



Towards inclusive collaboration in volcanology: guidelines for best-engagement protocols in international collaboration

IAVCEI-INVOLC International Network for Volcanology Collaboration^{1,2,3,4,5,6,7,8,9,10,11}

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Abstract

The International Network for Volcanology Collaboration (INVOLC) is a network formalised by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) with the specific ambition to enhance volcanology globally through improved international collaboration. IAVCEI-INVOLC was created with a focus on volcano scientists working in resource-constrained contexts, including those based in low- or middle-income countries. After a community-wide online survey and inaugural workshop during which INVOLC's ambitions were discussed, a series of challenges, as commonly experienced by those working in resource-constrained settings, were identified. These challenges may present barriers to participation in volcano science in an international context and are related to both organisational resources (financial, human, technical) and inclusion in research collaborations. In this perspectives paper, we present a series of 15 guidelines for best-engagement protocols in international collaboration in volcanology that may be adopted during times of quiescence, volcanic unrest and/or an eruption and its aftermath. Our aspiration is that these guidelines will help build more respectful, equitable and sustainable partnerships that will ultimately advance the science of volcanology.

Keywords Volcanology · International collaboration · Equity · Inclusiveness

Introduction

Volcanology is inherently a multidisciplinary science of global interest and has specific societal applications in early warning, hazards evaluation and other areas of disaster risk reduction and management, as well as in natural resources. Due to its multidisciplinary nature, developments in volcano science are often rooted in collaboration between scientists of various disciplines, often for the goals of geoscientific research, technology development and application and/or capacity-building. Moreover, applied volcanology is also

marked by collaborations between scientists and various stakeholders (e.g., local communities at risk of eruption impact, government authorities, emergency response agencies). Collaboration is therefore key in advancing volcanology, both at national and international levels, and may occur between academic institutes, volcano observatories, geological surveys, private or public companies, professional societies, etc. (Lowenstern et al. 2022). For these reasons, it is ideal that volcano scientists based in countries with active volcanoes lead scientific developments in all disciplines of volcano science and are also represented proportionally in the international community: in literature, at conferences and at all levels of global professional organisations, including their governing and thematic committees. However, despite the regularity of collaboration in volcanology, there currently exists an imbalance in tangible outcomes that can be gleaned from a few evident measures. Around 57% of the world's Holocene active volcanoes (Global Volcanism Program 2023) are in low- or middle-income countries (LMICs; World Bank 2022), yet, well over 80% of the scientific knowledge production in volcanology, as published in the international English peer-reviewed literature, is led (and reviewed) by scientists based in high-income regions,

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particularly in Europe, North America, New Zealand and Japan (Kavanagh et al. 2022). Together, these four high-income regions are home to 35% of active volcanoes (Global Volcanism Program 2023), demonstrating a disequilibrium in scientific advancement and visibility in global volcanology.

Furthermore, a recent bibliometric survey of the international volcanology literature suggests that 40% of the published studies on any specifically named volcano do not include an author based in the country of the respective volcano (Lerner et al. 2023). The same analysis indicates that only 44% of the published papers globally are led by authors based in the country of the volcano on which the study is focused. However, these rates are highly biased by the most researched volcanoes, which are all located in high-income countries (USA, Italy, New Zealand and Japan; Lerner et al. 2023). A more country-specific analysis reveals that across LMICs, on average 27% of studies are led by locally domiciled authors (based on analysis of Supplementary Information provided in Lerner et al. 2023). Particularly, volcano scientists who are based in resource-constrained contexts, including, but not limited to, LMICs, seem less likely than those in high-income settings to publish in international English-language scientific literature and/or attend international conferences.

Lastly, membership data from the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), considered the global reference community for professional volcanologists, show similar disparities as those in the peer-reviewed literature, with only ca. 11% of its registered members in 2023 being based in LMICs (IAVCEI 2023). Moreover, 50% of countries that have known dormant or active volcanoes (Global Volcanism Program 2023) do not have any registered IAVCEI members (IAVCEI 2023). IAVCEI membership is strongly incentivised by participation in activities organised by IAVCEI, most notably the international conferences of the IAVCEI General Assembly, IAVCEI Scientific Assembly and Cities on Volcanoes. Membership is compulsory for all presenters at IAVCEI Scientific Assemblies, whereas presenters at Cities on Volcanoes conferences that are not affiliated with universities, research institutes or volcano observatories are not obliged to be IAVCEI members. Whilst activities organised by IAVCEI Commissions or Networks are open to non-members, applications for travel grant assistance will only be considered for IAVCEI members (IAVCEI 2024). Furthermore, whilst IAVCEI makes efforts to offer reduced or waived membership fees depending on income scale and/or career status (IAVCEI 2024),

it remains highly likely that attendance to workshops and seminars (either in-person or online) organised by IAVCEI or one of its commissions or networks will be dominated by scientists from high-income countries. Anecdotally, personal experience by the contributors to this manuscript recognise attendance at volcano science conferences as beneficial both to individual scientist's careers, as well as to their organisations, and for the development and maintenance of relationships and collaborations. More broadly in science, academic conferences are regarded as key sites for knowledge sharing, interaction, accumulation of status and recognition (Haus 2021).

These disparities in volcano-scientific literature and IAVCEI membership are only one example of the measurable evidence of global inequalities that exist in the international volcanology community. This paper presents an organised initiative to tackle these and related disparities for the purpose of advancing both the state and status of volcanology for all regions.

IAVCEI-INVOLC

The IAVCEI International Network for VOLcanology Collaboration (IAVCEI-INVOLC) has the ambition to enhance collaboration and increase visibility and full participation of volcano scientists worldwide into the international community. It also has a particular focus on those scientists working in resource-constrained contexts, which may include, but are not limited to, LMICs. In this paper, we focus on a series of recurring challenges often faced by those in LMICs and that may present barriers to inclusiveness into the global community. To address some of these challenges, we present a set of suggested protocols and guidelines of best practice for international collaboration in volcanology.

The aim of IAVCEI-INVOLC is to “Foster Cross-Country Partnerships to Overcome Challenges in Resource-Constrained Settings for the Advancement of Global Volcano Science” (IAVCEI INVOLC 2019). This definition includes partnerships between any nations and institutes (e.g., universities, research centres, monitoring agencies) and reflects the specific ambition to foster inter-regional partnerships between scientists working in resource-constrained contexts. INVOLC's core vision is to advance global volcano science through the removal of structural barriers (e.g., organisational priorities, insufficient funding, few human resources) to representation and scientific participation from the wider global community.

Challenges in international volcanology

A global online survey of volcanologists from research and academic institutes and volcano observatories was undertaken in 2019 as part of the preparatory activities to set up INVOLC. It reached 89 respondents around the world, 90% of whom were—at the time—based in LMICs and identified as working in a resource-constrained context. The survey anonymously probed for challenges related to participation in the global scientific community, as well as challenges related to collaborations in an international context, primarily in the form of hosting international researchers.

Nearly all respondents agreed that international collaborations are beneficial for the advancement of science (e.g., > 80% either agreed or strongly agreed that collaborations allow research activities that otherwise would not be possible) as well as for their personal careers (~95% agreed or strongly agreed). International collaboration and the sharing of knowledge and datasets were acknowledged to provide valuable insights, e.g., for low-frequency, high-consequence volcanic events of which understanding was key to scientific progress and local preparedness (Lerner et al. 2023). Collaboration is thus highly valued, and a general recognition and appreciation exist that external collaborations make it possible to obtain equipment and undertake work that is beyond the capacity of local resources. However, the survey results also suggested that volcano scientists overwhelmingly based in LMICs face many structural (e.g., organisational priorities, insufficient funding, few human resources) and professional challenges (e.g., limitations in specialised knowledge) when undertaking volcanology in their country and area of monitoring responsibility, as well as in a context of international collaboration.

Using the 2022 World Bank's country classification (World Bank 2022), in the period between 2000 and 2020, the expenditure on research and development, as percentage of GDP, rose on average from 1.40 to 1.87% in high-income countries, whereas it remained relatively stable, at 0.44 to 0.53%, in LMICs (UNESCO Institute for Statistics 2022). However, data do not exist for all countries worldwide, and within each class, notable differences exist between specific countries. Variable levels of research funding are, however, neither the only nor the main drivers for challenges to undertaking volcanology in a national or international context. In addition to challenges related to funding for research or human resources, others are related to, e.g., language barriers, the pressure to publish on an international platform, the interactions with international scientists and data availability. For this reason, we identify two main categories of challenges: those related to resources and those related

to collaboration. In Table 1, we summarise some of the main challenges, as specifically recognised in the survey, and which have served as a starting point of discussion towards the best-engagement protocols presented in the next section.

Principles and recommendations: best-engagement protocols in international volcanology collaboration

We present a set of 15 guidelines, in no particular order, for best-engagement protocols in international collaboration in volcano science, regardless of whether the ambitions of the collaboration are in research, technical assistance and exchange or capacity building. These protocols are both related to times of volcanic crises (unrest and/or eruption and/or post-eruption hazards) and collaborations at all other times (i.e., volcano science undertaken in all sectors, including, but not limited to, operational and academic settings). Some guidelines presented below may be more straightforward and practical to implement than others, largely depending on the nature, ambitions, scale and scope of any collaboration. We encourage the wider volcanology community at all times to engage in any kind of collaboration in a respectful and collegial manner.

Best-engagement protocols

- 1a. Research activities carried out by foreign teams in a country should be undertaken in partnership with (an) appropriate monitoring agency(ies) or scientific institute(s), i.e., the local institution(s). Ideally, the local institution(s) should be contacted and involved in the research strategy, rollout and outcomes. The minimum should be that the local institutions (i.e., those institutions based in the country where the research target is located) are informed well in advance of research implementation and research outcomes shared.
- 1b. Research teams using satellite remote sensing on a particular region in a country other than where they are based, but without any on-the-ground field component of data collection, are strongly encouraged to engage with a research partner of the respective country and include them in the research. They are advised to share their results with relevant organisations mandated with crisis response in the host country, especially regarding potentially increasing volcanic unrest or activity and related hazardous phenomena.

Table 1 Challenges to international collaboration in volcanology experienced by individuals working either at academic institutions or volcano observatories. Note this list is non-exhaustive and only refers to challenges specifically mentioned in survey results**1. Resource Challenges****a. Financial resources**

- i. Limited funding for (volcano) research and/or monitoring
- ii. Too high travel and registration costs to international conferences
- iii. High costs associated with (Open Access) publication in international journals

b. Human resources

- i. Limited number and/or capacity of staff
- ii. Difficulty attracting and retaining personnel (“brain drain”)
- iii. Limited specialised knowledge among staff
- iv. Limited specialised training opportunities

c. Facilities

- i. Inadequate equipment, laboratories, or technology
- ii. Reliance on external groups for analyses
- iii. Inadequate access to and training in the use of new techniques
- iv. Limited ability to adapt and improve techniques in a resource-constrained context

2. Collaboration Challenges**a. External researchers undertaking work without prior consultation or collaboration**

b. External researchers only contacting local researchers after a research proposal was written or funded, meaning local scientists do not have the opportunity to ensure that the project:

- i. Is aligned with in-country and/or observatory priorities
- ii. Meets national rules and regulations
- iii. Includes local knowledge of the volcanic system, published or unpublished
- iv. Includes an agreement on mutual exchange of data and information

c. Inadequate collaboration affecting credibility of local scientists in their own countries, complicating risk mitigation efforts**d. A lack of a data sharing policy creating conflicts or misunderstandings when results of a study are presented**

2. At the start of a partnership, an assessment of needs and knowledge gaps of the involved partners should be openly discussed. This assessment should be the basis for the definition of the objectives of the partnership and the selection of suitable partners.

3. The long-term goals of each partner and how the project feeds into those goals are essential factors and should be openly discussed between partners to ensure common understanding. This requires consideration of, for example:

- the exchange of knowledge and building of human capacity in local institutions
- the structural and sustainable development of infrastructures (including instrumentation and software systems)
- the inclusion of local partners within the international research community (e.g., participation in conferences, research outputs, outreach)

4. During the design of a project, the roles and responsibilities of each partner (including during changes in level of activity or unrest at a volcano) should be

clearly defined at initiation of a partnership, where possible, as a component of a written partnership agreement that also articulates the scope and duration of the project. As much as possible, project responsibilities should be shared between the foreign and local partners to promote equitable decision-making during the formulation and implementation of the project.

5. Prior to the establishment of a new partnership, a data sharing and use policy should be agreed upon, as one component of the partnership agreement. This policy should include the rights and limitations in using and sharing relevant existing and new data* collected during the project with third parties for the duration of the partnership and beyond. **Subject to the agreement of all parties, “data” may include any samples, results, analyses, code, metadata, etc.*

6. As part of the establishment of a new partnership, all partners should be aware of any relevant national or institutional regulations related to scientific activities of foreign scientists in the host country. Compliance with these regulations is essential before starting the research activities.

7. The partnership agreement should clearly define the expected contributions from and associated needs of all parties, including financial and any other resources, e.g., human, existing infrastructure, equipment.
8. The partnership agreement should clearly describe the ownership of tangible assets, intellectual property, research output (e.g., scientific publications, outreach materials), etc. during and after the end of the partnership.
9. Duties and priorities of the local partners should be considered so that the partnership activities do not impose any undue burden on the available resources of the local institution.
10. Dissemination of any research output, e.g., through scientific publications, outreach activities, project web pages, should be undertaken with explicit mutual agreement of all partners, and properly acknowledge the contribution of all partners and all data sources.
11. All partners should be encouraged to contribute to the interpretation and publication of all research results from the partnership, including in international and national publication venues. Local partners should be encouraged and supported to contribute to and, where possible, lead publication of the results arising from the partnership.
12. Foreign partners should be aware of and respect the established relationships and trust between the local partners and their stakeholders (e.g., other national and international (research) collaborators, communities, civil protection, authorities). As appropriate, the partnership should seek to contribute to the interactions with stakeholders, under the lead of the local partner.
13. Foreign partners should comply with the existing IAVCEI protocols regarding the professional conduct at times of crisis (IAVCEI Subcommittee for Crisis Protocols 1999; IAVCEI Task Group on Crisis Protocols 2016). These include necessitating invitation from the host scientific team handling the crisis, deferring to the local decision-making culture and refraining from issuing public statements.
14. Foreign partners should consider and respect the cultural realities of the region involved in the partnership.
15. A communication strategy related to the partnership should be agreed upon at initiation of the collaboration among all project partners, including conditions of revision of the strategy. The strategy should be repeatedly discussed and reviewed throughout, and where appropriate, beyond the duration of the collaboration. The strategy should encompass, but is not limited to communication through social media, outreach activities, etc., and with specific attention to potentially sensitive information during crises.

Concluding remarks

IAVCEI-INVOLC believes in promoting international collaboration that supports the mutually beneficial application and development of volcanology and related science in a respectful manner. IAVCEI-INVOLC endorses engagement with formalised terms of cooperation, whenever possible, that is executed willingly and adhered to by all partners. We acknowledge that these guidelines alone are not sufficient to increase participation of all volcano scientists in the international volcanology community, and many other additional avenues are needed, in the form of structural policies and individual responsibilities. We expect that these guidelines will encourage and enable scientists and institutes receiving requests for collaboration to fully engage in any research partnerships.

Adopting principles of inclusive collaboration, as presented in this paper, will lead to enhanced participation, recognition and visibility of all volcano scientists in the international community, and further drive the development of global volcanology. We therefore urge all members of IAVCEI and the wider volcanological community to adhere to these guidelines so that international volcano science may evolve towards an inclusive community across all times scales of volcano science, and not just during times of volcanic unrest and/or eruption as described in IAVCEI Subcommittee for Crisis Protocols (1999).

Finally, we recommend that funding agencies incorporate these guidelines in their ethics policies and eligibility criteria for funding and evaluating research projects. Scientific publishers and organisations may equally encourage authors to provide evidence of best-practice collaboration and credit all relevant contributions to research presentations, publications, policy reports and any other data products (e.g., European Geosciences Union 2023; Xenopoulos et al. 2024). Publishers might consider supporting publication of short-format data reports encouraging volcano observatories to lead-author the publication and maintain full credit of monitoring data and reports on recent activity. Scientific organisations may also provide codes of conduct for their professional meetings to provide a safe and welcoming environment for all participating members (e.g., IAVCEI Volcanic & Igneous Plumbing Systems Commission 2021; American Geophysical Union 2023). Ideally, relevant data and transparent reports on membership, conference participation, award nominations, etc. are collected and publicised so that progress towards inclusive practice may be tracked and quantitatively evaluated (Engwell et al. 2020; Kavanagh et al. 2022).

For further information about the IAVCEI-INVOLC network, we refer the reader to <https://involc.iavceivolcano.org/>.

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In 2019, we conducted an online survey (“*Developing a new IAVCEI network for colleagues working in resource-constrained contexts*”) for the purposes of determining whether (1) there was a need to organise a network such as IAVCEI-INVOLC, and (2) if so, for what specific purposes and on what particular activities it should focus. We are extremely grateful to all the survey participants who took the time to complete this survey, which informed the establishment of the INVOLC network and prioritised the engagement protocols.

An initial version of the guidelines presented in this paper was drafted via group discussion during an inaugural workshop of IAVCEI-INVOLC, “Fostering developed-developing country partnerships for the advancement of global volcano science”, hosted by The University of the West Indies Seismic Research Centre (UWI-SRC) from 4 to 7 June 2019. Financial support for the inaugural INVOLC workshop in 2019 was provided by IAVCEI, the International Union of Geodesy and Geophysics (IUGG), the USAID-USGS Volcano Disaster Assistance Program (VDAP), The University of the West Indies (UWI), Vrije Universiteit Brussel (Belgium) and the Université libre de Bruxelles (Belgium). In total, 25 participants from 20 different countries, primarily LMICs, participated (IAVCEI INVOLC 2019). We extend our warmest thanks to each of the participants at the workshop who supported the initiation of the network and its proposal to become part of IAVCEI, and who contributed to the intent and wording of the best-engagement protocols. Beyond members of the Task and Working groups of this manuscript, these colleagues are Mariano Agosto, Michal Camejo, Sandrine Cuevard, Ramon Espinasa, Eduardo Gutierrez, Mikhail Herry, Katcho Karume, Cristian Lopez, Lloyd Lynch, Jeffery Marso, Elisante Mshiu, Javier Pacheco, Solomon Possy, Richard Robertson, José Saballos, Raúl Salguero and Francisco Vasconez.

These guidelines were then presented to the IAVCEI Executive Committee (EC 2018–2023) during the 27th IUGG General Assembly in July 2019, Montreal, Canada. The IAVCEI EC formally endorsed INVOLC to function as an IAVCEI network and requested some minor changes to the draft guidelines. The updated version was presented to the wider volcanology community as a series of 15 recommendations for additional feedback in June 2022, and presented during the IAVCEI Scientific Assembly in January–February 2023 in Rotorua, New Zealand. Feedback and comments, including also from the 2023–2027 EC, were incorporated into the current version. We extend our thanks to the IAVCEI ECs (2018–2023 and 2023–2027) for considering and supporting the proposal for the incorporation of the INVOLC network within IAVCEI as well as providing their endorsement to the protocols.

The final text of the engagement principles and this report is a consensus of the IAVCEI-INVOLC Working Group.

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