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Stress analysis for the 2010 Haiti seismic crisis: an example of strain partitioning on a transpressive setting

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The Mw=7 event occurred the 12th of January, 2010 triggered a seismic crisis in the southern Haiti that continued for 3 months. The epicentral region was located in an E-W oriented transpressive plate boundary where the Caribbean and North American plates converge $\sim$20 mm/y trending 070º. The convergence is very oblique yielding a strain partitioning model where coexist E-W trending structures that accommodate the left-lateral strike-slip motion (e. g., Enriquillo-Plantain Garden fault zone; EPGFZ) and NW-SE trending structures that accommodate the compressive motion component (Transhaitian thrust belt; TTB). The main shock occurred at 15 km southward of Port-au-Prince and to 12 km of depth yielding large personal and material damage. Despite of its significant magnitude and relative shallow depth this event did not yield surface rupture complicating the studies about the source fault. The main event was followed by 50 aftershocks with magnitudes between 4.5 and 5 located to the west of the main event along an E-W trending segment of 50 km of length. All the events occurred along the interaction zone between the NW-SE oriented compressive structures of the TTB and E-W strike-slip structures of the EPGFZ. The TTB and the EPGFZ are first-order structures that define the eastern boundary of the Gonave microplate.

In this study we show the results of the stress inversion analysis carried out over the focal mechanisms calculated from the centroid tensor method for the main event and 50 aftershocks of the 2010 seismic crisis. Calculated active stress tensors (maximum horizontal stress, Shmax, and stress regime) have been compared with structural data and inter-seismic surface deformations derived from GPS data. The main event was generated by a N084º north-dipping fault plane with a major left-lateral slip component and a reverse component located at the deformation front of the TTB (i. e., Léogâne fault). This reverse oblique fault was activated by a Shmax trending 020°. All the aftershocks have been generated by ENE-WSW pure reverse faults located in the area of interaction between the 135º oriented compressive structures of the TTB front and 085º oriented strike-slip structures of the EPGFZ. These aftershocks have been activated by a very homogeneous uniaxial compressive stress regime with Shmax oriented 017º$\pm$10º. Their focal depths (located between 7 and 12 km), together with the absence of surface rupture indicate that the sources of the aftershocks are blind thrusts oriented between 097º and 117º. Although the reverse faults derived from focal mechanisms agree with the compressive structures of the TTB, there is an angular deviation of 18º-38º between these blind thrusts and the mapped thrusts orientations. The inter-seismic surface convergence, derived from GPS velocities for the epicentral region, shows an angular deviation of $\approx$30° related to the orientation of Shmax derived from the stress inversion analysis. These differences between the surface and deep deformations strongly suggest that a significant part of the elastic energy accumulated in the island arc crust along the E-W trending EPGFZ was not released during seismic crisis of 2010. This study supports the hypothesis that there is an increased probability of occurrence of a significant earthquake in southern Haiti that accommodates the E-W deformation component did not released during the seismic crisis of 2010.