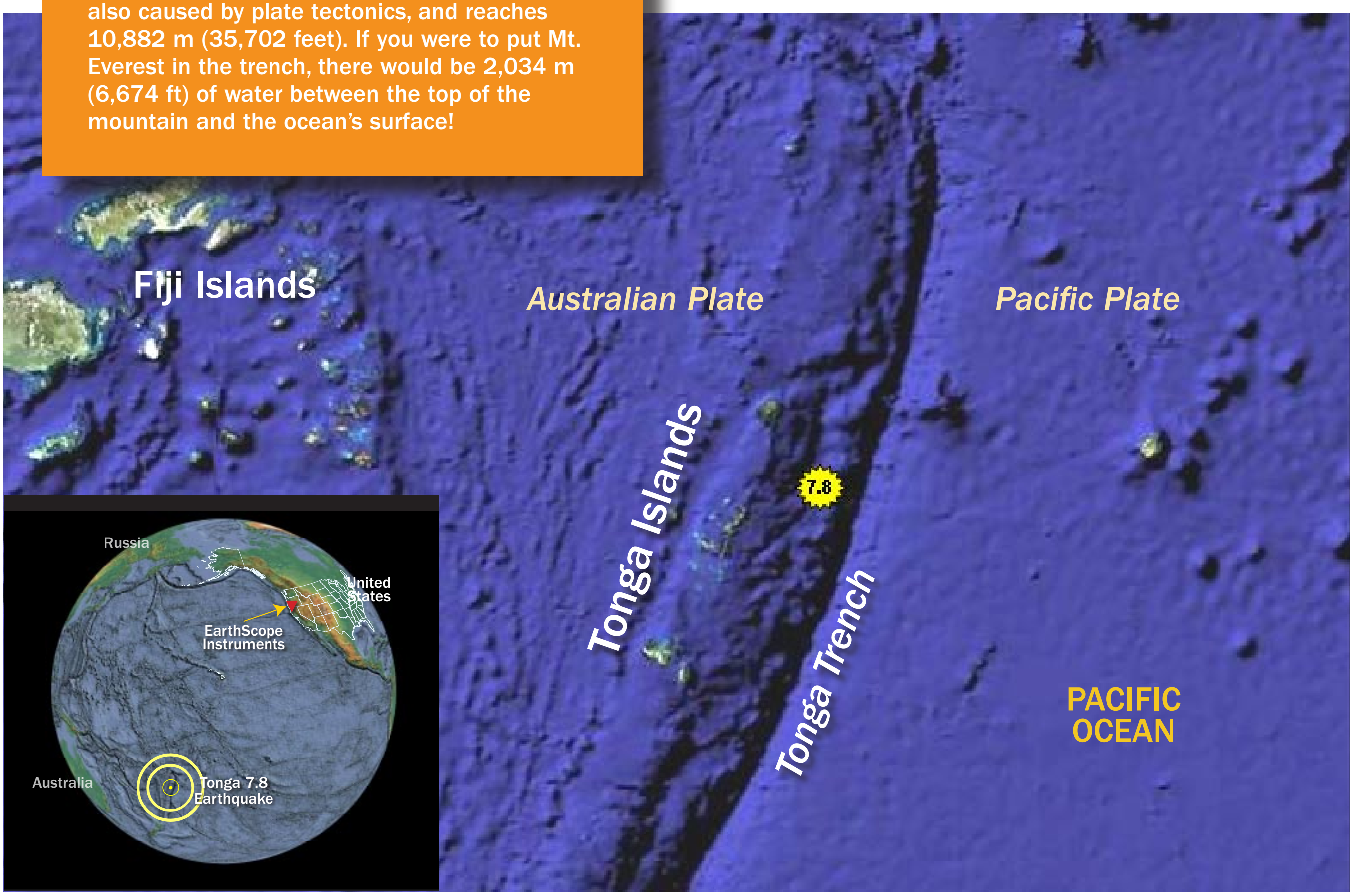
EarthScope Education and Outreach Bulletin:

Earthquake in Tonga

TONGA — On May 4, 2006, at 4:26:40 AM local time, a magnitude 7.9 earthquake shook the islands of Tonga, causing damage to the buildings on the island but no deaths. EarthScope scientists are excited by this earthquake because it provides one of the best examples of how different instruments can be used to provide a more complete picture of the Earth's interior. The combined information from seismometers, strainmeters, and GPS stations, will reveal much about how the forces inside of the Earth are driving the changes we see on the outside.

Tonga, which means South in the native language, is a small group of islands in the south Pacific, near Australia. Sometimes called the Friendly Islands because of the warm welcome always given to visitors, only 36 of the nearly 170 islands in this archipelago are inhabited. Many of these islands are volcanoes created by plate tectonics just like Alaska's Aleutian Islands; the newest of these emerged in a series of eruptions during the 1990's. The Tonga Trench which runs beside the islands was also caused by plate tectonics, and reaches 10,882 m (35,702 feet). If you were to put Mt. Everest in the trench, there would be 2,034 m (6,674 ft) of water between the top of the mountain and the ocean's surface!

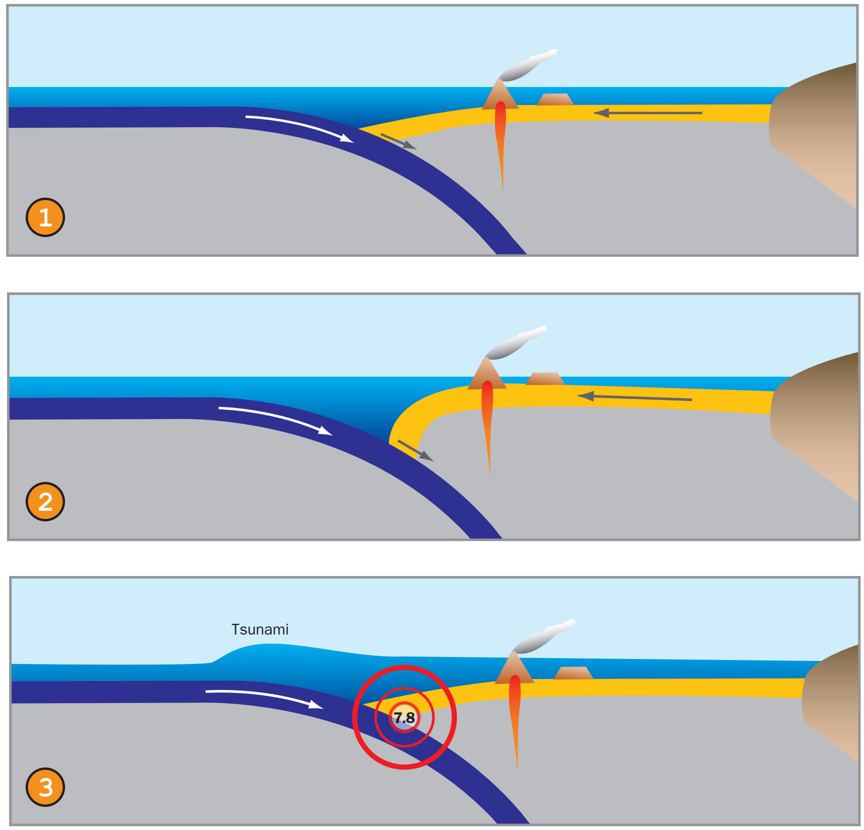
The Tonga Trench is the place where the Pacific and Australian plates meet. The motion of these two plates has created one of the most seismogenic ("earthquake making") regions in the world; every year, there are approximately 200 earthquakes near Tonga! Most of these are very small, but large earthquakes happen about once every decade; great earthquakes (those larger than magnitude 7) happen there about once a century. The effects of these earthquakes can be felt around the world. The energy from the earthquake travels as a sound wave through the Earth, and is picked up on seismometers. This sound wave causes the local rock to change shape (to strain); this change is recorded by strainmeters. And the small changes in position caused by the sound wave are detected on GPS sensors. Even though Tonga is about 9,300 km (5,800 miles) away from Seattle, EarthScope's instruments are sensitive enough to detect these changes.



Images courtesy of Google Maps, NASA, and IAGT; earthquake location from USGS.

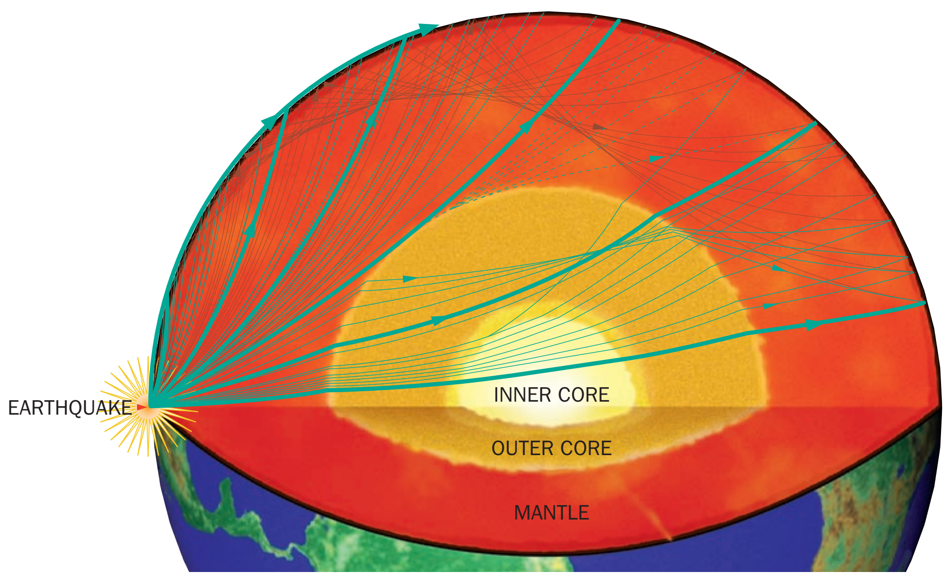
> Making Subduction Zone Earthquakes

Subduction zones have earthquakes because these are places where two plates move against each other. One plate moves under the other ("subducts"), it slowly bends the overriding plate **(1)**. This causes both plates to bend; in some cases, this bending can raise volcanoes and atolls above the ocean's surface, creating new islands **(2)**. Eventually, the overriding plate slips, creating an earthquake **(3)** and submerging some of the islands. This description of the cycle of events is known as the "elastic rebound model" and can tell us much about where earthquakes can be expected. Scientists developed it to explain their observations following the 1906 earthquake in San Francisco; however, it wasn't until the 1960's that plate tectonic theory was able to explain what causes the motion driving the earthquakes.



> Why are earthquakes interesting?

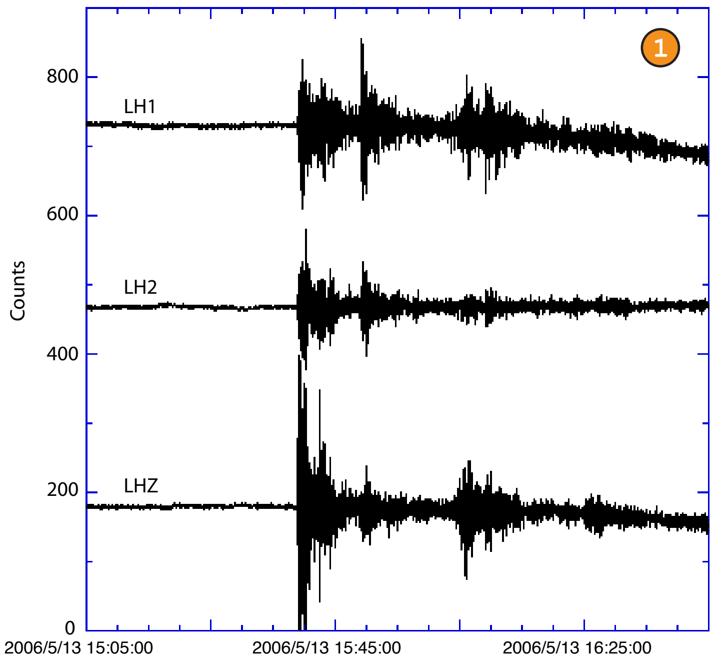
Earthquakes can build mountains and level cities, but that isn't why most scientists find them interesting. To scientists, earthquakes are interesting because they provide information about the inaccessible interior of the Earth. The deepest that anyone has drilled into the Earth is a mere 12,262 m (40,229 ft), or just 0.002% of the way to the center! All of our other information about the Earth's interior comes from observing natural phenomena such as earthquakes. By combining data from seismometers, GPS units, and strainmeters, EarthScope may help us to understand the forces underlying plate tectonics and how they create phenomena such as earthquakes and volcanoes.



The green lines show the paths earthquake energy takes as it travels through the Earth. Image courtesy of IRIS.

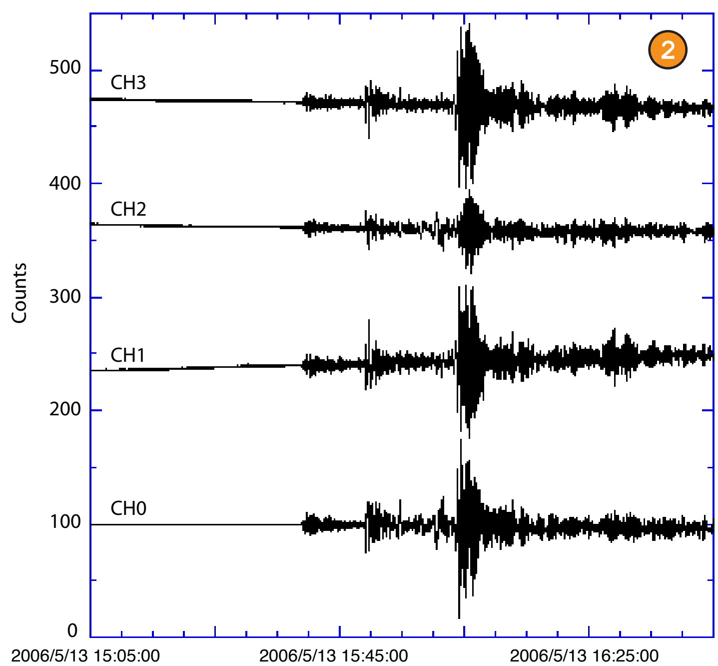
> Why do we need different instruments?

Each of EarthScope's instruments tells us something different about what happens during an earthquake or a volcanic eruption.



The seismometer **(1)** tells us how the interior of the Earth transmits the sound of the event. The strainmeter **(2)** tells us how the shape of the Earth changes. By comparing the recordings of these instruments (the data), scientists can discover new things about how the Earth works.

In these recordings, you can see when the energy from the Tonga earthquake was first recorded. The seismometers show more of the shorter waves, which tells scientists how different parts of the Earth transmitted the energy. The strainmeters only show longer waves, which tells scientists how the local rocks respond to the energy. And the GPS shows small movements but very little total change, which tells scientists that the earthquake had a small but measurable effect on local conditions. This is not unusual; for example, the 2002 earthquake in Denali, Alaska, changed the eruption pattern of geysers in Yellowstone.



Images courtesy of Kathleen Hodgkinson, EarthScope Plate Boundary Observatory.

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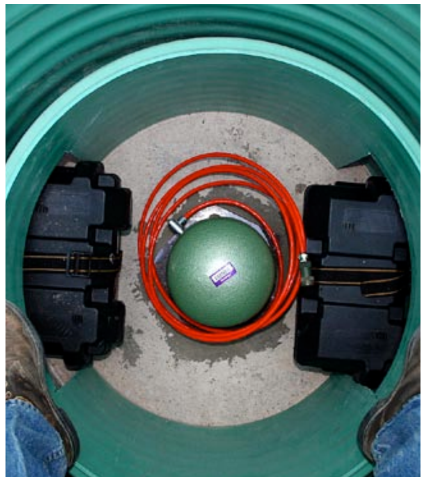
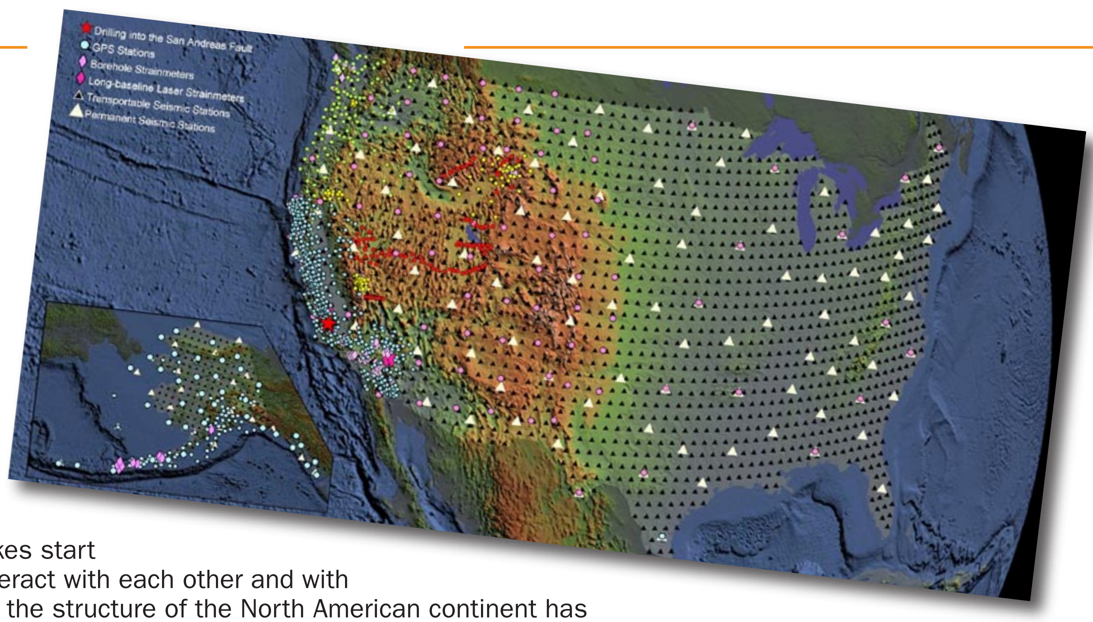


EarthScope is installing borehole strainmeters, seismometers, and GPS stations across the Pacific Northwest. Sensitive enough to record events a world away, they will tell us much about the Earth's interior and how different regions are changed by plate tectonics.

Things to think about:

1) **Will there be another earthquake near Tonga soon? Why do you think so?**
2) **How is Tonga similar to Alaska? How does plate tectonics explain their similarities and their differences?**
3) **What evidence is there that this earthquake was caused by subduction?**
4) **What will happen to Tonga in a few million years? What will happen to the subduction zone?**



What is the EarthScope Project?

Scientists working for EarthScope are examining North America's features and how they change through time. We are investigating how volcanoes grow and change, how the plate boundary deforms, how earthquakes start and grow, how faults interact with each other and with the landscape, and how the structure of the North American continent has developed. To do this, we will have over a thousand instruments placed across North America, including:

- 3.2 km (2 mi) borehole into the San Andreas Fault holding instruments to detect earthquake changes
- Hundreds of permanent GPS stations that can measure movements of less than an inch
- Almost two hundred borehole strainmeter stations that can discover changes of less than a half-inch
- About one hundred permanent seismic stations capable of detecting hundreds of earthquakes a day
- Several hundred transportable seismic stations that will be moved to more than two thousand sites

Visit us on the web at www.earthscope.org to find out more.