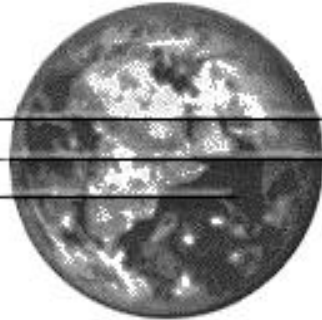


# **Geoscience 101**

## **The Solid Earth**



### **Lecture 9**

M-W-F    November 13, 15, 17  
T-R        November 14, 16

## **EARTHQUAKES**

### **CHAPTER 18**

This is only an outline of the lecture. You will need to go to class to fill in the outline, although much of the relevant information is also in the text.

# EARTHQUAKES

## FOCUS AND EPICENTER

Earthquakes are caused by movement of faults --by the fault breaking and the two sides moving in opposite directions.

Between earthquakes, energy is stored in the rock as it is in a spring: by elastically deforming (bending) the rock.

When the rock breaks, the energy is released as an earthquake.

Earthquakes rupture a section of a fault, not necessarily the entire fault.

The place in the ground where the rupture starts is called the FOCUS of the earthquake.

The location on the ground surface directly above the focus is called the EPICENTER.

## SEISMIC WAVES

Seismic waves are vibrations in rock that can be recorded by a seismograph, and which we can feel, if they are large enough.

Seismic waves pass through the rock without breaking it. They deform the rock slightly, but it springs back. This, also, is elastic deformation.

Seismic waves are divided into two classes. These are: body waves and surface waves.

Body waves travel through the Earth, whereas surface waves follow the surface.

## BODY WAVES

There are two types of body waves:

### P - Waves

Primary Waves are longitudinal or compressional waves.

Vibrations are back and forth along the direction the wave is travelling.

P Waves are the fastest waves, so they are detected first, but they are not very strong.

### S - Waves

Secondary Waves are transverse or shear waves.

Vibrations are crosswise to the direction the wave is travelling.

S waves are slower than P waves, and also are stronger.

## SURFACE WAVES

Surface waves are slower than body waves.

The rolling motion that you may see during a large earthquake is a surface wave.

There are two types of surface waves:

Raleigh waves move in vertical ellipses, like water waves.

Love waves move side to side and cause great damage to buildings. Motion is greatest at the ground surface, so they even damage building foundations.

## LOCATING THE EPICENTER

Since the P wave is faster than the S wave, it will arrive at a seismograph before the S wave.

The difference between the arrival times is used to find the epicenter of an earthquake.

The further the epicenter is from the seismograph, the greater will be the difference in arrival times.

Using a graph of distance the waves have travelled vs time elapsed since the earthquake, we can find the exact distance to the earthquake from our seismograph station.

Then we can draw circle around our station on a map, with a radius that is equal to that distance.

The earthquake must lie on that circle.

We do the same for at least two other stations.

The circles around the stations must all intersect at exactly one point. That point is the epicenter.

## MAGNITUDE

The magnitude of an earthquake is a measure of the energy released by the earthquake.

In the original Richter Scale, this was determined from the amplitudes (heights) of the P and S waves as recorded by a seismograph.

Each step on the Richter Scale is a 10x increase in the amplitude of the waves. The energy, however, increases about 30x with each step. It's the energy that does the damage.

[These numbers may be contrary to what you were taught in physics class, but earthquakes are complex events.]

The amplitude of the waves decreases with distance from the earthquake, so one needs both the distance and the amplitude to determine the size of the earthquake.

Seismologists now use a number called the Moment Magnitude which is more complicated to calculate but also a more accurate measure of the energy released.

## EFFECTS OF EARTHQUAKES

Please read pages 423 to 431 about Earthquake Destructiveness. This is information you need because the entire west coast is earthquake country.

Damage is caused in many ways, including:

1. The ground shifts. In 1906, the San Andreas Fault shifted 21 feet laterally. In Alaska in 1964, the ground went up as much as 39 feet in some places, and down 16 feet in others.
2. Landslides occur, mainly as a result of the shaking.
3. Unconsolidated sediment liquifies, shakes like jello, and can swallow the entire first floor of an apartment building, not to mention tilting the building on its side.
4. Fires are started when gas lines rupture, heaters and stoves are knocked over, chimneys are destroyed.

## 5. TSUNAMIS

Tsunamis are seismic sea waves that occur when the sea floor moves up or down.

They are most common in subduction zone earthquakes.

[They can also be caused by massive landslides into the sea, as geologists worry may happen to the side of Kilauea volcano in Hawaii.]

Tsunamis do strike the Oregon Coast.

If there is a subduction zone earthquake along our coastline, it is likely to be followed by a huge tsunami.

Pick up a Tsunami Hazard pamphlet (while they last).

Read the warning signs on the beach!

## EARTHQUAKES AND PLATE TECTONICS

Most earthquakes are around plate edges, because this is where most of the faults are.

The map shows earthquakes since 1963.

Subduction zones have the most and biggest earthquakes.

Our Cascadia subduction zone has very large, but rare earthquakes.

## MID-OCEAN RIDGE EARTHQUAKES

Earthquakes occur as the plates separate.

The plates are thin and hot at the ridge, so the earthquakes are small (< magnitude 6) and shallow.

The faults that form here are normal faults.

## TRANSFORM BOUNDARY EARTHQUAKES

Transform boundaries are strike-slip faults.

There are also other types of faults associated with the strike-slip faults.

The faults mostly break through the upper part of the crust, which is brittle, but the plate boundary fault probably breaks all the way through the plate. This is about 200 km (120 miles) thick.

Most transform boundary faults are in the ocean, connecting segments of mid-ocean ridge.

Transform fault earthquakes can be very large --above magnitude 8, like the 1906 earthquake in San Francisco.

Transform faults (strike slip faults) in Oregon are not plate boundaries. These include the Portland Hills fault and many faults in eastern Oregon.

Portland has had earthquakes of approximately magnitude 6 in the past 50 years.

## ZONES OF CONTINENTAL CONVERGENCE

When continents collide, for instance, because a subduction zone has brought them together, many reverse faults form.

The most famous zone of continental convergence is the Himalaya, which formed by convergence of India and Asia.

Very large earthquakes occur in and around the Himalaya and Tibetan Plateau, which was uplifted by the convergence of the plates.

There are also strike slip faults with large earthquakes, formed by sideways movement within each plate.

## SUBDUCTION ZONE BOUNDARIES

Subduction zones can have the largest earthquakes --greater than magnitude 9.

The 1964 Alaska earthquake was a subduction zone earthquake of magnitude 9.2.

Subduction zone plate boundaries are giant reverse faults.

Deeper earthquakes occur as the subducting plate descends into the mantle and is subjected to strong compressional and tensional forces.

The zone of deep earthquakes is called the Wadati-Benioff Zone.

The deep earthquakes occur because the plate stays brittle as long as it is cold.

It takes a long time to warm up. Earthquakes occur as deep as 700 kilometers below the surface.

## OREGON EARTHQUAKES

Oregon has giant subduction zone earthquakes every 300 to 500 years.

The last of these giant quakes was in 1700. There is a written record of the tsunami that hit Japan from this earthquake.

Indian villages along the coast were destroyed by the tsunami, according to legends still known to elders of coastal tribes.

The 1700 earthquake seems to have struck the coast from southern Washington state to northern California.

The 1700 earthquake may have been as large as magnitude 9, but we may be seeing the evidence of several magnitude 8 quakes, one after another, within a year or two.

Geologic evidence of giant earthquakes in Oregon include sediment deposits in many of the bays along the coast from Washington to northern California.

These deposits show that beach sand was suddenly deposited in the bays over the marshes that had formed there.

This occurred because the ground suddenly dropped when the earthquake occurred. Then, the tsunami hit, washing sand over the marsh.