

Teachable Moment: Earthquake and Tsunami in Japan

On Friday, March 11, 2011, Japan experienced a catastrophic earthquake at 2:46:23 pm local time (i.e. 12:46:23 am EST). The earthquake occurred off the coast of the island of Honshu, approximately 80 miles (129 km) east of the community of Sendai. The 9.0 Richter magnitude earthquake, and the accompanying tsunami that resulted, have provoked the largest crisis that Japan has encountered in the 65 years since the end of World War II. The Honshu earthquake was the world's fourth largest earthquake since 1900 and the largest in Japan since modern instrumental recordings began 130 years ago.

About 1,500 earthquakes strike the island nation every year. Minor tremors occur on a nearly daily basis

Instructors Note: This file provide notes for each image, movie and flash interactive included in your download. Additional information/lessons at www.LayeredEarth.com.

Part A. Tectonic Plates

Image: 01_Tectonic Plates

The rigid outer shell of the Earth, called the lithosphere, is broken up into many rigid segments of different sizes and shapes.

Image: 02_Tectonic Plates Velocity

These rigid segments, called plates, are in fluid motion relative to each other. Speed vectors highlight the fact that the Pacific plate is the fastest moving tectonic plate on the Earth's surface.

Image: 03_Tectonic Plates Strain Rate

As the giant plates move, along their borders, tremendous energies are unleashed resulting in tremors that transform Earth's surface.

Image: 04_Tectonic Plates Shaded

Japan sits on the boundaries of four tectonic plates; the Pacific plate, the Philippine plate, the Okhotsk plate and the Eurasian plate.

Image: 05_Tectonic Plates Arrows

The March 11, 2011 Honshu earthquake was caused by the Pacific plate sliding under the Okhotsk plate at a convergent boundary. A convergent boundary represents an area where two plates are moving toward one another, or converging.

Earthquake Fault Types Flash Interactive

On the web at: <http://www.thelayeredearth.com/demo.interactive.faults.html>

Interactive animation showing the rapid release of stored energy that causes an earthquake. The Honshu earthquake occurred along a reverse fault.

Part B. The Earthquake

Image: 06_Tilted_Shaded_Earthquakes

The movement of the Pacific plate under the Okhotsk plate has resulted in the formation at the plate boundaries of a deep oceanic trench known as the Japan Trench. The Japan Trench has a maximum depth of 9,000 m (19,500 ft).

Image: 07_Epicenter_Nuclear_Plants_Volcano_Tilted

A tilted view of the many aftershocks that followed the magnitude 9.0 earthquake on March 11, 2011. The location of the Onagawa, Fukushima Daiichi, Fukushima Daini and Tokai nuclear power plants are highlighted with triangular markers.

Image: 08_Epicenter_Nuclear_Plants_Volcano Locations

Japan has continued to experience a large number of smaller earthquakes following the catastrophic March 11 earthquake.

Image: 09_Colored_Earthquake_Magnitude_Nuclear_Plants

The location of the Onagawa, Fukushima Daiichi, Fukushima Daini and Tokai nuclear power plants are highlighted with triangular markers. A star indicates the epicenter of the March 11 earthquake. Red dots represent magnitude 6+ or aftershocks, yellow dots magnitude 5-6 aftershocks and green dots less than magnitude 5 aftershocks.

Image: 023_Earthquake_Shake_Map

A shake map for the Honshu earthquake. A shake map shows ground movement and shaking intensity for an earthquake. Notice how the shaking intensity of the earthquake was higher near the earthquake epicenter (yellow star marker). Several nuclear power plants (triangle markers) are located in areas that experienced severe shaking.

Image: 010_Ring_Of_Fire

The Honshu earthquake occurred in an area known as the Pacific Ring of Fire. The Pacific Ring of Fire is a broad 40,000 km (approximately 25,000 miles) band around the Pacific Ocean shaped like a horseshoe. This region contains over three-quarters of the world's volcanoes and accounts for 90% of the world's earthquakes.

Affects on the Earth

Image: 011_Earth_Tilt_Rotation

The Honshu earthquake was so powerful that the island of Honshu moved 2.4 meters to the east. This slight shift in the Earth's mass has resulted in a slight increase to the Earth's speed of rotation by 1.6 microseconds, thereby fractionally shortening the length of the Earth's day.

Movie: 012_Earth_Rotation.mov

The Honshu earthquake created a shift in the Earth's mass that speed up the rotation of the Earth and thereby shortened the length of a day. The Pacific plate sliding under the Okhotsk plate (resulting in an earthquake) is akin to a spinning figure skater pulling her arms in closer to increase rotation speed.

Part C. The Tsunami

Image: 013_Tsunami DART buoys

A worldwide series of early-warning sensors known as DART buoys (Deep Ocean Assessment and Reporting of Tsunamis), provided advance warning for the tsunami generated by the Honshu earthquake.

Image: 014_Tsunami_Warning_Wave_Height

On March 11, 2011 a tsunami warning was issued for Japan. The areas highlighted in red represented an estimated tsunami wave height of 3 meters or more.

Tsunami Flash Interactive

On the web at: <http://www.thelayeredearth.com/demo.interactive.tsunami.html>

Animation illustrating how water is a tsunami piles up into a large wave in coastal areas.

Image: 015_Japan on Feb 22 2011 with nuclear plants and Sendai city

Satellite image of Japan on February 22, 2011. In the March 11, 2011 earthquake, coastal areas of the city suffered catastrophic damage from the the 10-meter (33 foot) high tsunami. The tsunami damaged the backup cooling systems needed to remove heat from the reactors radioactive fuel.

Image: 016_Tsunami Energy Map

The estimated tsunami wave heights in the Pacific basin. Dark color indicate where the force of the tsunami was directed.

Image: 017_Tsunami_Travel_Time_Globe

A travel-time map for the tsunami generated by the Honshu earthquake on March 11. The tsunami travel-time map has lines and numbers (in hours) on it to indicate how long it took the tsunami to travel through the Pacific Basin.

Image: 018_Tsunami_Travel_Time_Flat

A travel-time map in mercator projection for the tsunami generated by the Honshu earthquake on March 11. The tsunami travel-time map has lines and numbers (in hours) on it to indicate how long it took the tsunami to travel through the Pacific Basin.

Image: 019_tilted shaded along fault line

The backup cooling systems at the Fukushima Daiichi nuclear power station was heavily damaged by the tsunami.

Part D. Shinmoedake Volcano Eruption

Image: 020_shinmoedake volcano

On Sunday March 13, 2011, the Shinmoedake volcano in southern Japan erupted (seen as a yellow volcano icon). In addition to earthquakes, colliding plates can also form new volcanoes or built up old ones. Whether there is a link between the March 11 earthquake and the March 13 eruption is not certain.

Image: 021_shinmoedake volcano closeup

A close up view of the Shinmoedake volcano that erupted on March 13, 2011.

Part E. Fukushima Daiichi Power Plant

Image: 022_Daiichi_Evacuation_Area

Japanese government officials have informed people living within 20 kilometers of the Fukushima Daiichi Nuclear Power Plant to evacuate, and people within 30 kilometers to stay indoors.