**Central America—Earthquakes & Tectonics NARRATION for:**

<https://www.iris.edu/hq/inclass/animation/637>

Central America lies along an eastern segment of the seismically and volcanically active circum-Pacific “Ring of Fire”. The North American Plate moves west-southwest with respect to the Carib*be*an Plate along the Motagua–Swan Islands left-lateral transform plate boundary. On the west, the Cocos Plate subducts beneath the Carib*be*an Plate producing hundreds of earthquakes every year and stunning volcanoes that loom over the region. Nearly 50 million people are concentrated along this fertile volcanic belt where, over the past century, transform faults and shallow *INTRA-*plate earthquakes have had more human impact than have subduction zone earthquakes.

To understand why, let’s first examine earthquakes in the Cocos–Carib*be*an subduction zone.
Since 1970, there have been 13 major magnitude 7 earthquakes on or near the megathrust plate boundary, but there have been no great events of magnitude 8 or larger since 1900. In cross section, we see that shallow earthquakes occur along and inland from the plate boundary while deeper earthquakes occur only within the Cocos Plate. Major earthquakes generally occur along the plate boundary at depths of 20 km to 60 km. Ground shaking is strongly controlled by distance of an earthquake from an observing location. A magnitude 7.4 earthquake occurring offshore at 20 km depth will cause Very Strong shaking at the coast but only Light shaking along the volcanic arc where population centers are located. The same magnitude 7.4 earthquake occurring beneath the coast at 60 km depth will also cause Very Strong shaking at the coast but intensity will decrease to Moderate shaking along the populated volcanic arc. In 2001, a magnitude 7.7 earthquake occurred offshore of El Salvador. Extension in the upper part of the Cocos Plate where it bends resulted in a normal fault rupture that propagated from 54-km deep… upwards with maximum displacement of over 5 meters at about 35 km depth. Strong to very strong ground shaking affected the rugged topography inducing thousands of landslides that caused most of the 844 fatalities.

In a typical tsunami-generating megathrust earthquake, rupture occurs at 3 to 4 km/sec producing seismic waves and resulting ground motion with a range of frequencies, including short-period oscillations that people feel. This ground shaking is nature’s warning to move quickly away from shore to high ground in anticipation of a tsunami.” In 1972, Hiroo Kanamori proposed the term “tsunami earthquake” for a megathrust earthquake that ruptures slowly and smoothly along the boundary at 1 to 1.5 km/second, less than half the normal rupture velocity, so it radiates less energy in short-period seismic waves and more energy in longer-period waves that people might not feel. On September 1, 1992 at about 7 PM local time, an earthquake off the coast of Nicaragua initiated at 45 km depth on the subduction plate boundary. Some coastal residents felt weak ground shaking but not strong and prolonged shaking that would have been taken as the natural tsunami warning. Within 30 minutes of the earthquake, a tsunami with run-ups reaching almost 10 meters struck the coast. Although initial earthquake magnitude based on short-period seismic waves was only 6.8, subsequent analysis of broadband records revealed a maximum fault displacement of 4 meters and a moment magnitude of 7.7. This event confirmed Kanamori’s tsunami earthquake hypothesis and it motivates combining GPS and seismic observations to provide more accurate and rapid tsunami warnings.

The Motagua Fault of Guatemala forms the on-land segment of the North America–Carib*be*an transform plate boundary. At 3:03 AM local time on February 4, 1976, a major earthquake with moment magnitude of 7.5 initiated at 5 km depth beneath the epicenter near Los Amates and ruptured 60 km eastward and 170 km westward along the Motagua Fault. The 230-km-long ground rupture was the longest in the western hemisphere since the 1906 San Francisco earthquake. Along the rupture zone, very strong to violent ground motion was amplified in areas underlain by young volcanic ash deposits. Offset of features, such as chalk lines on soccer fields, rail lines, and roads, verified left-lateral displacement. Over 3 meters of offset on the Fault occurred 30 km northeast of Guatemala City. Earthquake-induced landslides occurred on steep valley walls, including within Guatemala City. The impact of the earthquake was staggering. Houses with adobe-block walls collapsed on sleeping residents. This scene shows adobe houses reduced to rubble while the steel-reinforced concrete block school buildings with corrugated roofs were essentially undamaged. Widespread damage of transportation systems hampered recovery efforts. Normal fault displacement also occurred on the Mixco Fault in the western suburbs of Guatemala City. Basin-and-range-style crustal extension south of the Motagua Fault causes normal-faulting that also pose local earthquake hazards.

The Nicaragua Depression is a topographic valley along the volcanic arc through much of northern Central America. Detailed analysis of shallow subduction zone earthquakes and recent GPS observations indicate that a “Forearc Sliver” of the Carib*be*an Plate between the Middle America Trench and the volcanic arc is moving NW parallel to the trench at a rate of 1.4 cm/yr. Shallow crustal earthquakes have resulted in disasters for population centers located along the Nicaragua Depression. Some strike-slip earthquakes along the volcanic arc, have resulted from right-lateral faulting on NW-SE oriented strike-slip faults that accommodate northwest transport of the Forearc Sliver. An example of this was the February 13, 2001 M6.6 event on the El Salvador Fault. Three decades earlier and 360 km southwest, magnitude 6.2 earthquake struck just after midnight rupturing the ground surface along faults that ran directly through central Managua. Ground displacements provide clear evidence for left-lateral offset of multiple NE-SW oriented strike-slip faults during this earthquake. The majority of wood-frame-and-adobe or poorly-reinforced masonry buildings were heavily damaged or destroyed by the 10 seconds of very-strong to violent ground shaking. In a scene reminiscent of San Francisco in 1906, fires burned for days because fire-fighting equipment was destroyed in collapsed firehouses and roads were covered in rubble. For fear of epidemic disease, portions of the city were turned into mass graveyards. But how do the NE-SW oriented left-lateral strike-slip faults relate to the Forearc Sliver? Let’s examine textbooks tilting on a bookshelf. As the books tilt, the “faults” between the books are offset in a left-lateral sense. In a similar fashion, left-lateral strike-slip faulting between rotating crustal blocks in the Nicaragua Depression can accommodate coast-wise transport of the Forearc Sliver.

While transform fault and shallow crustal intraplate earthquakes have dominated the recent history of deadly and destructive earthquakes in Central America, we should never underestimate the potential destructive power of subduction zone earthquakes.  The Sumatra 2004 and Japan 2011 magnitude 9 earthquakes and resulting tsunamis delivered the lesson that many centuries may pass between great subduction zone earthquakes.  We do not know whether or when a great magnitude 8 or 9 subduction zone earthquake may occur on the Cocos – Caribbean plate boundary.” What we do know is that Central America is one of the most vulnerable and highest risk areas in the world for earthquakes.  Advancing emergency management and improving earthquake resilience of buildings and infrastructure are vitally important to minimize the impact of future earthquakes.