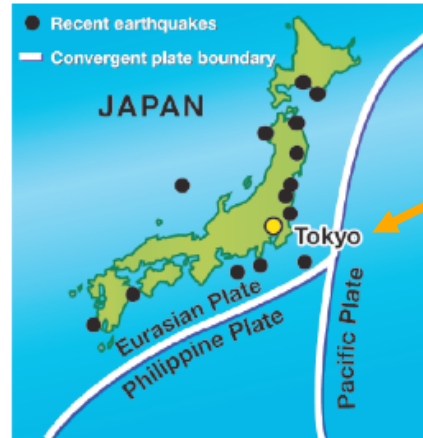# Chapter Twenty: Earthquakes and Volcanoes

20.1 Learning Goals

- Describe the plate interactions that causes earthquakes.

- Discuss the types of information scientists learn from seismograms.

- Compare and contrast the scales used to measure and describe earthquakes.

20.1 Earthquakes and plate boundaries

- **Earthquakes commonly occur at the boundaries of lithospheric plates.**

- **This is because plate boundaries tend to be zones of seismic activity.**

Earthquakes and Plate Boundaries

20.1 Earthquakes

- The second longest ever recorded earthquake occurred in 1964 in Alaska and lasted for four minutes.

The 1964 Alaska earthquake was the largest ever recorded in the United States. The area within this pink patch slipped seaward up to 66 feet.

March 27, 1964

- During an earthquake, strong shaking makes the ground move up and down and back and forth.

20.1 When an earthquake occurs

- **An earthquake is the movement of Earth's crust resulting from the release of built-up potential energy between two stuck lithospheric plates.**
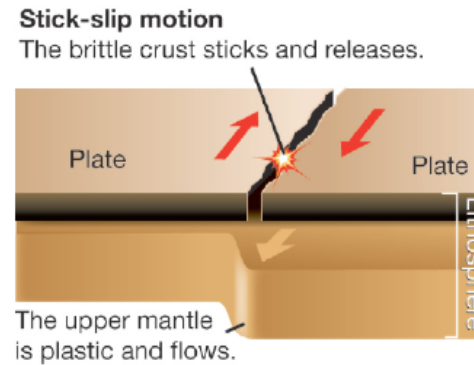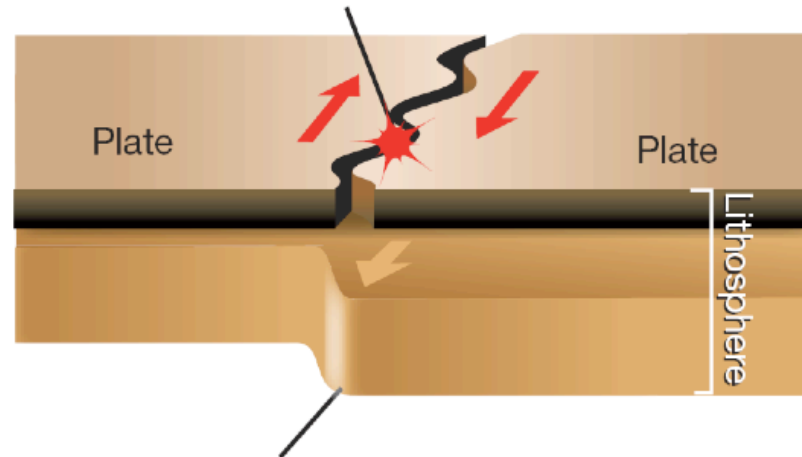
Stick-slip motion
The brittle crust sticks and releases.

Plate   Plate

Lithosphere

The upper mantle is plastic and flows.

Plate Stick-Slip Motion
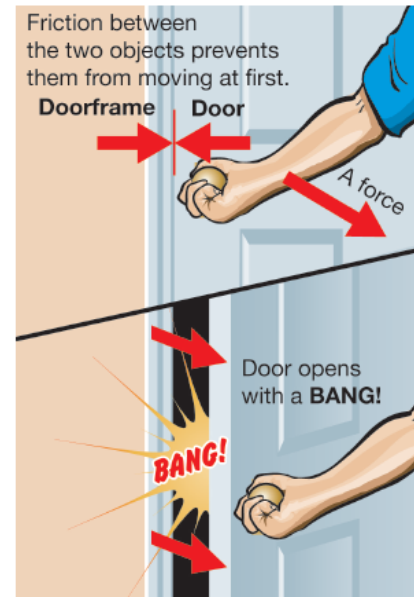
Stick-slip motion
The brittle crust sticks and releases.

Plate

Plate

Lithosphere

The upper mantle is plastic and flows.

20.1 Stick-slip motion

- An earthquake is a form of stick-slip motion.

- Stick-slip motion can be compared to a stuck door.

Friction between the two objects prevents them from moving at first.

Doorframe   Door

A force

Door opens with a BANG!

BANG!

20.1 Stick-slip motion

- **Three conditions are needed for stick-slip motion:**
  1. Two objects that are touching each other where at least one of the objects can move.
  2. A force, or forces, that will cause the movement.
  3. Friction strong enough to temporarily keep the movement from starting.

20.1 When an earthquake occurs

- The point below the surface where the rock breaks is called the earthquake focus.
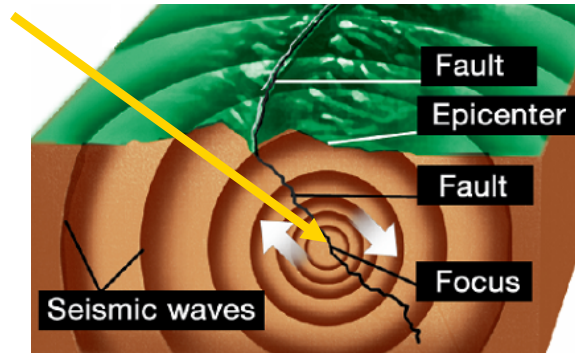
20.1 When an earthquake occurs
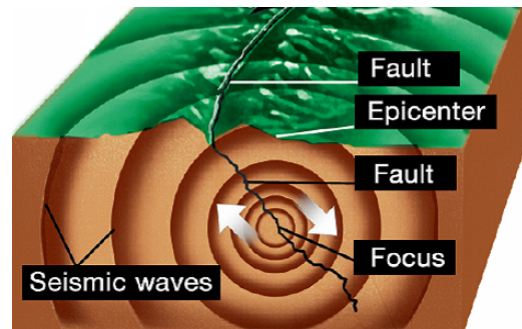
- As soon as the rock breaks, there is movement along the broken surface causing a split in the surface called a fault.
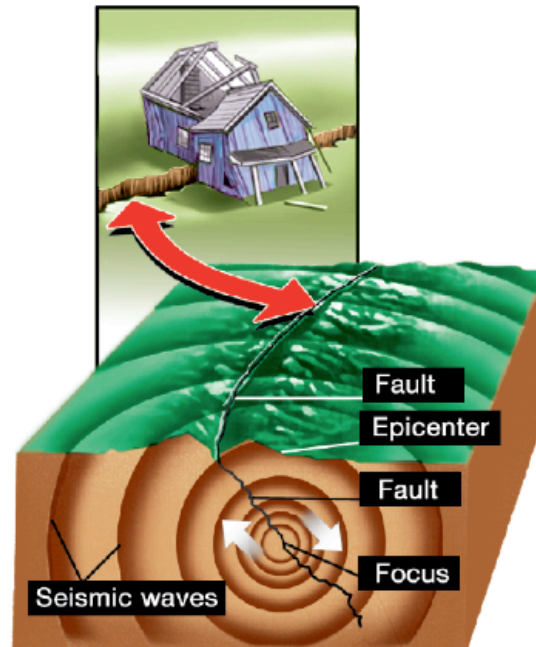
20.1 What causes earthquakes?

- The seismic waves from an earthquake are usually strongest at the epicenter, the point on the surface right above the focus.

Parts of an Earthquake

20.1 Lithospheric plates have many sections

Regions where the plates are locked together

Regions where the plates are creeping past each other

San Andreas Fault, Central California

North American Plate

Photo courtesy of U.S. Geological Survey.

San Francisco

Parkfield

Pacific Plate

Los Angeles
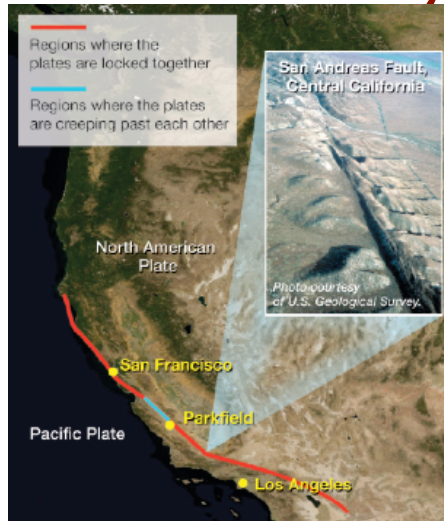
- A lithospheric plate may be thousands of km across.

- It takes a long time for movement on one end of the plate to affect a section further away.

20.1 Seismic waves

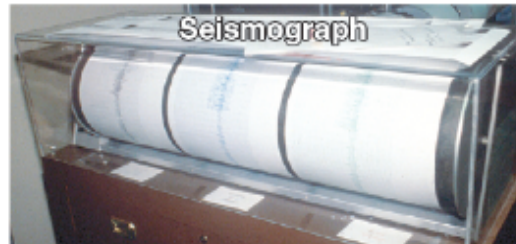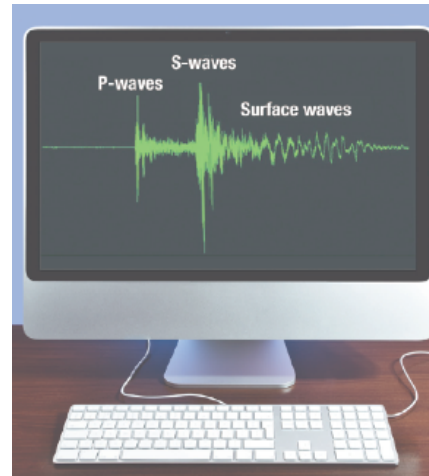- Seismic waves are recorded and measured by an instrument called a seismograph.

- Seismic waves inside Earth are called body waves.

- The two main types of body waves are P-waves and S-waves.

Seismograph

20.1 Seismic waves

- After an earthquake occurs, the first seismic waves recorded will be P-waves.

- S-waves are recorded next, followed by the surface waves.

20.1 Seismic waves

DOTTED LINE:
radius and distance
between station
and epicenter

Epicenter

A

B

C
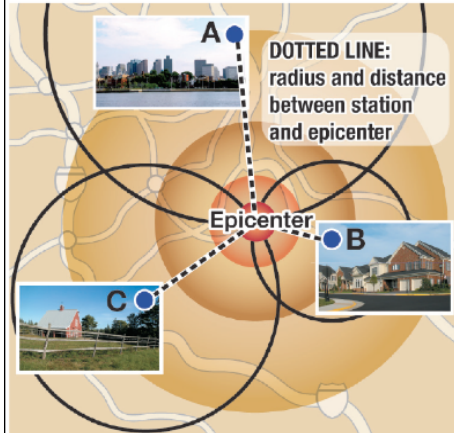
- Seismic waves radiate from the focus after the earthquake.

- <u>Three</u> seismic stations can accurately determine the times of body wave arrival.

- The larger the difference in arrival time, the farther the epicenter is from the station.

The Richter Scale		
Level	**Magnitude**	**Effects*** (*These descriptions are not part of the scale.)
Micro	Less than 2.0	Barely felt but recorded by seismographs
Very minor	2.0–2.9	Recorded but not felt by most people
Minor	3.0–3.9	Little damage but felt by people
Light	4.0–4.9	No serious damage; objects shake
Moderate	5.0–5.9	Major damage to poorly designed buildings
Strong	6.0–6.9	Serious damage over a 100-km area or less
Major	7.0–7.9	Serious damage over a larger area
Great	8.0–8.9	Serious damage over several hundred kilometers
Rare great	9.0 or greater	Serious damage over several thousand kilometers

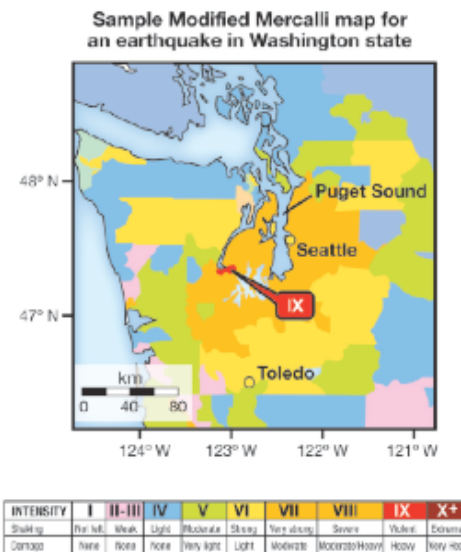# 20.1 Measuring earthquakes

- The Moment Magnitude scale rates the total energy released by an earthquake.

- The numbers on this scale combine energy ratings and descriptions of rock movements.

- Seismologists tend to use the more descriptive Moment Magnitude scale to distinguish between strong earthquakes.

20.1 Measuring earthquakes

- The Modified Mercalli scale has 12 descriptive categories.

- Each category is a rating of the damage experienced by buildings, the ground, and people.

Sample Modified Mercalli map for an earthquake in Washington state

INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
Shaking	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
Damage	None	None	None	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

The Modified Mercalli Scale		
Category	Effects	Richter scale (approximate)
I. Instrumental	Not felt	1–2
II. Just perceptible	Felt by only a few people, especially on upper floors of tall buildings	3
III. Slight	Felt by people lying down, seated on a hard surface, or in the upper stories of tall buildings	3.5
IV. Perceptible	Felt indoors by many, by few outside; dishes and windows rattle	4
V. Rather strong	Generally felt by everyone; sleeping people might be awakened	4.5
VI. Strong	Trees sway, chandeliers swing, bells ring, some damage from falling objects	5
VII. Very strong	General alarm; walls and plaster crack	5.5
VIII. Destructive	Felt in moving vehicles; chimneys collapse; poorly constructed buildings seriously damaged	6
IX. Ruinous	Some houses collapse; pipes break	6.5
X. Disastrous	Obvious ground cracks; railroad tracks bent; some landslides on steep hillsides	7
XI. Very disastrous	Few buildings survive; bridges damaged or destroyed; all services interrupted (electrical, water, sewage, railroad); severe landslides	7.5
XII. Catastrophic	Total destruction; objects thrown into the air; river courses and topography altered	8

Modified Mercalli Scale vs. Richter Scale

	Modified Mercalli Scale	
Category	**Effects**	**Richter Scale (approximate)**
I. Instrumental	Not felt	1-2
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