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Published in *EOS* (October 2003) 84 (43): 457-458, 460-461. Copyright 2003, American Geophysical Union. doi:10.1029/2003EO430002 . Used by permission. Link to pre-print version: www.awg.org/gender-workshop03/forthcoming-Eos-article-Holmes-et-al.pdf.

Academic Specialties in U.S. Are Shifting; Hiring of Women Geoscientists Is Stagnating

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Women have been receiving a greater proportion of the bachelor's and master's degrees in the geosciences over the last 10 years, reaching near 40% in 2000 (latest data available), while receiving only 28% of the Ph.D.s that year. Women are now only 20% of assistant professors at Ph.D.-granting institutions, a proportion that has not changed in the last four years. As part of a larger

study to find what key barriers continue to prevent larger numbers of women geoscientists from becoming academics, data have been compiled from the National Science Board [NSB, 2002], and the American Geological Institute's (AGI) *Directory of Geoscience Departments* [Claudy, 2001] on geoscience specialty by gender.

The data are broken down by the specialty

of the Ph.D., and compared to hiring rates at Ph.D.-granting institutions over the last 10 years. These institutions are the focus because they are the source of future Ph.D.s, and diversity of their faculty is critical to assuring diversity and consequent intellectual vigor and strength of our future academic workforce. The data reveal both a slight shift in the subdisciplines of all geoscientists

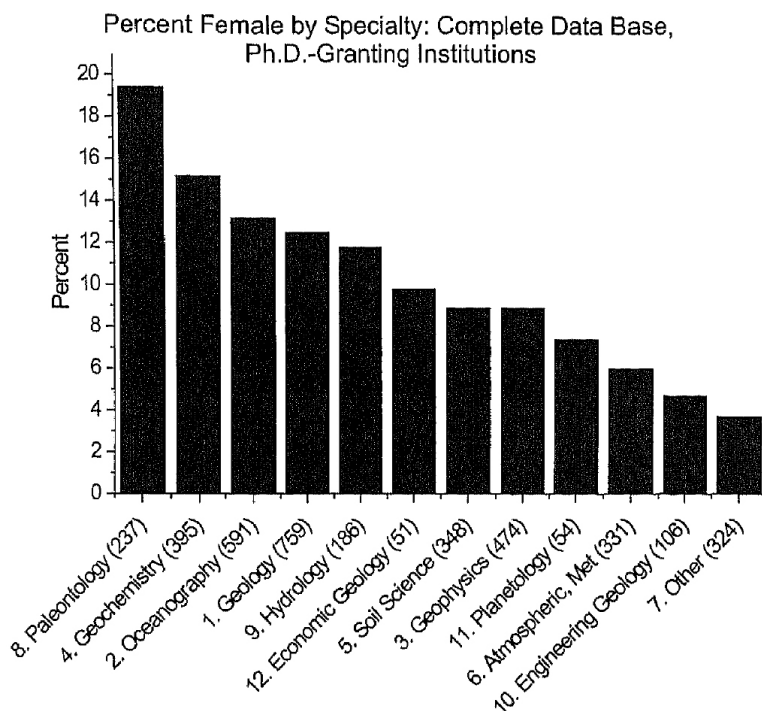


Figure 1. The proportion of women in different geoscience specialties listed in the AGI Directory (1999-2001). Absolute numbers by specialty are in parentheses along x-axis. Ordinal numbers by specialty in the x-axis refer to the numerical rank of the specialty for all persons in the data base.

employed in tenure-track positions at Ph.D.-granting institutions, and that hiring of women into tenure-track positions in specific subdisciplines has not kept pace with their Ph.D. production during that time.

Data from the NSB are compiled on their Web site (<http://srsstats.sbe.nsf.gov>) which provides total numbers of male and female

recipients by each specialty. Data from the AGI Directory were provided in electronic format that included the name of the individual, the year of the Ph.D., and geoscience specialty, as self-reported, to the individual's department. Geosciences departments supply an individual's data to AGI. Gender identity was provided by AGI for about three-fourths

of the entries. The Gender of over 3,000 "unknowns" was determined by 1) gender-specific first names; and 2) for gender non-specific first names, we asked colleagues and searched the Internet for photos or gender-identifying text. Seventy-seven persons at Ph.D.-granting institutions remain "unknown." Seventy-eight entries in Ph.D.-granting institutions had no graduation year and were excluded from the analyses. Of these, ten are listed as assistant professors and 21 as associate professors.

Of 652 persons hired into assistant professor positions at Ph.D.-granting institutions listed in the Directory over the last 10 years, 54 (52 males, 1 female, 1 unknown gender) received the Ph.D. from some institution outside of the U.S. (including six unspecified institutions). The subdisciplines with the greatest proportion of non-U.S. Ph.D.s include geochemistry, which had 10 males out of 59 from non-U.S. institutions hired as assistant professors; geophysics, which had 12 of 68; and oceanography, which had 11 males out of 58 total hired. All persons listed in the Directory were reported regardless of where the Ph.D. was obtained, because these are the positions at Ph.D.-granting institutions that were open and had persons hired into them in the U.S. over the last 10 years.

All specialties in the Directory were grouped together to determine the proportion of gender for each specialty. The two data bases, NSB's and the Directory, differ slightly in how the specialties are classified, but some cross-comparisons are possible. Statistical differences reported here are based on χ^2 tests for independence and for associations.

20% of Recent Ph.D.s now in AGI Directory; Fewer than 10% in Tenure-track Positions

Over the period 1992-2001, 8,877 Ph.D.s were awarded in the geosciences (Table 1; NSB, 2002). Twenty percent (1,925) of these Ph.D. recipients are now listed in the 2001 Directory as employed by academia, state surveys, museums, and research institutions (Table 2). Six hundred fifty-two (7%) of these Ph.D.s were hired into tenure-track positions (assistant professors) at Ph.D.-granting institutions (Table 3), there is some error in the percentages, because 921 of the geoscience Ph.D.s were in soil science. While the Directory includes only 20 soil science/agronomy departments, thus underreporting soil scientists working at Ph.D.-granting institutions, Excluding soil science, 598 of the 7,966 Ph.D.s produced – or 7.5% were hired into tenure-track positions at Ph.D.-granting institutions (Table 3).

Some institutions hired a greater proportion of women than the proportion of women who received a Ph.D. These include non-degree-granting academic programs, museums, non-tenure-track positions at master's and bachelors-granting institutions, and tenure-track positions at bachelors degree-granting institutions (Table 2).

Table 1. Numbers of Ph.D.s Earned in the Geosciences Over The Last 10 Years, by Specialty. Data Compiled from NSF (2001). Bolded Values Have A Greater-Than-Average Percentage of Females.

Field of Ph.D., 1992-2001	Female	Male	Total	% female
Atmospheric Sciences/Meteorology	254	1006	1260	20.2%
Geochemistry	141	373	514	27.4%
Geology	363	1274	1637	22.2%
Geology & Related Sciences, General	34	139	173	19.7%
Geology & Related Sciences, Other	66	194	260	25.4%
Geomorphology/Glacial Geology	43	108	151	28.5%
Geophysics/Seismology	187	794	981	19.1%
Hydrology/Water Resources	79	258	337	23.4%
Mineralogy/Petrology	47	121	168	28.0%
Oceanography/Marine Sciences	375	877	1252	30.0%
Paleontology	56	149	205	27.3%
Soil Science	197	724	921	21.4%
Stratigraphy/Sedimentology	44	152	196	22.4%
Environmental	288	544	832	34.6%
Total	2174	6713	8887	24.5%
without soil science	1977	5989	7966	24.8%

Table 2. Proportion of Males and Females at Different Types of Institutions and in Different Positions Listed in the AGI Directory Who Earned the Ph.D. in the Last 10 Years. Unknowns Are Entries for Whom We Have Not Been Able to Determine Gender. Bolded Values Have a Greater-Than-Average Percentage of Females.

	female	male	unknown	% female
AA-Granting	4	19	3	15%
Non-degree Academic	5	9	1	33%
State Surveys	5	53	4	8%
Research Centers	25	109	16	17%
Museums	6	12	2	30%
Ph.D., tenure-track	136	508	8	21%
Ph.D., non T-T	87	279	21	22%
Master's, tenure-track	59	191	4	23%
Master's, non T-T	14	31	0	31%
Bachelor's, tenure-track	84	190	3	30%
Bachelor's, non T-T	15	22	0	41%
Total	440	1423	62	20.2%

Conversely, lower-than-average hiring of women Ph.D.s occurred at AA-granting institutions, research centers, state surveys, Ph.D.-granting institutions (tenure-and non-tenure-track), and tenure-track positions at master's-granting institutions (Table 2). State surveys hired the lowest proportion of women: only 8% of hires in the last 10 years were female. The people hired into tenure-track positions at doctoral-granting institutions will be producing the new Ph.D.s in the coming decades. One hundred thirty-six

women—6.3% of all female Ph.D.s earned between 1992 and 2001—were hired into tenure-track positions at Ph.D.-granting institutions, while 508 (7.6% of male Ph.D.s) men were hired. These proportions are not significantly different (based on a X^2 test).

Numbers of Women Ph. D. s; Where They've Been Hired

Twenty-four percent of the Ph.D.s awarded in the geosciences between 1992 and 2001

for a new Ph.D. of being hired in to an institution listed in the *Directory* are not statistically different for men and women. However, women have been hired in significantly greater proportions (based on a X^2 test; $P = 0.9926$) at non-Ph.D -granting academic institutions, rather than into tenure-track positions at Research Institutions (Table 2).

Specialty Drift and Hiring Stagnation

Of those geoscientists listed in the *AGI Directory*, which includes geoscientists with Ph.D.s earned as long ago as 1946, most geoscientists list themselves as 'geology' specialists, followed by oceanography, geophysics, geochemistry, and soil science (Figure 1). For academics hired only in the last 10 years, the dominant specialty remains geology, followed by geochemistry, geophysics, oceanography, and hydrology (Figure 2). The proportions of paleontologists, soil scientists, and atmospheric/meteorologists in tenure-track positions at Ph.D.-granting institutions listed in the *Directory* have declined over the last 10 years.

Specialties of Recent Ph.D.s

Geoscience specialty is significantly different between men and women (based on a X^2 test for association, $p = 0.000$). The geoscience specialty most sought after by women is oceanography/marine sciences and geology (375, or 17% of women's Ph.D.s are in each field; see Table 1). Rounding out the top five subdiscipline choices for women are the

Table 3. Number of Persons, By Geoscience Specialty, in The AGI Directory Who Have Received a Ph.D. In The Last 10 Years. Bolded Values Have A Greater-Than-Average Percentage of Females.

Last 10 years of AGI Directory	female	male	unknown	% female	total	% Hired	% Female Ph.D.s Hired	% Male Ph.D.s Hired
Atmospheric, Met (49)	6	43	0	12.2%	49	4%	2%	4%
Economic Geology (4)	1	3	0	25.0%	4			
Engineering Geology (13)	0	13	0	0.0%	13			
Geochemistry (91)	30	59	2	33.0%	91	18%	21%	16%
Geology (53)	6	42	0	12.5%	48	3%	2%	3%
Geomorphology/Glacial Geology (22)	2	20	0	9.1%	22	15%	5%	19%
Geophysics (77)	12	65	0	15.6%	77	8%	6%	8%
Hydrology (55)	8	46	1	14.5%	55	16%	10%	18%
Mineralogy/Petrology	3	15	0	16.7%	18	11%	6%	12%
Oceanography (76)	21	52	3	27.6%	76	6%	6%	6%
Other (70)	13	56	1	18.6%	70			
Paleontology (42)	15	27	0	35.7%	42	20%	27%	18%
Planetology (4)	1	3	0	25.0%	4			
Soil Science (52)	16	35	1	30.8%	52	6%	8%	5%
Stratigraphy/Sedimentology (26)	1	25	0	3.8%	26	13%	2%	16%
Environmental	1	4	0	20.0%	5	1%	0%	1%
Total	136	508	8	20.9%	652	7.3%	6.3%	7.6%
without soil science	120	473	7	20.0%	600	7.5%	6.1%	7.9%

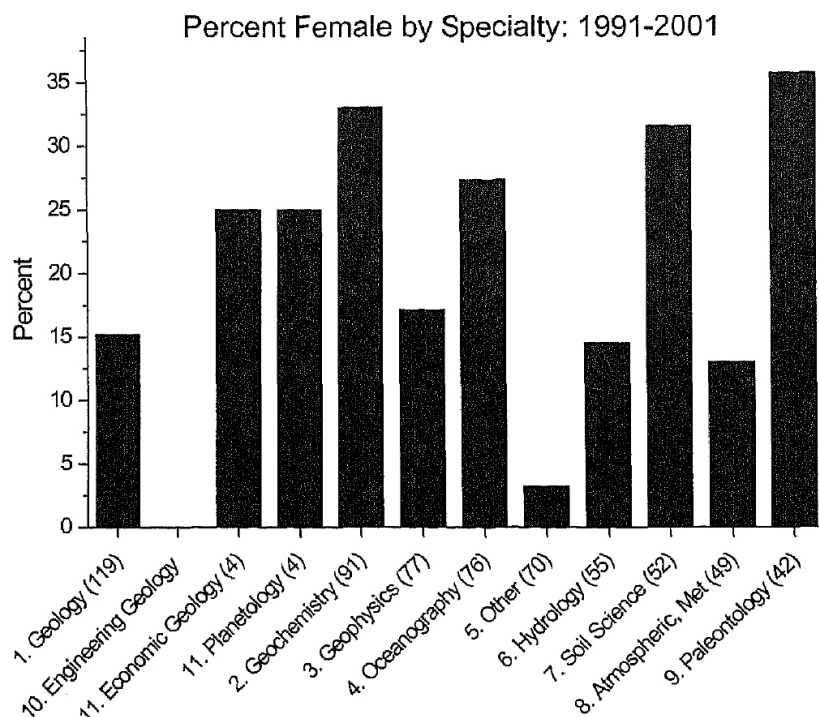


Figure 2. The proportion of women in different geoscience specialties listed in the AGI Directory (1991-2001) who have received a Ph.D. in the last 10 years. Absolute numbers by specialty are in parenthesis along x-axis. Ordinal numbers by specialty in the x-axis refer to tile numerical rank of the specialty for all persons in the data base.

fields of environmental, (363; 13%), atmospheric sciences/meteorology (254; 12%), and soil science (197; 9%). Most men received the Ph.D. in "geology" (1,274; 19%), followed by atmospheric sciences/meteorology (1,006; 15%), oceanography/marine sciences (877; 13%), geophysics/seismology (794; 12%), and soil science (724; 11%).

Hiring into Ph.D. Tenure-track Does Not Match Ph.D. Production

Hiring of the subdisciplines by Ph.D.-granting institutions did not match Ph.D. production during 1992-2001. The discrepancy between production and hiring is somewhat greater for males than for females: $X^2 = 210.5$ for males; 116.5 for females; $p = 0.000$ for each value). Most women were hired into geochemistry positions (30), followed by oceanography (21), soil science (16), paleontology (15), and geophysics (12; see Table 3). Most men were hired into geophysics positions (65), followed by geochemistry (59), oceanography (52), hydrology (46), atmospheric/meteorology (43), and geology (42).

Most women academics are paleontologists, followed by geochemists, oceanographers, geologists, and hydrologists (Figure 1). In the last 10 years, the fields in which women have fared better than average (*i.e.*, hired into assistant professor positions at rates equal to or greater than the average production of female Ph.D.s) are paleontology, geochemistry, soil science, oceanography, and economic geology (Figure 2).

Hiring rates for women in geomorphology/glacial geology has significantly underperformed Ph.D. production ($X^2 = 3.749$; $p = 0.053$). Women earned 43 (28%) of the Ph.D.s in geomorphology, but only two women, or 9%, of the new geomorphology positions, were hired by a Ph.D.-granting institution. For all other specialties, there was no significant difference between male and female Ph.D. production and hiring into assistant professor positions at Ph.D.-granting institutions.

Future Studies

A series of focus groups of geoscientists at different academic ranks are now being completed to determine whether the experiences and perceptions of women geoscientists differ from men as they ascend the ranks of academia. Based on an initial preview of the data, there is a greater difference in perception between generations than there is between genders. There is little difference in attitudes by race or ethnicity, but low numbers of racial and ethnic minorities in our field preclude us from making firm generalizations.

Older geoscientists, both male and female, expressed frustration with the slow pace of women's advancement through the ranks of academia. Younger geoscientists are split between a discomfort with the data and an optimistic view that their science has become more diverse (at least in terms of gender). They believe that this trend will continue

without the need for any type of intervention or alteration in the way academia is conducted. Older geoscientists do believe intervention will be necessary to advance gender equity.

Data from NSF on proportions of women receiving a bachelor's, master's, and Ph.D.s do indicate increases over the last 10 years; but we see stagnation in the hiring of female assistant professors, particularly at Ph.D.-granting institutions, in the last four years [Holmes *et al.*, 2002a and b]. Although the causes are complex, we believe that there are, among the more intransigent barriers, some simple structural barriers that geoscience departments can easily overturn if they are interested in increasing the gender diversity of their faculty. These include 1) raising awareness that there is a problem with lack of diversity in the geosciences, understanding that this affects the intellectual vigor and strength of our field, and beginning to earnestly work toward a more diverse faculty (without a will, there will be no way); 2) assuring that teaching climates are amenable and fair: Are female students being called on at the same rate as males? Are they allowed to give complete comments/questions without interruption from other students and faculty? Are female students' ideas given credence and credit? And, 3) assuring that female graduate students are included in the network of colleagues who can help them find postdoctorate positions and academic jobs. We need to begin thinking seriously about how to accommodate the overlap of the tenure and biological clocks as elucidated in de Wet *et al.* [2002].

Acknowledgments

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