Bull Volcanol (1999) 60:323–334

ORIGINAL PAPER

IAVCEI Subcommittee for Crisis Protocols

Professional conduct of scientists during volcanic crises

Received: 7 January 1998 / Accepted: 4 October 1998

Abstract Stress during volcanic crises is high, and any friction between scientists can distract seriously from both humanitarian and scientific effort. Friction can arise, for example, if team members do not share all of their data, if differences in scientific interpretation erupt into public controversy, or if one scientist begins work on a prime research topic while a colleague with longer-standing investment is still busy with public safety work. Some problems arise within existing scientific teams; others are brought on by visiting scientists. Friction can also arise between volcanologists and public officials. Two general measures may avert or reduce friction: (a) National volcanologic surveys and other scientific groups that advise civil authorities in times of volcanic crisis should prepare, in advance of crises, a written plan that details crisis team policies, procedures, leadership and other roles of team members, and other matters pertinent to crisis conduct. A copy of this plan should be given to all current and prospective team members. (b) Each participant in a crisis team should examine his or her own actions and contribution to the crisis effort. A personal checklist is provided to aid this examination. Questions fall generally in two categories: Are my presence and actions for the public good? Are my words and actions collegial, i.e., courteous, respectful, and fair? Numerous specific solutions to common crisis problems are also offered. Among these suggestions are: (a) choose scientific team leaders primarily for their leadership skills; (b) speak publicly with a single scientific voice, especially when forecasts, warnings, or scientific disagreements are involved; (c) if you are a would-be visitor, inquire from the primary scientific team whether your help would be welcomed, and, in general, proceed only if the reply is genuinely positive; (d) in publications, personnel evaluations, and funding, reward rather than discourage teamwork. Models are available from the fields of particle physics and human genetics, among others.

Key words Volcanic crises · Protocols · Ethics · Communication · Teamwork

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Introduction

Cooperation and camaraderie are widespread among volcanologists, who get to know each other at meetings, on field trips, in collaborative research, and in crisis responses. Volcanologists stand in common awe of their subjects, and those who have worked together through volcanic crises share a special bond.

During volcanic crises, though, stress and individual sensitivities are high and offense is sometimes given or taken. Offense, in turn, distracts from the primary jobs at hand: to use and improve the science for public safety and welfare. Work with others during volcanic crises requires common courtesy, humility, extra sensitivity, respect for differences of culture or view, and special attention to communication.

This report is an effort by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) to recognize problems of personal and institutional interaction that have arisen in the past, and to suggest measures that will minimize such problems in future volcanic crises.

Approach

This document reports past problems, without names of specific volcanoes or protagonists, and offers suggestions to minimize these problems in the future. Because IAVCEI is neither policeman nor judge, compliance with these suggestions is by individual or observatory choice. We trust that most readers who are alerted to potential problems will try to avert those problems. The subcommittee recognizes that, for many of the situations described, different individuals and cultures will choose different paths. Our suggestions are not the only possible solutions; they are simply solutions that have been found helpful during previous crises.

Note that this document:

- Does not address methods of scientific study, the value of one parameter vs another, or the quality and interpretation of data
- Does not judge the scientific credibility and competence ("crisis worthiness") of individual scientists and groups. We do not attempt or recommend accreditation. There are many instances in which a member observatory of the World Organization of Volcano Observatories (WOVO) is the obvious and preferred source of advice for civil defense officials; however, many other scientists and scientific groups have important contributions to offer
- Does not consider issues of scientific interaction during non-crisis times; however, the ability to interact smoothly during a crisis is strongly influenced by interaction during non-crisis periods. Many of our suggestions therefore apply to interaction at all times: before, during, and after crises
- Does not propose a full code of ethics for IAVCEI, or consider obvious ethical violations such as collusion for personal gain, dishonesty, or plagiarism. Here, we focus on more subtle problems that arise during crises and are easily caused by any of us, despite our good intent. Readers who are interested in general ethical issues for scientists and engineers may find discussions in American Physical Society (1991); American Chemical Society (1994); Institution of Engineers, Australia (1994); Committee on Science, Engineering, and Public Policy (1995); American Society of Civil Engineers (1996); Beatley (1996); The Royal Society of New Zealand (1997); American Institute of Professional Geologists (1998); and WWW Ethics Center for Engineering and Science (1998). Readers who are interested in a general code of ethical conduct for disaster relief may consult InterAction (1995) and International Federation of Red Cross and Red Crescent Societies and Oxfam (1997).

Guiding principle

The guiding principle of this document is that during volcanic crises, volcanologists' highest duty is to public safety and welfare. This safety and welfare require:

- Efficient teamwork, among scientists and with public officials
- A balance of proven volcanologic methods, research to advance volcanologic knowledge, and wide communication of results

Past problems and suggested solutions

The next six sections describe common problems of professional interaction during crises, and our suggested solutions.

Poor communication and teamwork among scientists

Failure to value diverse scientific expertise, approach, and experience

> On the scientific team, make sure that all of the relevant disciplines (e.g., geology, geophysics, geochemistry, risk analysis, and communication) and approaches (e.g., empirical, process oriented, modeling) are consulted and effectively integrated for the best possible forecasts and warnings.
>
> Hold frequent meetings of the full scientific team, for coordination of work, data sharing, discussion of working hypotheses, and "team building."

Overselling of new methods

During the rush of a crisis, enthusiastic innovators sometimes fail to alert the team to uncertainties and limitations of their new method.

> Scientists wishing to test new methods should be encouraged in their innovation, but they should take special care to brief the team on limitations of their method. Because the method is new, its proponents must be their own toughest critics. Proponents should also refrain from public discussion of the method that might raise unjustified public hopes. New methods need to be treated as experiments until they are proven reliable.

Failure to honor prior work on a volcano, and, in the reverse direction, failure to share study opportunities

Some would-be new workers on a volcano are insensitive to the intellectual and emotional investment of long-time workers on that volcano. Also, some long-time workers are reluctant to share "their" volcano with others who could do work that is complementary to that already done or currently underway.

No individual or group "owns" a volcano, but local experience and prior investment of much time and work deserve respect as scientific tasks and opportunities are subdivided among team members. Conversely, those with long experience on the volcano should share as much as they can and limit their own crisis responsibilities to what they can realistically do well. Those with "ownership" concerns can candidly explain them to new workers and jointly explore aspects that could be shared. More often than not, there is constructive, mutually advantageous room for oldtimers and newcomers, if they talk early and openly.

Failure to share information and scarce logistical resources

This is a sensitive matter whenever one individual or group has data or logistical resources that are needed by the whole team.

During crises, promptly share all data, ideas, and resources. Some scarce resources, e.g., helicopter time, will need to be prioritized by the team. Pursuit of individual fame or funding must be subordinated to the higher goal of public safety.

Failure to work as a single scientific team, and thus loss of potential synergism, i.e., loss of a cooperative result that is greater than the sum of individual results

In most cases, one local team has the primary responsibility for the direction and outcome of a crisis response, and some individuals or other teams work independently. In a few cases, no team has primary responsibility and there is serious confusion about who should advise public officials.

Resist temptations to form and/or work in separate, competing "splinter" scientific groups. Those on the team need to work out any internal conflicts and stay together. Autonomy and competition from non-crisis times need to be set aside during crises.

Those who have needed expertise and who are not already on the team should offer to join, and the team should welcome such help. Admittedly, an extra effort is required to integrate outside help into the team when time and patience are already taxed. Language differences can also be a barrier. But it is easier and more productive to make that effort than to later explain why important help was not accepted, or to cope with a now-separate scientist or group who feel spurned.

When formation of a single team is impossible, as it sometimes is, representatives of the separate teams need to meet frequently to coordinate their activities and to share results.

Failure of scientists to use a single voice for public statements

Unless scientists speak with a single voice, officials and the public will be confused. Important mitigation decisions may be delayed, or based on misunderstandings arising from this confusion, or based on the personality and media appeal of one scientist vs another. Any public bickering among scientists causes officials and the public to distrust all scientists.

Solicit team members' estimates of the probability of each possible outcome. An informal or formal elicitation method (expert opinion polling) that is keyed to clearly stated branches of a logic tree can clarify disagreements and lead to a joint forecast and an indication of uncertainty (Coppersmith and Youngs 1990; Cooke 1991; Aspinall and Woo 1993). Reasons given for each estimate can help to focus discussion in team meetings. Every contributor's input is incorporated, and every contributor agrees to support the results of the elicitation. An interesting trial of formal elicitation is in progress on Montserrat, where it is considered in government decisions (Montserrat Volcano Observatory 1998; Montserrat Development Unit 1998).

If some observed phenomena are new and not yet understood, or if serious differences in interpretation persist, gather data for critical tests. In the meantime, retain multiple working hypotheses as a healthy part of the scientific process. Public presentation of critical differences in data or hypotheses, made by a neutral team leader or spokesperson, is educational and assures officials of efforts to resolve scientific differences. The team leader or spokesperson can also offer as much guidance to officials as possible, despite any unresolved scientific issues.

Public presentation of uncertainty and scientific differences varies from culture to culture. In some countries, expressed uncertainty is mistaken as scientific incompetence, whereas in other countries, perfect consensus without debate would be taken as a sure sign of coverup! In general, uncertainty should be acknowledged.

Forecasts, warnings, and other important public statements are best when written first. The process of drafting such statements helps the scientific team to check whether consensus has been reached and helps to convey its messages clearly to users. Date-stamped, team-approved hazard maps, together with their assumptions, should also be entered into the formal record of warnings. Competing or uncoordinated, multiple hazards maps are confusing to the public and should be avoided.

Failure of science-funding agencies, job supervisors, and promotion panels to give full credit for self-sacrifice and teamwork during volcanic crises

Many science-funding agencies, job supervisors, and promotion panels reward individual work, whereas teamwork is far more useful during crises.

All deans, promotion panels, thesis committees, and science-funding agencies need to recognize that crisis scientists are required to help the team as well as do their own research. These goals need not conflict. Credit should be given for contributions to teams and team results, even when the contributor is but one of many alphabetically listed co-authors.

The volcanologic community can solve some of this problem by itself. Particle physicists, geneticists, and several other scientific communities now give full credit to participation in large teams, with each individual's contribution noted in a separate letter from the team leader to evaluators. Volcanic crisis teams might do the same. Volcanic crises are a time for selfless work on large teams, more than for the individual effort and authorship that are valued during non-crisis interludes. IAVCEI can engage national and international scientific funding sources and journal editors in a dialogue on this issue.

Work during volcanic crises is inherently dominated by monitoring and data collection for the common good, rather than on data collection for one or more individual research problems. After a period of several years, though, the early focus on group data collection usually leads to a wealth of research papers and new opportunities for contributors.

Leadership problems

Leaders without leadership skills

Far too often, team leaders are selected for their scientific skills with little or no consideration of their leadership ability, particularly in a volcanic crisis situation! As one colleague put it, "We don't think about leadership skills until we realize that our leader doesn't have them."

Each country or responsible institute should identify, in advance of crises, a pool of potential leaders for scientific response teams, and a mechanism for selecting a team leader for a specific volcano when necessary. The best leaders will have respected scientific depth and breadth, excellent communication and personal skills with colleagues, the media, the public, and public officials, and the ability to propose and make decisions. Fairness and courtesy are critical. Leaders must listen objectively to all interpretations and advice, and, from them, move the team to decisions. They must be able to handle criticism constructively and be sufficiently secure in their own careers that they can be selfless during the crisis. They should also be politically astute, because they may need to search for a neutral course between competing, sometimes shifting political agendas.

Failure of leaders to recognize the limits of their own technical expertise

If this happens, other scientists on the team may find that their own competent advice is being overruled by the leader's incompetent advice.

Leaders should recognize that no scientist can be an expert in all aspects of volcanology. It is wise to acknowledge, within the team, limits of their own technical expertise. The same holds true for experience during volcanic crises. No leader will have as much experience in volcanic crises as the sum of experience on his or her team, and every leader should actively seek the experience of others.

Confusion about team roles, policies, and procedures

Each nation or observatory should prepare a clear written guide to its crisis team organization, policies, and procedures. For example, every team member will need to know policies and procedures for making public statements. The basic content of such a guide is suggested herein (see "A team plan for crisis response") The need for such a plan might seem too obvious to state, but egalitarian, collegial scientists often forget or are reluctant to face the issues that must be addressed in such a plan.

Failure to encourage those who can and wish to help

This has included failure to encourage the ideas of newer or quieter members of a team, or to invite outside individuals and groups to help when needed. This has often included government agencies' failure to tap the full potential of scientists from academia.

A good leader will actively encourage contributions, recognizing that some may hesitate to speak up in a large group, in a group of more senior scientists, or when they are in a linguistic minority. A good leader will also seek help from those whose analytical skills, experiences at other volcanoes, and fresh ideas could complement the expertise of local observatory scientists. A simple, up-to-date list of tasks and unresolved scientific issues can often help a newcomer to find a constructive niche, whether on-site or from a distance.

On-site, a chalk or white board suffices; at greater distances, questions and needs can be posted on e-mail, a listserv, or a Web page. Replies are best made privately and directly to the team leader, for the benefits of direct communication and to ensure that proffered help will not be mistaken for presumptuous meddling.

Whether a team leader should seek or accept additional help from outside the team is often a difficult judgment. Inclusion of would-be contributors may bring needed expertise and minimize frustration and public statements from outside the team. On the other hand, the potential contributions of volunteers might not be fully known, and there are practical limits both to logistical support and the size of a team that can work effectively together. Would-be volunteers should explain their potential contributions fully, and they should understand that team leaders must sometimes decline offers of help, especially if the volunteer's expertise is already present.

Failure to develop (a) respect for scientific differences within a team, (b) a method for developing consensus, and (c) a means for acknowledging differences that cannot be resolved

Differences in opinion are healthy and to be expected; they must be dealt with candidly, respectfully, and fairly within the scientific team. Dogmatism and arrogance during crises are counterproductive. Hasty, peremptory rejection of a colleague's ideas is one of the most common sources of conflict within crisis teams. A wise team leader will be sensitive to professional disagreements within the team and will proactively mediate them before they escalate. The leader will clarify differences, suggest tests, and seek consensus. She or he may remain neutral and leave advocacy of interpretations to team members, or may express a personal interpretation yet also seek and respect other views. A rigorous scientific leader may encourage an atmosphere in which each team member tries to disprove his or her own hypotheses. In especially difficult cases, the team leader may need to seek help from a respected third party who is skilled in conflict resolution.

Informal or formal expert polling, such as that described previously, can be helpful because it acknowledges the likelihood of different views and discourages overly simplistic, personality-linked judgments that one individual scientist is right and another is wrong.

Failure to balance risk and rewards of dangerous field work

Some risks of death or injury are a necessary part of crisis volcanology. Excessive caution by the team leader can block competent field scientists from making critical, reasonably safe observations. However, risk-taking can also endanger the lives of colleagues, give unintended reassurance to local residents, and detract from the credibility of warnings. Either excessive caution or excessive risk-taking leads to internal team dissension.

The benefits and risks of proposed field work must be carefully evaluated (IAVCEI Task Group for Safety Recommendations 1994). Some useful questions are: (a) How much will this field work reduce risk for the public? (b) Is this reduction greater than the risk of the fieldwork to scientists, and the risk that an accident would seriously diminish team credibility? (c) Is there any less risky way to collect the necessary information? (d) Is anyone being pressured to take risks against his or her judgment? Candid team discussion may be helpful to reach consensus on an appropriate middle ground.

Failure to recognize and minimize fatigue

More than once, fatigue has jeopardized clear-headed analysis of a volcanic threat or damaged much-needed communication. It is a special problem when the same scientific staff gather data by day, analyze data in the evening, present the data in sometimes-lengthy team meetings, and are "on call" at all hours, day after day. Crises that drag on for months or years are special problems.

A good leader seeks sufficient staff to allow rest for all. Alternates should be identified for all key roles, including the team leader. Another requirement is personal discipline and encouragement from the team leader and colleagues to take that rest. Military and other emergency responders understand the dangers of fatigue and guard against it (Flin 1996). Fatigue should not be allowed to diminish judgment or interaction. (Note: Rotations of staff may be necessary to avoid fatigue but should be organized to ensure continuity of both the science and the advice to officials.)

Readers who wish to read more about issues of crisis team leadership will find helpful introductions in Mitroff and Pearson (1993) or Flin (1996).

Issues for visiting scientists, invited and uninvited

Scientists who arrive at a crisis without invitation

No matter how well intentioned, uninvited visitors may be more of a burden than a help. The host scientific team – ideally, a unified or primary host country team – may feel obligated to share its scarce time and logistical resources. Furthermore, visitors have inadvertently diminished the credibility of local scientists because their presence implied to officials and news media – or to local scientists' institutions – that the local team lacked the needed expertise and tools. A few uninvited scientists have demanded support of their unsought work or, even worse, publicly contradicted the local team.

Before all else, would-be visitors should ask the host scientific team whether their help is needed and would be welcomed. If "yes," agree upon your specific role (and that of your group) and a mutually beneficial time to visit. If the reply is "no," or if there is no response, stay away. If the response is less than enthusiastic, it is wise to seek frank clarification. Be sensitive to the fact that in some cultures, requests for invitations will almost always be honored, even if the visit is not genuinely desired. Clarifying your role will usually help you judge whether the invitation is genuine or just polite.

This may seem like an onerous restriction to some and may risk the loss of some scientific lessons. But it is a necessary and strong suggestion. Otherwise, your presence is likely to tax the local team at a time when it can ill afford distractions. Presently, with e-mail, faxes, and telephones, there is no excuse for traveling uninvited to a volcanic crisis.

Invitations from other than the primary scientific team, e.g., from a competing or peripheral local group

Such invitations place the visitor in an awkward position, perhaps regarded by the primary scientific team as an interloper. Sometimes, diplomatic offers of assistance are accepted by the ministry of foreign affairs without consultation with the local scientists.

Would-be visitors should try to identify the primary scientific team and to work through it. Such identifications are usually though not always easy. The WOVO directory is a good place to start (World Organization of Volcano Observatories 1997), and additional advice is usually available from colleagues.

Unilateral foreign funding decisions

Some organizations fund travel for a scientist to another country to study a volcano in crisis, whether or not that scientist has been invited by a host-country team. If no invitation exists, there is a high risk that the visitor will hamper the work of the host team. An organization that funds uninvited travel then bears some responsibility when problems arise.

Foreign science-funding agencies should require, from the applicant, evidence of an invitation and genuine collaboration with the host country, preferably from the primary scientific team. Other criteria might include:

(a) Will the applicant bring some expertise or equipment that is not locally available?
(b) Is the scientist well prepared for work in this area, with adequate logistics, language skills, and personal contacts?
(c) Will samples and data be freely shared in both directions?
(d) Can scientific inquiry be pursued at this time without interfering with the more immediate goal of saving lives?

Cultural differences regarding scientific discussion and decision making

Scientists who are accustomed to quiet consensus building may be uncomfortable with cultures that value more aggressive challenges to each other's ideas. Similarly, those who are accustomed to democratic decision making may be uncomfortable with hierarchical decision making. At the same time, the hosts may also be uncomfortable with a visitor's different style, particularly if the latter disrupts their own operation or diminishes their local credibility.

Visitors should try to contribute in ways that are consistent with the local scientific and decision-making culture. Sometimes this requires private discussions with a host-country colleague or team leader, rather than trying to make a point in group discussions. Referring to technically competent but domineering visitors, one host-country scientist wished that they would "lead from behind." In other situations, quiet scientists may need to be more assertive than normal.

Public statements by visiting scientists

No matter how well intended or seemingly innocuous, public statements by visiting scientists commonly create an unwelcome burden for local scientists (see Olson 1989; Rodolfo 1995). At best, such statements require local scientists to answer new queries from officials, the media, and citizens (often arising from misquotation or quotation out of context). Worse, they can diminish the credibility of local scientists because of the same implication noted previously – that the local team needs help.

Visiting scientists should generally refrain from making public statements and politely but firmly refer insistent news media to the host scientific team. This is a tried and true solution. If a public statement is requested by the local team, be very cautious with your words, because tabloid news media may look for a disagreement between your words and those of the local team. Be aware that the most sensitive topics are the competence and credibility of the local team, forecasts, and speculation about the future.

If as a visitor you disagree irreconcilably with the host scientific team on an important matter, and feel morally obligated to make public your opposing view, first ask the host team to publicly acknowledge your view and to offer you a chance to explain it at the same time the team presents its view. If your request is not granted, decide whether the benefits of your public statement will outweigh its damage to your and other scientists' credibility and working relations. Ultimately, the highest priority is public safety, not individual or team ego.

Preemption of research and publication opportunities by visitors, while local scientists are still busy managing the crisis

Even when inadvertent, this severely inhibits the free sharing of data and ideas, and, from that, compromises public safety. It also causes serious resentment on the crisis team and virtually kills opportunities for future collaboration, not only for the specific visitor but even for other visitors.

Place yourself in the shoes of your host colleagues. If you had their public responsibilities, and long-term investment in data and credibility, how would you feel if another scientist or team came to "your" volcano, gathered your publicly available data as well as his or her own data, and published immediately after returning home?

Within reason, let the host scientists and primary scientific team guide the publication of team results. Help host-country scientists or the team to be first to publish; your specialized publication(s) can follow.

Beware of the all-too-common mistake of overlooking the research interests and skills of host colleagues with less funding or recognition. Note in particular that international volcanology has changed dramatically in recent decades, and volcanologists in developing countries are rightfully proud of their work and expect to be treated as full colleagues.

Support the aspirations of local students. In many instances, volcanic crises bring unparalleled opportunities for graduate theses, and visiting scientists from academia will do themselves and their hosts a favor if they encourage thesis work by local students (including sponsorship for international study, if appropriate). This need not be to the exclusion of one's current students; when done sensitively, pairing of one's current students with students from the area of the volcanic crisis benefits all.

Unwise and unwelcome warnings

Warnings from pseudo-scientists

Volcanic crises attract pseudo-scientists, some well-meaning and some perfect charlatans. They usually decline to pass their methods and warnings through the filter of rigorous peer review. If propagated by the news media, their warnings or forecasts can seriously mislead officials and the public and take valuable time to counter.

Pseudo-scientists' warnings and forecasts are best ignored. However, if one causes serious public anxiety, present a careful scientific rebuttal of major points without attacking the pseudo-scientist. Combative, personalized comments in the popular press will increase media attention and public confusion. In extreme cases, convene a respected panel to formally evaluate the forecast (Spence et al. 1993).

Warnings or forecasts from scientists from other fields

Sometimes, well-meaning but naive colleagues from other scientific fields "discover" an important new method for forecasting eruptions. Those who are not familiar with the volcanologic community or do not know the far-reaching impacts of public forecasts have occasionally offered their ideas directly to local officials or to the news media.

Invite them to join ongoing volcanologic discussions and submit their ideas through peer review, as any legitimate scientist would.

Warnings or forecasts by volcanologists working in isolation, either on-site or far from the volcano in question

Some warnings and forecasts, especially those based on remote sensing data alone, have ignored important constraints from other disciplines. Some that were intended only for limited professional discussion "escaped" into the public domain. Some are from scientists unable to resist the siren call of media exposure; many are innocent, media-solicited forecast-like comments from individuals who are utterly unaware of how disruptive their comments can be for team scientists. Whatever the cause, the effects are serious distraction from more pressing duties, loss of credibility for all scientists, and, usually, misguidance for public officials.

Each scientist needs to stay within the limits of his or her own expertise and to submit all ideas to on-site team review. Let the on-site team leader or spokesperson provide all public updates and forecasts, including those on the Internet.

Exaggerated statements of risk, or, conversely, overly reassuring statements about safety of an area when significant risk exists

Two of the most difficult matters for professional judgment, and thus two of the most common points of scientific disagreement, are estimates of the potential severity and certainty of danger. Overestimates are unnecessarily disruptive; underestimates are often tragic. Such estimates were at issue during the 1976–1977 eruption of Soufriere Guadeloupe and became the subject of heated debate in later editorials (Bostok 1978; Sigvaldason 1978; Barberi and Gasparini 1979; Fiske 1979; Tomblin 1979).

The best protection against unintentionally exaggerated or insufficient statements is peer review of all estimates of danger. A crisis situation makes peer review difficult but very important, and some oral or written review is usually possible during a team meeting or lull in the unrest.

Use probabilities to calibrate qualitative assessments of risk. Avoid commonly used adjectives such as "soon" or "high-" or "low-(risk)," because they mean different things to different people. Probabilities and comparisons to familiar non-volcanic risks help to avert misunderstanding that risk is higher or lower than it actually is.

Under no circumstances should hazard be intentionally overstated or understated. Any decision to "err on the safe side" should be a conscious, openly discussed decision. Never disregard what seems like a low-probability, "worst case" event, because such events can and do occur (e.g., Mount St. Helens and Pinatubo). Instead, estimate the probabilities of worst-case and lesser scenarios, as above, to put the "worst-case scenario" in proper perspective.

Outdated warnings or forecasts in need of change

As a volcanic crisis and information about it develop, there will be times when forecasts, alert levels, or other warnings must be revised. At most volcanoes, revision is routine and expected, but there have been a few instances when changing conditions at the volcano – or errors or misjudgments – have not been acknowledged. Reasons have included inattention to timeliness, a desire to "play it safe," and fear that a revision would diminish scientific credibility. One common scenario is when an high alert level is maintained even after a hazard has probably passed.

Both scientific credibility and the safety of the public depend on prompt revisions of public statements whenever necessary. Alert levels should be raised or lowered as soon as the scientific information warrants. Of course, forecasts that change frequently with each fluctuation in unrest will be counterproductive, but teams can usually reach consensus on whether an apparent change is definite and stable enough to warrant revision of a forecast or alert level. Frank and open disclosure of new information may bring criticism about "inconsistent scientists," but it will ultimately augment, not diminish, the credibility of scientists.

Poor communication between scientists and public officials

Unfamiliarity with each other's needs and expectations, methods, expertise, and limits

At a national level and, where feasible, at regional and local levels, establish and maintain pre-crisis rapport between scientists and public officials. Discuss your respective priorities, expertise, and limits. When a crisis arises, do the same with any new officials. Investments in this rapport are amply repaid during crises. Explain to public officials the nature and limitations of advice, forecasts, and warnings that scientists can offer.

Ask civil defense and other officials whether they wish only factual information and forecasts or also suggestions of possible mitigation measures. In some countries, scientists are asked only for scientific information; in other countries, they may be asked to recommend mitigation measures. Either request is legitimate. In extreme cases, scientists are asked to choose and order mitigation measures. In the last-mentioned case, scientists should be wary if they are being asked to judge social issues far beyond their usual training or to assume public officials' legal and political liability.

Understand that a decision-making official who is presented with an uncertain scientific forecast, clear socioeconomic issues, and political pressure might not always follow scientific advice.

Ask officials not to seek the unrealistic condition of zero risk. To achieve zero risk, a large area around each potentially active volcano would need to be evacuated immediately and kept evacuated forever. This is unrealistic and unnecessary. People are always willing to accept some risk in return for perceived benefits, such as being able to remain in their homes or continue their work. Ask leaders to engage citizens in a dialogue about the level of risk that citizens are willing to accept before major precautionary steps such as evacuations must be taken. Low tolerance for risk may lead scientists to issue relatively frequent false alarms, or to recommend early evacuations; high tolerance for risk will allow scientists to watch the volcano for longer and to issue later warnings with greater certainty. Explain this point to the public and to news media, as well.

Agree on each group's public information responsibilities, including "who will announce what." In general, political or civil defense leaders will want to announce mitigation measures, and some may also wish to announce major scientific findings.

Agree to immediately address, in private, any unmet expectations.

A conscious decision to withhold or delay some hazards information

Sometimes, information that does not meet the usual high scientific standards for certainty is withheld. At other times, information is withheld for fear that officials or the public might become unnecessarily alarmed or angry. Whatever the reason, scientists' credibility can be lost quickly and irreversibly.

Non-scientists can deal much better with worrisome information and uncertainty than many scientists believe. As soon as the team is confident of important information, no matter how worrisome, the leader or designated spokesperson should release it quickly, first to officials and then to the news media. Scientific caution in the face of uncertainty is good, but it needs to be balanced against the legitimate information needs of decision makers and the public at risk. If the data do not allow a definitive forecast, factual statements about what is known are an important step. Warnings of serious events that are known to be **possible**, issued before such events can be forecast as **probable**, may hasten precautions and save lives.

Low-probability but particularly high-risk outcomes pose a special problem. If such an outcome is credible enough that volcanologists will watch for its possible precursors or take some personal precaution, then officials should be told. Together, scientists and officials can decide whether public discussion of this possibility is needed.

Frequently, scientists and public officials are concerned that release of hazards warnings will cause economic loss. Sometimes losses occur, but they are probably not as great as feared and no more than those that occur if warnings are not issued. Some economic losses must simply be accepted as a necessary trade off for public safety. Frank discussion among scientists, public officials, and citizens about hazards, acceptable risks, and the trade offs that are implied in decisions about acceptable risk will help to protect against unnecessary economic losses and unnecessary losses of scientific credibility.

Official skepticism of scientific advice

Most officials will be initially skeptical of scientific concerns about a volcano. This is especially true if the volcano has been quiet in recent decades. Beyond this healthy skepticism, some officials listen only to the scientific advice that best justifies their preferred actions; worse yet, some government officials give almost no credence to scientific concerns about volcanic hazard.

Scientists should expect official skepticism and set aside extra time to overcome it. Overcoming official skepticism is a difficult task. Helpful steps include showing of the IAVCEI volcanic hazard videotapes or other videos pertinent to a specific hazard; introductions to counterpart officials from areas that have recently experienced volcanic disaster; careful listening to officials or community leaders, to understand their points and reasons of skepticism; and patient explanation of ample data about the hazard.

A matter that might seem unimportant to some scientists is personal appearance. Scientists who ignore professional appearance may have a hard time overcoming official skepticism and may also embarrass host colleagues. The importance of appearance will vary from one setting to another, but we have seen it considered often enough that we mention it here.

Be aware that any public complaint by scientists about official skepticism or official reluctance to heed scientific advice may be counterproductive. Such complaints jeopardize further communication between scientists and skeptical leaders. In at least one situation, though, the opposite was true: a public challenge by scientists led to a significant improvement in communication. Weigh the benefits and risks of public complaint.

Procedural failures in communication with public officials

Examples and solutions include:

(a) *Failure to put warnings in writing, for clarity and later accountability*. Be sure that all verbal warnings are also written and distributed.

(b) *Failure to distribute warnings to all key parties. Establish a clear "chain of communication" between scientists, public officials, and external agencies such as civil defense*. Make and use a prioritized notification list (voice, fax, e-mail). Test it before a crisis, again at the onset of a crisis, and frequently thereafter. Include news media in the list, but be sure that public officials receive your information first. The World Wide Web can help spread information widely but is not a substitute for direct, interactive contact with officials and news media.

(c) *Failure to confirm that officials truly understand our warnings*. Avoid technical terms and subtle distinctions. Restate warnings to each other until you are confident that understanding is complete. Be sure that warnings are given in the language of the local officials. Generally, a local scientist should be the spokesperson; if that is not possible and if language or cultural translations are needed, engage the help of skilled translators.

Ineffective relations with news media

Inadequate interaction with the news media

Some scientists refuse to work with the news media or hesitate to release worrisome information, with the result that crucial opportunities for public education are lost and the credibility of the scientific team is endangered. Some teams respond to media inquiries but fail to develop, with the media, materials for comprehensive public education about volcanic risks.

Premature or excessive interaction with the news media

Premature use of the media can force public officials into defensive postures that complicate the job of hazard mitigation. The presence of news media during field work and scientific discussion disturbs and inhibits most scientists and/or lets unanalyzed data and untested ideas escape to officials and the public. Self-serving use of the news media diminishes a scientist's or a team's credibility among colleagues, officials, and the media (Rossbacher and Buchanan 1988).

The primary scientific team should choose one or two scientifically qualified, media-savvy spokespersons to provide good quality, consistent public information. Other individuals on the team should coordinate media contacts through these spokespersons (Peterson 1988).

In general, do not allow media access to scientific discussions of the team or to crisis fieldwork. Special exemptions can be made for public education. Offer the media good alternatives for information. Daily press briefings with written updates are an efficient way for the scientific team to assist the media and save the rest of scientists' daily time for crucial data gathering and analysis. The daily press briefing also helps reporters to learn from each other's questions and helps to avoid the common problem that answers in separate interviews might seem to contradict each other. Similarly, for field visits, organized trips for representatives of the media ("media pools") are the most efficient use of scientists' time and are most likely to result in accurate, consistent reporting. Most reporters and news organizations prefer "exclusive interviews" and "scoops," but they can organize group briefings and "pooled" field visits by a limited number of their representatives when asked to do so during crises.

Written statements to public officials should generally also be provided to the news media as soon as officials have had time to understand the content and implications of the statements and to formulate responses. Be sure that the spokesperson for the scientific team is keenly aware of the distinction between science and public policy and is careful to refer discussion of public policy issues to politicians, civil defense, or others, as arranged in the team plan.

To help in information dissemination, set up an official, team-based World Wide Web site for the crisis and assign a competent Webmaster to keep it current. This way, scientists, officials, persons at risk, and other interested parties can have easy access to plans, data, and forecasts. Recent examples from Ruapehu, Soufriere Hills (Montserrat), and Grimsvotn are excellent. (Internet access is still limited in some countries, but access will improve dramatically over the next several years.)

A team plan and a personal checklist

Because many, perhaps most, problems of personal interaction during volcanic crises result from poor communication or inadvertent insensitivity, we propose two tools: a written plan in each country or region for scientific team response to volcanic crises, to include goals, leadership and other roles, policies, and procedures; and a checklist by which each of us can examine our own actions and ensure that we help, rather than hinder, the crisis effort.

A team plan for crisis response

A written protocol for crisis response should be prepared by each national or regional scientific group that has formal responsibility for volcanic hazard warnings. Such a plan should be prepared well in advance of any crisis, in consultation with other interested scientific groups and civil defense officials, and should include:

1. Clear identification of scientific, warning, and other tasks (including communications with civil defense, news media, and others)
2. Clear identification of responsibility (group or individual) for each task, including that of team leader
3. Clear identification of a mechanism for selecting team leader(s)
4. Procedures and policies on likely issues of scientific interaction, including: (a) rights and responsibilities for data and sample sharing; (b) resolution of differences in scientific approach and/or interpretation; (c) preparation and release of forecasts, warnings, and other public statements; (d) restrictions of access to hazardous areas (and application/approval procedures for access permits); (e) requirements and roles of visiting scientists; (f) communication, within and outside the scientific team; and (g) publication of scientific results, and distribution of authorship.

The plan should be simple and clear, with bureaucratic procedures kept to a minimum. It should also be flexible enough to allow discretion and adjustments as events might require.

Its primary audience would be current and prospective members of the scientific team; for those off-site, it could be made available on the World Wide Web and by e-mail. Some observatories might choose to request signatures of concurrence from team members. In most cases, this plan will be part of a larger emergency management plan that guides crisis responses by all parties.

One such plan has been prepared by the Montserrat Volcano Observatory team (Montserrat Volcano Observatory 1997a, b). The IAVCEI Commission for the Mitigation of Volcanic Disasters and the World Organization of Volcano Observatories will facilitate sharing of such plans as they are prepared; WOVO could also prepare a generic plan for adaptation by its member observatories.

A personal checklist

Before and while working with a crisis team, each of us should ask the following:

1. Are my presence and actions for the public good?
   (a) Am I really helping those whose lives and property are at risk?
   (b) Am I really helping local officials and community leaders?
   (c) Am I putting public interests above personal and institutional gain?
   (d) Might I inadvertently be doing harm? For example, am I exaggerating hazard in the interest of conservatism or being overly reassuring?

2. Are my presence and actions collegial?

   As a member (or leader) of the host team:
   (a) Am I sharing opportunities, resources, and data?
   (b) Am I encouraging all who can contribute, up to the limits of available logistics and team efficiency?
   (c) Am I doing my share of necessary jobs, no matter how onerous and inglorious? Am I willing to help in team leadership, if needed?
   (d) Am I helping to communicate and build trust within the team, with local officials, and with the public?
   (e) Am I being fair to colleagues, including visitors?

   If I am a visitor:
   (f) Am I helping, not burdening, the host scientific team as it strives to cope with a crisis?
   (g) Am I sharing all of my samples and information with the host team, for their use in hazard mitigation?
   (h) Am I reinforcing, not diminishing, hard-won credibility for local scientists?
   (i) If the host team is not yet self-sufficient, does my presence help or delay them toward that goal? Could I do more to improve its self-sufficiency?
   (j) Am I, within reason, preserving research and authorship opportunities for those scientists who have a long-vested interest in this volcano but who have no time for research during the crisis?

   Irrespective of my role:
   (k) Am I treating colleagues with courtesy, as I would like them to treat me? Asked differently, do I try to imagine myself in the position of my host colleagues?
   (l) Are my words and actions free of any presumption of superiority?
   (m) Am I acting with appropriate humility and prudence in the face of volcanoes' proven ability to confuse and surprise even the best scientists?
   (n) Am I open to others' ideas and interpretations and willing to change my views if new data or insights favor change?
   (o) Am I willing to accept team leadership and try to resolve interaction problems within the team?

Please consider these and other suggestions of this report, and discuss them with your team and other colleagues. They are intended to help avoid unnecessary problems of interaction during crises and thus avoid distractions from our best scientific and humanitarian effort.

Acknowledgements P. Hall, S. Williams, and B. Voight offered helpful comments. Numerous other colleagues commented on previous drafts of the manuscript. Some review comments were diametrically opposed, a sign of differences in individual philosophies and experiences. The final text is a consensus of our subcommittee; in some cases, it still differs from views of individual reviewers.

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