

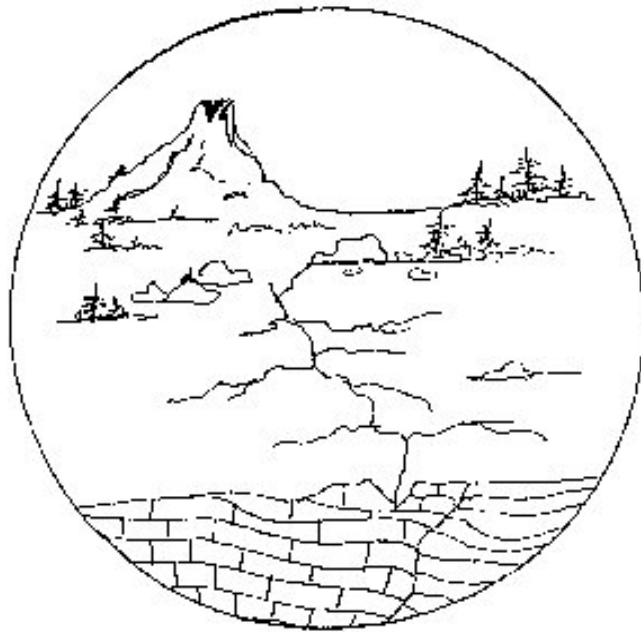


# Plate Tectonic Cycle

Earth's Moving Force



## FIFTH GRADE PLATE TECTONICS



1 WEEK  
LESSON PLANS AND  
ACTIVITIES

## **PLATE TECTONIC CYCLE OVERVIEW OF FIFTH GRADE**

### **VOLCANOES**

#### **WEEK 1.**

PRE: *Exploring the rocks produced by volcanoes.*

LAB: *Comparing igneous rocks.*

POST: *Critiquing books on volcanoes for their scientific content.*

### **EARTHQUAKES**

#### **WEEK 2.**

PRE: *Analyzing the types of waves produced by earthquakes.*

LAB: *Interpreting seismograms with associated damages.*

POST: *Analyzing earthquakes around the world.*

### **PLATE TECTONICS**

#### **WEEK 3.**

PRE: *Investigating the patterns produced by volcanoes and earthquakes.*

LAB: *Testing models of crustal movement.*

POST: *Defining plate boundaries.*

### **HAZARDS**

#### **WEEK 4.**

PRE: *Comparing volcanic and earthquake hazards.*

LAB: *Determining what type of viscous mixtures can cause the most damage.*

POST: *Exploring earthquakes that are associated with volcanoes.*

## PLATE TECTONIC CYCLE - PLATE TECTONICS (5)

### PRE LAB

Students research patterns of earthquakes and volcanoes on the Internet.

### OBJECTIVES:

1. Exploring how the crust moves.
2. Investigating the patterns produced by volcanoes and earthquakes.

### VOCABULARY:

asthenosphere  
inner core  
outer core  
crust  
lithosphere  
mantle  
plate tectonics

### MATERIALS:

world map  
physiographic globe showing a cross section of the Earth



A map of the plates and active volcanoes, from the USGS

### BACKGROUND:

Geologists have distinguished three main internal subdivisions of the Earth, based on the behavior of seismic waves and laboratory experiments. The outermost layer is the crust. The Earth has two types of crust. Continental crust underlies much of the Earth's land surface. The ocean floors are underlain by oceanic crust. These materials are composed of different kinds of silicate minerals. The continental crust is composed mainly of the minerals that are in the igneous rock granite, and the oceanic crust is mainly composed of minerals that are in basalt.

Underlying the crust is the second layer, the mantle. It comprises the largest portion of the Earth. Like the crust, it is also composed of silicate minerals. The innermost portion of the Earth is the core. It is composed of metallic elements, primarily iron and nickel. The core is subdivided into two parts. The outer core is liquid metal, while the inner core is solid. The radius of the Earth is 6371 km (inner core = 1200 km; outer core = 2200 km; mantle = 2900 km; and crust = 71 km).

Remember that the composition of the inner part of the Earth has not been directly observed. The layers presented above are based on the interpretation of seismic waves and experimental data by geologists and seismologists. Remind students that we cannot even drill all the way through the crust!

The plates are composed of the crust and the uppermost part of the mantle. These two layers are often called the lithosphere because they are both composed of solid rock. The underlying, partially molten part of the mantle, on which the plates slide, is called the asthenosphere. In contrast to the crust–mantle–core division, which was based on composition, the lithosphere and asthenosphere are separated based on strength. The lithosphere is strong, rigid rock, while the asthenosphere is a weaker, very viscous fluid.

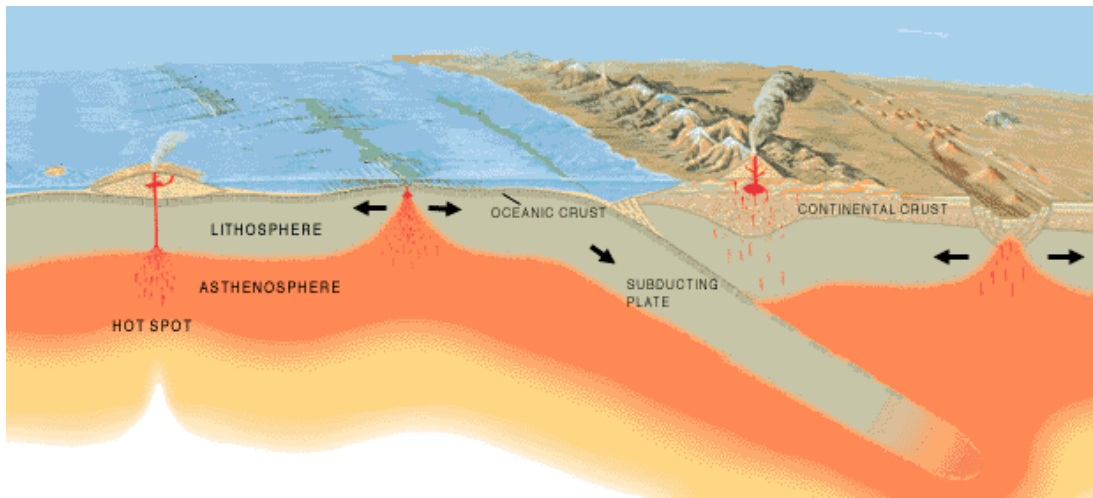
The plates are layers of rigid, solid rock. However, as they move, plates interact at their edges or boundaries. These interactions generate earthquakes and volcanoes. There are three basic directions or types of boundary interactions. At diverging plate boundaries, earthquakes occurs as the plates pull away from each other. Volcanoes form between the plates, as magma rises upward from the underlying mantle. Second, two plates may come together, at a converging plate boundary. Two situations are possible at converging plate boundaries. First, only earthquakes occur when two plates collide (obduct), building a mountain range. Second, both volcanoes and earthquakes form where one plate sinks under the other, instead of colliding. This process is called subduction. Finally plates can also slide past each other horizontally. Transform plate boundaries commonly have only earthquakes.

## PROCEDURE:

1. Introduce the students to the internal structure of the Earth. The physiographic globe illustrates these layers well, or use the presentation image below. Make sure to give them the thickness of each layer.



2. Introduce students to the basics of plate tectonics. Describe each type of plate boundary, the type of motion occurring there, and whether or not earthquakes and volcanoes are generated.



3. As a homework assignment, have the students search the Internet for information on the global distribution of earthquakes and volcanoes. You may wish to tell them to look for patterns and/or exceptions to the occurrence of these phenomena at plate boundaries. Here are some suggested websites:

<http://pubs.usgs.gov/publications/text/dynamic.html>

This Dynamic Earth - an introduction to plate tectonics from the U. S. Geological Survey

[http://volcano.und.nodak.edu/vwdocs/vwlessons/plate\\_tectonics/introduction.html](http://volcano.und.nodak.edu/vwdocs/vwlessons/plate_tectonics/introduction.html)

Introduction to Plate Tectonics at Volcano World. Well presented, good graphics.

<http://www.ucmp.berkeley.edu/geology/tectonics.html>

The plate tectonics page at the UC Berkeley Paleontology museum.

## PLATE TECTONIC CYCLE - PLATE TECTONICS (5)

### LAB

Students test models for the origin of stress in the Earth.

### OBJECTIVES:

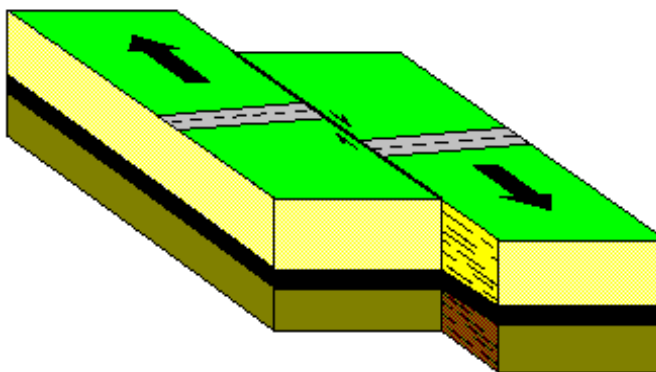
1. Testing models of crustal movement.
2. Experimenting with materials to make mountains.

### VOCABULARY:

contracting  
expanding  
mountain building  
compression  
tension  
shear

### MATERIALS:

round balloons  
flour  
water  
lab sheet  
wax paper  
aluminum foil  
worksheet



This fault is an example of shearing stress within the Earth.

### BACKGROUND:

Understanding the movement and behavior of the Earth's outermost layers has been a painstakingly long scientific process. The theory of plate tectonics is our current "best explanation" and working model for answering these questions. Plate tectonic theory has developed slowly and progressively since it was developed in the 1960s. It is a theory that truly has the entire world as its experiment.

Scientific ideas are subject to change as new information is gathered. This is why there are no "facts" in science. Every interpretation can be improved upon and altered as new research is completed. Scientific interpretations are continually tested and updated.

In this lab, students will test plate tectonics against two other hypotheses: 1) the Earth is expanding in size, and 2) the Earth is contracting in size. Both of these are real hypotheses proposed by earth scientists. They are not accepted, because, as the students will see, they do not accurately explain the behavior of the Earth's crust.

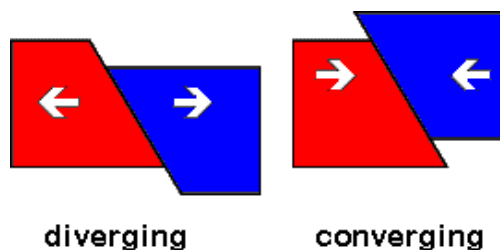
This lab focuses on testing the ability of each of ideas to explain the stresses

observed in the plates (especially the crust). Three types of stress are common. Compression is when a squeezing force is applied to a rock. Compression or converging plates builds mountains, which often occur in parallel ranges, with valleys between them. Diverging plates or extension is a when a pulling apart force effects a rock; it is the opposite of compression. Diverging also creates sets of parallel valleys. Transform motion along plate boundaries produces a shearing force is when two forces are applied to a rock, but in parallel and opposite directions.

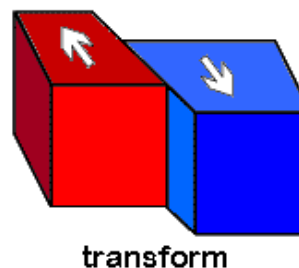
In the lab, the students will discover that a contracting Earth only produces converging and that an expanding Earth creates only diverging. Only plate movement can produce all three types of motion.

## PROCEDURE:

1. Review the types of motion that are common in the Earth's crust. Make sure the students understand the differences between stress caused by converging, diverging, and transform.



2. Have the students work with a lab partner. Demonstrate lab procedures to the class before they begin to work. Emphasize to the students that the experiments should be done slowly. Also emphasize that they should carefully observe the types of stress created in each experiment, and why they occur. Make sure they record their findings on the worksheet.



3. For theory 1 and 2 students use the flour mixture to simulate the lithosphere (crust and upper mantle) moving on top of the balloon (asthenosphere). Students can try to be realistic about making continents out of the flour mixture. In the expanding Earth, the flour mixture will move apart, making cracks and wrinkles that are parallel. The contracting earth will have the lithosphere moving together causing parallel mountains and valleys. Plate tectonics will also give you parallel features.

4. For theory 3, the arrows indicate the direction of pressure. In 1, the students demonstrate compression. They should first squeeze a piece of aluminum foil with equal pressure from both hands, and then with one hand exerting more pressure. In 2, the students experiment with shear. They should move one hand diagonally down while the other hand goes diagonally up. This is similar to movement on the San Andreas Fault in California. 3 and 4 represent a more realistic models of the Earth where different densities of respond differently to stress. Key observations are the creation of parallel mountains

and valleys.

5. When they are finished, review the students' findings. Focus on Theory 3 (Plate Tectonics) so that they get an understanding of mountain building, earthquakes, and volcano formation as they relate to crustal movement. There are many reasons why the contracting and expanding Earth theories are not good explanations. They do not fit all the data that geologists have accumulated over the years. Geologists can measure the Earth's diameter, and the Earth does not seem to have gotten larger nor smaller. Students should discuss various tests. Even if they come up with some silly answers, it gets them thinking about the pros and cons of the different models.



## PLATE TECTONIC CYCLE - PLATE TECTONICS (5) LAB

**PROBLEM:** What theories can explain volcano and earthquake distributions on the Earth?

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

### THEORY 1. EXPANDING EARTH

Make a paste mixture using approximately 1/4 cup water and 2 heaping teaspoons of flour. Blow up a balloon halfway. As one partner holds the balloon, the other partner will put a thin coating of mixture on about 1/4 of the balloon. This creates a model of the Earth's crust. As one partner slowly blows up the balloon; record what happens.

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### THEORY 2. CONTRACTING EARTH

Clean the balloon, and blow it up completely. Coat the balloon with the paste mixture to again model the crust. Deflate the balloon slowly, and record what happens.

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### THEORY 3. PLATE TECTONICS

Describe what happens when you apply equal or unequal pressures to the various objects, using your hands as charted below. Your teacher will clarify the diagrams.

Al=aluminum; w = wax paper;  = hand movement

	1  Al	2  Al  Al	3  Al W Al 	4 Al  W Al 
EQUAL PRESSURE				
UNEQUAL PRESSURE				

**CONCLUSION:** Which theory best explains the features of the Earth? Why?

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## PLATE TECTONIC CYCLE - PLATE TECTONICS (5)

### POST LAB

Students trace plate boundaries using earthquake occurrences.

### OBJECTIVES:

1. Making a model of the Earth.
2. Defining plate boundaries.

### VOCABULARY:

crust  
plate movement  
plates

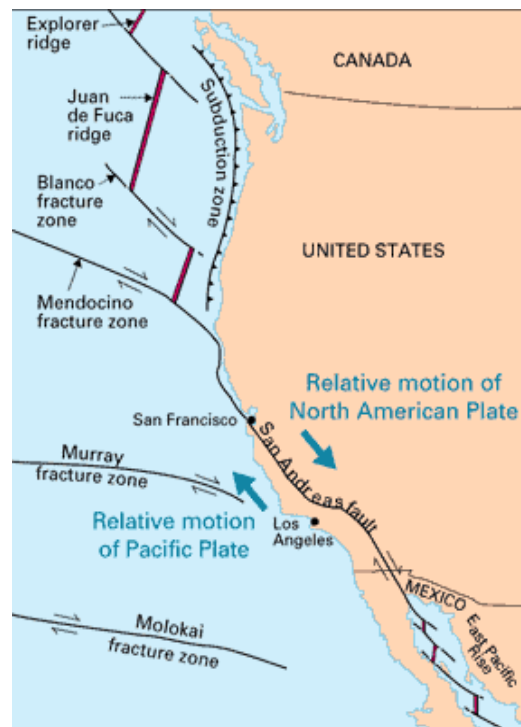
### MATERIALS:

Tetrahedron map by NGSDC  
paste  
scissors  
crayons

### BACKGROUND:

The plates are composed of rigid, solid rock. As they move, plates interact at their edges or boundaries. As discussed in the Pre Lab and Lab, there are three basic directions or types of boundary interactions. In some places, two plates move apart from each other; this is called a diverging plate boundary. Elsewhere two plates move together; this is a converging plate boundary. Finally plates can also slide past each other horizontally. This is called a transform plate boundary. Volcanoes and earthquakes help define the boundaries between the plates. Volcanoes form mostly at converging and diverging plate boundaries, where much magma is generated. Earthquakes occur at all three types of boundaries. Because the plates are rigid, they tend to stick together, even though they are constantly moving. When the strength of the rocks at the plate boundary is exceeded, they move rapidly, "catching up" with the rest of the plates. We feel this release of energy as an earthquake.

In this exercise, the students will color and assemble a map of the Earth showing earthquakes. The assembled map will make is a tetrahedron (a four-sided geometric figure) of the Earth. This map was designed by John Ward of the National Geophysical and Solar Terrestrial Data Center (NGSDC). The NGSDC acquires, reformats, archives, and distributes worldwide seismological data, many in cooperation with the U.S. Geological Survey. The earthquakes that are plotted on this tetrahedron map were



Earthquakes are common along the plate boundaries in the Western United States.

retrieved from the Earthquake Data File for the years 1963-1974 and had magnitudes of 4.5 or greater.

### **PROCEDURE:**

1. Before class make a copy of the tetrahedron for each student. Either copy the master sheet onto hard stock paper (50 lb or heavier is ideal, but 20 lb paper will work) or print it from your computer. This will help students make a better model.

2. Pass out the worksheets. Have the students lightly color the Earth, distinguishing land from the oceans. See if they can define "plates" using the data. Next, instruct them to draw in the plate boundaries. Ask them this question again after they have assembled the tetrahedron. It is much easier to see the plates when the puzzle is put together.

3. Have the students cut out the tetrahedron and paste it together, gluing the appropriate areas. Make sure that they fold all the black lines before they start to paste, otherwise it is difficult to put the model together.

4. Discuss the 3 different plate boundaries with the students. Differentiate which boundaries produce earthquakes and/or volcanoes. Converging and diverging boundaries both produce earthquakes. Only earthquakes are common at transform boundaries. Draw pictures on the board to reenforce these points, or use the presentation image below.

PLATE TECTONIC CYCLE - PLATE TECTONICS (5) - POST LAB

TETRAHEDRON MAP

