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Interseismic active deformation and stress fields along the North Ecuadorian – South Colombian margin

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The North Ecuadorian – South Colombian margin was the site of the 1906 Mw=8.8 megathrust earthquake. The 500 km long rupture zone of this earthquake was partially reactivated by three smaller thrust events in 1942 (Mw=7.8), 1958 (Mw=7.7) and 1979 (Mw=8.2). Focal parameters and rupture areas geometry of these earthquakes have already been studied in detail. On the other hand, due to a lack of seismological instrumentation, location and mechanisms of the seismic background activity, from the oceanic Nazca plate to the Andes, are not yet constrained. Data from a mixed onshore and offshore temporary seismic network deployed during 3 months in North Ecuador, combined with data of the national Ecuadorian network and Harvard CMT solutions, were used in order to determine the active deformation location, associated focal mechanisms and stress fields in the three main tectonic units of the margin: the interplate seismogenic zone (ISZ), the fore arc region which is part of the North Andean Block (NAB) and the downgoing oceanic Nazca plate. The magnitude range of the recorded events is from 2.2 to 5.5. The Gutenberg-Richter law, compared to the one obtained with data over the last 15 years, suggests that the margin is currently a steady state system and encompasses a slowly evolving phase of the seismic cycle, more likely the interseismic cycle. Along the plate interface, a northward gradual decrease of the microseismic activity, from the 1942 rupture area the 1979 surface rupture, also suggests, based on the Scholz model [1990], that the North Ecuadorian – South Colombian subduction zone is facing an interseismic period. Furthermore, we note that this along strike variation of interplate seismicity appears to depend on the time elapsed since the last large earthquakes in the area. The Updip and Downdip limits of the seismogenic zone have been determined to be at depths of 12 and 30 km respectively. Stress field determined for the plate interface exhibits a maximal stress axis ($\sigma 1$) oriented $\approx$EW, in agreement with the convergence direction in the region. Deeper, the Wadati-Benioff plane geometry is, for the first time, well defined down to 140 km depth facing the Carnegie Ridge, and presents a dip angle of 25° which disagrees with the hypothesis of a 100 km deep flat slab. The minimal stress axis ($\sigma 3$) is not normal to the trench, as commonly observed in the slabs during the interseismic period, when the plate interface is locked. It is oriented $\approx$N60°, and might traduce local perturbations of the slab stress field due to the variation of the slab dip at a larger scale, as we observe along the entire Andean margin. In the forearc region, the crustal seismicity reaches 40 km depth. This is interpreted as being the maximum depth extent of the brittle domain, traducing the presence of a thick skin tectonic. This thicken of the overlying plate brittle domain might be due to the successive accretion of oceanic blocks to the margin since the Mesozoic, and could be at the origin of the adakitic volcanism observed in Ecuador. This upper plate seismicity is mainly concentrated in a roughly 100 km wide stripe stretching from the coast at about 1°N and oriented WNW-ESE, which is coincident with the observed morphological segmentation of the margin. The stress tensor computed for the forearc region exhibits a transpressional regime, in agreement with the right lateral strike slip faults presented on the neotectonic map of Ecuador.