INDUCED SEISMIC ACTIVITY BY A GLACIER IN VOLCANIC AREAS: APPLICATION TO NORTH FLANK OF COTOPAXI VOLCANO, ECUADOR.

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INTRODUCTION

Cotopaxi (5897m) is an active volcano covered by large glaciers and located on the eastern cordillera of the Ecuadorian Andes and which has a base diameter of 25 Km (Hall and Mothes; 1997). Due to its frequent eruptive activity during the last few centuries, future eruptions pose serious hazards for an important sector of Ecuadorian territory especially for East valleys of Quito and Latacunga.

The monitoring of seismic activity of Cotopaxi is carried out by four permanent telemetered one-component seismic stations of the Instituto Geofísico of the Escuela Politécnica Nacional (EPN) since 1989. Additional information about seismic activity related is based on an experiment made by ORSTOM-IG EPN in 1996-1997 using 12 additional seismic stations (Métaxian et al; this volume).

Worldwide, there are few monitored active glacier-clad volcanoes, thus only a few studies have produced in volcanic areas. Nevertheless investigations made on Mount St. Helens and Mount Rainier volcanoes (Washington State, USA) by Weaver and Malone (1976, 1979), serve to these authors to relate the discrete glacier movement with of icequakes. Experiments made on Mount St. Helens were carried out placing sensors over rock and in the icecap. They found that icequakes have similar characteristics to low frequency earthquakes when they are registered on rock and that most of the seismicity on Mount St. Helens was of glacier origin. The authors pointed out the risk of confusion between icequakes and low frequency events which have volcanic-related sources.

In this work, we analyzed the seismic activity produced by Cotopaxi glaciers and we present their principal characteristics, which allows differentiating the icequakes from the volcanic events.

than those registered at CORE. Also the average amplitude of events registered at COHI station is ten times bigger than those registered at the CORE station. Finally, graphics of particle motion give a linear polarization in East-Vertical plane. The complete results strongly suggest that these events have shallow sources and are originated in the ice structure.

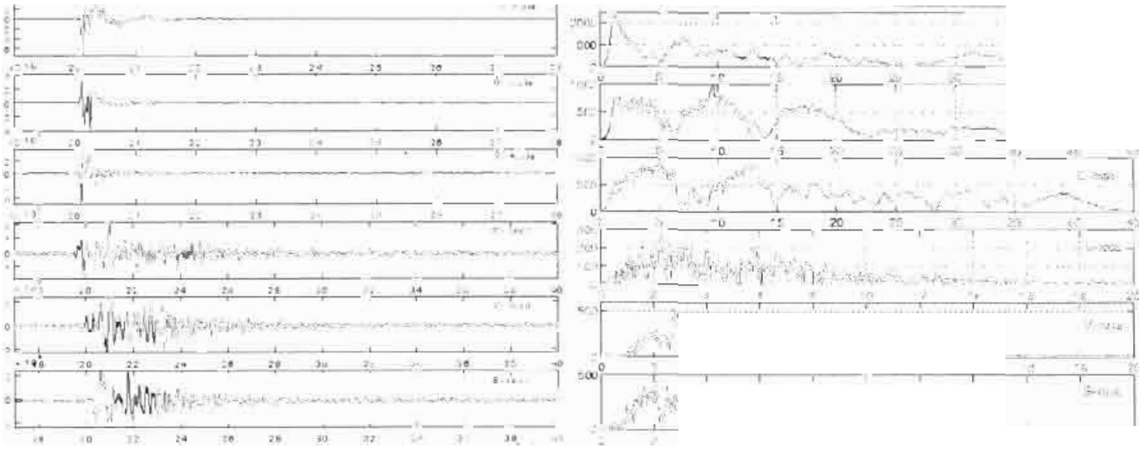
DISCUSSION ANDCONCLUSIONS

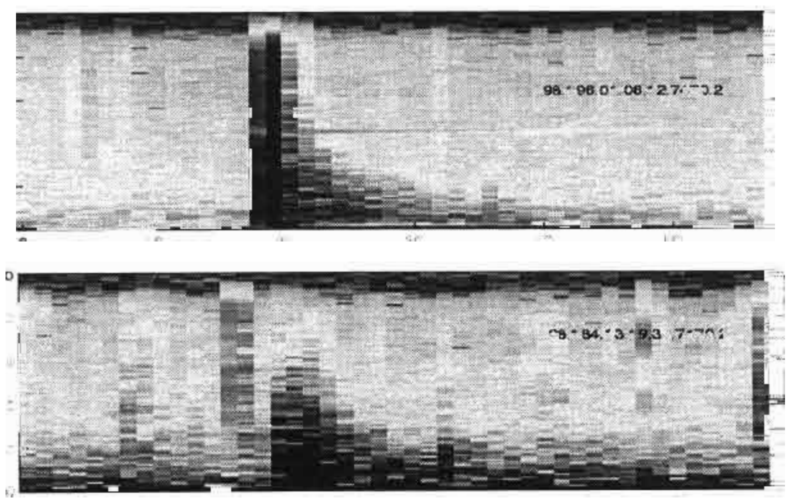
We observed two kinds of local events in Cotopaxi: 1) LP events which are related with volcanic process and 2) events normally associate with glacier movements. The characteristics of this second category of events coincides with the icequakes characterizied in the Cascade Volcanoes by Weaver-Malone (1976, 1979). In both cases we have: occurrence of almost one event per minute, initial detection and higher amplitude at the station placed on ice, shorter coda for an ice station's signals than those stations on bedrock and impulsive initial waves at the glacier station becomes emergent at the bed-rock station. We also observe, like for Mount St. Helens icequakes, a strong dispersion effect, which could be the result of an large velocity contrast across the ice-rock interface (Weaver-Malone; 1979). This observation is an additional argument to relate Cotopaxi events to a glacier origin.

The icequakes differ from LP events in all the analyzed parameters: signal shape, spectral content, spectrogram, wave front, duration, amplitude, S-P phases and particle motion. These differences are observable at the ice station but not at the bedrock station. No disperssion effects are observed for LP events. Icequakes and LP events are practically identical in the data registered on the bedrock, such was observed by Weaver and Malone (1976) at Mount St. Helens. This suggest that it is essential to install a seismometer on the glacier to differentiate both kinds of events.

Weaver and Malone (1979) suggest that icequakes are the result of a stick-slip type of motion taking place at the bed of the glacier. Other authors like Neave and Savage (1970) suggest that icequakes appear to originate fron extensional faulting near the surface of the glacier. Based on a particle motion diagram, we believe that icequakes are generated by cracks in crevasses produced by gravity force that moves the glacier downhill. Therefore, the registered seismic signal originates by elastic behavior of ice when it is submitted to the rupture process (Paterson; 1994, Feynman; 1972, Midelton-Wilcock; 1994)

We compared our set of LP events with the classification made by the IG EPN's data registered by the Cotopaxi permanent network (Convenio Inecel-EPN ; 1999). We found that 27% of the events classified as LP events are in reality icequakes (Fig 4). This confirms the similarity of LP events and icequakes when registered on bedrock. This could explain in part the great number of LP events registered in Cotopaxi by Ruiz et al. (1998).





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