Earthquake source mechanisms and their characteristics in the Dominican Republic

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Abstract

The island of Hispaniola, of which the Dominican Republic (DR) comprises the eastern two-thirds, is subject to a complex array of tectonic stresses. The southward-dipping North American tectonic plate is subducting obliquely under the Caribbean plate in the north, two significant transform fault systems transect the island from east to west, and the island is believed to have accreted from at least three distinct terranes through transform and convergent motions (Fig 1). Further, the Dominican Republic is the site of dramatic topography, from a broad, flat but uplifted plain in the east to the highest mountains in the Caribbean. These features are largely the result of offsets that were accompanied by earthquakes and the historical record contains numerous descriptions of devastating events. However, in the modern, instrumented era the frequency of large earthquakes has been fairly low, which has made it difficult to characterize of the range of potential earthquake sources.

The Centro Nacional de Sismologia (CNS), an organized research unit of the Autonomous University of Santo Domingo, is tasked with maintaining the network, analyzing its data, and compiling a comprehensive earthquake catalog. With the current network, which was expanded in 2013, approximately one thousand earthquakes per year are recorded and located in the DR with magnitudes between 2 and 6. We present focal mechanisms of ~146 earthquakes with magnitude 4 or greater recorded by ten or more stations since 2013. (The largest event to have occurred within the borders of the DR since 2013 is a magnitude 5.8.) Mechanisms, determined with first motion polarities and S/P amplitude ratios, for events with focal depths in the shallow to mid-crust share characteristics that correspond to surface tectonics but a set of intermediate-depth events beneath the eastern DR and the Mona Passage show a greater variety (Fig 2).

Methodology

In this ongoing project we have located thousands of events that occurred in and around Hispaniola from 2013 to 2017 and obtained 137 focal mechanisms for well-recorded earthquake with magnitudes greater than 4. (After review, some of these events were determined to have magnitudes to a final minimum of 3.7 and maximum of 6.2.)

A minimum of 10 recording stations were required for each event and focal mechanisms were determined with first motion polarities and S/P amplitude ratios. Four distinct programs that are now integrated into SEISAN (Ottomoller, L., Voss, P. y Havskov, J., 2014): FOMEC, Hash, FPFIT and Pinv were used. We then plotted the results in map view and in cross-sections for visual assessment.

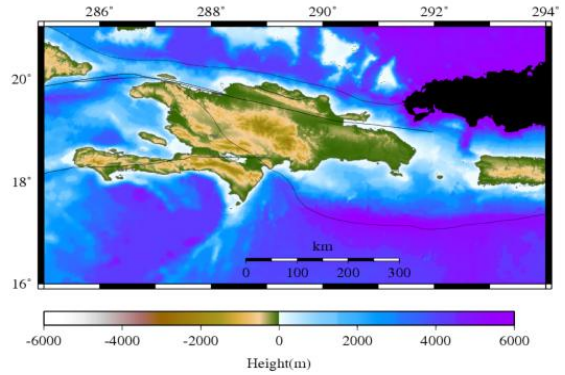

Figure 1. Bathymetry, topography and the main fault systems (black lines) of Hispaniola. Elevations vary over short distances from 0 at the coast to more than 3 km at Pico Duarte (the highest point in the Caribbean). The Puerto Rico Trench (shown in black at upper right) reaches a depth of 8.3 km.

Tectonic Setting

The island of Hispaniola is located in the North American–Caribbean plate boundary zone. The island shows a transition from highly oblique subduction of the North American plate beneath the Caribbean plate, in the northeastern part of Hispaniola, to roughly east-west pure strike-slip motion along the Cayman Trough (Dolan and Bowman, 2004; Ali et al., 2008).

The oblique collision with the Caribbean margin along northeastern Hispaniola is being accommodated, at least in part, by compressional deformation and elevation in central Hispaniola and, in part, by two parallel strike-slip fault systems: the left-lateral motion Septentrional in the north and the Enriquillo-Plantain Garden system in the southwest (Bakun et al., 2012).

The deepest earthquakes in the Caribbean occur beneath southeastern Hispaniola. Events have been reliably re-located to depths of ~200 km but catalogs contain focal depths to 250 km. Several models models for the fate of the subducted slab have been suggested (e.g., Dolan and Wald, 1998; Leonel and Hurukawa, 2013; Dillon et al. 1996) based upon a variety of data. In the southern part of Hispaniola deformation is accommodated along the left-lateral Enriquillo–Plantain Garden Fault and the north–dipping thrust fault of the Los Muertos (Dolan and Bowman, 2004).

Results

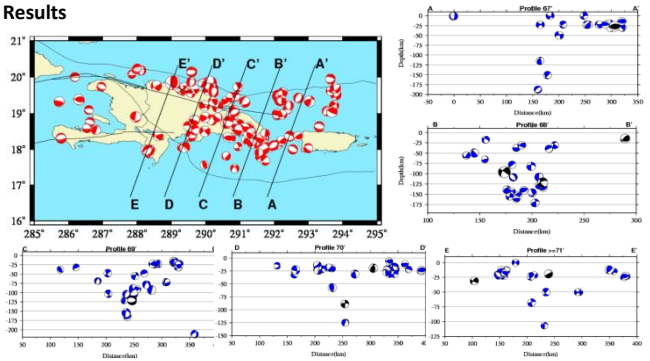

Figure 2. Focal mechanisms obtained for 137 local earthquakes in Hispaniola in 2013-2017. The map show a profile N18E orientation. Black focal Mechanisms show representatives shallow and intermediate seismicity.

Conclusions

- Events with focal depths in the shallow to mid-crust share characteristics that correspond to surface tectonics but a set of intermediate-depth events beneath the eastern DR and the Mona Passage shows a greater variety.
- A southward-dipping Wadati-Benioff zone that corresponds to North American plate subduction can be seen beneath eastern Hispaniola and western Puerto Rico (Fig. 2). A northward-dipping Wadati-Benioff that may correspond to Muertos subduction is less clear.
- The main contact zone between North America-Caribbean slabs (~68°W-70°W) shows high seismicity at depths of 70-125 km.
- The distribution of all recorded seismicity (not shown here) suggests that the highest concentration of earthquakes does not occur on Hispaniola's five main faults.
- We must compile a more extensive catalog before seismicity of Hispaniola can be characterized accurately and comprehensively.

References

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