THE 1999-2000 SEISMIC EXPERIMENT OF THE SWARM OF MACAS (ECUADOR) IN RELATION WITH A SUBANDEAN UNEXPECTED WRENCH FAULT SYSTEM

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INTRODUCTION

A seismological experiment of 10 portatile short-period stations has been carried out in 1999-2000 around a swarm close to the city of Macas, Ecuador. The corresponding event locations have been correlated with respect to structural geology. Two main trends have been found. One corresponds to the already well established NNE-SSW trend of the big aftershocks of the M_w=7.0 1995 Macas earthquake, in agreement with its focal mechanism and the orientation of one of the complex subandean faults systems. The other one in an unexpected NNW-SSE trend where most of the registred events occurred. In fact, this trend is also in agreement with Subandean structures and can be explained in a more general tectonic pattern.

The purpose of this study is to present and correlate our seismological results and structural analysis in order to characterize the active Subandean deformation, and to explain the origin of the Macas swarm. Tectonic implications at the Andean scale are discussed.

REGIONAL SEISMIC SETTINGS

Ecuador is situated near the change of orientation of the SSE-NNW Central Andes and the SSW-NNE Northern Andes. Hence, this particular elbow-like position (Huancabamba Deflection) is submitted to high stress changing and, as a consequence, may be responsible of the high volcanic and seismic activity of Ecuador respect to Peru and Colombia. In order to have a rough idea of stress tensors, we calculate them from CMT Harvard focal mechanisms for shallow (depth < 50 km) events of magnitude M_w bigger than 5.0. The whole region has been split into 10 regions for which a unique stress tensor could be calculated (Figure 1). The general tectonic behavior can be deduced from the shape factor R (Rivera and Cisternas, 1990) of the stress tensor (R<0 for a pure compression, R>1 for a pure extension and 0<R<1 for an intermediate state). All the stress tensors are compressional (with a vertical σ_3, figure 1 *i.e.* with R<0) except for two regions: the Southern part of Colombia Coast (crosses in figure 1), which is a small extensional region (R>1). The second region is the Macas swarm (diamonds in figure 1), which has an intermediate shear stress tensor (0<R<1). Hence, this Macas region is a transition zone between two compressional regions (Peru and Northern Ecuador), characterizing a transpressive deformation, in an elbow-like position between the change of Peru and Ecuador mountain orientation mentioned before. These results are close to the one of Ego et al. (1996), except for the region of Bogota (stars in figure 1) and for the Macas region (diamonds in figure 1). This difference may be attributed to the fact that those authors have not taken into account the 1995 M_w =7.0 Macas earthquake and its aftershocks and the 1995 M_w =6.5 earthquake and its aftershocks in the Bogota region (these events occurred after their study). This particular situation of Macas region will be discussed latter on in a geological pattern.

MACAS SEISMIC SETTINGS

In 03/10/1995 an M_w=7.0 shallow (25 km depth) earthquake occurred at 2.55°S, 77.53°W (event 10 in Figure 2) near Macas city. The main trend of the biggest USGS events (mainly aftershocks of the 1995 Macas earthquake) is NNE-SSW, in agreement with the focal mechanism of the main shock (Figure 2) and the orientation of some subandean reverse faults. Nevertheless, many small aftershocks (of local magnitude M_L<4.0) have been recorded in a NNW-SSE orientation few days after the main shock (Yepes et al., 1996, Alvarado et al., 1996) and more than 5 years after (this study).

LOCATION OF THE 1999-2000 EVENTS

In a first step, events have been pre-located using hypoellipse code (Lahr, 1995). In a second step, relative localisations using the Master Event technique (Spence, 1980) have been done (with the *a priori* information of the hypocenters given by hypoellipse code) and are shown in Figure 3. The model of propagation has been deduced from seismic sections done by Petroproduccion (Rivadeneira and Baby, 1999). Most events are between 0 and 25 km depth, and few events are deeper, until 181 km depth, corresponding to the subduction of the Nazca plate. The two NNE-SSW and NNW-SSE seismic trends still appear, but the NNW-SSE orientation is most dominant.

CONCLUSIONS

The seismic risk in the region of Macas is high, as proved by the M_w=7.0 1995 Macas event. Many people feel earthquakes each year even at present times (2001) in that region. The stress tensor of the Macas swarm corresponds to a local transpressive deformation along a local blind NNE-SSW reverse fault, associated to a NW-SE vrench faults system which explains the principal trend of the swarm. It expresses the active deformation of the transition zone of the Huancabamba Deflection between the central and northern Andes. In the Ecuadorian Andes, the NNW-SSE structural orientation, in addition to the classical NNE-SSW one, is probably a major trend of deformation which can be correlated with others Ecuadorian swarms.

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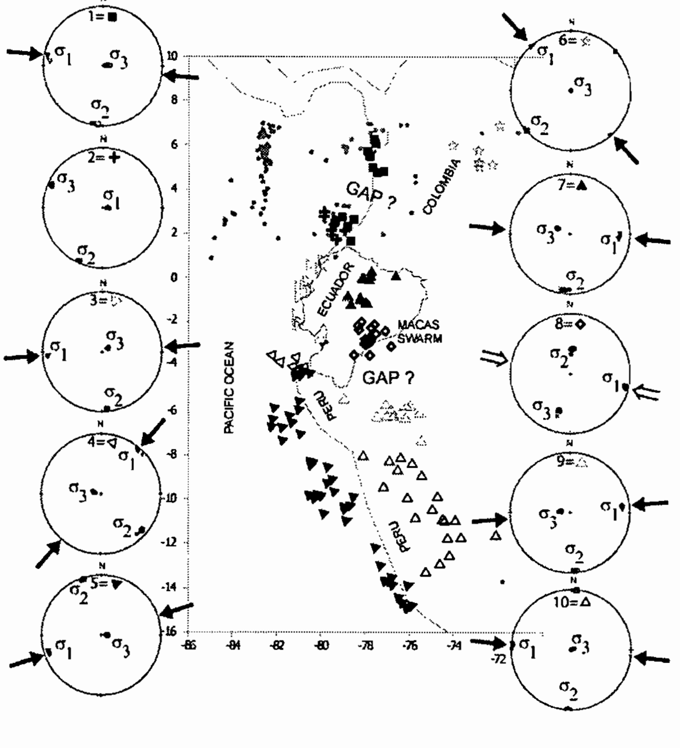

Fig. 1: Shallow (depth < 50 km) earthquakes (of M_w > 5.0) of the Harvard catalog (1973-2000) that have focal mechanism for 10 different regions and the corresponding stress tensors. Circles correspond to earthquakes that have not been used for stress tensor determinations. For the swarm of Macas, 3 additional events have been included (10/05/1963, 03/11/1963, 21/06/1967, see figure 2)

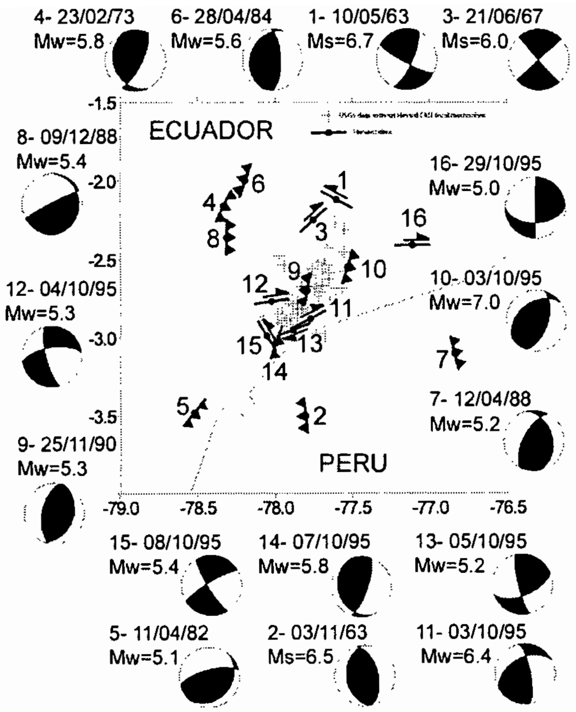

Fig. 2: Focal mechanisms of shallow (depth < 50 km) earthquakes (of M_w > 5.0) of the Harvard catalog (1973-2000) in the Macas region (region 8 of figure 1). 3 additional events have been included (10/05/1963, 03/11/1963, 21/06/1967). The fault planes selected during the stress tensor determination are shown. Cross correspond to the USGS data that have no Harvard focal mechanism (between –77.5/-78.6 and –2.1/-3.1).

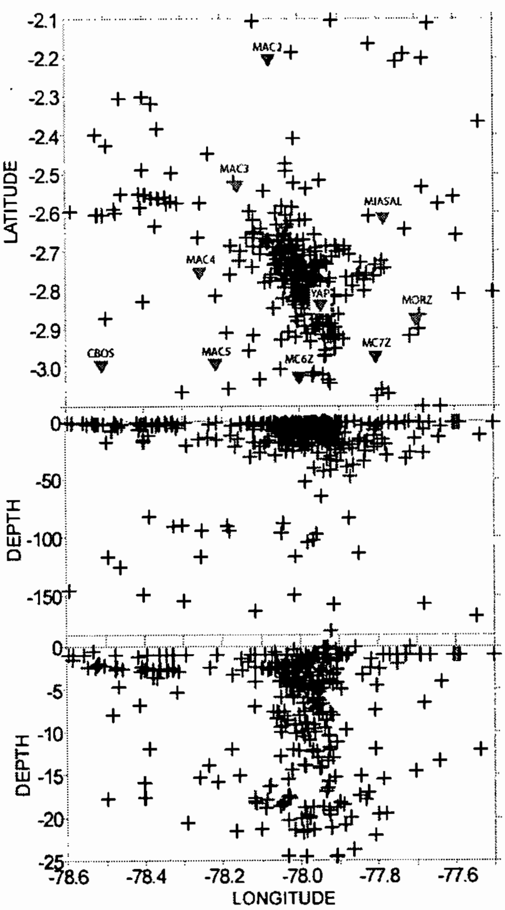

Fig. 3: Locations of the seismic portatile stations of the 1999-2000 experiment, and the seismicity recorded during this experiment.

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