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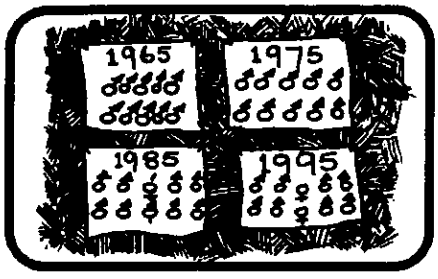

Challenges and Rewards of Graduate Studies in the Geosciences: A Woman's Perspective

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INTRODUCTION

In 1992, Barbara Sherriff asked if I would participate in the special session on women in geoscience which she was organizing for Geological Association of Canada–Mineralogical Association of Canada '93 in Edmonton. At the time, I was pursuing my doctoral degree in geology at Queen's University in Kingston, Ontario, and Dr. Sherriff asked if I would talk about life as a female graduate student in geoscience. I began reading papers about women in science and geoscience, to try to put my own experience into a broader context. The papers I read made me realize that many of the problems experienced by me and other female students in my department were not uncommon. However, many attempts to discuss these problems with men met with resistance. I was told that our experiences were merely "anecdotal" and therefore not evidence for any systematic problem in women's education or experience in geoscience.

I decided to approach the problem scientifically, by treating individual experiences as data points. Following the interest in the special session in Edmonton, some of the participants decided to organize a workshop entitled "Women in Geoscience: Strategies for Success." In preparation for the workshop, I designed a questionnaire and distributed it to women in universities and government surveys in Canada and the United States. The questionnaire was also sent out by the Association for Women Geoscientists to those of its membership who have electronic mail. The survey asked about the problems women may have faced while pursuing graduate studies, and the strategies that they may have used to overcome those problems. Having received 316 responses, I circulated a nearly-identical questionnaire to men, receiving 157 responses. The purpose of this paper is to discuss the problems that women sometimes face during graduate studies in geoscience, and how these problems may affect the number of women who pursue and ultimately complete graduate studies. Some results from the geoscience surveys are included.

WHAT IS THE STATE OF GRADUATE STUDIES IN THE GEOSCIENCES FOR WOMEN?

The situation that exists for women in geosciences has been referred to as a "leaking pipeline" (Brush, 1991; Barinaga, 1992; Suiter, 1992; Alper, 1993). While the proportion of women graduating with degrees in law and medicine approached 50% of total graduates in 1989 (McKay, 1992), the proportion of women obtaining undergraduate degrees in the geosciences remains less than 35% (Fig. 1). Except for the years 1988 and 1989, the proportion of women obtaining undergraduate geoscience degrees generally was consistent with the proportion of women enrolled (Fig. 1). In contrast, there has been a marked decrease from the percentage of women who enroll in graduate studies to the percentage (of the total graduates) who obtain doctoral degrees in geoscience (Fig. 2). In the United States in 1991, 24.7% of doctorates in geoscience were awarded to women, compared with 36.8% of doctorates in all fields (National Research Council, 1991). While the *number* of men who go on to graduate studies in any field, including geoscience, is lower than the number obtaining undergraduate degrees, the *proportion* of women who pursue graduate studies and complete graduate degrees is lower than the proportion of women obtaining undergraduate degrees. Not only are women under-represented at all levels of university geoscience education, but a higher proportion of women relative to men does not pursue or complete graduate studies (Fig. 2).

A recent survey of students in all faculties at the University of Manitoba revealed that 35% of undergraduates (33% of females and 39% of males) intended to pursue occupations in science and technology (University of Manitoba, 1995). The proportion of women in this group (45%) is higher than in geoscience, likely because of the participation of students in fields such as biological and life sciences, which attract more women (Benditt, 1992). The survey revealed that female and male students (in all faculties) did not have significantly different plans regarding the highest degree they intended to obtain (University of Manitoba, 1994). If students in general are similar to students in science and in geoscience, then there must be something about the educational experience that causes women in geoscience to change their academic goals.

WHY IS THIS A MATTER FOR CONCERN?

The decrease in the proportion of women who continue in graduate studies creates problems on a number of levels. North America will shortly experience a shortage of capable scientists (Brush, 1991), and sustaining its scientific preeminence will depend on attracting and *retaining* talented women. The supply problem is not uniform throughout geoscience; an oversupply of graduate students exists in some fields, while an undersupply exists in others (Smith, 1993). A quick scan of job advertisments in *Geotimes* or *Eos* demonstrates that the demand for qualified geoscientists is increasing, but in non-traditional fields such as hydrology and environmental and engineering geology. Retaining women will be of paramount importance to meeting the demand in these growing fields. Possibly because of obstacles faced during their academic and professional careers (described below), a high proportion of women seem to go into non-traditional fields within the geosciences. Based on names listed according to specialty in the 1994-95 edition of the American Geological Institute's Directory of Geoscience Departments, the proportion of female academics in North America listing the relatively new field of environmental geology as their specialty is nearly twice the proportion of women in the more traditional field of igneous petrology (Claudy, 1994). (In environmental geology, 19% are women, 73% are men, and 8% are unknown (either listed

by initials or having ambiguous given names); in igneous petrology, 10% are women, 84% are men, and 5% are unknown.) For a recently advertised faculty position in environmental earth sciences at the University of Manitoba, 25% of applicants from within Canada were female.

WHY DOES THIS SITUATION EXIST?

The decrease in the proportion of women who pursue and complete graduate studies has been attributed to a variety of causes, including obstacles experienced during graduate studies and discouraging prospects upon graduation. Both personal and external factors may contribute to the loss of women in geoscience. Many women suffer poor self-image from a young age. However, even women who exhibit self-confidence at the beginning of their studies experience a loss of confidence during their studies (Brush, 1991, and references therein). Lack of confidence was the most common problem cited by female respondents to the geoscience survey, experienced by 63% of the women (Larocque, 1994a). Lack of confidence or loss of confidence may arise in part from active and passive discrimination encountered in the educational system. Negative treatment such as sexual harrassment and unwanted sexual attention (experienced by 18% of respondents), and active discrimination by faculty and male students (experienced by 27% of respondents) obviously may be expected to interfere with a woman's sense of self-worth (Brush, 1991; Benditt, 1992, and papers therein). However, passive neglect (*e.g.*, lack of encouragement by male faculty), subtle obstacles (*e.g.*, unfriendly environments), and unconscious assumptions (*e.g.*, sex-stereotyping, double standards) can be equally damaging. After lack of confidence, passive neglect is the problem most commonly cited by women who responded to the geoscience survey (47%). These factors may be especially frustrating during graduate studies, as it is a time when students may expect to be approaching some kind of parity with professors within the educational hierarchy.

Societal expectations can exert extreme pressures on women, and influence their decisions to pursue or continue graduate studies. In general, science is viewed as an "unfeminine" career choice for women (Lafollette, 1988). Twenty-eight percent of the women who responded to the geoscience survey felt that societal expectations of women's roles created problems for them during graduate studies (Larocque, 1994b,d). Female scientists commonly are married to other scientists (Gibbons, 1992); among the female geoscientists who answered the survey question about their partner's occupation, 44% are partnered with other earth scientists, and 16% with people in other sciences or engineering (Larocque, 1994b,d). Among male respondents to the question, 18% are partnered with homemakers/housewives/mothers (in the men's own words), 11% with other earth scientists, and 3% with other scientists or engineers (unpublished data). Forty-five percent of women who responded to the geoscience survey felt that graduate studies had a negative impact on their relationships and family life (Larocque, 1994b,d). In a society that expects women (but not men) to put family ahead of career, female scientists are more likely to consider the effects of their jobs on their relationships and to put the relationships first. For many women, pursuing a career in science means sacrificing family life altogether. While the proportion of single women decreases with increasing age, a high proportion of women responding to the geoscience survey (33%) remains single after age 40. This trend is consistent with data for women in other areas of science (Amato, 1992). Similarly, 51% of female respondents over age 40 have no children (Larocque, 1994b,d). In contrast, among male respondents over age 40, 3% are single and 9% have no children.

Compounding the obstacles encountered during graduate studies, discouraging employment and funding prospects may motivate many women to curtail their education. Thirty-one percent of female respondents cited discouraging job prospects for geoscientists as a concern; 12% felt that job prospects were particularly discouraging for women. Cole (1979) documented strong statistical evidence that women in science are discriminated against in tenure and promotion decisions. Female science faculty are overrepre-

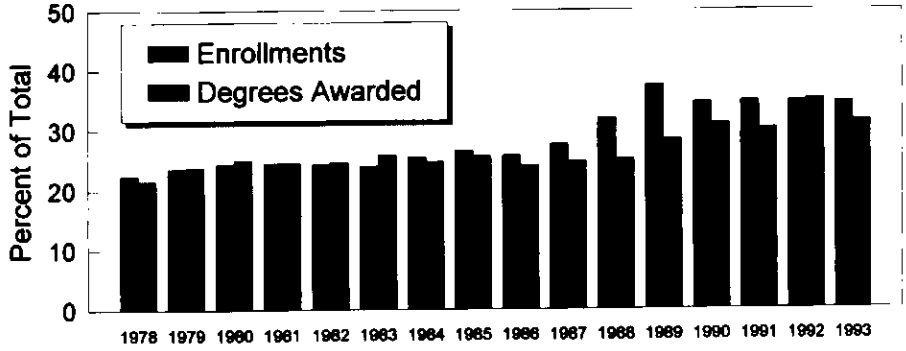

Figure 1 *Proportion of women as percent of total (i.e., women + men) enrolled and awarded degrees in undergraduate geoscience (data provided by American Geological Institute). These data are for geoscience education in the United States; however, the trends in Canada are expected to be similar.*

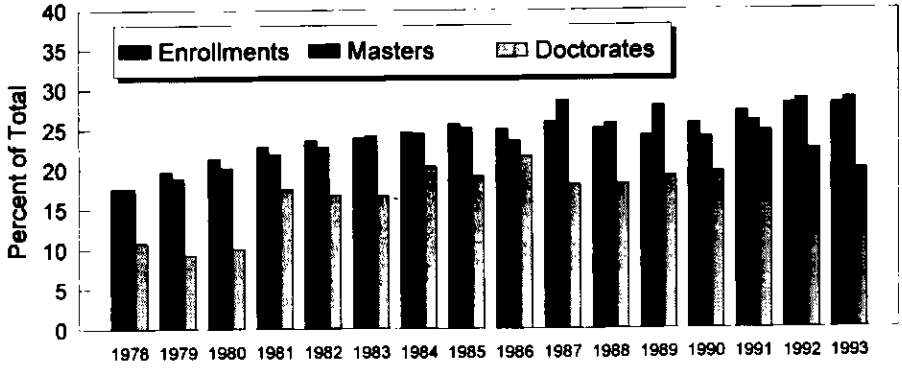

Figure 2 *Proportion of women as percent of total enrolled and awarded graduate degrees in geoscience (data from American Geological Institute; see also Suiter, 1992).*

sented in non-tenure track positions (Brush, 1991; Benditt, 1992; Amato, 1992), and women with doctorates in earth science have higher rates of underemployment than men (Benditt, 1992). Female scientists continue to earn less than males regardless of experience (Benditt, 1992), with the largest salary discrepancy occurring in the earth sciences (Brush, 1991; Suiter, 1992). In light of these facts, it is not surprising that some women do not pursue or complete graduate studies.

WHAT CAN BE DONE TO CHANGE THE SITUATION?

There are no simple solutions to the problem of the "leaking pipeline." Changes are required on a number of levels, by both individuals and institutions. Women must accept some of the responsibility for bringing about these changes. One characteristic that is commonly cited by women who have succeeded in science is determination (Benditt, 1992; McKay, 1992; unpublished results of my survey). Strategies for change that women may employ include: working on improving self-confidence, both in ourselves and in the women around us; applying creative solutions; seeking out female colleagues and role models; acting as mentors for each other; choosing supportive male colleagues and supervisors whenever possible; and communicating with men about our experiences as women in science (Larocque, 1994a,c,d). The latter is especially important. Most of the problems experienced by women at the hands of men have more to do with inertia and thoughtlessness than a "conspiracy of exclusion." Reasonable dialogue can do much to heighten awareness of problems, which is the first step to solving them. Men, if they recognize the advantages of the "gender solution" to the coming crisis in science, can help to improve the climate for women. However, conscious effort on their part is required. Men must recognize and eliminate their prejudices and preconceptions about the roles of women in society and science. This includes learning to accept that women are serious about scientific research. They need to overcome their unease with women, so that they may comfortably act as mentors for them. And, like women, they must learn to communicate more effectively, in a non-confrontational manner.

Changes in individual attitudes may be enhanced through the actions of institutions. For example, universities can strive to eliminate hostile environments by instituting mandatory education on gender issues for professors and students, and facilitating contact with role models. At Queen's University, women in their final year of engineering are invited to attend a dinner with female graduate students and faculty in applied sciences. The purpose of the event is to encourage these young women to consider graduate studies in engineering. Other incentives include re-entry programs and scholarships for women who have had to leave the educational stream because of family responsibilities, providing fellowships to help women advance their careers, and supporting women's universities. Universities must revise hiring, promotion and tenure practices, eliminating subjective criteria that work against women (Caplan, 1994), and acknowledging the time-consuming demands faced by scientists who are also mothers.

Affirmative action is a controversial, but necessary, policy that may be implemented by universities, industry and government alike. I have been told by several male professors who object to affirmative action that we must not "lower our standards" and that "excellence must be the only criterion." These comments imply that women scientists are not excellent. In my experience, however, the obstacles described above serve to weed out mediocre women (as well as some bright, capable women), thereby ensuring that women who do complete their studies are *at least* as intelligent and dedicated scientists as men. In some cases, affirmative action programs actually serve to open up positions that may not have existed otherwise, such as the Women's Faculty Award Program, which unfortunately is about to be phased out by the Natural Sciences and Engineering Research Council.

The most difficult changes to bring about will be those in the structure of our society. Until there is truly equal responsibility among women and men for child-rearing, as long as double standards for women and men exist, women will always face a more difficult time studying and working in scientific fields. However, as societal expectations for women are modified, so will the expectations for men change, extending to them the freedom to choose alternative routes.

WHAT ARE THE REWARDS?

The rewards of graduate studies in the geosciences are as varied as individual women. The main reward for me is the freedom to do research in a field that has interested me since I was a child, and which brings me great personal satisfaction. The love of science seems to be reward enough for many women (cited by 3% of female respondents and none of the male respondents to the geoscience survey). For institutions, the reward for encouraging women to complete graduate studies in the geosciences is the enhanced creativity that comes from a diverse work force. Such diversity can only serve to improve the nature of science itself, and our competitiveness in the global scientific market. These goals are surely worth striving for by all scientists, regardless of gender.

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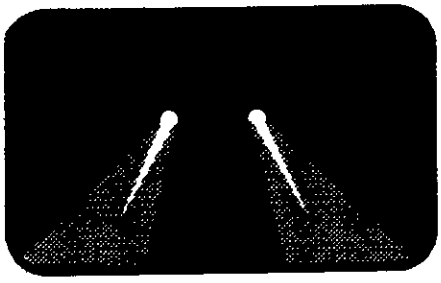

Will There Be Pink Jobs and Blue Jobs in Canadian Mining?

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INTRODUCTION

Canada's mineral wealth, and the expertise and technology for exploring and developing that wealth, have been crucial to economic growth over this century. Canada's mining industry is now facing its toughest challenges in years. The industry has struggled through the recession. Corporate profits and employment levels have been hard hit by low metal prices. Canadian firms have cut their funding for exploration in Canada.

In this competitive context, a committee made up of representatives from the Mining Association of Canada, the Canadian Institute of Mining, Metallurgy and Petroleum, and the United Steelworkers of America requested Human Resources Development Canada to commission a study of human resources in the mining industry. Price Waterhouse was selected to conduct the study. The primary objective of the study was to examine the current and future skill requirements of the mining workforce, and to find possible courses of action to ensure that the Canadian mining industry has the human resource capability to compete globally. The committee emphasized that the study should include consideration of demographic patterns of employment in mining.

EMPLOYMENT OF WOMEN IN MINING

That the mining industry is male-dominated comes as no surprise. Women make up only about 13% of the mining industry's workforce, compared to about one-quarter of the employees in all primary industries (Fig. 1). One of the challenges in this study was to obtain valid, current and reliable data on women's employment status in the industry. Although there is a bill before the Ontario legislature that would mandate employment equity, only a small proportion of mining operations (those within federal jurisdiction) are currently affected by legislated employment equity. Table 1 compares the proportion of women in the workforce of metal mines to that of all employers covered under the Employment Equity Act and the Canadian labour force (1986 Census data; Human Resources Development Canada, 1991). Compared to all employers covered under the Act, the metal mines sector has significantly fewer women. The data also show that the representation of women has not changed from 1989 to 1991.

Table 2 shows the distribution of designated group members by occupation for metal mines, and compares the distribution to that of all employees and men in that sector (Human Resources Development Canada, 1989). The first characteristic is an over-representation of women in clerical occupations, compared to men. Furthermore, women are under-represented in non-traditional occupations, but well represented in professional and managerial occupations. The Price Waterhouse survey of employers confirms that women tend to be concentrated at the administrative and support staff levels; however, they are beginning to make inroads in technical and professional occupations.

We found that women in mining encounter many of the same career hurdles as women in other non-traditional areas: there are rarely more than a few women in any workplace; women are isolated, some are harassed; they have few role models, as yet; each woman finds her own ways of balancing career and family.

In the past, women were not likely to seek educational programs that would lead to occupations in the mining sector. However, more women are enrolling in and graduating from technology and engineering programs. For example, nearly 9% of graduates from mining engineering programs in Canada from 1985 to 1990 were women, and about 13% of students enrolled in undergraduate mining engineering programs in Canada in 1990 were women (Statistics Canada, 1992). While somewhat less than the proportion of women graduating from all undergraduate engineering programs, and significantly less in comparison to