Shake, Rattle and Roll

Objective:
Students will learn the underlying cause of earthquakes and how they shape the land. They will model types of faults.

Grade: 6

Subject Areas: Art, Earth science, Geography, Physics

Skills: classifying, describing, identifying, observing, modeling, questioning

Duration: 1 hour

Connections: geology, engineering, oceanography, landforms, history

Vocabulary
- crust
- fault
- creep
- strike-slip fault
- normal fault
- reverse fault
- epicenter
- Mendocino Triple Junction
- Richter Scale
- Mercalli Intensity Scale
- liquefaction

Materials
- pictures of earthquake faults
- earthquake squeeze box
- 5 lbs of colored sand
- 3 lbs of flour
- 3 lbs of potting soil
- modeling clay of different colors
- rollers for rolling clay
- wooden 2x4 blocks (2 per student)
- manipulatives representing buildings, etc. (optional)
- map showing Mendocino Triple Junction
- cameras for before and after photos
- computer with internet and projection capabilities

Standards
Strands: Excellence in Environmental Education Guidelines
Strand 1 —Questioning and Analysis: F) Working with models and simulations: Learners understand many of the uses and limitations of models.
Strand 2.1 —The Earth as a Physical System: A) Processes that shape the Earth: Learners have a basic understanding of most of the physical processes that shape the Earth. They are able to explore the origin of differences in physical patterns.

California State Educational Standards:
Earth Science (ES) 1: Plate Tectonics and Earth's Surface: 1a: Students know the evidence of plate tectonics is derived from the fit of the continents; the location of earthquakes, volcanoes, and mid-ocean ridges; and the distribution of fossils, rock types, and ancient climatic zones.
ES 1d: Students know that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface. **1e:** Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, results from plate motions.
ES 1f: Students know how to explain major features of California geology (including mountains, faults, volcanoes) in terms of plate tectonics.
Earth Science (ES) 2: Shaping Earth's Surface: 2d: Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

Background

Shaking Earth

There are few things scarier, if you live in California, than a large earthquake. Earthquakes are common here because of numerous faults including the San Andreas Fault, a very large active fault that extends north-south through the state. Most earthquakes are the result of quick movements along a fault, however, any force large enough to send a wave through rock will register on a seismograph, the main instrument that measures them.

If you could look at a cross section of the Earth's interior, you would see the top of the planet is a relatively thin layer of solid rock. This surface is called the **crust**. For reasons still not understood, the crust is broken up into sections or plates. Below the crust is hot molten rock that moves the plates as if they are riding on a conveyor belt. The shifting of these plates causes major geologic events such as mountain building and volcanic eruptions. As the plates move, the rock they are made of fractures due to the stresses this motion causes.

A fault is a region where blocks of rocks or plates move relative to each other. They are basically fractures that can range from millimeters to thousands of kilometers long. The San Andreas fault is roughly 1280 kilometers or 800 miles long and is where the Pacific plate is grinding past the North American plate. Sudden movement along a fault causes an earthquake. Slow movement along a fault is called **creep**.

There are three main types of faults depending on the direction the forces involved are applied: strike-slip, normal and reverse.

A **strike-slip fault** is when two rock blocks move past each other. The San Andreas Fault may be the most famous strike-slip fault. The great earthquake of 1906 caused the San Andreas fault to rupture along almost three hundred miles. In some places, the offset was almost 30 feet. A **normal fault** is when the crust is being stretched apart. This causes one rock block to slip downward compared to the other block. The series of basins and ranges of central Nevada represent a large area of crustal extension. With the onset of crustal extension, great blocks of earth dropped down along normal faults, forming the long valleys that we see today. Lastly, there are **reverse faults** or thrust faults caused by compression forces or forces pushing towards each other. When this happens one rock block is forced upwards and over the other rock

Local Connection

The northern California coast is one of the most tsunami-prone areas in the world. Tsunamis are a series of sea waves that originate in the sea and are usually caused by earthquakes beneath the sea floor. The first wave to arrive is not always the most dangerous. The waves can travel up to speeds as fast as 600 miles per hour and the series of waves can last for hours.

The word tsunami is Japanese in origin. Tsunami literally means "harbor wave". Tidal wave is another term given to these waves except it is misleading. Tides do not cause the phenomenon, although they can influence the size of the waves. Furthermore, scientists often refer to tsunamis as seismic sea waves, however, tsunamis can be caused by underwater landslides and meteorite impacts, not just earthquakes.

One of the worse tsunamis ever recorded along the coast of California happened in 1964. It was caused by a 9.2 earthquake off the coast of Alaska. The waves radiated outwards and travelled down the coast of California hitting the hardest at the town of Crescent City north of Eureka.

Because of the threat these unique waves cause to life and property, early warning systems have been set up around the Pacific basin and elsewhere. If someone experiences an earthquake while in a coastal area, they are advised to reach for higher ground as soon as possible. Once the shaking stops, a person should try and get to an area that is at least 100 feet above sea level and 2 miles inland.

block. These are the common types of faults in Mendocino and Humboldt counties where the Juan de Fuca and Gorda plates are colliding with the North American plate. This motion continues to create a broad region of crustal compression resulting in folding and thrust faulting. Areas where the crust is being compressed may experience rapid rates of uplift as the crust buckles upwards.

The movements of crustal blocks past one another along a fault is typically not smooth and gradual. When the fault cannot allow for smooth slippage of crust past one another, strain accumulates. When the strain is suddenly released, an earthquake results. Most of the time, the released energy is small and barely noticeable. The exact location of the earthquake is known as the **epicenter**. Most earthquakes occur several miles underground.

The west coast of the United States is famous for earthquakes due to numerous faults. **The Mendocino Triple Junction** (MTJ) is an area adjacent to the King Range Natural Conservation Area (NCA) near Cape Mendocino. It is the most seismically active region in North America. The MTJ is where three plates merge. It is rare to have three plates converge so close to a shoreline. The Pacific Plate is heading in a northwest direction while the North American Plate is moving in a southeast direction along the San Andreas fault. A small remnant of a once larger plate, the Gorda plate, is colliding with North America and submerging below the North American plate along the Cascadia Subduction Zone. Finally, the Pacific and Gorda plates grind past one another in an east-west direction along the Mendocino Fracture Zone. The combination of all these plate movements and resulting faults, causes this area of the coast ranges to lift, twist, rattle, and roll.

Measuring Shakes

Earthquakes are measured a lot of different ways. The **Richter Scale** is a logarithmic scale from 1-10 and is most commonly used. Most people can't notice earthquakes under 4 on the Richter Scale. The difference in ground motion between two consecutive numbers on this scale (like 6 and 7) is ten times greater. However, the amount of energy released is thirty times greater compared. The energy released from an earthquake measuring 7 on the Richter Scale is equal to 475,000 million tons of TNT whereas one measuring 4 on this scale is equivalent to a mere 15 tons of TNT. The **Mercalli Intensity Scale** is more subjective than the Richter Scale. It measures the amount of damage done to buildings and other structures like bridges. The scale ranges from I (detectable only by instruments) to XII (total destruction). Many buildings will begin to experience damaging effects at an intensity level of around VII on the Mercalli Intensity Scale.

The amount of damage caused to buildings is dependent largely upon the type of rock or sediments they are built upon. Usually major damage to buildings in places with strict building codes like the United States occur with earthquakes measuring 6.2 and above. If the area is a filled in wetland, tidal flat, or some other area made of loose sediments, the ground movement may cause what is called **liquefaction**. This phenomenon changes the behavior of seemingly solid ground to act like a liquid and can cause severe damage. Individual earthquakes have played a role in shaping the landscape around us. In 1992, just north of the King Range NCA, a series of three relatively large earthquakes occurred measuring 7.1, 6.6, and 6.7 respectively. This event lifted the intertidal zone four feet above sea level stranding the organisms living in the tidal zone there. This was just one example of a localized uplift event causing a terrace. There is now evidence showing several events like this have happened repeatedly along the Lost Coast in the past causing geographic stair steps or terraces where the relatively flat seafloor is uplifted above sea level. Various events can be dated using the remains of stranded marine organisms such as attached mussel shells, barnacles and clam shells preserved in place. The higher the ancient marine terrace, the older it is. Other features created by local uplift events include the flat landscape on the western end of Shelter Cove, many parts of the Lost Coast Trail from the Mattole River south to Shelter Cove, and the excellent surfing location at Big Flat north of Shelter Cove. Good surfing is possible at Big Flat and other locations along the Northcoast because the waves break offshore due to reefs that have been uplifted into shallow water and have not yet had a chance to erode.

In other areas, particularly further north around the Eel River and Humboldt Bay, the land may rapidly subside allowing ocean water to intrude inland and flooding coastal lowlands. Large earthquakes may also generate giant landslides, reshaping entire mountainsides in an instant. This area apparently has had extremely powerful earthquakes in the past, most likely exceeding magnitude 8 and possibly magnitude 9 on the Richter Scale.

Activity: Modeling Earthquake Faults

Preparation

For the first demonstration, place at least three different layers of soil, flour and colored sand in the earthquake squeeze box. Pat down firmly. (See 1st procedure.) Check to make sure the school's computer system will allow you to open up: http://earthquake.usgs.gov/ for later use.

Materials

- modeling clay of different colors
- rollers for rolling clay
- wooden 2x4 blocks (2 per student)
- manipulatives representing buildings, etc. (optional)
- map showing Mendocino Triple Junction
- cameras for before and after photos
- computer with internet and projection capabilities

- *Has anyone here ever felt an earthquake?*
- *Has anybody ever been scared during an earthquake?*
- *Who knows what causes earthquakes?*
- *What do you know about local geology?*
- *Does anyone know a famous fault?*
- *What happens along faults?*
- *Does anyone know a the name of a type of fault that causes earthquakes?*
- *What types of damage do earthquakes cause?*
- *How do we measure earthquakes?*
- *Can we predict earthquakes?*
- *What would you like to know more about in regards to earthquakes?*
- *Do you think we know everything there is to know about earthquakes?*

Procedure

1. Explain to the students that models can help us learn about earthquakes and the faults that cause them. Model the earthquake in a box. (See photo.) Gently press the two side panels together. (A few faults should form.). Use this model to introduce faults.

2. Write down a KL (Know and Learn) chart on the board or overhead projector. Ask students questions about earthquakes.Write down student responses into the correct category: K is what they already know and L is what they want to learn more about.

3. Show the map of the Mattole Triple Junction and other pictures. Explain that this area is very seismically active. Briefly discuss the San Andreas Fault and the local geology of the region.

4. Next, hold up two wooden blocks and explain to them that they will be using these to model faults. Explain to the students that the wooden blocks represent huge blocks of rock. You may want to ask them if they think rock is very flexible. Have them investigate using the blocks to figure out how many different ways two blocks can move relative to each other. Pass out the wooden blocks. Give them a few minutes to explore.

5. While the students are exploring independently, log onto the website below to prepare to show them images: http://earthquake.usgs.gov/learn/faq/?faqID=55

6. Have everyone stop moving their blocks to continue with the next step. Write down the three different types of faults and the different directional forces (using arrows) for each.

(Activity continued on next page.)

Activity Continued

7. Project the webpage showing the animations of the various types of faults. Explain to them that once they see an animation they should model the same type of movement with their blocks of wood. Have them model the three types of faults a few times. The animations move quickly. If a computer is not available, you can model the three types of faults with them, or they can use a handout as a reference.

8. Lastly, have them model the affects of a transform fault on a landscape. This activity will take the longest. Remind them that this is the common type of fault locally. To do this, they need to first roll out clay using wooden rollers. The layer of clay should be about 1/4 inch thick.

9. Have them place the clay layer on top of two blocks of wood touching each other so they lay flat. To this basic clay layer, students can add manipulatives (wooden splints, monopoly pieces, etc.) or use different colors of clay to make features they want in their landscapes (house, trees, river, etc.). They are to model an active transform fault by moving the blocks in opposite directions (apply shear force).

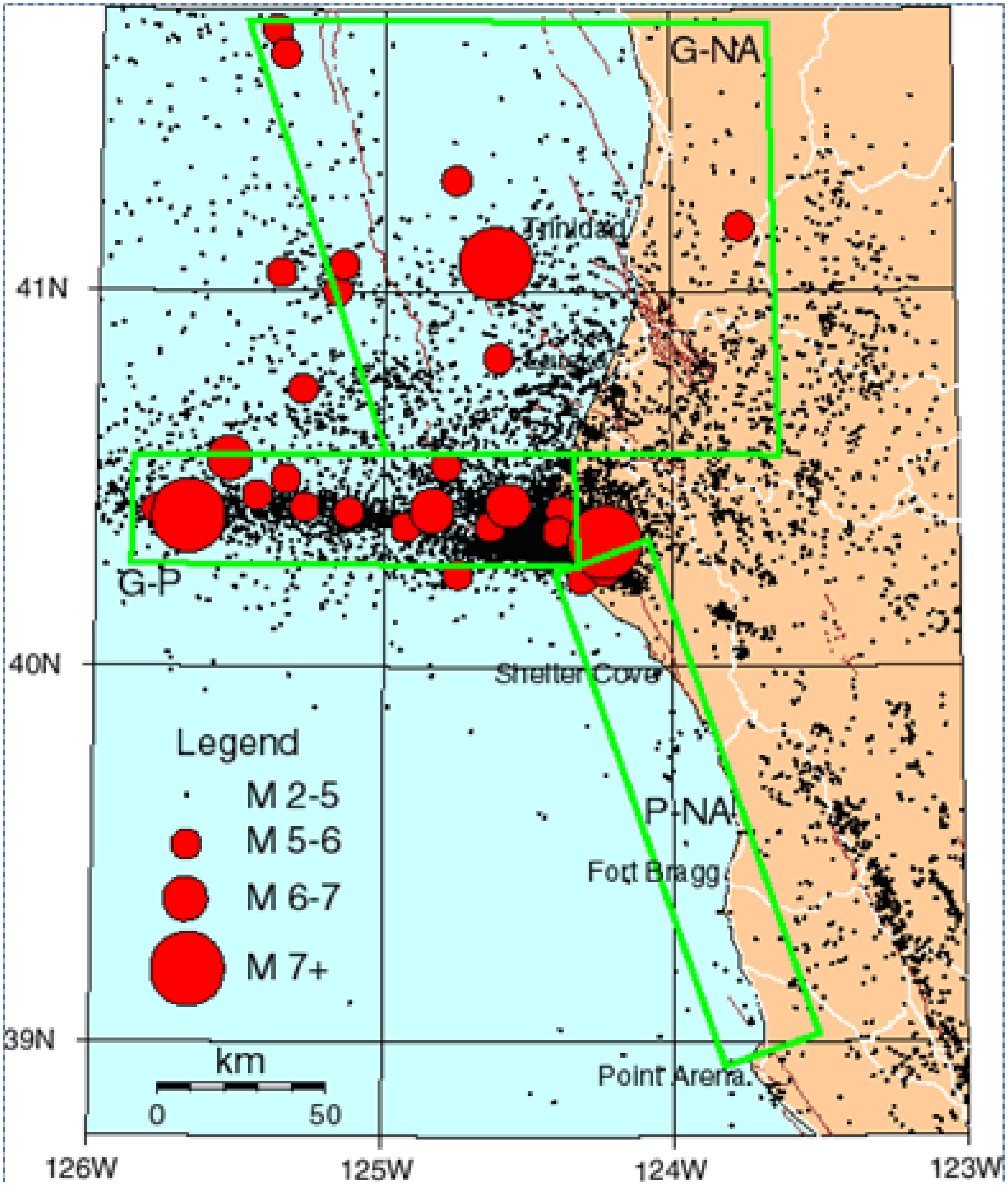
10. Taking pictures before and after may be a fun alternative. If time allows, they can model another type of fault or draw their landscape before and after the mock earthquake.

Extensions

- Connect earthquakes and faults to other Earth Science topics like mining and volcanoes.
- Have students perform online research about famous earthquakes around the world and then have them write a paper about one of them.
- Have students plot the epicenters of recent earthquakes or large earthquakes on a map.
- Use the radii from three or more seismograph stations to find an epicenter.
- Get a seismograph or meter at the school site for ongoing record keeping. Information available at www.iris.edu/hq/programs/
- Check out: Table Top Earthquakes from USGS: http://jclahr.com/science/earth_science/tabletop/ for a host of activities.
- Other sources: Living on Shaky Ground, www.humboldt.edu/shakyground/, Humboldt State University Northern California Earthquake Data Center, www.ncedc.org/ http://www.earthscope.org/

References

Animations: http://earthquake.usgs.gov/learn/faq/?faqID=55
Chart from : http://www.matter.org.uk/schools/content/seismology/richterscale.html, 2010
King Range National Conservation Area Draft Resource Management Plan and Draft Environmental Impact Statement, U.S. Department of Interior, BLM, Arcata Office, Jan. 2004
Living on Shaky Ground, http://www.humboldt.edu/shakyground/, Humboldt State University, 2010
The San Andreas Fault, http://spacedaily.com/, 2010
Tsunamis, http://www.ess.washington.edu/tsunami/toc.html
USGS FAQs: http://earthquake.usgs.gov/learn/faq/, 2010


G-NA
Trinidad
41N
G-P
40N
Shelter Cove
Legend
M 2-5
M 5-6
M 6-7
M 7+
P-NA
Fort Bragg
39N
km
0
50
Point Arena
126W
125W
124W
123W

From BLM

Name: ______________________ **Date:** ______________

Fault Predictions

Record your observations in the space below.

	Hypothesis (what you think will happen)	**Result** (what actually happened)
Strike-Slip Fault 		
Reverse Fault 		
Thrust Fault