Layers, Plates, and Quakes

Vocabulary

crust
lithosphere
mantle
outer core
inner core
plate
strike-slip (transform) plate boundary
convergent plate boundary
divergent plate boundary
volcano
magma

Learning Links

Language Arts: Discussion, note taking, vocabulary building, following directions

Math: Using a scale to build Earth wedge model

Art: Drawing, cutting, and taping paper models; building convection model

Content Concepts

1. The Earth has a layered structure.

2. The Earth's outer layer is broken into pieces called plates.

3. Three basic kinds of movement take place at the edges of the plates.

4. Plate movements create special surface features near the edges of the plates.

5. Convection currents in the mantle may be the cause of plate movements.

Objectives

Students will
—make a model of the layers of the Earth.
—be able to describe the composition of the layers and their interrelationships.
—model and describe activity at the three major types of plate boundaries.
—observe a demonstration of convection currents and relate the process to plate movement.
—construct a model of continental movement from ancient time through the present and into the future.

Assessment

Shakemeup, USA (a fictitious town) is located on the coast of California. Scientists know that subduction is occurring under this part of California. Describe what you think will happen to this town over the next 100 years.

Activity One: Crust to Core: A Pizza the Earth

Materials for the teacher
- Transparency made from Master 15, A Pizza the Earth
- Overhead projector
- Transparency markers

Materials for each student
- 3 sheets of unlined paper, standard size
- No. 2 pencil
- Meter stick
- Tape
- Copies of Master 16, Graph of the Earth's Layers
- Copies of Master 15 (optional)

Procedure

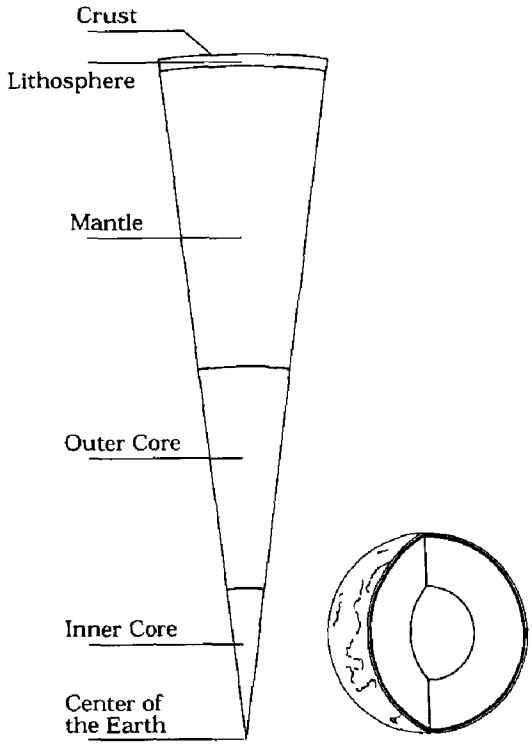
1. Elicit from class what they think the Earth is like below the surface. Accept various opinions. Depending on answers, class may need to use all or part of the first activity from Grades 3-4 in this unit.

2. Display the transparency of Master 15, A Pizza the Earth Explain that the Earth is layered and that we have learned about these layers largely from the study of earthquake waves. Define *crust, lithosphere, mantle, outer core,* and *inner core* (see the lower-grade lessons in this unit), and ask students to write definitions of the layers in their notebooks for future reference. (Or give the students copies of Master 15, A Pizza the Earth, and have them add the definitions there.)

3. Tell the class that they are going to create a scale model of a slice of the Earth, from its surface to the center, using the following procedure.

a. Attach three pieces of unlined paper by taping together the shorter sides to make a strip about 80 cm long.

b Turn paper over to the untaped side.



Master 15. A Pizza the Earth answers

"This Pizza the Earth sure has a thin crust"

mag • ma

Magma is liquid rock beneath the Earth's surface. When it erupts it is called lava.

vol • can • o

A volcano is a mountain of erupted hardened lava or volcanic rock fragments at the surface of the lithosphere.

Extensions

1. Research how scientists have discovered about the various layers of the Earth through the study of earthquake waves.

2. To the wedge model on Master 15 add the hydrosphere (average thickness of the oceans, about 3.8 km) and the atmosphere (about 960 km thick).

c. Draw, with the aid of a meter stick, a triangle 10 cm wide on top and 64 cm on its other two sides. (This is a scale of about one millimeter for each kilometer of the Earth's radius.) Label the 10-cm side **Earth's Surface** and the opposite end (the point of the wedge) **Center of the Earth.**

d. Compute the scaled distance from the Earth's surface to the bottom of each of the layers, using the data from Master 16. Graph of the Earth's layers. (Students will have to know the scale—1 millimeter equals 10 kilometers—and the definitions of the layers to be able to perform this task correctly. Be prepared to offer help as needed.)

e. Label the layers.

4. When the wedge models of Earth are completed, ask students to answer the following questions:

Which of Earth's layers is the thickest and accounts for most of its volume? (the mantle)

On which layer or layers are the plates? (lithosphere, or crust and upper mantle)

In which layer or layers can faulting occur to create an earthquake? (again, lithosphere or crust and upper mantle)

How does the part of the Earth we live on—the crust or lithosphere—compare in thickness to the Earth's interior? (It's the thinnest part.)

Activity Two: Slide, Collide, and Separate

Materials for the teacher
- Overhead projector
- Transparency made from Master 17, Plate Boundaries Map

Materials for each student
- Copy of Master 17, Plate Boundaries Map
- 10 sheets of lined notebook paper or other 8 1/2" x 11" sheets
- One sheet of colored construction paper
- Scissors
- Transparent tape
- Metric ruler

Procedure

1. Use the transparency and student copies of Master 17, Plate Boundaries Map, to explain that different types of interactions occur among lithospheric plates at their boundaries. You may want to use the hand movements from Level 2, Activity Three, of this unit to demonstrate.

a. Lateral boundaries exist where two plates slide and grind past each other as they move in parallel or opposite directions.

b. Convergent boundaries exist where two plates collide and destroy lithosphere by compacting, or shortening, and melting. There are two major types of convergence:

When two ocean boundaries or an ocean boundary and a continental boundary collide, an ocean plate edge sinks, and melting occurs. Plate boundaries of this type are associated with ocean trenches, coastal mountain ranges (e.g. Cascades), and island arc volcanoes. The melting forms magma, which rises, creating the volcanoes of the island arcs.

When two plates that have continental areas at their convergent boundaries collide, the lithosphere crumples up and new young mountain ranges form. This is happening today where India is colliding with Asia, forming the Himalayan Mountains.

c. Divergent boundaries exist where two plates diverge or separate, as at mid-ocean ridges. Divergence results in the formation of new lithosphere and crust, because separation allows liquid rock, or magma, to rise from the mantle below, forming volcanoes and new rock.

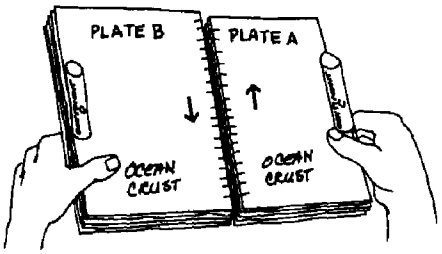
2. Tell the class that they are going to make some simple models of two major types of plate boundaries. If the class has never done hand motions to model the activity at plate boundaries, do Activity Three from the Grades 3-4 section of this unit first.

3. Ask students to get out their notebook paper and make two stacks of five sheets each. Then give them the following directions:

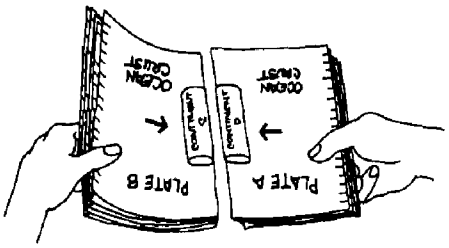
a. Using large letters, label the top sheet of one stack **Plate A** and the top sheet of the other **Plate B**. From now on, we will refer to the stacks of paper as "plates."

b. With scissors, cut .5" (1 cm) slashes at 1" (2 cm) intervals, fringing the long side of each plate. These slashes will represent the broken-up, crushed rock at the plate boundary.

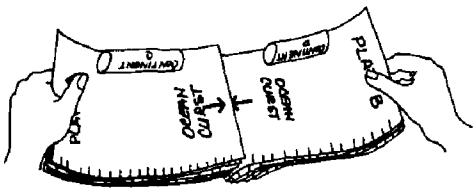
Teacher Take Note: To conserve paper use recycled paper or have students work in small groups.



Lateral boundary: Edge slide, but sometimes catch and jerk.



Convergent boundary with continents: Plate edge humps up, and may form mountains over time.



Convergent boundary with oceanic crust: One plate edge is forced under the other. This process may account for the formation of oceanic trenches.

c. Hold the plates together, one in each hand, in front of you. Push one plate forward and pull the other back towards your body.

What did you feel? (sliding with frequent hitches as the slashed edges engage)

What do you think this model represents? (A lateral plate boundary. The sliding motion represents fault creep, and the jerky motion represents the buildup and release of energy in an earthquake. The San Andreas lateral boundary in California exhibits this kind of motion. Plates slide, but locking of sections occasionally results in earthquakes.)

4. Tell students that next they will use their **Plates A** and **B** to model another type of plate boundary. Give these directions:

a. Label the top of each plate **Ocean Crust**.

b. Cut the sheet of colored construction paper in half lengthwise, and make a loop out of each section. Tape the loops closed, and press down on each one gently to flatten it.

c. Label one loop **Continent C** and the other **Continent D**, or make up names and write them on the loops. These loops will represent continents or continental crust.

d. Tape the middle of each loop to the short side of one of the plates with the closed side facing out.

e. Hold a plate-continent combination in each hand with the continent edges facing each other. Push the two plates together and observe what happens to the continents riding on the plates.

What do you see? (The plates will hump up and the edges of the continents will rise.)

What might this represent? (The demonstration represents the convergence of two plates, the shortening or folding of the crust and the formation of mountains.)

f. Turn the plates around so their plain short edges (without continents) face each other, then push those edges together.

What happened? (One of the plates slid under the other.)

What might this represent? (It represents two plates of oceanic crust converging. The depression which results represents an oceanic trench.)

5. Help students to summarize their observations, and answer any questions they may have.

Activity Three: The History of Geography

Materials for the teacher

- Transparency made from Master 18, Convection Currents and Plate Cross Section
- Transparency made from Master 19, Formation and Break-up of Pangaea
- Overhead projector
- Materials and directions from Unit II, Level 2, Activity Four
- World map or globe

Procedure

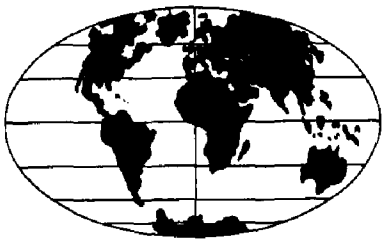
1. Ask students what they think might cause the Earth's plates to move. Accept various suggestions, then explain that the mechanism of plate movement is one of the major unsolved mysteries in Earth studies. The most widely accepted explanation is that convection currents in the Earth's mantle drive the plates. If students are not clear on the definition of *mantle*, review the definitions in Level 1.

2. Briefly describe convection currents, and project Master 18, Convection Currents and Plate Cross Section. Give several common examples of convection, such as hot air rising and cold air falling in the classroom, or warm water rising to the top and cool water sinking to the bottom in a lake or pool.

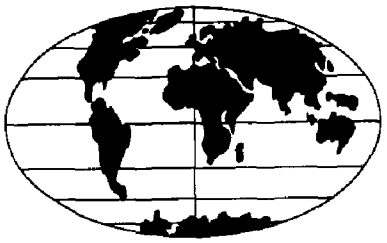
3. Discuss possible energy sources for convection and the movement of plates. (Many Earth scientists believe that heat energy is produced within the interior of the Earth, perhaps by the decay of radioactive materials like uranium and radium within the core and mantle.)

200,000,000 years ago

65,000,000 years ago



Today



50,000,000 years from now

Master 19, Formation and Breakup of Pangaea

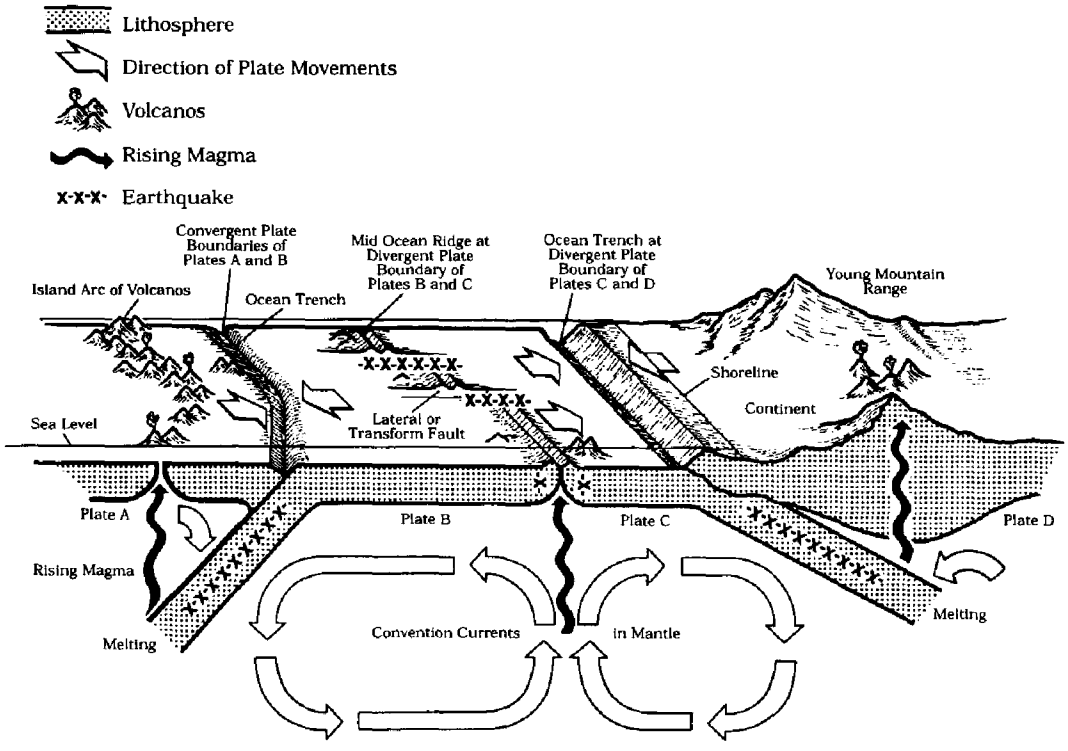
4. Refer to a globe, a world map, or a transparency of a world map, and ask how Africa and South America could fit together, almost like parts of a jigsaw puzzle. Students may see a similar fit among Europe, North America, and Greenland. Query class for a reason for this fit, and lead up to a brief discussion of Pangaea, the supercontinent of 200,000,000 years ago.

5. Using the transparency of the breakup of Pangaea (Master 19), very briefly show how we think the supercontinent changed to become the continents of today. Be sure to emphasize that the continents move only as parts of plates, not by themselves.

6. Indicate to the class that they are going to observe a model showing how convection currents could move the plates and the continents that ride on them. This model may explain the breakup of the supercontinent Pangaea over the last 200,000,000 years.

7. Do Activity Four, "Hot Stuff Rises and Cold Stuff Sinks," from Level 2 of this unit.

8. Again direct students' attention to the transparency of Master 18, Convection Currents and Plate Cross Section. Point out and briefly discuss what happens where convection currents rise and sink.



Activity Four: Flippin' through Pangaea

Materials for the student

- 1 copy of each Master 20a through 20d for each student
- Scissors
- Stapler (in classroom)

Procedure

1. Tell the students they are going to construct a flip book that illustrates the last 200,000,000 years on Earth. (You may want to show a finished book to emphasize careful cutting and to give the general idea.)

2. Direct students to very carefully cut masters 20a, 20b, 20c, and 20d apart on the straight lines. After cutting, they should stack the rectangles in sequential order. Numbered corners should be face up and in the upper left corner. The two blank ellipse panels should be on the bottom.

3. Align lower edges by tapping on a hard surface. Then align the left edges similarly. Hold the stack with both hands, having thumbs on top. Bend the stack back and forth several times until the edges on both sides are "slightly" offset. Hold the book with your right hand and staple it together (in far enough to include all the pages, about .5 cm.)

4. Ask students to describe the changes in the pictures from panel 1 to panel 22. (The large dark mass, "Pangaea," breaks apart, and the continents as we know them today are formed.) Ask students to make predictions about what will happen to the continents in the future. (There will be further movement of continents in the same direction.)

5. Direct students to draw their predictions on the last two blank ellipses. (Remind students that they should make their drawings sequential.)

6. Have students discuss their predictions and drawings.

Unit II. Why and Where Earthquakes Occur

Materials List

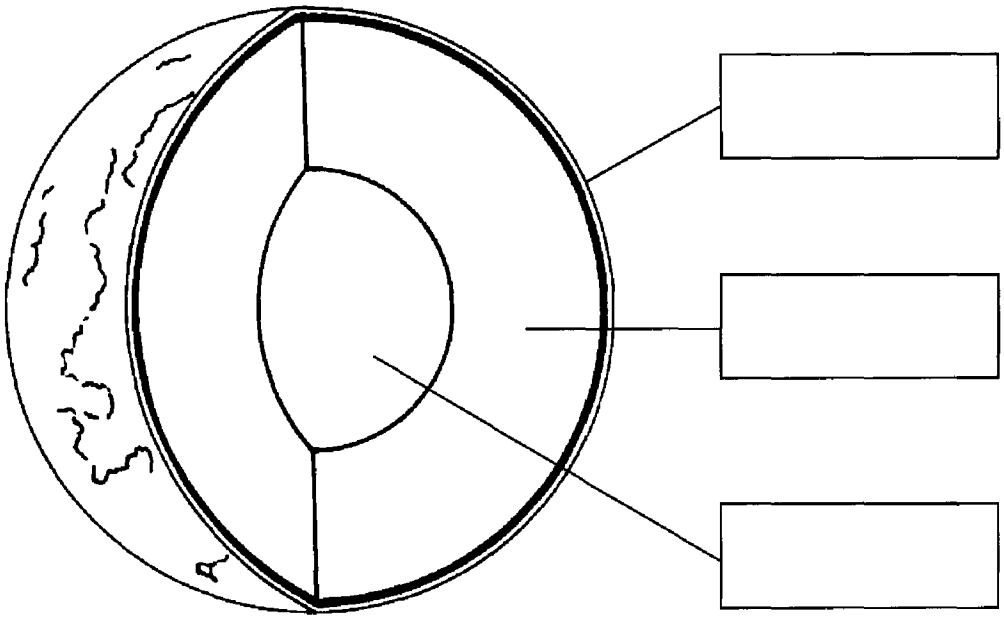
Grades K-2
hard-boiled egg
permanent marker
dental floss or butter knife
construction paper
toothpicks
modeling clay
paper
crayons
markers
scissors
paste or glue
overhead projector

Grades 3-4
globe
crayons
colored pencils
glass baking dish or aquarium
immersion heater
plastic bag with twist tie
tape
eyedroppers
red food coloring
blue food coloring
ice cubes
hard-boiled eggs
small kitchen knife
overhead projector
narrow permanent marker
broad permanent marker
paper circles from hole puncher

Grades 5-6
unlined paper
pencils
metric stick
watch with second hand
colored pencils or crayons
lined paper
colored construction paper
scissors
transparent tape
metric ruler
glass baking dish
plastic bag with twist tie
immersion heater
tape
red food coloring
blue food coloring
eyedroppers
paper hole punches
ice cubes
globe
overhead projector
transparency markers

Layers of the Earth

Name _____

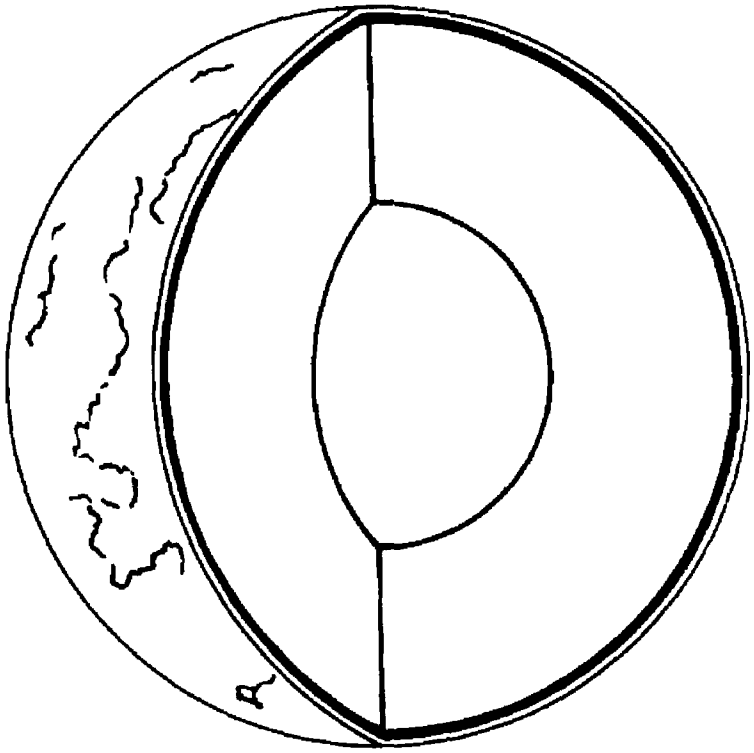


1. Color the layers of the Earth.
2. Cut out the words and paste them in the correct boxes.

Crust	Mantle	Core

Earth Layers Worksheet

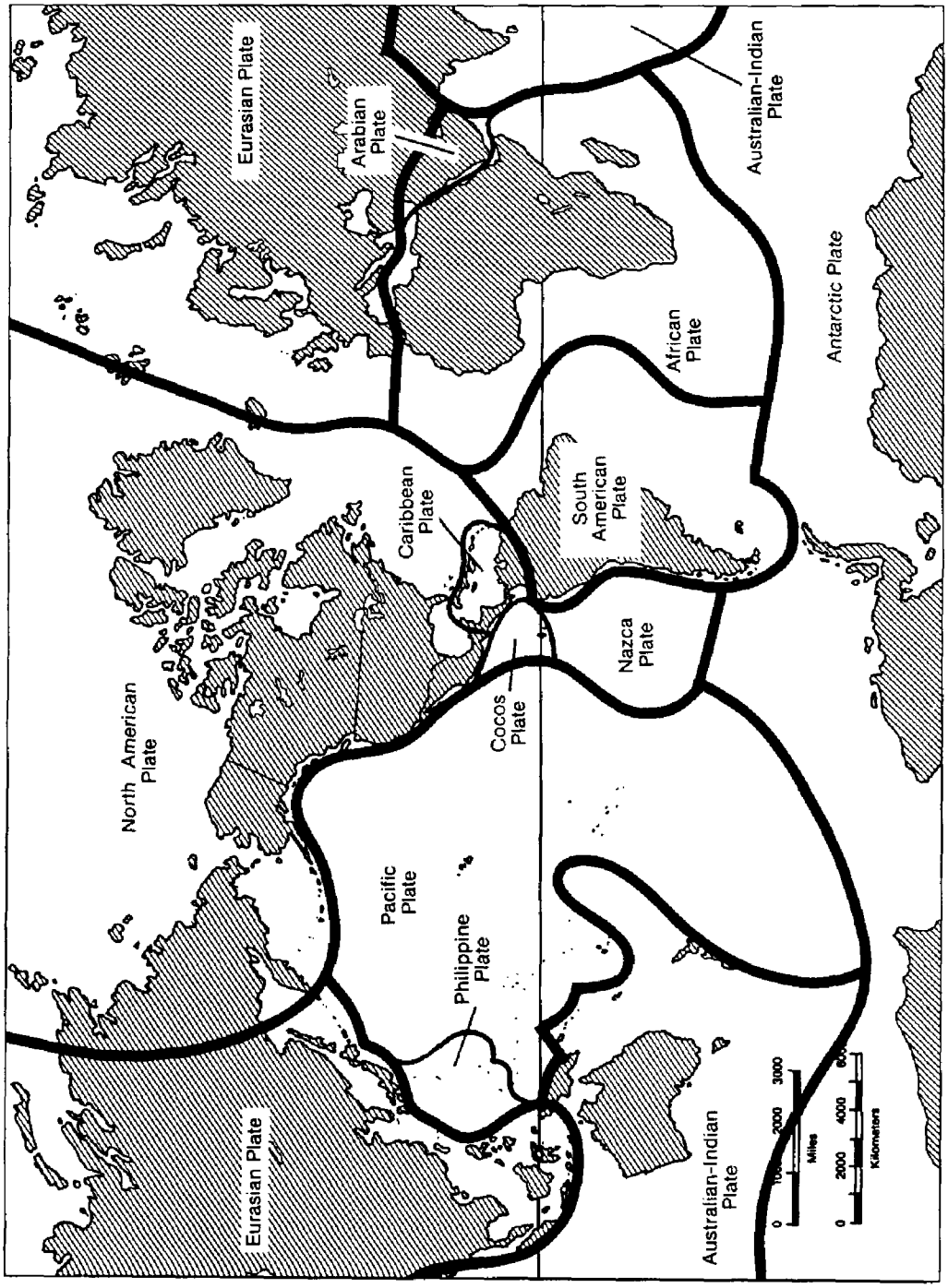
Name _____



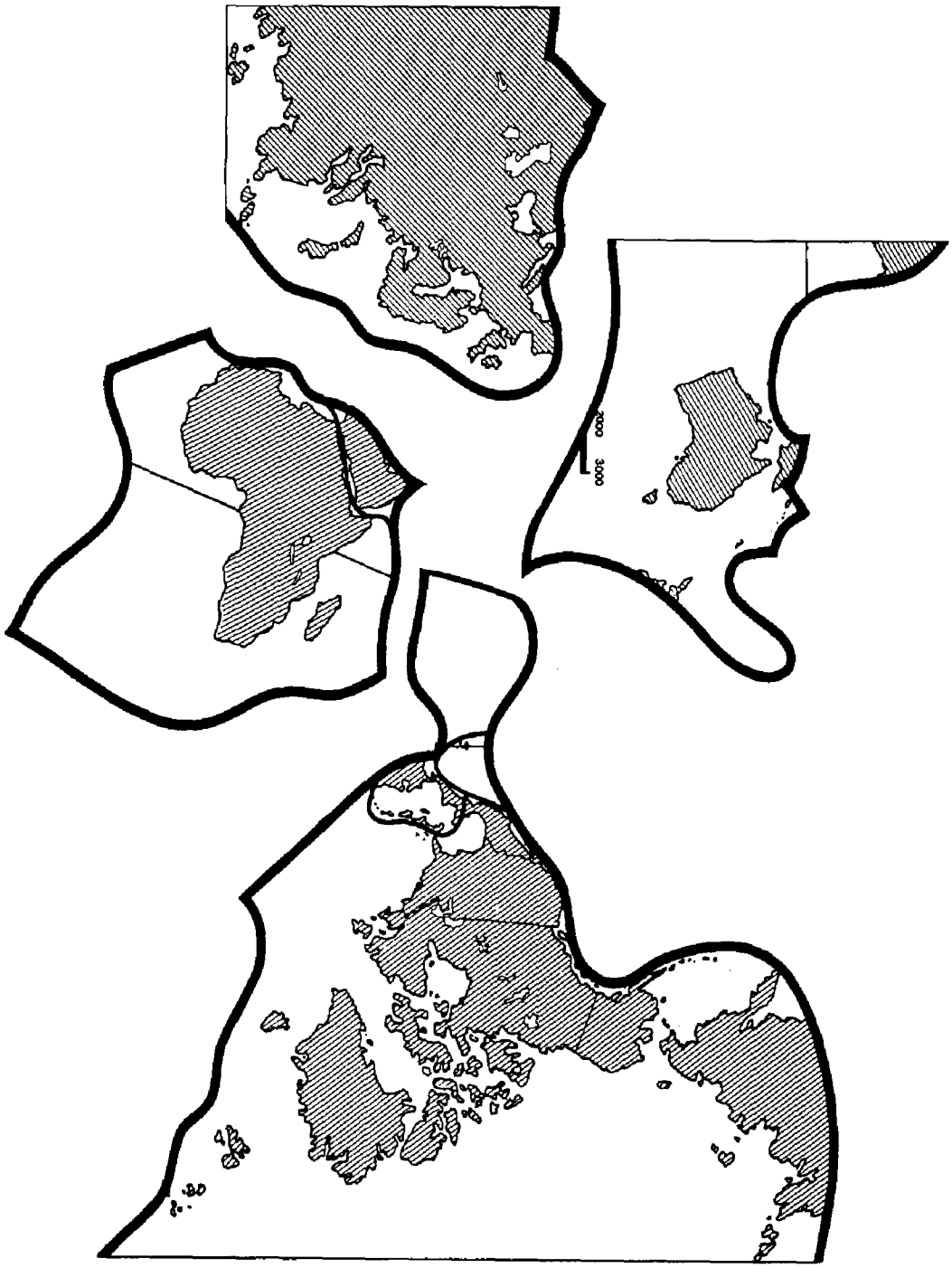
1. Color the core red.
2. Color the mantle yellow.
3. Color the crust blue.
4. Put a brown line around the very hot layer.

Earth Plates

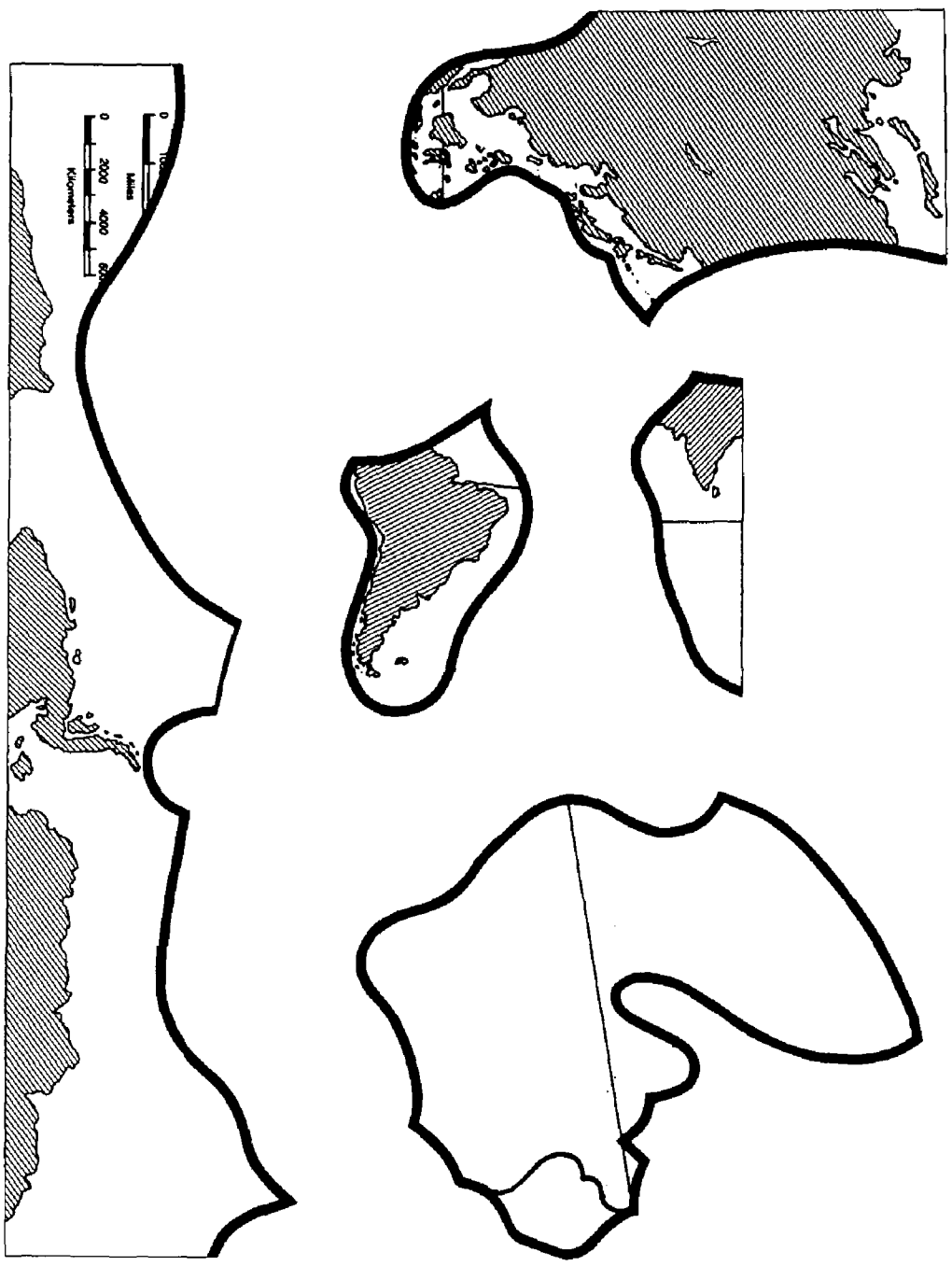
Name _____



Earth Plate Puzzle Pieces

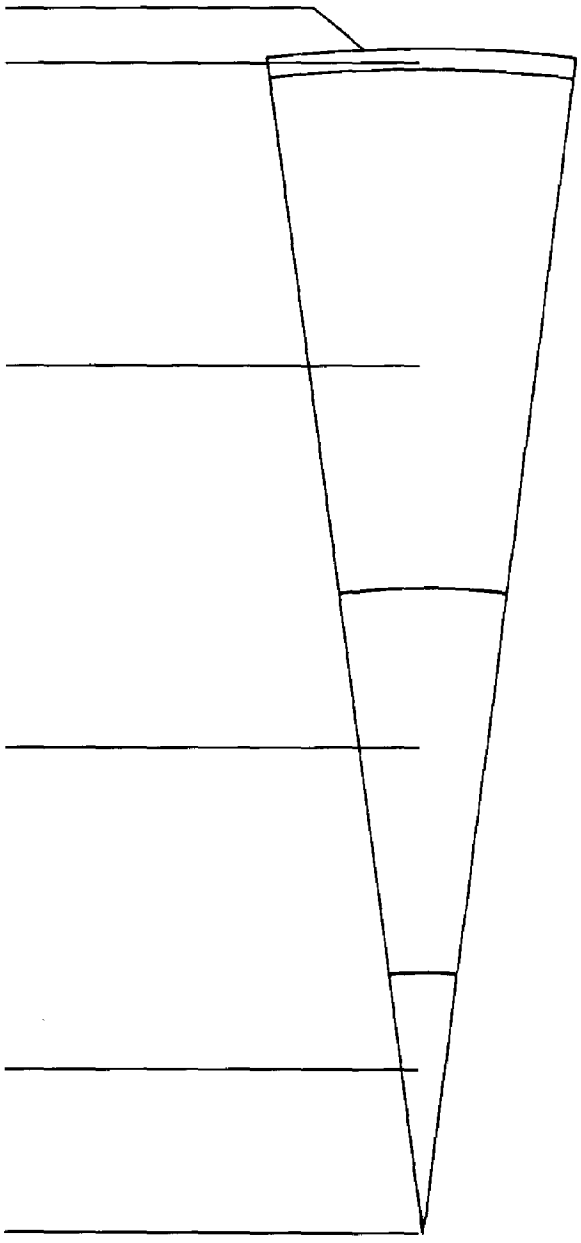


Earth Plate Puzzle Pieces



A Pizza the Earth

Name _____



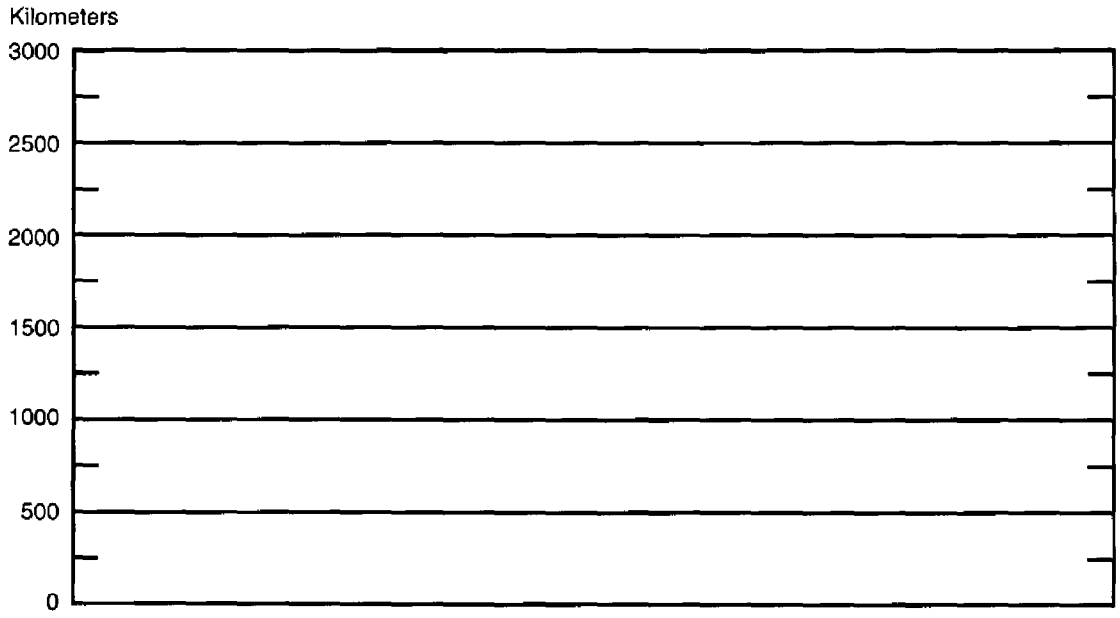
1. Label each layer.
2. Color each layer a different color.

Word Bank

Outer Core
Crust
Mantle
Lithosphere
Inner Core
Center of the Earth

Graph of the Earth Layers

Name _____



1. Use the following data to construct a bar graph of the thickness of the Earth's layers:

Layer	Thickness in Km
crust	40
lithosphere	100
mantle	2,900
outer core	2,000
inner core	1,400

2. Which layer of the Earth is the thickest?

_____

3. Which layer of the Earth is the thinnest?

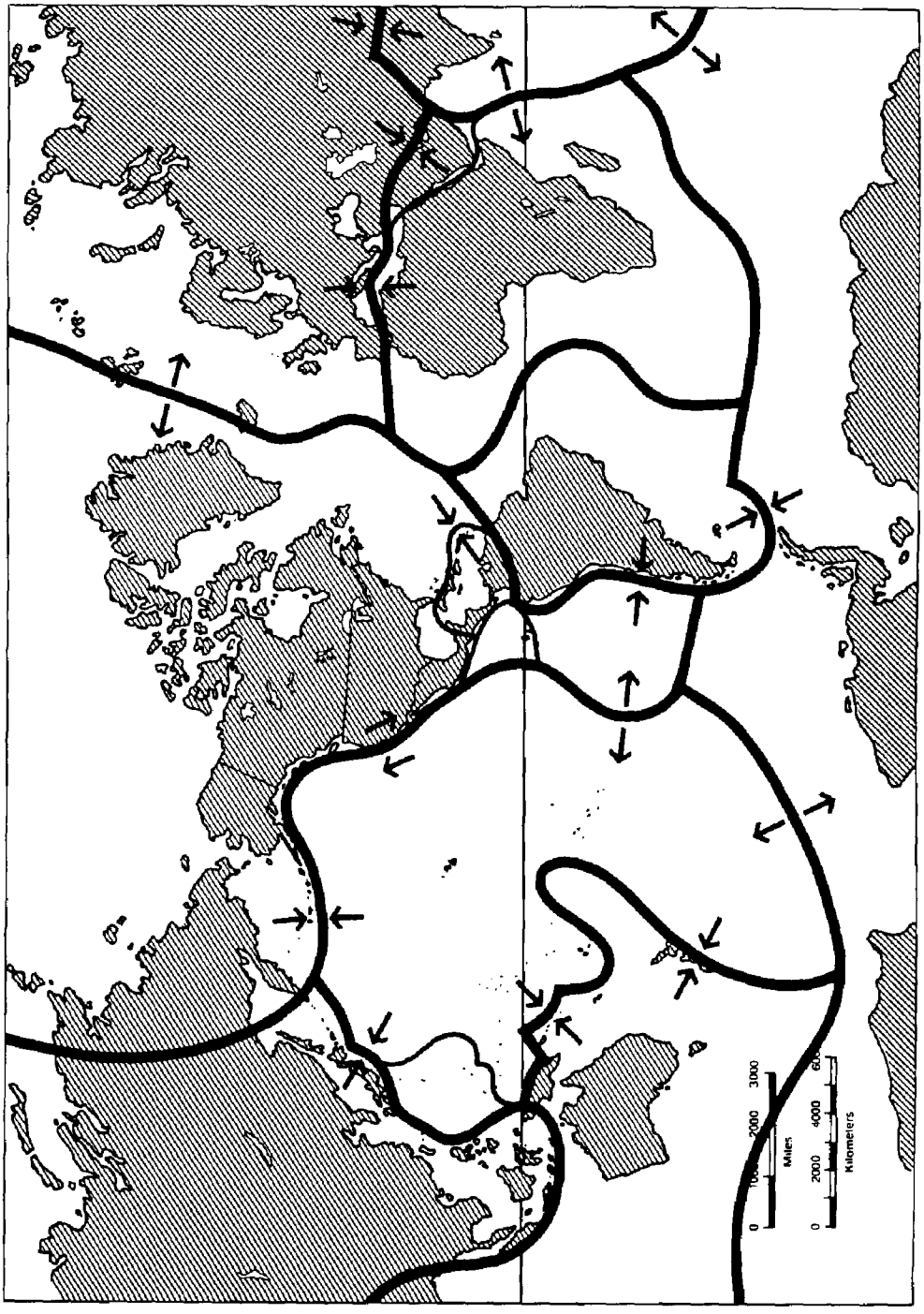
_____

4. What is the total thickness of all the Earth's layers?

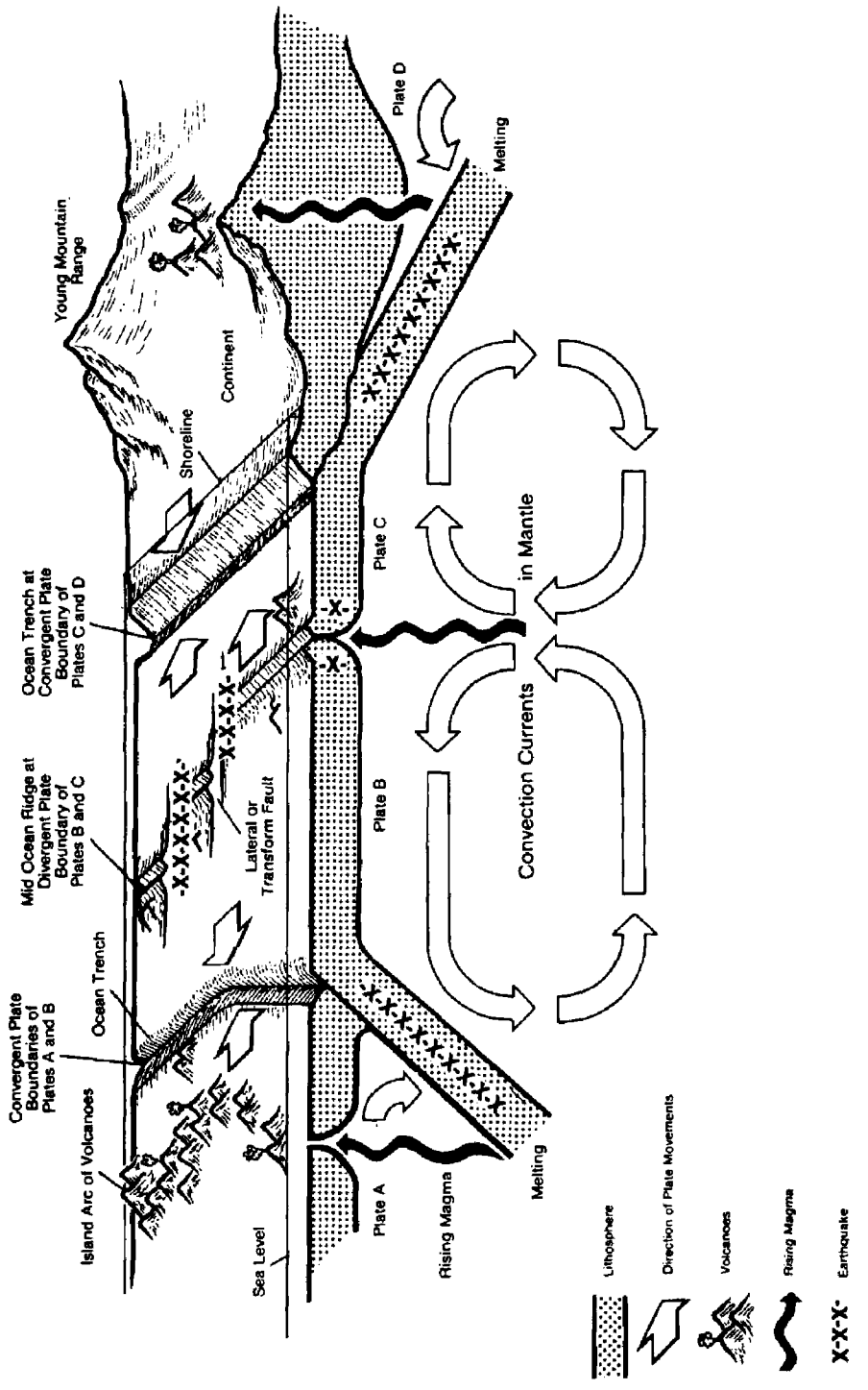
_____

Plate Boundaries Map

Name _____

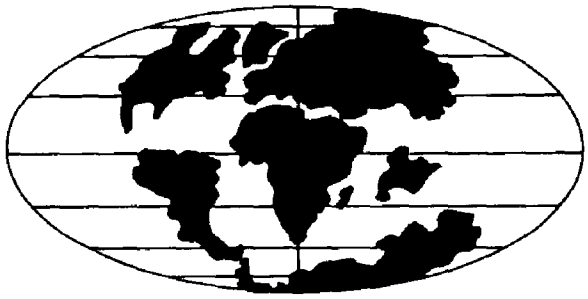


Convection Currents and Plate Cross Section

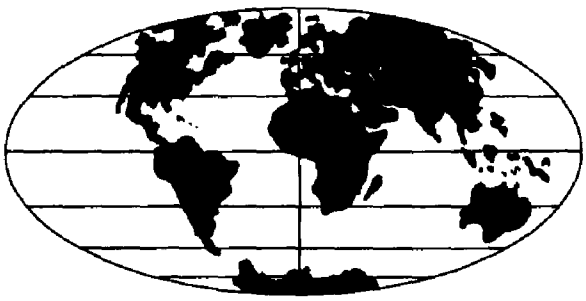


Formation and Breakup of Pangaea

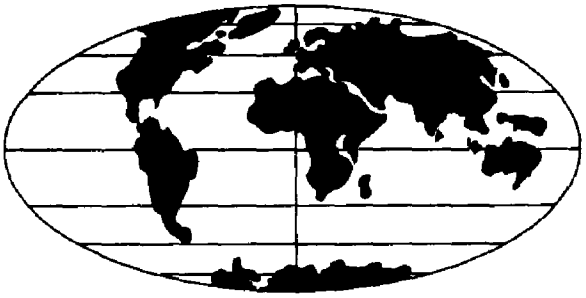
Earth's land masses about 200,000,000 years ago when there was one large land mass–Pangaea, or supercontinent.



Earth's land masses about 65,000,000 years ago when the supercontinent broke up into smaller continents.

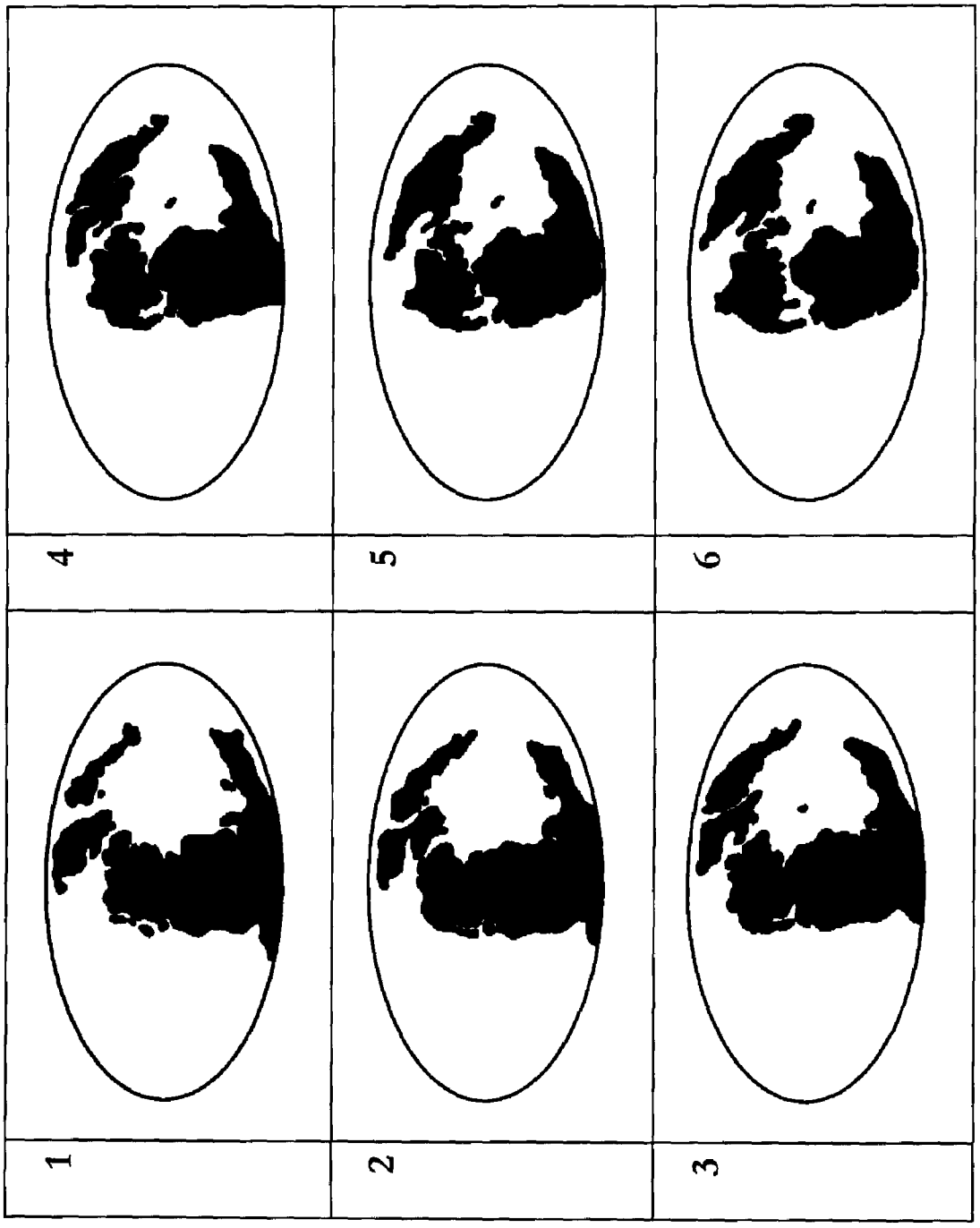


Earth's land masses today where India has collide with Eurasia. Eurasia continues to separate as the Atlantic Ocean widens.



Earth's land masses about 50,000,000 years into the future.

Pangaea Flip Book



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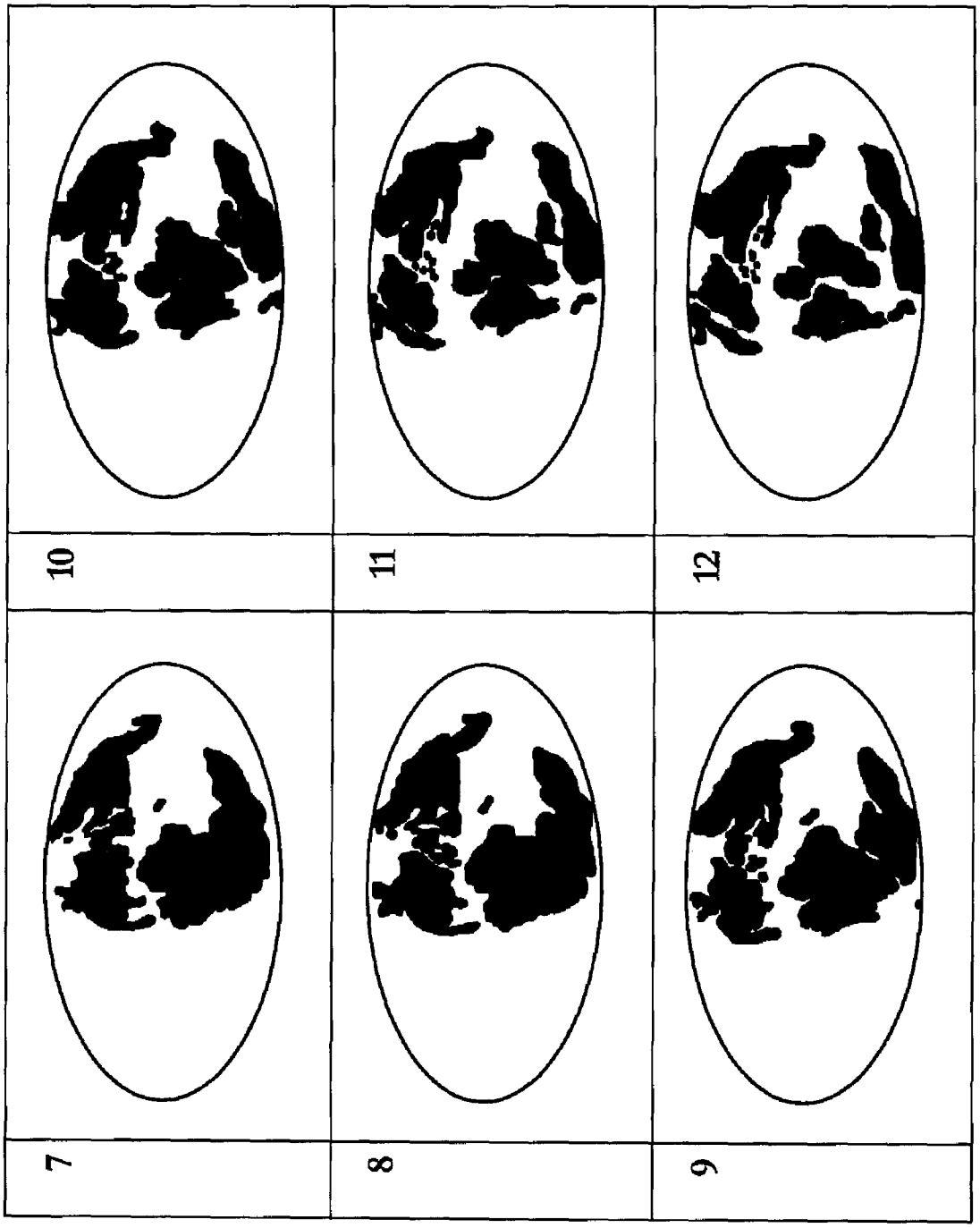

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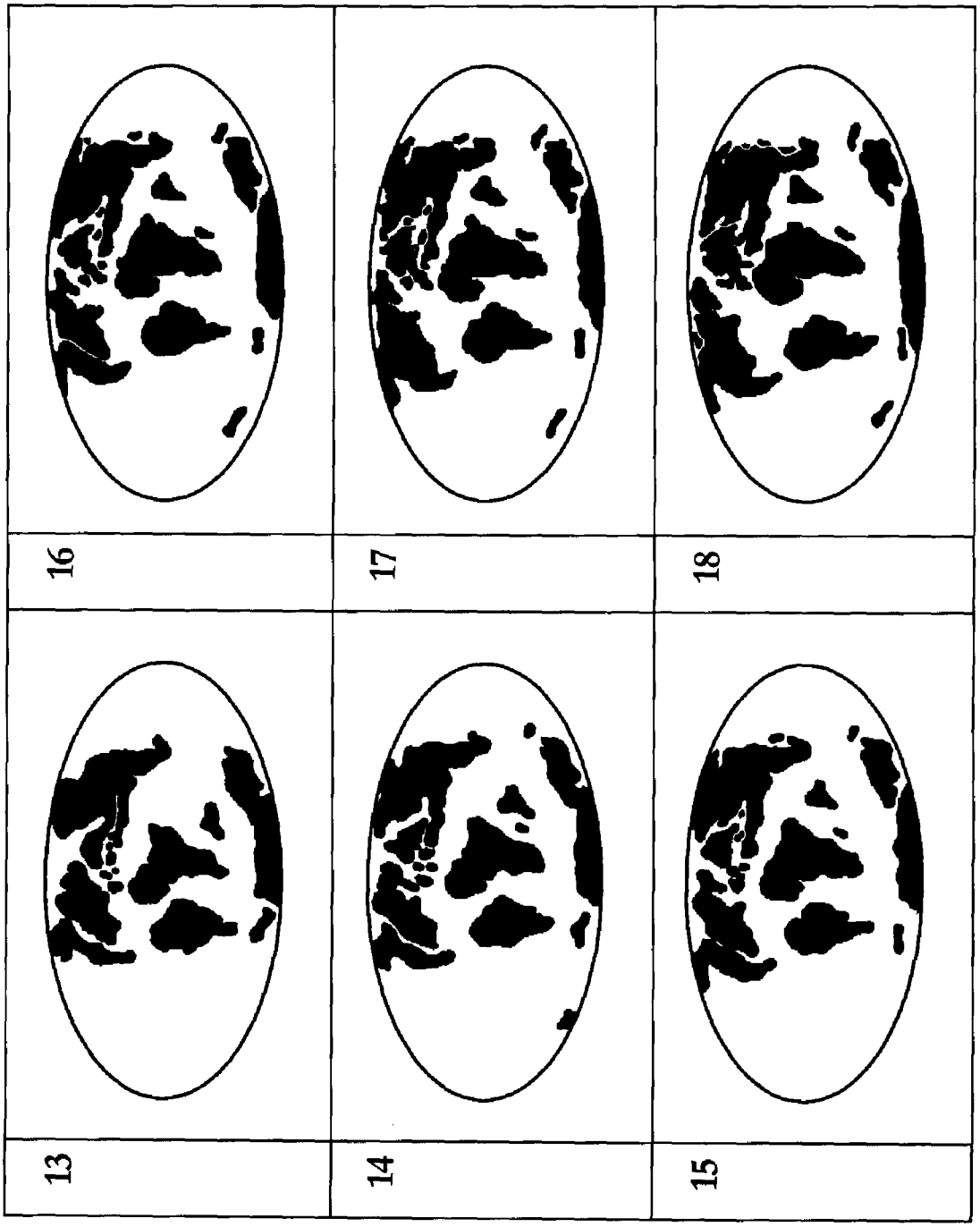

Pangaea Flip Book