

Tsunamis and Jamaica

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I wrote this article just to state my opinion on the topic quite clearly. I responded to the question on the threat to Jamaica of a tsunami similar to the one that occurred in the Indian Ocean on December 26, 2004 many times and each time I tried to say the same thing. However, reporters usually write their own stories and make the decision about what to use and what not to use, so everything I say does not come out in any single interview whether audio or written. Therefore I write this to present all the facts and issues surrounding the topic in one place at one time for the benefit of readers who may have heard or read just bits and pieces of the story.

Tsunamis are a series of waves generated in the sea by sudden vertical displacements of a column of seawater. They come in all sizes from less than 1 cm to tens of metres. This article is primarily concerned with significant tsunamis that can devastate coastlines and kill people. The causes of tsunamis illustrate how they are generated. They are:

1. Large (magnitude ≥ 6.5) underwater dip-slip earthquakes which move the seafloor either up or down by significant amounts and over a significant area.
2. (a) submarine slides consisting of large volumes of seafloor material which move rapidly down slope on the continental or island shelf
(b) subterranean slides consisting of large volumes of land and rocks from high steep slopes which fall directly into the sea
3. large submarine volcanic eruptions
4. the impact of extraterrestrial bodies at sea.

Let us examine these sources, starting with the least likely:

Exterrestrial Impact

Areas like the Gulf of Mexico and Chesapeake Bay along the east coast of the USA are believed to have been formed by meteorite impact at sea and with these events came large tsunamis for which evidence has been uncovered in the form of buried relic-sediments and artefacts around the affected areas and from the general discovery of the crater like shape of the sea-floor in these areas. These phenomena are documented and described in a number of articles and books. Should another such impact occur it can wipe out whole populations over very wide areas.

Submarine volcanic eruptions

Kick 'em Jenny volcano comes immediately to mind. Located near to the island of Grenada studies done up to 2003 indicate that the volcano is not likely to cause a tsunami that would be a serious threat to even neighbouring islands much less Jamaica. Apparently the volume of ejaculate anticipated from the volcano is insufficient and the

vent is too deep to have such an impact. There are no known active volcanoes in the vicinity of Jamaica or in the Greater Antilles.

Landslide sources

The north coast of Puerto Rico is apparently very susceptible to submarine slides which have caused a number of tsunamis along that coast line. Other talked-about sources include a volcano in the Canary islands off the west coast of Africa which is considered as a potential source if the flanks of the volcano were to be blown off and fall into the sea the volume of material would be very large such that a large tsunami would be generated that could affect the Caribbean. While this is possible the outer islands of the Caribbean Sea would be more susceptible to this teletsunami (pronounced tele-soonami i.e. a tsunami from a source over 1000 km away) than Jamaica.

The truth is none of the above sources pass energy efficiently to the sea water as do earthquakes on the seafloor. Volcanic eruptions tend to dissipate energy rather than focus it on the water column. Despite the many volcanoes ringing the Pacific Ocean as the penname, "Ring of Fire" depicts, according to one statistic, 82% of all Pacific tsunamis are generated by earthquakes.

Earthquake tsunamis

However, not all earthquakes can generate tsunamis - certain conditions are required. The earthquake must have a magnitude of 6.5 or higher which is an indication of the large quantity of movement or slip on the causative fault that is required. In addition, the earthquake must displace the sea floor vertically, either up or down. Large destructive earthquakes result from sudden movements within the earth's crust on either side of a fault and this happens when the accumulated strain overcomes the friction on the fault. The earth's crust varies from 5 km (sea floor crust) to 70 km (under continents) thick so one can imagine that the forces to move such thicknesses of solid earth must be infinitely large.

Tsunamis are far rarer in the Atlantic Ocean than in the Pacific, and with good reason. Atlantic plate margins are predominantly passive while those in the Pacific are active. Plate margins are zones where most earthquakes are generated and these can be of three types: divergent where the two plates are moving away from each other (see Figure of Mid-Ocean ridge); transcurrent where two plates are sliding past each other; and convergent where two plates are colliding (see Figure of ocean trench). The latter are also called "active" plate margins, whereas the former two are called "passive" plate margins. The Pacific Plate margin is largely synonymous with the Pacific Ocean which is ringed by convergent plate margins known as subduction zones, which create and sustain volcanoes and generate the largest earthquakes known. The deepest ocean trenches form where the converging plates consist of seafloor and the older plate then is driven beneath the younger ocean crust. The faults typified by these margins are known as thrust faults in which the seafloor of the overriding plate is pushed up in powerful surges. According to preliminary estimates from the USGS an area of seafloor measuring 1200 x 100 km was moved an average of 15 meters in the Sumatran earthquake of December 26, 2004. The forces that did this were inconceivably massive and since the seafloor is well-coupled to the water above it, much of the energy released went into that

most deadly tsunami. In addition, the highest mountain chains known, such as the Himalayas were built at convergent margins, as the plate encompassing the Indian continent converged with the Eurasian Plate.

In the Atlantic on the other hand we have the North American Plate encompassing the continent of the same name and extending right across the western half of the Atlantic Ocean floor. The plate boundary runs north-south along the centre of the Atlantic Ocean and is a passive margin where the action of the plates is divergent. The continental margins of the USA and West Africa are not plate boundaries and are therefore associated with little to no seismicity, except for two relative small areas, the Caribbean and the Mediterranean Seas. Both of these seas, like the Pacific Ocean are essentially synonymous with plates of the same name. In the Mediterranean, North Africa is moving toward south-western Europe (site of the Alpine Mountain chain) by means of a tsunamigenic convergent zone skirting the coast line of North African countries and extending into the Middle East. Back in 1755 the great Lisbon earthquake, so-called because of the devastation wreaked on Portugal's coastal city sent a tsunami all the way across the Atlantic which affected islands of the Lesser Antilles to varying extent. Waves of between 2-3 metres were reported without casualties. There is no report of this tsunami reaching Jamaica. As recently as May 2003, a magnitude 6.8 earthquake, known as the Algiers-Boumerdes event thrust up a section of the coastline north of Algiers, which killed over 2,000 people and set off a 2-metre (6 ft.) tsunami that raced toward the Spanish Balearic islands damaging and/or sinking about 100 small leisure boats that were anchored in the islands' mariners. An earthquake of similar magnitude (M 6.9) struck just south of Grand Cayman on December 14, 2004, and off the coast of south-eastern Cuba in 1972 with no such effect.

Jamaica is located in/on the north-central Caribbean Sea/Plate where the plate margin is passive, typified (so far) by transcurrent crustal movements (see map of Caribbean plate). Cuba and the Cayman Islands are positioned at the southern boundary of the North American Plate, and are moving relatively eastward with respect to Jamaica, along the Oriente Fracture Zone, the plate boundary fault. South of Grand Cayman is another passive feature known as the Cayman Spreading Centre where the crustal movement is divergent like that found along the middle of the Atlantic Ocean. In the present state of motion, which has been the case for the past 10 million years at least, the Oriente Fracture Zone and the Cayman Rise should not generate tsunamigenic earthquakes. As one moves around the Caribbean Plate margin the sense of motion changes from transcurrent to convergent in the region north of Hispaniola. Convergence typifies the margin north of Puerto Rico and east of the Lesser Antilles where subduction zones like those of the Pacific Ocean margins are found. Earthquakes capable of generating tsunamis do happen along this part of the Caribbean plate margin. But the consensus among earth scientists which is based on historical occurrences and current plate motions and seismicity is that the risk of a Sumatra-type event is low. A news release from the Seismic Research Unit states that there have been only 10 earthquake-generated tsunamis in the Caribbean over the past 500 years and these killed a total of about 350 people. The worst affected territories were Haiti (1842), Virgin Islands (1867), Puerto Rico (1918) and the Dominican Republic (1946). In order to create a tsunami of that size all of the

eastern Caribbean plate boundary would have to move at once and that earthquake would probably be felt across the entire region much less the tsunami it might generate. The maximum credible earthquake along the Caribbean plate boundary is thought to be of magnitude 7.5, based on my own estimates and those of other geo-scientists in the region.

The history of tsunamis in the Caribbean by Lander et al. tells of two certain events occurring in Jamaica over the past 300 years. The sinking of a part of Port Royal into the sea in 1692 caused a wave of 1.8 metres (6 feet) to cross the Harbour with a withdrawal of 274 metres. At Yallahs a withdrawal of 1.6 km is mentioned though not substantiated by the Tomblin & Robson earthquake catalogue or by any consequent damage reports. In 1907, waves of 1.8 - 2.4 metres were reported along the north coast between Portland and St. Ann, accompanied by withdrawal of the sea by 70-90 metres. In Kingston harbour waves of 2.5 metres were observed. Both events followed strong to major local earthquakes which displaced land at Port Royal and probably along the north coast suddenly and vertically into the sea. There are no reports that anyone was killed by the tsunamis. The death toll from the earthquakes was 2000 out of a population of 8,000 at Port Royal (1692) and 1,000 in Kingston (1907).

While it is true that all low-lying coastal areas are and remain vulnerable to the threat posed by tsunamis and that nature is in detail unpredictable, as evidenced by the recent final path of Hurricane Ivan, based on the history and the existing knowledge of plate motions and potential sources in the region, the threat of large Sumatra-type tsunamis affecting Jamaica is relatively low when compared to the Pacific and now the Indian Ocean territories.

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