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Applying an intersectionality lens to expand equity in the geosciences

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ABSTRACT

Geosciences remains one of the least diverse science disciplines. Recent efforts in the discipline have aimed to address leadership, organizational, and structural factors to increase engagement of diverse participants. As these efforts expand, it is important to recognize the interrelated roles of distinctive social identities in affecting opportunity structures to pursue geosciences. In particular, attending to groups who hold multiple marginalized identities is especially critical to advance equity. In this piece, we examine how intersectionality, a lens from the social sciences, can be employed conceptually and practically to broaden participation in geosciences, particularly among underrepresented groups such as women of color or others with multiple marginalized statuses. We first outline the key concepts constituting a lens of intersectionality and explain a specific model of intersectionality that incorporates multiple individual, cultural, and historical layers. Second, we examine extant research literature to explore how intersectionality might be applied in geoscience education. Third, we draw on geoscience education and more general science education research to explore how individual and intersecting identities, organizational dimensions, and cultural-historical factors, as integrated in this lens of intersectionality, can enhance understanding of students' lived experiences and historical conditions. We supplement this analysis with exemplars from our own empirical research on the culture of inclusion and exclusion in fieldwork. Finally, because intersectionality focuses on expanding life opportunities for historically marginalized groups, we conclude with recommendations on how researchers and practitioners can apply intersectionality to advance equity in geosciences.

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Despite investment by the National Science Foundation (NSF) and other agencies in recruiting diverse students to geosciences in the United States, this discipline has remained one of the least diverse fields in the nation among science, technology, engineering, and math (STEM) fields over the last 40 years (Bernard & Cooperdock, 2018; Huntoon, Tanenbaum, & Hodges, 2015; NSF, 2017). Recently, efforts to create a more inclusive culture to foster equity in the field have increased. For its 100th anniversary in 2019, the American Geophysical Union (AGU) developed a Diversity and Inclusion Task Force to generate a plan for addressing inclusivity in the discipline that updates prior efforts from the early 2000s (Williams, 2018), and collaborated with other organizations, including the American Geophysical Institute (AGI), to address sexual harassment (Schneider, Holmes, & Marin-Spiotta,

2018; St. John, Riggs, & Mogk, 2016). These initiatives correspond with broader efforts across STEM fields to address sexual harassment (National Academies of Sciences, Engineering, and Medicine, 2018a). Geoscience scholars have also organized other efforts to address and expand inclusivity in geosciences, such as the Earth Sciences Women's Network (ESWN), which focuses on gender and was recognized through a 2018 Presidential Science Award for Excellence in Science, Mathematics, and Engineering Mentoring (NSF, 2018), and the International Association of Diversity in Geosciences (IADG), which addresses the needs of those with disabilities (Atchison & Gilley, 2015).

As efforts grow to expand participation of historically underrepresented populations¹ in geosciences, it is also important to keep in mind that the issue of underrepresentation in geosciences, as in other STEM

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¹We use the phrase "historically underrepresented populations" to indicate that populations historically called "minority" are no longer the numerical minority in some contexts (e.g., Hispanics are now the majority population in number in California).

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fields, is compounded for individuals from multiple historically marginalized groups, such as women of color (e.g., Mattheis & Schneider, 2018; Ong, Wright, Espinosa, & Orfield, 2011). To develop the most effective initiatives to advance inclusivity in geosciences, it is critical to disrupt and transform organizational power dynamics that have historically privileged some groups and marginalized others in the discipline. It is also important to recognize the “double bind” (e.g., Malcom, Hall, & Brown, 1976; Ong et al., 2011; Williams, Phillips, & Hall, 2016) or “double jeopardy” (Clancy, Lee, Rodgers, & Richey, 2017), of racism and sexism that women of color in the discipline face, and even multiple “binds” when additional identities (e.g., class, disability, sexual identity) are considered (e.g., Carbajal, Marshall, & Atchison, 2017; Ham & Flood, 2009).

In this piece, we explore how *intersectionality*, a lens from the social sciences, can be employed conceptually and practically to broaden equity and participation in geosciences. As sociologist Patricia Hill Collins (2015) characterizes it, “The term intersectionality references the critical insight that race, class, gender, sexuality, ethnicity, nation, ability, and age operate not as unitary, mutually exclusive identities, but as reciprocally constructing phenomena that in turn shape complex social inequalities” (p. 2). Intersectionality has been used in a variety of social science disciplines and legal research to address social inequalities in diverse domains such as work, the law, human rights, and education. Scholarship employing intersectionality has broadly addressed three areas: (1) the ongoing development of intersectionality itself as a field of study, (2) intersectionality’s role as an “analytical strategy” to examine social phenomena, and (3) intersectionality’s role “as a form of critical praxis” that “does not separate scholarship from practice, with scholarship providing theoretical frameworks that people are encouraged to apply to practice” (Collins, 2015, p. 5). In this piece, we follow the latter two sensibilities, using intersectionality to analyze the construction of structural inequalities in the geosciences, and applying this scholarly analysis to recommend strategies to address these inequalities. Given the complex construction of educational inequalities in geosciences, and the slow pace of change toward equity, employing an intersectionality lens is essential, particularly to address the double or multiple binds experienced by those who are underrepresented in the discipline.

The recent *Community Framework for Geoscience Education Research* (St. John, 2018), organized by the National Association of Geoscience Teachers, calls for strengthening theoretical knowledge to improve

undergraduate learning and equity in geosciences, including applying frameworks from other fields like higher education. In this framework, examining the roles of multiple organizational contexts (e.g., Wolfe & Riggs, 2017) and multiple, intersecting identities (e.g., Callahan et al., 2017) have been identified as offering promising theoretical avenues to inform future research and practice to diversify geosciences. Riggs, Callahan, and Bray (2018) assert that a “richer understanding of [underrepresented students’] lived experiences as members of the community” (p. 63), that takes into account intersectionality in identities, would enhance practices to increase equitable participation and success in geosciences.

In reviewing results from over a decade of research and evaluation funded by NSF programs focused on broadening participation in geosciences, Karsten (2019) asserts that too often, such efforts focus on individual students or programs, and are not institutionalized beyond the life of the program or the funding. Broadening participation will require a focus on transforming cultural and structural elements, in addition to developing individual talent. This will require a shift in mindsets among geoscientists to integrate inclusion in their practices and to take collective responsibility to advance equity in the discipline (Karsten, 2019).

This piece applies the lens of intersectionality to offer one perspective on understanding the multiple individual, cultural, and structural dimensions that can be transformed to broaden participation in geosciences. We first outline the key concepts constituting a lens of intersectionality and explain a specific model of intersectionality that incorporates multiple individual, cultural, and historical layers. Second, we describe how we identified extant research literature to examine how intersectionality might be applied in geoscience education. Third, we draw on geoscience education literature and, in some cases, STEM literature, more broadly, to explore how the model of intersectionality can help explain how individual and intersecting identities, organizational dimensions, and cultural-historical factors may be integrated to enhance understanding of students’ lived experiences and historical conditions that can and have been marginalizing to certain groups (Riggs et al., 2018). To enhance this understanding, we supplement this analysis with exemplars from our own empirical research on the culture of inclusion and exclusion in fieldwork. Finally, because intersectionality focuses on expanding life opportunities for historically marginalized groups (e.g., Crenshaw, 1991; Hancock, 2016), we conclude with recommendations on how researchers

and practitioners can apply intersectionality to advance equity in geosciences.

Conceptual background

Intersectionality emphasizes that there are interlocking systems of oppression, such as patriarchy, capitalism, racism, and ableism, that can differentially affect the life chances of people with different social identities. Like intersectionality, the concept of social identity has been explored in different disciplines. In this context, we employ the conception of *social identity* to mean those aspects of a person that are defined in relation to their membership in various social groups (Deaux, 2001). A person may apply these aspects to themselves, or have these aspects imposed upon themselves by others, or by the society at large (Deaux, 2001). Such identities include, but are not limited to, those based on: race, ethnicity, gender, class, sexuality, and ability identities. While there are several ways in which social identities may be discussed and analyzed, we are particularly interested in social identities as they pertain to the social contexts in which they are situated.² Individuals hold simultaneous multiple social identities, often including both privileged and marginalized identities (Wijeyesinghe & Jones, 2014). It is important to consider how some identities may become more or less salient, depending on a variety of factors, such as the setting in which one is located, and the influence of others who participate in creating that setting (Deaux, 2001).

Given the salience of multiple identities for individuals in different social contexts, it is therefore critical to consider intersectionality in relation to social identity. According to Wijeyesinghe and Jones (2014), “Intersectionality attends to identity by placing it within a macrolevel analysis that ties individual experience to a person’s membership in social groups, during a particular social and historical period, and within larger, interlocking systems of advantage and access” (p. 11). As noted earlier, intersectionality also focuses on social transformation to foster equitable opportunity structures, particularly for those who have been historically disadvantaged within these systems (Collins, 2015). The development of intersectionality scholarship has a long and rich history in scholarship and activism, beginning in the 1800s (Hancock, 2016). One key advancement in the arc of this scholarship was the work of Crenshaw (1989, 1991), who, using the

example of welfare reform, highlighted how the intersection of racism and patriarchy shapes legal policies that limit economic, political and social opportunities of Black women in ways that White women do not experience. In her focus on centering Black women’s experiences in relation to legal policy, Crenshaw sharpened the understanding of intersectionality itself, employed it as an analytical strategy to understand the social phenomenon of welfare reform, and considered social and legal change to advance more equitable policies to address and incorporate the perspectives of Black women (Collins, 2015). Readers interested in the development of intersectionality as a field are encouraged to consult sources such as Collins (2015), Crenshaw (1989, 1991), and Hancock (2016).

An implication of an intersectionality lens is that the effects of societal practices and policies are not whole-sale, nor can they be reduced to one social identity. Rather, these must be ascribed to multiple identities and how these identities interact with societal structures of opportunity. Accordingly, intersectionality also posits that people can simultaneously hold both privileged and marginalized identities. However, intersectionality not only accounts for the interactions between multiple social identities, it highlights the role of power dynamics in societal structures and systems in shaping the nature and scope of these opportunities. Thus, research that employs intersectionality can provide tools not only to address the role of social identities in shaping educational opportunities, but to promote social change through organizational transformation (e.g., Collins, 2015; Crenshaw, 1991; Hancock, 2016).

In its expansion over the years, intersectionality scholarship has been applied to address how multiple social identities and are associated with educational inequities. In this piece, we extend current applications of intersectionality to education research (Abes, Jones, & McEwen, 2007; Anthias, 2013; Núñez, 2014a, 2014b; Wijeyesinghe & Jones, 2014) and to geoscience education research (e.g., AdvanceGEO Partnership, 2018; Mattheis & Schneider, 2018) to map out a conceptual application to research and practice that seeks to advance equity in geosciences. Specifically, we employ Núñez’s (2014a, 2014b) multilevel model of intersectionality that draws on the work of Anthias (2013), to examine three levels. The first level involves *social identities* and highlights how the role of membership in multiple social categories (e.g., gender³, race/ethnicity, class, disability, sexual orientation, and

²See Owens, Robinson, and Smith-Lovin (2010), for a more detailed history of various theories and approaches to understanding social identity.

³We chose to use gender versus sex in our article since sex refers to biological differences between females and males, and gender relates to the ascribed roles that have been imposed by society onto an individual.

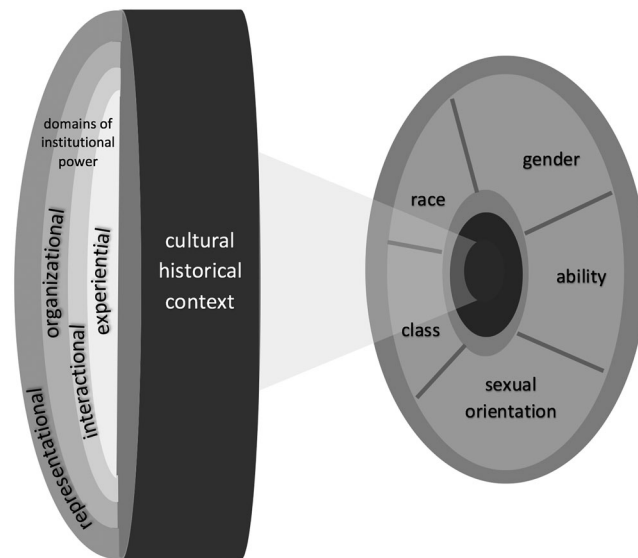


Figure 1. To represent the first level of social identities, the right side of the figure depicts an eye with a pupil and iris. Surrounding the pupil are five identities that an individual might hold, among other identities. As depicted in the iris, these identities might blend together and overlap, representing certain intersections. Together, they shape the perspective through which an individual might see or experience the world. To represent the third level of cultural-historical context, a lens is depicted that situates the individual and their social context in a particular place and time. To represent the second level, different filters are depicted within the lens. The filters represent the four domains of institutional power – representational, organizational, interactional and experiential – through which individuals experience institutions such as education. Together, the three levels shape opportunity structures of education. Adapted from Anthias (2013) and Núñez (2014a, 2014b).

others) shapes the extent to which individuals encounter barriers to advancement in educational settings.

The second level involves *domains of institutional power* and focuses on how multiple environmental factors in educational settings organize environments that can hinder participation of historically underrepresented populations. The domains of institutional power are classified into four types: (1) *organizational*, or how pedagogy and curricula are organized (e.g., the extent to which gatekeeper classes might inhibit the participation of students in STEM fields), (2) *representational*, or the extent to which diverse groups compose faculty or professional ranks and to what extent these groups are represented in materials depicting the geosciences profession (e.g., association websites, departmental web pages, other media about the discipline), (3) *interactional*, meaning the nature of interactions between and among instructors and students in educational settings (e.g., Holmes, 2015), and (4) *experiential*, or how individuals' sense-making of their own educational progress relates to their perceptions of their own social identities in shaping their opportunities (Núñez, 2014a, 2014b). For example, individuals' perceptions that people with their social identities do not tend to participate in activities often associated with the geosciences (e.g., stereotypes such as, Blacks and Hispanics are not "outdoorsy" and never visit national parks), could affect the extent to

which they see geosciences as a fitting or comfortable career field for themselves.

The third level in this model, *cultural-historical context*, places the first and second levels within a broader temporal context: how the historical and cultural foundations of geosciences have intertwined to differentially shape opportunities in geosciences for historically underrepresented populations to pursue geosciences. As we discuss later, the discipline of geosciences developed in part through military history, expansion of national territories to colonize often indigenous lands, and the extraction of natural resources. These historical foundations, coupled with differential and hierarchical assumptions about the abilities of different groups across STEM fields (e.g., Carter, Razo Dueñas, & Mendoza, 2019), have involved the privileging of some groups and oppression of others.

In focusing on multiple identities, domains of institutional power, and cultural-historical contexts, this application of intersectionality aligns with Wolfe and Riggs's (2017) "macrosystems" framework that identifies multiple organizational sites and systems of influence, both within and outside of educational settings, on participation of historically underrepresented populations in the discipline. We extend this work to identify specific organizational dynamics that are key foci to increase historically underrepresented populations' participation in geosciences, through reviewing

the geoscience education research literature in relation to our model. We also extend current work by addressing how the historical culture of the discipline could hinder a sense of community for particular marginalized groups.

Figure 1 shows how the interplay between multiple identities, domains of institutional power, and historical contexts affect the engagement of geoscientists in the discipline. Together, these levels and dimensions play a role, and sometimes overlap, in the way that they shape possibilities to advance equity in geosciences. This multilevel model offers a lens that incorporates both individual identities and contextual and structural factors to understand the interplay of individual, interactional and institutional concerns in shaping the extent to which institutional dynamics in geosciences engage participation of diverse groups (Holmes, 2015).

To represent the first level of social identities, the right side of the figure depicts an eye with a pupil and iris. Surrounding the pupil are five identities that an individual might hold, among other identities. As depicted in the iris, these identities might blend together and overlap. Together, they shape the perspective through which an individual might see or experience the world. To represent the third level of cultural-historical context, a lens is depicted that situates the individual and their social context in a particular place and time. To represent the second level, different filters are depicted within the lens. The filters represent the four domains of institutional power – representational, organizational, interactional and experiential – through which individuals encounter institutions such as education. Together, the three levels shape opportunity structures of education, including possibilities to pursue geosciences.

Methods

For this inquiry, our team conducted a comprehensive literature review to gain general insights into structural issues that might limit participation for diverse groups in the geosciences. Subsequently, we connected our results from that review with the findings of an empirical study conducted by the first author to explore inclusion and exclusion in fieldwork in the geosciences. Fieldwork has been identified as a compelling site to study inclusion and exclusion in geosciences, as it is a key site of socialization into the discipline (e.g., Mogk & Goodwin, 2012). Yet, the discipline's distinctive emphasis on field experiences may discourage participation of diverse students on the

basis of gender, race/ethnicity, class, disability, or sexual orientation (e.g., Karsten, 2019; O'Connell & Holmes, 2011). Thus, incorporating our empirical research on fieldwork to complement the results from the broader literature review enabled us to illustrate how students' lived experiences call for the consideration of multiple social identities and intersectionality in interventions to recruit and retain diverse students in the geosciences.

To conduct our literature review in geosciences, we utilized several search terms including “geosciences,” “geology,” “earth science,” and “earth science systems.” To identify salient literature, we drew sources from educational text databases such as H. W. Wilson Education Full Text. In addition, we examined articles in select journals and publications related to the field, including but not limited to: *Journal of Geoscience Education*, *Journal of Women and Minorities in Science and Engineering*, *Nature*, and *Science*.

Our review revealed some limitations in the literature on diversity and inclusivity within geosciences. Most research in geoscience education examines the experiences and outcomes of individual students or individual programs, rather than the organizational culture and everyday dynamics that hinder or enhance participation in geosciences (Callahan et al., 2017). Put differently, geoscience education literature has paid little attention to how domains of institutional power (Level 2 in our model) and historical contexts (Level 3 in our model) have limited opportunity structures for historically marginalized groups to pursue geosciences. Yet, attention to domains of institutional power and cultural-historical contexts is critical in shaping more inclusive geoscience educational settings. Accordingly, given the limitations in geoscience literature on the role of identity and diversity in advancing equity in the discipline (e.g., Callahan et al., 2017), we expanded our literature search to include the broader STEM fields and education to further inform our understanding of the multiple factors affecting educational opportunity structures in geosciences.

To respond to calls to understand lived experiences in relationship to multiple social identities of historically underrepresented populations in geosciences (Riggs et al., 2018), we also connected findings from our own empirical research on geoscience fieldwork to results from the literature review. Qualitative methods like ethnography are well-positioned to examine issues of identity and intersectionality, because open-ended interview questions and observations of phenomena *in situ* enable study participants to “relate

themes of self to the historical and social events in which they are played out” (Deaux, 2001, p. 7). Ethnographic research on geosciences in general and geoscience fieldwork in particular has been rare (see Feig, 2010; Goodwin, 2018, for exceptions), yet it is valuable for exploring the application of intersectionality to geosciences because of its emphasis on participants’ experiences within the social contexts they navigate. The process of ethnography involved participating in and observing the daily lives of participants in geoscience fieldwork for an extended period of time, to gain more in-depth understanding of participants’ experiences and the cultural dynamics of their social setting (Hammersley & Atkinson, 1983; Jones, Torres, & Arminio, 2014).

Specifically, the first author of this piece fully participated in a residential, field-based geoscience course (a required undergraduate field camp) to collect data about faculty and students’ activities and experiences in that naturalistic setting. The research involved two continuous weeks of participant-observation in a typical six-week undergraduate field course required to complete a bachelor’s degree in geosciences in the U.S. In addition to conducting 115 hours of observations of the field camp, the first author of this piece interviewed 16 participants, including students, instructors, and TAs, in the field camp, about factors enhancing or hindering their engagement in fieldwork. Among the 23 students who participated, just over 20% were from historically underrepresented racial/ethnic populations, and just over one-third were women, so the sample was relatively diverse as compared to discipline at-large, which could be perceived as a limitation in that it was not representative of the general composition of the discipline. However, this condition could also serve as a strength, enabling more insights about the experiences of students from marginalized social identities to come forth.

This research was part of a larger study on dynamics of inclusion and exclusion that affect participation of diverse groups in geosciences (Núñez, Posselt, Hallmark, Rivera, & Southern, 2019; Posselt & Núñez, 2018). The study was intended to inform the development and administration of an intervention to support geoscientists in developing more inclusive field experiences (Posselt et al., 2019). It should be emphasized that one initial inspiration to write this manuscript was the recognition that students in our ethnographic study experienced marginalization in more complex ways than expected, and on the basis of multiple identities. Early on in the project, the researcher who was collecting data recognized the importance of attuning

more carefully to how participants framed the salience of their own identities, rather than imposing an external conception or interpretation of the most relevant marginalized identities. It is possible that spending an extended, immersed period of time with these students in field settings augmented the researcher’s access to this understanding. It should be noted that although the development of intersectionality as a field of study is often framed as integrally linked with the experiences of Black women,⁴ the research-based examples we discuss are not directly grounded in the experiences of Black women. This is because there were no Black women enrolled in the field course, a condition that reflects the extremely low percentage of women of color in the geosciences from historically underrepresented racial/ethnic populations (NSF, 2019). Although our research therefore does not focus on the experiences of Black women per se, we draw on intersectionality’s distinctive potential as a tool to offer insight for understanding the experiences of populations that experience multiple marginality (Hancock, 2016).

The following sections apply the model of intersectionality in Figure 1 to illustrate how individual identity (Level 1), institutional (Level 2), and cultural-historical (Level 3) concerns shape opportunities to pursue geosciences. After reviewing the geoscience education literature in relation to each level, we include a section called “connections to findings from the ethnographic study” – examples from our own ethnographic research on geoscience fieldwork. These examples illustrate the complex experiences of students that defy simple reductions to particular identities and unfold within different institutional domains of power and cultural-historical disciplinary trends. We assert that such complexity requires a lens like intersectionality to more holistically engage diverse participants in geosciences.

Results

This section applies the Figure 1 model to examine how multiple identities, institutional domains of power, and cultural-historical contexts shape opportunities for students from diverse backgrounds to pursue geosciences. We review the extant scholarship on inclusivity in geosciences and apply our own empirical

⁴Black women, since at least the 1800s, have played a central role in advancing intersectional ideas in scholarship and activism, a movement that has been closely intertwined with the development of the scholarly field of Black feminism. See Collins (2015) for a general analysis, and Hancock (2016) for a detailed intellectual history of their role in these developments and the deep relationship between the field of intersectionality and that of Black feminism.

research on the culture of geoscience fieldwork, which we call “connections to findings from the ethnographic study,” to examine how an intersectionality lens can inform how to increase inclusivity in the discipline. Subsequently, we proceed to identify recommendations based on findings from the research reviewed here.

Level 1: Social identities

In considering the roles of various social identities, geosciences continues to be among the least diverse STEM fields with regard to gender, and *the* least diverse with regard to racial/ethnic representation (Holmes, O’Connell, Frey, & Ongley, 2008). In the past 40 years, the representation of women in the discipline has increased, but the racial/ethnic representation has not shifted (Bernard & Cooperdock, 2018). Women make up four out of ten bachelor’s degrees recipients in geosciences, compared to over half (55%) of bachelor’s degree earners in all science fields (NSF, 2017), and just 20% of tenure-line faculty in 106 top-ranked geoscience programs in the U.S (Glass, 2015). In 2017, underrepresented groups (i.e., African American, Hispanic/Latino, and Native American) earned 8% of bachelor’s degrees in geosciences (Wilson, 2018). Meanwhile, people with disabilities compose 9% of geoscience workers, compared with their share among all undergraduates (11%) or among the overall U.S. population (12.6%) (NSF, 2017).

Over the past 40 years, about 85% of PhD recipients in geosciences have come from White, non-Hispanic backgrounds, while only seven percent have come from underrepresented groups (Bernard & Cooperdock, 2018). Out of the 610 geoscience doctoral degrees awarded to U.S. citizens and residents in 2016, Whites received 480 (79%), Hispanics 27 (4%), Blacks 11 (2%), and Native Americans 5 (less than .1%) (NSF, 2019). It is easy to see that to further subdivide these numbers by gender to examine issues like being a dual minority (e.g., Ong et al., 2011) leaves extremely small sample sizes for analysis. We could not find disaggregated statistics on racial/ethnic participation in the geoscience professoriate, presumably because racial/ethnic minorities are represented in such small and statistically insignificant numbers (e.g., Mogk, n.d.). Collectively, these data indicate extremely low representation of these social identities, particularly at higher professional levels.

Research indicates that the lower the share of a social identity represented in a higher education setting, the more salient that social identity becomes to that individual (Hurtado, Ruiz Alvarado, &

Guillermo-Wann, 2015; Ruiz Alvarado & Hurtado, 2015; Steck, Heckert, & Heckert, 2003). Thus, the lack of representation along gender, race/ethnicity, and diverse class backgrounds in geosciences can make historically underrepresented populations’ identities more salient, and isolated, in these learning settings. To date, the literature about participation of those with marginalized identities in geosciences has primarily focused on gender, race/ethnicity, class, and disability. Indeed, research shows that LGBTQ+⁵ students are more likely to leave STEM fields in general (Hughes, 2018), and that gay male engineering students face challenges in integrating their sexual and scholarly identities (Hughes, 2017), but there is less scholarship available on lesbian, gay, bisexual transgender, queer and questioning (LGBTQ+) students’ experiences in geosciences specifically. An intersectionality framework recognizes that identities vary in their degree and quality of privilege and marginalization, and that the nature of privilege and marginalization of identities can vary by context, as Hurtado et al. (2015) suggest.

Recognizing the influence of multiple identities is critical for recognizing the complex experiences that individuals bring with them, such as women of color, who can face a “double bind,” a condition in which race/ethnicity and gender interact to simultaneously produce distinct experiences in science for women of color (e.g., Malcom, Hall, & Brown, 1976; Ong et al., 2011; Williams et al., 2016). For example, research has found that 48% of Black women scientists and 47% of Latina scientists report being mistaken for administrative or cleaning staff, compared with 32% of White women and 23% of Asian women (Williams et al., 2016). Clancy and colleagues (2017) found that, among astronomers and planetary scientists, Black and Latinx women were far more likely than others to report that they experienced hostile work environments. Practical implications of this are that barriers can vary even for students within the same social category (e.g., gender), and that efforts to address only one social category in isolation may not be as effective in broadening participation in geosciences.

Another example in which we may see variation within the same social category is when we examine class across race/ethnicity. Class – also sometimes referred to as socioeconomic status – is often correlated with race/ethnicity, as students of color are more likely to come from low-income backgrounds

⁵We are utilizing the LGBTQ+ symbol as used by Pitcher, Camacho, Renn and Woodford (2018), in order to be inclusive of populations that are not limited to lesbian, gay, bisexual, transgender, queer and questioning.

(Sullivan et al., 2015). Students of color also borrow more in loans for the same degrees as their White peers, and are more likely to default on their loans as well (Goldrick-Rabb, Kelchen, & Houle, 2014; Huelsman, 2015). However, focusing solely on race/ethnicity overlooks the serious financial barriers that many low-income students face, while focusing solely on class ignores the role that racism continues to play in opportunity structures, departmental cultures, and society broadly.

Research has found that students of color and students from low-income backgrounds reporting having fewer informal outdoor experiences while growing up, which could make the outdoor component of geosciences less familiar or even less comfortable (e.g., Mogk & Goodwin, 2012; O'Connell & Holmes, 2011; Stokes, Levine, & Flessa, 2015). With regard to field-based experiences, the costs of hiking equipment, field tools, and other necessities pose an even larger burden for students from low-income backgrounds (Ham & Flood, 2009) – especially considering that attending field camps, which are typically held in the summer and last multiple weeks, requires that students forgo some summer earnings or take time away from jobs or family caretaking responsibilities. Some field camps may be too expensive for students from low-income backgrounds, costing as much as \$8,954 for one summer course, which far exceeds the typical cost for a course during the academic year (Kelleher, 2017). Beyond costs, several other barriers may impede persistence for low-income students in STEM, such as lacking necessary cultural capital (i.e., limited knowledge about study habits or what to bring to field camp) or experiencing feelings of not belonging (i.e., feelings of being stigmatized due to not wearing name-brand gear).

Even among those with disabilities, there is variation in geoscience experiences according to the type of disability. Research indicates that geosciences are most accessible to students with hearing impairments and least accessible to students with visual and cognitive impairments, while people with physical impairments are able to participate, but mostly in indoor geoscience activities (Atchison & Libarkin, 2016). Navigating difficult and potentially dangerous terrain of many field-based activities can create barriers for students with disabilities (e.g., Stokes et al., 2012).

Connections to findings from the ethnographic study

Jay, a Black immigrant from Africa who was enrolled in the field camp we studied, had transferred to the

university from a Historically Black College and University (HBCU), which, like many Minority Serving Institutions (MSIs), did not offer a geoscience program (Petcovic et al., 2016). In an interview, he explained his keen awareness of being identified by others as African American in the U.S., although that, as an immigrant with roots in another country, his identity was not equivalent. He noted that an instructor at his HBCU, an immigrant from an Asian country, became a key role model who informed his decision to pursue a degree in geosciences. This instructor took Jay to his first meeting of the National Association of Black Geoscientists (NABG), where Jay met Black geologists for the first time. As a result of this experience, Jay described an increase in his capacity to envision himself as a geoscientist, because he had more role models to relate to on their basis of being Black or international and in his profession of choice.

When asked what advice he would recommend to other students going out into the field, Jay's response did not focus on his Black, immigrant, or international identities – rather, it focused on a class-related dimension: finding inexpensive gear. He described how, in preparation for fieldwork, he would show students that they did not have to buy brand-name gear like Patagonia to be “comfortable” in the field, and would guide them to places like Goodwill and other less expensive stores for more affordable, yet comfortable gear. Here, he implicitly referenced his own class and limited access to monetary resources, imagining that such financial concerns would be important to other students in pursuing geoscience fieldwork. Jay's experiences indicated that, although he perceived that people in the U.S. primarily saw him as Black, his own social identities that were salient to becoming a geoscientist could not be reduced to just one. He described feeling isolated in coursework on the basis of being Black and international, and challenges in navigating fieldwork on the basis of financial concerns. Jay's case illustrates the importance of listening to how students make sense of their own identities – that is, understanding students' lived experiences in geosciences (Riggs et al., 2018), to better address their needs and engage them in the discipline.

Level 2: Domains of institutional power

An intersectionality framework also calls for addressing the organizational structures that perpetuate limited representation and engagement in geosciences of historically marginalized groups. Most analyses of student experiences and outcomes in geosciences have focused on individual affective, cognitive, or (to a

lesser extent) social identity characteristics, rather than institutional factors that constrain or expand opportunities to pursue to field (e.g., Callahan et al., 2017; St. John, 2018). Here, we examine how the four domains of institutional power identified earlier – organizational, representational, intersubjective, and experiential – illustrate processes and practices that can expand or hinder participation in geosciences for diverse groups.

Organizational

The organizational dimension addresses behaviors in an organization that may perpetuate marginalization. In the context of geosciences, it includes how curricula are organized and who is admitted into a class, such as field camp. Gatekeeper courses in geosciences, such as calculus, physics, and advanced chemistry may also serve to “weed out” those students from marginalized backgrounds, particularly students of color and women (Busch-Vishniac & Jarosz, 2004; Sanabria & Penner, 2017). The time required for laboratory courses, and the length of field camp, which typically runs around six-weeks (e.g., Oleson, 2013), may deter the participation of low-income students who are struggling to balance work with school (Carnevale & Smith, 2018). Geoscience activities that require strenuous physical participation, including certain fieldwork, can be inaccessible for people with disabilities (e.g., Atchison & Libarkin, 2016).

On a systemic level, institutional tracking occurs at the postsecondary level that channels students of color and low-income students into less selective or nonselective postsecondary institutions, including comprehensive universities and community colleges that are far less well-resourced than their flagship public or selective private higher education counterparts (Carnevale, Van Der Werf, Quinn, Strohl, & Repnikov, 2018). Compared with four-year institutions, two-year institutions are about half as likely to offer geoscience programs (Wilson, 2018). Geoscience courses are also less likely to be offered in MSIs (Petcovic et al., 2016). Less selective institutions are less well-resourced to offer curricular options, lab equipment, and field equipment to support geoscience students (Carnevale et al., 2018).

Representational

The representational dimension addresses the predominant depiction of geoscientists and geosciences, through either symbolic portrayals of the profession or available role models in the profession. These

portrayals or role models may be seen in media depictions including web sites, program brochures, or magazine covers for geological associations, departments, or textbooks. Given the low representation in geosciences of marginalized groups noted previously, a lack of visible role models available to students from marginalized racial/ethnic, gender, disability, and other groups could make it difficult for these students to envision themselves in the field of geosciences.

In many geoscience promotional materials, the typical geoscientist is represented as a White, physically fit male. In an evaluation of fifteen textbooks, of the 307 people that were represented throughout all of the textbooks, people of color were only represented in about four percent of figures, women were represented in 20 percent of figures (Mattox et al., 2008) and other studies evaluating whether visibly disabled students were portrayed in images of fieldwork found no examples (Hall, Healey, & Harrison, 2004; Sexton, O’Connell, Banning, & Most, 2014). The severe lack of variation in representation in portrayals of geoscientists could signal to students that they do not fit in the profession (e.g., Hall et al., 2004).

These patterns of representation extend to the prevalence of images of women who receive distinguished awards in the field. Among geoscientists, women receive disproportionately low numbers of recommendations for awards, and some sections of the American Geophysical Union (AGU) receive no women nominees for awards in any given year (Davidson & Bell, 2018). Such tendencies limit the visibility of women’s accomplishments in the discipline.

Interactional

The interactional dimension addresses the role of interpersonal interactions in affecting inclusivity in an educational setting. For example, interactional barriers stemming from implicit bias, or negative assumptions about underrepresented populations, can adversely affect recruitment into and retention in geosciences (Holmes, 2015). Sexual harassment in settings like fieldwork is not uncommon; in one survey, 25% of women geoscientists reported that they had been victims of sexual assault at least once in their careers (Clancy, Nelson, Rutherford, & Hinde, 2014). Such interactions, which include those between peers, faculty and students, can affect fieldwork participants’ sense of belonging in a group, their own perceptions of their abilities, and their capacity to work together as a group (Clancy et al., 2017; Nelson, Rutherford, Hinde, & Clancy, 2017).

Although research about this is not yet available in geosciences, studies in other STEM fields have shown the impact that having faculty members from the same gender (e.g., Griffin, Gibbs, Bennett, Staples, & Robinson, 2015) or racial/ethnic group (e.g., Newman, 2011) can help students from marginalized groups envision that they, too, can become scientists. Such faculty may be able to relate to students' cultural background and bring a unique understanding of students' academic and social capabilities as assets to broaden perspectives and enhance problem solving in science (e.g., Griffin et al., 2015; Newman, 2011).

Mogk and Goodwin (2012) have noted that geoscience fieldwork can involve a "boot camp mentality" (p. 140) where instructors might push students too hard to navigate challenging terrain. A norm of toughness in geosciences can impede students' engagement and learning in the discipline. This applies to students who have physical abilities or health conditions that are challenging for handling rough terrain at a fast pace (Núñez, Posselt, Southern, Hallmark, & Rivera, 2019; Posselt & Núñez, 2018).

Racial or gender microaggressions (Sue et al., 2007) include discriminatory comments or actions on the basis of identity, and can adversely affect participation in geosciences for underrepresented populations (Callahan et al., 2017). Women and women of color are more likely to face gender- and race-based insults, jokes, and images in their environments, as well as assault and harassment, all components of toxic work environments which can increase dissatisfaction, impede career advancement, or even lead in the longer term to departure from geoscience careers altogether (Clancy et al., 2017; Holmes et al., 2008; Nelson et al., 2017; Williams et al., 2016). Faculty members' negative biases about the intellectual and physical capabilities of people with disabilities, such as assuming that people with disabilities cannot perform certain tasks or complete certain jobs, could limit faculty members' likelihood of extending particular opportunities for participation, potentially limiting the engagement of people with disabilities in geosciences (Atchison & Libarkin, 2016). The centrality of social interactions in geoscience coursework, fieldwork, and labwork raise the importance of the potential for those at all levels to be able to make contributions to research and assignments, share equally in the work, and fully engage in geosciences.

Experiential

The experiential domain of institutional power involves how geoscience scholars make sense of their

own abilities in relation to educational opportunity structures or broader societal trends, and the extent to which they attribute their success to internal or external factors. Negative stereotypes about women's and people of color's intellectual abilities have long been part of the culture of science and geoscience in particular (Carter et al., 2019; Saini, 2017; Yusoff, 2018). *Stereotype threat* involves when students internalize stereotypes to such an extent that they experience extra pressure to counteract a negative stereotype from society about their ability, and stereotype threat can adversely affect performance for women and people of color in STEM fields (Steele, 2010; Steele & Aronson, 1995).

Callahan et al. (2017) have also identified *self-efficacy*, defined as a person's level of confidence in their capabilities to complete tasks (Bandura, 2001) as a potentially useful concept to guide future research on learning of diverse groups in geosciences. Baber, Pifer, Colbeck, & Furman (2010) found that activities that enhanced students' self-efficacy helped explain why summer research programs could be successful in recruiting underrepresented populations to the discipline. To connect the interactional with the experiential domains of power, researchers have found that STEM instructors' assumptions about their students' academic capabilities (such as assuming a growth mentality, associated with the psychologist Carol Dweck) are associated with students' performance (Sutherland, 2019).

Connections to findings from the ethnographic study

Ines, a Latina in the field camp observed by the first author, had less access to co-curricular geoscience experiences than others in the course, because she worked at least 25 hours a week during the school year as a waitress to pay for her education. Meanwhile, the geoscience departmental seminars and social events were held at times that conflicted with her schedule. From an organizational standpoint, prior to field camp, Ines had comparatively limited opportunities to become socialized into the discipline. From an interactional standpoint, however, taking field camp exposed her to important mentoring opportunities, because she had more chances to interact with her instructors. During one dinner in the course, an instructor encouraged her to go to graduate school, and offered to connect her with a specific professor in her field of interest, to learn more about potential programs that would be a good fit.

From an experiential standpoint, Ines said, "In some ways, it's getting out there that's the great

equalizer... Once you get out in the field, as far as different background, different color, all that kind of just washes out, 'cause... Your skills are what really carry you.” Her belief that “your skills are what really carry you” in fieldwork reflected a level of *self-efficacy*, as she described how fieldwork, and the groupwork that it entailed, helped her learn more about herself and her strengths and weaknesses in collecting and analyzing data. These experiences helped her gain confidence in executing these tasks, such as when she said to her working group, “I can take a strike and dip like a gangster!” Further, Ines was identified as one of the most talented students in the class by her instructors, and indeed, it was her detailed field notebook which was chosen and held up as an example for the rest of the students to follow in their later assignments.

Ines's experience illustrates how the interplay of domains of institutional power can reveal multiple institutional activities that can hinder or enhance historically underrepresented populations' engagement in geosciences. From an organizational perspective, having to work extensively during college, as Ines did, could also affect the capacity to engage in geoscience-related activities. Ines explained that she was able to take the six-week field camp class because her employer was flexible, but not all students might have that option. Her supportive interactions with instructors offered her encouragement to go to graduate school and raised her awareness of pathways in geosciences, which could increase the possibility that she would pursue the profession. Organizationally, having access to learning environments so that she could apply her full range of skills, coupled with mentoring from instructors, could counter the lack of Latina role models in the field (in the representational domain of power).

Positive exposure to and immersion in geosciences afforded by an extended field camp countered Ines's limited prior opportunities for immersion during the school year. Having the capacity to build self-efficacy in the field enhanced her confidence to continue in geosciences. These observations are supported by the fact that the fall after field camp, she joined an undergraduate research group for the first time. She also spent a lot more time around the department, participating in seminars and working with professors, expanding her potential for longer-term opportunities in geosciences.

Level 3: Cultural-historical context

The historical development of geosciences as a discipline and as a “technology for extraction, settlement,

and displacement” (Yusoff, 2018, p. 71) cannot be separated from dynamics of social hierarchy and interacting with the earth that have been exclusionary on the basis of gender, class, and race. Certainly, a central impetus for the initial development and growth of the discipline was to extract natural resources and to alter the land for human purposes (Winchester, 2001). A history of being associated with the extraction of earth's resources and expansion of territory through colonization of what were often indigenous lands is connected with a history of labor relations in which Blacks and indigenous peoples have been enslaved to till the land; mine resources like gold, tin, and coal from the earth; or, in other cases, exploited to build railroads or highways to facilitate commerce and White settlement of land (e.g., Yusoff, 2018).

Geological mapping helped facilitate westward expansion efforts like the Pacific Railroad (Turner, 1893) and the U.S. highway system (McPhee, 1998). Indigenous populations were significantly displaced in these movements, and Asians (including Japanese, East Indian, and Filipino) and Mexican populations were exploited for their labor in building of the trans-continental railroad in the western U.S. A legacy of slavery and Jim Crow laws made the wilderness extremely dangerous for Blacks as well, inhibiting the development of welcoming and safe outdoor spaces and national parks (Finney, 2014). Considering this past, it is not difficult to see that for Black, indigenous, Latinx, and Asian people, geology's history cannot be separated from associations with violence, displacement from their land, or limitations on their potential for human, social, and economic agency (Whyte, 2017; Yusoff, 2018).

Scientific disciplines like geosciences have historically ranked the capabilities of people in hierarchies that privilege White people and men and devalue others, including women, Black, and indigenous people (e.g., Harding, 2015; Saini, 2017). Scientific claims that non-Whites and non-males are separate races within the human species have perpetuated arguments that non-Whites and non-males merit separate and lesser rights, reinforcing societal power relations of sexism, racism, and classism (Carter et al., 2019). In his influential 1849 book *Principles of Geology*, Charles Lyell intertwined observations of the natural world with interpretations of social history that incorporated racist views. One chapter ledger in this book read as follows: “Return to Fossil Human Skeleton – Species of Shells common to Eocene Strata in America and Europe – Condition of Slave population –

Cheerfulness of the Negroes: their Vanity-State of animal existence – Invalidity of marriages” (Lyell, 1849, as cited in Yusoff, 2018, p. 74). Lyell also employed the notion of geological deep time to argue that although Blacks might have the potential to be similarly intelligent as Whites, their intellectual capabilities were so poorly developed in comparison that they could never become equal to those of Whites, or merit their equal participation in society (Yusoff, 2018).

In early nineteenth century Britain, where many foundations of current geosciences were established, promising scientists were excluded from participation and recognition in the discipline on the basis of social class and gender. Most scientists in Britain, for example, were male, and came from families of considerable means that were able to pay for their higher education and gave them inheritances to allow them the time to pursue scientific inquiry. Denied the opportunity to pursue higher education, and to gain initial membership in the Geological Society of London, due to his modest means, William Smith’s significant contributions in creating the first geological map and advancing the science of stratigraphy were not initially recognized. He nearly had his intellectual work stolen by other students of geology, before being awarded the first Wollaston medal, instituted in 1831 by the Geological Society of London, for his significant advancements to the discipline (Winchester, 2001).

The contributions of British scientists Mary Anning and Etheldred Bennett (nicknamed “the first lady geologists”) went unrecognized because they, too, could not participate in disciplinary organizations like the Geological Society of London (Winchester, 2001). The society did not allow women members until 1919, did not have a woman president until 1982, and even prohibited the attendance of women who won the organization’s awards, when women were still barred from becoming members (Geological Society of London, 2016).

The autobiographical accounts of Margaret Winslow (2012, 2016), one of the first women to be awarded a doctorate in geosciences at Columbia University in the early 1970s, illustrate how she was nearly excluded from the profession on the basis of gender and other intersecting identities, including class background. As she was nearing the completion of her bachelor’s degree studies in the discipline, she had to transfer institutions because women were not allowed to participate in the required field camp course for graduation (Winslow, 2012). Due in part to working significant hours while in college, Winslow

had few opportunities to hike to prepare herself for the physical rigors of fieldwork. As the only woman in her first doctoral fieldwork expedition, she was often nearly left behind by the men and encountered sexual harassment from crew members on her boat and locals in the geographic region, to the point where she aimed to act like “one of the guys” and dressed to obscure her femininity as a form of self-protection (Winslow, 2012, 2016). Research by Clancy and colleagues (2014, 2017) and more recent stories of sexual harassment in the field, including the news of a Boston University professor fired for sexual harassment (Wadman, 2019), indicate a sustained historical arc of sexist behavior in the discipline.

Connections to findings from the ethnographic study

In the field camp that was observed, one of the assignments involved identifying and drawing cross-sections of rock strata. While most of the strata were named after rock types, the name of one in particular stood out. It was clearly an indigenous word, named for a local Native American tribe; however, the derivation of this word was not mentioned. Similarly, a small guide written by students and faculty in the geosciences department at the nearby university about the same landscape did not describe the presence of indigenous people. Rather, the human history described in the brochure began with the White settlers arriving in the 1860s and engaging in economic activities.

Practices of not acknowledging the full human history of the land neglect the presence and contributions of indigenous peoples, rendering them invisible in human and geological historical accounts. For indigenous and other populations from backgrounds that might associate such land with dispossession, violence or exploitation, not addressing these human histories hinders opportunities to understand the full range of ancestors and legacies reflected in the study of the history of the earth. In this sense, these populations might not see themselves as fitting into the curricula of geosciences.

This very brief historical account illustrates that the roots of geosciences are intertwined with exclusionary practices that endure to this day. The historical arc of the discipline has differentially affected opportunities via multiple exclusionary processes that have been institutionalized and inherited over time. This brief historical review indicates how practices of exclusion have in the past and the present have limited the potential contributions that marginalized groups can make to the discipline.

Table 1. Recommendations to apply intersectionality toward equity in geosciences.**Level 1: Social identities**

- Affirm scholars' multiple identities
- Recognize and respect agency of scholars to define and ascribe the salience of their multiple identities, in different contexts
- Expand experiences in geosciences associated with a wider set of social identities
- Build alliances across professional associations that emphasize various social identities

Level 2: Domains of institutional power

- Offer pre-college experiences to expose scholars with diverse social identities to opportunities to learn about education and careers in geosciences (e.g., coursework, outdoor exploration)
- Examine and address dynamics in first-year and introductory classes that may hinder the participation of scholars from diverse social identity backgrounds
- Conduct and apply research about pedagogical approaches that are responsive to experiences and needs of scholars from diverse cultural backgrounds
- Form mutually beneficial partnerships with Minority-Serving Institutions to learn about effective strategies to enhance diverse participation in geosciences, and to recruit and retain scholars from diverse cultural backgrounds
- Increase the quality and quantity of media representation of diverse social identities in geosciences
- Involve scholars with diverse social identities to compose conference panels, award selection committees, and to participate in other national and international modes of engagement in the discipline
- Build supportive networks of intra- and intergenerational scholars with diverse social identity backgrounds
- Raise visibility of historical and current participation of geoscientists from diverse social identity backgrounds

Level 3: Cultural historical context

- Articulate the interdependence between geoscientific inquiry and broader social issues
- Recognize the exclusionary history of the development of geosciences as a discipline (e.g., identify activities, such as the laborious extraction of natural resources, that have served to privilege certain social identities and exclude others)
- Identify and highlight historical contributions of scholars from diverse social identity backgrounds to geoscientific inquiry
- Incorporate broader sense of history of how the presence of indigenous populations and populations of people of color have shaped the land and understanding about the land
- Conduct land acknowledgments in courses, conferences, and other venues to recognize the indigenous roots of stewardship of lands that serve as sites for geological inquiry

Recommendations

Based on this review, we offer several recommendations to apply an intersectionality lens to advance equity in geosciences. Table 1 summarizes these recommendations. Many of these recommendations cut across several themes emerging in our review.

In Level 1 of our intersectionality model, the past two decades have seen increasing research on gender, race/ethnicity, and disability in geosciences, and we recommend that this research be extended to address other identities that have been less examined, such as sexual orientation and class. Understanding more about the experiences of students with distinctive identities will inform the development of inclusive practices to serve these students and enhance equitable conditions in the discipline. It is important for instructors and leaders to understand lived experiences of diverse participants in the discipline. At the same time, it is important to be sensitive to students' privacy about disclosure of various identities and let students decide the salience of their identities in different settings. For example, while using preferred pronouns may be welcoming to some students, others may not feel comfortable employing pronouns, especially if they have a non-binary gender identity. Examining the conditions that make students more comfortable in sharing their identities could inform instructors to cultivate learning settings where students' distinctive backgrounds, identities, and histories are honored.

While it is important to recognize and address the needs of students with distinct identities, so is recognizing that students' experiences cannot be reduced to one identity. Developing alliances across identities, perhaps through different advocacy groups along the lines of gender (e.g., Association for Women Geoscientists, 2018; Earth Science Women's Network, 2018), disability (e.g., International Association for Geoscience Diversity, 2019), and race (e.g., National Association of Black Geoscientists, n.d.), can build capacity for the development of more attuned strategies to advance equity in participation for different groups in the discipline. Rather than ranking the marginalization of underrepresented groups or centering one group in particular conversations, applying an intersectionality lens should offer opportunities to foster a sense of community across identities, and to build diverse coalitions to advance equity in geosciences (Armstrong & Jovanovic, 2017). In other words, these efforts can follow feminist scholar Audre Lorde's (2007) perspective that "There is no such thing as a single-issue struggle, because we do not live single-issue lives... Our struggles are particular, but we are not alone" (p. 138).

In Level 2 of our intersectionality model, research can continue to address how *domains of institutional power* hinder or enhance participation in the discipline for diverse groups. With regard to the *organizational* domain of power, examining the role of pre-college outdoor or schooling experiences, timing of undergraduate curricula (e.g., gatekeeping and first-

year classes) that has the greatest consequences for retention in the major, and presence of culturally responsive curricula can inform understandings of the role of outreach programming and curriculum in affecting geoscience opportunity structures at all educational levels (e.g., St. John, 2018). To serve students of color in the institutions where they are more likely to enroll, attending to recruitment and retention practices and mutually beneficial partnerships with two-year and MSIs is warranted (Houser, Nunez, & Miller, 2018; McDaris, Manduca, Iverson, & Orr, 2017; Wolfe, 2018).

With regard to the *representational* domain of institutional power, extending research on how depictions of geoscientists challenge or reinforce stereotypes about scientists is needed, particularly in an age when social media provides new avenues of representation. It would be helpful to examine and expand the extent to which such efforts counter the images represented on web pages, magazines, or institutional web sites and broaden perspectives on role models in the discipline (Guertin, 2018). Engaging diverse groups in conference sessions, peer review, and award nomination and selection processes can expand whose contributions are emphasized and recognized (e.g., Davidson & Bell, 2018; Pendergrass et al., 2019).

With regard to the *interactional* domain of institutional power, research should address how to structure supportive faculty-student and peer interactions that will improve students' sense of community in the discipline. Models like those in the Earth Women's Science Network indicate examples of effective strategies that address engagement, mentoring, and recruitment at critical times in geoscience careers (Hernandez, et al. 2018). Other initiatives by ESWN and the NSF-funded ADVANCE program, which focuses on faculty diversity, provide ideas for strengthening supportive interactions for marginalized groups in geosciences and transform assumptions towards supporting and affirming marginalized groups (see Holmes, O'Connell, & Dutt, 2015, for more on these programs).

With regard to the *experiential* domain of institutional power, future research could examine the stereotype threat that students can experience as a result of negative assumptions about their abilities or the representations in the media or in the discipline. Interventions to address stereotype threat and challenge negative stereotypes about marginalized groups have been successful in raising achievement of marginalized students in other learning settings and disciplines (e.g., Steele, 2010) and could be adapted to

geosciences. For example, providing historical and current representations of geoscientists that align diverse students' backgrounds and goals could foster opportunities for students to challenge negative stereotypes and to envision themselves in the field.

In Level 3 of our intersectionality model, the advent of the Anthropocene epoch could serve as an opportunity to recognize and affirm geosciences' connection with critical social issues, including hierarchies that have separated and privileged some humans over others, and hierarchies that have separated and privileged the human versus the natural world (Latour, 2017; Yusoff, 2018). A "social geology" (Yusoff, 2018) that examines disciplinary practices that have been sustained over time to privilege some groups and exclude other groups' perspectives and contributions (Carter et al., 2019; Harding, 2015) could identify practices that have rendered invisible or devalued some social identities and could be transformed in the future to advance equity. Highlighting the contributions of women, people of color, and other historically underrepresented populations provides a more expansive view of the discipline and its possibilities for greater equity (e.g., Johnson, 2018).

With regard to addressing cultural historical factors in practice, disciplinary societies are reckoning with the exclusionary nature of their discipline through dissemination efforts and strategies to address the history of exclusionary practices in the discipline. The Geological Society of London (2016), for example, has dedicated some of its web page to the historical exclusion of women from the profession. Many initiatives at AGU, including those that mark the 100th anniversary of the disciplinary society and the sexual harassment, diversity task force, and ethics committees (Williams, 2018), are addressing the discipline's exclusionary history.

Instructors can incorporate knowledge about social problems or local history into their courses to make their courses more socially relevant, as evidenced in place-based education efforts (e.g., Semken, Ward, Moosavi, & Chinn, 2017). It does not have to be an elaborate, time-consuming effort. For example, taking the time to learn the local history of a field site and engaging students in considering the histories of people with different social identities in that site could help students from multiple backgrounds feel as if their histories are seen. Land acknowledgments of indigenous inhabitants could also help in this regard.

An intersectional lens requires a multidimensional approach to expanding research and strategies to increase participation and equity in the discipline.

Our intent here has been to lay out considerations that span multiple identities, institutional practices, and historical contexts for exploring the application of intersectionality to advance geosciences equity. We hope this piece will serve as a departure point to address how these dimensions can broaden opportunity structures for diverse geoscientists.

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