

# Issues in Canadian Geoscience - Women in the Geosciences in Canada and the United States: A Comparative Study

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Article abstract

The literature on women in the geo-sciences is mainly limited to the experiences of women in Canada and the United States. Compared to women in other scientific careers, women in the geosciences have historically been disadvantaged relative to men because of restrictions on working in the field combined with the lesser value accorded to laboratory and office work. Recently, however, times have changed; linear extrapolation of data from the USA suggests that women earned 50% of undergraduate geoscience degrees in 2008. In Canada the situation has been similar, with 45% of bachelor's and other undergraduate degrees in geological and earth sciences/geo-sciences disciplines in 2005–2006 having been awarded to women. However, current trends suggest that US women will not attain 50% of geo-science doctorates until about the year 2021 and will not make up half of geoscience faculty until 2084. Increasing the proportion of women faculty is appropriate, given that gender parity has been achieved at the undergraduate student level. The obvious geoscience departments to begin recruiting more women would be those with the lowest percentage of female faculty. Faculty gender representation should better reflect the fact that 34% of geoscience doctorates were awarded to women in North America in 2002, and probably approached 40% in 2010. Overall in Canada in 2006, 18.8% of all geologists, geochemists and geophysicists were women and in the USA for the same year, 16% of geoscientists were women, so the percentages are low for both countries.

# SERIES



## ISSUES in CANADIAN GEOSCIENCE

### Women in the Geosciences in Canada and the United States: A Comparative Study

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#### SUMMARY

The literature on women in the geosciences is mainly limited to the experiences of women in Canada and the United States. Compared to women in other scientific careers, women in the geosciences have historically been disadvantaged relative to men because of restrictions on working in the field combined with the lesser value accorded to laboratory and office work. Recently, however, times have changed; linear extrapolation of data from the USA suggests that women earned 50% of undergraduate geoscience degrees in 2008. In Canada the situation has been similar, with 45% of bachelor's and other undergraduate degrees in geological and earth sciences/geosciences disciplines in 2005–2006 having been awarded to women. Howev-

er, current trends suggest that US women will not attain 50% of geoscience doctorates until about the year 2021 and will not make up half of geoscience faculty until 2084. Increasing the proportion of women faculty is appropriate, given that gender parity has been achieved at the undergraduate student level. The obvious geoscience departments to begin recruiting more women would be those with the lowest percentage of female faculty. Faculty gender representation should better reflect the fact that 34% of geoscience doctorates were awarded to women in North America in 2002, and probably approached 40% in 2010. Overall in Canada in 2006, 18.8% of all geologists, geochemists and geophysicists were women and in the USA for the same year, 16% of geoscientists were women, so the percentages are low for both countries.

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La documentation sur la présence des femmes en géosciences est principalement limitée à la main-d'œuvre canadienne et étasunienne. Par rapport aux femmes dans d'autres domaines scientifiques, les femmes en géosciences ont été historiquement défavorisées dû aux restrictions du travail de terrain combiné à la sous-évaluation du travail de bureau et de laboratoire. Mais la situation a changé récemment; l'extrapolation linéaire de données étasuniennes montre que les femmes ont obtenu 50 % des diplômes de premier cycle en géosciences en 2008. Au Canada la situation a évolué pareillement, où 45 % des diplômes de baccalauréat et de premier cycle en sciences géologiques ou sciences de la Terre ou géosciences ont été décernés à des femmes en 2005–2006. Cependant, les tendances étasuniennes actuelles montrent qu'il

faudrait attendre autour de 2021 avant que 50 % des doctorats en géosciences ne soient décernés à des femmes, et que ce ne serait qu'en 2084 qu'elles représenteraient 50 % du personnel enseignant universitaire. L'accroissement de la proportion de femme enseignant à l'université est justifié étant donné que la parité a été atteinte au niveau des étudiants du premier cycle. Évidemment, les premiers départements de géosciences visés devraient être ceux comptant le moins de femmes dans leur personnel enseignant. La représentation des genres chez les enseignants universitaires devrait mieux refléter le fait que 34 % des doctorats ont été décernés à des femmes en Amérique du Nord en 2002, et approchera probablement 40 % en 2010. Globalement, au Canada en 2006, 18,8 % de tous les géologues, géochimistes et géophysiciens étaient des femmes et, aux É.-U. pour la même année, 16 % des géoscientifiques étaient des femmes; des proportions faibles pour les deux pays on en conviendra.

#### INTRODUCTION

Although much has been written on 'women in science' (e.g. Ramirez and Wotipka 2001; Andres and Adamuti-Trache 2007; Burke and Mattis 2007; Ceci and Williams 2007; Xu 2008), and there are numerous references in the Wisconsin Bibliographies in Women's Studies (ca. 1994), less has been written about female Canadian scientists and engineers (Heap 2003; Ainley 2006), and still less about Canadian women in the geosciences. In 2002, in the United States, women made up only 16% of all employed scientists, compared to 45% of all employed people, suggesting that the growing demand for science and technology workers would

not be met without a policy aimed at recruiting women to senior positions at universities, government and industry (Organization for Economic Cooperation and Development (OECD) 2006). However, some women have commented that they have felt a backlash and discrimination as a consequence of affirmative action programs. Also, they have reported that the most common problem for women in science, technology, engineering and mathematics (STEM) positions has been balancing work and family responsibilities (Rossier 2006).

The problem of not producing sufficient scientists in Canada has been even more acute: there were 1163 science graduates per 100 000 employed people in the 25 to 34 year age group, compared with the OECD average of 1295 (Tibbets 2007). However, such statistics must be viewed cautiously because critical to the matter is the capacity of a country to absorb its graduates into the workforce. For university programs in mathematics, engineering and computer science, enrollment of women in Canada increased from 441 students in 1972 to 9805 in 1995, but the increase in female doctoral students was modest, from 2.7% in 1972 to 10.4% in 1994 (Gadalla 2001). The data reveal that for engineering and applied sciences in Canada, women are still under-represented at postsecondary institutions (Canadian Association of University Teachers (CAUT) 2008). This is not the general case, however, given that 58.5% of the 698 607 undergraduate students at Canadian universities in 2006–2007 (calculated as full-time equivalent enrolments) were female (CAUT 2010, p. 25).

Why are females so under-represented in the sciences? A number of reasons have been proposed. For instance, Astin and Sax, as quoted in Pasztor and Slater (2000, p. 335), stated that

*“...science teaching was seen as alienating many students by encouraging competition, which was counter to the sensibilities of women who favour the connectedness of science to social consciousness and human welfare.”*

Could these differences in approaches and interests explain why women have not seen science as relevant, and could

men be asking research questions that women have perceived as not sufficiently relevant to themselves or society? Research questions, after all, are selected by researchers and in this sense, science is not as objective as has been advertised (Harding 1986). Would women researchers be more interested in selecting different research topics? Or could it be that women do not receive enough research support? In this regard, only 17% of the 1000 chairs awarded in the Canada Research Chairs Program went to women, even though women constituted 26% of full-time faculty, a discrepancy that prompted a complaint to the Canadian Human Rights Commission (Birchard 2004).

There is also a gender gap in average salary at universities, according to the annual University and College Academic Staff Survey; in 2005/2006, male faculty earned at least \$15 000 more per annum than female faculty at several Canadian universities (Statistics Canada 2008). However, in Canada in 2007, female Full Professors earned 95%, Associate Professors 97%, and Assistant Professors 96% of the salary of their male counterparts (CAUT 2010, p 5), so overall the salary gap is narrow. More recent Statistics Canada data based on the annual survey for 2008–2009 showed that the University of Toronto had the largest salary gap, paying its male full-time teaching staff (excluding medical and dental faculty) an average of \$20 362 more than comparable female faculty members, which was explained by university officials as a consequence of past hiring practices favouring men, as well as the age, rank and gender distribution among different disciplines having different pay scales (Cross 2010). For all Canadian geoscientists, the Canadian Geoscience Council 2001 Census of Geoscientists showed, according to Coultish (2002, p. 101), that

*“A gender-based differential in compensation is not evident for males and females less than 40 years old, but is present for older respondents even after standardizing for educational level.”*

## WOMEN IN THE GEOSCIENCES FROM A HISTORICAL PERSPECTIVE

### Canada

The first woman geology graduate in Canada, according to available records, was Grace Anna Stewart, who received her undergraduate degree from the University of Alberta in 1918 and went on to complete M.A. and Ph.D. degrees. She opted for an academic position in the United States because of a lack of opportunities at Canadian universities and because of prejudice against women at the Geological Survey of Canada (Ainley 1990). In fact, the only woman geologist in the first half of the 1900s to have had a successful academic career in Canada was Madeleine Fritz at the University of Toronto (Ainley 1990). Another woman geologist to reach prominence in Canada was Alice Wilson (1881–1964), who completed an Honours B.A. in modern languages and history in 1911 at Victoria College in Toronto and a Ph.D. in Geology in 1929 from the University of Chicago (Meadowcroft 1990; Montagnes 1966), with her doctoral thesis on the geology and paleontology of the Cornwall, Ontario area (Sinclair 1966). Alice Wilson had two brothers, one a geologist and the other a mathematician, according to Burek (2002), which may, in part, explain her career choice. She worked for the Geological Survey of Canada, first as a Museum Assistant in 1909 (Library and Archives Canada (LAC) 2005), an Assistant Paleontologist in 1920 (Russel 1965), an associate geologist in 1940 and a ‘full’ geologist in 1945 (Meadowcroft 1990). Alice Wilson became one of the first Members of the Order of the British Empire, the first woman to be elected a Fellow of the Royal Society of Canada (1938), and the first Canadian woman to be elected a fellow of the Geological Society of America (Rossiter 1982). However, she was repeatedly denied promotions; LAC (2005) and Meadowcroft (1990) documented some of the details of this gender discrimination. Alice Wilson retired officially in 1946, but kept an office at the GSC until she was 82 (Montagnes 1966). She became a lecturer in Paleontology at Carleton College from 1948 to 1958 (LAC 2005)

and was the first female to be awarded an honorary Doctor of Laws degree from Carleton in 1960 (Meadowcroft 1990; Montagnes 1966). Another prominent geologist was Marie Stopes, a paleobotanist with a Ph.D. from the University in Munich in 1904 and a D.Sc. from the University of London in 1905, who undertook paleobotanical work on the Fern Ledges near Saint John, New Brunswick in 1911, but is now remembered best for her writings on sex, marriage and birth control (Falcon-Lang and Miller 2007). As mentioned, the Canadian literature on women geoscientists is sparse, although O'Donnell (2000) interviewed 34 women who worked as geoscientists in the resource industry, government research, and academia in Alberta between 1914 and 1999 and concluded (p. 4312) that

*“in spite of outdated exclusionary practices...a majority of women geoscientists interviewed in the study are experiencing or have experienced fulfilling and financially rewarding careers.”*

At Canadian universities during 2005–2006, in the combined category of geology and related disciplines at the assistant, associate and full professor levels, there were still only 63 females out of a total of 381 faculty members (CAUT 2009). The CAUT almanacs from 2005–2006 to 2009–2010 have shown an increase in the number of appointments in geology and related subjects from 352 to 396, with an accompanying but slight increase in female faculty representation from 15.3% in 2001 to 17.4% in 2006.

### United States

Before 1850 only about a dozen of the 11 000 citations in geology referred to contributions by women, some of which were textbook contributions and geological books for children (Aldrich 1990). Several women did paleontological work between 1840 and 1960, initially as illustrators of specimens (Aldrich 1982). Almira Phelps at the Troy Female Seminary wrote a textbook on geology and in the 1890s influenced women to become geoscientists (Arnold 1977). Another renowned geologist was Florence Bascom (1862–1945), who received the first Ph.D. awarded to a woman at

Johns Hopkins University in the late 1800s, and then started a geology department at Bryn Mawr College (Arnold 1977). Bascom was important also for educating many of the early women geologists (Clary and Wandersee 2007), and became, along with Mary Holmes, the first two women to be elected to the Geological Society of America in 1889 and 1894, respectively (Rossiter 1982). Female geology faculty members at women's colleges included Elizabeth Fisher at Wellesley College in 1894, Ida Ogilvie at Barnard College in 1903 and Mignon Talbot at Mount Holyoke College in 1904 (Rossiter 1981). Among industry geologists, Carlotta Maury (1874–1938) became a petroleum geologist with Royal Dutch Shell (Elder 1982).

Another notable female geoscientist was Winifred Goldring, who became the state paleontologist of New York, apparently with the support of Professor Charles Schuchert of Yale University (Rossiter 1982). In 1949, she became the first President of the Paleontological Society (Arnold 1977), showing that women were beginning to be recognized for their contributions. Between 1947 and 1961, 2675 doctorates were awarded in the geosciences, 96 of which, or 3.6%, went to women at a time when ‘woman's work’ included editing and compilation of bibliographies (Rossiter 1995). Between 1956 and 1958, only 217 women were employed in geological fields of all kinds, representing a mere 2.2% of geologists in the United States (Rossiter 1995).

### CAREER CHOICES AND BARRIERS

Among young women, over 40% of the effect of gender on majoring in science at university has been attributed to inadequate high school preparation (Haines and Wallace 2002). In particular, in many countries high school science courses are prerequisites for postsecondary science studies. In Holland, for instance, where this has been the case, many female students did not select enough science and mathematics courses in secondary school, and while the exact reason for this remains unclear, it was determined that those female students with higher IQs and more educated parents chose more science and math subjects than

those with lower IQs whose parents were less educated (Van Langen 2006). Given the magnitude of this problem in terms of subsequent barriers to university science programs, this issue should be examined further.

One of the major problems encountered by women geologists between the 1700s to about the 1970s was field work. This problem manifested itself in practices ranging from requiring chaperones (in the earliest days) to sexual harassment (Burek and Kölbl-Ebert 2007). Employers often would not permit women geologists to travel to remote locations. In the case of Alice Wilson, for instance, Meadowcroft (1990, p. 208) noted that *“...it would have been considered scandalous, in 1913, for a woman to camp out with a group of men.”* At the Geological Survey of Canada, women were not allowed to do field work until 1970 (Ainley 1990) but Alice Wilson was excluded from this restriction because the Ottawa area was not considered remote.

Teaching and research opportunities for women in the sciences generally, including Earth Science, were affected by lateral and hierarchical segregation, which was explained by Ainley (2006, p. 252) as follows:

*“Women often experienced hierarchical segregation when they remained in undervalued and underpaid positions. They were laterally segregated when they were channelled into certain areas of science considered suitable for women, such as botany or household science.”*

Both types of segregation were experienced by women in Earth Science because over time the various tasks of geology had gained different degrees of importance, with field work (from which women were excluded) being valued most, to laboratory work, which was considered of intermediate value and from which women were also excluded, to office work, which was valued least (and dominated by women) (Ainley 1994). In later years, the formation of all-female geological field parties at the Ontario Geological Survey, the Department of Indian Affairs and Northern Development, the Geological Survey of Canada, and elsewhere, solved the problem, but this only happened after a critical mass of women geoscientists had been hired.

Questioning the commitment

of a female geoscientist deciding to have a family was also prevalent. As an undergraduate, Ann Edging had a supportive male professor, but when she went on to her masters studies at another university, she felt that she was not taken seriously as a married student with a family; nevertheless, she went on to complete her Ph.D. and subsequently began a successful academic career (Rosser 2004). Among men, married male faculty had higher positions and earned more than single male faculty (Bellas and Toutkoushian 1999), but the commitment of married male faculty deciding to have a family, in contrast to married female faculty, was apparently not in question. The desire of many women to have children has also conflicted with the tenure process. In fact, the lack of female geoscience academics, according to Gail Ashley (quoted in Reed 2003), is because

*“...many women in their mid-30s are deciding not to continue an academic career and face the pressures of making tenure because the tenure process occurs at the same time in their lives when the decision whether or not to have a family becomes biologically critical.”*

Ashley believed that a change in the tenure system could solve this problem. Another issue has been a difficulty in understanding the weighting of the criteria for awarding of tenure, and these vary considerably from one institution to another. For example, 628 US geoscience departments were surveyed to investigate the criteria used; 280 of the completed questionnaires revealed the following average percentage weights in judging faculty for tenure (Foos et al. 2004): teaching, 47.9%; research, 37.1%; service, 14.2%; other, 0.8%. The range of responses varied widely, probably depending on whether the institution focused on teaching or research. How these criteria are weighted should be made clear to all faculty members at their particular institutions. In this regard, more time teaching correlates with lower research output, and women have been found to teach more than men only at research universities (Bellas and Toutkoushian 1999). This disparity in teaching loads, and the importance of research to career advancement at research universities, suggests a division of labour disadvan-

tageous to women.

The low proportion of women geoscience faculty (12.5%) in US colleges and universities around the year 2000 was explained by de Wet et al. (2002) in this way:

*“A combination of biological factors, lifestyle choices, dual career pressures, double standards for social and professional interactions, and gender-based discrimination creates an effective filter, reducing women in geoscience departments to a surprisingly low level.”*

## STATISTICS ON WOMEN GEOSCIENTISTS

### Canada

In Canada, most geoscientists work in mining, petroleum, academia or various branches of government. In the 1970s, however, few women worked in these sectors; for example, in 1971 only 21 women geoscientists worked in the mining industry, and in 1974, only 120 were employed in the petroleum industry (Mioduszewska 1977; Schwarzer and Hileman 1977). Since the 1970s, more women have been hired as geoscientists. At Canadian universities between 1983 and 1993, 14 of the 106 tenure track appointments (13%) went to women (Pe-Piper 1994). At Canadian universities in 2005–2006 in the combined category of geology and related disciplines at the assistant, associate and full professor levels, 16.5% were women (CAUT 2009). Overall, based on the 2006 Statistics Canada census, 2290, or about 18.8% of a total of 12 180 geologists, geochemists and geophysicists, were women.

### United States

Some of the more comprehensive recent reviews of women in the geosciences by Holmes and O’Connell (2003) and Huntoon and Lane (2007) have included statistical data revealing trends over the past few decades. These reviews, as well as other studies, have shown that the geosciences are still under-represented by women in a number of ways.

The Bureau of Labour Statistics (2010) reported that in 2008 there was a total of 33 600 geoscientists, excluding college and university faculty. Each year in the USA, about 4000 bachelor degrees and 800 Ph.Ds are

awarded in the combined fields of geology, atmospheric sciences, geophysics, oceanography and space sciences, compared to a total in all categories of 1.2 million B.Sc. degrees and 42 000 Ph.Ds (Czujko and Henley 2003). In 1998, the proportion of B.Sc. degrees in science awarded to women was 37% in the geosciences, 52.7% in the biological and agricultural sciences, 26.9% in computer science and only 18.6% in engineering (Rosser 2006). In 2001, 41% of B.Sc. degrees in the geosciences had been awarded to women, about double that for engineering (Huntoon and Lane 2007); in 2002 this figure was 42% (Holmes et al. 2008; Table 1). Between 1972 and 1974, Ph.D. degrees awarded to women in the geosciences increased from 8 to 11%, and between 1986 and 2002, from 22 to 34% (Crawford et al. 1977, 1987; Holmes et al. 2008; Table 1). However, as of 2006, only 16% of all geoscientists were women (Gonzales 2010).

By 1938 in the USA, there were only 45 female geology academics in higher educational institutions, accounting for 7.7% of all geology faculty members (Rossiter 1982). By 1946, of a total of 11 000 male and 330 female geologists, the number of female academics had increased to 93 (Rossiter 1995), although there was no percentage increase. In the 1996–1997 academic year, the American Geological Institute (AGI) Directory of Geoscience Departments showed that 911 (about 12%) of 7595 geoscience faculty members were female, but that 17% of this number were in non-tenurable adjunct, visiting, lecturer or instructor positions (Ongley et al. 1998). By 2002, this number had increased to 1760 (13.6%) of the 12 941 listings in the AGI Directory, although again many of these positions (especially those held by persons without Ph.Ds) were in non-tenure-track ‘cooperating’ faculty, adjunct professor, lecturer and research associate positions (Holmes et al. 2008). In terms of departmental rankings, the breakdown of female faculty members during 1994–1995 shows 13% full professors, 24% associate professors, 30% assistant professors, 3% department chairs, 4% emeritus professors, 9% research associates, and 17% other (Macfarlane and Luzzader-

**Table 1.** US and Canadian comparisons of geoscience degrees awarded to women and the percentages by rank of female geoscience faculty. Note that the Canadian data report student enrolment rather than degrees awarded.

Academic Rank/Degrees Awarded	USA percentages as of 2002 (Holmes et al. 2008)	Academic Rank/Student Enrolments	Canadian percentages as of 2005-06 (CAUT 2009)
Full Professor	8.0	Full Professor	10.6
Associate Professor	14.0	Associate Professor	23.7
Ph.D. Degree	34.0	Ph.D. Enrolment	34.4
Masters Degree	45.0	Masters Enrolment	48.9
Bachelors Degree	42.0	Bachelors Enrolment	45.0

Beach 1998).

Linear extrapolation based on the data in Macfarlane and Luzzader-Beach (1998) and Holmes et al. (2008), suggests that in the USA in 2009, about 40% of Ph.Ds in the geosciences would have been awarded to women and that 20% of geoscience faculty were female, but unless the trends change, equal numbers of male and female faculty members in the geosciences will not be reached until 2085.

### THE ISSUE OF FEWER WOMEN SCIENTISTS AND EFFORTS TO INCREASE THEIR NUMBERS

#### Women Choosing Careers Other Than Science

Have women been under-represented in the sciences because they have decided to choose other careers? A survey of 204 men and women in the final undergraduate year of their science programs revealed that at least these males and females had different career aspirations, with more males than females aspiring to science careers; also, it was found that among those with science degrees, females were 4 times more likely to take up non-science careers than their male counterparts (Nevitte et al. 1990). As more and more women enroll in the geosciences and more women achieve successful careers related to their education, one would expect fewer losses of females to careers other than the geosciences. Given that 45% of the 1843 B.Sc. and other undergraduate degrees in geological and earth science/geoscience disciplines in Canadian universities were awarded to females in 2005–2006 (CAUT 2009), it seems

reasonable to assume that more of these women will expect to pursue careers related to their geoscience qualifications.

#### Female Role Models

Webb (1995) reported that female role models and inclusive language in environmental science are considered important to make women feel at home, as is equal treatment of males and females by professors. However, female geoscience students have fewer role models because many female holders of geoscience doctorates have decided on careers outside of academe (Karsten 2003). Even so, the increasing number of female graduate students should have an influence as Teaching Assistant and Research Assistant role models. The effect of female professors as role models does seem to have a positive effect on women in geology, but not in engineering, according to Bettinger and Long (2005), suggesting that female role models should be studied separately for these disciplines.

#### Support Groups and Initiatives to Increase Female Representation in the Geosciences

The Association for Women Geoscientists (AWG) is an international organization of 1200 members created in 1977 in San Francisco to support women in environmental geology, geochemistry and geophysics (AWG 2001). In the USA, in 2003 'The Joint Society Conference on Increasing Diversity in the Earth and Space Sciences' was held in Maryland with the purpose of examining ways of increasing the hiring and retention of women, minorities, and people with disabilities in the geosciences (Karsten 2003). Another

initiative to increase the proportion of women in STEM fields was the National Science Foundation's ADVANCE program (Holmes and O'Connell 2003). Recommendations to eliminate gender bias in academe by the Committee on Maximizing the Potential of Women in Academic Science and Engineering (CMPWASE) have included calls to recruit, retain and promote women into faculty and leadership positions by soliciting the support of trustees, university presidents, provosts, deans, departmental chairs and tenured faculty (CMPWASE 2006). However, Hausman (2008) has criticized inaccurate statements in the CMPWASE (2006) report.

### DISCUSSION

In Canada, CAUT (2008) pointed out that more than 6000 (67%) of the 9000 full-time university teachers hired between 1984 and 2004 were women. From 2001 to 2007, the percentage of full-time female university teachers increased from 28% to 34%, and for 2006–2007, 40.6% of the 2616 appointments of full-time university teachers were female (CAUT 2010). However, in the geosciences the percentage of women appointed to tenure track positions between 1983 and 1993 was only 13% (Pe-Piper 1994), and in 2006–2007 females accounted for only 28.6% of the 21 appointments (CAUT 2010), below the average for all fields.

Many early women geologists were attracted to paleontology, possibly because of its close relationship to biology. With the dramatic drop in enrollments in geology between 1980 and 1985, following the plunge in oil prices, geoscience departments added more environmental geoscience programs (Rhodes 2008). For example, Schneiderman and Sharpe (2001) developed an Environmental Earth Science course with a 'feminist' perspective, but this kind of initiative is at an early stage of development. Given the increase in Environmental Earth Science programs, it would be interesting to obtain recent percentages for men and women in this field versus the more traditional specialties, such as petroleum geology or economic geology. Information for the USA has shown that at institutions granting Ph.Ds, the decreasing order of female

representation in geoscience faculty by specialty was as follows: geochemistry, paleontology, oceanography, soil science, geology and geophysics (Holmes and O'Connell 2003).

Based on USA B.Sc. degrees awarded from 1964 to 2001 in the geosciences (Huntoon and Lane 2007), female and male undergraduate percentages should have reached equal numbers in 2008. However, the trends for US geoscience Ph.D. degrees (Crawford et al. 1977, 1987; Holmes et al. 2008), suggest that equal numbers of male and female Ph.Ds will not be reached until about 2021. The question that naturally follows is, "*At what rate should women faculty be recruited to achieve parity with men if parity is considered desirable?*" If male/female parity is considered a desirable goal, then the rate at which it is to be achieved should be fair to both genders. Hiring the best qualified person of either gender seems reasonable, but the 'best qualified', like beauty, is in the eye of the beholder. The most objective criteria for hiring might be course grades and research productivity, but many positions have very specific requirements, and references may not reflect a candidate's potential.

## CONCLUSIONS

Improvements should be made at the secondary school level to ensure that female students obtain at least the required science and mathematics prerequisites. The lower percentage of science students compared with other OECD countries, and the lower percentage of geoscience students in particular, makes recruiting more women into the geosciences at all levels, from students to senior positions, a priority. A consideration of the history of the geosciences has shown that women geoscientists have been disadvantaged by societal norms as well as by lateral and hierarchical segregation, especially in terms of field work; preferentially promoting married male faculty with children while questioning the commitment of women starting families of their own reveals a double standard. In addition, women have noted that the optimum child-bearing years correspond with the pressures of the tenure process and that appropriate accommodations should be made to correct

this. Furthermore, the tenure process should be made more transparent so that the relative weightings for teaching, research and service are understood by everyone. Another problem faced by women is their greater teaching load at research universities compared to men, a situation limiting available time for their own research and related promotion opportunities. To improve the representation of women geoscientists in North America from the current ratio of about 1 female to 4 males, much needs to be done.

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