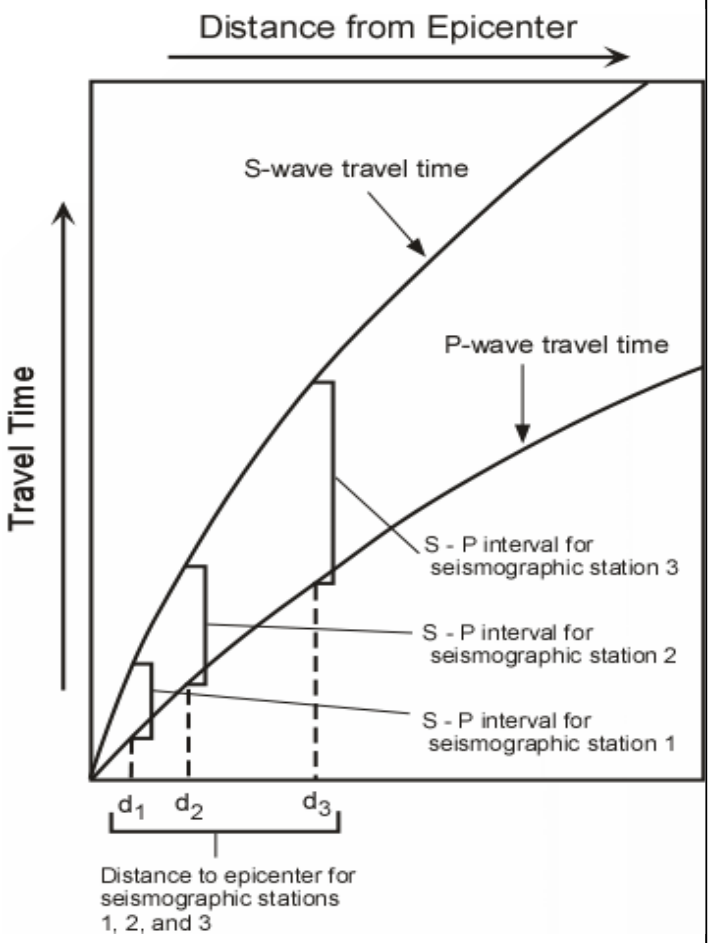
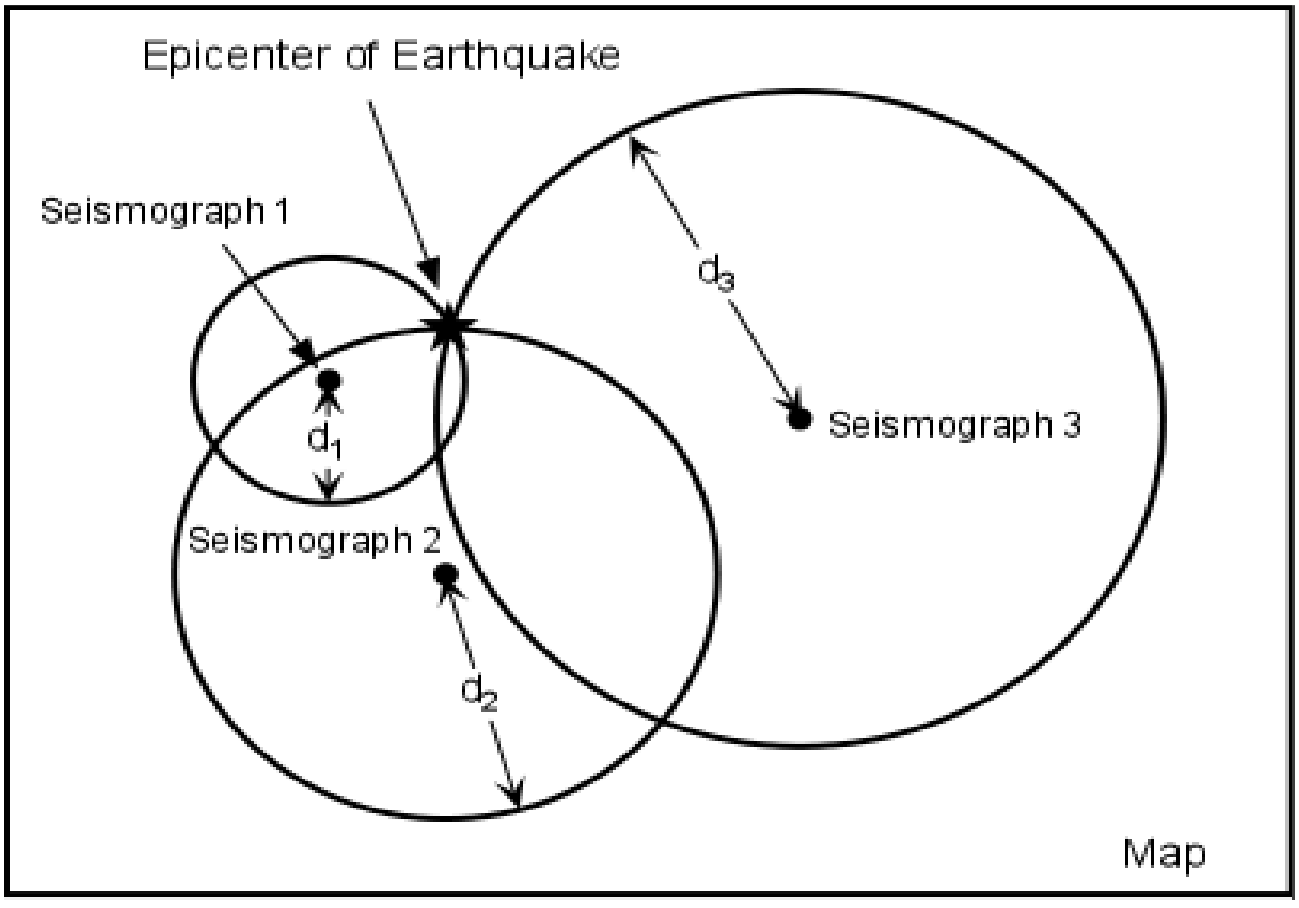
LOCATING EARTHQUAKES USING P AND S WAVES

- Location of Earthquakes - In order to determine the location of an earthquake, we need to have recorded a seismograph of the earthquake from at least three seismographic stations at different distances from the epicentre of the quake. In addition, we need one further piece of information - that is the time it takes for P-waves and S-waves to travel through the Earth and arrive at a seismographic station. Such information has been collected over the last 80 or so years, and is available as travel time curves.

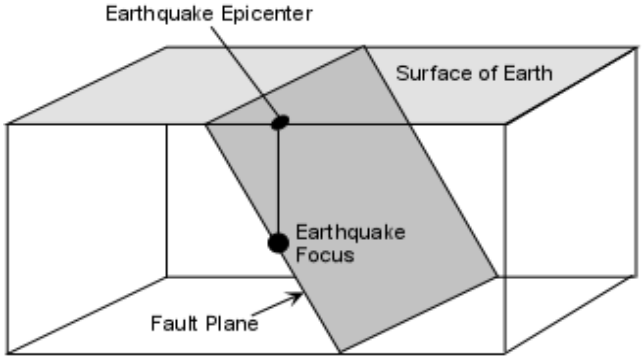
- From the seismographs at each station one determines the S-P interval (the difference in the time of arrival of the first S-wave and the time of arrival of the first P-wave. Note that on the travel time curves, the S-P interval increases with increasing distance from the epicentre. Thus the S-P interval tells us the distance to the epicentre from the seismographic station where the earthquake was recorded. Thus, at each station we can draw a circle on a map that has a radius equal to the distance from the epicentre.





SEISMIC WAVES

Seismic Waves. The source of an earthquake is called the ***focus***, which is an exact location within the Earth were seismic waves are generated by sudden release of stored elastic energy. The ***epicentre*** is the point on the surface of the Earth directly above the focus. Sometimes the media get these two terms confused. Seismic waves emanating from the focus can travel in several ways, and thus there are several different kinds of seismic waves

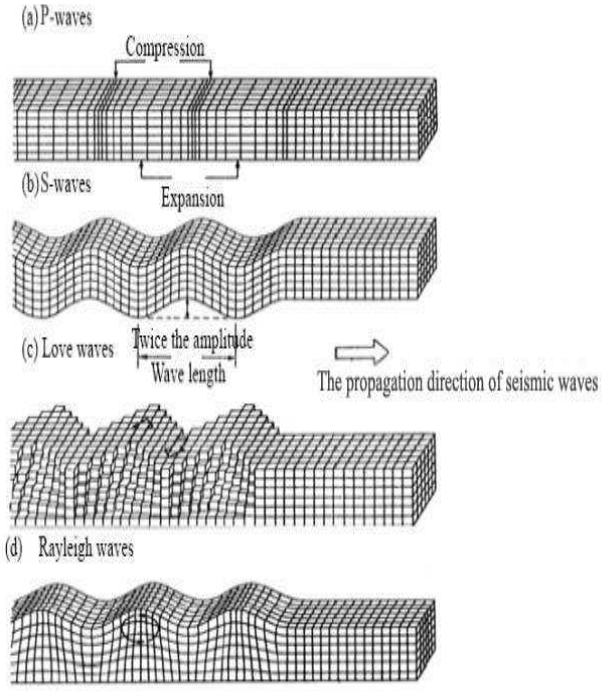


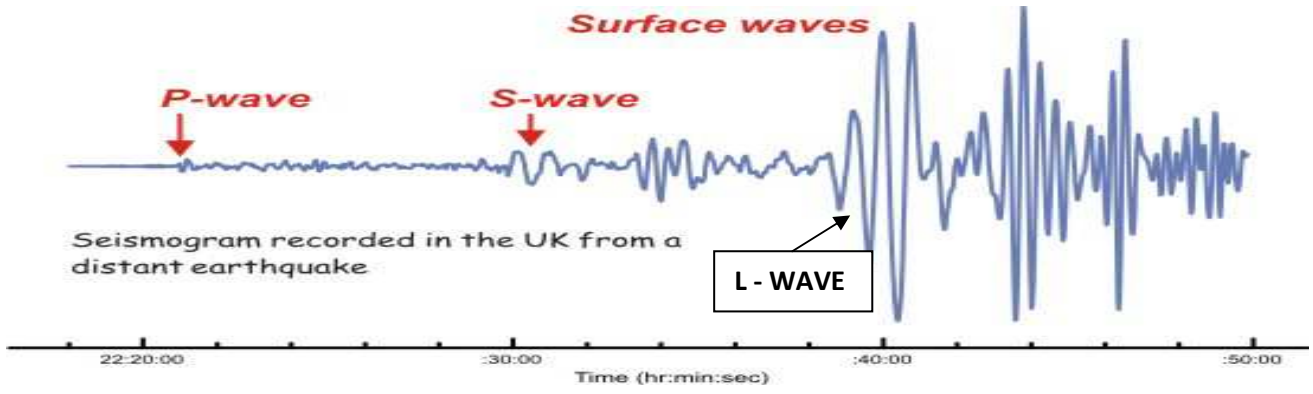
The released energy travels through the Earth in the form of waves. These waves are separated into three classes: primary, secondary and surface waves.

Primary, or P waves, are the first waves felt because they are the fastest. They move in a compressional, "push-pull" manner similar to a spring that temporarily changes the volume of the material they're moving through. These waves can travel through liquid, solid and gaseous matter.

Secondary, or S waves, are felt next. These waves move in an oscillatory, "up and down" manner similar to shaking a rope that temporarily changes the shape of the material they're travelling through. Because liquids respond to changes in volume but not shape, they will not transmit S waves.

Finally the surface waves are felt. These waves are more complex. Rayleigh waves move up and down like ocean swells along the Earth's surface while Love waves move side to side or horizontally. Surface waves are most damaging to man-made structures.





P-waves:

1. **They are Primary waves - also called comPressional waves**
2. **They travel the fastest – Phastest!!**
3. **They travel by particles vibrating Parallel to the direction the wave travel (they are longitudinal Push Pull waves)**
4. **They travel through solids, liquids and gases - all Physical matter**

S-waves:

1. **They are Seconday or Shear waves.**
2. **They travel Slower than P-waves.**
3. **They travel to right angles to the vibration of the particles - they are tranSverse(see diagram 2).**
4. **S-waves cannot pass through liquids - only travel through solids - Solely Solids.**

THE SIZE OF AN EARTHQUAKE RICHER:MAGNITUDE MERCALLI:INTENSITY

Magnitude -- measure of energy released during an earthquake. There are several different ways to measure magnitude. Most common magnitude measure is **Richter Magnitude**, named for the renowned seismologist, Charles Richter.

Richter Magnitude

- Measure amplitude of largest S wave on seismograph record.
- Take into account distance between seismograph & epicenter.

Richter Scale

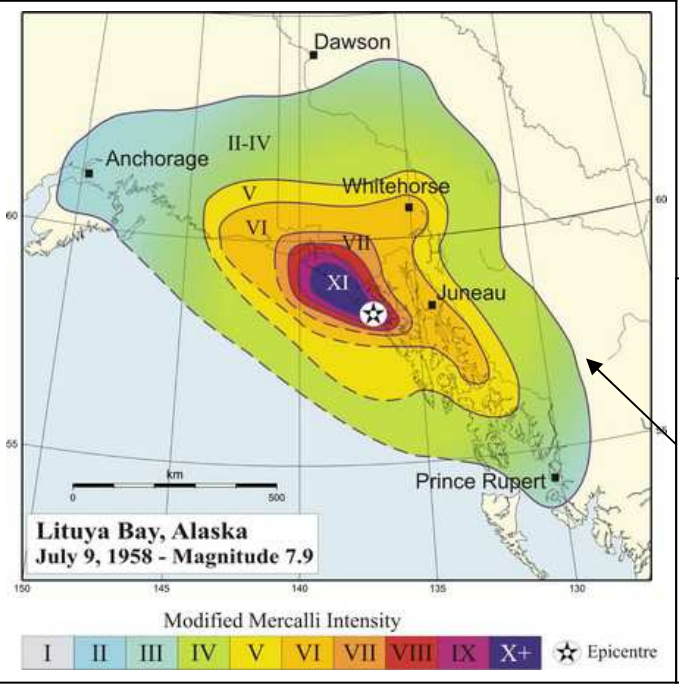
- Logarithmic numerical (NOT a physical) scale
- Increasing one whole unit on Richter Scale represents 10 times greater magnitude.
- Going up one whole unit on Richter Scale represents about a 30 times greater release of energy.

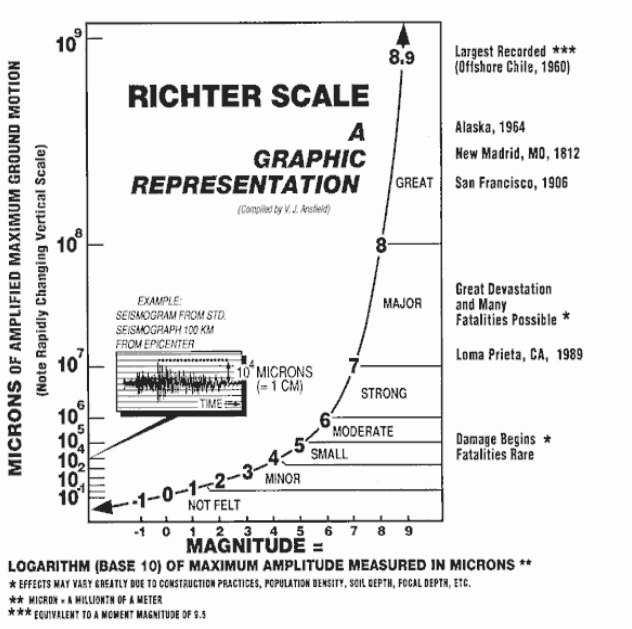
Intensity

- Intensity refers to the amount of damage done in an earthquake
- Mercalli Scale is used to express damage

Modified Mercalli Scale

I.	Not felt.
II.	Felt by persons at rest, on upper floors, or favorably placed.
III.	Felt indoors. Vibration like passing of light trucks.
IV.	Vibration like passing of heavy trucks.
V.	Felt outdoors. Small unstable objects displaced or upset.
VI.	Felt by all. Furniture moved. Weak plaster/masonry cracks.
VII.	Difficult to stand. Damage to masonry and chimneys.
VIII.	Partial collapse of masonry. Frame houses moved.
IX.	Masonry seriously damaged or destroyed.
X.	Many buildings and bridges destroyed.
XI.	Rails bent greatly. Pipelines severely damaged.
XII.	Damage nearly total.





Hazards associated with Quakes

- Shaking: Frequency of shaking differs for different seismic waves.

High frequency body waves shake low buildings more.
Low frequency surface waves shake high buildings more.
Intensity of shaking also depends on type of subsurface material.
Unconsolidated materials amplify shaking more than rocks do.
Fine-grained, sensitive materials can lose strength when shaken. They lose strength by ***liquefaction***.
Buildings respond differently to shaking depending on construction styles, materials
Wood -- more flexible, holds up well
Earthen materials -- very vulnerable to shaking.

- Ground displacement:

Ground surface may shift during an earthquake (esp. if focus is shallow). Landslides may occur on steep unstable slopes
Vertical displacements of surface produce ***fault scarps***.

- Tsunamis (NOT tidal waves)

Tsunamis are huge waves generated by earthquakes undersea or below coastal areas.
If earthquake displaces sea surface, wave is generated that can grow as it moves over sea surface.

- Fires

Usually occurs from shifting of subsurface utilities (gas lines)

Iso-seismal lines are lines joining all places of equal earthquake intensity on the Mercalli Scale. They are produced using many reports from around the epicentre where people record the effects the earthquake had. Lines are then drawn around sites of equal intensity. The intensity will usually decline with distance from the epicentre as the energy released and the effects of the earthquake decline. But other factors such as the type of rock, soil, chances of liquefaction, and even the perception of the individuals reporting the event may influence the Mercalli score given.

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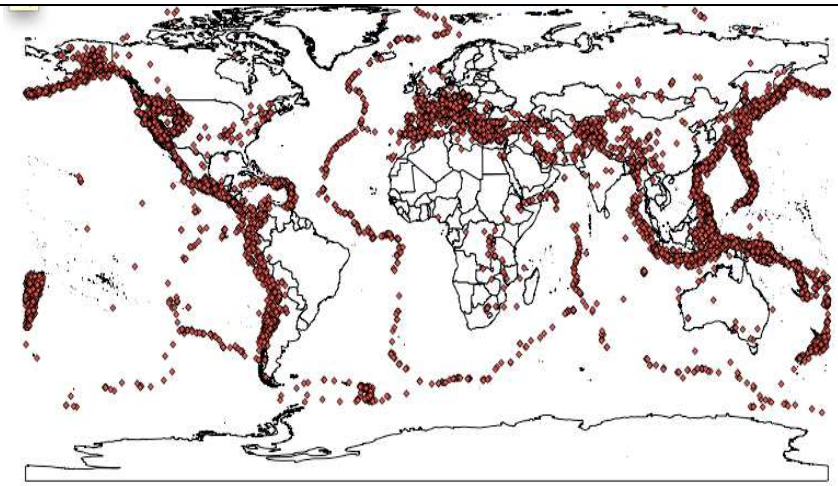
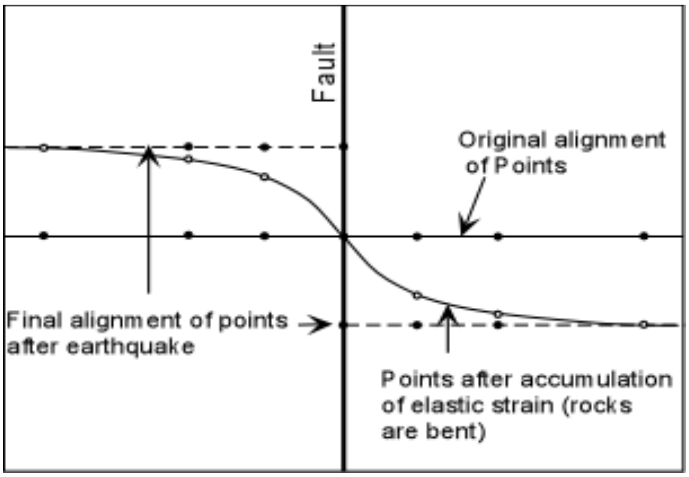
EARTHQUAKES

Earthquakes

Earthquakes occur when energy stored in elastically strained rocks is suddenly released. This release of energy causes intense ground shaking in the area near the source of the earthquake and sends waves of elastic energy, called seismic waves, throughout the Earth. Earthquakes can be generated by bomb blasts, volcanic eruptions, and sudden slippage along faults. Earthquakes are definitely a geologic hazard for those living in earthquake prone areas, but the seismic waves generated by earthquakes are invaluable for studying the interior of the Earth.

World pattern of earthquake epicentres follows plate boundaries





Cause of an earthquake

Most natural earthquakes are caused by sudden slippage along a fault zone. The ***elastic rebound theory*** suggests that if slippage along a fault is hindered such that elastic strain energy builds up in the deforming rocks on either side of the fault, when the slippage does occur, the energy released causes an earthquake. This theory was discovered by making measurements at a number of points across a fault. Prior to an earthquake it was noted that the rocks adjacent to the fault were bending. These bends disappeared after an earthquake suggesting that the energy stored in bending the rocks was suddenly released during the earthquake.

- **Seismographs - Seismic waves travel through the Earth as vibrations. A seismometer is an instrument used to record these vibrations and the resulting graph that shows the vibrations is called a seismograph. The seismometer must be able to move with the vibrations, yet part of it must remain nearly stationary**
- **This is accomplished by isolating the recording device (like a pen) from the rest of the Earth using the principal of inertia. For example, if the pen is attached to a large mass suspended by a spring, the spring and the large mass move less than the paper which is attached to the Earth, and on which the record of the vibrations is made.**