Earthquakes

The rock first breaks underground along a fault line. This location where the rock first breaks is known as the focus.

The shock waves spread outward in every direction. The point directly above the focus on the surface is known as the epicenter.

The primary (p) waves are the fastest moving waves, traveling underground, in a compressional manner (push & pull/squeeze & stretch) and shake the ground. P waves can travel through all matter (solid, liquid, gas).

The secondary (s) waves are a little more than half the speed of P waves, traveling underground, and shaking the ground side-to-side. S waves can only travel through solids, no liquid or gases.

Eventually, the waves reach the surface and begin to cause the most damage of all the waves.

Surface waves shake the ground side-to-side (Love waves) or in a rolling motion like a roller coaster (Rayleigh waves).

Seismic stations pick up the surface wave, P, & S waves using a seismograph. Seismographs record the shaking on a piece of paper called a seismogram.

Scientists can use at least three different seismic stations to determine the location of the epicenter. This is called triangulation.

Looking at data on the seismogram, scientists can find the S-P time interval. This is the difference in arrival times between the P and S waves. The S-P time interval allows scientists to determine how far away the epicenter is (or where the earthquake began.)

a. 1
b. 4
c. 8
d. 2
e. 7
f. 5
g. 9
h. 3
i. 6

An earthquake is...

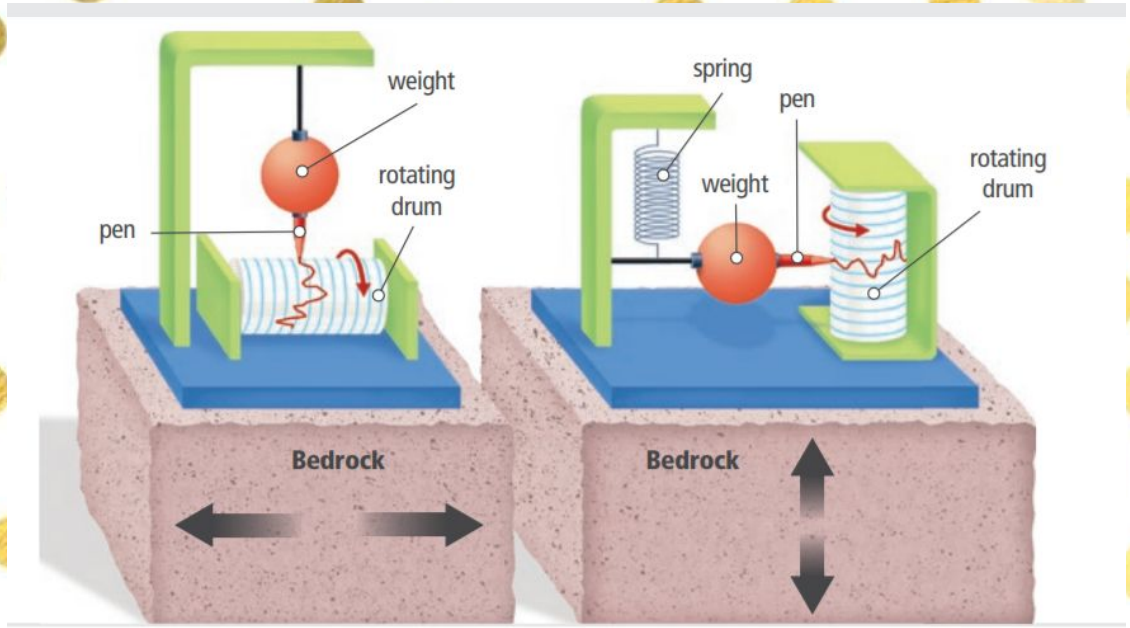
- The shaking of the earth's crust caused by a release of energy.
- Earthquakes can be caused by:
  - Eruption of a volcano
  - Collapse of a cavern
  - Impact of a meteorite
  - Strain built up along boundaries between plates

A fault is...

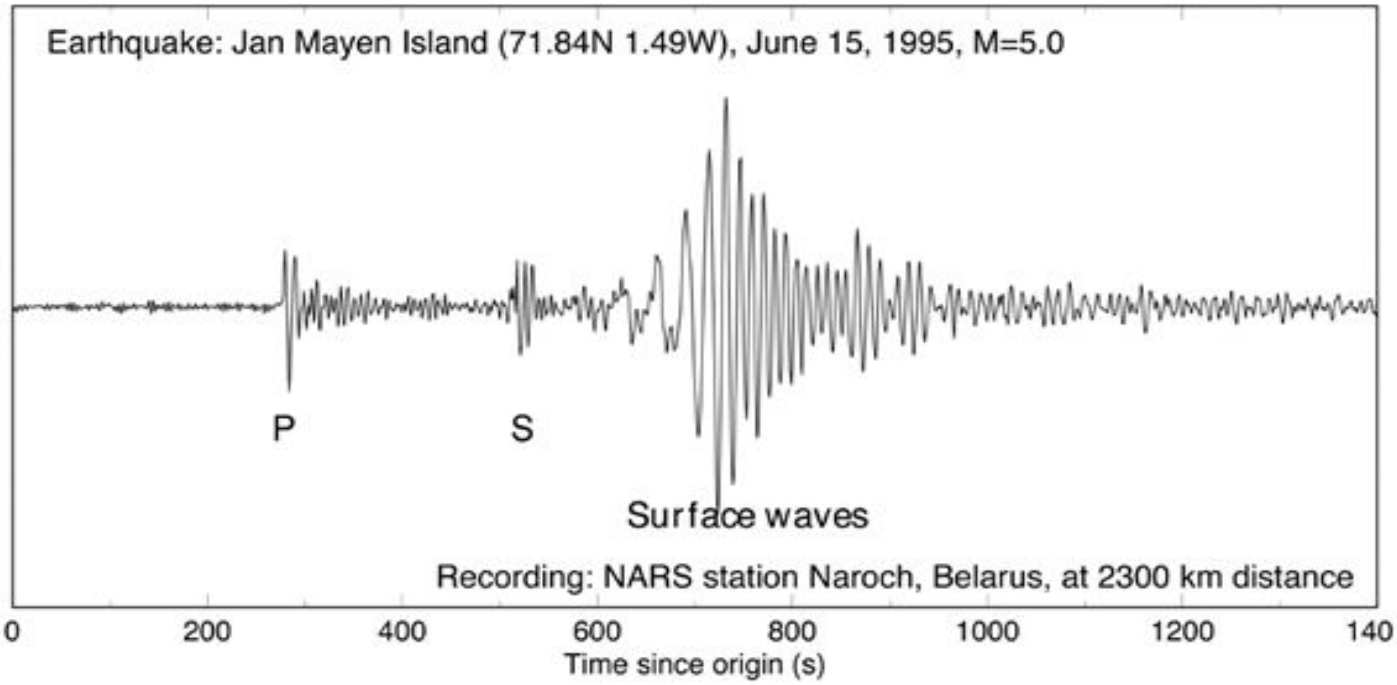
- A break in the lithosphere along which movement has occurred. Most earthquakes occur in this way.
- Friction between plates prevents them from moving, so strain builds up. The rock deforms. Eventually, the strain becomes great enough that the rock moves, and returns to normal shape this is called elastic rebound theory. The release in friction causes an earthquake.

Measuring Earthquakes

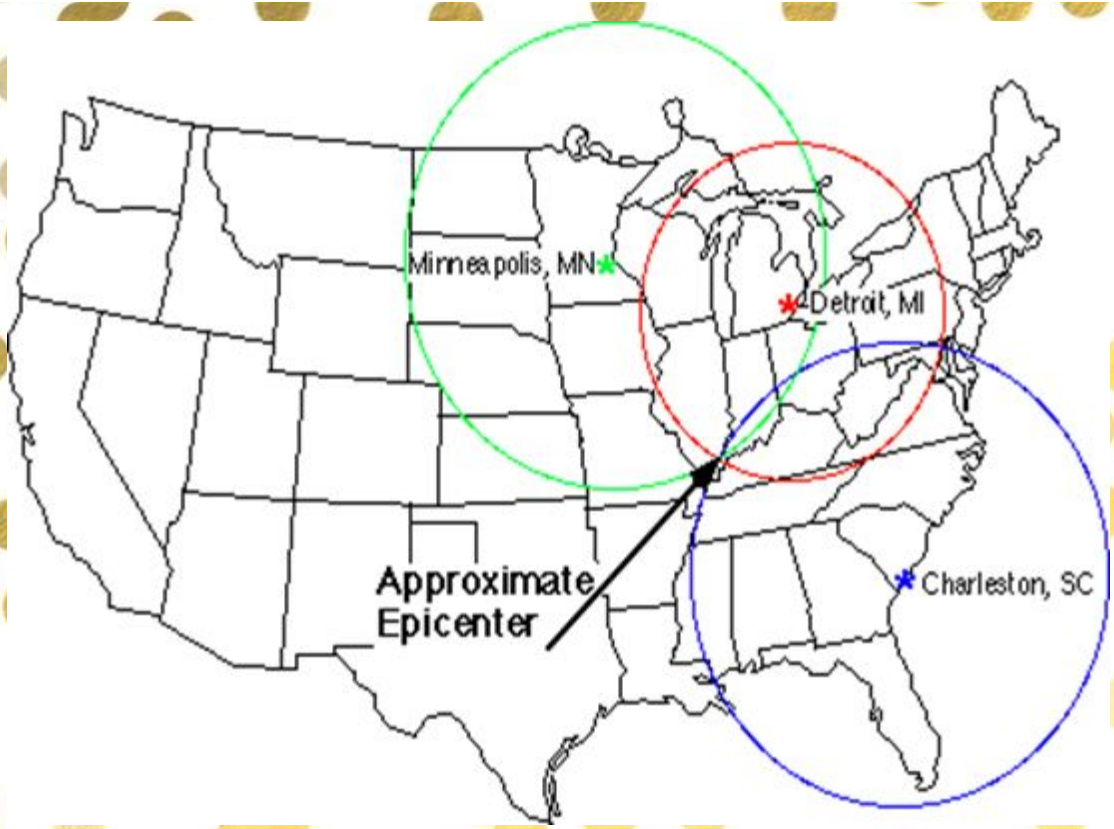
- Seismograph: Instrument used to measure an Earthquake
- Seismogram: The paper record of the Earthquake data (shaking) is called a seismogram



S-P Time Interval

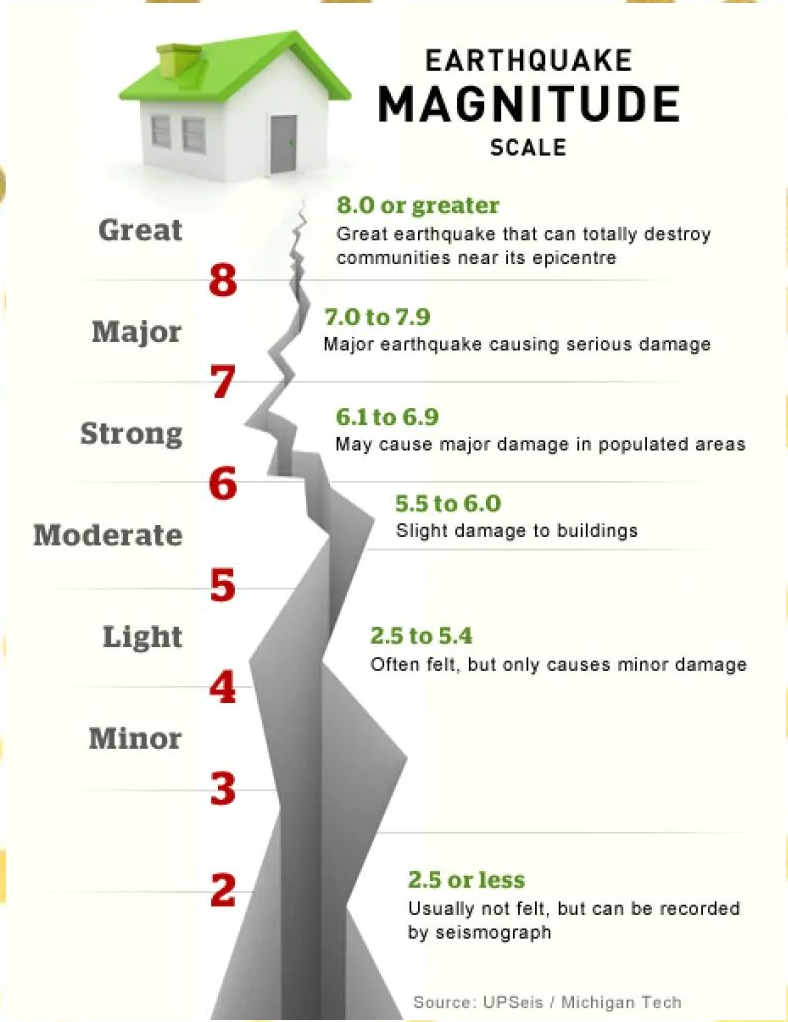


Triangulation



Earthquake Strength

- Earthquake magnitude is the strength of an earthquake measured by the amount of released energy.
- The scale used to measure the strength of earthquakes is known as the Richter scale.



Charles Richter

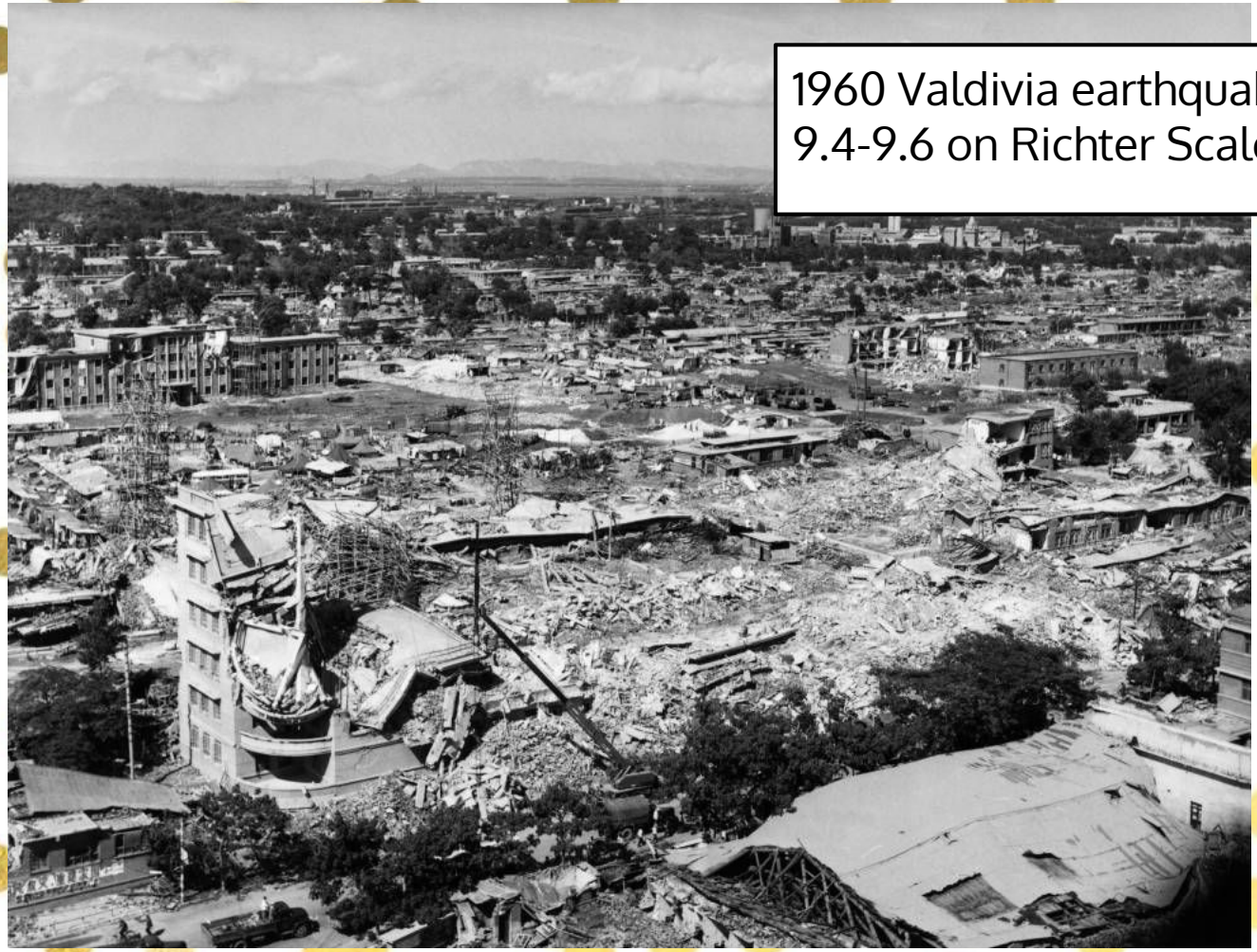
- The Richter scale was developed in 1935 by American seismologist Charles Richter (1891-1989) as a way of measuring the magnitude, or strength, of earthquakes.
- Richter, who was studying earthquakes in California at the time, needed a simple way to precisely express what is qualitatively obvious: some earthquakes are small and others are large.

The Richter Scale

- The Richter Scale is a scale from 1 to 10, measuring increasing earthquake magnitudes.
  - 1 being the best case scenario and 10 being the worst.
- Each increase in number on the Richter scale is a 10x increase in power.
  - So a 2.0 is 10x stronger than a 1.0, and a 3.0 is 20x stronger than a 1.0.

Understanding the Richter Scale

Richter Magnitude	Feels like KG of TNT	Extra Information
0-1	0.6 -20 kilograms of dynamite	We can not feel these.
2	600 kilograms of dynamite	Smallest quake people can normally feel.
3	20,000 kilograms of dynamite	People near the epicenter feel this quake.
4	60,000 kilograms of dynamite	This will cause damage around the epicenter. It is the same as a small fission bomb.
5	20,000,000 kilograms of dynamite	Damage done to weak buildings in the area of the epicenter.
6	60,000,000 kilograms of dynamite	Can cause great damage around the epicenter.
7	20 billion kilograms of dynamite	Creates enough energy to heat New York City for one year. Can be detected all over the world. Causes serious damage.
8	20 billion kilograms of dynamite	Causes death and major destruction. Destroyed San Francisco in 1906.
9	20 trillion kilograms of dynamite	Rare, but would causes unbelievable damage!



1960 Valdivia earthquake in Chile
9.4-9.6 on Richter Scale.

The Other Scale

- In 1931 by the American seismologists Harry Wood and Frank Neumann developed the Mercalli scale.
- This scale, composed of increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals.
- Unlike the Richter scale which measures earthquake magnitude or strength, the Mercalli scale measures earthquake intensity.

The Mercalli Scale

- The effect of an earthquake on the Earth's surface is called the intensity. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally - total destruction.
- This scale, composed of increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead it is an arbitrary ranking based on observed effects.
- The lower numbers of the intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage.

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felto nly by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Earthquake Hazards

- Fire: Causes the most damage in an Earthquake, some utility lines and roads get damaged
- Liquefaction: When the ground turns to quicksand due to the shaking
- Tsunamis: Are caused by underwater earthquakes that make a big wave.


Japan 2011


New Zealand 2011


Taiwan 2017