To be valuable as a benchmark, as many details as possible about the experiment should be available.

2) *Systematic experimental work on material properties.* Experimental work is needed to characterize material properties in support of the increasingly sophisticated models developed for impact crater collapse studies. In particular, parameters associated with porosity and strength models are not well characterized, and values not appropriate for geological materials are often used in modeling efforts. These experiments should be done in conjunction with the collection and distribution of older work, which is often not well known by the community.

3) *Detailed field studies of mid-sized terrestrial craters.* A field research program should be developed to characterize terrestrial impact craters in the 15–30-km diameter range. A handful of these craters are well preserved and well exposed on the Earth. They occur in a variety of targets and are large enough that they show many of the complex structures observed in planetary craters. Each crater should be studied with an emphasis on thoroughly characterizing the amount and nature of deformation outward from the crater, the overall motion of material during the impact, and the locations and volumes of impact melt.

There was consensus that the cratering process would be a good candidate for a long-term organized community study project. In such a project, teams of scientists would work to summarize the existing state of knowledge of different aspects of the cratering process, conduct short-term research to fill minor existing gaps, and put forth plans for long-term research. The session topics for the workshop provide a starting point for dividing the cratering process into manageable topics for the teams.

The workshop, "Impact Cratering: Bridging the Gap Between Modeling and Observations," was held 7–9 February 2003 in Houston, Texas.

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FORUM

Righting the Balance: Gender Diversity in the Geosciences

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The blatant barriers are down. Women are now routinely chief scientists on major cruises, lead field parties to all continents, and have risen to leadership positions in professional organizations, academic departments, and funding agencies. Nonetheless, barriers remain. Women continue to be under-represented in the Earth, ocean, and atmospheric sciences. Let's do the numbers: As of 1997, women received 41% of all Ph.D.s in science and engineering, but only 29% of the doctorates in the Earth, atmospheric, and oceanographic sciences [*NSF*, 1999a]. Women were 23% of employed Ph.D.s across all fields of science, but only accounted for 13% in the geosciences. Women's salaries also lag: the median salary for all Ph.D. geoscientists was $60,000; for women, the figure is $47,000 [*NSF*, 1999b]. The growing number of women students is a step in the right direction, but only a step.

What must be done to attain gender parity? While many studies have addressed the institutional influences on the careers of women scientists [e.g., *Cole and Zuckerman*, 1987; *MIT*, 1999], there has been scant attention to how women's careers are played out in specific disciplines. Solving the problem of gender imbalance in the geosciences requires understanding of the particular obstacles women face in our field. As is true in science, a problem to be solved is both a challenge and an opportunity to progress.

The under-representation of women offers Earth science departments, universities and research centers, funding agencies, and professional organizations like AGU opportunities for constructive action.

Opportunities for Departments: Balance Demographics

A study by the Commission on the Status of Women at Columbia University, New York, examined women's progress through the academic pipeline [*Applegate et al.*, 2001]. From 1990 to 2000, the representation of women in the natural sciences rose from 8% to 11%, while the percentage of women in the graduate student population grew from 20% to 33%. The picture at Columbia mirrors national trends in the physical sciences [*Long*, 2001], but the Columbia study provides more detailed information, highlighting the points where women are not progressing through the academic pipeline at the same rate as men. Specifically, women are under-represented in the applicant pools for faculty positions, and few women are hired into the tenured faculty.

The Columbia study showed that once they are in the applicant pool, women compete well and are hired at an equitable rate. The chokepoint is the relatively small number of women who are applying for entry-level jobs. The reasons for this are not clear. It may be due to the greater percentage of women relative to men who leave the scientific workforce, the greater percentage of women who seek employment in industry [*Long*, 2001], the reluctance of women to relocate [*Shauman and Xie*, 1996], or the tendency of women to be part of a dual-career family, and hence a dual-job search family [*Sonnert and Holton*, 1995].

Although women are being tenured at a rate equivalent to that of men at Columbia, a demographic imbalance persists because of external hires into the tenured ranks. Fully half of all new appointments to tenure come from outside Columbia. These external hires are significantly less likely to be female than are candidates promoted from within the university. The imbalance is particularly noticeable when departments hire what administrators call "targets of opportunity" and the rest of us call "stars." Over the decade studied, 11 male and no female scientists were hired as "stars" in the natural sciences at Columbia.

This analysis indicates two points in the pipeline to be fixed. As producers of Ph.D.s and post-docs, departments should seize the opportunity to encourage young women scientists to pursue the academic life. As consumers of young Ph.D.s, departments have the opportunity to actively recruit the good young women scientists, to convince them that applying for academic jobs will not be a possibly humiliating waste of time, but an opening to great opportunities. The most convincing argument would be to make it the truth. At the second point, departments should make aggressive efforts to recruit female "targets of opportunity." To aid these efforts, women should be strongly encouraged to visit institutions for sabbaticals and as visiting scientists. The connections made during such visits often lead to recruiting efforts at all levels.

Opportunities for Universities and Research Centers: Transparency and Open Distribution of Funds

To win the game, you have to know the rules—the real rules. Women are often not included in the informal network in which information about promotion possibilities and job openings is exchanged [*Ragins and Sundstrom*, 1989]. Consequently, well-documented, widely disseminated information on promotion and advancement has been identified as an important element in creating a positive climate for women scientists. Increasing the transparency of promotion and review procedures is a challenge to universities and research centers. Recent experience at Lamont-Doherty indicates that implementing and communicating well-defined criteria for promotion requires a significant investment of time and effort. Promotion criteria must be defined, all scientists must be informed of these criteria, and provisions must be made for providing regular written and oral feedback to junior scientists.

The *MIT* [1999] report indicated that science departments with undocumented hiring or advancement procedures also tended to give women department members inequitable access to institutional resources. Clearly, this handicaps women in their research and creates an additional impediment to advancement. Access to matching funds for proposals, institutionally supported fellowships and research assistants, funding for new instrumentation, start-up packages, and seed funding for new projects has been identified as one of the major sources of gender inequity by both the *Zuckerman et al.* [1991] study and the MIT report. An open, peer-reviewed process for distributing internal discretionary funds for new project development will reduce this discrepancy.

Opportunities for Funding Agencies: Easing the Financial Burdens of Fieldwork

Across the sciences, the academic workplace is now a more congenial environment for women and men with families to work productively. Many institutions such as Lamont-Doherty have developed clear family leave policies and invested in childcare facilities. But the geosciences often require extended fieldwork in remote locations, which raises unique issues for parents. In oceanography, polar sciences, and marine geosciences, data collection and experimentation require that scientists spend weeks to months on research vessels in remote locations. Fieldwork, a major attraction to graduate students, becomes increasingly difficult for early and mid-career scientists, particularly women and men with children. This critical component in the career of a young scientist inevitably increases the tension between career and family.

Providing financial support for parents conducting extensive fieldwork, "family field pay," would go part of the way toward reducing this tension. In the marine sciences, the cost of sea pay (~$50/day) is routinely budgeted to cover the hardships of the sea-going experience. The funding agencies have an opportunity to help scientists balance the demands of fieldwork and family by accepting family field pay as an allowable expense on field program budgets. Examples of potentially useful expenditures for family field pay include temporary babysitting services, extended hours of child care, transportation costs to bring a family member back for home visits, or even support for taking a babysitter into the field.

Opportunities for Professional Organizations

AGU annually documents the employment patterns and demographic characteristics of recent Ph.D.s in Earth and environmental sciences. Many studies have been conducted on the status of women in science at all levels. While knowledge of the status of women is necessary, it is not sufficient. Just as we cannot understand climate change by merely measuring the temperature over a decade, we cannot understand how to increase the contribution of women in the geosciences without understanding the fluxes and control points in the system. Professional organizations such as AGU and the Geological Society of America should develop projects to monitor the career patterns of scientists, both men and women, beyond graduate school and the first job. A study could involve longitudinal tracking cohorts of geoscientists through graduate school to 20 years post-Ph.D. Accompanying this should be a study to identify critical points in the advancement or attrition of women scientists. Such a study could address the question of why women take industry jobs at a rate greater than men [*Long*, 2001]. The current hypothesis—that women prefer the security of industrial environment—is based on speculation, not data. Conducting flux studies and identifying the decision points in the advancement of scientists will provide fundamental data for designing successful programs to enhance diversity in the geosciences.

The Future

The scientific challenges facing the geosciences and the realization that research budgets will never grow as quickly as research opportunities make it imperative that the Earth and environmental sciences use all of the resources available to them, including the growing number of women scientists. These scientists have the training, background, and will to advance the frontiers of research in our fields. Ensuring that they will have the opportunity to do so is the responsibility of us all.

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LETTERS

Klondike

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In the book review of *Barren Lands: An Epic Search for Diamonds in the North American Arctic* (*Eos*, 13 May 2003), one sentence caught my eye: "the man who triggered a mining stampede not seen since the Klondike Gold Rush of 1849."

Whoa, there! The 1849 gold rush was in California, triggered by the discovery of gold in Sutter's mill. The Klondike gold rush—around Dawson, Yukon territory, also in northern Canada—began in 1897.

—DAVID P. STERN, Greenbelt, Md.