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"you just look at rocks, and have beards" Perceptions of Geology From the United Kingdom: A Qualitative Analysis From an Online Survey

Steven L. Rogers[1]*, Sam Giles[2], Natasha Dowey[3], Sarah E. Greene[2], Rehemat Bhatia[4], Katrien Van Landeghem[5] and Chris King[6†]

[1]School of Geography, Geology and the Environment, Keele University, Keele, United Kingdom, [2]School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, United Kingdom, [3]Department of the Natural and Built Environment, Sheffield Hallam University, Sheffield, United Kingdom, [4]Earth Science Women's Network, Madison, WI, United States, [5]School of Ocean Sciences, Bangor University, Bangor, United Kingdom, [6]Keele University, Keele, United Kingdom

In the last few decades, Geology courses, particularly in the Global North, have seen a decline in student enrolment. Geologists have linked this downturn to a lack of exposure to the subject at school and college level. This work seeks to understand the public's relationship with Geology and draws on over 5,000 open-ended question responses to a survey disseminated in 2021. The survey asked both those who had, and had not, studied geology as a subject a series of questions in order to explore their perceptions of the discipline. Our findings indicate that individuals "outside" of geology see the subject as old fashioned, boring, and environmentally damaging; simply the study of rock samples with nothing new to be discovered from; and with poor job prospects outside of the oil and gas industry. Geologists who responded to the survey paint a picture of a broad, interdisciplinary subject, with vibrant employability opportunities—yet struggle to coherently and collectively describe this when asked, "what is geology?". In addition to the identified perception of geology as boring, and notions of poor employability being a barrier to prospective students, diversity and inclusivity issues are highlighted as significant barriers by those who study geology. Our findings indicate that both geologists and the geology curriculum need to coherently describe what geology *is* more effectively. We need to develop and better communicate the subject's interdisciplinary nature and links to critical societal issues, such as the role of responsible mineral extraction in the energy transition and the importance of geology in vital areas such as climate change science, water resource management, environmental conservation, and sustainable urban/built development. Finding new ways to show that, far from being boring, geology is a subject that can fundamentally change the way you see and interact with the world around you is of central importance to achieving this. Efforts to make the subject more equitable are also highlighted as being critical in creating a more inclusive and accessible discipline.

Keywords: geology, perceptions, boring, EDI, employment

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Kathryn Goodenough,
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Royal Scientific Society, Jordan
Kirstin Lemon,
British Geological Survey, The Lyell Centre, United Kingdom

***Correspondence**
Steven L. Rogers,
s.l.rogers@keele.ac.uk

[†]Deceased

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INTRODUCTION

A long-term decline in the number of students studying geology and allied subjects has led to continued concerns from academic and industry geoscience communities (Mirsky, 1990; Riggs and Alexander, 2007; Davis, 2012; Boatright et al., 2019; Wadsworth et al., 2020; Geoscience on the chopping block, 2021; Macallan, 2023). Geology and geoscience courses have been reduced or removed from a range of universities both in the UK and internationally (Geoscience on the chopping block, 2021; Selway, 2021). Many have linked this drop in student numbers to the loss of vocational opportunities in the oil and gas sector and poor perceptions of alternative and other extractive industries (e.g., Simmons, 2019; Whitchurch, 2019). There is evidence that recent geology students identify less with the image of an 'exploitative' scientist and prefer to highlight the role of geology towards a sustainable future (Almeida et al., 2013; Carter et al., 2021). However, most views on why student recruitment is in decline are typically anecdotal and assumed, and derived principally from those in geology-related disciplines, be that academic, industry or otherwise affiliated. Crucially, the voices of individuals from outside the discipline are missing; especially those of prospective students, individuals who have never (formally) studied the subject, and those with no strong interest in geology at all.

In this study, we investigate perceptions of geology among a wide range of individuals from the United Kingdom, and those who have studied in the United Kingdom. While this work is focussed on UK geology programmes, our work complements global discussion of falling recruitment and perceptions of geology.

In order to investigate perceptions of geology and possible reasons for its slide in recruitment, we surveyed nearly 600 people, all over the age of 16, including both those who have studied geology and those who have not. Here we present analysis of over 5,000 responses to open-ended questions (in addition to closed questions) to understand feelings towards, and concepts of, geology, and whether these perceptions vary between different groups and identities. We also explore potential barriers to studying geology, their role in perceptions of the discipline, and discuss ways to change practice and remove these barriers.

We hope that the results of this study help geologists to reflect on their subject, behaviour and teachings, and form the basis for creating a discipline that is inclusive, diverse, just and accessible; a discipline that embraces its interdisciplinarity, that is aware of and prepared for the grand challenges that society faces and can meaningfully work towards a sustainable and equitable future. This study shows that geology is probably quite different to how many of us describe it; we advocate for working towards a different self-conceptualisation and a new, more coherent, definition of the subject that requires innovative communication and framing.

PERCEIVED BARRIERS TO STUDENT RECRUITMENT AND STUDY IN GEOLOGY

Geology treads a difficult path in the UK education sector. The discipline is absent from the curriculum as a subject in its own right until GCSE level (typically sat by students aged 14–16), and then only at a select number of schools. Prior to this point, and in schools where the subject is not available, geology is taught incidentally as part of other subjects, leading to limited comprehension of what geology "is" (King, 2008). Boatright et al. (2019) highlight that numbers of students taking geology A-Levels fell from over 4,000 in the early 1980s to 1,525 in 2018. They also raise important points around reasons for poor recruitment, highlighting teacher confidence and ability to teach geology, and significant reduction in the availability of geology in schools and colleges, which is likely to have negatively affected recruitment at degree level. These factors lead to a commonly invoked barrier to student recruitment—a lack of exposure to the subject pre-university. However, comparison with other courses that have no availability at GCSE or A-Level, such as Forensic Science, suggests that this is not necessarily a barrier to recruitment. The increase in Forensic Science student numbers has been linked not to an increase in career prospects—in fact it has been highlighted that there are very few employers in the sector (SEMTA, 2004)—but rather student perceptions of the discipline, enhanced through television dramas and high-profile media coverage (SEMTA, 2004; Rincon, 2005; Alldredge, 2015). 45% of students surveyed by SEMTA (2004) indicated a main reason for pursuing Forensic Science was a general "interest in science."

While GCSEs and A Levels are only offered in "geology" (there is no standalone geology option for Scottish National Qualifications or Highers), degree courses are offered under a range of related names. Terms such as "geology," "geoscience" and "Earth science" are often used interchangeably. In the United Kingdom, the majority of these degrees are accredited by the Geological Society of London, who provide a broad overview of which topics and skills must be taught in order for degree courses to be accredited. Fieldwork has historically been an integral component of UK geology courses and is typically undertaken in every year of the degree, with students participating in anything from 40 to over 100 days in the field in total.

Geology and geologists appear to be less commonly presented in popular western media, with extractive industries dominating media coverage of geology. The links between fossil fuels and the climate crisis often make headlines, mining companies are exposed for destroying indigenous lands, and all extractive industries are called out for environmental disasters. Mining is irrevocably associated with words like "*Dirty*," "*Wasteful*," "*Bad for the environment*" and "*Dangerous*" (Crane, 2020), with limited discussion of the need for mining to transition to green/renewable energy (Stewart, 2023). As a result, public understanding of geology

in this context is unsurprisingly negative, with low levels of social acceptance of geoscience activities and their role in sustainability (Almeida et al., 2013; SLR Consulting Ireland, 2015). Research has also highlighted perceptions of geology as lacking both high-paying (Hoisch and Bowie, 2010) and high-prestige or altruistic career options (Sherman-Morris and McNeal, 2016).

As well as poor perceptions of the discipline, the subject itself has accessibility and inclusion issues that have long been raised as barriers for geology student recruitment and retention. Four structural and cultural barriers that cause persistent bias against diverse student cohorts were highlighted by Marín-Spiotta et al. (2020): 1) historical legacies of exclusion, 2) hierarchical power dynamics, 3) a culture of impunity (i.e., a tolerance towards bullying, harassment, etc.), and 4) fieldwork. Núñez et al. (2020) highlight intersectional barriers to equity within the geosciences including links between social identities, the power of institutions and cultural historical context. The role of fieldwork and implications for underrepresentation of students from certain demographics has received perhaps the most attention (e.g., Clancy et al., 2014; Gilley et al., 2015; Mol and Atchison 2019; Stokes et al., 2019; Giles et al., 2020; Greene et al., 2021; Jackson, 2021). Despite this, marketing of geology degrees often highlights fieldwork opportunities; Carter et al. (2021) suggests that aligning geology courses with societally relevant and altruistic careers, for example, those that help people and the environment, may align better with the ideals of modern students.

Recent years have seen an increase in the recognition and discussion of these and other barriers embedded within the UK geology system. Many of these barriers have likely arisen and been maintained due to the closeness of the academic or discipline "silo" associated with the subject (Trowler et al., 2012; Rogers and Cage, 2017). These discipline silos tend to attract/produce students and academics who share and follow the pedagogy and epistemological knowledge sets of those who taught them. Technology, university governance, policy and processes, and—increasingly—employer expectations also play a powerful role in sculpting discipline identity, controlling who studies a subject and who belongs within a geoscience organisation (of any kind). Diversity of representation is a tangible and strong factor in individuals' choices in the activities they pursue (e.g., Adamuti-Trache and Andres, 2008; Smith, 2011; Archer et al., 2015). Geology is a relatively young and colonial discipline, born through activities of European empire (e.g., Gohau et al., 1990; Sangwan, 1993; Nyblade and McDonald, 2021; Rogers et al., 2022). It was created by wealthy, able bodied, white men with power, who are often remembered for their expeditions, travel and "pioneering" spirit. Our textbooks are dominated by images of white men, with the role of others downplayed (Mattox et al., 2008). The "Whiteness" of the subject, which reproduces racial inequalities (including pedagogical, content, social and representation issues) has been shown to impact the degree awarding gap between racial and ethnic minority students and their white peers (Singh et al., 2022).

While carrying out this research, the authors were aware of many prospective issues pertaining to geology and potential barriers to studying the subject, including those highlighted above. Although now discussed openly within the discipline, it is unclear how visible and tangible these are to those outside geology, including potential students and those within adjacent fields (e.g., archaeology).

Ultimately, there remains great uncertainty of the critical factors relating to the geology student recruitment decline, and, crucially, how to address it: are barriers to geology recruitment the same as the barriers that impact student retention once within the discipline? This survey was designed to pose and answer some of these questions, to influence the sector and its stakeholders and to drive positive change within recruitment and retention activities.

METHODS

The authors of this study came together from a range of directions, via social media discussions of geology perceptions, and from collaborations on other projects aimed at making geoscience more accessible, equitable, diverse and inclusive. Collectively, we have professional experience within sectors inside, adjacent to and outside academia. This research builds on knowledge derived from the practice and experiences of individuals who may or may not be geologists, in order to inform geological activities, communication, reputation and image building, and recruitment strategy.

We employed a grounded theory approach (Charmaz, 2014) with aspects of reflexive thematic analysis (Braun and Clarke, 2006; Clarke and Braun, 2017; Braun and Clarke, 2019; Braun and Clarke, 2021) and narrative inquiry. Grounded theory involves structured gathering and subsequent analysis of data, allowing the researcher to categorise common ideas or concepts found in the data (Glaser and Strauss, 2017). These categories are reviewed with the aim of forming a theory to explain a specific perception or behaviour. Martin and Turner (1986) encourage researchers using grounded theory to approach problems with an open mind, and to make sure that any theorised conclusions are resultant from the data, and not from preconceptions held by the researcher (they do, however, emphasise that preconceptions should not be abandoned). This methodology relies on the researcher to fully analyse gathered data before hypothesising. Whilst this approach is different to how a project is usually conducted within the natural sciences (including geology) it is a beneficial model to work with when looking at educational and societal phenomena.

Approach

The Surveys

We created and deployed a single survey with a major branch point early in its questioning. One survey pathway was

TABLE 1 | The questions asked in the survey, grouped into broad areas of questioning. The pathway differences (if a respondent has studied geology or not) are highlighted in the table.

Broad area of question	Questions
Personal Information	"How old are you?" "If known, who is your Local Council Authority (LCA)? Please indicate the LCA where your home is (i.e., not your work, school, university, etc., LCA)" "How do you describe your gender?" "How do you describe your ethnicity?" "What is your highest level of completed education to date? (e.g., GCSEs, A-Level, Bachelors Degree, Masters, PhD, etc.)" "When did you complete this qualification (if appropriate)? A rough estimate is fine." "Please indicate your religious affiliation" "How do you describe your sexuality?" "Do you have any ongoing caring responsibilities? (A sole primary carer is responsible for 100% of caring responsibilities, a primary carer carries out more than half of the caring responsibilities, and a co-carer shares up to and including half of the caring responsibilities.) Select all that apply to you." "Do you consider yourself to be an "outdoors" person? (e.g., do you like sport outside, walking in the countryside, or maybe just gardening?)" "Do you consider yourself to have a disability?" If Yes "What name would you give to your disability/disabilities?"
Experience of study/ing	"Have you ever studied geology as a subject (e.g., geology, geoscience, geological oceanography, environmental geoscience and not as a part of another subject)" If Yes "At what educational level are you studying/have you studied geology? (Select all that apply to you)" "Why did you decide to study geology?" If No "Was geology ever available as a choice for you to study?" "Why didn't you study geology?" "If geology had been a subject available to you, do you think you would have chosen to study it? Include why, if possible."
Perceptions of geology a) what is geology	"What is geology?" "What does a geologist do?" "Has anyone you know ever studied or worked in geology?"
Perceptions of geology b) Barriers, negatives and positives	"Please suggest up to three things that represent a barrier to studying geology (please type each answer in the separate space provided)" "Please give any positive perceptions you have of geology" "Please give any negative perception you have of geology" "If you could suggest one thing to improve participation in geology, what would it be?"
Subject relevance	Section 9 of the questionnaire listed a range of categories and asked respondents to rank the relevance of each to geology (on a Likert scale of 1–5–with 1 being core and 5 irrelevant) "Are there other areas you would associate with geology?" "Which three subjects do you most enjoy studying? (e.g., Art, Spanish, Physics)"

designed for individuals who were studying geology at the time of responding or had studied it in the past, and the other pathway for those who have never studied geology as a standalone subject (rather than as part of, for example, a geography GCSE). These two surveys contained slightly different wording, but the questions were very similar, allowing us to draw comparisons between the groups. The separation of respondents into those who have and have not studied geology was intended to identify any different perceptions between the groups; we do not suggest the title of "geologist" is reserved solely for individuals with formal geological education. The group of respondents who have never formally studied geology likely includes individuals who consider themselves as geologists.

Questions were shaped in part by our own thoughts of perceptions of geology, our experiences of the discipline, and what we thought people perceived the subject to be. Collectively, we—as a group—predicted that individuals (including potential students) did not fully appreciate the breadth of the discipline, or its applicability towards wider society and developing a sustainable future. We felt that there would potentially be differences in perceptions between those who had studied the subject and those who had not. Several authors suggested that individuals may perceive the subject to be niche, with a "...male, stale and pale..." stereotype, linked to destructive extractive industries, and ableist in terms of geology "mandating" working outdoors.

The questions were grouped into the following broad areas: 1) personal information; 2) experience of studying geology; 3) perceptions of geology; and 4) subject relevance (see **Table 1**). Each of these broad question groups were analysed separately from the perspective of participants who have studied/are

studying geology, and those who have not, and comparisons drawn between these groups. The majority of the questions had open text answers allowing participants to include as much detail as they wanted, and to explain or expand on points. It was felt that a survey that relied heavily on Likert scales (or similar) would not provide the same level of insight and that more interpretation/bias would likely be involved in pinpointing the reasons for the perceptions selected. However, we also acknowledge that people are less likely to give in-depth and detailed answers to online questionnaires (compared to an interview, for example) (Hay and Cope, 2021).

The surveys were designed to be anonymous, but we did collect protected characteristics data to allow for comparison between groups. We kept many of these personal information questions open, rather than using lists, to ensure individuals could identify as they wish, rather than choosing the "most appropriate" category available. This flexibility, we hoped, would be more inclusive for participants, and also allow us to get a more accurate sense of the diversity sampled.

The survey was disseminated to university and college students studying geology and cognate subjects, and was also shared on social media and emailed to over 50 relevant groups that the authors were aware of and/or had existing links with (e.g., the Earth Science Teachers Association, University Geoscience UK, The Geological Society, the Royal Geographical Society, NGO's, student societies, industry contacts, school alumni associations, etc.). When we disseminated the survey we requested that participants further share it; we do not know the total range of individuals and groups that the survey was disseminated to.

We used the term "geology" throughout the questionnaire, but introduced commonly related terms ("e.g., geology, geoscience, geological oceanography, environmental geoscience") on its first use.

Favourable ethical opinion was obtained from the relevant Institutional Ethics Committee.

Analysis

The responses to open text questions were analysed using NVivo 12 software. Responses were thematically analysed (see Braun and Clarke, 2006; Braun and Clarke, 2019; Braun and Clarke, 2021) by coding (grouping) to capture patterns or shared concepts that neatly summarise the core meaning of free text responses. Responses to individual questions were analysed and a "domain summary" assigned; a summary of the range of data for each question. Each domain summary was established from "codes," which represent the smallest unit of analysis and capture a feature relevant to the research aims (Terry et al., 2017). These codes and domain summaries are then used to form "themes," which provide a way of reporting and interpreting observations from across the entire data set.

A simplified example of this analysis would be; to the question "What is Geology?" an answer of "the study of rocks" would be coded with other similar responses. An answer of "the study of rocks to investigate Earth history" would be coded together with the former response ("the study of rocks") and would also be included in a domain summary indicating geology is involved with the study of the Earth. Through this process, common answers lead to certain "themes" being assigned to the wider responses. Themes represent common and pervasive topics, ideas, positions (etc.) that are representative across the whole data set. The answer of "the study of rocks" would ultimately contribute to a theme (or multiple themes) representing our interpretations of patterns of meaning from the data. Due to the size of our data set, the number of different questions, and the range of answers given, multiple themes were created—most of them mutually inclusive, where an answer can fit with more than one theme. We used these themes to explore the responses and compared the population of respondents who considered themselves geologists/studied geology with those who had had no formal geological education. At each stage of constructing these themes, we provide critical discussion and narrative to the analysis. For example, we highlight where perceptions were what we expected, or where they surprised us. We also suggest reasons why some perceptions may be common or why they might be incorrect. Through this dialogue, we highlight what the perception of geology is, and if it is an accurate reflection. We use the analysis to highlight ideas, thoughts and perceptions of the discipline that are (potentially) positive, but that do not currently contribute to people's perceptions of the subject. We also explore the data to suggest what a modern geologist and the modern discipline look like, and indeed could look like in the future.

RESULTS AND DISCUSSION

Personal Information

In total, 559 individuals participated in our survey resulting in over 5,000 individual responses to the open-ended questions. Most participants answered each question with a sentence or two. Most of our responses came from people living in the United Kingdom (85% indicated they lived in a UK Local Council Authority area), reflecting both the reach of the UK-based research team and the intentions of our study.

Roughly two-thirds of participants 367 (66%) had studied or are studying geology as a formal subject (i.e., a GCSE, A-level, degree, etc.). This percentage is clearly not representative of the UK population, but the bias is simple to explain: the survey was disseminated by a group of geoscientists, our networks (academic or otherwise) contain more geologists than the general public, and a survey with "geology" in the title is more likely to engage those with an existing interest in the discipline. We also wanted to include participants who had studied geology to better understand if a perceptional difference between this group and those who had not studied it. The number of participants in this study is the highest number of individuals that the authors are aware of for a study focusing on perceptions of geology, and barriers (either perceived or experienced). Similar surveys have had higher numbers of participants (Hoisch and Bowie, 2010;

Carter et al., 2021), but did not focus on open-ended text answers and thematic analysis.

Participant ages ranged from 16–79, with most individuals being 17–28 years old, but there is good representation across age ranges.

315 participants identify as female or women (57%), 218 as male or men (39%) and 11 as non-binary, genderqueer, transgender or genderfluid. 12 participants did not provide this information. The significantly higher number of female/women participants in this survey is somewhat surprising given a) the general population statistics for gender breakdown, and b) the gender imbalance in geology and cognate disciplines (HESA, 2019). 42% of respondents who have studied/are studying geology are male, compared to 34% of respondents who have not studied it. This discrepancy may be related to women/female participants feeling that they have experiences of barriers, or negative perceptions of geology, that they want to share; a perception that the author team were aware of through their own experience of geology as being a male-dominated subject with greater barriers for non-cis male individuals. The dissemination of the survey may have meant that more females and women received/saw the survey. It has also been shown that female participants are more likely to participate in online surveys (Smith, 2008).

Participants identifying as "white," "white British" or a similar category (e.g., "white Welsh") make up the largest proportion of the participant population, accounting for at least 457 (82%) responses. Some participants identified as (e.g.) British, and therefore ethnicity is impossible to ascertain for these individuals (this accounts for 11% of respondents). The UK population was 87.2% "White British" in mid-2014 according to the Institute of Race Relations (2021). Only 7% of participants identified as an ethnicity other than white, these include "Chinese" (1%), "Asian" (1%), Black (1%) and several others (e.g., Arab, Malay, Hispanic) which fall below 1% representation. This lack of representation from minority groups is somewhat prescient of a major theme that emerges from the data analysis. There are studies that suggest underrepresented minorities may not be well represented in online surveys, reasons given for this include historical exclusion and a digital divide.

57 (11%) of respondents considered themselves to have a disability 15 (3%) did not wish to provide this information.

Participants have a wide range of educational experiences. The most common level of highest education are A-Levels (162), and participants with Bachelors degrees (87) are less numerous than those with Masters degrees (131) or PhDs (96). 115 of the 131 participants who have studied to Masters level and 80 of the 96 who have PhDs have gained these qualifications in geology or a related discipline.

Domain Summaries

The following section provides domain summaries for each of the questions. These highlight the breadth and range of meaning in the data related to each question—we highlight, for example, where responses around a particular topic are common, or not.

What Is Geology?

> "*The study of rocks! Kidding!. . .*"

Participants who have studied geology most commonly responded that the discipline is the study of the Earth, with many expanding to include processes and systems as being the focus. A range of responses were included here, many generically suggesting "*. . .processes. . .* " or "*. . .systems. . .* ", while others suggested particular phenomena (natural hazards, tectonics, landscapes, etc.). Linked to processes and systems were "rocks" and their formation, as well as Earth history. A smaller number of responses linked geology to biology, physics and chemistry and the application of those disciplines. Areas that were mentioned by a minority included Earth structure and materials. Future-facing applications were barely mentioned, "policy" was only included once, and responses relating to social, human or sustainability did not appear.

> "*A subset of earth sciences with a focus on rocks and the processes that have the Earth's landscape through time.*"
>
> "*Understanding of the world around us, primarily focusing on rocks.*"

Respondents who have never formally studied geology overwhelmingly suggested that geology was about the study of rocks (the exact phrase "study of rocks" appeared 71 times). This response was almost twice as frequent as the next commonly suggested domain: the study of the Earth. Unlike those who had studied geology, these responses rarely linked the study of Earth to its processes and systems. Earth history and structure were included in a lower number of responses. The association of geology and rocks is unsurprising, but the lack of deeper understanding of why rocks are studied is crucial and suggests that as geologists we struggle to define and effectively communicate the meaning and relevance of our discipline. Forward facing aspects (social, human, sustainability) of geology were also absent from these responses.

> "*The study of rocks*"
>
> "*The study of rocks and minerals*"

Amongst respondents who have not studied geology, the widespread impression that geologists "just study rocks" is in line with the authors' expectations, but the overall cookie-cutter uniformity and simplicity of the responses was unexpected. Even internet search engine results for "what is geology" are more nuanced, and "the study of rocks" doesn't appear in any top search results.

More surprising are the responses from those who *have* studied geology. Rather than expounding innovative environmental histories, planet-scale stories or critically important material exploration, most answers are narrow

and focus on the physical aspect of materials and processes. Influence on policy is almost completely absent from responses, although geologists often talk about how they are missing from crucial conversations and work around environmental policy and work (Geology for Global Development, 2021). Perhaps the behaviour of geologists in relation to engaging with policy has led to our own exclusion; if we do not extol the value of geology in its broadest sense then why would we expect individuals outside of the subject area to come seeking advice?

The responses to this question highlight a key issue that geologists may have in disseminating their work and communicating the broader societal relevance of geology; there is no clear and specific consensus amongst participants on a definition of the discipline. "The study of the Earth" as an explanation of what geology is appears vague and nebulous, and seemingly does not translate well to a non-specialist audience, leading to the common trope of "just" studying rocks. Is there an uncertainty amongst geologists how to define the discipline? Is the discipline too sprawling to capture in a mere sentence or two? Or is the discipline growing and changing and our definitions are yet to catch up?

What Does a Geologist Do?

> "A little difficult to give a definition."

In a similar fashion to "What is geology?," this question was met by a swathe of different responses from those who have studied geology. The most common response was that a geologist's role is broad; this was often followed with some clarification resulting in a set of commonly suggested sub-domains. These included studying or understanding the Earth, which was most common, followed by resource exploration and extraction (not just fossil fuels, but including other extractable Earth resources), studying rocks, understanding Earth Systems (including tectonics, volcanism, etc.) and Earth history. Responses with less emphasis included working to solve societal issues, work in the construction/engineering and geotechnical sector, the environmental sector and eco-geology. Climate change, policy making and working in the hazard sector occurred in a handful of responses. Interestingly, fieldwork and mapping—both staples of undergraduate curricula—only appeared in a similar number of responses as these lesser mentioned activities. This broad picture of what a geologist does is unsurprising for a discipline that covers such deep time and so many varying sub-topics. What is clear from the responses is that most geologists are aware of the breadth of the discipline, but (potentially due to its breadth) struggle to explain what it is geologists as a whole do, or at least how geology intersects with wider society. The lack of future-facing and human-linked responses could be interpreted to be a legacy of the colonial, 'non-human' facing origins of a subject that was often focussed on resource extraction.

> "*It's too broad for a simple definition! From zapping zircons to remote sensing*"

> "*That really depends on the branch of geology: it could be anything from forensics to abseiling into volcanoes.*"

The responses from participants who have never studied geology were again overwhelmingly related to the study of rocks. "*Studies rocks*," "*Not entirely sure. Looks at rocks*?", "*Looks at/licks/analyses rocks*" are a few examples of this type of response. Other responses went a little further, linking the study of rocks to Earth composition and history, but these were in the minority. Earth, Earth history, and Earth systems were suggested by fewer respondents as areas that geologists work on, and it was often suggested that these were studied through research. The idea that a geologist's role was broad was highlighted by this group of participants, but in far fewer responses compared to respondents who have done geology. Resource extraction is an area that was suggested by a modest number of respondents. Even within this smaller group of respondents, the number who suggested that geologists work in climate change and policy was similar to the larger group that did study the subject (and in both cases was very minor). Other suggestions that were given by a handful of respondents included: science, mapping, land formations, eco-geology and fieldwork. Only five respondents indicated that they had no idea what a geologist does. Several responses indicate where the perception of studying rocks comes from: "*Study and classify rocks and minerals*," "*Studies the Earth relating to the rock cycle and tectonic activity*" and "*Studies rocks and minerals*." These quotes perhaps reflect the sort of exposure to the discipline that individuals who do not formally study geology receive; classification and curation of mineral samples (e.g., collecting "gemstones" and minerals, visiting museums) and topics taught at school such as the rock cycle and tectonics. Given the vague and often simplistic descriptions given by those who have studied geology, these responses are understandable: a discipline that struggles to coherently define itself will in turn struggle to communicate its appeal and importance. It is disheartening that a subject which embraces and relies on many aspects of other disciplines, including social sciences, is not recognised as being interdisciplinary or regarded as being of general science interest by those outside of the subject.

Why Did You Study Geology?

> "*It provides a fascinating insight into our past, is essential to our current lives and can indicate important future issues.*"

This question was only asked of respondents who indicated that they have studied or are studying geology. The most common response was an interest in or fondness for the planet or one or more specific feature (e.g., volcanoes, fossils, rocks). Many participants were exposed to geology in geography teaching and developed an interest from there,

with several indicating their teachers directed them to the subject. Fieldwork and a love of the outdoors was identified as a strong influence for studying geology, as was the inter/multi-disciplinary nature of the subject. The mix of science subjects and the applied nature of geology appears to have influenced a good number of the participants; some elaborated that geology allowed them to pursue more than one science and others suggested that the discipline allowed them to pursue a science that they loved but didn't necessarily have the best attainment in its pure discipline—but they excelled at its application to geological sciences. This particular set of responses, highlighting the interdisciplinary nature of the subject, is contradictory to the insular and narrow responses to the previous two questions by this group of respondents.

> "*I liked geography but my A-level grade was going to be my worst, and I liked (and was better at) science, so when I stumbled across geology as a subject in university prospectuses, it seemed to be an opportunity to apply what I was good at to what I was interested in.*"
>
> "*. . .Liked physical geography at GCSE but not human geography so chose Geology A-level and loved it*."
>
> "*It just doesn't interest me as I'm more interested in human geography . . . I feel geology is closer to Science which I never enjoyed*"

Quotes like the above, reflected many responses from prospective geology students, suggesting that they liked subjects like geography but aligned themselves with either the physical or human elements of the subject. Geology perhaps represented a purer "hard science" and was pursued by those students that preferred physical geography, but not human geography.

Jobs and employability were a minor response, perhaps surprisingly given evidence that young people care a great deal about job security and salary (Royal Geographical Society, 2022), as was family or personal influence. Although responses including reference to sustainability and the human and environment intersection were low, these almost exclusively came from younger participants, highlighting the current shift in young people's priorities towards sustainable topics.

The answers supplied for this question are not particularly surprising and reflect most of the authors' anecdotal experiences. The multi- and inter-disciplinary nature of the subject is a factor perhaps currently missing from geology marketing materials, that may be effective at engaging students taking science subjects at school and college. It is interesting that very few people indicated they studied the subject to go into the extraction or geotechnical sectors, industries that are both vital to a sustainable and stable future. Perceptions of the mining industry, a critical component of the transition to renewable energy, are still firmly tied to the fossil fuel industry, and both have a negative reputation (e.g., Wahlquist and Allam, 2020a; Wahlquist and Allam, 2020b). However, geologists who are environmentally and societally aware are needed more than ever before in responsible resource extraction.

Barriers to Studying Geology

> "It might seem a bit of an "anorak" subject due to requirement for lab and field work, and indeed anoraks"

A range of barriers were identified by respondents who have studied or are studying geology. The most commonly mentioned barrier was around the lack of exposure to geology itself. It is important to note that this perception is voiced by respondents who have already chosen to study geology. Issues suggested for a lack of exposure to geology include limited subject availability, the fact that people do not know what geology is (as evidenced above in "What does a geologist do?"), negative perceptions of the discipline, and a lack of exposure to the discipline or related activities. These factors potentially play a large role in the number of individuals applying for and undertaking formal geology education. While they may appear to be external factors, they are all interlinked, and addressing them ultimately falls within the responsibility of geologists. For example, the lack of course availability is most likely linked to declining numbers of students and negative perceptions of discipline (along with ever restricted resources and expertise) amongst senior management, both of which are driven by perpetuated stereotypes, a lack of understanding of the discipline, and perceptions driven by activities such as fieldwork. A lack of available geology courses undoubtedly impacts the number of individuals who are introduced to the topic and go on to study it in further and higher education, although we note that other subject areas with no GCSE or A Level equivalent (e.g., nursing, forensic science, engineering) do not face similar recruitment issues. This discrepancy is likely related to the perceived clear vocational employment paths for subjects such as forensics and nursing, in contrast to the evident confusion around geology-related career paths.

The next most common domain constructed from the responses from those who have studied or are studying geology relates to accessibility and diversity. Fieldwork and outdoor work (particularly on remote and/or difficult terrain) was highlighted as a barrier, most commonly in association with physical accessibility and/or the financial implications of field kit, accommodation, equipment and travel. The perception of geology being mostly outdoors, or for "outdoorsy" people was also noticeable, something often reflected in marketing materials for geology courses. A reasonable number of responses indicated that they were interested in geology due to their love of the outdoors, so there may be a link here to this; individuals who got into the subject because of the outdoors concluding that the outdoors must be the main reason anyone might do so. Diversity of the subject was suggested as a significant barrier, particularly the male dominated environment (especially on fieldwork). Many of the responses that suggested fieldwork is a barrier highlighted that fieldwork skills are not necessary for many

jobs in the discipline, and that some individuals, even though interested in geology, may opt not to study it for this reason:

> "*The stereotype that a geologist is a certain type of person who loves the outdoors. People need to know that geologists do all sorts of roles in all types of environments (office, lab, field).*";
>
> "*Field work—current accreditation requirements make it challenging to get an accredited degree if you are not able to do field work—this is not consistent with being a modern geologist.*"

The fact this barrier has been highlighted should not be a surprise to geological educators, and difficulties relating to these factors have been discussed in the literature for many years. While a range of resources have suggested mechanisms for us to provide a more inclusive environment so that everyone can undertake and enjoy fieldwork (e.g., Gilley et al., 2015; Gordon and Houghton, 2019; Houghton and Gordon, 2019; Stokes et al., 2019; Chiarella and Vurro, 2020; Giles et al., 2020; Houghton et al., 2020; Jackson, 2020; Greene et al., 2021; Lawrence and Dowey, 2022), these have yet to be implemented by institutions in a systemic way.

Fieldwork is an important aspect of geological teaching (Whitmeyer and Mogk, 2009), and as such should be accessible to all—however the survey data suggests that some individuals who have studied geology do not think it necessary to undertake fieldwork for a successful career within the discipline, and highlight digital, desk and lab-based roles. The traditional emphasis (and accreditation requirement in the United Kingdom) towards fieldwork as being the most important part of a geology degree is likely a strong factor in creating perceptions that most geology has to be field-based. More emphasis on important lab and digital skills should be celebrated and shared, particularly in subject marketing materials. The recent update to the Geological Society's accreditation requirements includes a more flexible approach to field studies, whilst still emphasising its importance (The Geological Society, 2022). The changes include the removal of a specific required number of field days across a degree, and the introduction of the option for students to undertake major project work in a range of geological topics/skills (rather then the previously mandated mapping-based project). This change will potentially see more accessible degree courses (or routes through them) which are more appealing to a wider range of students, and programme teams now need to be supported to implement this flexibility and embrace the accessibility it allows. A small minority of respondents suggested that more fieldwork is needed to ensure they are trained for employment, analysis of these responses shows they came from individuals whose fieldwork experiences were limited by the impact of COVID-19.

The whiteness of the discipline, as well as the poor gender balance, was also highlighted as a barrier. When asked to list barriers, a number of responses included specific reference to the discipline being white and male dominated, typical responses included: "*Heavily white male dominated*," "*Predominately filled with white men who hike >10 miles a day and drink a lot.*" and "*It's very white, middle class and male, which is really off-putting*." These issues are far from newly reported—for example, poor racial diversity within geosciences in the US has been discussed since the 1970s (Bromery et al., 1972). In 1972, Randolph W. Bromery convened a conference which proposed many recommendations to improve diversity in the geoscience community for the first time, including recommendations that are still proposed and attempted by colleagues—early and senior career—today. In 2007, an issue of the *Journal Of Geoscience Education* was dedicated to this problem (e.g., Huntoon and Lane, 2007); these issues are far from being resolved. Bernard and Cooperdock (2018) highlight that diversity amongst those earning doctorates within geoscience (in the United States) has not improved in over 40 years, and work by Singh et al. (2022) focusses on of the EDI issues experienced by, in particular, ethnic minority students in the United Kingdom. In 2022, three early career researchers—Rachel Bernard, Raquel Bryant and Benjamin Keisling—led a follow-on conference (The Second National Conference: Justice in Geoscience) to the aforementioned 1972 conference.

A few survey respondents raised concerns around sexuality, in particular fieldwork locations in countries with anti-LGBTQ+ laws—this issue has been previously raised with calls for additional support for staff and students (Olcott and Downen, 2020; Jackson, 2021).

A sub-domain relating to accessibility was the science content itself as a barrier; the idea that a good science background is required (in chemistry, physics, and biology) and that many of the mathematical components of geology as a taught subject are often unexpected (to students) and are not well supported, leading to learners distancing themselves from the subject. This may have two consequences: firstly, that some students may believe they are excluded from studying geology at university due to not having the appropriate science qualifications at A Levels or Highers (or equivalent); and secondly, students may commence studying the subject without expecting challenging scientific content. A few respondents indicated that there was a tendency for non-geologists to view the discipline as a "soft-science" in comparison to other science subjects. The idea that geology is an easier or "soft science" (i.e., that it is "easier" than other STEM subjects (e.g., Mervine, 2010)) has been sustained for a long time (e.g., Halstead, 1989). This raises the issue that if the geology curriculum was to embrace more "social" or "cultural geology" the perception as a "soft science" may increase, if the perception of geology is to be transform into a modern and future facing discipline, a holistic approach highlighting the impact of the discipline is required.

The majority of respondents that highlighted EDI-related barriers were white women or female participants. As previously mentioned, respondents to our survey were mainly white. It is well documented that women and minority groups within geology face greater barriers in their careers and experience more hostile environments (e.g., Dutt,

2020; Berhe et al., 2022; Marín-Spiotta et al., 2022; Mattheis et al., 2022). The demographics of the groups which inform these conclusions are largely from women and minority groups (e.g., see data within Mattheis et al., 2022; Marín-Spiotta et al., 2022; Marin-Spiotta et al., 2023). Recent statistics from a US led study (Zippia, 2022) show that white women and women of colour take on more diversity officer responsibilities than men—something which is anecdotally known within UK Higher Education. Other studies have shown the negative impact of cultural taxation on scholars of colour within STEM in a variety of sub-disciplines (Gewin, 2020). Whilst we imagine that this section reflects the statistics of the majority of our respondents, it also reflects who might be more likely to report and/or comment on barriers to participation—with the caveat that respondents who have additional marginalised identities (e.g., ethnic minorities) might not feel comfortable to report negative experiences for fear of repercussions due to the additional barriers and bias they face in the sector.

As mentioned above, EDI-related barriers are becoming a topic of regular discussion within the discipline. But what about the perceived barriers of those who have not studied the topic? Participants who had not studied geology suggested the biggest barrier to studying geology for them was not knowing what geology is, linked to a lack of exposure to the subject. Many highlighted the lack of geology teaching at school, that material was not signposted as "being" geology when taught as part of other subjects (such as geography and science). A nod to pop-culture references in mainstream media was given by a respondent as an example of how false perceptions of the discipline are perpetuated, with the result that fewer people know what the discipline can offer. For example, "The Big Bang Theory" ridicules geology on several occasions: "*Physics answers the question "What is the nature of the universe?". Geology answers the question, you know, "What'd I just trip over?"*" and "*Dumb as a bag of geologists*."

Uncertainty around employability options is also a common domain. Many responses indicated a general lack of awareness of what one could do with a geology degree, while others specified that they didn't want remote, offshore jobs, and didn't want to work in or be associated with the fossil fuel industry. This is an understandable point; even the "symbol" of geology, often crossed hammers or pick axes, evokes extraction and destruction. Other respondents indicated they believed the skills learned on a geology course would not be transferable. Geologists need to reflect on this, and decide how they can shape the future perception of their discipline to more accurately portray the wide range of applications and careers it has to offer.

> "*Geology courses basically exist to provide technically trained labour for the fossil fuel extraction industry.*"

The next most common response is unique to respondents who have not studied the subject: geology is "*. . .boring. . .*". In describing why, looking at rocks appears once again—"*A lot of people think its just looking at rocks*." This lack of interest and direct belief that a subject is boring is sure to act as a significant barrier to recruitment. Specific content of the discipline (mathematics and chemistry in particular) was given as a reason for not pursuing the subject, and a minority of responses suggested that the content was too restrictive and specific.

EDI-related barriers were mentioned by those who had not studied the subject. A lack of diversity among geologists and the accessibility (financial and physical) of the discipline were suggested as a barrier, although this area came up in far fewer responses than for those who had studied geology. This is perhaps not surprising, as many of the respondents who have not studied geology will likely know less about the internal demographics of the discipline. Concerns around fieldwork and finances relating to travel/equipment were also common responses assigned to this domain.

Positive Perceptions of Geology

> "It has made me a very inquisitive thing."

Those respondents who have studied or are studying geology overwhelmingly described it as being essential to understanding and resolving many of the grand challenges facing global societies, including climate change, natural hazards, the energy transition and general sustainability. The passion for these activities was clear from the free text responses, as were links between discipline and society, people, and the environment. Respondents commonly expressed that the subject is of general interest and is enlightening: that once you have studied geology you never look at the world in the same way; that you appreciate how different systems interlink and can appreciate how the planet might change in the future by investigating changes in the past.

> "*You never see the world and the environment around you the same again*"
>
> "*It's a wondrous subject, the drama of the earth and how it's been formed and is still changing*."

Inter- and multi-disciplinarity was suggested as a positive in association with geological skills and knowledge being applied to authentic experiences. The option to travel and work outdoors was also highlighted. The welcoming and collegiate nature of the majority of geologists was also mentioned here. The vision of geology described here is a future facing, relevant and socially responsible discipline; a vibrant, multi-disciplinary subject with great job prospects. This, in comparison to the responses describing what geology is and what geologists do, is striking. The responses here were incredibly positive, words like "fascinating," "exciting," "interesting" and "important" were commonly used—a very different picture than a subject that just looks at "boring" rocks!

Responses from individuals who have not studied geology were closely aligned to areas already covered. They mostly indicated an unfamiliarity with geology. However, a number suggested that the discipline is enlightening in that it allows us

to understand the planet and how it works, and others suggested it was generally interesting. A large number of these responses were very broad but generally related by being something positive about the specifics of collecting rocks, fossils or studying volcanoes and dinosaurs.

Negative Perceptions of Geology

"you just look at rocks, and have beards"

Participants who have formally studied the discipline highlighted the perception of a boring subject, oil and gas industry links to environmental destruction, a poor understanding of employability from a geology degree, and equality and diversity issues as their perceived negatives. The "*male, stale and pale*" dominated environment of the subject was the most common negative raised, and specific responses ranged from general statements indicating the subject is male-dominated to significant and disturbing accounts of toxic, degrading and discriminative behaviour. "*Banter*," alcohol/pub culture and ableism were highlighted to be particularly problematic on field courses. There is overwhelming evidence of exclusive gendered discourse and sexism in science disciplines; geology, and fieldwork, are no exception (St. John et al., 2016; Fairchild et al., 2022; Sexton et al., 2018; MacFerrin, 2022). Fairchild et al. (2022) highlight that perceptions of geology fieldwork perpetuate stereotypes of natural differences (men are more used to hard/sweaty work), preferences (women don't like the outdoors as much as men) and social expectations (women aren't generally found in the outdoors). The perceptions evident from our study support these findings. The expense and expectation for field work (and mapping), particularly where some geo-related jobs require neither, was highlighted. Resource extraction and associated environmental damage was the next common negative response, with an emphasis placed on the oil and gas sector.

> "*Studying rocks feels old fashioned, and maybe a little like stamp collecting. Is there anything new to discover with rocks?*"

Responses from those who have not formally studied geology suggest the discipline as being boring was the biggest negative perception of the discipline. The white, male dominated aspect of geology was the next common negative given, as well as suggestions that the subject is outdated and boring/dull. This linked to views around employability, with oil and gas being highlighted as the area geologists work in, and that these positions would dwindle as we move away from these products. Some participants highlighted that some of the maths and science components made the subject difficult.

> "*Oil and gas, mining, Rio tinto destroying cultural sites, old white men with hammers, fieldwork is exclusive (costs, ability etc)*"

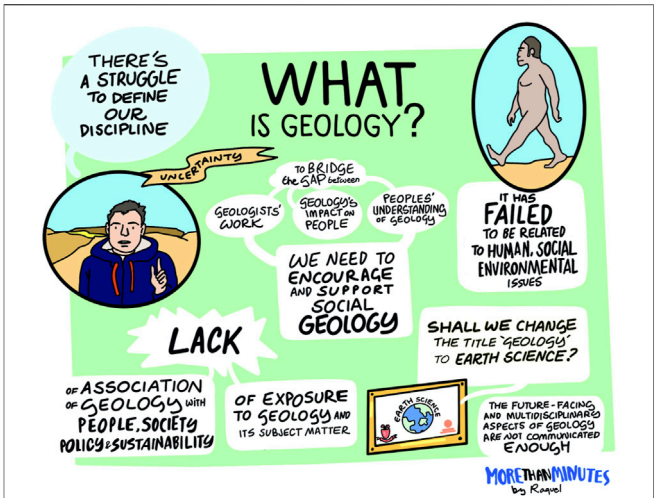

FIGURE 1 | A graphical interpretation of the first theme "Do we know what geology is?"

> "*Oil and gas, old fashioned, white able-bodied bearded men in the field with hammers and boots*"
>
> "*I think its often thought of as an antiquated science associated with fossil fuels and mining etc,*"

Interestingly, a number of (generally white, male) participants in both groups did not report any negative perceptions of geology. These omissions are unsurprising: the prevalence of reports relating to the inaccessibility and inequality of geology coupled with a lack of action towards rectifying this indicates there are a number of geologists that are either happy with or ambivalent to the situation. A lack of negative perceptions likely comes from those within the discipline where their needs are met and their comfort/success is prioritised; we argue that this lack of awareness of these widely publicized and evidenced issues can no longer be chalked up to ignorance. At this point ignorance is willful ignorance. One respondent who is currently studying geology succinctly described this: "*It's full of old white men who back the status quo because it supports them and refuse to change, and who seem to define geology very narrowly. The core of geology as it seems to be understood is practical and field-based, and even though I have a master's and half a PhD in geoscience, I don't have any of the key skills that most geologists would define as being necessary to call myself one (e.g., mapping)—so what am I?*"

Themes

In this section we establish themes that the narrative data represents. These themes are derived from an analysis of the domain summaries provided above.

Theme 1: Do We Know What Geology Is?

The first theme relates to the uncertainty around what the discipline of geology is, and what geologists do (**Figure 1**). This uncertainty is shared both by those with formal geology

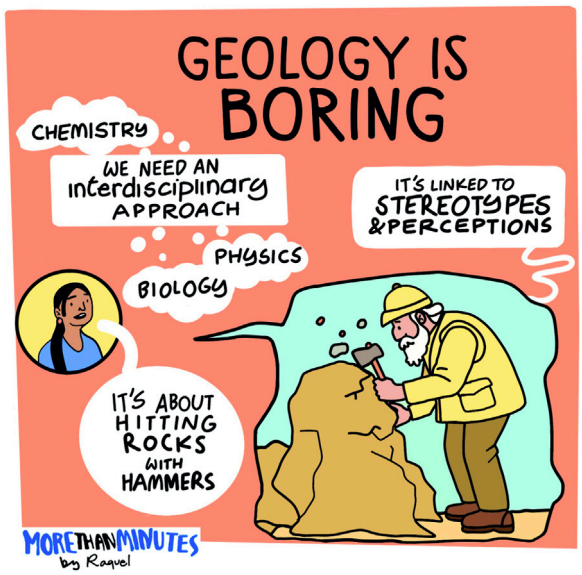

FIGURE 2 | A graphical interpretation of the second theme "Geology is boring, rocks are boring."

FIGURE 3 | A graphical interpretation of the third theme "Employability and destructive practices."

education and those without. For those with formal geology educational experience, most descriptions of the subject focus on its breadth and tend to use different descriptors. In contrast, those without formal geology education feel the discipline is niche and centers on the curation/description of rocks, with limited understanding of what the rocks are "used for." An important aspect of this theme is the almost complete lack of association of geology with people and society, policy, and sustainability. This uncertainty is suggested here to inevitably stem from geologists' own struggle to define our discipline. When more specific descriptions were given, these often referred to a specialist "sub-discipline": would a non-specialist know that a volcanologist or palaeontologist is a *type* of geologist? To bridge the gap between the work geologists do, geology's impact on people and the environment, and people's understanding of what geology is/geologists do, we need to encourage and support "social geology" as a sub-discipline, as described by Stewart and Gill (2017). As the discipline develops to embrace and celebrate interdisciplinarity it might be sensible to reconsider "geology" as the title of educational awards/degree names offered and embrace a broader title like "Earth Sciences."

A lack of exposure to geology and its subject matter was a common response for those who hadn't studied the subject formally. This is perhaps surprising, given that most individuals will have interacted with or learned about earthquakes, volcanoes, mining (and related extractive products), and dinosaurs, etc., at various points in their lives (in geography and science lessons at school, for example). This suggests that interactions with the discipline through mainstream education, news, games and other media are not typically recognised as geology. The lack of emphasis on the transferrable and applied aspects of the subject, as well as the failure to relate it to human, social and environmental issues, clearly translates from those who have studied geology to those that have not. The future-facing and multidisciplinary aspects of geology are clearly not communicated enough, either within the discipline or outside of it.

Theme 2: Geology Is Boring, Rocks Are Boring

For those who have never studied it, geology was perceived as a boring subject. Such was the strength of this perception that the word "boring" appeared in 121 responses across the dataset (words like "dull," "stale," and "old-fashioned" were also used numerous times). This theme is apparent throughout the data and is interpreted to directly link to a miscommunication and misunderstanding of what geology is (**Figure 2**). It is also likely strongly linked to stereotype perceptions that emerged, of a geologist being a bearded, white, male either hitting rocks with hammers (to add to their collection) or shuffling through dusty boxes curating specimens. To those who have not studied it, geology is perceived as a niche subject focusing on the collection and classification of rocks, with little recognition of vital role that these rocks—and geologists—play in the present and future of our planet. This misconception may stem from how the discipline presents itself externally, and how it is presented in pop-culture. The general science interest of geology, future facing geology, the grand stories of Earth history and change, and the interdisciplinary potential between biology, chemistry, physics (and most other disciplines) were rarely perceived by subject outsiders. Balanced against this is some people's perception of the chemistry- and maths-based elements of geology being potentially off-putting. The pervasiveness of the idea that geology is boring from across respondent demographics suggests there are no particular groups who see the subject as more or less boring.

FIGURE 4 | A graphical interpretation of the fourth theme "Diversity and inclusion."

Theme 3: Employability and Destructive Practices

The perception that geology lacks transferrable skills and has limited employment prospects is highlighted throughout the responses (**Figure 3**). The oil and gas sector and other extractive industries are perceived as a likely employment for geologists and are seen an unpalatable option for many, including social-justice oriented young people ("oil," "gas," "mining" and similar words linked to the extractive industry were used in well over 200 responses with a negative connotation). The importance of extractive industries, such as the critical mineral sector in battery technology and the green energy transition, for example, is mentioned by just a handful of geologists and in vague terms by a couple of non-geologists. There is a clear—and crucial—failure to communicate the skills gained from a geology course and the applicability to a wide variety of employment, especially in future-facing jobs linked to sustainability.

The perception of geological work as field-based and remote translates into a common feeling that geology jobs involve significant travel, time away from home and a requirement of being an "outdoorsy" person. This "outdoorsy" perception is also reality, but only to a limited extent: fieldwork is a necessary part of geology degree programmes, and is pedagogically important, but recent changes to accreditation criteria and recommendations to make fieldwork more inclusive can negate barriers associated with ableism, expense, and toxic behaviour if they are broadly implemented.

Theme 4: Diversity and Inclusion

The exclusionary nature of geology as a discipline clearly comes through in the responses (**Figure 4**). This manifests in a variety of ways, with the most common perception being that it is a mostly white, masculine, physically ableist pursuit focused on expensive fieldwork (both in terms of equipment and the act of travelling). The toxic "lad" and drinking culture associated with geology feeds into this theme. The media depiction and stereotype of geologists as boring, stuffy, old men in remote field locations is a barrier to studying the subject for those who have not formally studied the subject, and the overwhelmingly male dominated reality of the subject provides a barrier to those who have.

ARCHETYPICAL PERCEPTIONS OF GEOLOGY AND GEOLOGISTS

The data from participants who have never studied geology draws an image of a boring, old fashioned, hammer wielding, white male dominated group who work exclusively in the extractive industry with no wider relevance to society, and curate and collect rocks.

There is a feeling among the responses from those who have studied geology of what a "modern" geologist is: a modern geologist is not fully "outdoorsy," they work in an interdisciplinary manner where connections and experience in the social sciences and policy making would be beneficial. They seek to represent the discipline and topics in an exciting and engaging way. A modern geology discipline supports and is relevant to industry that is not entirely extraction focused, but sustainability focused. A geology that is diverse, and accessible. This archetype (for geologist and discipline) built from the data from this survey could be used to argue for innovative changes in the way geology is taught—we need to adapt to meet the desire and imagination of "prospective modern geologists."

CONCLUDING THOUGHTS AND RECOMMENDATIONS

This project was conducted to provide data-informed insights into the perceptions of geology, with the hope of stimulating discussions about the discipline and its future. The themes emerging from this work, and their implications, raise serious questions that cannot be solved overnight. Some of the findings presented here, particularly the dominant stereotypes and barriers, may make some uncomfortable. This need not be a bad thing; discomfort may be essential for growth and change. Many of the negative perceptions of geology and the barriers to working in the discipline, chime with both anecdotal discussions and published recommendations, but these have largely gone ignored; leading to the development and pervasiveness of current perceptions of geology and geologists.

It is time for the geological community to take more responsibility for supporting the development and promotion of a modern, inclusive, important, and respected discipline. The stereotypes and caricatures of geology often feel unfair to geologists—but recent critiques of the subject and its accessibility, inclusion, diversity and actions suggest that

they are deserved. The discipline is not diverse, it is siloed in its pedagogy and curricula. In many other ways, it is still the subject that arose due to colonial expansion.

Storytelling, communication and outreach—how we market what our subject is, and how we bring diverse audiences along with us—is crucial to these efforts, and has been considered in depth by others working at the interface between geology and social science (Stewart and Nield, 2013; Gibson and Roberts, 2018; Ford, 2019). It is important that we continue to bridge this gap between disciplines to create relevant and effective narratives, to improve our pedagogy and teaching, to allow society to feel more connected to geology (Stewart and Hurth, 2021), to promote geological activities, and to help shape our thinking and progress as a discipline. But it is not enough to simply change outreach activities to highlight the best parts of the current subject—we need decisive development in curricula, procedure, activities and behaviors across geology to catalyse and deliver a new, modern subject. Geology needs to better align itself to other disciplines and nurture the inter- and multi-disciplinary facets of the subject. Should geology remain the traditional "hard" science or is there scope to introduce elements of "softer," social science? Is it possible to have elements of a "social geology" or "cultural geology"? Are any barriers to this due to tradition/convention of geology teaching staff, or due to the fundamental lack of relevance for geology as a discipline? Would a geology degree that (for example) explored how people interacted with geology, or the ethics surrounding extraction practices be less of a geology degree?

We need to take sustainability seriously, as supposed key players in energy transition, projects and activities should be built with sustainability at the heart of the matter, not a continuation and rebranding of past activities. Geological education needs to prepare individuals to be aware of, be critical of, and equipped to challenge the environmental and human rights records of their employers, sponsors and indeed their own actions. Our relationships with the companies we work with should align to those with sustainable and ethical commitments and values.

We acknowledge the severe lack of data from ethnic and racial minorities within our dataset. Their thoughts are not represented, and whilst there are ongoing efforts to capture their views and support these individuals [e.g., Fernando and Antell (2020) and The Explorers Programme (Natural History Museum)], we recommend further targeted surveys are conducted to provide us with a deeper understanding to improve recruitment and retention of ethnic and racial minorities into our discipline.

Efforts to improve equity, diversity and inclusion in our subject *are* slowly gaining ground (e.g., BAME-EDI-Report, 2020; Dowey et al., 2021; Mildon et al., 2021; Tooth and Viles, 2021; Kavanagh et al., 2022; Singh et al., 2022) but are still too often seen as fringe activities, often undervalued (and underfunded or unfunded), or hindered (Bhopal, 2022), and fall to individuals from historically excluded groups (Padilla, 1994; Cleveland et al., 2018; Ahmet, 2021). Interventions also preferentially favour white women rather than being truly equitable (Bernard and Cooperdock, 2018; Bhopal and Henderson, 2021; Ranganathan et al., 2021). Learning from existing initiatives and continuing to broaden and develop the scope of interventions is essential; however, initiatives have been proposed for many years and mostly ignored (e.g., Bromery et al., 1972; Huntoon and Lane, 2007, etc.). Improving equity and diversity in geoscience is critical for social justice, but should also be appreciated as part of the existential battleground to challenge and improve long-held perceptions of our subject.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/ **Supplementary Material**.

ETHICS STATEMENT

The studies involving humans were approved by the KIITE Educational Research Ethics Committee (KIITE-REC). The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/ next of kin because a "gatekeeper approach was adopted to disseminate the survey to 16/17 year olds." A draft of the questionnaire was sent to a potential gatekeeper (FE teacher) who indicated the level of information, and what it covers is at the right level/amount for 16/17 year olds a previous version of the information page was regarded too long and it was suggested that 16/17 year olds may not read it and miss important information—we therefore produced the more concise information sheet. Feedback from this potential gatekeeper, and from Earth Science Teachers Association, indicate that they do not feel the survey requires secondary consent from a 16/17 year olds parents/guardians and is similar to other surveys they have supported in the past.

AUTHOR CONTRIBUTIONS

All authors designed and developed the research question and surveys. SLR analysed the data and wrote the main draft. All authors contributed to the article and approved the submitted version.

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CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.escubed.org/articles/10.3389/esss.2024.10078/full#supplementary-material

Supplementary Table 1 | Anonymised data set used in this research.

Supplementary Figure 1 | A graphical interpretation of the article, highlighting prevalent perceptions and themes.

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