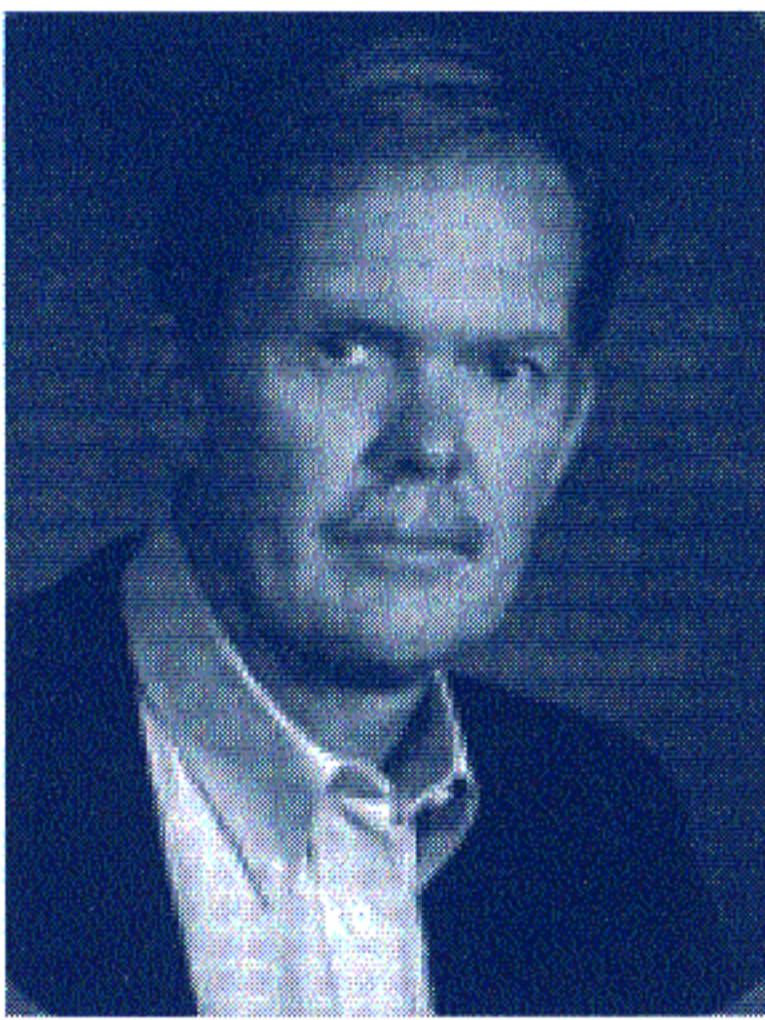


FROM THE PRESIDENT



Grant Heiken

IAVCEI AND THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS (IUGG)

When I first began participating in IAVCEI activities, I didn't realise that we were part of a union composed of seven associations representing geodesy, seismology, volcanology, geomagnetism and aeronomy, meteorology, hydrology, and oceanography. As a participant in volcanological activities, I really didn't care if we were part of an IUGG. This was justified in part, by my myopia, and by the fact that IUGG meetings were mostly a gathering of seven associations that each conducted more or less autonomous meetings at IUGG General Assemblies. There was serious discussion in 1991 of IAVCEI breaking away from IUGG to be an independent organisation. It was not a happy coexistence.

However, the nature of geosciences is changing. We no longer can afford to play in our own, specialised 'sandbox'. To be effective, much of our work by necessity is interdisciplinary; even reaching out to the social sciences when addressing problems in hazard mitigation. In parallel, IUGG has been changing. Changes have not been easy but are progressing—in our case, mostly thanks to the intense efforts of Wally Johnson and the immediate past-presidents Paolo Gasparini and Shigeo Aramaki.

Continued on page 2:>>

COTOPAXI VOLCANO, ECUADOR: MITIGATION OF DEBRIS FLOW IMPACT — DAUNTING TASK?

COTOPAXI VOLCANO

Cotopaxi Volcano, with an elevation of 5897 m, a diameter of 25 km and almost 3000 m of relief, is a classic stratovolcano in the Cordillera Real, Ecuador's second volcanic row, located some 40 km east of the main volcanic front that forms the Cordillera Occidental. It is one of the 30 or so potentially active volcanoes in Ecuador and the most active historically. Its glacier-clad flanks define the continental divide — its western, eastern and southern drainages flow eastward to the Amazon Basin, while the northern and northeastern rivers terminate at the Pacific Ocean.

Although the volcano has experienced bi-modal eruptive activity during the Holocene, its historical eruptions have been characterised by andesitic eruptions. These generated pyroclastic flows that descended to the then uninhabited base of the cone; ashfalls that generally went to the southwest, west, and northwest; and large debris flows that resulted from the energetic interaction between pyroclastic flows and the glacier cap. In contrast, rhyolitic eruptions have occurred about every 2000 years and their impact has been far reaching (Hall and Mothes, 1995). They have produced ash flows several cubic kilometres in volume which have travelled 40 km down-valley from the crater, as well as regional ashfalls which have deposited up to 1.5 m of fine ash in the Quito basin, 65 km to the north. In addition the largest debris flow yet reported in the Andes, with an estimated peak flow of 2.6 to 6.0 million $m^3 s^{-1}$, formed on the flanks of Cotopaxi 4,500 years ago, as a result of a rhyolitic ash flow melting the glacial icecap (Mothes et al, in press).

In the last major eruption of Cotopaxi in 1877, debris flows were generated, descended all of the drainages, and affected many towns and haciendas (Mothes, 1992). Down the northern drainage, the flow arrived at the Pacific Ocean in 18 hours, having travelled 326 km!

Continued on page 4:>>

"YOUR SAFETY MATTERS!"

This issue features a pull-out supplement on safety protocols when in the field. The text of these recommendations, compiled by experienced volcanologists, is in both English and Spanish.



Giant Tortoises in the Caldera of Alcedo Volcano

Next June 60 lucky participants will be attending the Geological Society of America Penrose Conference in the Galapagos Islands, Ecuador, on the evolution of ocean island volcanoes. The field-intensive conference is sponsored by IAVCEI and the Charles Darwin Foundation. On a five-day tour by boat, from the oldest part of the archipelago (San Cristobal and Espanola Islands) to active volcanoes (Sierra Negra and Espanola Islands), there will be abundant opportunity to observe the wildlife for which the archipelago is renown. Three days of oral presentations, poster sessions and discussions will then be held in the Charles Darwin Research Station. For more details see the Calendar on the opposite page.

FROM THE PRESIDENT

The other associations within IUGG are also forcing change, again with a focus on interdisciplinary science. This is evident in the composition of program planned for the 1999 IUGG General Assembly, to be held in Birmingham, UK, which features eight Union Sessions and 50 Inter-Association Symposia. To highlight inter-association collaborations for the upcoming General Assembly with regard to IAVCEI, 85% of our symposia are with other associations. This General Assembly will not be a common geographic location for seven association meetings — it will be ten days of truly interdisciplinary scientific exchange, under the thoughtful leadership of IUGG President Peter Wyllie.

My first response to the announcement of the next site for the IUGG General Assembly was “Why Birmingham?” I had envisioned turn-of-the-century smoke-blackened buildings and foul air until we recently held a program planning meeting on the campus of the University of Birmingham. The University has a spacious park-like campus and excellent meeting facilities. The organising committee has arranged for affiliated associations to meet in lecture rooms that are close together. No symposia on the campus are more than a 5-minute walk from other lecture

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rooms, preventing the isolation experienced at Boulder and Vienna.

There will be ample housing on campus, ranging from basic student rooms to self-catering flats (3,360 rooms booked on campus and 600 hotel rooms off-campus). Student facilities are in a park-like environment around a lake. Hotels are mostly downtown, but there is a train connection and there will be shuttle buses for the General Assembly. Shops and banks (which handle international currency) are on and adjacent to campus.

Maybe it's my age, or perhaps the result of combined efforts of association and union officers to change the face of IUGG, but I'm optimistic about this next IUGG General Assembly. It is truly interdisciplinary and we (IAVCEI) can benefit from such a meeting; after all, we are the small, but noisy and productive association that has a lot of experience in working across disciplines.

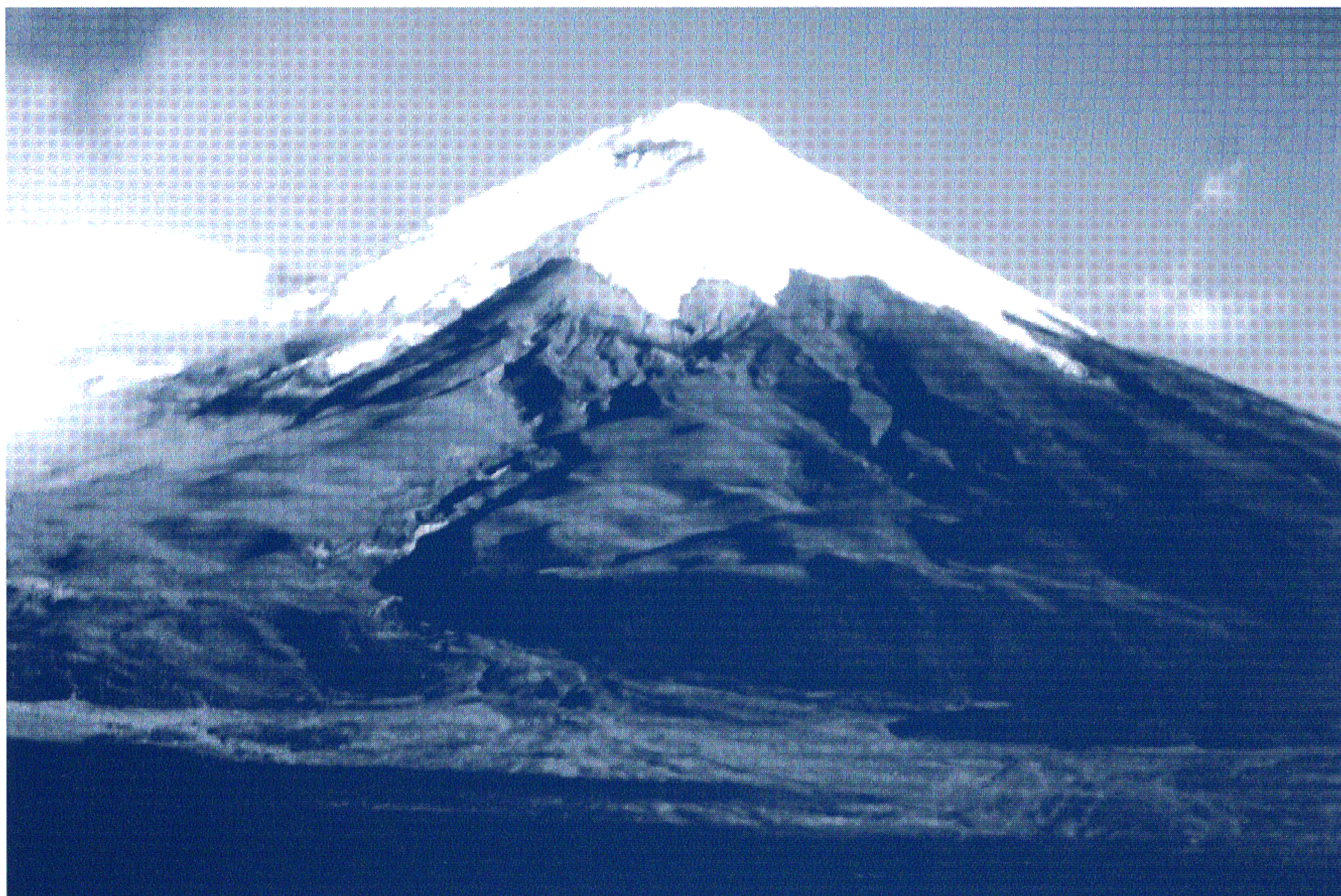
Grant Heiken
President of IAVCEI

Los Alamos National Laboratory
E-mail: heiken@lanl.gov

CALENDAR OF EVENTS FOR 1998 - 99

- **27 - 30 April 1998** **Santiago - Chile**
International IDNDR Conference on '*Modern preparation and response systems for earthquake, tsunami and volcanic hazards*'. Co-sponsored by IASPEI and IAVCEI. Papers will be received until 1 January 1998. Second circular is now out. Contact: International IDNDR Conference, IUGG Chile National Committee, PO Box 4-D, Santiago, CHILE Phone: +56 2 696 8221 Fax: +56 2 698 8278 E-mail: seisvolc@conf.dgf.uchile.cl
- **4 - 12 June 1998** **Galapagos Islands - Ecuador**
IAVCEI and the Charles Darwin Foundation are co-sponsoring the Geological Society of America Penrose Conference. This is a field intensive conference on '*Evolution of Ocean Island Volcanoes*', limited to 60 participants. Application deadline is 1 January 1998. Contact: Dennis Geist, Geology Department, University of Idaho, Moscow, ID 83844, USA
Fax: +1 208 885 5724 E-mail: dgeist@uidaho.edu
WWW: <http://www.uidaho.edu/~dgeist/Penrose/Announce.HTML>
- **28 June - 4 July 1998** **Roma and Napoli - Italy**
'*Cities on Volcanoes*' This meeting will build toward the 1999 IUGG symposium on natural hazards in megacities. Second circular is now out. Deadline for the submission of abstracts and payment of registration fee is 15 March 1998. Contact: Secretariat - CITIES ON VOLCANOES, Osservatorio Vesuviano, Viale Gramsci 17b, 80122 Napoli, ITALY
Fax: +39 81 7616062 E-mail: CITONVOL@OSVE.UNINA.IT
- **11 - 17 July 1998** **Cape Town - South Africa**
The IAVCEI International Volcanological Congress on '*Magmatic diversity: volcanoes and their roots*'. Contact: Secretariat, IVC'98, Department of Geological Sciences, University of Cape Town, Private Bag, Rondebosch 7701, Republic of South Africa
Fax: +27 21 6503783 E-mail: ivc98@geological.uct.ac.za
WWW: <http://www.uct.ac.za/depts/geolsci/ivc98>
- **19 - 30 July 1999** **Birmingham, UK**
The 22nd General Assembly of the International Union of Geodesy and Geophysics. Symposia organised by six associations affiliated to the IUGG (IAG, IAGA, IAHS, IAMAS, IAPSO, IASPEI and IAVCEI). Proposals for the symposia should be made to the Secretaries General of the Associations before January 1998.
Information on how to register and submit an abstract will be given in the second circular of the Assembly in May 1998. To receive a copy register your name and address. The deadline for abstracts will be 15 December 1998. Contact: IUGG99, School of Earth Sciences, University of Birmingham, Edgbaston, Birmingham B15 2TT, UK
Fax: +44 121 414 4942 E-mail: IUGG99@bham.ac.uk
WWW: <http://www.bham.ac.uk/IUGG99/>

* **NEW DEADLINE for Bulletin of Volcanology Special Offer - NOW 31 January 1998** *



Cotopaxi volcano (5900 m) rises about 3000 m above its base, which is covered by large debris flow from the 1877 eruption. View of the north flank.

COTOPAXI VOLCANO, ECUADOR: MITIGATION OF DEBRIS FLOW IMPACT — DAUNTING TASK?

>>Continued from page 1:

Eruptions in 1742, 1743, 1744, and 1768 produced lahars of similar size, if not larger, which also brought havoc upon the inhabitants living near the river channels. An event of similar magnitude, if it were to occur today, would directly affect more than 80,000 people and the important infrastructures developed in several high risk zones. The towns of San Rafael, Sangolquí, and Selva Alegre on the northern route and Lasso, Latacunga, and Salcedo on the southern route would be the most severely affected.

Given that Cotopaxi has experienced many eruptions in the past centuries and that 120 years have passed since the last eruption, there is a high probability of an eruption in the near future. Furthermore, because of the dense population and important infrastructures already established upon the debris flow deposits, we have placed a high priority on determining the past flows' limits, dynamics, characteristics, and travel times.

HAZARDS EVALUATION AND CIVIL DEFENCE ACTIVITIES

An evaluation of Cotopaxi's hazards was first carried out in 1976 in collaboration with the US Geological Survey (USGS) and more detailed maps (1:50,000) of the debris flow limits were published in 1988. In addition vulnerability maps (1:10,000) of ten threatened areas were prepared which show the population distribution, evacuation routes, safe areas,

etc. Based upon historical eruptions, the most probable scenario for future eruptions was prepared for civil defence planning, which attempted to encourage the proper CD and population response to the increasing pre-eruption activity, set in a one month time frame. This, in turn, prompted the authorities to conduct a crisis simulation, whereby a scenario was presented to the officials of the six provinces directly affected, who had to immediately confront and resolve a sequential series of problems associated with both the pre-eruption activity as well as an advancing debris flow. Later, practice evacuations involving up to 5,000 inhabitants were carried out in towns on both the northern and southern lahar paths.

LONG TERM MONITORING

The continual monitoring of Cotopaxi by the Instituto Geofísico, which permanently scrutinises the seismicity of 11 volcanoes, has not observed a departure from its normal background activity. The volcano has been monitored with at least one seismograph since June 1977 and with a permanent seismic net consisting of 5 telemetered seismic stations since 1989. One of the stations — perhaps the highest in the world — is located on Cotopaxi's summit. An intensive study to determine the nature of the wide variety of seismic events (A and B type, LP, glacial events, and fluid movement) that occur on this volcano was carried out in 1996–97 in collaboration with ORSTOM of the French government,

employing an array of 15 additional stations. Moreover, 12 EDM deformation lines as well as several GPS bases are read frequently and show no changes since they were established. Hot springs waters are also analysed.

CHARACTERISTICS OF THE 1877 DEBRIS FLOW

Careful field work and numerical modeling of the 1877 event done by the Escuela Politécnica Nacional (Castro et al, 1992) show that velocities, as estimated from flow superelevations at various sites, were between 70–75 km hr⁻¹ on the depositional plain 10 km north of the crater; they were undoubtedly faster on the steep flanks of the cone. At a point 22 km north of the volcano where two parallel channels merge, a peak discharge of about 90,000 m³ s⁻¹ is estimated by determining the overall area flooded by the lahar and its superlevation velocity. Along the steep-walled canyon of the Rio Pita, velocities of 60 km hr⁻¹ were maintained, until the flow reached the populated Chillos Valley (18 km southeast of Quito), where the flow formed a 1.5 km wide path. Here, velocities were between 15–20 km hr⁻¹ and peak discharges ranged from 12,000–20,000 m³. According to the modelling, travel times on the order of 50–60 minutes are expected for the 45 km-long path. On the west side of the volcano, the town of Latacunga (population 80,000), located 43 km from the crater, would be reached in about 75 minutes. The travel times on the west side are generally greater because of the lower gradients on the cone and the long depositional plain upstream from Latacunga.

It is a sobering fact that future debris flows could have volumes and peak discharges similar to that of the 1877 lahar. As such, the potential for extreme loss of life, property, and infrastructure (Trans-Ecuadorian oil pipeline, major water systems, hydroelectric and thermal power plants, strategic bridges, etc.) is very high, and could easily dwarf the loss suffered in the 1985 Nevada del Ruiz lahars, given the greater economic development of this high risk zone.

ACOUSTIC FLOW MONITORS

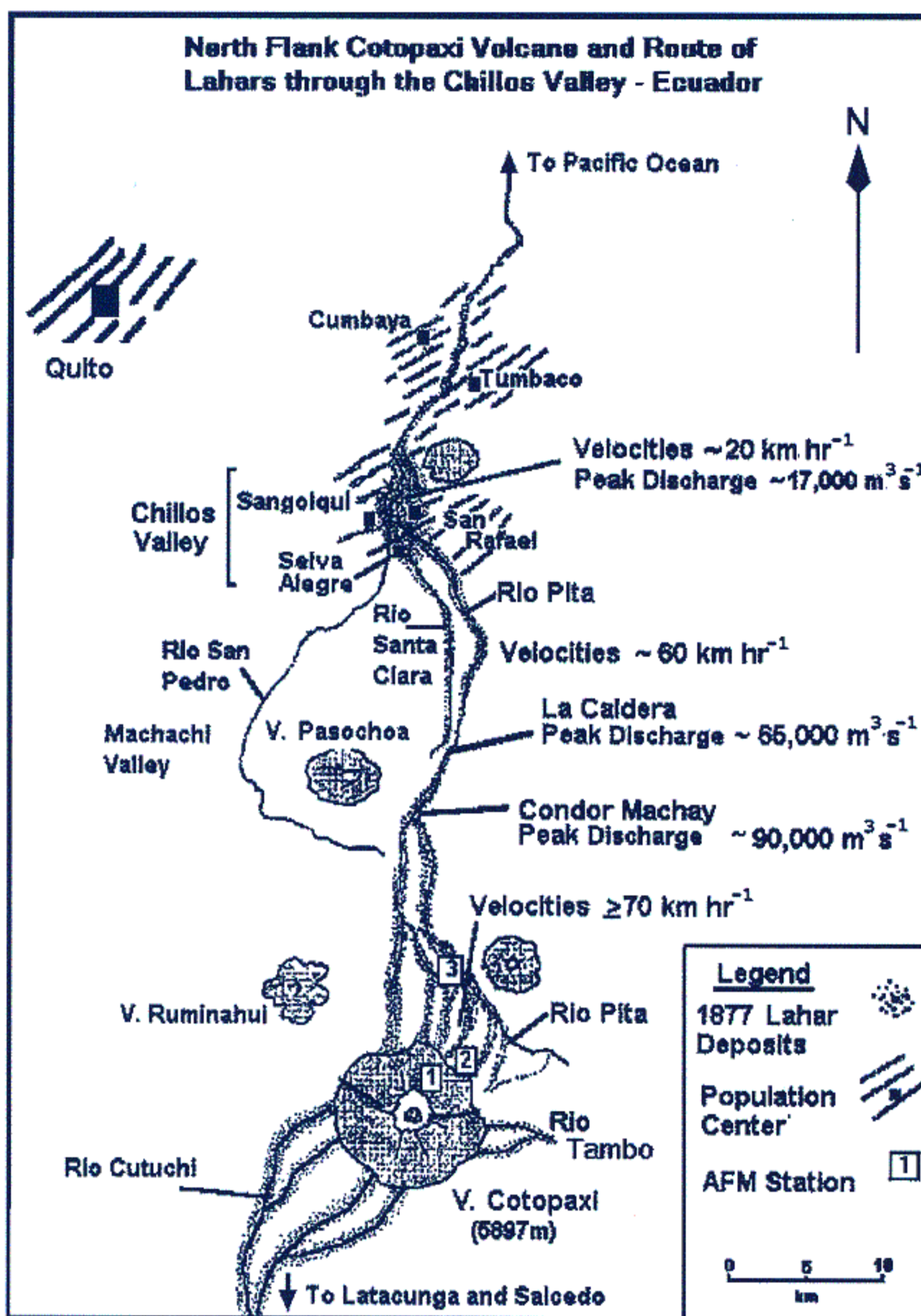
Given the importance of obtaining an early warning of approaching lahars, telemetered acoustic flow monitors (AFM) were developed and installed by the USGS at three points along the northern lahar route. The two AFM stations closest to the cone will give the first warning that lahars are in transit down two major canyons, only 3 km apart. The other sensor, located 8 km downstream from the previous two, will provide confirmation of the lahar's advance and allow its velocity to be calculated. Unfortunately, an infallible alert system, needed to warn the populace, has yet to be installed in the Chillos Valley.

THE CIVIL DEFENCE DILEMMA

The stakes are high. Emergency planning updates, evacuation simulations, and continued public education are required. However, with the volcano presently at rest, it is difficult, if not impossible, to maintain even a moderate level of awareness and interest in volcano hazards, either among the government authorities or the population at risk. In the past decade, despite the dissemination of hazards propaganda and publicised evacuation exercises, the high risk zones are becoming progressively more urbanised and consequently the impact of future eruptions will be enormous.

Undoubtedly, it is only the reactivation of the volcano itself that will provide the impetus to government officials to seriously prepare the population for a major disaster.

Typically civil defence organisations, responsible for the mitigation of disasters, are bureaucratic institutions with poor technical preparation and little institutional memory. It is often only the rare, motivated individuals who are the movers that formulate and maintain long-term educational programs.



Furthermore, third-world governments, faced by day-to-day economic survival, generally have limited funds to upgrade their CD organisations or maintain vital monitoring systems on volcanoes. Thus, it would seem that many tasks, traditionally considered to be the responsibility of CD, are falling increasingly upon the shoulders of the scientists.

When the time comes — when Cotopaxi nears its climactic moment — we hope that we are not only able to correctly interpret the pulse of the volcano, but can also capably advise the CD authorities about the developing situation and the available options, such as the evacuation and relocation, if necessary, of thousands of residents in the high risk zones. Since very few other people adequately comprehend the devastating nature of the lahars, it has become imperative that the volcanologist be an actor with additional responsibilities during volcanic crises — this is certainly true here in Ecuador, where the summit of Cotopaxi glistens just up-valley.

Continued on page 6:>>

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FROM THE SECRETARY GENERAL



Wally Johnson

NATIONAL CORRESPONDENTS TARGETED!

Your Secretariat recently reviewed the list of IAVCEI National Correspondents and their contact details. I then wrote to each National Correspondent asking whether they were the current, official, IAVCEI National Correspondent for that country and asking for any update on their contact details. I then went on to write the following:

'You may have been National Correspondent for many years and regard the position as an honorary one. However, the new IAVCEI Statutes and By-Laws stress the importance of

fee-paying personal members in the Association and this gives further emphasis to the need for active National Correspondents who can truly represent paid-up IAVCEI members at the national level. National Correspondents have an important role to play in the life of IAVCEI and many of you give wonderful service to your country and to the Association. Some countries change the National Correspondent every few years so as to generate new, forward-looking approaches and to ensure that the responsibility is provided regularly to energetic (commonly younger!) people. Please consider whether your own country sees value in this approach and, if change is required, contact your own IUGG Adhering Body and make your recommendations known to it.

We note in our records that only 12 of the 49 listed National Correspondents are paid-up members of IAVCEI. I therefore enclose a membership form that you can pass on to a friend if you one of the 12, but which you may return to us completed if you are not!'

Please contact your own National Correspondent to make known your views on what you think the role of National Correspondents should be.

Wally Johnson
Secretary General, IAVCEI
E-mail: wjohnson@agso.gov.au

BOOK REVIEW

Mount St Helens features prominently in the new edition of **Volcanoes by Decker and Decker** which is reviewed on page 8 by Hazel Rymer. This excellent photograph of the eruption on May 18, 1980, at 8:32 a.m. Pacific Daylight Time was taken by Austin Post of the US Geological Survey.

COTOPAXI VOLCANO, ECUADOR: MITIGATION OF DEBRIS FLOW IMPACT — DAUNTING TASK?

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Minard L. Hall and Patricia A. Mothes
E-mail: instgeof@uio.satnet.net



