, there are no categories for geographers, hydrologists, geoscience managers and soil scientists. Additionally, many of the challenges with identifying geoscientists that occur in the SOC codes (such as post-secondary geoscience teachers) also occur within the National Science Foundation's classification schema.

**Appendix Table 2: Geoscientists are Found within the Following SOC Codes**

SOC Code	SOC Title	Definition
11-9041	Architectural and Engineering Managers	Plan, direct, or coordinate activities in such fields as architecture and engineering or research and development in these fields. Excludes "Natural Sciences Managers"
11-9121	Natural Science Managers	Plan, direct, or coordinate activities in such fields as life sciences, physical sciences, mathematics, statistics, and research and development in these fields. Excludes "Architectural and Engineering Managers" and "Computer and Information Systems Managers"
17-2051	Civil Engineers	Perform engineering duties in planning, designing, and overseeing construction and maintenance of building structures and facilities, such as roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, and water and sewage systems. Includes architectural, structural, traffic, ocean, and geo-technical engineers. Excludes "Hydrologists".
17-2081	Environmental Engineers	Research, design, plan or perform engineering duties in the prevention, control, and remediation of environmental hazards using various engineering disciplines. Work may include waste treatment, site remediation, or pollution control technology.
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	Conduct sub-surface surveys to identify the characteristics of potential land or mining development sites. May specify the ground support systems, processes and equipment for safe, economical, and environmentally sound extraction or underground construction activities. May inspect areas for unsafe geological conditions, equipment, and working conditions. May design, implement, and coordinate mine safety programs. Excludes "Petroleum Engineers".
17-2171	Petroleum Engineers	Devise methods to improve oil and gas extraction and production and determine the need for new or modified tool designs. Oversee drilling and offer technical advice.
19-1013	Soil and Plant Scientists	Conduct research in breeding, physiology, production, yield, and management of crops and agricultural plants or trees, shrubs, and nursery stock, their growth in soils, and control of pests; or study the chemical, physical, biological, and mineralogical composition of soils as they relate to plant or crop growth. May classify and map soils and investigate effects of alternative practices on soil and crop productivity.
19-1031	Conservation Scientists	Manage, improve and protect natural resources to maximize their use without damaging the environment. May conduct soil surveys and develop plans to eliminate soil erosion or to protect rangelands. May instruct farmers, agricultural production managers, or ranchers in best ways to use crop rotation, contour plowing, or terracing to conserve soil and water; in the number and kind of livestock and forage plants best suited to particular ranges; and in range and farm improvements, such as fencing and reservoirs for stock watering. Excludes "Zoologists and Wildlife Biologists" and "Foresters"
19-2021	Atmospheric and Space Scientists	Investigate atmospheric phenomena and interpret meteorological data, gathered by surface and air stations, satellites, and radar to prepare reports and forecasts for public and other data uses. Includes weather analysts and forecasters whose functions require the detailed knowledge of meteorology.
19-2041	Environmental Scientists and Specialists, Including Health	Conduct research or perform investigation for the purpose of identifying, abating, or eliminating sources of pollutants or hazards that affect either the environment or the health of the population. Using knowledge of various scientific disciplines, may collect, synthesize, study, report, and recommend action based on data derived from measurements or observations of air, food, soil, water, and other sources. Excludes "Zoologists and Wildlife Biologists", "Conservation Scientists", "Forest and Conservation Technicians", "Fish and Game Wardens", and "Forest and Conservation Workers".
19-2042	Geoscientists, Except Hydrologists and Geographers	Study the composition, structure, and other physical aspects of the Earth. May use geological, physics, and mathematics knowledge in exploration for oil, gas, minerals, or underground water; or in waste disposal, land reclamation, or other environmental problems. May study the Earth's internal composition, atmospheres, oceans, and its magnetic, electrical, and gravitational forces. Includes mineralogists, crystallographers, paleontologists, stratigraphers, geodesists, and seismologists.
19-2043	Hydrologists	Research the distribution, circulation, and physical properties of underground and surface waters; and study the form and intensity of precipitation, its rate of infiltration into the soil, movement through the earth, and its return to the ocean and atmosphere.
19-3092	Geographers	Study the nature and use of areas of the Earth's surface, relating and interpreting interactions of physical and cultural phenomena. Conduct research on physical aspects of a region, including land forms, climates, soils, plants, and animals, and conduct research on the spatial implications of human activities within a given area, including social characteristics, economic activities, and political organization, as well as researching interdependence between regions at scales ranging from local to global.
19-4041	Geological and Petroleum Technicians	Assist scientists or engineers in the use of electronic, sonic, or nuclear measuring instruments in both laboratory and production activities to obtain data indicating potential resources such as metallic ore, minerals, gas, coal, or petroleum. Analyze mud and drill cuttings. Chart pressure, temperature, and other characteristics of wells or bore holes. Investigate and collect information leading to the possible discovery of new metallic ore, minerals, gas, coal, or petroleum deposits.

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SOC Code	SOC Title	Definition
19-4091	Environmental Science and Protection Technicians, Including Health	Perform laboratory and field tests to monitor the environment and investigate sources of pollution, including those that affect health, under the direction of an environmental scientist, engineer, or other specialist. May collect samples of gases, soil, water, and other materials for testing.
25-1032	Engineering Teachers, Postsecondary	Teach courses pertaining to the application of physical laws and principles of engineering for the development of machines, materials, instruments, processes, and services. Includes teachers of subjects such as chemical, civil, electrical, industrial, mechanical, mineral, and petroleum engineering. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research. Excludes "Computer Science Teachers, Postsecondary".
25-1051	Atmospheric, Earth, Marine, and Space Sciences Teachers, Postsecondary	Teach courses in the physical sciences, except chemistry and physics. Includes both teachers primarily engaged in teaching, and those who do a combination of teaching and research.
25-1053	Environmental Science Teachers, Postsecondary	Teach courses in environmental science. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research.
25-1064	Geography Teachers, Postsecondary	Teach courses in geography. Includes both teachers primarily engaged in teaching and those who do a combination of teaching and research.

### Office of Personnel Management: Handbook of Occupations Groups and Families

The Office of Personnel Management released this Handbook in order to provide agencies with a starting point to classify positions.

**Appendix Table 3: Geoscientists are Found within the Following OPM Handbook Codes**

Code-Title	Description
0028-Environmental Protection Specialist Series	This series covers positions that involve advising on, managing, supervising, or performing administrative or program work relating to environmental protection programs (e.g., programs to protect or improve environmental quality, control pollution, remedy environmental damage, or ensure compliance with environmental laws and regulations). These positions require specialized knowledge of the principles and methods of administering environmental protection programs and the laws and regulations related to environmental protection activities.
0150-Geography Series	This series covers positions the duties of which involve professional work in the field of geography, including the compilation, synthesis, analysis, interpretation and presentation of information regarding the location, distribution, and interrelationships of and processes of change affecting such natural and human phenomena as the physical features of the earth, climate, plant, and animal life, and human settlements and institutions.
0401-General Natural Resources Management and Biological Science Series	This series covers positions that involve professional work in biology, agriculture, or related natural resource management when there is no other more appropriate series. Thus included in this series are positions that involve: 1) a combination of several professional fields with none predominant; or 2) a specialized professional field not readily identified with other existing series.
0457-Soil Conservation Series	This series covers positions involving the performance of professional work in the conservation of soil, water, and related environmental resources to achieve sound land use. Conservation work requires knowledge of: 1) soils and crops; 2) the pertinent elements of agronomy, engineering, hydrology, range conservation, biology, and forestry; and 3) skill in oral and written communication methods and techniques sufficient to impart these knowledge to selected client groups.

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Code-Title	Description
0470-Soil Science Series	This series covers positions that involve professional and scientific work in the investigation of soils, their management, and their adaptation for alternative uses. Such work requires knowledge of chemical, physical, mineralogical and biological properties and processes of the soils and their relationships to climatic, physiographic, and biologic influences.
0819-Environmental Engineering Series	This series covers positions managing, supervising, leading, and/or performing professional engineering and scientific work involving environmental programs and projects in the areas of: 1) environmental planning; 2) environmental compliance; 3) identification and cleanup of contamination; and 4) restoring and sustaining environmental conservation.
0880-Mining Engineering Series	This series covers positions managing, supervising, leading, and/or performing professional engineering and scientific work to explore, remove, and transport raw metals, nonmetallic minerals, and solid fuels from the earth. Mining engineering work involves: 1) a variety of mineral substances to include metal ores, nonmetallic minerals, and solid fuels and energy sources; 2) working with mining systems, including underground mining, surface mining, solution mining, and placer mining; and 3) traditional mining activities, including the heavy construction industry (involving rock excavation and support for highways, tunnels, dams, power stations, and underground chambers) and exploration and development of mineral deposits located under large bodies of water.
0881-Petroleum Engineering Series	This series covers positions managing, supervising, leading, and/or performing professional engineering and scientific work involved in the discovery and recovery of oil, natural gas (e.g. methane, ethane, propane, butane), and helium. The work includes: 1) exploration and development of oil and natural gas fields; 2) production, transportation, and storage of petroleum, natural gas, and helium; 3) investigation, evaluation, and conservation of these resources; 4) regulation of the transportation and sale of natural gas; 5) valuation of production and distribution facilities for tax, regulatory, and other purposes; and 6) research on criteria, principles, methods, and equipment involved in exploration and development activities.
1301-General Physical Science Series	This series includes positions that involve professional work in the physical sciences when there is no other more appropriate series, that is, the positions are not classifiable elsewhere. This series also includes work in a combination of physical science fields, with no one predominant.
1313-Geophysics Series	This series includes professional scientific positions requiring application of knowledge of the principles and techniques of geophysics and related sciences in the investigation, measurement, analysis, evaluation, and interpretation of geophysical phenomena and artificially applied forces and fields related to the structure, composition, and physical properties of the earth and its atmosphere.
1315-Hydrology Series	This series includes positions that involve professional work in hydrology, the science concerned with the study of water in the hydrologic cycle. The work includes basic and applied research on water and water resources; the collection, measurement, analysis, and interpretation of information on water resources; the forecast of water supply and water flows; and the development of new, improved or more economical methods, techniques, and instruments.
1321-Metallurgy Series	This series includes positions that require primarily professional education and training in the field of metallurgy, including ability to apply the relevant principles of chemistry, physics, mathematics, and engineering to the study of metals. Metallurgy is the art and science of extracting metals from their ores, refining them, alloying them and preparing them for use, and studying their properties and behavior as affected by the composition, treatment in manufacture, and condition of use.
1340-Meteorology Series	This series includes positions that involve professional work in meteorology, the science concerned with the earth's atmospheric envelope and its processes. The work includes basic and applied research into the conditions and phenomena of the atmosphere; the collection, analysis, evaluation, and interpretation of meteorological data to predict weather and determine climatological conditions for specific geographical areas; the development of new improvements of existing meteorological theory; and the development or improvement of meteorological methods, techniques, and instruments. Positions in this occupation require full professional knowledge and application of meteorological methods, techniques, and theories.
1350-Geology Series	This series includes professional scientific positions applying a knowledge of the principles and theories of geology and related sciences in the collection, measurement, analysis, evaluation, and interpretation of geologic information concerning the structure, composition, and history of the earth. This includes the performance of basic research to establish fundamental principles and hypotheses to develop a fuller knowledge and understanding of geology, and the application of these principles and knowledge to a variety of scientific, engineering, and economic problems.
1360-Oceanography Series	This series includes professional scientific positions engaged in the collection, measurement, analysis, evaluation, and interpretation of natural and physical ocean phenomena, such as currents, circulations, waves, beach and near-shore processes, chemical structure and processes, physical and submarine features, depth, floor configuration, organic, and inorganic sediments, sound and light transmission, color manifestations, heat exchange, and similar phenomena (e.g. biota, weather, geological structure, etc.). Oceanographers plan, organize, conduct, and administer seagoing and land-based study and research of ocean phenomena for the purpose of interpreting, predicting, utilizing and controlling ocean forces and events. This work requires a fundamental background in chemistry, physics, mathematics, and appropriate knowledge in the field of oceanography.

## Industry Classifications

### North American Industry Classification System (NAICS)

The NAICS (<https://www.census.gov/eos/www/naics/>) is the federal government’s standard industry classification system that groups employers into industries based on the activities in which they are primarily engaged. The United States, Canada, and Mexico developed the system to provide comparable statistics across the three countries. The NAICS is a comprehensive system covering the entire field of economic activities. There are 20 sectors in the NAICS and 1,065 detailed industries in the NAICS for the United States. The NAICS (United States version) is used by U.S. statistical agencies to facilitate the collection, tabulation, presentation, and analysis of data relating to business establishments. It

allows for inter-agency comparison of statistical data describing the U.S. economy. The NAICS is used by the U.S. Census Bureau, U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis, and by the National Science Foundation.

The top-level categories for NAICS are outlined in following table. Geoscientists work in the Mining, Utilities, Construction, Manufacturing, Wholesale Trade, Transportation and Warehousing, Information, Finance and Insurance, Professional, Scientific, and Technical Services, Management of Companies and Enterprises, Administrative and Support and Waste Management and Remediation Services, Educational Services, and Public Administration industries

**Appendix Table 4: All Occupations Fall Within the Following NAICS Codes**

NAICS Code	NAICS Industry Title
11	Agriculture, Forestry, Fishing and Hunting
21	Mining, Quarrying, and Oil and Gas Extraction
22	Utilities
23	Construction
31-33	Manufacturing
42	Wholesale Trade
44-45	Retail Trade
48-49	Transportation and Warehousing
51	Information
52	Finance and Insurance
53	Real Estate and Rental and Leasing
54	Professional, Scientific, and Technical Services
55	Management of Companies and Enterprises
56	Administrative and Support and Waste Management and Remediation Services
61	Educational Services
62	Health Care and Social Assistance
71	Arts, Entertainment, and Recreation
72	Accommodation and Food Services
81	Other Services (except Public Administration)
92	Public Administration

## AGI's Working Definition of Geoscience Occupations

In light of how existing data sources define the geosciences, AGI has worked with its stakeholders to establish a working definition for the geoscience profession in order to improve compatibility of data across sources and time periods. With this definition, AGI and its partners will be able to capture the depth and breadth of the geoscience profession, clearly define it, and estimate employment trends. The resulting data can then be used in a proposal to federal data agencies to more accurately define the geoscience in federal data sources.

AGI's working definition of the geoscience is as follows:

### Geoscientist

**Subfields: Environmental Science, Hydrology, Oceanography, Atmospheric Science, Geology, Geophysics, Climate Science, Geochemistry, Paleontology**

Studies the composition, structure, and other physical aspects of the earth. Includes the study of the chemical, physical, and mineralogical composition of soils, analysis of atmosphere phenomenon, and study the distribution, circulation, and physical and chemical properties of underground and surface waters. May study the earth's internal composition, atmospheres, oceans, and its magnetic, electrical, thermal, and gravitational forces. May utilize knowledge of various scientific disciplines to collect, synthesize, study, report, and take action based on data derived from measurements or observations of air, soil, water, and other resources. May use geological, environmental, physics, and mathematics knowledge in exploration for oil, gas, minerals, or underground water; or in waste disposal, elimination of pollutants/hazards that effect the environment, land reclamation, or management of natural resources.

### Geoscience Engineer

**Subfield: Environmental**

Designs, plans, or performs engineering duties in the development of water supplies and prevention, control, and remediation of environmental hazards utilizing various engineering disciplines. Work may include waste treatment, site remediation, pollution control technology, or the development of water supplies.

**Subfield: Exploration**

Determines the location and plan the extraction of coal, metallic ores, nonmetallic minerals, and building materials, such as stone and gravel. Work involved conducting preliminary surveys of deposits or undeveloped mines and planning their development; examining deposits or mines to determine whether they can be worked at a profit; making geological and topographical surveys; evolving methods of mining best suited to character, type, and size of deposits; and supervising mining operations. Devises methods to improve oil and gas well production and determine the need for new or modified tool designs. Oversees drilling and offer technical advice to achieve economical and satisfactory progress.

**Subfield: Geotechnical**

Studies that structural behavior of soils and rocks, perform soil investigations, design structure foundations, and provides field observations of foundation investigation and foundation construction.

### Geoscience Manager

Plans, directs, or coordinates activities in such fields as geoscience engineering and geoscience. Engages in complex analysis of geoscience principles. Generally oversees one or more professionals, but may still be active in technical work.

## Appendix B: Data Sources

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### AGI Data Sources:

#### GeoRef

AGI's GeoRef database contains over 2.9 million references to geoscience journal articles, books, maps, conference papers, reports and theses. GeoRef includes all geoscience publications that pertain only to surface and sub-surface processes. Publications pertaining to atmospheric and space sciences are excluded.

#### AGI's Directory of Geoscience Departments Database

AGI's Workforce Program has been collecting basic demographic information annually about all the geoscience programs at two-year and four-year institutions worldwide, along with other geoscience organizations and agencies, for nearly 50 years creating an extensive database. This database is used to for the AGI publication, the Directory of Geoscience Departments, and for current data on the health of geoscience departments in the U.S. and abroad.

#### AGI's Geoscience Student Exit Survey

AGI collects data from students graduating with their bachelor's, master's, and doctoral geoscience degrees in order to ascertain their educational background, degree information, co-curricular experiences, and immediate future plans after graduation. Some of the data is presented within this report. For more information about this study and to see more of the most recent data, please visit <https://www.americangeosciences.org/workforce/exit-survey>.

### Other Public Sources:

American Geophysical Union's Journal of Geophysical Research publications: <https://agupubs.onlinelibrary.wiley.com/journal/21562202>

American Meteorological Society publications: <https://www.ametsoc.org/index.cfm/ams/publications/journals/>

Association for the Sciences of Limnology and Oceanography publication: <https://aslo.org/page/aslo-publications>

ACT: <https://www.act.org/>

Baker Hughes: <https://www.bhge.com/>

College Board: <https://www.collegeboard.org/>

Energy Information Administration: <https://www.eia.gov/>

Geological Society of America publications: [https://www.geosociety.org/GSA/Publications/GSA/Pubs/GSA\\_Publications.aspx](https://www.geosociety.org/GSA/Publications/GSA/Pubs/GSA_Publications.aspx)

National Association of Geoscience Teachers publication: <https://nagt.org/nagt/jge/index.html>

National Science Foundation's Budget Internet Information Systems: <https://dellweb.bfa.nsf.gov/starth.asp>

National Science Foundation's National Center for Science and Engineering Statistics: <https://www.nsf.gov/statistics/>

OFX: <https://www.ofx.com/en-us/>

U.S. Bureau of Economic Analysis: <http://www.bea.gov/>

U.S. Bureau of Labor Statistics: <https://www.bls.gov/>

U.S. Census Bureau: <https://www.census.gov/>

U. S. Department of Education's Integrated Postsecondary Education Database: <http://nces.ed.gov/ipeds/>

U.S. Department of Education's National Center of Education Statistics: <https://nces.ed.gov/>

U.S. Geological Survey: <https://www.usgs.gov/>

U.S. Office of Personnel Management: <https://www.opm.gov/>

World Gold Council: <https://www.gold.org/>

## State Department of Education websites:

Alabama: <https://www.alsde.edu/>

Alaska: <https://education.alaska.gov/>

Arizona: <http://www.azed.gov/>

Arkansas: <http://www.arkansased.gov/>

California: <https://www.cde.ca.gov/>

Colorado: <https://www.cde.state.co.us/>

Connecticut: <https://portal.ct.gov/SDE>

Delaware: <https://www.doe.k12.de.us/>

District of Columbia: <https://sboe.dc.gov/>

Florida: <http://www.fldoe.org/>

Georgia: <http://www.gadoe.org/Pages/Home.aspx>

Hawaii: <http://www.hawaiipublicschools.org/Pages/Home.aspx>

Idaho: <http://www.sde.idaho.gov/>

Illinois: <https://www.isbe.net/>

Indiana: <https://www.doe.in.gov/>

Iowa: <https://educateiowa.gov/>

Kansas: <https://www.ksde.org/>

Kentucky: <https://education.ky.gov/Pages/default.aspx>

Louisiana: <https://www.louisianabelieves.com/>

Maine: <https://www.maine.gov/doe/home>

Maryland: <http://marylandpublicschools.org/Pages/default.aspx>

Massachusetts: <http://www.doe.mass.edu/>

Michigan: <https://www.michigan.gov/mde/>

Minnesota: <https://education.mn.gov/MDE/index.html>

Mississippi: <https://www.mdek12.org/>

Missouri: <https://dese.mo.gov/>

Montana: <https://mt.gov/education/>

Nebraska: <https://www.education.ne.gov/>

Nevada: <http://www.doe.nv.gov/>

New Hampshire: <https://www.education.nh.gov/>

New Jersey: <https://www.state.nj.us/education/>

New Mexico: <https://webnew.ped.state.nm.us/>

New York: <http://www.nysed.gov/>

North Carolina: <http://www.ncpublicschools.org/>

North Dakota: <https://www.nd.gov/dpi>

Ohio: <http://education.ohio.gov/>

Oklahoma: <https://sde.ok.gov/>

Oregon: <https://www.oregon.gov/ode/Pages/default.aspx>

Pennsylvania: <https://www.education.pa.gov/Pages/default.aspx>

Rhode Island: <http://www.ride.ri.gov/Home.aspx>

South Carolina: <https://ed.sc.gov/>

South Dakota: <https://doe.sd.gov/>

Tennessee: <https://www.tn.gov/content/tn/education.html>

Texas: <https://tea.texas.gov/>

Utah: <https://www.schools.utah.gov/>

Vermont: <https://education.vermont.gov/>

Virginia: <http://www.doe.virginia.gov/>

Washington: <https://www.sbe.wa.gov/>

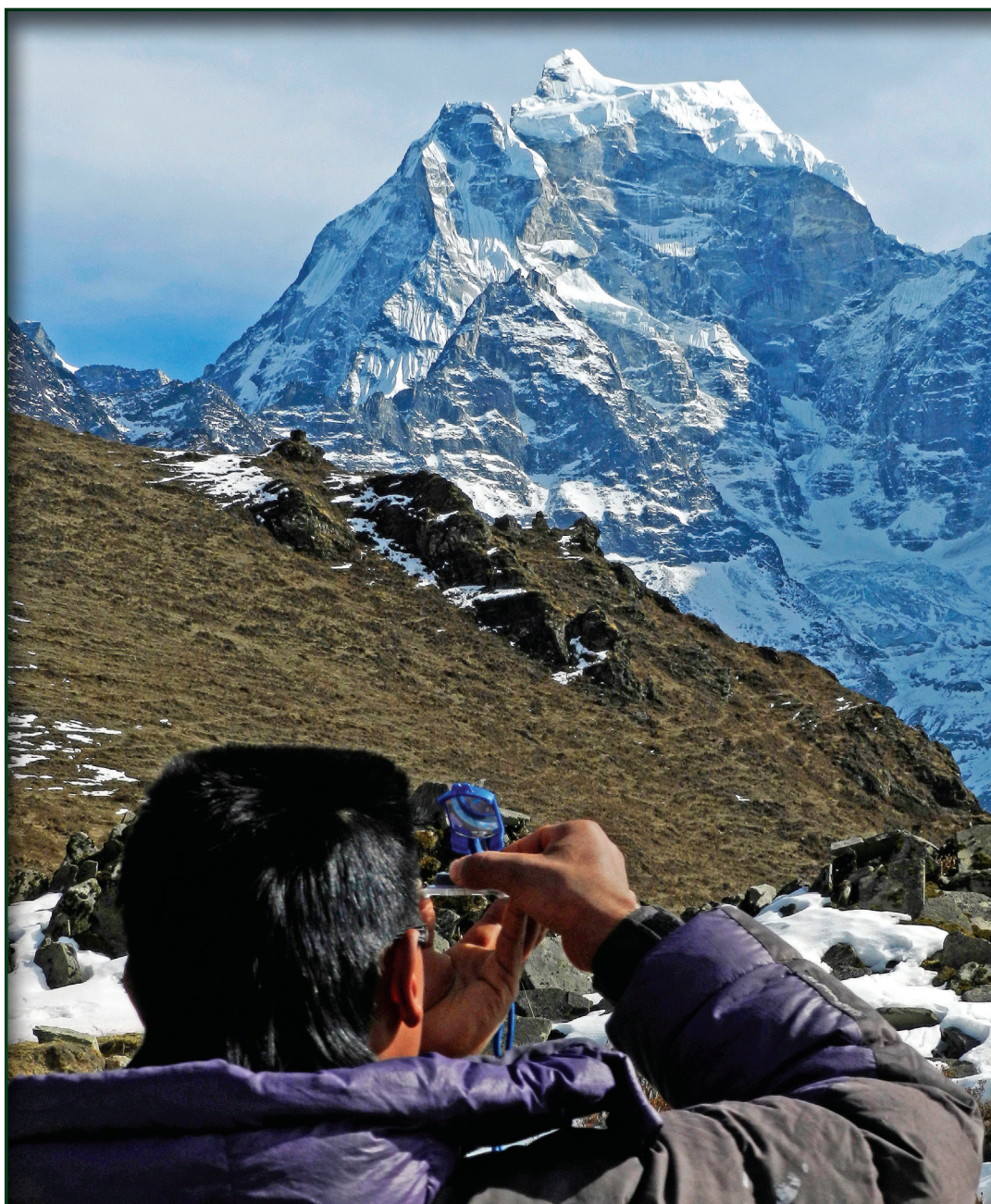
West Virginia: <https://wvde.us/>

Wisconsin: <https://dpi.wi.gov/>

Wyoming: <https://edu.wyoming.gov/>







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American Geosciences Institute  
4220 King Street, Alexandria, VA 22302-1507, U.S.A.  
phone: 703-379-2480; [www.americangeosciences.org](http://www.americangeosciences.org)