Plate Tectonics Introduction

Geologists believe the Earth is made up of three basic layers: the crust, a thicker mantle, and a dense central core. The crust is the only layer scientists have been able to study directly; they rely on indirect evidence from many sources to determine the characteristics of the other layers. There are many clues which suggest the mantle and core are themselves made up of several layers and that the layers are not clearly distinct from each other. Between all of the Earth's layers there are transition zones and each layer varies in thickness and density. There is some discussion among geologists as to exactly how the layers interact with each other to produce changes on the Earth's surface.

Evidence suggests that approximately 1% of the mantle is liquid; the rest is solid rock that behaves plastically because of the great heat and pressure present in the mantle. Scientists think the uppermost part of the mantle, the part lying directly underneath the crust, is more rigid than the lower parts of the mantle. This upper part of the mantle, combined with the crust, forms the lithosphere. The Earth's core is made up of two parts: the outer core is liquid and the inner core is solid (and both are composed largely of iron and nickel). Most geologists think that powerful convection currents in the mantle, driven by heat given off by the core and radioactive decay, provide the force which causes many of the changes that occur in the crust.

According to the Theory of Plate Tectonics, the lithosphere is made up of about 12 major and several minor thin, rigid "plates" covering the planet like the shell of a cracked egg. The plates border each other but have been in constant motion for perhaps as long as 3 billion years. They are colliding, separating, grinding past and even overriding each other. Most mountain building, earthquakes, and volcanic activity take place along the margins of the plates.

One component of Plate Tectonics is the Theory of Continental Drift which was proposed in 1915 by Alfred Wegener. Wegener presented evidence that approximately 200 million years ago all the continents were together in one giant supercontinent he called Pangaea ("all lands"). Pangaea broke up into two large sections about 180 million years ago, called Laurasia and Gondwanaland. Since then, the continents have "drifted" to their present locations, raising mountains and causing earthquakes and volcanoes.

Using recent advances in seismology and sophisticated computer models, scientists continue to strive to understand the composition of the deep layers of the Earth. Scientists have very recently discovered that the solid inner core of the Earth is spinning faster than the rest of the planet, but the cause of this is still under discussion. There is much more work for scientists to do to understand the complex interactions of the Earth's interior.

According to the National Science Education Standards (1996), students in grades K-4 should develop an understanding that:

- The surface of the Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.

Students in grades 5-8 should develop an understanding that:

- The solid Earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core.

- Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions.

- Land forms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment.

- The Earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past.

Introducción a las Placas Tectónicas

Los geólogos creen que la Tierra está formada en tres capas básicas: La corteza, un manto más espeso y un denso núcleo central. La corteza es la única capa que los científicos han podido estudiar directamente; ellos cuentan con la evidencia indirecta de muchas fuentes para determinar las características de las otras capas. Hay muchos indicios que sugieren que el manto y el núcleo a su vez están formados de varias capas y de que éstas no son muy distintas una de la otra. Entre todas las capas terrestres hay zonas de transición y cada capa varía en grosor y densidad. Hay algunas controversias entre los geólogos sobre exactamente cómo interactúan las capas entre sí para producir cambios en la superficie terrestre.

Las evidencias sugieren que aproximadamente el 1% del manto es líquido; el resto es roca que funciona en forma plástica debido al gran calor y presión existente en el manto. Los científicos creen que la parte más elevada, parte que yace directamente bajo la corteza, es más rígida que las partes más bajas del manto. Esta parte alta del manto, combinada con la corteza, forma la litósfera. El núcleo de la Tierra está formado en dos partes: el núcleo exterion es líquido y el núcleo interior es sólido (y ámbos están compuestos en gran cantidad de hierro y niquel). La mayoría de los geólogos piensan que poderosas corrientes de conducción en el manto, llevadas por el calor generado por el núcleo y el deterioro radiactivo, provee la fuerza que causa muchos de los cambios que ocurren en la corteza.

De acuerdo a la Teoría de las Placas Tectónicas, la litósfera está formada de aproximadamente 12 "placas" delgadas y rígidas de mayor importancia, y algunas otras de menor importancia, cubriendo el planeta como el cascarón cuarteado de un huevo. Las placas lindan entre sí pero han estado en constante movimiento, quizá tanto como 3 billones de años. Ellas chocan, se separan, se rozan e inclusive pasan una sobre otra. La mayor parte de las estructuras montañosas y actividad de terremotos y erupciones volcánicas tiene lugar a lo largo de los márgenes de estas placas.

Un componente de la Placa Tectónica es la Teoría del Derive Continental que fué propuesta en 1915 por Alfred Wegener. Wegener presentó la evidencia de que hace aproximadamente 200 millones de años todos los continentes estaban unidos en un supercontinente gigante que el llamó "Pangaea" ("todas las tierras"). Pangaea se dividió hace aproximadamente 180 millones de años en dos grandes bloques llamados Laurasia y Gondwanaland. Desde entonces, los continentes se han separado a sus actuales posiciones, elevándose montañas y causando terremotos y erupciones volcánicas.

Usando sofisticados modelos de computadoras y recientes avances en sismología, los científicos continúan esforzándose por entender la composición de los profundos estratos terrestres. Los científicos muy recientemente han descubierto que el sólido núcleo interior de la tierra está girando más rápido que el resto del planeta, pero la causa de esto está aún

en discusión. Los científicos tienen aún mucho trabajo por hacer para entender las complejas interacciones del interior de la tierra.
De acuerdo a las Normas de la Educación Nacional de Ciencia (1996), [National Science Education Standards (1996)], los estudiantes en los grados K-4 deberían desarrollar el entendimiento de que:

- La superficie terrestre cambia. Algunos cambios son debido a lentos procesos, tales como erosión y daños causados por la intemperie, y algunos otros se deben a rápidos procesos, tales como deslizamientos, erupciones volcánicas y terremotos.

Los estudiantes en los grados 5-8 deberían desarrollar el entendimiento de que:

- La Tierra sólida está compuesta de capas: La litósfera; el manto caliente y conductivo; y un núcleo, denso y metálico.

- Las placas litosféricas en las escalas de continentes y océanos constantemente se mueven en una proporción de centímetros por año en respuesta a movimientos en el manto. Los eventos geológicos de mayor importancia, tales como terremotos, erupciones volcánicas y la formación de estructuras montañosas, resultan de los movimientos de esas placas.

- Las formas de los suelos son el resultado de una combinación de fuerzas constructivas y destructivas. Las fuerzas constructivas incluyen la deformación de la corteza, erupciones volcánicas y deposición de sedimentos.

- Los procesos de la Tierra que vemos ahora, incluyendo erosión, movimiento de las placas litosféricas y cambios en la composición atmosférica, son similares a aquellos que ocurrieron en el pasado.

BE THE EARTH

Grades		
2-4	whole class	20 min.

Description: Students will role-play the layers of the Earth to develop an understanding of the different parts of the Earth's interior.

Materials for Whole Class: large diagram of the layers of the Earth (provided)
30 slips of paper labeled as follows:
1—inner core
3—outer core
6—deep mantle
8—asthenosphere
12—lithosphere

Safety: Be clear about rules for role-playing to prevent rough play.

Procedure:

1. Show students the diagram of the layers of the Earth.

2. Take the students to a large open area outside and explain that they are going to "be" the Earth.

3. Have each student pick a part to play by drawing a slip of paper with a layer of the Earth on it.

4. Explain what movements or sound each role makes (see below) and allow students time to practice.

5. Build the Earth from the inside out as follows:
   - The inner core flexes his/her muscles (or pretends to lift weights) and stands in the center of the area. This represents that the inner core is very dense and is solid metal.

   - Have the outer core kids form a circle around the inner core. They should face in, toward the inner core. Have them walk counterclockwise around the inner core while holding their arms out to the sides and waving them up and down. This represents the fact that the outer core is liquid and is moving.

- Students playing the deep mantle join hands to form a circle around the outer core. Have them chant "hot rock, hot rock, hot rock."

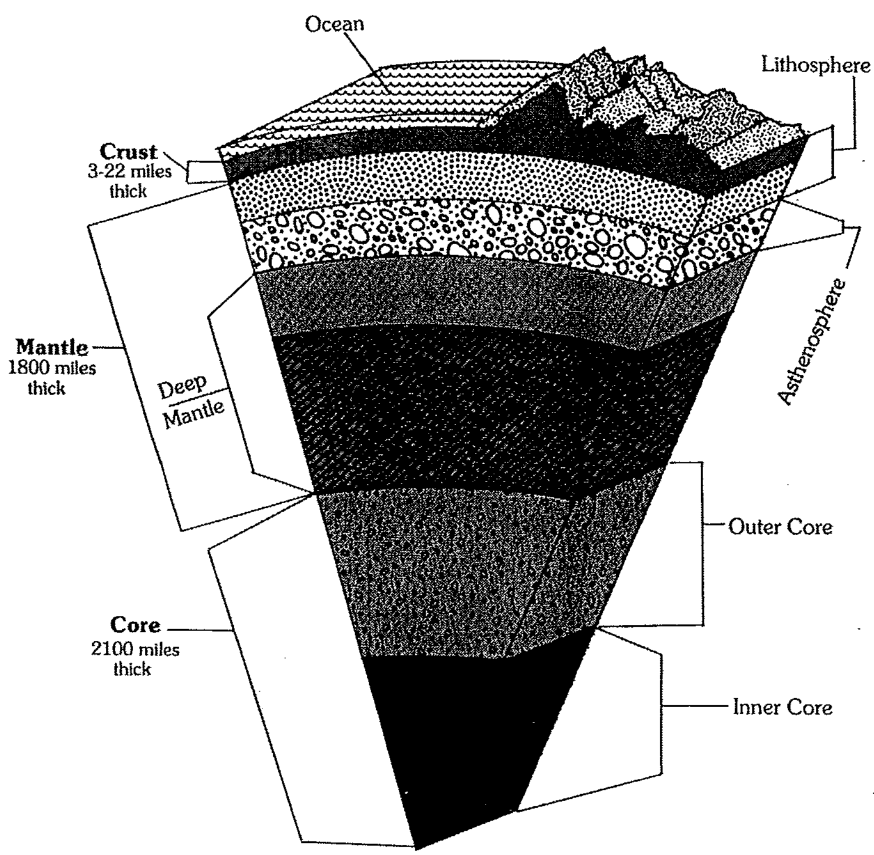
- The asthenosphere students surround the deep mantle. They should slowly sway their bodies back and forth to represent the movement that occurs in this layer.

- Finally, the lithosphere students form a circle around the entire rest of the Earth. Have them face outward and slowly walk around the rest of the Earth, chanting "moving plates, moving plates."

Questions to Ask During the Activity:

1. How do you think scientists know what the inside of the Earth is like? [Scientists have **not** drilled through the crust to the mantle. Scientists have developed a model for the interior of the Earth based on studies of earthquake waves, geological observation of surface rocks, studies of the Earth's motions in the solar system and other laboratory experiments on surface minerals and rocks at high pressure and temperature.]

Why It Happens: The planet Earth is made up of three main shells: the very thin, brittle crust, the mantle, and the core; the mantle and core are each divided into two parts. (See Plate Tectonics Introduction for more details.)



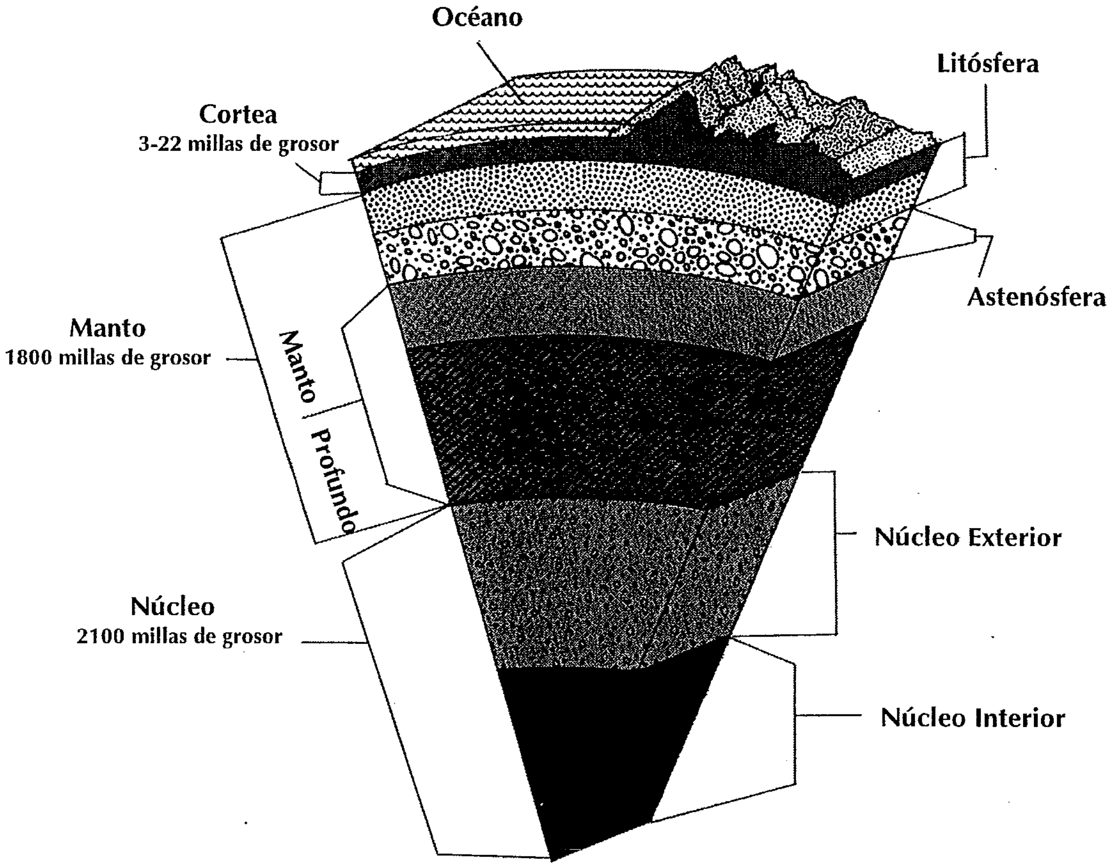
Adaptations for Participants with Disabilities: Students with mobility impairments may need to play a role which does not involve motion.

Extensions: Follow this activity with the Earth Building activity in this unit in which students make a physical model of the Earth.

References:

NatureScope, Geology: The Active Earth. Washington, D.C.: National Wildlife Federation, 1988.

Sé la Tierra


Océano
Litósfera
Cortea
3-22 millas de grosor
Astenósfera
Manto
1800 millas de grosor
Manto
Profundo
Núcleo Exterior
Núcleo
2100 millas de grosor
Núcleo Interior

EARTH BUILDING

Grades		
2-4	individuals	(2) 50 min. periods

Description: Students will make a model of the Earth consisting of three layers with continents and oceans painted on the surface.

Materials for Each Model:

8 inch piece of string
1/2-inch diameter ball of red flour dough
2-inch diameter ball of yellowish-red flour dough
3 to 4-inch diameter ball of brown flour dough

Flour-dough recipe:
Mix 1 cup flour with 1/2 cup salt. Add 1/2 cup water (with appropriate food coloring added) a little at a time. Knead mixture until pliable. Make six batches of this recipe to represent the crust, four batches for the mantle, and two for the core. Store any extra in an air-tight container.

Procedure:

1. Demonstrate for students how to build the model using the following steps:
   - Tie a big knot in the end of the string to represent the inner core.
   - Form the smallest piece of dough (red) into a ball around the knotted end of the string to represent the outer core.
   - Form the larger piece of dough (yellowish-orange) around the core to represent the mantle.
   - Flatten the 3-inch diameter brown dough piece and wrap it around the mantle. This represents the crust on which we live; it should be very thin. Instruct students to pinch out small mountain ranges, make valleys, etc., because the crust of the earth varies in thickness.

2. Tie the exposed end of the string to a fixed object and allow models to dry; the dough will harden. Students can paint oceans and land masses on the surface of their models.

3. Cut open your demonstration model to show the layers. You can have students cut open their models, also, but many may be reluctant to do so.

Questions to Ask During the Activity:

1. What does each layer of the model represent? [string—inner core, red dough—outer core, yellowish-orange dough—mantle, brown dough—crust]

2. Which part of the Earth do we live on? [crust]

3. Which part is the thinnest? [crust; the thinnest part of the crust is under the oceans]

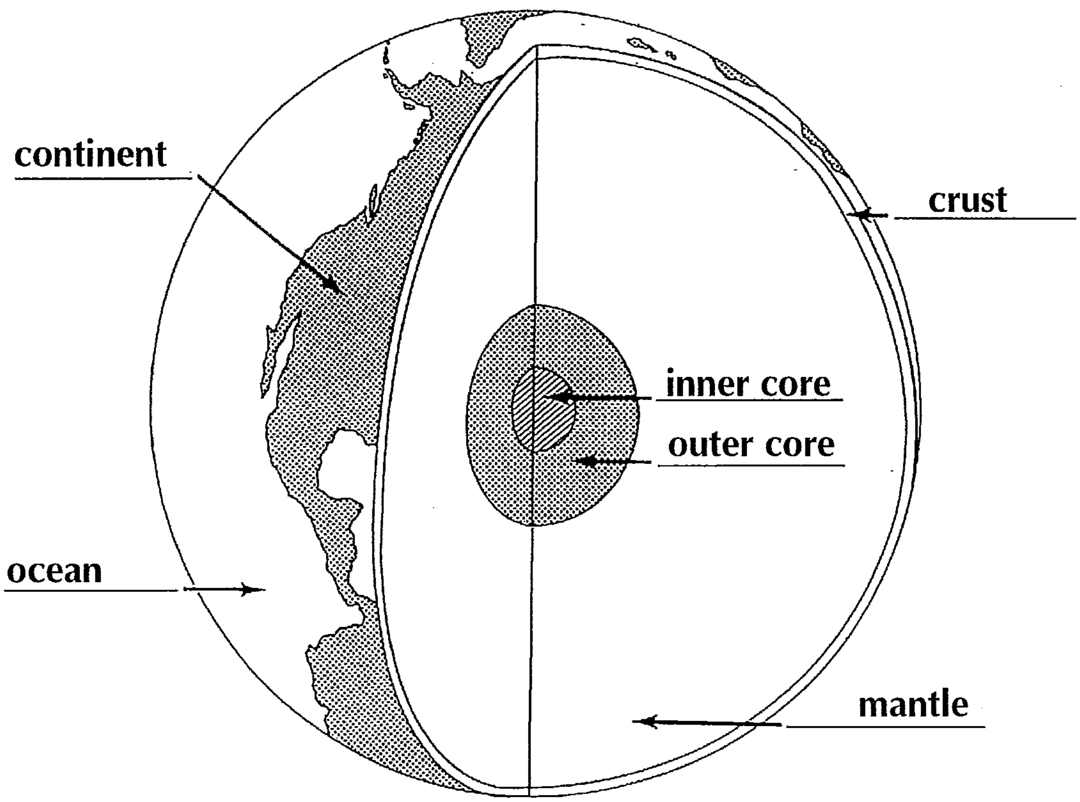
4. Which part would break or crack most easily? [crust]

Why It Happens: Scientists have used evidence from many sources including studies of earthquakes, laboratory experiments on surface minerals and rocks at high pressure and temperature, and observations of the Earth's motions in the solar system to develop theories which describe the composition and characteristics of the Earth's interior.

Based on this information, the current model of the Earth divides the Earth into three layers—the crust, the mantle, and the core. The crust is the relatively thin outside layer of sedimentary, metamorphic and igneous rocks. The crust is much thinner under the oceans than under continents. The crust makes up 1 percent of the Earth's volume, but only 0.4 percent of its mass.

The next layer, called the mantle, starts below the crust and is about 2,900 km thick. The mantle itself consists of layers; its rigid upper and lower parts surround a middle layer that is able to move slowly like very thick syrup. The mantle makes up 84 percent of the earth's volume and about 2/3 of the Earth's mass; it is composed mostly of silicon and oxygen.

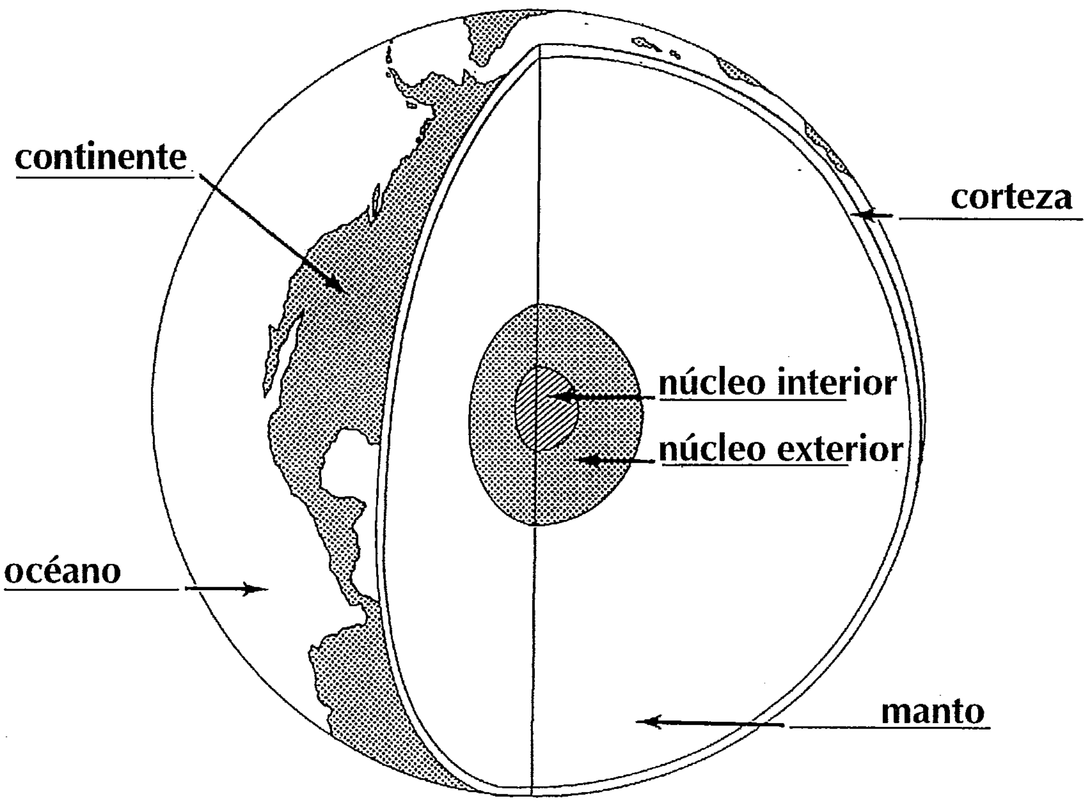
The core is the large, dense center part of the Earth. The core is believed to be composed of two parts, the inner and outer cores. The inner core is believed to be made of solid materials surrounded by a liquid outer layer. Both are thought to be made of iron and nickel. The core makes up 15 percent of the Earth's total volume and about 1/3 of its mass (see graphic on following page).



Extensions: Read Journey to the Center of the Earth to students and compare its fictional account to scientists' current model of the earth.

References: Project Storyline: Science—Primary Geology. The California Science Implementation Network, University of California at Irvine, 1993.

Estructura de la Tierra



PRIMARY PLATE PUZZLE

Grades		
K-3	individuals/ pairs	20 min.

Description: Students will cut out puzzle pieces representing major tectonic plates and assemble them to complete a jigsaw puzzle of the world.

Materials for Each Student or Pair:
puzzle piece handout (duplicate on heavy stock paper if possible)
scissors
crayons or markers

Materials for Whole Class: 1 hard boiled egg

Procedure:

1. Crack the shell of a hard boiled egg. Use it to illustrate the idea that the surface of the Earth is made up of several large "plates".
2. Show the completed "Earth Plates" picture on the overhead to show how the Earth's plates can fit together like pieces of a puzzle.
3. Hand out the Earth Plate Puzzle Pieces. Have students color in the shaded portion of each piece—these represent land.
4. Have students cut out the pieces.
5. Depending on the level of your students, either have students try to fit the pieces together without further guidance, or give them the completed Earth Plates world map and have students match the pieces to complete the puzzle.

Questions to Ask During the Activity:

1. Why does one puzzle piece have no shaded area? [It is an ocean area.]
2. Can you see these cracks on the Earth's surface like you could see the cracks in the egg shell? [No, although there is some visual evidence such as ocean ridges and rifts.]

Why It Happens: There is much evidence that the Earth's surface is made of plates which are continually, but very slowly, moving. Where these plates meet are areas of considerable geological activity such as earthquakes, volcanoes and mountain building.

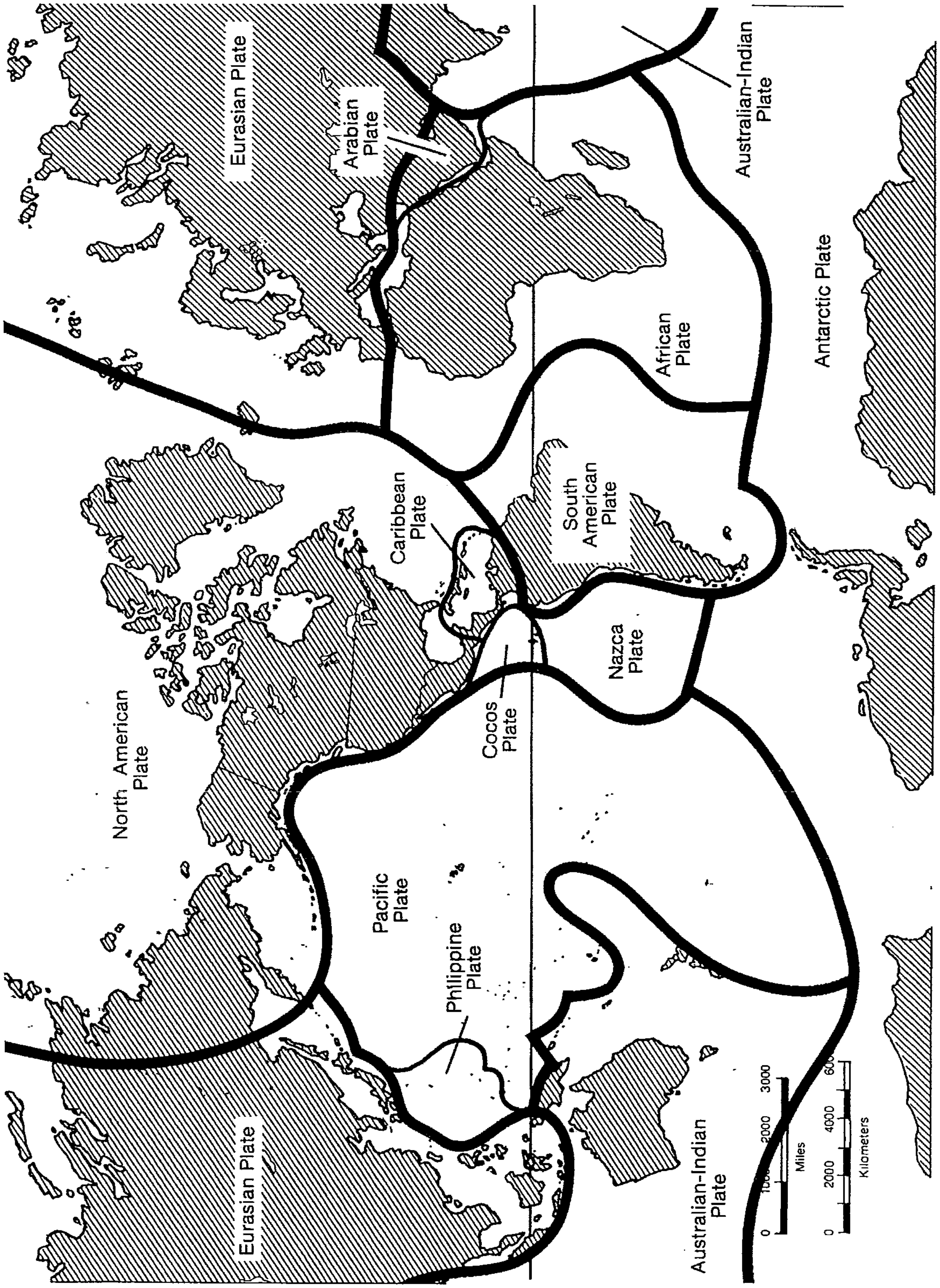
Adaptations for Participants with Disabilities: Students with visual impairments may be able to fit together puzzle pieces which are made of a sturdy, thick material such as cardboard.

Extensions: Use the completed world map with plates to show where earthquakes and volcanoes happen.

References:

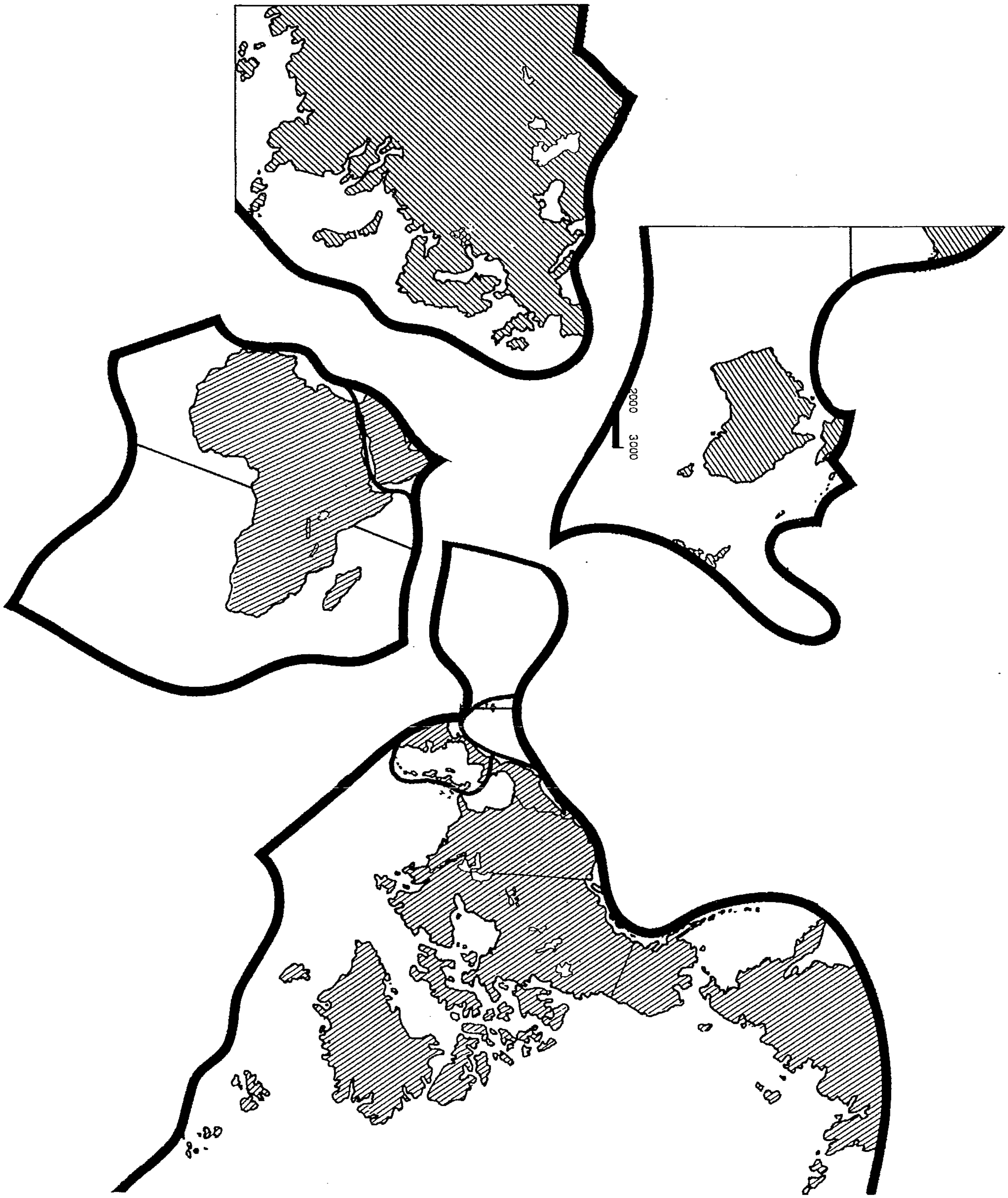
Earthquakes. National Science Teachers Asociation, Washington, D.C., 1988.

Earth Plates

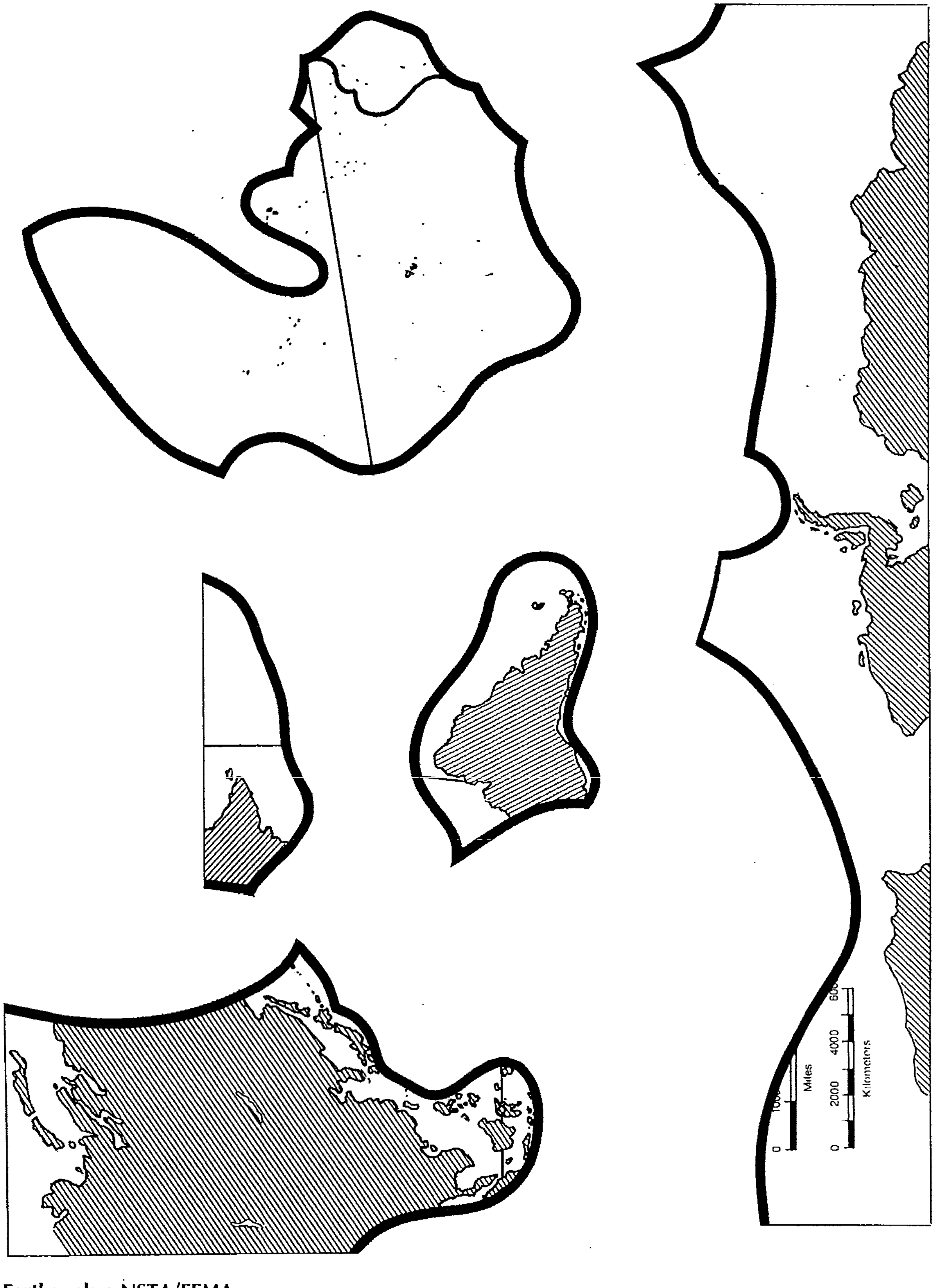


Earthquakes-NSTA/FEMA

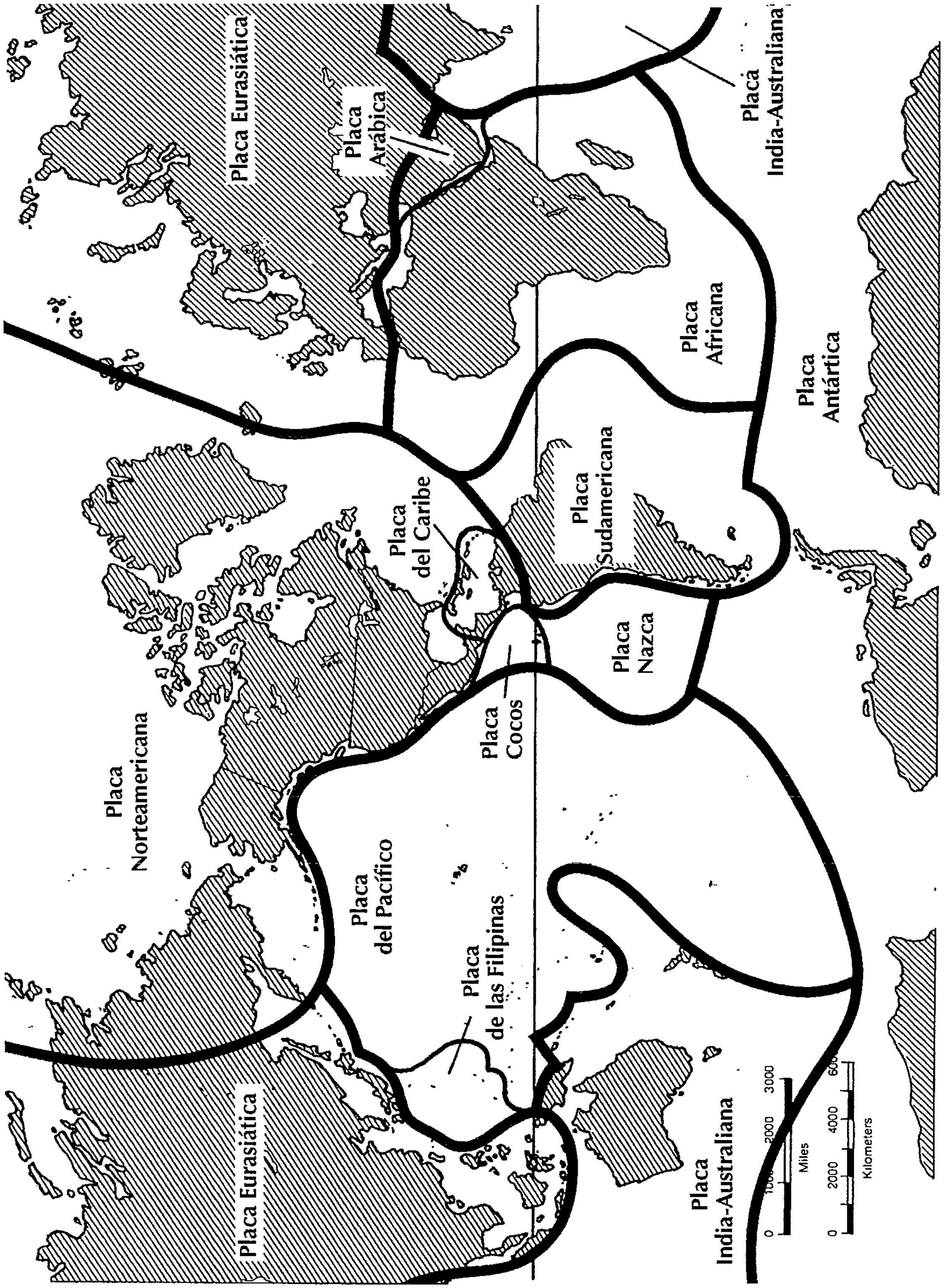
Earth Plate Puzzle Pieces



Earth Plate Puzzle Pieces

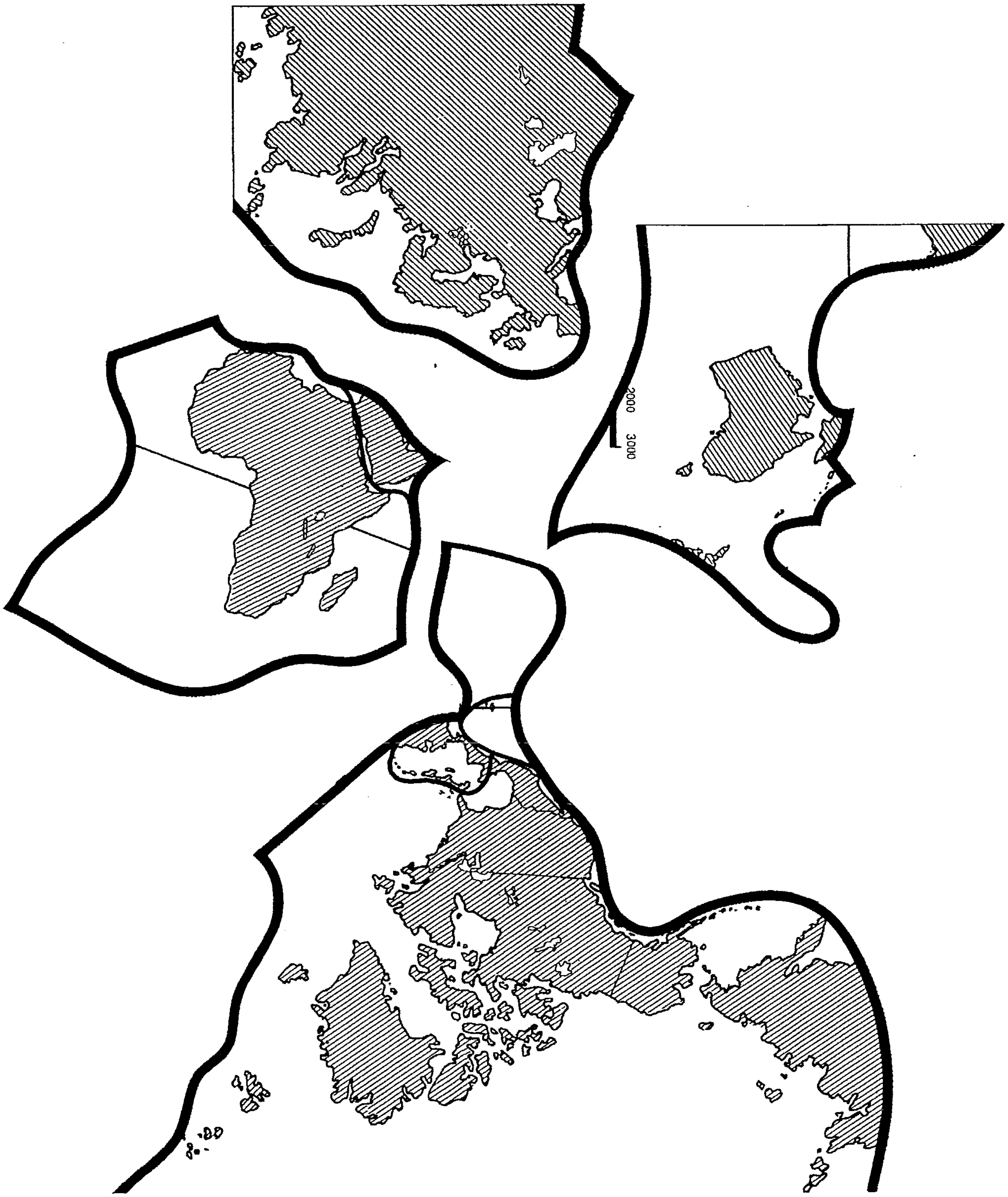


Placas Terrestres

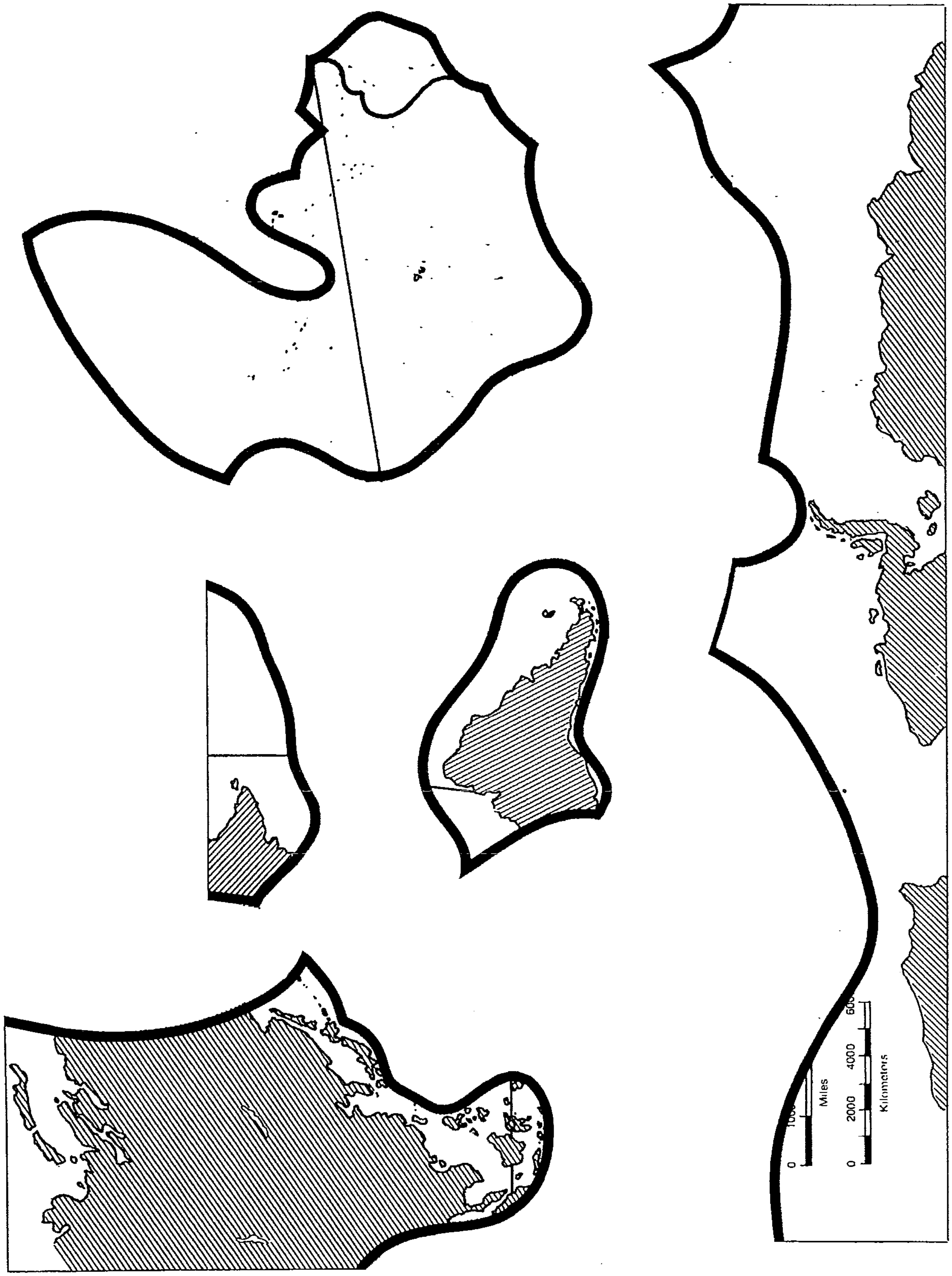


Earthquakes-NSTA/FEMA

Rompecabezas de las Placas Terrestres



Rompecabezas de las Placas Terrestres



Earthquakes-NSTA/FEMA

PLATE PUZZLE

Grades		
4-6	individual	(2) 50 min. periods

Description: Students will manipulate tagboard cutouts of the Earth's continental land masses to reconstruct the theoretical prehistoric land mass known as Pangaea. They will then construct a flipbook to illustrate the movement of the continents during the last 200 million years.

Materials for Each Student:
4 pieces of 8 1/2 x 11 inch tagboard
1 map of current continental land masses
glue stick
scissors
scotch tape
handouts: continent cut-outs and flip book pictures (provided)

Part I

Procedure:

1. Distribute the continent cut-outs. Have students glue them to a piece of tagboard. Once it is dry, students can cut out the continents.

2. Have students try to fit the pieces together into one mass as they think Pangaea might have existed.

3. When they are satisfied with the arrangement, they can tape the arrangement to a piece of paper or tagboard.

4. Have students display and compare their models. Discuss ways in which they are the same and different.

5. Show a model of Pangaea that scientists believe is correct based on current evidence. Have students compare their models to this one.

Part II

6. Distribute the flip book handouts. Write the assembly instructions on the board and model how to make the flip books for the students.
   Assembly:
   - color the maps (blue for water, green & brown for land, etc.)
   - paste the flip book pages to tagboard

- cut out each map
- stack the pages in chronological order from 50 milliion years in the future to 200 million years ago (or visa versa)
- staple the pages together

7. Have students flip their books to visualize the break up of Pangaea. Explain that the forces which caused this movement of plates continue today.

Questions to Ask During the Activity:

1. What could cause the land masses to move? [see Why It Happens]

2. What effects could shifting land masses have on plant and animal populations? [As continents shift, the range for a given species may become limited if it is not able to cross large expanses of water or if the climate changes. As the distribution of species changes, the complex web of interspecies interactions will change.]

Why It Happens: The Theory of Continental Drift suggests that the Earth's continents were once a large, single land mass that moved apart. Alfred Wegener first proposed this theory in 1915 and cited several pieces of related information to support his theory. He noticed the apparent fit of the continents of Africa and South America and studied similar plant and animal remains on several continents which were separated by wide oceans.

Wegener's theory was not widely accepted initially, but later discoveries identified a process that could account for motion of whole continents. By careful observation and analysis of the ocean floors, they developed a theory called sea floor spreading. Scientists now theorize that the Earth's crust is broken up into several large and several small crustal plates. Some of these crustal plates contain the continents. This theory, which relies on the theories of sea floor spreading and continental drift, is called the Theory of Plate Tectonics.

Extensions: Have students brainstorm how today's world would be different if the continents were together as they were 200 million years ago.

Have students cut out maps of the continents in their current arrangement and model how they might shift in the next 50, 100 or 200 million years.

Further investigate the evidence for the Theory of Plate Tectonics.

Learn and practice the following song.
(To the tune of "It's a Small World")

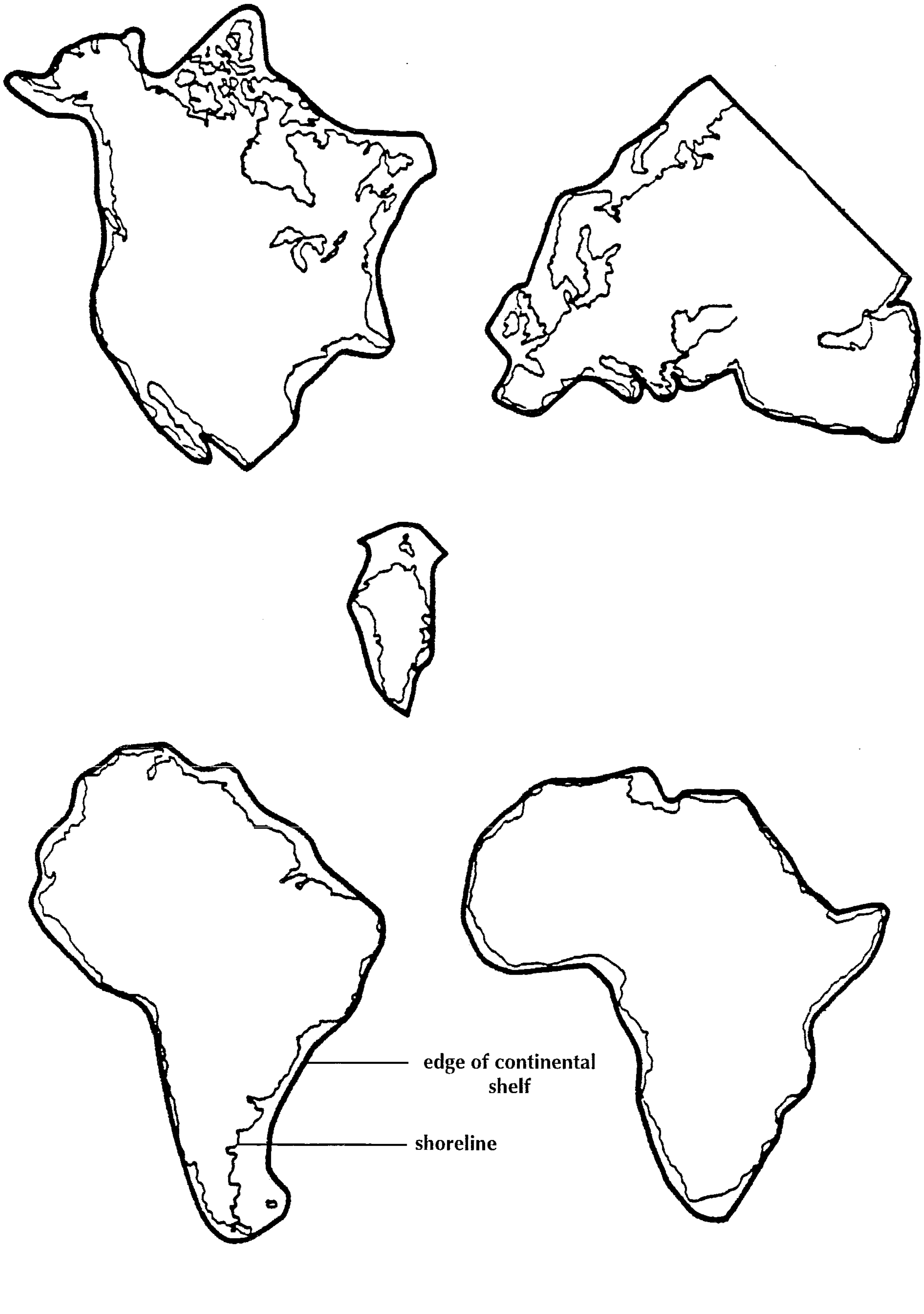
It's a world of earthquakes
A world of storms.
It's a world of plates
Changing earth's very form.
And it's all interlinked,
Take one part out—we sink.
It's a small world after all.

Chorus

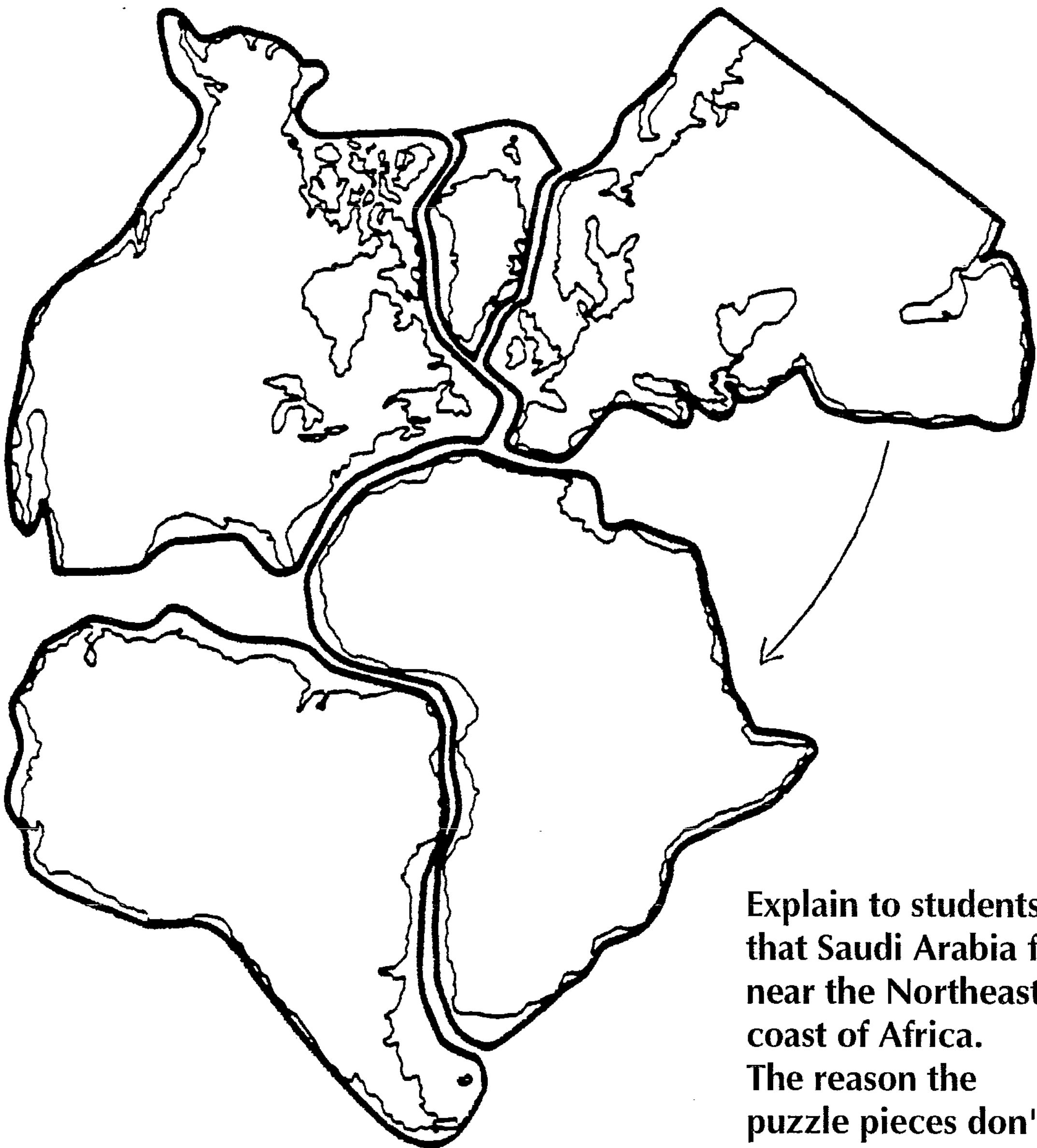
It's a small world after all. (Repeat 2 more times)
It's a small, small world.

References: Project Storyline: Geology: The Changing Earth. The California Science Implementation Network, University of California at Irvine, 1993.

Continent Cut-outs



Continental Cut-outs: Answer Key



Explain to students that Saudi Arabia fits near the Northeast coast of Africa. The reason the puzzle pieces don't fit here is that we are making a flat map of a round Earth.

Get the drift? Make a flip book.

What would have been the consequences if the continets had remained as shown 150 million years ago?

200 million years ago

190 million years ago

180 million years ago

150 million years ago

135 million years ago

100 million years ago

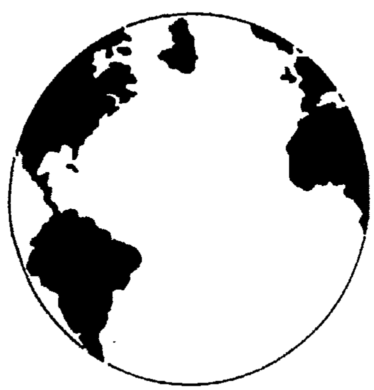
65 million years ago

30 million years ago

10 million years ago

World at present

25 million years in the future



50 million years in the future

¿Agarraste la idea? Haz un cuaderno.

¿Qué consecuencias hubiera habido si los continentes hubieran permanecido como parece que fueron hace 150 millones de años?

Hace 200 millones de años

Hace 190 millones de años

Hace 180 millones de años

Hace 150 millones de años

Hace 135 millones de años

Hace 100 millones de años

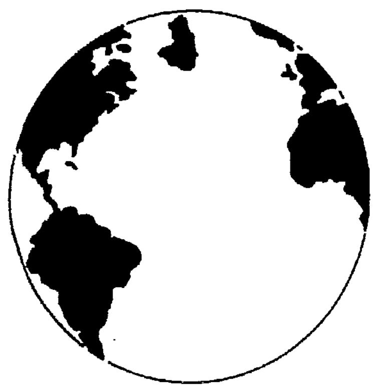
Hace 65 millones de años

Hace 30 millones de años

Hace 10 millones de años

Mundo Actual

25 millones de años después



50 millones de años después

PROYECTO FUTURO

NEW MEXICO VOLCANOES

Grades		
2-6	5-8	40 min.

Description: Students will create clay models of four different types of volcanoes and locate examples of each on a map of New Mexico.

Materials for Each Group:
3 lb. of clay (terra cotta works best)
large piece of butcher paper
markers
11 Dixie cups
1 spoon
1/2 cup of baking soda

Materials for Whole Class:
1 bottle of vinegar
1 piece of thin wire for cutting clay
1 small bottle of red food coloring
newspaper
bucket of water
large map of New Mexico

Safety: Be careful when using the thin wire to cut the clay.

Procedure:

1. Either give students a description of each of the four types of volcanoes (see Why It Happens), or have students find descriptions of the volcanoes.

2. Cut the clay into fist-sized balls. There should be one ball for each student.

3. Fill the Dixie cups with a small amount of vinegar (3 Tbs.). Add one drop of red food coloring to each.

4. Cover tables and work space with several layers of newspaper.

5. Have students follow the instructions on the Student Activity Sheet to make, position, and erupt their clay volcanoes. You will instruct students when it is time to actually cause the eruptions.

6. To clean up, have students dunk their volcanoes in the bucket of water to clean them off and return the clay to the container for later use.

Questions to Ask During the Activity:

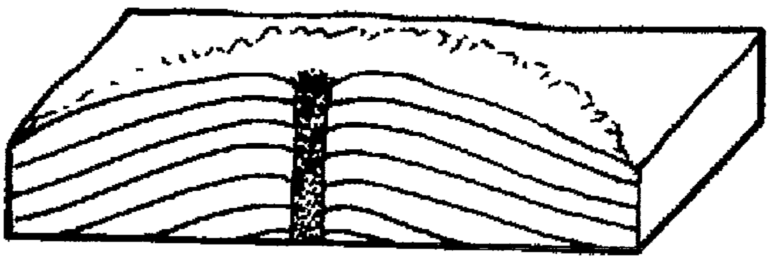
1. What are some hazards caused by volcanoes? [lava flow, hot ash flow, ash fall, mud flow, earthquake]

2. What resources do volcanoes provide? [fertile soil, sulfur, scoria rock, pumice stone, precious minerals]

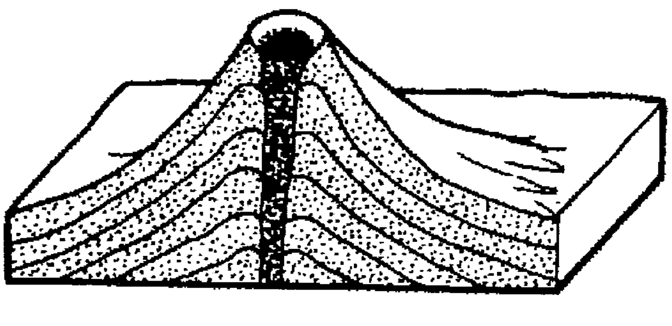
3. Where do volcanoes occur on the Earth? [see following map, p. **212**]

Why It Happens: A volcano is an opening in the Earth's surface through which hot, melted rock from beneath the Earth's surface has emerged. There are four basic volcano types found in New Mexico:

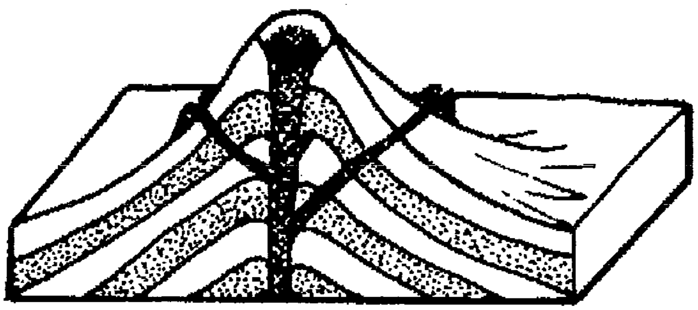
Shield Volcanoes are made of basalt and the lava is very runny. Shield volcanoes are low domes. Hawaiian volcanoes are shields. In New Mexico, shields occur near Taos and in the northeast corner of the state near Capulin National Monument.



Cinder Cones occur in basalt lava that also has lots of gases. The gases escape from the fluid, causing the lava to froth. The eruption can be forceful, throwing liquid lava into the air, where it cools and falls back as cinders. The cinders pile up around the vent in a cone shape. Cinder cones rarely develop heights greater than 1000 feet (300 m). Cinder cones are common in New Mexico. They occur as the Albuquerque Volcanoes, as cones in the El Malpais areas near Grants and Carrizozo, in Capulin National Monument, and near Taos.



Composite or Strato Volcanoes are the classic high cone volcanoes. Composites form as the result of repeated lava flows, hot ash flows, and cinder cone eruptions. The Andes, the Cascades and, in New Mexico, Mt. Taylor, are classic composite volcanoes.

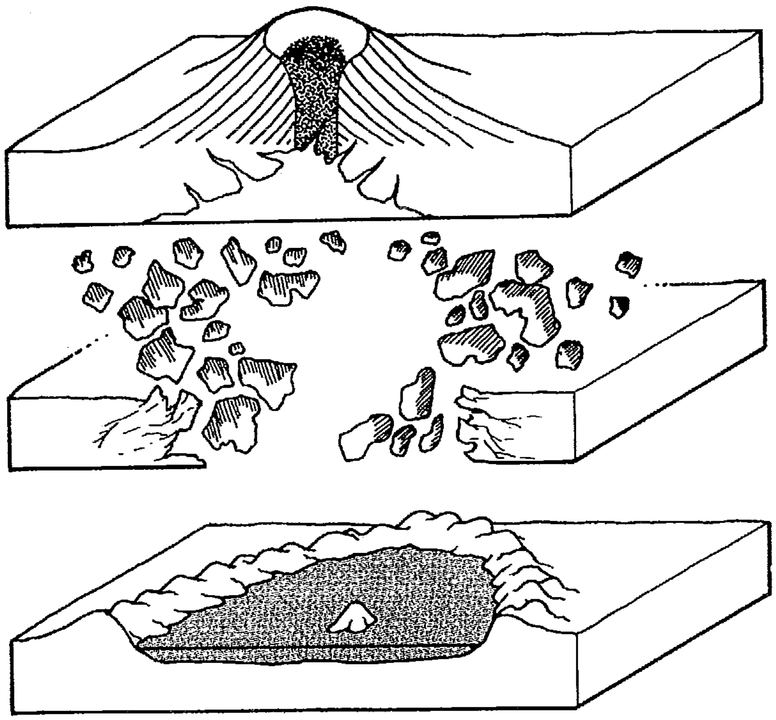


Calderas are huge volcanic craters caused by the violent eruption of sticky rhyolite lava. The eruptions cast volcanic ash and debris for thousands of square miles around the volcano. Caldera eruptions usually result in the collapse of the volcano into itself, forming a large bowl. The Jemez mountains are the result of a caldera eruption approximately 2-4 million years ago. Older calderas in New Mexico are found in the Gila Mountains and in the far southwest corner of the state.

a

b

c



Volcanic basins (calderas)
These may be formed in several ways, one of which is shown (left).

a) A lava plug bottles up explosive gases below

b) In time, pent-up gas pressure blasts off the top of the volcano

c) The explosion leaves a great shallow cavity - a caldera or basal wreck

Adaptations for Participants with Disabilities:

- Students with mobility impairments may need assistance in placing the volcano on the large map.
- Students with visual impairments may need additional descriptions of volcano types from which to build a volcano. Completed models may help.

Extensions: Have students investigate ancient myths and legends from different cultures about volcanoes.

Use the following Volcano Pattern to have students create a three-dimensional model of a stratovolcano. You can enlarge the pattern on a copier to make it easier for young children to cut out.

Have students learn the following "rap":

The Volcanoes

Chorus We're the volcano erupting crew. Our lava's pouring
out and it's coming to get you.

Verse

1st person: I'm a hot-spot volcano. I'm close to the ground.
When my lava comes out, you better get out of town.

2nd person: I'm a continental volcano. I live on the ground.
Everybody knows I don't mess around.

I can burn, I can sizzle any time of the day.
When I erupt you better get out of the way.

(Repeat chorus)

3rd person: I'm a magma pool. I come out the spout. I'm
really hot , so you better look out.

4th person: I'm an island volcano. I'm in the water, and
when my lava comes out, you'd better holler.

(Repeat chorus)

Fade out chanting: VOLCANO...VOLCANO...VOLCANO...

By Rose West in Water, Stones, & Fossil Bones

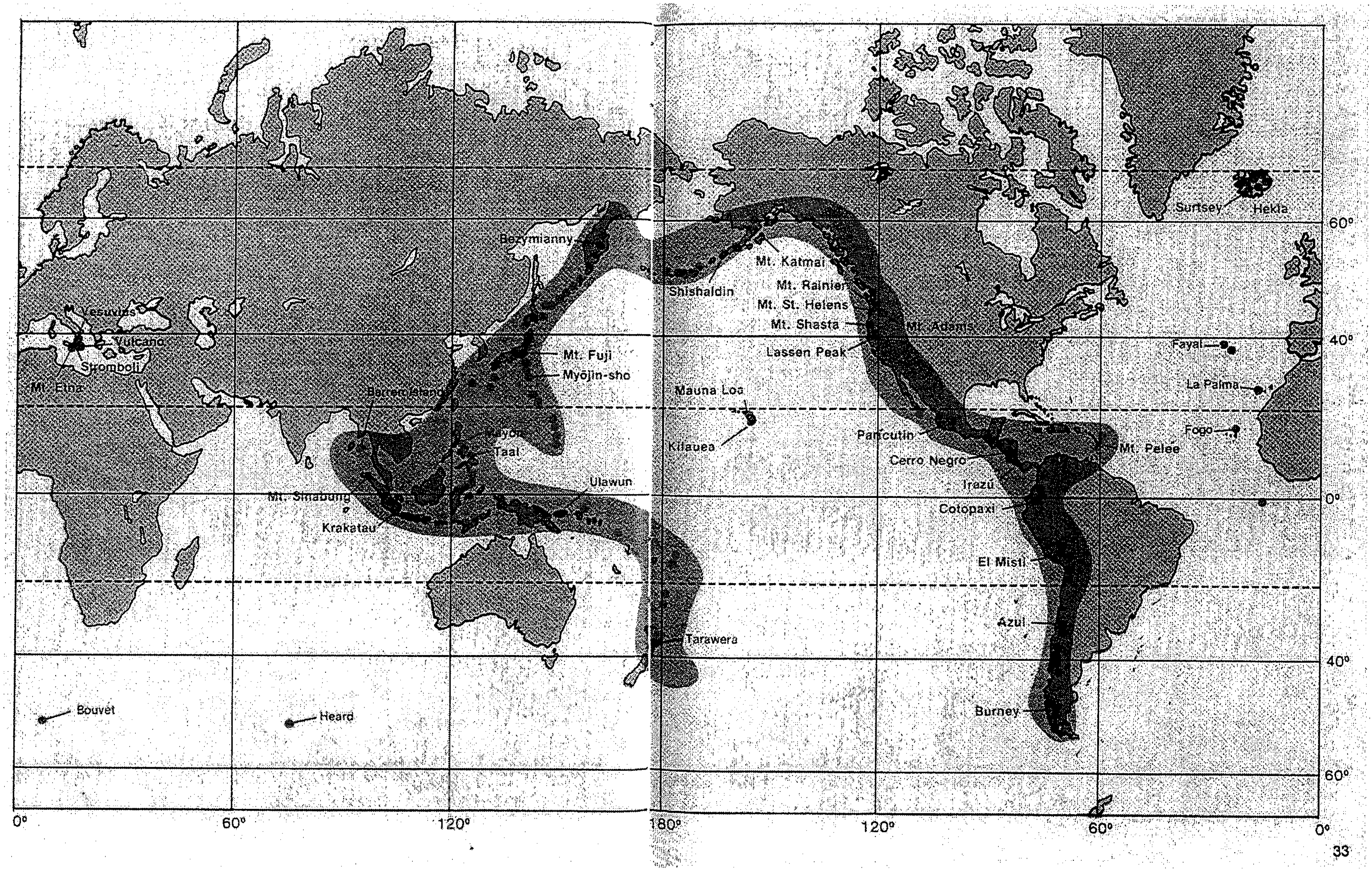
References: Lambert, David and the Diagram Group. The Field Guide to Geology. New York: Facts on File, 1988.

Lind, Karen K., ed. Water, Stones, & Fossil Bones. Washington D.C.: National Science Teachers Assocation, 1991.

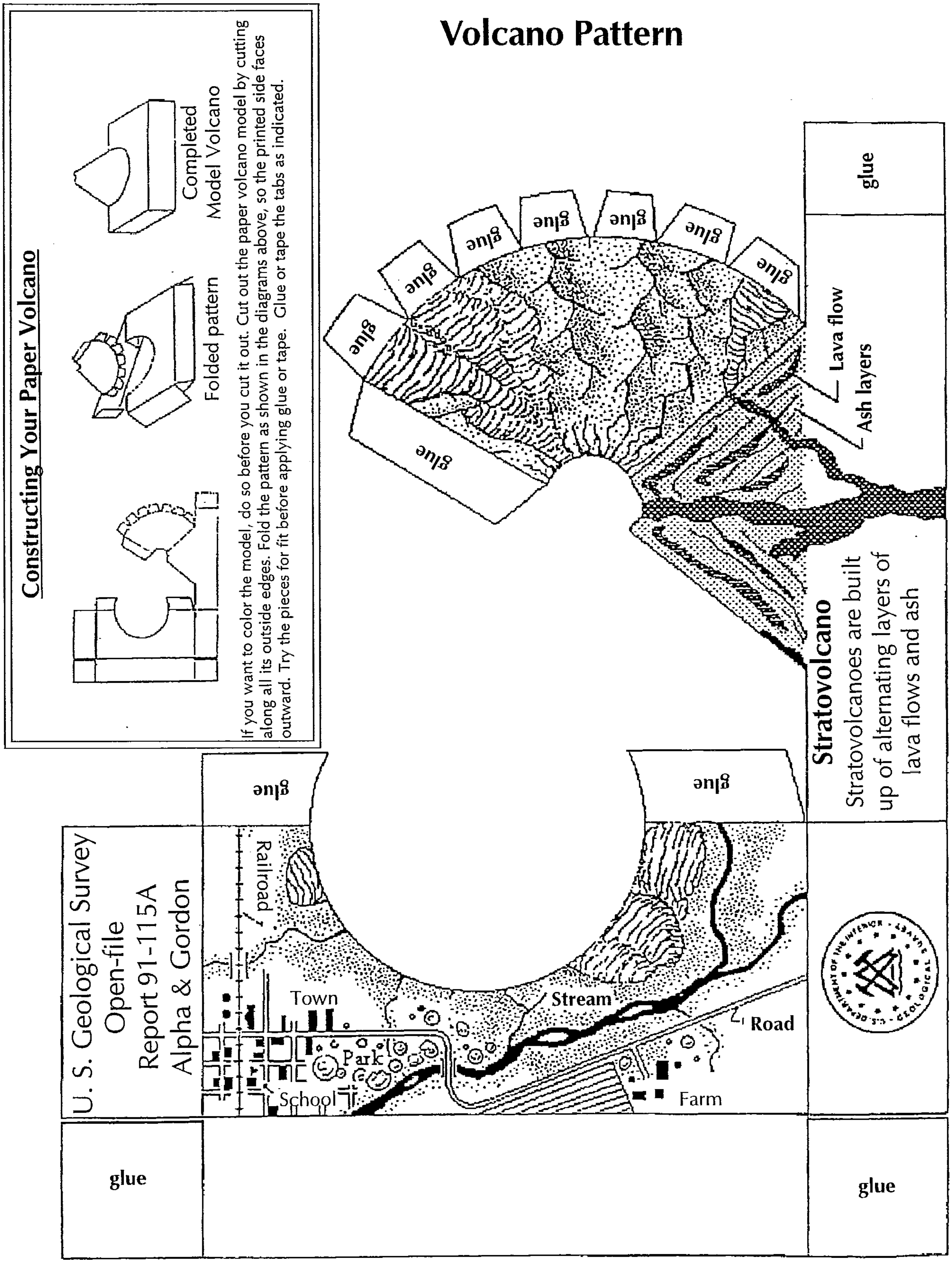
NatureScope, Geology: The Active Earth. Washington, D.C.: National Wildlife Federation, 1988.

Volcanoes. U.S. Geological Survey, Washington, D.C.

The distribution of some of the Earth's volcanoes.

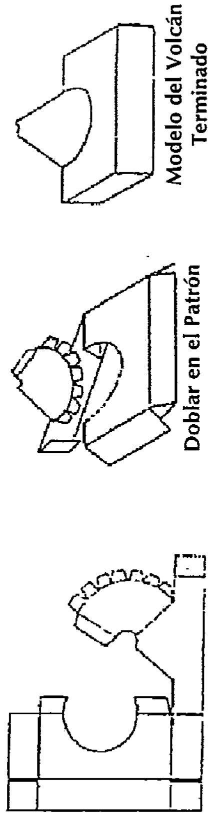


Volcano Pattern

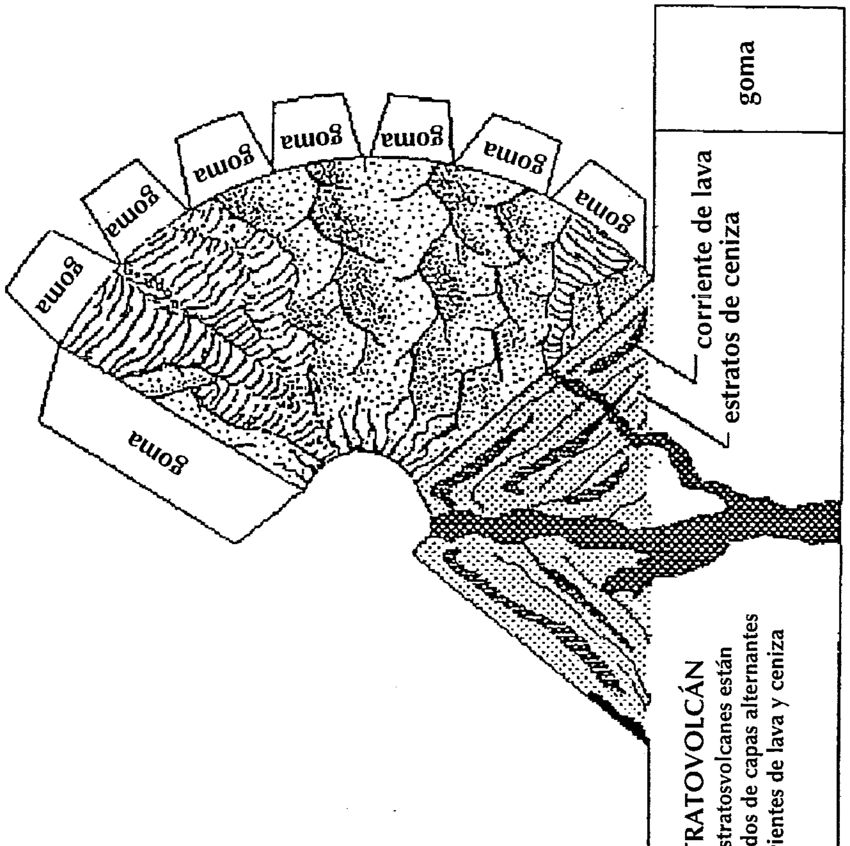
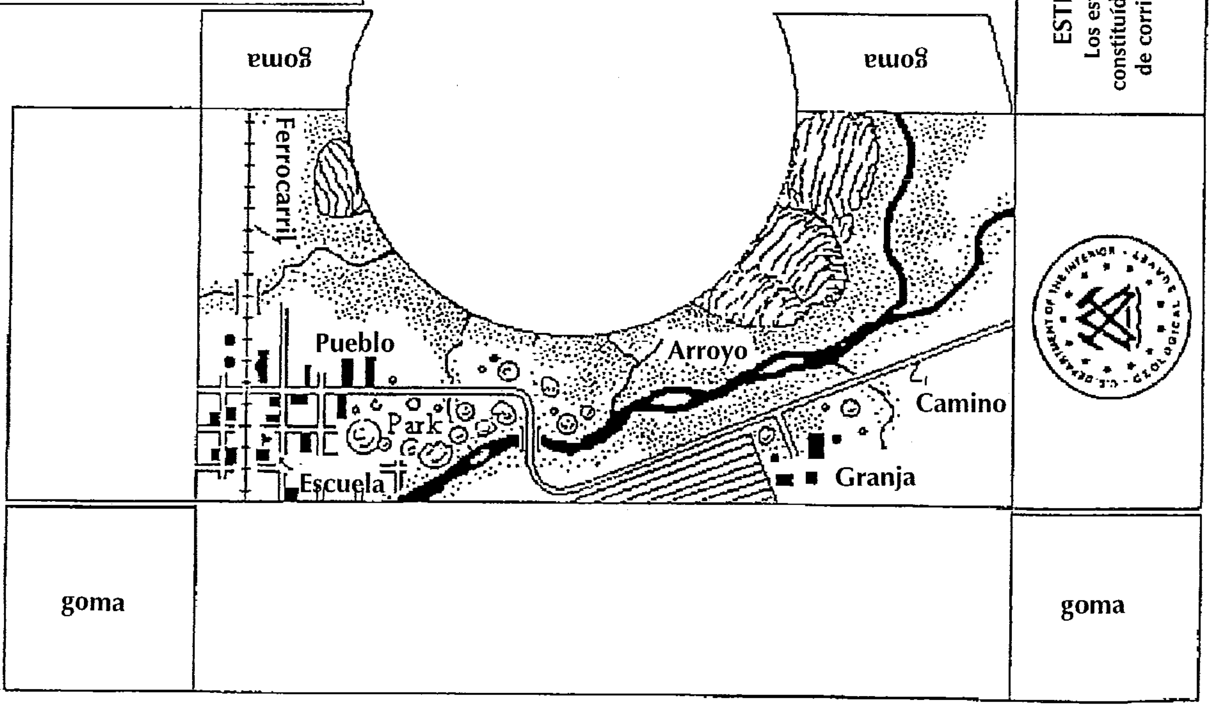


Patrón de un Volcán

Construyendo su Volcán de Papel



Si se desea colorear la muestra, hacerlo antes de recortar. Recortar el modelo siguiendo el contorno de la figura. Doblar como se muestra en el diagrama de arriba de modo que el lado impreso quede hacia afuera. Tratar de unir las piezas antes de poner goma o cinta adhesiva. Pegar con goma o cinta las lengüetas, como se indica.

New Mexico Volcanoes
Student Activity Sheet

Description: You will identify, construct, and locate on a map of New Mexico four types of volcanoes.

I. Draw a picture of each type of volcano listed below:

Shield Volcano	**Cinder Cone**
Composite Volcano	**Caldera**

II. Clay Models

Materials for Your Group: 3 lbs. of clay
large piece of butcher paper
markers
11 Dixie cups, with colored vinegar
1/2 cup of baking soda
1 spoon

1. Using clay, your group will build 2 shield volcanoes, 5 cinder cone volcanoes, 2 composite volcanoes and 2 calderas. Be sure to put a small crater at the top or side of each volcano and to use the information you recorded in Part I to construct each volcano correctly.

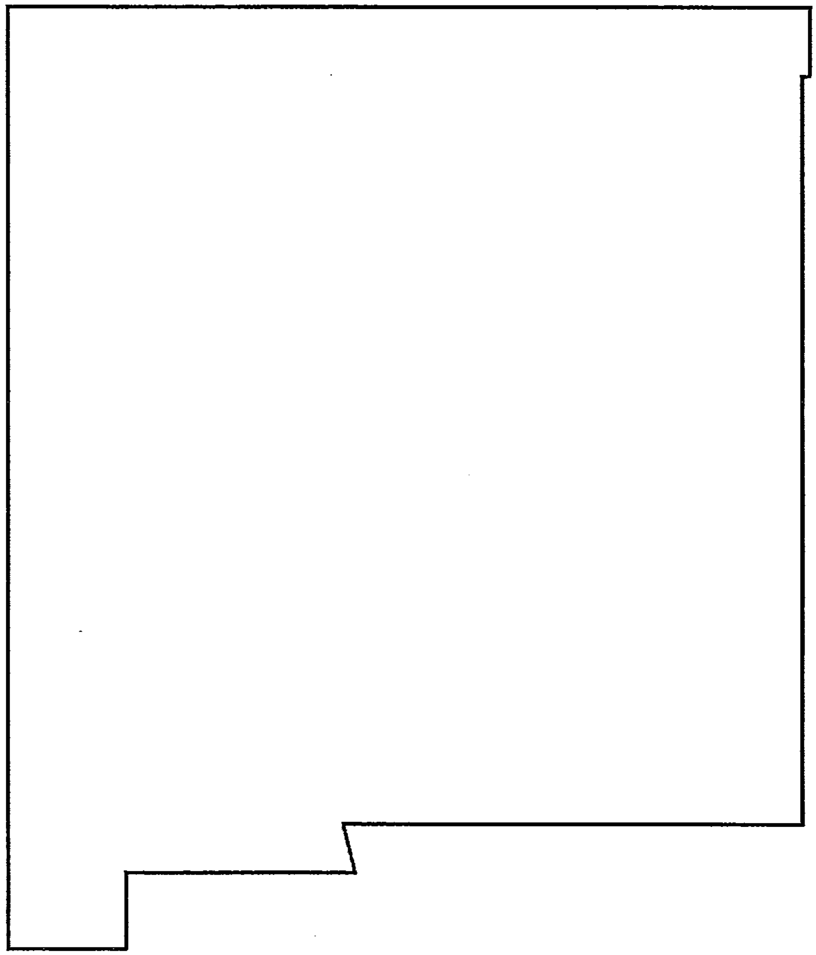
2. On the large piece of butcher paper, use the markers to draw a large (approximately 3 feet on a side) outline of New Mexico. Put in 4-5 cities as landmarks and an arrow to indicate north.

3. Place the clay volcanoes on the map in the correct place based on the following information (use a map of New Mexico to locate the cities listed):
   - 2 Shield Volcanoes—near Taos and in the northeast corner of NM near Raton;
   - 5 Cinder Cones—near Taos, Albuquerque, Grants, Raton, Carrizozo;
   - 2 Composites—near Ruidoso and Grants;
   - 2 Calderas—near Jemez and Silver City.

4. In the map on the following page, draw the 11 volcanoes from your large map in the correct places. Label the volcanoes.

5. Place one teaspoon of baking soda into the crater of each volcano. Distribute the Dixie cups of vinegar to each group member. Arrange yourselves so that everyone is in position to pour the vinegar into a volcano at the same time. **When your teacher gives the command**, pour the vinegar into the craters, erupting the volcanoes.

6. Compare the resulting "lava flows." How did the size and shape of the volcano affect the eruption? Did the position of the crater make a difference? Summarize your observations on the following page.



Summary of your observations:

Volcanes de Nuevo México
Hoja de Actividad para el Estudiante

Descripción: En un mapa de Nuevo México se identificarán, construirán y localizarán cuatro tipos de volcanes.

I. Hacer un dibujo de cada tipo de volcán listado enseguida:

Volcán tipo Escudo	Cono de Ceniza
Estratovolcán o Compuesto	**Caldera**

II. Modelos de Arcilla

Materiales para Su Grupo:

3 libras de arcilla
una pieza grande de papel de envoltura
marcadores
11 vasos deshechables "Dixie," con vinagre coloreado
1/2 taza de bicarbonato de sodio
1 cuchara

Procedimiento:

1. Usando la arcilla, el grupo construirá 2 volcanes tipo escudo, 5 conos de ceniza, 2 estratovolcanes y 2 calderas. Para hacer cada volcán correctamente, asegurarse de poner un pequeño cráter en la cima o al lado de cada volcán y de usar la información que se registró en la Parte I.

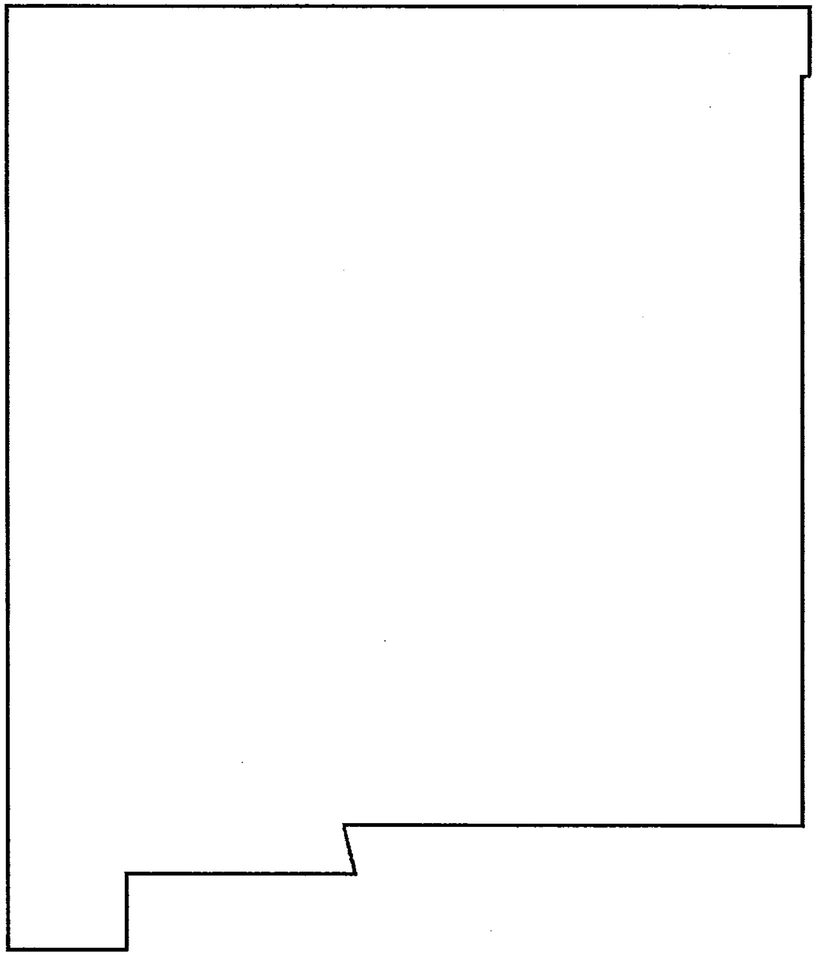
2. En la pieza de papel de envoltura, usar los marcadores para hacer en tamaño grande el contorno del estado de Nuevo México (aproximadamente 3 pies por cada lado). Colocar 4-5 ciudades como referencias y una rosa de los vientos para indicar el Norte.

3. Colocar los volcanes de arcilla sobre el mapa en el lugar correcto basándose en la siguiente información (usar el mapa de Nuevo México para localizar las ciudades listadas):
   - 2 volcanes tipo escudo - uno cerca de Taos y otro en la esquina Noreste de Nuevo México, cerca de Ratón;
   - 5 conos de ceniza - cerca de Taos, Albuquerque, Grants, Ratón y Carrizozo;
   - 2 volcanes compuestos - cerca de Ruidoso y de Grants;
   - 2 calderas - cerca de Jemez y de Silver City.

4. En el mapa de la siguiente página,dibujar los 11 volcanes de su mapa grande en los lugares correctos. Rotular los volcanes.

5. Poner una cucharadita de bicarbonato de sodio en el cráter de cada volcán. Distribuir los vasos deshechables con vinagre entre cada miembro del grupo. Acomodarse a sí mismos de tal manera que cada uno esté en posición de vaciar el vinagre en el volcán al mismo tiempo. **Cuando el maestro dé la órden**, vaciar el vinagre en los cráteres, haciendo que éstos hagan erupción.

6. Comparar la resultante "corriente de lava." ¿Cómo afecta la erupción el tamaño y forma del volcán? ¿La posición del cráter hizo alguna diferencia? En la siguiente página hacer un sumario de sus observaciones.



Sumario de sus observaciones:

EARTHQUAKE MAPPING

Grades		
6-8	pairs	40 min.

Description: Students will use longitude and latitude information to plot actual earthquakes on a world map.

Materials for Each Group:

copy of earthquake data
world map (with latitude and longitude)
pens
overhead transparencies and pens (optional)
transparency of "World Map with Epicenters" (optional)

Procedure:

1. Review how to find latitude and longitude on a map.

2. Pass out the earthquake data and maps and have students plot the earthquakes listed.

OR

1. Copy the world map onto overhead transparencies and give each group a transparent world map.

2. Divide the earthquake data and have each group plot their assigned earthquakes.

3. Gather the completed maps and align them on the overhead projector to show all of the earthquake plots together.

Questions to Ask During the Activity:

1. Can earthquakes happen anywhere? Are they more likely to occur in one place than in another? [Almost all earthquakes happen along fault lines, many of which are along plate boundaries. Some active faults are intra-plate, such as in Montana.]

2. How is the strength of an earthquake measured? [See Why It Happens]

3. When students are done, ask if they see any pattern as to where the quakes have occurred.

Why It Happens: The crust and the mantle of the Earth are believed to be divided into several large plates that move slowly. As the plates move, they pull apart, collide, override, or slide past each other. This movement creates the stress that forces rocks to break along faults. Every year nearly a million earthquakes occur in the world. Only a few thousand of these are strong enough to be felt by people. Many earthquakes occur as swarms around volcanic centers, such as at Yellowstone, the Cascades, and Hawaii.

Seismic waves are the vibrations from earthquakes that travel through the Earth; they are recorded on instruments called seismographs. The time, location, and magnitude of an earthquake can be determined from the data recorded by seismograph stations. The Richter magnitude scale was developed as a mathematical device to compare the size of earthquakes. On the Richter scale, each whole number increase in magnitude represents a tenfold increase in measured amplitude. As an estimate of energy, each whole number step in the magnitude scale corresponds to the release of about 31 times more energy than the amount associated with the preceding whole number. Although the Richter Scale has no upper limit, the largest known shocks have had magnitudes in the 8.8 to 8.9 range.

Adaptations for Participants with Disabilities: Students with visual impairments may need to work with a partner to find map locations.

Extensions: Use a transparency of "World Map with Epicenters" with a transparency of "Plates" (from Primary Plate Puzzle activity) to show and discuss how the plate boundaries align with the earthquake epicenters. You may also compare the earthquake plots to the locations of volcanoes (see the New Mexico Volcanoes activity).

Have students investigate the myths and legends about earthquakes.

Have students research the effects of major earthquakes in recent history.

Have students learn and sing "Shimmy—Shimmy—Shake!" (on page 227)

References:

Earthquakes. National Science Teachers Asociation, Washington, D.C., 1988.

NatureScope, (Geology: The Active Earth). Washington, D.C.: National Wildlife Federation, 1988.

The Severity of an Earthquake. U.S. Dept. of the Interior/Geological Survey. 1990.

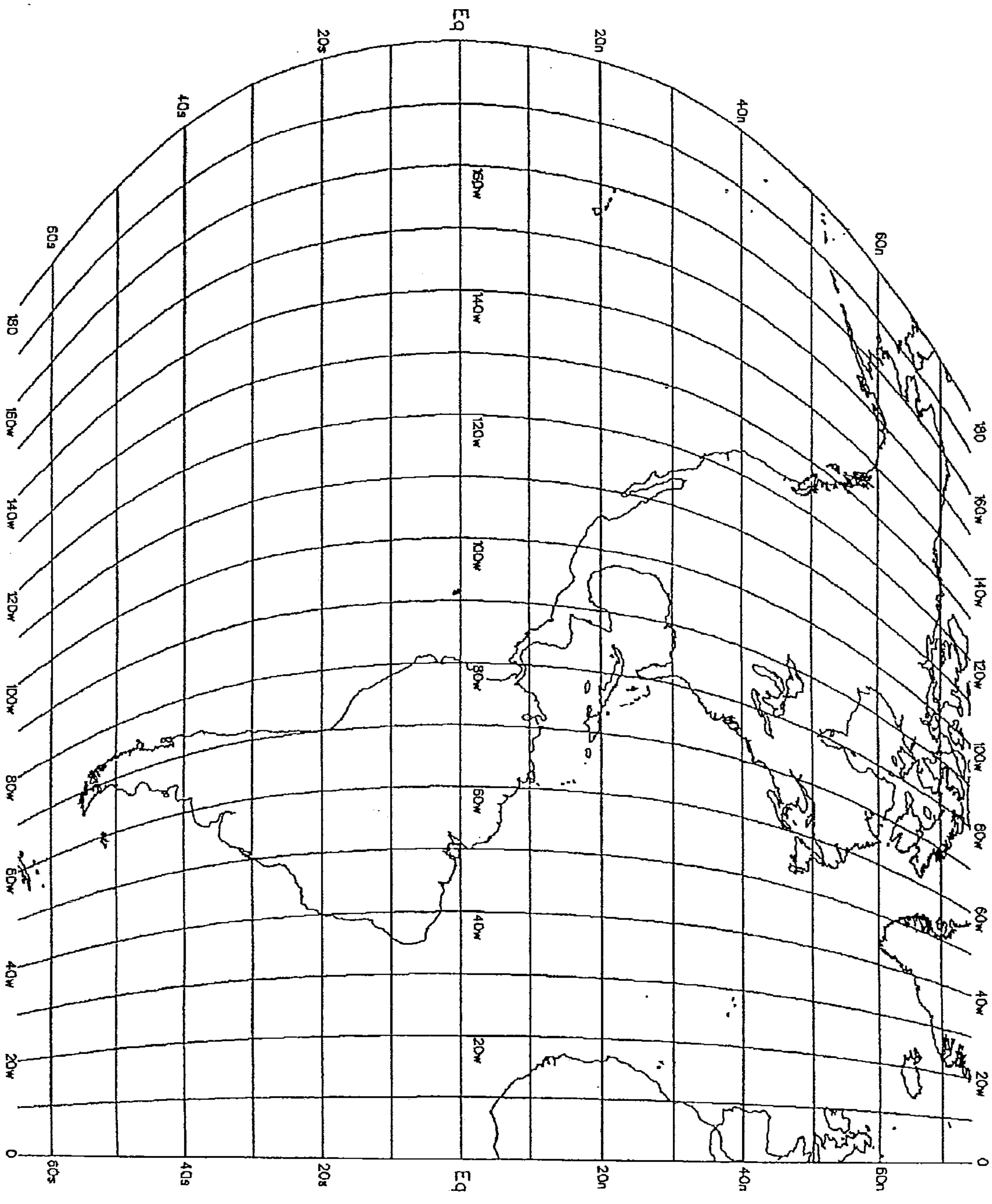
Earthquake Data

DATE	LATITUDE	LONGITUDE	MAGNITUDE
1-8-83	15S	173W	6.1
1-17-83	38N	20E	6.1
1-24-83	13N	94E	6.1
1-24-83	16N	95W	6.3
3-10-83	44N	147E	6.2
3-18-83	5S	154E	6.5
3-21-83	21S	175W	6.3
4-3-83	9N	83W	6.5
4-4-83	6N	95E	6.6
4-4-83	15S	156E	6.1
4-4-83	5S	167E	6.2
4-12-83	28N	78W	6.5
4-18-83	41N	62E	6.5
4-30-83	46N	144E	6.5
5-1-83	36N	153E	6.1
5-2-83	5S	120W	6.2
5-10-83	49N	151E	6.1
5-26-83	40N	139E	6.8
6-1-83	17S	175W	6.2
6-9-83	40N	139E	6.3
6-9-83	51N	174W	6.2
6-21-83	41N	139E	6.7
6-24-83	22N	103E	6.1
6-24-83	24N	122E	6.1
7-3-83	20N	122E	6.1
7-5-83	23S	171E	6.1
7-11-83	61S	53W	6.1
7-12-83	61N	147W	6.1
7-24-83	54N	158E	6.1
8-6-83	40N	25E	6.2
8-17-83	56N	161E	6.6
8-17-83	18N	121E	6.2
8-25-83	34N	131E	6.1
9-12-83	37N	71E	6.1
10-4-83	27S	71W	6.4
10-22-83	60S	25W	6.5
10-28-83	44N	114W	6.2
10-30-83	40N	42E	6.1
11-16-83	19N	155W	6.4
11-22-83	0	80W	6.3
11-24-83	7S	128E	6.4
11-30-83	7S	72E	6.6
12-11-83	8N	137E	6.2
12-21-83	28S	63W	6.2
12-22-83	12N	14W	6.4
12-30-83	36N	71E	6.6
1-1-84	34N	137E	6.5
1-4-84	45N	151E	6.2
2-7-84	10S	160E	6.6

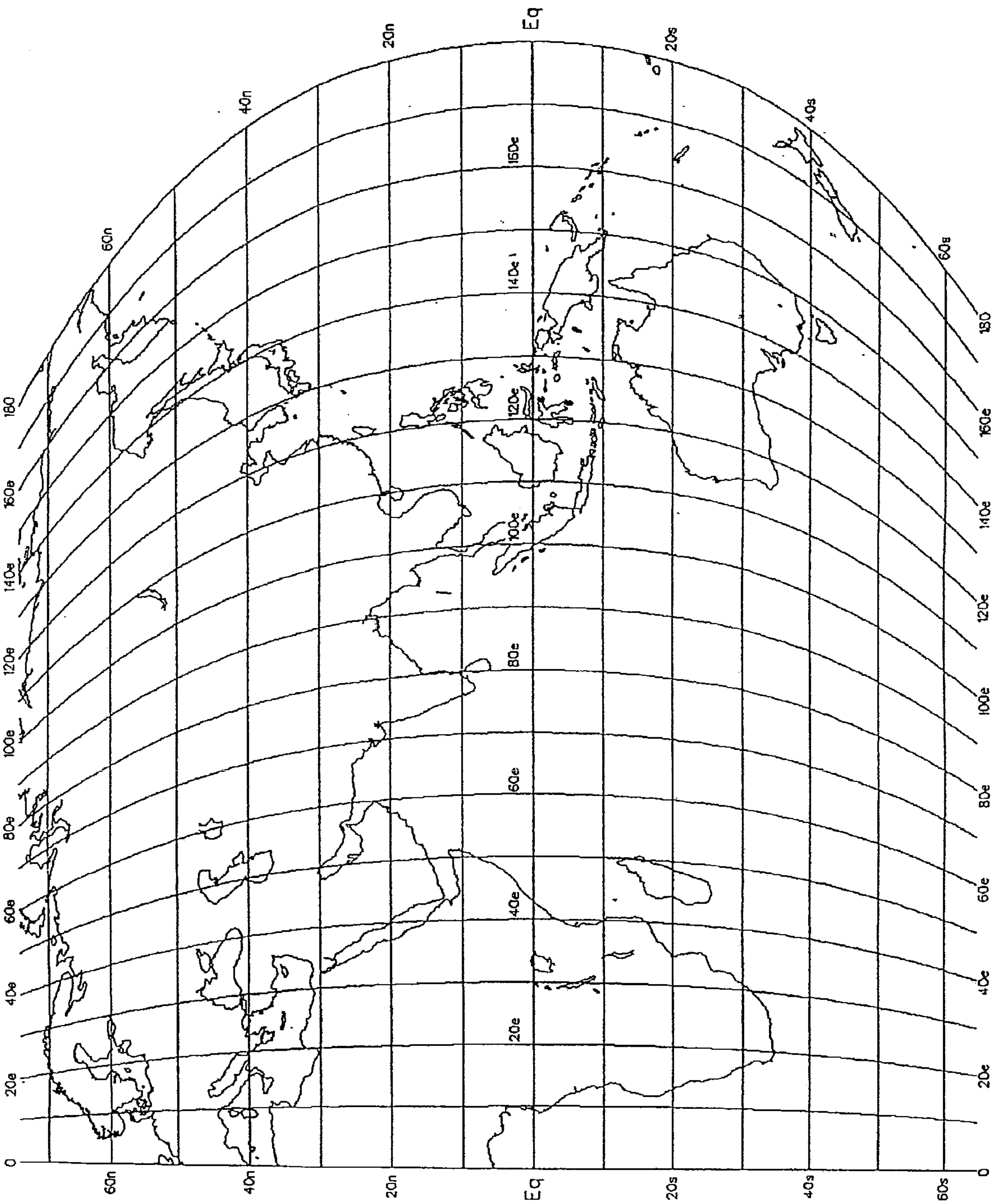
DATE	LATITUDE	LONGITUDE	MAGNITUDE
2-17-84	7N	130E	6.1
3-5-84	8N	124E	6.5
3-6-84	29N	139E	6.2
3-19-84	40N	63E	6.5
3-24-84	44N	148E	6.1
4-24-84	31N	138E	6.1
6-11-84	31S	71W	6.3
6-22-84	58S	16W	6.2
7-14-84	50N	79E	6.2
7-19-84	28N	130E	6.1
8-6-84	0	123E	6.2
8-6-84	32N	132E	6.3
8-31-84	18S	172E	6.1
9-10-84	41N	127W	6.1
9-18-84	34N	142E	6.6
9-28-84	26S	176W	6.4
10-13-84	15N	94W	6.1
10-15-84	16S	174W	6.5
11-1-84	8N	39W	6.5
11-6-84	19S	67E	6.2
11-15-84	22S	171E	6.3
11-17-84	0	98E	6.3
11-17-84	19S	178W	6.1
11-20-84	5N	125E	6.4
12-28-84	56N	163E	6.2
12-30-84	37S	177E	6.2
1-5-85	10N	80W	6.1
3-3-85	33S	72W	6.7
3-13-85	44N	128W	6.1
3-16-85	17N	62W	6.3
3-28-85	40N	140E	6.1
4-13-85	9S	114E	6.2
4-13-85	2N	126E	6.4
4-23-85	15N	121E	6.3
4-28-85	40S	76W	6.1
5-19-85	54N	161E	6.1
6-3-85	15S	174W	6.2
6-6-85	1N	28W	6.3
7-3-85	4S	153E	6.3
8-2-85	36N	71E	6.1
8-21-85	9S	79W	6.1
8-23-85	39N	75E	6.4
8-28-85	21S	179W	6.1
9-19-85	18N	103W	6.8
9-26-85	35S	179W	6.3
10-9-85	55N	160W	6.2
10-29-85	10S	151E	6.1
11-7-85	35S	179W	6.2
12-23-85	62N	124W	6.4

Data courtesy of the U.S. Geological Survey, Golden, Colorado

World Map

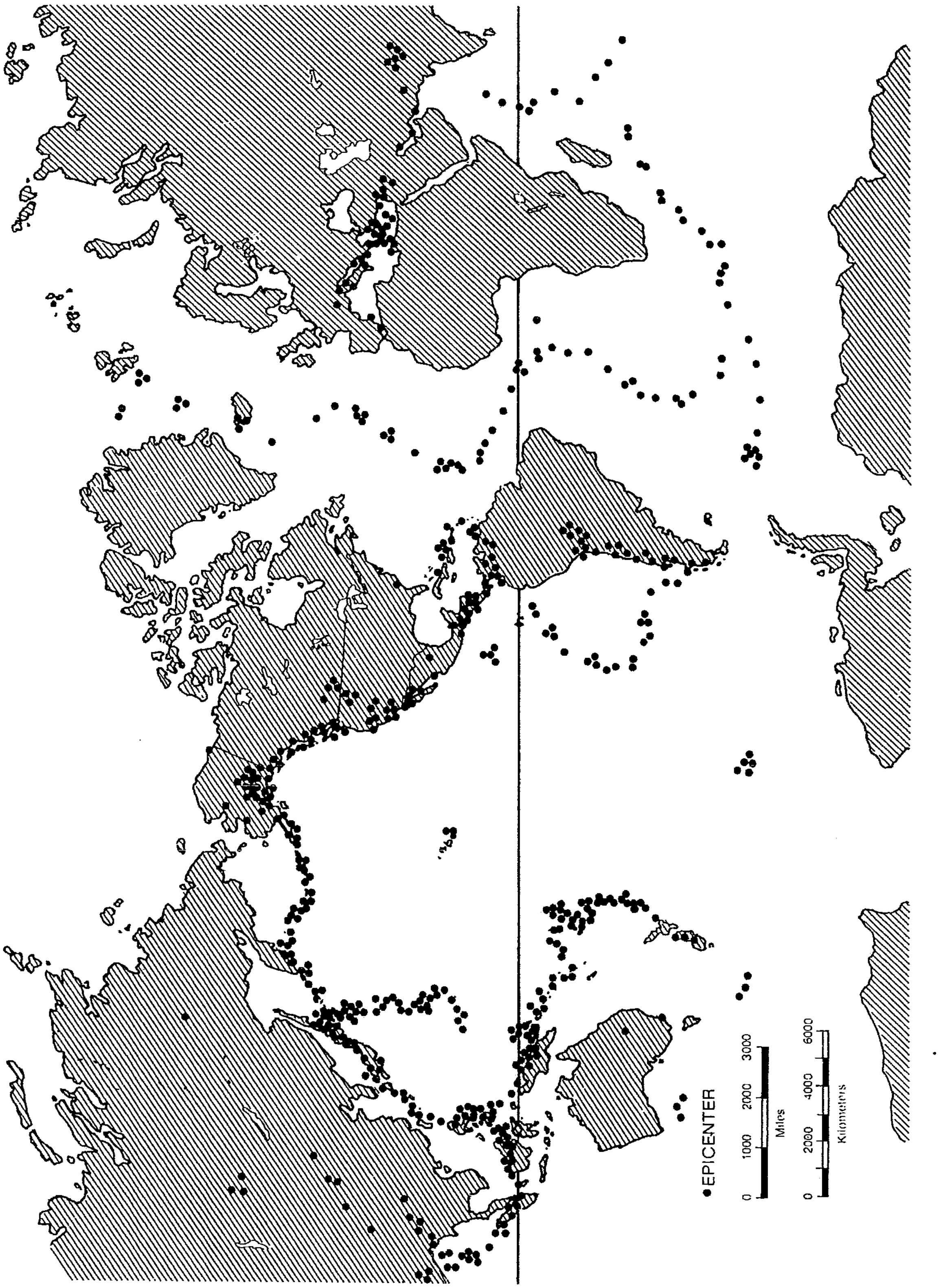

Eq
20s
40s
60s
20n
40n
60n
180
160w
140w
120w
100w
80w
60w
40w
20w
0

World Map



Eq
20n
40n
60n
20s
40s
60s
0
20e
40e
60e
80e
100e
120e
140e
160e
180

World Map with Epicenters



Earthquakes-NSTA/FEMA

Shimmy--Shimmy--Shake!

(To the tune of Old McDonald's Farm, lyrics adapted from Sylvia Herndon)

Verse 1
Rumble, rockin', shakin' ground
Shimmy - shimmy - shake!
Whoops! it's hard not to fall down . . .
Shimmy - shimmy - shake!

With a rattle rattle here
And a rumble tumble there

Here a rattle - there a rumble . . .
Everywhere a rumble tumble.
Rumble, rockin', shakin' ground . . .
Shimmy - shimmy - shake!

Verse 2
Someone says It's an earthquake!
Shimmy - shimmy - shake!
Best to hurry, don't you wait . . .
Shimmy - shimmy - shake!

With a rattle rattle here
And a rumble tumble there

Here a rattle - there a rumble
Everywhere a rumble tumble.
Rumble, rockin', shakin' ground . . .
Shimmy - shimmy - shake!

Verse 3
Get under something near and safe
Shimmy - shimmy - shake!
You must be fast, now don't you wait . . .
Shimmy - shimmy - shake!

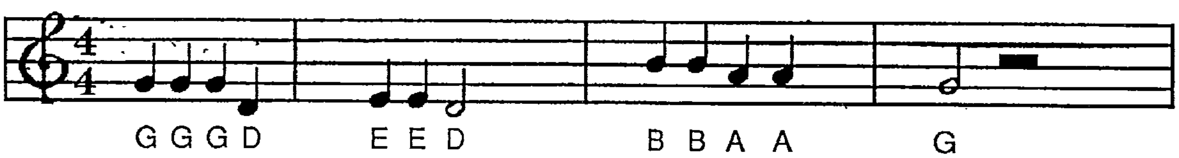
With a rattle rattle here
And a rumble tumble there

Here a rattle - there a rumble
Everywhere a rumble tumble.
Rumble, rockin', shakin' ground . . .
Shimmy - shimmy - shake!

Verse 4
Hold on tight and 'fore you know
Shimmy - shimmy - shake!
Rockin's over, you can go . . .
No more shimmy - shake!

No rattle rattle here
No rumble tumble there

Here no rattle - there no rumble
Gone is all the rumble tumble,
Rumble, rockin', shakin' ground . . .
No more shimmy - shake!



* Developed by Disaster Mitigation Planning Section, Office of Emergency Services, P.O. Box 758, Conway, AR 72032-0758

PROYECTO FUTURO