

STEADY LONG-PERIOD ACTIVITY AT CAYAMBE VOLCANO, ECUADOR. LOCATION, SPECTRAL ANALYSIS AND CONSEQUENCIES.

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INTRODUCTION

A continuous monitoring of the Nevado Cayambe Volcano has started in 1988, with the installation of one vertical seismic station included in the Escuela Politecnica Nacional - Instituto Geofísico (EPN-IG) seismic array. Both LP and VT activities do not occur in swarm, but are continuous without period of complete calmness. From November 1997 to March 1998 a network of 3 to 5 stations (1 component, 1 Hz) has been installed to check out this activity. LP events were located in a N120 ellipse form, with a main axis of 8.5 km and a small one of 2.3 km (N30), between an elevation of 1 to 12 km depth beneath the bottom of the volcano. The VT events are mostly located in the northwestern flank of the volcano in column of 2 km diameter and concentrated at a depth from 3 to 9 km. From a total set of 1190 LP earthquakes located during the experiment, about 20% had a low-frequency content (< 2 Hz), 69% had a medium-frequency content (2 to 4 Hz) and 11% had a high-frequency content (4 to 6.5 Hz) (figure 1). Filtering of the mixed-frequency events waveform let suggesting that they are low-frequency events triggered by earthquakes, with a probable unique source.

DATA ACQUISITION AND LOCATION

The locations were performed using the Hypoinverse program (Klein, 1978), modified to run it on Macintosh platform and to automatically improve the earthquakes location, using time delay to take account of the station elevations (figure 2). We did a trial and error method to locate the earthquakes (both LP and VT) with a flat one-layered model computed with a P-wave velocity varying from 0.1 to 5.0 km/s, with a 0.1 km/s step. We have taken this approach because the velocity structure of the Cayambe Volcano is unknown and as the difficulties to use travel-time curves due to the emergent nature of the onset of LP P-waves.

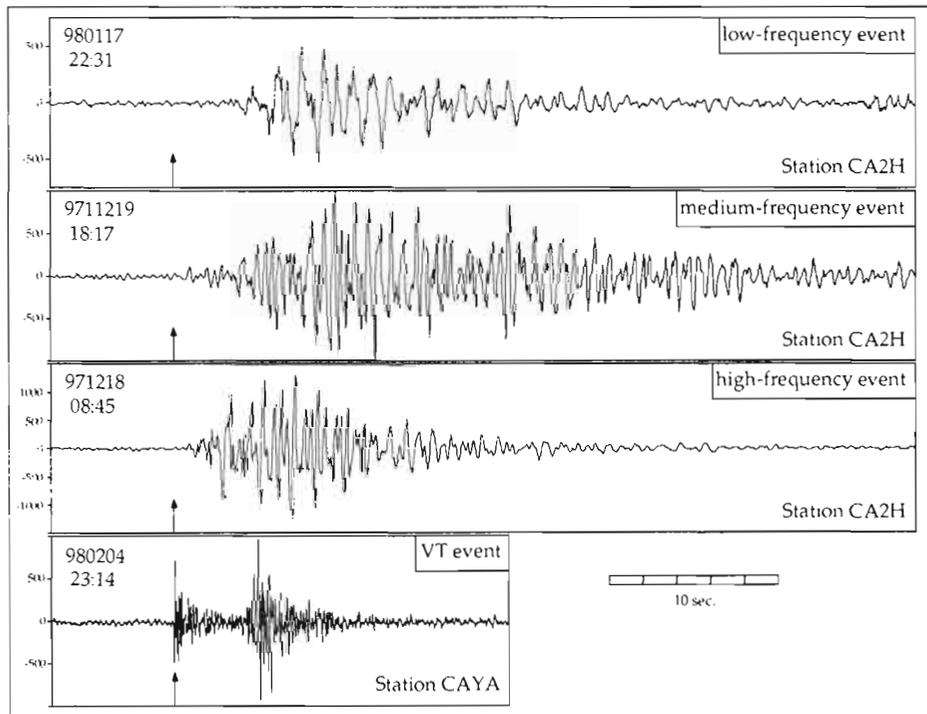


FIGURE 1 : Waveforms for a 4 different typical events on Cayambe Volcano. From the top to the bottom : 3 LP events (low, medium and high-frequency) and VT event.

We assumed that the best locations were found when a minimum was reached on each plots of average ERH, ERZ, RMS and Condition Number versus P-wave velocity. For both LP and VT events, the minimizations were converging for a P-wave velocity of 0.8 km/s. These very low P-waves velocities are in agreement with other observations for LP events (Chouet, 1981 ; McNutt, 1986) and for tremors waves assumed as sustained LP events (Aki, 1984 ; Gordeev et al., 1990). For VT events, the 0.8 km/s velocity is unknown, but if we assumed that the source is the same for LP and VT events, the velocities for both kinds of events have to be the same.

For LPs the criteria found for the selection of events are : (1) number of P+S arrival times • 5, (2) ERH•0.8 km, (3) ERZ•0.6 km, (4) RMS•0.25 sec., (5) Condition Number•25, that gave a final set of 875

LP events. For VTs, the same criteria are : (1) number of P+S arrival time•5, (2) ERH•0.6 km, (3) ERZ•0.7 km, (4) RMS•0.30 sec., (5) Condition Number•17, giving a final set of VT events of 90 from the initial set of 146 events.

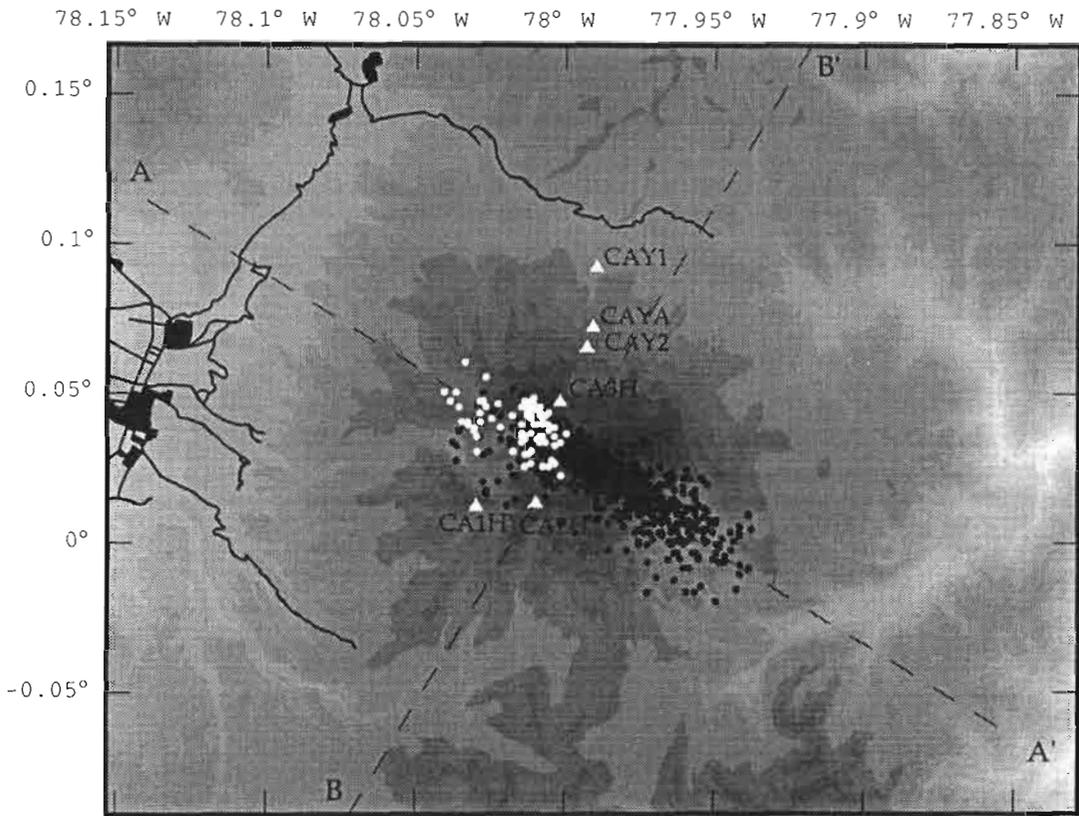


Figure 2 : Map showing the distribution of the selected LP events (closed circles) and VT events (open circles) . The stations used for the present study are shown by white triangle. The telemetred station of the EPN-IG is called CAYA ; CAY1 and CAY2 are portable stations when CA1H-CA2H and CA3H have been telemetred to Quito. A-A' and B-B' are cross-sections shown on figure 3.

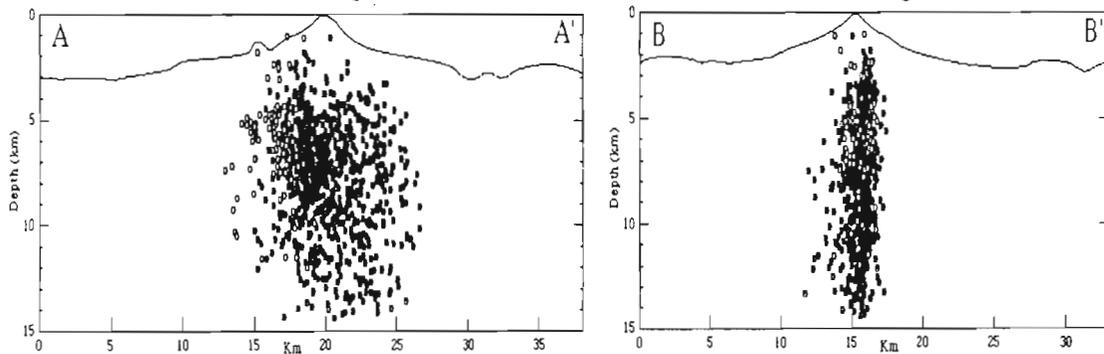


Figure 3 : N120 (A-A') and N30 (B-B') cross-sections of LP (closed circles) and VT (open circles) events selectionned as on figure 4.

CONCLUSION

The actual shallow LP-VT activity on Cayambe volcano is not occurring in swarm like a lot of volcanoes, but is a steady activity like in the Cotopaxi and Tungurahua Volcanoes. LP activity is concentrated in an ellipsoid form, with a major extensional axis (N120) compatible with the geometrical form of the volcano, the migration of the summital domes (migration westernward in a N110 direction) and the structural lineaments observed on the volcano which could be assumed as possible dike intrusions with a N110-120 direction (Samaniego, 1997). For VT events, they are located on the western flank of the volcano, near the last eruptive area of the volcano (youngest dome). For both LPs and VTs, the main concentration in activity is found between 4 and 8 kilometers depth, beneath the Cayambe volcano, compatible with the depth steady activity found in the Cotopaxi Volcano (Ruiz et al., 1998).

The Cayambe LP activity is classified by the spectrum content of the events : 20% of the events are real LP events with a low-frequency content (less than 2Hz), 69% have a medium-frequency content (2 to 4 Hz) and 11% a high-frequency content (4 to 6.5 Hz) giving possible crack size from 20 to 6 meters. The medium and high-frequency events, containing a low-frequency event triggered to a normal earthquake (VT ?) with a common P-wave arrival time and velocity, let suggest a real homogeneity of the source.

Moreover, this steady LP activity can not be assumed as a precursor eruption activity, but a residual one, due to the interaction between magma conduits and water system inducing pressure perturbations causing finally LP events as proposed by Chouet (1996).

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