Linking Past to Present in a Postcolonial Field Science: How Scientific Training and Practice in US Geology Perpetuates Marginalization

Tamara Pico[1] and Tamara Pico[1]

[1]UC Santa Cruz

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Abstract

Stories about the foundation of US geology as a discipline are prominent in the culture of field geology today. This article traces the threads of such "origin stories" through field geology practices and undergraduate training. The repetition of these origin stories obfuscates the colonialist and race-fueled motives that underpin the actions of the US geologist characters featured in these stories. I extend concepts of performativity from feminist theory to interrogate the role of such stories in constructing an idealized field geologist's body. I theorize the field geologist as a social construction forged through repeated practice ingrained within narratives about the origin of US geology. Increasingly, the field is recognized as a site of sexual and racial harassment and abuse. By making visible the racialized subplots in the history of US geology, which include entrenchment in racial science and land dispossession, I posit that the curated origin stories repeated today perpetuate processes of exclusion and subjugation in field geology.

Foundational Stories: Performing the Origins of US Field Geology

Tamara Pico*[1,2]

[1] Earth & Planetary Sciences, UC Santa Cruz, Santa Cruz, CA

*tpico@ucsc.edu

Abstract

Stories about the foundation of US geology as a discipline are prominent in the culture of field geology today. This article traces the threads of such "origin stories" through field geology practices and undergraduate training. The repetition of these origin stories obfuscates the colonialist and race-fueled motives that underpin the actions of the US geologist characters featured in these stories. I extend concepts of performativity from feminist theory to interrogate the role of such stories in constructing an idealized field geologist's body. I theorize the field geologist as a social construction forged through repeated practice ingrained within narratives about the origin of US geology. Increasingly, the field is recognized as a site of sexual and racial harassment and abuse. By making visible the racialized subplots in the history of US geology, which include entrenchment in racial science and land dispossession, I posit that the curated origin stories repeated today perpetuate processes of exclusion and subjugation in field geology.

I began working in the geosciences after a summer experience in field geology studying ancient ice ages before starting a PhD program in Applied Physics at Harvard University. My first semester of graduate school I switched disciplines into Earth Sciences to follow an interest in the ice age. Fieldwork brought me into geoscience, but those experiences also kept me from pursuing research in the field. Despite my entry via the field, I did not become a field geologist. I

am now a computational geoscientist studying past ice sheets and sea level by modeling how the solid Earth deforms under the weight of massive ice sheets, which grow and melt over tens of thousands of years. I hold an assistant professor position in Earth Science at UC Santa Cruz, a US public research university. I am a white-presenting Jewish Latina American woman. My mother is Argentine and Jewish, and my father is American, of Mexican Californio and Jewish Romanian descent.

Throughout my time in the geosciences, I became increasingly aware of patterns of exclusion. I was particularly struck by both visible and invisible rules about how geologists' bodies were expected to act or look in the field. The stories we tell and the stories we repeat set norms for our discipline's culture and practice. In geology the stories I heard were stewed in masculine ruggedness and adventure. I started to ask myself where these dominant stories come from. How do the stories we tell, and more importantly, the stories we choose not to tell, construct an ideal of the field geologist's body?

In seeking to answer these questions, I am inspired by Judith Butler's concept of gender performance to consider how the field geologist's body is expected to behave to be seen as legitimate. Butler proposes that "a body becomes its gender through a series of acts which are renewed, revised, and consolidated through time" [1]. Thus, gender identity can be considered a social construction, created by a repeated performance. I extend this concept to the field geologist's body, which can similarly be identified and recognized as a "field geologist" through its behavior or performance. Further, I invoke Sharon Traweek's conception of scientific culture as constructed by repeated practices and daily routines, which render a set of actions and beliefs as the only obvious and rational approach [2].

[1] Judith Butler, "Performative Acts and Gender Constitution : An Essay in Phenomenology and Feminist Theory," *Theatre Journal* 40, no. 4 (1988): 519–31.
[2] Sharon Traweek, *Beamtimes and Lifetimes: The World of High Energy Physicists* (Harvard University Press, 1992).

I am writing this piece for both geoscientists, who are exploring strategies for engaging with complex social issues in field practices, and for critical feminist science scholars, who have thought broadly about gender and race in the field sciences. I hope this piece can engage us in shared conversation and inspire further connections. Traveling between these academic spaces has challenged my own approach to science and my connection to the Earth. I see a rich interdisciplinary space that helps geologists identify more inclusive and equitable ways to practice science by borrowing feminist theory and methodologies. Further, I believe a closer dialogue with geologists can deepen the critical science scholar's understanding of the production of power through scientific practice, especially pertaining field culture and Earth's exploitation.

Stories told in geology codify a culture with a set of rules for how bodies should perform in field environments. The field geologist can then "become" a field geologist through actions, guided by social rules and reinforced through storytelling. If we suppose that a field geologist can be recognized by a set of cultural acts, then Butler argues that "the performance renders social laws explicit", setting rules that define the identity of the field geologist. Although rich cultural traditions in geology exist across the globe, this essay focuses on US field geology, and is specifically concerned with deep time rock-centric research.

In the US, there are stories about the foundation of geology as a discipline that remain strong fixtures in field geology today. As geologists trained in the US are aware, these "origin stories" are often stories of adventure and exploration rooted in 19th century US geology that sanction scientific rigor. The implicit storylines about the motivation of early US geologists are in the backdrop: the history of settler-colonialism, Native American removal, and creation of racial hierarchies ordained by US science. Repetition of these origin stories, and the reperformance of the values they uphold, sets a disciplinary culture that positions geologic fieldwork as an act, predetermined by behavioral rules and expectations. Such repeated performance, ingrained in routines and cultural norms, is reinforced by the stories told within the discipline, creating a seemingly "neutral" field geologist.

Stories about the foundation of geology as a discipline make invisible rules about the type of bodies required (through classifiers such as class, race, gender, and ability) and how these bodies can act (through emulating others) to be seen as legitimate field geologists that "do" field work. When contextualized within the foundation of the discipline, the origin of these body performance rules is clear: US geology's foundation was steeped in scientific racism, and justifying racial hierarchies was a major motivation for science of the Earth in the US. These subplots are less known by the geology community today and are made invisible when stories about racism and colonialism in Earth science's foundation are silenced. Can we locate the stories that are still "living" in the field geology community? What stories are retold and what stories are not? Which bodies can tell stories in geology? And do these stories only get told about certain bodies?

My intervention in field geology is to make visible the racial subplots in the stories we tell about the history of US geology. I theorize the field in US geology as a social performance constructed by centuries of repeated origin stories. By documenting the ways that the idealized field geologist's body is constructed through the repetition of origin stories, I aim to demonstrate how the gendered, racialized, and able-bodied nature of this body perpetuates exclusion and subjugation in both training and research practice, evocative of the colonial practices so central to US geology's disciplinary foundation.

As a practitioner of Earth science, and a beginning feminist science studies scholar, I am inspired by Feminist Science and Technology Studies scholars before me who have critically examined practices in their scientific disciplines, such as Donna Haraway, Banu Subramaniam, Deboleena Roy, Sara Giordano, and others. In "Ghost Stories for Darwin," Subramaniam argues that the history of eugenics continues to haunt scientific research in genetics and ecology on diversity [3]. I am inspired by Subramaniam's analysis of science history to illustrate how the

[3] Banu Subramaniam, *Ghost Stories for Darwin: The Science of Variation and the Politics of Diversity* (University of Illinois Press, 2014).

institution of science can be accessed at different times for different purposes, and this inspires me to listen to the ghosts in the walls of my own discipline to uncover these multiplicities. Science is always socially situated. I am drawn to Donna Haraway's assertion that is difficult to imagine "the possibility of new stories not strangled by the same logics of appropriation and domination" [4], especially when the stories we tell and retell are stories based on oppression.

Feminist scholars have called attention to studies of science that invoked performativity as an analytical framework, noting that these analyses are sometimes limited in addressing the precise relationship between discourse and the production of bodies [5]. My intervention does not address this specific theoretical gap. Rather, I focus on scientific culture as a means for discourse to produce bodies. I argue that origin stories create a culture that invokes rules about body performance. Thus, the stories themselves do not produce bodies. The stories reinforce cultural cues for behavior. The repetition of this behavior (its performance) allows the field geologist to be recognized as a field geologist. This body can then retell stories about bodies in the field, in turn becoming a body that stories are told about. I document the cultural conditioning of the field geologist through an analysis of discourses in geology origin stories.

Increasingly, the field is recognized as a site of sexual and racial harassment and abuse [6]. Understanding such behaviors in the field requires illuminating the pervasive cultural norms that allow patterns of abuse to persist. Importantly, if we can identify when and where such

[4] Donna Haraway, *Primate Visions: Gender, Race, and Nature in the World of Modern Science* (New York: Routledge, 1989).
[5] Rebecca Herzig, "On Performance, Productivity, and Vocabularies of Motive in Recent Studies of Science," *Feminist Theory*, 2004, https://doi.org/10.1177/1464700104045404.
[6] Kathryn B H Clancy et al., "Survey of Academic Field Experiences (SAFE): Trainees Report Harassment and Assault" 9, no. 7 (2014): 1–9, https://doi.org/10.1371/journal.pone.0102172; Kathryn B.H. Clancy et al., "Double Jeopardy in Astronomy and Planetary Science: Women of Color Face Greater Risks of Gendered and Racial Harassment," *Journal of Geophysical Research: Planets* 122, no. 7 (2017): 1610–23, https://doi.org/10.1002/2017JE005256.

behavioral norms are transmitted through training of the next generation of field scientists, then it may be possible to intervene. At stake is the safety of students and science practitioners.

Other research has considered the field as a socially situated site that impacts research questions, process, and outcomes. A substantial body of literature in anthropology reflects on the positionality of the fieldworker, especially how the research practice itself is modulated by body markers such as race, gender, or able-bodiness. Such literature focuses on how information gained during fieldwork is mediated by the body or how experiences of embodiment influence the choice of field sites and research topics [7]. I wish to apply these ideas to field geology, considering how embodiment impacts the field even when the studies do not involve humans as subjects. Further I extend the concept of embodiment to include the behavioral norms imposed on the field geologist's body through cultural cues. I will connect the expected performance of the field geologist's body to origin stories told in geology today about the history of the discipline.

Connections between geology, colonialism, and race-based exclusion today have been explored in geoscience education literature. One such study applied an intersectional conceptual

[7] Emily Billo and Nancy Hiemstra, "Mediating Messiness : Expanding Ideas of Flexibility , Reflexivity , and Embodiment in Fieldwork" 0524 (2013), https://doi.org/10.1080/0966369X.2012.674929; Rebecca Hanson and Patricia Richards, "Sexual Harassment and the Construction of Ethnographic" 32, no. 3 (2017): 587–609, https://doi.org/10.1111/socf.12350; Frances B Henderson, "' We Thought You Would Be White': Race and Gender in Fieldwork," *Political Science and Politics* 42, no. 2 (2009): 291–94; Johanna Carolina Jokinen and Martina Angela Caretta, "When Bodies Do Not Fit : An Analysis of Postgraduate Fieldwork," *Gender, Place & Culture* 0524 (2016): 1–12, https://doi.org/10.1080/0966369X.2016.1249343; Henrika Kuklick and Robert E Kohler, "Introduction: Science in the Field," *Osiris* 11, no. 1996 (1996): 1–14; Jennifer A Reich, "Pregnant with Possibility : Reflections on Embodiment , Access , and Inclusion in Field Research" 26, no. 3 (2003); Matthew Sparke, "Displacing the Field in Fieldwork," *BodySpace. Destabilsing Geographies of Gender and Sexuality*, no. 206 (1996): 212–33; Aaron Turner, "Embodied Ethnography . Doing Culture," *Social Anthropology*, 2000, 51–60; Patricia J Lopez and Kathryn Gillespie, "A Love Story : For ' Buddy System ' Research in the Academy," *Gender, Place & Culture* 0524 (2016): 1–12, https://doi.org/10.1080/0966369X.2016.1249354.

framework to geoscience education to identify how cultural identity, institutional power, and historical socio-cultural factors influence retention and success of undergraduate geoscience majors [8]. Nuñez and others identify how the history of geology in westward expansion can be unwelcoming to communities of color, in addition to the expectation of toughness or expensive gear required to be comfortable in the field. A recent article by Monarrez and others explored how the history of colonialism and extraction in paleontology and geosciences shape the structure of the science today[9].

Recent initiatives in the geosciences and other field sciences have brought such discussions to the forefront through community-led discussions and publications [10], as well as research funding sources, such as the National Science Foundation's recent focus on shifting community relationships in Arctic research [11]. The focus on race and colonialism in these initiatives has been highlighted in studies on pedagogical practices in geoscience. An analysis of geoscience textbooks found pervasive themes that included sexist messaging, people of color portrayed in negative aspects, and positive and nationalist messaging about military-industry complex [12]. Other work brought feminist science perspectives into climate system curricula[13]. I recently led

[8] Anne-marie Núñez, Jessica Rivera, and Tyler Hallmark, "Applying an Intersectionality Lens to Expand Equity in the Geosciences," *Journal of Geoscience Education* 68, no. 2 (2020): 97–114, https://doi.org/10.1080/10899995.2019.1675131.

[9] Pedro M Monarrez et al., "Our Past Creates Our Present : A Brief Overview of Racism and Colonialism in Western Paleontology," no. July (2021): 1–13, https://doi.org/10.1017/pab.2021.28.

[10] Melissa R Cronin et al., "Anti-Racist Interventions to Transform Ecology, Evolution and Conservation Biology Departments," *Nature Ecology & Evolution* 5, no. September (2021), https://doi.org/10.1038/s41559-021-01522-z; "URGE Geoscience," 2021, https://urgeoscience.org/.

[11] "Navigating the New Arctic - National Science Foundation," accessed June 1, 2022, https://beta.nsf.gov/funding/opportunities/navigating-new-arctic-nna.

[12] Jaime Phillips and Kathryn Hausbeck, "Just Beneath the Surface: Rereading Geology, Rescripting the Knowledge-Power Nexus," *Women's Studies Quarterly* 28, no. 1/2 (2000): 181–202, https://doi.org/10.1002/mmce.20539.

[13] Maralee Mayberry and Margaret N . Rees, "Feminist Pedagogy , Interdisciplinary Praxis , and Science Education," *NWSA Journal* 9, no. 1 (1997): 57–75, https://www.jstor.org/stable/4316487; Maralee Mayberry and Leigh Welling, "Toward

a geoscience curriculum intervention, GeoContext, that builds off this work; its aim is to incorporate a socio-political historical context in commonly taught subjects in introductory geoscience [14]. These teaching modules, with subjects that include volcanology, meteorites, landscapes, and oceanography, illustrate how the history of these studies is tied to colonial or racist histories.

At a time when geoscientists are attempting to tackle issues of diversity and equity, there is a need for positive efforts for inclusion. I aim to expand and deepen the range of practices in geology. In this piece, I raise the possibility of telling alternate stories – stories that resist the dominant cultural narrative of heroic origins of US geology. I propose telling a multiplicity of stories, which include the racialized and colonial threads within geology. Instinctually, as geologists we may avert our gaze from difficult pasts. Nevertheless, telling darker stories can allow for a full and complex history. Learning about these darker histories of racism helped me to recognize and weave through existing power dynamics in geoscience. From my perspective, such knowledge can illuminate pathways for those on the margins to navigate the tunnels of geology's modern social structure, which carry traces of its problematic foundation through culture and practice.

Building off literature in geoscience education and embodiment in anthropological fieldwork, I focus on the field as a site of performance through cultural conditioning. First, I document origin stories told about the foundations of US geology through a textual analysis of undergraduate textbooks. Next, I ask how these stories set behavioral norms for field geologists by analyzing North American field geologists' language in field experience descriptions. Finally, I turn to undergraduate training practices, considering which stories are told and which stories are omitted in undergraduate field education. By invoking concepts of performativity from

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Developing A Feminist Science Curriculum : A Transdisciplinary Approach To Feminist Earth Science Education," *Transformations : The Journal of Inclusive Scholarship and Pedagogy* 11, no. 1 (2000): 1–16.

[14] Tamara Pico et al., "GeoContext: A Social and Political Context for Geoscience Education," 2021, https://doi.org/https://doi.org/10.6084/m9.figshare.14158457.

feminist theory, I theorize the field geologist's formation through repeated practice imposed by a culture ingrained within narratives.

Documenting Geology Origin Stories

In US Earth science courses, both introductory and advanced, the glorification of US 19th century geologists is common practice. Stories about the origin of the discipline become formalized through undergraduate teaching and are documented in textbooks. These stories indicate to students where the discipline came from and what values geologists hold as a discipline. I document the language of origin stories used in undergraduate geoscience textbooks published in the US, which frequently include anecdotes about foundational characters in 19th century US geology.

For example, most geologists trained in the US are familiar with John Wesley Powell, who is famous for leading a government-sponsored expedition to raft down the Colorado River into the Grand Canyon. A classic textbook published in the 1970's recounts the Powell expedition in heroic terms, insisting that today it is "still an adventure" to travel the Colorado River and repeat the "first perilous journey" led by Powell in 1869 with "his party of nine men in four small rowboats". The textbook shares that Major Powell was a geologist that contributed to founding the United States Geologic Survey (USGS), becoming one of the agency's first leaders++[15].

Nevertheless, Powell's legacy is more complicated. Powell also conducted ethnographic work on Native American tribes in the regions he was mapping out [16]. Powell used ethnographic research on Ute languages to justify the superiority of English and Christianity, and the inferiority of Native American cultures, noting that "next to teaching them to work, the most

[15] F. Press and R. Siever, *Earth* (San Francisco, CA: Freeman, 1974).
[16] Wallace Stegner, *Beyond the Hundredth Meridian; John Wesley Powell and the Second Opening of the West* (Cambridge, MA: The Riverside Press, 1954).

important thing is to teach them the English language. Into their own language there is woven so much mythology and sorcery that … the ideas and thoughts of civilized life cannot be communicated to them in their own tongues." [17]

With a powerful role in government decisions around Native American affairs as the director of the USGS and head of the Bureau of Ethnology at the Smithsonian, Powell was commissioned by the Bureau of Indian Affairs to report on the status of Native American tribes in the Canyonlands and make recommendations on how to integrate these peoples into white American society[18].

Powell collaborated with Nathaniel Southgate Shaler, a Harvard professor in geology who, at the turn of the 20th century, wrote volumes detailing how North American topography is unfit to produce civilized peoples, yet perfectly suited for the institution of slavery [19]. At Harvard, Shaler was one of numerous faculty involved in research with strong bends of scientific racism that ultimately contributed to the eugenics movement [20].

More recent textbooks echo a similar adventuring and glorifying rhetoric about Powell. A 2010 textbook extols that "[Powell's] greatest feat was a journey by boat through the Grand Canyon of the Colorado River in 1869" [21]. A later edition of this textbook even adds additional detail highlighting Powell's bravery: "John Wesley Powell saw service during the Civil War. He lost his

[17] J.W. Powell and G.W. Ingalls, "Report of Special Commissioners J. W. Powell and G. W. Ingalls on the Condition of the Ute Indians of Utah; the Pai-Utes of Utah, Northern Arizona, Southern Nevada, and Southeastern California; the Go-Si Utes of Utah and Nevada; the Northwestern Shoshones" (Washington, D.C., 1875).

[18] Stegner, *Beyond the Hundredth Meridian; John Wesley Powell and the Second Opening of the West*.

[19] Nathaniel Southgate Shaler, *Nature and Man in America* (New York: C. Scribner's Sons, 1897).

[20] Luca Fiorito, "SOCIAL STRATIFICATION , HEREDITARIANISM , AND EUGENICS . A HARVARD TALE $," in *Including a Symposium on Robert Heilbroner at 100: Research in the History of Economic Thought and Methodology*, vol. 37, 2019, 99–144, https://doi.org/10.1108/S0743-41542019000037C006.

[21] Harold Levin, *The Earth Through Time* (John Wiley & Sons, Ltd, 2010).

right arm as a result of a wound received during the Battle of Shiloh. That handicap, however, did not curtail his geologic work in the slightest." [22]

This language highlights the values held by geologists today. According to these stories, geologists are those that seek out adventure. Geologists persevere when faced with any physical barrier. The description of Powell's body and actions becomes a "supercrip" narrative of overcoming adversity [23], and such stories produce complex responses for the disabled community [24]. Stories about Powell in textbooks published in both the 1970s and 2010s focus on heroism, adventure, and danger, echoing themes of white manly heroism identified in 19th and early 20th century US society [25]. Throughout decades this origin story has been repeated, without including Powell's more complex racialized legacy.

Louis Agassiz is frequently discussed in geology courses for his contributions to glacial geology, despite his outsized contributions to racial science [26]. In geoscience textbooks Agassiz is described as a naturalist and geologist.

A 1970s textbook lauds Agassiz's accomplishments as a "a young professor, not yet thirty" who was a "pioneer in the measurement of glacier flow", recounting how Agassiz and his students

[22] Harold Levin, *The Earth Through Time* (John Wiley & Sons, Ltd, 2013).
[23] Sami Schalk, "Reevaluating the Supercrip," *Journal of Literary & Cultural Disability Studies* 10, no. 1 (2016): 71–86, https://doi.org/10.3828/jlcds.2016.5.
[24] Kenny Fries, "The HIstory of My SHoes and the Evolution of Darwin's Theory," 2007, 1–14.
[25] Naomi Oreskes, "Objectivity or Heroism? On the Invisibility of Women in Science," *Osiris* 11, no. Science in the Field (1996): 87–113; Gail Bederman, *Manliness and Civilization: A Cultural History of Gender and Race in the United States, 1880-1917* (University of Chicago Press, 1995); Sarah Jaquette Ray, *The Ecological Other: Environmental Exclusion in American Culture* (University of Arizona Press, 2013).
[26] Louis Menand, "Morton , Agassiz , and the Origins of Scientific Racism in the United States," *The Journal of Blacks in Higher Education* 34, no. 34 (2001): 110–13, https://www.jstor.org/stable/3134139.

built a hut on a glacier and tracked its velocity. This textbook notes Agassiz as "instrumental" in founding glacial geology "here", in the United States[27].

A 2010 textbook emphasizes Agassiz as a well-regarded American scientist: a Harvard professor who founded the Harvard Museum of Comparative Zoology and published important studies[28].

Through the decades, these textbook anecdotes include no hints to Agassiz's more complex legacy aimed at justifying white supremacy and racial hierarchies. Agassiz advocated for polygeny, the idea that different human races were different species, and thus should not intermix. Agassiz's research included studies of skulls and daguerreotypes often collected without consent [29]. Indeed, the development of racial science in US universities parallels the involvement of higher education in the institution of slavery [30]. Academic scientists at 19th century US universities expounded the use of science to justify racial categories and hierarchies. Agassiz and his contemporaries played important roles in legitimizing ideas about racial hierarchy, bolstered by their position as scientists. Nevertheless, the stories told about these individuals in undergraduate geoscience textbooks highlight certain aspects (brilliance, discovery, or bravery) while burying colonial and racist motivations.

Origin stories in geoscience textbooks offer cultural cues to students about the discipline. These stories about the foundation of US geology underscore geology as a discipline of exploration and adventure. This narrative avoids US geology's connection to white supremacy and colonialism. These stories mark the geologist's body with implicit social categories of gender, race, and able-bodiness. Historians of science are aware of the connection between geology

[27] Press and Siever, *Earth*.
[28] Levin, *The Earth Through Time*, 2010.
[29] Deirdre Fernandes, "Agassiz Descendants Put Pressure on Harvard to Give up Slave Photos," *Boston Globe*, 2019; Menand, "Morton , Agassiz , and the Origins of Scientific Racism in the United States."
[30] Craig Wilder, *Ebony and Ivy: Race, Slavery, and the Troubled History of America's Universities* (Bloomsbury Publishing, 2013).

and imperialism in the US [31]. However, knowledge of this critical literature has not been integrated into stories told by geologists about the origin of the discipline. Retelling these stories reinforces a narrative that privileges the white, masculine, and exceptionally fit body (set on overcoming any physical obstacles), as the legitimate field geologist. The repetition of these stories and practices makes the cultural norms and expectations for the geologist's body, and its performance, appear neutral and natural.

How do practicing field geologists connect to origin stories? The Hero-Scientist Trope

In geology, stories from the field elicit awe and honor. In graduate school, when a fellow student returned from the field, I sat listening to harrowing tales of a postdoc nearly falling off a waterfall to his death as the research group climbed across rocks in Peru. Geologists place especially high value on field work in remote-to-access areas. In scientific talks I have regularly witnessed speakers include photographs from the field that highlight an especially dangerous aspect of field work (crossing a river rapid, scaling mountains in a blizzard, or camping near polar bears). For example, a 2021 virtual series on Precambrian research featured a talk with multiple slides showcasing the field conditions, which included a description of "boats overladen with equipment and food" and a field camp photo taken "at about 1 o'clock in the morning when we finished setting up" after being stuck in a "bad storm" and moving camp at 9 pm [32].

These field anecdotes reify the notion of the tough and rugged geologist. The implicit requirements for a geologist's body and its performance are signaled through stories that emphasize physical and mental rigor. Such a narrative about geologists fits snugly into the

[31] Megan Black, *The Global Interior: Mineral Frontiers and American Power* (Harvard University Press, 2018); Michael F. Robinson, *The Coldest Crucible; Arctic Exploration and American Culture* (Chicago: University of Chicago Press, 2006).

[32] Rob Rainbird, "Old Mushrooms to Meteorite Impacts: Highlights from a Geological Transect along the Coppermine River, Canadian Arctic," Virtual Seminars in Precambrian Geology, 2021, https://www.youtube.com/watch?v=6YKI2dHeGc0.

"hero-scientist" role, which, as Mary Terrall analyzed in "Heroic narratives of quests and discovery", required "risk-taking and physical toughness, to accompany the intellectual brilliance required of the successful man of science" [33]. These actions linked to masculinity, as "men sought glory through the emulation of soldiers", which rendered science a means for seeking honor.

Today the hero-scientist trope is accessed through stories of danger in the field. By choosing (and bragging about) dangerous field sites in scientific talks, geologists prove character through sacrifice, a theme analyzed by Rebecca Herzig in *Suffering for Science* [34]. As Herzig illustrates, the suffering by scientists which legitimizes their place as heroes can only be accessed by some bodies. For example, the Peary expedition to the Arctic glorifies the suffering of the two white men explorers, extolling how their brilliant discoveries rested on these sacrifices, while diminishing and silencing the contributions of the Matthew Henson, the black male explorer who was "arguably the most crucial member of the team"[35].

In *The Coldest Crucible*, Michael Robinson argues that the combination of science and exploration reinforced 19th century notions of masculinity: "traits considered essential to science, such as rationality and discipline, also played important roles in defining ideals of manliness". These explorers attained status through storytelling, using "different forms of rhetoric—scientific, manly, and moral", and such stories "more than specimens or scientific observations, constituted the real currency of Arctic exploration" [36]. Naomi Oreskes, in "Objectivity or Heroism", uncovers how the perception of "scientific heroism," a characterization less likely attributed to women, plays an important role in validating scientific

[33] Mary Terrall, "Heroic Narratives of Quest and Discovery," in *Configurations*, vol. 6 (John Hopkins University Press, 1998), 223–42.
[34] Rebecca Herzig, *Suffering for Science: Reason and Sacrifice in Modern America* (New Brunswick, N.J.: Rutgers University Press, 2005).
[35] Herzig.
[36] Robinson, *The Coldest Crucible; Arctic Exploration and American Culture*.

work as "objective" [37]. Scientific talks that include images and anecdotes of remote-to-access field sites and physical challenges affirm these aspects of fieldwork as part of scientific ability. These stories make implicit claims for what kinds of bodies can perform this science today. The markers for this body are gendered and raced, reinforcing the white and masculine hero-scientist role.

How do practicing field geologists connect to origin stories? The privileging of remote sites

Remote-to access-sites offer the opportunity to prove scientific value through physical rigor. I posit that a deeper analysis suggests that privileging remote field work is connected to racialized perceptions of nature. The conceptual history of nature and wilderness is tied to ideas about racial purity and human primitivity [38]. A common metaphor in scientific reports or expedition narratives written by 19th century US geologists is that of celestial or divine objects. Powell described his descent into the Grand Canyon as a descent into hell, likening the stratigraphy to pages in a bible [39]. This language fits into a larger trend in the 19th century, where wilderness was depicted as containing the supernatural just behind the surface [40]. In *Black Faces, White Spaces*, Caroline Finney illustrates how during the mid-19th century, landscapes inhabited by Indigenous peoples were thought to represent untouched nature, and these places, uninhabited by white US Americans, became idolized as sites of national identity (Finney, 2014). In *The Ecological Other*, Sarah Jaquette Ray argues that rhetoric about conservation was "more about body politic", citing the "wilderness as a purification tool for the ideal Anglo American man". Despite viewing Native American bodies as something to be sacrificed for environmental good, the "Native American body is seen to be 'at one with'

[37] Oreskes, "Objectivity or Heroism? On the Invisibility of Women in Science."
[38] William Cronon, *Uncommon Ground: Toward Reinventing Nature* (New York: Norton & Co, 1995).
[39] John Wesley Powell, "Exploration of the Canyons of the Colorado." (New York: Dover Publications, 1895).
[40] Cronon, *Uncommon Ground: Toward Reinventing Nature*; Carolyn Merchant, *Reinventing Eden: The Fate of Nature in Western Culture* (Routledge, 2003).

nature" [41]. Through the institution of slavery, Black people were similarly rendered a part of a primitive nature scene "treating them with the same mixture of contempt, false reverence, and real exploitation that also marks American environmental history" [42].

Ideologies about race and wilderness have influenced the relationship of people of color in outdoor spaces in the United States[43], and these stories continue to have an impact today. As geology formalized as a discipline in the 19th century, ideas about race and nature were implicit in research practices. As Pratik Chakrabarty shows in *Inscriptions of Nature*, in India under British colonial rule, ancient landscapes were used to make claims on the ancientness and primitivity of Indigenous populations [44].

Today, field sites that are seen as remote or difficult-to-access are often considered pure and untouched knowledge vessels by Western scientists. Geologists are likely familiar with colleagues justifying the choice of a field site by explaining that "no one" has mapped this region since pre-plate tectonics theory (1970s) or that there are no measurements of X technique in this region. One perspective shared in an interview with a field geologist notes:

> Working in the Arctic, working in Mongolia, what really attracts me to places like this is that they're so undescribed, so unknown. You go out there and make a lot of first order observations, and you're seeing it for the first time. Nobody has seen these, nobody has made these observations, so there's still this really fresh sense of discovery. [45]

[41] Ray, *The Ecological Other: Environmental Exclusion in American Culture*.
[42] Caroline Finney, *Black Faces, White Spaces: Reimagining the Relationship of African Americans to the Great Outdoors* (Chapel HIll: The University of North Carolina Press, 2014).
[43] Finney.
[44] Pratik Chakrabarti, *Inscriptions of Nature: Geology and the Naturalization of Antiquity* (John Hopkins University Press, 2020); P Chakrabarti, "Gondwana and the Politics of Deep Past," *Past and Present* 242, no. 242 (2019), https://doi.org/10.1093/pastj/gty016.
[45] "Becoming a Geologist," Harvard Museum of Natural History, 2014, https://www.youtube.com/watch?v=aPUO-buB088.

This geologist views their knowledge of a remote site as the "first" despite these spaces being inhabited by people, who have likely made "first order observations".

In a flashback to 19th century geology, spaces deemed wild, natural, and primitive are privileged for field work, and one feature of these spaces is their inhabitation by Indigenous populations. Thus, the field sites most valued by geologists are those where the Indigenous population forms a part of this nature scene, rendering communities of color invisible as humans, and camouflaged into the landscape. Geologists may be drawn to conducting research in these areas to gain legitimacy through the heroic explorer scientist trope. Unaware, or unable to articulate these power dynamics, the US geologist mimics the same oppressive practices performed by 19th century colonialists, exploiting natural and human resources to attain their scientific goals. I argue that field geology today continues to uphold disciplinary cultural norms that privilege remote sites as closer to understanding primitive nature. These practices result in an emphasis on remote sites and a tendency to view Indigenous populations as part of field site's resources.

Is the choice of remote sites driven by geology origin stories about the primitivity of landscapes inhabited by Indigenous populations? Do field geologists form an intellectual wall between the physical geology they are studying and the humans that inhabit this space? If so, geologists' determination to separate the geology from the people mirrors other scientific disciplines that impose strict boundaries between the scientific and the social [46]. Or do geologists view this population as part of the existing toolset at their field site? This case recalls 19th century geologists who wrote about Indigenous people in their same reports about rocks, imagining them as a primitive part of the landscape they studied. In this situation, the field site blends natural and human resources. Such practices perpetuate stories about what bodies can be seen as legitimate scientists and what bodies can be seen as part of the landscape.

[46] Sandra Harding, *Sciences from Below: Feminisms, Postcolonialities, and Modernities* (Duke University Press, 2008).

How do practicing field geologists connect to origin stories? Embodied identities in the field

Modern geologic fieldwork shares some themes with 19th century nationalist-driven geology. The history of military involvement in nationally sponsored geography and geology expeditions renders the field a site of conquest. As examined by Matthew Sparke in "Displacing the Field in Fieldwork", fieldworkers are free to enter and leave their field site, a position that communities inhabiting this space cannot claim [47]. In this way, field geologists mimic the military in how they enter a site unexpectedly, dominate this space and acquire resources, and remove themselves when their goal is complete. The status of the fieldworker plays an important role in acquiring this level of power. I interviewed a colleague who is a PhD student in field geology, who shared that

> the culture of the country you're in affects how you behave. In [country of field site] there are conservative ideas for the role of men and women. Guys will wrestle and horserace, but they'll expect different things from women. My male colleague played into these roles… It's a way of earning people's respect that is less accessible for me

The position of gender and race mark the fieldworker in the new field space and modulate access to power over resources in this space [48].

Challenges accessing a field site, such as trekking through mountains for days with little (or rotten!) food, or hitchhiking on motorbikes, are seen as an aspect of scientific rigor, and the more remote or untouched by other scientists, the more prestigious the work. These challenges can be safer for certain identities: my colleagues who are white men have lodged at brothels during fieldwork, which my women colleagues have told me would be uncomfortable or unsafe situations for them.

[47] Sparke, "Displacing the Field in Fieldwork."
[48] Henderson, "' We Thought You Would Be White': Race and Gender in Fieldwork"; Robert M Vanderbeck, "Masculinities and Fieldwork : Widening the Discussion," *Gender, Place & Culture* 12, no. 4 (2005), https://doi.org/10.1080/09663690500356537.

Norms in geologic fieldwork that stress rugged heroism are designed for only some bodies to feel safe. These norms are laden with social markers and expectations. My field geologist colleague notes how she feels less valued in the field because of her smaller size: "I'll feel bad about not being able to carry things, they'll say just hand it to me and not get in my way". This colleague also cites the need to act in a certain way: "In the field there is pressure to suck it up, you have to get along with people. You're really dependent on other people for work to happen. If you upset them, they can cut you off easily. You're in a foreign country with no resources". For instance, choosing to "suck up" racist comments to preserve relationships with scientists who are "giants in the field".

Through these comments, we can see that there are expectations for a field geologist's behavior that extend beyond research outcomes. The expectations for exceptional physical ability and adventurous character evoke the historical archetype described in origin stories, always a white man. While anyone may be punished for not fitting the behavioral mold, bodies that are not white, able-bodied, straight, and cis-gendered male will be subject to additional challenges. These bodies may be expected to brush off comments or situations that reveal their body to be otherwise. When the training of new field geologists includes physical ability and adventure-seeking as scientific rigor, stories are repeated about who can be seen as a legitimate field geologist.

The repetition of stories and behaviors sets cultural rules and disciplinary norms. These repeated practices become part of the quotidian, making the rules seem natural. As these rules are imposed, an idealized field geologist body is constructed. In this way, becoming a field geologist can be seen as a performance, through imitating the behavior of others seen as legitimate field geologists, and cued by cultural norms and values expressed in storytelling. These social performances, which share similarities to the origin stories that are alive in the discipline, are then transmitted to the next generation. Therefore, I argue that stories do not necessarily produce bodies. Rather the curation and transmission of origin stories produce a culture that imposes regulations on the performance of bodies. Through these repeated

performances, the field geologist' body becomes recognizable as such. These stories curate which bodies can tell the stories, and which bodies can be the subject of stories.

What stories are omitted in undergraduate field training? Racist and sexist encounters

Field experiences in undergraduate geoscience are seen as central and formative to a geologist's training [49]. As of January 30, 2022, many Earth Science departments in the US have websites that explicitly require or strongly encourage a class focused on fieldwork for undergraduate majors [50]. The respected role of the outdoors in geoscience education is highlighted in a study analyzing field learning, which adds that "studying geology in the field has also contributed to the social structures that have served to train generations of geoscientists".

Underrepresented minorities make up < 7% of undergraduate geoscience majors in the US[51]. Studies analyzing factors for underrepresentation of students of color in geology cite the importance of early experiences in the outdoors, which are more common for white students, and socioeconomic barriers related to expense and unfamiliarity with camping (and other outdoor) gear[52]. Although undergraduate field courses often reinforce values included in origin stories such as those shown in geoscience textbooks, stories about exclusion (such as the reasons students of color are less likely to declare geology as a major) are less often included.

[49] J. Anadu, H. Ali, and C. Jackson, "Ten Steps to Protect BIPOC Scholars in the Field," *EOS*, 2020, https://doi.org/https://doi.org/10.1029/2020EO150525; Robert P. Sharp, "Earth Science Field Work : Role and Status," *Annual Review of Earth and Planetary Sciences*, 1988.

[50] "UT Austin Jackson School of Geosciences," n.d., https://www.jsg.utexas.edu/wp-content/uploads/2021/04/EVS_20-22_Degree_Plan.pdf; "Colorado College Geology," n.d., https://www.coloradocollege.edu/academics/dept/geology/courses/; "University of Wyoming Geology," n.d., http://www.uwyo.edu/geolgeophys/undergraduate/bs-geology.html; "University of Montana Earth Sciences," n.d., https://www.montana.edu/earthsciences/programs/Images/geo2012_14.pdf.

[51] Stokes, "Why Are There so Few Hispanic Students in Geoscience ?"; Rachel E Bernard and Emily H G Cooperdock, "No Progress on Diversity in 40 Years," *Nature Geoscience*, no. April (2018), https://doi.org/10.1038/s41561-018-0116-6.

[52] Núñez, Rivera, and Hallmark, "Applying an Intersectionality Lens to Expand Equity in the Geosciences"; Stokes, "Why Are There so Few Hispanic Students in Geoscience ?"

There are stories not told to students about the ableist, sexist, and racist encounters they will experience when they go into the field. Many field courses are conducted in rural regions of the United States, areas which are frequently openly hostile towards non-white US Americans. A recent video published by a geoscience undergraduate student recounted the constant racial tension he experienced as a Black person working in the field in the heart of the United States, including being stared down, being ignored by locals who spoke past him to his white colleagues, and threatening run-ins with people that had white supremacist and neo-Nazi symbols on vehicles or tattoos [53].

A recent campaign notes that more than 1400 place names in the United States contain racial slurs. While these names can be found in every state, the majority are in Western and Southern US states, and appear in rural regions where geologic fieldwork takes place. The geoscientists behind this campaign emphasize the uneasy effect of these place names: "we cannot ask for more diversity in the geoscience community and then put geoscientists of color in the situation of confronting this language in their daily work" [54]. While many of these names may be remnants from decades or centuries ago, these place names serve as visible reminders of the deeply rooted white supremacist ideologies that continue to haunt these landscapes.

During my month-long field camp in graduate school near Death Valley, California, every day when we drove out of our base camp, we passed a water tower vandalized with Latinx slurs. Racism during field experiences, either through encounters or language written on the landscape, will predominantly target students of color. Although such racist encounters may come from outside the geology community, an understanding of 19th century US geology

[53] Josh Anadu, "Hazards of Field Work While Black," YouTube, 2020, https://www.youtube.com/watch?v=W0B7xwGkl00&fbclid=IwAR2J-fuDcmRrBGApXXFFNxitxoOAq4NugVTJPbFmEeCZX8q6_PNZx6VgLGc.

[54] Meghana Ranganathan et al., "America's Maps Are Full of Racial Slurs—and That Needs to Change," *Scientific American*, 2021, https://www.scientificamerican.com/article/americas-maps-are-full-of-racial-slurs-and-that-needs-to-change/.

suggest that implicit storylines within the discipline related to imperialism, colonialism, and racial science play some role in these modern symptoms of a racist system.

Students are not often told stories of sexual abuse, despite the high likelihood of occurrence in field settings. Studies that show high rates of sexual harassment and sexual assault (experienced by ~70% of study participants) in fieldwork environments [55]. Such studies indicate that women of color are at particularly high risk for incidents of sexual harassment [56]. Recently, there has been a push for leaders in the field to purposefully anticipate these dangers[57]. Not only can geologists preempt these problems through preparation, but we can also understand the history of why they occur in our discipline. By bringing to light the history of colonialism and racial science in geology, it is possible to identify deeply ingrained cultures and practices that lead to race- and gender-based exclusion and harmful behaviors.

What stories are omitted in undergraduate training? Epistemic injustice

The exclusion of discussion surrounding the racist nature of foundational geology leaves an absence in knowledge that would allow a student of color to contextualize their experience in geology. This absence in knowledge regarding a significant part of this student's social experience is an example of systemic hermeneutical injustice, a term coined by Miranda Fricker to refer to structural prejudice that limits access to shared resources for interpreting social

[55] Clancy et al., "Survey of Academic Field Experiences (SAFE): Trainees Report Harassment and Assault."
[56] Clancy et al., "Double Jeopardy in Astronomy and Planetary Science: Women of Color Face Greater Risks of Gendered and Racial Harassment."
[57] Anadu, Ali, and Jackson, "Ten Steps to Protect BIPOC Scholars in the Field"; Amelia-juliette Claire Demery and Monique Avery Pipkin, "Safe Fieldwork Strategies for At-Risk Individuals, Their Supervisors and Institutions," *Nature Ecology & Evolution* 5, no. January (2021): 5–9, https://doi.org/10.1038/s41559-020-01328-5; A. N. Olcott and M. R. Downen, "The Challenges of Fieldwork for LGBTQ+ Geoscientists," *EOS*, 2020, https://doi.org/https://doi.org/10.1029/2020EO148200.

514 experiences [58]. Without access to an intellectual framework through which to understand their
515 lived experiences in geology, students are disconnected from epistemic resources that would
516 aid them in understanding which parts of their social experience are shared or isolated.
517
518 Because US undergraduate geology programs have a small number of majors that are students
519 of color[59], these students are less likely to have their experiences validated by others with
520 similar experiences. Furthermore, students of color may not be successful in having their
521 voices heard. As Kristie Dotson describes, because the audience (leaders in geology
522 departments) may not identify the speaker (a student of color) as a knower, their epistemic
523 authority may be questioned [60]. This epistemic silencing limits the ability of students to be
524 supported or even to testify to their own race-modulated experiences.
525
526 Furthermore, Dotson defines the idea of "testimonial smothering", where a speaker may
527 identify limitations in the audience's willingness or ability to appropriately understand the
528 testimony of their experience. Testimonial smothering results in the speaker curating their
529 testimony, such that it only contains content that the audience is deemed competent to grasp
530 (Dotson, 1998). Thus, students of color, realizing the limits of their leadership, may offer
531 abridged palatable versions of their experiences – such that leaders will inherently be limited in
532 knowing how race modulates students' experiences. This process perpetuates narratives told
533 by white field geologists.
534
535 Geology origin stories told to students exclude racialized histories and continue to glorify white
536 men invested in movements designed to uphold white supremacy. Student perspectives that do
537 not align may be smothered by a dominant white narrative before a student is even capable of

[58] Miranda Fricker, "Hermeneutical Injustice," in *Epistemic Inustice: Power and the Ethics of Knowing* (Oxford: Oxford University Press, 2007), https://doi.org/10.1093/acprof.
[59] Stokes, "Why Are There so Few Hispanic Students in Geoscience ?"
[60] Kristie Dotson, "Tracking Epistemic Violence , Tracking Practices of Silencing," *Hypatia* 26, no. 2 (1998).

articulating their experiences. Therefore, only certain bodies are allowed to tell stories about geologists, their bodies and how they behave. The retelling of origin stories is then codified.

GOING OFF SCRIPT: A MULTIPLICITY OF STORYTELLING IN GEOLOGY

In geology the field is a site bridging past and present. You can sweat in the desert sun, standing on rocks full of pebbles dropped by icebergs from a mostly or entirely ice-covered globe over half a billion years ago. Layers of time and climate are stacked and melted into each other. By critically examining how geologists act in this space, I aim to uncover and intercept deeply ingrained cultural patterns. I theorize the field as a site of performance predetermined by disciplinary cultural norms. I posit the field as a site where generations of storytelling set rules for behavior.

In this article I attempted to demonstrate that the behavioral norms required for US field geologists to be recognized as legitimate are encoded in the discourse of origin stories told in field geology training and research. Curated origin stories about the foundations of US geology are repeated to the next generation of geologists in field training. However, the racist subplots of these histories are often omitted, even though they foreshadow the racialized and sexualized encounters many students face when they enter the field. The omission of such stories perpetuates patterns of exclusion and abuse in both training and research practice.

This essay suggests a critical intervention in the discourse about the origin of US geology. By examining the values and practices ingrained in disciplinary narratives, is it possible to intercept the retelling of dominant storylines to insert space for alternate practices and viewpoints? Can we crack open the stories we've been told and unpack the values they teach? Can we begin to tell a multiplicity of stories that allow new possibilities for the future of geology?

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