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Seismicity and active tectonics in the Ilo region, southern Peru, using combined permanent and temporal network seismic observations

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INTRODUCTION

The plate boundary between the South American plate and the subducting Nazca plate along the Peru coast is the site of large destructive earthquakes for many centuries, including the last major June 23, 2001 (Mw=8.4) event. This segment of the subduction zone has undergone many subduction earthquakes this century, jumping from north to south along the subduction zone in 1942 (Mw=8.2), 1974 (Mw=8.0), 1996 (Mw=7.7), 1942 and 2001 (Mw=8.4). Modelling the teleseismic broadband P waveforms of the 2001 Peru earthquake indicate the source time function has two pulses of moment release with the larger second one located about 100-150 km southeast of the mainshock hypocenter (Giovanni et al., 2002; Tavera et al. 2005). Moreover this underthrusting event was followed by the spreading to the south of the aftershock sequence on an area of 300 km by 120 km (considering relocated aftershocks recorded during the first month by temporal seismic network). This southern migration of the aftershock sequence stopped its propagation right on Ilo Peninsula and after 14 months, in this region there happens an earthquake (M=5.8) of superficial area with epicenter to 60 km in direction NE of the peninsula. This earthquake presents a focal mechanism of normal type and principal axes orientated in direction NW-SE, coherent with the tectonic superficial one and being possibly an evidence of the reactivation of some fault with plane perpendicular to the trench.
A new dataset recorded by a temporary seismological network is analysed to study the post seismic period, during one month in 2004, in the area where were observed the last aftershock events. The existence of a perpendicular fault system, the Chololo Fault and a series of similar faults that are trending perpendicularly to the coast may indicate that the structure of the upper continental plate plays a role in aftershocks repartition on the subduction plane.

SEISMIC TEMPORAL AND REGIONAL NETWORK

The study area extends around Ilo town on a distance of 100 km along the coast and inside the continent (Figure 1). The seismotectonic settings in the Peruvian coastal area is largely controlled by the convergence of the Nasca and South American Plates. These two plates are converging at a rate of ≈ 80 mm/year, with a relatively eastward movement of the Nasca plate subducting beneath the South American Plate. Most of the relative plate motion is accommodated by slip along the subduction interface between these two plates, at which occurred the

2001, 23 June earthquake. This main shock was produced by rupture of a segment of the fault, of about 300 km long and 120 km wide. This fault rupture fits entirely within the previous fault rupture of the big southern Peru earthquake of 1868 (Mw 8.8). The southern Peru earthquake of June 23, 2001, showed a Mw of 8.2–8.4. The hypocenter was about 30km deep and located near the coast. Much of the energy release and the largest aftershock (Mw 7.6) occurred far to the southeast of the hypocenter, in the part of the fault-rupture zone nearest the study area of Ilo.

In Peru, the earthquake was recorded in the cities of Moquegua and Ilo. The regional-scale mapping of seismic intensities rated the maximum earthquake shaking intensity as a modified Mercalli (MM) VIII (relatively low for an earthquake of this magnitude) and intensities within the study area as MM VII–VIII (Tavera et al. 2005). It produced intense and widespread ground-failure effects (Keefer and Moseley, 2004). Damages in the central part of Ilo, in which bedrock is at the ground surface, were minimal, whereas in outlying areas built on softer materials (Pampa Inalambrica), local damages were stronger. In the upper part of Ilo town, surface breaks were observed in agreement with the tectonics of the area and with the focal mechanisms obtained by some aftershocks. We installed 7 stations around the study area during one month in May 2004 in order to study the microseismic activity and compare it to the regional tectonics.

TECTONIC SETTINGS

The climate in the study area was hyperarid during the Quaternary and thus the regional morphology is really well preserved. The Chololo fault system consists of sub-parallel fault segments that form a wide zone at the base of the south-facing front of the Cerro Chololo north of Ilo town. The fault cuts straight across Quaternary to Holocene alluvium and shows morphologic evidence for strike-slip motion. Regional seismic monitoring reveals little microseismicity at the northern end and along the fault system. We have investigated the fault zone at several sites selected from ASTER images and the study of aerial photography. The southernmost of these fault segments is the youngest and shows a prominent 2-m high scarp and lateral offsets. These young scarps are formed on piedmont intermittent alluvial fans and alluvial fans that issue from the range-front intermittent canyons. They are less well developed across the recent fan surfaces, probably as a result of recent erosion or deposition (Fenton and others, 1995). Fenton and others (1995) report that the youngest movement on the fault is probably Holocene or latest Pleistocene for the southernmost strand. Quaternary movement is documented on the remainder of the fault.

CONCLUSION

The purposes of this article are first to describe the continental seismotectonics in the area of the 2001 Peru earthquake sequence and aftershocks; and then to correlate eventual continental tectonic activity to the stop of the aftershocks propagation to the south.

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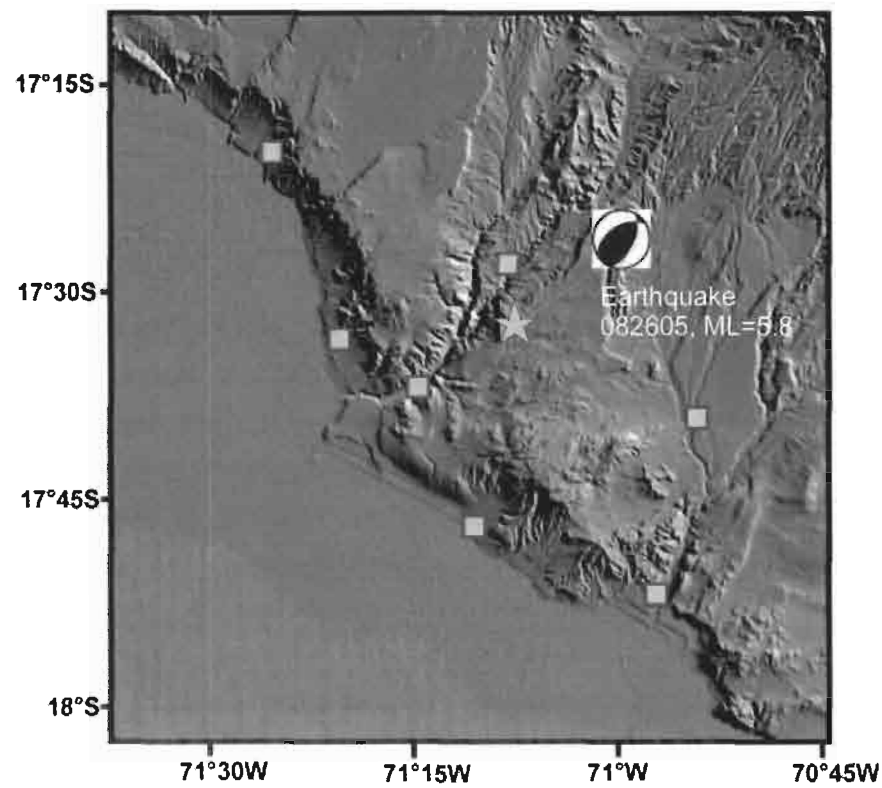

Figure 1: DEM SRTM and locations of the seismic stations of the temporal network (05/2004)