

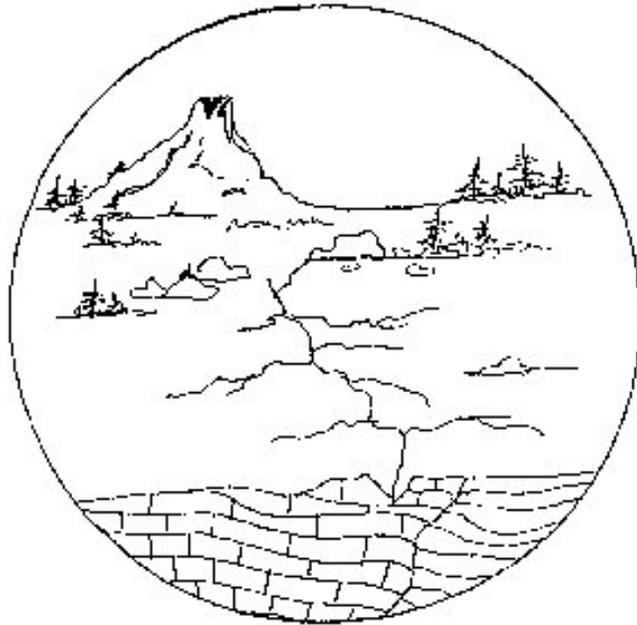


# Plate Tectonic Cycle

Earth's Moving Force

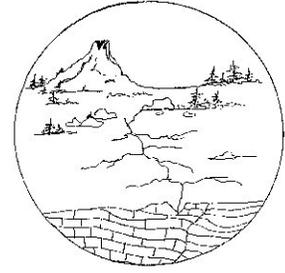


## SECOND GRADE EARTHQUAKES



1 WEEK  
LESSON PLANS AND  
ACTIVITIES

## PLATE TECTONIC CYCLE OVERVIEW OF SECOND GRADE



### VOLCANOES

#### WEEK 1.

PRE: *Investigating the parts of a volcano.*

LAB: *Comparing the parts of a volcano to different types of models.*

POST: *Discovering that volcanoes occur around the world.*

### EARTHQUAKES

#### WEEK 2.

PRE: *Discovering earthquake faults.*

LAB: *Tracing a fault map of the San Francisco Bay Area.*

POST: *Exploring how deep you can drill into the Earth.*

### PLATE TECTONICS

#### WEEK 3.

PRE: *Exploring how the Earth's outermost portion moves.*

LAB: *Exploring the results of movement on the Earth's crust.*

POST: *Exploring how plates have moved through time.*

### HAZARDS

#### WEEK 4.

PRE: *Discovering how to think during an earthquake.*

LAB: *Assessing what a mayor should do during a strong, moderate, and weak earthquake.*

POST: *Analyzing earthquake safety at home.*

## PLATE TECTONIC CYCLE - EARTHQUAKES (2)

### PRE LAB

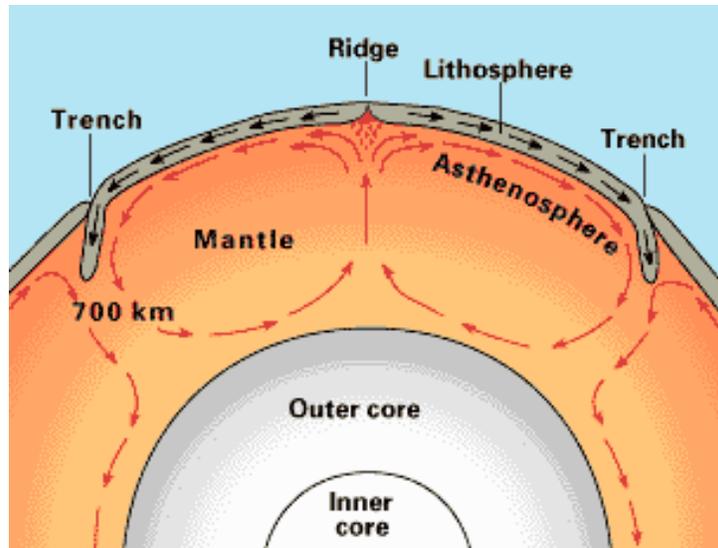
Students demonstrate stresses in the Earth.

### OBJECTIVES:

1. Discovering earthquake faults.
2. Exploring how stresses are caused in the Earth's crust.

### VOCABULARY:

crust  
earthquake  
fault  
inner core  
mantle  
movement  
outer core



### MATERIALS:

worksheet  
crayons

### BACKGROUND:

Earthquakes are caused by stresses from plate movement in the upper mantle and crust. Students should understand that stress within the plates can be "relieved" by giving off energy (earthquakes). This energy travels through the Earth as seismic waves. These waves move through the entire Earth and can cause minor to major damage to structures on the surface of the Earth, especially close to the origin of the earthquake. The damage depends on the intensity of the original stress and its dissipation (losing of strength) as it travels through the crust.

The seismic waves generated by an earthquake can be recorded and measured on a seismograph. The interpretation of the waves provides seismologists with a way of "seeing" into the inside of the Earth. The waves produced by earthquakes travel through the Earth and bounce off different features of the Earth's interior. The patterns they form after bouncing off these features can be used to create images of the interior.

The reflection of seismic waves indicates that the center of the Earth is composed of iron and nickel. This core has two parts, the outer core where the metal is liquid (not like milk, more like thick honey) and the inner core, which is solid. The core is surrounded by a layer called the mantle, which is divided into several sublayers. Basically, most of the mantle is a mush of crystals and magma (molten rock), perhaps similar to a snow cone in

texture (but much hotter!). The upper part of the mantle is solid, and is coupled with the crust, the outermost layer of the Earth, to make the plates. Since we cannot drill even through the Earth's crust, the evidence from different waves becomes important in interpreting the earth's structures.

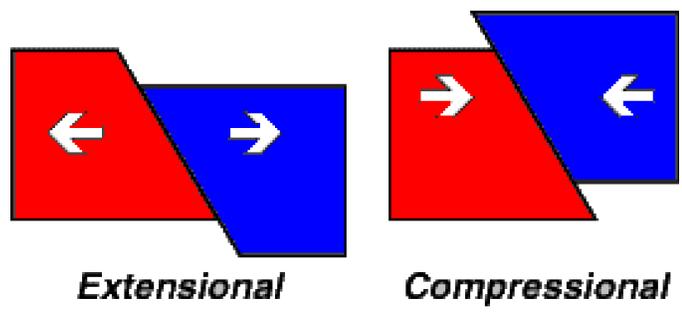
The inner core is about 1200 kilometers in thickness. The outer core is about 2300 kilometers. The mantle is about 2800 kilometers, while the crust ranges from 7-80 kilometers. The plates average about 100 kilometers in thickness.

A break in the surface of the Earth is called a fault. Many large faults are caused by the movement associated with earthquakes. The word "fault" has several meanings. As a noun it can mean weakness, blame, blunder, sin, fissure, or fracture; as a verb it can mean to accuse or blame. Most students think of that meaning when they hear the term. In geology, the word fault means a zone of weakness in a body of rock that breaks or moves under stress. On an geological or earthquake map, a fault is drawn as a black line. However, if you go up in an airplane, you do not see this line; it is a scientific interpretation of a ground feature. However, you would see the series of geological and topographic features that make the fault's location clear to scientists.

**PROCEDURE:**

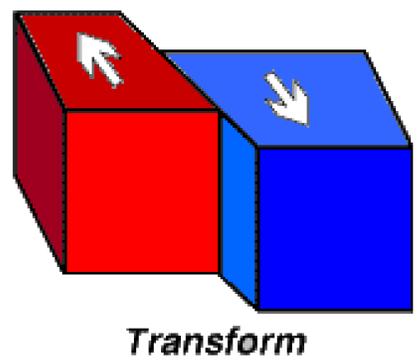
1. Review with students the structure of the inside of the Earth. Explain that faults, and hence earthquakes, only occur in the solid, brittle crust and upper mantle.

2. Demonstrate the different ways that stress is created in the crust and upper mantle. Stresses within the Earth's crust and outer part of the mantle causes earthquakes and faults. You can use a glue ball, clay, silly putty, or just your hands. These movements, which are shown in the diagram as extensional, compressional, and transform, can be shown as follows.



Extensional refers to a moving away of two areas. This stresses the rocks on either side and causes a rift. You can use silly putty for this one, because as you stress it outward you will get a sudden break.

Compressional means that the plates are moving toward each other. These stresses can be shown with your hands bumping into each other with force. Neither one wants to move, so there is great stress in the area.



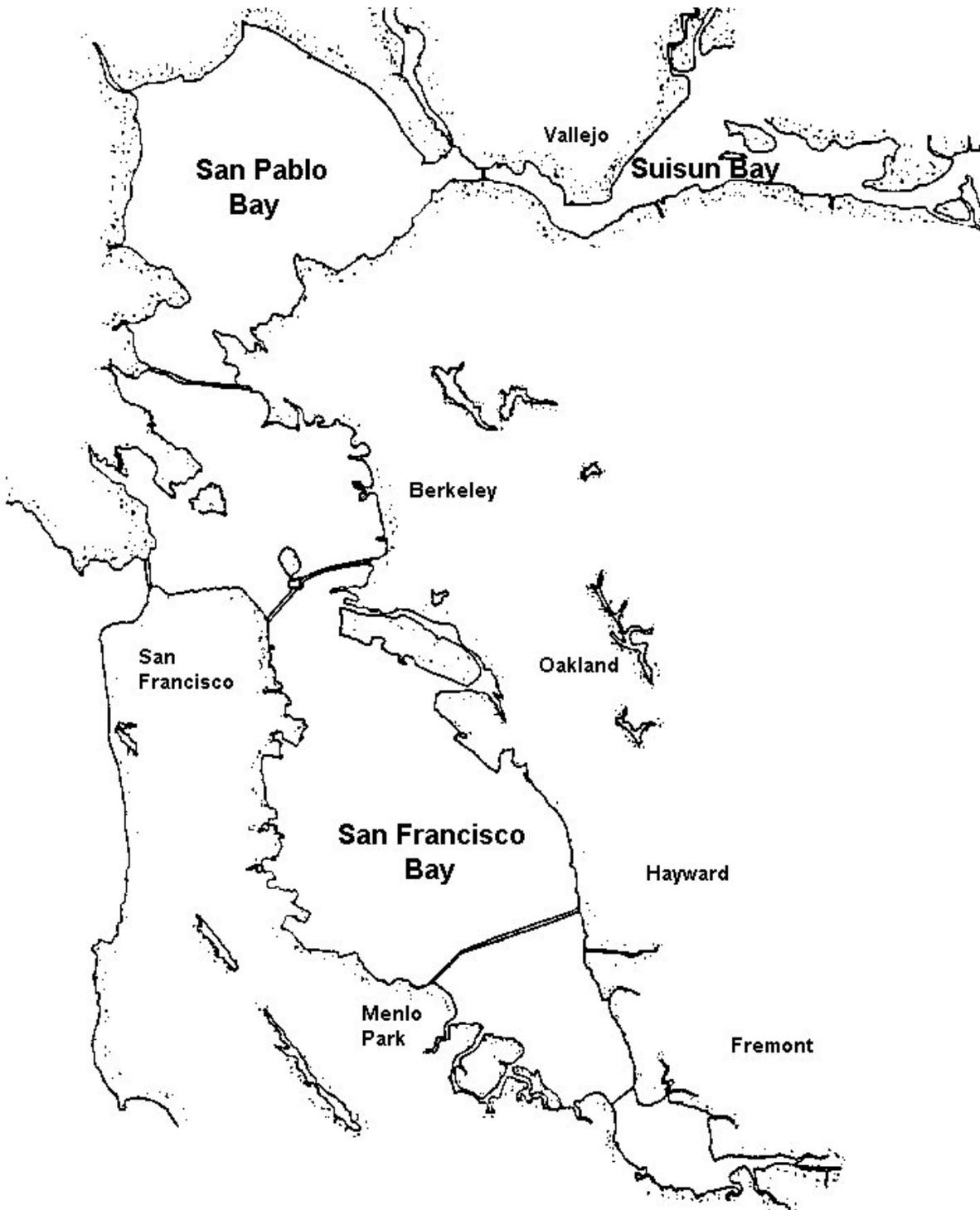
Transform can be easily shown with a glue ball, clay or silly putty. If you move one side past the other side, you will form cracks.

3. In the lab the students will look at a fault map of the San Francisco Bay area. Prepare your students for the lab by having students go over a map of the same area (worksheet). In lab the students will learn the major faults in this region. If you are a teacher in another area, try and get a local map of the area that you may have substituted for the San Francisco Bay area. Almost all areas have faults, although many of them may not be active (currently storing and releasing stress).

The United States Geological Survey website can be very helpful to locate local maps. Look at <http://usgs.gov> and look under Earthquakes.

## PLATE TECTONIC CYCLE - EARTHQUAKES (2)

### PRE LAB



## PLATE TECTONIC CYCLE - EARTHQUAKES (2)

### LAB

Students trace faults with yarn.

### OBJECTIVES:

1. Tracing a fault map of the San Francisco Bay Area.
2. Exploring faults.

### VOCABULARY:

fault  
stress

### MATERIALS:

San Francisco fault map  
yarn  
scissors  
paste  
San Francisco relief map (optional)



Fault in the San Francisco Earthquake in 1906 (near Pt. Reyes, California.)

### BACKGROUND:

Earthquake faults are zones of weakness, that "break" when stress builds up and needs to "relieve" itself. Most faults are actually zones of movement that can be hundreds of meters in width.

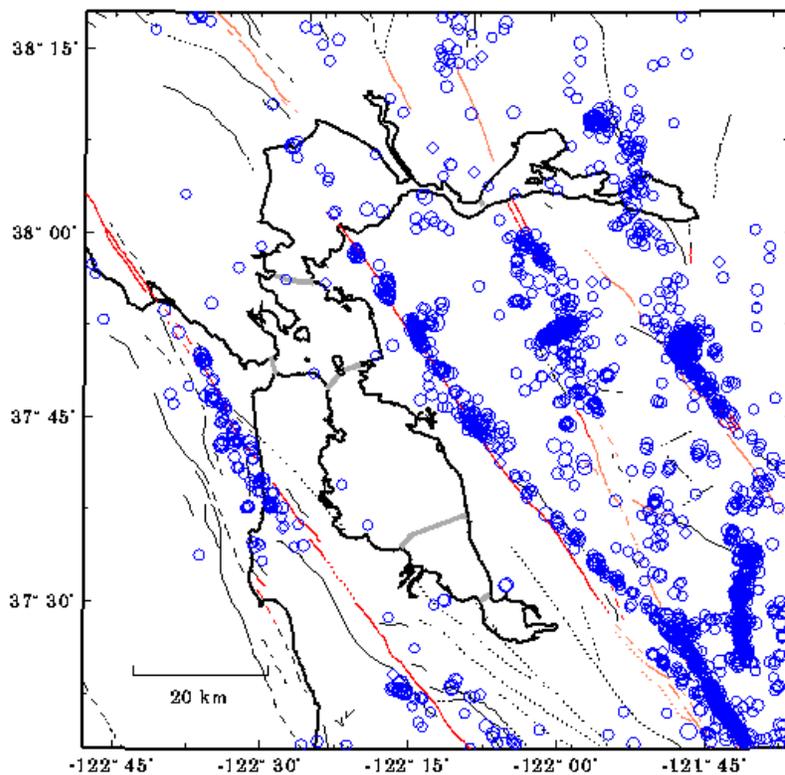
California is well-known for its earthquakes, both in the southern and northern parts of the state. The most famous fault in California is called the San Andreas Fault. It runs northwest to southeast near the coast, extending from offshore north of San Francisco, all the way to Baja California in Mexico. This fault marks the plate boundary between the North American plate to the east and the Pacific Plate to the west. These two plates are currently sliding past each other. The Pacific Plate is moving northwest relative to the North American plate.

In the San Francisco Bay area, the motion between the two plates is distributed between three major faults. These are:

a) The San Andreas Fault, roughly follows a line running from San Juan Bautista, between Watsonville and Gilroy, between San Jose and Los Gatos, and then following I-280 and Highway 35 before going out to sea at Mussel Rock in Daly City. It reappears onshore east of the Point Reyes Peninsula, separating it from the mainland. Here it runs from Bolinas Lagoon and cuts a straight valley to northwest to Tomales Bay.

b) The Hayward Fault trends along the east side of San Francisco Bay. North to south, it runs from just west of Pinole Point on the south shore of San Pablo Bay and

through Berkeley (just under the western rim of the University of California's football stadium). The Berkeley Hills were probably formed by an upward movement along the fault. In Oakland the Hayward Fault follows Highway 580 and includes Lake Temescal. North of Fremont's Niles District, the fault runs along the base of the hills that rise abruptly from the valley floor. In Fremont the fault runs within a wide fault zone. Southward, the fault lies between the lowest, most westerly ridge of the Diablo Range and the main mountain ridge to the east. Coyote reservoir, Leroy Anderson reservoir, and San Felipe Lake all lie on the fault. It joins the San Andreas Fault near Hollister.



Earthquakes from 1980-1997

c) The Calaveras Fault branches eastward from the Hayward fault near Gilroy. It runs in a fairly straight line that points toward north-northwest towards Vallejo. It may continue north of San Pablo Bay.

A color map of these faults follows this material. You may wish to project it to orient the students. We have also included a map showing all Bay Area earthquakes from 1980 through 1997. The correspondence between faults and earthquakes should be apparent.

On October 17, 1989, a Magnitude 7.1 earthquake struck the San Andreas Fault near Santa Cruz. The 8.3 earthquake in 1906 occurred underwater, just north of San Francisco. It was also on the San Andreas Fault.

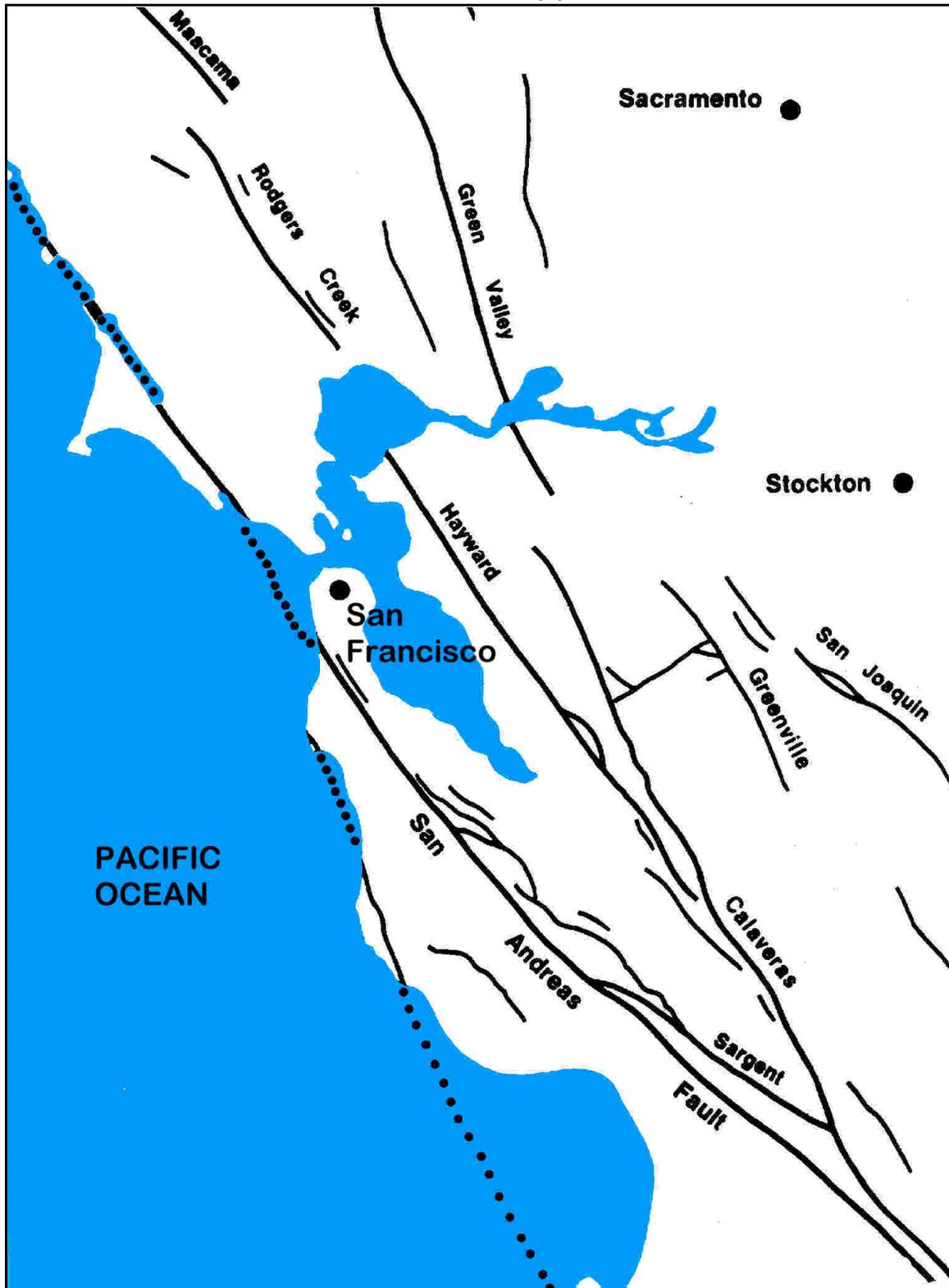
In this exercise the students will trace these faults in the San Francisco Bay area by pasting yarn on the map provided.

## PROCEDURE:

1. Show the students a map of the United States so that they can locate California. If you have a relief map of the San Francisco Bay area, show them that the faults follow the topography (hills and valleys) of the region. If you have a relief map of California, you may want to show the students how the mountain ranges are mainly parallel to each other.

2. Give students yarn, scissors, and paste. Have them cut the appropriate length
3. Have the students color the land brown and/or green on their maps. Instruct them to glue strips of a bright colored yarn over the fault lines on the map.
4. If you live in the San Francisco area, have the students locate where they live. See which fault is the closest to their home or school. Discuss what other structures are close to the faults, like big cities, railroads, or airports.
5. If you do not live in the San Francisco Bay area, you may want to find a local fault map of your region. You can consult your local university geology department. If you have trouble locating a map, please email us ([msn@msnucleus.org](mailto:msn@msnucleus.org)) and we will try to help you.

PLATE TECTONIC CYCLE - EARTHQUAKES (2) LAB



## PLATE TECTONIC CYCLE - EARTHQUAKES (2)

### POST LAB

Students make a paper plate model of the Earth.

### OBJECTIVES:

1. Exploring how deep you can drill into the Earth.
2. Determining where earthquakes occurs.

### VOCABULARY:

core  
crust  
drill  
earthquake

### MATERIALS:

paper plate  
crayons



The aftermath of an earthquake in Turkey.

### BACKGROUND:

Scientists have determined that the center of the earth is 6371 km below the surface. But how has this been determined? Many people might answer that question by saying scientists can drill into the Earth with machines. However, the drilling rigs that scientists use can only drill about 20 km in the Earth which is not very deep! In other words, we can only drill into upper part of the crust of the earth. Extremely high temperatures and pressures within the Earth make drilling into it very difficult.

Earthquakes are caused by the sudden movement and fracturing of rock masses along preexisting faults. A fault is a broken surface within the Earth's crust. The point on the fault at which the displacement begins is called the focus of the earthquake. The point on the surface of the earth directly above the focus is the epicenter. Your students need to understand that an earthquake happens in rocks that have been stressed. This stress is stored until the strength of the rock is exceeded. The actual break (the earthquake) then releases the energy. This energy travels in the form of seismic waves.

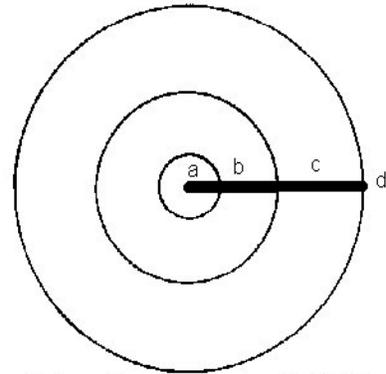
The seismic waves generated by an earthquake can be recorded and measured on a seismograph. The interpretation of the waves provides seismologists with a way of "seeing" into the inside of the Earth. The waves produced by earthquakes travel through the Earth and bounce off different features of the Earth's interior. The patterns they form after bouncing off these features can be used to create images of the interior.

Earthquakes generate many different types of seismic waves. Two major types are P (push/pull; compressional, or primary) and S (shear or secondary). There are some

basic rules that you need to understand. P-waves are faster than S-waves; S-waves cannot travel through liquid; P-waves can travel through liquids and solids, and both types of waves go faster through denser rock and slower through liquids. These basic facts (plus many more) help geologists and seismologists to interpret the inner structure of the Earth. For example, when S-waves are not received by a seismometer, it suggests that a liquid layer is present inside the Earth which we call the outer core.

**PROCEDURE:**

1. The students have learned that most earthquakes occur in the outer most portion of the Earth. Draw a picture of the Earth on the board as shown to the right. A = 1200 km (inner core); 2200 km (outer core); C= 2900 km (mantle); D = 7-100 km (crust). Ask students how far they think it is to the center of the earth from the surface. Have some volunteers come to the board and place an X at the depth to which they think we can drill.



2. Ask the students how they think scientists know what is inside the Earth. Explain that scientists can study the patterns of seismic waves released by earthquakes to determine the Earth's internal layers. You do not have to give much detail, just dispel the notion that we can drill to the center of the Earth.

3. You may want to have students make a paper plate model of the inside of the Earth. Instruct students to label layers as in the diagram. Label depths as follows: A = 1200 km (inner core); 2200 km (outer core); C= 2900 km (mantle); D = 71 km (crust).