GROUNDWORK
Furthering the Influence of Earth Science

Who will build the 21st century? Addressing critical demographic gaps in the geosciences

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INTRODUCTION

The geoscience workforce in the United States may be facing a critical shortage of trained personnel (Gonzalez and Keane, 2011; NRC, 2013; Mosher et al., 2014; Wilson, 2014a). The National Bureau of Labor Statistics projects a 16% increase in geoscience jobs by 2022. If, as projected, more than half of the present geoscience workforce retires by that time (Wilson, 2014a, 2014b), up to 185,000 new geoscientists will be needed. Graduation rates in U.S. geoscience programs (Wilson, 2014a) are slowly increasing but still lack the capacity to produce such numbers by 2022 (Fig. 1A). The result is a projected shortfall of 135,000 trained geoscientists within the next decade (Wilson, 2014a, 2014b). To meet these growing challenges to our ability to research, assess, and utilize our natural resources in an environmentally responsible manner, we must increase the number of geoscience students.

RECENT PROGRESS

The National Research Council (NRC) and National Science Foundation (NSF) addressed the impending shortage of geoscientists (NRC, 2013; Mosher et al., 2014) in the context of federal funding and undergraduate education (Fig. 1A). The NRC identified a three-tiered framework, *Awareness*, *Engagement*, and *Professional Preparation*, as steps in the process of training the next generation of geoscientists and suggested a "System Approach" to coordination of existing federal funding (NRC, 2013). The NRC called for better connections among Federal agencies, academic institutions, and professional societies to clarify educational and training pathways, as well as the need to collect more and better data on which programs are successful and why, with a focus on critical incident analysis as a means of understanding what brings students into the geosciences.

The recent NSF-supported Summit on the Future of Undergraduate Geoscience Education (Mosher et al., 2014) focused on *Curriculum and Competencies*, *Pedagogy/Technology*, and *Underrepresented Groups*. Participants agreed that the next generation of geoscience students needs to approach the field as the applied sum of all sciences (Mosher et al., 2014) and effectively communicate across disciplines as well as with the public. The K–12 Next Generation Science Standards can help develop these skills, but most school districts lack teachers with geoscience training, and most students will never take a K–12 geoscience course (Wilson, 2014a, 2014c; LaDue and Brown Manning, 2015). Of particular concern is how poorly the geosciences have recruited and retained students from underrepresented groups (Fig. 1B; Wilson, 2014a). Workforce data demonstrate that students exposed to K–12 geoscience are more likely to pursue geoscience degrees (Wilson, 2014a). Therefore, expanded opportunities and support for underrepresented students at all levels, as well as expanded opportunities for K–12 teacher training in the geosciences (LaDue and Brown Manning, 2015), are critical to rebuilding the geoscience workforce.

INCREASING CAPACITY

Nearly half of all students receiving a geoscience degree decide to become a geoscientist at some point after their first year of undergraduate education (Wilson, 2014c). Considered in light of the growing numbers of students who enter higher education at two-year colleges, the transition between two-year and four-year institutions is critical to expanding the geoscience student pipeline. Entry-level courses need to highlight the geosciences as a potential career path. These upstream improvements in awareness must include efforts to engage underrepresented students by recruiting them into introductory courses and providing mentorship and research opportunities in pursuit of geoscience degrees.

Undergraduate geoscience student enrollments are increasing (Wilson, 2014a); however, undergraduate and graduate professional training opportunities are relatively stagnant or even

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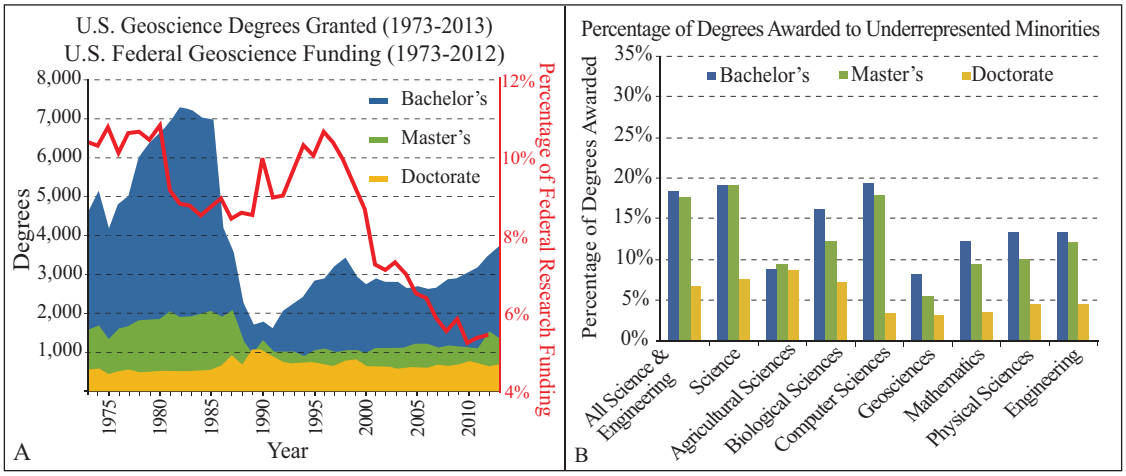

Figure 1. (A) Geoscience degrees granted by year and U.S. federal funding of geoscience as a percentage of total research spending. (B) Percentage of degrees awarded to underrepresented minorities. Data and figures from the American Geosciences Institute (Wilson, 2014a).

contracting. Student numbers in field camps are up nationwide, yet the number of universities offering field camps has declined by 60% since 1995 (Petcovic et al., 2014). Many universities offer anecdotal evidence that the number of applicants to geoscience graduate programs is increasing, yet the number of funded graduate student positions available has not kept pace. The M.S. degree is the "working" degree in the geosciences, but decades ago a trend began to remove M.S. programs to focus exclusively on Ph.D. programs, applying further pressure on the number of funded graduate student positions available. Increases in the number of students entering the upstream end of the geoscientist pipeline must be matched by growth in opportunities for advanced and graduate training downstream in the form of graduate funding, mentorship, and field and research opportunities.

Participation in the process of science (LaDue and Brown Manning, 2015) is critical to training the next generation of geoscientists, and more than half of all geoscience undergraduate students participate in some form of faculty-directed research (Wilson, 2014c). However, the average age of geoscience faculty in the U.S. is 60 years (Wilson, 2014a). As with industry, the lack of younger personnel is threatening the ability to train future students in key disciplines of the geosciences. This problem is exemplified by the looming extinction of paleontology in both academia and industry (Saucier, 2015). We must maintain our ability to train the future geoscience workforce by rebuilding the aging academic workforce.

SELF-IDENTIFICATION & COMPETENCIES

Student specialization, and increased social self-identification with that specialty, often comes increasingly early in academic careers. Students self-identifying as specialists, instead of geoscientists, leads to an increasingly narrow focus of study. Instead of embracing the interrelated facets of geology, early-career students are frequently advised to specialize at the expense of expanding their potential interests in disciplines they may not encounter early on. Furthermore, such specialization limits their core competencies and their ability to cross-train others in the future. Increased student specialization must be matched by mentorship that advocates for multidisciplinary research activities.

Colleges and universities can help bridge the gap between geoscience education and training objectives and end-user competencies by reengaging their alumni. Competency objectives should be driven by the eventual employers of geoscience students (both public and private), not exclusively by geoscience departments. Academia is just one of the professions in which geologists find employment, and it is critical that we expose students to other voices and perspectives early and often during their education if we are to rebuild the geoscience workforce.

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