Status of the Geoscience Workforce 2011

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SERVING THE GEOSCIENCES WORLDWIDE
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The "Status of the Geoscience Workforce" Report

The "Status of the Geoscience Workforce" report provides a comprehensive benchmark of the geoscience profession. The report is based on original data collected by the American Geological Institute as well as from existing data from federal data sources, professional membership organizations, and industry data sources. The report synthesizes all available data for the geosciences, from the supply and training of new students, to workforce demographics and employment projections, to trends in geoscience research funding and economic indicators. The report is available as a complete document, as well as on a per chapter basis. It will be available for download from AGI's website: http://www.agiweb.org/.

Chapter 1: Trends in K-12 Geoscience Education

This chapter examines the student participation in geoscience education at the K-12 level and includes data on state requirements for earth science education in middle and high school, and data pertaining to the number of earth science high school teachers. The chapter also examines trends in college bound students including SAT scores, aspirations for higher education, and choice of college major.

Chapter 2: Trends in Community College Programs

This chapter examines the availability of geoscience education at community colleges and examines the trends in Associate degrees conferred from geoscience programs at these institutions.

Chapter 3: Trends in Geoscience Education at Four-Year Institutions

This chapter summarizes all available data pertaining to geoscience enrollments, degrees conferred, field camp attendance, and funding of geoscience undergraduate and graduate students. The chapter also explores trends in department size, faculty numbers and research specialties, and funding of geoscience research at the university level.

Chapter 4: Geoscience Employment Sectors

This chapter explores the transition of geoscience graduates into the workforce, age demographics of the industries where geoscientists work, and projected workforce demand. Data pertaining to the current number of jobs and projected number of jobs in 2018 is also provided, as is current salary information for each profession.

Chapter 5: Economic Metrics and Drivers of the Geoscience Pipeline

This chapter provides data on productive activity (number of oil rigs, mines, etc.), commodity pricing and output, gross domestic product, and market capitalization of the industries where geoscientists work.

Appendix A: Defining the Geosciences

This appendix outlines how geoscience occupations and industries are defined in federal data sources. Additionally, this appendix details the definition proposed by AGI for tracking the geoscience occupation.

Appendix B: References

A list of the cited references in the report.

Acknowledgements

The AGI Geoscience Workforce program would like to thank the AGI Foundation for funding of the program and this report. The AGI Geoscience Workforce Program would also like to thank the following people, organizations, companies, and industries that provided data for this report, including:

Dr. Penny Morton, University of Minnesota-Duluth, who provided all field camp attendance data; Barry Jay Katz, ChevronTexaco for the "2003 Report on the Status of Academic Geoscience Departments"; American Association of Petroleum Geologists (AAPG); American Geophysical Union; Baker Hughes; College Board; Council of Chief State School Officers (CCSSO); Econostats.com; Energy Information Administration; Google Finance; Indexmundi.com; InflationData.com; Industry and corporate data collaborators; Integrated Postsecondary Education Data System (IPEDS); Kitco.com; National Center for Education Statistics (NCES); National Ground Water Association (NGWA); National Mining Association; National Science Foundation Division of Science Resources Statistics; National Science Foundation Award Database; OANDA.com; Office of Personnel Management; Society of Economic Geologists (SEG); Society of Exploration Geophysicists (SEG); U.S. Bureau of Economic Analysis; U.S. Bureau of Labor Statistics; U.S. Department of Education; U.S. Geological Survey; ACT; U.S. Census Bureau; American Meteorological Society.

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

Overview

K-12 education provides an important formative stage in a student's education, and the coursework to which students are exposed during this period (especially during high school) influences choices they make with regard to college majors. Mathematics and reading proficiency by grade 8 is important for preparing students for academic coursework in high school and beyond. Since the passage of No Child Left Behind in 2001, mathematics proficiency rates for students in grades 4 and 8 increased markedly by 2009 from 65 to 82 percent for grade 4 students, and from 63 to 73 percent for grade 8 students. Reading proficiency increased slightly for students in grade 4 (62 to 67 percent for years 1998 to 2009), and remained near 75 percent for students in grade 8.

Earth Science education is taught in grades 6 through 8 in the majority of states, although trends over the past 18 years indicate that only 11-15 percent of grade 7 and 8 students take an explicit Earth Science course. Integration of earth science into General Science courses and students fulfilling their Earth Science education requirements in grade 6 are leading factors depressing the middle school Earth Science participation rates.

Trends of degrees of U.S. K-8 teachers between 1993 and 2006 indicate few teachers possess geoscience degrees. In pre-kindergarten and elementary school, teachers most commonly have their highest degrees in the social sciences or in non-science and engineering disciplines. However, two to three percent of pre-kindergarten and kindergarten teachers have their highest degree in the geosciences compared to between one and two percent for other elementary teachers.

Although Earth Science is generally not a required course in high school, all states and the District of Columbia include earth science in their high school science standards. For the past 26 years, the percentage of high school students taking Earth Science courses has never exceeded 25 percent. (Enrollments in Chemistry and Physics have increased since

1982, and Biology enrollments have remained around 90 percent since 1990). Examination of the most recent diversity data from 2005 indicates that a slightly higher percentage of male high school students take Geology/Earth Science courses than female students. Course-taking patterns by race and ethnicity indicate that Earth Science coursework in high school is lowest for Asian-American/Pacific Islander students (16 percent) and between 20 and 24 percent for underrepresented minorities and non-minority students. Although the percentage of high school science teachers in Biology, Chemistry, Physics, and Earth Science has grown in the past 18 years, Earth Science has grown the least at 21 percent. Furthermore, approximately 3 percent of the high school science, math, and computer teachers have their highest degree in the geosciences.

The SAT test, a standardized test for college-admission, does not list Geoscience as an intended college major choice; however, this discipline is grouped into the Physical Science category. The number of students indicating either Physical Science or Interdisciplinary Studies as their intended college major area increased from 16,061 in 1996 to 19,891 in 2006, and has since dropped to 16,487 in 2009. The interest in these majors has remained at 1.2 percent of all college-bound students (1 percent for Physical Science, 0.2 percent for Interdisciplinary Studies) for the past two of decades. College-bound students indicating Physical Science as their college major outperformed those indicating Interdisciplinary Studies on both the verbal and math sections of the SAT between 1997 and 2006. However, after the redesign of the SAT in 2006, those intending majors in Interdisciplinary Studies consistently out-performed those intending majors in the Physical Sciences on the critical reading and writing sections of the SAT. Additionally, since 2007 mean math scores of intended Interdisciplinary Studies majors have been on par with those intending majors in the Physical Sciences. Furthermore, both groups have historically scored higher mean math and verbal (including critical reading and writing) scores than the total group of SAT test-takers. Interestingly, since 2000, approximately half of all college-bound secondary school students have indicated intent to obtain graduate degrees.

Indicators of college-readiness focus on student course-taking patterns (e.g. advanced mathematics, Advanced Placement / International Baccalaureate, etc.), and comparison of SAT and ACT test scores against national benchmarks (Montgomery County Public Schools, 2010; Kirst and Venezia, 2006). As of 2005, 70 percent of high school graduates completed Algebra II, 30 percent completed Pre-Calculus, and 14 percent completed Calculus prior to graduation. Although there is no AP Geology course, AP course-taking patterns for other science and math topics indicate a low percentage of high school graduates take AP courses (16 percent AP / honors Biology, 9 percent AP / honors Calculus, 8 percent AP / honors Chemistry, and 5 percent AP / honors Physics). Furthermore, mean math and verbal (including critical reading and writing) scores for those students with coursework or experience in Geology / Earth or Space Sciences have been consistently less than those with coursework or experience in the other natural sciences and less than the national benchmarks. In 2002, one-fifth of ACT test-takers met or exceeded all four subject benchmarks, and in 2009, almost one-quarter (23 percent) met this benchmark.

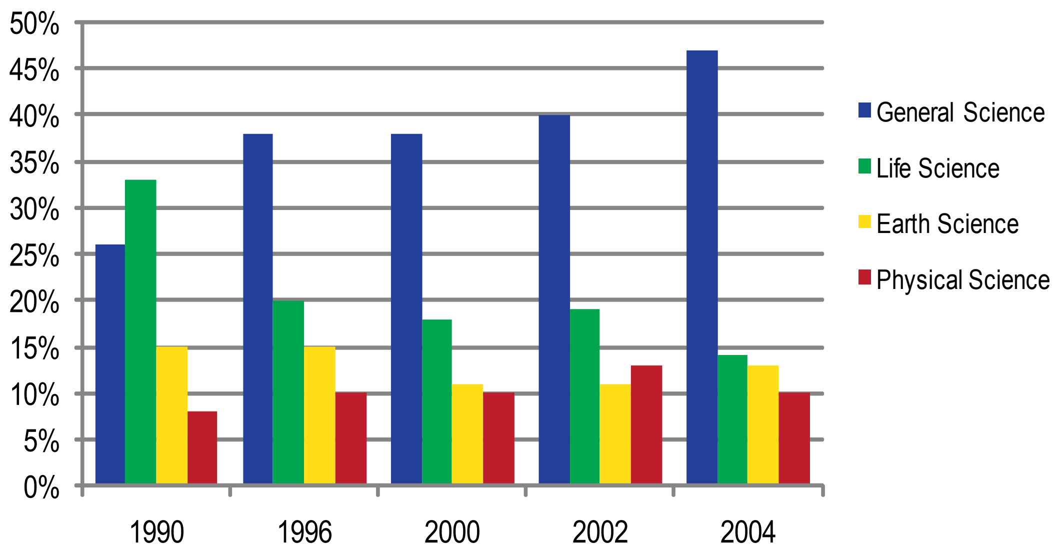
The College Board's "Standards for College Success" report (College Board, 2010) provides detailed standards, objectives, and performance expectations for both middle grade and high school students in order to ensure that students are prepared appropriately for college instruction and/or for the workforce. For the first time, Earth Science has been assigned its own chapter in the "Science Standards for College Success" section of the report. The extent to which this report will increase emphasis for earth science in the middle school curriculum remains to be seen over the coming years.

Grades K-8

During grades K-8, students are introduced to basic earth science content, and are prepared for more advanced study of these concepts in high school. In most states, earth and space science education in grades K-5 is integrated into the overall science curriculum and typically includes topics such as weather, rocks, fossils, soil, planets and natural hazards. Earth science education at the secondary level is usually most intensive in grades 6 through 8 when students learn about energy in the Earth system, geochemical cycles, and the origin and evolution of the universe and Earth.

According to AGI's 2009-2010 "Pulse of Earth Science: National Status of K-12 Earth Science Education" report, all states and the District of Columbia include earth science in the curriculum for grades 6 through 8. The majority of states (43) include earth science in the standards from grades 6 through 8, while a few states specify earth science in standards for one of the middle grades or extend the standards to include additional grade levels. Alabama, Georgia, and Michigan and the District of Columbia specify earth science in grade 6 standards; Hawaii and Minnesota specify earth science for grade 8 standards; and Arizona specifies earth science in the standards for grades 6 and 7. Arkansas is the only state to extend the earth science standards to span grades 5 through 8.

Although earth science in the U.S. is generally taught in middle school, the trend over the past 18 years among students in grades 7 and 8 indicates that only 11-15 percent of students take stand-alone Earth Science courses (Figure 1.1). Much of this trend can be attributed to a change in middle school curriculum that has integrated specific science courses into a General Science curriculum. Additionally, since Earth Science is taught between grades 6 to 8, it may be that many students fulfill their Earth Science requirement in grade 6.

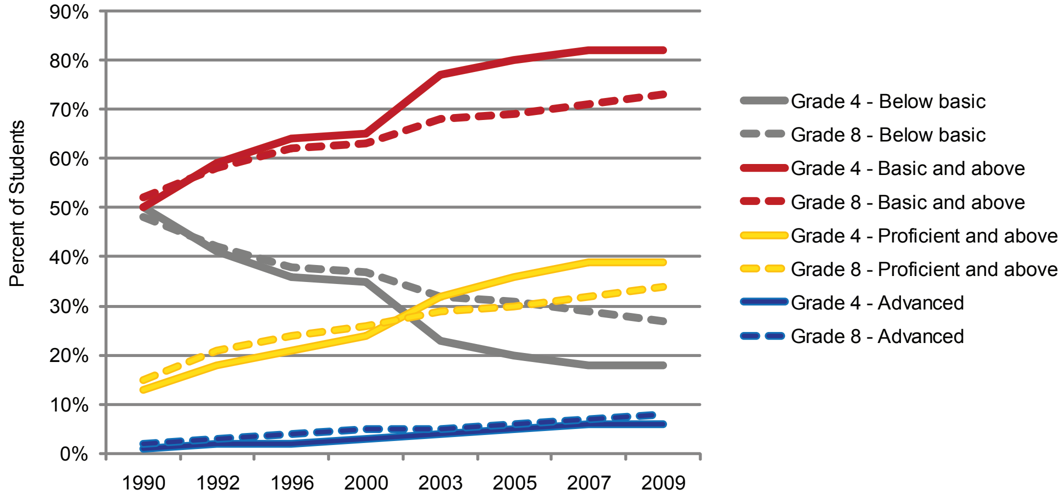


Source: AGI Geoscience Workforce Program, data derived from the CCSSO, *State Indicators of Science and Mathematics*, 2001, 2003, 2005, 2007

Figure 1.1: Percentage of 7th and 8th Graders Enrolled in Selected Science Courses

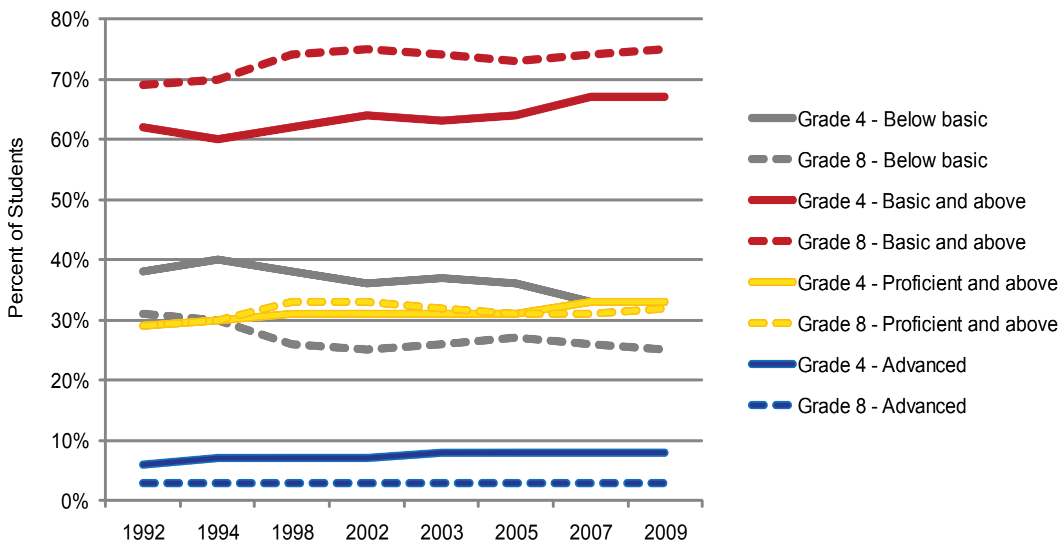
Mathematics and reading proficiency in grades K-8 is important for preparing students for academic coursework in high school and beyond. Since passage of the No Child Left Behind (NCLB) Act in 2001, mathematics proficiency rates for students in grades 4 and 8 increased markedly between 2000 and 2009 from 65 to 82 percent for grade 4 students, and from 63 to 73 percent for grade 8 students. Reading proficiency for students in both grades increased slightly for students in grade 4 (62 to 67 percent for years 1998 to 2009), and remained near 75 percent for students in grade 8 (Figs. 1.2 and 1.3).

A report by the Center for Public Education (Hull, 2008) used the "At or above basic" NAEP achievement level to compare NCLB state level standard results and NAEP achievement rates. Grade 4 students have shown the greatest increases in proficiency levels for mathematics at both the "At or above basic" and "At or above proficient" levels since 2000, with underrepresented minorities having the greatest increases, both in grade 4 and in grade 8 (Tables 1.1 and 1.2).



Source: AGI Geoscience Workforce Program, data derived from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1990, 1992, 1996, 2000, 2003, 2005, 2007, and 2009 Mathematics Assessments.

Figure 1.2: Grades 4 and 8 Math Achievement Rates



Source: AGI Geoscience Workforce Program, data derived from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1990, 1992, 1996, 2000, 2003, 2005, 2007, and 2009 Reading Assessments.

Figure 1.3: Grades 4 and 8 Reading Achievement Rates

	White		African American		Hispanic		Native American	
Year	Grade 4	Grade 8	Grade 4	Grade 8	Grade 4	Grade 8	Grade 4	Grade 8
2000	31%	34%	5%	5%	7%	8%	8%	10%
2003	43%	37%	10%	7%	16%	12%	17%	15%
2005	47%	39%	13%	9%	19%	13%	21%	14%
2007	51%	42%	15%	11%	22%	15%	25%	16%
2009	51%	44%	16%	12%	22%	17%	21%	18%

Table 1.1: Percentage of Students by Race and Ethnicity that performed "At or above proficiency" in Mathematics for Grades 4 and 8

(Source: AGI Geoscience Workforce Program, data derived from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1990, 1992, 1996, 2000, 2003, 2005, 2007, and 2009 Mathematics Assessments.)

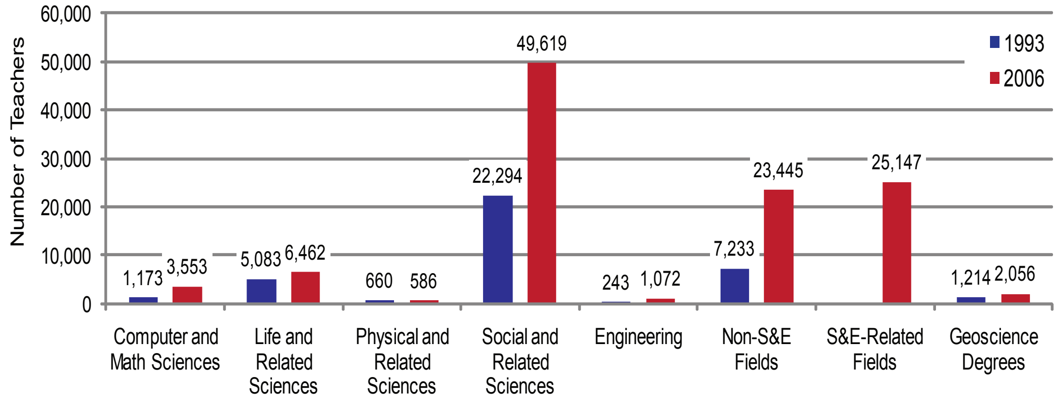
	White		African American		Hispanic		Native American	
Year	Grade 4	Grade 8	Grade 4	Grade 8	Grade 4	Grade 8	Grade 4	Grade 8
2000	78%	76%	36%	31%	42%	41%	60%	47%
2003	87%	80%	54%	39%	62%	48%	36%	52%
2005	90%	80%	60%	42%	68%	52%	32%	53%
2007	91%	82%	64%	47%	70%	55%	30%	53%
2009	91%	83%	64%	50%	71%	57%	34%	56%

Table 1.2: Percentage of Students by Race and Ethnicity that performed "At or above basic" in Mathematics for Grades 4 and 8

(Source: AGI Geoscience Workforce Program, data derived from U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1990, 1992, 1996, 2000, 2003, 2005, 2007, and 2009 Mathematics Assessments.)

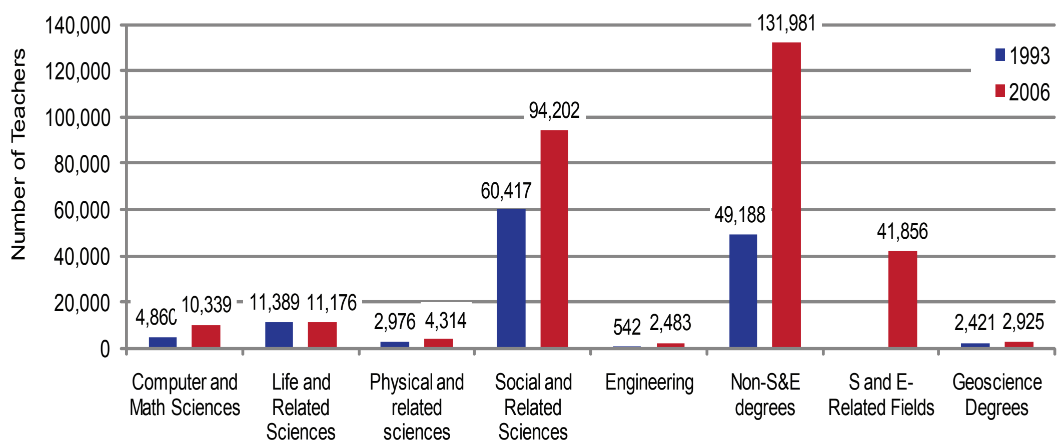
K-8 Teacher Trends

Trends in degrees of K-8 teachers between 1993 and 2006 indicate few teachers have geoscience degrees (Figs. 1.4 and1.5). Most primary school teachers have their highest degrees in the social sciences or other non-science and engineering disciplines. Interestingly, 2 to 3 percent of pre-kindergarten and kindergarten teachers have their highest degree in the geosciences compares to 1 to 2 percent for other elementary school teachers.



Source: AGI Geoscience Workforce Program; data derived from NSF's 1993 amd 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 1.4: Degree Fields of Pre-Kindergarten and Kindergarten Teachers (1993-2006)



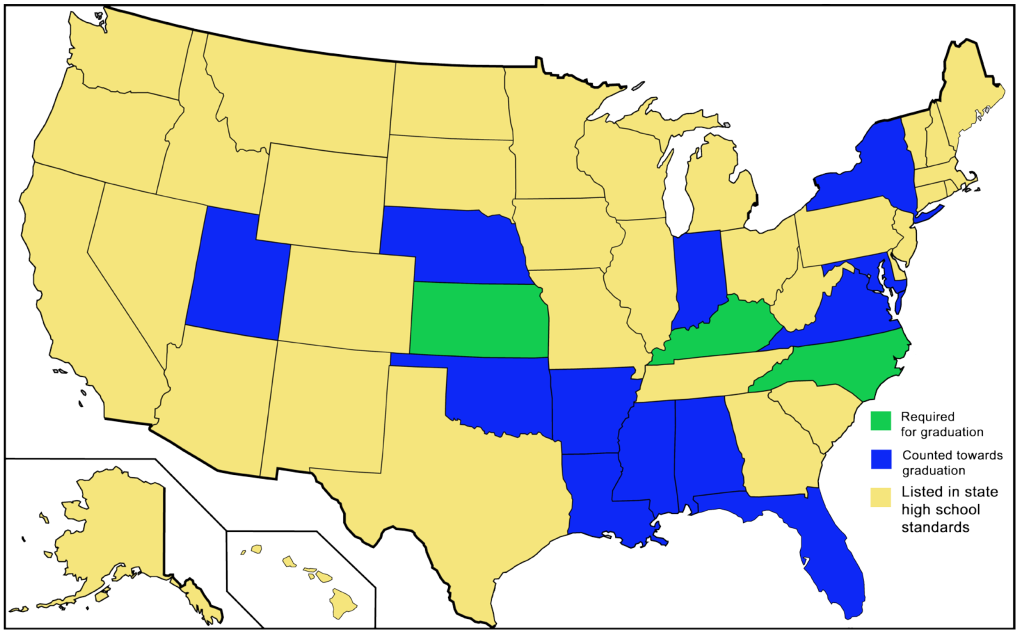
Source: AGI Geoscience Workforce Program; data derived from NSF's 1993 amd 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 1.5: Degree Fields of Elementary School Teachers (1993-2006)

Grades 9-12

In high school, Earth Science is generally taught in grade 9. Since there is no Advanced Placement exam for Earth Science, advanced high school coursework in the discipline is rare. According to AGI's 2009-2010 "Pulse of Earth Science: National Status of K-12 Earth Science Education" report, all states and the District of Columbia include Earth science in their high school science standards.

Figure 1.6 and Tables 1.3-1.5 indicate the states that require Earth science coursework for graduation or accept Earth Science credits towards the graduation requirements. The figure also indicates those states which include earth science in their high school science standards, but do not mention specifically that Earth Science coursework is required or accepted for graduation requirements.



Source: AGI Geoscience Workforce Program, data derived from AGI's National Status of K-12 Earth Science Education report update 2010.

Figure 1.6: Earth Science education requirements in high school

Is Earth Science a required course for graduation?			
State	**2002**	**2007**	**2009-2010**
Alaska	No	Determined by district	No*
Arizona	No	Determined by district	No*
Colorado	No	Determined by district	No*
Connecticut	No	Determined by district	No*
Idaho	No	Yes	No*
Illinois	No	Determined by district	No*
Indiana	No	Yes	No*
Kansas	No	Yes	Yes
Kentucky	Yes	Yes	Yes
Louisiana	No	Yes	No*
Massachusetts	No	Determined by district	No*
Michigan	No	Yes	No*
Nevada	No	Determined by district	No*
New Hampshire	No	Determined by district	No*
New Jersey	No	Determined by district	No*
New York	Yes	No	No*
North Carolina	Yes	Yes	Yes
North Dakota	No	Determined by district	No*
Oregon	No	Determined by district	No*
Pennsylvania	Yes	Determined by district	No*
Rhode Island	No	Determined by district	No*
Wyoming	Yes	Determined by district	No*

* denotes that earth science is included in the high school state science standards.

Table 1.3: Changes in State-level Earth Science Requirements for Graduation

Is Earth Science a recommended course in high school?			
State	2002	2007	2009-2010
Alabama	Yes	Yes	-*
Alaska	-	Yes	-*
Arizona	-	Determined by district	-*
California	-	Yes	-*
Colorado	No	Determined by district	-*
Delaware	-	Determined by district	-*
Florida	Yes	Yes	-*
Hawaii	-	Yes	-*
Idaho	-	Yes	-*
Illinois	No	Determined by district	-*
Indiana	Yes	Yes	-*
Kansas	No	Yes	-*
Kentucky	-	Yes	-*
Louisiana	No	Yes	-*
Maine	Determined by district	Yes	-*
Maryland	-	Yes	-*
Massachusetts	-	Determined by district	-*
Michigan	Yes	Determined by district	-*
Minnesota	Yes	-	-*
Mississippi	Yes	Determined by district	-*
Missouri	Yes	Yes	-*
Montana	Yes	Yes	-*
Nebraska	No	Yes	-*
Nevada	-	Determined by district	-*
New Hampshire	Yes	Determined by district	-*
New Jersey	Yes	Determined by district	-*
New Mexico	No	Determined by district	-*
New York	-	Yes	-*
North Carolina	Yes	Yes	-*
North Dakota	-	Yes	-*
Ohio	-	Determined by district	-*
Oklahoma	-	Yes	-*
Oregon	-	Determined by district	-*
Pennsylvania	-	Yes	-*
Rhode Island	-	Determined by district	-*
South Carolina	-	Yes	-*
South Dakota	-	Determined by district	-*
Tennessee	Yes	Yes	-*
Texas	-	Yes	-*
Utah	Yes	Yes	-*

Is Earth Science a recommended course in high school?			
State	**2002**	**2007**	**2009-2010**
Vermont	No	Determined by district	-*
Virginia	Yes	-	-*
West Virginia	Yes	No	-*
Wisconsin	No	Determined by district	-*
Wyoming	-	Yes	-*

* denotes that earth science is included in the high school state science standards.

Table 1.4: States Recommending Earth Science Coursework in High School

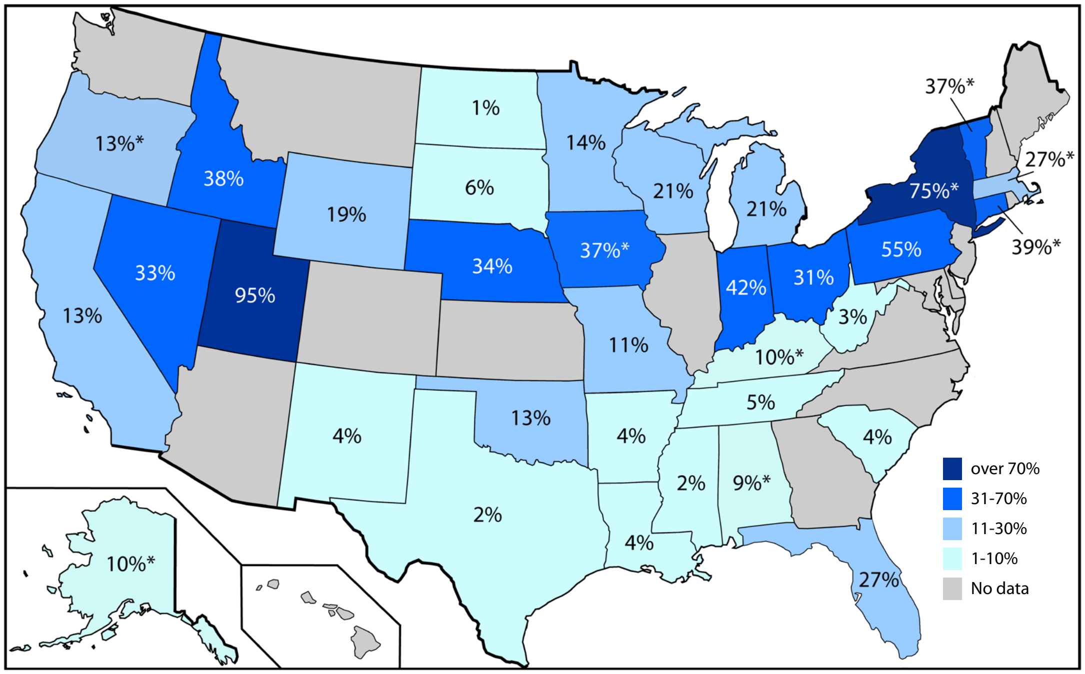
If Earth Science is taken, does it count towards graduation requirements?			
State	**2002**	**2007**	**2009-2010**
Alabama	Yes	Yes	Yes
Alaska	Yes	Determined by district	No*
Arizona	Yes	Determined by district	No*
Arkansas	Yes	No	Yes
California	Yes	Yes	No*
Colorado	Yes	Determined by district	No*
Connecticut	-	Yes	No*
Delaware	-	Yes	No*
District of Columbia	-	Yes	No*
Florida	Yes	Yes	Yes
Georgia	Yes	Yes	No*
Hawaii	Yes	-	No*
Idaho	Yes	Yes	No*
Illinois	Yes	Determined by district	No*
Indiana	Yes	Yes	Yes
Iowa	-	Determined by district	No*
Kansas	Yes	Yes	No*
Kentucky	Yes	Yes	No*
Louisiana	Yes	Yes	Yes
Maine	Yes	Yes	No*
Maryland	Yes	Yes	Yes
Massachusetts	Yes	Determined by district	No*
Michigan	No	Determined by district	No*
Minnesota	Yes	Yes	No*
Mississippi	Yes	Yes	Yes
Missouri	Yes	Yes	No*
Montana	Yes	Yes	No*
Nebraska	-	Determined by district	Yes
Nevada	Yes	Yes	No*
New Hampshire	No	Determined by district	No*
New Jersey	Yes	Yes	No*
New Mexico	Yes	Yes	No*
New York	Yes	Yes	Yes

If Earth Science is taken, does it count towards graduation requirements?			
State	**2002**	**2007**	**2009-2010**
North Carolina	Yes	Yes	No*
North Dakota	Yes	Determined by district	No*
Ohio	Yes	Determined by district	No*
Oklahoma	Yes	Yes	Yes
Oregon	Yes	Determined by district	No*
Pennsylvania	-	Yes	No*
Rhode Island	-	Determined by district	No*
South Carolina	No	Yes	No*
South Dakota	Yes	Yes, with lab only	No*
Tennessee	-	Yes	No*
Utah	Yes	Yes	Yes
Vermont	Yes	Yes	No*
Virginia	Yes	Yes	Yes
Washington	Yes	Yes, with lab only	No*
West Virginia	Yes	Yes	No*
Wisconsin	Yes	Determined by district	No*
Wyoming	Yes	Determined by district	No*

* denotes that earth science is included in the high school state science standards.

Table 1.5: States Counting Earth Science Coursework Towards Graduation Requirements

Nationwide trends indicate a net decline in grade 9 Earth Science enrollments between 1996-1997 and 2003-2004. Fifty-six percent of states that provided data for all survey years reported a decline in grade 9 Earth Science enrollments, and 39 percent reported an increase. Utah, New York, and Pennsylvania lead the nation in percentage of grade 9 student enrolled in Earth Science (Figure 1.7). Of the sixteen states shown in gray in Figure 1.7, fourteen did not reported data on grade 9 enrollments for any of the survey years. Two of the gray states shown in Figure 1.7, Maine and Delaware, last reported grade 9 enrollment percentages in 1996-1997 (58% and 15% respectively).

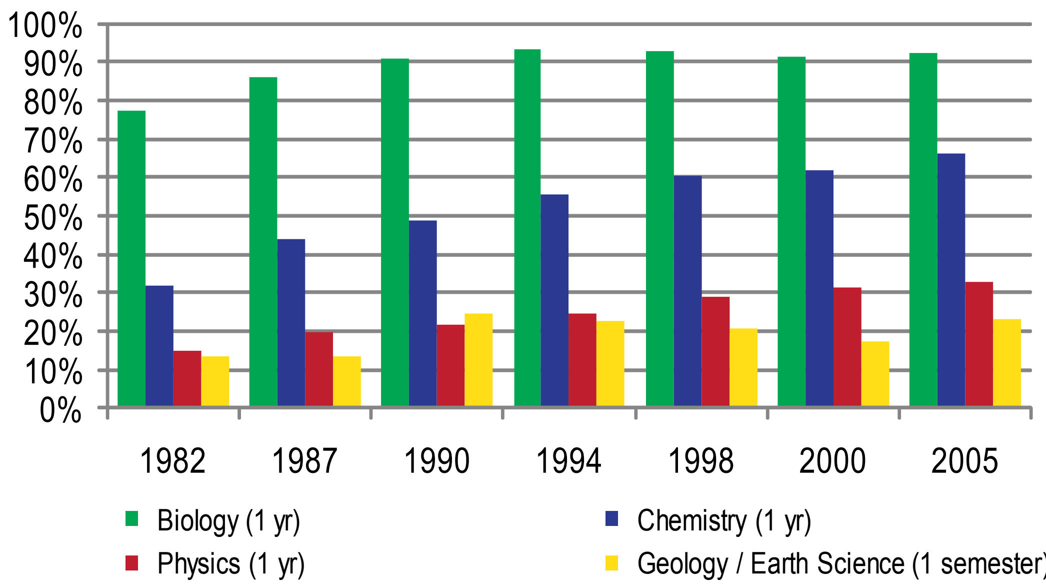


Source: AGI Geoscience Workforce Program, data derived from AGI's *Pulse of Earth Science: National Status of Earth Science Education, State by State,* 2007.

Figure 1.7: Percentage of Grade 9 Students Enrolled in Earth Science Courses.

States marked with (*) indicate percentages for the 1999-2000 school year. All other state values are for the 2003-2004 school year.

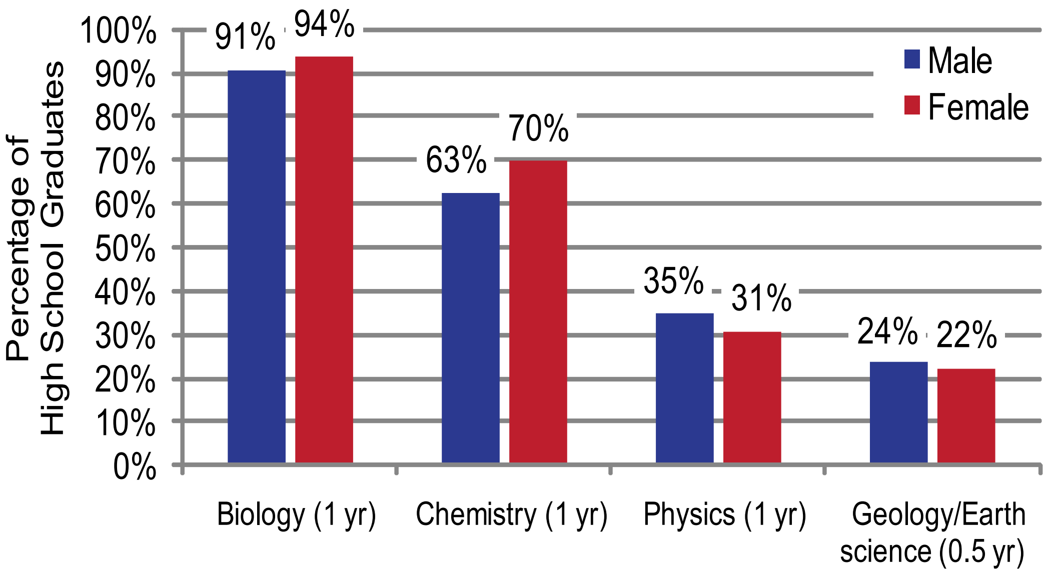
According to the NCES "Digest of Education Statistics", the percent of high school students taking Chemistry and Physics has increased since 1982, and Biology enrollments have remained around 90 percent since 1990 (Figure 1.8). Historically, enrollments in Earth Science courses have trailed far behind other science disciplines. Earth Science enrollments were highest in 1990 and in 2005, and have never exceeded 25 percent in the past 26 years.



Source: AGI Geoscience Workforce Program, data derived from NCES, *Digest of Education Statistics, 2007*

Figure 1.8: Percentage of High School Graduates Taking Science Courses in High School

Examination of the most recent diversity data from 2005 (Figure 1.9) indicates that a slightly higher percentage of male high school students (24 percent) take for Geology/ Earth science courses than female students (22 percent). Physics enrollments show a similar pattern, whereas Biology and Chemistry classes show the opposite trend with a higher percentage of female students enrolling (94 percent and 70 percent respectively) than male students (91 percent and 63 percent respectively). Course-taking patterns by race and ethnicity indicate that Earth Science coursework in high school is lowest for Asian-American/ Pacific Islander students (16 percent) and between 20 and 24 percent for underrepresented minorities and non-minority students (20 percent Hispanic, 23 percent Native American, 24 percent African American, 24 percent White).



Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

Figure 1.9: U.S. High School Graduate Science Course-taking Patterns by Gender

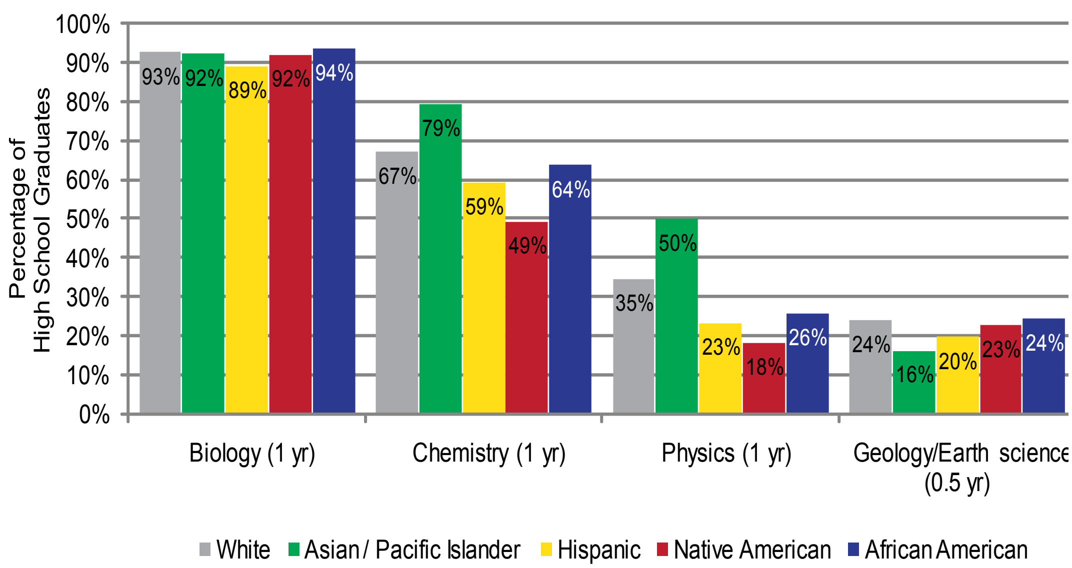
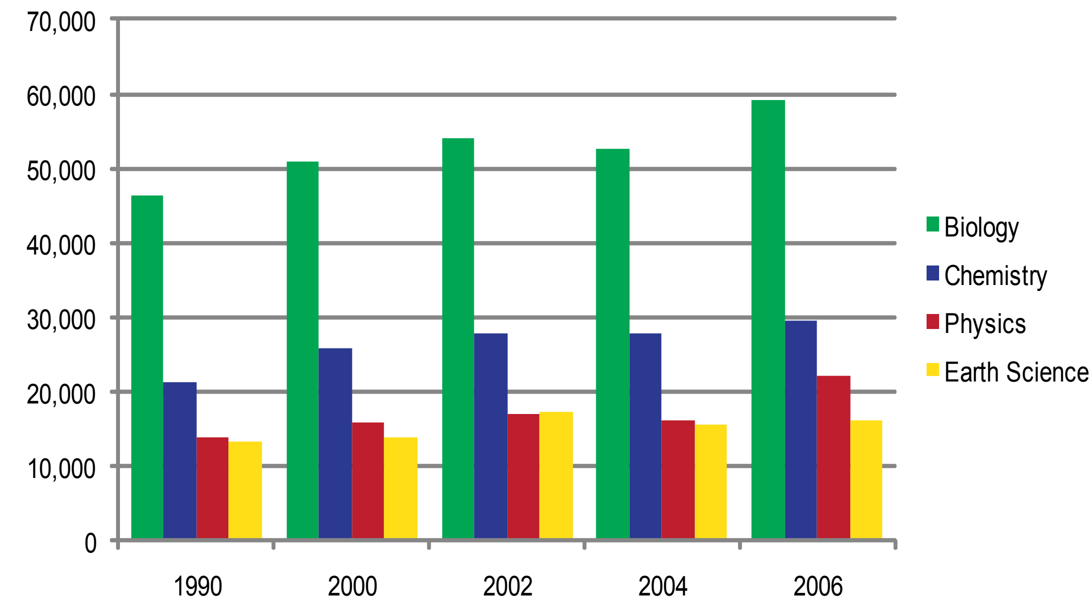


Figure 1.10: U.S. High School Graduate Science Course-taking Patterns by Race and Ethnicity

High School Teacher Trends

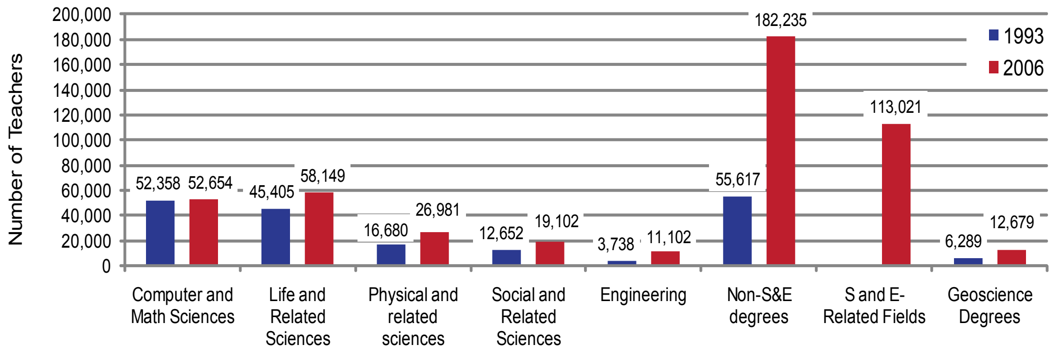
For the past 18 years, the number of Earth Science high school teachers has been consistently lower than other science disciplines (Figure 1.11). The one exception occurred in 2002 when there were approximately 400 more Earth Science teachers than Physics teachers. The percentage of teachers in each science discipline has grown in the past 18 years; however, Earth Science has grown the slowest, 21 percent over those 18 years. Between 2000 and 2002 however, the growth in Earth Science teachers outpaced the other disciplines, jumping 24 percent over 2 years. Additionally, all science disciplines showed a decline in the number of teachers between 2002 and 2004, and Earth Science had the greatest decline (10 percent).

In high school, the most majority of computer, math, and science teachers have their highest degree in either non-science and engineering (39 percent) or science and engineering-related fields (24 percent) (Figure 1.12). Approximately 3 percent of the remaining teachers have their highest degree in the geosciences. Additionally, the percentage of certified high school Earth Science teachers has been consistently lower than the rate of teaching within their certified area for other science disciplines during the 1990 and 2004 period (Figure 1.13). In 2006, the percentage of Earth Science teachers certified in their assigned field was only two percent higher than Physics (76 percent and 74 percent respectively). Furthermore, there has been an overall decrease in the percent of science teachers certified in their assigned field since 1990 for all science disciplines (4-5 percent for Biology, Chemistry, and Earth science, and 14 percent for Physics).



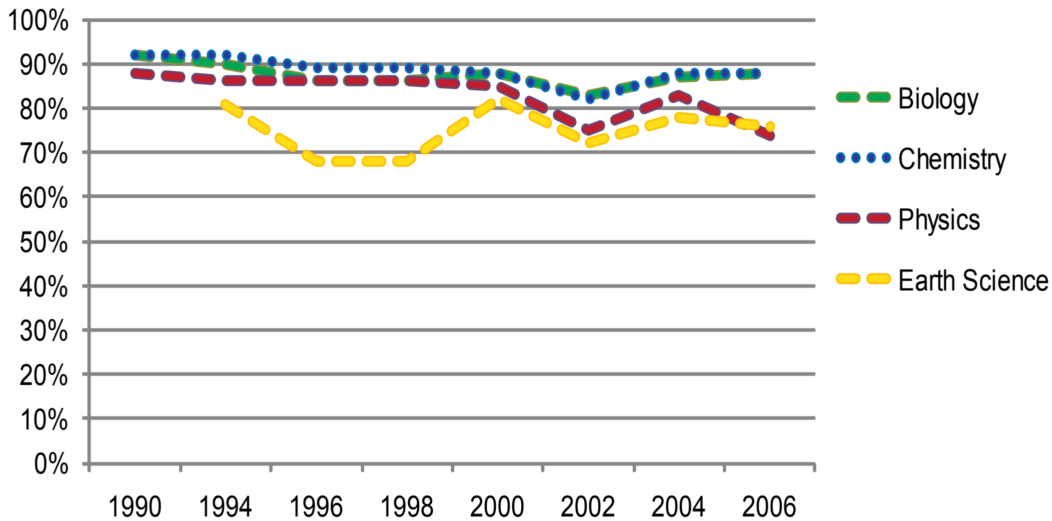
Source: AGI Geoscience Workforce Program data derived from the CCSSO, *State Indicators of Science and Mathematics*, 2001, 2003, 2005, 2007

Figure 1.11: Number of High School Science Teachers by Discipline



Source: AGI Geoscience Workforce Program; data derived from NSF's 1993 and 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 1.12: Highest Degree Fields of Computer, Math, and Science Secondary School Teachers



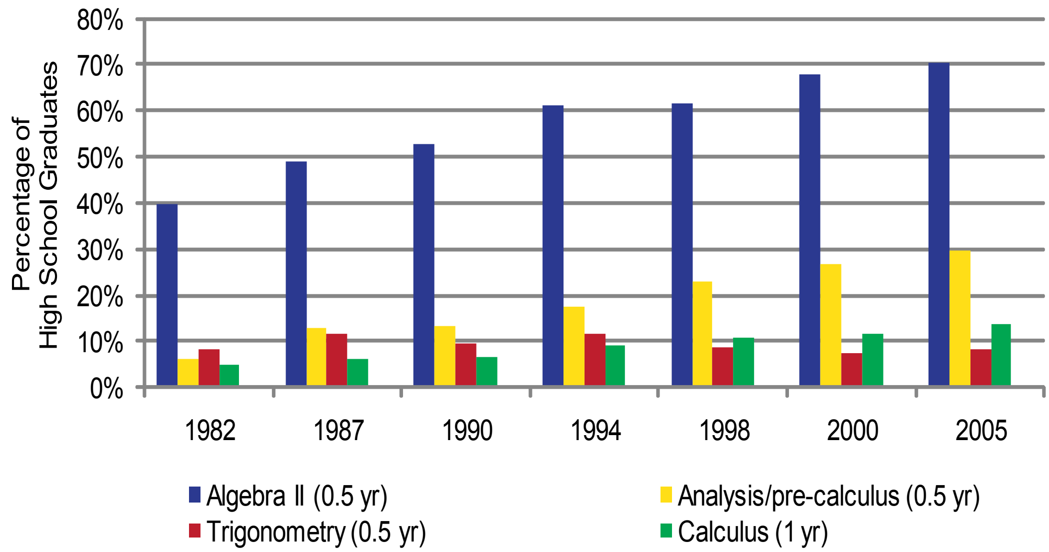
Source: AGI Geoscience Workforce Program data derived from the CCSSO, *State Indicators of Science and Mathematics*, 2001, 2003, 2005, 2007

Figure 1.13: Percentage of High School Teachers Certified in their Assigned Field

College Preparedness

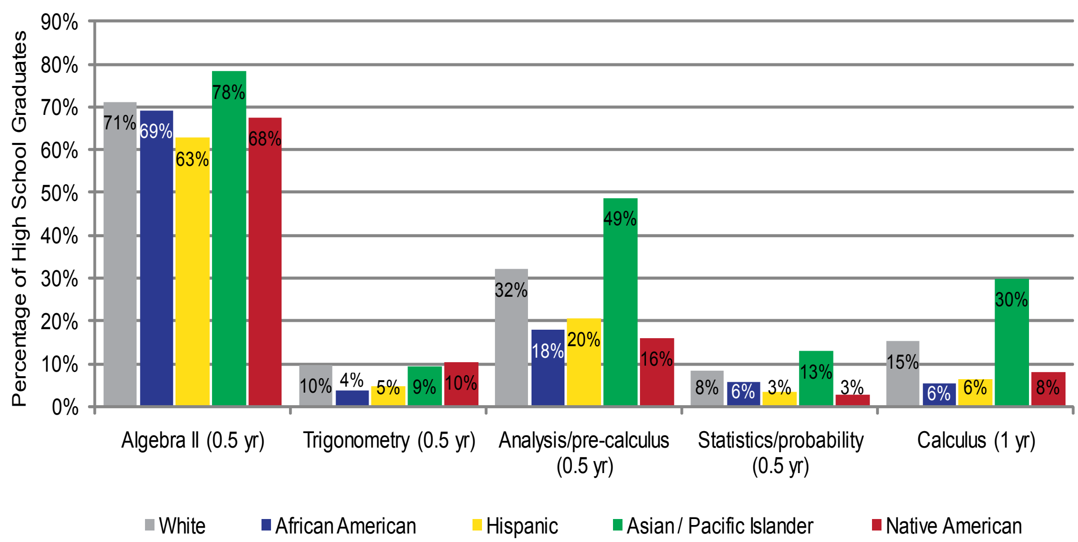
Indicators of college-readiness focus on student course-taking patterns (e.g. advanced mathematics, Advanced Placement / International Baccalaureate, etc.), and comparison of SAT and ACT test scores against national benchmarks (Montgomery County Public Schools, 2010; Kirst and Venezia, 2006). In this section, we examine the overall college preparedness of high school graduates and of potential geoscience undergraduate majors.

Advanced mathematics course-taking is one indicator of a student's ability to handle the rigor of university level education. According to Montgomery County Pulbic Schools (MD) recent report (MCPS, 2010), high school students should complete a math course at or above the Algebra II level prior to graduation to be ready for college work. Recent data from NCES's Digest of Education indicates a steady increase in the percentage of high school graduates taking advanced mathematics courses since 1982 (Figure 1.14). As of 2005, 70 percent of high school graduates completed Algebra II, 30 percent completed pre-Calculus, and 14 percent completed Calculus prior to graduation (Figure 1.14). Examination of mathematics course-taking patterns by race and ethnicity indicate that there is a higher percentage of Asian/Pacific Islander student enrolled in advanced mathematics courses (except Trigonometry) than for all other race/ethnic groups (Figure 1.15). Whereas the majority of students from all race/ethnic groups complete Algebra II prior to graduation, the percentage of underrepresented minority students (e.g. Hispanic, African American, and Native American) taking pre-Calculus or Calculus prior to graduation is less than 10 percent. Additionally, mathematics course-taking patterns by gender grouping reveal a higher percentage of female students taking advanced math than male students for most courses (except Calculus) (Figure 1.16).



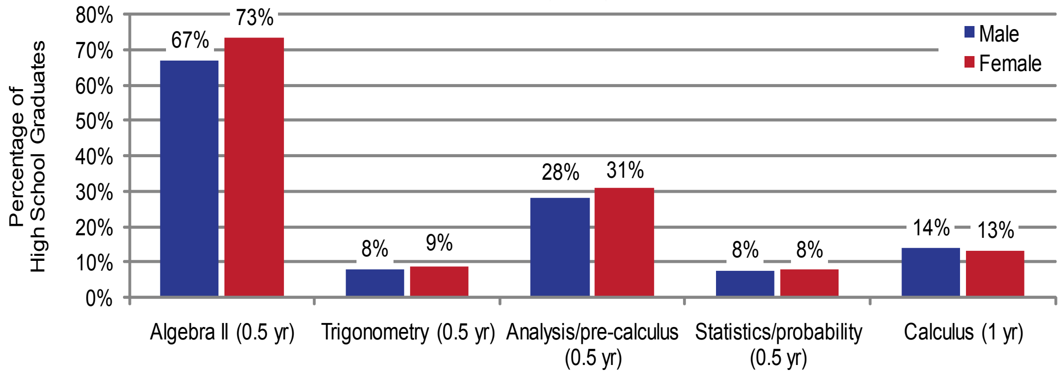
Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

Figure 1.14: U.S. High School Graduates Selected Math Course-taking Patterns



Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

Figure 1.15: U.S. High School Graduates Selected Math Course-taking Patterns by Race/ Ethnicity

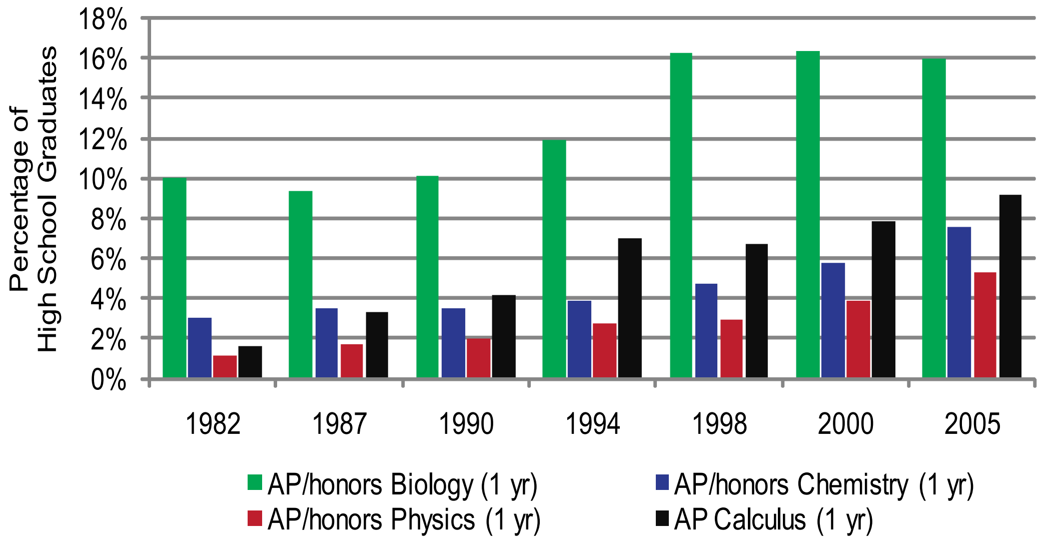


Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

Figure 1.16: U.S. High School Graduates Selected Math Course-taking Patterns by Gender

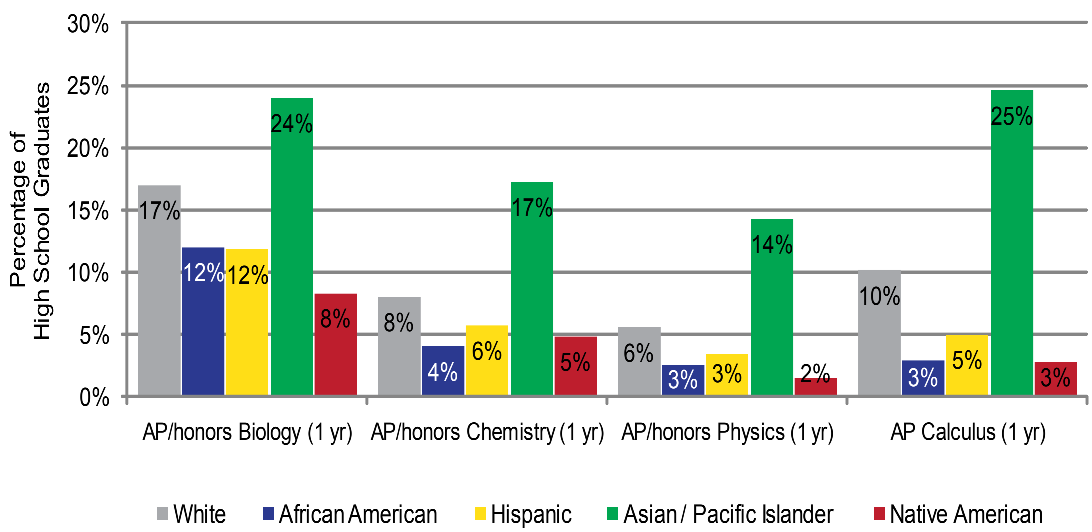
Advanced Placement course-taking is another indicator of a student's ability to handle the rigor of university level education. Since 1982, the percentage of students taking Advanced Placement / honors courses has increased markedly (Figure 1.17). As of 2005, 16 percent of high school graduates took AP / honors Biology, 9 percent took AP / honors Calculus, 8 percent took AP / honors Chemistry, and 5 percent took AP / honors Physics. Examination of Advanced Placement course-taking patterns by race and ethnicity indicate that there is a higher percentage of Asian/Pacific Islander student enrolled AP / honors courses than for all other race/ethnic groups (Figure 1.18). With the exception of AP / honors Biology, fewer than 10 percent of underrepresented minority groups and non-minority students take AP / honors Chemistry, Physics, or Calculus. Additionally, Advanced Placement course-taking patterns by gender grouping reveal a higher percentage of female students taking AP / honors Biology that male students and a higher percentage of male students taking AP / honors Physics and Calculus than female students (Figure 1.19).

To date, there is no AP / honors Geology course or exam, and university geoscience departments have implemented a variety of approaches to address this challenge. Such efforts include outreach activities such as workshops and lectures to raise community awareness of the geosciences and to bolster the professional development of K-12 teachers. Other departments directly engage high school students by offering dual-enrollment or college credit for advanced geoscience high school courses. The combination of outreach programs and direct engagement of high school students through advanced geoscience courses are making progress in filling the gap caused by the lack of an AP Geology course, increasing geoscience enrollments at the undergraduate level, and building community awareness of the importance of the geosciences.



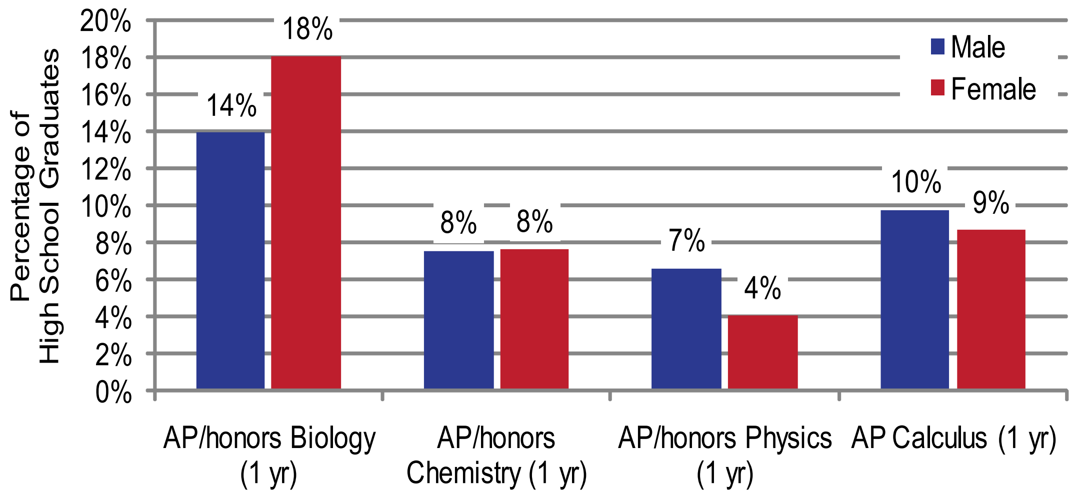
Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

Figure 1.17: U.S. High School Graduates Advanced Placement Course-taking Patterns



Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

Figure 1.18: U.S. High School Graduates Advanced Placement Course-taking Patterns by Race and Ethnicity



Source: AGI Geoscience Workforce Program, data derived from NCES, Digest of Education Statistics, 2009.

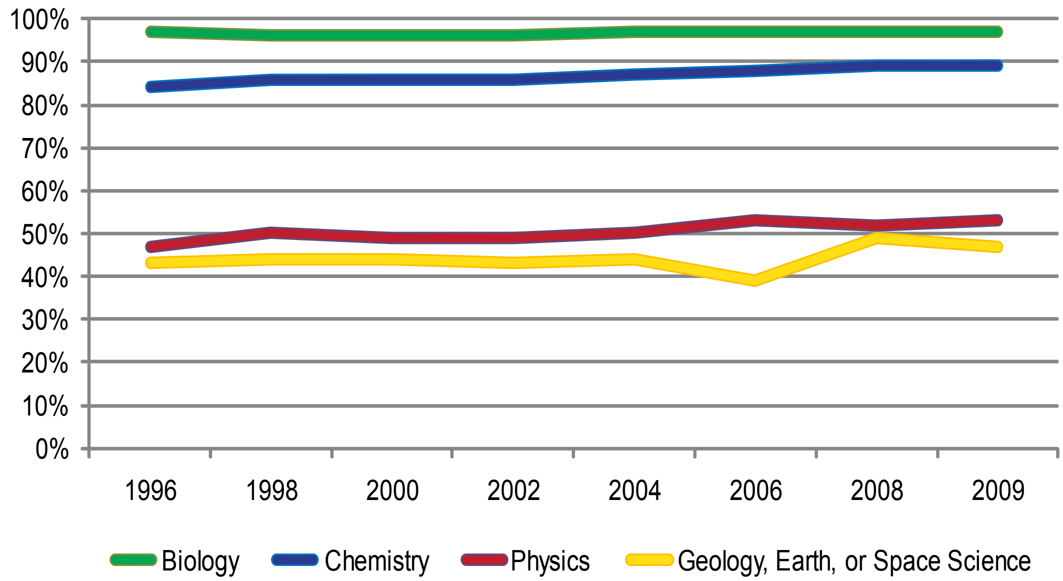
Figure 1.19: U.S. High School Graduates Advanced Placement Course-taking Patterns by Gender

SAT Test Taking and Score Trends

Since 1996, 97 percent of college-bound high school students who take the SAT have coursework or exposure to biology (Figure 1.20). In the other natural sciences, the percentage of students with coursework or experience in chemistry has increased from 84 percent in 1996 to 89 percent in 2009. In physics the percentage has increased from 47 in 1996 to 53 in 2009. In Geology / Earth or Space Science, the percentage of students has increased from 43 in 1996 to 47 in 2009. Since 2007, there has been a slight decrease (1-2 percent) in students with coursework or exposure to Physics (2007: 54 percent, 2009: 53 percent) and Geology / Earth or Space Science (2007: 49 percent, 2009: 47 percent).

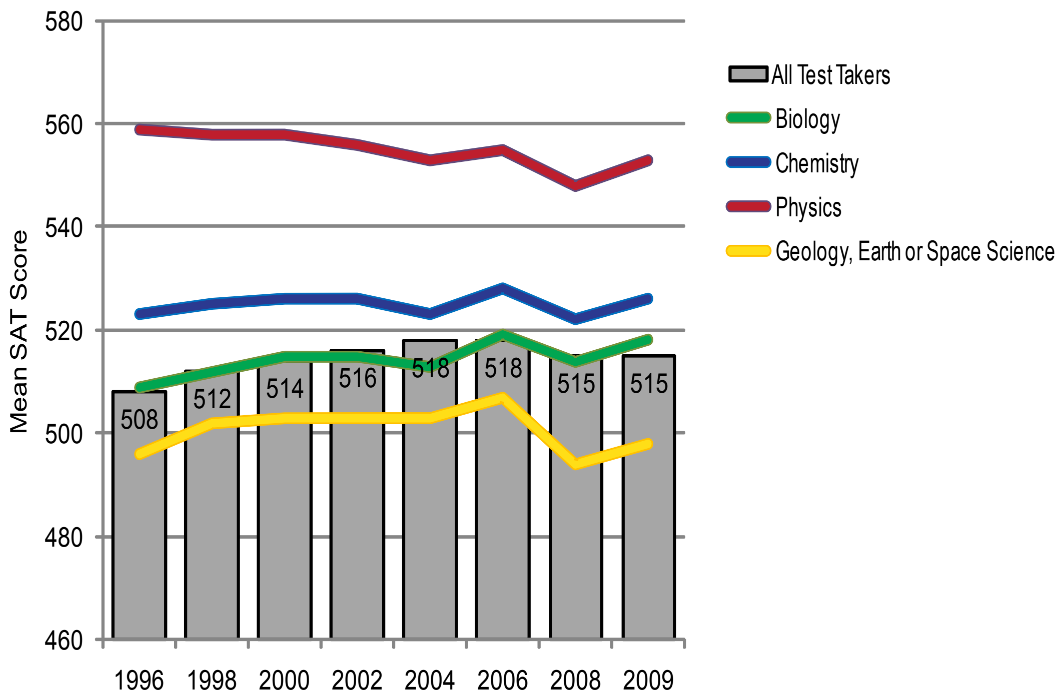
Mean math and verbal (including critical reading and writing) scores for those students with coursework or experience in Geology / Earth or Space Sciences has been consistently less than those with coursework or experience in the other natural sciences and less than the average scores for the entire test group (Figures 1.21 - 1.24). Students with coursework or experience in Physics have the highest mean math and verbal SAT scores for all students who have course work in the natural sciences.

The overall drop in SAT test scores between 2006 and 2008 may be caused by the restructuring of the SAT Test in 2006 in which the verbal and math sections were revised, and a new section "Writing" was added. The verbal section was renamed to "Critical Reading" and analogies were replaced with additional short and long reading passages. Additionally, Algebra II level questions were added to the math section, and quantitative comparison questions were eliminated. The new writing section included essay and multiple choice questions pertaining to identifying errors and improving sentences and paragraphs. The College Board made these revisions in order to better assess students on the skills they are learning in high school and need in order to succeed in college and beyond.



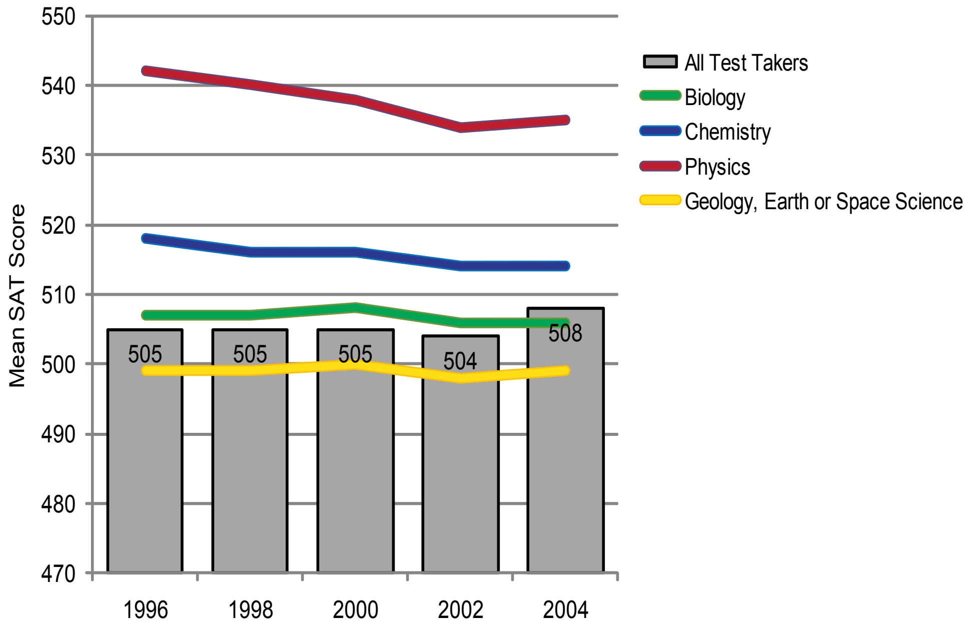
Source: AGI Geoscience Workforce Program, data derived from the College Board *College Bound Seniors, Total Group Report*, 1996 2009

Figure 1.20: Percentage of SAT Test-takers with Coursework or Experience in Selected Sciences



Source: AGI Geoscience Workforce Program, data derived from the College Board *College-Bound Seniors, Total Group Report*, 1996-2009

Figure 1.21: Mean Math SAT Scores for Test-takers with Coursework in Selected Sciences (1996-2009)



Source: AGI Geoscience Workforce Program, data derived from the College Board *College-Bound Seniors, Total Group Report*, 1996-2004

Figure 1.22 Mean Verbal SAT Scores for Test-takers with Coursework in Selected Sciences (1996-2004)

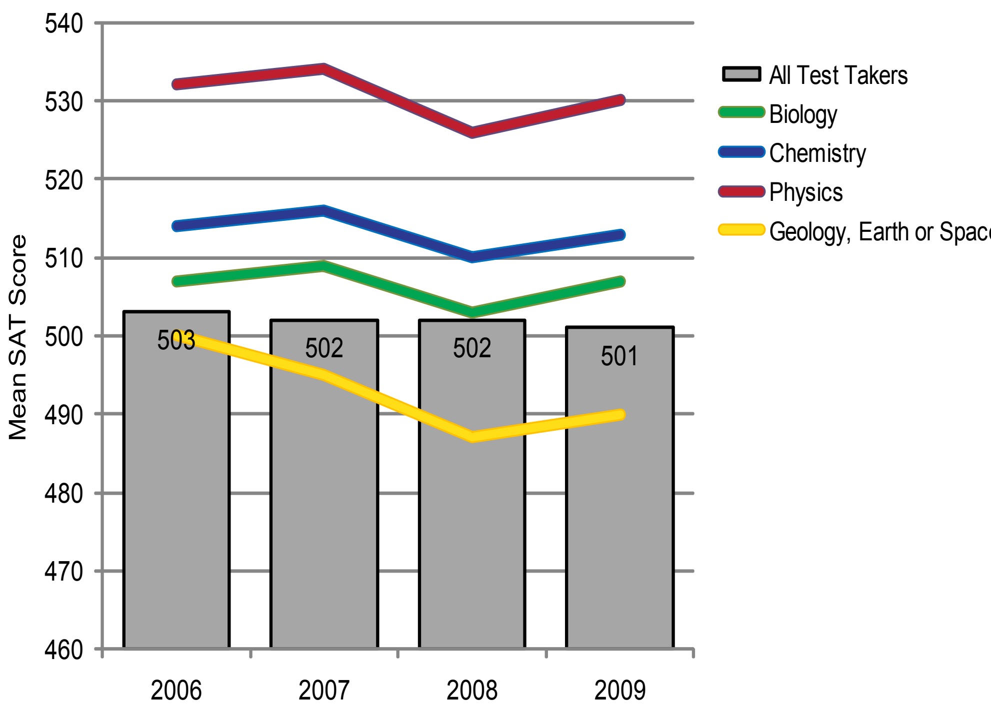


Figure 1.23: Mean Critical Reading SAT Scores for Test-takers with Coursework in Selected Sciences (2006-2009)

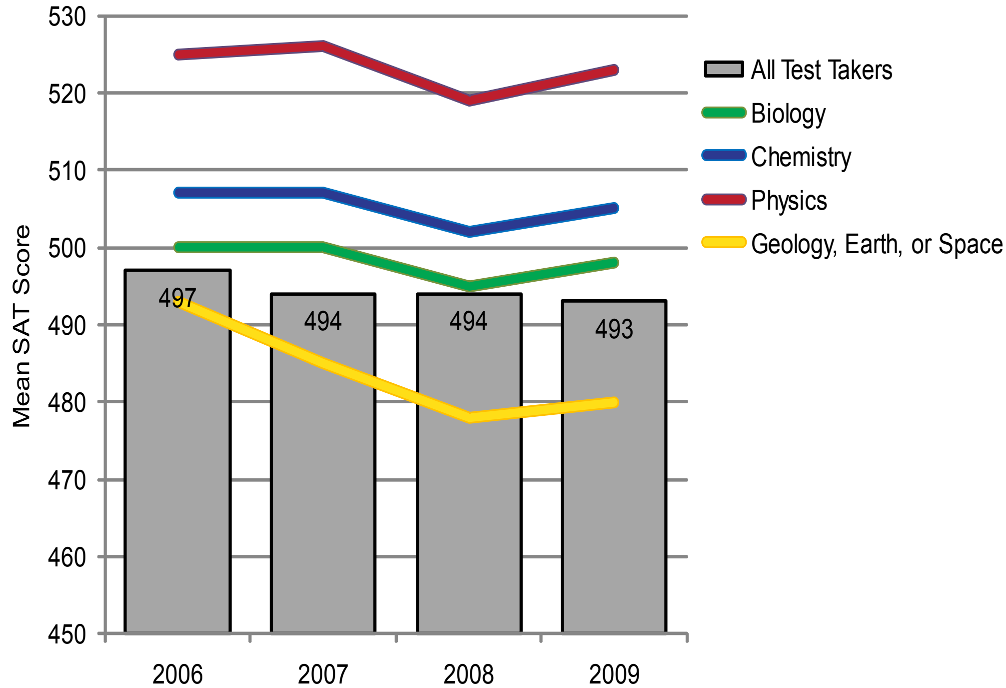
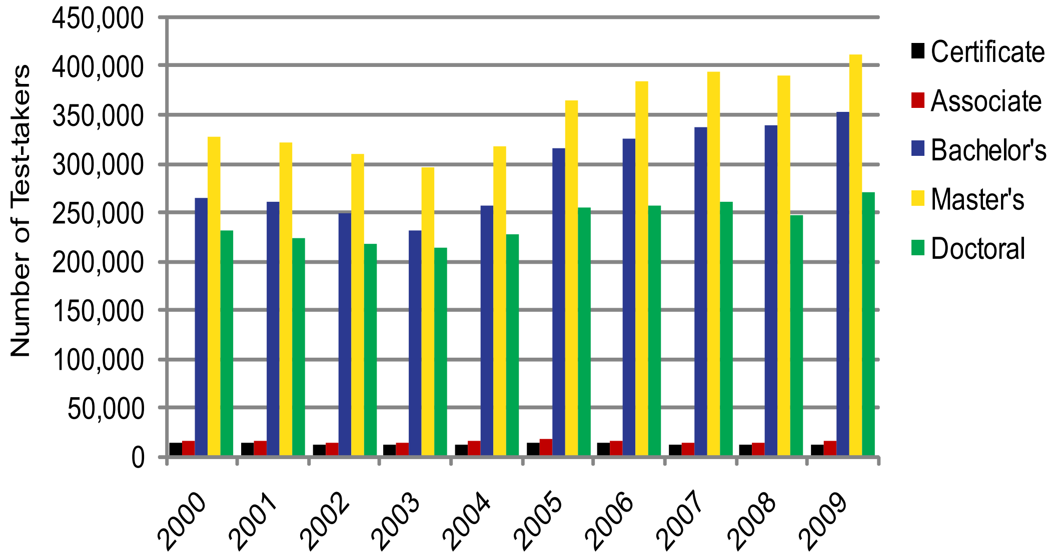


Figure 1.24: Mean Writing SAT Scores for Test-takers with Coursework in Selected Sciences (2006-2009)

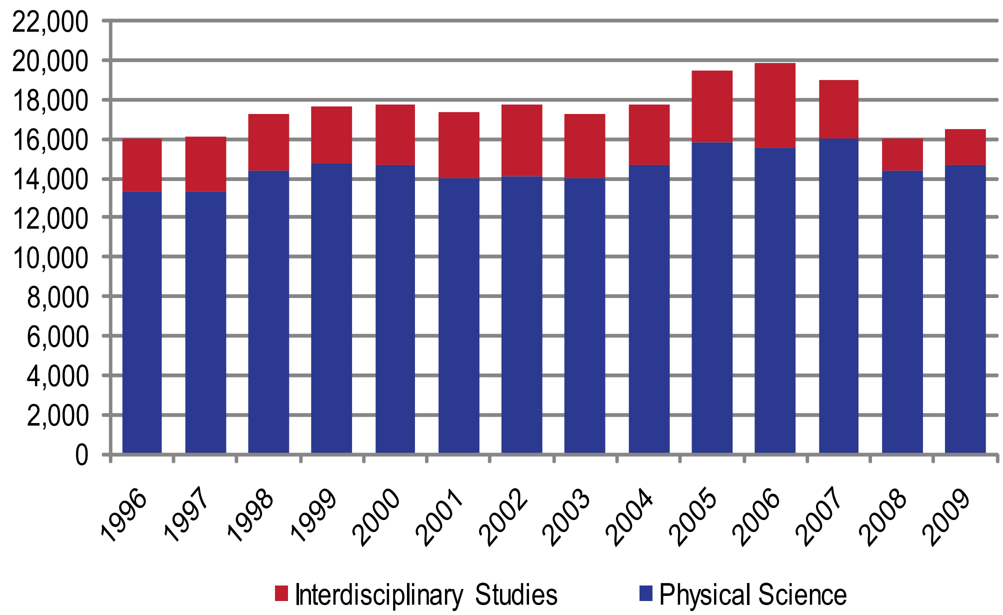
Since 2000, approximately half of all college-bound high school students indicate they intend to obtain graduate degrees (Figure 1.25). Given that graduate degrees are generally necessary for science careers, it appears that education level requirements do not appear to be a significant hurdle in the minds of prospective students. In the geosciences a Master's degree is required for most occupations. Analysis of NSF's 2006 SESTAT restricted-access database indicates that 43 percent of geoscience Master's degree recipients and 62 percent of geoscience doctorates have bachelor's degrees in the physical sciences. Based on these analyses, and because the list of intended college majors reported by SAT does not include Geology, Earth Science, or Geoscience, we chose to examine SAT test trends for students indicating Physical Science as their college major. We also examined the trends for students indicating Interdisciplinary Studies as their intended college major because a large proportion of geoscience graduate students do not typically follow a traditional academic pathway from their undergraduate to graduate study, and because geoscience research is becoming more interdisciplinary.

The total number of students indicating either Physical Science or Interdisciplinary Studies as their intended college major increased from 16,061 in 1996 to 19,891 in 2006, and has since tapered off to 16,487 in 2009 (Figure 1.26). The majority of the decline since 2006 has been driven by fewer students planning majors in Interdisciplinary Studies, and to a lesser extent a decline in students intending to major in the Physical Sciences.



Source: AGI Geoscience Workforce Program, data derived from the College Board *College-Bound Seniors, Total Group Report,* 1996-2009

Figure 1.25: Intended Degree Level of College-bound High School Seniors who took the SAT Test



Source: AGI Geoscience Workforce Program, data derived from the College Board *College-Bound Seniors, Total Group Report,* 1996-2009

Figure 1.26: Number of SAT Test-Takers Intending College Degrees in Interdisciplinary Studies or Physical Sciences

College-bound students indicating Physical Science as their college major outperformed those indicating Interdisciplinary Studies as their college major on both the verbal and math sections of the SAT between 1997 and 2006 (Figures 1.27-1.30). However, after the redesign of the SAT in 2006, intending majors in Interdisciplinary Studies consistently out-performed intending majors in the Physical Sciences on the critical reading and writing sections of the SAT. Additionally, since 2007 mean math scores of intending Interdisciplinary Studies majors have been on par with intending majors in the Physical Sciences. Furthermore, both groups have historically scored higher mean math and verbal (including critical reading and writing) scores than the total group of SAT test-takers.

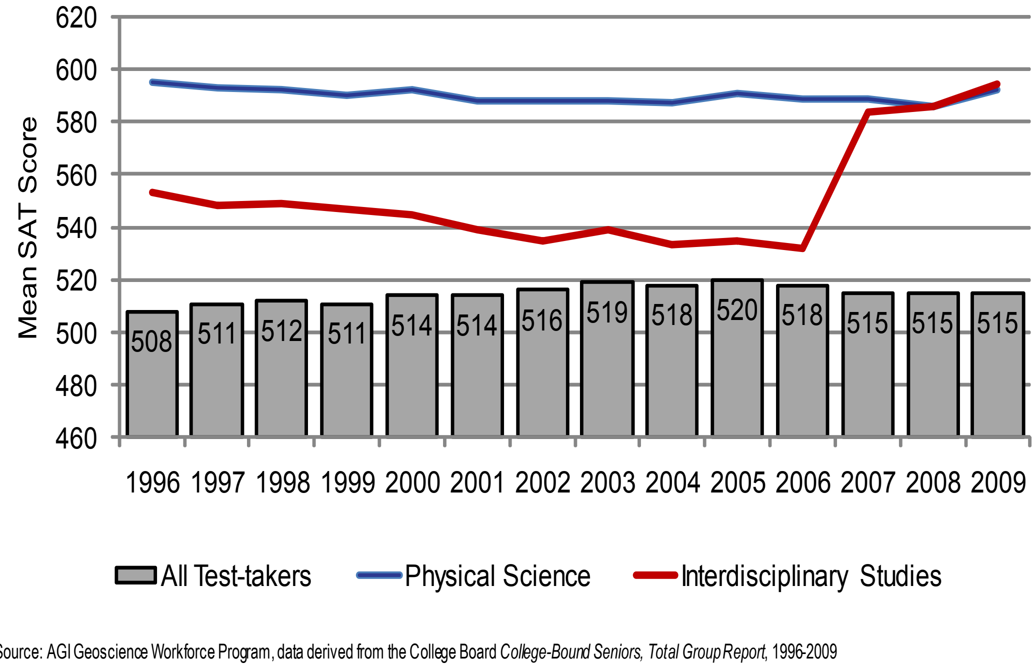


Figure 1.27: Mean Math SAT Scores for SAT Test-Takers Intending College Degrees in Interdisciplinary Studies or Physical Sciences

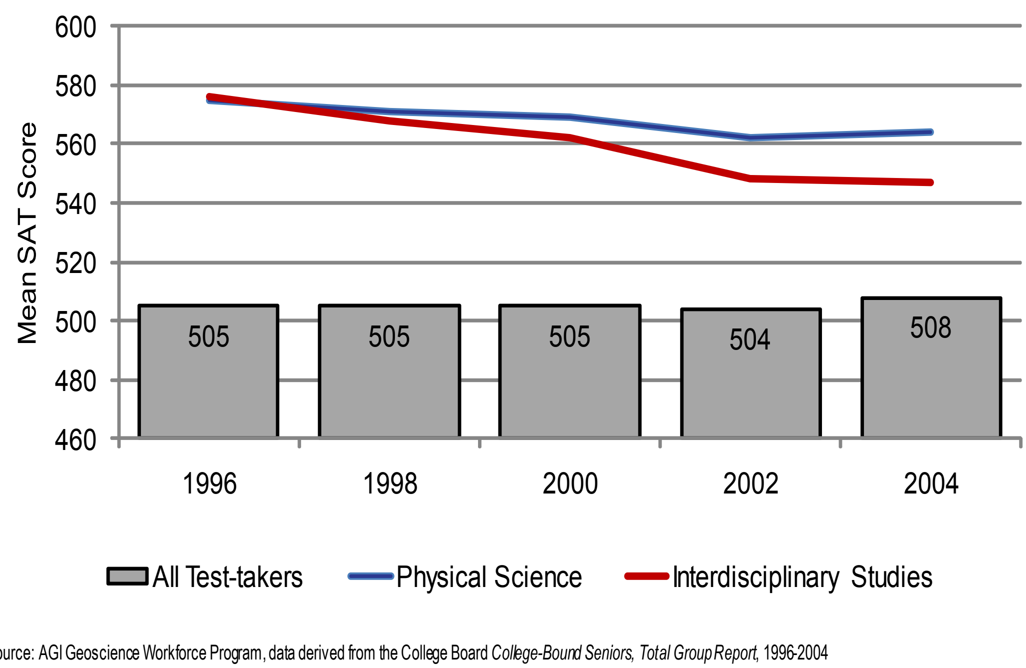
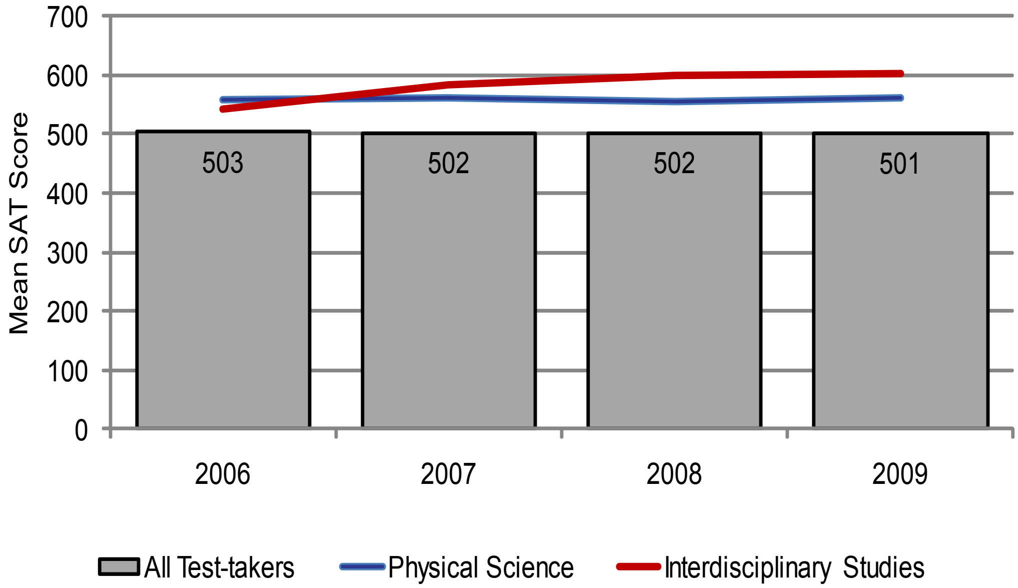
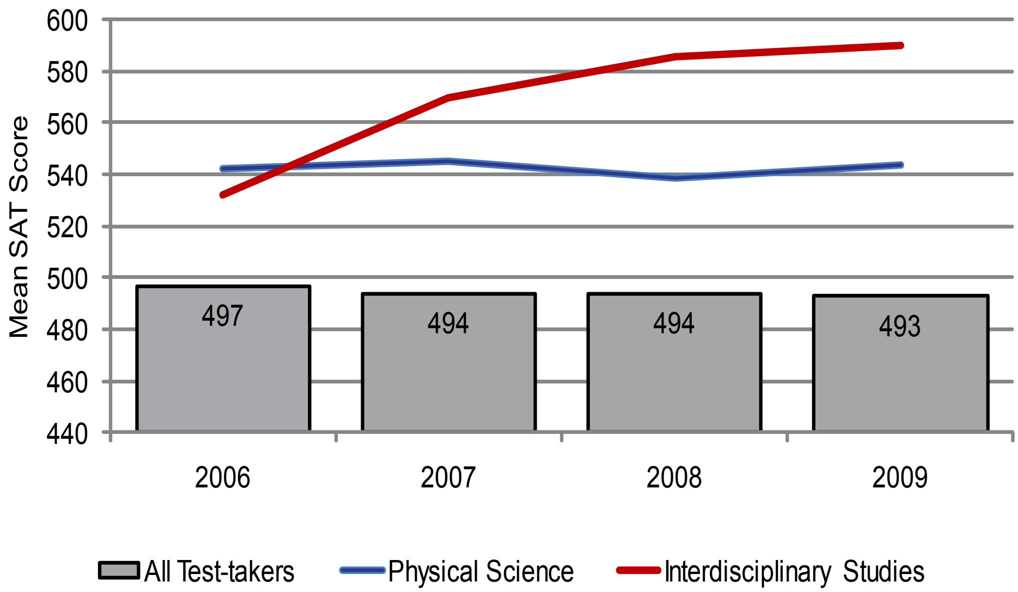


Figure 1.28: Mean Verbal SAT Scores for SAT Test-Takers Intending College Degrees in Interdisciplinary Studies or Physical Sciences (1996-2004)



Source: AGI Geoscience Workforce Program, data derived from the College Board *College-Bound Seniors, Total Group Report*, 2006-2009

Figure 1.29: Mean Critical Reading SAT Scores for SAT Test-Takers Intending College Degrees in Interdisciplinary Studies or Physical Sciences (2006-2009)



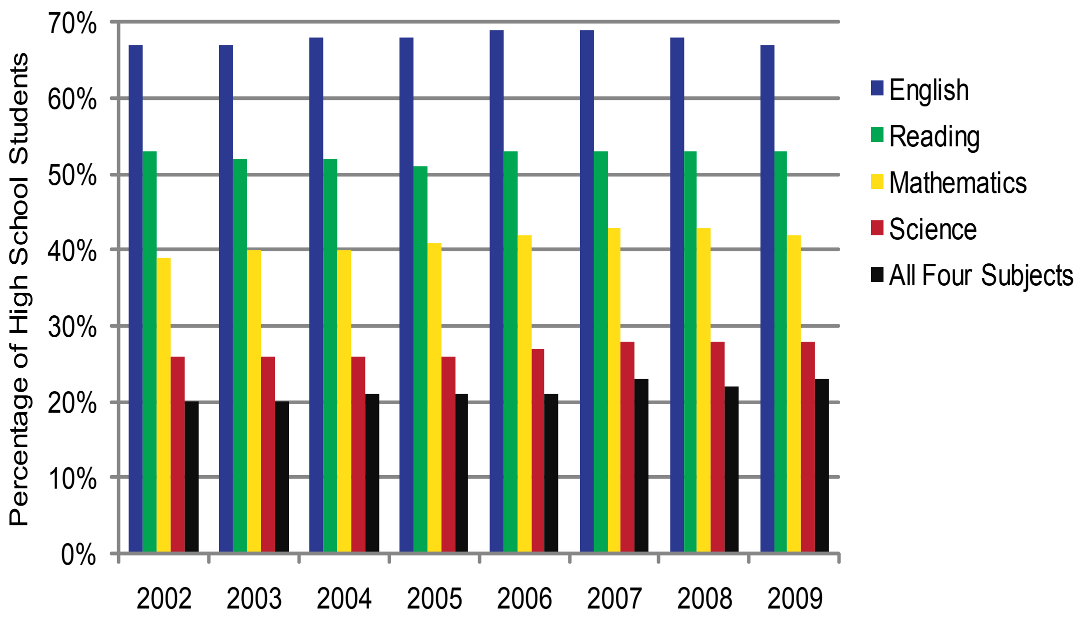
Source: AGI Geoscience Workforce Program, data derived from the College Board *College-Bound Seniors, Total Group Report*, 2006-2009

Figure 1.30: Mean Writing SAT Scores for SAT Test-Takers Intending College Degrees in Interdisciplinary Studies or Physical Sciences (2006-2009)

ACT Trends

The ACT releases an annual report that measures the college-preparedness of high school graduates. ACT measures college-preparedness by comparing the national average ACT scores (both specific subjects and across all four subjects) against national benchmarks. ACT states that the scores are "empirically derived based on the actual performance of students in college" (ACT, 2009). A student who achieves the ACT benchmark score for a given subject area has a 50 percent chance of earning a "B" or higher and a 75 percent chance of obtaining a "C" or higher in a college credit-bearing course in that subject area.

The ACT benchmark score for each topical section is as follows: English: 18; Math: 22; Reading: 21; and Science: 24. Since 2002, the percentage of students meeting or exceeding each subject benchmark has either remained steady (e.g. English) or increased by a few percentage points. As of 2009, the majority of students taking the ACT test met or exceeded the English and Reading benchmarks (67 percent and 53 percent respectively). Only 42 percent of students met or exceeded the Mathematics benchmark, and 28 percent met or exceeded the Science benchmark. In 2002, one-fifth of ACT test-takers met or exceeded all four subject benchmarks, and in 2009, almost one-quarter (23%) achieved this result.



Source: AGI Geoscience Workforce Program, data derived from ACT National Profile Report, 2002-2009

Figure 1.31: Percentage of High School Students Meeting ACT College Readiness Benchmarks

Chapter 2: Trends in Community College Geoscience Programs

Overview

Community colleges served nearly 7 million students in 2008. In 2008, fifty-eight percent of community college students were women and 33 percent were underrepresented minorities. Community colleges serve a multitude of purposes for the student body ranging from re-tooling for the workforce to completing educational requirements prior to transferring to four-year institutions. For science and engineering fields, community colleges represent a pool of diverse talent that could be tapped to increase diversity in their academic programs and workforce populations.

The community college student population is more diverse than at four-year institutions, and also plays a substantial role in the academic pathway of many four-year degree recipients. Nearly half of all Bachelor's degree holders attended community college, and approximately 20 percent earned Associate's degrees. At the graduate degree levels, Master's degree holders have higher rates of community college attendance (36-46 percent) and Associate's degree attainment (8-16 percent) than Doctorates (attendance: 16-32 percent; Associate's degrees: 4-13 percent).

Geoscience programs are offered at approximately 17 percent of all community college programs, and are distributed across the nation with the highest concentrations in California and Texas. (Geoscience programs are defined as having at least one geoscience faculty member teaching courses at a given community college.) The majority of community college geoscience programs have fewer than 3 faculty members, and just over half of all community college geoscience faculty are part-time instructors. Although community college geoscience programs have historically produced between 200 and 300 Associate's degrees per year, the total number of students taught per year is much higher. Geoscience degree conferral rates indicate that women and especially underrepresented minorities are under-recruited relative to the whole population as well as compared to other science and engineering disciplines. In 2008, women earned 36 percent of geoscience Associate's degrees, and underrepresented minorities earned 12 percent of geoscience Associate's degrees. When compared to other science and engineering disciplines, the geosciences confer a higher percentage of Associate's degrees to women than computer science, engineering, math and physics. However, even at the community college level where the student population is more diverse, the geosciences still confer a lower percentage of Associate's degrees to underrepresented minorities than other science and engineering disciplines. Minority Serving Institutions (MSIs) are a bright spot in the issue of diversity in the geosciences. Seventy-nine MSIs offer Associate's degrees in geoscience disciplines, and in 2008, these programs conferred 10 percent of all geoscience Associate's degrees. Despite the low number of degrees (29), 16 were earned by Native Americans and 2 by Hispanics, accounting for 62 percent of conferrals to underrepresented minorities.

National Benchmarks

Women and underrepresented minorities represent a large potential pool of talent for the sciences that are needed to expand innovation into the future. Since 2000, women have comprised 51 percent of the total U.S. population and 49 percent of the college-aged adults (e.g. 18-24 year olds), and these rates are expected to remain steady into the future. Underrepresented minorities (e.g. Hispanics, African Americans, and Native Americans) currently comprise 30 percent of the total U.S. population and 36 percent of college-aged adults (e.g. 18 to 24 year olds) (Figure 2.1). By 2050, underrepresented minorities are projected to make up 45 percent of the total U.S. population and 53 percent of college-aged adults. These increases will be primarily driven by expansion of the Hispanic population. By 2050, Hispanics will comprise 30 percent of the total U.S. population and 37 percent of college-aged adults.

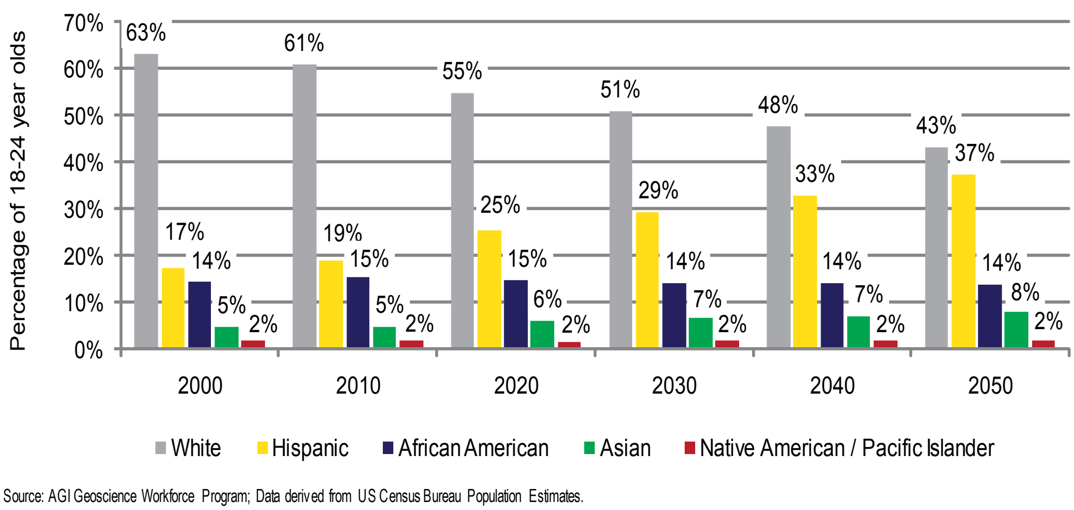
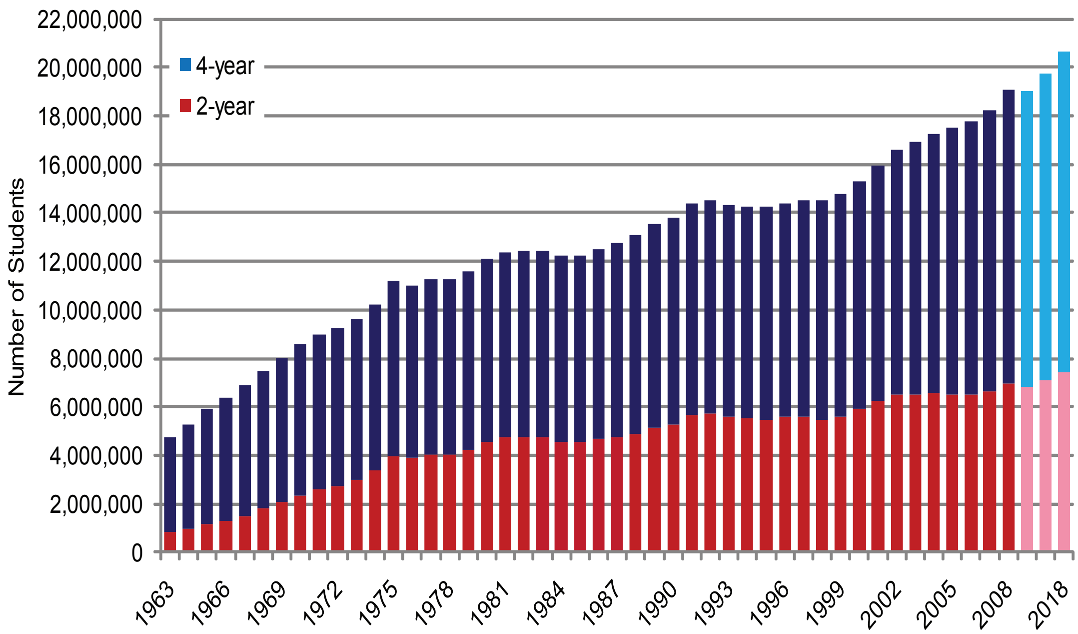


Figure 2.1: Age Demographics of Current and Future U.S. College-Age Population

In 2008, total U.S. college and university enrollments were 19.1 million, and thirty-six percent of total enrollments (approximately 7 million) were community college students (Figure 2.2). Since 1974, community college students have comprised approximately one-third the total college student population enrolled in post-secondary institutions within the United States. In the 1990's and the early part of 2000's community college enrollments comprised nearly 40 percent of total annual higher education enrollments. Projections from the National Center for Education Statistics (NCES) indicate that by 2018, U.S. college and university enrollments will reach 20.6 million. If the proportion of enrollments by institutional type remains at the 2008 levels, in 2018 there will be 7.4 million students enrolled at community colleges.

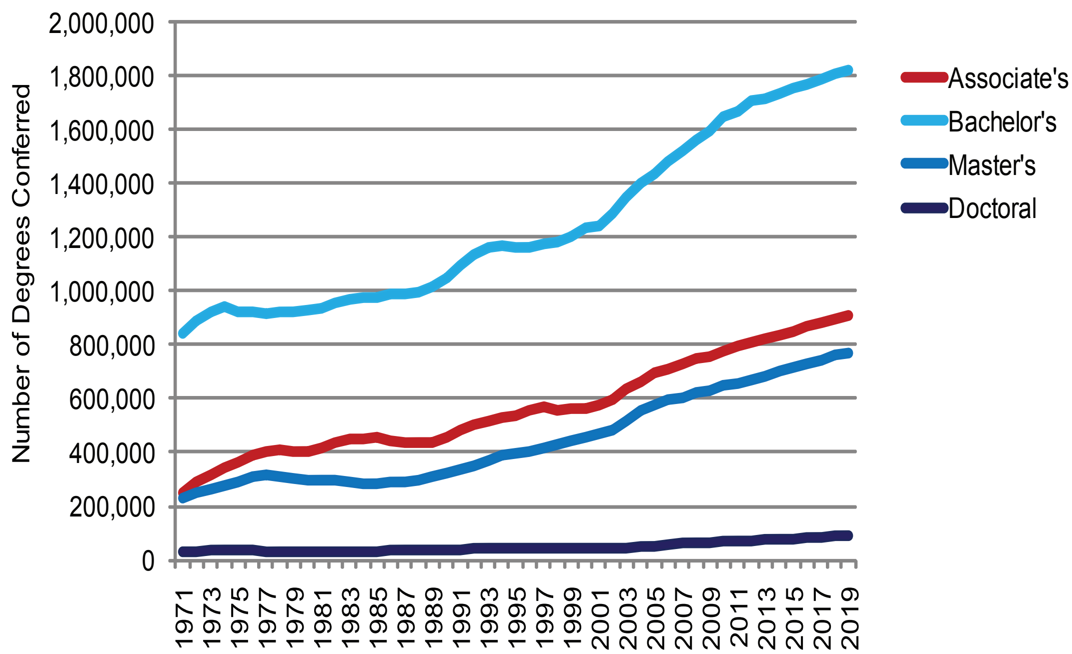
Associate's degree recipients have comprised a quarter of all degree recipients from U.S. post-secondary institutions since 1982. In 2010, a total of 778,000 Associate's degrees were conferred, and projections from NCES estimate that in 2019 the number of Associate's degrees conferred will reach 913,000 (Figure 2.3).



Source: AGI Geoscience Workforce Program. Data derived from NCES Digest of Education Statistics, 2009.

Figure 2.2: Fall Enrollments at U.S. Post-secondary Institutions

(Note: Enrollment data by institutional type for 2009-2018 are estimated based on 2009-2018 total enrollment data and 2008 enrollment data by institutional type from NCES.)

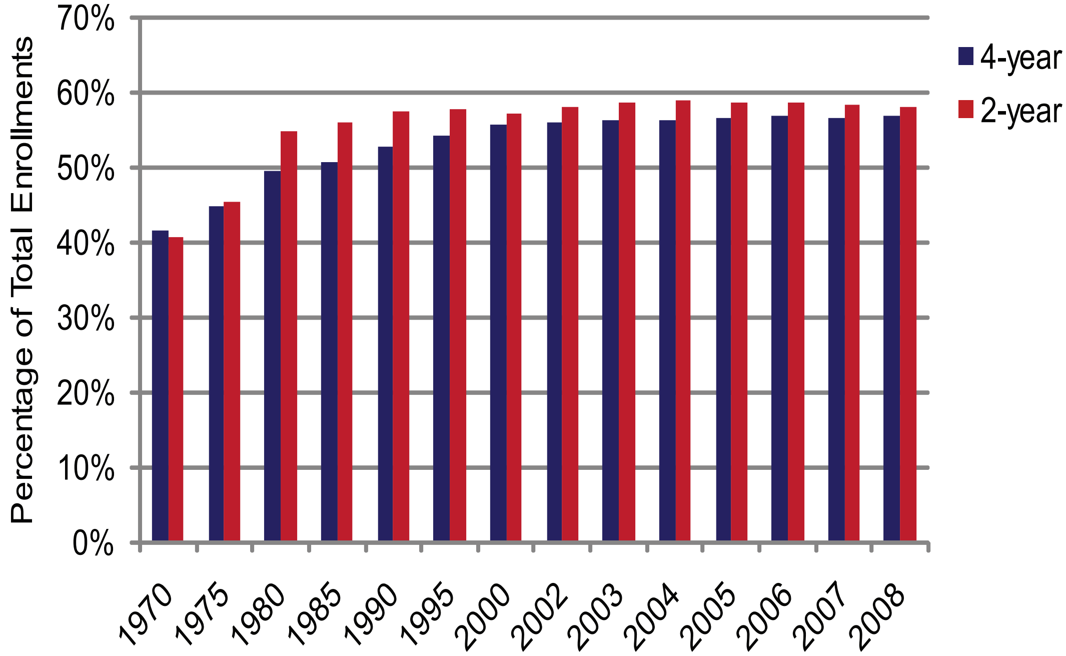


Source: AGI Geoscience Workforce Program. Data derived from NCES Digest of Education Statistics, 2009.

Figure 2.3: Degrees Conferred from U.S. Post-secondary Institutions by Degree Level

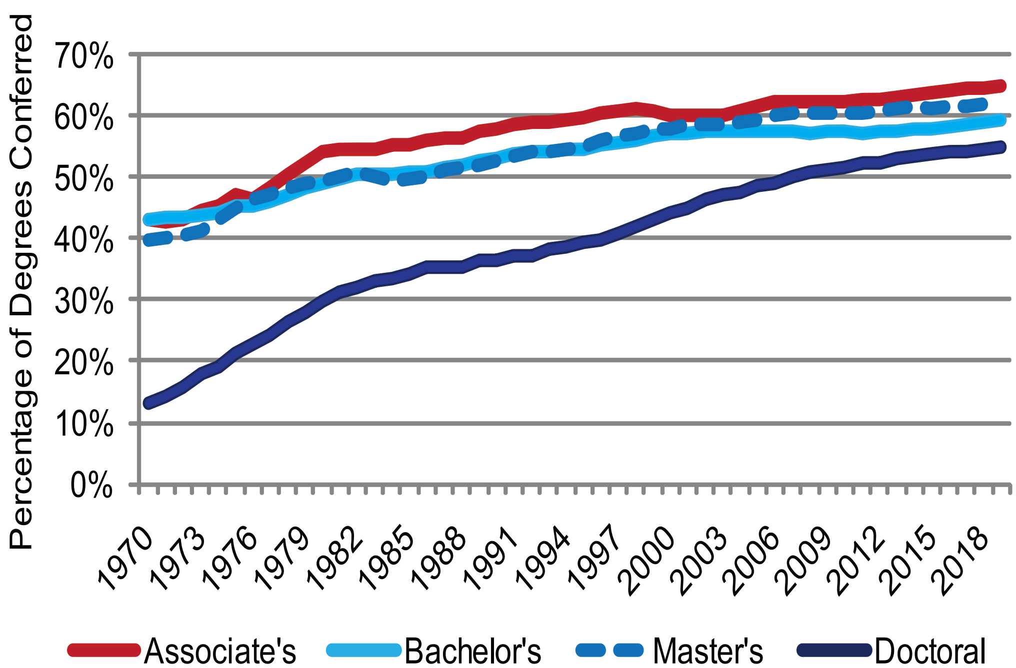
Between 1975 and 1980, community college enrollments reached gender parity (50 percent), leading four-year university enrollment trends by nearly 10 years (Figure 2.4). At four-year institutions, gender parity in enrollments was reached between 1980 and 1985. As of 2008, women have comprised 58 percent of all community college enrollments and 57 percent of four-year university enrollments.

Women now earn over half of all degrees from two- and four-year institutions (Figure 2.5). The equity point was passed in 1978 for Associate's degrees, in 1981 for Bachelor's and Master's degrees, and in 2007 for doctoral degrees. Currently, women earn 62 percent of all Associate's degrees, and a slightly lower percentage at four-year institutions (61-55%). Projections from the NCES Digest of Education Statistics indicate that women will earn 65 percent of all Associate's degrees by 2019, and between 55 and 62 percent of four-year degrees (Bachelor's: 59%; Master's: 62%; Doctorates: 55%).



Source: AGI Geoscience Workforce Program. Data derived from NCES Digest of Education Statistics, 2009.

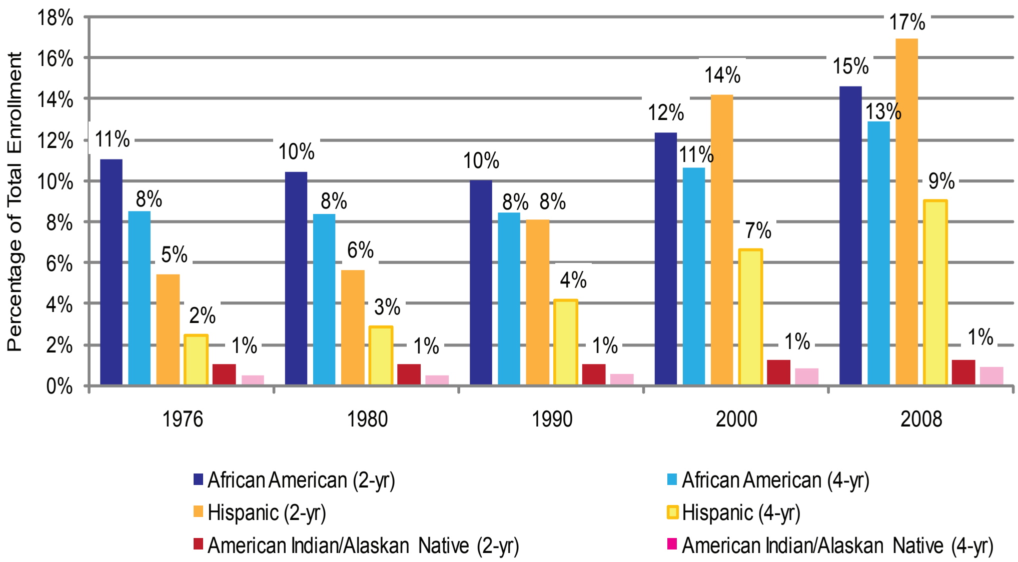
Figure 2.4: Participation of Women in College and University Enrollments



Source: AGI Geoscience Workforce Program. Data derived from NCES Digest of Education Statistics, 2009.

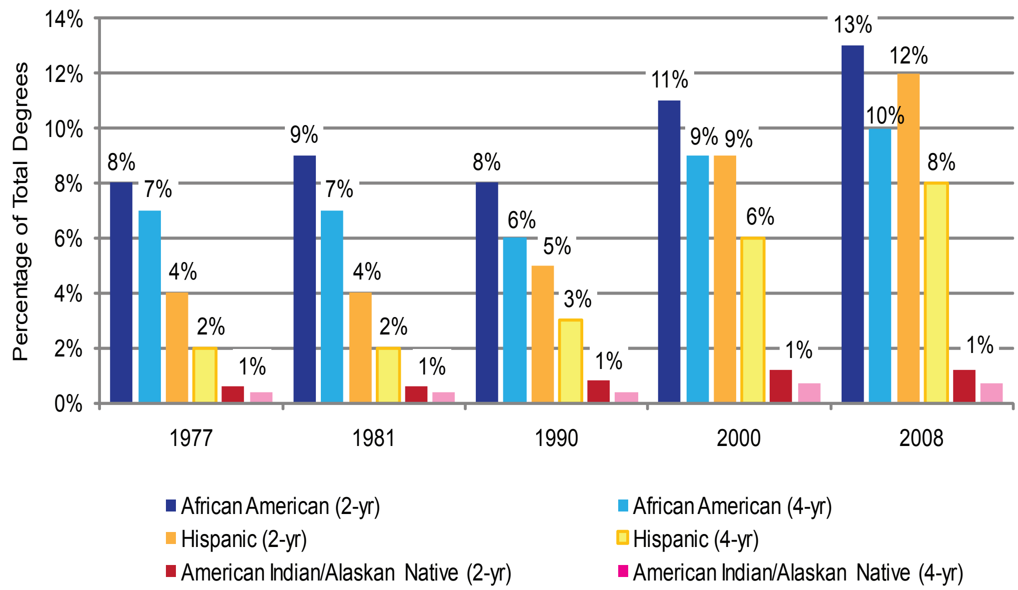
Figure 2.5: Percentage of Degrees Conferred to Women by Degree Level

Underrepresented minorities participation rates in science and engineering is less than their representation in the whole U.S. population. As such, these groups of minorities are of special concern to all science and engineering disciplines as the total potential human capital of the society is not being utilized. Over the past 30 years, participation of underrepresented minorities in community college enrollments increased from 17 percent at in 1976 to 33 percent in 2008 (Figure 2.6). At four-year institutions, underrepresented minorities comprised 11 percent of enrollments in 1976 and 23 percent in 2008. Underrepresented minorities at community colleges earned 13 percent of all Associate's degrees in 1976, and 26 percent of all degrees in 2008 (Figure 2.7). At four-year institutions, underrepresented minorities earned just over 9 percent of all degrees in 1976 and 19 percent of all degrees in 2008. The large increases in underrepresented minority participation have occurred over a single generation because Hispanic participation rates have increased rapidly, and to a slightly lesser extent, growth in African American participation rates.



Source: AGI Geoscience Workforce Program, data derived from the NCES Digest of Education Statistics

Figure 2.6: Underrepresented Minority Enrollments in Colleges and Universities



Source: AGI Geoscience Workforce Program, data derived from the NCES Digest of Education Statistics

Figure 2.7: Percentage of Degrees Conferred to Underrepresented Minorities by Degree Level

Geoscience Departments and Faculty

There are a total of 1,690 two-year colleges in the U.S., and AGI currently tracks geoscience faculty at 285 of these institutions. Geoscience programs are distributed across the nation, with the highest concentrations in California and Texas (Figure 2.8). In California, geoscience is available at approximately a third of all community colleges, and in Texas at nearly a quarter of all community colleges (Table 2.1). Of these 285 community colleges with geoscience programs, 37 percent have dedicated geoscience programs (e.g. Department of Geology, Department of Earth Science, etc.) and seven percent of geoscience programs are co-located with other disciplines (e.g. Department of Geology and Geography, Department of Physics, Chemistry and Earth Science, etc.). The majority of geoscience programs and faculty are located in either Math and Science divisions, or in Physical or Natural Science departments. For those states having more than ten community colleges with geoscience programs, Washington has the highest percentage of community colleges with geoscience programs (37 percent) (Table 2.1).

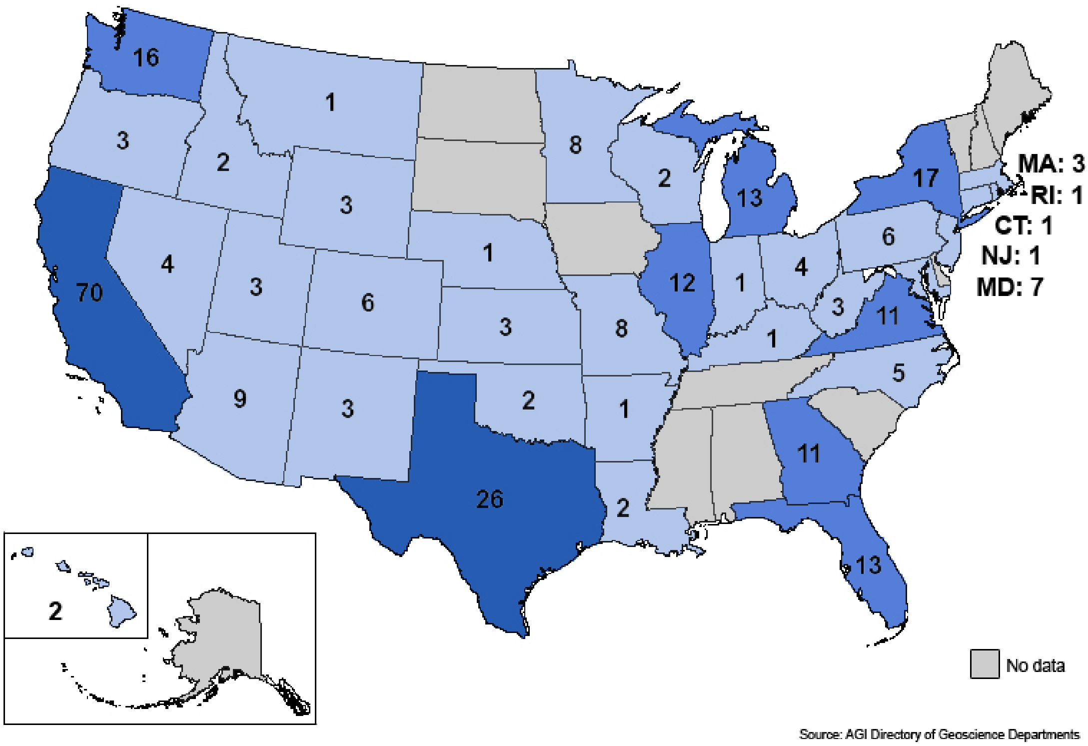


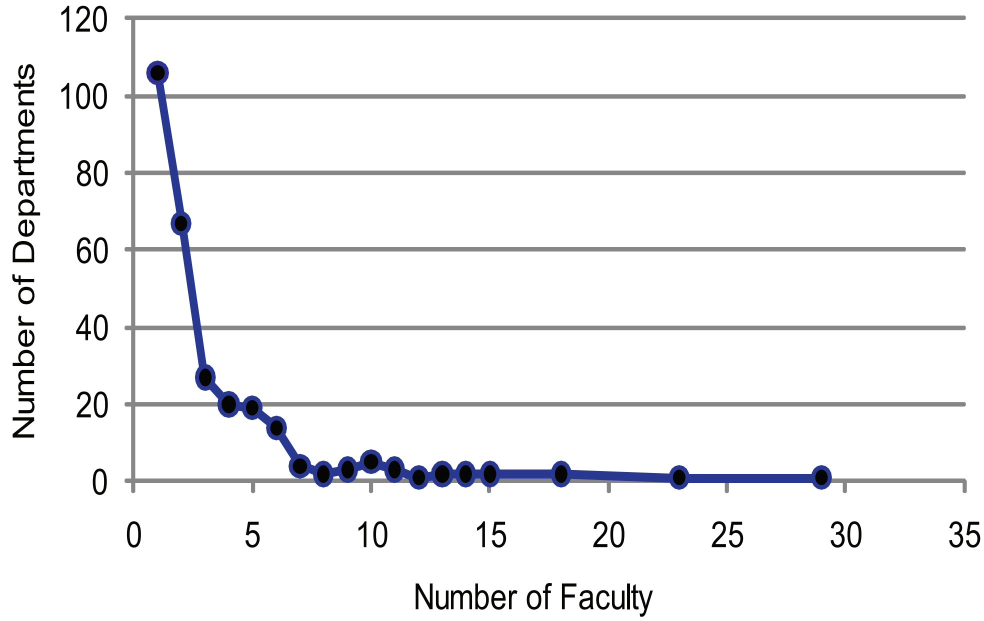
Figure 2.8: Number of Geoscience Departments / Programs at Community Colleges by State

State	Community Colleges with Geoscience Programs	Community Colleges in the State	Percentage of Community Colleges in the State with Geoscience Programs
California	69	218	32%
Texas	26	115	23%
New York	17	104	16%
Washington	16	43	37%
Florida	13	114	11%
Illinois	12	82	15%
Michigan	12	47	26%
Virginia	11	59	19%

Table 2.1: Percentage of Community Colleges with Geoscience Programs for Selected States.

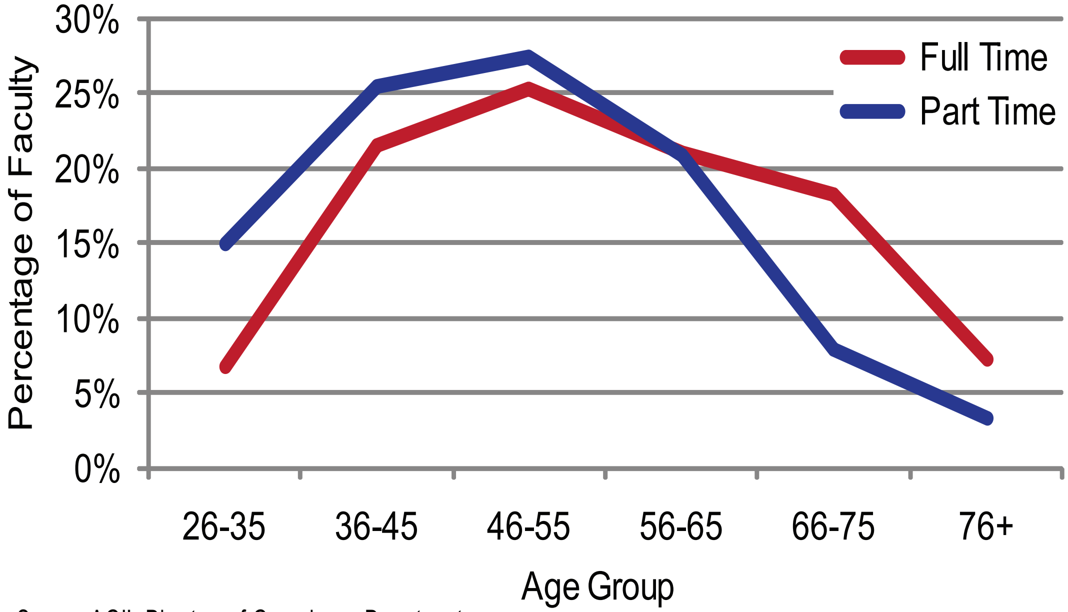
(Source: AGI Geoscience Workforce Program. Data derived from AGI's Directory of Geoscience Departments and NCES College Navigator.)

Geoscience community college programs tend to have smaller faculty sizes. Eight-five percent of geoscience programs at community colleges have less than five faculty members, and 62 percent have less than three faculty members (Figure 2.9). Furthermore, just over half of the geoscience community college professoriate is comprised of part-time faculty (53 percent) and this cohort tends to be younger than the cohort of full-time faculty (Figure 2.10). Additionally, a higher percentage of full-time geoscience community college faculty have graduate degrees (Master's: 52 percent; Doctorate: 35 percent) than part-time faculty (Master's: 43 percent; Doctorate: 15 percent).



Source: AGI's Directory of Geoscience Departments

Figure 2.9: Number of Faculty per Geoscience Department / Program at Community Colleges



Source: AGI's Directory of Geoscience Departments

Figure 2.10: Age Demographics of Community College Geoscience Faculty

Women hold a quarter of all geoscience community college faculty positions (Figure 2.11). Furthermore, women hold a higher percentage of faculty ranks at community colleges (except Assistant Professor and Instructor/Lecturer) than at four-year universities. At four-year universities women hold 16 percent of all geoscience faculty positions, 30 percent of Assistant Professorships, and 35 percent of Instructor/Lecturer positions.

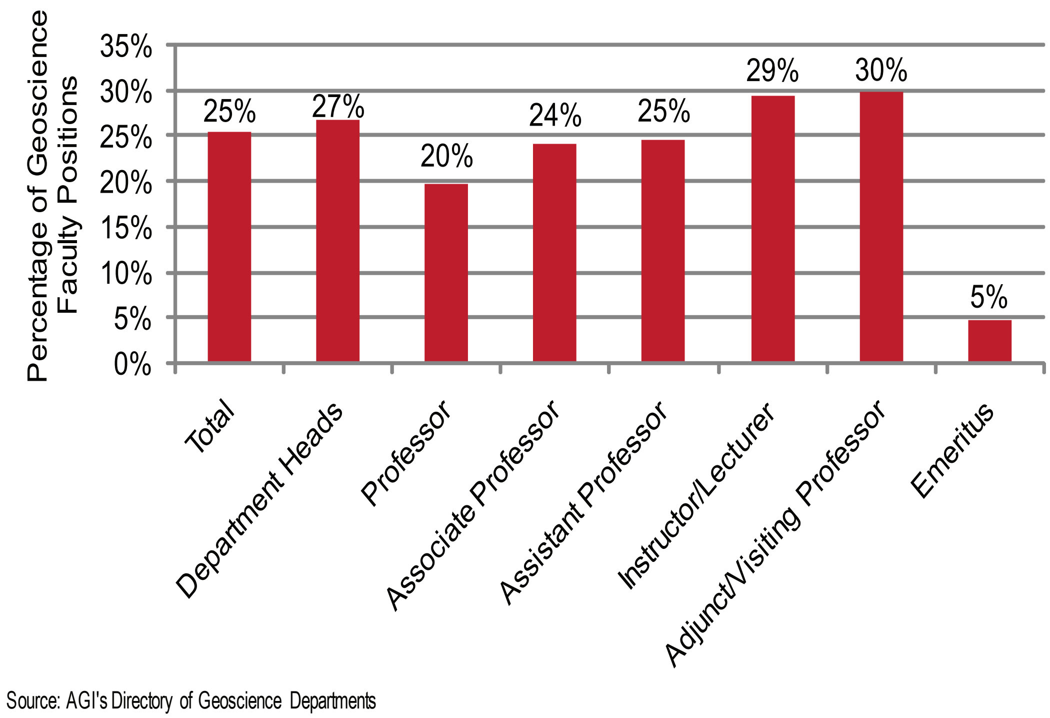
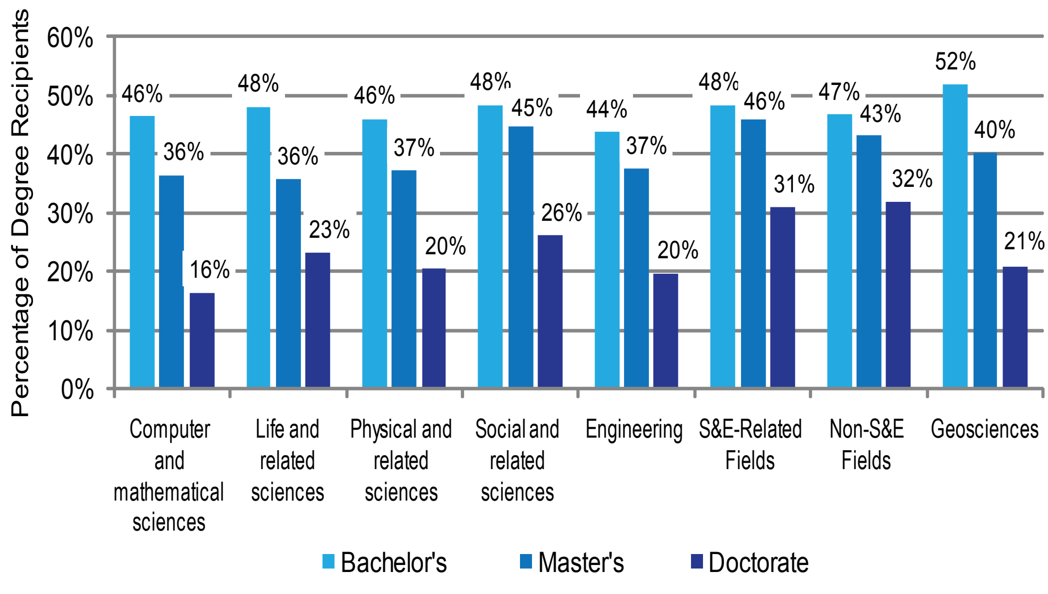


Figure 2.11: Percentage of Community College Geoscience Faculty Positions Held by Women

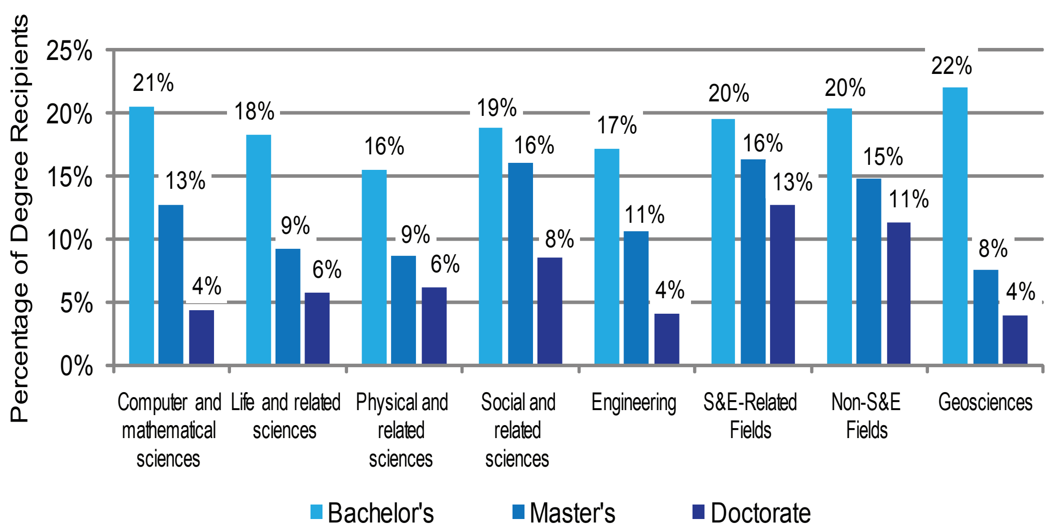
Geoscience Students

Geoscience faculty have indicated that the majority of the students they teach are not majors, but rather students taking geoscience courses to meet general education requirements or for personal interest. Investigation of community college experience of four-year degree recipients indicate that community colleges play a large role in the educational pathways of students graduating from four-year institutions. Nearly half of all Bachelor's degree holders attended community college (Figure 2.12), and nearly one-fifth earned Associate's degrees (Figure 2.13). At the graduate degree levels, Master's degree holders have higher rates of community college attendance (36-46 percent) and Associate's degree attainment (8-16 percent) than Doctorate's (attendance: 16-32 percent; Associate's degrees: 4-13 percent).



Source: AGI Geoscience Workforce Program. Data derived from NSF's NSCG 2003 Public Dataset

Figure 2.12: Four-year University Graduates by Highest Degree Field and Level Who Attended Community College (2003)



Source: AGI Geoscience Workforce Program. Data derived from NSF's NSCG 2003 Public Dataset

Figure 2.13: Four-year University Graduates by Highest Degree Field and Level Who Earned Associate's Degrees (2003)

NSF last collected data on Associate's degree achievement in 2003 and it was also the last year that degree classification codes were fine enough to distinguish geoscience degree fields from other physical science disciplines. In 2006, NSF data from the National Survey of Recent College Graduates indicated that community college attendance by Bachelor's degree recipients remained near 50 percent (except S&E Related fields which increased to 67 percent) (Figure 2.14). At the graduate level, Master's degree holders community college attendance rates varied between 27 and 58 percent and Doctorate's community college attendance rates varied between 11 and 44 percent. Physical science degree holders had slightly lower community college attendance rate than in 2003 for Bachelor's and Master's degree levels (-3 percent and -6 percent respectively), and slightly higher attendance rates at the doctoral level (5 percent).

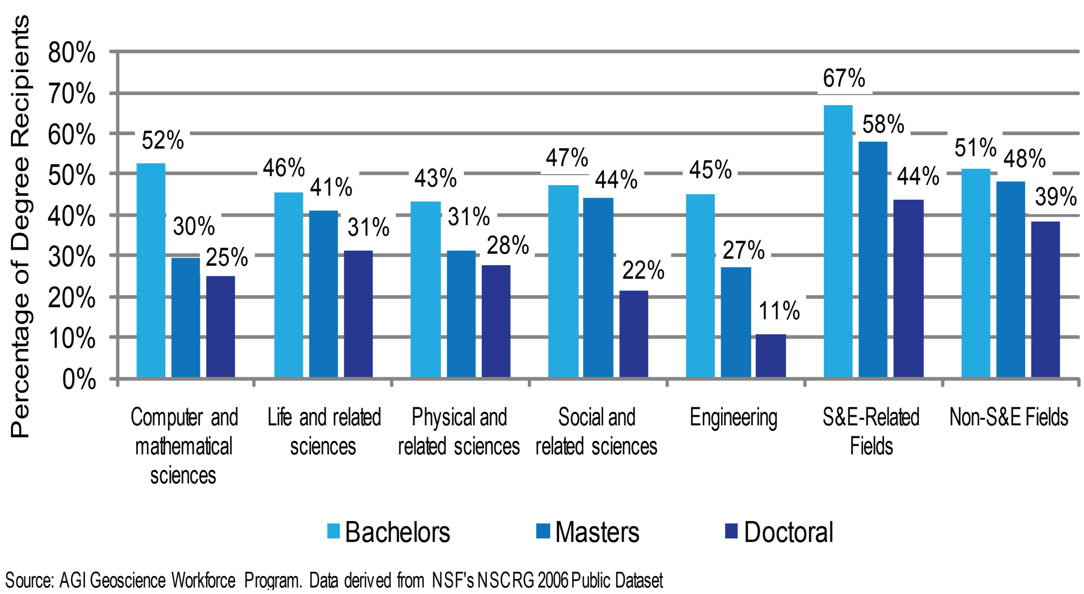


Figure 2.14: Four-year University Graduates by Highest Degree Field and Level Who Attended Community College (2006)

Community college attendance and associate's degree attainment rates for geoscience graduates varies by degree level and sub-discipline. Yet, for most geoscience sub-disciplines over one-third of Bachelor's and Master's graduates and over 10 percent of geoscience doctorates attended community college during their academic career (Figure 2.15). At least 10 percent of geoscience Bachelor's graduates from all sub-disciplines and 10 percent of geoscience Master's graduates from half of the sub-disciplines have an Associate degree (Figure 2.16). Atmospheric Sciences, Earth Science/Geology, Environmental Engineering, and Geophysical Engineering are the only sub-disciplines that have graduates from all degree levels with Associate's degrees. Of these, nearly one-tenth of doctorates from these fields (except Earth Science/Geology) have an Associate's degree.

Given the high proportion of environmental science programs and engineering technical programs at community colleges, the higher rates of community college attendance and Associate's degree attainment in environmental science and geoscience engineering fields is not surprising, as these community college programs may be able to more successfully transfer students to four-year institutions than other geoscience programs. Furthermore, even though Geology programs are rare at community colleges, the community college attendance and Associate's degree attainment rates of Geology graduates suggest that community colleges may play a larger role in geoscience academic pathways than previously thought; however, more research is needed to elucidate the influence of community colleges in the geoscience academic pathway.

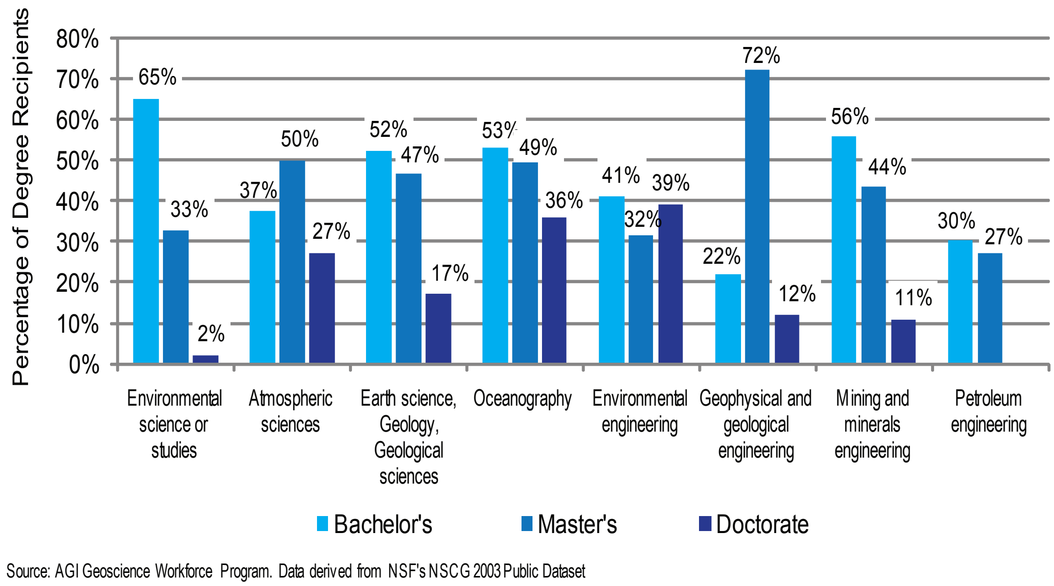


Figure 2.15: Geoscience Graduates by Highest Degree Field and Level Who Attended Community College (2003)

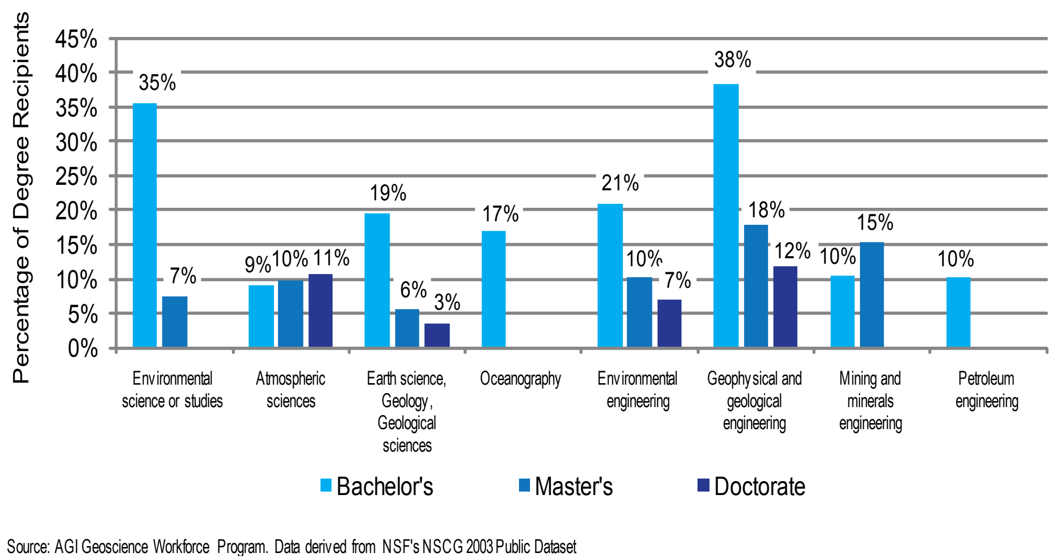
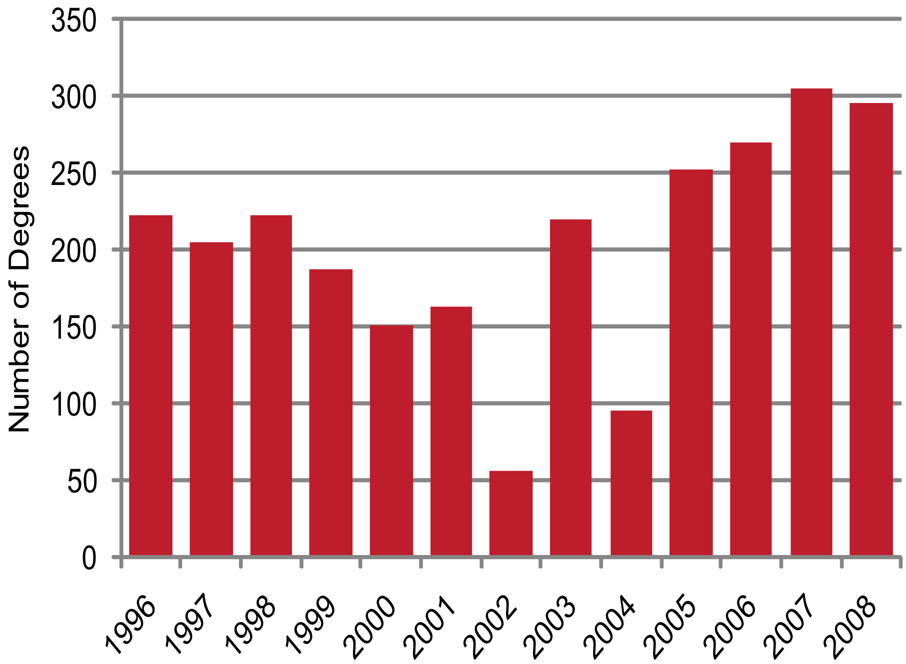


Figure 2.16: Geoscience Graduates by Highest Degree Field and Level Who Earned Associate's Degrees (2003)

Geoscience Associate's Degree Trends

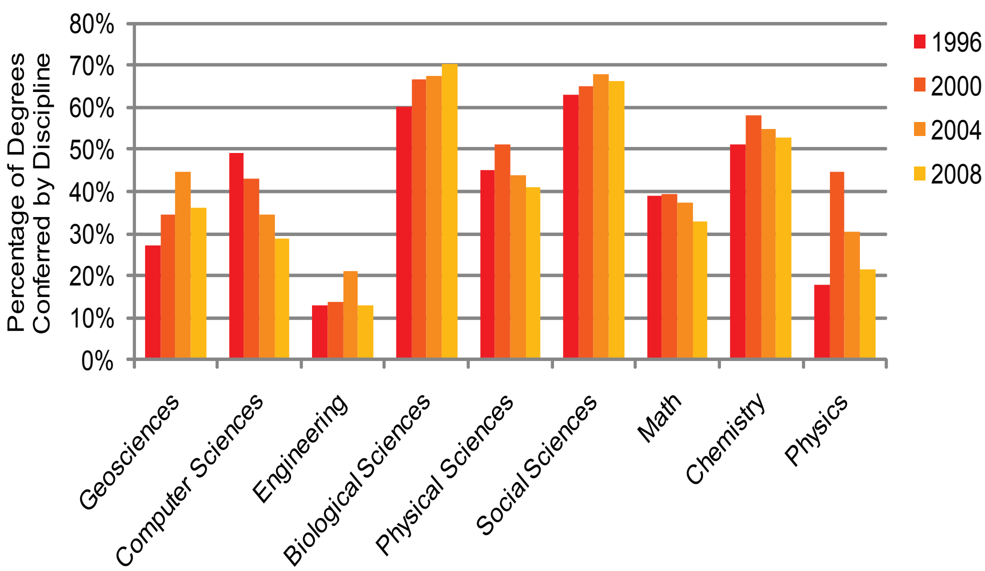
Since the 1996 the number of geoscience Associate's degrees conferred per year has varied between 200 and 300, with a decline in the early part of the 2000's (Figure 2.17). Despite the low number of degrees conferred annually, the percentage of geoscience Associate's degrees conferred to women increased from 27 percent 1996 to 36 percent in 2008 (Figure 2.18). Geoscience gender parity trends still lag far behind the overall Associate's degree conferral rate to women which is 62 percent. However, when compared to other science and engineering disciplines, the geosciences confers a higher percentage of Associate's degrees to women than computer science, engineering, math and physics. Additionally, geoscience

Associate's degree conferral rates are slightly lower than geoscience undergraduate and graduate conferral rates (~ 40 percent).



Source: AGI Geoscience Workforce Program. Data derived from IPEDS.

Figure 2.17: Geoscience Associate's Degrees Conferred Annually



Source: AGI Geoscience Workforce Program. Data derived from IPEDS.

Figure 2.18: Percentage of Associate's Degrees Conferred to Women by Discipline

Underrepresented minority participation in geoscience academic programs is still a systemic problem. In 2008, underrepresented minorities earned 12 percent of all geoscience Associate's degrees which is higher than the 6 percent conferral rate for four-year geoscience degrees. However, at community colleges where the pool of students is substantially more diverse than at four-year institutions, the percentage of underrepresented minorities earning geoscience degrees remains lower than other science and engineering disciplines (Figure 2.19), and far lower than overall Associate's degree conferral rates (26 percent).

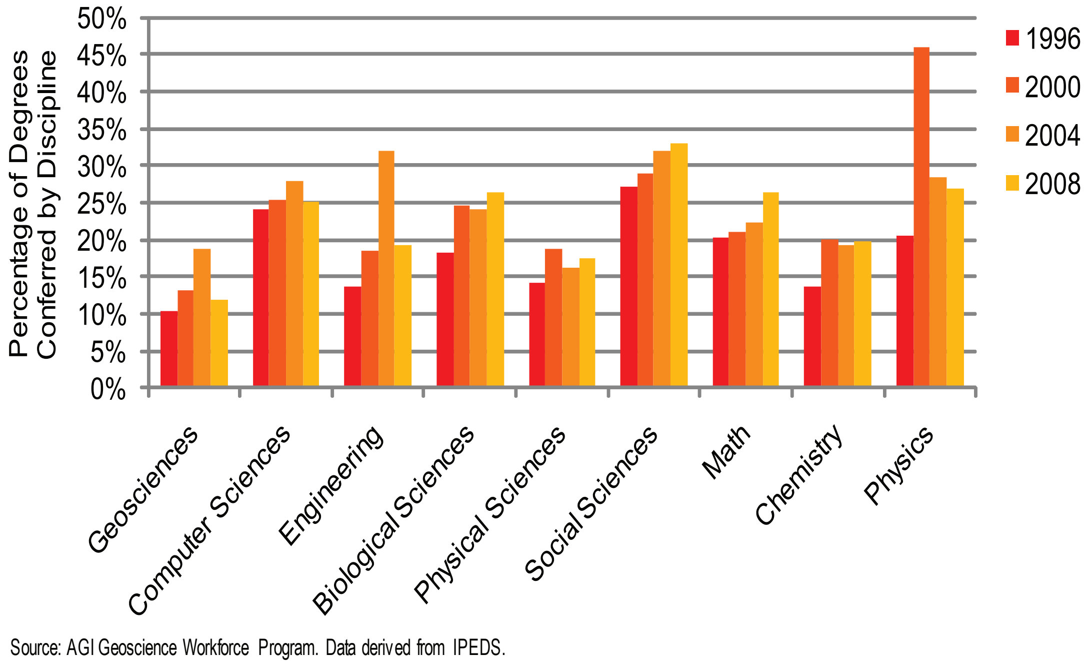


Figure 2.19: Percentage of Associate's Degrees Conferred to Underrepresented Minorities by Discipline

Currently, 79 Minority Serving Institutions (MSIs) offer Associate's degrees in geoscience disciplines (Figure 2.20), and the majority of these programs are located in California and Texas. Hispanic high-enrollment institutions offer the highest number of geoscience programs (46), followed by Tribal Colleges (23), while the Historically Black Colleges and Universities (HBCUs) have only one geoscience Associate's degree program. Although the majority of these degree programs are in environmental science, a few focus on traditional geology. In 2008, 10 percent of all geoscience Associate's degrees were conferred by MSIs. Of these 29 degrees, 16 were earned by Native Americans and two by Hispanics, equaling a 62 percent conferral rate to underrepresented minorities.

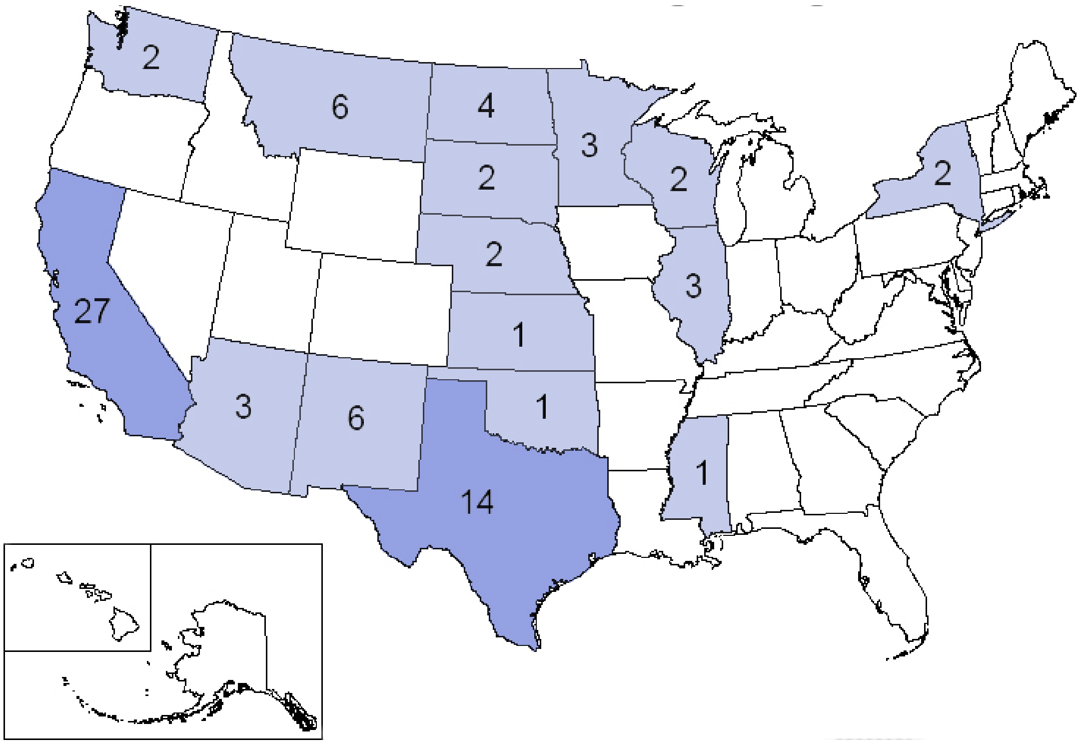


Figure 2.20: Location of Minority Serving Institutions Offering Geoscience Associate's Degree Programs

(Data derived from IPEDS. Note: Not all programs shown here are currently incorporated into AGI's Directory of Geoscience Departments. (see Figure 2.8) However, this information will be incorporated in 2012.)

Chapter 3: Trends in Geoscience Education at Four-Year Institutions

Overview

The academic sector is unique in that it serves as both a consumer and primary supplier of geoscience human capital. Thus, the health of geoscience academic departments, including the size of their student body and faculty, directly affect the size and expertise of the future geoscience workforce. Because a Master's degree is considered the professional degree in geoscience occupations, there is approximately a 5 year lag effect on the geoscience workforce for students who graduate with a geoscience Master's degree. Students with Bachelor's degrees in geoscience disciplines have limited job opportunities, and although there are opportunities available to geoscience doctorates in non-academic employment sectors, over 80 percent of geoscience doctorates pursue careers in academia. As a result, there is approximately a 10 to 15 year lag effect on the geoscience academic workforce depends upon the length of time that geoscience doctorates spend in post-doctoral positions before they begin a faculty position.

Geoscience departments at four-year universities can be found in every state, and the states with the most departments are California, New York, Pennsylvania, Texas, and Ohio. Between 2009 and 2010, twenty-nine states (58 percent of all US states) saw reductions in the number of geoscience departments, and 12 states saw increases in the ratio of student to tenure-track faculty. However, the majority of geoscience departments continue to have relatively low student to tenure-track faculty ratios (6-10 students or less per faculty member) which places geoscience programs in a favorable position from a teaching perspective. Between 1999 and 2007, the median size of departments decreased both in number of faculty (Professors, Associate Professors, Assistant Professors, and Instructors/Lecturers) and number of total students enrolled (undergraduate and graduate). However, since 2007, the median department size based on enrollments has increased from 45 to 56, while the median number of faculty remains near eight.

During the 2009-2010 academic year, the number of geoscience undergraduates enrolled in U.S. institutions reached its highest level in a decade at 23,983 majors. This is a 7 percent increase over 2008-2009 enrollments, and a 24.8 percent increase since the 2006-2007 academic year. For the first time in 5 years, graduate geoscience enrollments increased markedly to 9,054, jumping 15.7% from the 2008-2009 academic year. These increases in enrollments are likely linked to continued high prices of commodities, improved recruitment of students to the geosciences, and, for graduate enrollments, the perception of a negative job market, especially outside of the core geoscience industries. This perception drives undergraduates into graduate programs, even though geoscience employment opportunities remain robust.

The number of geoscience degrees conferred by U.S. institutions in the 2009-2010 academic year also increased markedly (Bachelor's degrees: 3,037, Master's degrees: 1,078, Doctorates: 668). The number of Bachelor's degrees conferred increased by 7 percent from the 2008-2009 academic year, and the number of graduate degrees also increased (3 percent at the Master's level and 6.2 percent at the Doctoral level). The increases in degree production are likely tied to prior growth in undergraduate enrollments and the poor state of the economy that is encouraging graduate students to complete their studies at a higher rate rather than seek employment prior to receiving their degree.

The ability to attract the maximum competent workforce to a profession is dependent upon its ability to recruit across gender, racial, and economic divides. Disparity between whole-population level of specific populations and their representation in the profession can be viewed as a first order proxy of the recruitment and sustainability of a discipline. In the geosciences, women currently earn nearly 40 percent of all geoscience degrees. During the 2009-2010 academic year, the geosciences saw a contraction in the percentage of women graduating from geoscience university programs at the Bachelor's and Doctoral degree levels (Bachelors: -2%, Doctorates: -9%) from the 2008-2009 academic year, yet the percentage of women enrolled in geoscience programs remain steady at all degree levels. Since 2008, the percentage of geoscience faculty positions held by women has increased by an average of two percent. In 2010, women held 16 percent of tenured and tenure-track geoscience faculty positions and 20 percent of non-tenure track geoscience faculty positions. Participation rates of women in geoscience faculty positions still lag broader science and engineering trends where women hold 28 percent of tenured and tenure-track positions in all science and engineering fields.

Compared to the progress made towards gender parity in the geoscience student population, the participation of underrepresented minorities in geoscience university programs remains extremely poor. As of 2008, underrepresented minorities comprised 23 percent of all enrolled students and 16 percent of all graduates at four-year universities. Yet, in geoscience university programs, less than 10 percent of geoscience graduates at all degree levels are underrepresented minorities. Compared with other science and engineering fields, the geosciences confer the lowest percentage of Bachelor's and Master's degrees to underrepresented minorities. However, at the doctoral level, the geosciences confer a slightly higher percentage of degrees to underrepresented minorities than do mathematics, engineering, and computer science.

Overall, Hispanics earn the largest percentage of geoscience degrees conferred to underrepresented minorities. This may be partly due to the geographic distribution of geoscience departments which are located in regions where there are large Hispanic populations. This geographic distribution may also account for the low participation rates of African Americans in geoscience programs. There are few geoscience programs at universities and community colleges in areas where there are large populations of African Americans. Considering that the composition of degree holders within a discipline is an important measure of disciplinary health, the geosciences have much to do to increase the participation rate of underrepresented minorities.

In the geosciences, a Master's degree is required for the majority of career paths. Examination of the academic degree backgrounds of geoscience graduate students reveals that the majority of geoscience graduate students have a interdisciplinary educational background rather than a traditional pathway (e.g. geoscience Bachelor's degree to geoscience graduate degree). Although the majority of geoscience graduate students have bachelor degrees in physical sciences or engineering, 27 percent of geoscience Master's degree recipients and 21 percent of geoscience doctorates hold bachelor degrees in other science disciplines. Furthermore, 9 percent of geoscience Master's degree recipients and 4 percent of geoscience doctorates have bachelor degrees from non-science and engineering fields. Only 42 percent of geoscience Master's degree recipients and 10 percent of geoscience doctorates hold bachelor's degrees in the geosciences. Additionally, 9 percent of geoscience Master's degree recipients and 4 percent of geoscience doctoral degree recipients have earned an Associate degree.

Since the 1970s, AGI's GeoRef database indicates that the majority of geoscience theses and dissertations pertain to geology topics. The change in theses and dissertation topics over the past four decades indicate a shift from resource-industry focused research towards environmental and interdisciplinary research, yet distinct differences exists between graduate degree levels. At the Master's degree level, petrology, stratigraphy, and economic geology have consistently ranked in the five most common theses topics since the 1970s, while at the doctoral level, the top five topics consistently include geophysics and engineering geology. Petrology which has consistently ranked in the top five most common theses topics, ranked fifth in the most common dissertation topic in the 1990s. Hydrogeology which ranked in the top five dissertation topic since the 1980s, only ranked in the top five theses topics in the 1980s and 1990s. Since the 1990's, environmental geology has ranked in the top two most common topics for both dissertations and theses, and this trend is concurrent with an increase in the percentage of geoscience federal funding applied to environmental science research at the university level during the same period.

Field camp is historically central to undergraduate geology education. There are currently 88 schools that offer summer field camps at least once every two years. This number is markedly lower than in 1995 when 257 schools offered summer field camp. There are several reasons for the decline in the number of departments offering traditional summer field camp experiences, including the rising costs of liability insurance and the changing face of geoscience departments in smaller schools that are combining with geography and environmental science programs. Also, summer field camps increase overall departmental expenses. Despite the decrease in the number of geoscience departments offering summer field camps, total attendance has increased over the past 10 years, with increases of several hundred students occurring approximately every two years since 1999. The most recent jump in attendance was between 2007 and 2008, when field camp attendance increased by 278 students. In 2009, 1,979 students attended field camp.

Faculty Demographics

Between 1999 and 2008, the numbers of Emeritus and Assistant Professors remained the same, but the number of all other faculty dropped. The percentage of geoscience faculty per rank has remained relatively steady since 2008. Currently, 58 percent of all four-year faculty are tenured, while 13 percent are untenured, but in tenure-track positions. Since 2008, the percentage of geoscience faculty positions held by women has increased by an average of two percent. In 2010, women held 16 percent of tenured and tenure-track geoscience faculty positions and 20 percent of non-tenure track geoscience faculty positions. Participation rates of women in geoscience faculty positions still lag broader science and engineering trends where women hold 28 percent of tenured and tenure-track positions in all science and engineering fields.

At a national level, the distribution of faculty specialties has remained relatively constant since 1999, despite an overall reduction in the number of faculty per specialty. However, there have been shifts in the distribution of faculty sub-discipline specialties over the same time period. The only faculty specialty category which has seen increases ince 1999 is "Other Geosciences". These increases are primarily due to the number of faculty teaching Geographic Information Systems, and an increase in the number of faculty teaching Atmospheric Science and a small increase in the number of faculty teaching Glaciology.

Research Funding

The steady decline of the percentage of federal research funds applied to the geosciences that began in the mid-1990s finally stabilized at 6 percent in 2007. Although the percentage of funding declined during this period, the absolute amount of funds applied to geoscience research at universities increased, peaking at $1.1 billion dollars in 2004 and remaining near $1 billion dollars since that time. Since 2006, oceanography has received the largest portion of this funding. Prior to this time, environmental science received the largest percentage of funding for geoscience university research during this decade. While funding for atmospheric science research has remained between 20 and 25 percent during this decade, funding for geological sciences has slowly increased to 20 percent over the same time period.

Between 2001 and 2008, the rate of funding for NSF grant proposals by the NSF Geoscience directorate decreased from 40 to 31 percent. This decrease can be attributed to an 18 percent increase in the number of proposals and a 6 percent decrease in the number of awards. With the influx of stimulus funds from the American Recovery & Reinvestment Act, funding rates increased in 2009 to 44 percent as the number of awards increased by 500 while the number of proposals remained steady from the previous year. In 2010, however, the funding rate dropped to 35 percent as the number proposals increased to approximately 4,800 while the number of awards issues tapered to approximately 1,700. Since 2001, the University of Hawaii, Columbia University, and Massachusetts Institute of Technology have consistently ranked in the top 10 of universities receiving the most funding from the NSF Geoscience Directorate across all of its divisions

As a result of the stimulus funding from the American Recovery & Reinvestment Act (ARRA), the NSF Geoscience Directorate funded 804 ARRA proposals. Thirty-six percent of these ARRA awards were given to 17 institutions, with Woods Hole Oceanographic Institution being awarded the most at 29 awards. The median size of the ARRA Standard Grant awards ranged from $347,988 for awards from the Atmospheric and Geospace Sciences division to $210,474 for awards from the Earth Sciences division. Forty-five percent of ARRA awards from the Atmospheric and Geospace Sciences division were for ICER (“Integrative Computing Education and Research”), atmospheric chemistry, and physical and dynamic meterology proposals. Fifty-one percent of ARRA awards from the Earth Sciences division were for ICER (“Integrative Computing Education and Research”), petrology and geochemistry, and geophysics proposal, and nearly a third of all ARRA proposals from the Ocean Sciences division were for chemical oceanography, marine geology and geophysics, and biological oceanography proposals.

Student Support

Direct support for geoscience students increased between 2006 and 2008, and that trend looks to continue in 2008-2009 with a projected 6 percent increase in available funds. These opportunities for student support include funds from government agencies (60 percent) and non-profit organizations (40 percent, which includes support from private foundations and companies). Graduate student support comprises 91 percent of all awards in the 2007-2008 academic year: over $2.4 million distributed among 570 individual awards. The largest student support program is the NSF Graduate Student Fellowship program. This program provided more than $1.13 million (from a total program budget of $40.5 million) in support to geoscience graduate students during 2007. In 2009, a total of 94 geoscience NSF graduate fellowships were awarded, up from 28 fellowships in 2008. With the large increase in the number of fellowships awarded in 2009, the total value of the NSF graduate fellowships awarded to geoscience students jumped from just over $1 million dollars in 2008 to $3.8 million dollars in 2009, largely with support from ARRA.

Geoscience Departments

Trends in the Status of Geoscience Departments

Although geoscience departments at four-year universities can be found in every state, the states with the most departments are California, New York, Pennsylvania, Texas, and Ohio (Figure 3.1). Between 2009 and 2010, twenty-nine states (58 percent of all US states) saw reductions in the number of geoscience departments. Seventy percent of these 29 states had only one geoscience department eliminated, and an additional 21 percent of these 29 states lost two geoscience departments. Virginia, Missouri, and Rhode Island were the hardest hit with geoscience department reductions (Virginia: -5; Missouri: -4; Rhode Island: -4). Despite the reductions in geoscience departments over the past year, New York, Pennsylvania, California, Texas, Ohio and Massachusetts still rank as the top six states having both the highest number of 4-year universities with geoscience departments and the highest number of geoscience departments in the state (Table 3.1).

Since the 2009 edition of this report, 12 states have seen increases in the ratio of student to tenure-track faculty and 7 states have witnessed decreases in this ratio (Table 3.2). However, the majority of geoscience departments continue to have relatively low ratios of student to tenure-track faculty (6-10 students or less per faculty member) which places geoscience programs with potentially favorable student to faculty ratios from a teaching perspective (Figure 3.2).

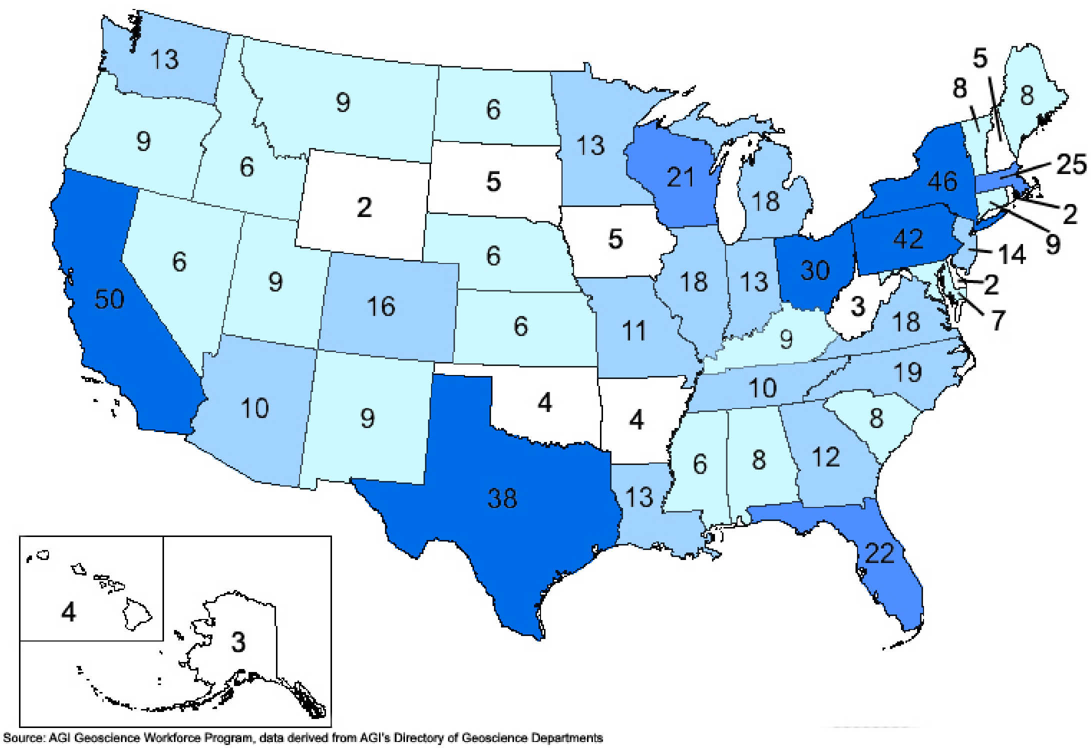


Figure 3.1: Number of Geoscience Departments per State

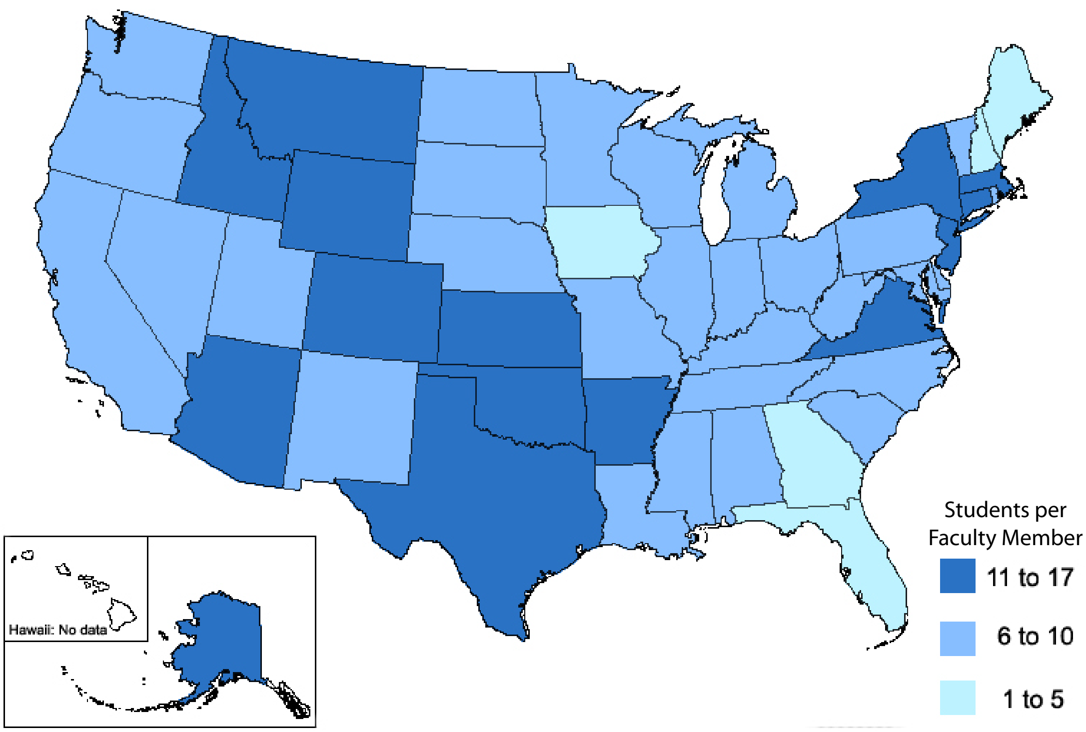


Figure 3.2: Number of Students per Tenure Track Faculty Member by State

State	4-year Universities with Geoscience Departments	Geoscience Departments in the State	State	4-year Universities with Geoscience Departments	Geoscience Departments in the State
New York	44	46	Mississippi	6	6
Pennsylvania	39	42	Montana	6	9
California	37	50	New Mexico	6	9
Texas	32	38	Vermont	6	8
Ohio	27	30	Idaho	5	6
Massachusetts	23	25	Kansas	5	6
Michigan	17	18	Maryland	5	7
Wisconsin	17	21	Nebraska	5	6
North Carolina	16	19	Utah	5	9
Florida	15	22	Arkansas	4	4
Illinois	15	18	Arizona	4	10
Virginia	14	18	Iowa	4	5
Colorado	12	16	North Dakota	4	6
Georgia	11	12	New Hampshire	4	5
Indiana	11	13	South Dakota	4	5
Minnesota	11	13	Oklahoma	3	4
Missouri	11	11	Rhode Island	3	4
New Jersey	11	14	West Virginia	3	3
Tennessee	10	10	Alaska	2	3

Louisiana	9	13	District of Columbia	2	2
Washington	9	13	Hawaii	2	4
Connecticut	8	9	Nevada	2	6
Alabama	7	8	Delaware	1	2
Kentucky	7	9	Guam	1	1
Maine	7	8	Puerto Rico	1	2
Oregon	7	9	Wyoming	1	2
South Carolina	7	8			

Table 3.1: Distribution of Geoscience Departments in the United States

(Source: AGI Geoscience Workforce Program, 2010)

State	Student : Faculty Member Ratio (2009)	Student : Faculty Member Ratio (2010)	2009-2010 Direction of Change
Florida	6-10	1-5	(-)
Georgia	6-10	1-5	(-)
New Hampshire	6-10	1-5	(-)
Delaware	11-17	6-10	(-)
Nebraska	11-17	6-10	(-)
Vermont	11-17	6-10	(-)
Washington	11-17	6-10	(-)
Alabama	1-5	6-10	+
Michigan	1-5	6-10	+
Missouri	1-5	6-10	+
Nevada	1-5	6-10	+
Rhode Island	1-5	6-10	+
Tennessee	1-5	6-10	+
Wisconsin	1-5	6-10	+
Oklahoma	1-5	11-17	+
Arkansas	6-10	11-17	+
Arizona	6-10	11-17	+
Massachusetts	6-10	11-17	+
Wyoming	6-10	11-17	+

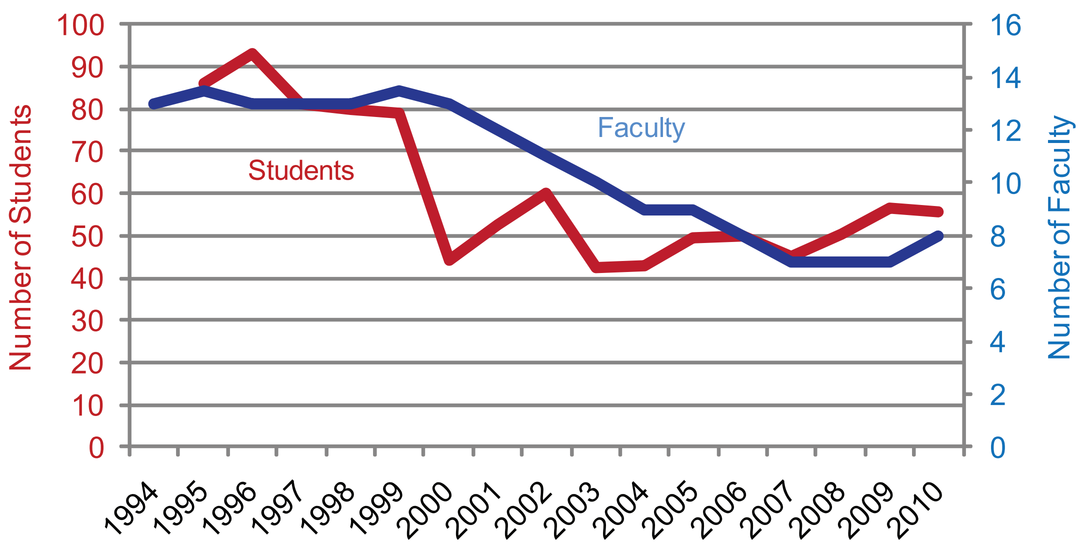
Table 3.2: States with Changes in Geoscience Student to Faculty Member Ratios (2009-2010).

(Source: AGI Geoscience Workforce Program, 2010)

Between 1999 and 2007, the median size of departments decreased both in number of faculty (Professors, Associate Professors, Assistant Professors, and Instructors/Lecturers) and number of total students enrolled (undergraduate and graduate). However, since 2007, the median department size based on the total number of enrolled students has increased from 45 to 56, while the median number of faculty still remains low (Figure 3.3).

Departments not only compete for students. Texas leads the nation in the number of undergraduate students enrolled in geoscience departments and is second to California for enrolling graduate students in geoscience departments (Tables 3.3 and 3.4). California, which leads the nation in enrolling the most graduate geoscience students, ranks fourth in the percentage of all undergraduate geoscience student enrollments.

State-level enrollment trends tend to be driven by local factors. In some cases, a strong influence in the local economy related to geosciences, such as resource companies, often supports greater enrollment levels, while in other cases, secondary education systems with upper-level earth science courses or states with a large number of institutions often support a large geoscience major population. In other cases, productive departments with faculty that are consistently winning federal grants allow departments to develop programs that attract and enroll graduate students. Whereas the local economy and large number of institutions may be influential at the undergraduate level, the productivity of a department may be more influential in attracting graduate students.



Source: AGI Geoscience Workforce Program, data derived from AGI's *Directory of Geoscience Departments* and *2003 Report on the Status of Academic Geoscience Departments*, Katz, B.J., 2003.

Figure 3.3: Median Size of Geoscience Departments Based on Number of Faculty and Number of Students

State	Percentage of All Undergraduate Geoscience Students
Texas	8.7
New York	6.7
Pennsylvania	6.6
California	5.9
Massachusetts	5.7
Colorado	5.2

Table 3.3: Percentage of All U.S. Geoscience Undergraduate Students Enrolled in 2009-2010

(Source: AGI Geoscience Workforce Program)

State	Percentage of All Graduate Geoscience Students
California	11.1
Texas	8.7
Colorado	5.5
Massachusetts	5.1

Table 3.4: Percentage of All U.S. Geoscience Graduate Students Enrolled in 2009-2010

(Source: AGI Geoscience Workforce Program)

Geoscience Field Camp Experience

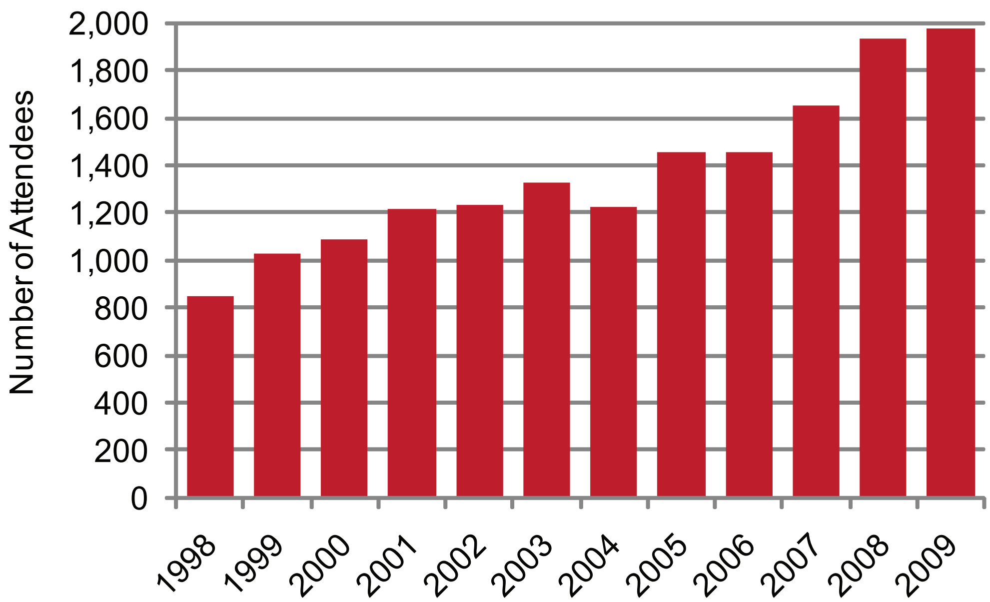
Field camp has traditionally served as a central part of undergraduate geoscience curricula, but this tradition appears to be disappearing. The American Geological Institute (AGI) performed a census of geoscience departments in the United States to identify schools that have offered geoscience field camps in the past two years. According to this search, there are currently 88 schools that offer summer field camps at least once every two years. This number marks a 60 percent decrease in the number of departments offering traditional summer field courses. The 1985 Directory of Geoscience Departments (DGD) listed 259 schools as offering summer field camps, and the 1995 DGD listed 257 schools as offering summer field camps. The current number of schools offering summer field camps represents less than 15 percent of the 695 schools listed in the 2006 DGD in the United States. In 1985 and 1995 close to 35 percent of schools offered summer field courses for geoscience students.

There are several reasons for the decline in the number of departments offering traditional summer field camp experiences, including the rising costs of liability insurance and the changing face of geoscience departments in smaller schools that are combining with geography and environmental science programs. Also, summer field camps increase the overall costs for the department.

A number of existing field camp programs are open to outside enrollment, and are designed as upper-level programs for undergraduate geoscience students. The cost for attending these summer courses averages more than $2,000 for tuition, with additional costs for transportation to the camp location and required field equipment. Most of the programs run 4 to 8 weeks and provide 4 to 8 credits that can be transferred to the student's home university. Two multi-institution field consortia were identified that pool resources to provide a more traditional field camp experience – the Wasatch-Uinta Field Camp Group and a group of schools from Virginia and North Carolina. There are several programs that have partnered with other programs to design and teach field camp. This past summer 88 programs offered field camps. The majority of these programs are traditional mapping-based geology field camps, but an increasing number of programs are being offered in environmental science, hydrology, and geophysics.

Despite the decrease in summer field camp options, a majority of the Bachelors of Science degrees in geology/earth science require field experiences as part of the core curriculum. Many departments are allowing for field experiences other than formal field camps to be used to fulfill this requirement. An increasing number of schools are offering semester field courses that combine field experience with written course work, while others allow field-based research projects to serve as field courses. Many departments offer a wide range of field trips and short weekend field experiences to introduce students to field techniques, instead of the summer course.

Despite the decrease in the number of geoscience departments offering summer field camps, total attendance has increased over the past 10 years, with increases of several hundred students occurring approximately every two years since 1999 (Figure 3.4). The most recent jump in attendance was between 2007 and 2008, when field camp attendance increased by 278 students. In 2009, 1,979 students attended field camp.



Data provided by Dr. Penny Morton, UMN-Duluth

Figure 3.4: Total Field Camp Attendance 1998 - 2009

Field Camp	State	Field Camp	State
University of Alaska - Fairbanks	AK	University of Missouri - Columbia	MO
University of Alabama	AL	University of Missouri - Kansas City	MO
University of South Alabama	AL	Montana State University	MT
University of Arkansas	AR	University of Montana	MT
Arizona Stae University	AZ	University of North Carolina	NC
Northern Arizona University	AZ	University of North Carolina - Wilmington	NC
University of Arizona	AZ	University of Nebraska	NE
California State University - Long Beach	CA	New Mexico Tech	NM
Humboldt State University	CA	University of New Mexico	NM
San Diego State University	CA	University of Nevada - Las Vegas	NV
San Jose State University	CA	Colgate University	NY
University of California - Davis	CA	Cornell University	NY
University of California - Santa Barbara	CA	State University of New York - Courtland	NY
University of California - Santa Cruz	CA	State University of New York - Oswego	NY
Adams State College	CO	University of Buffalo	NY
Colorado School of Mines	CO	Bowling Green State University	OH
Colorado State University	CO	Kent State University	OH
Fort Lewis College	CO	Miami University	OH
Mesa State College	CO	Ohio State University	OH
Florida State University	FL	University of Akron	OH
University of Florida	FL	Wright State University	OH
Georgia State University	GA	Oklahoma State University	OK
University of Georgia	GA	University of Oklahoma	OK
Iowa State University	IA	Oregon State University	OR
University of Iowa	IA	Southern Oregon University	OR

Field Camp	State	Field Camp	State
Brigham Young University-Idaho	ID	University of Oregon	OR
Idaho State University	ID	Lehigh University	PA
University of Idaho	ID	Black Hills Natural Sciences Field Station	SD
Eastern Illinois University	IL	University of Memphis	TN
Illinois State University	IL	Baylor University	TX
Northern Illinois University	IL	Texas A & M University	TX
Southern Illinois - Carbondale	IL	University of Houston	TX
University of Illinois - Urbana Champaign	IL	University of Texas - Arlington	TX
Western Illinois University	IL	University of Texas - Austin	TX
Wheaton College	IL	University of Texas – Dallas	TX
Ball State University	IN	University of Texas - El Paso	TX
Indiana University	IN	Brigham Young University	UT
Fort Hays State University	KS	Southern Utah University	UT
University of Kansas	KS	Utah State University	UT
Wichita State	KS	Weber State University	UT
University of Kentucky	KY	George Mason University	VA
Western Kentucky University	KY	Central Washington University	WA
Louisiana State University	LA	University of Washington	WA
University of Louisiana - Lafayette	LA	Washington State University	WA

Table 3.5: U.S. Geoscience Field Camp

(Source: Dr. Penny Morton, University of Minnesota-Duluth)

Geoscience Faculty

Geoscience Faculty Demographics

In 2009, there were 10,213 geoscience faculty and researchers employed in geoscience departments at US four-year universities, compared to 13,324 in 1999, and 10,051 in 2008. The percentage of geoscience faculty per rank has remained relatively steady since 2008. Currently, 58 percent of all four-year faculty are tenured, while 13 percent are untenured, but in tenure-track positions (Figure 3.5).

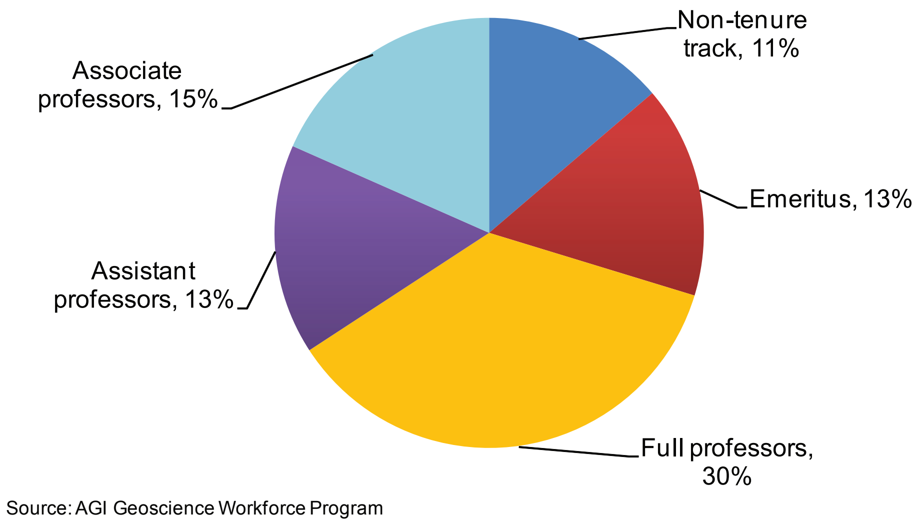


Figure 3.5: Percentage of Geoscience Faculty by Rank in Four-Year Institutions

The following ten schools produce one quarter of all geoscience faculty in the United States.

School where Faculty Earned Highest Degree	Total number of tenure or tenure-track faculty graduates
Massachusetts Institute of Technology	281
University of California. Berkeley	169
Washington University	157
Stanford University	152
University of Wisconsin	150
California Institute of Technology	138
Columbia University	126
Harvard University	126
Pennsylvania State University	114
University of Arizona	110

Table 3.6: Top Ten Degree Granting Institutions of U.S. Geoscience Tenure-Track and Tenured Faculty

(Source: AGI Geoscience Workforce Program)

Tenure-track geoscience faculty progress steadily through the academic ranks from assistant professor to full professor by the age of 60. Full professors tend to work later into their career, and there is a cross-over in the population of full professors and emeritus professors in the 71 to 75 age range.

The low number of faculty under the age of 40 likely reflects the growing tendency for geoscientists to take post-doctoral fellowships prior taking a faculty position. Lecturers, instructors, and visiting professors each comprise less than 5 percent of every age group. Adjunct professors, however, comprise 5 to 13 percent of each age group. This consistent percentage regardless of age, reflects a trend of multiple academic appointments throughout geoscience faculty careers.

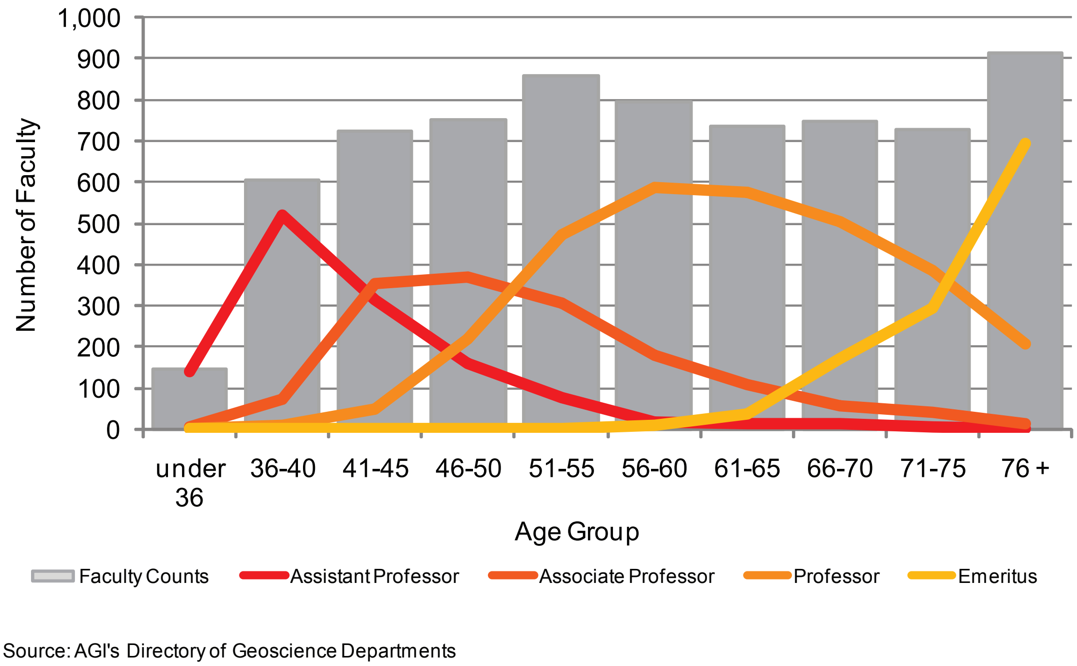


Figure 3.6: Number of Geoscience Faculty per Age Group and Rank

Since 2008, the percentage of geoscience faculty positions held by women has increased by an average of two percent (Figure 3.7). In 2010, women held 16 percent of tenured and tenure-track geoscience faculty positions and 20 percent of non-tenure track geoscience faculty positions. Participation rates of women in geoscience faculty positions still lag broader science and engineering trends where women hold 28 percent of tenured and tenure-track positions in all science and engineering fields.

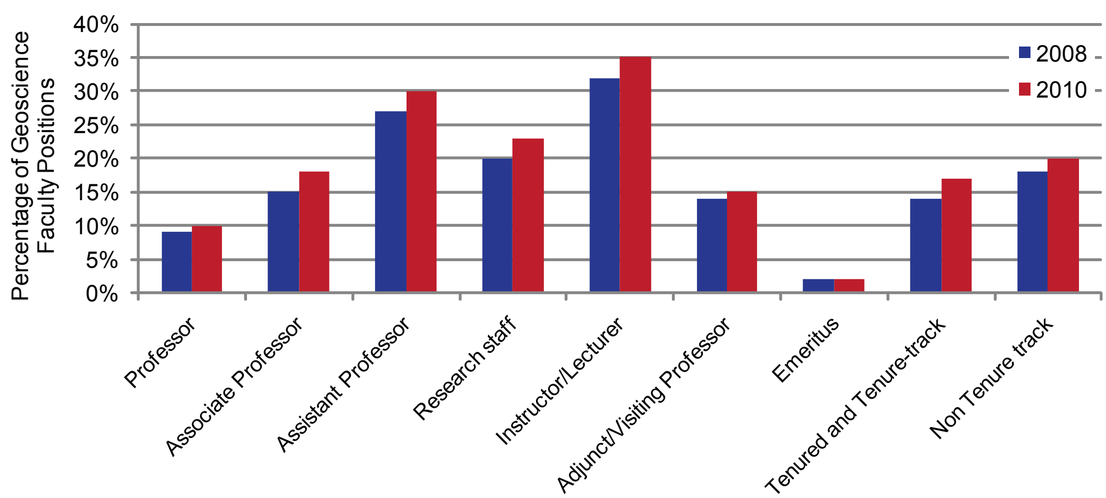


Figure 3.7: Percentage of Female Geoscience Faculty by Rank

Geoscience Faculty Publication Trends and Research Specialties

The number of geology publications as recorded by AGI's GeoRef database, has steadily increased over the past several decades from 160,885 journal articles in the 1970's to 217,700 in between 2000 and 2008. (Note that these data are limited to publications written in the English language from people affiliated with U.S. institutions.) Prior to 2000, the top three geology publication topics were economic geology, petrology, and geophysics (Figure 3.8 and Table 3.7). Between 2000 and 2008, the top three publication topics are environmental geology, economic geology, and Quaternary geology. Environmental geology was ranked fourth among all geology publication topics in the 1990's and Quaternary geology, currently ranked third, was ranked seventh in the 1990's.

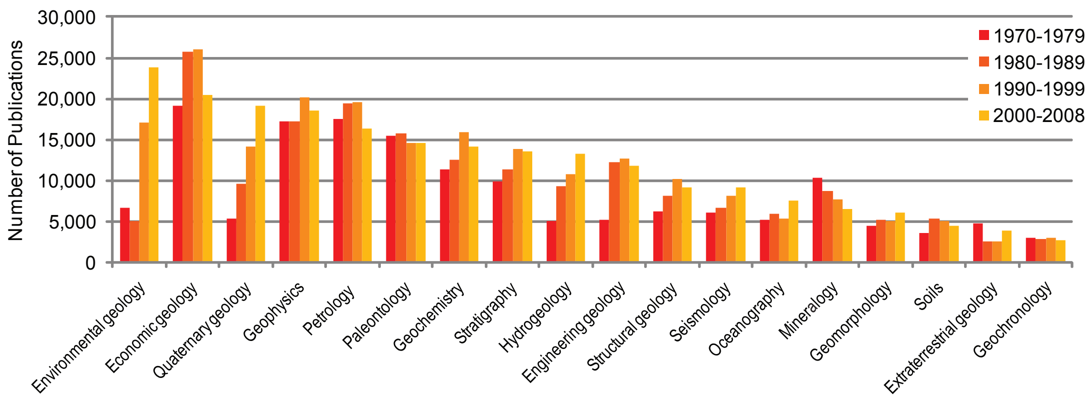


Figure 3.8: Trends in Geoscience Publications

Publication topics generally track with geology Master's theses and dissertation topic, although there is some variation by degree level. Whereas geophysics has consistently ranked in the top five dissertation topics since 1970, economic geology and petrology have consistently ranked in the top five Master's theses topics over the same period. Furthermore, environmental geology has ranked first among dissertation topics and within the top two ranks of Master's theses topics since the 1990's . (Note that there is a several year lag in the number of publications being indexed in GeoRef).

1970-1979	1980-1989	1990-1999	2000-2008
Economic geology (M)	Economic geology (M)	Economic geology (M)	Environmental geology (M,D)
Petrology (M,D)	Petrology (M,D)	Geophysics (D)	Economic geology (M,D)
Geophysics (M,D)	Geophysics (D)	Petrology (M,D)	Quaternary geology (M)
Paleontology (D)	Paleontology	Environmental geology (M,D)	Geophysics (D)
Geochemistry	Geochemistry (D)	Geochemistry	Petrology (M)

Note: Letters in parentheses indicate if publication topic is in the top five topics of geology theses or dissertations for the given year.

M: Denotes the topic is in the top five geology Master's theses topics for the given year.
D: Denotes the topic is in the top five geology Ph.D. dissertation topics for the given year.

Table 3.7: Top Five Geology Publication Topics 1970-2008

(Source: AGI Geoscience Workforce Program, data derived from AGI's GeoRef database.)

In addition to the trends in geology publications, data from the American Meteorological Society's journals and the American Geophysical Union's Journal of Geophysical Research indicate large increases since 2000 in the number of publications regarding climatology, oceanography, and space science (Table 3.8).

Journal Name	Articles (2000)	Articles (2010)	Articles (Jan-Nov 2000)	Articles (Jan-Nov 2010)	Change in Number of Articles (2000-2010)
J. of Applied Meteorology and Climatology (*)	179	173	141	161	14% (*)
J. of Atmospheric Sciences (*)	252	245	239	230	-4% (*)
J. of Physical Oceanography (*)	202	173	185	166	-10% (*)
J. of Climate (*)	293	452	266	389	46% (*)
JGR - Atmospheres	750	935	-	-	25%
JGR – Oceans	253	365	-	-	44%
JGR – Planets	142	143	-	-	1%
JGR – Solid Earth	465	479	-	-	3%
JGR – Space Physics	500	714	-	-	43%

*Note, 2010 data for AMS publications does not include all of December. For AMS journals only, data is provided for Jan-Nov for comparison purposes and percent change calculations.

Table 3.8: Publication Trends in American Meteorological Society (AMS) and AGI Journals

American Geophysical Union's (AGU) Journal of Geophysical Research (JGR) journals.
(Source: AGI Geoscience Workforce Program, 2010, data derived from the AMS and AGU journal publication websites.)

At a national level, the distribution of faculty specialties has remained relatively constant since 1999, despite an overall reduction in the number of faculty per specialty (Figure 3.9). However, there have been shifts in the distribution of faculty sub-discipline specialties over the same time period. The only faculty specialty category which has seen increases since 1999 is "Other Geosciences" (Figure 3.9). These increases are primarily due to the number of faculty teaching Geographic Information Systems (+105 since 1999) and an increase in the number of faculty teaching Atmospheric Science (+57 since 1999) and Glaciology (+7 since 1999) (Figure 3.20).

Shifts of five percent or more in the distribution of faculty sub-discipline specialties since 1999 occur in Paleontology (Paleoecology & Paleoclimatology: +6%), Soil Science (Soil Chemistry/Minerology: -5%, Other Soil Science: +10%), Engineering Geology (General Engineering Geology: +5%, Petroleum Engineering: +7%), Planetology (Extraterrestrial Geology: +8%, Meteorites & Tektites: -11%), and Other Geosciences (Geographic Information Systems: +8%).

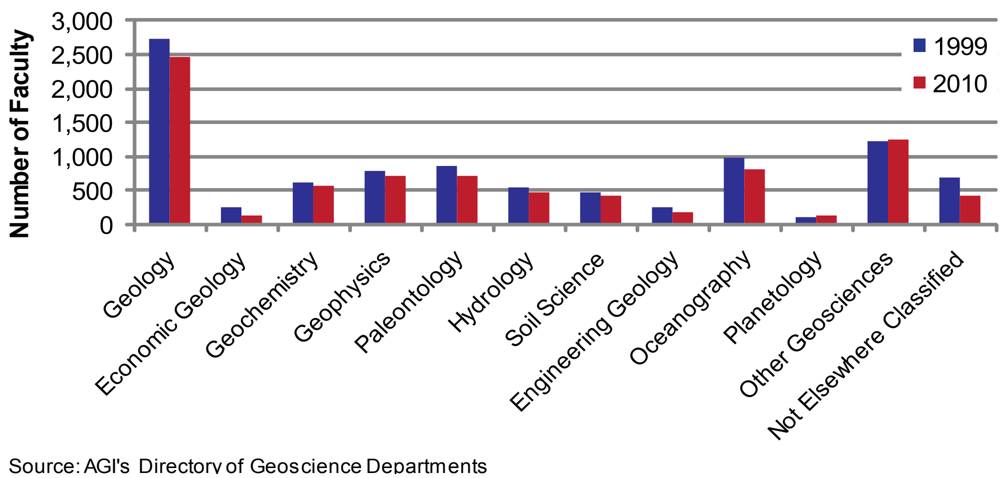


Figure 3.9: Trends in Geoscience Faculty Specialties (1999-2010)

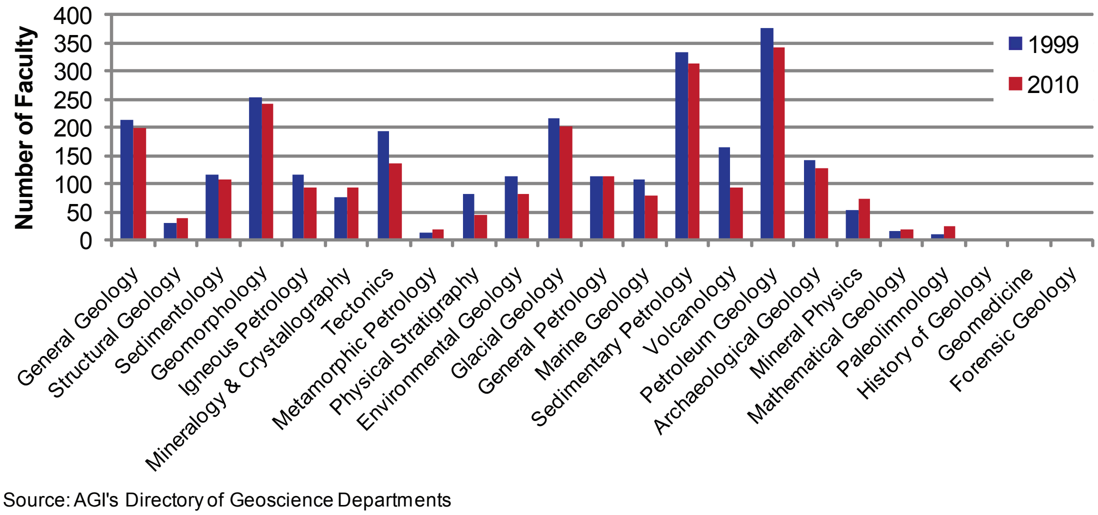


Figure 3.10: Changes in Faculty Specialties within Geology (1999-2010)

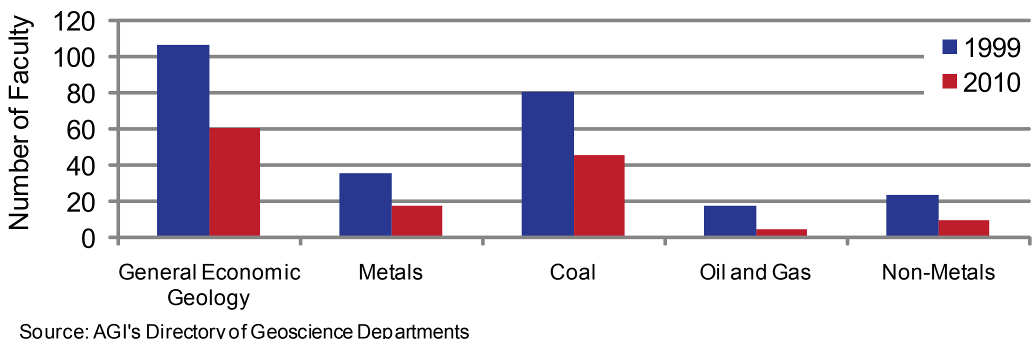


Figure 3.11: Changes in Faculty Specialties within Economic Geology (1999-2010)

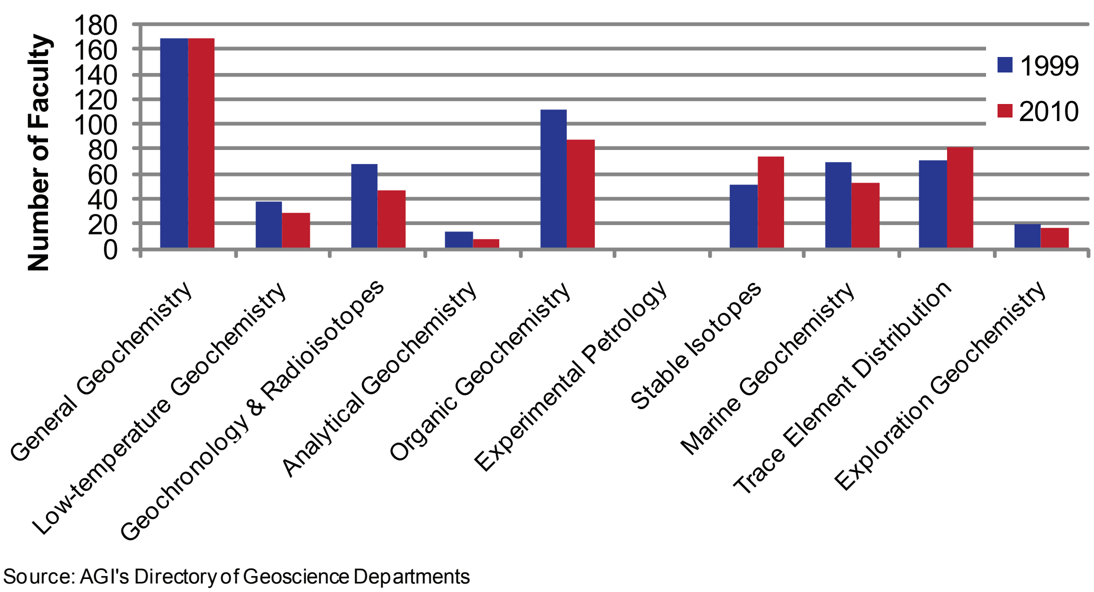
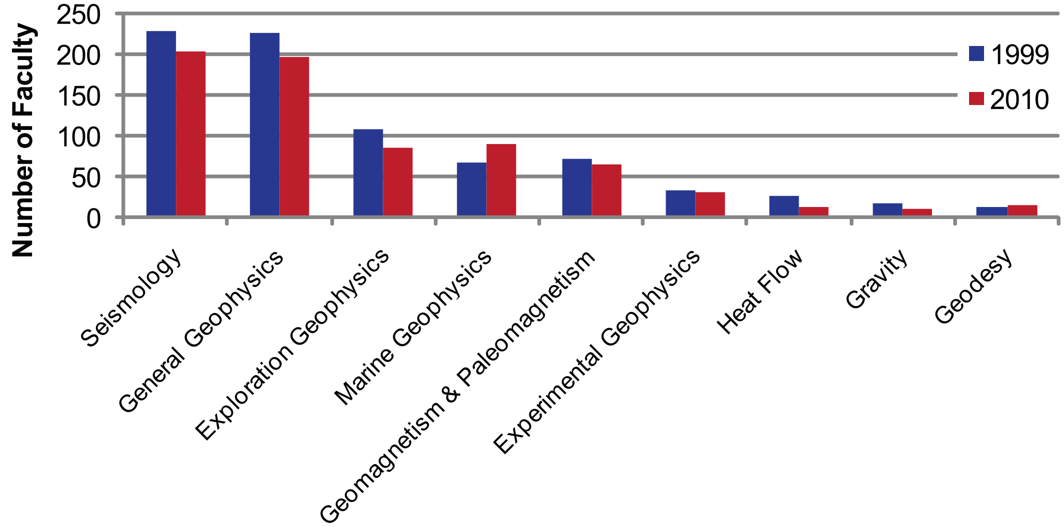
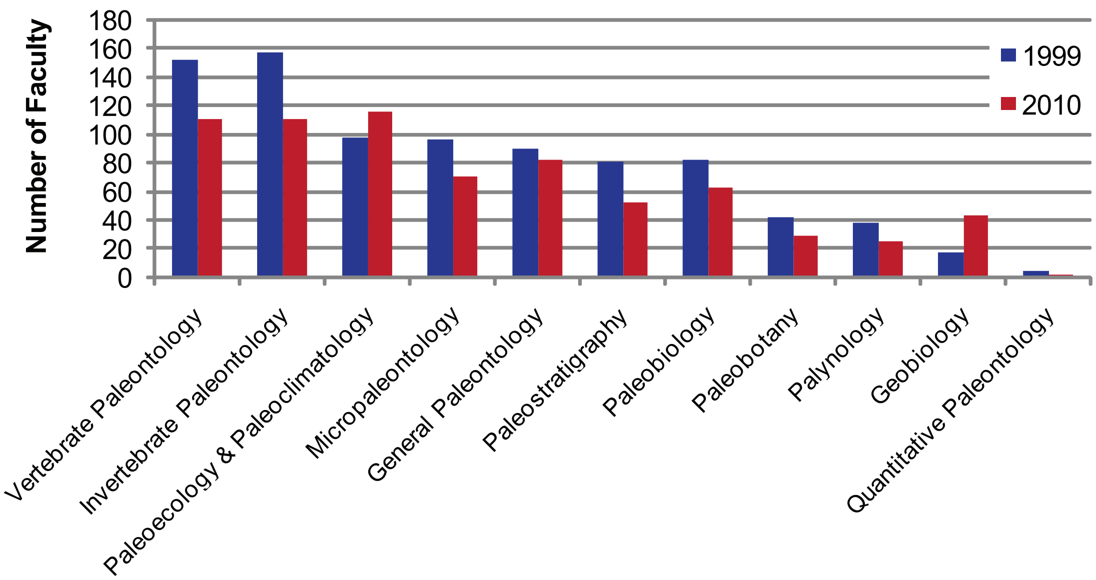


Figure 3.12: Changes in Faculty Specialties within Geochemistry (1999-2010)



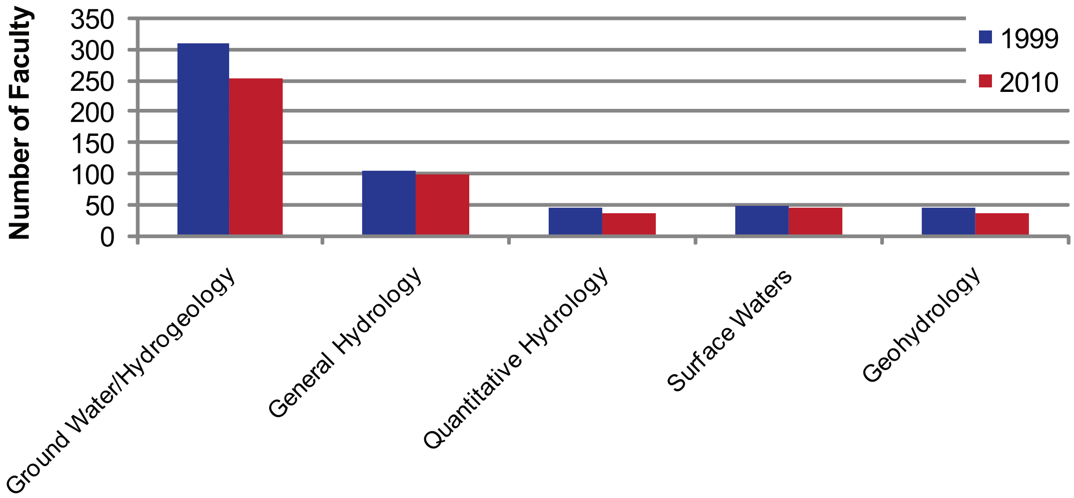
Source: AGI's Directory of Geoscience Departments

Figure 3.13: Changes in Faculty Specialties within Geophysics (1999-2010)



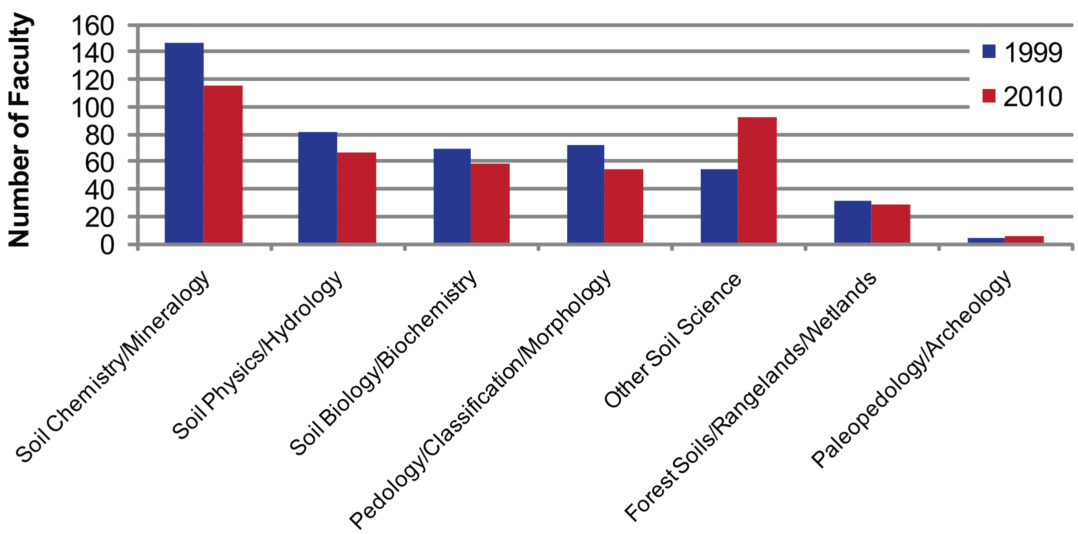
Source: AGI's Directory of Geoscience Departments

Figure 3.14: Changes in Faculty Specialties within Paleontology (1999-2010)



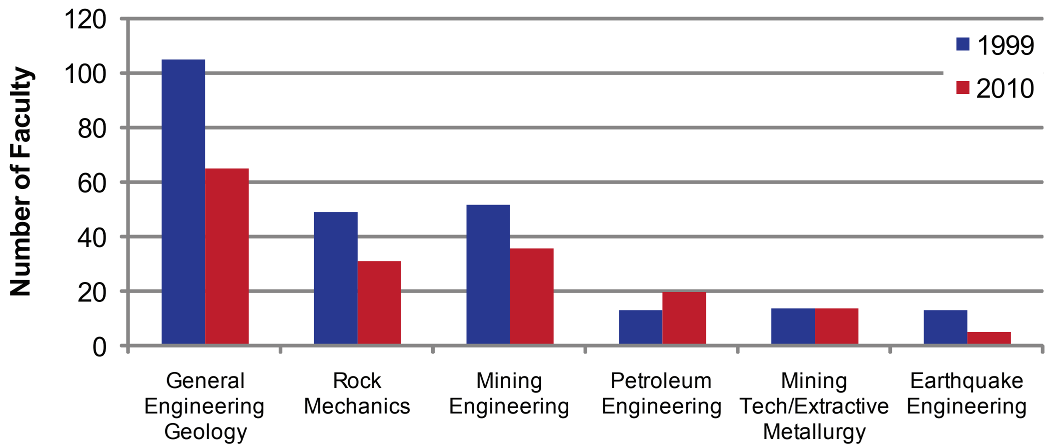
Source: AGI's Directory of Geoscience Departments

Figure 3.15: Changes in Faculty Specialties within Hydrology (1999-2010)



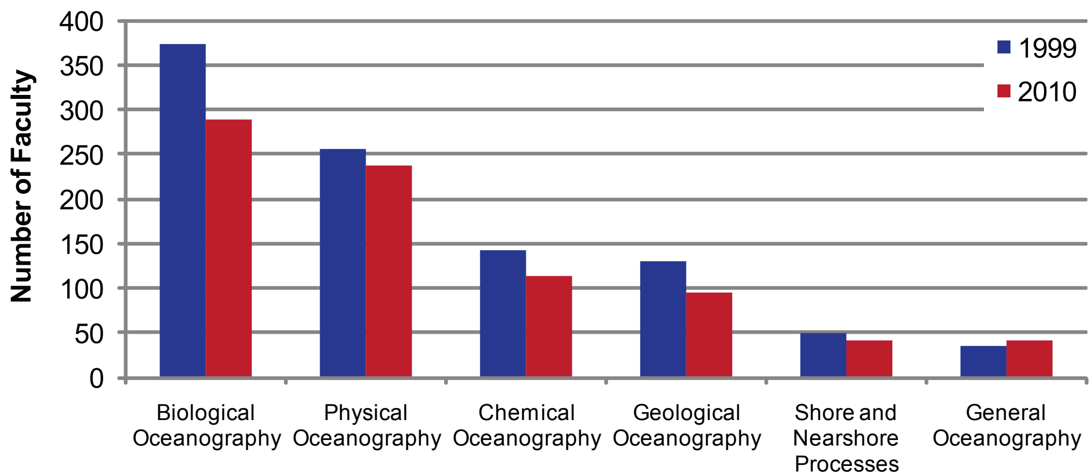
Source: AGI's Directory of Geoscience Departments

Figure 3.16: Changes in Faculty Specialties within Soil Science (1999-2010)



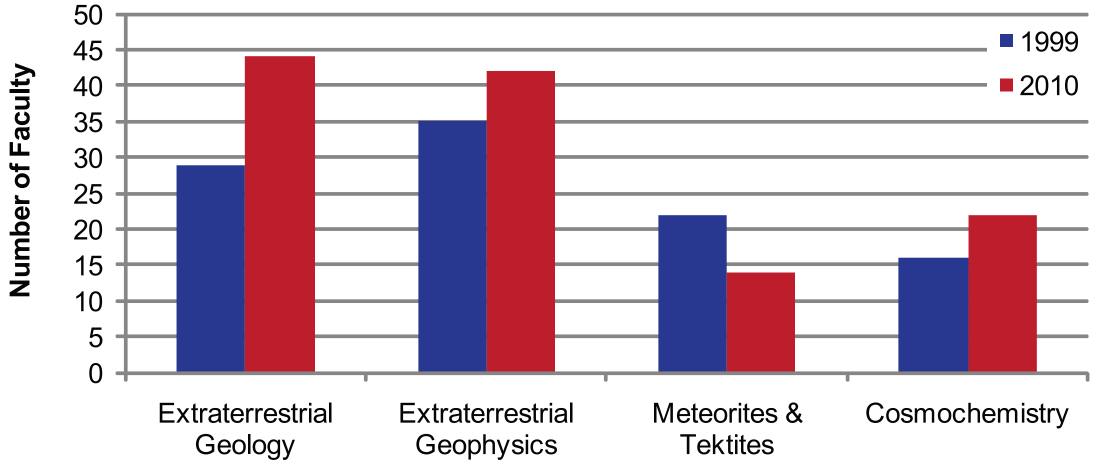
Source: AGI's Directory of Geoscience Departments

Figure 3.17: Changes in Faculty Specialties within Engineering Geology (1999-2010)



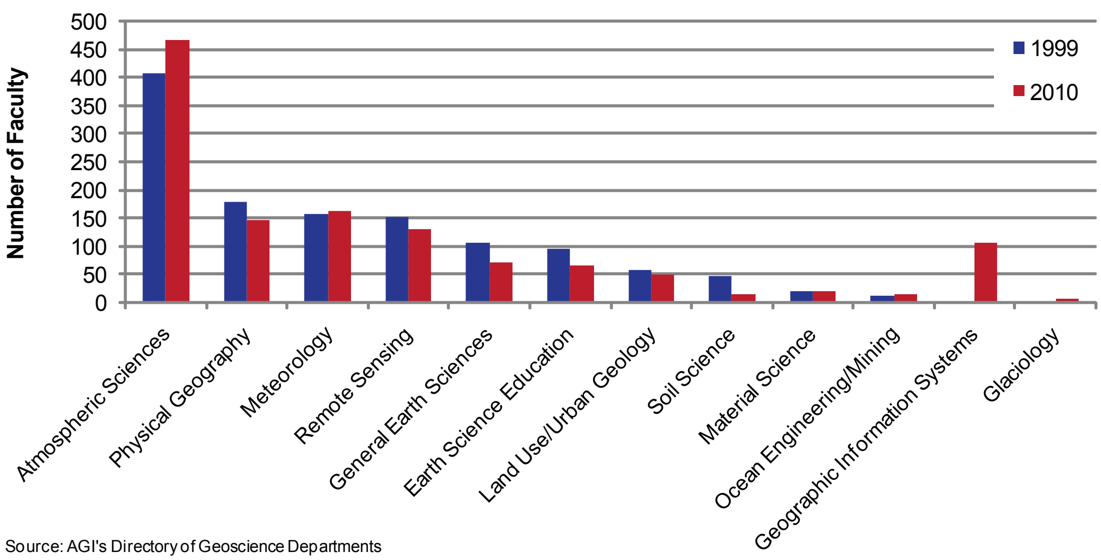
Source: AGI's Directory of Geoscience Departments

Figure 3.18: Changes in Faculty Specialties within Oceanography (1999-2010)



Source: AGI's Directory of Geoscience Departments

Figure 3.19: Changes in Faculty Specialties within Planetology (1999-2010)



Source: AGI's Directory of Geoscience Departments

Figure 3.20: Changes in Faculty Specialties within Other Geosciences (1999-2010)

Faculty Specialty	Faculty (2010)	Faculty Specialty	Faculty (2010)
Geology		Paleontology	
General Geology	198	General Paleontology	82
Structural Geology	40	Paleostratigraphy	52
Sedimentology	108	Paleobiology	62
Geomorphology	241	Paleobotany	29
Igneous Petrology	94	Palynology	25
Mineralogy & Crystallography	93	Geobiology	43
Tectonics	137	Quantitative Paleontology	1
Metamorphic Petrology	19	Hydrology	
Physical Stratigraphy	44	Ground Water/Hydrogeology	254
Environmental Geology	82	General Hydrology	98
Glacial Geology	203	Quantitative Hydrology	37
General Petrology	113	Surface Waters	47
Marine Geology	79	Geohydrology	38
Sedimentary Petrology	314	Soil Science	
Volcanology	93	Soil Chemistry/Mineralogy	115
Petroleum Geology	343	Soil Physics/Hydrology	66
Archaeological Geology	128	Soil Biology/Biochemistry	59
Mineral Physics	73	Pedology/Classification/Morphology	55
Mathematical Geology	18	Other Soil Science	92
Paleolimnology	26	Forest Soils/Rangelands/Wetlands	28
History of Geology	3	Paleopedology/Archeology	5
Geomedicine	3	Engineering Geology	
Forensic Geology	1	General Engineering Geology	65
Economic Geology		Rock Mechanics	31
General Economic Geology	61	Mining Engineering	36
Metals	18	Petroleum Engineering	20
Coal	46	Mining Tech/Extractive Metallurgy	14
Oil and Gas	5	Earthquake Engineering	5
Non-Metals	10	Oceanography	
Geochemistry		Biological Oceanography	289
General Geochemistry	169	Physical Oceanography	237
Low-temperature Geochemistry	28	Chemical Oceanography	113
Geochronology & Radioisotopes	46	Geological Oceanography	95
Analytical Geochemistry	7	Shore and Nearshore Processes	41
Organic Geochemistry	87	General Oceanography	41
Experimental Petrology	0	Planetology	
Stable Isotopes	74	Extraterrestrial Geology	44
Marine Geochemistry	53	Extraterrestrial Geophysics	42
Trace Element Distribution	82	Meteorites & Tektites	14
Exploration Geochemistry	16	Cosmochemistry	22
Geophysics		Other Geosciences	
Seismology	203	Atmospheric Sciences	465
General Geophysics	196	Physical Geography	145
Exploration Geophysics	85	Meteorology	163

Faculty Specialty	Faculty (2010)	Faculty Specialty	Faculty (2010)
Marine Geophysics	90	Remote Sensing	130
Geomagnetism & Paleomagnetism	64	General Earth Sciences	71
Experimental Geophysics	31	Earth Science Education	67
Heat Flow	13	Land Use/Urban Geology	49
Gravity	10	Soil Science	14
Geodesy	16	Material Science	19
Paleontology		Ocean Engineering/Mining	15
Vertebrate Paleontology	110	Geographic Information Systems	105
Invertebrate Paleontology	111	Glaciology	7
Paleoecology & Paleoclimatology	116	Not Elsewhere Classified	427
Micropaleontology	71		

Table 3.9: Changes in Faculty Specialty Subdisciplines (1999-2010)

(Source: AGI Geoscience Workforce Program)

Geoscience University Students

Enrollments and Degrees

During the 2009-2010 academic year, the number of geoscience undergraduates enrolled in U.S. institutions reached its highest level in a decade at 23,983 majors (Figure 3.21). This is a 7 percent increase over 2008-2009 enrollments, and a 24.8 percent increase since the 2006-2007 academic year. For the first time in 5 years, graduate geoscience enrollments increased markedly to 9,054, jumping 15.7 percent from the 2008-2009 academic year. These increases in enrollments are likely linked to continued high prices in commodities, improved recruitment of students to the geosciences, and, for graduate enrollments, the perception of a negative job market. This perception drives undergraduates into graduate programs, even though geoscience employment opportunities remain robust.

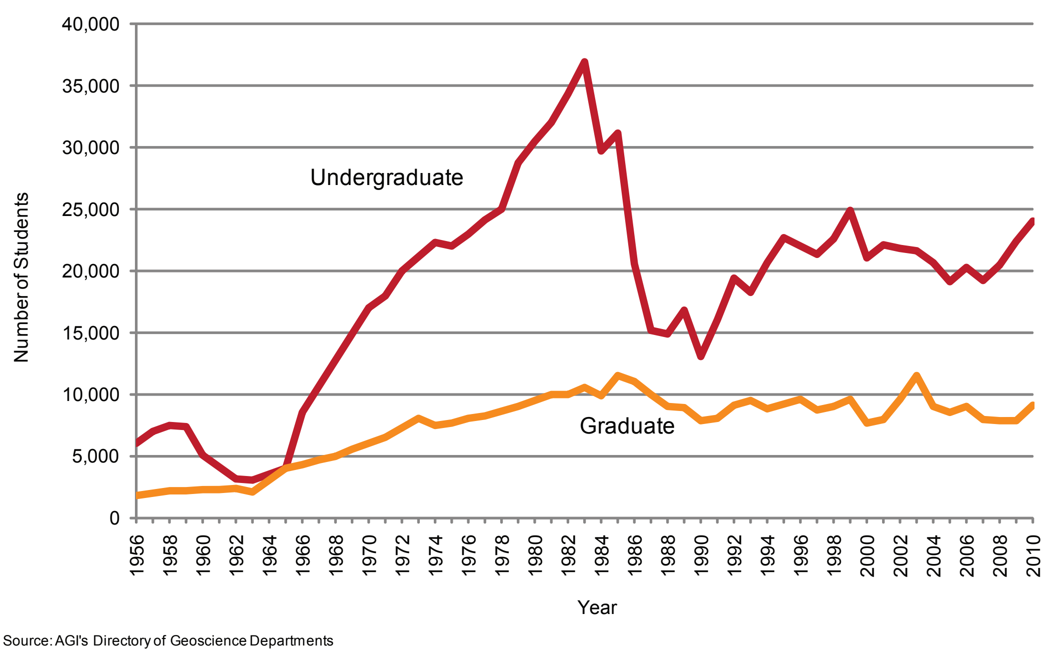


Figure 3.21: Geoscience Enrollments at U.S. Four Year Universities

The number of geoscience degrees conferred by U.S. institutions in the 2009-2010 academic year also increased markedly (Bachelor's degrees: 3,037, Master's degrees: 1,078, Doctorates: 668) (Figure 3.22). The number of Bachelor's degrees conferred increased by 7 percent from the 2008-2009 academic year, and the number of graduate degrees also increased (3 percent at the Master's level and 6.2 percent at the Doctoral level). The increases in degree production are likely tied to prior growth in undergraduate enrollments and the poor state of the economy that is encouraging graduate students to complete their studies at a higher rate rather than seek employment prior to receiving their degree.

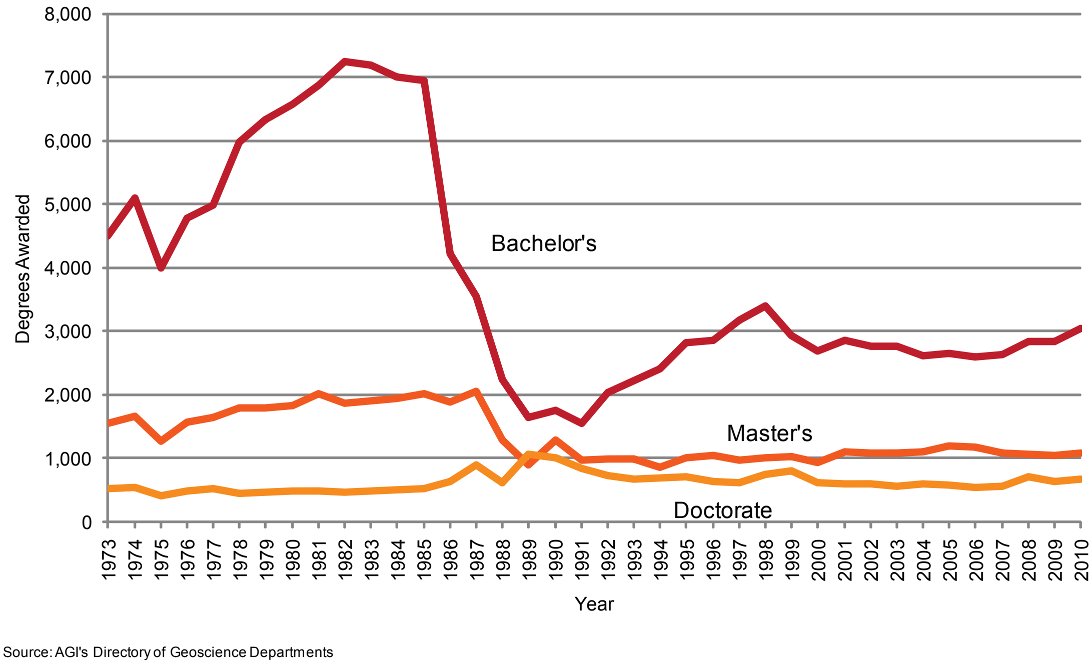


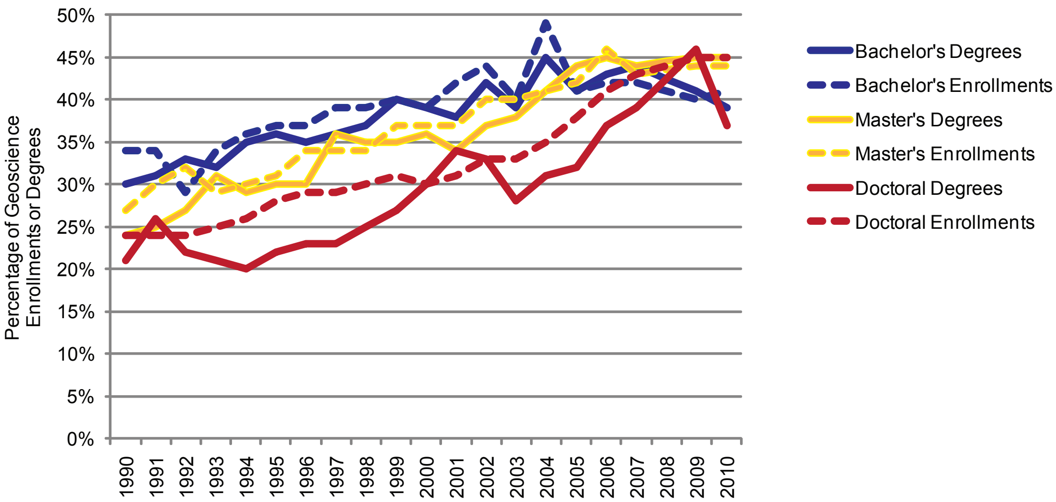
Figure 3.22: Geoscience Degrees Conferred at U.S. Four Year Universities

Diversity in Geoscience Enrollments and Degrees

Women and underrepresented minorities represent a large potential pool of talented scientists. According to the U.S. Census Bureau, women comprise 51 percent of the total U.S. population and 49 percent of the college-aged adults (e.g. 18 to 24 year olds). Underrepresented minorities currently comprise 30 percent of the total U.S. population, and 36 percent of college-aged adults. By 2050, underrepresented minorities are projected to comprise 45 percent of the total U.S. population and 53 percent of the college-aged adults (U.S. Census Bureau, 2008a,b). This increase will be primarily driven by the expansion of the Hispanic population which will comprise 30 percent of the total U.S. population and 37 percent of college-aged adults by 2050 (U.S. Census Bureau, 2008a,b).

The composition of degree holders is an important measure of disciplinary health. The ability to attract the maximum level of competency to a profession is dependent upon its ability to recruit across gender, racial, and economic divides. The disparity between whole-population level of specific populations and their representation in the profession can be viewed as a first order proxy of the recruitment and sustainability of a discipline.

During the 2009-2010 academic year, the geosciences saw a contraction in the percentage of women graduating from geoscience university programs at the Bachelor's and Doctoral degree levels (Bachelors: 39 percent (change: -2%), Doctorates: 37 percent (change: -9%) from the 2008-2009 academic year, yet the percentage of women enrolled in geoscience programs remain steady at all degree levels (Figure 3.23). Overall, the participation of women in the geosciences has steadily increased over the past several decades, and over the past 5 years, women have earned approximately 40 percent of all geoscience degrees. Although gender parity in geoscience degree conferral rates has not been achieved yet, substantial progress has been made over the past 20 years toward this goal.

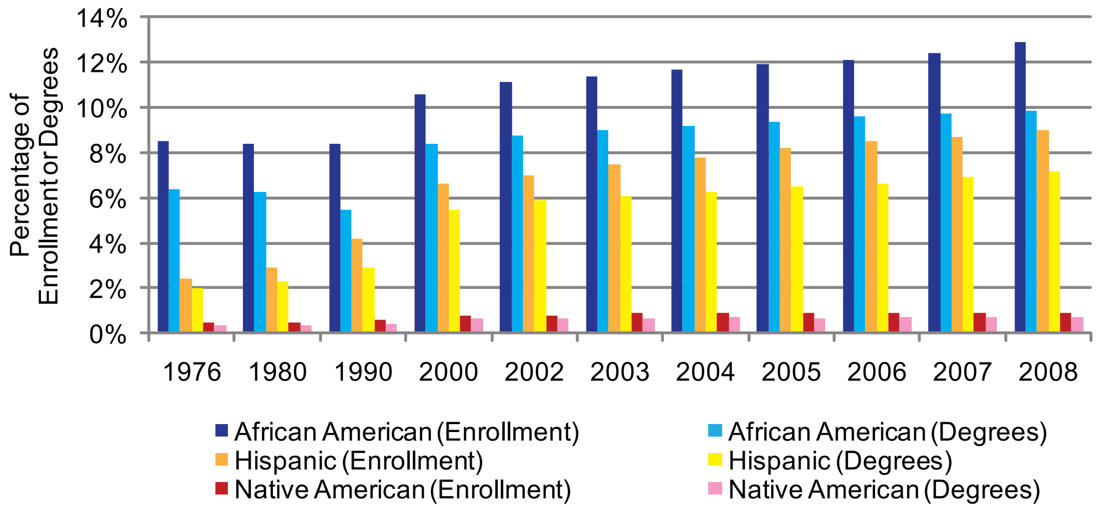


Source: AGI Geoscience Workforce Program.

Figure 3.23: Participation of Women in Geoscience Programs

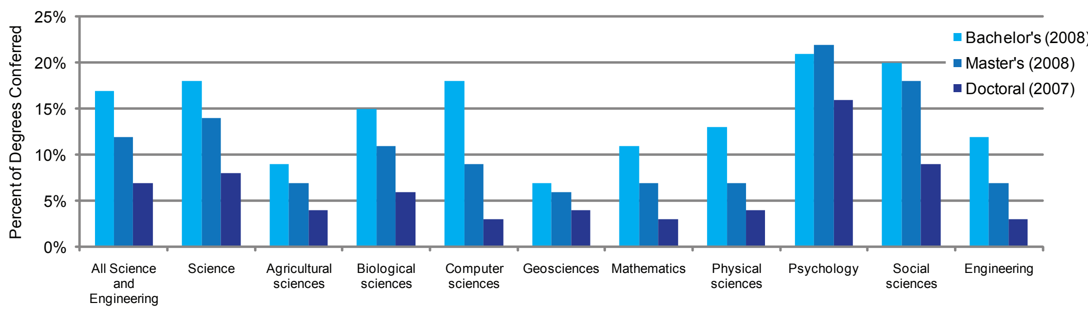
Compared to the progress made towards gender parity in the geoscience student population, the participation of underrepresented minorities in geoscience university programs remains extremely poor. As of 2008, the proportion underrepresented minorities comprised 23 percent of all enrolled students and 16 percent of all graduates at four-year universities (Figure 3.24). Yet, in geoscience university programs, less than 10 percent of geoscience graduates at all degree levels are underrepresented minorities (Figures 3.26, 3.27, and 3.28). Compared with other science and engineering fields, the geosciences confer the lowest percentage of Bachelor's and Master's degrees to underrepresented minorities (Figure 3.25). However, at the doctoral level, the geosciences confer a slightly higher percentage of degrees to underrepresented minorities than do mathematics, engineering, and computer science.

Overall, Hispanics earn the largest percentage of geoscience degrees conferred to underrepresented minorities. This may be partly due to the geographic distribution of geoscience departments which are located in regions where there are large Hispanic populations. This geographic distribution may also account for the low participation rates of African Americans in geoscience programs. There are few geoscience programs at universities and community colleges in areas where there are large populations of African Americans. Considering that the composition of degree holders within a discipline is an important measure of disciplinary health, the geosciences have much to do to increase the participation rate of underrepresented minorities.



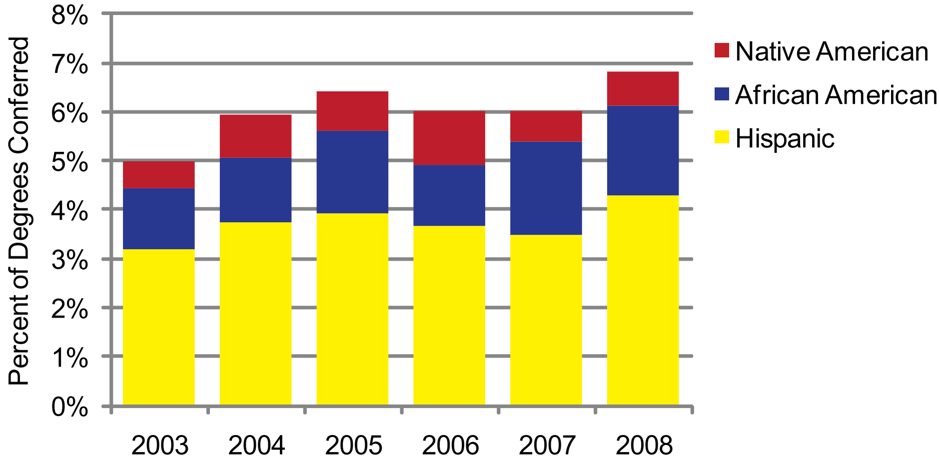
Source: AGI Geoscience Workforce Program, data derived from the NCES Digest of Education Statistics

Figure 3.24: Underrepresented Minority Participation in four-year institutions (Enrollments and Degrees)



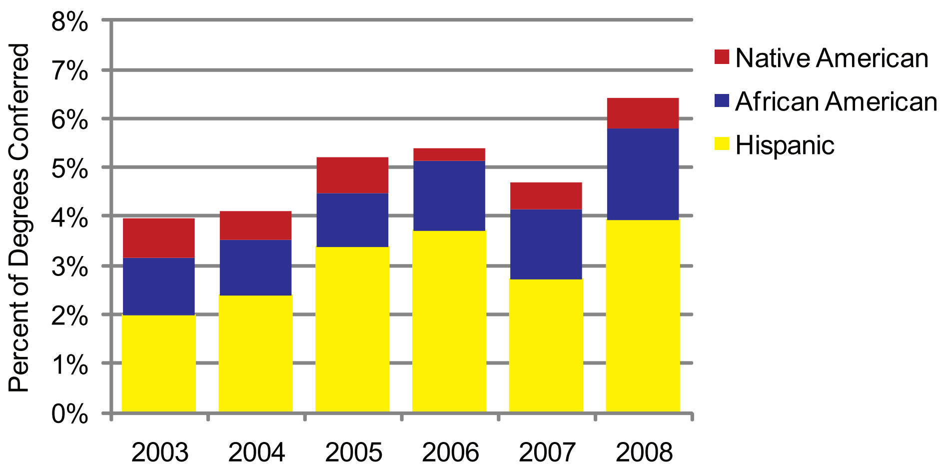
Source: AGI Geoscience Workforce Program, data derived from NSF's Women, Minorities and Persons with Disabilities report

Figure 3.25: Percentage of Science and Engineering Degrees Conferred to Underrepresented Minorities



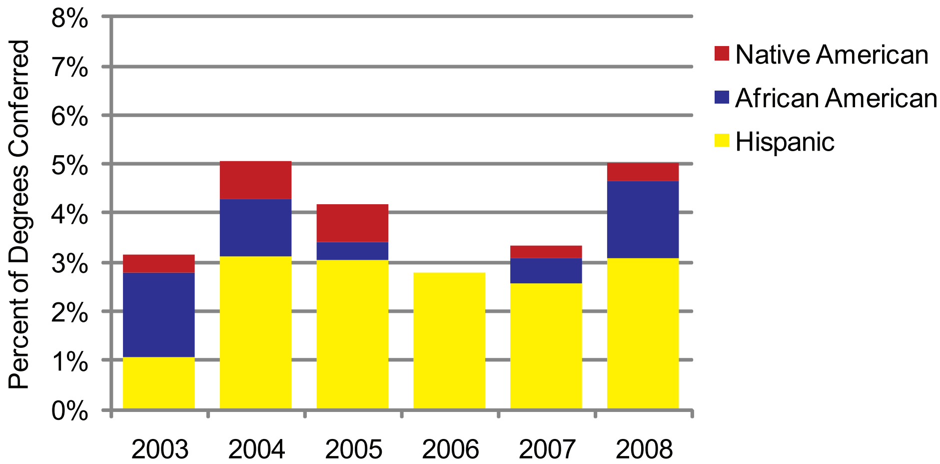
Source: AGI Geoscience Workforce Program, data derived from IPEDS

Figure 3.26: Percentage of Geoscience Bachelor's Degrees Conferred to Underrepresented Minorities



Source: AGI Geoscience Workforce Program, data derived from IPEDS

Figure 3.27: Percentage of Geoscience Master's Degrees Conferred to Underrepresented Minorities



Source: AGI Geoscience Workforce Program, data derived from IPEDS

Figure 3.28: Percentage of Geoscience Doctoral Degrees Conferred to Underrepresented Minorities

Geoscience Degree Completion Rates

A common assertion is that the number of geoscience degrees granted is dependent on the price of oil. However, this metric requires a response lag greater than oil price-change velocity. A more responsive mechanism would likely be the rate of degree completion – that students would be incentivized to complete their geoscience degree by improved economic prospects.

A close look at undergraduate geoscience enrollments show where attrition is occuring (Figure 3.29). This enrollment profile is based on historical data collected by AGI in previous geoscience enrollment surveys. Note that most geoscience departments do not recognize majors unitl they are in their sophomore year. As such, the enrollment profile does not capture the total number of freshmen who enter and exit a geoscience major before they are included in the official tally of undergrduate majors in their department. If the sophomore year is considered the peak of enrollments, then by senior year, 44 percent of these students have exited the major.

Graduation rates that calcuate from sophomore enrollments to graduate recipient status indicate 33 percent of sophomores reach graduation. Calculation from senior year enrollments indicate that approximately 60 percent of geoscience seniors graduate. Completion rates that measure from freshman student through graduate recipient are much lower than graduation rates. STEM-wide completion rates average about 25 percent. Additionally, approximately half of all freshmen exit the university system prior to matriculating to sophomore status. If we use this 50 percent attrition estimate and estimate our bulk freshman enrollments by back calculating from the sophomore numbers, we arrive at a 16% completion rate from freshmen status to degree recipient in four years.

It is more difficult to estimate graduate degree completion rates because of the different entry and exit points that students take. Graduate enrollments do differentiate between those students that start and finish in the Master's track versus those students who start in the Ph.D. track and exit with a Master's degree.

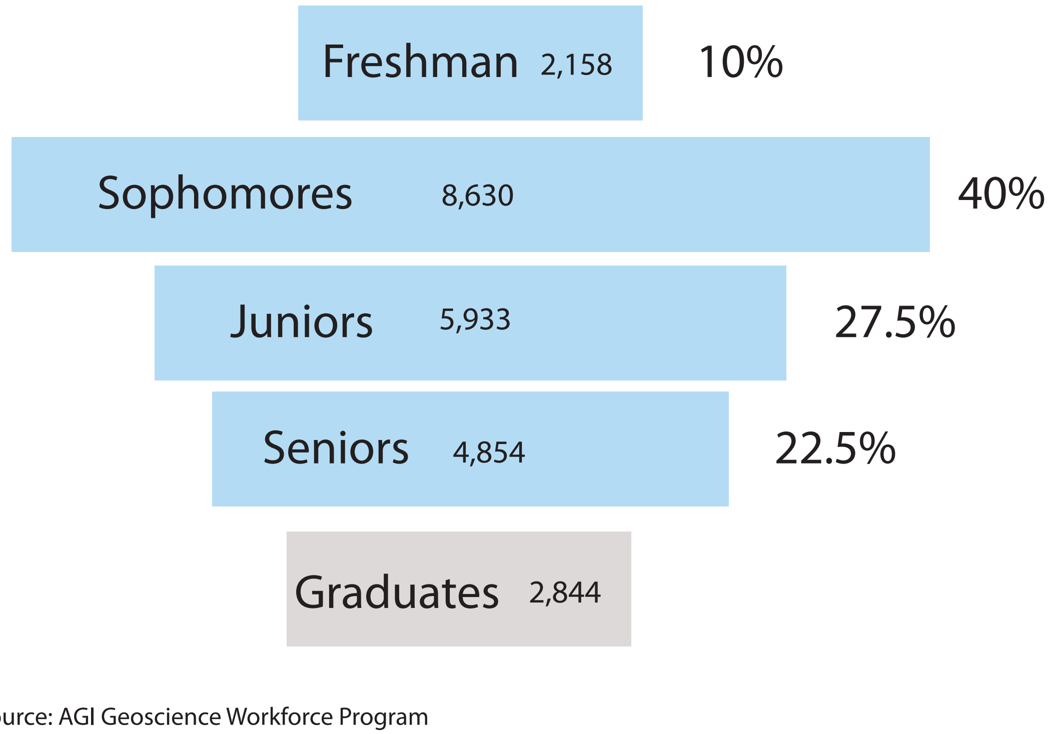
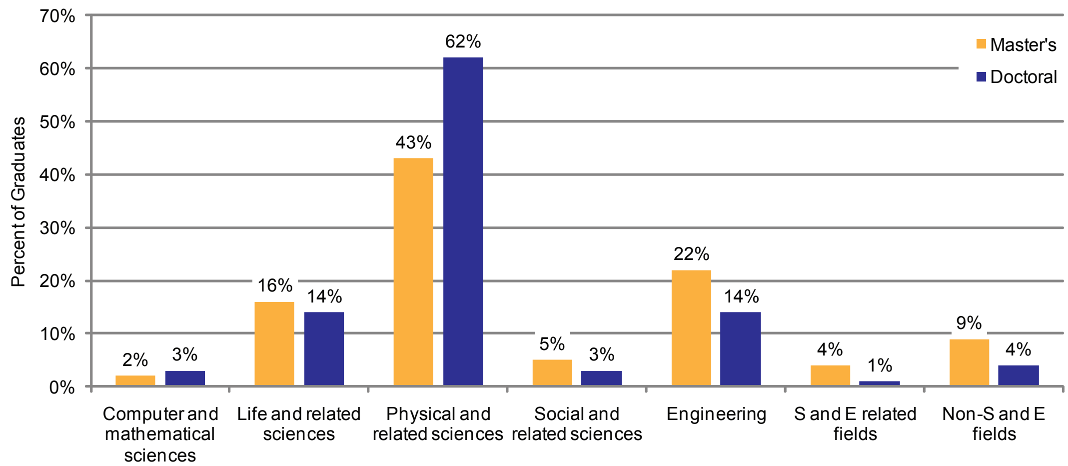


Figure 3.29: Geoscience Undergraduate Enrollment Profile

Note: Percentages of total geoscience undegraduate enrollment by class. Enrollment numbers and graduate numbers based on average geoscience enrollments and degrees from 1995-2010.

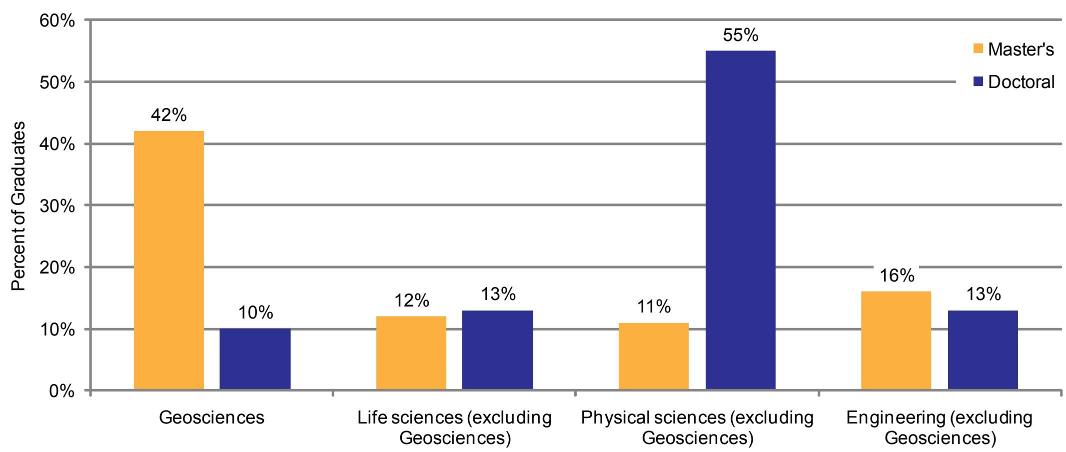
Academic Pathways in Geoscience Education

In the geosciences, a Master's degree is required for the majority of career paths. Examination of the academic degree backgrounds of geoscience graduate students reveals that the majority geoscience graduate students have a interdisciplinary educational background rather than a traditional pathway (e.g. geoscience Bachelor's degree to geoscience graduate degree). Although the majority of geoscience graduate students have bachelor degrees in physical sciences or engineering (Figure 3.30), a 27 percent of geoscience Master's degree recipients and 21 percent of geoscience doctorates hold bachelor degrees in other science disciplines. Furthermore, 9 percent of geoscience Master's degree recipients and 4 percent of geoscience doctorates have bachelor degrees from non-science and engineering fields. When geoscience fields are aggregated (e.g. Environmental Science (from Life Sciences), Earth, Atmospheric, and Ocean science (from Physical Sciences), and Petroleum, Mining, Environmental, and Geological Engineering (from Engineering), only 42 percent of geoscience Master's degree recipients and 10 percent of geoscience doctorates hold bachelor's degrees in the geosciences (Figure 3.31).



Source: AGI Geoscience Workforce Program; data derived from NSF's 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 3.30: Bachelor's Degree Fields of Geoscience Graduates – Broad Fields



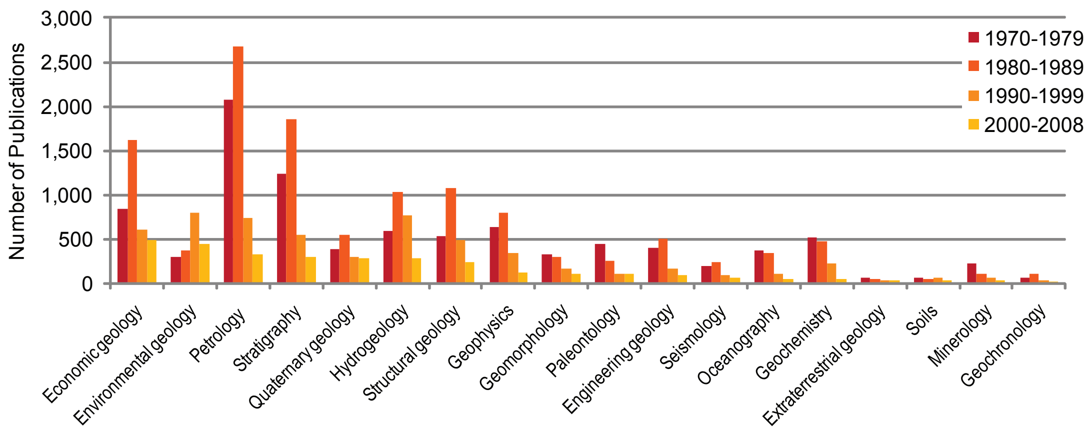
Source: AGI Geoscience Workforce Program; data derived from NSF's 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 3.31: Bachelor's Degree Fields of Geoscience Graduates – Fine Fields

Research Topics of Geoscience Graduates

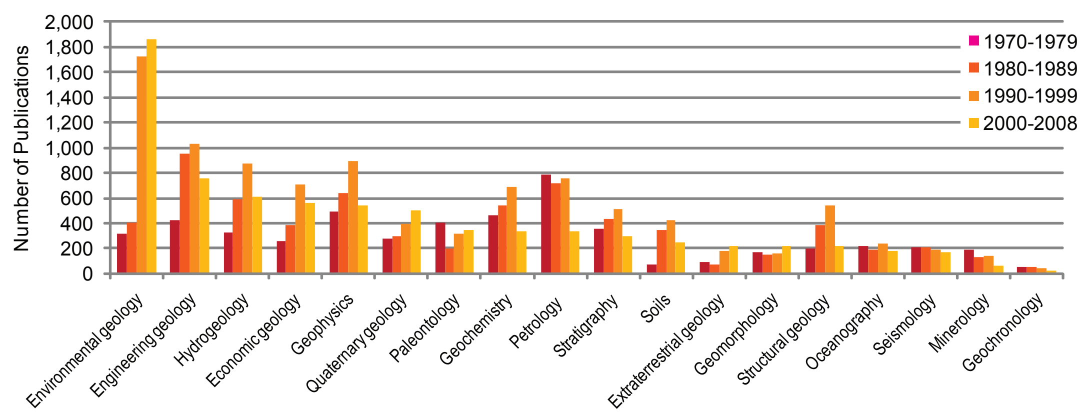
Since the 1970s, AGI's GeoRef database indicates that the majority of geoscience theses and dissertations pertain to geology topics. Of note is the increase in geoscience theses and dissertations pertaining to environmental geology from the 1990s through the current decade. This trend is concurrent with an increase in the percentage of geoscience federal funding applied to environmental research at the university level during the same period.

Master's theses production peaked in the 1980s with approximately 13,000 theses, and has since dwindled to approximately 3,000 in the current decade (Figure 3.32). Doctoral dissertation production peaked in the 1990s at approximately 10,000 dissertations, and production continues to remain steady with nearly 8,000 dissertations produced during the current decade (Figure 3.33). (Note that there is a several year lag in the number of theses and dissertations being indexed in GeoRef).



Source: AGI Geoscience Workforce Program, data derived from AGI's GeoRef Database.

Figure 3.32: Trends in Geoscience Master's Theses Topics



Source: AGI Geoscience Workforce Program, data derived from AGI's GeoRef Database.

Figure 3.33: Trends in Geoscience Doctoral Dissertation Topics

The change in theses and dissertation topics over the past four decades indicate a shift from more resource industry-focused research towards environmental and interdisciplinary research, yet distinct differences exists between graduate degree levels (Table 3.10). At the Master's degree level, petrology, stratigraphy, and economic geology have consistently ranked in the five most common theses topics since the 1970s, while at the doctoral level, consistent top five topics include geophysics and engineering geology. Petrology which has consistently ranked in the top five most common theses topics, was last ranked in the as the fifth most common dissertation topic in the 1990s. Hydrogeology which has ranked in the top five dissertation topic since the 1980s, ranked in the top five theses topics in the 1980s and 1990s. Since the 1990's environmental geology has ranked in the top two most common topics for both dissertations and theses.

Top Five Geoscience Master's Theses Topics			
1970-1979	**1980-1989**	**1990-1999**	**2000-2008**
Petrology	Petrology	Environmental geology	Economic geology
Stratigraphy	Stratigraphy	Hydrogeology	Environmental geology
Economic geology	Economic geology	Petrology	Petrology
Areal geology	Structural geology	Economic geology	Stratigraphy
Geophysics	Hydrogeology	Stratigraphy	Quaternary geology

Top Five Geoscience Doctoral Dissertation Topics			
1970-1979	**1980-1989**	**1990-1999**	**2000-2008**
Petrology	Engineering geology	Environmental geology	Environmental geology
Geophysics	Petrology	Engineering geology	Engineering geology
Geochemistry	Geophysics	Geophysics	Hydrogeology
Engineering geology	Hydrogeology	Hydrogeology	Economic geology
Paleontology	Geochemistry	Petrology	Geophysics

Table 3.10: Top Five Geology Theses and Dissertation Topics 1970-2008

(Source: AGI Geoscience Workforce Program, data derived from AGI's GeoRef database.)

Funding of the Geosciences at the University Level

The steady decline of the percentage of federal research funds applied to the geosciences that began in the mid-1990s finally stabilized at 6 percent in 2007 (Figure 3.34). Although the percentage of funding declined during this period, the absolute amount of research funds applied to geoscience research at universities increased, peaking at $1.1 billion dollars in 2004 and remaining near $1 billion dollars since that time (Figure 3.35). Since 2006, oceanography has received the largest portion of this funding. Prior to this time, environmental science received the largest percentage of funding for geoscience university research during this decade. While funding for atmospheric science research has remained between 20 and 25 percent during this decade, funding for geological sciences has slowly increased to 20 percent over the same time period.

Each federal agency that supports geoscience research at the university level distributes their funding differently to the geoscience sub-disciplines. The Department of Agriculture has primarily funded atmospheric science research since 1973 (Figure 3.36). In 2007, the department reduced its funding of atmospheric science to 67 percent and invested one-third of its funding into environmental science research. Geological research funding from the Department of Agriculture peaked during the late 1980's after which time it steadily declined. The Department of Defense has primarily funded oceanographic research since 1973, however geological science research received 30 to 40 percent of geoscience funding from 1985 to 1994 (Figure 3.37). In 2007, 80 percent of the Department of Defense's geoscience funding went to oceanographic research. The Department of Energy has focused its geoscience funding on different sub-disciplines through time (Figure 3.38). In the early 1970's, the majority of its funding went toward oceanographic research, and later in the 1980's towards geological science research. From 1997 to 2005, over 90 percent of its geoscience funds were applied to geological science, atmospheric science, and environmental science. NASA has funded primarily atmospheric science research; however, since 1985 it has directed an increasing amount of funding towards environmental research and less to geological science research (Figure 3.39). This trend, however, abruptly reversed in 2003, when atmospheric science and geological science funding increased and environmental science research funding decreased from 50 percent to less than 10 percent. The National Science Foundation has directed the largest proportion of its geoscience research funding towards oceanographic research since 1973 and funding trends within the sub-disciplines have been relatively stratified since 1975, with the exception of the period between 1991 and 1996 where the percent of funding applied to environmental science research and geological science research peaked at the expense of oceanographic research (Figure 3.40). Since 1997, there has been a slow decline in the percentage of funding applied to oceanography and a slow increase in the funding of geological and atmospheric science research.

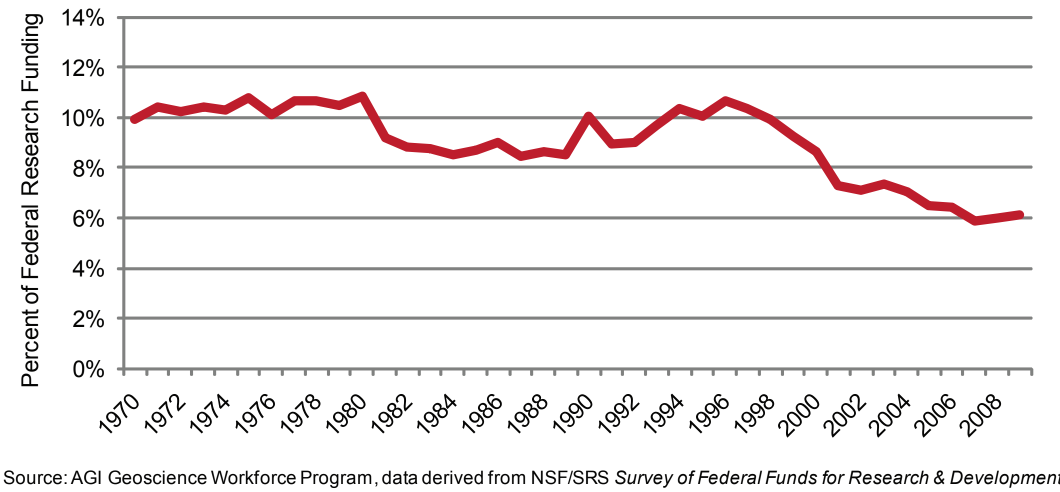


Figure 3.34: Percentage of Total Federal Research Funding Applied to the Geosciences

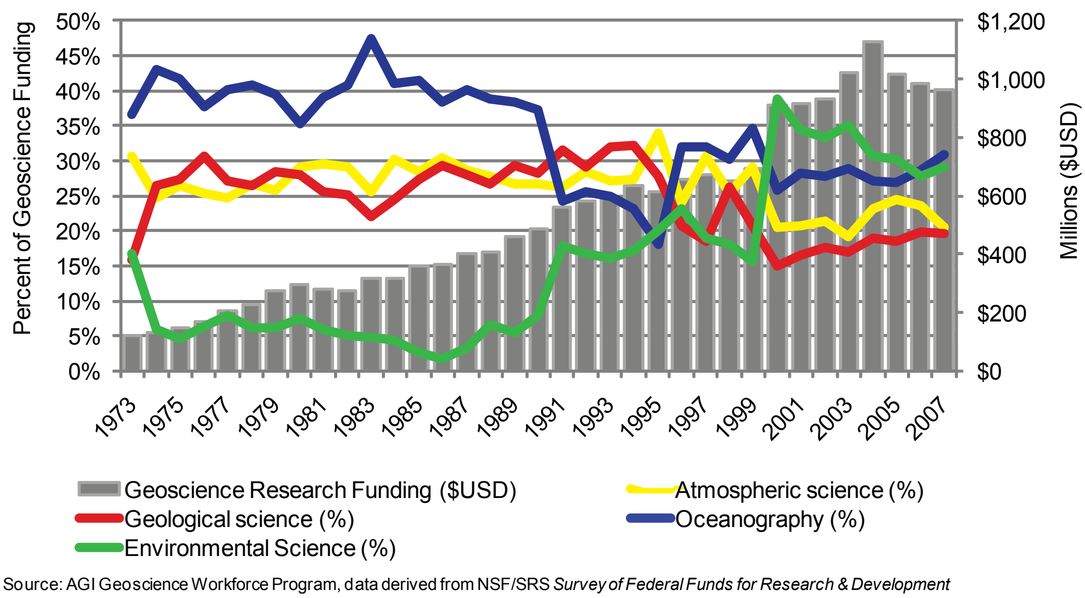


Figure 3.35: Percentage of University Geoscience Research Funding per Subdiscipline from Selected Federal Agencies

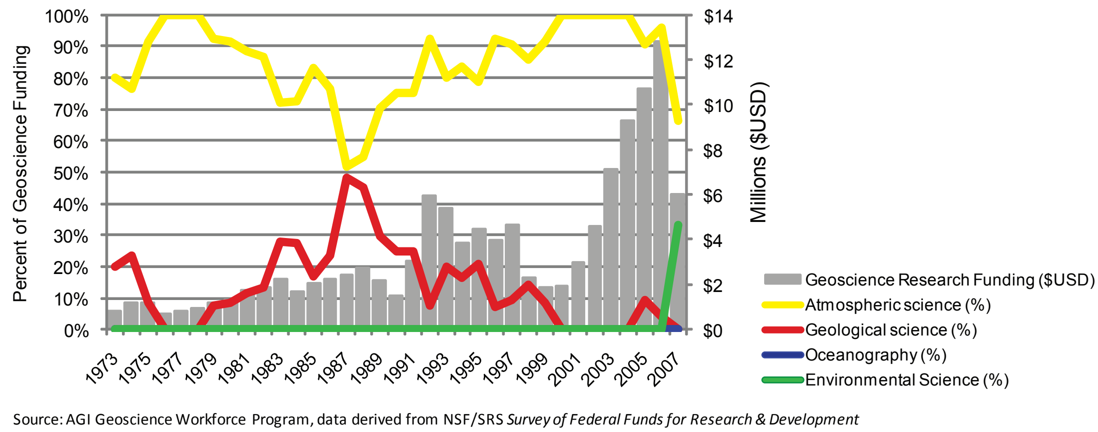


Figure 3.36: Percentage of University Geoscience Research Funding per Subdiscipline (Department of Agriculture)

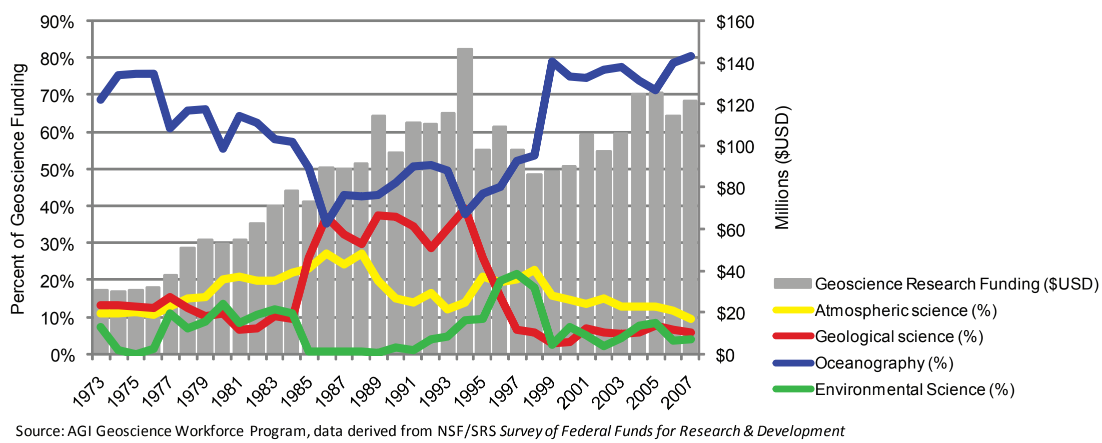
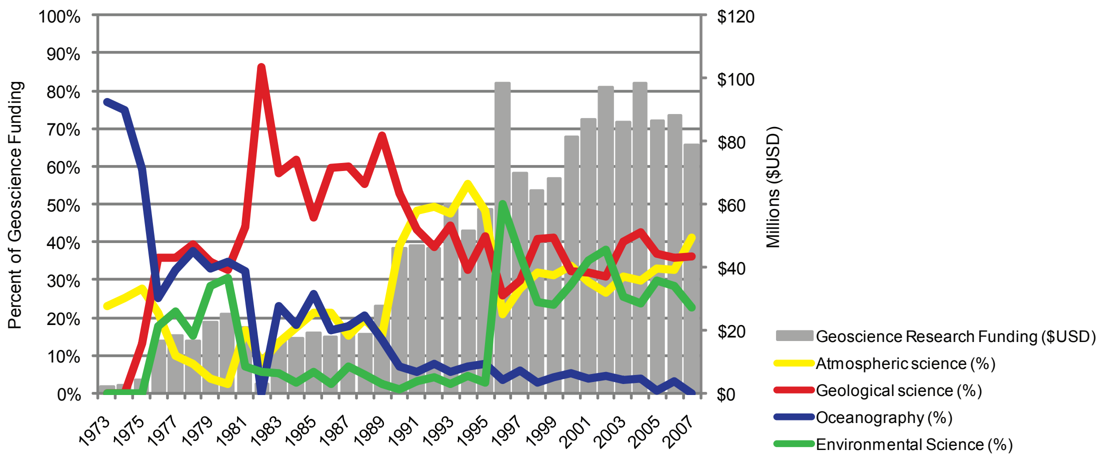
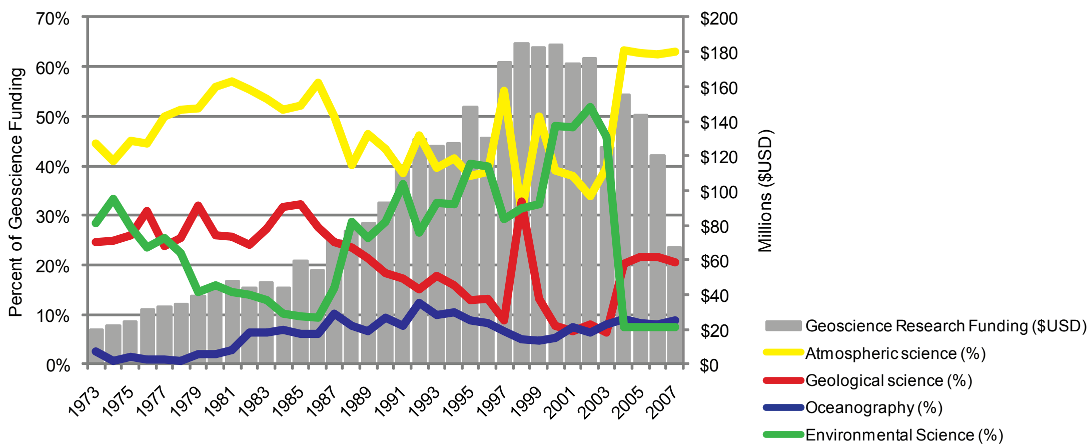


Figure 3.37: Percentage of University Geoscience Research Funding per Subdiscipline (Department of Defense)



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 3.38: Percentage of University Geoscience Research Funding per Subdiscipline (Department of Energy)



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 3.39: Percentage of University Geoscience Research Funding per Subdiscipline (NASA)

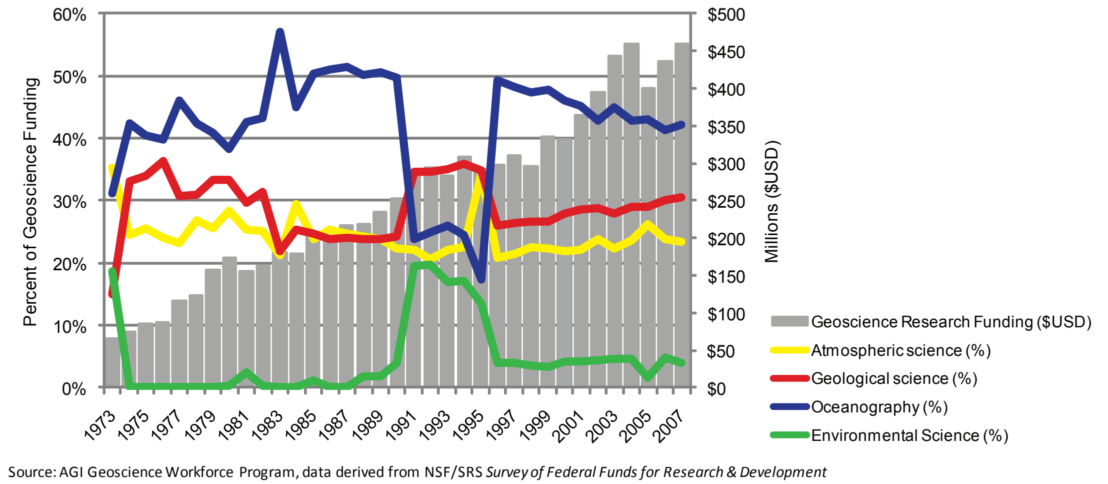


Figure 3.40: Percentage of University Geoscience Research Funding per Subdiscipline (NSF)

Between 2001 and 2008, the rate of funding for NSF grant proposals by the NSF Geoscience directorate decreased from 40 to 31 percent (Figure 3.41). This decrease can be attributed to an 18 percent increase in the number of proposals and a 6 percent decrease in the number of awards. With the influx of stimulus funds from the American Recovery & Reinvestment Act, funding rates increased in 2009 to 44 percent as the number of awards increased by 500 while the number of proposals remained steady from the previous year. In 2010, however, the funding rate dropped to 35 percent as the number proposals increased to approximately 4,800 while the number of awards issues tapered to approximately 1,700.

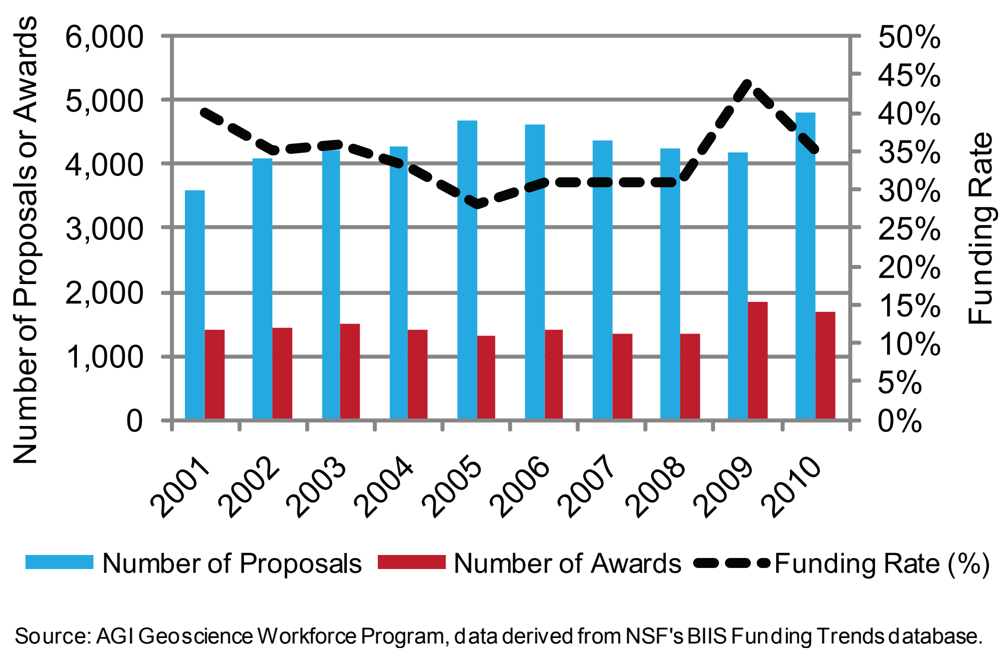
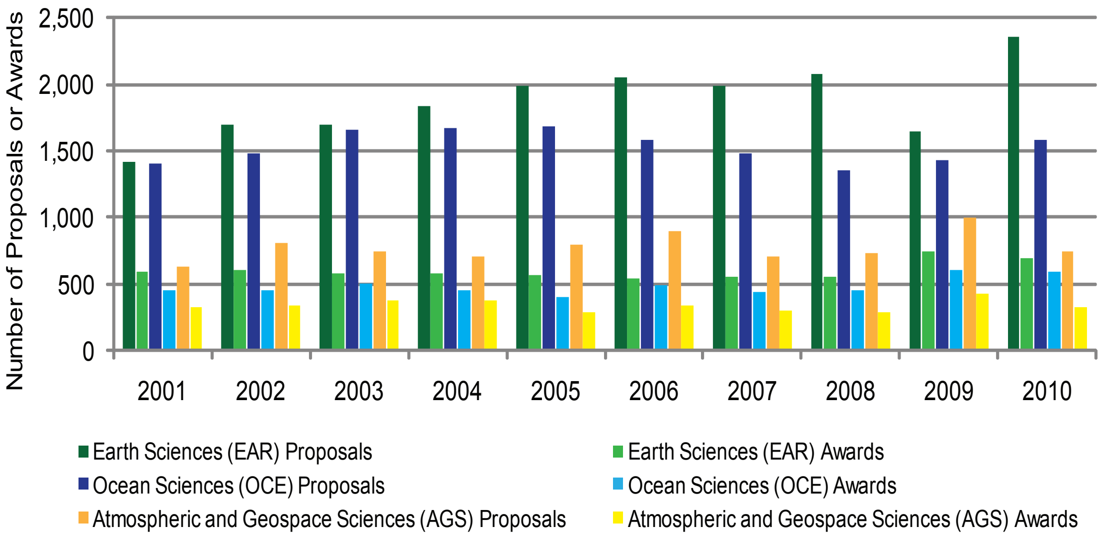


Figure 3.41: Funding of Geoscience NSF Proposals

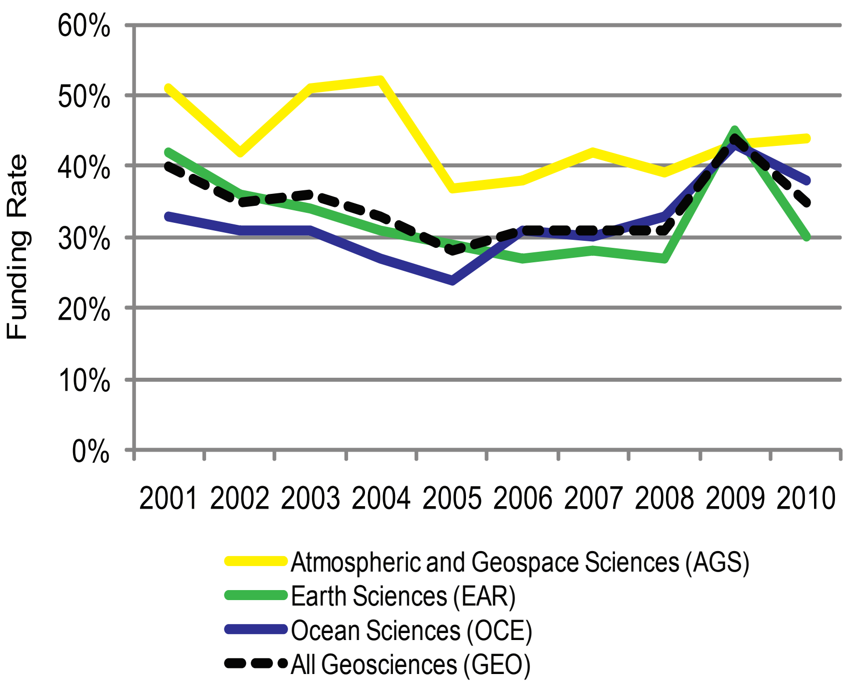
NSF's Geoscience directorate houses three divisions (Earth Sciences (EAR), Ocean Sciences (OCE), and Atmospheric and Geospace Sciences (AGS)) that fund different geoscience research topics. The Earth Science and Ocean Science divisions receive the greatest number of proposals and issues the majority of awards from the Geoscience Directorate

(Figure 3. 42), and as such they also have lowest funding rates than the Atmospheric and Geospace Sciences division (Figure 3.43). The median annual size of awards from the Geoscience Directorate's divisions ranges from $100,000 for Earth Science awards to $154,000 for Ocean Science awards (Figure 3.44). Since 2001, the University of Hawaii, Columbia University, and Massachusetts Institute of Technology have consistently ranked in the top 10 of universities receiving the most funding from the NSF Geoscience directorate across all of its divisions (Tables 3.11 to 3.13).



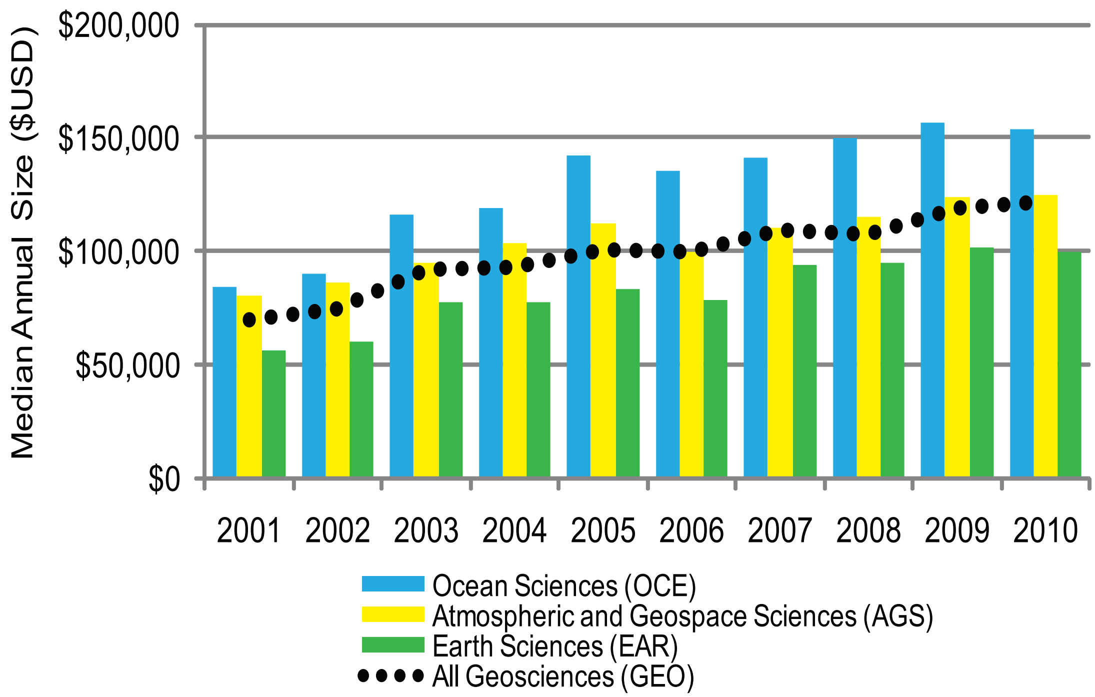
Source: AGI Geoscience Workforce Program, data derived from NSF's BIIS Funding Trends database.

Figure 3.42: Number of Geoscience NSF Proposals and Awards by GEO Division



Source: AGI Geoscience Workforce Program, data derived from NSF's BIIS Funding Trends database.

Figure 3.43: Funding of Geoscience NSF Proposals by GEO Division



Source: AGI Geoscience Workforce Program, data derived from NSF's BIIS Funding Trends database.

Figure 3.44: Median Annual Size of Geoscience NSF Awards by GEO Division

Institution	State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
University of Southern California	CA	$4.9	$4.5	$4.8	$5.9	$5.1	$4.7	$4.8		$7.2	$5.8
University of Minnesota - Twin Cities	MN	$2.6	$6.5	$7.3	$5.2	$6.3	$5.5	$8.0	$5.9	$7.5	$5.7
Pennsylvania State University	PA	$2.5				$3.1	$2.7		$3.0	$3.9	$4.2
University of Wisconsin - Madison	WI			$2.4	$2.8	$3.4					$4.0
University of Colorado - Boulder	CO			$3.0		$2.7		$3.9	$3.2	$4.9	$4.0
University of Texas - Austin	TX								$2.7		$3.8
University of Illinois - Urbana-Champaign	IL										$3.8
Columbia University	NY		$2.6				$2.9		$3.8	$4.4	$3.6
University of Chicago	IL			$2.6	$3.1			$2.7	$2.7		$3.6
Scripps Institute of Oceanography	CA										$3.1
University of Arizona	AZ	$5.6	$6.9	$6.5	$5.4	$6.2	$6.6	$6.3	$5.4	$11.6	

California Institute of Technology	CA	$2.4	$2.3		$3.3	$4.8	$4.6	$4.0	$4.0	$5.1	
Massachusetts Institute of Technology	MA	$3.3	$2.3		$3.7	$6.2	$3.1	$3.3	$3.1	$4.9	
University of Pennsylvania	PA									$4.8	
State University of New York - Stony Brook	NY	$3.5	$3.8	$5.0	$3.5	$3.9	$3.7	$3.3	$3.5	$4.5	
Stanford University	CA		$2.1	$8.9	$11.2	$3.1	$6.8	$6.3			
Oregon State University	OR							$4.4			
University of California - Berkely	CA	$2.7	$2.6	$2.5			$2.8				
University of California - Los Angeles	CA				$2.9						
University of Michigan	MI			$2.3							
Woods Hole Oceanographic Institute	MA	$2.3	$2.4								
University of Hawaii	HI	$2.3									

Table 3.11: Top 10 Universities Receiving NSF Earth Science (EAR) Awards (Millions of $USD) (2001-2010)

(Source: AGI Geoscience Workforce Program, data derived from NSF BIIS Funding Trends)

Institution	State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Colorado State University	CO	$5.0	$5.7	$4.3	$4.6	$6.6	$6.2	$8.3	$8.7	$8.8	$9.4
Boston University	MA	$2.6	$5.2	$4.8	$5.4	$5.7	$5.7	$5.6	$5.7	$6.1	$6.2
Cornell University	NY	$2.5	$5.5		$4.2	$2.8		$5.4	$6.5		$6.0
New Jersey Institute of Technology	NJ										$6.0
Massachusetts Institute of Technology	MA	$3.2	$4.1	$3.9	$3.9	$5.1	$3.9		$2.6	$5.5	$4.5
University of Colorado - Boulder	CO	$2.9	$4.0	$4.2	$5.3	$3.9	$3.2	$5.1	$4.6	$8.3	$4.4
University of Hawaii	HI				$3.2						$4.0
Columbia University	NY		$2.6			$3.2	$3.4				$3.7
University of Michigan	MI					$2.7					$3.4
Johns Hopkins University	MD								$2.9	$5.3	$3.0
University of Arizona	AZ							$2.9		$8.2	
Virginia Polytechnic Institute and State University	VA									$7.8	
University of Illinois - Urbana-Champaign	IL		$2.6	$2.7			$5.1	$2.8		$5.5	
University of Washington	WA	$3.4	$4.1	$4.1	$4.5	$4.4	$3.3	$4.4	$3.7	$4.8	
Pennsylvania State University	PA	$3.1		$3.2	$3.8					$4.4	
University of Oklahoma	OK						$3.3	$3.5	$3.4		
University of California - Los Angeles	CA	$2.9	$4.0	$3.6	$4.7	$2.6	$3.4		$2.7		
University of Wyoming	WY				$2.8				$2.5		
Scripps Institute of Oceanographic Research	CA		$2.5					$5.4			
University of California - Berkeley	CA						$3.2				
University of Minnesota - Twin Cities	MN					$2.7					
Oregon State University	OR			$3.2							
Harvard University	MA			$3.0							

University of Alaska - Fairbanks	AK	$3.5									
University of California - Santa Cruz	CA	$2.6									

Table 3.12: Top 10 Universities Receiving NSF Atmospheric and Geospace Science (AGS) Awards (Millions of $) (2001-2010)

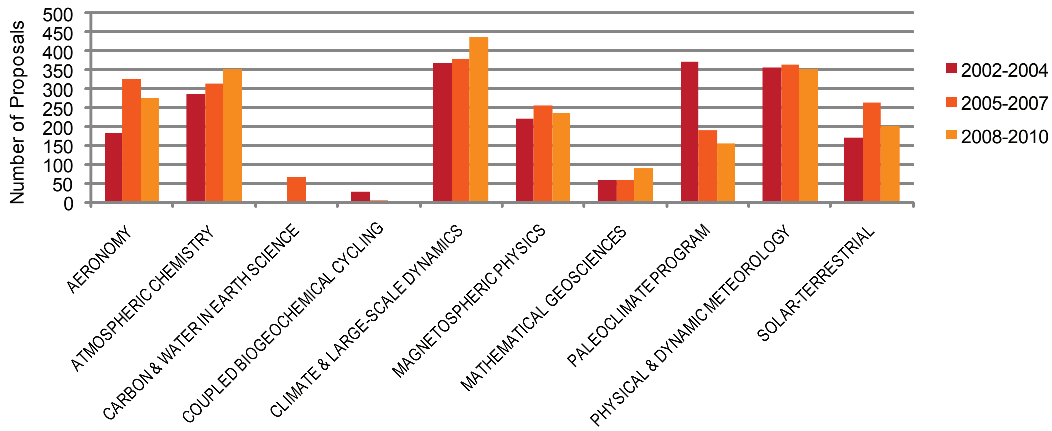
(Source: AGI Geoscience Workforce Program, data derived from NSF BIIS Funding Trends)

Institution	State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Woods Hole Oceanographic Institution	MA	$39.8	$43.0	$49.8	$57.9	$53.5	$58.7	$64.1	$56.6	$82.0	$67.6
University of Alaska - Fairbanks	AK	$4.6									$34.0
Scripps Institute of Oceanographic Research	CA	$28.9	$29.0	$28.7	$31.7	$27.9	$28.2	$29.0	$24.6	$40.0	$24.0
Columbia University	NY	$14.8	$15.5	$24.6	$19.8	$18.5	$17.9	$13.4	$22.8	$27.6	$18.6
University of Hawaii	HI	$8.1	$9.4	$10.7	$14.7	$10.0	$17.0	$15.5	$14.0	$19.9	$18.0
University of Washington	WA	$14.9	$12.6	$17.6	$15.7	$16.9	$17.1	$18.4	$14.8	$23.8	$15.9
Oregon State University	OR	$10.9	$11.9	$16.1	$9.8	$12.8	$14.7	$11.4	$11.4	$12.7	$7.9
University of California - Santa Barbara	CA			$6.8	$5.2	$3.3		$3.7	$4.3		$7.2
Uni of Miami	FL		$5.9	$8.3	$7.5	$6.8	$10.5	$7.3	$7.0	$10.0	$7.0
University Rhode Island	RI	$4.3	$6.5	$5.7	$5.5	$5.9	$4.8	$5.2	$5.2	$9.9	$6.3
Georgia Institute of Technology	GA									$4.8	
Massachusetts Institute of Technology	MA		$4.1						$4.6		
Oregon Health and Science University	OR						$3.0	$4.2			
University of Delaware	DE	$4.0		$4.4	$4.1		$2.5				
University of Southern California	CA					$4.0					
University of South Florida	FL		$3.7								
Rutgers University	NJ	$3.4									

Table 3.13: Top 10 Universities Receiving NSF Ocean Science (OCE) Awards (Millions $) (2001-2010)

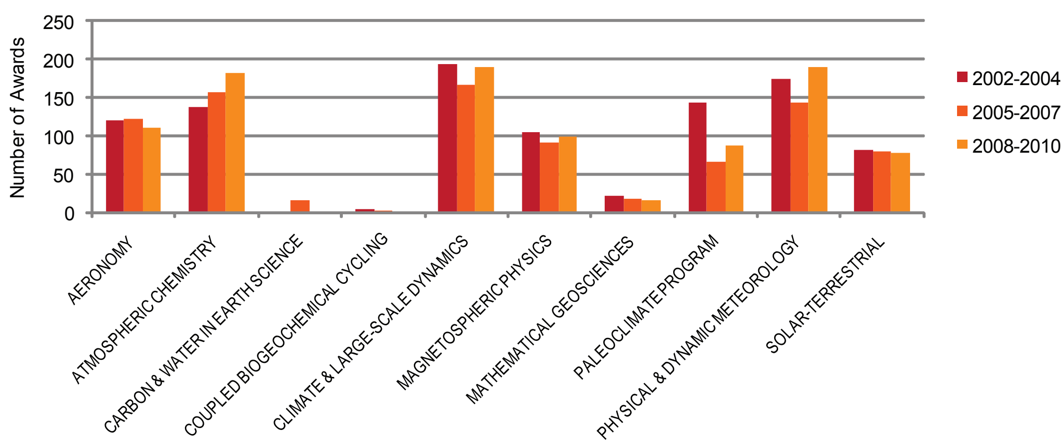
(Source: AGI Geoscience Workforce Program, data derived from NSF BIIS Funding Trends)

During this decade, the Atmospheric and Geospace Science division has issued awards at a relatively consistent level for proposals addressing the subjects of aeronomy, climate and large scale dynamics, magnetospheric physics, and solar-terrestrial research (Figures 3.45 to 3.48). There has been an increase in the number of awards for proposal addressing atmospheric chemistry, and physical and dynamic meterology and a decrease in the number of awards for proposals addressing paleoclimatology and mathematical geoscience subjects. During this decade, the Earth Science division has issued an increasing number of awards for EARTHSCOPE, Geobiology and low temperature geochemistry, global change, hydrological sicences, and sedimentary geology and paleobiology (Figures 3.49 to 3.52), and the Ocean Sciences division has increased the number of awards to proposals addressing biological oceanography and chemical oceanography Figures 3.53 to 3.56).



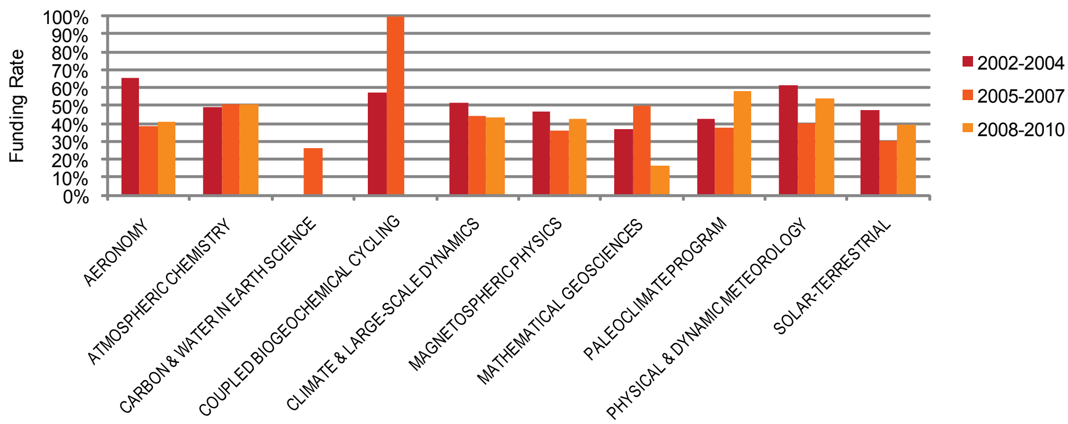
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.45: Trends in NSF Atmospheric and Geospace Science Proposals by Subject



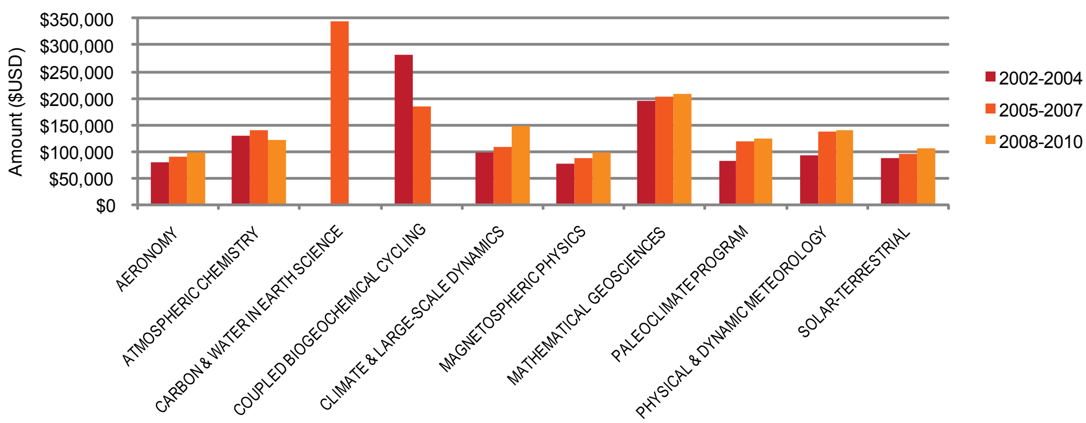
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.46: Trends in NSF Atmospheric and Geospace Science Awards by Subject



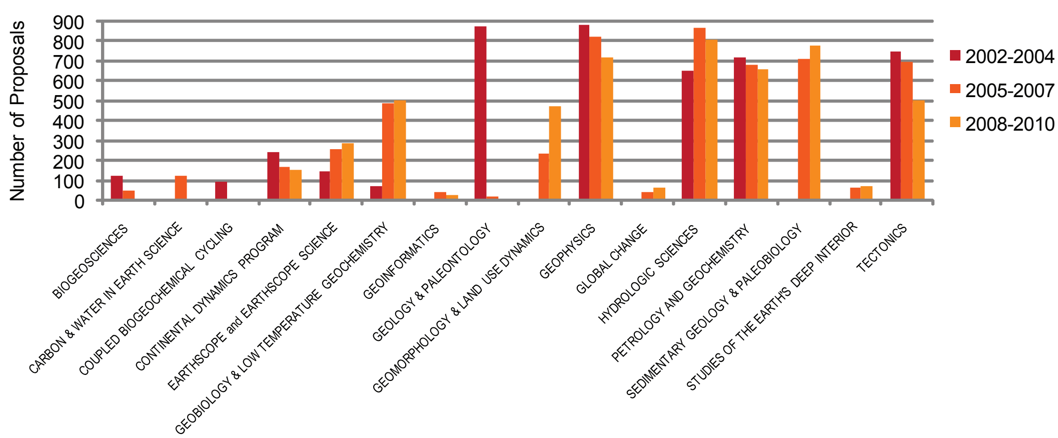
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.47: Trends in NSF Atmospheric and Geospace Science Funding Rates by Subject



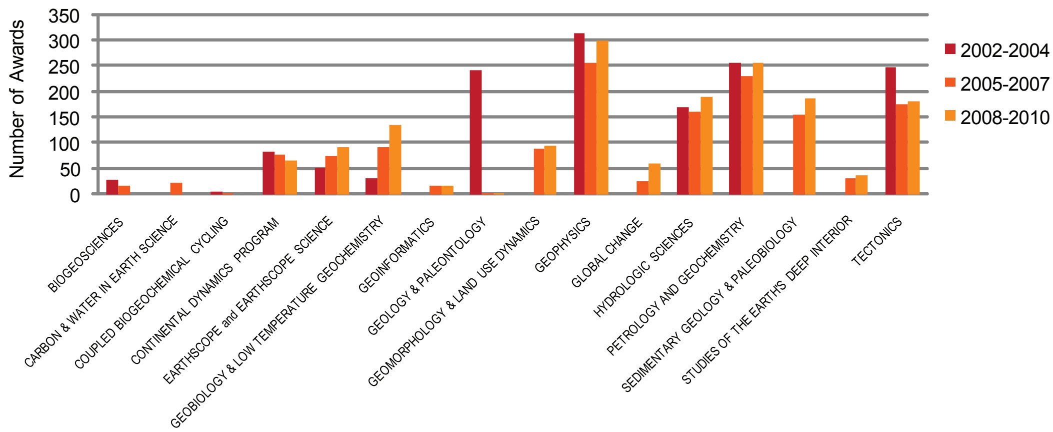
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.48: Trends in NSF Atmospheric and Geospace Science Award Size by Subject



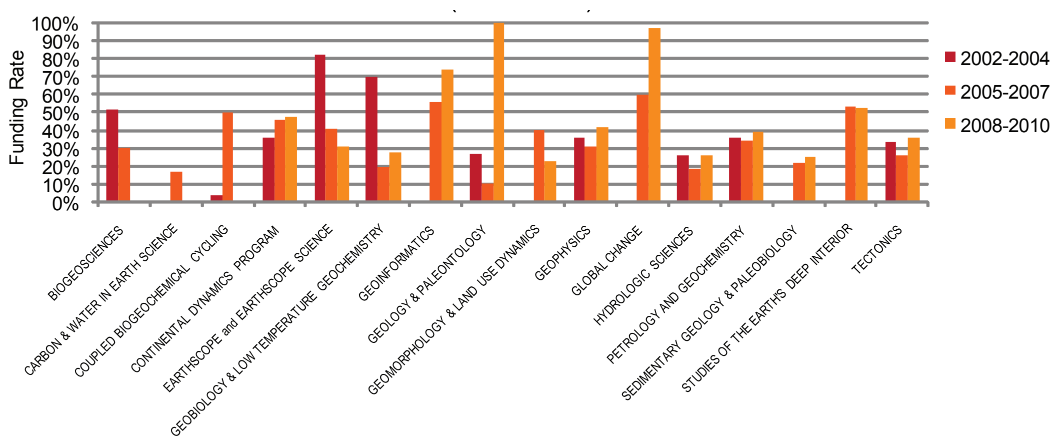
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.49: Trends in NSF Earth Science Proposals by Subject



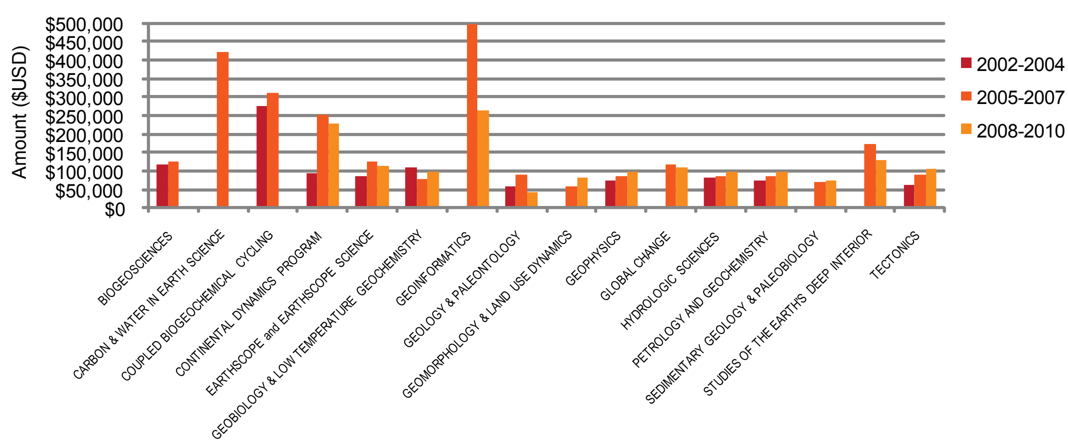
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.50: Trends in NSF Earth Science Awards by Subject



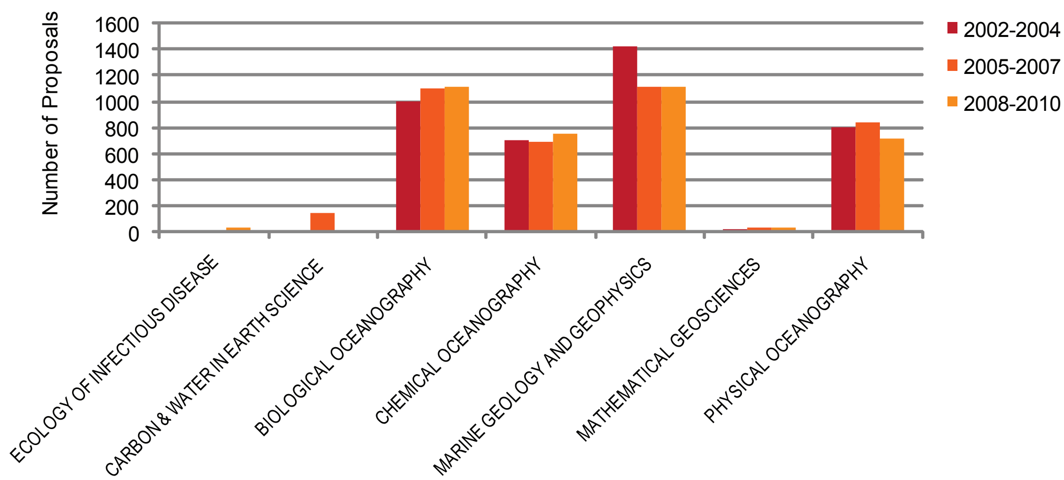
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.51: Trends in NSF Earth Science Funding Rates by Subject



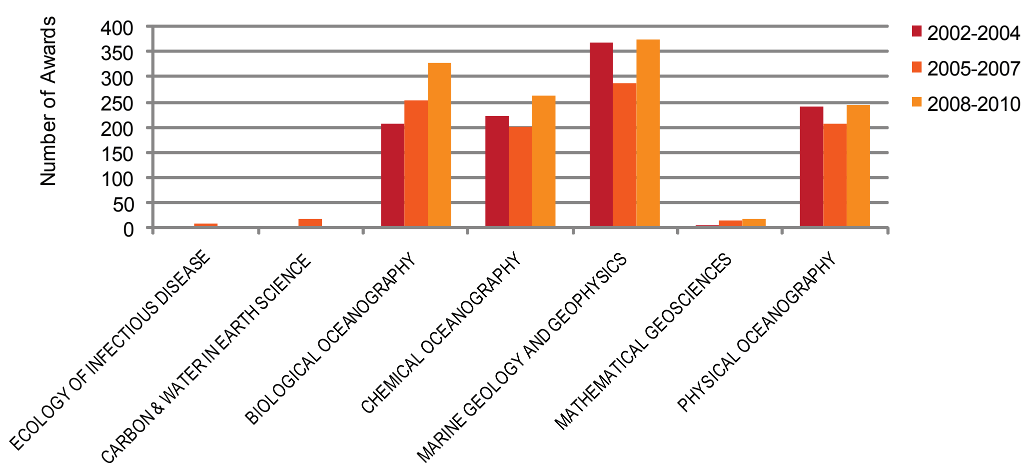
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.52: Trends in NSF Earth Science Award Size by Subject



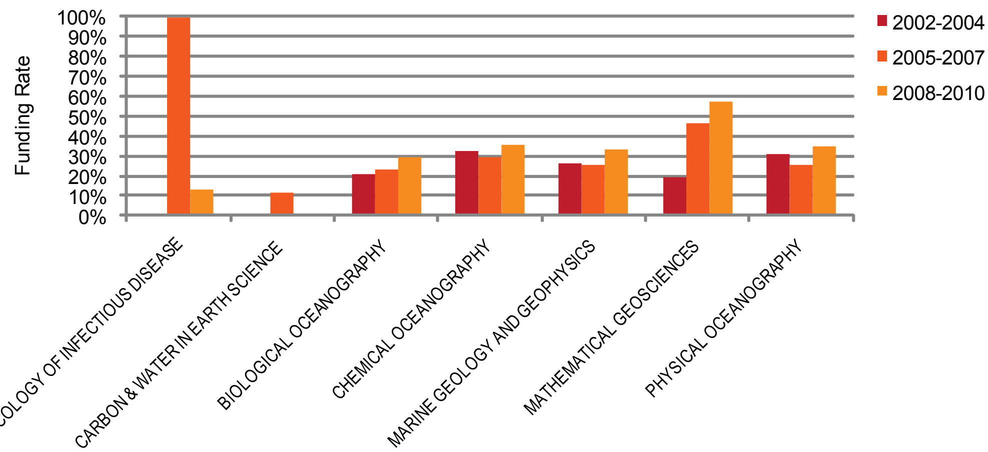
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.53: Trends in NSF Ocean Science Proposals by Subject



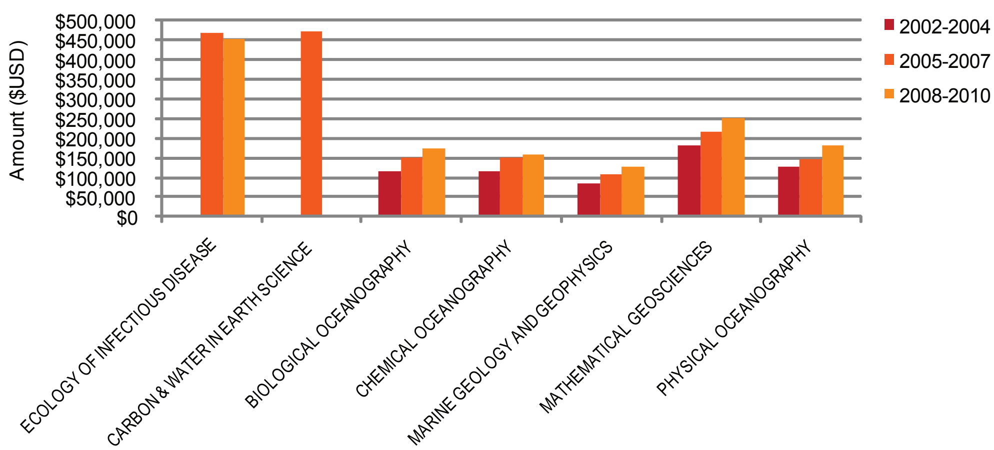
Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.54: Trends in NSF Ocean Science Awards by Subject



Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

Figure 3.55: Trends in NSF Ocean Science Funding Rates by Subject



Source: AGI Geoscience Workforce Program; data derived from NSF's BIIS Funding Database.

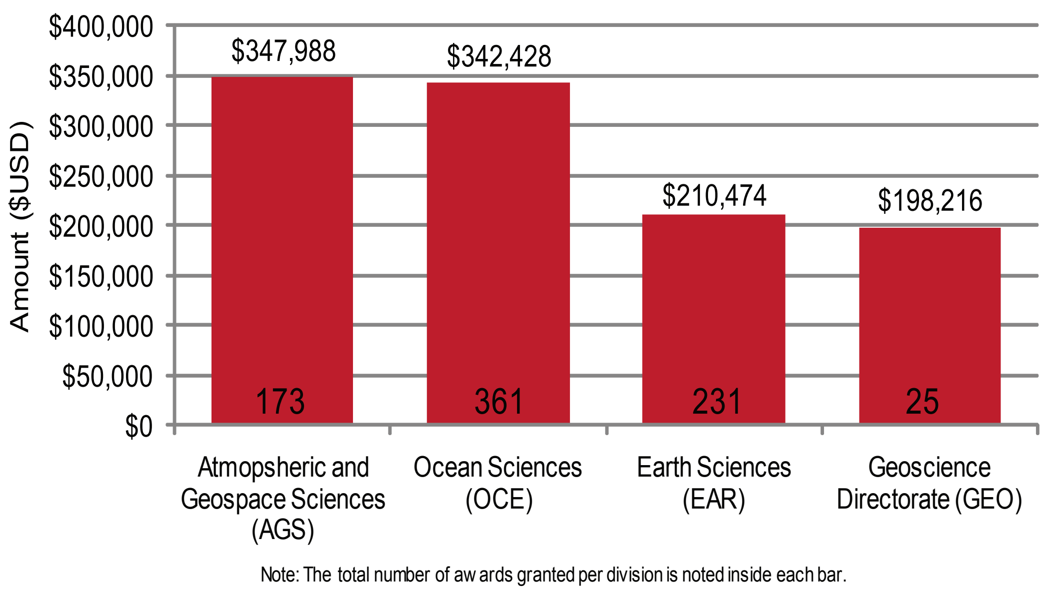
Figure 3.56: Trends in NSF Ocean Science Award Size by Subject

American Recovery & Reinvestment Act and Geoscience Funding from NSF

As a result of the stimulus funding from the American Recovery & Reinvestment Act (ARRA), the NSF Geoscience Directorate funded 804 ARRA proposals. Thirty-six percent of these ARRA awards were given to 17 institutions (Table 3.14), with Woods Hole Oceanographic Institution being awarded the most at 29 awards. The median size of the ARRA Standard Grant awards ranged from $347,988 for awards from the Atmospheric and Geospace Sciences division to $210,474 for awards from the Earth Sciences division (Figure 3.57). Forty-five percent of ARRA awards from the Atmospheric and Geospace Sciences division were for ICER ("Integrative Computing Education and Research") , atmospheric chemistry, and physical and dynamic meterology proposals (Figure 3.58). Fifty-one percent of ARRA awards from the Earth Sciences division were for ICER ("Integrative Computing Education and Research"), petrology and geochemistry, and geophysics proposal, and nearly a third of all ARRA proposals from the Ocean Sciences division were for chemical oceanography, marine geology and geophysics, and biological oceanography proposals (Figure 3.59 and 3.60). Additionally, the Geoscience Directorate also awarded 22 awards for proposals submitted to the "Opportunities for Enhancing Diversity" program, two awards for ICER proposals, and one award for magnetospheric physics (Figure 3.57).

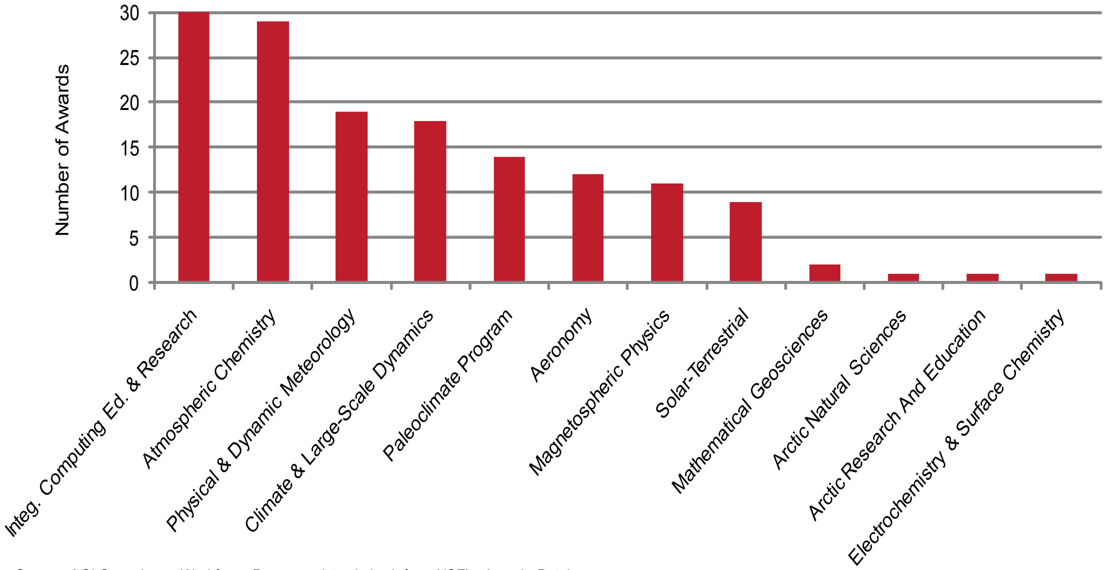
Organization	State	Awards
Woods Hole Oceanographic Institution	MA	29
Columbia University	NY	21
University of Hawaii	HI	20
University of California-San Diego Scripps Institute of Oceanography	CA	19
Pennsylvania State University - University Park	PA	18
University of Washington	WA	18
Massachusetts Institute of Technology	MA	15
University of Arizona	AZ	15
University of Colorado at Boulder	CO	13
University of Miami Rosenstiel School of Marine & Atmospheric Science	FL	13
Oregon State University	OR	13
University of California-Berkeley	CA	12
University of Minnesota-Twin Cities	MN	12
Stanford University	CA	10
University of Wisconsin-Madison	WI	10
University of Florida	FL	10
Purdue University	IN	10
University of Rhode Island	RI	10
Rutgers University New Brunswick	NJ	10
University of California-Santa Cruz	CA	10

Table 3.14: Organizations Awarded with Ten or More ARRA Awards from the NSF Geoscience Directorate



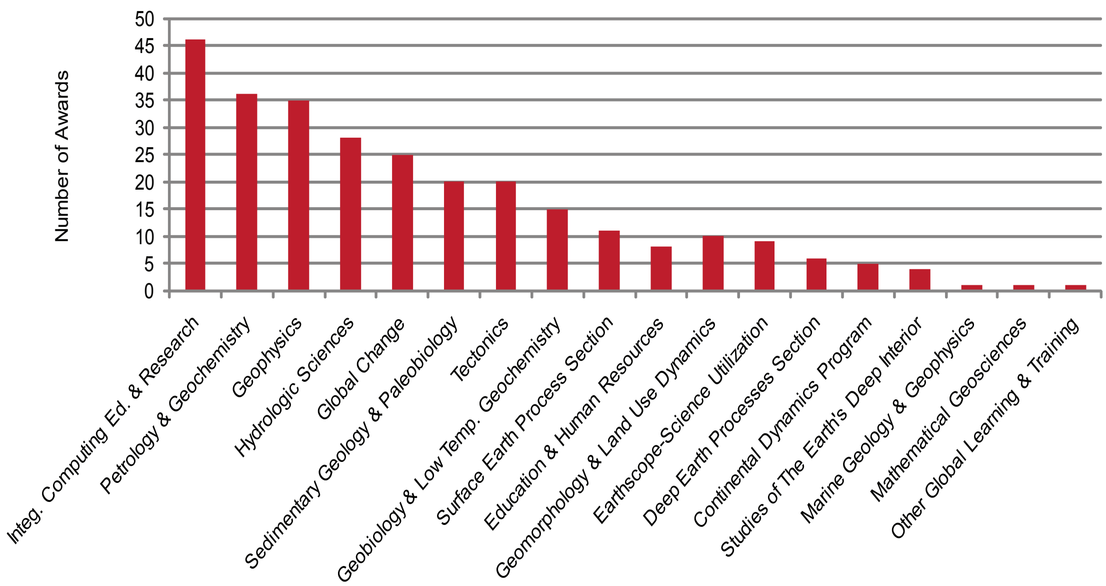
Source: AGI Geoscience Workforce Program, data derived from NSF's Awards Database

Figure 3.57: Median Size of NSF Geoscience ARRA Standard Grant Awards (2009-2010)



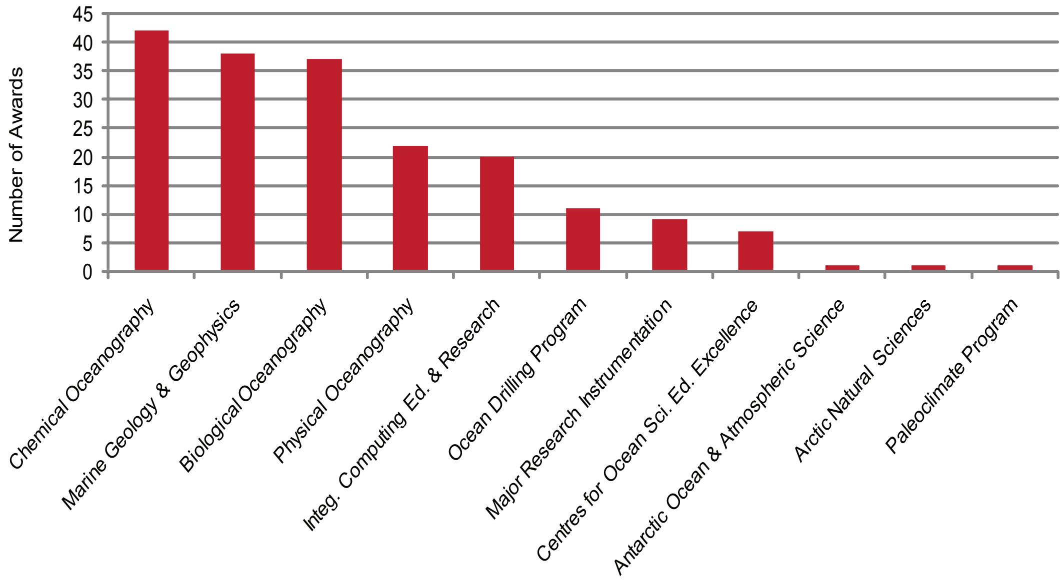
Source: AGI Geoscience Workforce Program, data derived from NSF's Awards Database

Figure 3.58: Number of Atmospheric and Geospace Science ARRA Awards by Topic (2009-2010)



Source: AGI Geoscience Workforce Program, data derived from NSF's Awards Database

Figure 3.59: Number of Earth Science ARRA Awards by Topic (2009-2010)



Source: AGI Geoscience Workforce Program, data derived from NSF's Awards Database

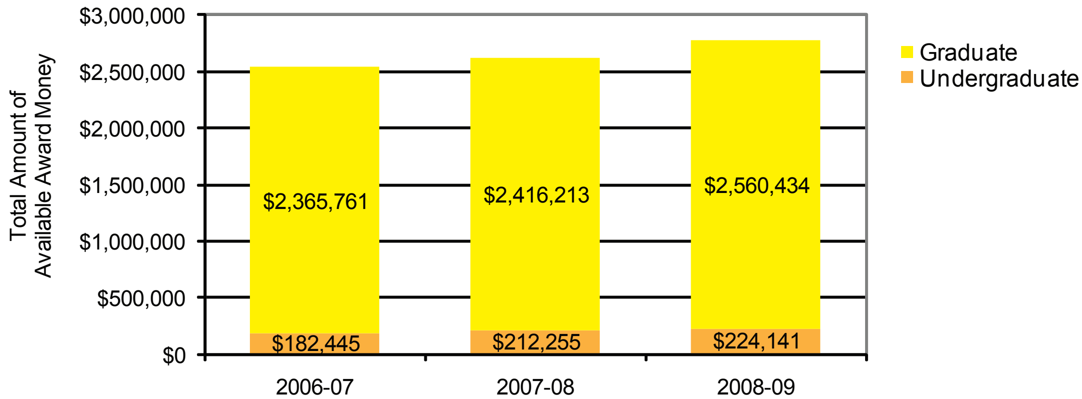
Figure 3.60: Number of Ocean Science ARRA Awards by Topic (2009-2010)

Funding of Geoscience Students

Direct support for geoscience students increased between 2006 and 2008, and that trend looks to continue in 2008-2009 with a projected 6 percent increase in available funds. These opportunities for student support include funds from government agencies (60 percent) and non-profit organizations (40 percent, which includes support from private foundations and companies).

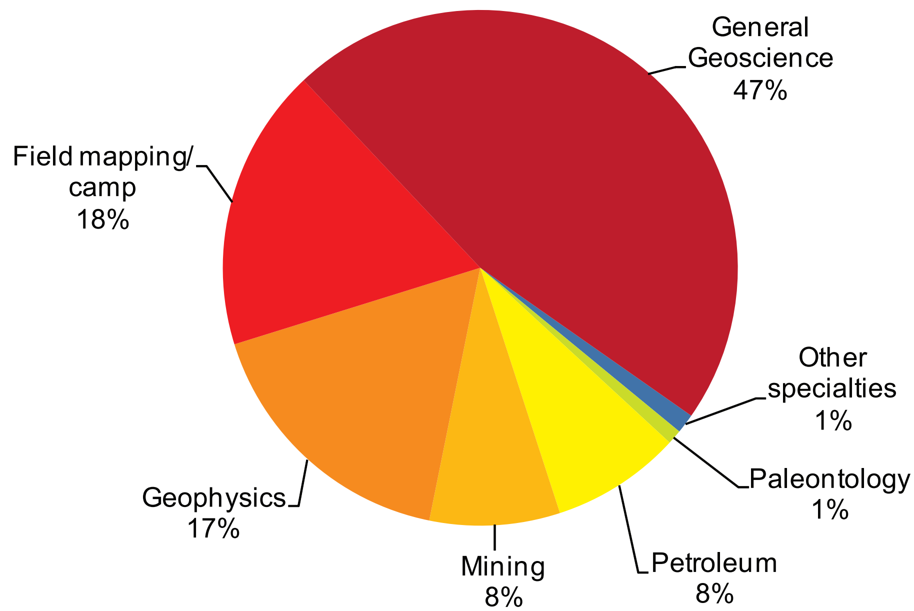
Graduate student support comprises 91 percent of all awards in the 2007-2008 academic year: over $2.4 million distributed among 570 individual awards. The largest student support program is the NSF Graduate Student Fellowship program. This program provided more than $1.13 million (from a total program budget of $40.5 million) in support to geoscience graduate students during 2007, and in 2009 reached $3.8 million.

Several programs have significantly grown in recent years, including the Society of Exploration Geophysicists scholarship program's 65 percent increase in awarded support since 2006-2007. Funding for student travel grants has increased by more than $32,000 since that time, though field camp scholarships have remained steady.



Source: AGI Geoscience Workforce Program

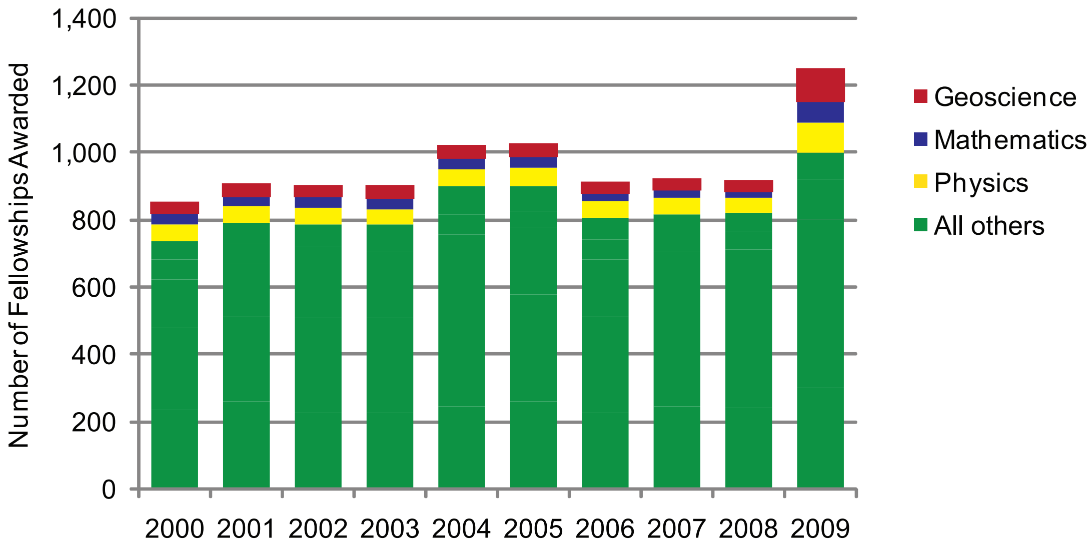
Figure 3.61: Total U.S. Geoscience Student Aid by Degree Level



Source: AGI Geoscience Workforce Program

Figure 3.62: 2007-2008 Geoscience Student Aid by Discipline

The NSF Graduate Fellowship program conferred 9,587 fellowships (Figure 3.63) to students in science and engineering fields between 2000 and 2009, amounting to a total value of $388,273,500. On average, 927 graduate fellowships were awarded per year between 2000 and 2008. Between 2000 and 2008, the majority (56-59 percent) of these fellowships were awarded to graduate students in the life sciences and engineering fields. During this period, approximately 3.5 percent of NSF graduate fellowships (~31 fellowships / year) were awarded to graduate students in the geosciences. In 2009, there was a 37 percent increase from the previous year in the number of graduate fellowships awarded primarily due to the influx of stimulus funding from the American Reinvestment & Recovery Act. The percentage of fellowships awarded to graduate students in the geosciences nearly quadrupled between 2008 and 2009 (from 26 to 94), and in 2009 geoscience graduate fellowships comprised 8 percent of the total number of NSF graduate fellowship awards.

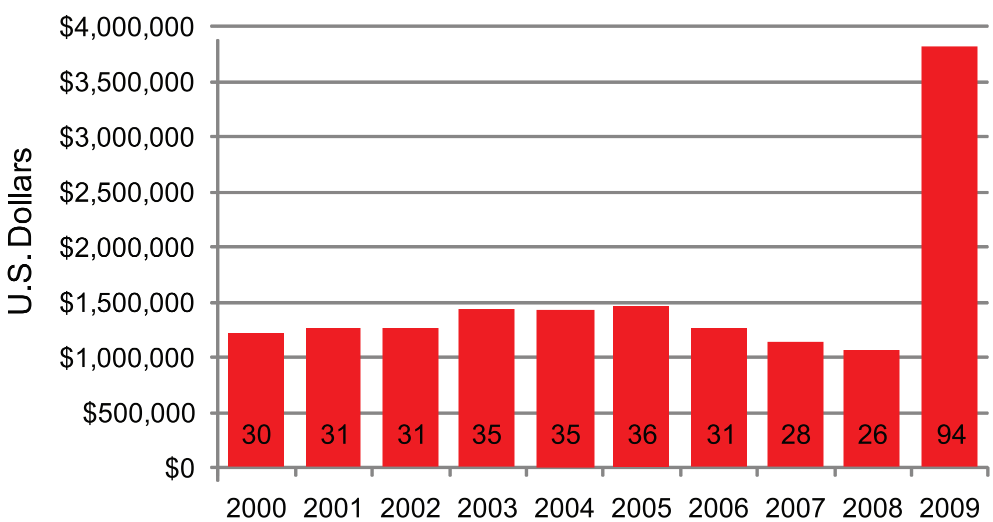


Source: AGI Geoscience Workforce Program. Data derived from NSF Graduate Fellowship Program reports posted on data.gov.

Figure 3.63: Number of NSF Graduate Fellowships Awarded (2000-2009)

Between 2000 and 2009, a total of 350 geoscience NSF graduate fellowships were awarded (Figure 3.64). With the large increase in the number of fellowships awarded in 2009, the total value of the NSF graduate fellowships awarded to geoscience students jumped from just over $1 million dollars to $3.8 million dollars.

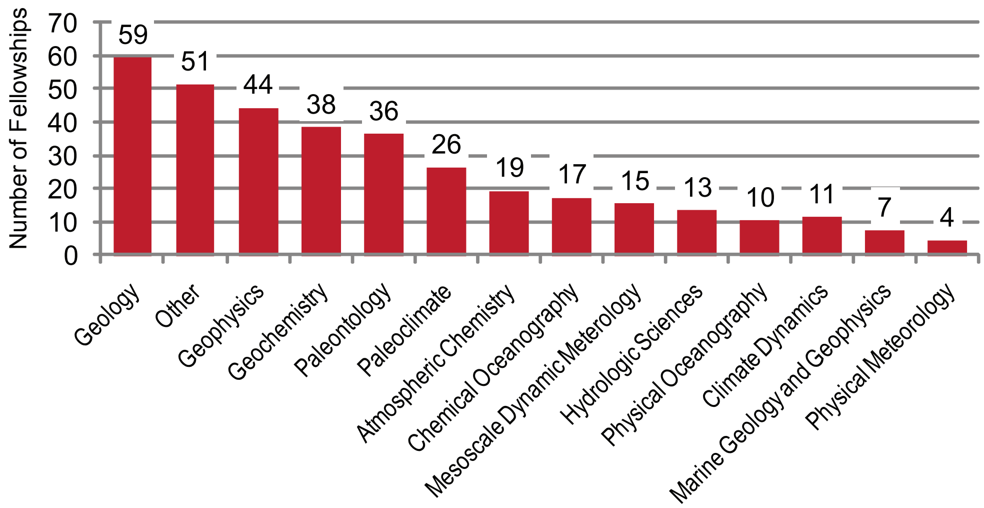
The top six fields of study for NSF graduate fellowships awarded to geoscience students between 2000 and 2009 (e.g. Geology, Other, Geophysics, Geochemistry, Paleontology and Paleoclimate) account for 73 percent of all fellowship awards (Figure 3.65). In 2009, the top three fields of study were Geology, Geophysics, and Paleoclimate with 12 fellowships awarded per field.



Note: The numbers inside the bars denote the total number of NSF graduate fellowships awarded each year to geoscience students

Source: AGI Geoscience Workforce Program. Data derived from NSF Graduate Fellowship Program reports posted on data.gov.

Figure 3.64: Total Funding of Geoscience NSF Fellowships



Source: AGI Geoscience Workforce Program. Data derived from NSF Graduate Fellowship Program reports posted on data.gov.

Figure 3.65: Geoscience Graduate Fellowships by Field of Study

Between 2000 and 2009, 43 percent of geoscience graduate fellows received their baccalaureate degrees from 19 schools (Table 3.15), and 48 percent of geoscience graduate fellows attended 11 graduate institutions (Table 3.16). The percentage of geoscience graduate fellows attending the top 11 graduate institutions who earned their bachelor's degrees from the same group of institutions varies between 18 percent (Yale University) and 47 percent (California Institute of Technology).

Baccalaureate Institution of Geoscience NSF Graduate Fellows	State	Number of Fellows (2000-2009)
Harvard University	MA	14
California Institute of Technology	CA	13
Carleton College	MN	13
University of California - Berkeley	CA	11
Massachusetts Institute of Technology	MA	10
Stanford University	CA	8
University of Chicago	IL	8
University of Arizona	AZ	7
University of California - Santa Barbara	CA	7
University of Michigan	MI	7
Pennsylvania State University - University Park	PA	7
Brown University	RI	7
Princeton University	NJ	6
Cornell University	NY	6
Yale University	CT	5
Washington University	MO	5
Dartmouth College	NH	5
Columbia University	NY	5
Oberlin College	OH	5

Table 3.15: Top Baccalaureate Institutions of NSF Geoscience Graduate Fellows (2000-2009)

(Source: AGI Geoscience Workforce Program)

Graduate Institution of Geoscience NSF Graduate Fellows	State	Number of Fellows (2000-2009)
Massachusetts Institute of Technology	MA	25
Harvard University	MA	20
University of Washington	WA	20
University of California - Berkeley	CA	18
Columbia University	NY	16
California Institute of Technology	CA	15
University of Arizona	AZ	12
University of California - San Diego	CA	12
Yale University	CT	11
Stanford University	CA	10
Pennsylvania State University - University Park	PA	10

Table 3.16: Top Graduate Institutions of NSF Geoscience Graduate Fellows (2000-2009)

(Source: AGI Geoscience Workforce Program)

Chapter 4: Geoscience Employment Sectors: Trends in Student Transitions and Workforce Dynamics

Society is currently facing many issues and challenges that require the application of geoscience knowledge and skills by professional geoscientists in a myriad of fields and in employment sectors as varied as the energy industry to academia to telecommunications. At any given point in time, the economy requires a certain portfolio of geoscience skills, and whether or not that portfolio is present not only represents a measure of the effectiveness of the profession, but also is a critical predictor of relevance of the discipline. As in any free market system, when human resource capital is lacking for a given profession or discipline, substitution of talent from other disciplines and or importation of human capital from other countries will be used to meet the economic and societal goals.

Given the demonstrable shortage of geoscience talent in the U.S. economy over the last decade, the geoscience profession has experienced substantial erosion in regards to public awareness of the profession as well as in investment in geoscience education. The measuring of the current workforce continues to be a critical part of evaluating the genuine impact of investments in the educational system.

Two critical issues face the geoscience workforce, and subsequently impact both the entire geoscience discipline and the U.S. economy - the rate at which new talent is transitioned into the profession and the rapid loss of experienced talent. This chapter examines both of these issues.

The transition from formal schooling and into a profession is a critical point in an individual's life. This is also a junction that leads to substantial attrition from what are considered linear, traditional trajectories. Likewise, this transition period is not limited to the moment of decision by a new graduate as to the employment they take, but to their disposition five years following the end of their formal education. This five-year point is a traditional measure of the entry of an individual into a career - many people take their first job in a field related to their education but find personal, professional, and economic issues precipitate changes. To this end, most measures of science, engineering, and mathematics fields indicate that of undergraduate degree recipients in those fields, only about 1 in 4 will cross that 5 year career threshold in their original field of study. For the geosciences, this rate has historically been approximately 1 in 8. The core of any profession will be the predictable and linear trajectory of education to career. The flux in and out of that system adds substantial depth to the economy, but if the flux is decidedly negative, as it appears to have been in the geosciences, skill shortages and potential economic substitution become measurable risks.

Perceptions of career opportunities and their pathways influence students' career choice and their major. This is reinforced by the alignment of job search activity and geoscience graduate student perceptions of employment sectors. In an AGI/AGU survey of new graduate students, 81 percent of new geoscience doctorate recipients reported that they searched for jobs in academia, 45 percent in the government, and 31 percent in the private sector. Sixty-seven percent of recent geoscience graduates found jobs in academia, 18 percent in government, and 10 percent in private industry. Geoscience Master's graduates were less selective in their job search efforts: 58 percent searched for jobs in academia, 55 percent in the government, and 35 percent in the private sector. However, only 24 percent of geoscience Master's graduates found work in academia, 22 percent in the government, and 50 percent in private industry (21% oil & gas industry, 20% environmental industry, 9% other industry). Since 2006, data from NSF's Survey of Earned Doctorates indicates a continued increasing percentage of geoscience doctorates moving into postdoctoral positions. For those new geoscience doctorates finding employment in non-postdoctoral positions, between 2007 and 2008, there was a substantial increase in those finding employment in industry and a decrease in the percentage of those finding employment in government and academia.

With approximately 1,500 geoscience graduate degree recipients transitioning into the professional workplace each year, the supply of newly trained geoscientists falls short of geoscience workforce demand and replacement needs. According to the U.S. Bureau of Labor Statistics there were a total of 262,627 U.S. geoscientist jobs in 2008, and in 2018, the projected number of U.S. geoscientist jobs will be 322,683, a 23 percent increase. The increase in job growth will vary among industry with the professional, scientific, and technical services industry having the highest geoscience job growth (50 percent). These projections do not include replacements due to attrition. Given the age demographics of the geoscience discipline, we expect a 12 percent replacement rate for attrition. With this adjustment, aggregate job projections are expected to increase by 35 percent between 2008 and 2018.

Data from NSF's 2006 SESTAT database indicates that 35 percent of geoscience graduates at all degree levels work in core geoscience occupations. This percentage increases with degree level from 30 percent at the Bachelor's degree level to 68 percent at the doctoral level. Although the majority of geoscience Bachelor's and Master's geoscience degree holders work outside of core geoscience occupations, the majority of these graduates work within science and engineering fields. The low percentage of geoscience Bachelor's degree holders working in core geoscience occupations is likely due to the low number of geoscience jobs available to undergraduate degree holders. Additionally, at the Master's degree level, the low percentage of geoscience graduates working in core geoscience occupations may be due to the variety of sectors in which graduates search for work and the applicability of a geoscience degree in a variety of occupations.

The majority of geoscientists in the workforce are within 15 years of retirement age. Data from federal sources, professional societies, and industry confirm an imbalance in the age demographic of geoscientists. The percentage of geoscientists between 31 and 35 years of age is less than half of geoscientists between 51 and 55 years old. All geoscientist occupations in the government, with the exception of meteorologists and oceanographers, experienced an age shift towards the 50 to 54 year old age group between 2003 and 2007. Between 2007 and 2009, a marked shift in age distribution from the 50 to 54 year old age group to the 55 to 59 year old age group occurred, and a concurrent slight increase in the percentage of geoscientists under the age of 35 in most government geoscience occupations.

Even in oil and gas companies, which typically offer the highest salaries of all geoscience employing industries, the supply of new geoscientists is short of replacement needs. The number of younger geoscientists in their early 30's is approximately half the number of those nearing retirement age. This number is greater than the data reported from federal agencies and professional societies. Additionally, the supply of geoscientists is not expected to meet the demand for geoscientists over the next 20 years. By 2030, the unmet demand for geoscientists in the petroleum industry will be approximately 13,000 workers for the conservative demand industry estimate.

Support activities for mining and oil and gas is the only geoscience employing industry where the demographics provide for the replacement of the older generation of geoscientists who will retire within the next 15 years.

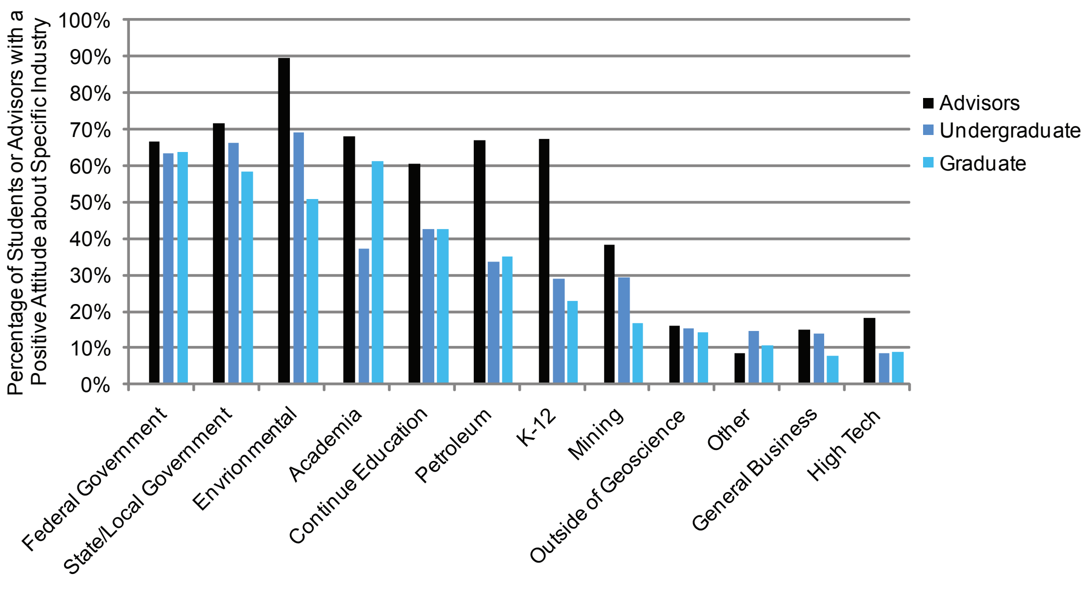
In academia, like other geoscience sectors, those with full professorships are older (late 50's to mid 70's), and there are 30 percent fewer assistant and associate faculty than full professors. Between 2008 and 2010, the number of full professor faculty declined slightly as the number of emeritus faculty increased indicating the retirement of more full professors. Given the current age demographics of geoscience academic faculty, we expect this trend to continue for the next 10 to 15 years. In addition to the decline in full professorships between 2008 and 2010, there was an overall increase in the number of assistant professors, especially between the ages of 35 and 40. Yet, at the associate professor rank, the number of faculty remained steady over the same time period.

The Transition from Student to Professional

Faculty and Student Attitudes about Career Pathways

Student perceptions of career opportunities influence how and where they conduct their job searches. Peers, parents, and mentors, including academic advisors shape students' perceptions of careers and the means to enter that career. Ultimately, these perceptions and the actions based upon them are reflected in the geoscience workforce.

The American Geological Institute conducted a survey from March to April 2006 of 1,358 students and 558 advisors from 262 schools with geoscience departments in order to document the attitudes of students and academic advisors of the professional pathways for geoscientists. Academic advisors tended to have more positive attitudes than graduate and undergraduate students about most career pathways, especially the environmental industry, petroleum industry, academia, and K-12 education (Figures 4.1-4.4 and Tables 4.1-4.3). However, when the data is analyzed by degree and career experience, it is apparent that doctoral students and graduates had a more positive opinion about academia than their advisors.



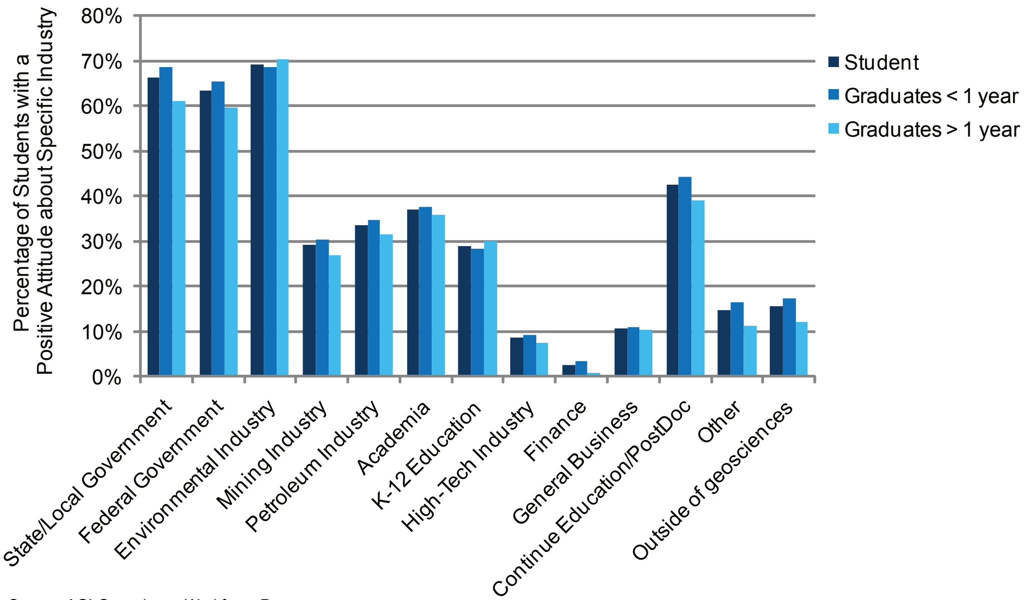
Source: AGI Geoscience Workforce Program

Figure 4.1: Percentage of Geoscience Students and Advisors with Positive Attitudes Pertaining to Careers in Different Employment Sectors (2006)

Sector	Undergraduate Students	Graduate Students	All Students	All Advisors
State / Local Government	66%	59%	63%	72%
Federal Government	64%	64%	64%	67%
Environmental Industry	69%	51%	61%	89%
Mining Industry	29%	17%	24%	38%
Petroleum Industry	34%	35%	34%	67%
Academia	37%	61%	48%	68%
K-12 Education	29%	23%	26%	67%
High-Tech Industry	9%	9%	9%	18%
General Business	14%	8%	11%	15%
Continue Education / Post-doc	43%	43%	43%	60%
Other	15%	11%	13%	8%
Look Outside of Geoscience	16%	14%	15%	16%

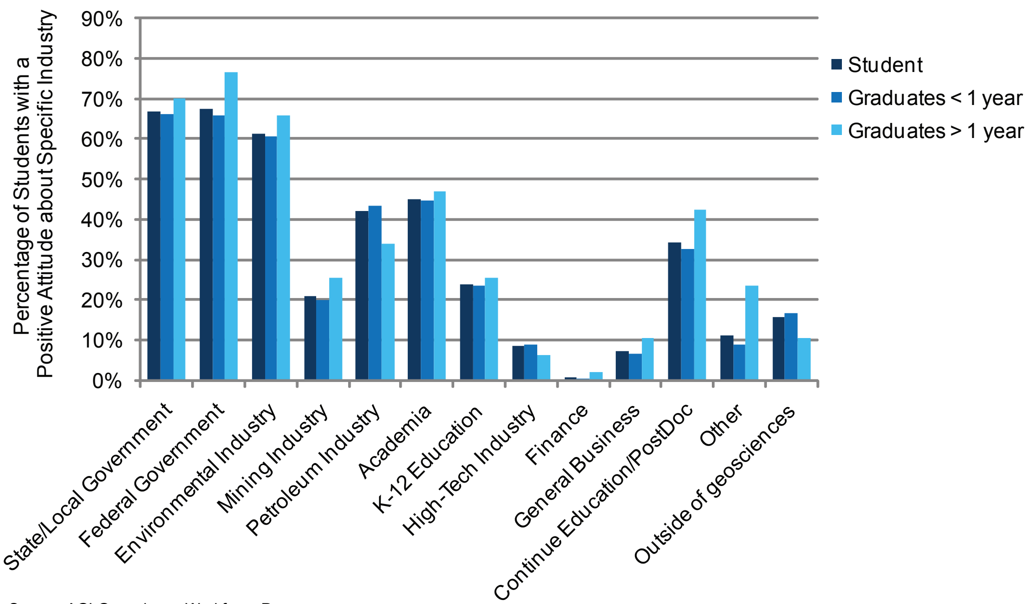
Table 4.1: Percentage of Students and Faculty with Positive Attitudes Pertaining to Students Pursuing Careers in Different Employment Sectors (2006)

(Source: AGI Geoscience Workforce Program)



Source: AGI Geoscience Workforce Program

Figure 4.2: Percentage of Geoscience Undergraduates Recipients with Positive Attitudes Pertaining to Careers in Different Employment Sectors (2006)



Source: AGI Geoscience Workforce Program

Figure 4.3: Percentage of Geoscience Master's Students with Positive Attitudes Pertaining to Careers in Different Employment Sectors (2006)

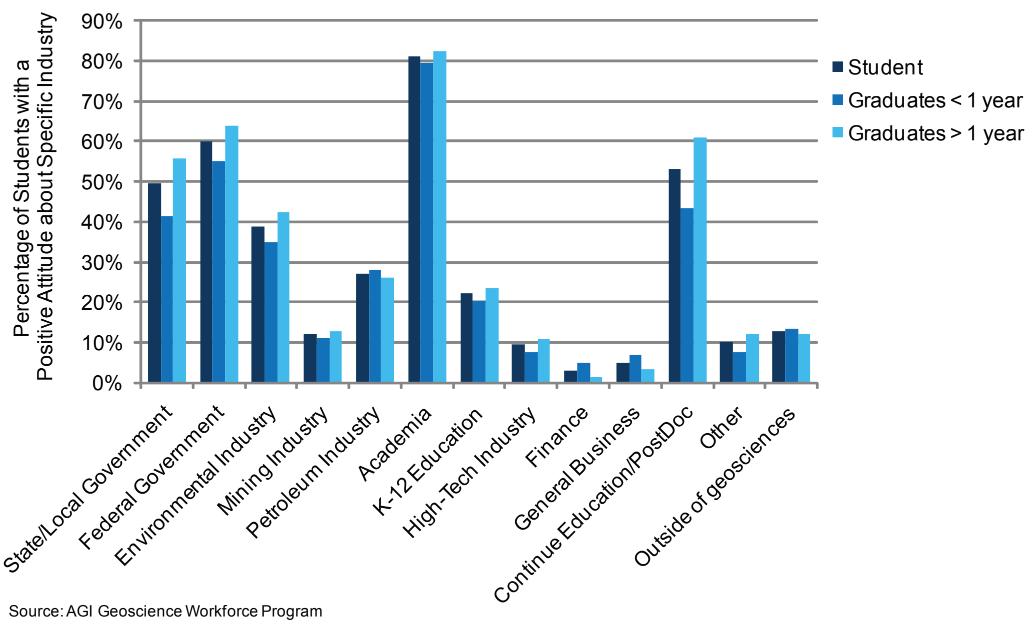


Figure 4.4: Percentage of Geoscience Doctoral Candidates with Positive Attitudes Pertaining to Careers in Different Employment Sectors (2006)

Sector	Undergraduate	Master's	Ph.D.
State/Local Government	66%	67%	49%
Federal Government	64%	67%	60%
Environmental Industry	69%	61%	39%
Mining Industry	29%	21%	12%
Petroleum Industry	34%	42%	27%
Academia	37%	45%	81%
K-12 Education	29%	24%	22%
High-Tech Industry	9%	9%	9%
Finance	3%	1%	3%
General Business	11%	7%	5%
Continue Education/PostDoc	43%	34%	53%
Other	15%	11%	10%
Look Outside of geosciences	16%	16%	13%

Table 4.2: Percentage of Students with Positive Attitudes Pertaining to Careers in Different Employment Sectors (2006)

(Source AGI Geoscience Workforce Program)

Sector	Undergraduate		Master's		Ph.D.	
	<1 yr	> 1 yr	<1 yr	> 1 yr	<1 yr	> 1 yr
State/Local Government	69%	61%	66%	70%	42%	56%
Federal Government	65%	60%	66%	77%	55%	64%
Environmental Industry	69%	70%	61%	66%	35%	42%
Mining Industry	30%	27%	20%	26%	11%	13%
Petroleum Industry	35%	32%	43%	34%	28%	26%
Academia	38%	36%	45%	47%	80%	83%
K-12 Education	28%	30%	23%	26%	20%	23%
High-Tech Industry	9%	8%	9%	6%	8%	11%
Finance	3%	1%	0%	2%	5%	1%
General Business	11%	10%	7%	11%	7%	3%
Continue Education/PostDoc	44%	39%	33%	43%	43%	61%
Other	16%	11%	9%	23%	8%	12%
Look Outside of geosciences	17%	12%	17%	11%	14%	12%

Table 4.3: Percentage of Students with Positive Attitudes Pertaining to Careers in Different Employment Sectors at less than 1-year prior to and more than 1-year prior to Graduation (2006)

(Source AGI Geoscience Workforce Program)

Recent Geoscience Graduates – Career Trends

In an AGI/AGU survey of new Ph.D.'s and Master's degree recipients, 81 percent of geoscience doctoral students searched for jobs in academia, 45 percent in the government, and 31 percent in the private sector. This trend of preference for academia, government, and then private sector is also evident in the attitudes of doctoral students towards these industries and in the employment sectors of recent graduates (Figures 4.5-4.8).

Geoscience Master's students however had less preference in the places they searched for jobs: 58 percent searched for jobs in academia, 55 percent in the government, and 35 percent in the private sector. As with geoscience doctoral students, the sectors in which geoscience Master's students searched for jobs were similar to their perceptions of different employment sectors. However, half of geoscience Master's graduates found initial employment in the private sector (21% oil and gas industry, 20% environmental industry, and 9% in other private sector industries) (Figure 4.5). This may be driven by the high percentage of geoscience Master's student with a positive perception of employment in the environmental industry (61%) and in the petroleum industry (42%) (Table 4.2).

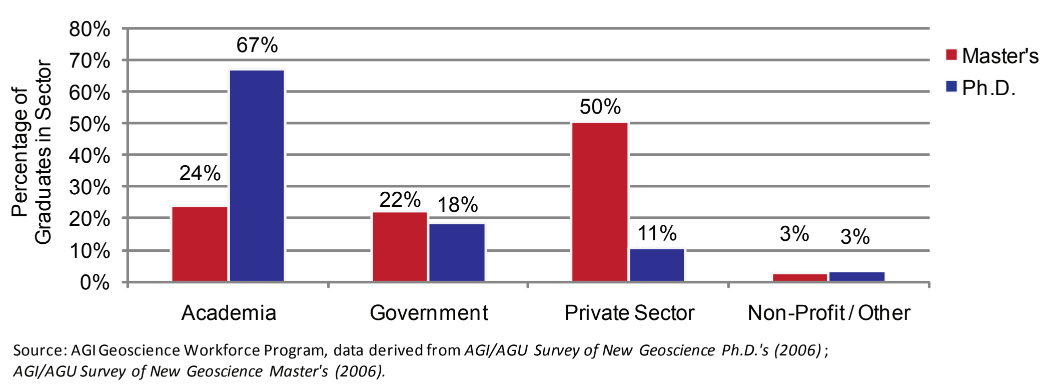
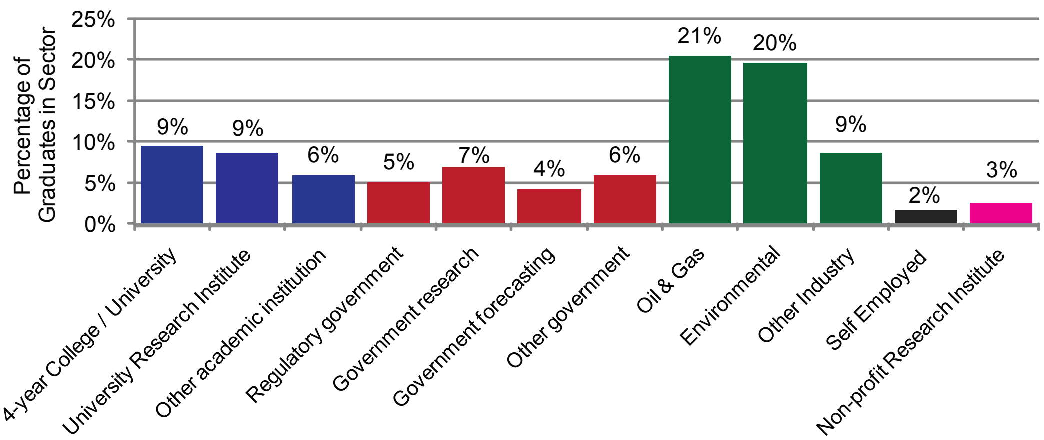
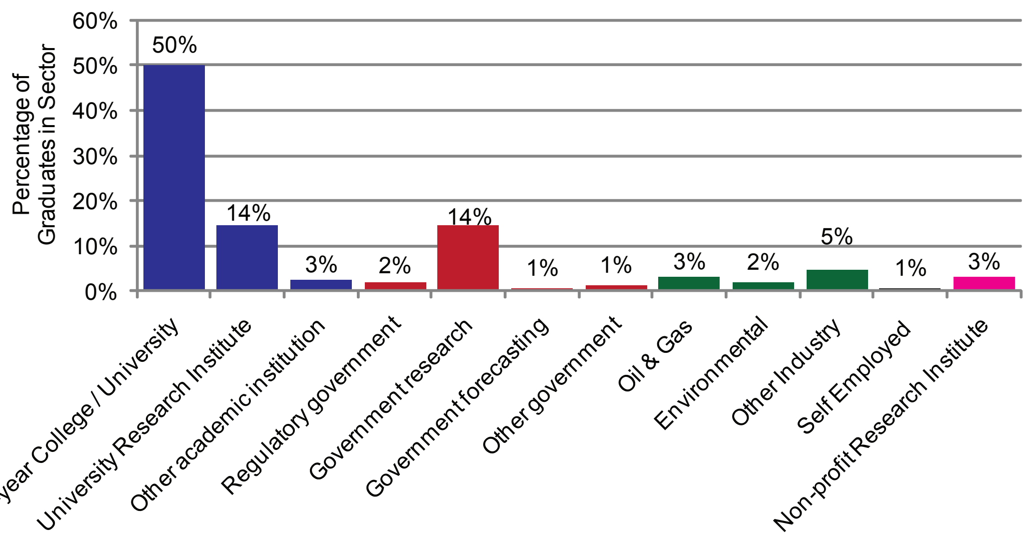


Figure 4.5: Percentage of Geoscience Graduate Degree Recipients Working in Different Employment Sectors



Source: AGI Geoscience Workforce Program, data derived *AGI/AGU Survey of New Geoscience Master's (2006).*

Figure 4.6: Percentage of Geoscience Master's Degree Recipients Working in Different Employment Sectors



Source: AGI Geoscience Workforce Program, data derived *AGI/AGU Survey of New Geoscience Ph.D.'s (2006).*

Figure 4.7: Percentage of Geoscience Ph.D. Degree Recipients Working in Different Employment Sectors

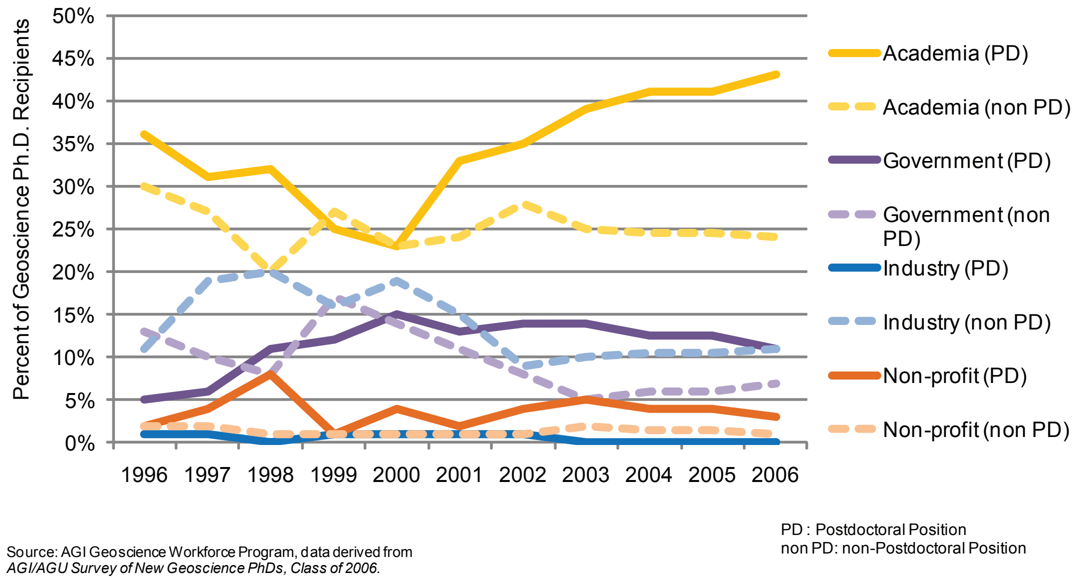


Figure 4.8: Percentage of Geoscience Ph.D. Degree Recipients Working in Post-Doctoral and Non Post-Doctoral Positions

Since 1996, the majority of new geoscience Ph.D. graduates have entered into academic positions (both post-doctoral and non-postdoctoral). Of note, is the increase in new geoscience Ph.D. recipients taking academic post-doctoral positions since 2000 (Figure 4.8). This is due to a variety of factors:

The dot-com bust (1999-2001) caused a decrease in job opportunities as markets shrank. As a result of the ensuing recession, more geoscience faculty began to work later into their careers, delaying retirement. As a result, there were fewer openings in faculty positions in the following years.

In 2000, there was a sharp increase of over two hundred million dollars in federal funding for the geosciences, the majority of which was marked for interdisciplinary geoscience research. With more faculty delaying retirement thus reducing the number of open tenure-track faculty positions, and more funding available for geoscience research at universities, more post-doctoral positions became available. New Ph.D. graduates during this period were suited for this funding environment. The majority of Ph.D. dissertations in 1999 and 2000 pertained to either interdisciplinary science (44%) or geological sciences (44%).

The majority (81%) of new geoscience Ph.D. recipients focus their job search on academic positions, and most (62%) plan to work in academia in the next 10 years. Additionally, geoscience doctoral recipients have a more positive attitude about the academic sector than they do of other employment sectors. Conversely, new geoscience Master's recipients focus their job searches primarily in the private sector and government, and most new geoscience Master's degree recipients plan to work in either the private sector or academe in the next 10 years. Three-quarters of new geoscience Master's degree recipients find employment within 3 months of job searching, and over 80 percent of new Ph.D. recipients find employment within 6 months of job searching.

Since 2006, data from NSF's Survey of Earned Doctorates indicates a continued increase in geoscience doctorates moving into postdoctoral positions (Figure 4.9). Between 2007 and 2008, there was a substantial increase in the percentage of geoscience doctorates finding employment (non-postdoctoral positions) in industry and a decrease in the percentage of doctorates finding employment in government and academia (Figure 4.10). Furthermore, between 2007 and 2009, the percentage of geoscience doctorates employed in non-U.S. locations increased from 10 percent to 12 percent.

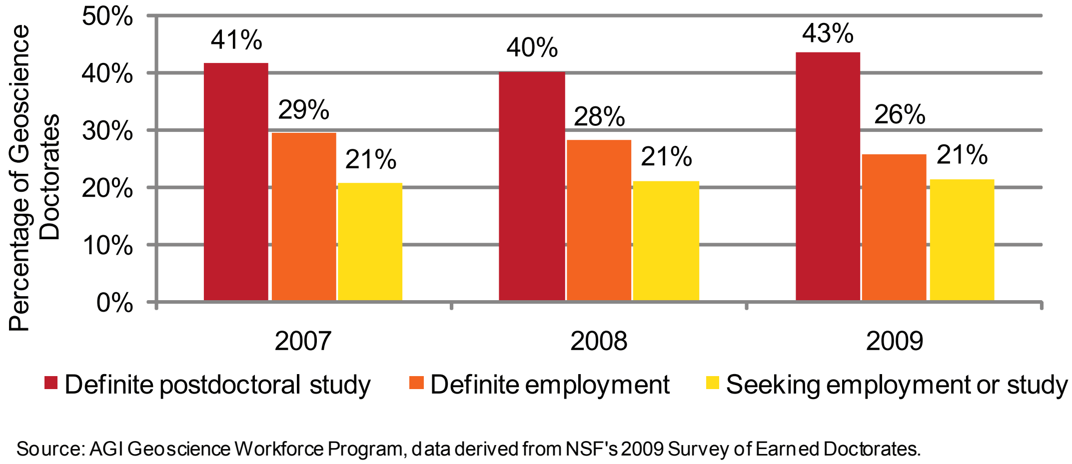


Figure 4.9: Post-Graduation Plans of Geoscience Doctorates (2007-2009)

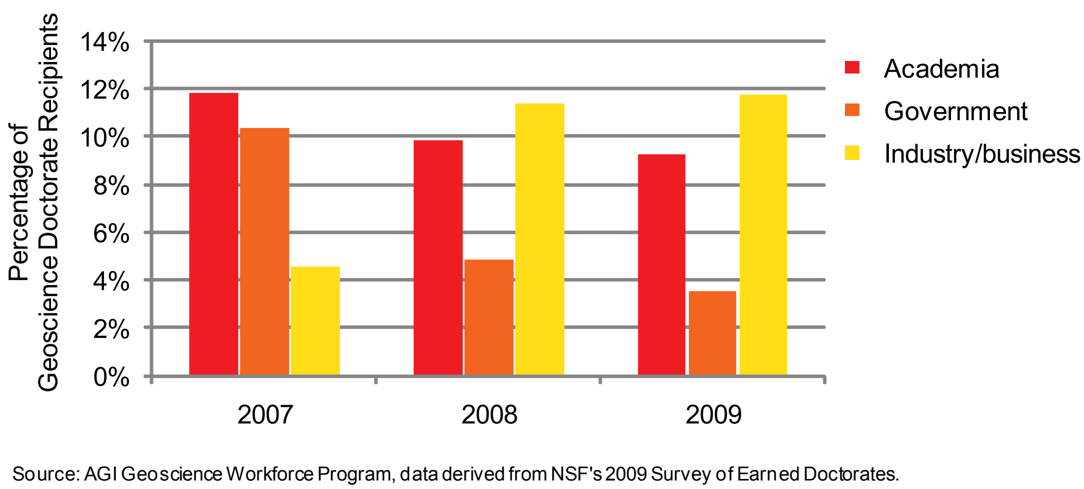


Figure 4.10: Employment Sectors of Recent Geoscience Doctorates Employed in Non-Postdoctoral Positions (2007-2009)

Starting Salaries of Recent Geoscience Graduates

Geoscience starting salaries were competitive with other science and engineering fields in 2007. Bachelor's geoscience graduates, generally employed in the environmental and hydrogeology industry, earned an average of $31,366 p.a. compared to $31,258 for life scientists and $32,500 for chemistry students.

Recent geoscience Master's recipients had the highest starting salaries in the oil and gas industry, with an average of $81,300 per year, according to a new AGI/AGU study of recent geoscience graduates (Table 4.4). This salary level is significantly higher than the average starting salary of all science Master's degree recipients, who earned an average of $46,873 per year. New doctorate recipients in all fields of science earned an average salary of $62,059 in the private sector, while new geosciences doctorates commanded an average salary of $72,600 (Table 4.5).

Industry	Average Salary	Median Salary
Oil & Gas Industry	$81,300	$82,500
Environmental Industry	$47,500	$45,550
Government	$46,200	$45,000

Table 4.4: Starting Salaries for New Geoscience Master's Degree Recipients

(Source: AGI Geoscience Workforce Program, data derived from AGI/AGU Survey of New Geoscience Master's, Class of 2006)

Industry	Average Salary	Median Salary
Postdoc- Academia	$43,100	$42,000
Postdoc-Government	$55,200	$53,000
Potentially Permanent - Academia	$51,900	$52,500
Private Sector	$72,500	$71,000

Table 4.5: Starting Salaries for New Geoscience Ph.D. Degree Recipients

(Source: AGI Geoscience Workforce Program, data derived from AGI/AGU Survey of New Geoscience PhD's, Class of 2006)

Skills Used by New Geoscience Master's and Doctoral Degree Recipients

Unsurprisingly, a higher percentage of geoscience doctorates than Master's recipients use cognitive skills, technical skills, and use knowledge from their research field as well as a broad knowledge of geoscience (Figure 4.11). In part, this may be because the majority of geoscience doctorates enter into academia where these skills, developed during their academic training, are continued to be used. The majority of geoscience Master's graduates find work in the private sector or in government positions where cognitive skills are used, but specific technical skills developed in their education may not be used as they adopt industry-specific techniques. Of note is the high percentage of geoscience Master's graduates that use knowledge from their research field and those who use a broad knowledge of the geosciences in their jobs.

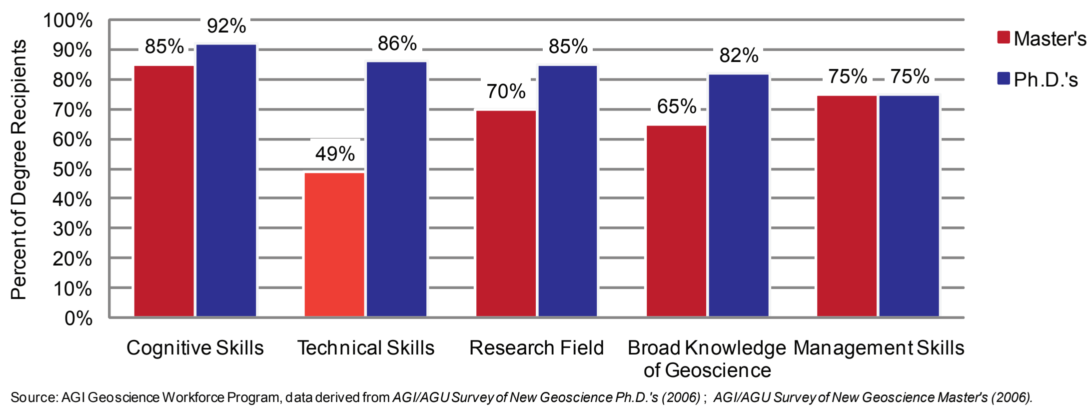


Figure 4.11: Knowledge and Skills Used by Geoscience Graduate Degree Recipients

For geoscience Master's degrees, cognitive skill percentages are down-weighted by those in government positions and the other skills and knowledge percentages are down-weighted by those working in the environmental industry. Those geoscience Master's graduates working in the oil and gas industry use knowledge and skills across all categories more than those geoscience Master's graduates working in other sectors, and more than overall geoscience Ph.D. graduates working in the private sector.

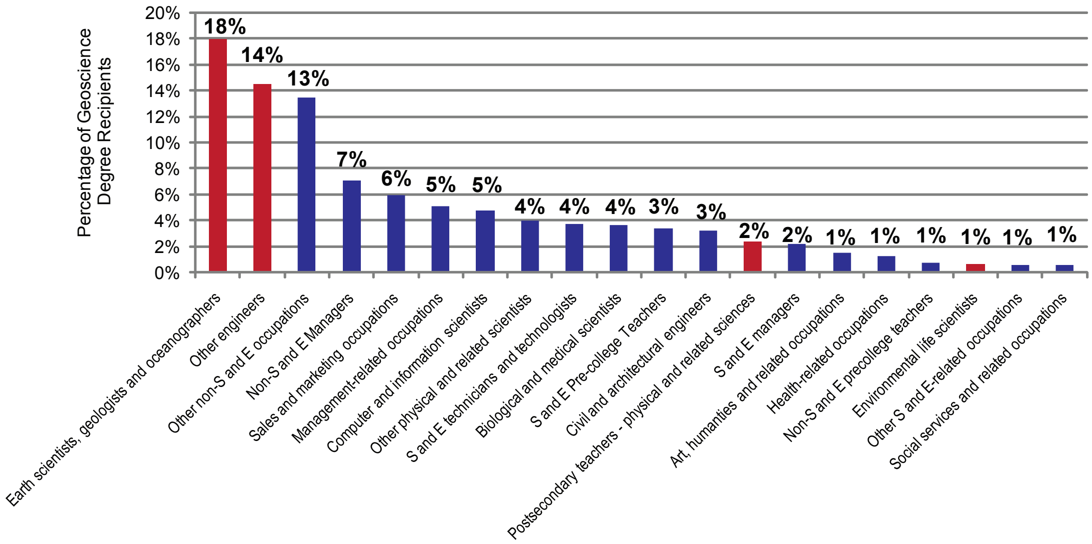
	Cognitive Skills	Technical Skills	Research Field	Broad Geoscience Knowledge	Management Skills
Ph.D.'s					
Any Post-doctoral position	96%	94%	97%	90%	70%
Potentially Permanent - Academe	89%	75%	79%	79%	82%
Private Sector	94%	75%	44%	75%	75%
All Other Sectors	80%	81%	77%	65%	81%
Average for all Ph.D.'s	92%	86%	85%	82%	75%
Master's					
Oil & Gas Industry	100%	79%	69%	71%	79%
Environmental Industry	82%	70%	39%	52%	78%
Government	77%	77%	54%	65%	77%
All Other	84%	67%	43%	68%	71%
Average for all Master's	85%	70%	49%	65%	75%

Table 4.6: Knowledge and Skills Used by New Geoscience Ph.D. and Master's Degree Recipients (2006)

(Source: AGI Geoscience Workforce Program, data derived from AGI/AGU Survey of New Geoscience PhD's, Class of 2006 and from AGI/AGU Survey of New Geoscience Master's, Class of 2006)

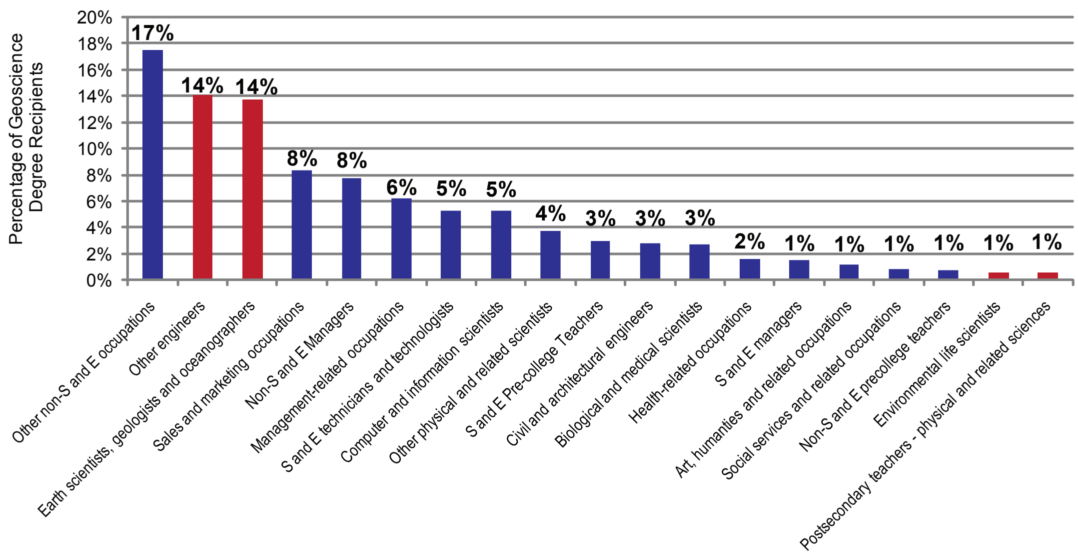
Career Trajectories of Geoscience Degree Recipients

Data from NSF's 2006 SESTAT database indicates that 35 percent of geoscience graduates at all degree levels work in core geoscience occupations (highlighted on Figure 4.12). This percentage increases with degree level from 30 percent at the Bachelor's degree level to 68 percent at the doctoral level (highlighted on Figures 4.13-4.15). Although the majority of geoscience Bachelor's and Master's geoscience degree holders work outside of core geoscience occupations, the majority of these graduates work within science and engineering fields. The low percentage of geoscience Bachelor's degree holders working in core geoscience occupations is likely due to the low number of geoscience jobs available to undergraduate degree holders. Additionally, at the Master's degree level, the low percentage of geoscience graduates working in core geoscience occupations may be due to the variety of sectors in which graduates search for work and the applicability of a geoscience degree in a variety of occupations.



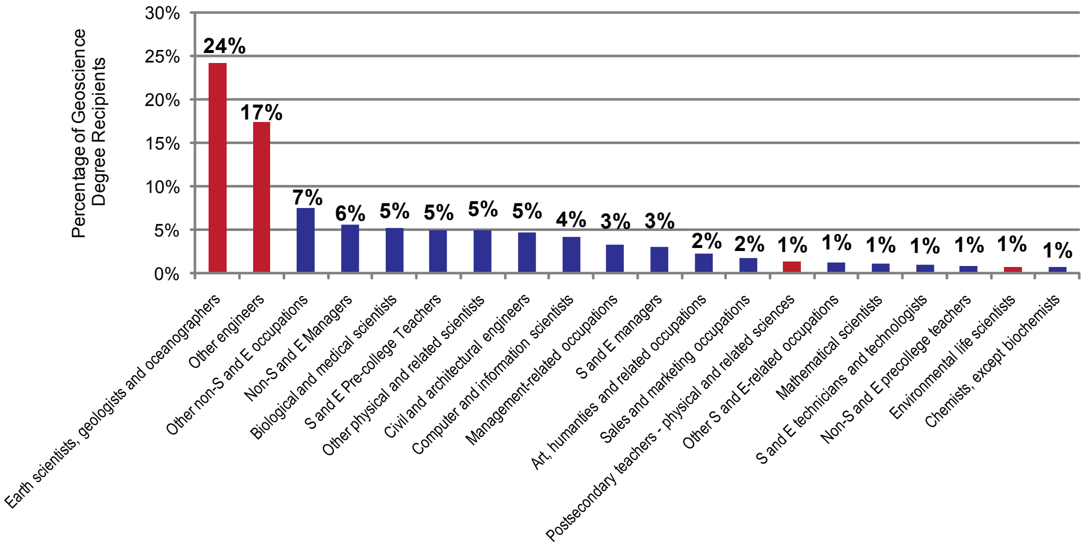
Source: AGI Geoscience Workforce Program; data derived from NSF's 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System.
The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.12: Career Trajectories of All Geoscience Graduates for All Degree Levels (2006)



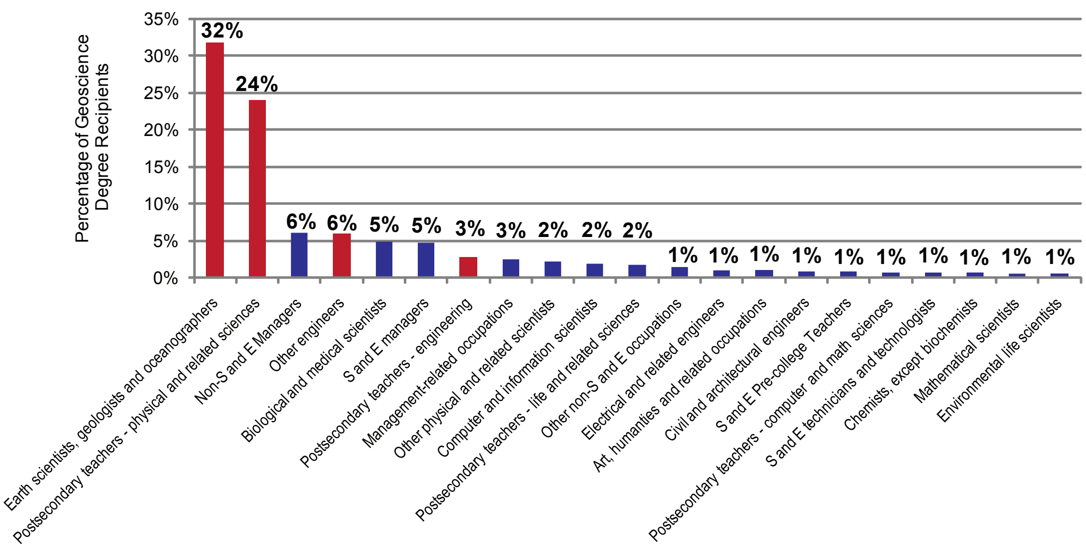
Source: AGI Geoscience Workforce Program; data derived from NSF's 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System.
The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.13: Career Trajectories of Geoscience Bachelor's Degree Recipients (2006)



Source: AGI Geoscience Workforce Program; data derived from NSF's 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System.
The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.14: Career Trajectories of Geoscience Master's Degree Recipients (2006)



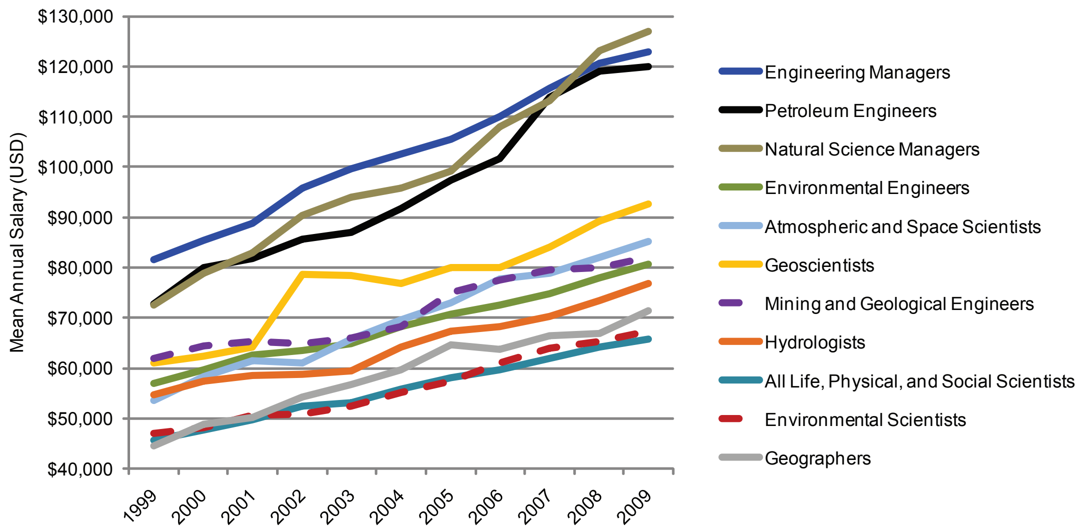
Source: AGI Geoscience Workforce Program; data derived from NSF's 2006 SESTAT Restricted Access Files. SESTAT is the Scientists and Engineers Statistical Data System.
The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.15: Career Trajectories of Geoscience Doctoral Degree Recipients (2006)

Salary Trends for Geoscience Occupations

Despite the U.S. economy's downturn, geoscience salaries increased by 3.1 percent between 2008 and 2009, which was slightly more than the salary growth for other science occupations (2.1%) and for all U.S. occupations (2.8%) (Figure 4.16). In 2009, the top geoscience salaries were for management positions (Natural Science Managers: $127,000, Engineering Managers: $122,810), petroleum engineers ($119,960), and geoscientists (excluding hydrologists and geographers) ($92,710). Mean annual salaries for environmental scientists ($67,360) were $1,700 greater than national average for other science occupations.

Salary growth between 1999 and 2009 for environmental scientists, environmental engineers, hydrologists, and mining and geological engineers lagged the national average salary growth for other science occupations. However, mean annual salaries for the majority of geoscience occupations increased more than the national average for other science occupations between 2008 and 2009.

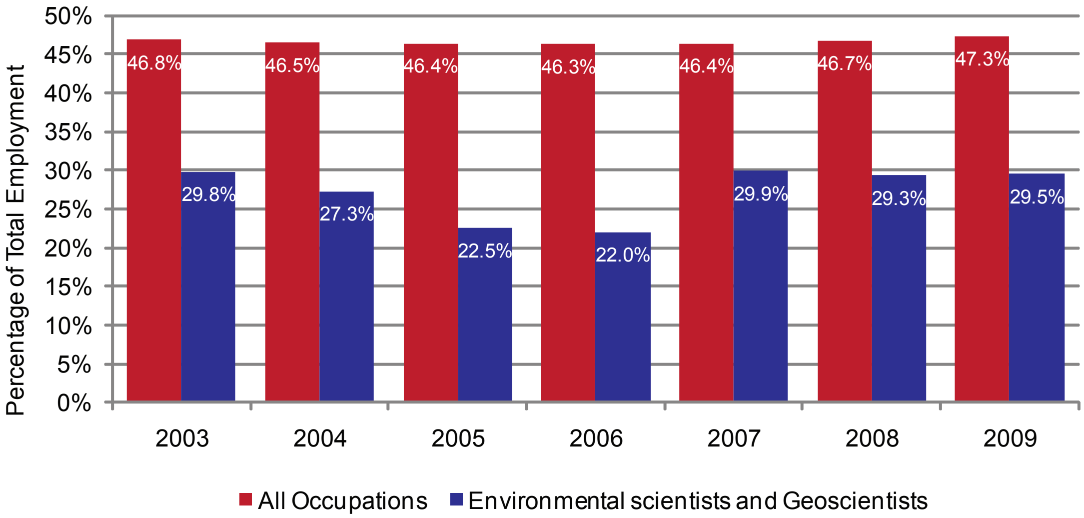


Source: AGI Gesocience Workforce Program, data derived from the U.S. Bureau of Labor Statistics, National Occupational Employment and Wage Estimates, 1999-2009

Figure 4.16: Mean Annual Salaries of Geoscience Occupations (1999-2009)

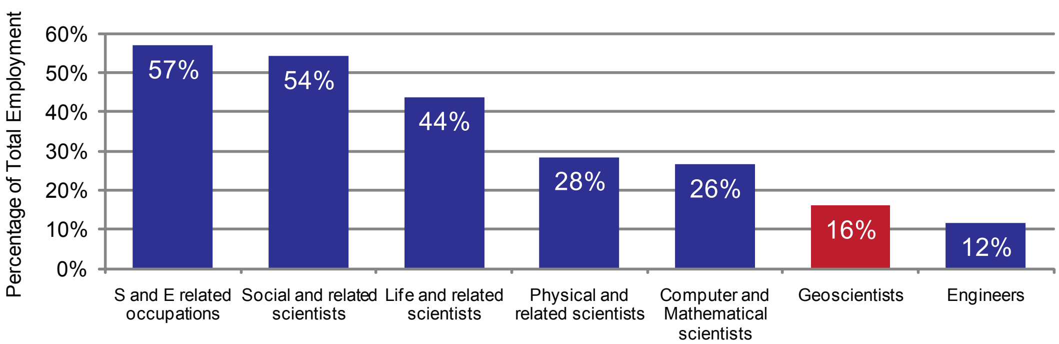
Demographics of the Geoscience Profession

The percentage of women in the U.S. workforce has remained near 47 percent since 1995, and although women earn nearly 40 percent of all geoscience degrees, the percentage of women in geoscience and environmental science occupations has remained near 30 percent since 2003 (Figure 4.17). In 2006, the representation of women in geoscience occupations lagged other science disciplines, but was higher than engineering disciplines (Figure 4.18). Examination of gender parity in detailed geoscience occupational categories reveals that women have the highest participation rates in oceanography (28 percent) and the lowest in mining and geological engineering (2%) (Figure 4.19).



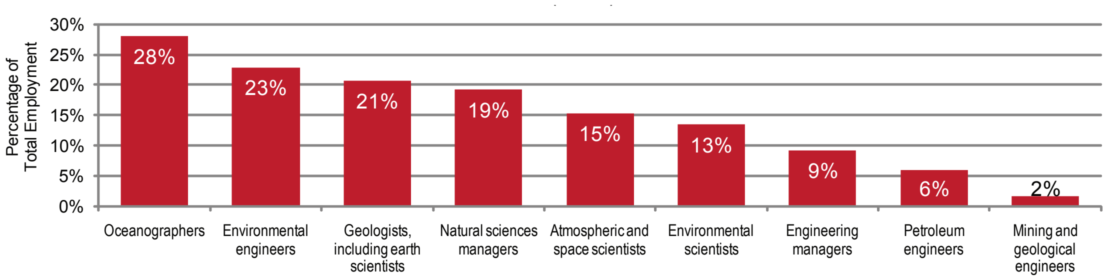
Source: AGI Geoscience Workforce Program, data derived from the U.S. Bureau of Labor Statistics, Current Population Survey

Figure 4.17: Percentage of Women in Environmental Science and Geoscience Occupations



Source: AGI Geoscience Workforce Program; data derived from NSF's SESTAT 2006 Restricted Access Database. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.18: Percentage of Women in Geoscience and Other Science and Engineering Occupations



Source: AGI Geoscience Workforce Program; data derived from NSF's SESTAT 2006 Restricted Access Database. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.19: Percentage of Women in Detailed Geoscience Occupations

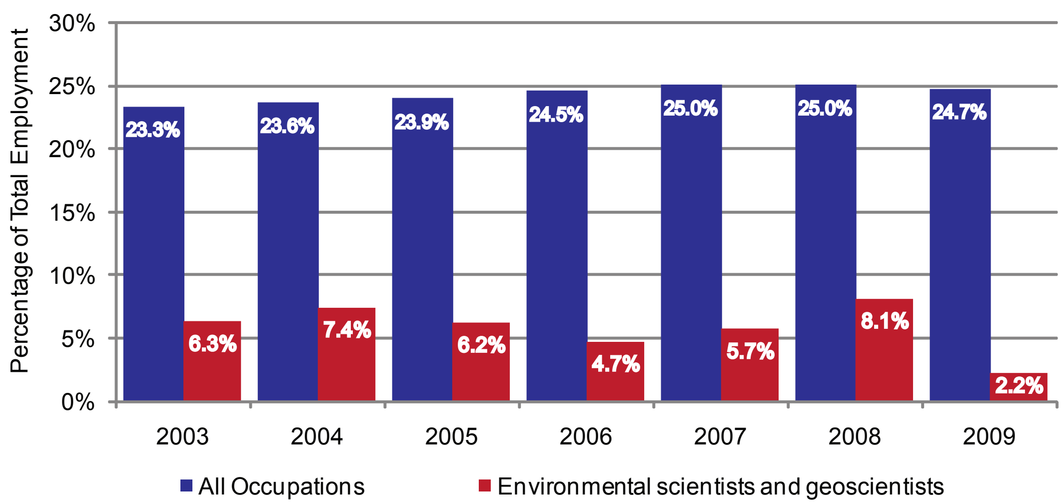
The participation of underrepresented minorities (e.g., Hispanics, African Americans, and Native Americans) in the whole U.S. workforce increased from ~23 percent to ~25 percent between 2003 and 2009 (Figure 4.20). This increase was driven by growth in Hispanic participation rates (12.6 percent to 14 percent). In comparison, the percentage of underrepresented minorities in environmental science and geoscience occupations varied between 4.7 percent and 8.1 percent between 2003 and 2008, and dropped to 2.2 percent in 2009. In general, Hispanic and African American participation in the geoscience workforce have remained comparable.

NSF's data shows some disagreement with the U.S. Bureau of Labor Statistics data for the 2006 underrepresented minority participation in geoscience occupations (NSF: 3 percent Hispanic and 1.9 percent African American vs. BLS: 1.8 percent Hispanic and 2.9 African American) which may be due to nomenclature classification differences between the two datasets (Figure 4.21). Additionally, the small size of the underrepresented minority population working in environmental and geoscience occupations may cause high variability in the percentages.

Examination of NSF's 2006 data allows for the comparison of underrepresented minorities in geoscience occupations with other science and engineering (S and E) and non-S and E occupations (Figure 4.21). Hispanic participation averages between 4-5 percent for most categories, with the exception of computer sciences and mathematics (3.4 percent) and geosciences (3 percent). African American participation varies the most with the highest participation rate in non-S and E occupations (6.4 percent) and lowest in the geosciences (1.9 percent), and Native American representation approximates 1 percent for all occupational categories.

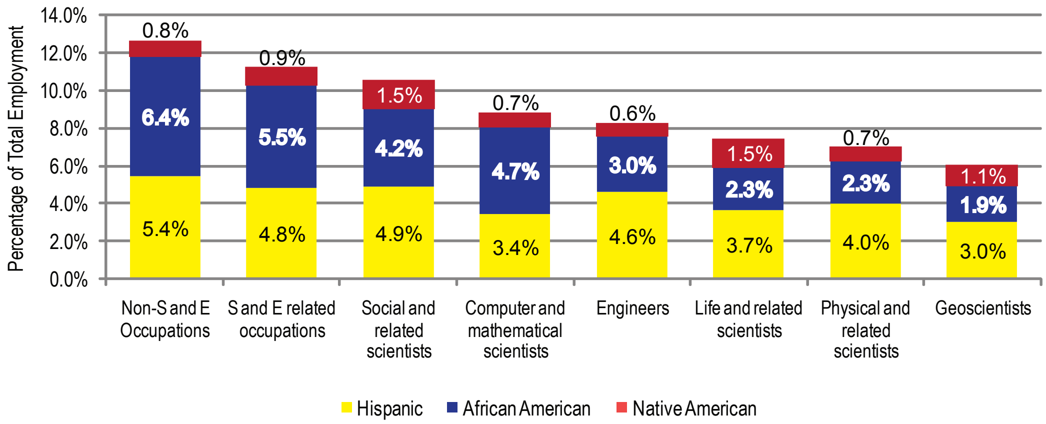
Examination of detailed geoscience occupational data for 2006 reveals that the participation of underrepresented minorities varies greatly by job-type and race/ethnicity (Figure 4.22). Native American participation is greatest in natural sciences manager occupations (7.2 percent), African American participation is greatest in environmental engineering occupations (4.5 percent), and Hispanic participation is greatest in petroleum engineering (5.1 percent) occupations.

Trends in underrepresented minority participation in geoscience occupations is closely linked to participation rates in geoscience academic programs. Effective recruitment programs, retention efforts in these academic programs, and assistance in bridging the transition into successful geoscience careers are needed to boost diversity in both geoscience university programs as well as the geoscience workforce.



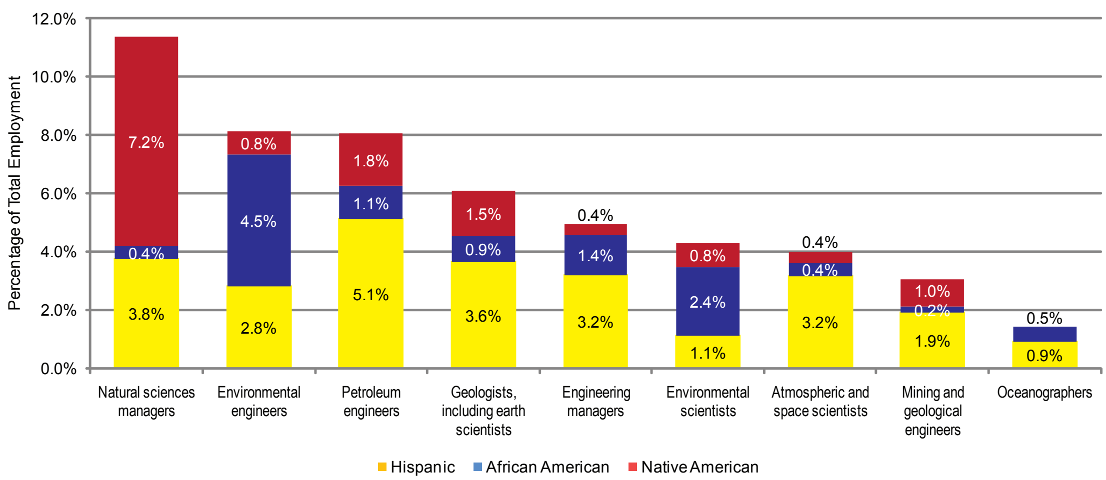
Source: AGI Geoscience Workforce Program, data derived from the U.S. Bureau of Labor Statistics, Current Population Survey

Figure 4.20: Percentage of Underrepresented Minorities in Environmental Science and Geoscience Occupations



Source: AGI Geoscience Workforce Program; data derived from NSF's SESTAT 2006 Restricted Access Database. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.21: Percentage of Underrepresented Minorities in Geoscience and Other Science and Engineering Occupations

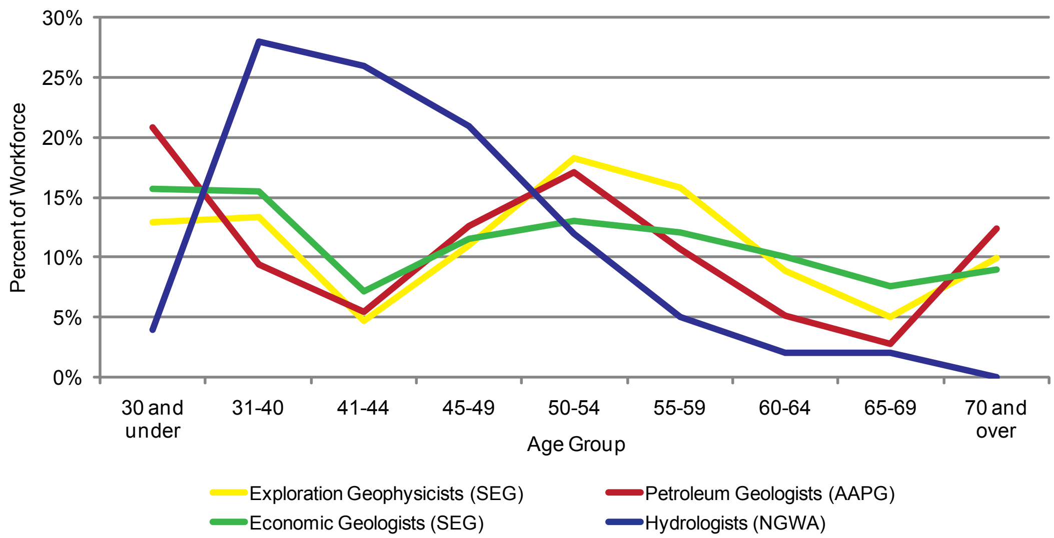


Source: AGI Geoscience Workforce Program; data derived from NSF's SESTAT 2006 Restricted Access Database. SESTAT is the Scientists and Engineers Statistical Data System. The use of NSF data does not imply NSF endorsement of the research, research methods, or conclusions contained in this report.

Figure 4.22: Percentage of Underrepresented Minorities in Detailed Geoscience Occupations

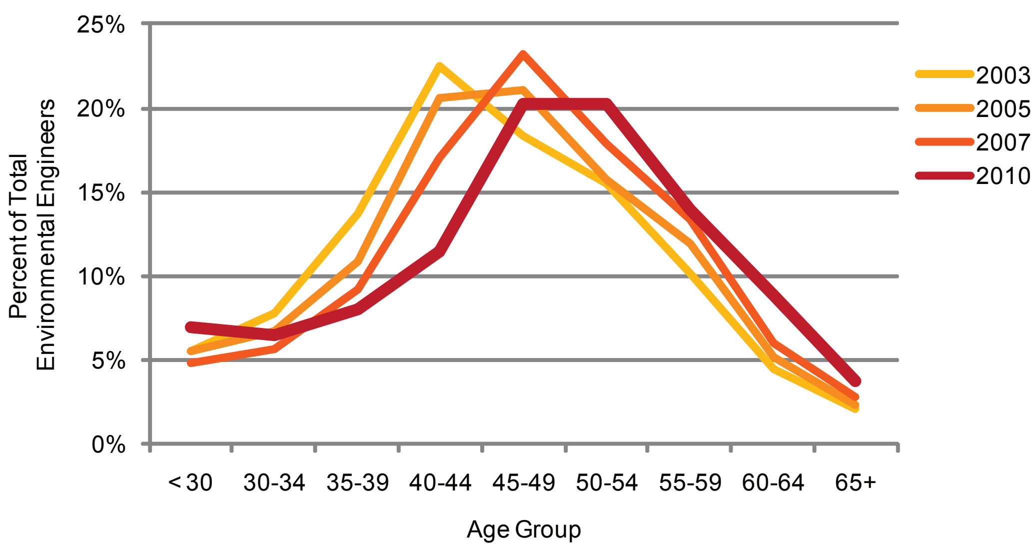
Workforce Age Demographics

The majority of geoscientists in the workforce are within 15 years of retirement age, and data from federal sources, professional societies, and industry indicate this imbalance of the age of geoscientists in the profession. The percentage of geoscientists between 31 and 35 years of age is less than half of geoscientists between 51 and 55 years old. All geoscience occupations in the government, with the exception of meteorologists and oceanographers, have experienced an age shift towards the 50 to 54 year old age group between 2003 and 2009 (Figures 4.24-4.32). Between 2007 and 2009, a marked shift in age distribution from the 50 to 54 year old age group to the 55 to 59 year old age group, and a concurrent slight increase in the percentage of geoscientists under the age of 35 in most government geoscience occupations.



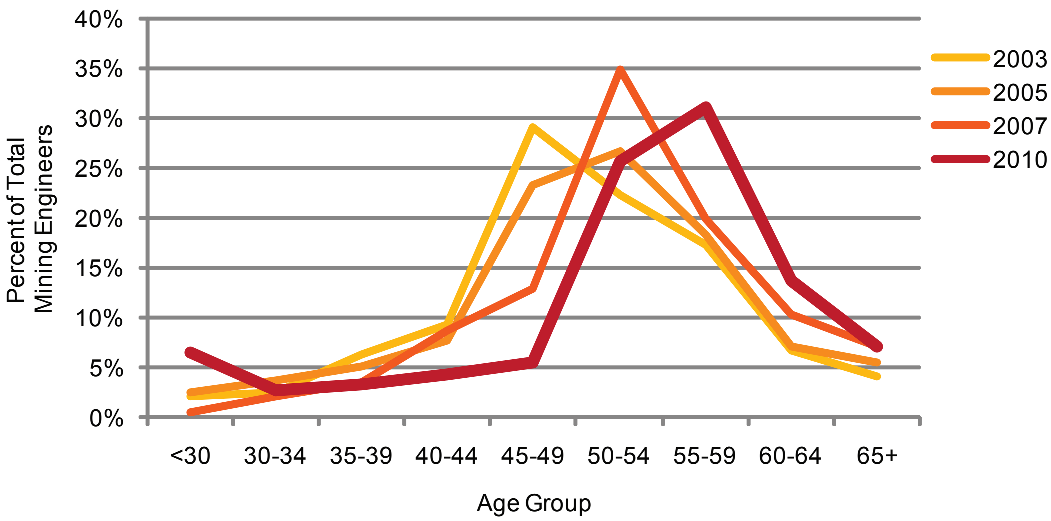
Source: AGI Geoscience Workforce Program, data provided by the Society of Exploration Geophysicists, American Association of Petroleum Geologists, Society of Economic Geologists, and the National Ground Water Association

Figure 4.23: Geoscience Age Demographics by Membership Society



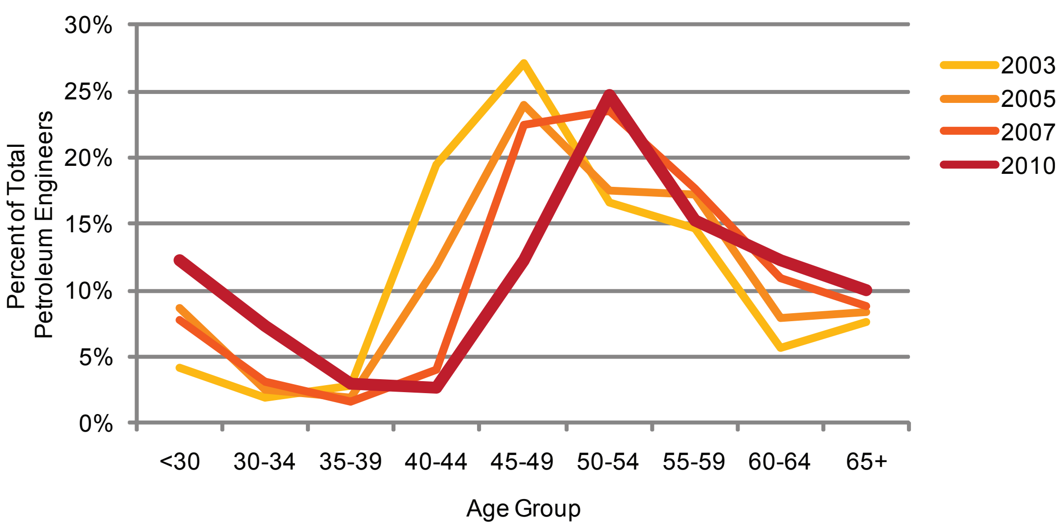
Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.24: Age Distribution of Environmental Engineers in the U.S. Government



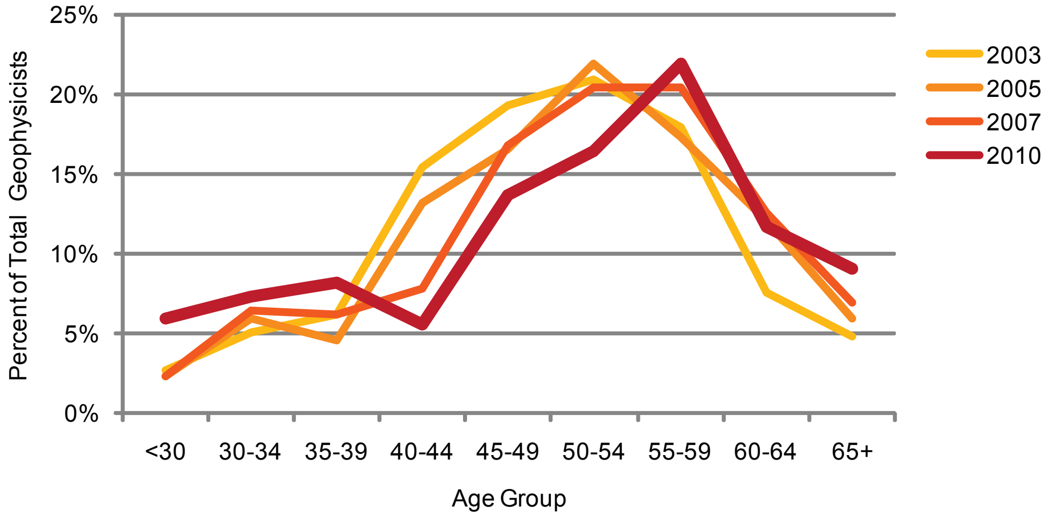
Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.25: Age Distribution of Mining Engineers in the U.S. Government



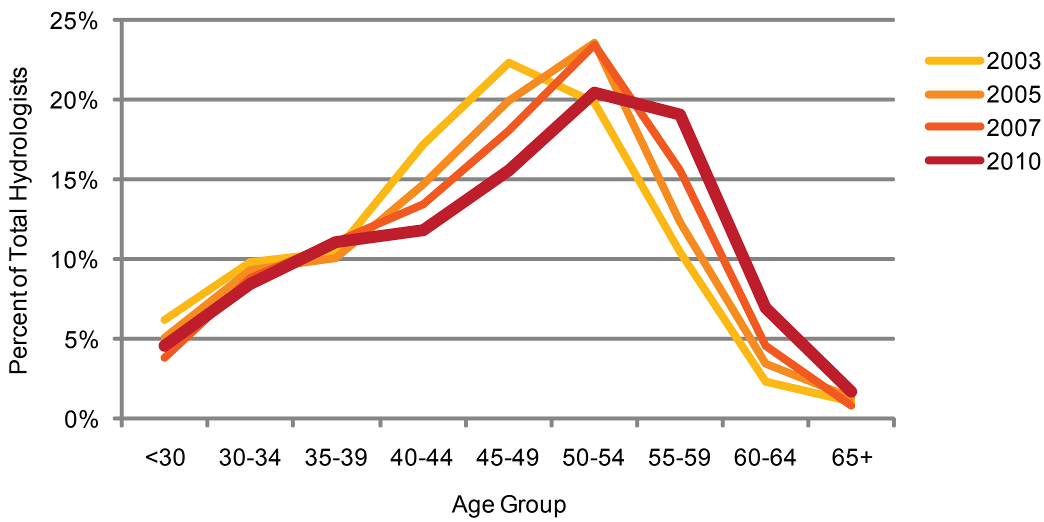
Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.26: Age Distribution of Petroleum Engineers in the U.S. Government



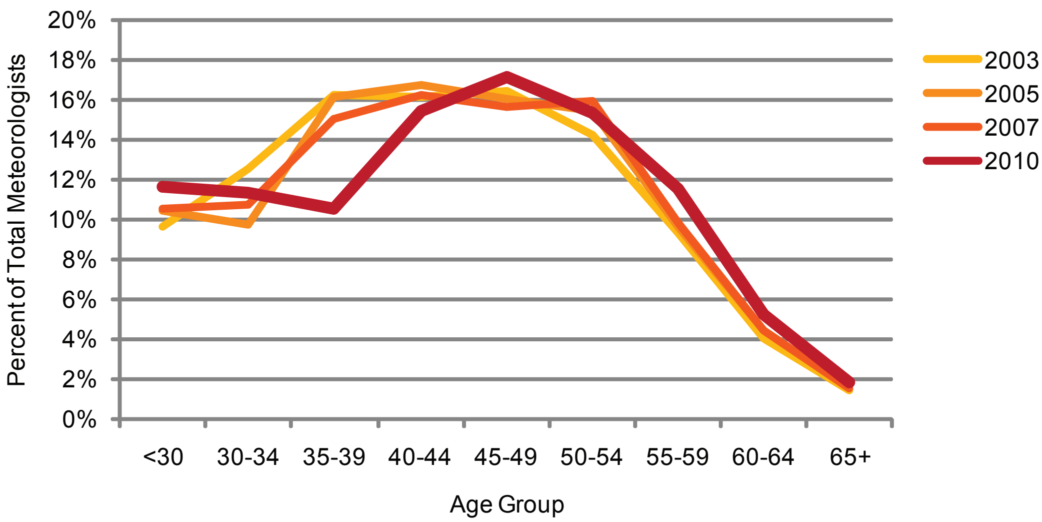
Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.27: Age Distribution of Geophysicists in the U.S. Government



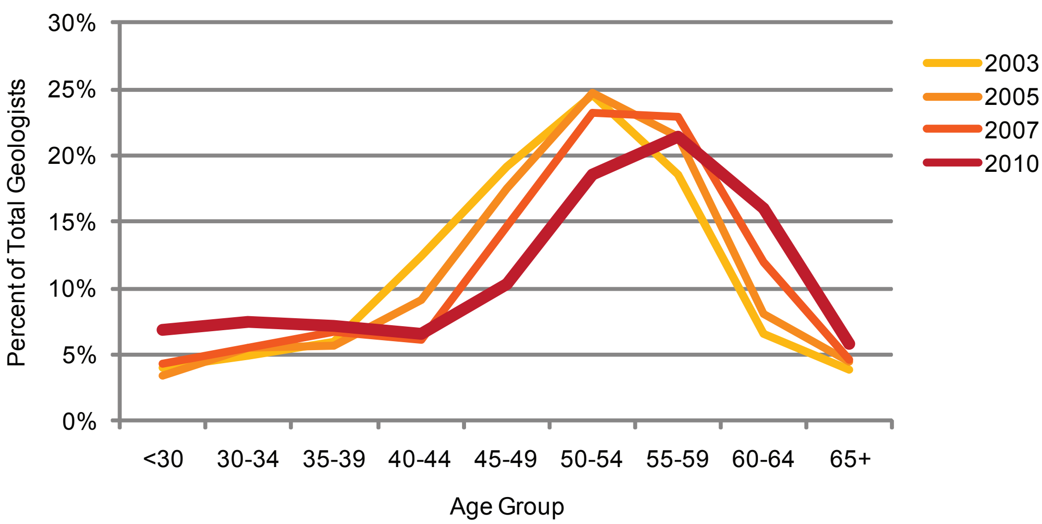
Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.28: Age Distribution of Hydrologists in the U.S. Government



Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.29: Age Distribution of Meteorologists in the U.S. Government



Source: AGI Geoscience Workforce Program. Data derived from the Office of Personnel Management fedscope database.

Figure 4.30: Age Distribution of Geologists in the U.S. Government

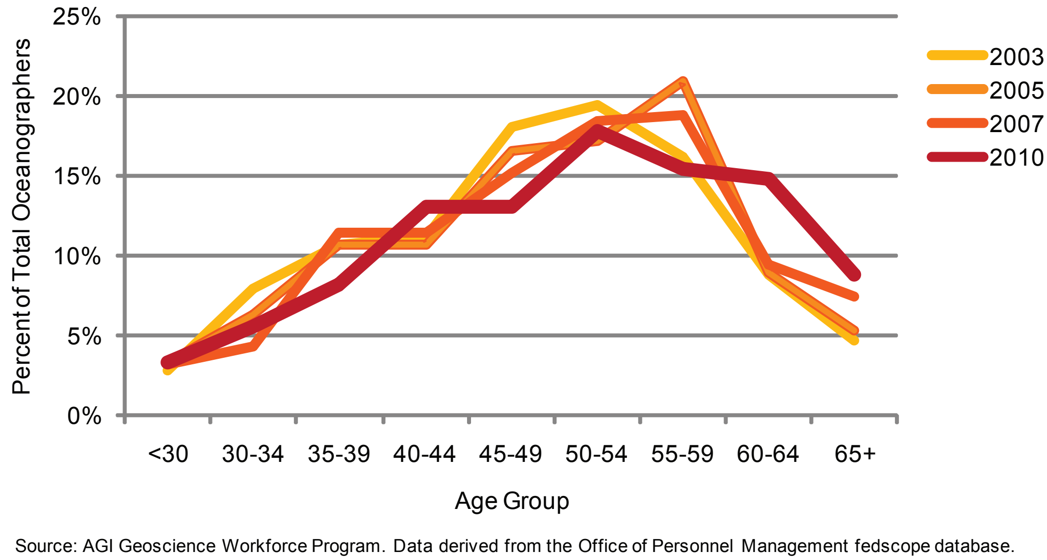


Figure 4.31: Age Distribution of Oceanographers in the U.S. Government

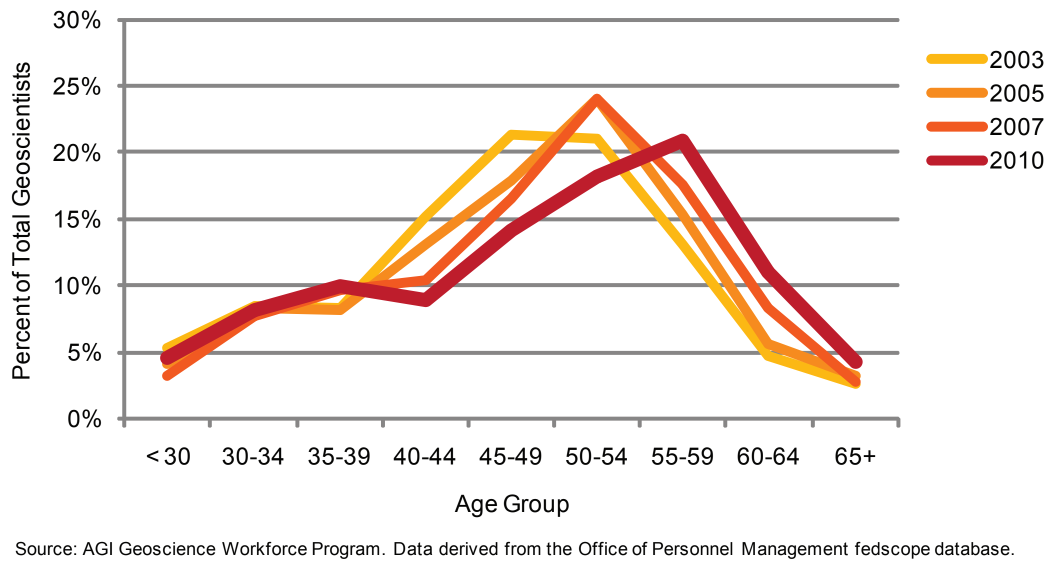


Figure 4.32: Age Distribution of Geoscientists in the U.S. Geological Survey

In oil & gas companies, which typically offer the highest salaries of all geoscience employing industries, the supply of new geoscientists falls short of replacement needs. The number of younger geoscientists in their early 30's is approximately half the number of those nearing retirement age (Figure 4.33).

Figure 4.33: Age Distribution of Geoscientists in the Oil and Gas Industry

Additionally, the supply of geoscientists is not expected to meet the demand for geoscientists over the next 20 years in the oil and gas industry (Figure 4.35). Even with an optimistic three percent increase in graduate geoscience students entering the petroleum industry and a conservative of two percent growth in annual demand for geoscientists after 2011, by 2030, the unmet demand for geoscientists in the petroleum industry will be at least 13,000 for the low-demand estimate. Even if the supply of foreign geoscience graduates is added to the U.S. graduate pool, the gap is not significantly narrowed.

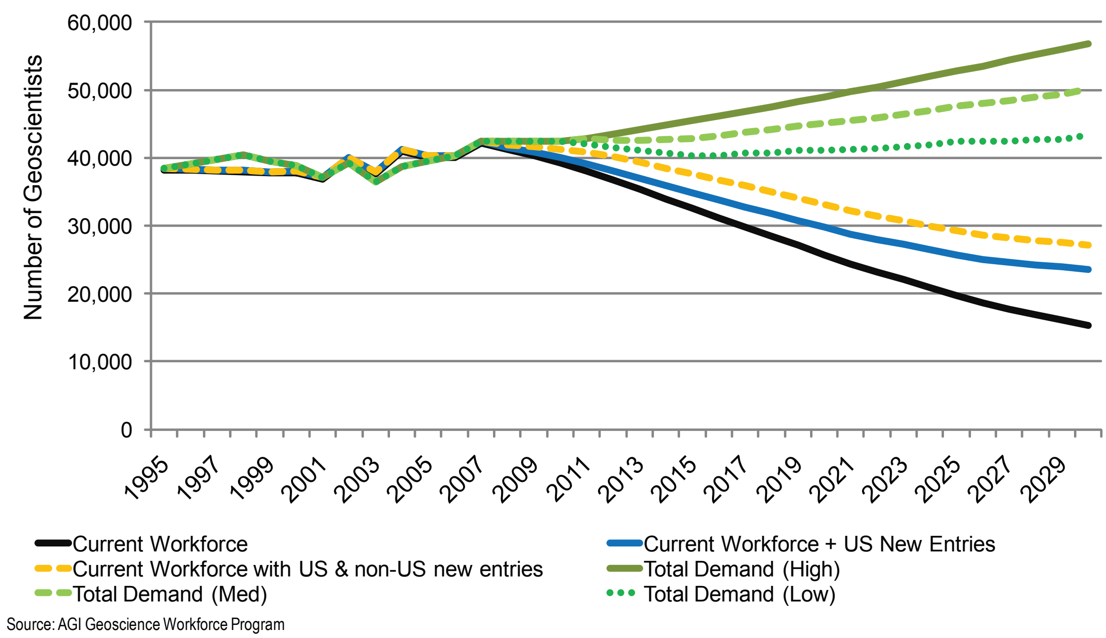
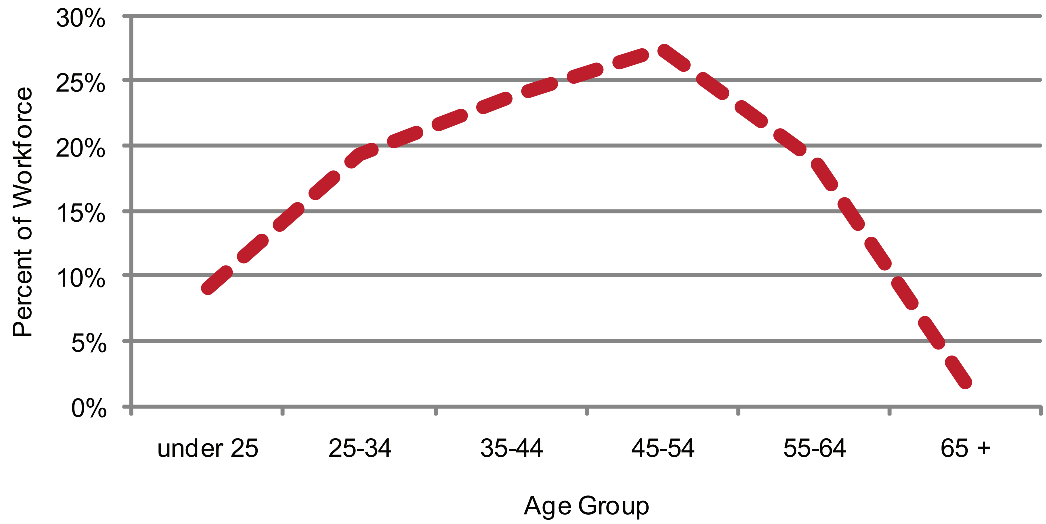


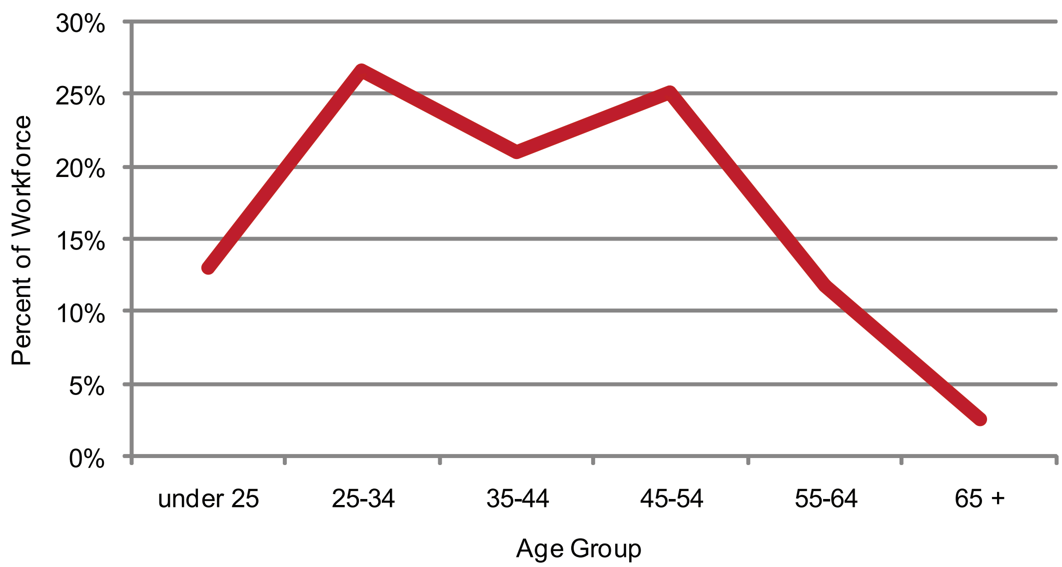
Figure 4.34: Oil & Gas Industry Geoscientist Supply and Demand

In the mining industry, the age demographic trends are similar to other geoscience employing sectors for all mining (except oil and gas extraction), but not for support activities (Figure 4.35). Support activities for mining and oil and gas is the only geoscience employing industry with the demographics that will provide for the replacement of the older generation of geoscientists who will retire within the next 15 years (Figure 4.36).



Source: AGI Geoscience Workforce Program, data derived from the National Mining Association

Figure 4.35: Age Distribution of Geoscientists in Mining

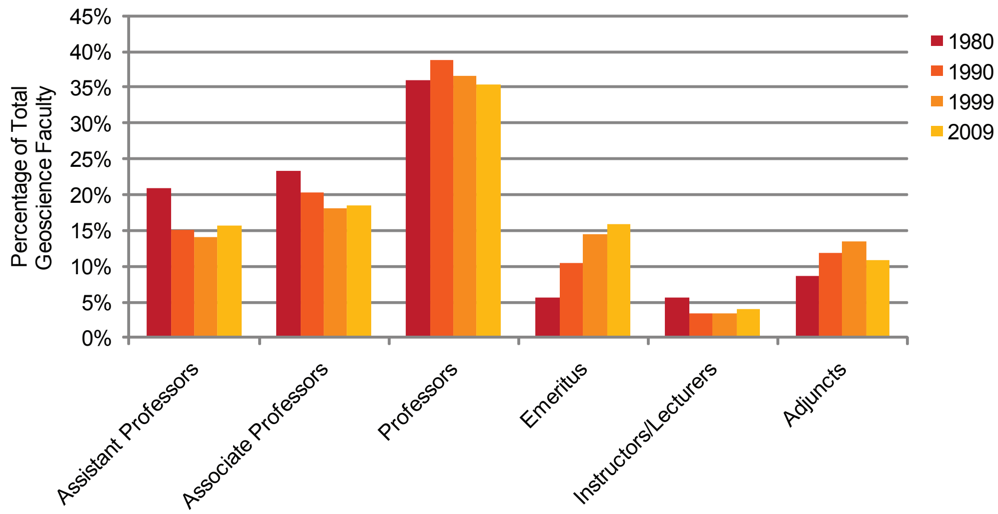


Source: AGI Geoscience Workforce Program, data derived from the National Mining Association

Figure 4.36: Age Distribution of Geoscientists in Support Activities for Mining and Oil & Gas

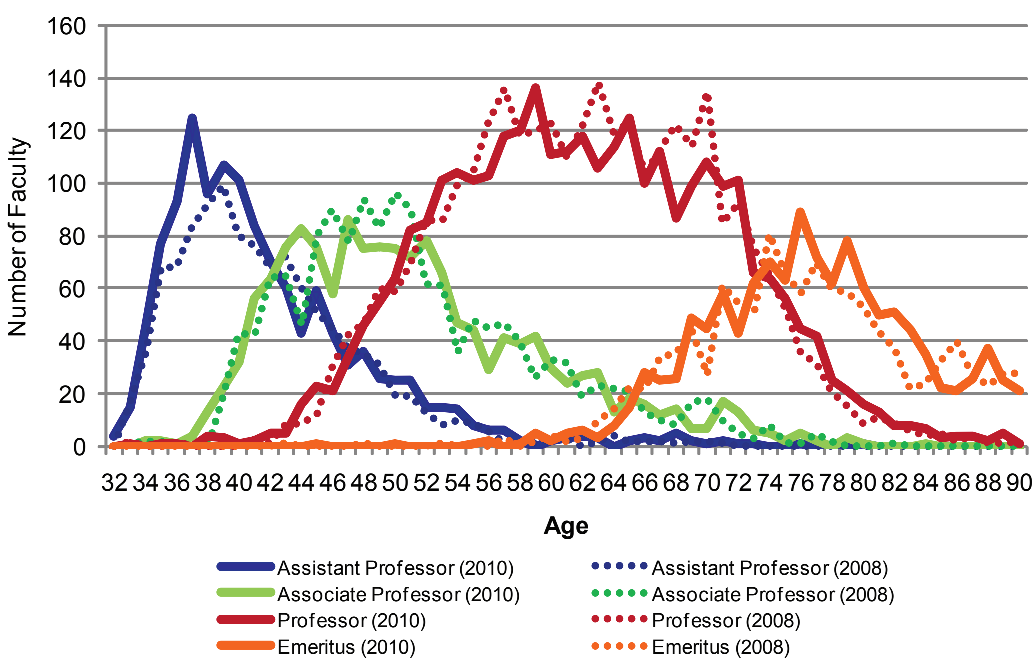
In academia, decadal trends in faculty by rank indicate a increasing percentage of both adjunct and emeritus professors and a decrease in the percentage of tenured and tenure-track positions (Figure 4.37). Within the tenure-track geoscience faculty ranks, geoscientists progress steadily through the academic ranks to full professor by the age of 50 (Figure 4.38). Full professors tend to work later into their career, and there is a cross-over in the population of full professors and emeritus in the 71 to 75 age range. As with other geoscience industries, faculty with full professorships are older (late 50's to mid 70's) and there are 30 percent fewer assistant and associate faculty than full professors.

Between 2008 and 2010, the number of full professor faculty declined slightly as the number of emeritus faculty increased indicating the transition of full professors retire into emeritus positions. Given the current age demographics of geoscience academic faculty, we expect this trend to continue for the next 10 to 15 years. In addition to the decline in full professorships between 2008 and 2010, there was an overall increase in the number of assistant professors, especially between the ages of 35 and 40. Yet, at the associate professor rank, there the number of faculty remained steady over the same time period. Although there was large increase in the number of associate professors between the ages of 41 and 44, there was a decrease in the number of faculty in this rank for all other age groups.



Source: AGI Geoscience Workforce Program. Data derived from AGI's Directory of Geoscience Departments.

Figure 4.37: Trends in Faculty Rank Distribution at Four-Year Institutions (1980-2009)



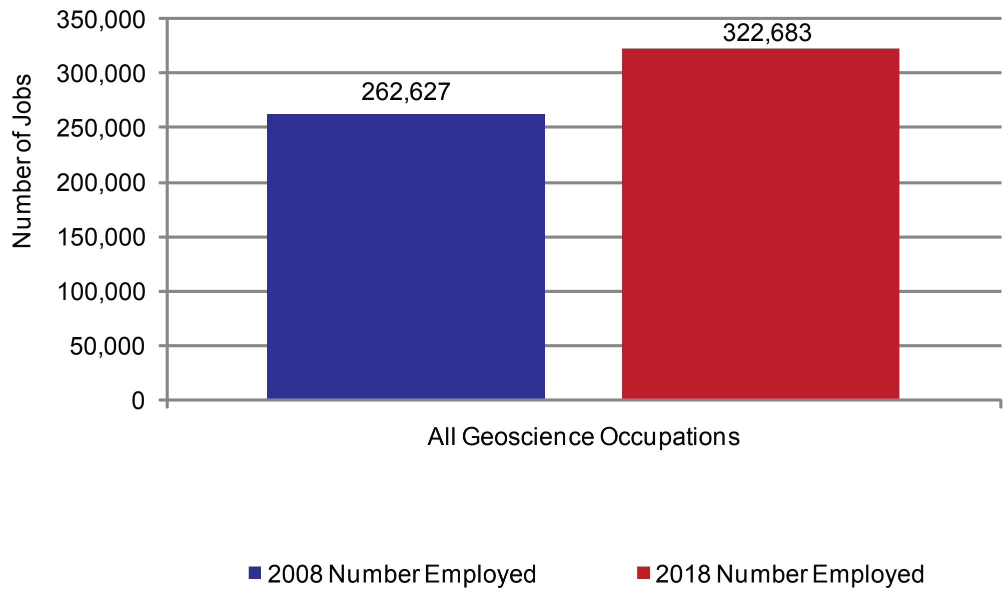
Source: AGI Geoscience Workforce Program.

Figure 4.38: Age Distribution of Geoscience Faculty Members

Geoscience Employment Projections 2008-2018

According to the U.S. Bureau of Labor Statistics there were a total of 262,627 U.S. geoscientist jobs in 2008, and in 2018, the projected number of U.S. geoscientist jobs will be 322,683 (Figure 4.39). Overall, there is a projected 23 percent increase in the number of geoscientist jobs between 2008 and 2018. The increase in job growth will vary among industry with the professional, scientific, and technical services industry having the highest job growth (50 percent) of all industries that employ geoscientists.

These projections do not include job replacements due to attrition. Given the age demographics of the geoscience discipline, we expect a 12 percent job replacement rate for attrition. Although the total demand will remain the same, the total number of jobs available is expected to increase on average by 35 percent between 2008 and 2018 (Figures 4.39-4.41).



Data derived from U.S. Bureau of Labor Statistics, Employment Projections

Figure 4.39: Employment Projections for Geoscience Occupations (2008-2018)

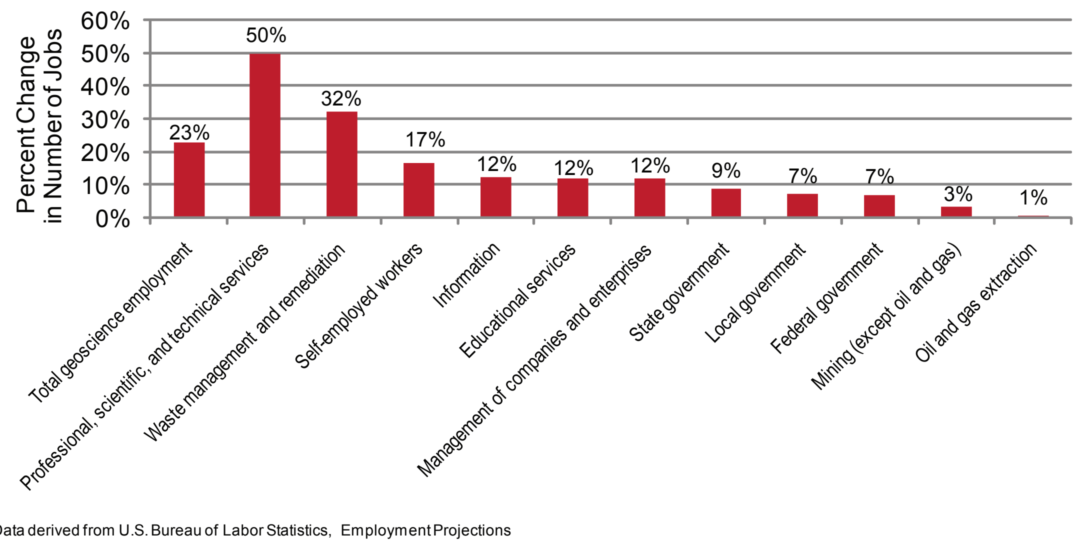


Figure 4.40: Employment Projections for All Geoscience Occupations by Industry Sector (2008-2018)

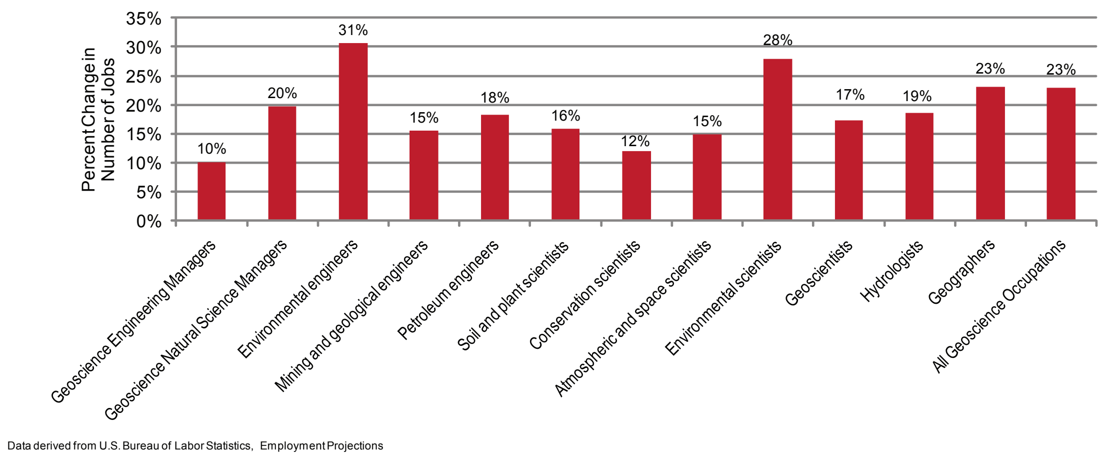


Figure 4.41: Employment Projections for Detailed Geoscience Occupations (2008-2018)

The following table documents the number of jobs in 2008 and in 2018, as well as the 2009 mean annual salaries for geoscientists by occupation and industry. These data were derived from the U.S. Bureau of Labor Statistics.

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
Total employment, all workers				
Engineering Managers (*)	7,105	7,822	10%	$122,810
Natural Science Managers (*)	1,722	2,061	20%	$127,000
Environmental engineers	54,300	70,900	31%	$80,750
Mining and geological engineers, including mining safety engineers	7,100	8,200	15%	$82,080
Petroleum engineers	21,900	25,900	18%	$119,960
Soil and plant scientists	13,900	16,100	16%	$65,180
Conservation scientists	18,300	20,500	12%	$61,180
Atmospheric and space scientists	9,400	10,800	15%	$85,160
Environmental scientists and specialists, including health	85,900	109,800	28%	$67,360
Geoscientists, except hydrologists and geographers	33,600	39,400	17%	$92,710
Hydrologists	8,100	9,600	19%	$76,760
Geographers	1,300	1,600	23%	$71,420
All Geoscience Occupations	262,627	322,683	23%	
Self-employed workers, all jobs				
Engineering Managers (*)	20	20	-2%	-
Environmental engineers	300	300	0%	-
Petroleum engineers	100	100	0%	-
Soil and plant scientists	1,700	1,900	12%	-
Conservation scientists	300	400	33%	-
Environmental scientists and specialists, including health	2,000	2,500	25%	-
Geoscientists, except hydrologists and geographers	800	900	13%	-
Hydrologists	200	200	0%	-
All Geoscience Occupations	5,420	6,320	17%	
Oil and gas extraction				
Engineering Managers (*)	433	365	-16%	$151,650
Natural Science Managers (*)	96	52	-46%	$163,810
Environmental engineers	200	200	0%	$85,160
Mining and geological engineers, including mining safety engineers	1,100	1,000	-9%	$97,140
Petroleum engineers	8,800	9,800	11%	$126,090
Environmental scientists and specialists, including health	300	200	-33%	$73,560
Geoscientists, except hydrologists and geographers	6,300	5,700	-10%	$136,270
All Geoscience Occupations	17,229	17,317	1%	
Mining (except oil and gas)				
Engineering Managers (*)	200	203	2%	$107,000
Environmental engineers	300	300	0%	$74,950
Mining and geological engineers, including mining safety engineers	2,200	2,400	9%	$76,780

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
Environmental scientists and specialists, including health	100	100	0%	$73,030
Geoscientists, except hydrologists and geographers	400	300	-25%	$78,700
All Geoscience Occupations	3,200	3,303	3%	
Support activities for mining				
Engineering Managers (*)	233	205	-12%	$135,280
Mining and geological engineers, including mining safety engineers	300	300	0%	$84,410
Petroleum engineers	3,900	4,000	3%	$102,190
Environmental scientists and specialists, including health	0	0	0%	$64,100
Geoscientists, except hydrologists and geographers	1,900	1,600	-16%	$96,330
All Geoscience Occupations	6,333	6,105	-4%	
Utilities				
Engineering Managers (*)	208	185	-11%	$116,670
Natural Science Managers (*)	8	5	-47%	$123,820
Environmental engineers	800	800	0%	$82,390
Mining and geological engineers, including mining safety engineers	100	100	0%	$74,190
Petroleum engineers	500	500	0%	$110,710
Environmental scientists and specialists, including health	1,000	900	-10%	$79,310
Geoscientists, except hydrologists and geographers	100	100	0%	$85,380
All Geoscience Occupations	2,716	2,589	-5%	
Construction				
Engineering Managers (*)	21	21	0%	$111,160
Environmental engineers	200	200	0%	$70,640
Environmental scientists and specialists, including health	0	0	0%	$66,080
All Geoscience Occupations	221	221	0%	
Manufacturing				
Engineering Managers (*)	561	455	-19%	$120,220
Natural Science Managers (*)	52	47	-9%	$149,580
Environmental engineers	2,900	2,500	-14%	$82,220
Mining and geological engineers, including mining safety engineers	100	100	0%	$80,710
Petroleum engineers	2,200	1,900	-14%	-
Soil and plant scientists	200	200	0%	$74,370
Conservation scientists	0	0	0%	-
Atmospheric and space scientists	100	100	0%	$79,700
Environmental scientists and specialists, including health	1,000	900	-10%	$70,370
Geoscientists, except hydrologists and geographers	900	700	-22%	$114,390
All Geoscience Occupations	8,013	6,902	-14%	
Wholesale trade				
Engineering Managers (*)	31	30	-4%	$130,300
Natural Science Managers (*)	9	9	4%	$132,970
Environmental engineers	200	200	0%	$80,100
Petroleum engineers	200	200	0%	-

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
Soil and plant scientists	1,800	1,700	-6%	$64,570
Environmental scientists and specialists, including health	100	100	0%	$74,290
Geoscientists, except hydrologists and geographers	100	100	0%	$127,280
All Geoscience Occupations	2,440	2,339	-4%	
Transportation and warehousing				
Engineering Managers (*)	33	30	-8%	$119,620
Environmental engineers	200	200	0%	$81,750
Petroleum engineers	500	500	0%	-
Atmospheric and space scientists	100	100	0%	$77,940
Environmental scientists and specialists, including health	200	200	0%	$80,490
All Geoscience Occupations	1,033	1,030	0%	
Information				
Engineering Managers (*)	8	8	-7%	$126,640
Environmental engineers	0	0	0%	$63,610
Petroleum engineers	100	100	0%	-
Atmospheric and space scientists	700	800	14%	$83,150
Geoscientists, except hydrologists and geographers	0	0	0%	$107,220
All Geoscience Occupations	808	908	12%	
Finance and insurance				
Engineering Managers (*)	0	0	-8%	$133,880
Natural Science Managers (*)	0	0	-8%	$162,400
Environmental engineers	0	0	0%	$80,880
Petroleum engineers	100	100	0%	-
Geoscientists, except hydrologists and geographers	100	100	0%	$88,650
All Geoscience Occupations	200	200	0%	
Professional, scientific, and technical services				
Engineering Managers (*)	2,872	3,957	38%	$129,360
Natural Science Managers (*)	786	1,092	39%	$140,570
Environmental engineers	27,800	42,500	53%	$82,530
Mining and geological engineers, including mining safety engineers	2,300	3,200	39%	$80,420
Petroleum engineers	3,600	6,000	67%	$123,410
Soil and plant scientists	3,200	4,500	41%	$68,570
Conservation scientists	900	1,500	67%	$62,440
Atmospheric and space scientists	3,700	4,800	30%	$78,400
Environmental scientists and specialists, including health	35,600	55,200	55%	$71,270
Geoscientists, except hydrologists and geographers	14,300	20,300	42%	$76,210
Hydrologists	3,800	5,000	32%	$78,770
Geographers	200	400	100%	$70,460
All Geoscience Occupations	99,058	148,449	50%	
Architectural, engineering, and related services				
Engineering Managers (*)	3,591	4,596	28%	$123,850
Natural Science Managers (*)	216	266	23%	$111,180

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
Environmental engineers	15,200	20,300	34%	$82,980
Mining and geological engineers, including mining safety engineers	1,800	2,300	28%	$77,210
Petroleum engineers	2,300	3,500	52%	$120,980
Soil and plant scientists	400	500	25%	$57,840
Conservation scientists	100	200	100%	$60,820
Environmental scientists and specialists, including health	12,900	15,900	23%	$65,240
Geoscientists, except hydrologists and geographers	7,600	9,600	26%	$76,220
Hydrologists	2,100	2,600	24%	$79,270
Geographers	100	200	100%	$72,890
All Geoscience Occupations	46,307	59,962	29%	
Testing laboratories				
Engineering Managers (*)	132	138	4%	$124,640
Natural Science Managers (*)	109	122	12%	$106,770
Environmental engineers	1,000	1,100	10%	$73,460
Petroleum engineers	100	100	0%	$74,710
Soil and plant scientists	400	400	0%	$58,500
Conservation scientists	0	0	0%	$39,780
Environmental scientists and specialists, including health	3,000	3,300	10%	$60,190
Geoscientists, except hydrologists and geographers	500	600	20%	$70,510
All Geoscience Occupations	5,241	5,760	10%	
Computer systems design and related services				
Engineering Managers (*)	6	9	46%	$138,690
Natural Science Managers (*)	0	0	5%	$147,780
Environmental engineers	100	200	100%	$90,170
Petroleum engineers	0	0	0%	$125,500
Environmental scientists and specialists, including health	700	1,000	43%	$94,410
Geoscientists, except hydrologists and geographers	100	200	100%	$91,910
All Geoscience Occupations	907	1,410	55%	
Management, scientific, and technical consulting services				
Engineering Managers (*)	678	1,216	79%	$125,260
Natural Science Managers (*)	388	703	81%	$113,160
Environmental engineers	10,600	19,700	86%	$81,690
Mining and geological engineers, including mining safety engineers	300	700	133%	$86,550
Petroleum engineers	800	1,800	125%	$125,360
Soil and plant scientists	1,000	1,900	90%	$64,550
Conservation scientists	600	1,200	100%	$62,380
Atmospheric and space scientists	500	900	80%	$70,740
Environmental scientists and specialists, including health	18,000	33,400	86%	$73,470
Geoscientists, except hydrologists and geographers	5,500	9,200	67%	$73,920
Hydrologists	1,500	2,200	47%	$78,450
Geographers	100	200	100%	$61,660

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
All Geoscience Occupations	39,966	73,120	83%	
Scientific research and development services				
Engineering Managers (*)	304	377	24%	$150,790
Natural Science Managers (*)	389	480	23%	$151,630
Environmental engineers	1,800	2,300	28%	$83,870
Petroleum engineers	400	600	50%	$130,680
Soil and plant scientists	1,700	2,200	29%	-
Conservation scientists	100	100	0%	-
Atmospheric and space scientists	1,600	2,000	25%	$87,180
Environmental scientists and specialists, including health	4,000	4,900	23%	$78,380
Geoscientists, except hydrologists and geographers	1,000	1,300	30%	$85,190
Hydrologists	100	100	0%	$69,410
Geographers	0	0	0%	$68,700
All Geoscience Occupations	11,393	14,357	26%	
Other professional, scientific, and technical services				
Engineering Managers (*)	3	3	-11%	$129,730
Natural Science Managers (*)	3	3	-11%	$138,390
Atmospheric and space scientists	1,400	1,500	7%	$63,200
Environmental scientists and specialists, including health	0	0	0%	$71,740
All Geoscience Occupations	1,406	1,506	7%	
Management of companies and enterprises				
Engineering Managers (*)	106	113	7%	$128,190
Natural Science Managers (*)	34	37	9%	$152,480
Environmental engineers	1,000	1,000	0%	$97,820
Mining and geological engineers, including mining safety engineers	300	400	33%	$91,890
Petroleum engineers	1,400	1,700	21%	$125,470
Soil and plant scientists	200	200	0%	$70,420
Environmental scientists and specialists, including health	600	600	0%	$80,730
Geoscientists, except hydrologists and geographers	700	800	14%	$130,590
All Geoscience Occupations	4,340	4,850	12%	
Administrative and support and waste management and remediation services				
Engineering Managers (*)	58	78	33%	$120,160
Natural Science Managers (*)	7	8	7%	$144,160
Environmental engineers	2,800	3,600	29%	$79,750
Petroleum engineers	100	100	0%	$143,240
Soil and plant scientists	200	300	50%	$42,970
Conservation scientists	0	0	0%	$75,230
Environmental scientists and specialists, including health	1,600	2,100	31%	$65,620
Geoscientists, except hydrologists and geographers	300	400	33%	$82,410
All Geoscience Occupations	5,065	6,585	30%	
Waste management and remediation services				
Engineering Managers (*)	185	248	34%	$119,760

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
Natural Science Managers (*)	31	31	0%	$91,040
Environmental engineers	2,400	3,100	29%	$80,560
Environmental scientists and specialists, including health	900	1,200	33%	$62,970
Geoscientists, except hydrologists and geographers	100	200	100%	$67,030
All Geoscience Occupations	3,616	4,779	32%	
Educational services, public and private				
Engineering Managers (*)	23	25	8%	$111,440
Natural Science Managers (*)	59	65	10%	$106,340
Environmental engineers	300	300	0%	$80,200
Petroleum engineers	100	100	0%	-
Soil and plant scientists	2,000	2,300	15%	$54,850
Conservation scientists	800	900	13%	$53,010
Atmospheric and space scientists	1,200	1,400	17%	$80,870
Environmental scientists and specialists, including health	3,700	4,100	11%	$59,920
Geoscientists, except hydrologists and geographers	1,700	1,900	12%	$77,700
Hydrologists	0	0	0%	$71,700
Geographers	100	100	0%	$50,930
All Geoscience Occupations	9,982	11,190	12%	
Federal government, excluding postal service				
Engineering Managers (*)	572	602	5%	$126,690
Natural Science Managers (*)	853	904	6%	$110,770
Environmental engineers	4,100	4,400	7%	$96,410
Mining and geological engineers, including mining safety engineers	200	200	0%	$87,340
Petroleum engineers	300	400	33%	$94,460
Soil and plant scientists	2,000	2,100	5%	$78,250
Conservation scientists	7,200	7,800	8%	$71,950
Atmospheric and space scientists	3,200	3,200	0%	$94,210
Environmental scientists and specialists, including health	6,100	6,500	7%	$93,700
Geoscientists, except hydrologists and geographers	2,600	2,800	8%	$94,560
Hydrologists	2,200	2,300	5%	$82,150
Geographers	700	900	29%	$76,170
All Geoscience Occupations	30,025	32,106	7%	
State government, excluding education and hospitals				
Engineering Managers (*)	377	419	11%	$86,840
Natural Science Managers (*)	450	477	6%	$75,170
Environmental engineers	7,200	7,900	10%	$66,470
Mining and geological engineers, including mining safety engineers	0	0	0%	$83,120
Petroleum engineers	100	100	0%	-
Soil and plant scientists	400	500	25%	-
Conservation scientists	0	0	0%	$53,000
Atmospheric and space scientists	0	0	0%	$82,230

Occupation	2008 Employed	2018 Employed	Change	2009 Mean Annual Salary
Environmental scientists and specialists, including health	21,400	23,200	8%	$56,480
Geoscientists, except hydrologists and geographers	3,000	3,200	7%	$62,550
Hydrologists	0	0	0%	$64,000
All Geoscience Occupations	32,928	35,796	9%	
Local government, excluding education and hospitals				
Engineering Managers (*)	536	565	5%	$104,860
Natural Science Managers (*)	83	89	8%	$97,670
Environmental engineers	5,400	5,800	7%	$74,650
Soil and plant scientists	600	600	0%	-
Conservation scientists	0	0	0%	$53,110
Environmental scientists and specialists, including health	10,500	11,300	8%	$60,030
Geoscientists, except hydrologists and geographers	100	100	0%	$77,150
Hydrologists	0	0	0%	$68,590
Geographers	100	100	0%	-
All Geoscience Occupations	17,319	18,553	7%	

Data derived from the U.S. Bureau of Labor Statistics, Occupational Employment Statistics (OES) Program: May 2009 National Occupational Employment and Wage Estimates United States and the **Employment Projections Program (EPP):** Industry employment by occupation data tables.

(*): 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.

Table 4.7: U.S. Bureau of Labor Statistics Current and Projected U.S. Geoscience Employment

Chapter 5: Geoscience Metrics and Drivers of the Geoscience Workforce

The fundamental driver of employment in science and technology fields is investment in research and development (R&D) from public and/or private sources. The fortunes of the workforce respond rapidly to changes in R&D investment, but the workforce supply pipeline responds more slowly to these changes, and often rapid changes in investment are echoed in enrollments and degrees awarded years later.

Although the total amount of federal research funding for geoscience research increased steadily between 1970 and 2004, over the past several years there has been a steady decline in the total amount of federal funding invested in the geosciences. Furthermore, the percentage of all federal funding for research and development applied to the geosciences has decreased from nearly 11 percent in 1996 to 6 percent in 2007. Since 1970, the majority of total federal geoscience research funding has been applied to atmospheric science research. Of note is the increase in the percentage of funding applied to environmental science research since 1986. Of additional interest are the drops in funding for oceanographic research (1989 to 1995) and geological science research (1995 to 1998) and the less drastic drop in atmospheric research (1995 to 2003) that are most evident in the basic research funding trends.

Information pertaining to industry research funding of geoscience is limited. Data pertaining to the trends in company research and development funds are available from the NSF / SRS Industry R&D Funding reports for the mining, extraction & support industries. Unfortunately, this data is aggregated so distinct trends for these three industries cannot be investigated. Of note is the abrupt switch from development to research funding that occurred between 2001 and 2002. This trend is also coincident with the drop in commodity output, gross operating surplus, and taxes on production and imports for the oil & gas extraction industry, productive activity (rig counts, a reduction in GDP for all three industries), and a decrease in rig counts and well counts.

A number of geoscience industries are responsible for producing important commodities that keep our society running, such as oil, gas and minerals. In general, commodity price indices follow the energy (fuel) price index. However, with the recent economic shocks, it is interesting to note the independence of some price indices from energy price index. Several metal price indices peaked prior to the energy price peak (e.g. nickel, zinc, lead, nickel and uranium). Of these metal indices, the uranium price index, which peaked one year prior to the oil price crash, took nearly a year and a half longer than the energy index to begin to recover. For grain commodities, it is also interesting to note that wheat prices started to decline in early 2008, about five months prior to the drop in the energy price index. Natural gas prices, although similar in the overall trend to oil prices, have much more variability when compared to oil prices. Natural gas prices have two peaks that occur prior to the large spike in prices at the end of 2008: 1) in late 2000 / early 2001 and 2) in late 2005. The 2000-2001 price spike was primarily due several factors, including increased demand as a result of a colder than average winter, low natural gas stocks, and well head and spot prices that were twice as high as the previous year. The price spike in 2005 was a result of the hurricane season in the Gulf of Mexico (including Hurricanes Katrina and Rita) when approximately four percent of U.S. production shut down. According to the U.S. Energy Information Administration, between 2007 and 2009, U.S. shale gas proved reserves and production nearly tripled. Proved reserves increased from 23,304 Bcf to 60,644 Bcf and production increased from 1,293 Bcf to 3,110 Bcf. Increases in reserves and production in conjunction with the sharp drop in oil prices helped to drive natural gas prices to levels not seen since the early 2000's. In order to adapt, companies had to shift their focus to the development of shale gas locations that also yielded natural gas liquids and condensates as well as crude oil (e.g. Marcellus Shale and Eagle Ford Shale). The higher prices of these non-shale gas fuels offset the economic impacts of the natural gas prices and thus make the development of these sites more economically feasible. Natural gas prices remain low primarily due to the high production levels and reserve increases of the various domestic shale gas plays. Additionally, demand remained low in 2010 due to a warmer than usual winter and lingering effects of the recent recession.

Total domestic commodity output data for the oil, gas, and mining sectors from 2002 through 2008 indicate a steady increase for all industries followed by a sharp decline in 2009 following the drop in oil prices as a result in depressed demand from the economic crisis in 2008-09. The oil & gas extraction and support activities industries also show a drop in commodity output during the prior recession of 2001. Of note is the leveling of output for oil & gas extraction between 2005 and 2006 and the increase in output in the support activities for mining and oil & gas industry. Mining (except oil & gas) output is relatively steady until 2003 when it begins to increase steadily until 2008 largely driven by increased global demand from rapid economic growth in China and India.

Profit margins for major and independent energy companies increased steadily between 2002 and 2007. In the second quarter of 2007, profit margins began a slow decline which ended in the third quarter of 2008 with a spike in profit margins reflecting the oil price spike and increase in rig activity that was then followed by a precipitous decline that bottomed out in the first quarter of 2009 reflecting major losses for producers due to the declines in both oil and natural gas prices and a decrease in drilling activity. Recovery may have been faster for independent energy companies as these are more heavily invested in shale gas plays than are majors. The focus-shift from shale-gas only plays to locations where shale gas, natural gas liquids, condensates and crude oil occur enabled independent companies to offset the low natural gas prices. Major energy companies were able to recover through the increase in oil prices and in increase world-wide production which offset domestic production.

The geoscience component of industry gross domestic product (GDP) represents the best first-order economic contribution of geoscientists to the U.S. economy. The geoscience component of industry GDP more than doubled between 2002 and 2006, and subsequently contracted slightly in 2008. Total geoscience GDP in 2002 was $27.27 billion, $58.93 billion in 2006, and $57.44 billion in 2008, largely driven by increases in commodity prices boosting the value of all components of the extraction industries. Additionally, the geoscience component of national GDP, which increased from 0.26 percent in 2002 to 0.44 percent in 2006 declined slightly to 0.40 percent in 2008. Total geoscience industry GDP is projected to increase to $73.2 billion by 2018 with all industries seeing increases in their GDP contribution. However, the geoscience component of national GDP is expected to shrink to 0.37 percent by 2018 as total industry GDP grows faster than geoscience industry GDP.

Productive activity in geoscience industries increased steadily over the past decade despite the sharp drop in 2009. Fifty-three percent of the world's drilling rigs are in the U.S., and even at the lowest level of productive activity in 2009, the U.S. still accounted for 45 percent of all drilling rigs in the world. Of all the world regions, Africa did not experience a drop in the number of drilling rigs during the 2008-09 crisis. The majority of the increase in U.S. drilling rigs can be attributed to the increase in onshore (land) and natural gas rigs, and these rigs were impacted the hardest by the 2009 crisis.

Unlike the oil & gas industry, the mining industry has not seen the same amount of productivity growth. The total growth in this industry was due solely to the increase of 2,500 U.S. sand, gravel, and stone mines between 2001 and 2002. Since 2002, the number of sand, grave, and stone mines have decreased by 1,800. The number of U.S. mineral ore and industrial mineral mines (excluding sand, gravel, and stone mines) slowly decreased between 1997 and 2002. Between 2002 and 2008, the number of metal ore mines remained relatively steady, while the number of industrial mineral mines (excluding sand, gravel, and stone mines) increased by 48.

Sand, gravel, and stone mines increased the amount of material handled between 1994 and 2006 by 1,018 million metric tons. Despite the decrease in the number of industrial mineral and metal ore mines, industrial mineral mines increased the amount of material handled by 810 million metric tons and metal ore mines reduced the material handled by 546 million metric tons between 1994 and 2006. Since 2006, metal ore mines have increased the material they handle by 290 million metric tons, while sand, gravel and stone mines have decrease the amount of material handled by 581 million metric tons. Industrial mineral mines only slightly increased the amount of material handled between 2006 and 2008 by 11 million metric tons.

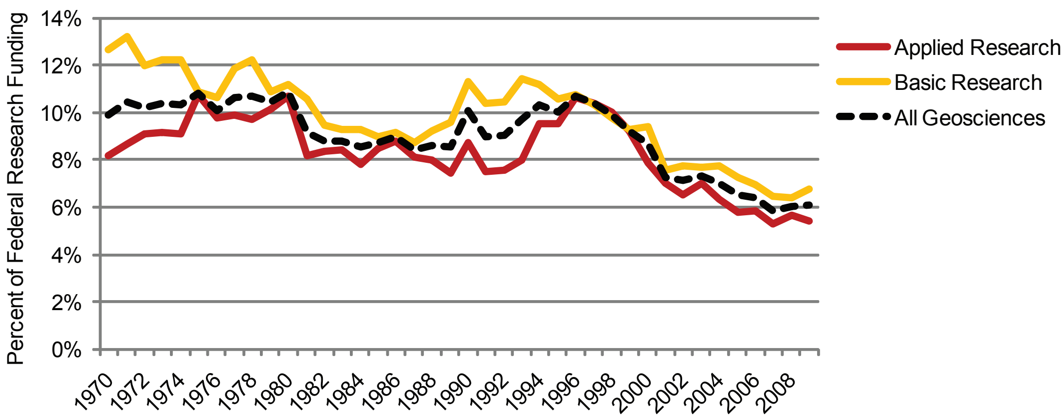
The value of non-fuel mineral production in the U.S. is primarily driven by industrial minerals (including sand, gravel, and stone). Between 2003 and 2006, there was a steady increase in U.S. non-fuel mineral production for both metals and industrial minerals. After 2006, non-fuel production continued to increase for metal ores and industrial minerals (excluding sand, gravel, and stone), and slightly declined for sand, gravel and stone minerals.

Market capitalization of geoscience industries was calculated based on AGI's geoscience stock index which is comprised of a set of 199 companies from the following industries: Cement & Aggregates, Coal, Environmental, Metals & Mining, Oilfield Services, Oil & Gas (both Integrated and Producing), Precious Metals, Utilities (primarily water). In February 2011, the market capitalization of these companies totaled $2.3 trillion. By far, integrated oil & gas companies contribute the most (approximately $1 trillion) to the total current market capitalization of geoscience industries, followed by oil & gas producers ($442 billion). Water utilities and precious metal companies contribute the least to the total market capitalization at nearly $8 billion. Since June 2010, market capitalization has steadily grown by $588 billion.

Federal Research Funding of Geoscience Research

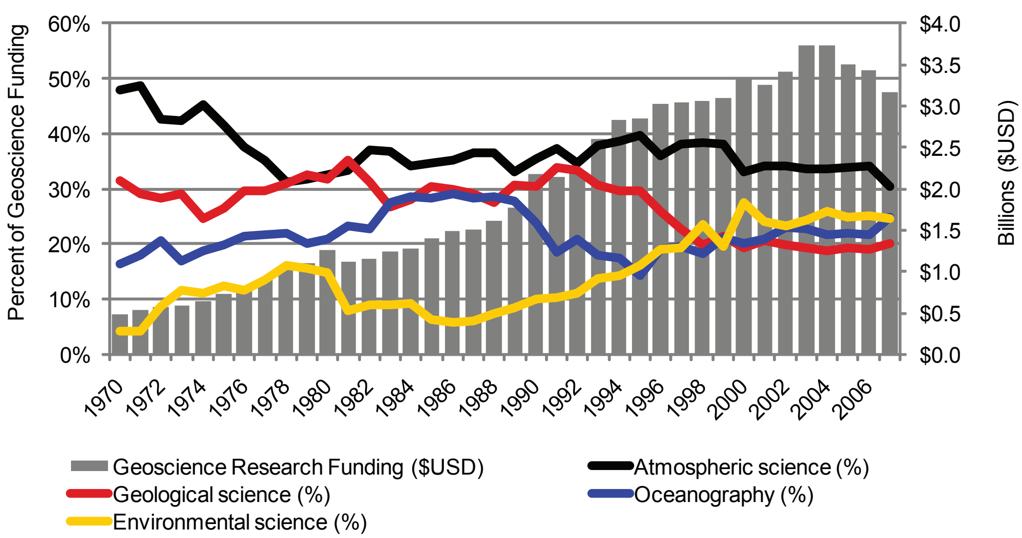
Federal research funds are allocated to federal agency programs, industrial firms, universities and colleges, non-profit institutions, and federally-funded research and development centers. Therefore it is not surprising that trends in total research funding and research funding applied to universities vary from the aggregate trends (see Chapter 2 for college and university geoscience funding trends).

Although the total amount of federal research funding for geoscience research increased steadily between 1970 and 2004, over the past several years there has been a steady decline in the total amount of federal funding invested in the geosciences. Furthermore, the percentage of all federal funding for research and development applied to the geosciences has decreased from nearly 11 percent in 1996 to 6 percent in 2007. Since 1970, the majority of total federal geoscience research funding has been applied to atmospheric science research. Of note is the increase in the percentage of funding applied to environmental science research since 1986. Of additional interest are the drops in funding for oceanographic research (1989 to 1995) and geological science research (1995 to 1998) and the less drastic drop in atmospheric research (1995 to 2003) that are most evident in the basic research funding trends.



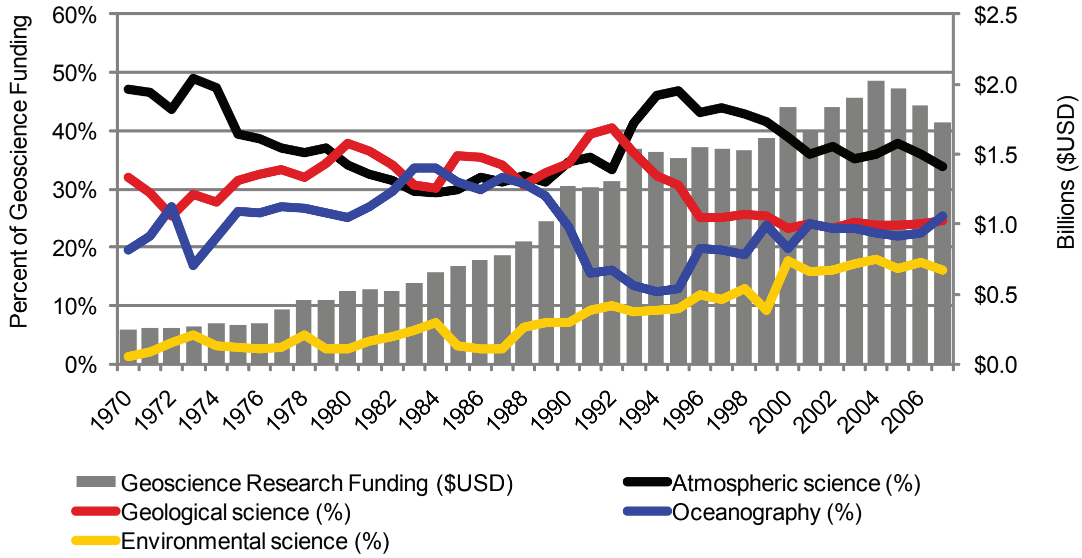
Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.1: Percentage of Federal Research Funding Applied to the Geosciences



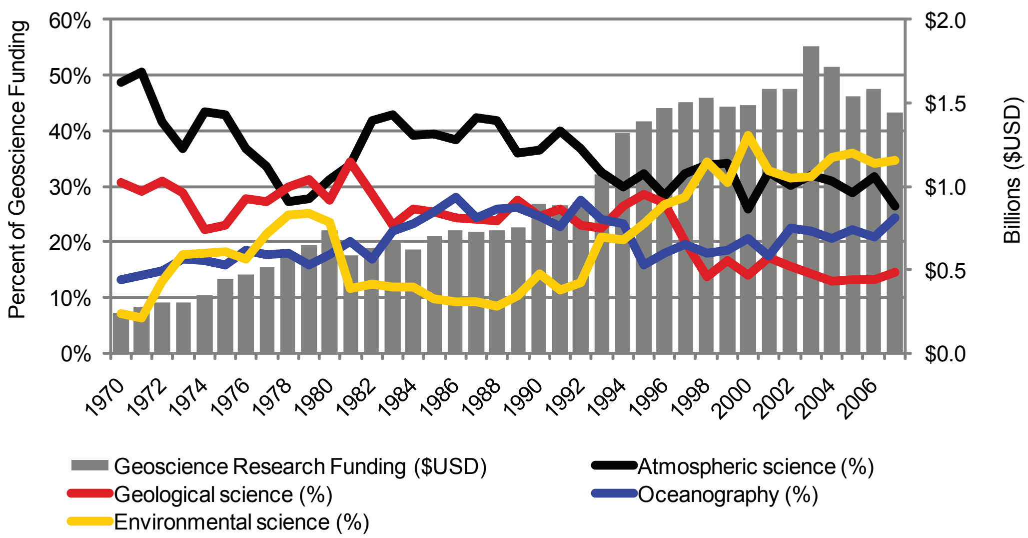
Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.2: Total Federal Research Funding of the Geosciences



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

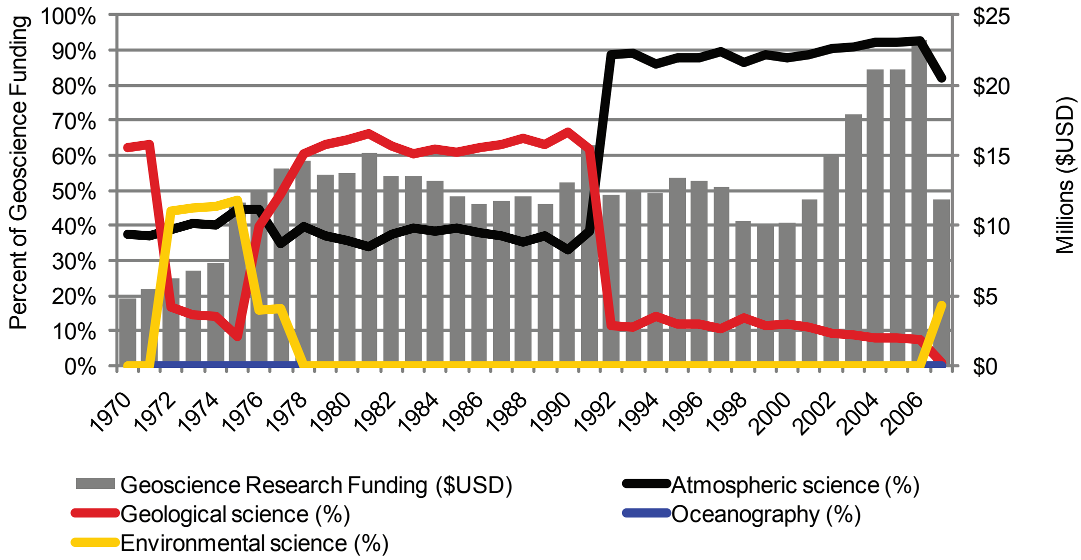
Figure 5.3: Federal Funding of Basic Research in the Geosciences



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.4: Federal Funding of Applied Research in the Geosciences

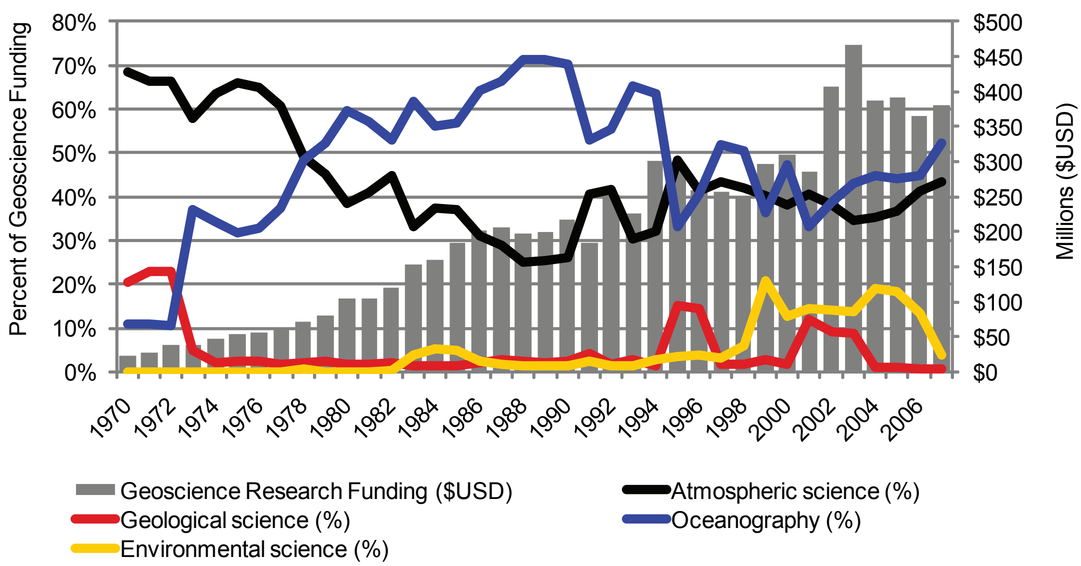
Trends in geoscience funding differ by federal agency. The Department of Agriculture supports geological science and atmospheric science. Between 1976 and 1990, geological science research received just over 60 percent of all geoscience research funds, and after 1990, atmospheric science research received approximately 90 percent of all geoscience research funding. In 2007, however, there was a 10 percent increase in funding for environmental science and a subsequent decrease in funding for both atmospheric and geological science.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.5: Geoscience Research Funding from the Department of Agriculture

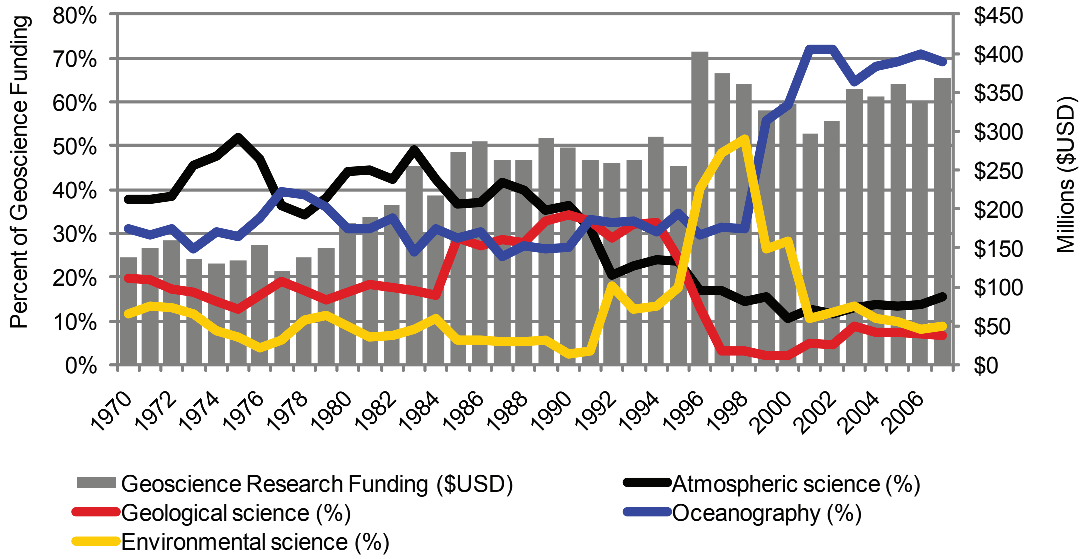
The Department of Commerce primarily funds oceanographic and atmospheric research. From 1970 to 1990 the percentage of funds applied to atmospheric research dropped from 70 to 25 percent while the percentage of funds applied to oceanographic research increased from 10 to 70 percent. From 1996 to 2005, funding for each sub-discipline hovered around 40 percent, and increased between 2005 and 2007 as the percent of funding invested in environmental science decreased to 4 percent of total funding.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.6: Geoscience Research Funding from the Department of Commerce

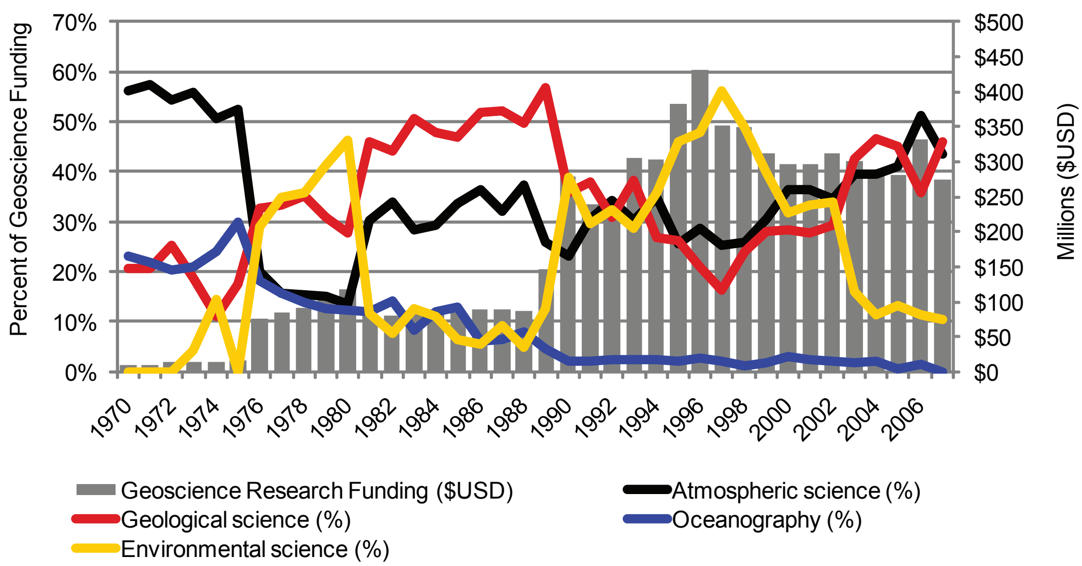
Atmospheric research received the highest percentage of funding of all geoscience sub-disciplines from the Department of Defense between 1970 and 1990. However, the funding for this sub-discipline began to decline in 1983. Funding for geological science research by the Department of Defense peaked between 1984 and 1994 and quickly declined thereafter. Of note is the brief peak in funding for environmental science research (1995 to 1999) followed by the increase in funding for oceanographic research that began in 1999.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.7: Geoscience Research Funding from the Department of Defense

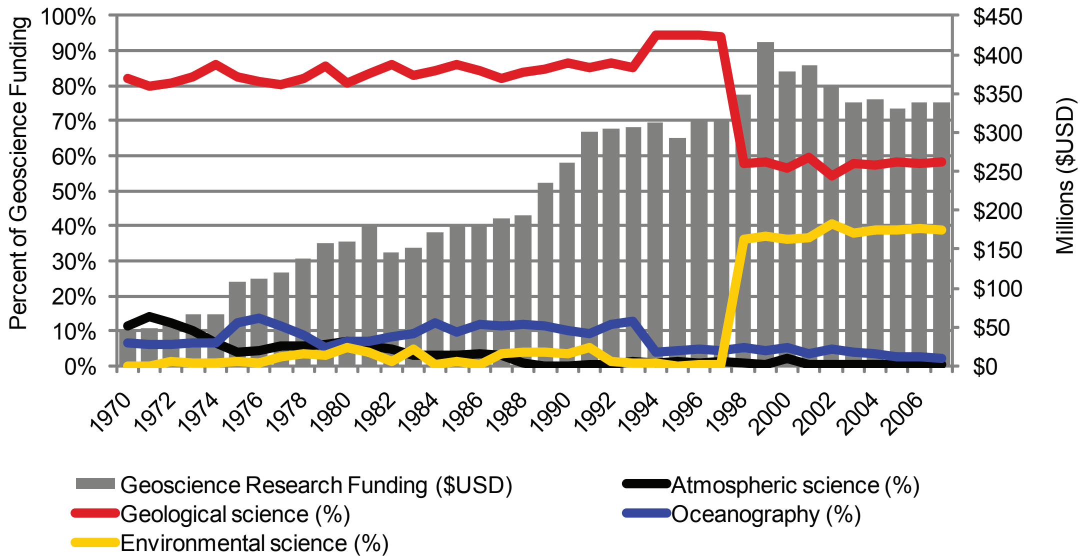
Geological science, atmospheric science and environmental science research have received the majority of geoscience funding from the Department of Energy at different periods of time since 1970. Geological science research received the majority of funding between 1961 and 1989 and from 2003 to 2005, while atmospheric science received the majority of funding from 1970 to 1974. Environmental science research received the majority of funding during two separate intervals: 1976 to 1980 and 1994 to 1999.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.8: Geoscience Research Funding from the Department of Energy

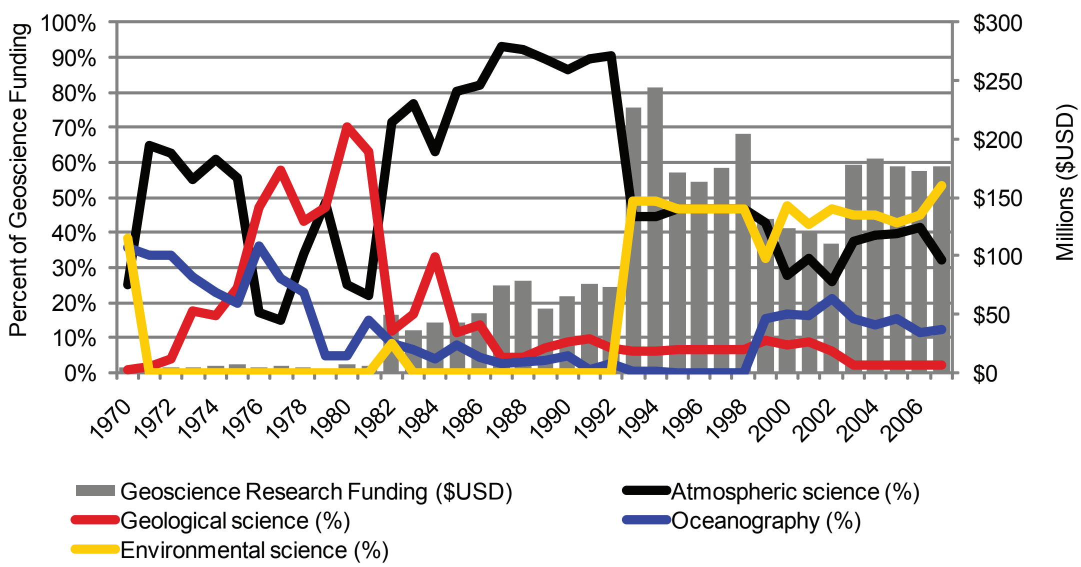
The Department of Interior primarily funds geological science research. An interesting inflection point in the funding trend is the sharp increase (~ 40%) in environmental science research and decrease in geological science funding that occurred between 1997 and 1998. This is most likely attributed to a reclassification of geological science research to environmental science research during this year.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.9: Geoscience Research Funding from the Department of Interior

The majority of research funding from the Environmental Protection Agency (EPA) has primarily been applied to atmospheric research (1971 to 1975, and 1983 to 1993). Geological sciences received the most funding of all geoscience sub-disciplines between 1976 and 1982. From 1994 to 1999, environmental science research and atmospheric science research received similar amounts of funding from the EPA. After 1999, environmental science research has consistently received the most funding from the EPA.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.10: Geoscience Research Funding from the Environmental Protection Agency

The majority of geoscience research funding from National Aeronautics and Space Administration is applied to atmospheric research. Between 1972 and 1990, 20 to 30 percent of geoscience funding from NASA was applied to environmental science research. Geological sciences have received between 10 to 30 percent of geoscience funding since 1970.

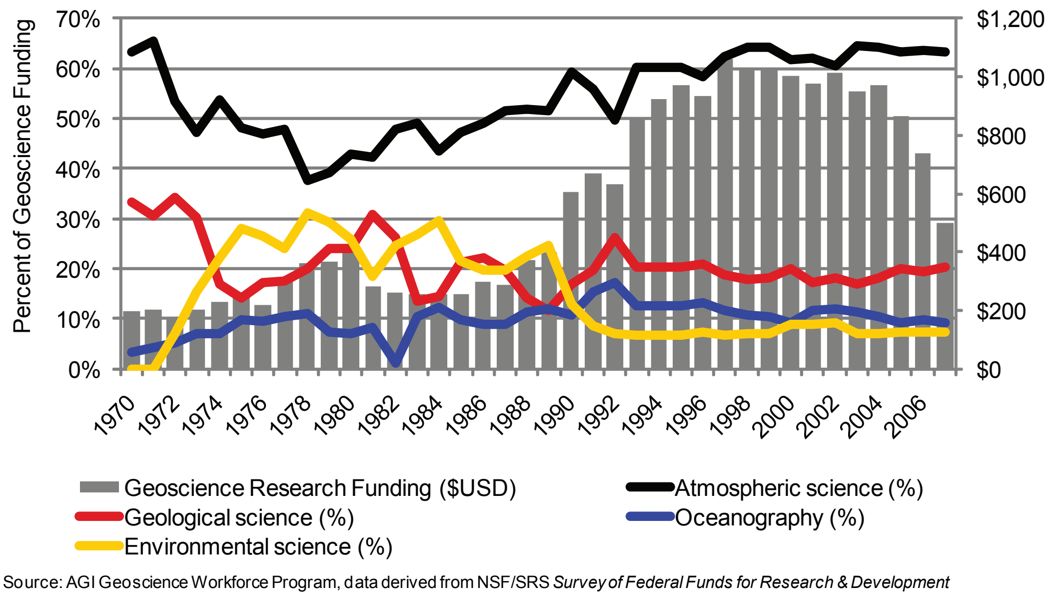
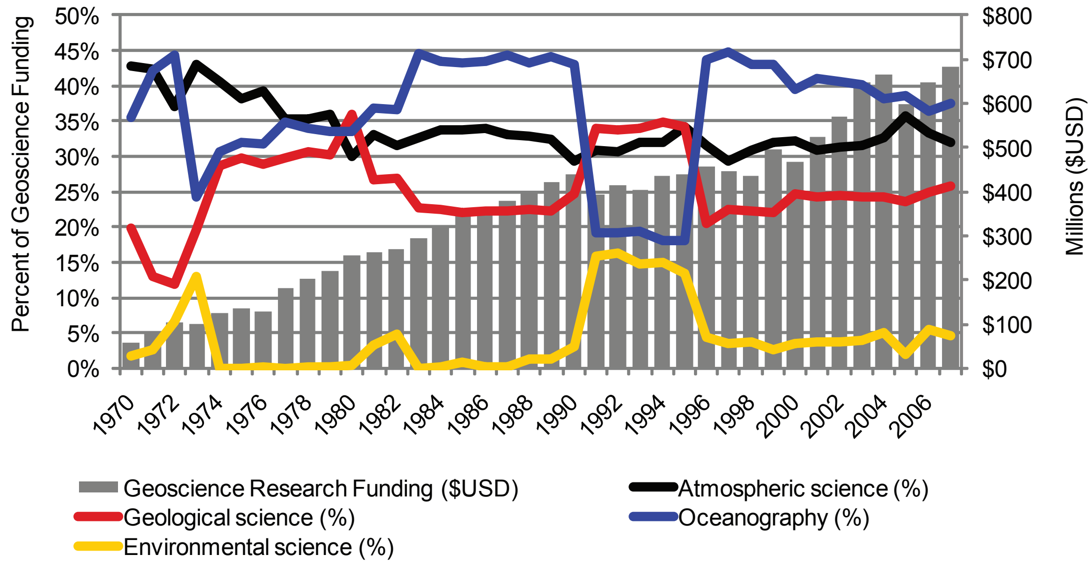


Figure 5.11: Geoscience Research Funding from the National Aeronautics and Space Administration

Atmospheric research, oceanographic research, and geological science research have received the majority of geoscience funds from the National Science Foundation at different time periods from 1970 to 2005. Oceanographic research received the majority of funding during the 1980's and from 1996 to 2007. Atmospheric research received the majority of NSF geoscience funding from 1973 to 1979. Geological science research received the majority of funding from 1991 to 1995. However, the sharp drop in oceanographic research and sharp increase in environmental science research suggests that there may have been a reclassification of oceanographic research to environmental science research during this interval.



Source: AGI Geoscience Workforce Program, data derived from NSF/SRS *Survey of Federal Funds for Research & Development*

Figure 5.12: Geoscience Research Funding from the National Science Foundation

Industry Research Funding

Information pertaining to industry funding of geoscience research is limited. Data pertaining to the trends in company research and development funds are available from the NSF / SRS Industry R&D Funding reports for the mining, extraction & support industries. Unfortunately, this data is aggregated so distinct trends for these three industries cannot be investigated. However, of note is the abrupt switch from development to research funding that occurred between 2001 and 2002. This trend is also coincident with the drop in commodity output, gross operating surplus, and taxes on production and imports for the oil & gas extraction industry, productive activity (rig counts, a reduction in GDP for all three industries, and a decrease in rig counts and well counts. The substantial decline in absolute levels of funding between 1999 and 2000 likely reflects the divestiture of many of the oil and gas majors from formal upstream research centers, where 13 such centers existed in the late 1990's, but only 1 remained by the early 2000's.

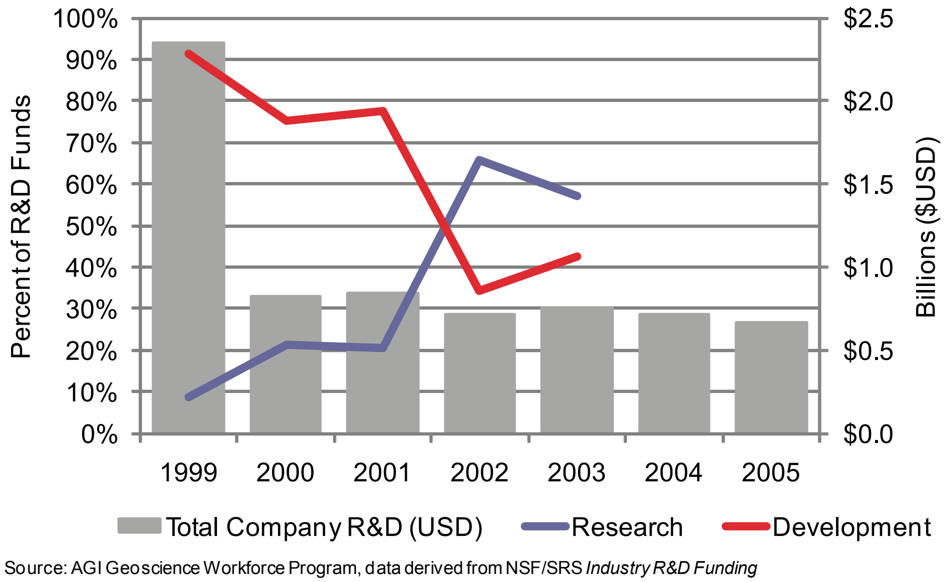


Figure 5.13: Distribution of Total Company R&D for the Mining, Extraction & Support Activities Industries

Commodity Pricing and Output

The drop in the dollar has caused concern in oil-producing countries which use it as the basis for the commodity, and often their currency. Figure 5.14 shows the spot market price of crude oil per barrel (BBL) in US dollars and in euros from 1999 to 2010. The price of oil grew faster relative to the dollar than to the euro throughout the economic recession and through the existing recovery period. Yet, a portion of the rise in oil prices is due to the fall of the value of the dollar. Figure 5.14 also shows the number of barrels of crude oil per cost of an ounce of gold, demonstrating the parallel growth in commodity pricing.

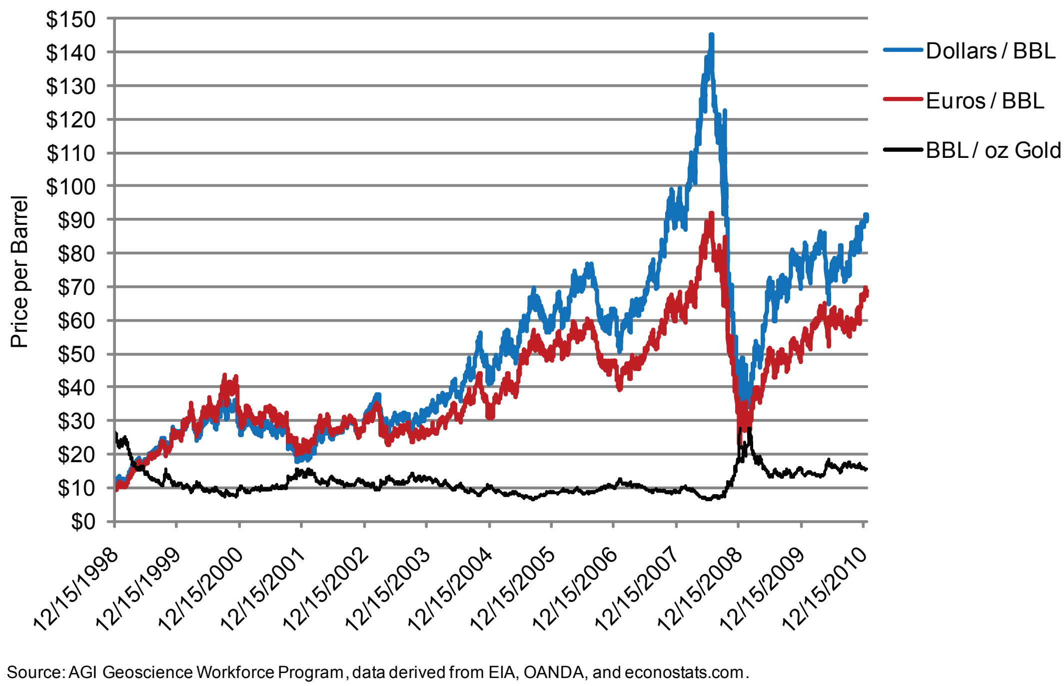


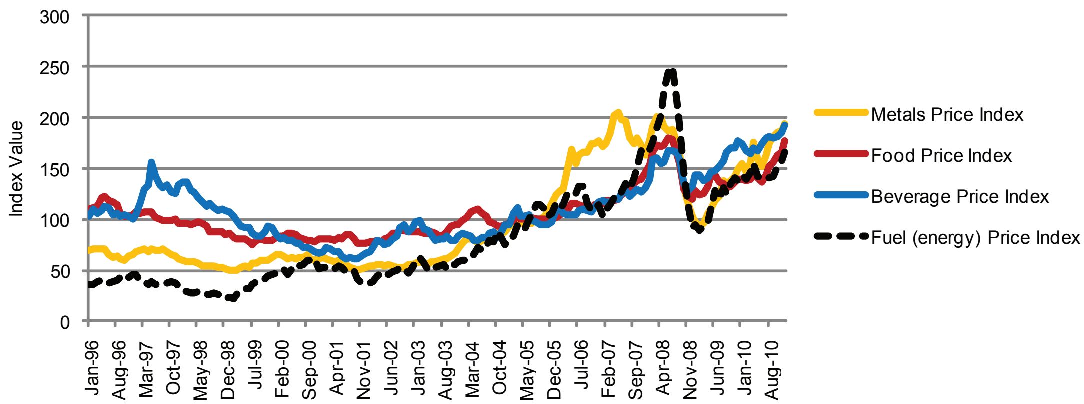
Figure 5.14: Price of Oil by Currency and by Gold

A number of geoscience industries are responsible for generating important commodities that keep our society running, such as oil, gas, and minerals. All commodity price indices generally follow the energy (fuel) price index. However, it is interesting to note that there is some independence of metal price indices from energy price indices. Nickel, zinc, lead, and uranium peaked prior to oil, and tin and aluminum peaked at the same time as oil, thus creating a bi-modal peak in the metal price index.

Food and beverage commodity price indices follow the trend of the energy (fuel) price index because of their dependence on transport and energy intensive production; however it is interesting to note that the metals price index did not follow the energy price index as closely prior to the peak in oil, but did follow the energy index as oil price peaked. The bi-modal peak in the metals price index is representative of those metals that peaked prior to the peak in oil (nickel, zinc, lead, and uranium) and those that peaked at the same time as oil (tin, and aluminum). Copper interestingly has three peaks, the first beginning in 2006 and the last ending with the drop in oil prices. Also interesting to note is the price of uranium, which peaked in June 2007, one year prior to the oil price crash, and started to recover in April 2010, nearly a year and a half after the energy index started to increase.

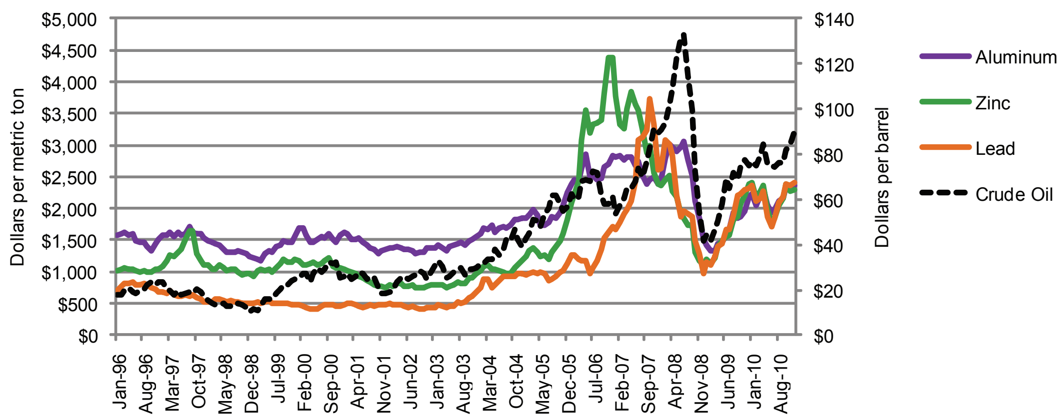
With the exception of a small peak in 2008 that is concurrent with the peak in oil prices, commodity prices for beef and pork do not follow the trend in oil price like other commodities. Prices for grains (soybeans, rice, wheat, barley, and corn) peaked and declined at about the same time as the spike in oil prices. Soybean prices, which tracked oil prices from 2001 to 2003, decreased between 2004 and 2006, and later increased and peaked as oil prices shot up in 2007 and then peaked in 2008. Wheat prices, interestingly, started to decline in early 2008, about five months prior to the drop in oil prices. Rice prices which were slowly increasing since 2000, shot up by $615 per metric ton between January and May 2008 and decreased quickly thereafter. All grain commodity prices have started to increase again since April 2010.

Natural gas prices, although similar in the overall trend to oil prices, have much more variability when compared to oil prices. Natural gas prices have two peaks that occur before the large spike in prices at the end of 2008: 1) In late 2000 / early 2001 and 2) in late 2005. Furthermore, the decline in natural gas prices continued until September 2009, nearly 9 months after the energy price index reached bottom. Between September 2009 and December 2010, natural gas prices increased by $45.41/ m3 to $152.91 /m3, a price that has not been seen since November 2002.



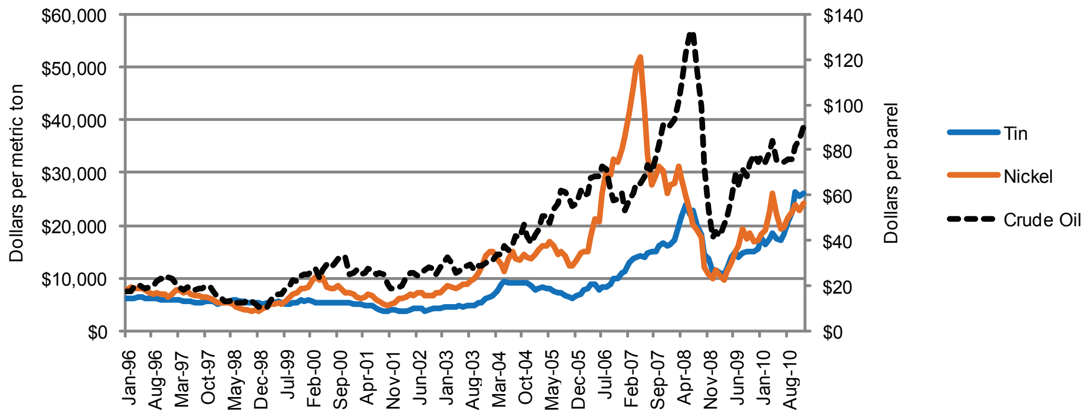
Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.15: Commodity Price Indices



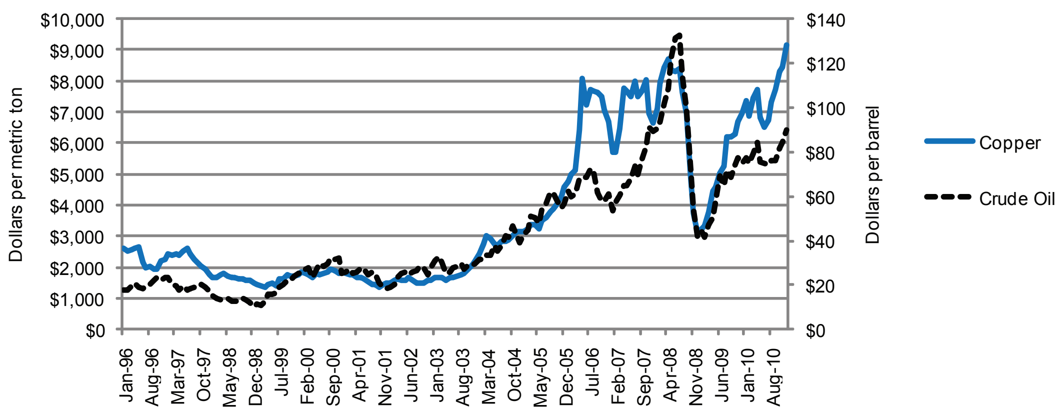
Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.16: Commodity Prices for Selected Metals and Oil



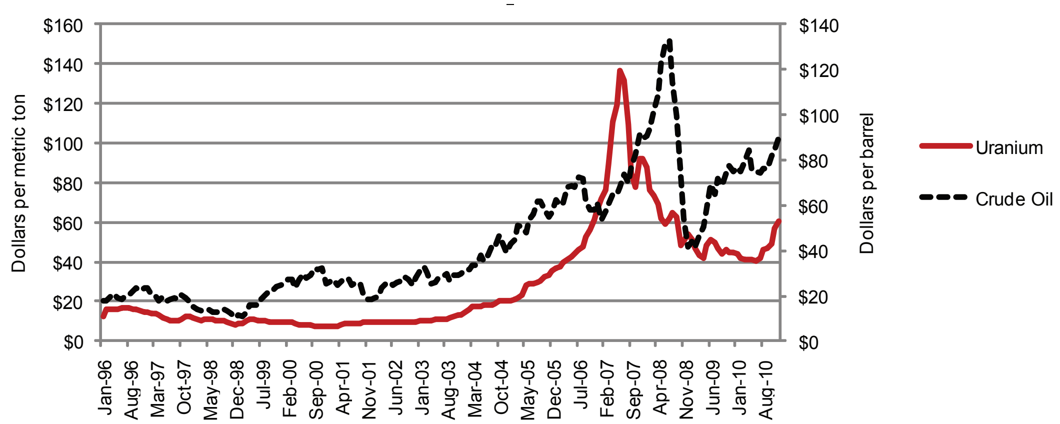
Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.17: Commodity Prices for Tin, Nickel, and Oil



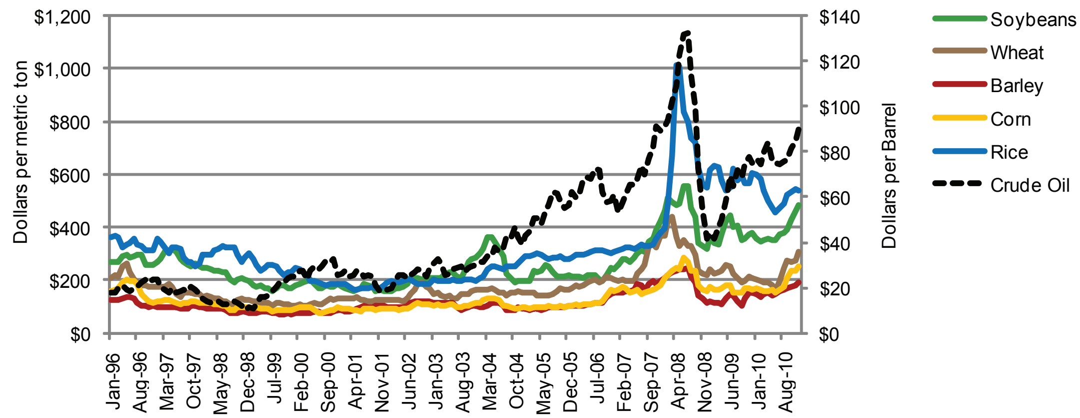
Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.18: Commodity Prices for Copper and Oil



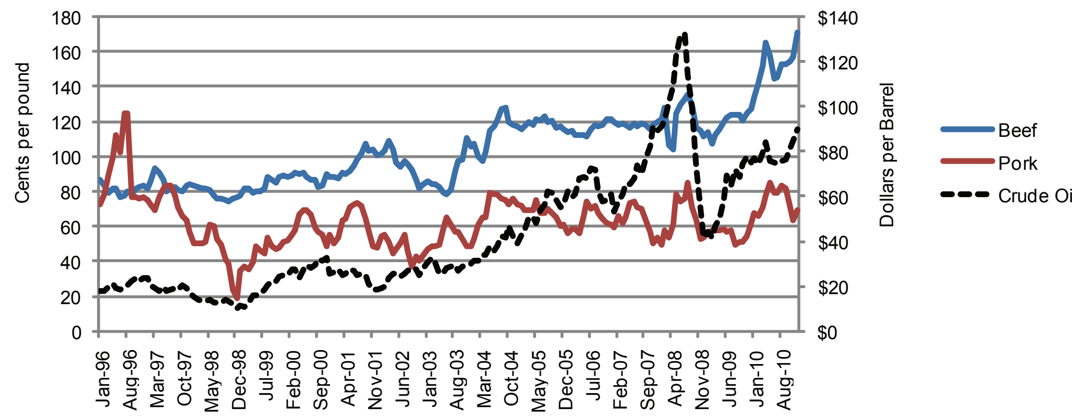
Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.19: Commodity Prices for Uranium and Oil



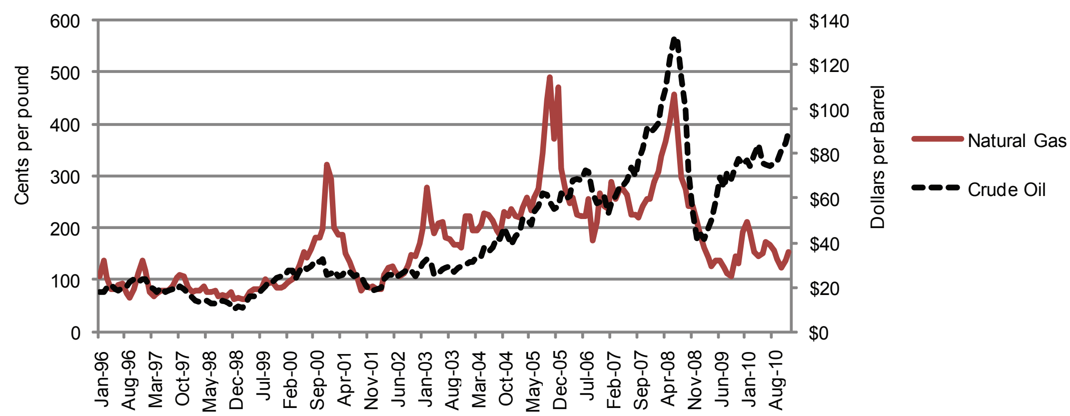
Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.20: Commodity Prices for Grains and Oil



Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

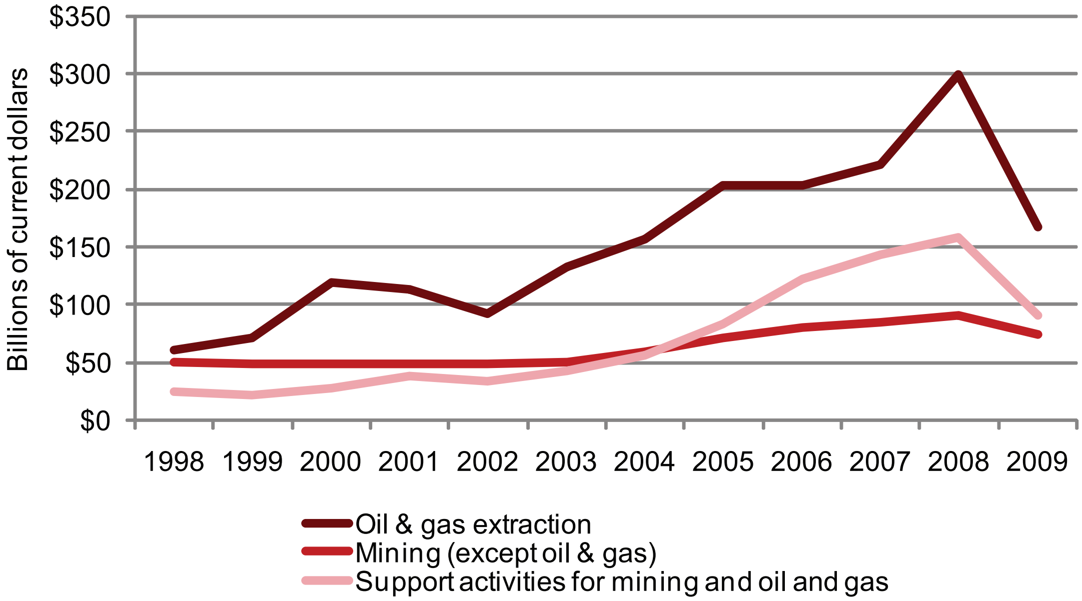
Figure 5.21: Commodity Prices for Beef, Pork and Oil



Source: AGI Geoscience Workforce Program, data derived from indexmundi.com

Figure 5.22: Commodity Prices for Natural Gas and Oil

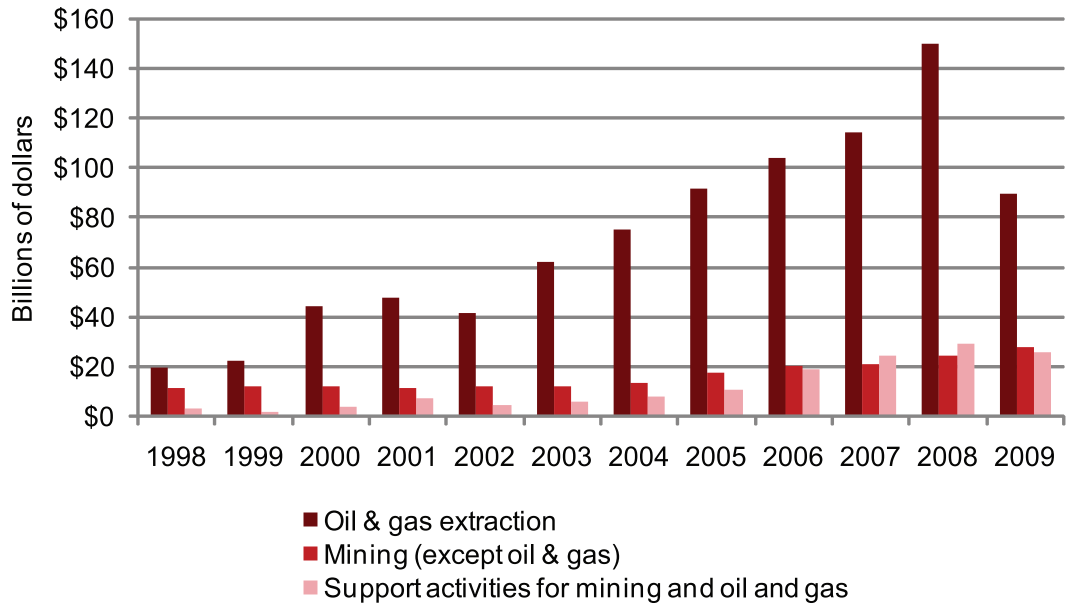
Total domestic commodity output data for the oil and gas and mining sectors from 2002 through 2008 indicate a steady increase for all industries followed by a sharp decline in 2009 following the drop in oil prices and the start of the current recession. The oil and gas extraction and support activities industries also show a drop in output during the last recession between 2001 and 2002. Of note is the leveling of output for oil and gas extraction between 2005 and 2006 and the increase in output in the support activities for mining and oil and gas industry. Mining (except oil & gas) output is relatively steady until 2003 when it begins to increase steadily until 2008.



Source: AGI Geoscience Workforce Program, data derived from the U.S. Bureau of Economic Analysis

Figure 5.23: Commodity Output for the Mining, Oil and Gas Extraction, and Support Industries

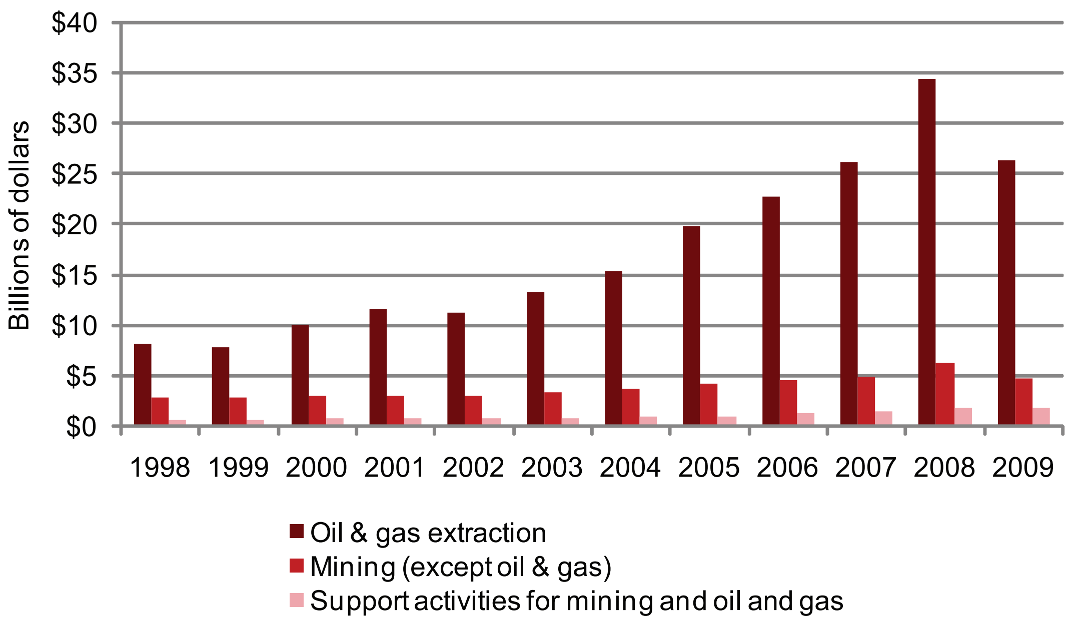
Gross operating surplus for the oil and gas and mining sector grew steadily for all industries until 2008, after which only mining continued to increase as gross operating surplus for the oil and gas and support activities industries declined by 40 and 11 percent respectively. Gross operating surplus for the support activities industry shot up between 2005 and 2006, leading the jump in the oil and gas industry in 2007.



Source: AGI Geoscience Workforce Program, data derived from the U.S. Bureau of Economic Analysis

Figure 5.24: Gross Operating Surplus for the Mining, Oil and Gas Extraction, and Support Industries

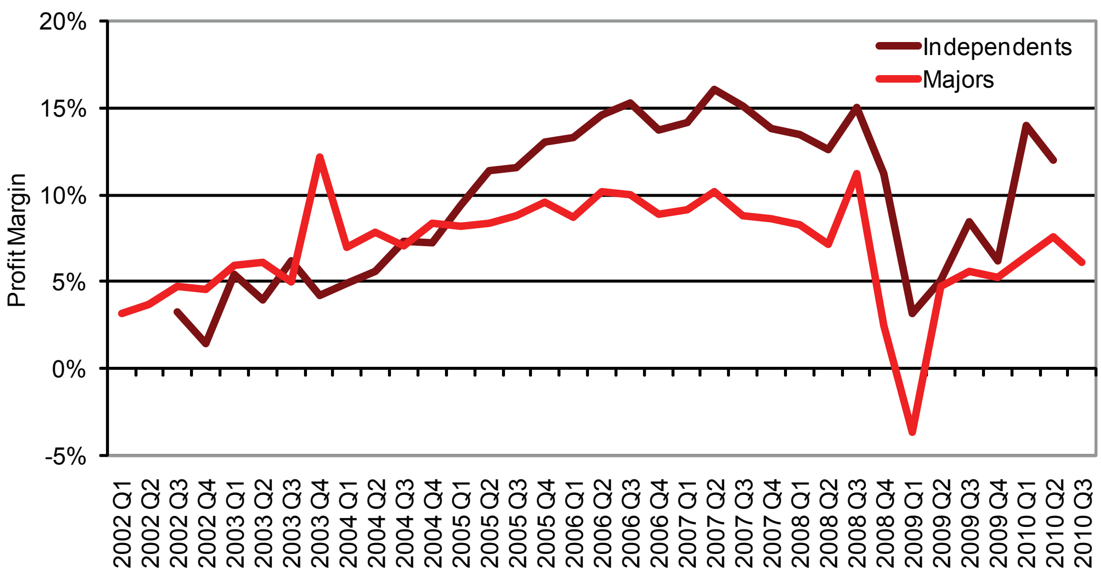
In examining the taxes on production and imports for these industries, it is not surprising that the oil & gas extraction industry has the highest taxes. Of interest is that the support activities industry has the lowest taxes, and since 2004, higher commodity pricing has increased the mining industry's total tax bill.



Source: AGI Geoscience Workforce Program, data derived from the U.S. Bureau of Economic Analysis

Figure 5.25: Taxes on Production & Imports for the Mining, Oil and Gas Extraction, and Support Industries

Profit margins, calculated by dividing the net income by total revenue, indicate steady increases between 2002 and 2007 for major and independent energy companies. The second quarter of 2007 is when profit margins started a slow decline which ended in the third quarter of 2008 with a spike in profit margins driven by the oil price shock at the time followed by a precipitous decline that bottomed out in the first quarter of 2009 reflecting major losses for producers due to the declines in both oil and natural gas prices and a decrease in drilling activity. Major energy companies suffered a much larger drop in profit margins and a stronger and faster recovery than did independent energy companies. As of the third quarter of 2010, profit margins for both major and independent companies were 4 percent below their prior peak in the second quarter of 2007. Recovery may have been faster for independent energy companies as these are more heavily invested in shale gas plays than are majors. The focus-shift from shale-gas only plays to locations where shale gas, natural gas liquids, condensates and crude oil occur enabled independent companies to offset the low natural gas prices. Major energy companies were able to recover through the increase in oil prices and in increase world-wide production which offset domestic production.



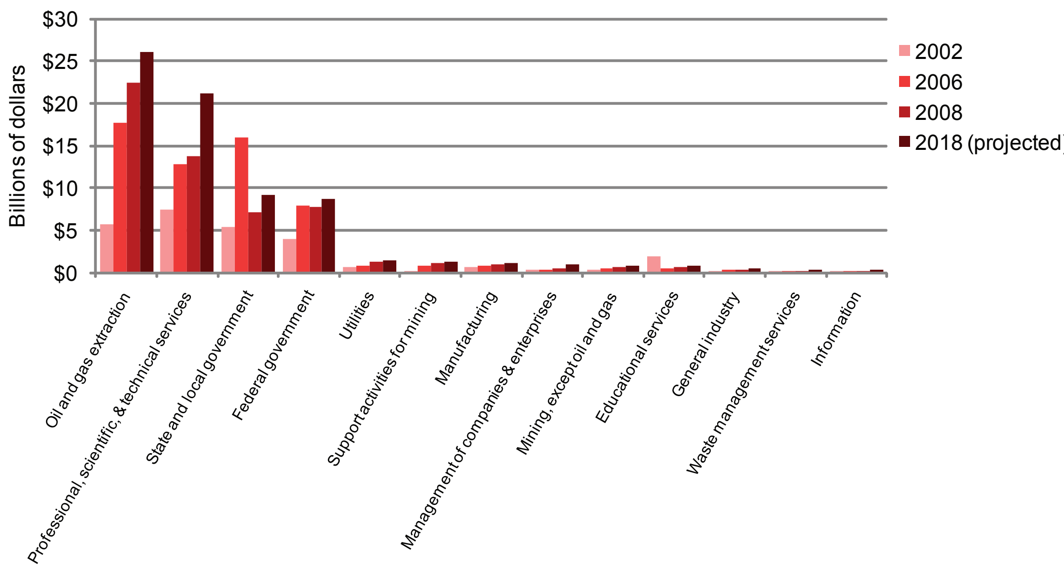
Source: AGI Geoscience Workforce Program, data derived from Energy Information Administration

Figure 5.26: Profit Margin Increases for Independent and Major Energy Companies

Gross Domestic Product Contribution of Geoscience Industries

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, in 2008, US domestic mineral production was valued at $71 billion dollars, whereas the value added for the mining industry was only $47 billion dollars and this number likely excludes the value added for sand and gravel. Since geoscientists only comprise 1.4 percent of the mining industry's workforce, the total geoscience contribution to the mining industry's GDP was $0.67 billion dollars. In the oil and gas industry, US domestic production was $170 billion dollars in 2008 and the total value added amount was $210 billion dollars. In oil and gas, geoscientists comprise 10.7 percent of the industry's employment. As such, the geoscience component of the oil and gas industry's GDP in 2008 was $22.48 billion dollars.

The geoscience component of industry GDP more than doubled between 2002 and 2006, and subsequently contracted slightly in 2008. Total geoscience contribution to GDP in 2002 was $27.27 billion, $58.93 billion in 2006, and $57.44 billion in 2008. Additionally, the geoscience component of national GDP, which increased from 0.26 percent in 2002 to 0.44 percent in 2006 declined slightly to 0.40 percent in 2008. Total geoscience industry GDP is projected to increase to $73.2 billion by 2018 with all geoscience industries contributing to this increase. However, the geoscience component of national GDP is expected to shrink to 0.37 percent by 2018 as total GDP grows faster than the geoscience contribution to GDP.



Source: AGI Geoscience Workforce Program, data derived from U.S .Bureau of Economic Analysis, US Bureau of Labor Statistics, and AGI's Directory of Geoscience Departments

Figure 5.27: Percentage of Geoscience Industry GDP Contributed by Specific Industries

Industry	GDP 2002 (billions $USD)	GDP 2006 (billions $USD)	GDP 2008 (billions $USD)	GDP 2016 (projected) (billions $USD)
Oil and gas extraction	$5.79	$17.67	$22.48	$26.09
Professional, scientific, & technical services	$7.50	$12.80	$13.84	$21.21
State and local government	$5.46	$15.91	$7.17	$9.14
Federal government	$4.01	$7.94	$7.70	$8.66
Utilities	$0.69	$0.82	$1.28	$1.49
Support activities for mining	$0.20	$0.87	$1.13	$1.38
Manufacturing	$0.65	$0.78	$0.98	$1.15
Management of companies & enterprises	$0.31	$0.36	$0.60	$0.96
Mining, except oil and gas	$0.34	$0.52	$0.67	$0.85
Educational services	$1.86	$0.48	$0.68	$0.80
General industry	$0.07	$0.29	$0.34	$0.52
Waste management services	$0.15	$0.22	$0.26	$0.41

Industry	GDP 2002 (billions $USD)	GDP 2006 (billions $USD)	GDP 2008 (billions $USD)	GDP 2016 (projected) (billions $USD)
Information	$0.12	$0.12	$0.18	$0.32
Transportation and warehousing	$0.03	$0.07	$0.10	$0.12
Finance & insurance	$0.02	$0.05	$0.04	$0.08
Construction	$0.06	$0.03	$0.02	$0.02
Sum Total	**$27.27**	**$58.93**	**$57.44**	**$73.20**
Geoscience Contribution to Total U.S. GDP	**0.26%**	**0.44%**	**0.40%**	**0.37%**

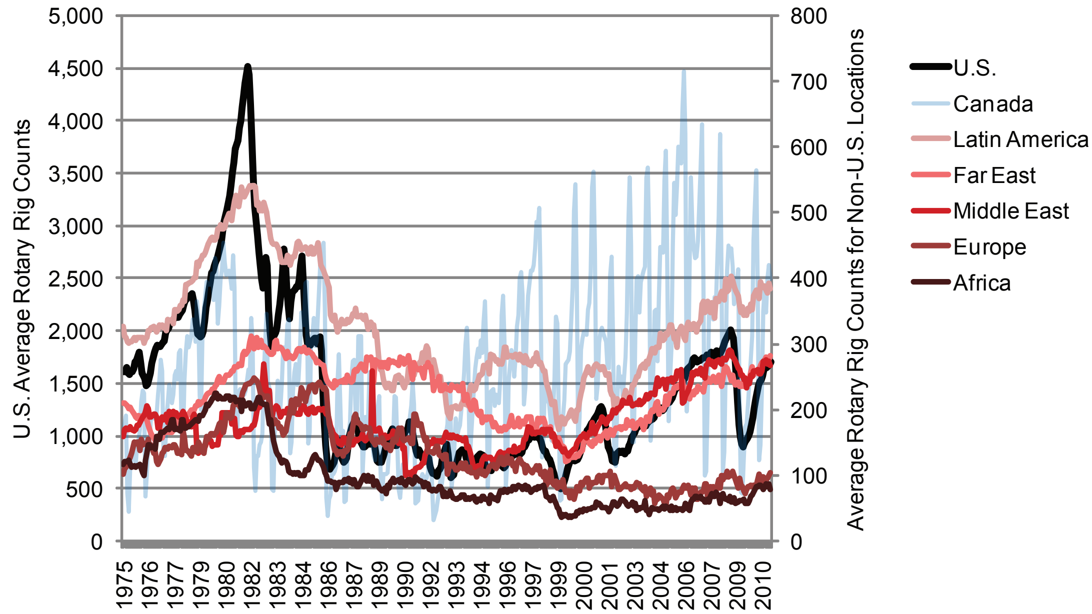
Table 5.1: Geoscience Industry GDP and U.S. Total GDP (2002-2016)

(Data derived from the U.S. Bureau of Economic Analysis)

Productive Activity of Geoscience Industries

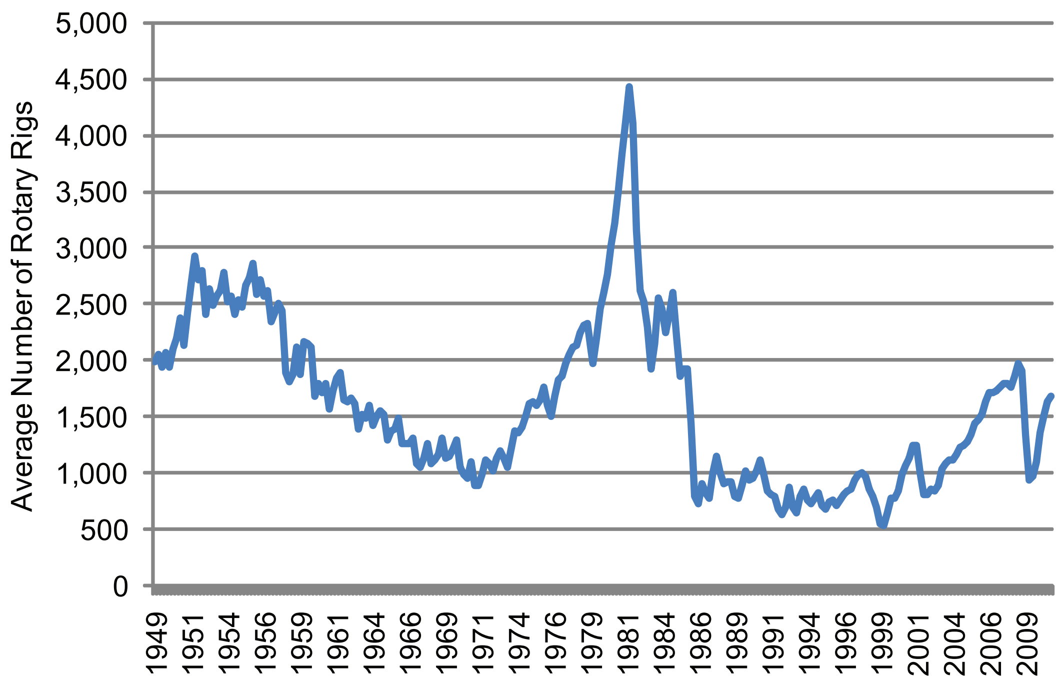
Productive activity in geoscience industries increased steadily over the past decade despite the sharp drop in 2009. Fifty-three percent of the drilling rigs are in the U.S., and even at the lowest level of productive activity in 2009, the U.S. still accounted for 45 percent of all drilling rigs in the world. Of all the world regions, Africa did not experience a drop in the number of drilling rigs during the 2009 crisis. The majority of the increase in U.S. drilling rigs can be attributed to the increase in onshore (land) and natural gas rigs, and these rigs were impacted the hardest by the 2009 crisis. Furthermore, where as the number of crude oil rigs rebounded by 450 percent since 2009, the number of natural gas rigs only increased by 130 percent.

The number of natural gas and crude oil wells drilled increased from the mid- to late-1990s until 2008, with marked increased activity between 2002 and 2006. Additionally, the drilling success rate has slowly increased from 1987 until 2004, with two jumps in efficiency between 1987 and 1989 (+3%) and 1998 and 2001 (+6%). Since 2004, drilling success has leveled off to 92 percent. The average depth of crude oil wells increased between 1983 and 1994 as exploration of the outer continental shelf commenced. Note that the average drilling depths for crude oil rigs have not exceeded the 1994 limit of 5,169 feet. Natural gas well depths have increase in leaps as shale gas technology has improved over time. The mid-1990's increase in average natural gas well depths can be attributed to exploration of the Barnett Shale in Texas, and the increases in well depths in the 2000's can be attributed to exploration for deeper reserves, including those in Haynesville, Marcellus, and other shale plays.



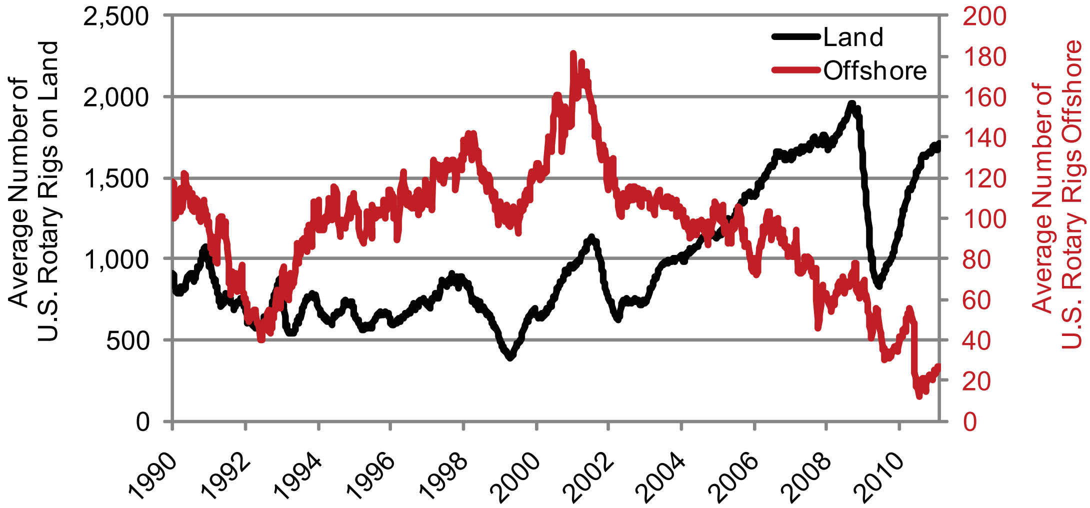
Source: AGI Geoscience Workforce Program, data derived from Baker Hughes

Figure 5.28: Average Rotary Rig Counts by World Region



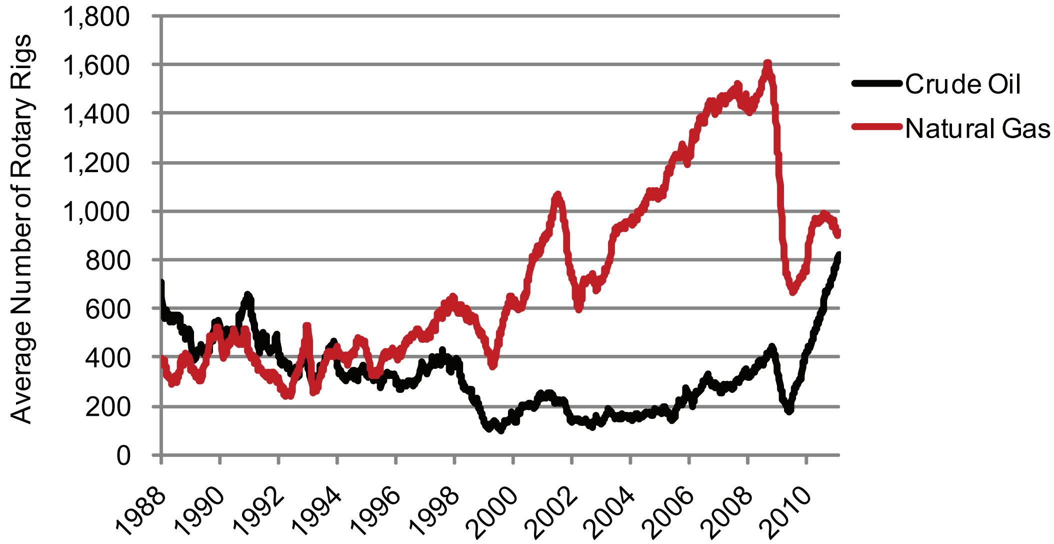
Source: AGI Geoscience Workforce Program, data derived from Baker Hughes

Figure 5.29: U.S. Rotary Rig Counts



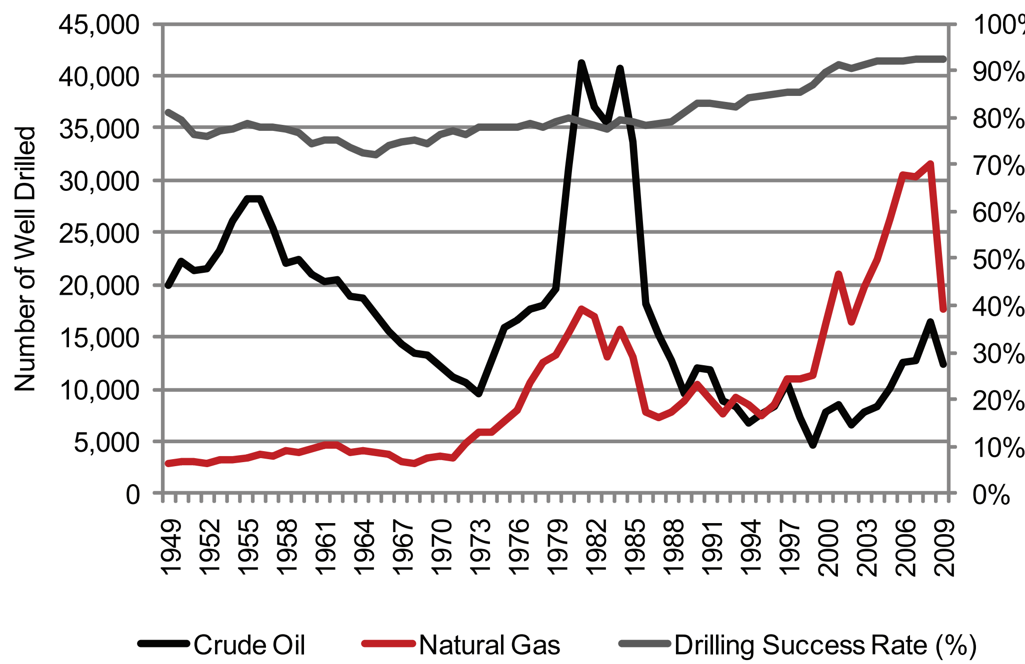
Source: AGI Geoscience Workforce Program, data derived from Baker Hughes

Figure 5.30: U.S. Rotary Rigs by Location



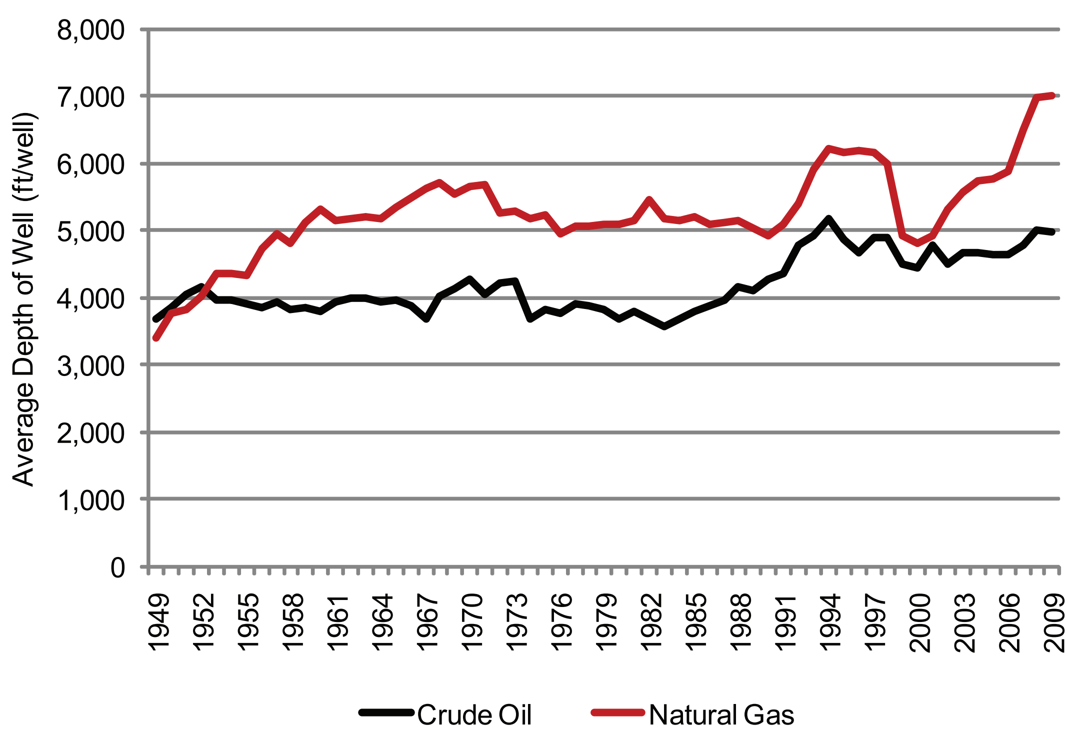
Source: AGI Geoscience Workforce Program, data derived from Baker Hughes

Figure 5.31: U.S. Rigs by Type



Source: AGI Geoscience Workforce Program, data derived from U.S. Energy Information Administration

Figure 5.32: Number of Wells Drilled by Type and Drilling Success Rate

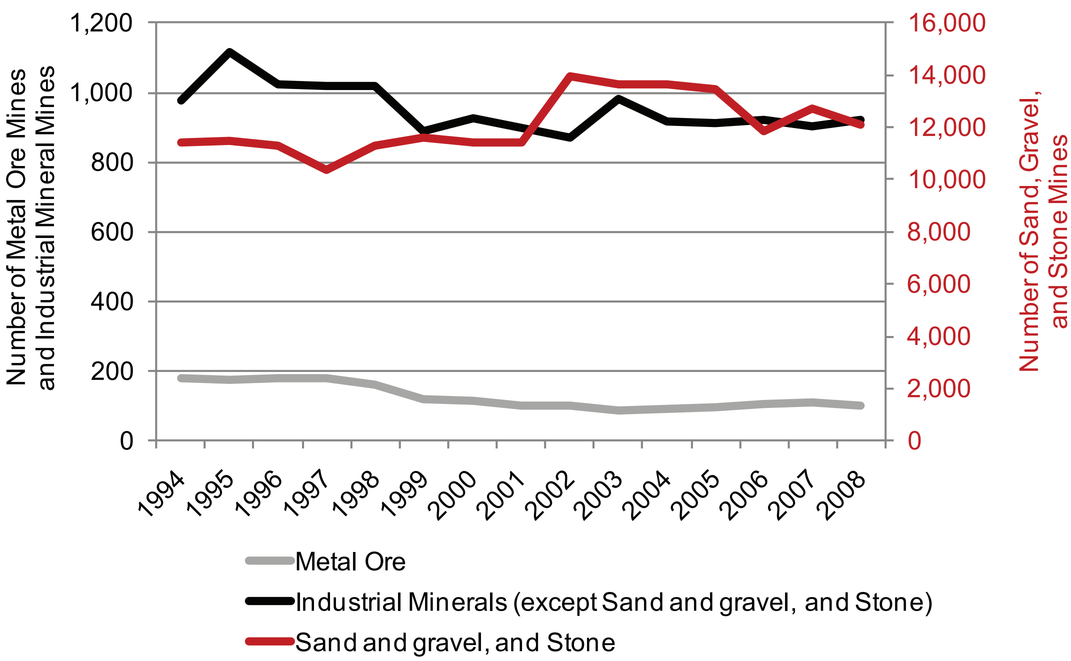


Source: AGI Geoscience Workforce Program, data derived from U.S. Energy Information Administration

Figure 5.33: Average Depth of Wells Drilled by Type

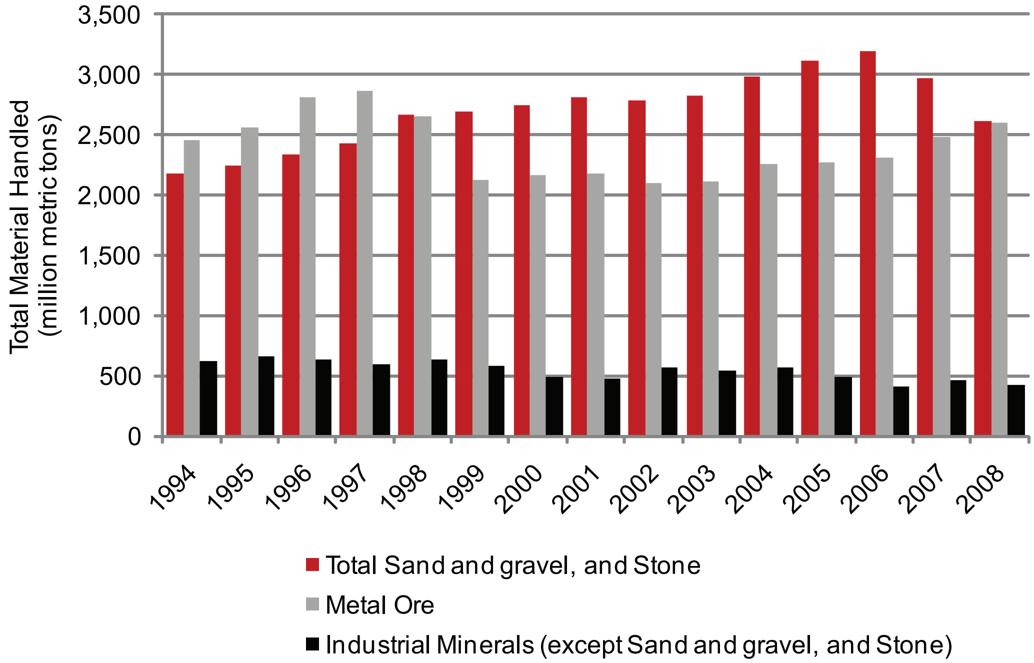
Unlike the oil & gas industry, the mining industry has not seen the same level of productivity growth. The total growth in this industry was due solely to the increase of 2,500 U.S. sand, gravel, and stone mines between 2001 and 2002. Since 2002, the number of sand, grave, and stone mines have decreased by 1,800. The number of U.S. mineral ore and industrial mineral mines (excluding sand, gravel, and stone mines) slowly decreased between 1997 and 2002. Between 2002 and 2008, the number of metal ore mines remained relatively steady, while the number of industrial mineral mines (excluding sand, gravel, and stone mines) increased by 48.

Sand, gravel, and stone mines increased the amount of material handled between 1994 and 2006 by 1,018 million metric tons. Despite the decrease in the number of industrial mineral and metal ore mines, industrial mineral mines increased the amount of material handled by 810 million metric tons and metal ore mines reduced the material handled by 546 million metric tons between 1994 and 2006. Since 2006, metal ore mines have increased the material they handle by 290 million metric tons, while sand, gravel and stone mines have decrease the amount of material handled by 581 million metric tons. Industrial mineral mines only slightly increased the amount of material handled between 2006 and 2008 by 11 million metric tons.



Source: AGI Geoscience Workorce Program, data derived from the USGS *Mining & Quarrying Trends*

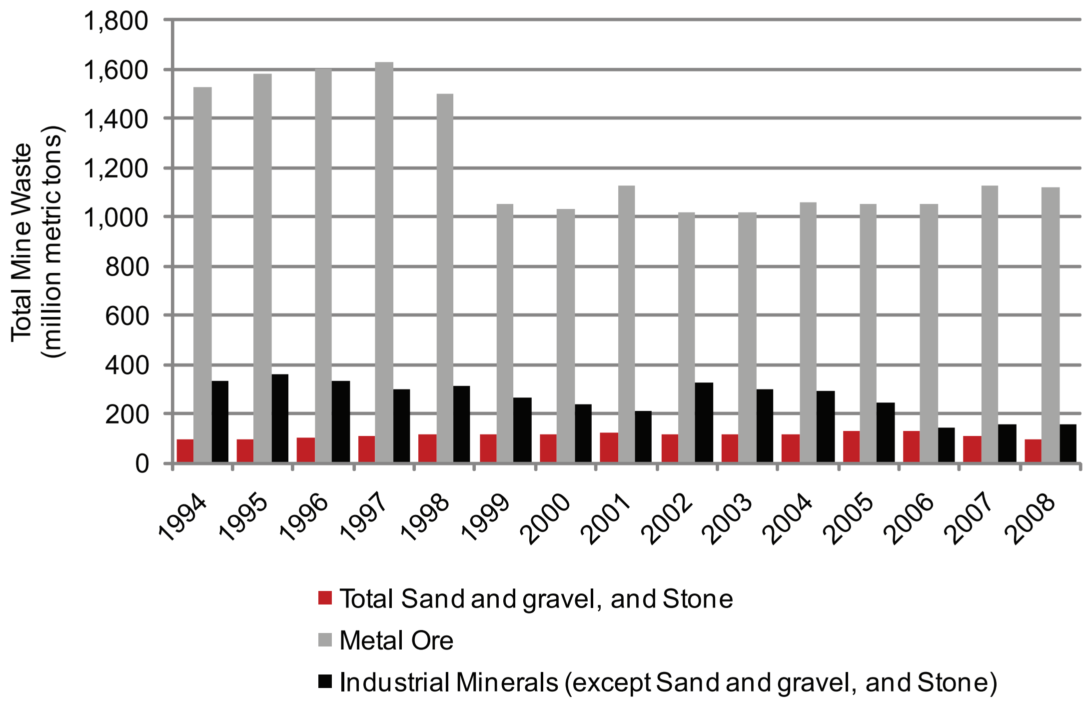
Figure 5.34: Number of U.S. Mines



Source: AGI Geoscience Workorce Program, data derived from the USGS *Mining & Quarrying Trends*

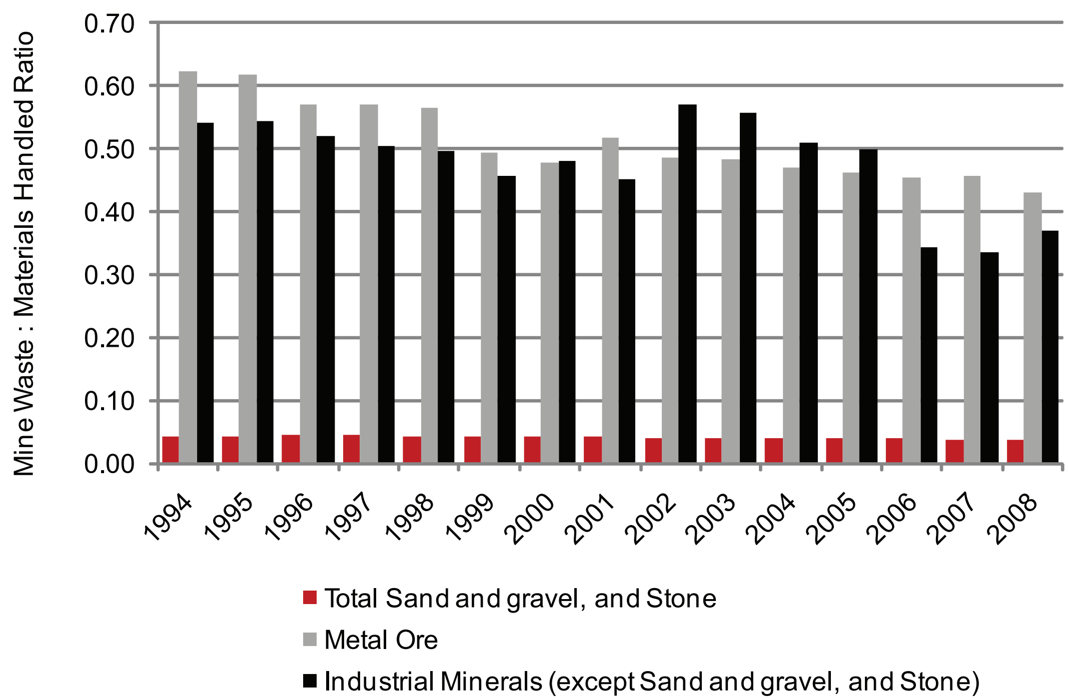
Figure 5.35: Material Handled at U.S. Mines

The amount of mine waste at both metal ore and industrial mineral mines decreased between 1994 and 2006. Mine waste for sand, gravel and stone mines only increased slightly over this period by 33 million metric tons. Since 2006, however, the opposite occurred where mine waste at metal ore and industrial mineral mines increased by 70 and 15 million metric tons respectively, whereas mine waste at sand, gravel and stone mines decreased by 28 million metric tons. The mine waste-to-material handled ratio which measures efficiency has improved substantially for industrial mineral mines between 2005 and 2006 (.50 to .34). Sand, gravel, and stone mines, which produce the least amount of mine waste, have held a steady mine waste-to-material handled ratio of .04 since 1994.



Source: AGI Geoscience Workorce Program, data derived from the USGS *Mining & Quarrying Trends*

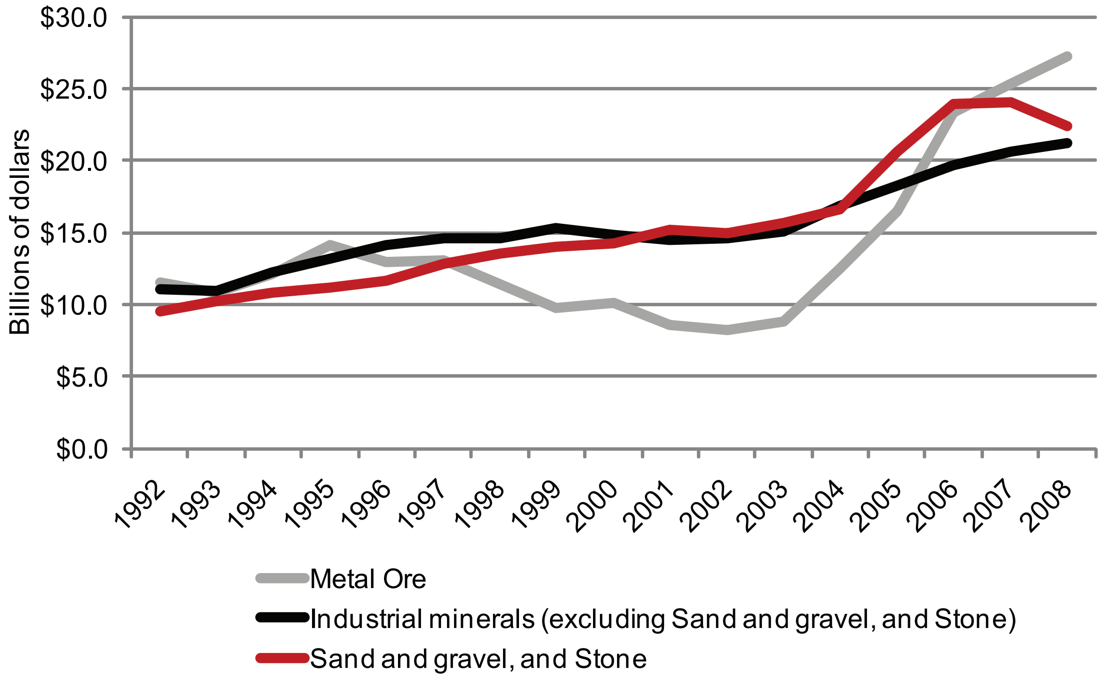
Figure 5.36: Mine Waste from U.S. Mines



Source: AGI Geoscience Workorce Program, data derived from the USGS *Mining & Quarrying Trends*

Figure 5.37: Mine Waste/Materials Handled Ratio at U.S. Mines

The value of non-fuel mineral production in the U.S. is primarily driven by industrial minerals (including sand, gravel, and stone). Between 2003 and 2006, there was a steady increase in U.S. non-fuel mineral production for both metals and industrial minerals. After 2006, non-fuel production continued to increase for metal ores and industrial minerals (excluding sand, gravel, and stone), and slightly declined for sand, gravel and stone minerals.



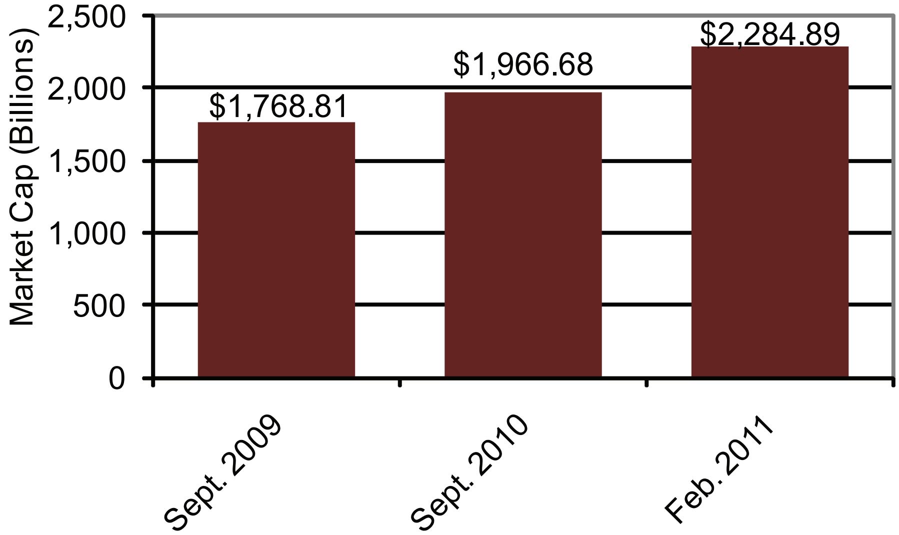
Source: AGI Geoscience Workforce Program, data derived from USGS *Minerals Yearbook*

Figure 5.38: Value of Non-fuel Mineral Production from U.S. Mines

Market Capitalization of Geoscience Industries

One proxy of the aggregate health of the private sector components with key geoscience interests is the market capitalization of the major companies in those sectors. Though stock prices are impacted by a wide variety of financial and external forces, the normalized trends of an index can shed light on current and expected health of those sectors, and as a result, of potential positive or negative impacts on the geoscience workforce. AGI has developed a geoscience stock index, identifying a diverse set of representative companies that have a major focus on U.S. activities in geoscience-related industries. The market capitalization of the AGI geoscience stock index was $2.28 trillion as of February 2011, and is comprised of a set of 200 companies from the following industries: The index is reporting with a nominal value of 100 as of September 30, 2009.

- Cement & Aggregates
- Coal
- Environmental
- Metals & Mining
- Oilfield Services
- Oil & Gas (both Integrated and Producing)
- Precious Metals
- Utilities (primarily water)



Source: AGI Geoscience Workforce Program

Figure 5.39: Historical Total Market Capitalization of Selected Representative Companies Across Geoscience Industries

Appendix A: Defining the Geosciences

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 the data collection (national occupation trends, science & 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 the 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. Thought 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. Now that the national census is a rolling monthly survey, the Standard Occupational Classification (SOC) codes will now be updated every 5 to 10 years. This is an opportunity for AGI and its partners to edit the SOC codes so that they capture the depth and breadth of the geoscience profession, clearly define it, and estimate employment over at least 5 years. This data can then be included in a proposal to federal data agencies to more accurately represent the occupation.

Many federal data sources use the Classification of 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 Estadistica, Geografia e Informatica in order to allow for economic comparisons between North American countries.

Appendix A: Defining the Geosciences

Educational Classifications

Classification of Instructional Programs (CIP)

The National Science Foundation and National Center for Education Statistics use the Classification of Instructional Programs (CIP) is to classify educational programs including fields of study and program completions. The CIP website (http://nces.ed.gov/pubs2002/cip2000/index.asp) also has an online application that allows for the cross-referencing of instructional programs to the Standard Occupational Classification codes.

CIP codes that refer to geoscience programs are:

CIP Code	Title	Description
1.1201	Soil Science and Agronomy, General	A program that generally focuses on the scientific classification of soils, soil properties, and their relationship to agricultural crops. Includes instruction in soil chemistry, soil physics, soil biology, soil fertility, morphogenesis, mineralogy, hydrology, agronomy, and soil conservation and management
1.1202	Soil Chemistry and Physics	A program that focuses on the application of chemical and physical principles to research and analysis concerning the nature and properties of soils and the conservation and management of soils. Includes instruction in soil and fluid mechanics, mineralogy, sedimentology, thermodynamics, geomorphology, environmental systems, analytical methods, and organic and inorganic chemistry
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. Includes instruction in biology, chemistry, physics, geosciences, climatology, statistics, and mathematical modeling
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
14.0805	Water Resources Engineering	A program that prepares individuals to apply mathematical and scientific principles to the design, development and operational evaluation of systems for collecting, storing, moving, conserving and controlling surface- and groundwater, including water quality control, water cycle management, management of human and industrial water requirements, water delivery, and flood control
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 communications systems

CIP Code	Title	Description
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
30.1801	Natural Sciences	A program with a combined or undifferentiated focus on one or more of the physical and biological sciences
40.0101	Physical Sciences	A program that focuses on the major topics, concepts, processes, and interrelationships of physical phenomena as studied in any combination of physical science disciplines
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 behavioral 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
40.0601	Geology/Earth Science, 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

CIP Code	Title	Description
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, magnetrometry, 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 life forms, ecosystems, and geologic 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 of 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
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
45.0701	Geography	A program that focuses on the 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

The College Board

The College Board (http://www.collegeboard.com) has its own definitions for geoscience educational programs which it lists on its careers site. For the SAT Reasoning Test, the geoscience coursework is listed under "Natural Sciences". This heading includes biology, chemistry, physics, geology/earth or space science, and other sciences. Intended college major choices include "Natural Resources and Conservation", "Multi/Interdisciplinary Studies", "Physical Sciences", and "Engineering".

Test scores, goals for higher education, and related information published by the College Board are used for various purposes. Universities and colleges use test scores in conjunction with other relevant application information to assess an incoming student's preparedness for academic study. Counselors use the information to provide students with information about course selection, college programs, and career pathways. Recruiters also use the information to assess the relative strengths of students and their preparedness for certain careers. Additionally, the data provided by the College Board is used by researchers to study trends in academic performance between disciplines as well as trends in national academic performance relative to other countries.

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.

Occupational Classifications

Standard Occupational Classification Codes

The U.S. Census Bureau, U.S. Bureau of Labor Statistics, and National Science Foundation (NSF) use the 2000 Standard Occupational Classification (SOC) codes (http://www.bls.gov/soc/home.htm) to classify geoscientists; however, each organization has a different focus for its surveying and data collection. The Office of Personnel Management uses its Handbook of Occupational Groups and Families to define occupations.

Data from the U.S. Census Bureau and 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 because geoscientists fall within twenty-three occupational categories in the SOC codes, thirteen occupational categories within the National Science Foundation's National Survey of College Graduates, sixteen occupational series within the OPM's Handbook of Occupational Groups and Families.

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 Sciences Managers. Geoscience teachers at post-secondary institutions are grouped into 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 geoscientsts that occur in the SOC codes (such as post-secondary geoscience teachers) also occur within the National Science Foundation's classification schema.

Appendix A: Defining the Geosciences

Geoscientists are found in the following SOC definitions:

SOC Code	SOC Title	Definition
11-9041	Engineering Managers	Plan, direct, or coordinate activities in such fields as architecture and engineering or research and development in these fields. Exclude "Natural Sciences Managers"
11-9121	Natural Sciences Managers	Plan, direct, or coordinate activities in such fields as life sciences, physical sciences, mathematics, statistics, and research and development in these fields. Exclude "Engineering Managers" (11-9041) and "Computer and Information Systems Managers" (11-3021)
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, water and sewage systems, and waste disposal units. Include architectural, structural, traffic, ocean, and geo-technical engineers. Exclude "Hydrologists" (19-2043)
17-2081	Environmental Engineers	Design, plan, or perform engineering duties in the prevention, control, and remediation of environmental health hazards utilizing various engineering disciplines. Work may include waste treatment, site remediation, or pollution control technology
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	Determine the location and plan the extraction of coal, metallic ores, nonmetallic minerals, and building materials, such as stone and gravel. Work involves 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
17-2171	Petroleum Engineers	Devise methods to improve oil and gas well production and determine the need for new or modified tool designs. Oversee drilling and offer technical advice to achieve economical and satisfactory progress
19-1013	Soil and Plant Scientists	Conduct research in breeding, physiology, production, yield, and management of crops and agricultural plants, 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 from fire and rodent damage. 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. Exclude "Zoologists and Wildlife Biologists" (19-1023) and "Foresters" (19-1032)
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 uses. Include weather analysts and forecasters whose functions require the detailed knowledge of a meteorologist

SOC Code	SOC Title	Definition
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. Utilizing knowledge of various scientific disciplines may collect, synthesize, study, report, and take action based on data derived from measurements or observations of air, food, soil, water, and other sources. Exclude "Zoologists and Wildlife Biologists" (19-1023), "Conservation Scientists" (19-1031), "Forest and Conservation Technicians" (19-4093), "Fish and Game Wardens" (33-3031), and "Forest and Conservation Workers" (45-4011)
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. Include mineralogists, crystallographers, paleontologists, stratigraphers, geodesists, and seismologists
19-2043	Hydrologists	Research the distribution, circulation, and physical properties of underground and surface waters; 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 nature and use of areas of 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
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. Include teachers of subjects, such as chemical, civil, electrical, industrial, mechanical, mineral, and petroleum engineering. Include both teachers primarily engaged in teaching and those who do a combination of both teaching and research. Exclude "Computer Science Teachers, Postsecondary" (25-1021)
25-1043	Forestry and Conservation Science Teachers, Postsecondary	Teach courses in environmental and conservation science. Include both teachers primarily engaged in teaching and those who do a combination of both teaching and research. Exclude "Agricultural Science Teachers" (25-1041)
25-1051	Atmospheric, Earth, Marine, and Space Sciences Teachers, Postsecondary	Teach courses in the physical sciences, except chemistry and physics. Include both teachers primarily engaged in teaching, and those who do a combination of both teaching and research
25-1053	Environmental Science Teachers, Postsecondary	Teach courses in environmental science. Include both teachers primarily engaged in teaching and those who do a combination of both teaching and research
25-1064	Geography Teachers, Postsecondary	Teach courses in geography. Include both teachers primarily engaged in teaching and those who do a combination of both teaching and research

Appendix A: Defining the Geosciences

Office of Personnel Management: Handbook of Occupational Groups and Families

The Office of Personnel Management's Handbook of Occupational Groups and Families defines geoscience occupations in the following manner:

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.
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 that involve professional engineering work to protect or improve air, land, and water resources in order to provide a clean and healthful environment. Such work requires the application of: (1) professional knowledge of the principles, methods, and techniques of engineering concerned with facilities and systems for controlling pollution and protecting quality of resources and the environment; and (2) an understanding of and the ability to utilize pertinent aspects of chemistry, biological sciences, and public health that pertain to the control or elimination of pollutants.
0880 – Mining Engineering Series	This series covers positions that require primarily the application of professional knowledge of mining engineering. The work requires the ability to apply the principles of mathematics, chemistry, geology, physics, and engineering to mining technology. It also requires general knowledge of construction and excavation methods, materials handling, and the processes involved in preparing mined materials for use. Mining engineer positions are concerned with the search for, efficient removal, and transportation of ore to the point of use; conservation and development of mineral lands, materials, and deposits; and the health and safety of mine workers.
0881 – Petroleum Engineering Series	This series covers positions that require primarily the application of a professional knowledge of petroleum engineering. The work is concerned with exploration and development of oil and natural gas fields; production, transportation, and storage of petroleum, natural gas, and helium; investigation, evaluation, and conservation of these resources; regulation of transportation and sale of natural gas; valuation of production and distribution facilities for tax, regulatory, and other purposes; and research on criteria, principles, methods, and equipment.

Code-Title	Description
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 conditions 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 or the improvement 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 theory.
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, and mathematics and appropriate knowledge in the field of oceanography.

Industry Classifications

North American Industry Classification System (NAICS)

The NAICS (http://www.census.gov/epcd/www/naics.html) 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 NA-

ICS is a comprehensive system covering the entire field of economic activities. There are 20 sectors in the NAICS and 1,170 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 as 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.

NAIC Code	NAICS Industry Title
11	Agriculture, Forestry, Fishing and Hunting
21	Mining
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

Energy Information Administration

The Energy Information Administration (EIA) is part of the U.S. Department of Energy. It collects and analyzes data related to energy issues, and publishes reports and relevant information on its website: http://www.eia.doe.gov/. EIA provides useful educational tools about the energy industry and maintains an online glossary of terms related to the energy industry.

AGI's Working Definition of Geoscience Occupations

In light of how existing federal data sources define the geosciences, AGI has worked with its stakeholders to establish a working definition for the geoscience profession in order to improve comparability 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 geosciences in federal data sources.

AGI's working definition of the geosciences 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 of 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 involves 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 the structural behavior of soil 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: References

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