

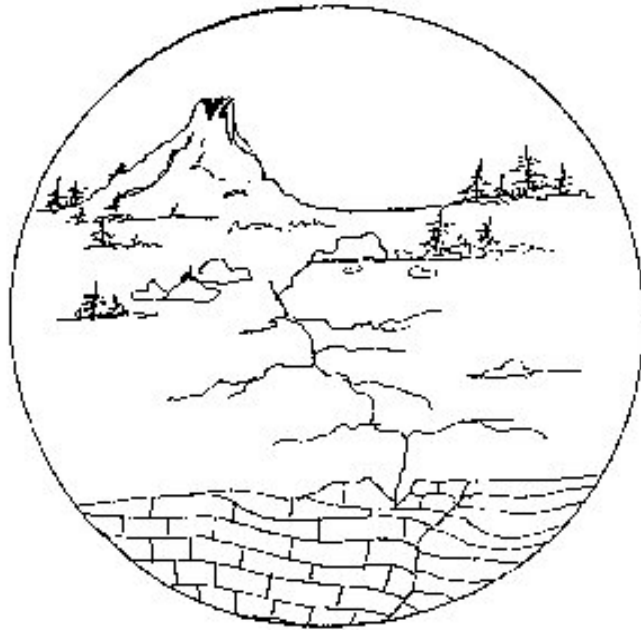


# Plate Tectonic Cycle

Earth's Moving Force

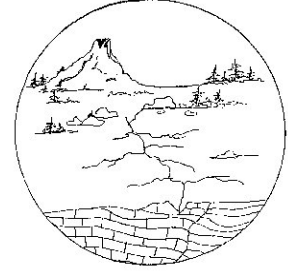


## SIXTH GRADE EARTHQUAKES



1 WEEK  
LESSON PLANS AND  
ACTIVITIES

## PLATE TECTONIC CYCLE OVERVIEW OF SIXTH GRADE



### VOLCANOES

#### WEEK 1.

PRE: *Comparing the structure of different types of volcanoes.*

DURING: *Plotting 3 different types of volcanoes on a globe.*

POST: *Researching where volcanoes occur around the world.*

### EARTHQUAKES

#### WEEK 2.

PRE: *Comparing energy waves from earthquakes.*

DURING: *Experimenting with energy waves through different substances.*

POST: *Observing fault movements.*

### PLATE TECTONICS

#### WEEK 3.

PRE: *Locating different plates.*

DURING: *Illustrating the difficulty in defining and counting plates.*

POST: *Observing the movement of the Earth's crust.*

### HAZARDS

#### WEEK 4.

PRE: *Comparing earthquakes in Alaska and Hawaii.*

DURING: *Designing structures that withstand different earthquake intensities.*

POST: *Comparing earthquake dangers in different areas.*

## PLATE TECTONIC CYCLE - EARTHQUAKES (6)

### PRE LAB

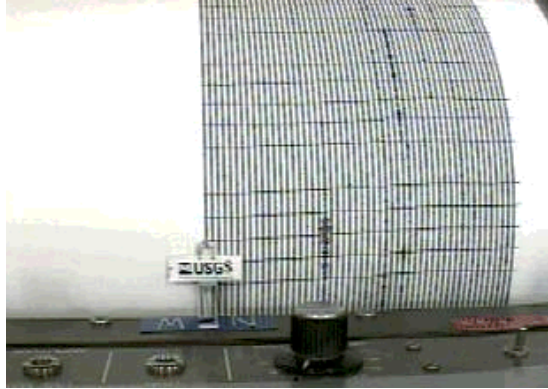
Students learn to identify the characteristics of seismic waves.

### OBJECTIVES:

1. Comparing energy waves from earthquakes.
2. Exploring how waves travel through different substances.

### VOCABULARY:

crest  
frequency  
liquefaction  
seismic wave  
seismograph  
trough  
wave speed  
wave height  
wavelength



### MATERIALS:

none



### BACKGROUND:

The energy released by earthquakes travels through the Earth as seismic waves. These waves pass through different substances at different speeds and frequencies. Seismic waves can be recorded and measured on a seismograph. The record produced by a seismograph is called a seismogram. The interpretation of the waves provides

seismologists with a way of "seeing" into the inside of the Earth. Since we cannot drill very deep into the Earth's crust, the evidence from seismic waves is very important in interpreting the Earth's internal structure.

Waves transmit energy between different points. Seismic waves are a type of physical or vibrational wave. Waves have several parts, as shown in the figure 1. In the picture, the dotted line represents the undisturbed surface, and the wave is moving left to right. The crest is the high

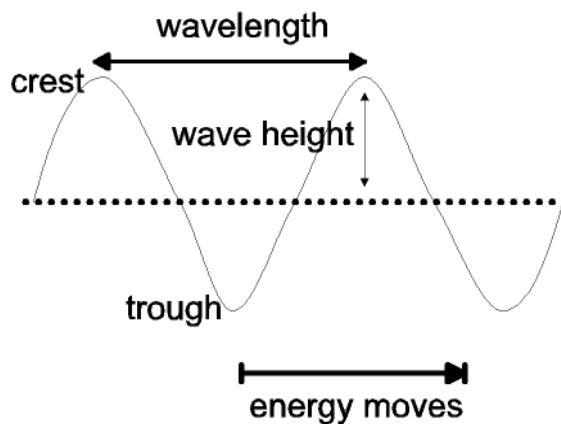


Figure 1.

point of a wave. The trough is the low point. The wavelength is the distance between adjacent crests (or troughs). The wave height is the vertical distance from the undisturbed surface to the wave crest. In general, the bigger the waves, the more energy they carry. Larger waves will be steeper than smaller, less energetic waves of the same wavelength. If the wavelength stays the same, but the energy increases, wave height increases as well.

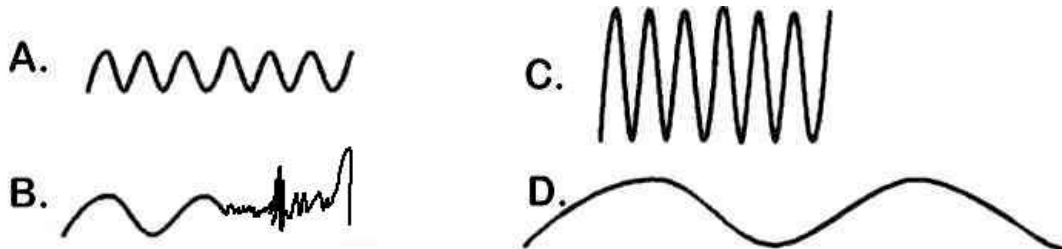
As they go through different substances, seismic waves will change speed and sometimes change direction. In lab, students will look at some of these changes. During an earthquake wave motion can cause serious damage. For example, an earthquake may cause little damage at its epicenter if that area is on stable bedrock, even though it is the closest point to the focus. However, as the waves travel further away through the Earth, they may encounter unstable rock or soil. This area may respond by "sinking," due to liquefaction. Liquefaction takes place when ground shaking makes sandy or wet soil to become "liquid". The water flows out of the ground, allowing it to compact. Liquefaction will cause buildings to become unstable and possibly collapse. Although far away, damage in such an area may be greater than at the epicenter.

The Pre Lab helps students to visualize wave movement. In the Lab, students will be asked to visualize how energy is transmitted through different substances.

### PROCEDURE:

1. Review the words on the vocabulary list with the class. It is important that they understand these terms, which they will use in Lab. Draw the wave diagram shown in the Background section on the board.

2. Draw the following seismograms on the board, or use the presentation images. Ask students the following questions:



1. Which seismogram has the shortest frequency? A
2. Which seismogram represents the most energy? C
3. Which seismogram has the largest wavelength? D
4. Which seismogram has the shortest wavelength? A
5. Which seismogram shows different sizes of waves? B

## PLATE TECTONIC CYCLE - EARTHQUAKES (6)

### LAB

Students learn how energy transmits through different materials.

### OBJECTIVES:

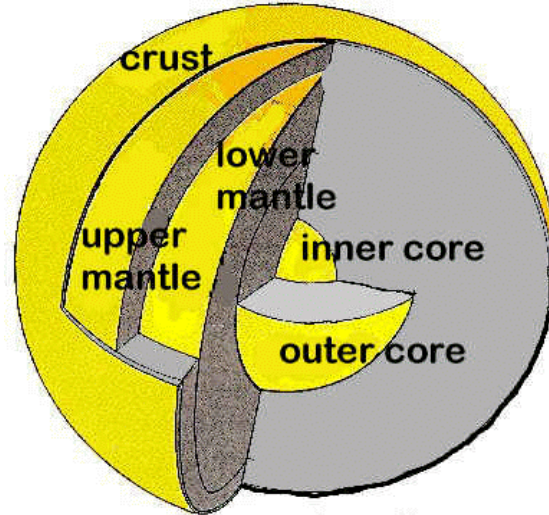
1. Experimenting with energy waves.
2. Observing how energy waves go through different substances.

### VOCABULARY:

frequency  
seismic waves  
seismograms  
waves

### MATERIALS:

density timers  
pennies  
nickels



### BACKGROUND:

As introduced in the Pre Lab, energy waves pass through different substances at different speeds and frequencies. Seismic waves demonstrate this in several ways. First, both P-waves and S-waves go faster through high density rocks like granite than they do through low density materials like soil or sand. Second, when these waves pass through unconsolidated (loose) soil or sediment, the waves slow down and are amplified; wave height increases. Finally, S-waves cannot travel through liquids. The molecules in a liquid “slide past each other” too easily to transmit the shearing motion of S-waves. In this lab the students will experiment with the transmission of energy through different substances. They will not work with seismic waves directly’ the experiments they conduct are direct analogs for their behavior.

The behavior of seismic waves as they travel through the Earth has been used to determine the Earth's interior structure. Through careful study of seismograms, scientists have found that seismic waves change as they travel through the Earth. From this work, they have determined that the Earth has a three-part internal structure.

From its center to the surface, the Earth consists of core, mantle, and crust. The core is composed primarily of two metals, iron and nickel. It 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 mantle surrounds the core, and is composed of very dense silicate minerals.

Most of the mantle is a mush of crystals and a little magma (molten rock), perhaps similar to a snow cone in texture (but MUCH hotter!). The upper part of the mantle is solid. It is coupled with the crust the outermost layer of the Earth, to make the plates.

### **PROCEDURE:**

1. Set up the lab materials for each student or student group. Explain to the class that energy waves travel through different substances in different ways. A good analogy which might be familiar to the students is the way that sound travels in air versus underwater. Sound seems distorted underwater because it travels faster through this denser medium.

Explain to the students that they will observe the transfer of energy through different substances. The reactions they will record are caused by the differences between the substances and the amount of energy they will apply to the experiment. Stress that the experiments should be done SLOWLY and CAREFULLY.

2. Have the students complete the lab.

3. Have the students try to determine the conclusion independently, then have a group discussion to ensure they understand the correct answer. Stress that their experiment is analogous to the behavior of seismic waves inside the Earth.

**ANSWERS TO LAB QUESTIONS:** Exercise I. When you hit the penny, energy is transferred from you (the energy source) to the penny. As the penny hits another penny it again transfers energy, but there is not a total transfer of energy. The penny will slow down. It is important for students to somehow show that when the first penny hits the second the energy, i.e., speed changes. They can answer the question several ways, as long as they describe a change in the energy pattern. The same is true for the nickel, except the change should look different from with the penny to another penny. This is analogous to seismic waves traveling between two types of rock, where a change in (wave) energy also takes place. Here are suggested answers to each question:

1. straight, energy transfer slowed down a little
2. straight, nickel much slower
3. the direction of pennies goes at an angle
4. direction of nickel goes at an angle, slower than in #3
5. energy is not as great as when nickel was used

The direction of waves can change if the transfer of energy forces the energy to go into several directions.

In Exercise II and III, the students should recognize that the same energy goes through different substances differently. They can see the difference in Exercise II (one fluid will have bigger waves than the other). In Exercise III students can hear the difference. For the conclusion students should realize that different substances allow

energy waves to travel differently. They should also understand how geologists use seismic waves to study the interior of the Earth, expressing the information presented in the Background in their own words.

## PLATE TECTONIC CYCLE - EARTHQUAKES (6) LAB

**PROBLEM:** Do waves pass through different substances differently?

**PREDICTION:** \_\_\_\_\_

**PROCEDURE:** Earthquakes produce seismic waves. This lab will explore how waves behave as they travel through different substances.

**EXERCISE I. MATERIALS:** 4 pennies, 4 nickels, graph paper

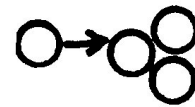
1. Place 1 penny about 8 inches away from another penny on top of the graph paper. Snap one penny into the other. Record the motion of the penny and how far the penny moved.

\_\_\_\_\_

2. Repeat the exercise, replacing one penny with a nickel. Use the same amount of "snap" as in the picture to the right. Record what happens.



3. Place the pennies as in the picture to the right. Snap one penny. Record what happens.



4. Repeat the exercise using nickels. Record what happens.

\_\_\_\_\_

5. Repeat #4, except use one penny behind the shooting line. Is there a difference? \_\_\_\_\_ If so, why? \_\_\_\_\_

**EXERCISE II.**

**MATERIALS:** density timer

Tap one side of the density timer. Do the waves travel differently through the oil and water? Record what happens. \_\_\_\_\_

**EXERCISE III.**

**MATERIALS:** 1 balloon filled with water, one balloon filled with air.

Tap the side of each balloon. Is there a difference between the two? Why?

\_\_\_\_\_

**CONCLUSION:** If waves go through different substances at different speeds, how can we use this information to determine what is inside the earth?

\_\_\_\_\_

\_\_\_\_\_



## PLATE TECTONIC CYCLE - EARTHQUAKES (6)

### POST LAB

Students construct a paper model showing fault motion in the 1989 Loma Prieta earthquake

### OBJECTIVES:

1. Constructing a model of earthquake movement.
2. Observing fault movement.

### VOCABULARY:

fault  
focus

### MATERIALS:

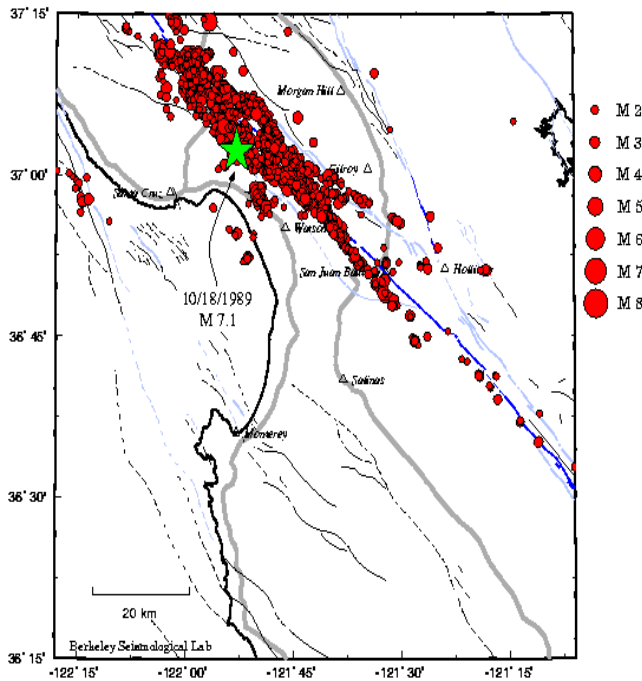
worksheets  
tape or glue



### BACKGROUND:

On October 17, 1989, a Magnitude 7.1 earthquake occurred south of San Francisco, California. The resulting disaster was not the largest in the history of the United States, in terms of either money or lives. In this Post Lab, students will construct a paper model of the 1989 fault rupture. This model will help students visualize the process of fault movement during earthquakes. By examining this model they can better visualize the complexity of faulting during an earthquake. This paper model is from U.S. Geological Survey Open File Report (89-640 B) by T. R. Alpha, J. C. Lahr, and L. F. Wagner. The version below includes the model and instructions; the Report also includes background information. If you wish to order your own copy of the Report, it is available through the Internet at:

<http://geology.er.usgs.gov/eastern/models.html>



Loma Prieta Area Seismicity - 10/18/1989-11/18/1989

The first place along a fault to break during an earthquake is called the focus. The focus is always located within the Earth. The point on the Earth's surface directly above the focus is the earthquake's epicenter. During an earthquake, movement proceeds very rapidly from the focus along the fault. The total area that moves is often called the rupture. The size of the rupture is controlled by many factors, such as the amount of energy stored along the fault, the strengths of the rocks involved, and the orientation of the fault. Generally, the larger the rupture, the bigger the earthquake. Ruptures do not always break through to the Earth's surface. In this situation, the surface above the fault is torn or bend by fault movement. This is what happened in most locations during the 1989 Loma Prieta earthquake.

Aftershocks from the 1989 earthquake, defining the rupture surface.

Here is a detailed description of the Loma Prieta earthquake and associated surface movements, from the Open-File Report by Alpha, Lahr, and Wagner:

"The northern California earthquake of October 17, 1989 occurred in the Santa Cruz mountains between San Francisco Bay and Monterey Bay. It was named after Loma Prieta, a nearby mountain peak. The focus, the point where movement began within the Earth, was on the San Andreas fault at of depth of 18 kilometers. The break expanded rapidly along the fault plane, moving at approximately 12,000 km/hr (7,000 mi/hr). It extended upward to within 6 km of the surface and along the fault for 25 km to the northwest and 25 km to the southeast. With respect to the North American plate, the Pacific plate moved northwest 1.6 meters and upward 1.1 meter at an angle of 70 degrees during the event.

Because the main fault rupture, or break, did not continue all the way to the surface the upper layers of the earth were bent rather than broken. An area of fissures, or deep cuts in the earth, mapped near the north end of the rupture may have been a result of this bending. In the paper model a series of cuts, which form a stepped or "en echelon" pattern are placed directly above the fault rupture. These cuts were caused by the motion on the fault below them . They illustrate how surface layers might be deformed by underground fault movement. The actual pattern of bending and fissures, however is more complicated and is not portrayed by the paper model."

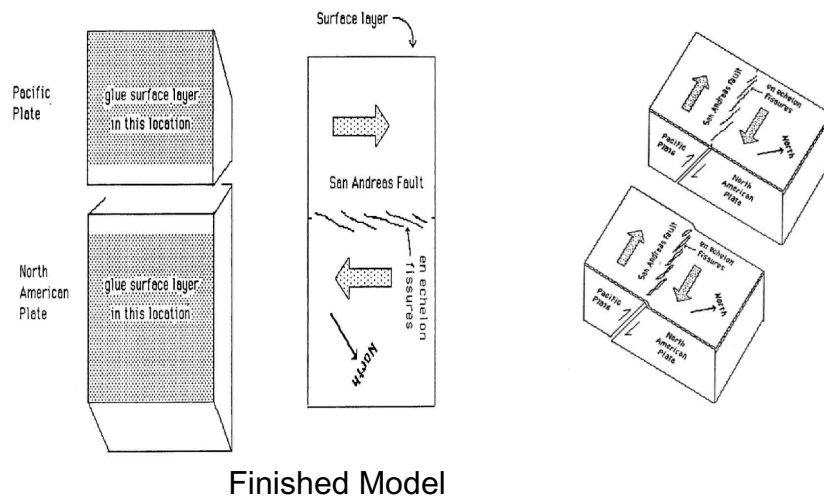
## PROCEDURE:

1. Explain fault movement and surface rupture to the class. Give them background information on the 1989 Loma Prieta Earthquake.
2. Have the students cut out and construct the paper model. When they have finished, have them simulate the earthquake displacement by shifting the "Pacific Plate" box upward and to the north. Have the students closely observe the surface of the model; they should see how the fissure buckles in an en echelon pattern.

## MAKING A PAPER MODEL OF THE 1989 LOMA PRIETA EARTHQUAKE

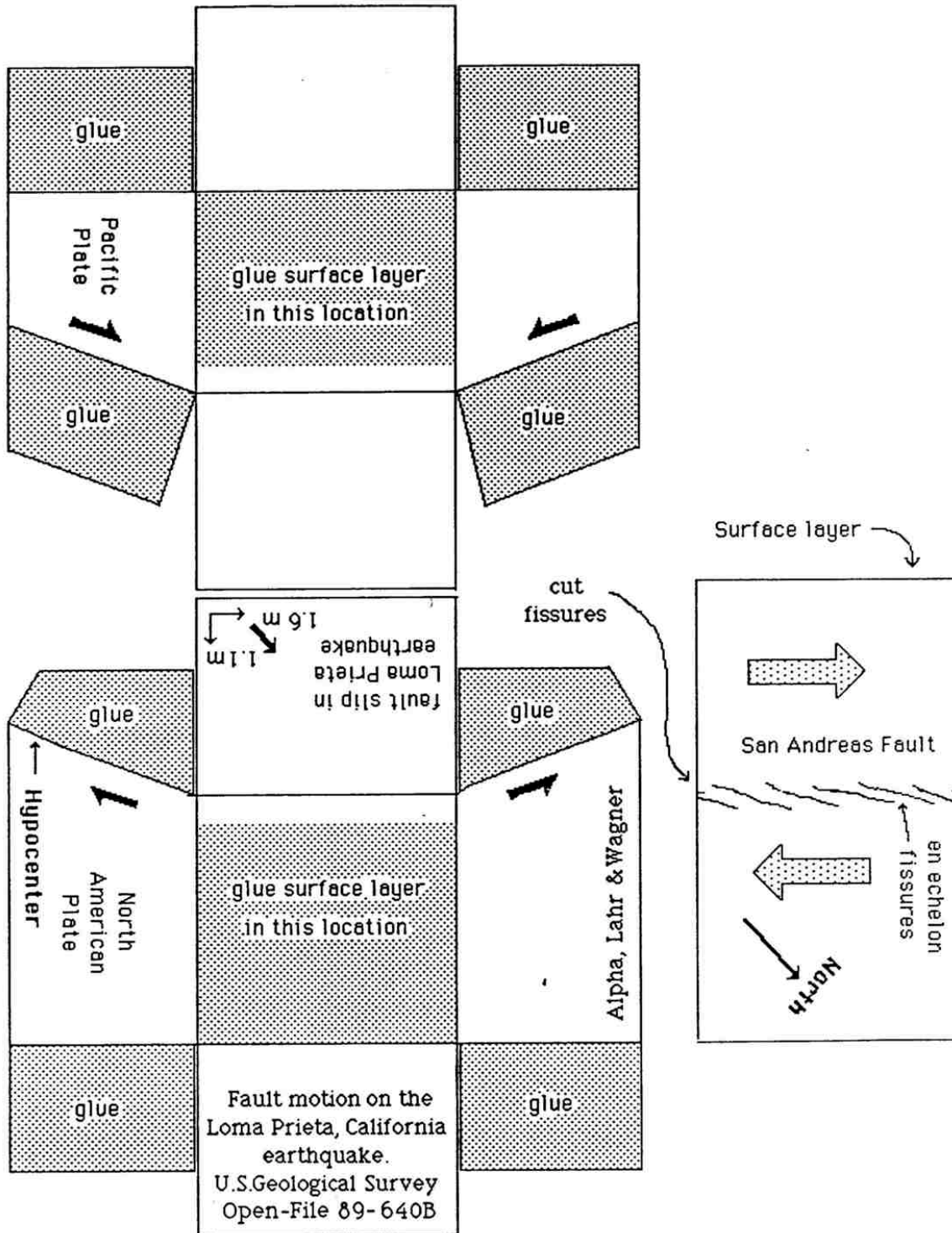
### INSTRUCTIONS:

1. Cut out all three pieces of the model (next page).
2. Fold the two large pieces into box shapes, as illustrated. Make sure you fold all the areas before you start gluing.
3. Glue the tabs of the two boxes and assemble them.
4. Glue the surface layer to the tops of the two boxes. Be careful that the area of the fissures remains glue free.
5. To simulate the earthquake displacement, shift the "Pacific plate" box upward and to the north. Notice how the fissure buckles.



# PLATE TECTONIC CYCLE - EARTHQUAKES (6) - POST LAB

Model (Instructions on next page)



# PLATE TECTONIC CYCLE - EARTHQUAKES (6) - POST LAB

Cut the model as shown below.

