SEISMIC ACTIVITY AT GUAGUA PICHINCHA VOLCANO, ECUADOR

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INTRODUCTION

Guagua Pichincha volcano, located in the Western Cordillera of the Ecuadorian Andes, is one of the most dangerous active volcanoes in the country. It is located 12 km to the west of Quito (population 1.5 million). Guagua Pichincha has shown a progressive reactivation since its onset in 1981 that consists mainly in phreatic explosions, shallow seismicity and morphological changes in the interior of the caldera. This volcano has been permanently monitored by the Instituto Geofísico since 1981.

Eleven years ago, from July to December 1988, a swarm of 785 volcano-tectonic (VT) events occurred 8 km SE from the cardera. This activity migrated toward the caldera as well as the depth location did from 10 km to 4-5 km (Bonilla et al., 1992). Between 1989 and 1997, the average seismic activity was 130 LP and VT events per year. Since June 1998, a swarm of about 4000 events has been registered in the north of Quito (16-km NE from the caldera, 10-20 km depth). It could be related with Guagua Pichincha present activity (Calahorrano et al., This volume).

On August 4,1998 a major subduction earthquake (Mw=7.1) (Segovia et al., This volume) hit the Ecuadorian coast near Bahía de Caráquez, 210 km west from the volcano. Three days later, on August 7, an abnormal phreatic activity began with a moderate explosion (Reduced displacement RD=0.63 cm^2). For the past 8 months, until present, this activity has continued. More than 140 explosions have been recorded. October 1998 and February 1999 have been the months with the greatest number of explosions (26 and 28 respectively), although the number of explosions has been moving up and down with time. It is remarkable that 8 of the 10 biggest explosions have occurred since December 23, 1998.

SEISMICITY

The total number of seismic events increased dramatically from 64 in August 1998 to 1840 in September 1998, then it decreased progressively until December (294 events) to increase again until February (2359 events).

Seismicity during this period has principally consisted of VT, LP, and MP (medium period or "moscas") events (Figure 1). MP are similar to those observed at Soufriere Hills Volcano from July 1995 to September 1996 (White et al., 1998). White proposed that these events were produced as the magma column degassed into adjacent cracks.

Events from January 1998 to March 1999 were relocated using a new velocity model and HYPOELLIPSE (Lahr, 1995). Map and cross-sections show that hypocenters are well constrained to a zone 0-4 km beneath the caldera (Figure 2).

TEMPORAL VARIATION OF B-VALUE

Temporal variation of the b-value obtained from the frequency-magnitude distribution was calculated using a least squares method over the period January 31, 1998 to February 24, 1999, for windows of 100 located events overlapped 25% (Figure 3). The b-value for Guagua Pichincha earthquakes ranges between 1.0 to 1.6 for this period.

The decrease in b-value from November to December 1998 can be correlated with a decrease in seismicity. Similarly, since late December, the b-value increased again as well as the number of seismic events did.

There are a number of possible explanations for the changes in b-values and seismicity observed in this period. Factors that can alter b-value include increased heterogeneity of the material (Mogi, 1962), and an increase in applied or effective stress (Wyss, 1973; Urbancic et al., 1992).

CONCLUSIONS

Guagua Pichincha volcano has been presenting abnormal high seismic and phreatic activity since August 1998. Although during November and December 1998, it shows an important decrease in the number of seismic events that can be correlated with lower b-values, which could be correlated to an increase in the stress field applied under the volcano.

On the other hand, the progressive increment in b-value since the end of December could be correlated with an increase in the energy of phreatic explosions. More frequent and energetic explosions could be more efficiently fracturing the material in the volcano conduit. Understanding these phenomena can be useful in predicting the future activity of Guagua Pichincha volcano.

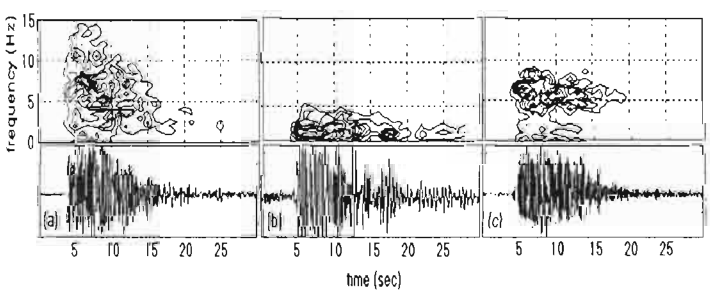


Fig. 1: spectrograms for (a) a VT, (b) a LP, and (c) a MP event, all registered at CGGP station (inside the caldera)

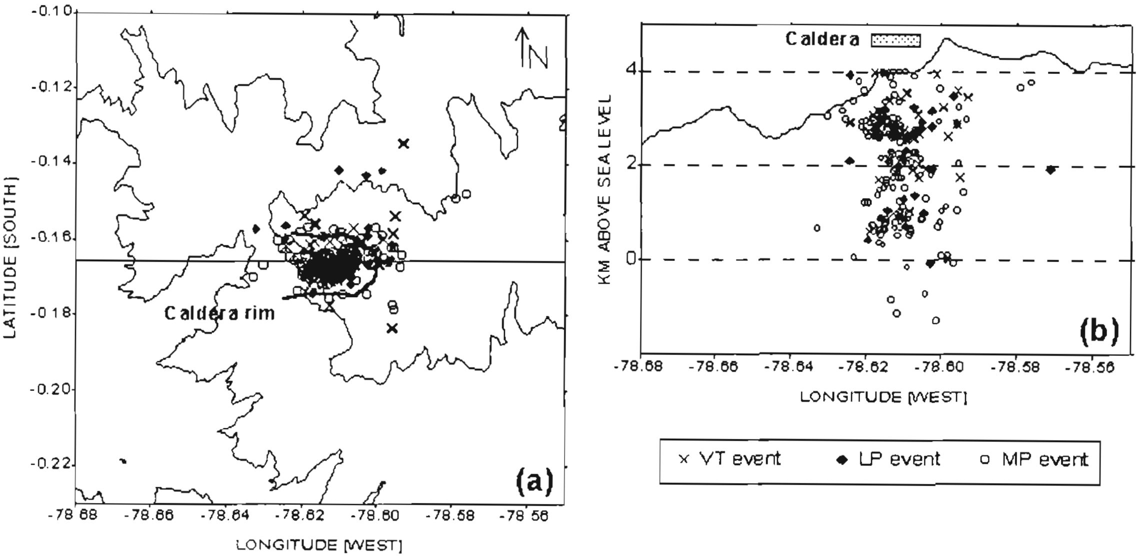
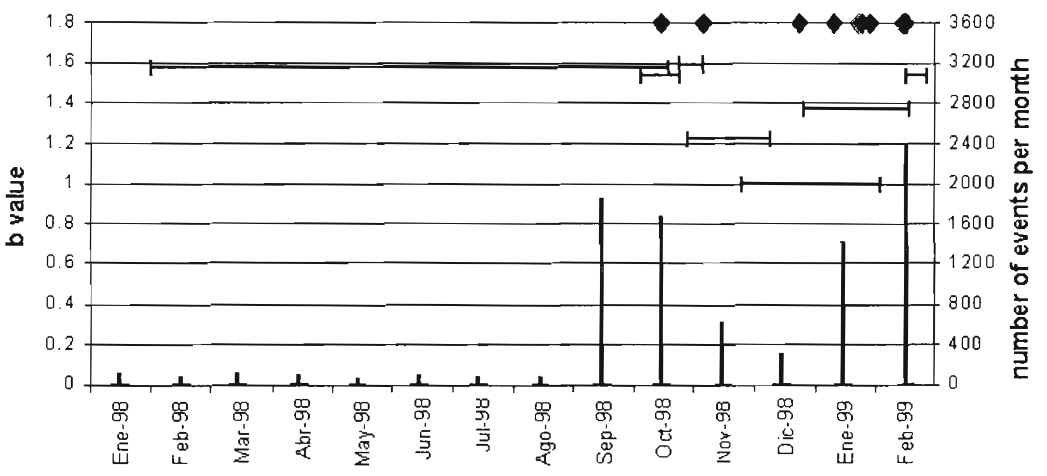


Fig.2: (a) Map and (b) west-east vertical section showing selected hypocenters (rms<0.1 seg, vertical and



horizontal errors<1 km)

Fig.3: Relationship between monthly seismicity, b-value and phreatic explosions. Horizontal bars are temporal variation of b-value (see text), columns are total number of seismic events per month, and diamonds are the 10 biggest explosions as reference.

REFERENCES

Bonilla F.L., Pérez V.H., Sánchez A., Ruiz M., Yepes A., Chatelain J.L. 1992. Análisis preliminar de la microsismicidad de la zona de Quito-Ecuador Período: 1988-1992, Segundas Jornadas en Ciencias de la Tierra, Quito-Ecuador, 12-14

Calahorrano A., Yepes H., Guillier B., Segocia M., Villagómez D., Andrade D., 1999, Seismic Swarm in Quito(Ecuador): tectonic or volcanic origin?, This volume

Lahr J.C. 1995. HYPOELLIPSE/Version 3.0: A computer program for determining hypocenter, magnitude, and first motion pattern of local earthquake. U.S. Geol. Surv.,Open-File Rep. 95-xxx, 90p.

Mogi K. 1962. Magnitude-frequency relation for elastic shocks accompanying fractures of various materials and some related problemm in earthquakes. Bull. Earthq. Res. Inst., 40, 831-853.

Segovia M., Pacheco J., Shapiro N., Yepes H., Guillier B., Riuz M., Calahorrano A., Andrade D., Egred J., 1999, The August 4, Bahia Earthquake (Mw=7.1) Rupture Mechanism and comments on the potential seismic activity, This volume

Urbanicic T.I., Trifu C.I., Long J.M., and Toug R.P. 1992. Space-time correlations of b-value with stress release, PAGEOPH, 139, 449-462.

White R.A., Miller A.D.,Lynch L., Power J. 1998. Observations of hybrid seismic events at Soufriere Hills Volcano, Monserrat: July 1995 to September 1996, Geophys. Res. Let., 19, 3657-3660

Wyss M.K. 1973. Towards a physical understanding of the earthquake frequency distribution, Geophys. J.R. Astr. Soc. , 31, 341-359.