BLOCK MOTION AND INTERSEISMIC INTERPLATE COUPLING ALONG THE ECUADOR AND NORTH AND CENTRAL PERU SUBDUCTION ZONE.

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ABSTRACT

We use GPS measurements collected between 2008 and 2012 to define the Nazca/South America interplate locking distribution, from central Peru to north Ecuador subduction zones (2°N to 14°S). The fast subduction of the Nazca plate (~ 7 cm/yr) under the northern Andes margin leads to a complex surface deformation involving principally bock motions superimposed on the seismic cycle interseismic signal. The GPS velocity field shows the expected northeastward motion of the North Andean Block at about 7 mm/yr in Ecuador. In north Peru, we discover an unexpected continental block (the Inca Block) moving southeastward at about 5 mm/yr parallel to the trench axis. Superimposed to these block motions appears a heterogeneous pattern of interseismic interplate coupling where two highly coupled segments in Ecuador and Central Peru encompass a low interplate coupled segment of about 800 km long (from 1°S to 9°S). The GPS measurements suggest that the interplate coupling, from 1°S to 9°S, does not exceed 30 km depth and that the plate contact is slipping aseismically below 30-km depth of the megathrust. In Ecuador, the interplate coupling indicates a very highly heterogeneous pattern suggesting the existence of at least 4 marjor seismic asperties consistent with historical large earthquakes. South of 9°S, along Lima district up to Pisco, a strong coupling is also observed delimitated by the subduction of two major geomorphological features, the Mendaña fracture zone and the Nazca ridge that may act as seismic barriers. Central Peru and Ecuador segments are characterized by a historically active seismicity of large and great events. On the contrary no large earthquake is documented in the weakly coupled northern Peru segment. However, two unusual shallow tsunami earthquakes, with long rupture durations and shallow depths, occurred in 1960 (Mw 7.6) and 1996 (Mw 7.5), and are consistent with the hypothesis of very shallow coupling along the trench.

STATE OF THE ART

The Mw=9.1 Sumatra-Andaman of 2004 has pointed out the importance of correctly assessing the seismic hazard in subduction zones and the need to improve our understanding on the processes that lead to the occurrence of giant earthquakes. Indeed, the mechanisms whereby strain and stress are being accumulated and released along the plate interface have yet to be understood in details.

Fast subduction of the oceanic Nazca plate beneath the South American continent induces large earthquakes with a characteristic repeat time of 100-150 years in Chile and southern Peru (Comte and Pardo, 1991; Dorbath, et al., 1990; Nishenko, 1991).

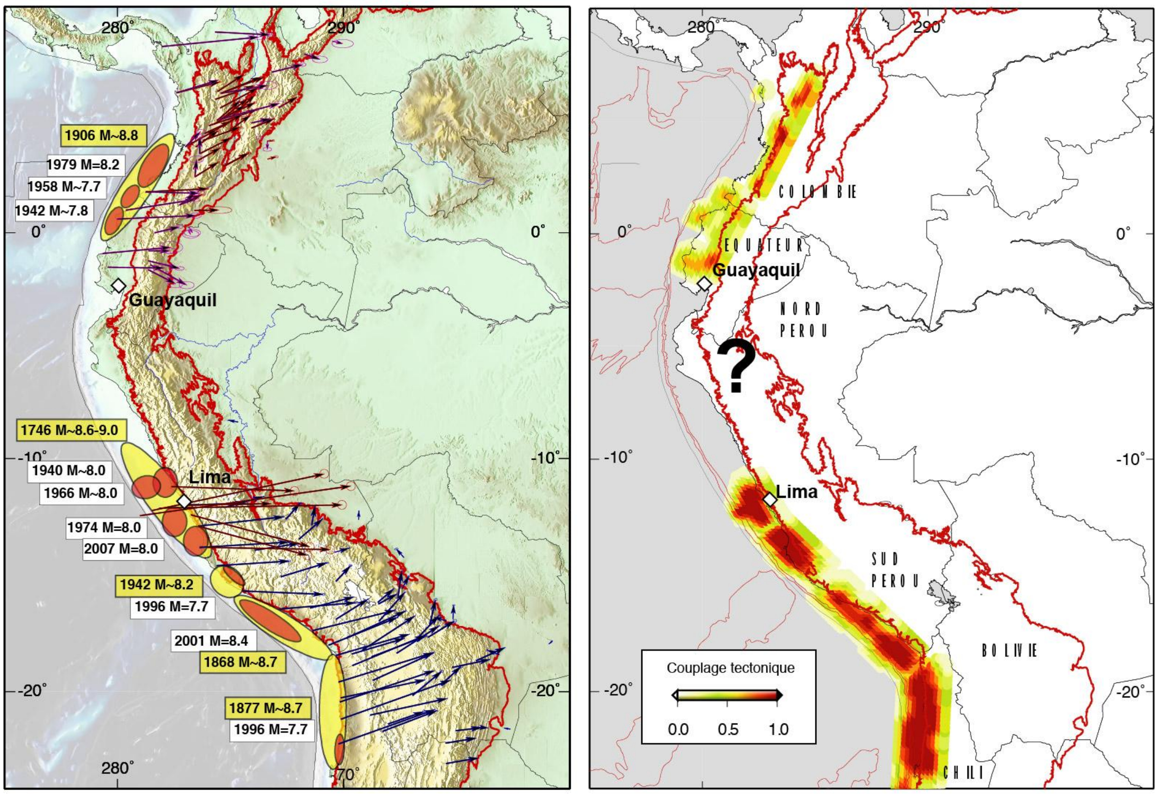

Figure 1 : Left: Rupture area for known earthquakes with M>7.6 and GPS campaigns measurements since 1990 (Norabuena, et al., 1998; Bevis, et al., 2001; Kendrick, et al., 2001; Trenkamp, et al., 2002; White, et al., 2003; Chlieh, et al., 2004). **Right:** GPS derived model of interplate coupling along the subduction interface (Chlieh et al. 2011). Highly coupled zones are shown in red. They show similar sizes to presumed area of ruptures for historical and recent earthquake.

Previous studies of the interseismic deformation along the Andes subduction using GPS and/or InSar have shown a current significant level of locking of the interplate interface all along the margin (Figure 1). However, the overall picture is still missing information from the latitude 10°S (north of Lima) to 2°S (south of Ecuador). In that area, no large earthquake has been recorded for the last five centuries (Dorbath et al., 1990, Kelleher, 1972, fig. 1), suggesting on one hand that this portion may be freely aseismically slipping. On the other hand, the factor usually assumed to control the level of locking (convergence rate, age of the ocean floor, presence of sediments along the trench, Ruff and Tichelaar, 1996) are not very different from the adjacent segments where large earthquakes have occurred in the past. The question posed is: has the plate interface accumulated large stress during the last centuries possibly triggering a giant earthquake in the next years or is it aseismically sleeping?

On the contrary, along the Ecuadorian coast (between lat. 2°S and 2°N) has experienced three major earthquakes during the last century (1942, Mw=7.9, 1958, Mw=7.8, 1906, Mw=8.8, Kelleher, 1972; Kanamori and McNally, 1982; Beck and Ruff, 1984; Fig. 1). Also, in Central Peru (between the Mendaña fracture zone and the Nazca ridge), the great 1746 megathrust earthquake ruptured the entire zone and Lima's port Callao was devastated by a tsunami with only a few hundreds out of 6000 people surviving (Walker, 2008). Dorbath et al. (1990) estimated the magnitude of this event to be of the order of M_w~8.6, but Beck and Nishenko (1990) suggested a larger value of M_w~8.8 to 9.5. The 1746 great earthquake was followed by two centuries of seismic quiescence, interrupted in the 20th century by the occurrence of three M_w~8.0 earthquakes: the 1940 event followed by the 1966 and 1974 earthquakes. The M_w=8.0 Pisco earthquake of 2007 whose rupture stopped at the northern edge of the Nazca ridge, completed the sequence to spatially encompass approximately the whole rupture area of the great 1746 earthquake (Tavera and Bernal, 2008; Biggs et al. 2008; Perfettini et al. 2010)

NEW DISCOVERIES

This presentation will focus on these three segments of the north Andes subduction zone, extending from central and north Peru up to north Ecuador. We propose an integrated approach involving geodesy, seismology, tectonics and modelling in order to address the following questions:

(1) How is stress currently being accumulated along the subduction plate interface in the northern Andes? What part of the convergence is accommodated through large earthquakes and what part is accommodated aseismically along the interplate contact?

(2) What part of the Nazca/South America convergence is accommodated along the subduction interface and what part is transferred to the overriding plate as long-term strain? Does the tectonic deformation of the forearc in Ecuador and northern Peru reflect different behaviours of the subduction earthquake cycle?

(3) What can we learn about subduction earthquake source processes? Can we relate the source characteristics of subduction earthquakes with the characteristics of the interseismic loading?

(4) What factors do control the interplate coupling and the repeat time between large earthquakes? Can we propose a model of the seismic cycle in Ecuador and northern Peru predicting correctly all geodetic and seismological observations and explaining the behaviour difference between northern Ecuador and northern Peru?

(5) Finally, how detailed knowledge on the earthquake cycle in subduction zones can contribute to a better assessment of the seismic and tsunami hazard and improve the risk mitigation?

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