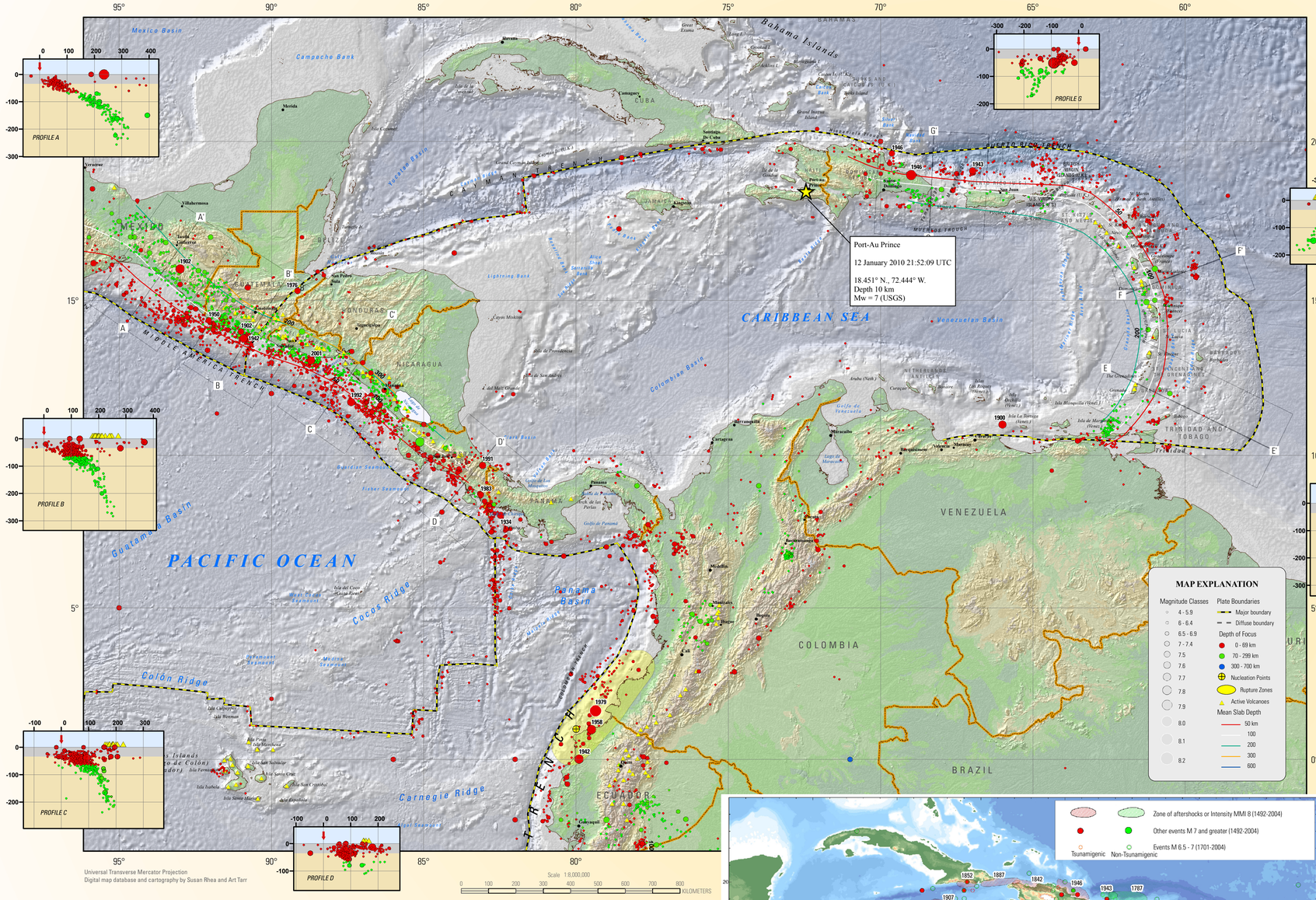
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Map not approved for release by Director USGS
14 January 2010

Seismicity of the Earth 1900 - 2007

Caribbean Plate and Vicinity

Compiled by Arthur C. Tarr, Susan Rhea, Gavin Hayes, Antonio Villaseñor, Kevin P. Furlong, and Harley Benz



TECTONIC SUMMARY

Extensive diversity of tectonic regimes characterizes the perimeter of the Caribbean plate, involving no fewer than four major adjacent plates (North America, South America, Nazca, and Cocos.) Inclined zones of deep earthquakes (Wadati-Benioff zones), deep ocean trenches, and arcs of volcanoes clearly indicate subduction of oceanic lithosphere along the Central American and Atlantic Ocean margins of the Caribbean plate, while shallow seismicity and focal mechanisms of major shocks in Guatemala, northern Venezuela, and the Cayman Ridge and Cayman Trench indicate transform fault and pull-apart basin tectonics.

The depth profile panels on this map portray earthquakes that extend from the Middle America Trench axis in the west to depths as great as 300 km beneath Guatemala, and from the Lesser Antilles Trench axis in the east to depths of approximately 200 km beneath Guadeloupe and the NE Caribbean. In contrast, seismicity along the segments of the Caribbean plate margins from Guatemala to Hispaniola and from Trinidad to western Venezuela is indicative of transform fault tectonics.

Along the northern margin of the Caribbean plate, relative North America moves toward the west at approximately 20 mm/yr, resulting in major transcurrent faults (e.g., Motagua fault in Guatemala) and troughs (e.g., Cayman Trench). Farther east, the North America plate subducts beneath the Caribbean plate resulting in surface expression of the deep Puerto Rico Trench and a zone of intermediate focus earthquakes in the subducted slab.

The plate boundary curves around Puerto Rico and the northern Lesser Antilles where the plate motion vector of the Caribbean plate relative to the North and South America plates is less oblique, resulting in active island arc tectonics. The North and South America plates subduct beneath the Caribbean plate along the Lesser Antilles Trench at rates of about 20 mm/yr; consequently, there are both intermediate focus earthquakes within the subducted South America plate and a chain of active volcanoes along the island arc.

The southern Caribbean plate boundary with the South America plate strikes east-west across Trinidad and western Venezuela and is characterized by major strike-slip faults (e.g., El Pilar and Boconó faults) and shallow seismicity, resulting from relative plate motion of about 20 mm/yr. Further to the west, a broad zone of convergent deformation trends southwest across western Venezuela and central Columbia. Plate boundaries are not well defined across northern South America, but there is a transition from Caribbean/South America convergence in the east to Nazca/South America convergence in the west, described in more detail below. The transition zone is characterized by high seismic hazard.

The Nazca-Caribbean plate boundary offshore of Columbia is characterized by convergence (Nazca plate subducting under South America plate) at about 65 mm/yr. The 6 January 1906 Mw = 8.5 megathrust subduction earthquake occurred on a shallow-dipping interface of this plate boundary segment. The 1906 earthquake occurred in the Colombia-Ecuador region, with a seismic moment (Mo; equivalent to radiated energy) of 6x10**28 dyne-cm (Okal, 1992), and a moment magnitude (Mw) of 8.5 (Tarr and others, 2009.) The nucleation point of this earthquake is indicated on the map (rupture area is from Kanamori and McNally, 1982.)

Along the western coast of Central America, the Cocos plate subducts beneath the Caribbean plate at rates of 72-81 mm/yr, resulting in a relatively high seismic hazard and a chain of numerous active volcanoes; here intermediate-focus earthquakes occur within the subducted Cocos plate to depths of nearly 300 km.

DATA SOURCES

Earthquakes: (a) the Centennial earthquake catalog (Engdahl and Villaseñor, 2002) and annual supplements for the interval 1900-2007, where the magnitude floor is 5.5 globally and (b) a catalog of earthquakes having high-quality depth determinations for the period 1964-2002 and a magnitude range of 5.0≤M≤5.4 (Engdahl, personal communication.)

Great Earthquakes (M≥8.3): nucleation points are plotted with a special symbol, their rupture areas are shown as pale yellow polygons. Major earthquakes (M≥7.5) are labeled with the year of occurrence.

The Seismic Hazard and Relative Plate Motion panel displays the generalized seismic hazard of the region (Giardini and others, 1999) and representative relative plate motion vectors of the Caribbean plate relative to the adjacent Pacific, North and South America plates using the NUVEL-1A model (DeMets, et.al., 1994) and updates (Dixon, et.al., 1998; Weber, et.al., 2001).

Base map data sources include GEBCO 2008, Volcanoes of the World dataset (Siebert and Simkin, 2002), plate boundaries (Bird, 2003), Digital Chart of the World and ESRI.

REFERENCES

Bird, Peter, 2003, An updated digital model of plate boundaries: Geochemistry Geophysics Geosystems, v. 4, no. 3, 52p.
British Oceanographic Data Centre, 2003, Centenary Edition of the GEBCO Digital Atlas [CD-ROM]: Liverpool, UK.
DeMets, C., Gordon, R.G., Argus, D.F., and Stein, S., 1994, Effects of recent revisions to the geomagnetic time scale on estimates of current plate motions: Geophys. Res. Lett., v. 21, 2191-2194.
DeMets, C., Jansma, P.E., Mattioli, G.S., Dixon, T.H., Farina, F., Bilham, R., Calais, E., Mann, P., 2000, GPS geodetic constraints on Caribbean -North America plate motion: Geophys. Res. Lett., v. 27, 437-440.
Dixon, T. H., F. Farina, C. DeMets, P. Jansma, P. Mann, and E. Calais, 1998, Relative motion between the Caribbean and North American plates and related boundary zone deformation from a decade of GPS observations, J. Geophys. Res., 103(B7), 15,157–15,182.
Engdahl, E.R. and Villaseñor, Antonio, 2002, Global seismicity 1900-1999. in International Handbook of Earthquake and Engineering Seismology, Chap. 41, v. 81(A), p. 1-26.
Giardini, D., Grünthal, G., Shedlock, K., Zhang, P. and Global Seismic Hazards Program, 1999, Global Seismic Hazards Map, *http://seismo.ethz.ch/GSHAP*
GLOBE Task Team and Hastings, D.A., Dunbar, P.K., Elphingstone, G.M., Bootz, M., Murakami, H., Maruyama, H., Masaharu, H., Holland, P., Payne, J., Bryant, N., Logan, L., Muller, J.-P., Schreier, G., and MacDonald, J.S., 1999, The Global Land One-kilometer Base Elevation (GLOBE) Digital Elevation Model, Version 1.0, National Oceanic and Atmospheric Administrtion, National Geophysical Data Center, Boulder, Colorado, USA.
McCann, 2006, Estimating the threat of tsunamigenic earthquakes and earthquake induced landslide tsunami in the Caribbean, in Caribbean Tsunami Hazard, Proceedings of the NSF Caribbean Tsunami Workshop, 2004, p.43-65.
Siebert, L., and Simkin, T., 2002, Volcanoes of the World: An illustrated catalog of Holocene volcanoes and their eruptions: Smithsonian Institution, Global Volcanism Program Digital Information series, GVP-3. http://www.volcano.si.edu/world/
Tarr, A. C., bla bla bla, 2009, in press, Global Seismicity 1900 – 2007, USGS Science Investigation Map.
Weber, J.C., Dixon, T.H., DeMets, C., Ambeh, W.B., Jansma, P., Mattioli, G., Saleh, J., Sella, G., Bilham, R. and Pérez, O. 2001, GPS estimate of relative motion between the Caribbean and South American plates, and geologic implications for Trinidad and Venezuela: Geology, v. 29, no. 1, p. 75-

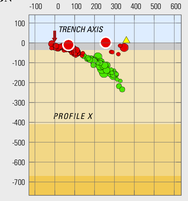
DEPTH PROFILE EXPLANATION

Magnitude Classes
4 - 5.9
6 - 6.4
6.5 - 6.9
7 - 7.4
7.5
7.6
7.7
7.8
7.9
8.0
8.1
8.2

Depth of Focus
0 - 69 km
70 - 299 km
300 - 700 km
Nucleation Points
Quaternary Volcanoes

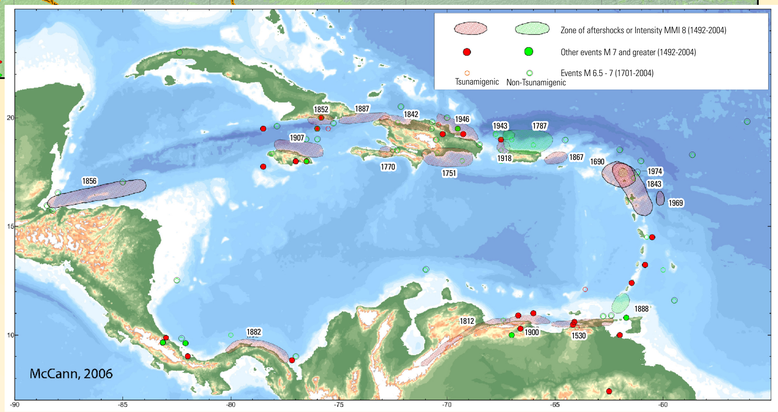
Earth Structure
Air
Crust
Upper Mantle
Transition Zone
Lower Mantle

Profiles of earthquake and volcano locations are constructed from the mapped data. Locations of the profile intersection with the surface are drawn in the map and labeled to coincide with the profile label. Length of the profile graphic is the same as in the map. Distance in kilometers from the trench axis is indicated in the X direction, depth in kilometers is indicated in the Y direction. There is no vertical exaggeration. See Explanation at side for color key. Not all earth layers are visible on every map.



Historic Earthquakes and Tsunami 1492 - 2004

Note: Historic earthquakes in the interior and west coast of Central and South America are not included in this figure.



Seismic Hazard and Relative Plate Motion

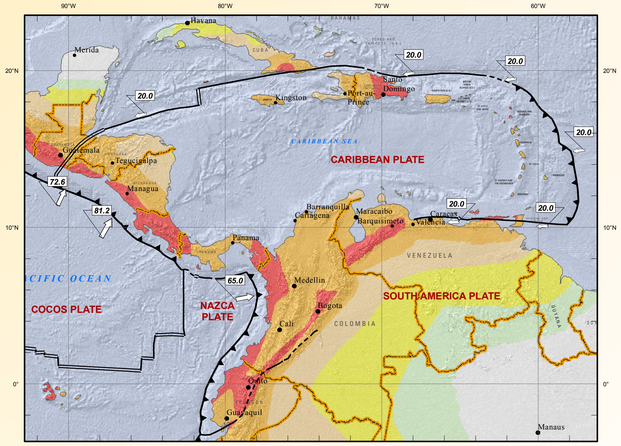


FIGURE EXPLANATION

Peak Ground Acceleration
0 - 0.2 m/sec²
0.2 - 0.4
0.4 - 0.8
0.8 - 1.6
1.6 - 3.2
3.2 - 6.4
6.4 - 9.8

Relative Plate Motion
11.0 - 19.9
20.0 - 39.9
40.0 - 59.9
60.0 - 79.9
80.0 - 100.0

Plate Boundaries
Subduction
Transform
Divergent
Others