PAPERS

Valtellina Landslide and Flood Emergency, Northern Italy, 1987

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This report describes the progress of the landslide and flood emergency that occurred in Valtellina, in the northern Italian Alps, during July and August 1987. For the authorities, the critical problem was one of controlling the rise of a large lake impounded on the River Adda by landslide debris that threatened to breach catastrophically, releasing a major floodwave. Several lessons can be learned from the way in which the emergency was managed. First, helicopters played a critical role in evacuating survivors and moving supplies around the disaster area, but there was scope for better co-ordination of operations. Secondly, high levels of private car ownership allowed greater flexibility in designing mass evacutation plans for threatened communites, but such high personal mobility proved difficult to control in order to ensure public safety. In future, education programmes could be used to help people appreciate the dangers of driving during periods of great natural hazard risk. Thirdly, the Valtellina disaster coincided with a change of national government, including substitution of the Minister of Civil Protection. This led to a policy vacuum, sub-optimal decision making and erosion of public confidence in political leaders. Landslide-dammed lakes represent a widespread but rather unpredictable hazard: they therefore require flexible emergency repsonse, but not without decisive leadership.

INTRODUCTION

Valtellina, in the Province of Sondrio among the Rhaetian Alps of Northern Italy (Figure 1), was the scene of a landslide and flood emergency that lasted from 18 July until the beginning of September 1987. Fifty three people were killed or remained unaccounted for, at least 110 were injured and 25,000 were evacuated from 40 municipalities that have a combined population of 48,500. Damage and destruction, which were widespread throughout the Alps, have been valued at £450 million in Valtellina alone, and it took five months merely to re-open the valley to through traffic. Essentially, flooding of the River Adda (which flows into Lake Como) provoked landslides and led to casualties, destruction and disruption from 18 July until, on 28 July, major debris avalanches blocked the Adda and began the impoundment of a large lake. During the following month, the authorities had to design a strategy that would reduce the risk of overtopping or breaching of the debris dam as the water level rose. This necessitated evacuating settlements for 50 km downstream of the lake and then releasing water impounded behind a hydro-electric dam

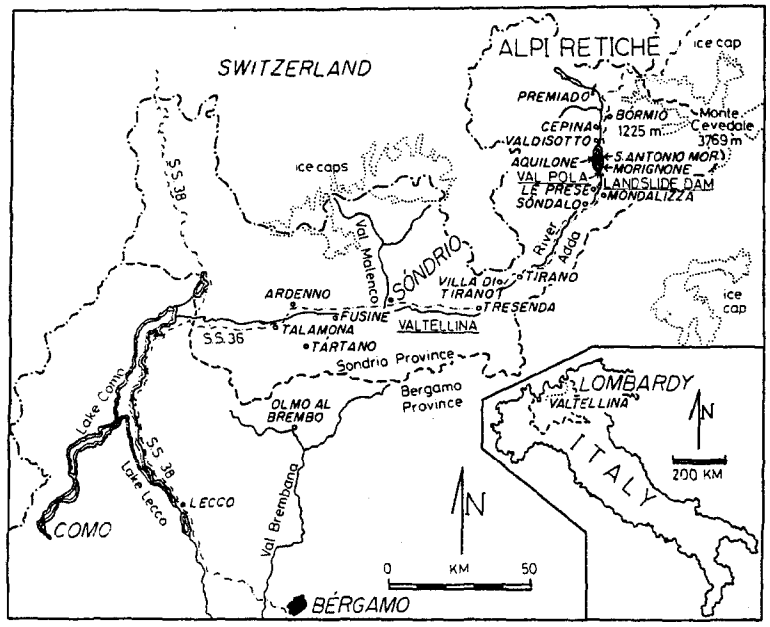

FIGURE 1 *Valtellina: location map*

upstream, in order to scour a relief channel through the debris barrier.

In this report I will describe the evolution of the emergency and make some general conclusions. From the point of view of disaster studies, the event is particularly interesting for what it tells us about two problems: the use and misuse of helicopters and private cars; and the impact of government indecisiveness on the supervision of relief work, the enforcement of evacuation measures and the degree of public confidence in elected leaders.

THE SETTING

Since 1945 landslides and floods in Italy have killed more than 10,000 people and caused damage valued at £40,000 million (Alexander, 1987a). A 1987 survey of 26 provinces identified 1,670 landslides at an average density of one per 53.8 km^2 (Ministry of Civil Protection, 1987). About 25 percent of these are periodic or continuous, 20 percent have damaged buildings and 47 percent have damaged roads. The study emphasized the special vulnerability of the Bergamo-Como-Sondrio triangle in the Alps, in which 255 damaging landslides were identified, 70 percent of them in close proximity to settlements. In Valtellina since 1800 landslides and floods have provoked damage and sometimes destruction with an average recurrence interval of no more than 15 years. At Tresenda, near Sondrio (Figure 1) in May 1983, 17 people were killed in a major debris slide associated with heavy rainfall (Azzola and Tuia, 1983).

Undoubtably, the primary cause of such instability lies in the tectonic and post-glacial conditions of the valley. Orogeny in the Alps has involved collisional tectonogenesis among continental rocks from several crustal plates and microplates situated above a crystalline basement. Folding mainly occurred in the first half of the Tertiary (65–25 m.y. B.P.), with phases of quiescence during which

erosion succeeded in keeping pace with the bursts of uplift (Embleton *et al.*, 1984). More recently, the Alpine Orogeny ended in the Pliocene and early Quaternary, after which neotectonics continued the process of active crustal adjustment to pre-existing stresses. The section of Valtellina from Lake Como to Tresenda follows the Insubric Line (known to Italians as *la linea tonale*), a suture that divides the Southern Alps from the northern, Austro-Alpine nappes. This discontinuity may be a form of overthrust, or possibly a strike-slip fault with up to 300 km of dextral movement (Ollier, 1981). In any event, it has guided the orientation of the lower valley. North of it, south- and east-facing overthrusts are present, and the upper valley is cut in metamorphic rocks, such as gneiss and micaschist, with exposed plutonic rocks that include granite, porphyrite and acid diorites. These Archeozoic to Mesozoic rock formations are complemented by small outcrops of slate, limestone and dolomite.

Among five or six Quaternary glaciations, the penultimate or Riss (200,000 yrs. B.P.) and the last or Wurm (80–60,000 yrs. B.P.) appear to have extended the furthest and removed many traces of earlier cold periods (Embleton *et al.*, 1984). Hence, the valley is undergoing morphological adjustment to both neotectonics and the post-glacial conditions of the last 11–14,000 years. The River Adda has not yet removed all fluvioglacial deposits from its valley, and the most unstable slopes include those cut in moraines, tills and debris cones at the foot of hanging valleys.

A secondary but by no means insignificant cause of slope instability is poor environmental management, mainly involving deforestation, mismanagement of water resources and overdevelopment of settlements and routeways. About 8.7 million hectares (28.8 percent) of Italy is forested, an area that compares well with European Community averages. Most trees occur on 20–25 percent slopes and about 0.9 percent of the woody biomass of 1000 million m^3 is cut each year. But 40 percent of forests suffer damage to a greater or lesser extent as a result of soil erosion, fires or acid deposition (Docter, 1987). Valtellina has suffered additionally since 1918 from progressive deforestation. Demand for wood as a building material and fuel has recently been replaced by demand for steeper land. Although much of the area is theoretically protected under conservation laws of 1923 (for drainage basin management) and 1939 (regarding preservation of scenic beauty), as well as a Ministerial Decree of 1963, the laws are seldom respected at any level of authority (Cederna, 1975, regarded the nearby Stelvio National Park as merely a "geographical expression," utterly unprotected against incursion by developers). In 1984–85 3200 trees were cut down to open up new runs for the World Ski Championships, and this signalled a renewal of demands for planning permission to develop chair lifts, hotels, restaurants and access roads in many parts of the valley. State participation was not lacking: £450 million was invested in a 20-year project to upgrade State Road S.S. 36 north of Lecco, including the construction of 28 km of tunnels. No environmental impact statement was prepared.

In short, development to some extent followed the model identified by Kariel and Kariel (1982) for an Austrian valley that had changed from a traditional agricultural economy to one based largely on commercial tourism. Environmental and natural hazard safeguards were minimal, although in the months preceding the 1987 disaster £18 million were spent on slope consolidation in Valtellina, a sum that commentators regarded as "too little, too late" (*La Stampa*, Turin, 21 July 1987). Lombardy Region at the time spent only

0.4 percent of its budget on environmental protection, according to the weekly *L'Europeo* (8 August 1987). To some extent, any reduction in the hazardousness of slopes was counteracted by increase in that of flood-plains. For example, ENEL, the state electricity generating authority, raised the bed of the River Adda at Ardenno, in order to accommodate a hydro-electric plant.

Apart from the electricity demands of Po Valley settlements such as Milan, tourism has been the major impetus to environmental modification in Valtellina. Twenty five percent of the local economy is based on recreation, which is worth £680 million a year. Bormio, which is at the head of the valley 20 km from the Swiss border, is one of the richest municipalities in the country and normally earns about £90 million a year from tourism. The 1987 floods and landslides occurred during the high season, causing tourist presence in the valley to fall by 60 percent, and confirmed reservations to drop 90 percent.

THE DISASTER

On Friday, 17 July 1987, the Italian Meteorological Service predicted heavy rain over the north of the country. The Ministry of Civil Protection in Rome was alerted during the early hours of Saturday 18th. By 11 hrs. on that day a landslide and flood warning had been transmitted to the Prefectures of seven northern regions, who had warned local municipal mayors. In Valtellina and Val Brembana campsites were evacuated and motorists were warned via television news and three radio channels. By the afternoon of Monday 20th, 11 bodies had been recovered, 23 people were missing, 120 were injured, 2730 had been evacuated and damage was provisionally estimated at £450 million. Army, airforce, fire brigade, ambulance and bulldozer crews and personnel in the field amounted to 3620, using 332 vehicles and 42 helicopters and aircraft. Bormio was accessible only from Switzerland and 21 settlements were isolated in Val Brembana. Sixty municipalities had been affected, 2000 buildings flooded and six bridges washed away. Local administrators requested that a State of Emergency be declared for an 80 km stretch of Valtellina from Talamona to Bormio.

Mudflows had buried 20 vehicles at Sant'Antonio Morignone and swept away a hotel at Tartano, in which seven people died. Most victims were hit by fast-moving rockfalls, mudslides or debris avalanches, although incidences of drowning in the floodwaters were reported from various places in the Italian Alps, as well as in concurrent events in Austria, Switzerland, France and Belgium. Lake Como rose gradually to 283 cm above its datum, flooding the centre of Como city; by 18 hrs. on Sunday 19 July the lake was receiving a discharge of 1600 cumecs and disgorging only 760. About 290 mm of rainfall was received over the period 18–20 July.

During the subsequent week the floodwaters ebbed, but mass movements continued to damage roads and railways, posing a hazard to transport. For example, 200,000 m^3 of sediment created a temporary barrier to the River Adda near Sondalo. Fractures were observed in the east side of the valley at 2000 m above sea level (800 m above the valley floor) about 8 km south of Bormio. Air photographs taken on 21 July showed them to be 1 km long, at which point the co-ordinator of a geological office that had been set up at Bormio warned the Minister of Civil Protection, the Hon. Giuseppe Zamberletti, that a major slope failure was probable. The location, Val Pola, had been identified as a landslide risk zone in a report dated 1972 (Pozzi and Sfondrini, 1972), although a more superficial survey

of 1984 had been reassuring (*L'Europeo*, 8 August 1987). On 26 July the Minister signed an ordinance allowing only relief workers access to the evacuated area south of Bormio. A day later he suspended it, but seven construction workers had nevertheless acquired authorization to retrieve a bulldozer from Sant'Antonio Morignone. Their bodies were never recovered.

At 7.18 hrs. on Tuesday, 28 July, the Val Pola landslide began to mobilize. At 7.27 it slid as an avalanche of at least 10 million m^3 of debris, accelerating to 70 m/sec (250 kmh). The movement lasted 31 seconds and caused tremors at magnitude 3.9 on the Richter scale. The settlements of Morignone and Sant'Antonio Morignone were obliterated and, as the debris climbed the opposing sideslope, damage was extensive in the valley-side village of Aquilone, which had not been evacuated. The lower part of this settlement was crushed by moving rock debris and the upper part impacted by a faster-moving air pressure wave. One body and nine injured people were recovered, while 27 remained missing. The River Adda had its course blocked by a barrier of saturated debris 9 km^2 in size, 2800 m long and 40–70 m deep (similar landslides in the Alps have been described *in extenso* by Heim, 1932, and Erismann, 1979). The debris drained in a continuous anastomosing flow towards the southerly floodplain of upper Valtellina. At a time when Lake Como was gradually subsiding towards its normal level, the flow of the River Adda (albeit much reduced by abstraction via a network of hydro-electric dams and aqueducts) was discharging 20–22 cumecs of water into a new lake basin 1,500,000 m^3 in volume in the municipality of Valdisotto, south of Bormio.

The rate of discharge into the lake fell to 2–3 cumecs as the weather improved for a while. But a brief interlude of heavy rain on 30 July provoked fears that a further 2 million m^3 of rock would cascade into the lake, causing a floodwave that might overtop or breach the debris barrier, leading to damage downstream akin to that which in 1963 killed 2100 people in the Piave Valley near the Vajont Reservoir (Kiersch, 1965; Quarantelli, 1979). Fears were reinforced by the occurrence of a 1.5 million m^3 landslide at Fusine that together with floods damaged 110 houses and killed one person.

In early August it was predicted that the lake would swell to 21 million m^3 of water within six weeks, or sooner if there was heavy rain – provided, that is, that the debris barrier did not fail. As there was little evidence that this was about to happen, plans were laid to install in the debris a drainage tunnel 1.6 m in diameter capable of discharging 5–6 cumecs, plus an open spillway over which water would be pumped. Later a tunnel would be built that would carry up to 400 cumecs through a tube 6 m in diameter. Pumping would not begin until 19 September, although preliminary installation work was carried out over the period 3–18 August. Unfortunately, rockfalls and slides continued to occur on the sideslopes (providing dramatic television footage). Throughout this time evacuation downstream was minimal, as a 5–12 hour lead time (later raised to 12–15 hours) was expected in the event of a serious flood. But on 24 August work on the debris barrier was suspended amid conditions of great uncertainty. At 22.32 hrs. the Prefect of Sondrio signed evacuation orders for 19,500 downstream residents, at a time when the lake waters were only 7 m below the top of the debris. At this point, the Hon. Remo Gaspari, who had replaced Sig. Zamberletti as Minister of Civil Protection, took the difficult decision to flush the debris barrier by augmenting the discharge of the River Adda, in the expectation that this would erode a spillway deep enough to reduce the lake level

and thus the risk of destruction of the barrier.

The operation was without doubt extremely risky, as there was no guarantee that flushing would occur evenly, rather than as a major floodwave. Upstream, the Premiado Reservoir of the Milanese Electrical Company (AEM) held 244 million m^3 of water behind a 140 m-high dam. Normally, it released 13–26 cumecs in order to generate 150 MW of electricity. The sluice-gates were to be opened at 4 hrs. on 30 August. The River Adda, whose discharge had fallen to 4 cumecs from a flood peak of 120, would reach more than 20 cumecs. Although 24 hours would be needed to achieve tangible results, it was conceivable that massive scour damage could occur as far south as Villa di Tirano, 30 km downstream, and that the floodwave would still be 4 m high at Sondrio, a further 25 km down the valley. The alternative, to reduce the discharge and cut a new spillway, was deemed too slow, given the continued hazard of rockfalls into the lake.

Seven thousand people at Sondrio were put on evacuation alert and the discharge of the Adda was increased gradually to 35 cumecs. State television ran a seven-hour live broadcast that captured 77 per cent of viewers nationally, some 3.8 million people. In the event, the operation succeeded and more normal engineering works were then employed to drain the lake, at its lower level. A 10 km tunnel was constructed on State Road S.S. 38 and opened in January 1988, thus restoring direct communications between Sondrio and Bormio. The government allotted £680,000 to the families of victims and £51 million for repair of basic intrastructure. Reconstruction of the worst-damaged settlements would take decades.

PROBLEMS OF TRANSPORTATION

Distinctive problems were experienced during the emergency with two of the most useful modes of transportation: helicopters and private cars.

Throughout the emergency about 40 helicopters were used. These included many light, single-rotor machines and a small force of double-rotor Chinooks, capable of carrying more than 30 people, but less manoeuvrable and less easy to land than the smaller craft. The helicopters belonged to the Italian Airforce, Army Light Air Transport Command, Revenue Police, Carabinieri, Forestry Corps and private aviation firms. They were especially useful during the period of floods, when occupied homes in the valleys were submerged, and afterwards when roads were interrupted by landslides. An illustration of how heavily they were used is furnished by information supplied from the Ministry of Civil Protection command post at Bormio after the first three days of the emergency: the Airforce made 300 helicopter flights, moving 2600 evacuees, and 30 Army helicopters carried 1600 people during 171 flight-hours of operations. At Talamona during the initial floods 35 people had been winched to safety aboard helicopters in three hours. Bergamo city airport had been the main base for flights, and in Valtellina local sports pitches had been used as landing pads.

Although the helicopter operation was an undoubted success, it was not without drawbacks. Hours of continuous manoeuvring during heavy rain, amid cloud cover and in deep Alpine valleys, exerted a serious strain upon the pilots. At Olmo al Brembo, in Val Brembo, a light helicopter crashed onto a filling station after its rotor became entangled in overhead power lines; fortunately, there were no casualties. While Valmalenco was submerged by floodwaters, pilots working for private companies are alleged to have offered stranded residents a trip to safety at prices of up to £4,500. Unless

payment was made immediately in cash, the victims allegedly were not winched up. Other unscrupulous people assumed the role of intermediaries who would, for a price, find survivors space in the free flights made by Army helicopters. The Prefect of Sondrio promptly issued an order banning such practices, but they proved difficult to stamp out.

Some of these problems, one supposes, might have been resolved by improving co-ordination among helicopter corps. Ideally, it would seem appropriate to plan to have all helicopters at work in a disaster area under the command of one traffic controller and to ensure that pilots have training – and licenses – adequate to the special conditions associated with civil emergencies, such as floods, in which visibility is poor and many helicopters are at work in a restricted airspace.

The problems associated with the use of private cars were rather different. There is no doubt that rapid mass evacuation of groups of people as large as the 19,500 evacuated downstream of the Val Pola dam could not have been achieved efficiently without private transportation – at least, not without careful preparation of public transport. Hence the private car lent a degree of flexibility, and perhaps even spontaneity, to evacuation plans. However, the other side of the story is that mandatory evacuation became very difficult to enforce. After the formation of the Val Pola debris dam, for example, downstream communities were evacuated by order of the Prefect of Sondrio and Minister of Civil Protection. Although police surveillance of State Road S.S. 38 was continuous, some 300 official waivers of restrictions on access were issued in the first 36 hours after evacuation. There were many more illegal entries into the cordoned areas, such that supposedly evacuated villages near Sondrio developed traffic jams and crowds. Such a combination of free-will and personal mobility proved extremely hard for the authorities to control.

There is also mounting evidence that people have an inflated idea of the degree of safety offered by an automobile during flood and landslide emergencies. Travellers were warned of the hazard by broadcasts on national radio and television at 13 hrs. on Saturday, 18 July 1987. The Ministry of Civil Protection held the warnings to be adequate, but not the public response. The storms of July 1987 killed about a dozen people in transportation accidents that occurred in various parts of Europe. In Italy at least six died in cars while driving in valleys with high flood, rockfall or mudflow risks; others had narrow escapes. One might question the necessity or wisdom of such journeys and the awareness of danger shown by car users. Similar conclusions were reached by Gruntfest (1977) and Gruntfest *et al.* (1987), who investigated the reliance on cars to escape flash floods in the Colorado canyons and found that driving tended to increase people's vulnerability in comparison to more carefully considered evasive action. The key to the problem may lie in improving public awareness of these risks.

THE IMPACT OF POLITICAL DECISIONS

The frequent changes of government in post-War Italy tend to leave one with the suspicion that a cabinet of ministers is only semi-relevant to the conduct of national affairs (Allum, 1973). As it happened, such a change coincided with the Valtellina disaster, upon which it had a profound influence.

In the 1976 Friuli and 1980 Irpinian earthquake disasters, the Italian government appointed the Christian Democrat politician Hon. Giuseppe Zamberletti as Special Commissioner for Relief Work. The 1980 disaster involved Zamberletti so

profoundly, and with such high government expenditure (estimated at 3 percent of GDP per annum for five years), that a full scale Ministry of Civil Protection was established in Rome under his direction on 1 August 1982 (Alexander, 1986a, 1987b). National legislation enacted to set up the Ministry has been described in detail by Pastorelli (1986). For a brief period during the 1983 Pozzuoli (Naples) volcano-seismic emergency Hon. Vincenzo Scotti became Minister, but the next cabinet reshuffle restored Zamberletti to the post, as he was the man with the greatest experience of government involvement in disaster relief and had earned a fair measure of public trust by his way of administering it. This achievement is all the more remarkable, as the reserve of national funds allotted to the relief and prevention of natural catastrophe (*il serbatoio*) falls far short of the sums actually needed by a government that sets itself up as the chief indemnifier of the public against disaster losses (Alexander, 1987a).

Following the precedent he had set himself in previous disasters, Zamberletti set up a Ministerial command post at Bormio in Valtellina, from which he directed relief operations with the help of Dr. Elveno Pastorelli, the Head of the National Civil Protection Council. His working relationship with the Valtellinesi was, however, jeopardized by the question of who had signed the papers authorizing the seven workers who died in the Val Pola landslide to enter the risk zone on the morning of 28 July. Although the matter was rapidly placed *sub judice*, it appeared that a misinterpretation of orders had occurred at a lower level of command, and so the Minister was not formally implicated.

On 29 July 1987 the first government to be headed by Giovanni Goria was announced. Zamberletti immediately lost his ministerial post to Remo Gasperi, also a Christian Democrat, who had been a parliamentarian since 1953 and a minister frequently since 1970. Dr. Pastorelli resigned with the passing of Zamberletti. Essentially, the latter had been sacrificed to the so-called "Cencelli Code," in which the coalition government is maintained by appointing ministers from each participating party in strict proportion to their level of support from colleagues in the Italian Lower House. At the same time a Socialist was appointed Minister of the Environment and a Social Democrat to the Ministry of Public Works.

It is certain that the act of substituting a competent minister at the height of the crisis did little to reinforce public confidence in the government's ability to manage the Valtellina disaster. It was widely held to have been at best insensitive and at worst a cynical act (*La Repubblica*, Rome, 26 August 1987). Gasperi's inexperience showed. During the emergency he failed to convene the government's Commission on Great Risks (*Commissione sui Grandi Rischi*), which is the steering committee for government intervention during disasters and has a hydrogeological section chaired by a geologist, Professor Lucio Ubertini. The eminent European parliamentarian Professor Felice Ippolito promptly resigned his Vice-Presidency of the Commission in protest. Commentators also noted that the government's Environmental Commission was not due to meet until 28 August at the Chamber of Deputies and 8 September at the Senate. The result was a policy vacuum that manifested itself as indecision, or wrong decisions, and gradually filtered down the chain of command in Valtellina until it eroded public confidence.

During August 1987 Gasperi changed his approach to managing the Val Pola lake from a strategy based on pumping to one based on flushing the debris barrier by opening the flow of water from hydro-

electric reservoirs. Controversy among geologists and hydrologists as to the possible effects of this highlighted the seriousness of the dilemma. In the Autumn of 1807 a landslide dammed the River Adda near Tirano and attempts to manage the debris barrier led to catastrophic breaching and heavy scour damage downstream. In 1987 the day on which the discharge of the Adda was increased, 29 August, was dubbed by the press, not "D-Day," but "Gasperi-Day," as the Minister's reputation hung on the outcome (*La Repubblica*, Rome, 30 August 1987). The success of the operation saw demands for Gasperi's resignation subside with the waters of the Val Pola lake.

Despite his eventual success, Gasperi's management of the emergency was clearly improvised, even to the extent that he found himself on holiday at Vasto, 750 km away, during the critical phase (to the fury of local politicians in Valtellina). The change in the strategy for managing the lake led to *ad hoc* policies for evacuation downstream, and hence was a factor in the mass violation of evacuation orders. At Le Prese, near Sondalo, poor identification of risks led to residents being evacuated five times in 11 days; on 28 August they joined with residents of nearby Mondalizza in a demonstration against the Minister. There had been a precedent in that on 5 August at Cepina 1000 people resisted an evacuation order that they did not consider necessary.

Questions of governmental lassitude and ministerial incompetence apart, the administrators faced a serious dilemma concerning the external image of Valtellina. Politicians were caught between the need to demonstrate that they were facing up to a very threatening natural catastrophe and the desire to minimise the risks in the hope that tourists would return to the area and revive its economy. The press and television oscillated between reassurance and nicknaming Valtellina "Death Valley." Much of the equivocation, however, reflected the day-to-day unpredictability of the crisis and government response to it.

CONCLUSION

Cases of the impoundment of rivers behind landslide debris dams are not difficult to find in the geomorphological literature (Schuster and Costa, 1986). Many of the examples have seismic causes: for example, the Hebgen Lake earthquake of 1959 in Montana (Wittkind *et al.*, 1962), the Huascaran debris avalanche in 1970 in Peru (Plafker *et al.*, 1971), and the Bairaman River landslide of May 1985 in Papua New Guinea (King *et al.*, 1987). The last of these, triggered by a magnitude 7.1 earthquake, breached suddenly, losing 40 million m^3 of water and about 80 million m^3 of rock debris downstream in less than 3 hours. In contrast, the Torrente Lago landslide-dammed lake created in Calabria by the 1783 earthquakes there, which was 15 million m^3 in size, was only drained laboriously by human intervention 40 years after it formed (Cotecchia *et al.*, 1969). Thus it is clear that there is no set procedure for handling landslide-dammed river emergencies. The literature indicates that they can be just as volatile as glacier meltwater impoundments, which have been a persistent problem in the Alps (Tufnell, 1984) and Andes (Lliboutry *et al.*, 1977).

In general terms, the Italian Alps undoubtably deserve to be regarded as a high-risk zone for natural hazards. Govi *et al.* (1979) summarized events and the damage they caused during three years of repeated intense rainstorms, 1972–74, while Tropeano (1978) described examples of flood and mudflow damage near Turin that look depressingly similar to those of Valtellina. According to Benedini and Gisotti (1985), the floods of 20–24 May 1983 in Valtellina caused 240 landslides

and damage valued at £109 million. One person died at a campsite and 17 in the Tresenda di Teglio debris avalanche; 5200 people had to be evacuated. Thus the 1987 disaster must be seen in the light of repeated and widespread Alpine hazards, for which too little preparation has been made and which occur in a context of steadily rising vulnerability. Indeed, many of the criticisms made in the press about the government's environmental management policies merely repeated those made after the 1985 Stava mudflow disaster in the Dolomites, in which 267 people were killed (Alexander, 1986b).

The case of Valtellina 1987 was one in which the emergency phase, waxing or waning, lasted for nearly seven weeks. During that period it was necessary to reconcile two conflicting needs, the maintenance of evacuation orders and of access to the risk zone. The former was needed in order to ensure public safety and the latter to move plant and equipment to where it could help reduce the risk. The case of the seven workmen who lost their lives in the Val Pola landslide highlighted the perils of laxity in controlling movements around the disaster zone. On the other hand, personal mobility in Italy is such that many residents evaded the cordons in order to return home. The less mobile members of society, especially old people, would instead hide indoors when called upon to evacuate: the Italian concept of *domus*, that the home is a sacrosanct shelter, evidently prevailed (Haycraft, 1987).

Firm and decisive leadership might have persuaded more Valtellinesi to put their faith in alternative arrangements at the evacuation centres, rather than in the invulnerability of home or car. However, it is always possible that draconian measures would have side-effects that outweigh their benefits, and so the best future strategy would probably involve the sort of education programme that teaches Alpine valley residents to recognize the risks, including those associated with staying at home or travelling on hazardous roads during the emergency.

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