

routes which are likely to remain open. In this context, it will be advisable to consider the vulnerability of each route not only to ash falls, pyroclastic flows, mudflows or lava flows emanating from the volcano, but also to landslides and bridge or tunnel damage which may be caused by strong local earthquakes. Fine ash fall, even if only a few centimetres thick, may make asphalt road surfaces slippery, causing traffic congestion on steep slopes or accidents at corners and road junctions. Each of the escape routes will need to be examined, and measures taken as far as possible to control and maintain the traffic flow at expected danger points.

It is hardly necessary to point out that although the first consideration in selecting escape routes will be to move people as quickly as possible out of the immediate danger zone, it will also be desirable to bring them with the minimum delay to those safe areas where facilities exist for their reception and accommodation.

5.8 Means of transport, traffic control

As has already been indicated, the plan for transporting people and their property out of the danger zones should be designed for two levels of emergency: namely, phased response and immediate evacuation. In a phased evacuation, when there is sufficient time between the official evacuation order and the onset of destructive eruption, one may assume that each family possessing its own vehicle or boat will look after itself and any neighbours for whom it has space and has made a specific commitment. All other evacuees will be collected by public transport from pre-arranged pick-up points. Each public transport driver, including especially hired or requisitioned truck drivers, will be instructed to collect people from one of these pick-up points (and not elsewhere). All private and public vehicle drivers will be briefed on which escape roads to use and when to leave. The public transport will continue to make return trips as long as roads remain open or until all evacuees and as much property as possible have been removed.

In the event of an unexpectedly rapid escalation of destructive activity, transport will become increasingly difficult to control (due to attempts of people to scramble on to the nearest available truck or bus), and traffic movement along the escape routes out of urban areas may become impossible because of the large number of people leaving on foot. In this case, the plan will have to be abandoned in favour of a "crash" plan allowing any vehicles returning to the hazard zone to collect fleeing pedestrians at *ad hoc* pick up and turning points (preferably under police or civil defence control) along the escape route.

In order to plan evacuation transport in detail, it will be necessary:

- (a) To establish how many people have private vehicles and/or boats, and to designate the routes these will follow;
- (b) To make an inventory of the numbers and locations of people needing public transport;
- (c) To designate pick-up points for public transport;
- (d) To make an inventory of available public transport and drivers and to assign pick-up points to each of them;
- (e) To make arrangements for requisitioning and fuelling private trucks and buses (and boats if appropriate) and to provide any other necessary incentives to those normally based outside the hazard zones whose services may be required. It may be judged necessary or appropriate, for example, for the government to undertake to make good any loss or damage suffered by private vehicles or boats brought into the danger zone to assist with the evacuation.

5.9 Accommodation in refuge zones

Once the evacuees have reached the refuge zones, the problems of shelter, feeding, hygiene and morale will be similar to those of evacuees from any other natural or man-made disaster, and hence do not merit special discussion in a text on volcanic emergency management. There is, however, one factor in the case of volcanoes which does not normally apply to cyclone, earthquake or flood disasters: namely, that the eruption may continue for many months with repeated destructive paroxysms (possibly exceeding in scale the first one), and that it may not be safe to allow or encourage the return of evacuees, or to commence rehabilitation and reconstruction, for many months after the initial disaster-causing event. Volcanic evacuations therefore often last longer than those caused by other natural phenomena.

5.10 Rescue, first aid and hospital services

During or after an evacuation, some people known to be living or working in a hazard zone may fail to appear at any of the safe transit points or in a refuge zone, and it may be necessary to organize searches for them.

There may also be people isolated in areas which are not exposed to any danger but to which the access routes are blocked by pyroclastic flows, mudflows or lava flows. There may be need for aerial and/or marine

reconnaissance missions as soon as conditions are favourable, for food supply or rescue. It will be necessary to plan what equipment will be available and how such missions will be carried out.

First aid and hospital treatment will be needed mainly for three types of injury:

- (a) Respiratory problems among people who have been exposed to breathing air laden with fine silicate dust, possibly also containing dangerous levels of H₂S, SO₂, and other volcanic gases;
- (b) Broken limbs, lesions and bruises resulting from the impact of rock fragments or lava lumps falling from a great height;
- (c) Skin burns (first to third degree) and burns to breathing passages and lungs, resulting from exposure to steam and hot dust clouds, especially those spreading from the fringes of pyroclastic flows. In the event of the latter, some of the casualties will probably be severely burnt over most of their bodies, and in critical condition.

In addition to the above, there may also be victims of toxic gases such as carbon monoxide (CO) or of suffocation in pools of carbon dioxide (CO₂) or other dense gases which may have accumulated in house cellars, valley bottoms or other low-lying places. Later, medical problems may arise from the drinking of water from reservoirs or tanks contaminated by toxic compounds.

5.11 Security in evacuated zones

Unless the danger to life is immediate and obvious, people will be reluctant to leave their homes without assurance that these will be guarded against burglary and looting during their absence. Adequate precautions must therefore be taken to prevent the access of unauthorized persons to evacuated zones, and regular police patrols of the zones should be maintained as long as this does not endanger the lives of the police.

5.12 Alert procedures within government

As distinct from other natural hazards, volcanic hazards are strongly localized, the most destructive effects of eruptions being limited to areas within a few tens of kilometres of each volcano. The main responsibility for action of the kind described above may often devolve on local or provincial rather than national government agencies, except when the magni-

tude of the disaster is such that the local government is unable to cope with the situation.

The emergency plan will define the responsibilities of the various departments of government in dealing with the situation and the procedures by which the various elements of the plan will be put into effect when required.

Overall responsibility will generally be vested in an inter-departmental committee composed of representatives of the government departments concerned and presided over by the head of the national, provincial or local government. Each government department represented on the committee will prepare its own plans for action in response to alerts, in accordance with the directives given by the committee.

In general, it will be possible to define several stages of alert, each corresponding to a different level of hazard as assessed by the scientific team monitoring the volcanic activity. An example is given in table 3.

TABLE 3

Stages of alert for volcanic eruption

	<i>Phenomena observed</i>	<i>Interpretation— violent eruption possible within a period of:</i>	<i>Action by Disaster Control Committee and by Departments</i>
<i>Alert stage:</i>			
I.....	Abnormal local seismic activity; some ground deformation; fumarole temperature increases	Months or years	Inform all responsible officials. Review and update emergency plans.
II (Yellow)..	Significant increase in local seismic activity, rate of deformation, etc.	Weeks or months	Check readiness of personnel and equipment for possible evacuation. Check stocks of materials and relief supplies.
III (Orange)..	Dramatic increase in above anomalies, locally felt earthquakes, mild eruptive activity.	Days or weeks	Public announcement of possible emergency and of measures taken to deal with it. Mobilization of personnel and equipment for possible evacuation. Temporary protective measures against ash falls.
IV (Red)...	Protacted seismic tremor, increased eruptive activity.	Hours or days	Evacuation of population from hazard zones.

The responsibility for declaring the various stages of alert will lie with a designated official, who will act on the advice of the scientific team monitoring the volcano. There will usually be an element of personal scientific judgement in deciding what interpretation to place on the observed volcanic phenomena and much will depend on knowledge of the past history of the particular volcano. In practice, the decision as to which stage of alert has been reached may often be based not so much on an objective assessment of the probability of a violent eruption as on the number of false alarms which can be tolerated without loss of confidence by the civil authorities and by the public.

5.13 Formulation and communication of public warnings

Since the measures that can be taken to protect life and property during a volcanic eruption will affect to some degree the whole population, it is of vital importance to keep the public fully and accurately informed of the nature of the hazard and of what is being done (and what they should do) for their protection. This inevitably entails some degree of control of the information transmitted to the public by the news media. This control will usually be exercised by a responsible official on behalf of the government.

In order to avoid panic or other adverse reactions to the situation, the form and content of public announcements will, as far as possible, be decided in advance of any emergency, and the public will be familiarized with the arrangements made for their information, so that they know what to expect. The details of these arrangements will vary from place to place and from country to country, according to the political and social structure of the community and the technical means available. It is therefore difficult to lay down any detailed guidelines for public information and warning. However, as an example, we give here model texts that could be used to announce by radio the two highest levels of alert.

VOLCANIC ERUPTION—ORANGE ALERT

Draft for first official radio announcement
(to be included in all news bulletins)

Studio announcer: The Government has issued a warning about a possible volcanic eruption. Here is the _____ (appointment) _____ (name).

Statement to be read by a senior Government officer, either in person or broadcast from a pre-recorded tape in full without editing:

“The Government has declared an **Orange Alert** for a possible major eruption at volcano. This means that, although there is no imminent danger to life and property, there is a serious risk that a large eruption may take place in a matter of weeks or days.

“The Government is therefore taking extensive precautionary measures and certain routine services will be suspended. Maps of the potential danger areas are being circulated and displayed in public places.

“It is not yet necessary for people to leave the danger areas. You will be kept informed of the situation by frequent radio announcements. If the risk increases and the Government considers that an evacuation is necessary a **Red Alert** will be declared in time for everybody to move to safe areas before a major eruption occurs. At present no general evacuation is necessary.

“If you are at work there is no need to return home immediately; unless your employer tells you otherwise, you should therefore report for work as usual until further notice.

“Do not telephone the government or volcano monitoring authorities—you could jam the telephone network.

“The best way to help yourself and the authorities is to listen frequently to the radio for up-to-date information and further advice.

(Add further instructions if required on closure of schools, meeting or reporting for duty of emergency management staff, other preparatory measures to be taken by each household, specific hazards to particular areas, etc.).

“Make sure that your neighbours know about this warning.”

Studio announcer: This announcement will be repeated at _____ hours. (Repeat in at least two news bulletins.)

VOLCANIC ERUPTION—RED ALERT

Draft for official radio announcement
(to be broadcast as a News Flash)

Studio announcer: We are interrupting this programme for an **Urgent News Flash** about a possible major eruption at _____ volcano. Here is the _____ (appointment) _____ (name).

Statement to be read by a senior Government officer, either in person or broadcast from a pre-recorded tape in full without editing:

“In earlier announcements we have warned you of the possibility of a destructive eruption at volcano. The situation has become more serious and it is feared that violent explosions may occur within days or even hours. It has therefore been decided to declare a

Red Alert and order the evacuation of the _____ (specify colour(s)) area(s) shown on the evacuation maps which have been circulated and are displayed in public places.

“If you live in either the _____ (specify colour(s)) area(s), you should move out as quickly as possible, taking with you the possessions which we have already suggested. If you have your own transport use it. If you need government transport go immediately to the nearest pick-up point, as illustrated on the evacuation maps.

“All private motor vehicles, trucks and privately owned utilities due to be requisitioned should report immediately as already instructed.

“All roads (except _____), are open to traffic. Take the directions indicated on evacuation maps and/or follow police instructions.

“If you are using your own transport and have a place of refuge in the safe area, go there quickly. Everybody else should go to the nearest Transit Centre.

“Do NOT park on the roads or you will obstruct the traffic.

“Please do not telephone the government or volcano monitoring authorities—you could jam the telephone network.

“Stay tuned to the radio for up-to-date information and further advice. This will remain on the air 24 hours a day on this frequency until further notice.

“Please make sure that your neighbours know about this announcement.”

Studio announcer: This announcement will be repeated at _____ hours. (Repeat at least four times at hourly intervals.)

5.14 Review and revision of plans

No plan of this kind will remain for ever valid, and it will always be advisable to provide for its review and revision with appropriate publicity at regular intervals, say every two or three years. Changes may become necessary as a result of:

- (a) Progress in scientific knowledge of the volcano in question, which may lead to a redefinition of the hazard zones around it;
- (b) Changes in the pattern of settlement around the volcano, in the road system, communication networks and other technical infrastructure, which will modify the procedures for warning and evacuation in emergencies;
- (c) Changes in the administrative structure of the national or local government.

In addition, the plan will certainly have to be revised after each eruptive episode, in the light of the practical experience gained. Some imperfections in the plan will probably be revealed by any real emergency, no matter how much thought and planning has been put into it beforehand. This implies the existence of some permanent organization within the national

or local government, with prime responsibility for preparing and executing emergency plans for volcanic and other potential causes of disaster. In chapter 8, some examples are given of such organizations.