

REPORT OF THE CANADIAN SEISMOLOGISTS TEAM

VISIT TO THE NEVADO DEL RUIZ VOLCANO

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and Geomagnetism

PREAMBLE

The volcano Nevada del Ruiz in Colombia about 150 km west of Bogota erupted at about 2100 and 2300 hours (EST) November 13, 1985. Mudslides from the melting of part of the glacier and heavy rains resulted in very severe flooding, particularly of the Lagunillas River flowing eastward from the volcano. About 50 Km downstream where the river leaves its canyon like bed and empties onto a wide plane, the town of Armero was situated. The flood covered the town with mud killing about 25,000 people. Only about 5000 escaped or were rescued. A few smaller villages further downstream were also destroyed. Several hundred people were also killed in the town of Chinchina west of the volcano.

Request for aid by Colombia

In response to this tragedy and fearing further eruptions of the volcano, the Ambassador of the Republic of Colombia appealed for aid to the government of Canada. Amongst the list of items requested were seismograph stations.

Earth Physics Branch response

The request for seismographs and seismologists was received by the Earth Physics Branch (EPB) early in the evening of Thursday, November 14, 1985. Equipment that was thought to be useful in this instance was assembled on the 15th and sent to Uplands Airport in Ottawa. Since working conditions at the volcano were unknown, the following equipment was assembled: 2 MEQ-800 seismographs, 1 Regional Station, 3 Backpacks, and most of one telemetered station. Batteries and electric generators to permit operating without local electric power were also taken.

To operate the equipment and analyze the data from the seismographs an instrument engineer, Frede Andersen and a seismologist, Goetz Buchbinder, were appointed to go to Colombia.

Departure from Ottawa

Departure was scheduled for 2300 hours on Friday, November 15 from Uplands Airport by Canadian Armed Forces Hercules aircraft. Besides our equipment the aircraft was filled with blankets and medical supplies from the Canadian Red Cross. Because of mechanical problems, departure was delayed until 0030 hours, November 16. After a refuelling stop in San Juan, Puerto Rico, we arrived at 1300 hours at the Military Air Base Palanquero near Bogota.

Arrival in Colombia

Upon our arrival at Palanquero we were greeted by the Canadian Ambassador to Colombia, Mr. Gibson, and the Secretary, Mr. Bastien.

We were also meet by Mr. Francisco Zambrano Ortiz, Subdirector of Geological Cartography in Instituto National de Investigaciones Geologico-Mineras (INGEOMINAS). Since we spoke no spanish, Mr. Zambrano was to accompany us to Manizales a city about 28 km west of the volcano where the Committee of Volcanology has established its headquarters. However, an hour later Mr. Zambrano decided to go to Bogota on the Canadian Hercules with the Ambassador and Mr. Bastien. He gave us the names and telephone numbers of three people in Manizales that we should contact on arrival.

Departure for Manizales

Shortly after our arrival at Palanquero we were told by the Base Commander, a Brigadier-General that we would fly out on the next helicopter. However, this was not the case.

It must be remembered that helicopters had not been able to fly immediately after the explosion because of the dust, and they were constantly ferrying people and medical supplies when we arrived at Palanquero. We understood that about one dozen American helicopters and some Colombian ones were involved. The Brigadier-General appeared to be in complete charge of the Hercules' landing and taking off from the base, about one per hour, but had no influence over the American officer who dispatched the American helicopters. Finally around 1530 hours half of our equipment of a total of 900 kg left in a Black Hawk (helicopter). At 1600 hours another one took us and the rest of the equipment on board.

In spite of having very sophisticated navigation equipment aboard they could not use it since they had to stay away from the high mountain peaks reaching over 17,000'. As a consequence our pilot became lost and had to land in a village to ask for directions. We finally arrived only at sunset and dark in Manizales at about 1800 hours.

We landed at an Army Base and were taken to the Commander's office. Here an english speaking Lieutenant was placed at our disposal. He helped us telephone John Tomblin UNDRC (disaster relief) coordinator in Manizales who suggested we come with all our equipment to the Cafetero Bank Building where the headquarters (HQ) for all geophysical, geochemical and geological monitoring were installed on the 11th floor.

Introduction to the Volcano

By about 2000 hours our equipment was locked in a basement room because there was concern about possible theft. We then had a meeting with Tomblin and Darrell Herd, USGS, from Reston. It was explained to us that there were three instruments operating on the west side of the volcano, but none on the east. We therefore decided to volunteer to go to the east side and worked out the details at a meeting at 0800 hours the following morning, November 17.

Preparations to go to the East Flank of Riuz

In the morning we had lengthy discussions with two professors from the National University of Bogota, Bricano and Coral as to where we might install our seismographs, some Civil Defence people also gave advice. In the end it all boiled down to putting the instruments as close as possible to the volcano as safety and roads would permit. The state of the roads was quite uncertain at this time.

It was decided that Professor Coral should accompany us for a few days since we did not speak Spanish, and that we should leave as soon as the necessary topography maps arrived.

Later in the morning D. Herd returned from a flight over the volcano and briefed us as follows: only about 5-10% of the snow and ice cap was gone from the volcano, there were some fumaroles near the crater under the ice and the crater was deeper than in September 1985 when he last flew over. Herd suggested that the explosion was mainly straight up but winds pushed the ashes towards the north-east. At this session we were also briefed on the major structures in the region that might produce earthquakes not related to the volcano.

Our departure from Manizales was constantly delayed, first due to bad flying weather and then by the arrival of the French Minister for Disaster Prevention, H. Tazieff. At lunch we met Dr. Lopez, Director of INGEOMINAS. He was very apologetic about these delays.

The Civil Defence Director, Mr. Abt, was supposed to be in charge of directing the 3 helicopters at his disposition, but it was apparent that others changed his orders readily. At 1700 hours we ended up at the army base again, but the Colombian helicopter crew did not like the weather in Libano, our destination. After long discussions on the telephone between the Base Commander, a Colonel, and his General we were promised a flight at 0600 hours the next day so we stayed in Manizales for the night..

Departure for Libano

At 0630 hours, November 18, we departed on a Colombian helicopter with 500 kg of equipment accompanied by Professor Coral. Whilst the Americans are restricted to flying below 14,000' the Colombians were not so encumbered and we flew very close to the volcano and over the ridge to the east. For two reasons, our destination was Libano, a town of about 25,000 inhabitants, 28 km from the volcano. It was the only place where ground transport was to be had and it was at a reasonably safe distance from the volcano.

Since nobody knew where to land we settled on a pasture on the outskirts of the town. The local civil defence (CD) people picked us up in two ambulances and took us to the regional hospital.

By 0800 hours the mayor, police chief, army chief, CD chief, fire chief and hospital director all arrived to welcome us and start a lengthy discussion. The outcome was that we will be quartered in the hospital (which

was nearly empty since half the population of Libano had left the area) and that we will have a hospital truck and driver for transport. Rental vehicles were not available in Libano.

About 1130 hours we left the hospital and went to the town hall to pick up a shovel and a pick. We drove about 40 km which brought us to within 7 km horizontally of the crater. At that point the road crossed the Lagunillas River but the bridge had been destroyed. We installed one station, CA1 at the hacienda La Cabana, where we received no radio time signal. We then installed a second station CA2 10 km from the volcano at Rosarito. The elevation was 3600 m for both places. The seismometer for site CA1 was placed on an outcrop on very large rock about 100 m above the road. For site CA2 no outcrop could be found reasonably close to the road and we only dug a hole into the seemingly very thick overburden. This site was unfortunately considerably noisier than CA1. Finally, we returned to Libano around 1800 hours.

On the morning of November 18 we tried to obtain radio time signals in Libano and were most surprised to receive CHU on 14.67 MHz, since we had expected WWV to come in. This permitted us to calibrate the clocks of our seismographs accurately.

Just before we intended to leave for La Cabana we received a call from HQ in Manizales. They informed us that they were seeing lots of seismic activity and told us to wait until further notice.

We had intended to install our regional station near the other two stations. Because we thought it informative to have a station near the hospital we installed it near there. This permitted us to detect the larger earthquakes, if there were any, but not very small ones, because of the high background noise level in Libano.

About noon we received word that the seismic activity had died down and we left for La Cabana to change the paper on the seismographs. The "road" was a single lane dirt track full of holes and rocks. The one-way trip took nearly 2 hours. This first day we recorded 24 earthquakes at CAL and periods of harmonic tremors. We continued operating the stations until Monday, November 25.

On November 20 we were invited by the "Town fathers" to explain what we knew about the volcano Ruiz, volcanoes in general, e.g., Mt. St. Helen and La Soufrière and what we were doing in Libano. After answering these questions the discussion turned to whether or not Libano should be evacuated. We explained at length that we were not competent to give advice on that question and that we only contributed seismological data to the HQ Manizales where all the data was collected and analysed and an opinion was then transmitted to the Presidential Palace (there was a direct line between Manizales and Bogota). There seemed to be little faith in the government and it was mentioned that since we were foreigners, whom the government did not want to lose, the town was safe whilst we were there. Until this time we had not been particularly worried about Ruiz. After the meeting we became rather apprehensive. A very violent electrical storm the next morning that resulted in a long electrical power failure did nothing to improve our state of mind.

On November 21 Tomblin informed us that Dave Harlow and Randy White from the USGS were in the process of installing telemetered stations around the volcano and as soon as the east side was covered we could return to Manizales, perhaps on November 23.

On November 22, Professor Coral left for Bogota. Fortunately, this left us only temporarily without an interpreter since an english speaking intern at the hospital decided that he would like to learn more about seismology and spent a lot of time with us.

Return to Manizales

We finally received word that we are to depart November 25. We packed up all our material and were ready to go by 1200 hours. With us were also Dave Harlow, U.S.G.S. and H. Duarte from Bogota University. They had been left on the volcano 2 days earlier while installing stations when the helicopter could not pick them up because of bad weather and they had to walk out 15 km at 4000 m before hitching a ride to Libano. We think their presence helped to persuade the U.S. helicopter team to come for us. We all left Libano at 1650 hours and were taken to Melgar, a helicopter base, for the night. We were supposed to leave at 0800 hours the following day, but managed that only at 1300 hours after numerous phone calls by Harlow. We arrived in Manizales at 1400 hours and stored our equipment. At 1900 hours we took part in the daily meeting regarding the present risk evaluation that was sent to the Presidential Palace.

On 27 November we packed and also spent time talking to people. We left for Bogota by commercial aircraft 29 November.

Proposal for a 10 station telemetered volcanic watch Network (TVWN) by EMR and EA (see appendix)

It had been suggested by EMR and EA that Colombia might profitably make use of a 10 station telemetered seismic network to monitor some of the more potentially dangerous volcanoes. In view of this during our stay in Libano we had already talked to Professor Coral directly and by telephone, with Darrell Herd, USGS and John Tomblin. In Manizales we extended these conversations with Professor H.J. Meyer, University at Cali, Bruno Martinelli, Eidgenoessische Hochschule in Zurich and J.J. Bastien of the

Canadian Embassy in Bogota. During our stopover in Bogota we also talked again to Diana Rivington, first secretary, Canadian Embassy in Bogota and Professor Coral and several of his colleagues at the National University in Bogota. As a result of all these conversations we would like to make the following suggestions regarding the network.

It should be noted that long distance telephone lines are very expensive in Colombia and that they often tend to fail. Therefore, all telemetering must be done by radio. For this reason and the geography of Colombia the network should most economically be split into two, one centred in Cali in the south and one in Bogota in the centre.

The University del Valle group in Cali proposed a volcano watch network a couple of years ago to IDRC, but was turned down. Lately they asked the Swiss government for funds to buy a 15 station network, including 5 telemetered stations, to monitor earthquakes in Southern Colombia. This will be deployed in the next year. For technical cooperation they use the "Corporacion autonoma regional del Cava" (CVC) an electric power corporation that is interested in the seismic risk evaluation.

Professor H.J. Meyer of Cali prepared a short and an unfinished (he lacked time) proposal for a volcano watch network that is enclosed as an appendix. The Cali group would need relatively little training of their seismologist, but some training for an engineer.

It should be noted that the Swiss network does not watch the volcanos, but that the TVWN would contribute to the seismic risk evaluation. As per the appendix, the Cali group would concentrate on the southern 4-5 volcanoes.

The group at the National University in Bogota only started a graduate course in geophysics one semester ago. They have about 4 seismologists with

education from the PhD on down. What their engineering skills are we do not know. The Bogota group would concentrate on the central and northern volcanoes excluding Nevado del Ruiz, which is well covered now by american stations and future Japanese ones. For technical aid and cooperation they may select INGEOMINAS.

It must also be remembered that such a network is intended to detect the reawakening of a volcano. It cannot be used to monitor a volcano in the early stages of an eruption, a dense local network must then be used, which should be able to locate earthquakes in nearly real time.

The TVWN could initially record only in an analog fashion. Once the system is running and starting with the Cali group appropriate additional devices could be added to make full use of the digital capability of the recording stations.

Scientific results

The deployment of our seismograph stations on the eastern flank of the volcano resulted in the first recordings of earthquakes with accurate time. All other stations only had relative time until November 26. The stations were crucial to the accurate location of the hypocenters, since with only stations on the western flank the hypocenters were severely mislocated.

The recording of volcanic harmonic tremors and crater explosions afforded us an unique opportunity to record such signals and study them in greater detail at the Manizales headquarters where there were a number of experts in this specialized field.

Additional Comments

We found the computing power at the Universities to be considerably below that of Canadian Universities or government. The libraries are also poorly stocked with books or relevant scientific journals.

Ashfall from Ruiz

The explosions of Ruiz are considered to be small in comparison with such recent explosions as Mt. St. Helens in the U.S.A. Nevertheless the following comment may be of interest. The ash eruptions prevented helicopters from flying in the area until about Friday November 15. This severely retarded the necessary rescue and supply missions.

The ashfall at the Palanquero Air Base about 100 km west of Ruiz consisted of a thin layer of very fine dust, which the helicopters kept stirring up. At Manizales, 28 km west of Ruiz, there was supposed to have been an ashfall, but we detected no sign of it. However, at Libano, 28 km east of Ruiz, we saw a layer of about 1 cm of rather coarse sand.

Travelling towards the volcano from Libano we did not see much change in ashfall until about the village of Murillo 20 km from Ruiz. Beyond Murillo the ash on the surface became progressively coarser. At La Cabana approximately 7 km from Ruiz, the ashlayer consisted of coarse material, some pieces more than 20 cm across. Most of the pieces were rather full of holes, but some small dense rocks were also to be found. The roofs of the houses all had large numbers of holes, except those made of asbestos. We were told that no people had perished here, but that a number of cattle died.

TERMS OF REFERENCE FOR A PROGRAM
ON GEOPHYSICAL VOLCANO-WATCH IN SOUTHWEST COLOMBIA

Volcanoes and volcanic risk in SW-Colombia

Proposed sites

Data transmission and recording

Resources needed

Seismology at the Universidad del Valle

Human resources

Facilities

Universidad del Valle
Cali - Colombia
A.Aéreo 25360

1. VOLCANOES IN SOUTHWEST COLOMBIA

To the south of the volcanic group that includes Ruiz, Cerro Bravo, Tolima and Machin and beyond a gap between 4.5°N and 3.0° N, the volcanic belt of SW-Colombia extends down to the border with Ecuador.

More than 10 volcanoes along this belt in the Central Cordillera include Colombia's highest (Huila, 5.750 m, 75 km SE of Cali) and most active (Puracé, Dona Juana and Caleras) ones.

Only the Nevado del Huila has a permanent ice cover.

Active Periods:

Many historical records give testimony of earthquake sequences preceding the major eruptive events.

2. volcanic risk in southwest colombia

Due to their record of historic activity and due to the populated areas they can affect, the highest risk is attached to the volcanoes Puracé, Dona Juana, Caleras and Chiles/Cumbel.

Two major cities of SW-Colombia, both provincial capitals, are seated at the base of volcanoes, Popayan (V. Puraci) and Pasto (V. Caleras).

Either one had major ash eruptions as recently as 1945 (Caleras) and 1949 (Puracé).

3. PROPOSED SITES FOR MONITORING

Due to their level of risk, monitoring priority should be given to the volcanoes Puracé, Galeras, Dona Juana and Cumbel.

A monitoring station for Volcan Puracé could be localized such as to be able to detect also activity from Volcan Sotara.

4. DATA TRANSMISSION AND RECORDING

Either one of the four mentioned has a repeater station on its flanks (Galeras) or line of sight to at least one of the major repeater stations of SW-Colombia.

At these stations, belonging to national authorities, facilities such as equipment housing, antenna towers and power supply are available.

The data transmission should be in the UHF-band, in order to guarantee sufficiently low interference.

5. SEISMOLOGY AT THE UNIVERSIDAD DEL VALLE

Work in seismology started at the Universidad del Valle in 1976. Post-earthquake studies (Trunaco and Cartago, 1979), aftershock studies (Popayan, 1983) and studies on historical seismicity were done. A cooperative study of Ruiz was undertaken.

The University began in October 1985 a detailed seismic risk study for Cali, supported by the Municipality and the "Corporacion Autonoma Regional del Cavca - CVC).

The national science foundation - COLCIENCIAS - granted Col. pesos 12,000,000 (\$Can. 100,000) in 1985 for our project "Sistema Regional de Observacion e Investigacion Sismologica para el Suroccidente Colombiano". The setup of this network, covering Colombia's highest seismic risk area, starts in December 1985, with 5 telemetry stations, 5 local recording stations and 5 portable stations. Central recording and data processing will be at the Universidad del Valle. This project will be implemented in cooperation with the "Corporacion Autonoma Regional del Cavca" (the regional power and natural resources authority) and the Swiss Federal Seismological Service.

From the repeater station Pan de Azucar (4000 m) the signal can be brought down for central recording to the campus of the Universidad del Valle (Cali).

5. RESOURCES NEEDED

76°W

-5°N



CONVENTIONS

- VOLCANO
- MAJOR CITIES
- △ MAIN REPEATERS
- TELEMETRY LINES

0 50 100 KM

-30

MANIZALES
ARMERO
RUÍZ

TOLIMA

BUENAVENTURA

CALÍ

PAN DE AZÚCAR
4000

HUILA

POPAYÁN

MUNCHIQUE
3000m

PUERCO

SOTARÁ

PAN DE AZÚCAR

PETACAS

DOÑA JUANA

4200m
PASTO
GALERAS

COLOMBIA
ECUADOR

CUMBAL

-10