EOS
EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

VOLUME 91 NUMBER 33
17 AUGUST 2010
PAGES 289–296

Striving to Diversify the Geosciences Workforce

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The geosciences continue to lag far behind other sciences in recruiting and retaining diverse populations [*Czujko and Henley,* 2003; *Huntoon and Lane,* 2007]. As a result, the U.S. capacity for preparedness in natural geohazards mitigation, natural resource management and development, national security, and geosciences education is being undermined and is losing its competitive edge in the global market.

Two key populations must be considered as the United States looks to build the future geosciences workforce and optimize worker productivity: the nation's youth and its growing underrepresented minority (URM) community. By focusing on both of these demographics, the United States can address the identified shortage of high-quality candidates for knowledge-intensive jobs in the geosciences, helping to develop the innovative enterprises that lead to discovery and new technology [see *National Research Council* (*NRC*), 2007].

Changing Demographics and Workforce

Demographics continue to shift the character of the nation's workforce. As a result, diversity issues and workforce issues are now synonymous [*Bassett-Jones,* 2005]. The *U.S. Census Bureau* [2008] national population projections indicate that the United States will be composed of older and more diverse populations by 2050. Minorities are expected to compose about 50% of the population by 2050 (as seen in Figure 1), and minority children are expected to make up 62% of U.S. children overall. Despite these projections showing that the face of our nation will dramatically change by 2050, the geosciences workforce and student populations are predominantly white.

Workforce trends since the beginning of the 21st century have indicated that the traditional pipeline for science professionals is shrinking due to declining student enrollment [*NRC,* 2007]. A lack of U.S. students to fill science positions coupled with an aging scientific workforce have heightened interest within the science community in recruiting and engaging a younger and more diverse scientific population [*National Science Board,* 2003; *National Science Foundation* (*NSF*), 1998; *National Science and Technology Council,* 1998]. A decade's worth of diversity enhancement efforts in the geosciences, however, has had little impact. According to the *Bureau of Labor Statistics* (*BLS*) [2010] *Occupational Outlook Handbook*, professional occupations in the geoscientist category (environmental scientists and geoscientists) are currently 91.8% white, 4.0% black, 2.7% Asian, and 4.1% Hispanic/Latino. Further, the geosciences are ranked lowest in diversity when compared with other disciplines in science, technology, engineering, and math (STEM). The need for addressing diversity is compounded by the BLS projected employment growth of 18% by 2018 in geosciences occupations. If the workforce's population breakdown does not change but the nation's population shifts, the ability of the United States to draw upon its population for a highly skilled labor pool will be limited, which will negatively affect the U.S. economy and create a lower standard of living for the entire country [*NRC,* 2007].

Missing Links for Increasing Diversity in the Geosciences

Dialogue on the need for increased diversity within the scientific workforce has taken place for more than a decade, and many programs aimed at diversity have been effective at reaching out to small clusters of URMs [*Huntoon and Lane,* 2007]. Key components for continued success at increasing diversity in the geosciences include the following:

- research experiences at high-school, undergraduate, and graduate levels for URMs;
- collaborative partnerships between academic institutions and URM communities to enhance geosciences education and competitive research opportunities;

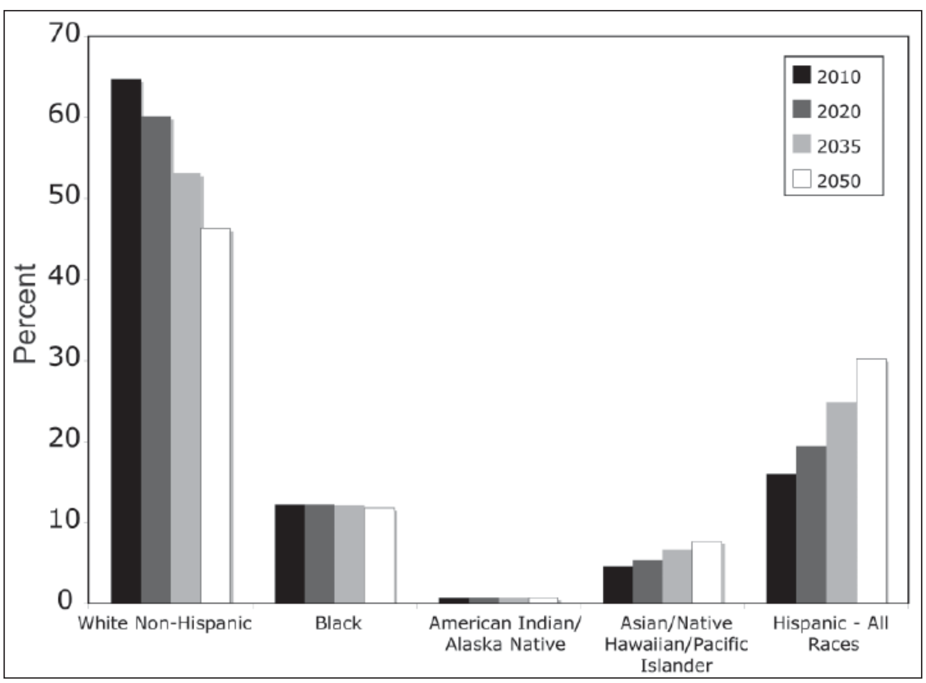

Fig 1. Projected breakdowns of the U.S. population in future years, according to race and Hispanic origin. Data are from U.S. Census Bureau *[2008] national population projections.*

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• high-school and undergraduate student mentoring by graduate students and faculty;

• incentives in the workforce to hire URMs; and

• financial assistance.

Unfortunately, inconspicuous factors such as personal and institutional barriers, a lack of multiagency strategies, and generational differences prevent the geosciences community from making significant strides in diversity. Many diversity programs exist in isolation and are not integrated into the broader mission of an organization (a "diversity check box" approach, where if a quota is filled, the issue is not pursued further).

Personal and Institutional Barriers

Generational differences coupled with residual attitudes like prejudice and discrimination can foster personal cultures that work against institutional diversification. Anecdotal evidence indicates that many URMs continue to be reminded that their education, awards, opportunities, and hiring occurred only because of affirmative action. Such experiences, in academic and government institutions and nongovernmental organizations, create a "chilly environment" that is detrimental [*Shang and Moore,* 1990]. At the college level, *Reynolds et al.* [2010] discuss how racism-related stress among URM students, specifically blacks and Latinos, impedes students from adjusting to their campus environments, building positive self-esteem, and retaining the motivation to graduate.

In grade school, URM students with an interest in science rarely encounter teachers with a geosciences background; moreover, they are probably not required to take an Earth science course prior to graduation [*Gonzales,* 2010]. The impact on diversity of this deep rift between K-12 students and the geosciences is exacerbated by institutional barriers in states like California and Texas, which have large URM communities. For example, the University of California system does not accept geology as a lab science credit for its undergraduate admission requirements (see geology's absence at http://www.ucop.edu/a-gGuide/ag/a-g/science_reqs.html). In Texas, the State Board of Education in 2009 weakened Earth and space science standards at the high-school level through a series of amendments that "opened the door for creationist teachers to bring non-scientific ideas into the science classroom," according to *Newton* [2009, p. 30]. Ironically, Texas hires more geoscientists than any other state, especially for oil and natural gas exploration, and pays these geoscientists the highest wages of any state [*BLS,* 2010]. These are examples of major roadblocks for recruiting high-school students to go on to college into the geosciences, especially in the growing URM community.

Lack of Multiagency Strategy

In an effort to increase diversity in the science workforce, interagency partnerships have been articulated in multiple "diversity" strategic plans [*Committee on Equal Opportunities in Science and Engineering,* 2009; *NSF,* 2009]. However, the lack of collaboration and coordination necessary to holistically address diversity is an institutional barrier that reduces the effectiveness of such plans [*NRC,* 2009].

For example, geosciences programs focused on diversity may prove to be highly successful, yet their funding tends to be ad hoc [*Williams et al.,* 2007] and little effort is placed on investigating which programs can be scaled to a state or national level. This creates a piecemeal approach in which programs only address small components of the workforce demand. Furthermore, these programs sometimes overlap and compete for the same students (i.e., recruiting at one or two of the same institutions that typically have high-performing minorities), rather than broadening the scope of recruitment efforts to match the changing demographics.

Generational Differences

Generations grouped by age and life experiences include veterans (born before 1941), baby boomers (~1941–1960), Generation X (~1961–1976), and Generation Y (~1977–1992). According to *Glass* [2007], these cohorts can clash in an educational or work environment because values and ideas about work ethics, management, and organizational hierarchy are different.

Although not everyone carries the exact values and ideas of his or her respective cohort, general characteristics outlined by *Glass* [2007] and *Trzesniewski and Donnellan* [2010] can be identified. Normally, members of Gen X and Gen Y are perceived as lazy by older cohorts because "working hard" as a means to achieve success carries less weight for younger generations. In the workforce, baby boomers tend to put a greater focus on their paycheck and see the ladder of success as a hierarchical process. Members of Gen X, however, tend to value a flexible work schedule over a high-paying job. People in Gen Y seek employment in places where leadership and collaboration are valued and rewarded through raises and promotions. Also, unlike baby boomers and members of Gen X, those of Gen Y are overall more dependent and thus tend to require more feedback. Further, the most frequent form of communication for baby boomers has been face-to-face interaction, but the preferred style of communication for younger people tends to be exchanging e-mails and text messages. Members of Gen X and Gen Y have also been found to distrust government and corporations, and although they are considered social, these younger groups tend to show indifference to social issues.

Although some may consider age the primary driver of such differences [*Wong et al.,* 2008] and some may argue that the differences are not dramatic [*Trzesniewski and Donnellan,* 2010], it cannot be discounted that the differences among these groups likely do exist. Thus, what an older person or a baby boomer may think will attract students into the geosciences is not what is attractive to today's students. These differences in perspective are rarely acknowledged and addressed when recruiting youth and the URM community. *Snieder and Spiers* [2002] emphasize that highlighting career opportunities and presenting more modern, less geeky images of diverse geoscientists are key when applied as marketing strategies in geosciences recruiting efforts.

Critical Needs for the Future

A scientific community that is representative of the population as a whole will be better suited to serve societal needs. However, until the science community launches a multiagency collaboration set out to tackle generational differences and personal and institutional barriers—as part of a long-term strategy to effectively address, market, and manage geosciences diversity—current strategies will continue to be ineffective piecemeal efforts in the geosciences education and workforce arenas.

In a speech in Mexico City in April 2010, First Lady Michelle Obama noted, "We must confront wrong and outdated ideas and assumptions that only certain young people deserve to be educated, that girls aren't as capable as boys, that some young people are less worthy of opportunities because of their religion or disability or ethnicity or socioeconomic class…because we have seen time and again that potential can be found in some of the most unlikely places…my husband and I are living proof of that." The current administration has stated its commitment to supporting science, technology, and innovation [*Office of Science and Technology Policy,* 2010]; thus, recruiting the nation's youth and the URM community into the geosciences can be accomplished through robust strategies that transcend current efforts.

Acknowledgments

The authors thank many colleagues for their ardent discussions over the years regarding diversity issues. We especially thank Maya Elrick, Jacqueline Huntoon, Luis Gonzalez, Claudia Alexander, and an anonymous reviewer for thoughtful reviews and constructive feedback. Aaron Velasco thanks the Society for the Advancement of Chicanos and Native Americans in Science

(SACNAS) for keeping him engaged with the critical issue of diversity in science. This article was inspired from our experiences over the years and stems from a talk originally given by Aaron Velasco at the 2006 annual meeting of the Incorporated Research Institutions for Seismology (IRIS).

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NEWS

Researchers Focus on Fire Clouds That Reach to the Stratosphere

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Volcanic eruptions are not the only violent events that can inject smoke-colored and cauliflower-textured clouds into the stratosphere. Pyrocumulonimbus (pyroCB) storms can, too. These recently discovered phenomena are storms caused or aided by fire; they have many characteristics similar to thunderstorms, including lightning, hail, and extreme vertical height through the troposphere and into the lower stratosphere.

Common wisdom had held that "the only event that can explosively pollute the stratosphere is a volcanic eruption," Michael Fromm, a meteorologist with the Naval Research Laboratory in Washington, D. C., said at a 9 August press briefing at the 2010 Meeting of the Americas in Foz do Iguaçu, Brazil. "Now we know that pyroCBs can do a version of this, thanks to the heat from fire."

Fromm is a coauthor of "The untold story of pyrocumulonimbus," a paper to be published in the *Bulletin of the American Meteorological Society*. The paper indicates that pyroCB firestorm dynamics and atmospheric impact are "one important but poorly understood aspect of wildfire behavior." The paper provides a brief history of the phenomenon, focusing on examples from 1989–1992, and notes that "direct attribution of the stratospheric aerosols to the pyroCB only occurred in the last decade."

The paper states that these events occur "surprisingly frequently"—with 17 now known to have occurred in Canada and the United States in 2002 alone, for instance—and likely are a relevant aspect of some historic wildfires, and that satellite-era data are helping scientists to better understand and characterize these events.

At the briefing, Fromm said that pyroCBs had been spawned at some major fires in recent history, including the Yellowstone fires in 1998; the Hayman fire in Colorado in 2002; and the Canberra, Australia, fire in 2003.

Fromm said pyroCBs have a volcano-like impact on the stratosphere, injecting material "far enough into the stratosphere that particles and gases can remain for months." He said researchers now have noted three consecutive years, 1989–1992, of smoke observed by satellites in the stratosphere that had been misidentified in prior peer-reviewed literature as volcanic particles.

While volcanoes can affect global temperature because of the mass of stratospheric aerosols that can be created from some eruptions, Fromm explained that pyroCB events cannot compete with the biggest eruptions. He added that repeated smaller contributions of aerosols from pyroCBs "may be something that we need to pay attention to."

Another speaker at the briefing, Nathaniel Livesey, an atmospheric scientist and principal investigator on the Aura spacecraft's Microwave Limb Sounder (MLS) instrument at the NASA/California Institute of Technology Jet Propulsion Laboratory, has been looking at gas chemicals emitted along with soot that are sent to the stratosphere by pyroCBs. Livesey explained that when he and some colleagues were reprocessing some MLS data in the late 1990s, they examined a 1992 incident off the coast of Florida where data indicated that there had been a large cluster of spikes in methyl cyanide. After ruling out a volcanic eruption, hurricane, or a failed rocket launch as the source of the methyl cyanide, the researchers narrowed the cause to an Idaho forest fire.

"It's a real nice detective story that just goes to show when you launch these satellites, you know that you are looking for some things, but other things take you by complete surprise," he said.

Fromm added that it is important to understand pyroCBs "because, number one, they had been missed. I think in the quest for better science it is best to try to uncover the processes that are going on around us." He said that pyroCBs have been affecting the atmosphere as well as lives and property, as the 2003 fires in Canberra did. "It's very important to understand these fires because they are occurring not only far away in remote lands but also where human beings live and build things."

—Randy Showstack, Staff Writer