Narration from the IRIS animation, “Puerto Rico: Earthquakes & Tectonics” found:

<https://www.iris.edu/hq/inclass/animation/717>

Puerto Rico in the northeast Caribbean Sea is home to over 3 million people with an additional 150,000 people living on the nearby Virgin Islands. In January 2020, Puerto Rico was rattled for more than three weeks by over 400 earthquakes greater than M3. Before addressing that sequence, let’s look at the broader tectonic setting and earthquake history.

The Caribbean Plate moves east at about 2 cm per year with respect to the North American Plate. The convergent plate boundary is curved so that oceanic lithosphere of the North American Plate enters the Puerto Rico Trench at an oblique angle. North of Hispaniola, oblique collision of the Bahama Platform produces additional trench-parallel forces. The result is a zone of distributed deformation with the Caribbean Plate broken into microplates, including the Puerto Rico–Virgin Islands microplate between the Lesser Antilles and Hispaniola.

Examining over 1800 recent earthquakes with M>4 shows shows the depth of the *deepest* earthquakes increasing with distance from the Puerto Rico Trench. This map of depth to the subducting plate shows the oceanic lithosphere has reached about 100 km depth beneath northern Puerto Rico which lies over 160 km from the trench. The distance from the trench to Puerto Rico AND the depth to the subducting plate beneath it, both contribute to seismic waves losing amplitude, and thus shaking potential, as they travel from the megathrust to Puerto Rico.

The most recent megathrust earthquake occurred beneath Mona Canyon in 1943. with magnitude 7.7 earthquake. Rupture started at 35 km depth and moved upward toward the trench, but stopped at 25 km depth so no tsunami was produced. Ground shaking in northwest Puerto Rico was strong but damage was minimal. This is the largest earthquake on this sector of the subduction plate boundary in the 500-year written record. It would be foolish, however, to assume it is the largest earthquake possible. Because great magnitude 8 and 9 earthquakes often have recurrence intervals over 1000 years, we do not know how large future Puerto Rico subduction zone earthquakes might be.

Returning to the cross section, we see the capping layers of the limestone carbonate platform of Puerto Rico dip toward the trench. Let’s go back 3 million years, when this shallow marine coral growth was originally flat to examine the evolution of the subduction zone. At about this time, subduction became steeper and depth of the trench increased to become the deepest part of the Atlantic Ocean. These changes in geometry may have decreased friction on the plate boundary so that great magnitude 8 or 9 megathrust earthquakes could be less likely.

However, this northward tilt makes the slope vulnerable to submarine landslides and two large amphitheater-shaped features are probably sites of immense prehistoric landslides. If the largest of these failed in a single landslide event, the resulting tsunami could have had runups approaching 16 meters along the north coast of Puerto Rico. Indeed, submarine landslides are an important tsunami hazard throughout the Greater and Lesser Antilles.

Let’s now examine the tectonic boundaries of the Puerto Rico – Virgin Islands microplate. When we hold the Caribbean Plate fixed, we observe a small component of North America Plate motion perpendicular to the trench and a larger component parallel to the trench. [Pause 1-2sec] As shown by the earthquake history and modern GPS observations, this oblique subduction drives separation of the Puerto Rico–Virgin Islands microplate from the Lesser Antilles to the southeast and from Hispaniola to the west.

An example earthquake between the Virgin Islands and Lesser Antilles occurred in 1867. Six meters of combined normal and left-lateral strike-slip displacement produced a fault scarp on the north wall of the Virgin Islands Basin during this earthquake with approximate magnitude 7.2. Uplift of the ocean floor generated a tsunami with runups over 7 meters at St Croix and 6 meters at St Thomas. At least 23 and perhaps as many as 50 fatalities occurred in the Virgin Islands. The 1785 and 1867 earthquakes document rifting of the Puerto Rico – Virgin Islands microplate from the Lesser Antilles through the Anegada Passage.

On October 11, 1918 a magnitude 7.2 earthquake with 3 meters of normal-fault displacement occurred in Mona Passage. Severe ground shaking on the west coast of Puerto Rico caused 76 fatalities. Five minutes after the earthquake, the sea receded from the shore at Punta Borinquen and Punta Higuero, then returned two minutes later in a wave that reached over 6 meters runup. Over the next 40 minutes, the tsunami swept down the west coast causing 140 drownings. Bathymetry reveals a scarp caused by a submarine landslide 9 km across, and 150 meters thick at the south end of Mona Canyon. Although tsunami modeling demonstrates this landslide could have caused the 1918 tsunami, close visual observations by submersible suggest it could be a much older landslide. The rifting in Mona Passage that resulted in the 1918 earthquake and continued extension of Mona Canyon is produced by oblique collision of the Bahama Platform with northern Hispaniola which causes Hispaniola to be pulled away from the Puerto Rico-Virgin Islands microplate.

A series of moderate to strong normal- and strike-slip-faulting earthquakes started in late December 2019 offshore of southwestern Puerto Rico. Recent GPS observations indicate that the boundary between the Hispaniola and Puerto Rico - Virgin Islands microplates passes through southwest Puerto Rico. The largest of the 2020 earthquakes, at magnitude 6.4, occurred on January 7 south of Guayanilla. Ponce, a city with population over 153,000, experienced very strong ground shaking with one person killed and 8 injured. Damage to buildings and infrastructure was estimated at $3.1 billion. Many onland faults, like the left-lateral Punta Montalva strike-slip fault zone, and offshore structures, like the Investigator and Caja de Muertos normal-fault zones, are located in this region. Ongoing research through the Puerto Rico Seismic Network and offshore submarine geophysical surveys will clarify the faults responsible for the 2020 earthquake swarm.

Plate boundary subduction zone earthquakes are important hazards for Puerto Rico and the Virgin Islands.  However, as demonstrated recently, shallow earthquakes on the microplate boundaries also present important earthquake and tsunami hazards.