"Earthquakes & Plate Tectonics" *ga_mountain_center_seismology.docx*
Georgia Mountain Research & Education Center
Blairsville, GA

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Major Points (brief list)

1. Rocks are not rigid
2. Earthquakes release elastic strain energy
3. Each part of a fault may slip at a different time
4. Earthquakes are frequent but rarely felt
5. Earthquakes are detected using seismometers
6. Seismometers are often deployed in "arrays"

Major Points (details):

1. Rocks are <u>not</u> rigid (undeformable). Rather:

a. near Earth's surface, they are *"brittle"* (meaning: they bend elastically, then break when the applied stress [force/area] exceeds the *"brittle fracture strength"*).
b. at greater depth, where the confining pressure and temperature are greater, they are *"ductile"* (meaning: they bend elastically, then flow when the applied stress exceeds the *"yield strength"*).

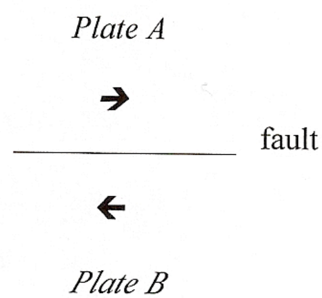
→ DEMONSTRATION: The difference between brittle fracture and ductile flow is demonstrated with the *"smash the caramel with a sledge hammer"* experiment. Frozen caramels are brittle, while warm caramels are ductile.

→ Importance: This is how solid rock within the mantle is able to "convect". It also explains how continents can move or "drift" over time. They don't plow through the solid crustal rock of the ocean basins, rather, both the continental and oceanic crust are embedded in thick, brittle plates of *"lithosphere"* that ride on top of ductile *"asthenosphere"*.

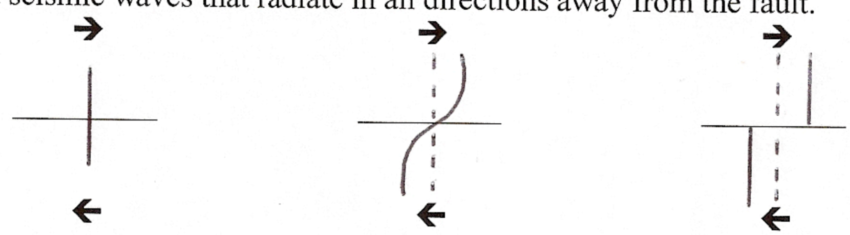
2. *Earthquakes release elastic strain energy*

In other words, earthquakes occur when:

a. two blocks of rock (for example, two tectonic plates) moving in opposite directions are in frictional contact along a fault (map view):



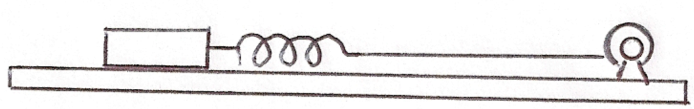
b. Initially, friction prevents the blocks from sliding past each other. The rock in the vicinity of the fault begins to bend elastically. It stores *"elastic strain energy"*, just like a stretched spring. This energy gradually builds up until the elastic force (analogous to the "pull" of a stretched spring) exceeds the frictional force across the fault. The stretched rock then abruptly "snaps" back, and the elastic strain energy stored in the rock is released as strong shaking near the fault and seismic waves that radiate in all directions away from the fault.



→ DEMONSTRATIONS:

i) "rubber band" analogy: the only way to generate a "sound" with a rubber band is to stretch it. That stores *"elastic strain energy"*. When the rubber band is released, the elastic strain energy is converted to sound waves. Likewise, the only way to generate an earthquake is to stretch the rock on either side of a fault. (note: "P waves" generated by earthquakes are a type of sound wave).

ii) "wooden board / slinky gizmo": the wooden block and board are in frictional contact. The slinky represents elastic behavior of rock. Pulling on the slinky does not cause the block to move right away. Rather, the slinky stretches (and stores elastic strain energy). When the force exerted by the slinky on the block finally reaches and exceeds the frictional force between the block and board, the block finally moves (simulating slip on a fault).



3. Each part of a fault may slip at a different time

Large earthquakes can involve motion along faults that are hundreds of miles long. During an earthquake, rocks on either side of the fault "unzip", i.e., each part of the fault slips at a slightly different time. For the largest earthquakes, slip can continue for several minutes. This can be hard to visualize

→ DEMONSTRATIONS:

i) each student is given a pair of sandpaper blocks. When given the signal, the students slide the blocks past each other in sequence, one student at a time.

ii) then, to shake the ground, each student jumps in sequence, again, one at a time.

4. Earthquakes are frequent but rarely felt.

This is because the amplitudes of seismic waves become smaller with distance from the epicenter, just as ripples on a pond die out as they travel outward.

5. Earthquakes are detected using seismometers

Although generally very small, ground motions from distant earthquakes can be detected by seismometers. The simplest seismometers use a magnet and coil of wire. When the ground shakes, the magnet shakes with it and the coil of wire (suspended by a spring) stays fixed. This generates an electrical current that is amplified and recorded by a "seismograph". (The electricity used in our homes is generated in much the same way).

→ DEMONSTRATION: students can hear the moving parts of a seismometer "rattle" when they shake it.

6. Seismometers are often deployed in "arrays"

A seismic array is a group of seismometers arranged in a straight line or in a 2D pattern. The direction in which the waves are traveling can be determined by tracking the differences in arrival time of the waves as they cross the array.

→ DEMONSTRATION:

We used an array of 12 seismometers to record the "earthquake" generated by the students jumping in sequence. The array was deployed along the path beyond our work area. Each seismometer was connected to a multichannel cable, and the cable was connected to the seismograph on the park bench. We triggered the recording several seconds before the students started jumping. The next page shows a few sample recordings:

NOTE:

1) The waves generated by the students are real "seismic" (elastic) waves. Most of the energy is in the form of "Rayleigh waves". This is the type of wave that does most of the damage during an earthquake.

2) The examples below were generated by hitting the ground with a sledgehammer and recording the vibrations with an array of 24 seismometers. The record is ½ second long (the array used for the student demonstration consisted of 12 seismometers and the record was 10 seconds long).

3) Each vertical trace corresponds to the ground motion felt by one seismometer.

4) Time after the hammer blow increases downward. The waves are traveling "left to right" (they reach the leftmost seismometer first).