Large Earthquakes, Tectonic/Geomorphic Features and Tsunami Hazard: Possible Methods for Estimating the Potential of Tsunamigenic Earthquakes and Earthquake Induced - Landslide Tsunamis in the Caribbean

McCANN, W. R., Earth Scientific Consultants, Westminster, CO 80021, esc@envisionet.net

The tsunami threat in the Caribbean is dominated by deformation occurring along the margins of the Caribbean Plate. That margin parallels the Lesser Antilles and extends along the Greater Antilles from Puerto Rico to Jamaica. Only the southern margin of the island of Cuba lies near the plate margin. The eastern boundary of the Caribbean plate near the Lesser Antilles is the locus of subduction of Atlantic seafloor. At least three distinct, shallow tectonic regimes parallel the margin. They are: an outer tectonic belt where the North America Plate bends to enter the subduction zone, the main interface or zone of contact between the plates, and an inner zone of intraplate activity in the overriding Caribbean Plate. The level of seismic activity and tsunami potential in each of these zones is influenced by the presence of aseismic ridges on the downgoing plate. The ridges may increase the probability of tsunamigenic earthquakes, particularly by reactivating thrust faults in the accretionary prism. Large earthquakes rupturing into the prism are sometimes slow, tsunamigenic earthquakes. Examples of large earthquakes in the three tectonic zones are 1969, 1843, and 1974 respectively. The first two generated tsunami.

The northeastern corner of the Caribbean Plate margin has a smooth transition from the relatively simple subduction zone in the Northern Lesser Antilles into a region of oblique convergence. It is a complex margin dominated by microplate tectonics from near Puerto Rico through Hispaniola. Here too the same three tectonic zones can be defined, but the third zone, “intraplate activity in the Caribbean Plate”, is more clearly delineated as microplate deformation in a wide plate boundary zone. Numerous large earthquakes have occurred in this part of the Greater Antilles in the last 200 years. An event in the outer zone occurred in 1946; the interplate zone moved in 1787, 1943, 1946, 1948 and 1953. The microplate deformation zone experienced events in 1867, and 1918. Most of these earthquakes generated tsunami.

Strike-slip tectonics dominates the region from Haiti westward to the northern coast of Honduras. Local bends in the transcurrent fault systems lead to vertical tectonics in the form of push-ups and pull-aparts. Some convergence is absorbed along the southernmost margin of Cuba. Many large earthquakes have occurred in this region; some have generated tsunami. Either the tsunamigenic events in this region had source mechanisms with significant vertical components, or they triggered submarine landslides that generated the tsunami.

Densely spaced bathymetric surveys and seismic reflection profiles reveal numerous submarine landslides in the vicinity of Puerto Rico and the Virgin Islands. Several of them appear associated with tectonic processes tilting, and thereby destabilizing, the seafloor. Manipulation of gridded bathymetric data to produce maps of seafloor slope, slope direction, and roughness as defined by the curvature of contours, can aid the identification of potential slides, or reveal portions of subduction zones more likely to produce tsunami earthquakes.

A survey of the northern and eastern Caribbean Plate boundary zone reveals several regions of high slope. Many of these are found where great earthquakes have or are likely to occur, possibly triggering submarine landslides. Regions such as the southern Lesser Antilles have steeper seafloor slopes in the backarc region than in the accretionary prism of the subduction zone.

It has been suggested that subduction of rough seafloor highs such as seamounts and fracture zones leads to dewatering and stiffening of the accretionary prism and, as the high enters the deeper portions of the subduction zone, activation of thrust faults within the accretionary prism i.e. above the main decollement. If this were the case, it would enhance the possibility of tsunami earthquakes. The subduction of rough bathymetric highs and its corresponding increasing roughness of the accretionary prism would then be another parameter to determine the likelihood of tsunami earthquakes. Using these criteria, four regions of the NE Caribbean stand out as more likely source for tsunami earthquakes.