**Narration from the animation:**

**Tsunamis Generated by Subduction Zone Earthquakes**

Three examples of deformation & displacement

Subduction-zone mega-thrust earthquakes, the most powerful earthquakes, can produce tsunamis through a variety of structures that are missed by simple models. The basic model shows rock above the convergent plate boundary being compressed and bent as it stores elastic energy . Once friction is o vercome, the overriding plate slides abruptlyup the fault causing the leading edge to heave seawater upward generating a tsunami. This shallow-angle reverse fault is called a thrust fault because the overriding plate thrusts *up* over the subducting plate. Let’s explore different tsunami-producing mechanisms by examining three famous earthquakes.

In 2011, the magnitude 9 Japan earthquake ruptureda fault area 500 kilometers long by 200 kilometers wide over an interval of nearly three minutes.. Surveys of sea-floor bathymetry before and after the earthquake document up to 50 meters of fault displacement at near the Japan Trench. What would that look like in cross section? During the rupture process, the overriding plate slid up the west-dipping fault plane, That uplifted the sea floor by 10-meters producing the local tsunami that rushed onshore within 20 minutes of the earthquake and the distant tsunami that spread over the Pacific Ocean Basin. Due to effective emergency education, 96% of citizens evacuated the tsunami inundation zone to survive this natural disaster.

Next let's examine how deformation, as well as fault displacement, of the overriding plate can produce a tsunami.

The 2010 magnitude 8.8 Chile earthquake tore a rupture zone 600 km long by 130 km wide. Although the rupture began at approximately the same distance from the trench, there was little, to no displacement at the trench as there was during the Japan earthquake. *So*, what generated the local tsunami that resulted in 123 deaths and produced major damage in coastal towns?

Fault displacement ranged from 5 meters at the hypocenter beneath the coast to 10 meters midway to the trench, then decreased to little or no pdisplacement at the trench. Westward displacement of the continental shelf above the plate boundary caused broad uplift of the seafloor. In addition, the change in amount of displacement along the plate boundary caused internal deformation of the overriding plate. These effects combined to uplift the ocean floor by 2 to 3 meters. This sudden uplift generated the deadly local tsunami *along the coast of South America and Juan Fernandez islands*. Alerted by strong ground shaking, coastal residents evacuated to high ground. Unaware of the danger, many vacationers did not evacuate and became victims of the tsunami.

Our third example introduces splay faulting during the rupture.

The 1964 magnitude 9.2 Great Alaska Earthquake ruptured a major segment of the eastern Aleutian subduction zone 800 km long lasting over 4 minutes. The continental shelf and slope of the overriding North American Plate was uplifted over 9 meters while inboard areas subsided as much as 2 meters. This sudden displacement of the ocean floor generated the tsunami that claimed lives from Alaska to northern California. *Less than 2 meters of regional uplift occurred at the Trench. So what caused the* **nine** *meter uplift of the continental shelf and generated the tsunami?*

In this example, we will show that there were three contributing factors to the devastation that ensued.

With few seismometers in the region in 1964, the progression of the rupture relative to the splay faults is unknown. For simplicity, we’ll show plate-boundary displacement branching into splay faults.

During this earthquake, displacement started on the plate-boundary megathrust fault producing 2 to 4 meters of regional seafloor uplift & subsidence.

However, most of the fault offset ramped up to the seafloor on “splay” faults like the Patton Bay Fault that was displaced 9 meters. Because displacement on steeply-dipping splay faults causes larger uplift of the ocean floor, a bigger tsunami is produced ***and*** it starts closer to shore providing less time to evacuate.

In steep-sided fiords and inlets, ground shaking caused landslides, some entirely below sea level, resulting in surges of seawater up to 50 meters high that struck coastal t owns, including Seward and Val-deez. This third type of tsunami took 77 lives. In these vulnerable locations, the usual “drop, cover, and hold on” response to ground shaking must become “evacuate immediately from low ground, even *during* earthquake ground shaking”.

The tsunami-producing mechanisms illustrated here are still just a glimpse into the variety of subduction zone earthquake faulting and folding processes.

The Alaska 1964, Chile 2010, and Japan 2011, as well as the catastrophic 2004 Sumatra subduction zone megathrust earthquakes have delivered powerful lessons that rapid evacuation of tsunami inundation zones *is* a life-saving emergency response.