



Volcanologists—who are we and where are we going?

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Abstract

Equity, diversity and inclusivity (EDI) are principles all scientific groups and organisations should strive to achieve as they secure working conditions, policies and practices that not only promote high-quality scientific output but also well-being in their communities. In this article, we reflect on the progress of EDI in volcanology by presenting data related to memberships of international volcanology organisations, positions on volcanology committees, volcanology awards and lead-authorship on volcanology papers. The sparse demographic data available means our analysis focuses mainly on gender identity discrimination, but we show that discrimination related to ethnicity, sexual orientation, religion, physical ability and socio-economic background is also occurring, with the intersection of these discriminations further exacerbating marginalisation within the volcanology community. We share suggestions and recommendations from other disciplines on how individuals, research groups and organisations can promote, develop and implement new initiatives to call out and tackle discrimination and advance EDI in the volcanological community. There is a lot of potential for improvement if we all see our role in creating a more equitable, diverse and inclusive volcanology community. This requires (1) awareness: acknowledgement of the problem, (2) commitment: through the statement of EDI core values and the development of action plans, codes of conducts and guidelines, (3) action: aiming for representation of all groups, and (4) reflection: development through critical self-reflection and a willingness to address shortcomings.

Keywords Equality · Diversity · Inclusion · Equity · Justice · Policy · Discrimination · Action

Abstrakt

Gleichstellung, Diversität und soziale Inklusion (EDI nach dem englischen equity, diversity and inclusivity) sind Prinzipien, nach denen alle Forschungsgruppen und Organisationen streben sollten, da sie Arbeitsbedingungen, Regelwerke

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und Praktiken gewährleisten, die neben qualitativ hochwertiger Wissenschaft auch das Wohlergehen der vulkanologischen Gemeinschaft fördern. In diesem Artikel erörtern wir die Fortschritte hinsichtlich EDI in der Vulkanologie auf der Basis von Mitgliedsdaten internationaler Organisationen, der Zusammensetzung von Gremien, der Verteilung von Preisen und der Hauptautorenschaft von wissenschaftlichen Artikeln. Wegen der geringen Menge verfügbarer demografischer Daten begrenzen wir unsere Analysen auf die Diskriminierung aufgrund von Geschlechtsidentität. Wir zeigen jedoch auch, dass Diskriminierung aufgrund von Ethnizität, sexueller Neigung, Religion, körperlicher Fähigkeiten und des sozioökonomischen Hintergrunds vorkommt und dass die Überschneidung dieser Faktoren die Marginalisierung innerhalb der Vulkanologie noch verschärft. Wir teilen Vorschläge und Empfehlungen aus anderen Disziplinen wie der Einzelne, Forschungsgruppen und Organisationen neue Initiativen ins Leben rufen, entwickeln und implementieren können, welche Diskriminierung identifizieren und unterbinden, sowie EDI in der Vulkanologie vorantreiben. Es gibt großes Verbesserungspotenzial, wenn wir alle unsere Verantwortung dafür sehen, eine besser gleichgestellte, diversere und integrative Gemeinschaft in der Vulkanologie zu erschaffen. Dies erfordert 1) Bewusstsein: das Problem anerkennen, 2) Engagement: durch das Feststellen von grundlegenden EDI-Werten und die Entwicklung von Handlungsplänen, Verhaltenskodizes und Richtlinien, 3) Handlung mit dem Ziel, dass alle Gruppen repräsentiert sein sollen und 4) Reflektion: Entwicklung durch kritische Selbstreflektion und den Willen, Fehler anzugehen.

Résumé

Equité, diversité et inclusivité (EDI) sont des principes fondamentaux auxquels tout groupe ou organisation scientifique devrait adhérer en assurant des conditions de travail, des politiques et des pratiques qui promeuvent non seulement une production scientifique de qualité, mais également le bien-être des membres de leur communauté. Dans cet article, nous proposons une réflexion sur les progrès de l'EDI en volcanologie en présentant des données sur les adhérentes et adhérents aux organisations internationales de volcanologie, sur les postes dans les commissions, sur les prix et médailles et sur les auteurs et autrices principales des articles de volcanologie. En raison de la rareté des données démographiques, notre analyse est centrée sur les discriminations liées aux identités de genre, mais nous montrons aussi que les discriminations liées à l'ethnicité, l'orientation sexuelle, la religion, la capacité physique et l'origine socio-économique sont présentes et que l'intersection de ces discriminations exacerbe la marginalisation des personnes concernées au sein de la communauté volcanologique. Nous reprenons les suggestions et recommandations émises dans d'autres disciplines sur la manière dont les individus, les groupes de recherche et les organisations peuvent promouvoir, développer et implémenter de nouvelles initiatives pour identifier et combattre les discriminations et faire ainsi progresser l'EDI parmi les volcanologues. Il existe un large potentiel d'amélioration de la situation si nous réalisons que nous avons tous et toutes un rôle à jouer dans la promotion d'une communauté volcanologique qui soit plus équitable, plus diverse et plus inclusive. Pour cela, nous avons besoin 1) d'une prise conscience : il nous faut admettre l'existence du problème, 2) d'engagement : grâce à la proclamation des valeurs fondamentales de l'EDI et au développement de plans d'action, de codes de conduite et de directives, 3) d'action : avec pour objectif la représentation équitable de tous les groupes, 4) de réflexion : grâce à l'évolution d'une pensée autocritique et à une volonté sincère de corriger nos déficiences.

Resumen

La equidad, la diversidad y la inclusividad (EDI) son principios que todos los grupos y organizaciones científicas deberían tratar de alcanzar al asegurar condiciones de trabajo, políticas y prácticas que no sólo promuevan la producción científica de alta calidad, sino también el bienestar de sus comunidades. En este artículo, reflexionamos sobre el progreso de la EDI en vulcanología presentando datos relacionados con la pertenencia a organizaciones internacionales, los puestos en los comités, los premios y la autoría principal de artículos de vulcanología. Los escasos datos demográficos disponibles hacen que nuestro análisis se enfoque principalmente en la discriminación por identidad de género, sin embargo, mostramos que también se produce discriminación relacionada con el origen étnico, la orientación sexual, la religión, la capacidad física y el entorno socioeconómico, y que la intersección de estas discriminaciones exagera aún más la marginación dentro de la comunidad vulcanológica. Compartimos sugerencias y recomendaciones de otras disciplinas sobre cómo los individuos, los grupos de investigación y las organizaciones pueden promover, desarrollar y poner en práctica nuevas iniciativas para denunciar y abordar la discriminación y hacer avanzar la EDI en la comunidad vulcanológica. Existe un gran potencial de mejora si todas y todos vemos nuestro papel en la creación de una comunidad vulcanológica más equitativa, diversa e inclusiva. Esto requiere 1) Conciencia: reconocimiento del problema, 2) Compromiso: a través de la declaración de los valores fundamentales de la EDI y el desarrollo de planes de acción, códigos de conducta y directrices, 3) Acción: con el objetivo de lograr la representación de todos los grupos, y 4) Reflexión: desarrollo a través de la autorreflexión crítica y la voluntad de abordar las deficiencias.

摘要

公平、多样性和包容性 (EDI) 是所有科学团体和组织在确保工作条件、政策和实践时应努力实现的原则, 这些工作条件、政策和实践不仅能促进高质量的科学产出, 还能促进其协会的健康发展。在本文中, 我们通过提供与国际火山学组织成员、火山学委员会职位、火山学奖项和火山学论文的主要作者相关的数据来反思 EDI 在火山学中的进展。可用的人口统计数据稀少意味着我们的分析主要集中在性别认同歧视上, 但我们表明, 与种族、性取向、宗教、身体能力和社会经济背景相关的歧视也在发生, 这些歧视的交叉进一步加剧了火山学协会内部的边缘化。我们通过分享其他学科关于个人、研究团体和组织如何促进、开发和实施新举措以呼吁和解决歧视并推进火山学协会EDI的意见和建议。如果我们都能看到我们在创建一个更加公平、多样化和包容性的火山学协会方面所起的作用, 那么就有很大的改进潜力。这需要 1) 意识: 承认问题, 2) 承诺: 通过 EDI 核心价值观的陈述和行动计划、行为准则和指南的制定, 3) 行动: 旨在代表所有群体, 以及 4) 反思: 通过批判性的自我反思和解决缺点的意愿来发展

Riassunto

Parità, diversità e inclusività (PDI) rappresentano principi che tutte le organizzazioni e gruppi scientifici dovrebbero sforzarsi di raggiungere dato che assicurano condizioni di lavoro, politiche e pratiche che non solo promuovono una produzione scientifica di elevata qualità ma anche il benessere nelle loro comunità. In questo articolo, ci soffermiamo sui progressi di PDI nella vulcanologia presentando dati legati all'appartenenza a organizzazioni vulcanologiche internazionali, alle cariche nei comitati vulcanologici, ai premi per la vulcanologia e alla paternità principale su articoli di vulcanologia. Gli scarsi dati demografici disponibili implicano che la nostra analisi si concentri principalmente sulla discriminazione dell'identità di genere. Tuttavia, mostriamo che si stanno verificando anche discriminazioni legate all'etnia, all'orientamento sessuale, alla religione, all'abilità fisica e al contesto socioeconomico, con il convergere di queste discriminazioni che inasprisce ulteriormente l'emarginazione all'interno della comunità vulcanologica. Condividiamo suggerimenti e raccomandazioni da altre discipline su come i singoli individui, gruppi di ricerca e organizzazioni possano promuovere, sviluppare e implementare nuove iniziative per denunciare e contrastare la discriminazione facendo progredire la PDI nella comunità vulcanologica. C'è un notevole margine di miglioramento se tutti noi riconosciamo il nostro ruolo nel creare una comunità vulcanologica più equa, diversificata e inclusiva. Questo richiede 1) Consapevolezza: riconoscimento del problema, 2) Impegno: attraverso l'affermazione dei valori cardine di PDI e lo sviluppo di piani di azione, codici di condotta e linee guida, 3) Azione: puntare alla rappresentazione di tutti i gruppi e 4) Riflessione: crescita attraverso la riflessione autocritica e la volontà di affrontare le carenze.

Abstrakt

Równość, różnorodność i inkluzywność (EDI) to podstawy, do których osiągnięcia powinny dążyć wszystkie grupy naukowe i organizacje poprzez zapewnienia warunków pracy, polityk i praktyk, które nie tylko promują wysokiej jakości wyniki naukowe, ale także dobrobyt w ich społecznościach. W tym artykule zastanawiamy się nad postępem EDI w vulkanologii, przedstawiając dane związane z członkostwem w międzynarodowych organizacjach vulkanologicznych, stanowiskami w komitetach vulkanologicznych, nagrodami vulkanologicznymi i główne autorstwo artykułów vulkanologicznych. Wskutek rzadkości dostępnych danych demograficznych nasza analiza koncentruje się głównie na dyskryminacji ze względu na tożsamość płciową, niemniej jednak pokazujemy, że występuje również dyskryminacja związana z pochodzeniem etnicznym, orientacją seksualną, religią, sprawnością fizyczną i pochodzeniem społeczno-ekonomicznym, przy czym przecięcie tych dyskryminacji dodatkowo pogarsza marginalizację w społeczności vulkanologów. Dzielimy się sugestiami i zaleceniami z innych dyscyplin na temat tego, w jaki sposób osoby, grupy badawcze i organizacje mogą promować, rozwijać i wdrażać nowe inicjatywy, aby wywoływać i zwalczać dyskryminację oraz rozwijać EDI w społeczności vulkanologicznej. Istnieje wiele możliwości ulepszeń, jeśli wszyscy przyjmimy naszą rolę w tworzeniu bardziej sprawiedliwej, zróżnicowanej i integracyjnej społeczności vulkanologicznej. Wymaga to 1) Świadomości: rozpoznania problemu, 2) Zaangażowania: poprzez określenie podstawowych wartości EDI oraz opracowanie planów działania, kodeksów postępowania i wytycznych, 3) Działania: dążenie do reprezentacji wszystkich grup, oraz 4) Refleksji: rozwój poprzez krytyczną autorefleksję i chęć zajęcia się niedociągnięciami.

Аннотация

Равенство, разнообразие и инклюзивность (На английском языке сокращено до EDI) — это принципы, к достижению которых должны стремиться все научные группы и организации, поскольку они обеспечивают условия труда, политику и практику, которые не только способствуют получению высококачественных научных результатов, но и благополучию их сообществ. В этой статье, мы размышляем о прогрессе EDI в вулканологии, представляя данные, связанные с членством в международных организациях по вулканологии, позициями в комитетах по вулканологии, наградами по вулканологии и авторством статей по вулканологии. Имеющиеся скудные демографические данные означают, что наш анализ сосредоточен в основном на дискриминации по признаку пола, но мы показываем, что дискриминация, связанная с этнической принадлежностью, сексуальной ориентацией, религией, физическими способностями

и социально-экономическим положением, также имеет место. Пересечение этих различий еще больше усугубляет маргинализацию в вулканологическом сообществе. Мы делимся предложениями и рекомендациями из других сфер и наук о том, как отдельные лица, исследовательские группы и организации могут продвигать, разрабатывать и реализовывать новые инициативы по выявлению и борьбе с дискриминацией и продвижению EDI в вулканологическом сообществе. Существует большой потенциал для улучшения, если мы все осознаем свою роль в создании более справедливого, разнообразного и инклюзивного сообщества вулканологов. Для этого требуется 1) Осведомленность: признание проблемы, 2) Приверженность: через заявление об основных ценностях EDI и разработку планов действий, кодексов поведения и руководств, 3) Действия: стремление к представлению всех групп и 4) Наблюдения: развитие через критическое самонаблюдение и готовность устранять недостатки.

Abstrakt

Jämlikhet, mångfald och inkludering (EDI efter engelska Equity, diversity and inclusivity) är värden som alla forskargrupper och organisationer ska sträva efter. Dessa värden säkrar arbetsvillkor, policies och praktik som inte bara främjar forskningsresultat av hög kvalitet men även det vulkanologiska samhällets välbefinnande. I denna artikel reflekterar vi över EDI framsteg inom vulkanologin genom att utvärdera internationella organisationers medlemsdata, sammansättningen av nämnder, fördelning av priser och förstaförfattarskap av artiklar i vulkanologiska tidskrifter. På grund av den otillräckliga tillgången på data fokuserar vi vår analys utifrån diskriminering som kan kopplas till könsidentitet, men visar även att diskriminering på grund av etnicitet, sexuell läggning, religion, fysisk förmåga och socioekonomisk bakgrund förekommer och att om flera av dessa faktorer korsas leder det till ännu värre marginalisering inom det vulkanologiska samhället. Vi delar förslag och råd från andra discipliner om hur individer, forskargrupper och organisationer kan främja, utveckla och implementera nya initiativ som identifierar och tar itu med diskriminering och förbättrar EDI inom vulkanologin. Det finns mycket förbättringspotential om vi alla ser vår roll i att skapa ett jämlikare, och inkluderande vulkanologiskt samhälle med mer mångfald. Att uppnå detta kräver: 1) Medvetenhet: erkännandet av problemet, 2) Engagemang: genom att anta EDI i värdegrunden och utveckla handlingsplaner, uppförandekoder och riktlinjer, 3) Handling med målet att uppnå alla gruppers representation och 4) Reflektion: utveckling genom kritisk självreflektion och viljan att ta itu med brister.

Abbreviations

AGU VGP -	American Geophysical Union section on Volcanology, Geochemistry and Petrology
ALVO -	Asociación Latinoamericana de Volcanología
Bull Volc -	Bulletin of Volcanology
ECR -	Early career researcher
ECS -	Early career scientist
EDI -	Equity, diversity and inclusion
EGU GMPV -	European Geosciences Union Division on Geochemistry, Mineralogy, Petrology and Volcanology
IAVCEI -	International Association of Volcanology and Chemistry of the Earth's Interior
INVOLC -	International Network for Volcanology Collaboration
IUGG -	The International Union of Geodesy and Geophysics
JAV -	Journal of Applied Volcanology
JVGR -	Journal of Volcanology and Geothermal Research
LGBTQ+ -	Lesbian, gay, bisexual, transgender, queer (or questioning) and others
STEM -	Science, technology, engineering and mathematics
VMSG -	Volcanic and Magmatic Studies Group

Introduction

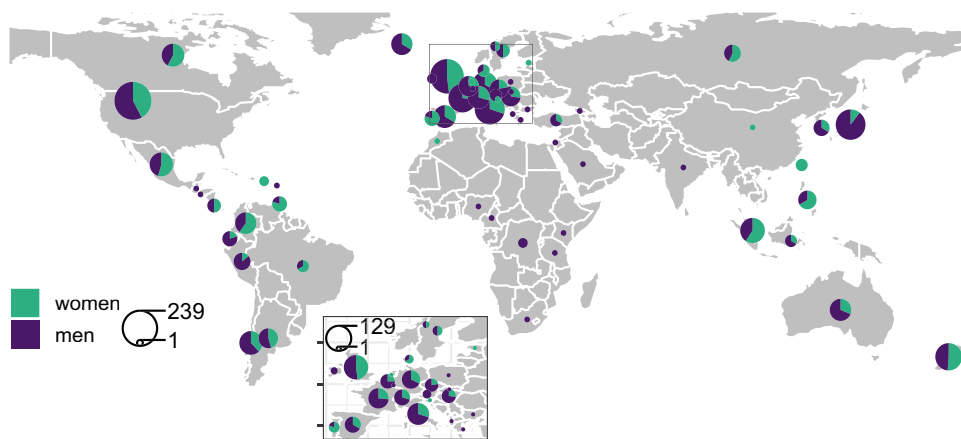
There is a well-documented diversity crisis in geoscience (e.g. Dowey et al. 2021; Dutt 2020; Johnson 2018; Marin-Spiotta et al. 2020); however, no international study has yet focused on equity, diversity and inclusion (EDI) in volcanology. Therefore, our intent is to collate and collect new data, raise awareness about the experiences of members of our community and recommend how individuals and organisations should move EDI forwards in volcanology.

We present a new analysis of diversity reflected by memberships of volcanology-themed international organisations and groups, positions on prestigious committees, award winners and lead-authors of publications. We have also collated over 100 anonymous stories from volcanologists and incorporate quotes from these throughout the text; these anecdotal and lived experiences record what some volcanologists are saying about their discipline and collectively describe a culture in volcanology that requires immediate change. Some accounts of witnessed and experienced discrimination are harrowing, and some comments readers may find distressing or offensive. The Supplementary Materials include summary information about the survey we conducted, how it was distributed, presents full transcripts of the stories from survey

Fig. 1 The number of IAVCEI members per country and pie charts showing the percentage of women and men IAVCEI members in 2021. The inset map shows European countries in detail for clarity

IAVCEI membership and gender distribution in 2021

Points are coloured according to the gender distribution. The size denotes the total members, where the upper bound is the maximum total for a single country.



participants and includes graphics detailing the demographics of the respondents and their frequency of experienced or witnessed discrimination in volcanology.

Who is the volcanology community?

To explore who the volcanology community is today, the only data available comes from membership data collected by international organisations with a focus on volcanology (for data and methods, see Online Resources 1, 2 and 3). We are limited by the categories these organisations use to collect data on gender, and by the lack of data on other demographics and protected characteristics.¹

The International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) is part of the International Union of Geodesy and Geophysics (IUGG) (Cas 2022). Its organisational structures, volcanology focus and international affiliation make for an interesting comparison to volcanology groups that are regional (Engwell et al. 2020) or only include some aspects of volcanology, such as the American Geophysical Union (AGU) Volcanology, Geochemistry & Petrology (VGP) Section or the European Geosciences Union (EGU) Geochemistry-Mineralogy-Petrology-Volcanology (GMPV) Division.

The IAVCEI 2021 membership data reports only the geographical location of the membership and the gender

identity (either male or female must be selected during registration, Fig. 1). In 2021, IAVCEI had 937 members (39% female, 61% male) across 62 countries (See Table 1). The overwhelming majority of countries around the world have more men than women IAVCEI members, and only three countries with > 4 members have close to 50% women (the UK, New Zealand and Mexico). A few countries have more women (e.g. Portugal, Denmark, the Philippines, Taiwan, Singapore, Brazil, Russia and Canada), and some countries have notably high percentages of men (e.g. Japan, South Korea, France, Ecuador and Peru). Across Africa, the Middle East and India IAVCEI members are few, but are all men.

The EGU GMPV report the gender, career stage and geographic location of members from 2016 to 2021. Since 2019, EGU has offered the option for members to select their gender as 'male', 'female', 'other' or 'prefer not to say'. There were 1365 EGU GMPV members in 2021 across 69 countries (39% female, 59% male and 0% other gender, see Table 1 and Figure S1a in Online Resource 1). In 2021, the top five member countries were Germany, the UK, Italy, France and the USA (Figure S2 in Online Resource 2), and so the bulk statistics are strongly influenced by them. The global distribution and proportion of the EGU GMPV Early Career Scientists (ECS) members has broadly increased from 2016 to 2021 (Figure S3 in Online Resource 2). Members joining from new countries, such as Pakistan, Nigeria, Bulgaria or Georgia, tended to be ECS (Figure S2 in Online Resource 2). During this time, there have been notable increases in the number of ECS members in, for example, Japan, the Netherlands, Ireland, Hungary, Canada, Spain, Portugal, and Italy, but decreases in Belgium and Sweden (Figure S3 in Online Resource 2).

The AGU VGP provided us with the gender identity and geographical region data of its members from 2013 to 2021

¹ Whilst these vary by country, the international human rights legal framework contains international instruments to combat specific forms of discrimination, including [discrimination against indigenous peoples](#), [migrants](#), [minorities](#), [people with disabilities](#), [discrimination against women](#), [racial](#) and [religious discrimination](#) or discrimination based on [sexual orientation](#) and [gender identity](#).

Table 1 Gender identity of members of volcanological groups in 2020/2021. Data for early career researchers (ECR, including students) is also provided in brackets where indicated: *AGU definition of students plus early career researchers, **EGU definition of early

career scientists, (–) indicates data were not collected by the organisation. In all groups, there is a higher proportion of women in earlier career stages

	Membership	Female %	Male %	Nonbinary	Prefer self-describe	Unknown	Other	Prefer not to say
IAVCEI 2021	937	39%	61%	(–)	(–)	(–)	(–)	(–)
AGU VGP 2020	2919	31%	67%	3 (0.1%)	0 (0.0%)	42 (1.4%)	(–)	29 (1.0%)
AGU VGP 2020 ECR and student*	1235 (42%)	46%	52%	2 (0.2%)	0 (0.0%)	7 (0.6%)	(–)	15 (1.2%)
AGU VGP 2020 non-ECR and non-student*	1684 (58%)	20%	77%	1 (0.06%)	0 (0.0%)	35 (2.1%)	(–)	14 (0.8%)
EGU GMPV 2021	1365	39%	58%	(–)	(–)	14 (1.0%)	0 (0%)	27 (2.0%)
EGU GMPV 2021 ECS**	808 (59%)	44%	55%	(–)	(–)	6 (0.7%)	0 (0%)	7 (0.9%)
EGU GMPV 2021 non-ECS**	557 (41%)	31%	64%	(–)	(–)	8 (1.0%)	0 (0%)	20 (3.6%)

and their career stage up to 2020. AGU offers the option for members to select their gender as ‘male’, ‘female’, ‘non-binary’, ‘prefer to self-describe’ or ‘prefer not to say’. Since 2013, these data have remained relatively stable, despite absolute numbers declining over this period (Figure S4 in Online Resource 2). With a total of 2919 members in 2020 (31% female, 67% male and 0.1% non-binary), the AGU VGP includes more individuals than the IAVCEI 2021 or EGU GMPV 2021 datasets (Table 1).

The AGU VGP section has a lower percentage of students and early career researchers (ECR) than the EGU GMPV ECS (42% compared to 59%, Table 1), but these groups have a similar gender balance across the organisations. The AGU VGP student and ECR data and the EGU GMPV ECS data both show that these groups have a higher proportion of women (46% and 44%, respectively) relative to the overall membership, and the AGU data suggests that this has been the case since at least 2014 (Table 1, Figure S5 in Online Resource 2). The senior volcanologists (non-student, non-ECR, non-ECS groups) have a particularly low female (19.7%, 31.2%) and high male (77.4%, 63.7%) proportion relative to the AGU VGP and EGU GMPV bulk statistics. This suggests a loss of women volcanologists with advancing career stage.

There are limitations to these data. Whilst IAVCEI, AGU and EGU are the largest international groups that volcanology members can engage with, not all volcanologists are members. Other volcanology organisations include the Latinamerican Association of Volcanology (Asociación Latinoamericana de Volcanología, ALVO) that was founded in 2010 and aims to strengthen and promote the ties amongst Latin American volcanologist; and several of their members

may not be IAVCEI, AGU or EGU members, and so are not represented in these datasets. The inauguration workshop for IAVCEI’s International Network for Volcanology Collaboration (INVOLC), which is working to foster cross-country partnerships and overcome challenges related to access to resources, was attended by many volcanologists from around the world who were not members of IAVCEI (K. Fontijn, *pers comm.*). National volcanology-specific organisations or subject-specific sub-groups of IAVCEI, such as IAVCEI Commissions, also have their own members, but generally do not collect demographic data—however, collecting and publishing demographic data on their members would be a great resource for the volcanology community, helping groups to identify opportunities to increase diversity and be more inclusive.

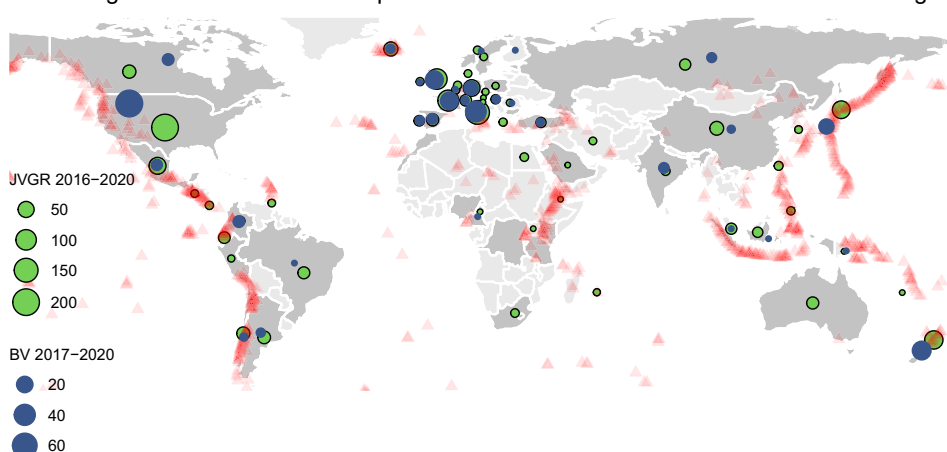
The gender identity data currently available from IAVCEI is limited and is in urgent need of updating. Currently, IAVCEI members can only select ‘female’ or ‘male’ during registration, erasing non-binary and genderqueer scientists (Cameron and Stinson 2019). It also does not allow for transgender scientists to identify as such if they wish. Individuals should always have the option to self-identify their gender in any demographics data collection (Strauss et al. 2021). Some volcanology organisations do not see the need for them to collect such data:

"No such data have ever [been] collected, practically as it was never really relevant to anything we've done."—an IAVCEI Commission Lead in response to our request for data

However, the lack of data means that any EDI issues may not be known or recognised, and the effectiveness of any

Fig. 2 The total number and country of affiliation of lead-authors of articles accepted for publication in volcanology journals in recent years. The location of IAVCEI members and volcanic eruptions in the Holocene are shown for reference

Recent publications in J. Volcanol. Geotherm. Res and Bull. Volcanol.
Red triangles denote Holocene eruptions. Countries with IAVCEI members are darker grey.



actions put in place to improve EDI cannot be assessed. Recently, some volcanology organisations and groups have started to collect membership data during registration to online events to learn about their members, for example prior to an IAVCEI Commission on Volcanic and Igneous Plumbing Systems (VIPS) online seminar in 2021, and for the IAVCEI Commission on the Chemistry of Volcanic Gases (CCVG) workshop in 2021. Other IAVCEI Commission leads we contacted expressed a desire to understand better why such data collection is needed, how this should be done responsibly and how data should be stored. Unfortunately, it is not possible for us to provide a template for this as the appropriate data to collect, and the laws which permit it to be collected, vary depending on geographical context. For example, in France, it is unlawful to collect data on race. However, in the UK Protected Characteristics data can be collected under the Equality Act. Ultimately each organisation should be guided by the requirements from their ‘host country’ (see Online Resource 4 for some suggestions), but we also suggest that the creation of a dedicated EDI role on the IAVCEI Committee would provide the community with a go-to person that organisations and groups in volcanology could contact to discuss ethical and lawful data collection methods and data storage.

Who publishes in volcanology journals?

The advancement of knowledge in volcanology is communicated primarily through peer-reviewed scientific publications, but a wealth of knowledge is also published in non-peer-reviewed eruption reports prepared by volcano observatories and information released through media outlets (Peltier et al. 2022). Decisions about grant funding,

postdoctoral appointments, and ultimately the ability to pursue an academic career are in part decided on an individual’s publication record. To understand who is allowed to create and disseminate knowledge, we analysed data from two of the most important volcanology journals (Cas 2022; Stevenson 2014)—the Journal of Volcanology and Geothermal Research (JVGR, Elsevier) and the Bulletin of Volcanology (Bull Volc, Springer). The other volcanology-themed journals we approached either did not respond or were unable to provide data. The only volcanology-specific journals we are aware of that are not currently only published in English are the Bulletin of the Volcanological Society of Japan, which publishes in Japanese with abstracts in English, Volcanica which offers a dual-language abstract option, and the Bulletin of Volcanology which can publish abstracts in 42 different languages. A recent Volcanica special issue of reports published full articles in English and in Spanish, done in part due to recognition of language barriers in volcanology (Chevrel et al. 2021).

The Bull Volc and JVGR data show a lack of diversity in lead-author affiliation country. The lead-authors of volcanology articles are most often from Europe, North America, New Zealand and Japan (Fig. 2). Regions with under-represented lead-author country affiliation and a higher rate of rejection (see Figures S6 and S7 in Online Resource 2), despite high levels of volcanic activity, include South America, Central America, East Africa and South-East Asia. This echoes similar trends observed in broad geoscience publications (North et al. 2020) and may reflect a well-established bias in academic publishing favouring the English-language (Ramírez-Castañeda 2020) or a tendency for researchers from these countries to not lead volcanology articles and instead produce non-peer-reviewed reports (Peltier et al. 2022).

Our collated narratives reveal the different experiences of authors depending on the research group's ethical practices and potential nepotism:

"Not being given the chance to co-author a paper despite having spent significant time helping out... I see others (both junior and senior folks) who contribute much less, sometimes hardly anything, repeatedly being put on papers, which only results in reinforcing their status as a well-known and/or promising researcher. This practice tends to happen in the inner circle of the big volcano groups."

Publication authorship should be based on contribution, and journals are increasingly asking for an author contribution statement to be included with the article. However, in some research groups, there is a perception that some contributions are 'valued' more than others:

"Women in volcanology are often 'forgotten' or their scientific contribution is devalued relative to a male of similar career stage."

A survey response suggests discrimination in publication authorship related to maternity leave:

"I have been erased [from the] list of authors of papers I have written and [that] I have worked for because I went on maternity leave."

Who decides what is published in volcanology?

One of the strongest voices in the publication of volcanology journal articles comes from the 120 senior editorial team and editorial board members of the leading volcanology journals: JVGR (Elsevier), Bull Volc (Springer), the Journal of Applied Volcanology (JAV, Springer) and Volcanica (a diamond open-access journal). We used the publicly available country of affiliation data (as of February 2022) to look at the geographic distribution of the editors of these journals, finding that 63% (75/120) are affiliated to countries where English is recognised as (one of) the official language(s): Australia, Ireland, New Zealand, Singapore, Trinidad, the UK, the USA and a part of Canada. The journal editor team (senior editors and editorial board members) have a lot of influence in the publication process and may be able to solicit guest editors, solicit research articles and propose thematic special issues, and they ultimately decide whether a paper is accepted or rejected. Editorial teams may also have a role developing and implementing the journals code of conduct that authors, reviewers and editors are required to adhere to. Explicit (or unconscious) bias against the authors, the reviewers or the editor may play a part in decisions the

editors make (e.g. Fox and Paine 2019; Hagan et al. 2020; Helmer et al. 2017; Poulson-Ellestad et al. 2020) and how these decisions are received. One editor wrote:

"It seems clear that some authors and reviewers find it harder to respect my decision (or me?) than they would if I were a man."

We are not aware of any volcanology journals that ask for information on protected characteristics of their authors or reviewers (and often not their editors either), and so we have found there is no data available to assess the contribution of different genders to volcanology articles. We emailed the 120 volcanology editors of Bull Volc, JAV, JVGR and Volcanica and asked them to complete a quick survey to tell us their gender identity and to confirm which journals they are editor, how many years since completing their PhD, whether or not they consider themselves to be an early career researcher (ECR) and whether they are an English native speaker. We had a 79% response to our survey (see Table 2 for a summary), with six individuals being involved in editing two of the journals listed. When no response was given, we used Internet searches to gather publicly available information on gender identity, career stage and native language.

There are more men than women in senior volcanology editorial positions and editorial boards (mostly > 60% men), except for the editorial board of Volcanica (43% men) and the editor-in-chief of JAV (a woman). Volcanica is the only volcanology journal which has early career researchers in the senior editorial committee, and it has a much larger proportion of ECRs in its editorial board (51% ECR) compared to the other volcanology journals (these have ~ 10% ECRs). The journals with the higher proportion of men in the editorial team (Bull Volc and JVGR) tend to have a lower proportion of native English speakers (< 50%). JAV and Volcanica have a relatively high proportions of women editors and have a relatively high proportion of English native speakers (> 70%). These editorial team trends appear to broadly mimic the gender balance of IAVCEI members around the world (Fig. 1, Table 1), and suggests that non-native English-speaking women are particularly underrepresented in volcanology editor teams.

Publishers, journals and editorial teams have a responsibility to act and address these issues (Mehta et al. 2020), and to ensure that actions put in place to increase geographic representation, for example, do not come at the expense of other important factors, such as gender balance (and vice versa). Publishers are now actively discussing how they can make their journals more inclusive, and new policies such as supporting the inclusion of trans scholars, introducing no restrictions on the number of equally contributing and corresponding author numbers, deciding how authors can choose to display their preferred pronouns, and a push to use more inclusive language, are all positive steps. However, pressure

Table 2 Characteristics of the editorial teams leading the main volcanology journals (in February 2022). The reported gender identity data was provided to us by individuals, and participants could select male (M), female (F), trans male (TrM), trans female (TrF), non-binary (nb) and prefer not to say (P). The number of non-responders is indicated (na). Early career researchers are self-identifying, and in the absence of information or ambiguity, we classified those who

have had their PhD for 10 years or less as ECRs. The reported ratio of men to women, the percentage of early career researchers, and percentage of native English speakers include data for non-responders collected through internet searches. Six individuals are editors for two of the journals. (+) includes four technical team members and one report editor (total 4 women and 1 man) who are all ECR and all English native speakers

Journal and role	Total number	Self-declared gender identity (M/F/TrM/TrF/nb/P/na)	Men: women	% ECR	% English native speaker
<i>Bulletin of Volcanology</i>					
Executive director and deputy editor	3	2/0/0/0/0/1 (66% response)	2:1 (66% M)	0%	33%
Associate editor	26	13/5/0/0/0/1/7 (73% response)	19:7 (73% M)	12%	42%
<i>Journal of Applied Volcanology</i>					
Editor-in-chief	1	0/1/0/0/0/0/0 (100% response)	0:1 (0% M)	0%	100%
Editors	11	5/4/0/0/0/0/2 (82% response)	6:5 (50% M)	9%	73%
<i>Journal of Volcanology & Geothermal Research</i>					
Co-editor in chief	6	3/2/0/0/0/0/1 (83% response)	4:2 (67% M)	0%	50%
Editorial board	32	14/8/0/0/0/0/10 (69% response)	22:10 (69% M)	9%	50%
<i>Volcanica</i>					
Editorial committee	8	5/3/0/0/0/0/0 (100% response)	5:3 (63% M)	50%	75%
Editorial board (+)	35	13/18/0/0/0/0/4 (89% response)	15:20 (43% M)	51%	77%

needs to come from those who have a voice in the system to push for more rapid change across the sector, to educate editors, authors and reviewers as to why it is needed and to continue to evolve in a positive direction.

Who leads our community?

"I feel that in volcanology there is a male-dominated culture, and this is reflected in many of the 'leaders' such as award-winners or leads of committees like IAVCEI [being] male. It's really hard to find diverse role models."

The gender and racial identity of individuals holding many key IAVCEI leadership roles since its inception in 1919 supports this assertion. A recent review article on the history of IAVCEI (Cas 2022) shows how women have been almost invisible in volcanology (photographs collated by Cas (2022) shows the individuals who have taken key IAVCEI roles—4 key personnel in the formation of IAVCEI, 22 Presidents, 10 secretaries, 11 Editors of Bull Volc—are all men. Women are under-represented in the IAVCEI Committee

relative to their proportion in the IAVCEI, AGU VGP and EGU GMPV membership. The current IAVCEI Committee comprises nine (75%) men and three (25%) women (see Fig. 3a) and currently has relatively good representation from IAVCEI member countries around the world (Figure S9 and Online Resource 2). Over more than 100 years, up to today, 100% of the IAVCEI General Secretaries and 100% of IAVCEI Presidents have been men (Fig. 3a), and only once has the President been affiliated with a southern hemisphere country (see Figure S9 and Online Resource 2). IAVCEI is unique amongst the eight scientific associations within IUGG in never having had a woman or non-binary President.

IAVCEI Commissions and Network board officers are slightly more diverse in gender than the IAVCEI Committee, comprising overall 63% men and 37% women. This gender balance is not evenly distributed: Nine out of seventeen IAVCEI Commissions (mostly inter-associations ones) have a 100% male board, five IAVCEI Commissions or Networks (including the ECR Network) have 50% men and 50% women on their boards and one IAVCEI Commission board is 100% women. Women lead seven out of seventeen (40%) of IAVCEI Commissions, two out of seven

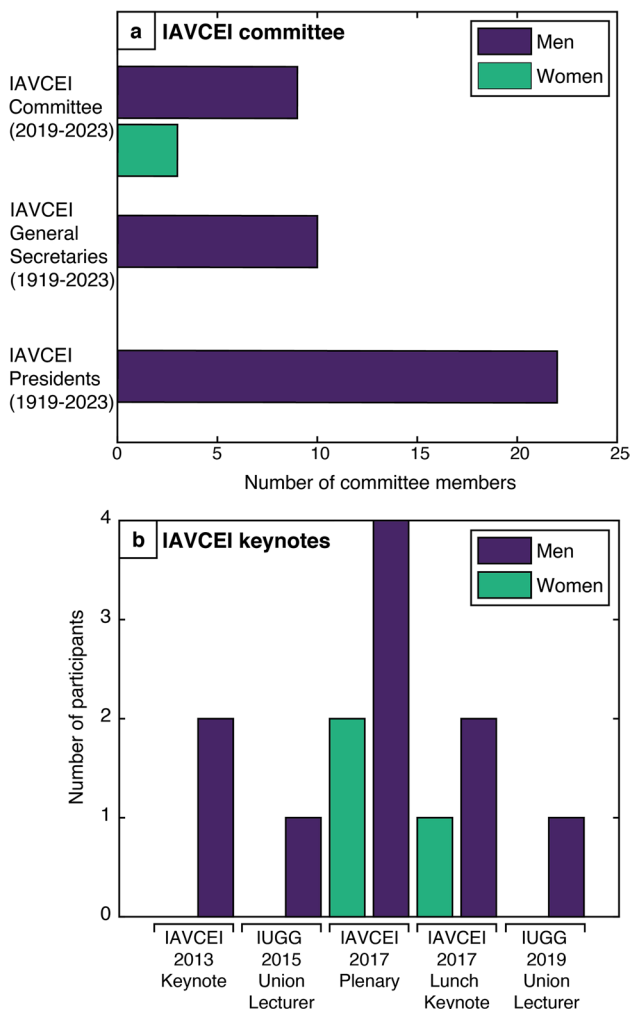


Fig. 3 Gender identity of **a** IAVCEI Committee leadership and members since 1919, and **b** keynote speakers at IAVCEI General Assemblies, since 2013

(29%) inter-Association Commissions and two out of two (100%) of IAVCEI Networks. The newer or ECR-focused IAVCEI Commissions or Networks, or those that have regular changes in their leadership, tend to have more gender equity or to be led by women, and this suggests gradual progress towards gender equity in the IAVCEI Commissions.

In the IAVCEI 2013 General Assembly and the IUGG 2015 and 2019 conferences, Union lecturers were 100% men. At IAVCEI 2017, there were 33% plenary and lunch keynote talks by women (Fig. 3b), and the only instance of a woman giving a plenary/keynote was when there were a series of different kinds of plenary talks at the conference. The country of affiliation of keynote speakers often aligns with the country where the meeting is held. For example, in 2017 when the IAVCEI general assembly was in Portland, Oregon, eight out of nine keynote talks were from scientists with a US-affiliation; and in 2013 when the IAVCEI general

assembly was in Kagoshima, both keynote speakers had a Japanese affiliation. The issue of women and under-represented minorities giving fewer talks is recognised broadly across Earth Science conferences (Ford et al. 2019).

Who do we reward?

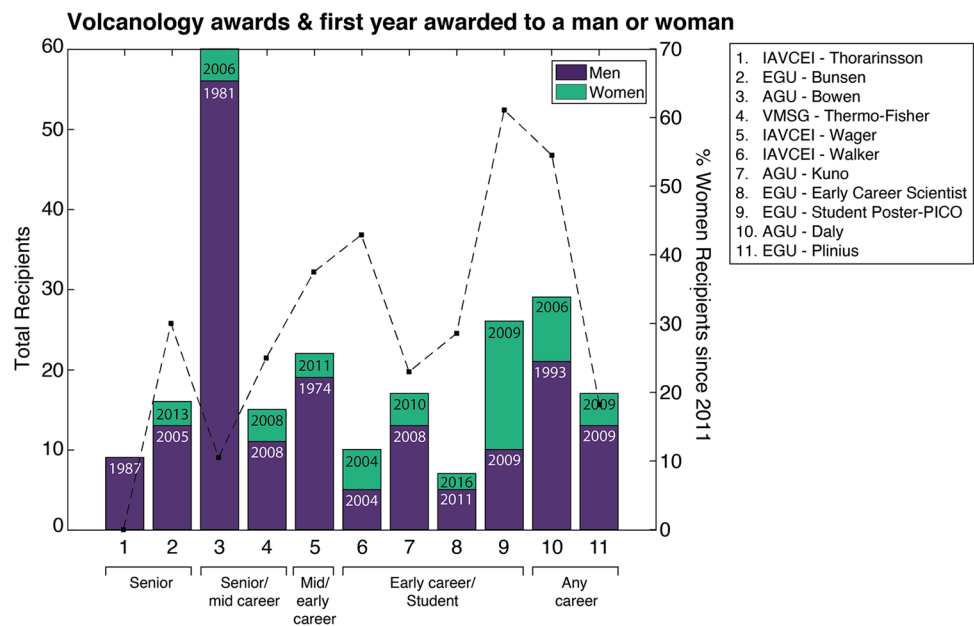
One way in which excellence in volcanology is recognised and celebrated is through awards and medals. Award winners are role models and are implicitly perceived as reflecting the values that volcanologists wish to promote.

The IAVCEI Thorarinson medal for senior volcanologists has never had a woman recipient. The awards that individuals from all career stages are eligible for also have relatively low women recipients (e.g. 5% women recipients of the AGU Bowen Award since 1981), whereas the early career stage awards are much more balanced in gender (e.g. 50% women recipients of the IAVCEI George Walker Award since 2004). The EGU award for students is unique in having a higher proportion of women recipients. The proportion of women award recipients decreases the more senior the medal in volcanology is (Fig. 4), and the affiliation countries of all IAVCEI Thorarinson, Wager and Walker award winners are exclusively restricted to the northern hemisphere, with the most southerly country being Singapore (Figure S8 in Online Resource 2). There are fewer women at the senior level in volcanology who would be eligible for these awards (e.g. Table 1) and fewer IAVCEI members in the southern hemisphere, but the fact that we do not see women or individuals affiliated with southern hemisphere countries receiving senior awards sends a message to the younger generation that there is a narrow vision of what success looks like, and that the contributions of women and other underrepresented people are not valued.

Recent trends show little improvement. Over the past 10 years, the percentage of women awardees ranges from 0 to 61% depending on the award category, and the more senior awards are associated with lower percentages of women awardees, i.e. 0% for the IAVCEI Thorarinson Medal, 30% for the EGU Bunsen Medal and 10.5% for the AGU Bowen Award (Fig. 4, Table S1 in Online Resource 1). These percentages are low relative to the likely proportion of non-ECR women in the volcanology community (Table 1), suggesting that senior women in academia win senior awards less frequently than their male counterparts. Over the past 5 years (2016 to 2021), in all cases, there has been a small increase in women award winners (Table S1 in Online Resource 1). Overall, this demonstrates that the Matilda effect (where the scientific efforts and achievements of women do not receive the same recognition as men) is present within the volcanology community (Lincoln et al. 2012).

A recent analysis conducted by the UK's Volcanic and Magmatic Studies Group (VMSG) showed that men were

Fig. 4 Gender identity of volcanology award winners for different career stages since the first year of data availability (bars), and the proportion of women recipients since 2011 (dashed line). The lower label on the bars indicates the first year of data availability and the upper label the first year there was a woman recipient



nominated far more frequently than women for their most-senior award, the Thermo-Fisher Award, but when women were nominated, they tended to be more successful (VMSG Website newsletter #50 <https://vmsg.org.uk/>). Since 2010, there have been 79% men and 21% women VMSG Thermo-Fisher Award winners, for which VMSG received 83% men and 17% women nominations. It appears that only outstanding women tend to be nominated for this award. Despite comparable quality of work, women are under-recognised by our awards, and men over-represented.

A common challenge for awards committees is ensuring nominations come in at all, and the selection committees can only choose from those who are nominated (McFadden 2018). In a bold move which has helped to raise awareness, the AGU Cryosphere Section declined to recommend any nominees to the AGU Union Fellows committee in 2021 due to lack of diversity in the pool (Cryosphere Fellows Selection Committee 2021). Perhaps other organisations also need to follow suit, or adopt an action plan (Ali et al. 2021), for what to do if/when a dramatically unbalanced nomination pool arises. The ambition must be that outstanding researchers will be nominated for awards, irrespective of their gender identity, status, socio-economic background, sexuality, ethnicity, etc., and yet the data we have accessed suggests that volcanology is far from realising this.

Experiences of discrimination in volcanology

The lack of diversity in volcanology highlighted by our analysis reflects ingrained discriminations that affect the whole of society. Some of the comments received in our survey indicate that some volcanologists do not feel included:

"For my specific subdiscipline, at least in my country, it feels like it's a club where you have to know the 'right' people, act the 'right' way, work on the 'right' topics, etc. to be included in it. Sometimes I think it's simply due an unconscious preference for 'people like me'"

Another theme that emerges seems to relate to harassment by superiors and power struggle in the workplace, with fear of retribution through career detriment. The first step towards an inclusive, fair, more diverse and therefore more creative volcanology community is the awareness and acknowledgement of the issues (e.g. Berhe et al. 2022; Keashly and Neuman 2010; McKay et al. 2008).

We received over 128 responses to our ethics-approved survey (see Supplementary Materials for details on our methodology, the questions asked, geographic reach of our survey and the protected characteristics of respondents). Discrimination means treating someone unfairly because of who they are based on characteristics such as age, disability, gender identity, pregnancy and maternity, ethnicity, religion or belief, sexual orientation, socio-economic status and profession/job status. Overall, 85 respondents (66%) reported experiencing discrimination, and 104 respondents (82%) reported witnessing discrimination in their volcanology work or study. From those who reported experiencing discrimination, 55 (43%) reported that this happened a few times per year or more, and four respondents reported constant discrimination (daily). Some individuals provided free-text comments to describe instances of discrimination witnessed or experienced during their volcanology studies or work (see Supplementary Materials). We have categorised these into 43 experiences and 23 witnessed accounts



Fig. 5 Word cloud of categories of volcanologists' experiences and witnessed accounts of discrimination in their work or study reported in our survey (see Supplementary Materials Online Resource 4 for full transcripts)

of discrimination, with the most common reported forms of discrimination relating to sexism (reported 35 times), activities during fieldwork (16 times), a toxic culture (10 times) and racism (9 times) (see Fig. 5).

In an EDI debate at the virtual European Geophysical Union General Assembly in 2021, it was stressed that responsibility for change should not be taken only by members of under-represented groups or those who have experienced discrimination; not only because these members are often not in a position of power, but mostly because the load of taking action should be fairly distributed. The impact of discriminatory experiences against, or witnessed by, individuals can be profound, and could lead to mental health problems and victims potentially leaving the field of volcanology. Achieving a fairer and less discriminatory volcanology community is the responsibility of all its members, and the work involved in this should be appropriately recognised and not fall exclusively on those who are marginalised (Gewin 2020).

Equity, diversity and inclusion in volcanology: looking forwards

Our view of the future of volcanology is of a community that makes all its members feel welcomed and respected, and where all scientists can thrive. The rather sobering current state of equity, diversity and inclusion (EDI) within

the volcanology community presented in this contribution should be a call to action for organisations, scientific journals and individuals. A number of studies have recently constructed evidenced-based action lists to address the lack of diversity in geoscience which can be used as road maps (e.g. Ali et al. 2021; Dowey et al. 2021; Kaaden et al. 2021; Núñez et al. 2020).

We thus conclude with four core recommendations to overcome ongoing and future EDI challenges.

1. **Awareness:** *Any change must be preceded by acknowledging the problem.* Inequities in science, technology, engineering and mathematics (STEM) research fields are well established in the literature (e.g. Clancy et al. 2014; Dutt 2020; Fox and Paine 2019; Lincoln et al. 2012). The data presented here also proves that these issues are endemic in volcanology; however, our analysis has been hampered by a lack of quality data. We thus encourage volcanological organisations and journals to implement and/or continue to develop measures to map out their current state of EDI so as to be aware of their specific situation, and to take counteractive measures if necessary. This includes, for example, the collection of quantitative (but anonymous) demographic data on society members, conference/event participants, authors, editor groups and reviewers. This, of course, must be done using best practice for inclusive data collection (Online Resource 4) and also be open to collecting anonymous feedback regarding EDI issues, and/or opportunities to discuss EDI should be provided. Several of the committees we contacted expressed a strong desire to be proactive in EDI but felt uncomfortable collecting protected data from their members. We thus suggest that EDI-dedicated roles be created on the IAVCEI Committee who can oversee and advise on data collection, storage and collection so that the effectiveness of actions can be measured.
2. **Commitment:** *Organisations and organisers should openly commit to EDI as core values and develop action plans, codes of conducts and guidelines.* Field experience can be uncomfortable for women and for other under-represented groups due to a pervasive macho culture, a lack of access to toilets, and unsafe environments for people of colour (Anadu et al. 2020) or the lesbian, gay, bi, transgender, queer (or questioning) and others (LGBTQ+) community (Olcott and Downen 2020). However, a series of measures can be implemented by field leaders to make fieldwork and field trips enjoyable and productive for all (Greene et al. 2021; Lawrence and Dowey 2021). Many scientific associations have codes of conduct and guidelines for events, including workshops and conferences (e.g. <https://vmmsg.org.uk/events/code-of-conduct-for-meetings/>). We call for all volcanological associations and commis-

sions to follow suit, and for all volcanologists to follow these guidelines. We need a zero-tolerance community regarding discrimination, disparaging comments and all forms of micro-aggressions occurring during volcanology events (e.g. fieldtrips, conferences and workshops). Crucially, organisations need to have a clear, transparent and confidential reporting structure in place, with a Code of Conduct in place so that staff and students feel safe when reporting any incidents or acts of harassment or bullying.

3. **Action:** *Organisations, journals and conference organisers should aim for representation of all groups amongst their members in their decision making.* Training regarding unconscious bias and how to improve EDI should be a requirement for all members of organisational leaderships, editorial boards, grant review panels, prize juries and conference-organising panels. At the same time, the effectiveness of these actions also needs to be monitored, and specific additional training should be available, for example, in the form of bystander training or anti-racism training. Nomination procedures for awards and prizes should be made more inclusive by allowing anonymised nominations and pro-actively seeking diverse nominations; the community needs to reflect on the purpose of awards and how they are used. Organisations and conference organisers should provide visibility to diverse role models. Ongoing initiatives amongst publishing houses and journal editor boards to address equality are a new focus and is leading to the development of new editorial policies through the review of procedures and standards. The role of an editor is multifaceted, and one element is attention to EDI.
4. **Reflection:** *Critical self-reflection and a willingness to address shortcomings should be part of everyone's development* (Dutt 2021).

There is clearly a lot of potential for improvement if we all see our role as one of creating a more equitable, diverse and inclusive volcanology community. Some pro-active initiatives to improve EDI are beginning to be put in place, and responding to the findings given here, as well as implementation of initiatives following our recommendations, should improve the situation over the coming decade. However, it will be through the systematic and sympathetic collection and analysis of data, and by listening to the voices of individual volcanologists and the volcanology community, that the impact of these initiatives will be known.

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Declarations

Ethics approval The use of survey data collected as part of this study is approved by a Research Ethics assessment (#2093) completed by Cambridge University's Department of Geography Ethics Review Group. Data was collected anonymously through a Google Form, released 30 September 2021 and closed 3 November 2021. Participants had to confirm consent agreement (tick box), and that respondents understood (1) that the participation is voluntary; (2) that data withdrawal is possible up to a month after the survey closes; (3) to which end the information will be processed; (4) that the information will be handled in accordance with the terms of the General Data Protection Regulation 2016/679 and (5) that the information provided may be subject to review by responsible individuals from the University for monitoring and audit purposes. All data is stored securely on a password-protected cloud storage, accessible only by the researchers, in an anonymised state (regardless of the participants choice whether or not to be anonymous with any personal identifying details stored in a separate file) and data will be destroyed after 10 years (01 September 2031).

Conflict of interest The authors declare no competing interests.

Informed consent All survey participants provided data anonymously.

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