THE Mw 6.8 MACAS EARTHQUAKE IN THE SUBANDEAN ZONE OF ECUADOR, OCTOBER 3, 1995.

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KEY WORDS : sismotectonics, neotectonics, seismic hazard, Andes, subandean zone, Ecuador.

INTRODUCTION

At 01:51 on 3 October 1995 (UT) a Mw 6.8 earthquake (Figure 1) occurred on the south-eastern flank of Cutucu cordillera, a NNE-SSW Jurassic-Cretacic anticline (Figure 1), located on the western edge of the subandean zone, overthrusting the lower part of the subandean zone along several reverse N-S faults.

No foreshocks were detected before the main shock at the detection level (Ml = 3.0) of the permanent network run by the Instituto Geofisico of the Escuela Politecnica Nacional of Quito. Four large aftershocks (magnitude ≥ 5.1) were observed within the first 4 days after the main event, including a magnitude (mb) 5.6 six minutes later, and the main aftershock (Mw = 6.4) eleven hours later. Three other aftershocks with magnitude (mb) 5.1 occurred in the period 21 - 29 October. About 750 aftershocks (Ml ≥ 3.0) were detected by the permanent network one week after the main shock,

amounting to more than 2100 until December 31 ; 350 of them had a magnitude 4 or larger, of which over 100 were felt in the epicentral zone. Three portable MEQ-800 stations were installed during 48 hours (2 from 5 to 6 October, and 1 from 11 to 13 October ; Figure 1). The latest recorded 1140 aftershocks, while the permanent network detected only 126, showing that the level of activity following the main event was much higher than observed with the permanent network because of its station distribution with respect to the seismic activity.

The epicenter of the main shock is located about 60 km SSE of the city of Macas (population 12,000). It has been widely felt in the entire country, including in the capital city of Quito (I = IV) and in the major cities (Guayaquil, I = IV ; Cuenca, I = V). It has also been felt in the neighboring countries of Colombia (as far as Bogota) and Peru (as far as Tarapoto). Fortunately this event occurred in a very low density populated area in the upper-amazonian jungle. Nevertheless at least 2 people were reported killed in Puyo (140 km North of the epicenter) and in Baños (170 km NNW of the epicenter) and several injured in the epicentral area. A complete survey of casualties and destructions in the zone was impossible to conduct due to the difficult logistic conditions (dense virgin rain forest covers most of the macroseismic zone). No surface ruptures have been observed. In the epicentral area decametric-size landslides and avalanches occurred on steep slopes. The bridge over the Upano river (60 km North of the epicenter) collapsed, interrupting the transit on the main road from the North to the eastern provinces ; cracks were observed on the roads, as well as power supply cuts and breaks of water supply pipes in several cities and villages up to Macas. Minor damages to buildings occurred in localities located along the Upano river, although some non-earthquake resistant buildings suffered slight to light damage in Puyo, Tena, Shell Mera, Cosanga, and as far as Gayaquil. Direct economic losses were estimated at $US 5 millions. Fortunately the earthquake occurred during a period of severe draught, otherwise the consequences could have been much more dramatic, as those following the 1987 Mw 6.8 earthquake that occurred in the northern part of the subandean zone (300 km North of the 3 October 1995 event) during a heavy rainy period, which killed over 1000 people and had much more economic consequences, most of them due to large landslides and mudflows related to the earthquake.

Preliminary location of 930 of the aftershocks during the 3 October - 31 December period shows a distribution of activity with a NW-SE trend (Figure 2), between 0 and 25 km depth, which does not correspond to any known fault. The Harvard University centroid-moment tensor solution for the main event shows reverse faulting with a nodal plan oriented N30E (Figure 2), sub-parallel to the sub-andean structures, with reverse thrust motion, compatible with an E-W compression.

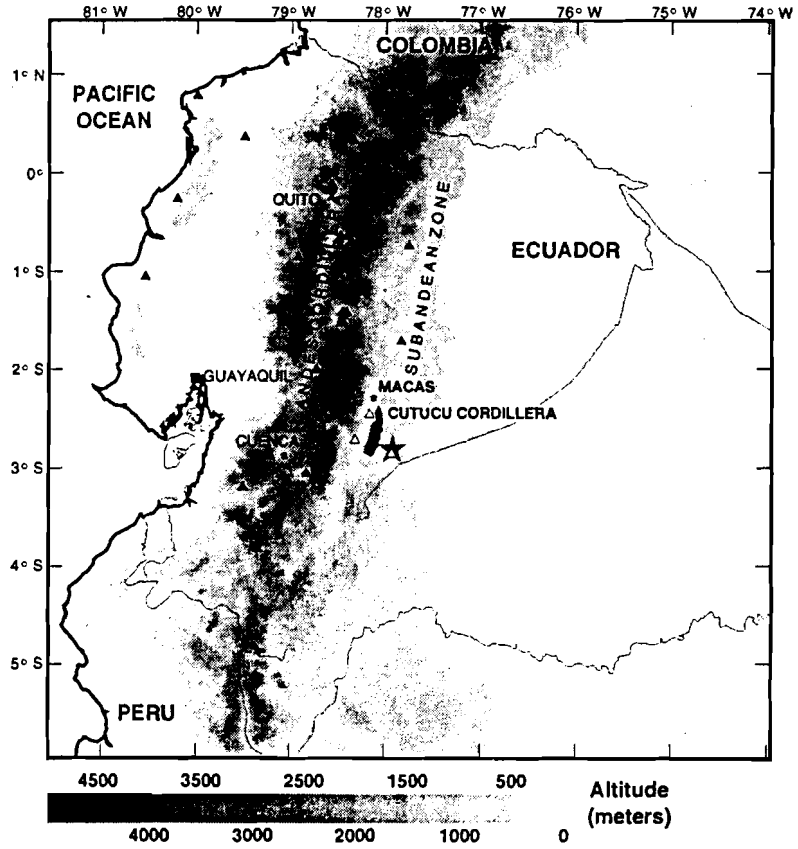

Figure 1. Map of Ecuador. The star is the epicenter of the 1995 Macas earthquake. Filled triangles are permanent stations of the ecuadorian seismic network. Open triangles are the temporary stations installed after the earthquake. The dark zone represents the Cutucu Cordillera.

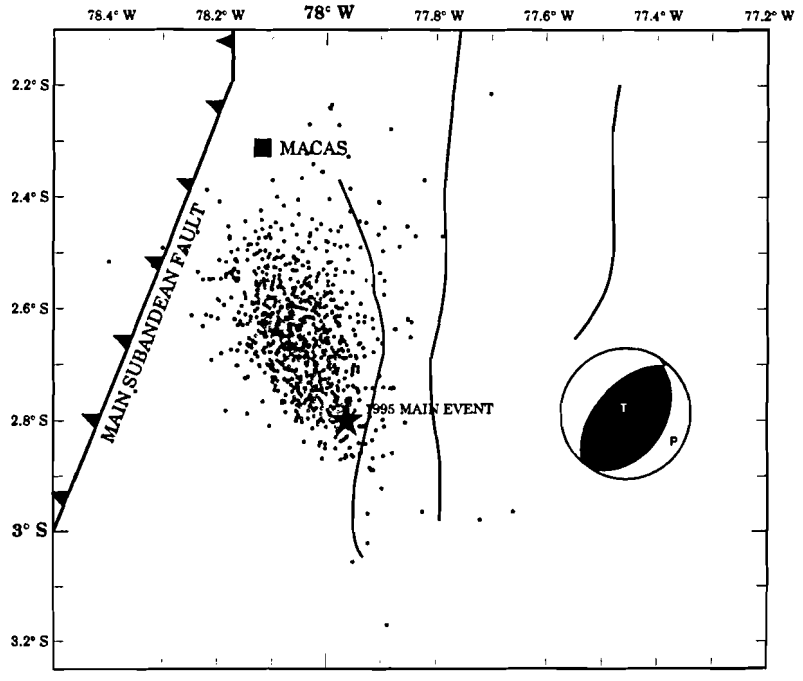

Figure 2. Epicenters of 940 selected aftershocks (RMS< 1.0, condition number > 100) during the period 3 October - 31 December 1995. Centroid-moment tensor solution for the main event from the Harvard University.

This earthquake is the largest shallow event to have occurred in this zone since at least 1952. A magnitude (Mw) 6.8 occured on May 10, 1963 about 90 kilometers NE of the 1995 event at a depth of 25 kilometers, and a magnitude (Mw) 7.5 earthquake on July 27, 1971, about 100 kilometers SE of the 1995 event at a depth of 90 kilometers. No data is available prior to 1952. There are no detailed reports describing the consequences of the 1971 and 1963 events in the epicentral areas. However, these two earthquakes produced similar consequences in the country as the 1995 event, and were also felt in the neighboring countries of Colombia and Peru.

The seismic hazard in the Andean-Sub-andean zone of Ecuador should be of major concern for the ecuadorian authorities as, for example, all the magnitude $\geq$ 6.5 ecuadorian events since 1985 occurred in the sub-andean zone, and a magnitude MS 5.7 hit the Latagunga region on 28 March 1996 provoking several tenths of casualties and major damage in the epicentral zone.