The intersection of geoethics and diversity in the geosciences

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Abstract: The geosciences (inclusive of geology, oceanography, atmospheric science and allied disciplines) have an ethical imperative to increase diversity in the profession. The diverse ways of exploring the Earth system, and the complexity of the grand challenges facing humanity living on Earth, require contributions of experience, skills, knowledge and motivations from diverse populations. Diversity increases creativity and problem-solving abilities in working groups, and ultimately is important for the long-term health of the geoscience discipline, for contributions that impact the health and security of society and for stewardship of the planet. Barriers and disincentives for people from underrepresented groups in the geosciences are identified, and interventions and remedies are recommended. Increasing diversity will take an all-discipline commitment by geoscientists and geoscience departments, companies and institutions. All people should have access and opportunity to pursue careers in the geosciences. Geoscientists have a responsibility to create work spaces that are welcoming, inclusive, safe and supportive.

The premise of this report should have been easy: diversity is good. It is hard to argue against this point, so now we can all go back to work. Or can we? Upon deeper inspection and reflection, it rapidly becomes evident that the life experiences of people from underrepresented minorities (URMs) are an amalgamation of indignities large and small, incivility and exclusion that permeates the whole fabric of society, and aspirations for diversity, equity and inclusiveness in our civic and professional institutions are far from being realized. The dual circumstances of spring 2020, the global COVID-19 pandemic and the international social unrest that has arisen from abuses of police authority, have exposed systemic and institutionalized inequities, injustices and racism experienced by minority populations across many sectors of society. These issues extend to the scientific enterprise (e.g. Cell Editorial 2020; Thorp 2020) and to the geoscience professions in particular (e.g. Dutt 2020) where participation of people from underrepresented groups in the geosciences has long been documented as being the lowest among the science, technology, engineering and mathematics (STEM) disciplines (e.g. Huntoon *et al.* 2015; Stokes *et al.* 2015). With this backdrop, now is an opportune time for the geosciences community to reflect on this diversity deficit, its consequences within the discipline and its impacts on people from underrepresented groups (defined by attributes such as race and ethnicity, but also gender, sexual identity, disability and socioeconomic status).

The International Association for Promoting Geoethics Constitution (http://www.geoethics.org/constitution, accessed 1 March 2020) and Cape Town Statement (http://www.geoethics.org/ctsg, accessed 24 June 2020) articulates: 'Geoethics deals with the ethical, social and cultural implications of geosciences knowledge, education, research, practice and communication, and with the social role and responsibility of geoscientists in conducting their activities'. The importance of the social aspects of geoethics, how we treat each other within the profession and how we interact with people in the larger civic community, is perhaps underappreciated by many geoscientists who focus mainly on Earth history and processes and warrants special consideration in these troubled times. An important role of geoethics reflects on the personal attitudes and behaviours that define the professional 'climate' of the geoscience disciplines. A healthy professional social structure is built on the foundations of the virtues of power (used to empower, enhance or enable), trust, respect, responsibility and justice (Mogk 2018). Inattention to these virtues can lead to the perception that the geosciences are not welcoming, inclusive, supportive or safe for people with diverse backgrounds and attributes. Diversity becomes an ethical issue when any person is denied the opportunity to participate in or is discouraged whether through commission or omission from participating in the profession based strictly on their personal attributes. Realization of a diverse geoscience profession is essential to optimize the human capital needed to address the grand challenges facing humanity living on Earth; to empower all people to be involved with decision-making about issues that impact their lives

From: Di Capua, G., Bobrowsky, P. T., Kieffer, S. W. and Palinkas, C. (eds) 2021. *Geoethics: Status and Future Perspectives*. Geological Society, London, Special Publications, **508**, 67–99.
First published online December 11, 2020, https://doi.org/10.1144/SP508-2020-66

and the health of their communities (e.g. related to geohazards, natural resources, impacts of climate change); to extend the influence of the geosciences into broader communities by demonstrating the relevance and importance of geosciences to communal health, security and economic well-being for all people; and, for the long-term growth and sustainability of the geosciences as a discipline. This contribution reviews the importance of diversity to the geosciences, provides perspectives on the biases and barriers diverse people experience in the geosciences, and makes recommendations for concrete actions that can be taken to broaden participation of URMs in the geosciences. As a geoscience profession and as individual geoscientists, we have a moral and ethical imperative and a collective and personal responsibility to support diversity in all of our professional activities.

Grand challenges in need of diverse solutions

Humanity is facing grand challenges to live responsibly and sustainably on Earth. Barnosky *et al.* (2016) have identified the need to address 'the intertwined problems of human population growth and overconsumption, climate change, pollution, ecosystem destruction, disease spillovers, and extinction, in order to avoid environmental tipping points that would make human life more difficult and would irrevocably damage planetary life support systems'. These issues track with UNESCO's Sustainable Development Goals (https://en.unesco.org/sustainabledevelopmentgoals, accessed 1 March 2020), are deeply related to geoscientists' understanding of Earth as a closed system that has operated on time scales far beyond human experience, with limited carrying capacity and with heterogeneous distribution of resources needed to sustain humanity. The geosciences can more effectively address sustainability goals by expanding interdisciplinary links with other environmental disciplines and also drawing from the human and behavioural sciences (Stewart and Gill 2017). The magnitude and complexity of these issues require the geosciences to use an all-hands approach to recruit new cohorts of workers with diverse interests, experiences and perspectives.

The corollary is that the geosciences as a profession must be supportive of all people interested in pursuing careers (or working with geoscientists) in the Earth and environmental sciences, and ensure that all geoscientists have the opportunity to pursue meaningful careers in work environments that are safe, inclusive and supportive. We cannot afford to exclude or lose human capital that is urgently needed to address the big questions confronting the geosciences in terms of basic research (on how the Earth works) and applied geoscience (on how humanity can best live on Earth). NASEM (2020) conducted a comprehensive review of underrepresentation of women in Science, Engineering and Medicine, and identified these consequences of not addressing diversity issues: '(1) A national labor shortage in many science, engineering, and medical professions, particularly in technical fields, that cannot be filled unless institutions and organizations recruit from a broad and diverse talent pool. (2) Lost opportunities for innovation and economic gain, particularly since research shows that more diverse teams generate more innovative solutions to problems, publish higher impact articles, and raise a company's bottom line. In other words, there are opportunity costs to perpetuating a scientific workforce that lacks diversity. (3) Lost talent as a result of discrimination, unconscious bias, and sexual harassment, which often prevents women from pursuing careers in science, engineering, and medicine'. The US National Science Foundation (NSF), in its Dear Colleague letter on the GOLD-EN programme (NSF 2020), affirms: 'Diversity is a vital priority for the geosciences community because it promotes innovation, strengthens the community's ability to tackle complex geoscience research problems, and engenders widespread public Earth and environmental science literacy'. It is an ethical imperative for geoscientists to embrace diversity in all aspects of the profession: to ensure the long-term growth and viability of the profession; in service to society; and as stewards of Earth. And, it's the right thing to do.

What is diversity and why is it important?

Diversity is recognized in many ways. Primary aspects of diversity refer to the intrinsic characteristics of individuals such as gender identity, sexual orientation, race, ethnic heritage, age and mental or physical abilities. In this contribution, the term underrepresented minority is used in a collective sense to include people with these diverse identities. Secondary characteristics may refer to the experiences of an individual such as primary language, work status, geographic location, communication style, level of education, military experience, work experience, income and religion/spirituality (from Williams 2013). (In the USA, Title VII of the Civil Rights Act of 1964 and subsequent legislation outlaws discrimination in employment based on factors such as sex, gender identity, race, age, disability, colour, creed, national origin, religion, genetic information, pregnancy and veteran status. Other countries and cultures may have additional designations for people from underrepresented groups such as immigration or refugee status.)

Why is diversity important? Diversity is not a goal in itself, a quota to be met to be able to demonstrate representation of different groups. Numerous recent studies have demonstrated that innovation, creativity and problem-solving thrive when done by diverse groups. Page (2007) developed a model wherein he demonstrated that 'diverse groups of problem solvers – groups of people with diverse tools – consistently outperformed groups of the best and the brightest. If I formed two groups, one random (and therefore diverse) and one consisting of the best individual performers, the first group almost always did better. In my model, *diversity trumped ability*'. Page (2007) also reports that an additional benefit of diversity is the increased probability of finding a truly gifted individual among the general population whose abilities might otherwise go unnoticed. By creating opportunities for all to participate, there is an increased probability of finding the 'one person who can solve the problem or who can make the key breakthrough'. Modern scientific research is increasingly cooperative, collaborative and cross-disciplinary, and there is good evidence that diversity makes science better, smarter and stronger (Medin and Lee 2012; Freeman and Huang 2014; Phillips 2014). Page (2017) further demonstrates that 'teams that include different kinds of thinkers outperform homogeneous groups on complex tasks producing "diversity bonuses". These bonuses included improved problem solving, increased innovation, and more accurate predictions – all of which lead to better performance and results'. Galinsky *et al.* (2015) amplify the benefits of diversity, recognizing effective decision-making, innovation, deeper information processing and complex thinking in their analysis of how to 'maximize the gains and minimize the pains of diversity'. However, they also caution that diversity can incite detrimental forms of conflict and resentment, and they recommend that resistance to diversity initiatives can be managed by emphasizing the benefits of multiculturalism (valuing intergroup differences) and perspective taking (imagining the world from another's vantage point). AlShebli *et al.* (2018), in a metanalysis of scientific literature, have documented that ethnic diversity in scientific collaborations can account for an impact gain of over 10% for papers and 48% for scientists.

Diversification of the geoscience workforce is a strategy for future growth and survival of the discipline. Diverse workers make more connections when working in complex systems and create stronger social networks that expand the relevance and importance of the geosciences beyond traditional disciplinary boundaries. As with any system (biological, social, economic), overspecialization can lead to collapse and extinction, whereas diversification provides protection against the vicissitudes that can threaten the discipline.

Geological reasoning – diversity in strategies and methods

Geology has been characterized as an interpretive and historical science, and 'geological reasoning has developed its own distinctive set of logical procedures' distinct from laboratory-centric disciplines (Frodeman 1995). Manduca and Kastens (2012) argue that geoscientists are united by 'a common commitment to testing hypotheses against observations of the natural system using multiple converging lines of evidence'. Intrinsic to the training of geosciences is the development of spatial reasoning (Liben and Titus 2012), temporal reasoning ('deep time'; Dodick and Orion 2006; Cervato and Frodeman 2012), an understanding of Earth as a complex system (Turcotte 2006; Stillings 2012), and a firm grounding in first-order observations of Earth in the field (Mogk and Goodwin 2012). Geological reasoning embodies diverse cognitive skills in a number of contexts. The geosciences build on the foundations of physics, chemistry and biology, but have established an epistemology distinct to the discipline (Frodeman 1995; Cleland 2001, 2002). The spatial scale of observation varies over many orders of magnitude from atomic to planetary. Temporal scales similarly span orders of magnitude from events or processes that occur instantaneously (and often catastrophically) to those that occur inexorably over eons. Post-diction, interpreting the history of Earth enables prediction of geological events by revealing that what has happened in the past can happen again. Geoscientists make direct observations of Earth in the field, but these observations may be enhanced by technology to extend human perception (e.g. by sensor, remotely operated vehicles or satellite using a variety of spectrometries). Indirect observations of Earth (e.g. using geophysical methods) enable geoscientists to explore and interpret Earth in environments that are not directly accessible. Comparison and correlation are used to interpret geological phenomena, but assignment of unique causality is often elusive (Cleland 2013). Complex problems are broken into smaller, more manageable components using analytical methods and reasoning, and at other times geoscientists must integrate numerous disparate lines of evidence using synthetic reasoning, a tradition long established in *The Inculcation of the Scientific Method* (Gilbert 1886) and *The Method of Multiple Working Hypotheses* (Chamberlin 1890). Geoscientists often work independently in the field or laboratory, but most modern research is done by cooperative and collaborative research groups (e.g. Goodwin 2018). Geoscientists often collect their own data, but increasingly Earth data is ubiquitously available and 'mining big data' is proving to be an illuminating approach to studying Earth history and processes. The work of geoscientists carries a pretty

heavy cognitive load, too much for a single individual, and is best realized when done collectively, collaboratively and as part of a diverse community.

Geoscientists are also confronted with large challenges to understanding Earth: the geological record is incomplete, and evidence is often missing; there are interactions and feedback mechanisms between physical, chemical and biological processes that are often complex and non-linear; the temporal and spatial scales of observation are often outside the bounds of human perception; there is inherently a high degree of ambiguity (Ault 1998) and uncertainty in reporting results and interpretation in geological investigations; and the language used to report on geological phenomena is often explanatory, using language that is almost always contingent (Dodick and Argamon 2006), and interpretations are rarely absolutely conclusive. However, geologists also have powerful tools in their ability to integrate basic field observations (increasingly enhanced by technology), experimental, analytical, theoretical and computational/modelling approaches. In addition, although Earth is the focus of geoscientists' work, there is an increasing need for positive interactions with colleagues in allied disciplines such as physical, biological and social sciences, public planning, policy, law, business and education to be able to effectively address the grand challenges identified above. Geoscientists must now be prepared to work in teams with people who do not share common knowledge, skill sets or experiences. Thus, there is a need for diversity in the geosciences from a practical perspective.

It all boils down to this: Earth is a big, complex planet. The geosciences employ many sophisticated methods and strategies to study it. This means that we must proactively attract people with diverse abilities and interests who can contribute collectively to the holistic study of Earth. The geosciences have been challenged to demonstrate that a career in geosciences is important, interesting and rewarding on many levels (e.g. O'Connell and Holmes 2011; Stokes *et al.* 2015; Karsten 2019). Although the many dispositions described above all contribute to geoscience expertise, any single geoscientist can't be expected to master all of these approaches. Each geoscientist will have their own special motivations, abilities, interests and experiences. So collectively, to fully explore the Earth system, and by extension to better contribute to humanity's survival on this planet, the geosciences must be inclusive of diverse people with diverse interests and abilities. The geosciences must provide a 'big tent' where everyone has the opportunity to contribute, and everyone's contributions are valued. The geosciences must be welcoming, inclusive and respectful of all people. The geosciences are demonstrably stronger as a profession when we enable, encourage and embrace diversity.

The geosciences have a diversity problem

Diversity is not a new challenge to the geosciences (e.g. Velasco and Velasco 2010). It is not too strong a statement to characterize the lack of diversity in the geosciences as an existential threat to the long-term health of the discipline. 'The geosciences suffer from a lack of racial and ethnic diversity, particularly at doctoral levels and within academia. Unfortunately, the geosciences have the lowest diversity of all the STEM fields at all levels of higher education' (reported by Huntoon *et al.* 2015 with data from the NSF National Center for Science and Engineering Statistics 2015, 2017; Stokes *et al.* 2015). In 1997, the NSF-sponsored Geoscience Education Working Group recommended: 'GEO should continue to recognize the problem of underrepresentation of minorities and women in the geosciences and should increase its efforts to correct this problem by encouraging participation of people from these groups in all of its programs' (NSF 97-171). The subsequent NSF (2001, NSF 01-53) report, identified a primary goal: 'to increase participation in geosciences education and research by members of groups that have traditionally been underrepresented in geoscience disciplines'. An important related goal follows: 'to enhance the understanding of the geosciences and their contribution to modern society by a broad and diverse segment of the population'. However, O'Connell and Holmes (2011; using data from NSF 2010) report: 'In 2008, >85 000 Hispanic, Black, and American Indian/Native Alaskan students, collectively called underrepresented minorities, received bachelor degrees in STEM subjects. Of that number, only 192 Hispanic, 89 Black, and 28 American Indian/Native Alaskan students earned degrees in geoscience. Between 2000 and 2008, underrepresented minorities earned 16%–17% of STEM degrees and only 5%–7% of geoscience degrees'.

The American Geosciences Institute has collected geoscience workforce data in the USA since 1955, and here are some recent indicators: the US Bureau of Labor Statistics estimates that women made up 27% of the geoscience workforce in 2015. In 2016, only 20% of the geoscience professoriate were women, an increase from 14% in 2006 (Wilson 2017, 2019). In 2016, 'Twenty percent of science graduate students were from underrepresented populations, whereas only 12% of graduate students in the geosciences were from underrepresented groups. Similarly, 9% of all science post-doctorates and 8% of geoscience post-doctorates were from underrepresented populations' (Wilson 2018). Owing in part to such low enrolment in degree-granting programmes, between 2003 and 2009 racial minorities comprised between 2.2 and 8.1% of the environmental science and geoscience workforce compared with

c. 25% of the total US workforce (Gonzales 2010). Some progress appears to have been made towards achieving gender equity, but Bernard and Cooperdock (2018) have documented the number of PhDs awarded by gender and race/ethnicity in the geosciences and have demonstrated that after 40 years little progress has been made in achieving racial or ethnic diversity. There are few demographic data available to document the degree of participation among other URMs such as members of the LGBTQ community and people with disabilities – an unfortunate oversight. Although these indicators are from the USA, they most likely reflect endemic, discipline-wide challenges for the global geosciences community to address this diversity deficit.

There are many factors that may contribute to the diversity challenges in the geosciences. In the USA, geo/Earth science is not universally required in K–12 curricula (AGI 2013; notwithstanding the Next Generation Science Standards; NRC 2013*a*) and many students may never get a formal introduction to the geosciences at any level. Even if offered, a geo/Earth science course may not be considered to be a recommended course for college admission. Although geoscience career information is available (e.g. AGI's Geoscience Workforce programme; website (https://www.americangeosciences.org/workforce)), many young students do not have access to this information and do not know about the career opportunities that are available. As a result, too few students declare geoscience as a major upon entering college, thus, introductory courses are important for attracting and recruiting students to the discipline (e.g. Holmes and O'Connell 2003; Hoisch and Bowie 2010; NRC 2013*b*; Stokes *et al.* 2015). Role models are an important factor in recruiting students and in increasing their self-efficacy that leads to persistence in the field (e.g. Baber *et al.* 2010; Thiry and Laursen 2011; Callahan *et al.* 2001, 2017), but once exposed to the geosciences, there is a lack of role models and mentors in geoscience departments who look like students from URMs (e.g. Levine *et al.* 2007). There may be a perception that work in the geoscience requires a lot of field work, and as attractive as that may be to some populations (Boyle *et al.* 2007; Mogk and Goodwin 2012), it may be a turn off for others if field experiences are not aligned with diversity recruitment goals (Levine *et al.* 2007). The 'culture' of the geosciences may also be perceived as unwelcoming to people from URMs, and even misogynist or racist (Dutt 2020). The geosciences may need a makeover regarding how the world perceives them: an enthusiasm for outdoor activities that is commonly aligned with a predisposition to enter the geosciences may be foreign and not attractive to many people from URMs, so there is a need to branch out and emphasize career opportunities in the geosciences that are not field-based (e.g. computational, theoretical and laboratory approaches); look for opportunities to build bridges with professions that require a knowledge of geoscience as a foundation that expands the application of geoscience knowledge to social or civic needs (e.g. public planning, policy, law, business, education); and improve the external perception of the geosciences to ensure that the geoscience culture is viewed as being welcoming, safe, inclusive and supportive (Huntoon 2016). An example of this perception problem is illustrated by a studies of representations of geoscientists to the public that portray the profession as being dominantly white and male (Bush and Mattox 2020). Mattox *et al.* (2008) reviewed figures of geoscientists in 15 introductory geology textbooks and found that 69.7% were male and 83.6% were white.

A systemic and sustained response is needed throughout the geoscience community to recruit, support and provide continuing professional development opportunities for people from URMs at all stages of their career trajectories. Numerous individuals and institutions have addressed these issues, but somehow the geoscience community has turned a blind eye or otherwise has not had the wherewithal to adequately respond. The first necessary step is to be aware of the issues. Then, there must be a commitment, individually and collectively, to take affirmative actions to make the changes that are needed. Karsten (2019) provides an assessment of a path forward: 'Better progress can be achieved if a larger community of geoscientists is engaged in advocating for and fostering diversity within the geosciences using the most cost-effective approaches. Significant and sustainable change will only be realized, however, when the levers that drive behaviour in the educational and professional systems of the geosciences are tuned so that diversity is recognized as a core value and fundamental feature of scientific excellence and integrity'. Evidence presented in this contribution on the nature and scope of the diversity issue in the geosciences, and examples of strategies and methods to address diversity, mostly derive from the USA. However, the principles and applications may be applied by the global geoscience community.

The experiences of individuals from underrepresented groups in the geosciences (how does it feel …?)

Numerous cultural, historical, interpersonal and institutional barriers have been identified that discourage broad participation in the geosciences. Some barriers are large and some are small, but in aggregate, day-to-day neglect or affronts to human

potential, capabilities and sensibilities take a toll. Rosen (2017) characterized this as a mountain of molehills facing (women) scientists. The following is a sampling of what people from URMs encounter every day as they aspire to careers in the geosciences. Perhaps some of these examples will resonate with your own professional experience and may be present in your work environment.

How does it feel …

… To be a woman in the geosciences. Holmes *et al.* (2015) have provided a thorough review of the issue of gender equity in the geosciences, and have provided positive and practical steps towards achieving parity. The lack of peer and faculty mentoring support systems for women is an important factor in recruiting and persistence towards successful completion of STEM degrees. Bostwick and Weinberg (2018) studied the effects of peer gender composition as a proxy for female-friendliness of STEM doctoral programmes, and demonstrated that women entering cohorts with no female peers are 11.9% less like to graduate within six years than male students. Holmes and O'Connell (2003) asked 'Where are the women geoscience professors?' Major reasons for lack of gender diversity of the faculty in the geosciences are underrecruitment of women into the major, too many women dropping out before obtaining a PhD and low rate of hiring women into tenure-track positions. Misra *et al.* (2011) reported on the 'ivory ceiling of service work' and provided evidence that women spend more hours on teaching, mentoring and service than men at the same rank. Steinpreis *et al.* (1999) demonstrated gender bias in reviews of identical job applications that were represented with either male or female names. They report: 'Both men and women were more likely to vote to hire a male job applicant than a female job applicant with an identical record. Similarly, both sexes reported that the male job applicant had done adequate teaching, research, and service experience compared to the female job applicant with an identical record'. Moss-Racusin *et al.* (2012) documented that science faculty engage subtle gender biases in favour of male students, and demonstrated in a double-blind study that applicant resumes with male names were rated more competent and hirable than females with identical applications. Reuben *et al.* (2014; a study of hiring practices in mathematics) found that stereotypes impair women's careers in science, and even when mathematics skills were identical, that men were twice as likely to be hired as women. Sheltzer and Smith (2014) found that in elite university laboratories, male graduate student and post-docs were preferentially hired over women. In an analysis of recommendation letters for postdoctoral fellowships ($n = 1224$ from 54 countries), Dutt *et al.* (2016) reported that female applicants are only half as likely to receive excellent letters v. good letters compared with male applicants, and that women are significantly less likely to receive excellent recommendation letters than their male counterparts at a critical juncture in their careers. Lerback and Hanson (2017) provided evidence that women of all ages have fewer opportunities to take part in peer review in a survey of the AGU's (American Geophysical Union) publication records. To the extent that participating in peer review helps build a professional portfolio, builds professional relations and is important for career development, it is problematic that 'women constituted 20% of all of the individual reviewers in 2012–15, substantially less than the proportion of distinct published female first authors (27%), published authors (23%) and AGU members (28%) or all-accounts holders (29%)'. Ford *et al.* (2018) report that women are allocated invited speaking opportunities less often and below the proportion of women authors, and this demonstrates the need to provide equal opportunities to women in speaking roles at scientific conferences. Similarly, Nittrouer *et al.* (2018) documented that women are underrepresented relative to men as colloquium speakers across six disciplines.

The specific issues of sexual harassment and assault and bullying in the geosciences demand to be addressed directly. The NASEM (2018*a*) report on the sexual harassment of women in academic science, technology, engineering, mathematics and medicine (STEMM) has provided a comprehensive (and depressing) analysis of the scope of this problem. Clancy *et al.* (2014) surveyed trainees in field settings ($n = 666$) and found that over 70% of the participants had witnessed or heard about instances of sexual harassment and over 20% had personally experienced sexual assault (i.e. physical and unwanted sexual contact without consent). Numerous instances of sexual harassment in the geosciences are being disclosed in the press (e.g. Waldman 2017*a*, *b*). Joyce (2016) reported on a climate of sexual hostility in the US Forest Service and National Park Services. Gries (2019) addressed this issue in her 2018 GSA Presidential Address, 'Navigating "Me, too" in the Geosciences'. These issues appear to be endemic, as Libarkin (2019; accessed 1 March 2020) reported 1023 publicly reported incidents of sexual misconduct in institutions of higher education. In her 2016 International Association for Promoting Geoethics keynote presentation at the 35th IGC conference, Peppoloni clearly identified the consequences of these behaviours: 'any kind of harassment and discrimination cannot be tolerated and must be denounced. Harassment and discrimination offend the dignity of the person, threaten the serenity of the working environment, limit the

individual's freedom of choice, and seriously undermines the integrity, quality and credibility of the geoscience community'. Sexual harassment and bullying in the work environment may have long-term psychological health (Verkuil *et al.* 2015) and physical health consequences (e.g. increased susceptibility to type 2 diabetes and cardiovascular disease; Xu *et al.* 2018*a*, *b*). Adverse health effects are not limited to the targets of harassment or bullying, and actually extend to other workers who witness these behaviours in the workplace (Lim *et al.* 2008; Farley *et al.* 2015).

… To be a person of colour in the geosciences. People of colour are often discouraged from pursuing careers in the geosciences owing to the lack of access to basic information about career possibilities, support systems, role models and life experiences. Czujko *et al.* (2008) have reported on the experience of African Americans in the geosciences and physics. They found that Historically Black Colleges and Universities (HBCUs) awarded the highest number of undergraduate degrees and that majority-serving institutions played only an insignificant role. They also note that underrepresentation worsens with each step up the academic ladder as the number of African American faculty members is very small, and these faculty members tend to work in the HBCUs. African American students feel excluded from a profession where few people look like them. The lack of role models from URMs makes this situation worse. Questions of self-identity become important (Carlone and Johnson 2007): am I capable of doing this work? Do I want to do this work, is it even possible? Is this my community, do I belong? Pernicious hidden biases exist. Bertrand and Mullainathan (2004) ask, 'Are Emily and Greg more employable than Lakisha and Jamal?' in their field experiment on labour market discrimination (the answer is yes). Black students and Latino students report that they receive little pre-college encouragement to pursue degrees in the geosciences (Whitney *et al.* 2005). This issue is being addressed in selected programmes such as Savannah State University (a HBCU), which seeks to provide immersive outdoor experiences, and by establishing informal educational science centres (Pride and Olsen 2007). There are implicit and explicit barriers that students of colour must overcome, such as family influences, cultural differences and other hidden barriers (e.g. O'Connell and Holmes 2011). Stokes *et al.* (2014) ask 'Why are there so few Hispanic students in geoscience?' They found: 'Hispanic geoscience majors had significantly more negative familial experiences than their white peers. Fewer Hispanics reported out-of-school outdoor experiences. Geoscientists are not as visible in the workforce as other scientists or engineers, and because there are so few Hispanics among them, parents may not easily see the value of the profession'. A survey of introductory students at Northern Arizona University (Hoisch and Bowie 2010) found that students perceived careers in geosciences to be low prestige, with low employment potential and low salaries. Levine *et al.* (2007) report that in some cultures, the outdoor work associated with the geosciences is typically associated with labourers rather than professionals. Dutt (2020) has commented on race and racism in the geosciences, and notes the importance of white geoscientists acknowledging their status and privilege and the imbalance of power in the profession, and the consequences of implicit racism: 'The less diverse a field, the less welcoming it is to minorities, and the more prevalent implicit biases become. Combined with structural and social factors, the relative homogeneity in geoscience reinforces the dominant culture. As a result, women, people from sexual and gender minorities, and Black and Hispanic people all leave the field at higher rates than the average student or practitioner'.

… To be a Native American or Indigenous person in the geosciences. Indigenous ways of knowing are often ignored or discounted, marginalizing people and their cultures, which creates barriers for recruitment efforts to the geosciences (Riggs and Marsh 1998; Riggs 2005; Palmer *et al.* 2009; Unsworth *et al.* 2012; Johnson *et al.* 2014; Reano and Ridgway 2015). The conduct of geoscience investigations may be done lacking sensitivity to local cultural standards (e.g. related to access or sampling of sacred places; offending local customs, e.g. Skandari 2015), creating ill will with local Indigenous communities. Native American students may not see the utility or applicability of geosciences, and need to be assured they will be able to develop skills such as GIS that they can use on reservations and for the benefit of their people (e.g. Mannel *et al.* 2007). Issues of development of geological resources and vulnerability to natural hazards (e.g. Hostettler 2015; Das 2015; Zúñiga *et al.* 2015) related to Indigenous lands raise questions of environmental justice (Potthast 2015). Too often, Indigenous people and their lands are exploited for resource development, with little immediate return to the community and with long-term environmental consequences (e.g. Impacts of Resource Development on American Indian Lands, Science Education Resource Center, Carleton College. https://serc.carleton.edu/research_education/nativelands/index.html, accessed 1 March 2020). These concerns may alienate people from Indigenous populations interacting with the geoscience community. Further, there are too few senior geoscientists from Indigenous cultures who can serve as role models and mentors in the recruitment of next generation

geoscientists. Van Cooten (2014) studied the absence of Indigenous leaders in US federal science and engineering organizations, and made recommendations for critical interventions for recruiting Native American/Alaska Native students to prepare for leadership positions in federal scientific organizations.

… To be a person with a disability in the geosciences. Atchison and Libarkin (2016) contend: 'Challenging traditional perceptions of identity in the geoscience community is an important step to removing barriers for students and geoscientists with diverse physical, sensory, and cognitive abilities, and to broadening entry into the myriad fields that make up the discipline'. They challenge the geosciences to address the perceptual, training and community-based barriers to inclusion that exist to make the geosciences more accommodating and accessible for all people. Students with disabilities are largely unaware of careers that exist in the geosciences without field requirements, and make the assumption, without being fully knowledgeable about the discipline, that accessible career options do not exist. Carabajal *et al.* (2017) conducted a synthesis of instructional strategies in geoscience education that address barriers to inclusion for students with disabilities. Access to, and the ability to participate in, field experiences has been a major barrier to students with disabilities. Suggestions on how to run an inclusive field trip have been addressed by Gilley *et al.* (2015), Hendricks *et al.* (2017), Stokes *et al.* (2019) and Giles *et al.* (2020), but these practices and procedures need to be universally applied to course field trips, departmental field camps and field trips sponsored by professional societies. A sector of society that has largely been excluded from the geosciences are people with autism or who are otherwise neurodiverse. Kingsbury *et al.* (2020) discuss their personal experiences, and recommend inclusive practices in geoscience education that include 'development of more effective communication pathways, presume competence and include autistic students in the planning of their own accommodations, and employ strategies for expectation management'.

…To be part of the LGBTQ community. Mostly to be LGBTQ means to be invisible in the geosciences. Freeman (2018) reports, 'People who identify as LGBTQ are leaking out of the scientific pipeline in similar ways to women and those from minority ethnic groups … LGBTQ people are 17–21% less represented in STEM fields than expected, male undergraduates from sexual minorities are much more likely than their straight counterparts to drop out of STEM degrees (26% straight v. 40% sexual minority left STEM), and they are dropping out of STEM degrees at a higher rate than women overall'. Cech and Pham (2017) report that LGBT individuals in US federal workplaces often face disadvantages in pay, promotion and inclusion and Cech and Rothwell (2020) find that in the US federal STEM workforce 'LGBT employees report worse workplace experiences than their colleagues across 16 measures of employee treatment, workplace fairness, and job satisfaction'. Workplace climate factors have been shown to be a major influence on persistence of LGBTQ people in STEM (Patridge *et al.* 2014; Yoder and Mattheis 2016). Groups such as Pride in STEM (https://prideinstem.org/, accessed 1 March 2020), Out in STEM (https://www.ostem.org/, accessed 1 March 2020) and the US National Organization of Gay and Lesbian Scientists and Technical Professionals (https://www.noglstp.org/, accessed 1 March 2020) provide information and support services, and are beginning to showcase LGBTQ people in the STEM disciplines.

Given this litany of real and perceived affronts, is there any question why people from URMs and marginalized groups may feel unwelcome, not included or discouraged from pursuing careers in the geosciences (and related STEM disciplines)? How well would you fare in the geosciences (and STEM) if confronted with a lifetime of barriers such as these? Employing a multicultural perspective, internalizing and viewing the world empathetically from others' point of view, as recommended by Galinsky *et al.* (2015), may be an important first step towards realizing diversity goals.

Professionalism and diversity in the geosciences

Mogk (2018) addressed the tenets of professionalism in the geosciences and identified attitudes and behaviours that impact the ability of scientists to do their work in the social environment of their workplace. Foundational principles of professionalism are power, trust, respect and responsibility. Many of the slights, affronts and transgressions described above have their origins in: the abuse of power in social structures and inappropriate use of power to intimidate, manipulate and denigrate individuals rather than support, enable and inspire; breach of trust between individuals, the profession and society; lack of respect for individuals, institutions, the profession and for the scientific enterprise; and abrogation of personal and collective responsibilities. Geoscientists can commit to overt, purposeful and explicit actions to make the geosciences a welcoming, inclusive, safe and supportive discipline for all people. Our personal conduct towards people from URMs can have large positive or negative impacts

on the people who we hope to include in the geoscience community.

It is important to have an awareness of the following types of behaviours that can impact workplace climate:

- Microaggressions are casual, day-to-day affronts that degrade or marginalize people (Sue 2010; Runyowa 2015). Microaggressions are cumulative, they hurt and they send a clear message that individuals are not welcome. Care must be taken in day-to-day use of language that may have unintended impacts (Harrison and Tanner 2018). Individuals who are subject to protracted microaggressions may experience diminished self-confidence, and it contributes to a poor self-image and potentially leads to mental health problems such as depression, anxiety and trauma (e.g. Pieterse *et al.* 2012).
- Implicit bias refers to the attitudes or stereotypes that affect our understanding, actions that are activated involuntarily without an individual's awareness or intentional control (American Women in Science, https://awis.site-ym.com/?POLICYISSUES, accessed 1 March 2020). Examples of gender bias include: women have to provide more evidence of competence than men in order to be seen as equally competent (Foschi and Valenzuela 2012) and may be subject to double standards in performance evaluations and review (Foschi *et al.* 2019); women may be caught in the bind that they are perceived as being too feminine to be competent or too masculine to be likable (Cuddy *et al.* 2004); and motherhood may present the stereotype that women lose their work commitment and competence after they have children (Heilman and Okimoto 2008). Other examples of implicit bias include: (1) the 'halo effect', which is a cognitive bias where the overall impressions of an individual affect how we perceive other attributes of their character, for example, someone who appears to be physically attractive might also be considered to be a good leader, smart, funny, well-liked, etc.; (2) anchoring bias, which is the human tendency to rely too heavily on one trait (and often a first impression) when making decisions; (3) confirmation bias, which occurs when the person performing the data analysis wants to prove a predetermined assumption – thoughts and actions are commonly influenced by ingrained stereotypes; and (4) selection bias, which occurs when data are subjectively selected.
- Stereotype threat describes the concept that some people have positive or negative attributes simply because they self-identify as a member of a particular group for which a stereotype of ability applies (Steele and Aronson 1995; Walton *et al.* 2015; ReducingStereotypeThreat.org, https://web.archive.org/web/20160429031230/http://reducingstereotypethreat.org/, accessed 1 March 2020). It is the situation where people feel they are at risk by conforming to stereotypes about their social standing, particularly when they expect discrimination owing to their association with a particular group – a self-fulfilling prophecy and destructive feedback mechanism (e.g. women can't do mathematics). Stereotype threat can result in diminished self-confidence, loss of interest in a subject, underachievement of academic tasks, engaging in 'self-handicapping' behaviours such as reduced preparation and effort (Stone 2002), 'disengagement' (distancing oneself from the threatening domain; Major *et al.* 1998), which can produce performance avoidance goals (Smith *et al.* 2007) and reduced sense of belonging (Good *et al.* 2012), and can also discourage students from pursuing careers in a discipline that appears to reinforce stereotype threats. Stereotype threat suppresses performance for a wide range of people from URMs, but this effect can be mitigated. Strategies for reducing stereotype threat can include: reframing questions or tasks to minimize association with stereotypical poor performance (e.g. assuring test takers that 'men and women perform equally well on these problems'; Quinn and Spencer 2001; Good *et al.* 2008); encouraging self-affirmation focusing on intrinsic self-worth (e.g. characteristics, skills, values, or roles that they value; Schimel *et al.* 2004); emphasizing the ability of everyone to succeed (e.g. reinforcing self-efficacy by providing constructive criticism accompanied by high expectations and the view that each student is capable of reaching those expectations; Cohen *et al.* 1999); providing role models who exhibit proficiency in a given domain (Blanton *et al.* 2000); and attributing other external difficulties as the source of anxiety or explicitly teaching about stereotype threat as a means to improve performance (Johns *et al.* 2005). Callahan *et al.* (2017) have demonstrated the negative impacts microaggressions and stereotype threat has had on recruitment and retention efforts of URMs into the geosciences.
- Imposter syndrome is the personal assessment that individuals make that question their accomplishments, and engenders a persistent fear of being exposed as a 'fraud'; the personal anxiety among many high-achieving people from URMs is that, no matter what they have achieved, it is simply not enough and they do not 'belong' or have not earned their place in an organization. Stereotype threat and imposter syndrome can be mitigated by increasing students' sense of belonging (Walton and Cohen 2007; Taylor and Walton 2011). Sense of belonging is characterized by feeling welcomed, recognized, included and

appreciated. The feeling is fostered by trust, supportive relationships and cross-group and cross-cultural dialogues about belonging in a specific setting (Steele 2010; Walton *et al.* 2015).

- Intersectionality recognizes that people cannot be categorized in terms of singular attributes (e.g. race, class, age, gender, sexuality, ethnicity, abilities), but as 'reciprocally constructing phenomena' (e.g. the intersection of race and gender; Collins 2015). Mattheis *et al.* (2019) conducted a decadal review of the literature on intersectionality and inclusivity in geoscience education research. They identified three emerging themes: (1) increasing challenges to the assumption that science is objective and neutral, and that science is a human endeavour that is potentially subject to bias because many aspects of geoscience research have social implications; (2) academic success is defined by meritocracy (i.e. effort expended, personal motivation, capacity or natural aptitude to succeed) and does not consider issues of marginalization and access; and (3) initiatives to increase diversity often attempt to assimilate inductees into the existing culture, whereas the culture itself must adapt and expand to become more inclusive. They recommend that geoscience education research should increase its focus on the role of individual and collective social identities. The Athena Swan Charter program (https://www.ecu.ac.uk/equality-charters/athena-swan/, accessed 1 March 2020) in the UK further elucidates: 'Individuals can experience complex discrimination, based on a combination of elements of their identity. It is therefore important that institutions' equality and diversity work – aimed at tackling discrimination – is mindful of this complexity when exploring issues and developing solutions. If an intersectional approach is not taken, the discrimination and barriers experienced by some individuals will not be fully understood and tackled'. Intersectionality can lead to a double-bind situation at the confluence of multiple barriers (e.g. Malcom *et al.* 1975; Ong *et al.* 2011; Williams *et al.* 2014; Collins 2015).
- People in vulnerable situations need to know that immediate support systems are present in the people around them. Should incidents of discrimination, harassment or bias emerge, bystanders must be empowered to intervene to mitigate a bad situation. Ashburn-Nardo *et al.* (2008) presented the confronting prejudiced response model for bystander interventions and recommended 'that for people to confront prejudice and discrimination, they must recognize the behaviour as prejudiced, perceive it as an emergency that requires an immediate response, feel a sense of personal responsibility for intervening, decide on a course of action, and see the benefits of confronting as outweighing the costs' (Ashburn-Nardo and Abdul Karim 2019). Hollaback! (Bystander Intervention Training, https://www.ihollaback.org/bystander-resources/, accessed 1 March 2020) has developed the '5 Ds' of bystander intervention: distract (take an indirect approach to de-escalate the situation), delegate (get help from someone else), document (notes or video about what transpired), direct (assess your safety first, and speak up firmly and clearly about the harassment) and delay (after the incident check in with the person who was harassed and offer continuing support).

  Neutrality is not an option. Silence is complicity. The impacts will be far reaching beyond the perpetrator and the target, and there will always be collateral damage to surrounding people and institutions. Everyone has a right to a safe and productive work environment, and everyone has an interest in and a responsibility to take a collective stand against harassment in all its forms.

There are many ways to combat these biases that only require small changes in day-to-day interpersonal interactions: recognize that everyone has biases, and take steps to identify your own. Pay attention to your language and be aware of what you say and how you say it. Question your own thinking and challenge your assumptions. Are your assessments of individuals consistent across the spectrum of human diversity? Proactively seek diversity in your friendships and interactions. Speak out and hold yourself and others accountable when biases surface. Avoid generalizations in reference to people. Listen, and exercise empathy for the experiences of others. Focus on fair treatment and respect in regular work activities. Support projects that encourage positive images of persons of colour, LGBTQ and women.

An awareness of the impacts of these types of behaviours in personal and professional lives is the first step towards achieving inclusivity and diversity goals. The next steps require affirmative actions.

Progress is being made …

The issue of diversity in STEM has been addressed at the highest policy levels for many years. AAAS (2001) published 'In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities'. The US National Academy of Sciences has published numerous comprehensive reports that address diversity issues in STEM: *Understanding Interventions That Encourage Minorities to Pursue Research Careers* (NRC 2007); *Expanding Underrepresented Minority Participation: America's Science and*

Technology Talent at the Crossroads (NRC 2011); *Seeking Solutions: Maximizing American Talent by Advancing Women of Color in Academia* (NRC 2013*c*); *Barriers and Opportunities for 2-Year and 4-Year STEM Degrees: Systemic Change to Support Students' Diverse Pathways* (NASEM 2016); *An American Crisis: The Growing Absence of Black Men in Medicine and Science* (NASEM 2018*b*). The US National Academy of Engineering (2020) recently released its *Diversity, Inclusion and Equity Statement, Definitions and Goals* with goals defined to embrace diversity, drive inclusion and expect equity in all NAE functions. NSF has also initiated its Broadening Participation (https://www.nsf.gov/od/broadeningparticipation/bp.jsp, accessed 1 March 2020) initiative which produced the NSF INCLUDES (n.d.) report (strategies, lessons learned, goals and metrics), and related reports from the multi-agency Committee on Equal Opportunities in Science and Engineering that the NSF oversees.

Specific to the geosciences, numerous individuals and groups have made considerable contributions to addressing diversity in the geosciences, and have prepared a strong foundation for the geosciences to affirmatively move ahead (e.g. National Science Foundation n.d. Geoscience Opportunities for Leadership in Diversity). These contributions have clearly identified issues of concern, and have provided guidance about how to best address thems. The NSF Directorate for Geosciences (2012) has developed its *Strategic Framework for Education and Diversity, Facilities, International Activities and Data and Informatics in the Geosciences* that identifies diversity in the geosciences as a priority goal. Karsten (2019) has reviewed the lessons learned from the NSF Opportunities for Enhancing Diversity in the Geosciences programme (https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf08605&org=NSF, accessed 1 March 2020) that operated from 2001 to 2013. NSF also sponsored the Geoscience Opportunities for Leadership in Diversity – Expanding the Network (GOLD-EN; NSF 2020) programme. The Geo-Needs Stakeholder Assessment for Broadening Participation in the Geoscience Workforce project made recommendations for academic administrators, instructors, resource providers and educational researchers (Petcovic *et al.* 2015). Two special volumes of the *Journal of Geoscience Education* have been dedicated to diversity in the geosciences (New Developments in Diversity and Inclusiveness in the Geosciences, Gates *et al.* 2019; Broadening Participation in the Earth Sciences, Riggs and Alexander 2007).

Professional societies have responded affirmatively to the challenges of broadening participation in the geosciences. Geoscience professional societies (e.g. AGU, GSA, AGI, EGU) regularly have convened thematic sessions, workshops, short courses and webinars to support diversity initiatives (e.g. most recently the European Geophysical Union General Assembly (2020) convened numerous theme sessions on diversity and equality). These sessions are organized for you! Plan to attend, meet some new colleagues, expand your horizons, and plan to contribute at the next opportunity. The Geological Society of America (2016, 2018) has adopted position statements on Diversity in the Geosciences Community and Removing Barriers to Career Progression for Women in the Geosciences. The GSA (n.d.*b*) On to the Future programme (https://www.geosociety.org/GSA/Education_Careers/Grants_Scholarships/otf/GSA/OTF/Home.aspx, accessed 1 March 2020) 'supports diverse communities to attend the annual meeting by offering partial travel funding, full meeting registration, one-year membership, mentorship, and special sessions with leadership while at the meeting'. The American Geosciences Institute has a long history of providing scholarships and mentoring through its Minority Participation Program (Callahan *et al.* 2001). The American Geophysical Union has developed the Ethics and Equity Center (https://ethicsandequitycenter.org/, accessed 1 March 2020), which provides extensive tools, resources and data to foster a positive work climate, has developed a Diversity, Equity and Inclusion Strategic Plan (American Geophysical Union n.d.), and has initiated its Bridge (https://www.agu.org/bridge-program, accessed 24 June 2020; McEntee 2019) programme to help geoscience departments recruit students from URMs to graduate programmes. The American Geosciences Institute has ratified a Disability Consensus Statement (https://www.americangeosciences.org/community/disability-consensus-statement, accessed 24 June 2020). The Geological Society of London has developed their Declaration on Diversity, Equality and Inclusion (https://www.geolsoc.org.uk/About/Diversity/Declaration-on-Diversity-Equality-and-Inclusion, accessed 24 June 2020), and the European Geophysical Union has established a working group on Equity, Diversity and Inclusion (https://www.egu.eu/outreach/diversity/, accessed 24 June 2020). The ADVANCEGeo Partnership (https://serc.carleton.edu/advancegeo/index.html, accessed 1 March 2020) provides training and resources on gender and related diversity issues. In the UK, the Equality Challenge Unit has created the Athena Swan Charter to support the cultural and systemic changes needed at the institutional level to make progress on equality and diversity and to encourage and recognize commitment to advancing the careers of women in STEM employment in higher education and research. In response to #BlackLivesMatter and #Shutdownscience movements, the Geochemical Society and European Association of Geochemistry convened a global virtual town hall discussion on

Black Lives Matter – Promoting Diversity, Equity, and Inclusion in Geochemistry (https://www.geochemsoc.org/news/2020/06/09/gs-eag-town-hall-discussion-black-lives-matter-promoting-div?fbclid=IwAR16hJT4b7v81A-fjxthUEHC1oEXrnGbwdc2UYzZHESadH7urRbgp63mKYk, accessed 24 June 2020), and numerous other professional societies have ratified position statements denouncing racism in the geosciences (AGU, GSA, NAGT among others). Independent organizations such as the Institute for Broadening Participation, Pathways to Science (https://www.pathwaystoscience.org/index.aspx, accessed 1 March 2020) and Understanding Interventions That Broaden Participation in Science Careers (http://understandinginterventions.org/, accessed 1 March 2020) programmes provide a plethora resources to support diversity initiatives.

The issues have been defined, the STEM community has been challenged, we know what needs to be done and how to do it.

… But we still have a lot of work to do (suggested remedies and interventions)

The geosciences need a discipline-wide commitment to work towards diversity and inclusion in the profession. Many creative strategies and methods have been designed, implemented and evaluated to address these issues in different settings and for different audiences. There is not a one-size-fits-all solution. The following are some disciplinary, institutional, instructional and personal approaches that can be tried, adopted or adapted for broad use by the geoscience community. Here are some areas where direct action can be taken immediately.

Towards equitable, inclusive, and safe professional practices

Sexual harassment and bullying

Zero tolerance. Period (Wood 2015). Marín-Spiotta *et al.* (2016) and St John *et al.* (2016) have addressed this issue head-on: there can be zero tolerance for this behaviour in any part of the geoscience community. The American Geophysical Union (2017) Scientific Integrity and Professional Ethics Policy specifically identifies all forms of harassment, bullying and discrimination as forms of scientific misconduct that are sanctionable with penalties varying from exclusion from participating in AGU events, serving in AGU leadership positions or standing for AGU awards to possible expulsion from the Union. Similarly, the Geological Society of America Code of Ethics and Professional Conduct (https://www.americangeosciences.org/community/agi-guidelines-ethical-professional-conduct, accessed 1 March 2020) promotes a culture of respect, fairness and inclusivity, and states explicitly 'We do not discriminate against, harass, sexually harass, bully, or engage in retaliation against others in our professional activities'. Violations will be referred to the GSA Ethics committee, and disciplinary actions may include censure, probation, suspension, revocation of honors and awards, or termination of membership. Alcohol consumption is often a contributing factor that contributes to uncivil behaviours, or that may be offensive to colleagues from some cultures, and the GSA Code of Ethics and Professional Conduct also addresses this topic: 'If we choose to drink alcohol or use other legal intoxicants in any professional settings, we will do so responsibly without compromising our ability to act professionally'.

Inclusivity at professional meetings

Haacker *et al.* (2020) have reported on why diversity and inclusion at conferences matter, and have identified numerous ways that many people are excluded from full participation at professional meetings. Lauer *et al.* (2020) provide guidelines to encourage participation by a diverse spectrum of attendees at scientific meetings. New parents may encounter difficulties in participating if day care facilities are not provided on site, or may have an added financial burden in finding extended care at home to be able to attend a meeting. Settles and O'Connor (2014) reported on incivility at academic conferences, and found that the relationship between incivility and sexist climate perceptions was stronger for women than men. Calisi (2018) addressed the childcare–conference conundrum, demonstrated the inequitable barriers for primary care givers (mostly women) to fully attending conference activities owing to lack of facilities and accommodation, and provided some practical recommendations for solutions. The International Association for Geoscience Diversity (IAGD; https://theiagd.org/, accessed 1 March 2020) has developed significant resources to create access and inclusion at face-to-face meetings for persons with disabilities in the geosciences. On the positive side, professional societies have established codes of conduct that strive to ensure that their meetings are welcoming, safe and inclusive (e.g. GSA Respectful Inclusive Scientific Events (RISE; https://community.geosociety.org/gsa2019/discover/rise, accessed 1 March 2020) and their related Events Code of Conduct (n.d.*a*) (https://www.geosociety.org/GSA/Events/EventConductCode/GSA/Events/Conduct-intro.aspx, accessed 1 March 2020), and the SAFE AGU programme; https://www.agu.org/Learn-About-AGU/About-AGU/Ethics/SafeAGU, accessed 1 March 2020). In the wake of the coronavirus pandemic, Viglione (2020) asks 'A year without conferences? How the

coronavirus pandemic could change research' and notes that there will be an inclusivity advantage to convening virtual conferences: 'Meeting spaces that are inaccessible to some disabled scientists, health considerations, a lack of access to childcare and travel restrictions can all end up alienating potential attendees from physical conferences'. The 2020 EGU conference has already been convened in a virtual format, and the Goldschmidt Conference (Geochemical Society), GSA Annual Meeting and AGU Fall meetings for 2020 are now all planned as virtual events. The lack of ability to engage face-to-face networking will be a loss, but there are many gains to be realized through greater access and inclusivity in these events.

Awards to women and people from underrepresented groups

Mukasa (2009) has identified the paucity of professional society awards given to women and colleagues from minority groups. He has made recommendations to identify and correct implicit bias in the nomination and review processes. Holmes *et al.* (2011) asked 'does Gender Bias Influence Awards Given by Societies?' and for the AGU found that of eight research medals (one awarded/year), zero were awarded to women from 1991 to 2000. From 2001 to 2010 eight were awarded, and that overall women received a disproportionate number of service and education awards compared with research awards.

Field work is good (except when it isn't)

To the extent that field work is a shared experience across the geosciences, we have to do a better job of making field experiences accessible and effective for all. Boyle *et al.* (2007) make a strong case that field work is good, and field work often provides the 'critical incident' that motivates students to continue in geoscience (Levine *et al.* 2007; Stokes *et al.* 2015). Mogk and Goodwin (2012) demonstrated that there are cognitive and affective gains that can only be made in the immersive field environment, and fieldwork is an important component of geoscientists training to enter the community of practice. Careful planning and execution of field experiences is essential (Mogk 2011), in part, to reduce 'novelty space' that influences students' ability to learn (e.g. preparing students to know where they are going, what the geological context is and what they are expected to do, and to assure students that their personal safety, comfort and needs will be met; Mogk 1997). Although field experiences are often cited as an important influence in attracting students to the geosciences, a poorly planned and executed field experience can have detrimental impacts, particularly for students from URMs or for those who have not had much exposure to outdoor experiences (e.g. Levine *et al.* 2007).

In addition, field work may provide a formidable barrier for students with varied sensory, cognitive and physical abilities. Giles *et al.* (2020) have identified numerous barriers to field work in undergraduate geoscience degrees: 'For too many students, fieldwork represents a barrier to studying geoscience at university. These barriers are especially felt by disabled students and those from racial and ethnic minorities, all of whom are critically underrepresented in the discipline … Those who didn't have access to hiking and camping trips growing up, many items that seasoned field geoscientists take for granted, such as sturdy boots, good waterproofs, and a reliable backpack, must be purchased. Students often go to the field unprepared and are unlikely to enjoy the experience – having cold and wet feet for a week can understandably erode the desire to learn. Unanswered questions about how to go to the toilet or deal with a period have a range of serious consequences, from dehydration to infections … The cost of fieldtrips themselves can present further roadblocks. Fieldwork can raise a host of accessibility issues, which need to be acknowledged and addressed. The intense nature of many undergraduate fieldtrips – involving 8–10 hours in the field each day with the potential of additional evening work – places a huge burden on both staff and students. Residential fieldtrips can conflict with work or caring responsibilities, and the long hours present both real and perceived barriers to people with physical and mental health issues. The high levels of physical activity often required, be it hiking over rough ground or scrambling up steep slopes, can render trips off-putting or completely inaccessible to some. The needs of those who must schedule prayer breaks, or are fasting, as well as those who cannot travel to certain countries due to laws surrounding sexuality or gender identity, must be taken into account. Harassment and inappropriate behaviour during fieldwork, affecting both staff and students, also deserve careful attention'. Gilley *et al.* (2015), Hendricks *et al.* (2017) and Stokes *et al.* (2019) have provided practical advice about the design and implementation of field trips that are accessible by all, and report that 'multisensory engagement, consideration for pace and timing, flexibility of access and delivery, and a focus on shared tasks are essential to effective pedagogic design'.

Geoscience education for everyone

'Academic institutions should be held accountable for creating, sustaining, and institutionalizing a culture of success in STEM for all students, with a

special emphasis on those from underrepresented backgrounds' (J. Matsui, keynote address to 2015 Earth Educators' Rendezvous). This will require both curricular and co-curricular interventions (Estrada 2014).

Instructional practice

Two seminal books in the 1990s clearly identified endemic issues that discouraged students from pursuing careers in the STEM disciplines. Tobias (1990*a*, *b*), in *They're Not Dumb, They're Different*, found that the physical sciences are content-centric with little regard for actual student learning, students have few opportunities to apply their personal strengths and interests and little opportunity to use the skills they learn elsewhere to help make sense of material presented in classes. Seymour and Hewitt (1997), in *Talking about Leaving: Why Undergraduates Leave the Science*, reported on factors that drive students away from STEM disciplines. It is not because the subject matter is perceived as being difficult. Rather, students reported a hostile, unwelcoming and uncaring learning environment in STEM classes. They reported that inadequate advising, counselling and tutoring were responsible for about one-quarter of all student decisions to switch out of STEM. These barriers are compounded for students from URMs. Barriers and opportunities for 2- and 4-year STEM degrees, and the need for systemic change to support students' diverse pathways has been prepared as a consensus report by NASEM (2016). This is particularly important because *c.* 50% of STEM student credit hours are taught in 2-year colleges. We ignore the importance of geoscience education at 2-year colleges for recruiting students, and particularly URM students, at our own peril (see resources at Supporting and Advancing Geoscience Education at 2-year Colleges, SAGE 2YC; https://serc.carleton.edu/sage2yc/index.html, accessed 1 March 2020).

Specific to the geosciences, Wolfe and Riggs (2018) have provided a holistic assessment of what is needed: 'These include peer support and faculty mentoring networks, institutional bridge programmes, systemic pedagogy reforms, and purposeful work to improve campus climate, culture, and accountability for diversity'. Huntoon and Lane (2007) identified four strategies that consistently appear to be effective in increasing diversity: (1) demonstrating the relevance of the field and opportunities for high-paying careers in it; (2) developing partnerships among multiple stakeholders to reduce 'leaks' from the educational pipeline; (3) promoting strong mentoring relationships among students and geoscience professionals, including opportunities for students to conduct research prior to graduate school; and (4) providing financial assistance when necessary. Baber *et al.* (2010) have reported on 'programmatic components that foster self-efficacy [i.e. confidence in one's ability to become a geoscientist], contributing to students' continued interest in careers in geosciences'. They found that collaborative learning opportunities, including direct participation in research projects, can increase diversity in the geosciences. Interactions with professors are another valuable component, and although there may not be faculty from URMs, it is important that demonstration of faculty commitment to diversity is just as important as visual representation of diversity. This study reveals how important social persuasion is for students from URMs, and support from family members and friends should be cultivated. Students from this study also valued the opportunity to meet with students from both similar and different backgrounds as they formed friendships around commonalities of their experiences. Huntoon *et al.* (2015) have further emphasized the importance of increasing students' 'sense of belonging', addressing stereotype threat and imposter syndrome, and the role of networks of friends and mentors to support the success of students from URMs.

Selection of a geoscience major

Sherman-Morris and McNeal (2016) studied student perceptions about the geosciences, and identified three major factors that influenced students' decision to choose a geoscience major: (1) important influencers (parents, guidance counselors, teachers, and department); (2) sustained identification with or interest in that major (strong interest before coming to university, knowing the subject they wanted to major in since they were young, and knowing someone in that field); and (3) descriptors of the major itself (ability to find a job and being prestigious). They also found that a student's advisor may be one of the greatest factors in which science classes an undergraduate student takes at a university. Levine *et al.* (2007) and Stokes *et al.* (2015) report on 'critical incidents' that created positive experiences for students, such as personal contacts with faculty, events in introductory courses, support from family members and outstanding field experiences. Hoisch and Bowie (2010) suggest that sharing information on employment opportunities, job security and starting salaries in geoscience fields should help to convince families that geoscience is a worthwhile degree. There may be a perception by students from URMs that the geosciences do not have the status of professions on par with business, law, medicine or engineering. Specific career counselling can use resources such as the American Geoscience Institute's Workforce Program: Career Resources for All Geoscientists, and particularly their new Career Compass resources (https://www.american

geosciences.org/citations/agi-workforce-program-career-resources-all-geoscientists, accessed 1 March 2020). It is commonly stated (in the USA) that the master's degree is the preferred level of professional training for most jobs in the geosciences. This also presents a major motivational barrier for many students from URMs, particularly first-generation college students, who already perceive that earning a baccalaureate degree is a huge life challenge. It is important to recognize and convey to students that there are many good technical jobs that only require an Associate's degree (2-year) or skill certification (e.g. GIS), and a geoscience bachelor's degree (4-year BSc or BA) is a great springboard to careers in related disciplines such as public policy, planning, education, business and environmental law.

Acceptance to graduate programmes

One example of an institutional barrier to diversity in the geosciences is reliance on the Graduate Record Exam (GRE) for acceptance to graduate programmes. The GRE has been demonstrated to be biased against women compared with men, and against people of colour compared with white or Asian people (Miller *et al.* 2019; Ledford *et al.* 2020). The cost of taking the GRE, and lack of access to preparatory testing programmes, may present initial barriers for students with a low socioeconomic status. The GRE is an invalid instrument in predicting the success of a candidate in a graduate programme because it does not assess the candidate's ability to formulate research questions, conduct research and synthesize results (Petersen *et al.* 2018). Miller and Stassun (2014) recommend that selection of applicants on the basis of skills and character attributes is a more predictive indicator of success in scientific research and of ultimate employability in the STEM workforce. This can be done through alternative assessments such as letters of recommendation, interviews that explore research experiences, leadership experience, service to community and life goals (although there is a caution that letters of recommendation and interviews may also be problematic owing to implicit biases).

Keep it local, make it relevant

Apple *et al.* (2014) have emphasized the effectiveness of teaching geoscience in the context of culture and place, realizing the importance of human experience, attachment and personal meaning that we affix individually and collectively to the places we inhabit. Geoscience can effectively engage students from URMs and their communities by integrating Indigenous knowledge and cultural relevance through place-based instructional methods (Riggs and Marsh 1998; Riggs and Semken 2001, 2003; Redsteer *et al.* 2004; Riggs 2005; Semken 2005; Riggs *et al.* 2007; Unsworth *et al.* 2012; Ward *et al.* 2014). Johnson *et al.* (2014) developed educational resources on the Flathead Indian Reservation 'through collaborations with local school communities, tribal elders, and cultural experts who approved the materials for general distribution'. Hammersley *et al.* (2012) developed an introductory course on the geology of Mexico specifically to increase the number of Hispanic students and Tewksbury (1995) developed a course on the geology of Africa to attract URM students in participating in the geosciences. Birnbaum (2004) utilized a field-based inquiry approach in an urban setting to engage students and instill more positive student attitudes. This study provided these instructional principles: (1) establish and support a class climate that fosters belonging for all students; (2) set explicit student expectations; (3) select course content that recognizes diversity and acknowledges barriers to inclusion; (4) design all course elements for accessibility; and (5) reflect on one's beliefs about teaching to maximize self-awareness and commitment to inclusion. DeFelice *et al.* (2014) 'used a place-based pedagogical approach to engage in real geoscience problem-based inquiry in a local urban park' and analysed journal reflections that 'showed that students' science identities were enhanced and student interest in learning science outdoors increased through participation in the program'.

The geoscience education community can engage with students from URMs and Indigenous communities by intentionally integrating topics of cultural relevance into coursework at all levels. Consider emphasizing course work that engages issues of sustainability (e.g. the InTeGrate Program for Interdisciplinary Teaching About Earth for a Sustainable Future; https://serc.carleton.edu/integrate/index.html, accessed 1 March 2020), and environmental, generational and distributional justice (see below). Engagement with diverse cultures must be done with respect for cultural standards and norms as Skandari (2015) cautioned in 'What Foreign Rescue Teams Should Do and Must Not Do in Muslim Countries'. In working with diverse communities, respect local knowledge and expertise (e.g. Johnson *et al.* 2014) and make sure that communications with these communities are open and transparent, and that motivations, expected outcomes and possible impacts are clearly articulated.

Recruiting and supporting URM students

Puritty *et al.* (2017) emphasized the importance of inclusivity in diversity initiatives. Inclusivity addresses how URM students are treated and how

they feel within their discipline. 'Simply admitting an URM student is not enough if that student feels unwelcome, unheard, and unvalued'. Karsten (2019) provides an overview of the components of effective recruitment of students from URMs: 'Integrating geoscience content with meaningful cultural context and relevance, authentic research experiences, cohort-based mentoring, direct financial support, and minority–majority institution collaborations have been found to be some of the most fruitful approaches for engaging, recruiting, and retaining minorities in geoscience pathways'. These are topics that can be addressed throughout the geoscience curriculum.

However, there are also external factors that influence recruitment to the geosciences. A primary issue that must be realized is that there are inherent structural inequalities in which minorities are not provided with the same resources or opportunities for a quality education as whites, and in part, these inequalities derive from the observation that 'institutions treat different groups of people unequally, making success less attainable for some groups than for others' (Lopez *et al.* 1998). This means that instructors/mentors must be aware of potential structural biases and seek ways to remediate in their own instructional settings. Further, there must be a recognition that students must be met where they are on their learning pathways (through no fault of their own), and rather than respond to students' needs in terms of remediation, opportunities should be provided that inspire confidence and support success. Starks and Matthaeus (2018) present evidence that 'a crucial factor in recruitment and retention is students' perception of their own suitability and eligibility, and that STEM faculty members, regardless of their ethnic background, are the messengers of this eligibility'. Stokes *et al.* (2015) have identified important factors that inform career decision-making by students from URMs, noting that 'positive experiences in introductory courses, supportive family members, personal characteristics that meshed with geoscience, and outstanding field experiences were the most commonly reported factors influencing the choice of a geoscience major'. Hurtado *et al.* (2010) report that 'Students continue to face "solo status" (where they are one of few racial minorities in the classes or majors) or presumptions of underpreparedness, despite their significant achievements', and consequently, educators should 'tailor their practices by being mindful of each (student's) unique needs, context, and attributes'. Students from URMs must develop the confidence that they can succeed (self-efficacy), and must develop a strong sense of belonging to the disciplinary community. Do not forget about the importance of a 'critical experience', a single act of kindness, interest or caring, that can be a life-changing event in the life of a student looking for a professional home (e.g. Levine *et al.* 2007; Stokes *et al.* 2015).

Tsui (2007) has provided a comprehensive list of intervention strategies that can be undertaken to expand diversity in the STEM disciplines:

- Develop explicit student recruitment procedures from high schools and 2 year colleges, including assistance with admission procedures, matriculation (e.g. procuring financial aid and orientation services, and providing linkages to student minority organizations).
- Summer bridge programmes 'or transitional programs for low-income students have become an established part of the effort to recruit, retain, and graduate students from URMs in higher education'.
- Provide mentoring ('each student needs at least one person to serve as a mentor, someone who has faith in them and will provide necessary information or support at key junctures involving choice;' Ginorio and Grignon 2000).
- Research experiences, 'engaging in hands- on research, whether within an academic setting or off-campus in a position with industry, are effective strategies in increasing the number who pursue degrees and careers in STEM fields'.
- Tutoring is 'widely used today as an intervention measure to enhance student performance and persistence'.
- Provide career counselling and awareness – 'there is a strong connection between career development and student background, particularly with regard to socioeconomic status … personal contact with a scientist was identified as the major factor affecting students' science-related career decisions' (Hill *et al.* 1990);
- Establish a learning centre ('A growing number of campuses have seen the contributions that a learning centre or drop-in centre can make toward student achievement').
- Hold workshops and seminars ('Academic enhancement activities designed to impart knowledge and refine skills that are instrumental to college success have become prevalent on many campuses … A large proportion of minority students, including some with strong pre- collegiate educational records, struggle once in college in part because of feelings of isolation, and poor awareness of school policy, procedures, and support programs').
- Academic advising is important ('Quality academic advising has been described as the "cornerstone" of student retention, and is a common strategy used in intervention programs that strive to reduce student attrition. Research suggested that quality academic advising positively impacts student retention as well as satisfaction with the institution').

- Provide financial support ('Minority intervention programs tend to recognize the importance of providing financial support to students'; e.g. Callahan *et al*. 2001).
- Undertake curriculum and instructional reform ('While some may perceive the deficit in STEM majors as the natural outcome of a "weeding out" process of those who are incapable of handling a highly quantitative curriculum, more are coming to recognize that the heavy flow of talented students from these fields signals a systemic problem in STEM undergraduate education in this country').

Mentoring

Successful mentoring of students requires more than advising (e.g. making sure that degree requirements are filled); it requires active advocacy and sincere interest in the well-being of students. Mentoring is a commitment in big and small ways. You can make a difference by being involved in a student's life during office hours, in the hallway, at work in the laboratory, via e-mail, in coffee shops, in the field, and at conferences. NASEM (2019*a*) has recently presented a comprehensive review of 'The Science of Effective Mentorship in STEMM' that identifies these important mentoring roles: role modelling, psychological and emotional support, career guidance, skill development and sponsorship and advocacy. An example of a successful mentoring programme that can be used as an institutional model is the Minority Students Pursuing Higher Degrees of Success in the Earth System Science Pilot Project (Pyrtle and Williamson Whitney 2008) that provides evidence that 'virtual and face-to-face mentoring, on-site professional development and community-building activities resulted in increased participant exposure to and engagement in the Earth system science professional community and served to better equip student participants to make informed post-baccalaureate academic and professional career decisions'. Another model programme, Fisk–Vanderbilt Master's to PhD Bridge Program (Stassun *et al.* 2011; Stassun 2013), recommends that programmes should emphasize the development of networks of support across the country, provide access to mentoring programmes and clearly identify and explain academic expectations for students who are not familiar with academic culture ('making the implicit explicit'). Role models and mentors who share racial/ethnic identities are particularly important in promoting diversity, as this influence can contribute to an individual's self-concept of pursuing similar careers – thus the need to redouble efforts to recruit a diverse faculty (see below). Mentoring365 (https://mentoring365.chronus.com/p/p1/about, accessed 1 March 2020) is a new initiative of five geoscience professional societies that provides virtual mentoring services such as 'structured, relationship-building tools to develop and accomplish focused career goals' (Davidson 2018).

Internships and REU Experiences for Students from Underrepresented Groups

Charlevoix and Morris (2014) have described an internship programme, Research Experiences in Solid Earth Science for Students sponsored by UNAVCO, that explicitly addresses the needs of students from URMs through focused mentoring (including continuing mentoring throughout the academic year), social support systems and additional financial support. Russell *et al.* (2007) have described the numerous benefits of undergraduate research experiences that can be directed specifically to recruit students from URMs (e.g. Pandya *et al.* 2007; Blake *et al.* 2013; Johnson and Okoro 2016). The importance of engaging authentic research in the first 2 years of the college experience has been reported by Locks and Gregerman (2008) describing the Undergraduate Research Opportunity Program (UROP) at the University of Michigan, which creates research partnerships between students (first year, second year and transfer) and faculty. In 2010–11, 1300 students participated in UROP, working with over 800 research mentors. The importance of research in the first 2 years of undergraduate education is a major recommendation of the PCAST (2012) *Engage to Excel* report.

Build partnerships and bridging programs with minority-serving institutions, 2 year colleges and 'feeder' school systems

McDaris *et al.* (2017) have compiled a survey of minority-serving institutions in the USA, and identified these institutions as a rich resource for building a diverse geoscience workforce. Only about 30% of these institutions have Earth-related degree programmes (identified as Geo-, Earth or Environmental Science), but many students do indeed have the opportunity to take geoscience coursework in a variety of interdisciplinary programmes. Minority-serving institutions are a rich resource to develop collaborations and to recruit URM students to graduate degree programmes. The US National Academy of Sciences has recognized minority serving institutions as America's underutilized resource for strengthening the STEM workforce (NASEM 2019*b*). Robinson *et al.* (2007) reported on partnership programmes instituted by the US National Oceanic and Atmospheric Administration (NOAA) and minority-serving institutions and recommend a number of 'best practices' such as collaborative planning

and programme design, alignment and integration with NOAA workforce goals, securing adequate funding and sustained investment, collaborations with NOAA scientists, provision of dedicated direct student support, monitoring of student progress and development of performance measures and metrics. Gilligan *et al.* (2007) described a partnership between Historically Black Colleges and Universities and marine research stations in which a bridge programme was used to attract students at earlier stages of professional development (particularly targeting underclassmen), who had little prior research experience. Pre-screening procedures identified individuals from URMs at a 'critical time' in their academic careers, when they were choosing a major and needed exposure to non-traditional professional/academic areas of interest. Pride and Olsen (2007) used the strategy at an HBCU to increase the number of African Americans teaching in informal educational centres and increase the number of trained geoscientists teaching in the schools to build the geoscience pipeline. Palmer *et al.* (2009) emphasized sense of place and Indigenous knowledge in their Earth Systems of the Southern Great Plains course. Adetunji *et al.* (2012) reported on a partnership between the Ohio State University and Columbus State Community College in the Geosciences Awareness Program (Project GAP) that emphasized the relevance of geosciences to society and the salary outlook for geoscientists, and provided examples of distinguished minority geoscientists. Dalbotten *et al.* (2014) described the Manoomin Science Camp Project as a model for engaging American Indian students in STEM, built on a trust- and relationship-building model that uses a holistic approach to learning that emphasizes the whole student. Carrick *et al.* (2016) described a 10 year running geosciences summer high school programme targeted to Hispanic students in the El Paso, Texas area. Hanks *et al.* (2007*a*, *b*) described a residential high school-to-college bridge programme for Alaska Native students to increase the visibility of geology as a desirable career option. Riggs *et al.* (2007) described the Sharing the Land Project in which universities provided on-reservation education to environmental managers, a residential summer college bridge programme and an internship programme in tribal environmental offices for Native high school and college students. They reported that 'Involvement of Native educators and elders is also critical to ensure cultural connection and continuity'. Mannel *et al.* (2007) demonstrated the use of GIS training at the Oglala Lakota (Tribal) College, Pine Ridge Reservation, South Dakota USA, to recruit Native American students and to employ GIS for the benefit of the community. Ward *et al.* (2014) demonstrated the utility of place-based, culturally informed geoscience assessments in working with students on the Blackfeet and Diné (Navajo) nations. Stokes *et al.* (2007) described a number of proactive outreach activities in an urban setting which include partnerships with libraries, science museum and public schools (Grades 9–12) by providing field experiences and geoscience career promotion. Houser *et al.* (2018) developed the Pathways to the Geosciences programme between a major research institution (Texas A&M University) and 2-year colleges by providing transfer advice (and for students transferring from other degree programmes at Texas A&M University), inter-institutional articulation agreements, personal academic milestones and guided pathway advice for each student that were developed in consultation with faculty academic advisors.

Creating a departmental/corporate 'climate' where everyone can succeed

There is a lot that can be done on the departmental/corporate level that can develop a workplace climate that is welcoming, safe, inclusive and supportive. Climate refers to the atmosphere or ambience of an organization as perceived by its members. An organization's climate is reflected in its structures, policies and practices; the demographics of its membership; the attitudes and values of its members and leaders; and the quality of personal interactions. How do you want your department/company to be viewed by students (prospective and enrolled), the administration, professional peers, clients, alumni and the community? Eight common concerns about departmental civility include (University of Wisconsin, n.d.):

- lack of respect, consideration and/or politeness;
- insufficient sense of community or belonging;
- lack of recognition, visibility and/or value;
- ineffective communication;
- lack of support or inequitable access to professional development opportunities;
- difficulties achieving balance between work and family or personal life;
- illegal behaviours and demeaning, sexualizing, hostile, condescending language and behaviours; and,
- issues related to retention and/or tenure of women and minority faculty, staff and students.

Consider the following actions – are these in practice, planned or a possibility in your work situation?

- Develop a departmental or institutional mission, vision and values statement that explicitly identifies diversity and inclusiveness as a collective goal.
- Insist on civility in all departmental functions. Incivility takes a toll. Cortina *et al.* (2001) report: 'This study extends the literature on interpersonal

mistreatment in the workplace by examining the incidence, targets, instigators, and impacts of incivility (e.g. disrespect, condescension, degradation) … negative effects on job satisfaction, job withdrawal, and career salience. Uncivil workplace experiences were also associated with greater psychological distress'.

- Explicitly make diversity a departmental/corporate goal.
- Make sure that your programme webpage, pictures on hallways and in class/meeting rooms, and all promotional literature exhibits diversity in the people represented. Sexton *et al.* (2014) did an analysis of geoscience department websites and found that posted images overwhelmingly were in outdoor settings. Most of the people in the photos were men, women were more likely to be students than instructors or geoscientists, and most of the people in the photos were white. They suggest that 'Thoughtful and deliberate design of the websites is needed to ensure that the websites offer a welcoming image to a diversity of people'.
- Commit to hire a diverse faculty/staff. The goal of attaining a diverse faculty that is representative of our students (and of society) has yet to be achieved in the geosciences, despite gains made in the recruiting and training of qualified women and students from URMs (Mogk 2014). To increase the chances of making a diverse faculty hire, make sure you have a diverse search committee and insist that they receive implicit bias training, use inclusive language in the job announcement and do not make the qualifications too restrictive, advertise broadly to reach qualified candidates from a variety of institutions, prepare ahead of time and cultivate relations with prospective candidates, and avoid bias in review of applications, letters of support and in the interview process. Dutt (2019) recommends making the recruitment and selection processes transparent and actively engaging minority students.
- Continue to support new and diverse faculty hires, and ensure their success. Workshops have been convened to support the academic development of faculty from URMs (Houlton *et al.* 2012), and since 2002 the On the Cutting Edge (n.d.) programme has offered their Early Career Geoscience Faculty: Teaching Research, and Managing Your Career Workshops to support faculty professional development, learn effective teaching skills, jump-start research programmes, address work–life balance questions and prepare for success in promotion/tenure reviews (Hill *et al.* 2015). Gewin (2020) reports on what Black scientists want from colleagues and their institutions, and this includes encouraging white colleagues to use their power to change the system, create opportunities to have difficult conversations, commit to bold hiring targets, consider 'cluster hiring', create a welcoming environment and make hiring for leadership posts more transparent.
- Avoid bias in conducting reviews, interviews (job applications, journal articles, grant proposals; e.g. Steinpreis *et al.* 1999) and in writing reviews and letters of recommendation (Dutt *et al.* 2016).
- Be equitable in assigning work responsibilities. Women can be assigned an inordinate amount of departmental service work, which can be a major barrier to career advancement (Misra *et al.* 2011).
- Conduct a departmental 'climate survey' for faculty, staff, students. The Survey of Organizational Research Climate (SOURCE) developed by National Center for Professional and Research Ethics (https://ethicscenter.csl.illinois.edu/source/, accessed 1 March 2020) is a good example. There may be some surprising revelations that need to be acted upon.
- Organize departmental speaker series to demonstrate a commitment to diversity, equity and inclusion. Graduate students at the University of Massachusetts Amherst redesigned their departmental seminar series with a goal of inviting at least 50% of the roughly 20 speakers to be women (up from an average of 40% over the previous 4 years) and more than one speaker to be a person of colour, and providing speaking opportunities for early career faculty, post-docs and graduate students to gain professional experience and to build resumes. In addition to traditional research topics, some invited presentations are focused on examples of how research impacts communities, and other special sessions are focused on student success to connect underrepresented postdocs and graduate students from different disciplines with successful scientists (Keisling *et al.* 2020).
- Schedule departmental functions to accommodate diverse needs of workers (e.g. avoid late afternoon meetings when parents have to pick up children from day care).
- Ethical leadership starts from the top. Make sure that administrators and senior faculty/workers set a good example at all times. Diniega *et al.* (2016) affirm that senior scientists must engage in the fight against harassment and provide nine steps that can be taken to change the scientific culture.
- *Be proactive*: put policies and procedures in place *now* to address issues that will impact departmental climate, and the ability to attract and support people from URMs! This is necessary to prevent bad behaviours from arising in the first place, and it provides the authority to mitigate or adjudicate (with consequences) issues should they emerge.

As geoscience educators:

- Commit to using the most effective, evidence-based instructional methods. This makes learning accessible for all students (e.g. Handelsman *et al.* 2007). And it turns out, instructional practices used to engage and support students from URMs are effective to promote learning by *all* students. Work to incorporate universal design learning practices to remove physical and non-physical barriers to provide access for students with physical and sensory disabilities (Carabajal *et al.* 2017).
- Diversity and inclusion – put it in the syllabus. Make an explicit statement that this course welcomes all students, and that all identities and perspectives will be respected (Linden and Wright 2017). Consider incorporating critical thinking activities that reflect on personal and communal values (Yacobucci 2013), and explicitly ask students to reflect on the values of diversity, inclusiveness, fairness and justice.
- Create an inclusive classroom (Armstrong 2011). Design and implement a variety of teaching activities that emphasize different skills and strategies. Make sure that everyone has an opportunity to participate. Respect diverse experiences and perspectives. Incorporate examples and case studies that will resonate with diverse student audiences. Avoid a 'winner take all' approach to your instruction (Mogk 2009).
- Chaudhary and Berhe (2020) offer advice on 10 simple rules for building an anti-racist laboratory. These include open discussion about racism in the laboratory environment, support writing papers and proposals with people from URMs, intentional implementation of equitable and inclusive policies, the setting of norms for acceptable workplace conduct and provision of opportunities for mentorship and networking.
- Consider abandoning use of the GRE in selection procedures for graduate programmes (Ledford *et al.* 2020), and employ alternative assessments of candidates that take a more holistic view of candidates' personal attributes, experiences and potential (Grabowski 2018; Bastedo *et al.* 2018).
- Intentionally recruit students from URMs to your graduate programme. Establish connections with 'feeder' institutions that have a high population of students from URMs, and establish personal networks to help students prepare for applications to your graduate programme. Consider joining the AGU Bridge Program (McEntee 2019) that is designed to partner with academic institutions across the country (USA) to recruit and retain unrepresented students, and provides departments with resources on inclusive practices for holistic admissions policies, and recruiting, admitting, retaining underrepresented students in geosciences graduate programmes.

Personal actions we can take as professional geoscientists: we can make a difference

- Make a personal commitment to support diversity efforts. Engage outreach activities at all educational levels and institution types to recruit students from URMs to the geosciences (e.g. K–12, 2-year college, minority-serving institutions). Provide career advice in formal class presentations and other informal meetings. Offer to serve as a mentor for students seeking research experiences, and for early career colleagues just starting their professional careers.
- Listen. Do not presume to make decisions for people from underrepresented groups. Ask. How can we best provide support (from our positions of privilege and power for those of us successfully established in the geoscience professions)? Good intentions can sometimes do more harm than good. Look for ways to engage and empower people from underrepresented groups, and work with them in collaboration, true partnership, and out of mutual respect.
- Be informed, but more importantly, commit to act. In response to the global civic disturbances of spring 2020 precipitated by police violence against Black people, the disproportionate health and mortality impacts of the COVID-19 pandemic on people of colour, and the social, economic and health inequities that have been exposed owing to institutionalized racism, an international day of reflection on this situation was promoted to review systemic racism in the STEM disciplines by the ShutDownSTEM (https://www.shutdownstem.com/about, accessed 24 June 2020) movement. Their website extols: 'It is not enough to say that you stand in solidarity. We need you to be accountable. We need your actions'. Rich resources are provided on their website to promote education, action, and healing. Become an ally and develop the communication skills to effectively confront racism as it arises (White Ally Toolkit, https://www.whiteallytoolkit.com/, accessed 24 June 2020). An editorial in *Nature* (2020) makes this affirmation: 'Systemic racism: science must listen, learn and change', and the American Association for the Advancement of Science (2020) (among other professional organizations) has acknowledged and supports the ShutDownSTEM movement. Notimefor Silence.org (2020) has issued A Call to Action for an Anti-Racist Science community from Geoscientists of Color: Listen, Act, Lead with specific action items identified for scientific professional societies, the National Science Foundation, community

and federally funded science centres, federal agencies and academic departments. 'It's not enough to be non-racist. Be anti-racist' (quote attributed to Black activist Angela Davis).

- Commit to daily, random acts of micro-inclusion (the antithesis of microaggressions). Biddle (2017) defines micro-inclusion as 'any small behaviour, gesture, or conversation that invites, takes in, or embraces a person or group of people into another group as part of the whole'. McDowell (2016) expands on this and says 'An antidote to microaggressions are micro-inclusions. These are little symbolic actions that force us to recall our humanity. They are acts of humanity that signal to those at the margins they are included'. So, set another place at the table. Go out of your way to invite diverse people to meetings and events. Get to know someone new, ask about their interests, address their needs. Express a genuine interest, show that you care. Invite participation, give credit for new ideas.
- We can do more. We can be better.
- In short: be excellent to each other (Bill 1989)!

Social virtues, diversity and the geosciences

Issues of diversity in the geosciences can be further explored by returning to the virtues introduced earlier in this text: power, trust, respect, responsibility and justice provide important contexts. Will the geosciences be recognized as a virtuous profession to the diverse people of the world?

- Let us start with reflections of *power* used or abused. The basis of social power is interesting because power can be realized based on the ability to reward or coerce, assigned through organizational authority, bestowed through association with others in power, acquired through mastery of expert skills or knowledge, or amassed owing to the ability to control access and use of information (French *et al.* 1959). In any social structure there will necessarily be power asymmetries and hierarchies. Power may be used 'over' people to control or denigrate, or it may be used 'with' people to enable and empower (Lammers 2005). So, it is fair to ask in the geosciences, who has power to define professional standards and norms, and by what authority? It is important to be aware of the power structures in your work environment, and ensure that power is fairly and equitably distributed to provide access and opportunity for all. Further, a review of the history of the geosciences (and science in general, Ahmad 2020; *Nature* 2020) will reveal that much of contemporary geological thought is built on a power base that is predominantly 'Western', white and male. 500 Women Scientists Leadership (2020) have gone so far as to call out science's legacy of racism as a wider culture shaped by white privilege and supremacy. This has important implications for diversity initiatives in the geosciences. People from URMs typically find themselves outside the extant power structures, and are forced to assimilate into this dominant culture (Mattheis *et al.* 2019), rather than expanding the scientific culture to accommodate and respect the new and diverse experiences, skills and knowledge that people from URMs bring to the discipline. To address this asymmetry of power (as knowledge is power), numerous programmes have been designed to incorporate Indigenous ways of knowing to recruit Native American students and to demonstrate opportunities for engagement with other cultural groups (e.g. Riggs and Marsh 1998; Riggs 2005; Palmer *et al.* 2009; Unsworth *et al.* 2012; Johnson *et al.* 2014; Reano and Ridgway 2015).
- *Trust* is the foundation of all science (National Academy of Sciences 2009) and society must trust that scientific research results are an honest reflection of a researcher's work. A corollary is that it is important to develop relationships based on trust within social hierarchies and among peers in work environments. This facilitates cooperative social interactions, engages people in the community and encourages participation from those outside, serves the community to work for a common greater good, and instills confidence and goodwill (Resnik 2011). Trust is essential for success of diversity programmes in the geosciences, as we know that success is predicated on the quality of interpersonal relations that create a sense of belonging. Further, the geosciences must establish trust with the diverse cultures and countries of the world. As the work of geoscientists spans the globe, individual workers must develop cultural literacy and sensitivity for the people in communities that are impacted by this work. Cultural literacy and the ability to engage in cultural interactions were identified as high-priority professional skills in the Geoscience Employers Workshop report of the Future of Undergraduate Geoscience Program (http://www.jsg.utexas.edu/events/future-of-geoscienceundergraduateeducation/, accessed 24 June 2020). Examples of breach of trust with communities and countries with vulnerable populations as a result of the work of geosciences are legion (e.g. exploitation of extractive energy and mineral resources, appropriation or contamination of water resources; environmental impacts, e.g. 'cancer alley' related to petrochemical development in the lower Mississippi River basin, toxic dumping of hazardous waste products in developing countries). Development of resources is necessary to

support the material needs of society, but it is incumbent on the geosciences to develop trusting relations with diverse communities to ensure that development is done in a responsible and sustainable manner without detrimental consequences.

- Geoscientists must be *respectful* of the diverse attributes, abilities and contributions that diverse people can make within the profession. This is true on an interpersonal level, and speaks to the ability of people from URMs to equitably contribute to collaborative work. And this is true on a global level too, as geoscientists must also be respectful of the cultural norms of the different societies in which they work. However, geoscientists must also be prepared to deal with discriminatory and bigoted practices that may be engrained in cultures across the world (e.g. denied access to education for women; criminal prosecution for sexual identity). Many of the geoscience professional societies have a large international membership, and their various codes of ethics, values and conduct set high standards regarding discrimination and subjugation of people because of their social status. In this, geoscientists can lead by example, and advocate for equitable and fair treatment for all people.
- Geoscientists must also accept personal and professional *responsibility* for increasing diversity in the geosciences. This includes responsibility for (1) developing personal values, attitudes and behaviours that positively impact other people, (2) creating a welcoming, safe and supportive work environment, which includes professional interactions among and between geoscientists, students, clients and end-users (Mogk 2018), (3) supporting the long-term growth and health of the geoscience profession that can only be sustained by being inclusive of diverse people and (4) increasing knowledge of Earth in service to society and for the benefit of humanity. Garibay (2015) addressed the contours of civic responsibility: 'STEM education should help develop students' understanding of social issues, their transformative potential to rectify structural inequities, and other outcomes important for a more democratic society (i.e. social responsibility, civic engagement, equity-orientation) in order to broaden and improve the impact of science and technology (S&T) on equity and the human good'. This study demonstrated that students from URMs had a greater desire to work for social change. Students from URMs commonly have a higher degree of altruism, motivation to develop the skills to expand their social and cultural agency and desire to serve and improve their communities (Seymour and Hewitt 1997). In the American Association for the Advancement of Science survey of STEM professionals, Wyndham *et al.* (2015) identified areas of social responsibility for scientists in general, and these also resonate with strategies to demonstrate the importance and relevance of the geosciences to diverse communities:
  - address tomorrow's needs and aspirations;
  - maintain global sustainability;
  - improve human health;
  - address economic disparities;
  - understand our place in the universe;
  - promote peace and security; and
  - direct the products of technology toward the betterment of society, nationally and worldwide.

These social responsibilities of scientists speak directly to the responsibility of the geosciences to address diversity issues for the long-term health, security and economic well-being of all people.

- *Justice*: treat people fairly (Fox and DeMarco 1990). López and Cesspooch (2019) were among the first to call for diversity initiatives to be built on the principles of justice and accountability. The work of geoscientists should be informed by a sense of justice and fairness as measured by the impacts on diverse people. This is manifest in three relevant aspects of justice: environmental justice (e.g. Mohai *et al.* 2009), generational justice (Tremmel 2006; Habib 2013) and distributional justice. The United States Environmental Protection Agency (n.d.) defines environmental justice as: 'the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys: the same degree of protection from environmental and health hazards, and equal access to the decision-making process to have a healthy environment in which to live, learn, and work'. To work for environmental justice, geoscientists cannot presume to impose answers or solutions on the people we aspire to help. We must treat diverse people with respect and as true collaborators within the geoscience profession, and engage people in their communities to understand needs and concerns in decision-making processes. Generational justice involves the wise use and stewardship of limited or non-renewable resources, and an awareness that human activities that are undertaken today that modify Earth systems have the potential to have impacts for generations to come. These concerns are particularly acute as the planet enters the Anthropocene (Steffen *et al.* 2007; Zalasiewicz *et al.* 2008; Tewksbury *et al.* 2013). Distributional justice addresses the equitable access to the legacy

of Earth resources among those people living today, recognizing that the distribution of resources has a large impact on the economies of countries and quality of life of people (e.g. mineral resources; Kesler *et al.* 2015). Distributional justice is also concerned with the disproportionate impacts of environmental issues such as energy (Jenkins *et al.* 2017) and climate change (e.g. Okereke 2010; Okereke and Charlesworth 2014), and takes into account population demographics and disparities among developed and developing nations. These concerns about justice are concordant with United Nations Declaration on the Rights of Indigenous People (https://www.un.org/development/desa/indigenouspeoples/declaration-on-the-rights-of-indigenous-peoples.html, accessed 24 June 2020).

Application of these virtues to the work of geoscientists will go a long ways towards making the geosciences more welcoming, inclusive, safe and relevant for all people. Diversity in the geosciences has both internal and external implications for the discipline. Arguments have been made throughout this contribution that the geosciences as a discipline will be strengthened by building a more diverse workforce. In addition, it is increasingly important for geoscientists to look beyond their disciplinary boundaries and consider the impacts of their work on cultures and communities. This will challenge many geoscientists to move out of the comfort zones of their field sites and laboratories, and from in front of their computer screens, and to proactively integrate their work with these social issues. 500 Women Scientists Leaders (2020) present this challenge: 'If scientists don't explicitly speak up on justice and social issues, they risk overlooking solutions, discarding talent, and perpetuating toxic power dynamics. We must all hold ourselves and each other accountable to dismantle the systems of oppression that persist in our society, the very systems that claimed the lives of George Floyd and countless other Black people'. Geoscientists have a real opportunity to make significant and enduring changes to the world in which we live.

Denouement: the intersection of geoethics and diversity – next steps

Broadening participation must be a global aspiration for the geosciences community. So, do the right thing. Increasing diversity in the geosciences will strengthen the quality of our science, help to sustain the geosciences as a profession, and contribute to the stewardship of the planet for the benefit of all people. However, increasing diversity in the geosciences has proven to be an elusive goal. Yet perhaps the geosciences have finally achieved a critical mass, or reached a tipping point in the trajectory of human events. Nothing short of a profession-wide commitment to diversity is needed in both personal and professional activities. As a profession, the geosciences must take a hard look in the mirror to critically evaluate who we are, and who we hope to be. It may require courage to significantly change, or even tear down and rebuild, the professional and institutional structures that have historically limited diversity, inclusiveness, and equity so that all people will be enabled to fully participate in the geosciences. The high-level 'white papers' have been written, conferences have been convened, professional society policies have been adopted, the issue is clearly documented and defined. However, the time for writing and talking is over. *Now we need broad implementation of a comprehensive diversity initiative in the geosciences. This is the time for concerted, dedicated and sustained action. We cannot just sit back and wait for new people to show up and expect that they will naturally succeed without our collective support.*

You do not have to start from scratch, nor reinvent the wheel. Many examples from this report reflect diversity initiatives by individuals, academic departments, professional societies and agencies in the USA. However, the underlying principles that inform and derive from these studies will hopefully have global applications to diverse people and cultures, the suggested approaches and remedies may be adopted or adapted to varying degrees as appropriate for local populations, and creative new solutions will emerge as circumstances dictate. There is an obvious need to conduct further international studies on the experiences of diverse people in the geosciences from around the world to demonstrate the efficacy of diversity programmes in different populations and cultural settings. As diversity initiatives grow and proliferate in the geosciences, there will be detractors who will claim that these programmes will 'water down' the discipline, will 'take away' from the central mission of the geosciences to study Earth, and that the geosciences are a physical science and should not be involved with the social science aspects of diversity issues. However, these objections are short-sighted and misguided. Diversity is not an obstacle, it is an opportunity. A more progressive perspective affirms that diversity serves to expand, enhance, enable, empower and enrich the geosciences. So, to every geoscientist: take stock of your immediate situation. Reflect on what is needed to increase diversity in your work environment and in the geoscience profession. Make a personal and professional commitment. What can you do today to make a difference?

Acknowledgements The author is indebted to career-long conversations and collaborations with

colleagues that provided the formative ideas presented in this contribution: Jill Karsten, Steve Semken, Eric Riggs, John Geissman, Dexter Perkins, Kim Kastens, the GeoNeeds PIs Heather Petcovic, Nicole LaDue, Sheldon Turner, Tina Cartwright, On the Cutting Edge PIs Heather Macdonald, Cathy Manduca, Barb Tewksbury, and the staff at the Science Education Research Center, Carleton College. Input from Chris Atchison and M. Brandon Jones, and reviews by Jill Karsten and an anonymous reviewer provided additional insights that helped to clarify and amplify key ideas in this contribution. The views expressed in this contribution are solely the responsibility of the author.

Author contributions **DWM**: conceptualization (lead), writing – original draft (lead), writing – review & editing (lead).

Funding Original funding for work on Geoethics was provided from an NSF Grant from the Ethics Education in Science and Engineering programme, grant number NSF 1338741.

Data availability Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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