Types of Waves

Seismic Waves

1. Seismic Deformation

- When an earthquake fault ruptures, it causes two types of deformation: **static**; and **dynamic**. Static deformation is the permanent displacement of the ground due to the event.
- After the earthquake, the formerly straight line is distorted into a shape having increasing displacement near the fault, a process known as **elastic rebound**.

Seismic Waves

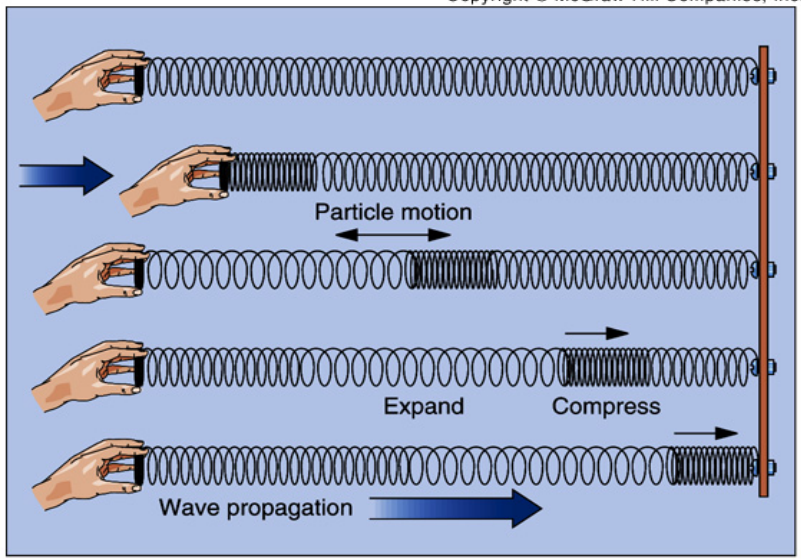
2. **Seismic Waves**

The second type of deformation, dynamic motions, are essentially sound waves radiated from the earthquake as it ruptures. While most of the plate-tectonic energy driving fault ruptures is taken up by static deformation, up to 10% may dissipate immediately in the form of **seismic waves**.

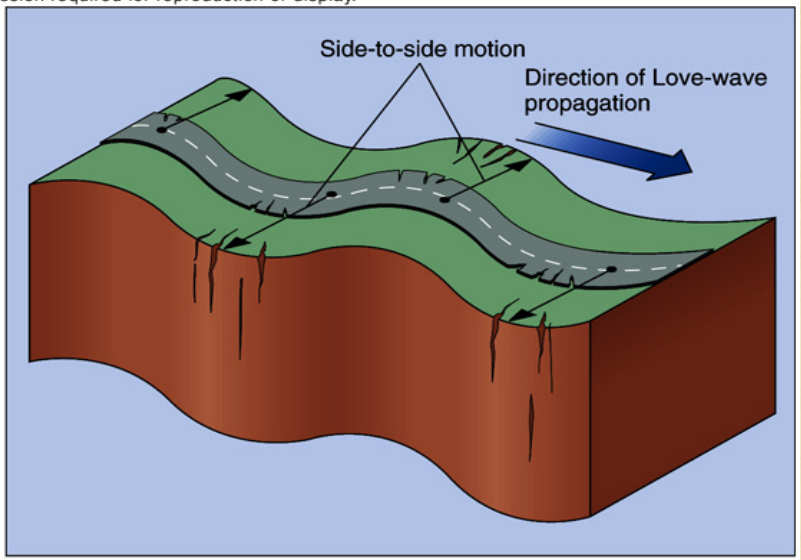
Seismic Waves: Body Waves

There are two types of body waves

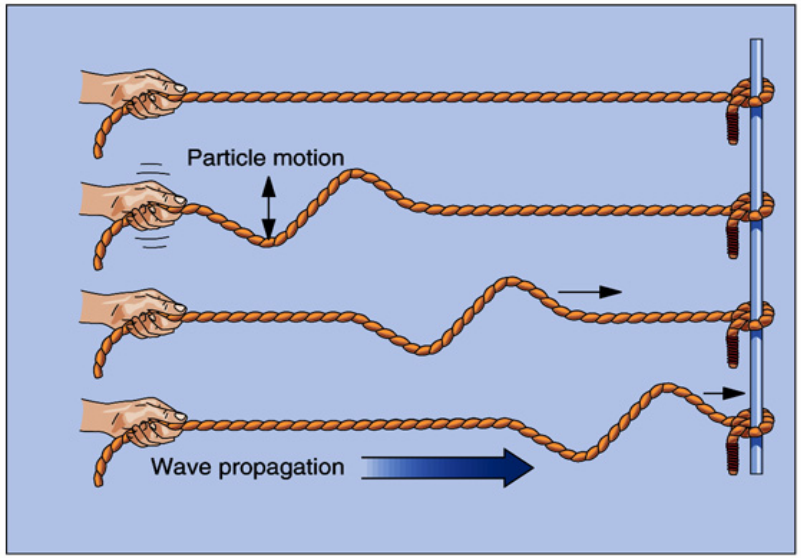
- P-Waves or Primary Waves
- S-Waves or Secondary Waves



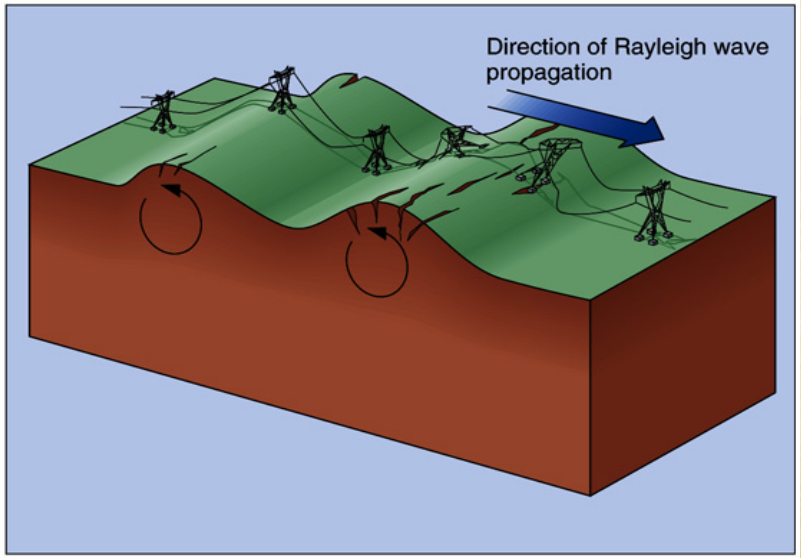
A Primary wave



C Love wave



B Secondary wave



D Rayleigh wave

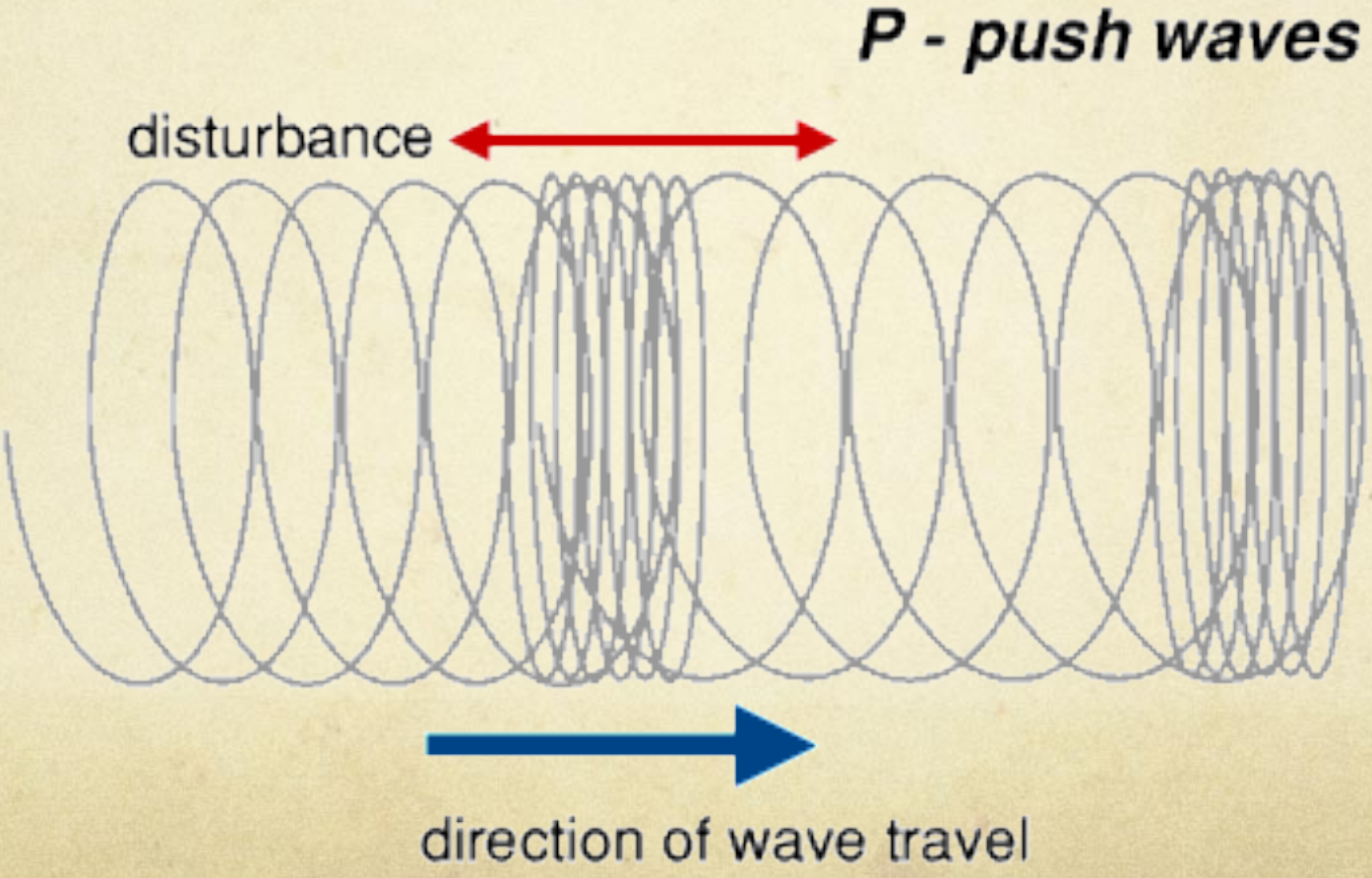
P-Waves

1. P waves arrive first. Primary, pressure waves.

- Analogous to sound waves.
- Particle motion is along the direction of travel (propagation) of the wave, i.e., longitudinal waves.
- P waves can travel through solids, liquids or gases.

P-Wave Motion

Push-Pull Motion



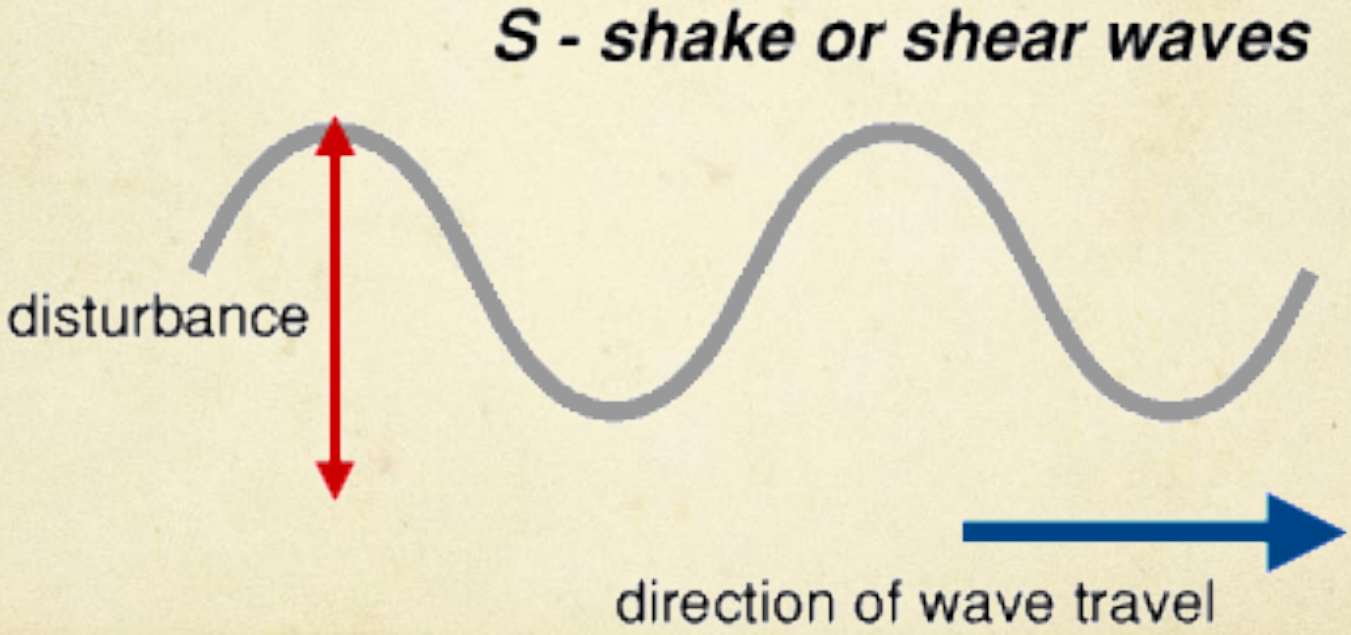
P-Wave Motion

P waves are *compression waves* - the wave pulse or pulses travels through the rock in a series of compression pulses. On either side of the compression the rock is stretched. The stretching and compression of the rock is relatively small, allowing the wave to travel very quickly.

A *P* earthquake waves arrive first and are heard and felt as a sharp thud.

S-Wave Motion

S-shake or shear wave



S-Wave Motion

S waves are characterized by a sideways movement. The rock materials are moved from side to side as the wave passes.

S waves are like water waves, the wave pulses travel along by moving the medium from side to side. As the pulse moves along, each section of rope moves to the side then back again in succession. Rocks are more resistant to sideways motion so the S wave travels more slowly.

Surface Waves

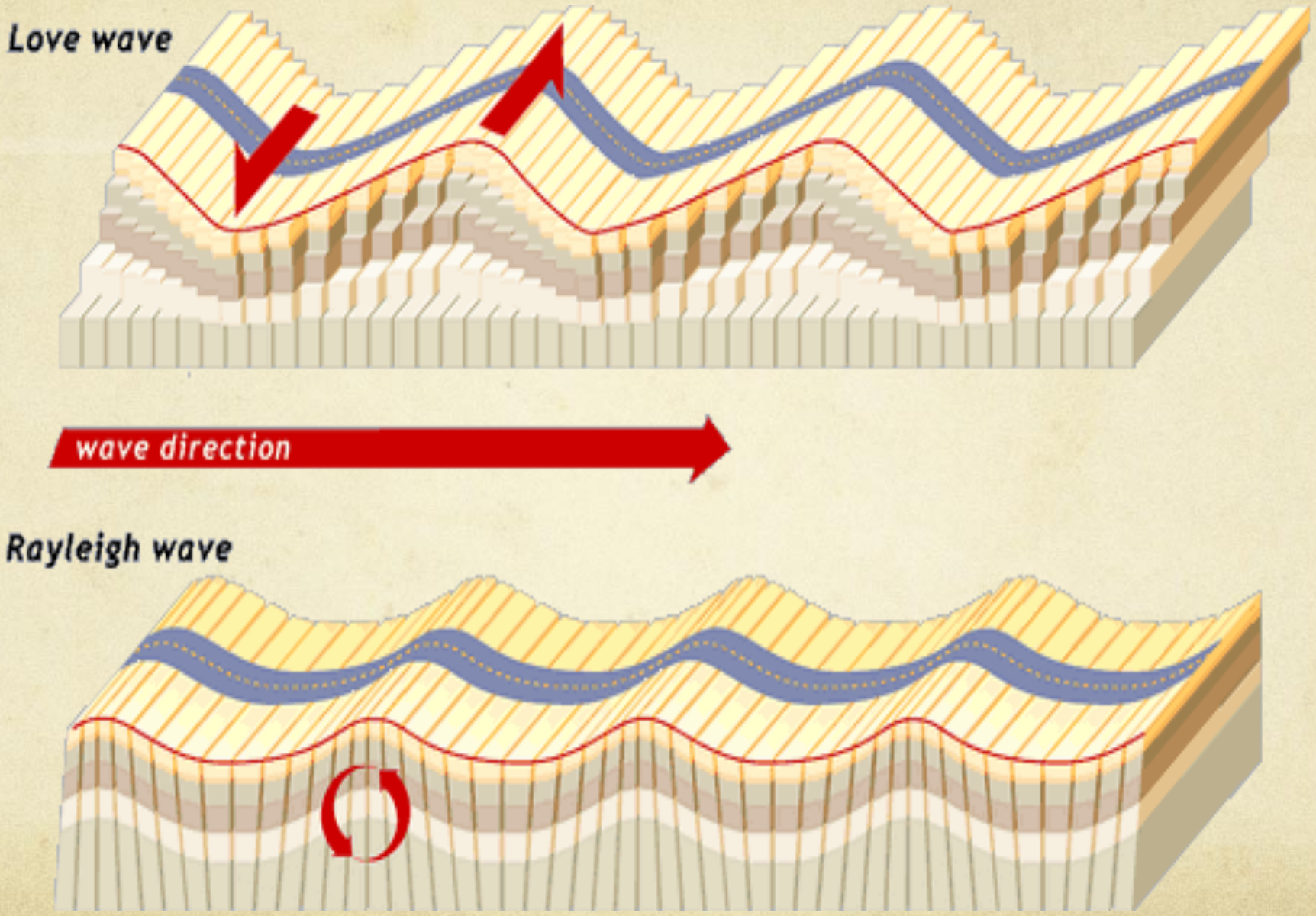
The surface waves are the slowest of the three earthquake wave types.

Two basic types of surface waves

1. Love Waves
2. Rayleigh Waves

1. L-waves or long waves.Complex motion. Up-and-down and side-to-side. Slowest. Causes damage to structures during an earthquake.

2. Rayleigh waves involve orbital motions, like water waves. A surface particle moves in a circle or ellipse in the direction of propagation.


Love wave
wave direction
Rayleigh wave

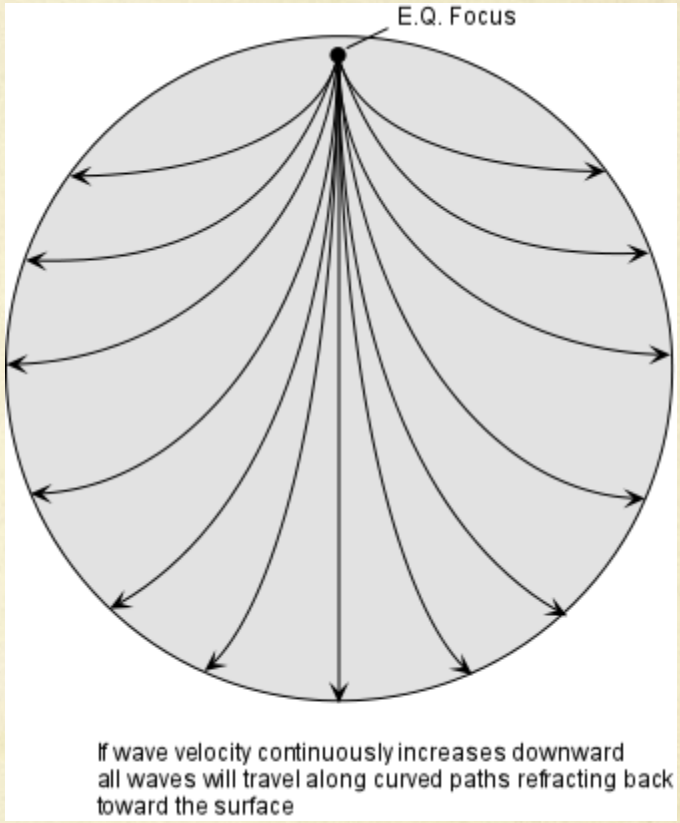
Using Seismic Waves to Study Earth's Interior

Seismic Waves travel through the entire Earth

Both S and P waves travel throughout the body of the earth, and can be picked up by seismometers - machines that record earthquakes - anywhere in the world.

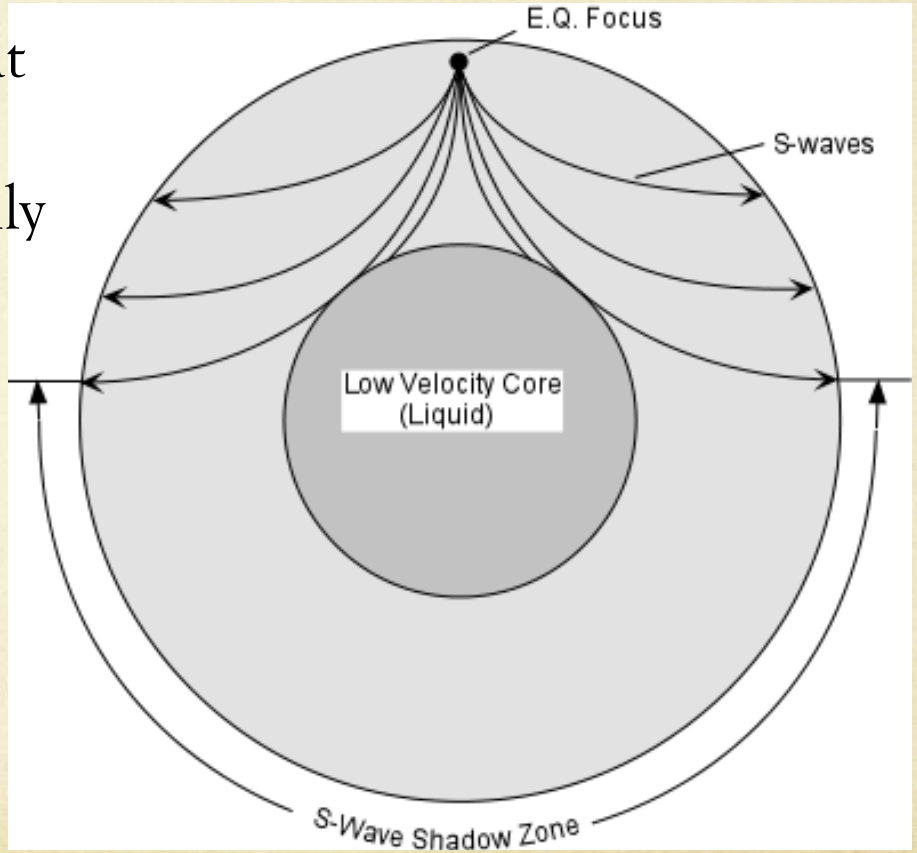
Seismic waves as "x-rays" to look inside the earth

- P-Waves travel through solid and liquid



Seismic waves as "x-rays" to look inside the earth

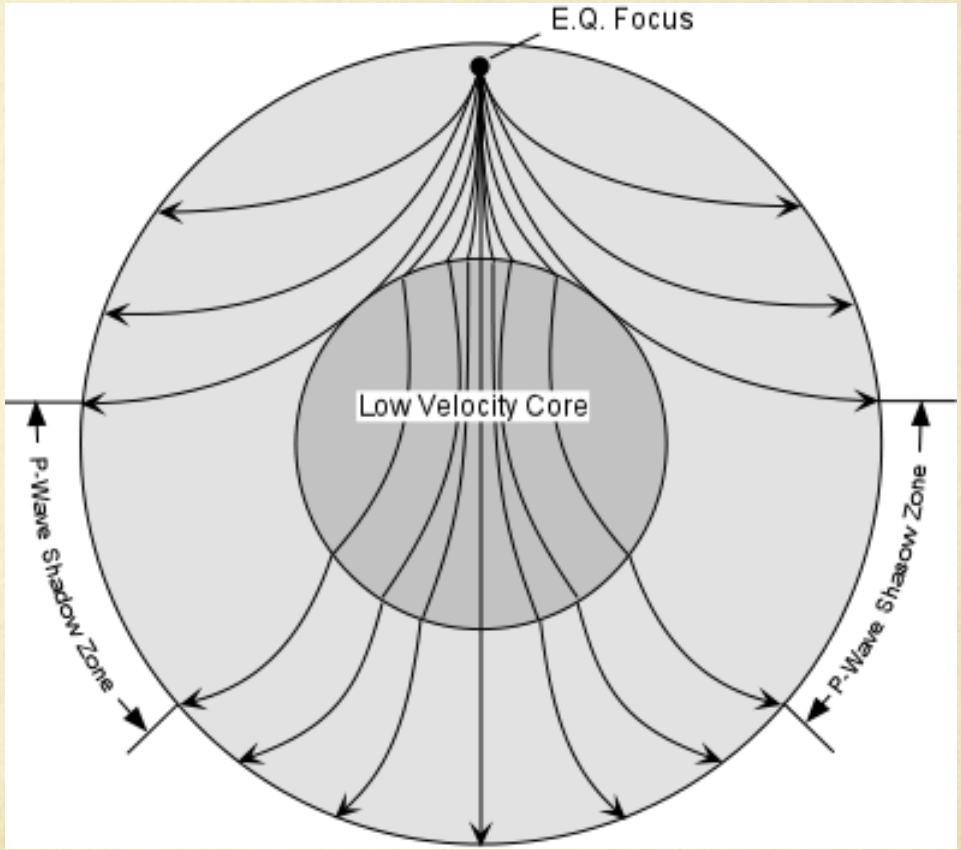
- However, it turns out that S waves cannot travel through the core, and only P waves are recorded in some places:



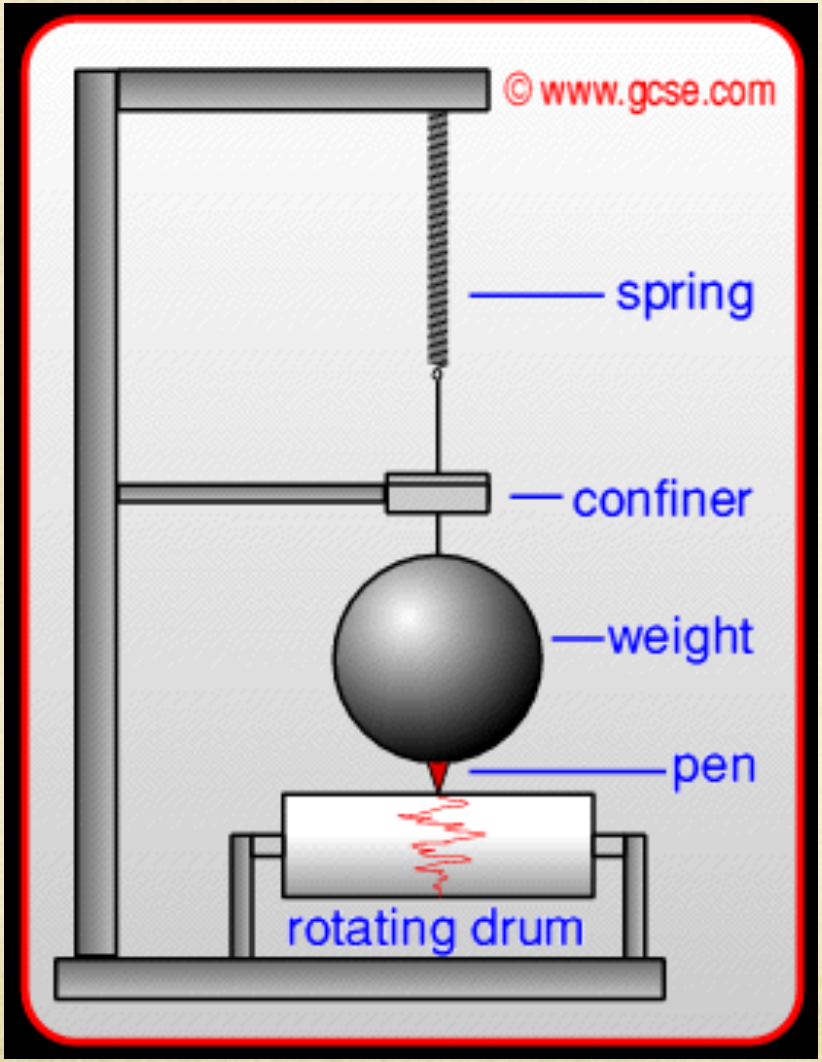
S-Waves travel only through solids

Using Seismic Waves to Study Earth's Interior

- Seismic waves travel faster through denser material.
- Because of this, the path traveled by a seismic wave is bent towards the surface.



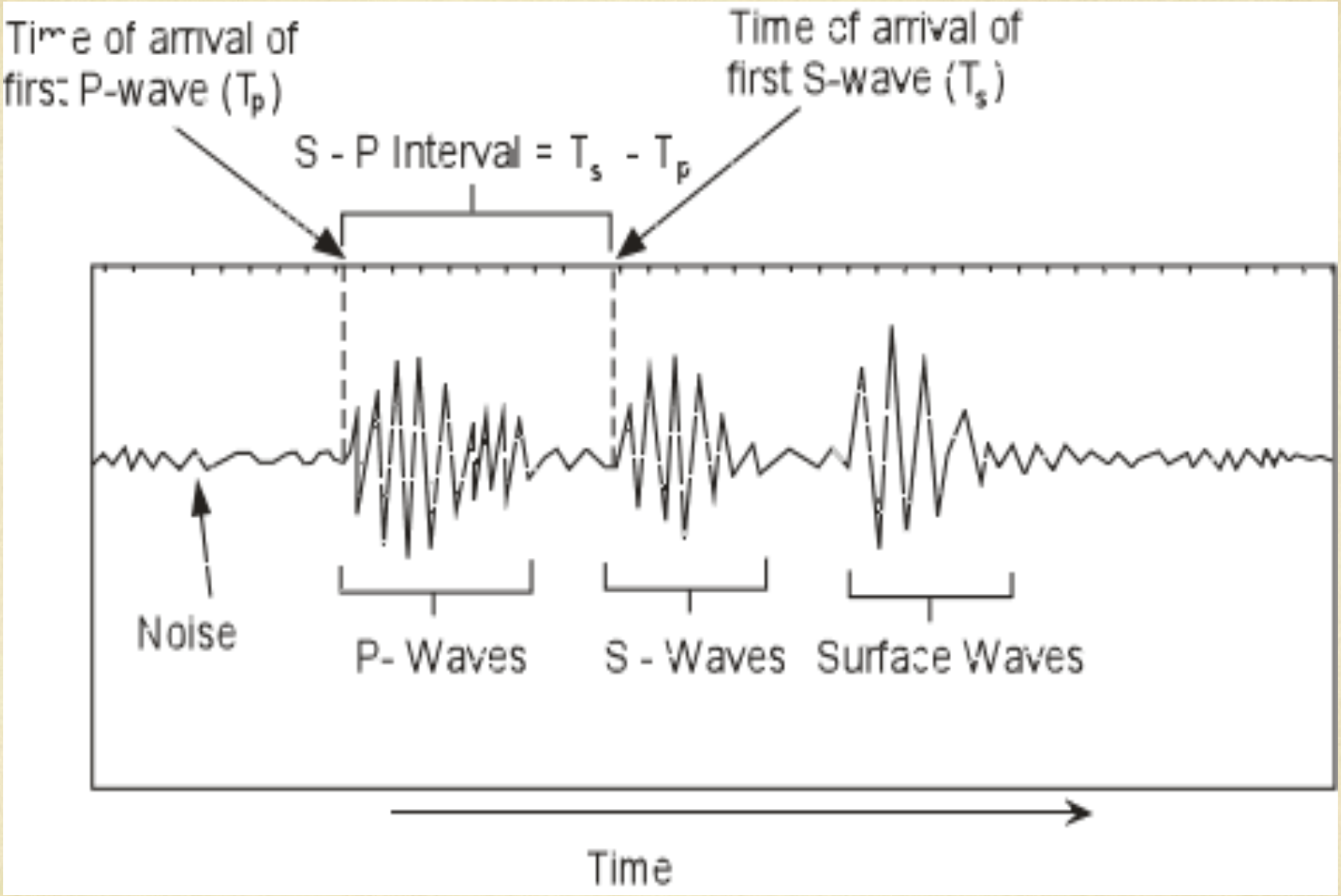
Seismometers



- A seismometer records the vibrations from earthquakes. Mechanical versions work by way of a large mass, freely suspended.
- In the example on the left, a rotating drum records a red line on a sheet of paper. If the earth moves (in this case from left to right) the whole machine will vibrate too.
- However, the large mass tends to stay still, so the drum shakes beneath the pen, recording a squiggle!

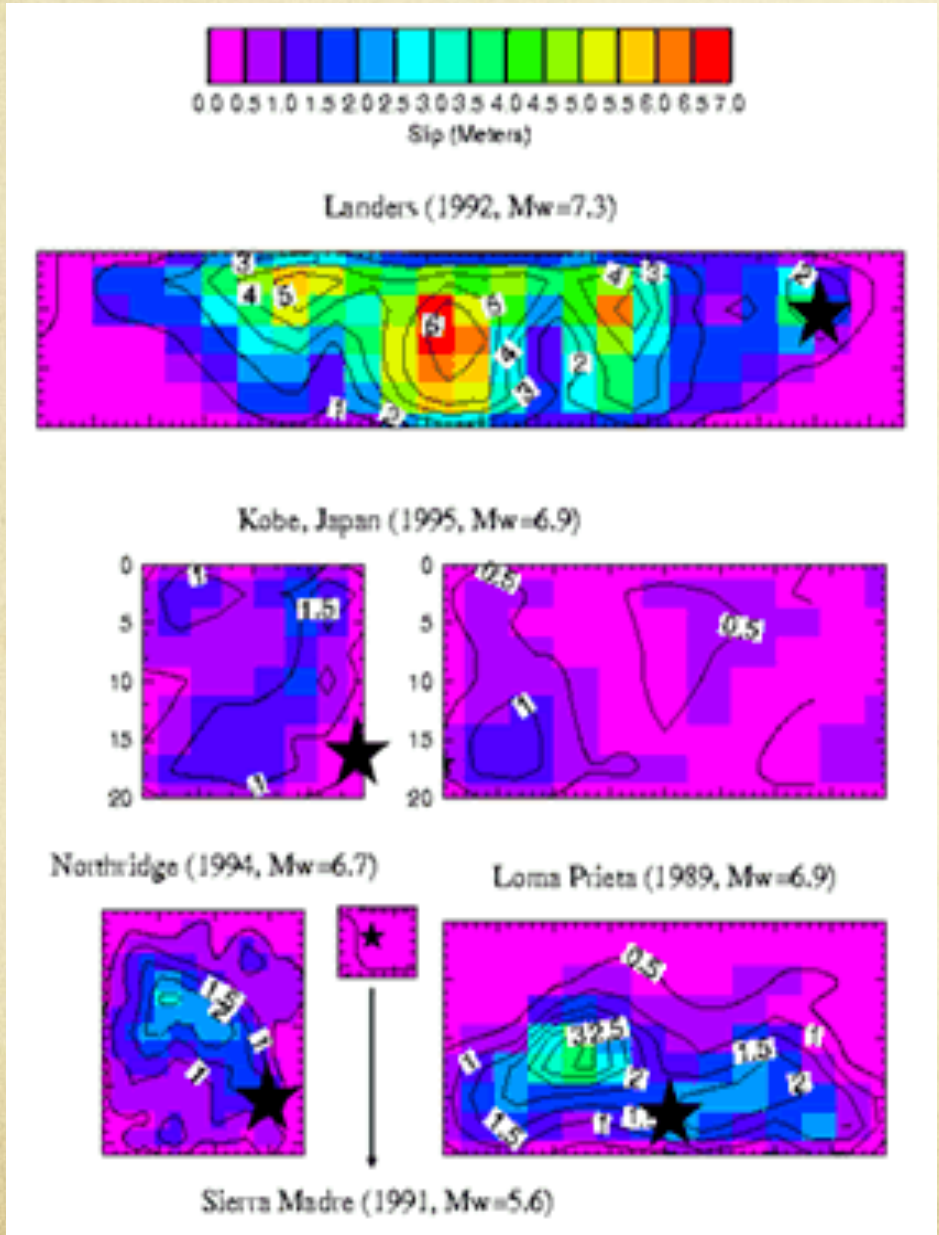
Seismograph: the record of the Earthquake

The record of an earthquake, a seismograph, as recorded by a seismometer, will be a plot of vibrations versus time. On the seismograph, time is marked at regular intervals, so that we can determine the time of arrival of the first P-wave and the time of arrival of the first S-wave.



Seismograph

Measuring Earthquakes



- There are at least 20 different types of measures
- 3 of them are the Mercalli scale, Richter scale, and the Moment Magnitude scale
- Magnitude is a measurement of earthquake strength based on seismic waves and movement along faults

Earthquake Strength

The intensity or strength of an earthquake is measured by seismologist in two main ways:

1. The Richter Scale

- measures the amount of energy that an earthquake releases
- Each number of magnitude is 10x stronger than the number below it.

The Richter Scale

Effects of Tremor	The Richter Scale
Only detected by seismometers	2
Felt by walkers, window and doors rattle	4
Severe structural damage to houses	6
Total destruction, ground actually rises and falls	8

- The Richter scale is a rating of the size of seismic waves as measured by a particular type of mechanical seismograph
- Developed in the 1930's
- All over the world, geologists used this for about 50 years
- Electric seismographs eventually replaced the mechanical ones used in this scale
- Provides accurate measurements for small, nearby earthquakes
- Does not work for big, far ones

Earthquake Strength

2. The Mercalli Scale

- Measures the amount of damage from an earthquake
- Ranges from I to XII
- Based on common earthquake occurrences such as "noticeable by people" "damage to buildings" chimneys collapse" "fissures open in the ground" .

The Mercalli Scale

- Developed in the twentieth century to rate earthquakes according to their intensity
- The intensity of an earthquake is the strength of ground motion in a given place
- Is not a precise measurement
- But, the 12 steps explain the damage given to people, land surface, and buildings
- The same earthquake could have different Mercalli ratings because of the different amount of damage in different spots

The Mercalli Scale

Earthquake Intensity	Earthquake Effects
I–II	Almost unnoticeable
III–IV	People notice vibrations like those from a passing truck. Unstable objects disturbed.
V–VI	Dishes and windows rattle. Books knocked off shelves. Slight damage.
VII–VIII	People run outdoors. Moderate to heavy damage.
IX–X	Buildings jolted off foundations or destroyed. Cracks appear in ground and landslides occur.
XI–XII	Severe damage. Wide cracks appear in ground. Waves seen on ground surface.

- The Mercalli scale uses Roman numerals to rank earthquakes by how much damage they cause

The Moment Magnitude Scale

- Geologists use this scale today
- It's a rating system that estimates the total energy released by an earthquake
- Can be used for any kind of earthquakes, near or far
- Some news reports may mention the Richter scale, but the magnitude number they quote is almost always the moment magnitude for that earthquake

Earthquake Magnitudes

Earthquake	Moment Magnitude
San Francisco, California, 1906	7.7
Southern Chile, 1960	9.5
Anchorage, Alaska, 1964	9.2
Loma Prieta, California, 1989	7.2
Northridge/ Los Angeles, California, 1994	6.7

How Earthquakes Cause Damage

- The severe shaking provided by seismic waves can damage or destroy buildings and bridges, topple utility poles, and damage gas and water mains
- With their side to side, up and down movement, S waves can damage or destroy buildings, bridges, and fracture gas mains.

Aftermath of an earthquake in Japan, 2004
Photograph by Kimimasa Mayama/Reuters

NATIONAL GEOGRAPHIC

Earthquake damage in Anchorage on March 27, 1964

San Francisco are built on sandy soil or fill. Many homes built on this type of soil were badly damaged during the 1989 Loma Prieta earthquake.

January 2, 2005

April 12, 2004

Tsunami Damage, Gleebruk, Indonesia


KALUTARA BEACH - SRI LANKA
BEFORE TSUNAMI
(*) Updated information provided by:
MGSD Nilantha
Remote Sensing and GIS Specialist
International Water Management Institute
Battaramulla - Sri Lanka
January 30, 2005
QuickBird Satellite Image acquired - January 1, 2004
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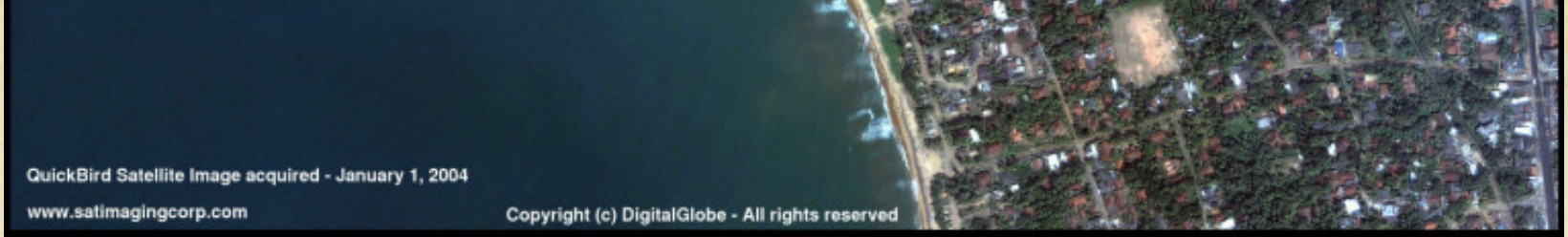
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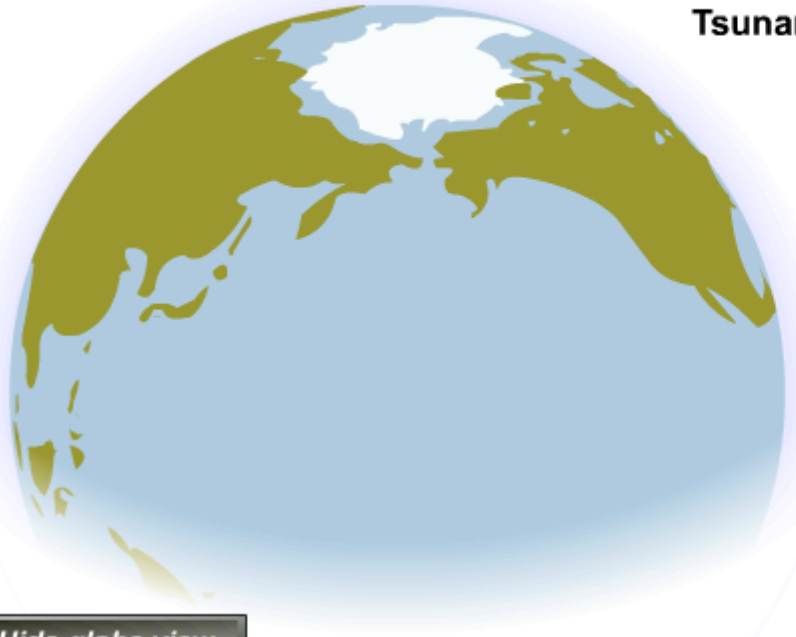
Tsunami



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