The Structure of the Earth

Grade Level or Special Area: 4th Grade
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Length of Unit: Seven lessons (approximately nine days, one day = 45 – 60 minutes)

I. ABSTRACT

A. This unit is intended to provide fourth graders with an overview of the Earth's interior, plates, and plate boundaries. Students will have an opportunity to investigate a variety of ways in which people have been affected by volcanoes and earthquakes. This unit uses a variety of approaches to learning, including writing and creating models. Through reading, class discussion, and activities, the students will gain a better understanding of the structure of the Earth.

II. OVERVIEW

A. Concept Objectives
   1. Students understand common properties, forms, and changes in matter and energy. (*Colorado Model Content Standard #2)*
   2. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. (*Colorado Model Content Standard #4)*
   3. Students understand interrelationships among science, technology, and human activity and how they can affect the world. (*Colorado Model Content Standard #6)*

B. Content from the *Core Knowledge Sequence*
   1. Fourth Grade Science, Geology: The Earth and Its Changes (pg. 105)
      a. The Earth's Layers
         i. Crust, mantle, core (outer core and inner core)
         ii. Movement of crustal plates
         iii. Earthquakes
            a.) Faults, San Andreas fault
            b.) Measuring intensity: seismograph and Richter Scale
            c.) Tsunamis (also called tidal waves)
         iv. Volcanoes
            a.) Magma
            b.) Lava, and lava flow
            c.) Active, dormant, or extinct
            d.) Famous volcanoes: Vesuvius, Krakatoa, Mount St. Helens
         v. Hot springs and geysers: Old Faithful (in Yellowstone National Park
         vi. Theories of how the continents and oceans were formed: Pangea and continental drift

D. Skill Objectives
   1. The student will identify each layer of the Earth and write a brief description of each.
   2. Students will be able to explain the theory of plate tectonics.
   3. The student will describe the three types of plate boundaries
   4. The student will be able to describe the theory of continental drift.
   5. The student will list evidence used by Alfred Wegener to form his theory and explain why other scientists rejected it.

6. Students will be able to describe the types of faults, why faults form, and where they occur.
7. Students will be able to describe how movement along faults changes Earth's surface.
8. Students will be able to build a model of a volcano and simulate a volcanic eruption using that model.
9. Students will be able to identify the structure of a volcano.
10. Students will be able to identify Earth's famous volcanoes.
11. Students will be able to locate Earth's famous volcanoes.
12. Students will be able to identify types of volcanoes as shield, cinder cone, or composite volcanoes.
13. Students will be able to list the similarities and the differences between a volcano and a geyser.

III. BACKGROUND KNOWLEDGE

A. For Teachers

1. *The Best Book of Volcanoes,* Adams, Simon
2. *Earthquakes,* U.S. Department of the Interior/ U.S. Geological Survey
3. *Volcanoes of the United States,* U.S. Department of the Interior/ U.S. Geological Survey

B. For Students

1. Introduction to units of length such as miles and kilometers
2. Measure and record temperature in degrees Fahrenheit and Celsius (*Core Knowledge Sequence* 3rd grade pg. 80)
3. Name of continent and country, and location of continents (*Core Knowledge Sequence* 1st grade pg. 27 and 3rd grade pg. 69)
4. Identify major oceans (*Core Knowledge Sequence* 1st grade pg. 27)
5. Geographical terms and features including peninsula *(Core Knowledge Sequence* 1st grade pg. 27)
6. Locate: the Equator, Northern Hemisphere, Southern Hemisphere, North and South Poles (*Core Knowledge Sequence* 1st grade pg. 27, 2nd grade pg. 47, and 3rd grade pg. 69)
7. Make linear measurements in yards, feet, and inches; and, in centimeters and meters *(Core Knowledge Sequence* 3rd grade pg. 79)
8. Identify angles (*Core Knowledge Sequence* 3rd grade pg. 80)
9. Measure volumes : cups, pints, quarts, gallons (*Core Knowledge Sequence* 2nd grade pg. 57)

IV. RESOURCES

A. Information text and pictures of volcanic eruptions (Vesuvius, Mount St. Helens, and Krakatoa)
B. Pictures of Old Faithful in Yellowstone National Park
C. Four or five globes that show physical features of the Earth
D. Eyewitness Volcano Video

V. LESSONS

Lesson One: Inside Earth (approximately 45 minutes)

A. *Daily Objectives*

1. Concept Objective(s)

a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. (*CMCS #4)*

b. Students understand common properties, forms, and changes of matter and energy. (*CMCS #2)*

2. Lesson Content
   a. The Earth's Layers
      i. Crust, mantle, core (outer core and inner core)
3. Skill Objective(s)
   a. The student will identify each layer of the Earth and write a brief description of each.

B. *Materials*
1. One wet apple
2. A knife to cut the apple
3. Small balls of clay (four different colors) for each student
4. A plastic knife for each student
5. Four to Five small tags for each student

C. *Key Vocabulary*
1. Core: Earth's super-hot center --- the outer core is liquid and the inner core is solid
2. Crust: Earth's cool outer layer of mostly solid rock
3. Mantle: Earth's vast middle layer
4. Geology: the study of the Earth's origin, history, and structure
5. Lithosphere: the outer part of the solid earth
6. Flexible: able to bend or change
7. Magnetic Field: the area around a magnet or electric coil that has the power to attract other metals, usually iron or steel
8. Molecule: the smallest part of a substance that displays all the properties of that substance

D. *Procedures/Activities*
1. Introduce the unit by explaining that the planet we call Earth is a really amazing place. In this unit we're going to learn what the Earth is made of, why it moves, what causes earthquakes, volcanoes, hot springs, and geysers.
2. Introduce the term Geology and explain to them that Geology is the study of the Earth's origin, history, and structure. Geologists unlock the secrets of rocks so they tell us something about how the Earth was formed and what forces have shaped it.
3. When the Earth was formed four and a half billion years ago, gravity pulled materials together. Heavy materials gathered to the center and lighter materials floated to the top of the Earth.
4. Explain that even though two-thirds of the globe's surface is covered by water, that even the deepest parts of the oceans reach less than seven miles. Compared to the thousands of miles of rock beneath them, our oceans don't amount to much more that a thin film of moisture – about as much as the morning dew on an apple.
5. Show students a wet apple. Cut the apple in half to illustrate layers of the Earth as they are introduced.
6. Explain that no matter where you are right now, there are about 8,000 miles (12,800 km) of Earth beneath your feet, and almost all of it is rock. Explain to the students that the solid parts of our planet are made up of layers, too. Tell them there are four layers of Earth beneath their feet.

7. Ask the students: "What do you think is inside Earth? Is it hot or cold? Solid or liquid? How far do you think it is to the center of the Earth?
8. Pass out Layers of the Earth sheet (Appendix A) for students to refer to and take notes on. Explain to the students that they will want to take notes on the discussion so they can describe each layer at the end.
9. Introduce the outer layer of the Earth as the Earth's crust. Explain that the crust is the part we know most about, because, after all, we live on it. Compared to the rest of the planet the crust is as thin as the skin on that apple we mentioned. Explain that it is cool too, unlike Earth's inside layers. Explain that the Earth's crust is mostly rock. Under the continents, the crust is up to 25 miles thick. Under the ocean, it is about three to six miles thick. If you compared Earth to the apple, the crust would almost be as thick as the apple's skin. Though no one has drilled to the bottom of the crust, the deeper people dig, the hotter it gets.
10. Below the crust is a layer of hot, heavy rock about 1,800 miles thick. Scientists call this layer the mantle. Together, the crust and the upper part of the mantle are called the lithosphere (the outer part of the solid earth). It's really toasty down there (between 1,600 and 5,500 degrees Fahrenheit). It is so hot; in fact, that in places the mantle rock isn't quite solid. It's thick and flexible (able to bend or change) – like Silly Putty. Explain that the mantle is under a lot of pressure.
11. Compare the middle of the apple to the mantle layer.
12. Beneath the mantle is an even heavier, hotter layer called the outer core. It's made mostly of the metals iron and nickel – liquid iron and nickel, that is. The entire outer core is melted through and through. The temperature is 5,500 to 7,200 degrees Fahrenheit. The movement of the liquid rock in the core is believed to cause Earth's magnetic field (the area around a magnet or electric coil that has the power to attract other metals, usually iron or steel). The outer core is 1,410 miles thick.
13. Compare the core of the apple to the outer core layer.
14. Finally, at the very center of the Earth is the inner core, a ball of solid iron nearly 800 miles thick from its outside to its middle. The coolest part of the core is about 6,000 degrees Fahrenheit, and the hottest part is nearly 12,000 degrees Fahrenheit. Tell your students that this is hotter than the surface of the sun. The inner core is mostly solid iron and nickel.
15. Ask them why the Earth's inner core is so hot, how come it's solid instead of molten, like the outer core? Give them time to give an answer. Then explain that because so much weight is pushing in on the core from all directions, its molecules (the smallest part of a substance that displays all the properties of that substance) don't have any room to move apart. They stay packed together – solid as a rock.
16. Compare the seeds in the apple to the inner core layer.
17. Pass out colored clay and plastic knives to students.
18. Invite students to roll a piece of clay into a ball. This represents Earth's inner core.
19. Next ask students to completely cover their balls with a layer of different – colored clay. This represents the outer core. Students repeat this step with another color of clay for the mantle. Have students model the thickness of each layer as they are creating their model.
20. A final covering represents the crust. It needs to be thin, so suggest that students pat the clay into a thin pancake before wrapping it around the ball.
21. To reveal the layers, invite the students either to cut their Earths in half or cut out a quarter.

22. Have the students make tags labeling each layer.
23. After they have created their model, have students make a diagram showing the layers of Earth, with a brief descriptive phrase about each layer.
24. Have them turn in their diagrams and clean up their clay.
25. After clay hardens for a couple days they can take their models home.
26. **Extension:** Challenge students to find out more about Earth's layers. Draw a diagram of Earth's layers on butcher paper and hang it on a wall or bulletin board. Divide students into four groups and assign each a layer. Have each group fill in their layer with facts and figures, as well as scientists' theories, about that layer of Earth.

E. *Assessment/Evaluation*
   1. Satisfactory completion of students' diagrams and descriptions of the Earth's layers.

Lesson Two: Crustal Plates (approximately 45 minutes)

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. (*CMCS #4)*
      b. Students understand that science involves a particular way of knowing and understanding common connections among scientific disciplines. (*CMCS #6)*
      c. Students understand common properties, forms, and changes of matter and energy. (*CMCS #2)*
   2. Lesson Content
      a. The Earth's Layers
         i. Movement of crustal plates
   3. Skill Objective(s)
      a. Students will be able to explain the theory of plate tectonics.
      b. The student will describe the three types of plate boundaries.

B. *Materials*
   1. One hard-boiled egg
   2. Plate Tectonics Worksheet (Appendix B)
   3. Two smooth wooden blocks

C. *Key Vocabulary*
   1. Lithosphere: the Earth's solid outer shell
   2. Plates: a section of the lithosphere that slowly moves, carrying pieces of continental and oceanic crust.
   3. Plate tectonics: is the geological theory that states that pieces of the Earth's lithosphere are in constant, slow motion, driven by currents in the mantle
   4. Subduction: the process by which oceanic crust sinks beneath a deep-ocean trench and back into the mantle at a convergent plate boundary
   5. Transform boundary: a place where two plates slip past each other, moving in opposite directions
   6. Divergent boundary: the place where two plates move apart
   7. Convergent boundary: the place where two plates come together
   8. Rift valley: a deep valley that forms where two plates move apart

D. *Procedures/Activities*
   1. Review with students the four layers of the earth (crust, mantle, inner core, and outer core).

2. Tell your students that you are going to try something with them.
3. Go outside and jump up and down a couple of times. Ask them if they felt the Earth shake.
4. Now have them stand very, very still. Ask them if they felt the ground moving.
5. Go back in the class room and review these two questions. Tell them that of course they didn't feel anything. Explain that humans aren't sensitive enough to notice. But the ground beneath your feet is actually slowly moving all the time. Every once in a while it moves too noticeable – in an earthquake, for instance.
6. Show the hard boiled egg. Ask them if they have ever dropped a hard boiled egg. Drop the egg for demonstration. (You may want to drop the egg outside or on an easy to clean up surface) Ask them if they noticed anything about the eggshell. Explain that they may have noticed that the eggshell cracked in an irregular pattern of broken pieces.
7. Explain that the Earth's lithosphere (its solid outer shell) is not one unbroken layer. It is more like that cracked eggshell. It's broken into pieces separated by jagged cracks.
8. Explain that the Earth's lithosphere is broken into separate sections called plates (a section of the lithosphere that slowly moves, carrying pieces of continental and oceanic crust). The plates fit closely together along cracks in the lithosphere.
9. Tell your students that these plates, dozens of miles thick, push and shove and bump and crape and pull apart and jam together. Each plate is attached to a piece of Earth's upper mantle and together they ride on top of the partly molten, putty-like layer in the mantle. Explain that the study of how the pieces of Earth's crust move is called plate tectonics. Explain that the theory of plate tectonics explains the formation, movement, and subduction of Earth's plates.
10. Explain that most of the action in Earth's crust happens at the seams, or cracks, where plates meet. In the Pacific Ocean, at least five large plates come together. That's why there are so many volcanoes and earthquakes in China, Japan, Hawaii, and California. There are a lot of places where chunks of the Earth are grinding together or moving apart.
11. The edges of different pieces of the lithosphere meet at lines called plate boundaries. Explain to the students that there are three kinds of plate boundaries: transform boundaries, divergent or spreading boundaries, and convergent boundaries. For each type of boundary, there is a different type of plate movement.
12. Introduce the three types of plate boundaries by demonstrating each type using wooden blocks.
13. Draw two arrows on the board, indicating the plates sliding past each other. Label this transform boundary. With the wooden blocks, slide one block past the other. Explain that a transform boundary is a place where two plates slip past each other, moving in opposite directions. Earthquakes occur frequently along these boundaries.
14. Draw two arrows on the board pointing out and label this divergent or spreading boundary. Using the wooden blocks, pull two blocks away from each other. Explain that a divergent or spreading boundary is where two plates move apart. Most divergent boundaries occur at the mid-ocean ridge. Explain that divergent boundaries also occur on land. When a divergent boundary develops on land, two of Earth's plates slide apart. A deep valley called a rift valley forms along the divergent boundary.
15. Draw two arrows pointing in. Label this convergent. Using the wooden blocks, push two blocks together. Tell the students that at these boundaries the plates

bump and push each other. Sometimes at convergent boundaries, one plate dives under the other one. When two plates collide, the one that weighs more is the one that dives under the other one.

16. Pass out Plate Tectonics W/S (Appendix B) and have students answer questions of material just learned. Have the students turn in their worksheet when they have finished.

E. *Assessment/Evaluation*

   1. Satisfactory completion of Plate Tectonics Worksheet (Appendix B)

Lesson Three: Pangea (approximately 45 minutes)

A. *Daily Objectives*

   1. Concept Objective(s)
      a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space.*(CMCS #4)*
      b. Students understand that science involves a particular way of knowing and understand common connections among scientific disciplines. (*CMCS #6)*
      c. Students understand common properties, forms, and changes of matter and energy. (*CMCS #2)*
   2. Lesson Content
      a. The Earth's Layers
         i. Theories of how continents and oceans were formed: Pangea and continental drift
   3. Skill Objective(s)
      a. The student will be able to describe the theory of continental drift.
      b. The student will list evidence used by Alfred Wegener to form his theory and explain why other scientists rejected it.

B. *Materials*

   1. Four or five globes that shows physical features of the Earth
   2. One piece of newspaper per person
   3. Variety of plant seeds
   4. How Are The Earth's Continents Linked Together (Appendix C)
   5. Scissors for each student

C. *Key Vocabulary*

   1. Pangea: the name of the single landmass that broke apart 200 million years ago and gave rise to today's continents
   2. Continental drift: the hypothesis that the continents slowly move across Earth's surface
   3. Fossil: a trace of an ancient organism that has been preserved in rock
   4. Hypothesis: a possible explanation for a set of observations or answer to a scientific question; must be testable
   5. Continental glaciers: thick layers of ice that cover hundreds of thousands of square kilometers

D. *Procedures/Activities*

   1. Start by reminding students of Earth's plates. Remind them that the Earth's plates have been moving around and pulling apart and bumping into each other for a long time.
   2. Group the students into groups of four or five.
   3. Pass out "How Are The Earth's Continents Linked Together?" WS (Appendix C).

4. Place a globe with each group of students. Have students write the answers to "How Are The Earth's Continents Linked Together?" (Appendix C) as you go through the steps of the activity.
5. Look at a globe showing Earth's physical features.
6. Find the oceans and the seven continents on the globe.
7. Ask the students how much of the globe is occupied by the Pacific Ocean? (Answer: more than one third) Does most of the Earth's dry land lie in the Northern or Southern Hemisphere? (Answer: Northern Hemisphere) Ask the students to find the points or areas where most of the continents are connected. Find the point at which several of the continents almost touch, but are not connected. (Answer: at the North Pole; at the South Pole)
8. Examine the globe more closely. Find the great belt of mountains running from north to south along the western side of North and South America. Ask if they can find another great belt of mountains on the globe. (Answer: through Europe and Asia)
9. After you have gone through all the questions with the students ask them to notice how the coasts of South American and Africa look as if they could fit together like jigsaw-puzzle pieces. Explain to them that if you pushed them towards each other, they'd match up perfectly side by side. Suggest that maybe they were connected once, and then just sort of floated apart.
10. Ask them if they think that the continents could have once been a single landmass. Ask if they think they could have floated apart? The continents? Millions of tons of rock?
11. If they say no, or ask how, explain to them that these are the same thoughts that most scientists asked when anyone suggested that maybe the continents had been connected long ago and then somehow moved apart. In the 1700s, the first geologists thought that the continents had remained fixed in their current positions throughout Earth's history.
12. Explain to them that in the early 1900's, however, one scientist began to think in a new way about these questions. His theory changed the way people look at the map of the world.
13. Explain that in 1910 a German scientist, Alfred Wegener, was the first to study the idea and say that it might be true. He came up with some pretty convincing evidence, too. However, it wasn't until 20 years after Alfred Wegener's death that geologists realized he was right. The continents and ocean floors really do "float" on moving rock plates, and have been for millions of years.
14. Explain that Alfred Wegener formed a hypothesis (a possible explanation for a set of observations or answer to a scientific question; must be testable) that Earth's continents had moved. Wegener's hypothesis was that all the continents had once been joined together in a single landmass and have since drifted apart. Wegener named this super continent Pangea.
15. Explain that over tens of millions of years, Pangea began to break apart. The pieces of Pangea slowly moved toward their present-day locations, becoming the continents as they are today. Wegener's idea that the continents slowly moved over the Earth's surface became known as continental drift (the hypothesis that the continents slowly move across Earth's surface).
16. Ask the students if they have ever tried to persuade a friend to accept a new idea or something that they don't think is possible. Ask them if it was hard to convince them. Ask them what they needed to convince them of the idea. Lead them to answer that they needed evidence.

17. Explain to the students that other scientists didn't believe Wegener. So, Wegener gathered evidence from different scientific fields to support his ideas about continental drift. He gathered evidence from landforms, fossils, and evidence that showed how Earth's climate had changed over many millions of years.
18. Explain that Wegener pieced together maps of Africa and South America. He noticed that a mountain range in Argentina lines up with a mountain range in South Africa.
19. Pass out pieces of newspaper and scissors to each student.
20. Have students cut their newspaper into six to eight large pieces.
21. Have the students trade their pieces with a partner. Try to fit the pieces of newspaper back together.
22. Explain to the students that Wegener compared matching landform features to reassembling a cut-up newspaper. If the pieces could be put back together, the "words" would match.
23. Tell the students that Wegener gathered evidence from fossils of reptiles on one continent with fossils from another separated by oceans and they matched. Wegener stated that the reptiles couldn't have swum great distances across salt water. He also compared a fern-like plant that lived 250 million years ago. The plant fossils have been found in rocks in Africa, South America, Australia, India, and Antarctica. The plant fossils on these widely separated landmasses convinced Wegener that the continents had once been united. The seeds of the plants were too large to be carried by the wind and to fragile to have survived a trip by ocean waves.
24. Show the students your collection of seeds and allow students to examine them closely. Ask them how the different seeds are moved from place to place. As a class, make a list of the seeds on the board and how they might be moved from one place to another. Have them especially consider whether any seeds could have moved across an ocean.
25. Wegener also used evidence of climate change to support his theory. Wegener found that deep scratches in rocks showed that continental glaciers once covered South Africa. Explain that continental glaciers are thick layers of ice that cover hundreds of thousands of square kilometers. But the climate of South Africa is too mild today for continental glaciers to form. Wegener concluded that, when Pangea existed, South Africa was much closer to the South Pole. According to Wegener, as a continent moves toward the equator, its climate becomes warmer. As a continent moves toward the poles, its climate becomes colder. But the continent carries with it the fossils and rocks that formed at its previous locations. These clues provide evidence that continental drift really happened.
26. Pass out Pangea rubric (Appendix D) to the students.
27. Have the students pretend that they are Wegener. Explain to them that they need to write a paragraph trying to convince the class that continental drift is possible and that there was once a super continent called Pangea.
28. After students have finished have them turn in their paragraphs.

E. *Assessment/Evaluation*
   1. Pangea rubric (Appendix D)

Lesson Four: Earthquakes (approximately 45-60 minutes)

A. *Daily Objectives*
   1. Concept Objective(s)

a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(CMCS #4)*
b. Students understand common properties, forms, and changes of matter and energy. *(CMCS #2)*

2. Lesson Content
   a. The Earth's Layers
      i. Earthquakes
         a.) Faults, San Andrea fault
         b.) Measuring intensity: seismograph and Richter Scale
         c.) Tsunamis (also called tidal waves)
3. Skill Objective(s)
   a. Students will be able to describe the types of faults, why faults form, and where they occur.
   b. Students will be able to describe how movement along faults change Earth's surface.

B. *Materials*
1. Small ball of clay in two or more colors for each student
2. Marking pen for each student
3. Plastic butter knife for each student
4. Fault Data Table (Appendix E) for each student
5. A piece of waxed paper, for each student, that will cover their desk
6. A piece of blank paper for each student

C. *Key Vocabulary*
1. Earthquake: the shaking that results from the movement of rock beneath Earth's surface
2. Fault: a break in Earth's curst where slabs of rock slip past each other
3. Strike-slip fault: a type of fault where rocks on either side move past each other sideways with little up-or-down motion
4. Normal fault: a type of fault where the hanging wall slides downward; caused by tension in the crust
5. Reverse fault: a type of fault where the hanging wall slides upward
6. Seismograph: a device that records ground movements caused by seismic waves as they move through Earth
7. Richter scale: a scale that rates seismic waves as measured by a particular type of mechanical seismograph
8. tsunami: a large wave produced by an earthquake on the ocean floor
9. Seismic wave: a vibration that travels through Earth carrying the energy released during an earthquake

D. *Procedures/Activities*
1. Ask the students if they know what quake means? (tremble or shake)
2. Tell them that today they are going to learn about earthquakes (when the Earth trembles or shakes).
3. Explain that an earthquake is a shaking and trembling that results from the movement of rock beneath Earth's surface. The movement of Earth's plates create powerful forces that squeeze or pull the rock in the crust.
4. Tell the students that depending on how strong an earthquake is, it can knock down buildings, bridges, tear up roads, cause avalanches, and open up giant crevasses in the ground.
5. Ask the students who have been in an earthquake to share their experiences.

6. Ask them if they think earthquakes happen very often. Tell them that earthquakes happen someplace in the world every thirty seconds. Most of them are so mild that people are not even aware of them.
7. Explain that scientists know they have happened because seismic waves (a vibration that travels through Earth carrying the energy released during an earthquake) from the earthquake travel through the ground. These waves can be picked up by an instrument called a seismograph.
8. Explain that a seismograph is a device that records ground movements caused by seismic waves as they move through Earth.
9. Explain to the students that energy from the earthquake causes the base of the seismograph to vibrate. A pen that is suspended above the base then makes a wavy line on paper. Bigger waves make bigger lines.
10. Explain to the students that the strength of the earthquake is measured on a scale from 1 to 10 called a Richter scale. Each number up from 1 is thirty times more powerful than the number before it. An earthquake measured at a 10 would be the most violent earthquake of all.
11. Explain to the students that tremendous forces under Earth's surface build up pressure, which is released in a fault (a crack in Earth's crust that allows the crust to slip.)
12. Tell the students to imagine you are bending a popsicle stick. When the pressure is great enough, the stick snaps in two. The energy is released by the snap and waves travel through the stick in your hands. The fault, however, doesn't come apart like the stick. Explain that portions of Earth's crust slide past each other, creating waves.
13. Explain that faults usually occur along plate boundaries, where the forces of plate motion compress, pull, or shear the crust so much that the crust breaks. Tell the students that there are three types of faults: strike-slip faults, normal faults, and reverse faults.
14. Explain that in a strike-slip fault, the rocks on either side of the fault slip past each other sideways with little up or down motion. The San Andreas fault in California is an example of a strike-slip fault.
15. Ask the students to hold up their hands. Have them hold the edges of the open hands against each other with the palms down, the fingers pointing away from the body, and the thumbs tucked below, and then slide one hand away from the body and the other hand toward the body. Explain to them that this is how rocks would move on a strike-slip fault.
16. Tell the students that in a normal fault, the fault is at an angle, so one block of rock lies above the fault while the other block lies below the fault.
17. Instruct them to hold up their hands again. Hold the open hands with the fingers pointing toward each other, lay the fingers of one hand over the fingers of the other hand, and then move the hands away from each other. Explain that this is how a normal fault works.
18. Explain that the last type of fault, a reverse fault, has the same structure as a normal fault, but the blocks move in the opposite direction.
19. Have them hold up their hands again. Hold the hands as described for a normal fault, but move them toward each other. This is what a reverse fault looks like.
20. Tell the students that in this activity, they will be using blocks of clay to represent Earth's crust. Ask: How will blocks of clay more closely resemble real blocks of rock than your hands did? (They can show several layers of rock).
21. Pass out waxed paper and cover the desktop to protect it.

22. Pass out colored clay, marking pen, plastic butter knife, and a Fault Data Table (Appendix E) to each student.
23. Have the students mold some clay into a sheet about 0.5 centimeter thick and about 6 centimeters square. Then make another sheet of the same size and thickness, using a different color.
24. Have the students cut each square in half and stack the sheets on top of each other, alternating colors. Make sure students cut the square in half from one side to the opposite side, not from corner to corner. Tell the to avoid breaking the plastic knife, do not press too hard as you cut. Explain that the sheets of clay stand for different layers of rock. The different colors will help you see where similar layers of rock end up after movement occurs along the model fault.
25. Tell the students to press the layers of clay together to form a rectangular block that fits in the palm of their hand.
26. Use the butter knife to slice carefully through the block at an angle (slant). You may need to draw or demonstrate an angle. If the students cut the block straight down instead of at an angle, have them press the two pieces firmly back together and recut the block.
27. Then tell the students to place the two blocks formed by the slice together, but don't let them stick together.
28. Review the descriptions of each type of fault. (Strike-slip fault; the rocks on either side of the fault slip sideways past each other with little up or down motion, Normal fault; the hanging wall (the block of rock that forms the upper half of a fault) slips downward past the footwall, (the block of rock that forms the lower half of a fault) Reverse fault; the hanging wall slides up and over the footwall.)
29. Decide which piece of your block is the hanging wall and which is the footwall. The hanging wall is the block with the larger surface area on top and the footwall is the lower block. Using the marking pen, label the side of each block. Ask: What part of your model stands for the fault itself? "The fault is the cut between the two blocks."
30. Ask: "What part of the model stands for the land surface?" (The land surface is the top surface.) Along the top surface of the two blocks, draw a river flowing across the fault. Also draw an arrow on each block to show the direction of the river's flow. The arrow should point from the footwall toward the hanging wall. Make sure students draw the arrows to show the river flowing toward the fault on the surface of the footwall and away from the fault on the surface of the hanging wall.
31. Using Fault Data Table (Appendix E), and your blocks, model the movement along a strike-slip fault. Record your motion and the results on the data table. (e.g., Under Type of Fault they would put Strike-slip fault. Under How Hanging Wall Moves they might put sideways. Under Changes in the Land Surface they might put that the riverbed is broken and moved sideways.) Have them repeat this step for a normal fault and a reverse fault.
32. Remember that for a strike-slip fault, the blocks should be moved sideways, with no up or down movement. For a normal fault the upper block should be moved down. For a reverse fault, the upper block should be moved up.
33. Have the students refer to their data table (Appendix E) to draw a chart that will help them answer questions 1 through 4 on the data table. Pass out a blank piece of paper for each student to draw their chart on. Have the student complete their data table and chart and turn them in.
34. Clean up and collect clay.

35. **Extension:** The San Andreas fault is particularly interesting because the deformation it produces in surface features are so clearly visible. Encourage students who need additional challenges to look through books and magazines to find photographs of such deformations and make multiple photocopies for the class to examine. Using evidence in the photographs, students could locate and mark the fault line in each photograph and draw arrows to indicate the directions in which the two opposing rock slabs moved.

E. *Assessment/Evaluation*
   1. Fault Data Table (Appendix E)

Lesson Five: Volcanoes (approximately 2 days, 45-60 minutes per day)

Daily Objectives

1. Concept Objective(s)
   a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. (*CMCS #4)*
   b. Students understand common properties, forms, and changes in matter and energy. *(CMCS #2)*
2. Lesson Content
   a. The Earth's Layers
      i. Volcanoes
         a.) Magma
         b.) Lava and lava flow
         c.) Active, dormant, or extinct
3. Skill Objective(s)
   a. Students will be able to build a model of a volcano and simulate a volcanic eruption using that model.
   b. Students will be able to identify the structure of a volcano.

B. *Materials*
   1. One tube of toothpaste about half full with a lid
   2. One pin
   3. Inside a Volcano (for transparency) (Appendix F)
   4. Any available pictures of volcanic eruptions
   5. Volcano Exploding Checklist (Appendix G)

   For groups of four to five students

   6. Small plastic water bottle with a narrow neck
   7. Small cardboard box
   8. Modeling clay (if modeling clay is not available make clay out of flour, salt, and water)
   9. Funnel or piece of heavy paper to roll into a funnel
   10. Measuring cup
   11. One pound baking soda
   12. Red food coloring
   13. One quart bottle of vinegar (any kind will do)
   14. Spoon

C. *Key Vocabulary*
   1. Magma: a mixture of gases and hot molten rock
   2. Lava: liquid magma that reaches the surface; also the rock formed when liquid lava hardens
   3. Geologist: a scientist who studies the forces that make and shape the planet Earth

4. Active volcano: said of a volcano that is erupting or has shown signs of erupting in the near future
5. Dormant volcano: said of a volcano that does not show signs of eruption in the near future
6. Extinct volcano: said of a volcano that is unlikely to erupt again

D. *Procedures/Activities*

Day One

1. **Including all students:** For those students whose primary language is not English, suggest that they start a personal glossary of vocabulary terms, with each term and its definition in English of one side and in the student's primary language on the other side. Encourage students to add to their glossaries as they study other sections in science.
2. Ask: "Have you ever given a bottle of soda a really hard shake and then popped the cap? What happened? All those bubble of gas in the soda push themselves and most of the liquid right out of the top.
3. Explain to the students that volcanoes are mountains, but they are clearly not the same as other mountains. Volcanoes are formed in a very special way.
4. Show the students your tube of toothpaste. Ask: What happens when you squeeze the bottom of a toothpaste tube? (Toothpaste comes out the opening at the top.) Demonstrate this. Ask: What if you squeeze the tube but did not take off the cap so the toothpaste had nowhere to go? Would pressure build up inside the tube? (yes)
5. Explain to the students that that is how a volcano erupts, too. Magma, (a mixture of gases and hot molten rock) collects in a chamber deep inside the earth. As more and more magma enters the chamber, more and more pressure builds. The magma pushes hard against the surrounding rock, opening up cracks wherever there are weak spots. Eventually one of the cracks opens almost all the way to the surface.
6. Tell the students that volcanoes have been called Earth's safety valves, releasing built up pressure from deep inside the Earth. Volcanoes erupt through weak spots in the Earth's surface, usually at plate boundaries.
7. With your tube of toothpaste (with the cap on) on a desk, ask students to imagine that the tube is the surface of the Earth. The toothpaste inside is hot, melted magma underground.
8. Distribute the toothpaste evenly in the tube. Then use the pin to make a tiny hole near the bottom. Ask students what the hole might represent. (A volcano's opening)
9. Press down on the tube near the cap. Ask students what this action might represent. (magma under pressure) What happens? (The magma oozes out of the volcano.)
10. Explain to the students that as the magma rises through the tube and gets closer to the surface, the gases in the molten rock form bubbles, like the bubbles in a shaken bottle of soda. The bubbles push even harder against the "cap" (the Earth's crust) until –KABOOM!! WHOOSH!! – they blast through, blowing a hole right through the surface. Hot steam, ash, and gases come bursting out, pushing huge chunks of rock and big globs of lava (liquid magma that reaches the surface; also the rock formed when liquid lava hardens) into the air. Then even more lava spills over the top.
11. Show the students the transparency of Inside a Volcano (Appendix F). Point out that the opening where the magma and gases shoot out of the ground in called a vent. Point out the main vent. Show the students that the magma has also

pushed through side vents. Point out the lava that pours or shoots out of the vent, runs down the side, cools, and hardens back into solid rock. Point out the magma that is under pressure underneath the ground.

12. Explain to the students that a volcano can erupt many times over the centuries. After each eruption, the lava and ash around the opening cool and harden. Layer after layer, eruption after eruption, the volcano grows. This how most of the world's tall, cone shaped volcanoes, such as Mount Vesuvius in Italy and Mount Fuju in Japan, came to be.
13. Explain that some volcanoes don't erupt with a huge explosion of dust and gas. Instead, the lava bubbles and boils and spurts to the surface and then flows down the sides, like a huge pot of thick soup that's been left on the stove too long. These are known as "quiet" volcanoes (even though their eruptions can be anything but.) Their lava flows build gently sloping, dome-shaped mounds. Most of Hawaii's great volcanoes, such as Mauna Loa and Kilauea, are dome-shaped volcanoes.
14. Explain to the students that the activity of a volcano may last from less than a decade to more than 10 million years. Most long-lived volcanoes, however, do not erupt continuously. Geologists (a scientist who studies the forces that make and shape the planet Earth) often describe volcanoes with terms usually reserved for living things, such as sleeping, awakening, alive, and dead. An active, or live, volcano is one that is erupting or has shown signs that it may erupt in the near future. A dormant, or sleeping, volcano is like a sleeping bear. Scientists expect a dormant volcano to awaken in the future and become active. However, there may be thousands of years between eruptions. An extinct, or dead, volcano is unlikely to erupt again.
15. Tell the students that there are nearly 850 active volcanoes in the world. At least 80 are beneath the oceans. When the edge of one ocean plate is pushed beneath another, the rock that has sunk into the mantle melts and rises, bubbling upward into the sea through weak spots in the other plate. When the lava touches water it cools and hardens. In some places so much lava has built up that it sticks far above the water. That's how volcanic islands in the Pacific Ocean, such as the islands of Japan, were formed.
16. Explain to the students that if you were to mark all the volcanoes in the world on a map and draw lines between them like a connect-the-dots puzzle, you'll have a pretty good sketch of Earth's pushiest plates. There are so many active volcanoes around the edge of the five big plates in the Pacific, that geologists call the area "The Ring of Fire!"
17. Divide the class into groups of five and distribute an empty plastic water bottle, small cardboard box, and modeling clay to each group.
18. Remove the lid from the bottle if it has one and stand the bottle in the middle of the cardboard box.
19. Use flat slabs of clay to model a volcano around the bottle. Leave the mouth of the bottle open.
20. Let your model sit until the next day to dry.

Day two

21. The students' volcanoes should have hardened over night. Pass out the funnel or piece of heavy paper to roll into a funnel, measuring cup, one pound of baking soda, red food coloring, one quart bottle of vinegar, and spoon to each group of five students.

22. Use the funnel (or piece of paper rolled into a cone) to pour about ¼ cup of baking soda into the mouth of the bottle. The amount you pour in will depend on how big the bottle is. You want to fill the bottle about halfway.
23. Pour a few drops of red food coloring into ½ cup of vinegar and stir or swirl it to mix it.
24. Now the excitement begins! Place the volcano on a countertop or table that is okay to get wet or is easy to clean up. Carefully pour some vinegar into the mouth of the volcano-and stand back!
25. The students can create several explosions without adding more soda simply by pouring in more vinegar each time the lava stops flowing. Have them notice where the lava flows. Does it flow in the same place each time? Does it flow in different places? Why might that be? What effect would this volcano have on the land, plants, buildings, and people nearby? In which ways is this model like a real volcano? In which ways is it different?
26. Walk around the class with the Volcano Exploding Checklist (Appendix G) to make sure each student is participating.
27. When students have finished using the model, lift the clay from the cardboard box, and gently pull on the bottle until it comes out. Then rinse out the bottle and dry them. They may be used again for future models. Pat the clay mountain shape dry. Clay may be used again as well. If you have made clay from flour, salt, and water just throw the clay away. It will not last another time.
28. Make sure students have cleaned up. Then have them return to their own seats.
29. Show the students any available pictures of volcanic eruptions. Then show the video "Volcanoes". Tell the students that they are required to find at least 10 facts or interesting details in the movie and take notes. Their notes will be turned in after the movie.

E. *Assessment/Evaluation*
   1. Volcanoes Exploding Checklist (Appendix G)
   2. Satisfactory notes from the movie

Lesson Six: Famous Volcanoes (approximately 45-60 minutes)

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(CMCS #4)*
      b. Students understand common properties, forms, and changes in matter and energy. *(CMCS #2)*
   2. Lesson Content
      a. The Earth's Layers
         i. Volcanoes
            a.) Famous volcanoes: Vesuvius, Krakatoa, Mount St. Helens
   3. Skill Objective(s)
      a. Students will be able to identify Earth's famous volcanoes.
      b. Students will be able to locate Earth's famous volcanoes.
      c. Students will be able to identify types of volcanoes as shield, cinder cone, or composite volcanoes.

B. *Materials*
   1. Volcano Paragraph Rubric (Appendix H)
   2. Informational texts on volcanic eruptions

C. *Key Vocabulary*

1. Shield volcano: a wide, gently sloping mountain made of layers of lava and formed by quiet eruptions
2. Cinder cone: a steep, cone-shaped hill or mountain made of volcanic ash, cinders, and bombs piled up around a volcano's opening
3. Composite volcano: a tall, cone-shaped mountain in which layers of lava alternate with layers of ash and other volcanic materials
4. Tsunami: a large wave produced by an earthquake on the ocean floor
5.

D. *Procedures/Activities*

1. Remind them that yesterday they exploded a volcano, but did they know that they made a specific type of volcano.
2. Explain to the students that rock and other materials formed from lava create a variety of landforms including shield volcanoes, composite volcanoes, cinder cone volcanoes, and lava plateaus. Tell the students that we are going to be discussing each type in today's lesson.
3. Tell the students that at some places of Earth's surface, thin layers of lava pour out of a vent and harden at the top of previous layers. Such lava flows gradually build a wide, gently sloping mountain called a shield volcano. Shield volcanoes rising from a hot spot on the ocean floor created the Hawaiian Islands.
4. Tell the students that a volcano can also be a cinder cone, a steep, cone-shaped hill or mountain. If a volcano's lava is thick and stiff, it may produce ash, cinders, and bombs. These materials pile up around the vent in a steep cone-shaped pile. For example, Paricutin in Mexico erupted in 1943 in a farmer's corn field. The volcano built up a cinder cone about 400 meters high.
5. Tell the students that sometimes, lava flows alternate with explosive eruptions of ash, cinder, and bombs. The result is a composite volcano. Composite volcanoes are tall, cone-shaped mountains in which layers of lava alternate with layers of ash. Examples of composite volcanoes include Mount Fuji in Japan and Mount St. Helens in Washington state.
6. Tell the students that instead of forming mountains, some eruptions of lava form high, level areas called lava plateaus. First, lava flows out of several long cracks in an area. The thin, runny lava travels far before cooling and solidifying. Again and again, floods of lava flow on top of earlier floods. After millions of years, these layers of lava can form high plateaus. One example is the Columbia Plateau, which covers parts of Washington, Oregon, and Idaho.
7. Tell the students that we are going to talk about three very famous volcanoes and then they will be able to research another. The three that we will discuss in class are Vesuvius, Mount St. Helens, and Krakatoa.
8. Vesuvius: Explain to the students that every year at least 60 volcanoes erupt somewhere in the world. Many eruptions are small, but some are huge and cause great damage. The eruption of Vesuvius, in Italy, in A.D. 79 buried the town of Pompeii in hot ash and cinders. The eruption of Vesuvius is probably the most famous volcanic explosion ever. The remains of the people killed in the huge blast lay undiscovered for 1,700 years. Survivors tied pillows to their heads as they fled the falling rocks and ash. But at Pompeii over 2,000 victims were suffocated by hot gas and entombed in hardened ash until the excavation of the towns, which began in 1709. Mount Vesuvius last erupted in 1944.
9. Mount St. Helens: Before the eruption Mount St. Helens, in Washington, was a peaceful, snow-topped mountain for 123 years before it erupted in May 1980. For two months, the north side of Mount St. Helens in Washington swelled up as if some life force was trying to escape. Then, on May 18, 1980, the mountain

burst open with a resounding bang. The explosion triggered a landslide of rocks and ice, which hurtled down the mountainside at speeds of up to 180 mph. Ash was rocketed into the atmosphere and scattered across northwestern America. The damage spread as rivers flooded and mudflows were set in motion. The force of the blast was felt 100 miles away. 57 people were killed. The explosion leveled everything in its path for up to 8 miles.

10. Krakatoa: Before August 1883, the tiny uninhabited island of Krakatoa in Indonesia was characterized by three volcanic cones that had been inactive since 1680. But in May 1883, one of the cones began to stir. Inhabitants of nearby islands were not worried by the eruptions until August 26, when their homes began to shudder. The next morning, five earth-shattering explosions hit Krakatoa, the force of which wiped out two-thirds of the island. The violent eruptions gave rise to gigantic tsunamis (a large wave produced by an earthquake on the ocean floor) that swept the shores of Java and Sumatra, swallowing up 165 villages. The blast left a 960-ft deep crater. 100 ft high tsunamis caused 3,600 deaths. A new volcano, Anak Krakatau, has grown from frequent eruptions since 1927.
11. Pass out the Volcano Paragraph Rubric (Appendix H) and explain to the students that they have just heard three paragraphs depicting volcanic explosions. Tell them that for the remainder of the class their assignment is to gather information on another volcanic explosion.
12. Explain to them that they are free to use the computer lab or informational text in the classroom.
13. They are then to write a paragraph explaining the eruption and turn it in.
14. If they don't finish their paragraph in the time allotted in class they will need to finish the assignment for homework and bring it in tomorrow.

E. *Assessment/Evaluation*
   1. Volcano Paragraph and Rubric (Appendix H)

Lesson Seven: Hot Springs and Geysers (approximately 45 minutes)

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students understand the processes and interactions of Earth's systems and the structure and dynamics of Earth and other objects in space. *(CMCS #4)*
      b. Students understand common properties, forms, and changes in matter and energy. *(CMCS #2)*
   2. Lesson Content
      a. The Earth's Layers
         i. Hot springs and geysers: Old Faithful (in Yellowstone Park)
   3. Skill Objective(s)
      a. Students will be able to list the similarities and the differences between a volcano and a geyser.

B. *Materials*
   1. Paper and pencil for each student
   2. Compare and Contrast Rubric (Appendix I)

C. *Key Vocabulary*
   1. Geyser: a fountain of water and steam that builds up pressure underground and erupts at regular intervals
   2. Hot Springs: a pool formed by groundwater that has risen to the surface after being heated by a nearby body of magma

3. Igneous rock: a type of rock that forms from the cooling of molten rock at or below the surface

D. *Procedures/Activities*

1. Ask the students if any of them have ever sat in a hot tub. What heats the water?
2. Explain to the students that our planet's insides are so fiery that in some place the heat just naturally boils out. Water from rain or underground streams flow through a spot where Earth's mantle is especially close to the surface. The rocks there are hot enough to make the water hot, too. These places are called hot springs (a pool formed by groundwater that has risen to the surface after being heated by a nearby body of magma). The steaming water that bubbles to the surface is great for bathing. People come from all over the world to special resorts, such as the one in Hot Springs, Arkansas. Water from hot springs may contain dissolved gases and other substances from deep within Earth.
3. Ask students if anyone knows what a geyser is. (a fountain of water and steam that builds up pressure underground and erupts at regular intervals) Tell the students that geysers are caused by volcano power, too.
4. Explain to the students that a geyser is a different sort of hot spring. You wouldn't want to take a bath in one! Instead of bubbling to the surface, the water in a geyser comes out in a rush of scalding steam. A geyser is an eruption of a column of steam and very hot water out of the ground. The eruption can last from seconds to an hour and happen every few minutes to every several years. Old Faithful, the famous geyser in Yellowstone National Park, erupts about every 70 minutes and shoots steam and hot water 12 stories into the air.
5. Show pictures of Old Faithful in Yellowstone National Park if available.
6. Tell the students that most geysers, though, aren't as predictable. Some take days, weeks, or even years to erupt again.
7. Explain to students that the eruption is caused by chambers of superheated water underground. When the water boils and enough pressure builds up, water and steam are forced up and go shooting into the air above ground.
8. Explain that the water that shoots out of a geyser is groundwater. It fills hollow underground chambers and is superheated by hot igneous rocks (a type of rock that forms from the cooling of molten rock at or below the surface). Nearly all groundwater comes from rain and melted snow that seep into soil and move down to fill the cracks and spaces in and between rocks.
9. Explain to the students that most of the world's hot springs and geysers are in only three countries: New Zealand, Iceland, and the United States. People in Iceland are especially good at using the naturally hot water to make their lives easier. Water heated by the Earth is piped directly to radiators and hot water tanks in homes and office buildings. Almost 100 percent of the city of Reykjavik, the capital of Iceland, is heated with hot springs.
10. Explain to the students that we have discussed the properties of a geyser, how they work, and how they are formed. Now tell them to think about how this is similar and different to the way a volcano works and is formed.
11. Tell the students to get out a piece of paper and a pencil.
12. Allow the students three to five minutes to list all the ways that volcanoes and geysers are similar.
13. Then allow the students three to five minutes to list all the ways that volcanoes and geysers are different.
14. Pass out the Compare and Contrast Rubric (Appendix H). Have the students write a compare and contrast paper on the similarities and differences between a

geyser and a volcano. (Students may want to write one paragraph showing similarities and one paragraph showing differences.)

15. Have students turn in their assignment when they have finished.
16. **Extension:** Geysers are just one product of superheated groundwater. Challenge students to find out about others, including sulfur-mud pools (also called mud pots or paint pots) and fumaroles. Students can make diagrams of how each works.

E. *Assessment/Evaluation*
   1. Compare and Contrast Rubric (Appendix I)

VI. CULMINATING ACTIVITY

A. The Structure of the Earth Summaritive Evaluation (Appendix J)

VII. HANDOUTS/WORKSHEETS

A. Appendix A: Layers of the Earth
B. Appendix B: Plate Tectonics worksheet and answer sheet (four pages)
C. Appendix C: How Are Earth's Continents Linked Together w/s and a/s (two pages)
D. Appendix D: Research Report: Pangea Rubric
E. Appendix E: Fault Data Table w/s and a/s (six pages)
F. Appendix F: Inside a Volcano Model
G. Appendix G: Volcano Eruption Checklist
H. Appendix H: Volcano Paragraph Rubric
I. Appendix I: Compare and Contrast Rubric
J. Appendix J: The Structure of the Earth Summaritive Evaluation (three pages)
K. Appendix K: The Structure of the Earth Summaritive Evaluation Answer Key (three pages)

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Appendix A

Earth's Layers

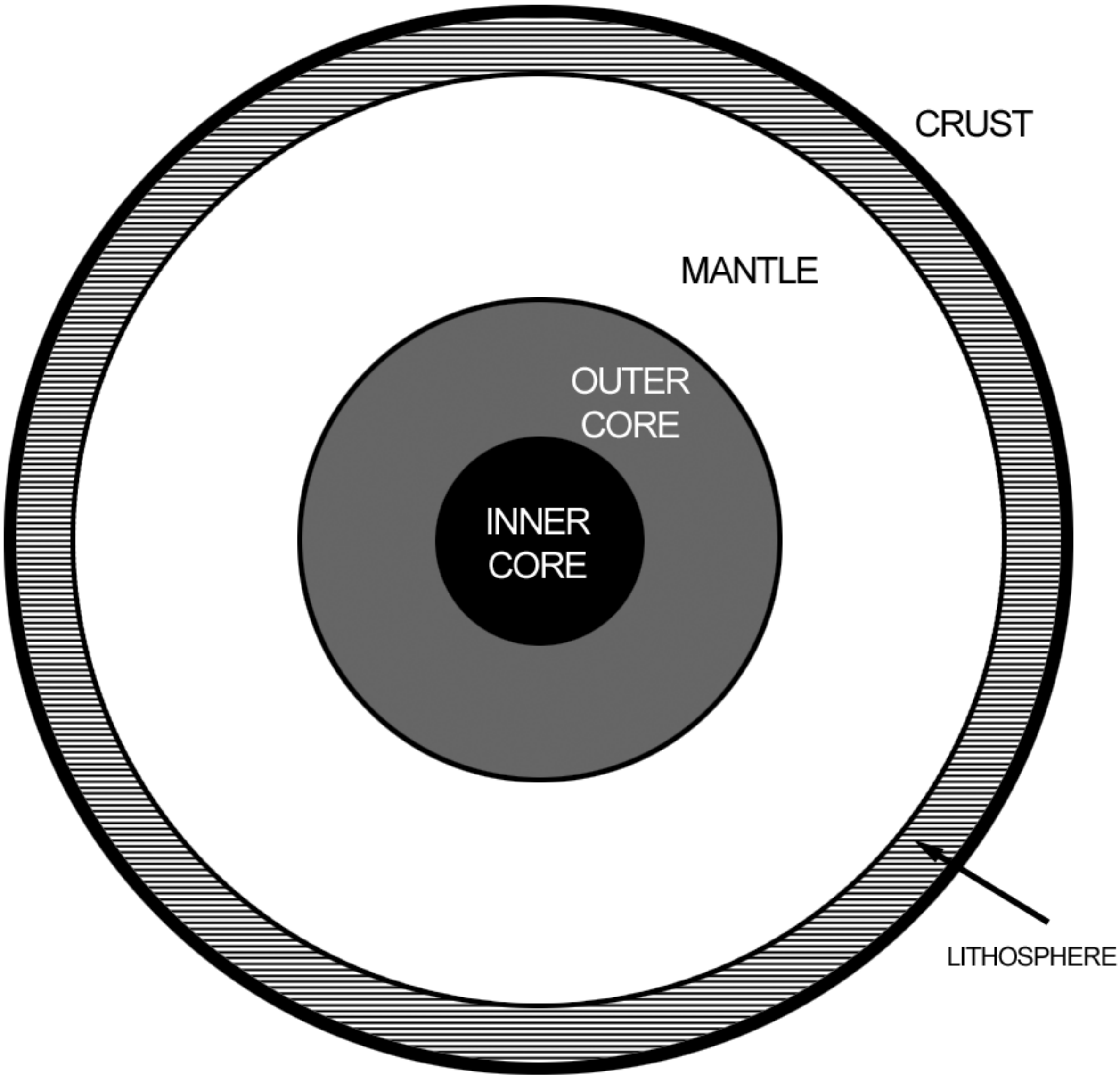


Plate Tectonics

Name__________ Date__________

1. What is a plate?

2. What is the theory of plate tectonics?

3. Name and describe the three different types of boundaries found along the edges of the Earth's plates?

4. Using the demonstration with the wooden blocks as a reference, make a drawing of each type of boundary with arrows showing the direction of each blocks movement.

Appendix B, page 3

Plate Tectonics Answer Key

Name___________ Date___________

1. What is a plate?

A section of lithosphere that slowly moves carrying pieces of continental and oceanic crust.

2. What is the theory of plate tectonics?

The theory that pieces of Earth's lithosphere are in constant motion, driven by currents in the mantle.

3. Name the three different types of boundaries found along the edges of the Earth's plates?

Transform boundaries, divergent boundaries, and convergent boundaries.

4. Using the demonstration with the wooden blocks as a reference, make a drawing of each type of boundary with arrows showing the direction of each blocks movement.

(Drawings may differ. However, transform boundaries arrows must be slipping past each other, divergent boundaries arrows must be moving apart and convergent boundaries arrows must be pointing together.)

Appendix C

How Are Earth's Continents Linked Together?

Answer the following questions as you go through the activity with your teacher.

1. **What are the oceans on the globe? What are the seven continents on the globe?**

2. **How much of the globe is occupied by the Pacific Ocean? Does most of the Earth's "dry" land lie in the Northern or Southern Hemisphere?**

3. **Find the points or areas where most of the continents are connected. Find the points at which several of the continents touch, but are not connected.**

4. **Examine the globe more closely. Find the great belt of mountains running from north to south along the western side of North and South America. Can you find another great belt of mountains on the globe?**

Appendix C, page 2

How Are Earth's Continents Linked Together?

Answer sheet

Answer the following questions as you go through the activity with your teacher.

1. **What are the oceans on the globe? What are the seven continents on the globe?**

Oceans: Pacific, Atlantic, Indian, and Artic
Continents: North America, South America, Africa, Europe, Asia, Australia, and Antarctica

2. **How much of the globe is occupied by the Pacific Ocean? Does most of the Earth's "dry" land lie in the Northern or Southern Hemisphere?**

More than one third

3. **Find the points or areas where most of the continents are connected. Find the points at which several of the continents touch, but are not connected.**

At the North Pole; at the South Pole

4. **Examine the globe more closely. Find the great belt of mountains running from north to south along the western side of North and South America. Can you find another great belt of mountains on the globe?**

Through Europe and Asia

Appendix D

Research Report : Pangea

Teacher Name:

Student Name: ________________________________

CATEGORY	4	3	2	1
Quality of Information	Information clearly relates to the main topic. It includes several supporting details and/or examples.	Information clearly relates to the main topic. It provides 1-2 supporting details and/or examples.	Information clearly relates to the main topic. No details and/or examples are given.	Information has little or nothing to do with the main topic.
Organization	Information is very organized with well-constructed paragraphs and subheadings.	Information is organized with well-constructed paragraphs.	Information is organized, but paragraphs are not well-constructed.	The information appears to be disorganized. 8)
Mechanics	No grammatical, spelling or punctuation errors.	Almost no grammatical, spelling or punctuation errors	A few grammatical, spelling, or punctuation errors.	Many grammatical, spelling, or punctuation errors.
Amount of Information	All topics are addressed and all questions answered with at least 2 sentences about each.	All topics are addressed and most questions answered with at least 2 sentences about each.	All topics are addressed, and most questions answered with 1 sentence about each.	One or more topics were not addressed.

Total Points______/16

Fault Data Table

Type of Fault	How Hanging Wall Moves	Changes in the Land Surface

Refer to your data table to draw a chart, on a blank sheet of paper that will help you answer questions 1 through 4.

1. **On your chart, show the direction in which the sides of the fault move for each type of fault.**

2. **On your chart, show how movement along a strike-slip fault is different from movement along the other two types of fault.**

3. **Add to your chart a column that shows how the river on the surface might change for each type of fault.**

4. **Assuming that the river is flowing from the footwall toward the hanging wall, which type of fault could produce small waterfalls in the surface river? (*Hint*: Recall how you tell which block is the hanging wall and which block is the footwall.)**

5. **If you could observe only the land surface around a fault, how could you tell if the fault is a strike-slip? A normal fault?**

6. **If you slide the hanging wall of your fault model upward in relation to the footwall, what type of fault forms? If this movement continues, where will the slab of rock with the hanging wall end up?**

7. **From an airplane, you see a chain of several long, narrow lakes along a fault. What type of fault would cause these lakes to form?**

8. **Extra Credit**

Remember; on Earth's surface, individual fault do not exist all by themselves. With one or more of your classmates, combine your models to show how a fault-block mountain range or a rift valley could form. (*Hint*: Both involve normal faults.) How could you combine your models to show how reverse faults produce a mountain range.

Fault Data Table

Answer Key

Type of Fault	How Hanging Wall Moves	Changes in the Land Surface
Strike-slip fault	Sideways	Riverbed is broken and moved sideways.
Normal fault	Down	Downstream part of river drops below upstream part.
Reverse fault	Up	Downstream part of river may form a lake where it meets hanging wall.

Refer to your data table to draw a chart, on a blank sheet of paper that will help you answer questions 1 through 4.

1. **On your chart, show the direction in which the sides of the fault move for each type of fault.**

Strike-slip fault: the hanging wall moves sideways
Normal fault: the hanging wall moves downward
Reverse fault: the hanging wall moves upward

2. **On your chart, show how movement along a strike-slip fault is different from movement along the other two types of fault.**

Students' charts should indicate that there is no upward or downward movement along a strike-slip fault.

3. **Add to your chart a column that shows how the river on the surface might change for each type of fault.**

Strike-slip fault: The continuous line of the riverbed would be broken and displaced horizontally.
Normal fault: The downstream part of the river would drop below the upstream part of the river part, creating a waterfall at the fault.
Reverse fault: The downstream part of the river would be thrust above the upstream part; water would collect at the fault to form a lake.

4. **Assuming that the river is flowing from the footwall toward the hanging wall, which type of fault could produce small waterfalls in the surface river? (*Hint*: Recall how you tell which block is the hanging wall and which block is the footwall.)**

A normal fault

5. **If you could observe only the land surface around a fault, how could you tell if the fault is a strike-slip? A normal fault?**

A strike-slip fault would be indicated by sideways displacement of a feature where it crossed the fault. A normal fault would be indicated by a break in the feature where the two blocks slipped past each other at the faults; the part of the feature on the surface of the hanging wall would be lower than the part on the surface of the footwall.

6. **If you slide the hanging wall of your fault model upward in relation to the footwall, what type of fault forms? If this movement continues, where will the slab of rock with the hanging wall end up?**

A reverse fault; above the footwall

7. **From an airplane, you see a chain of several long, narrow lakes along a fault. What type of fault would cause these lakes to form?**

A reverse fault or strike-slip fault

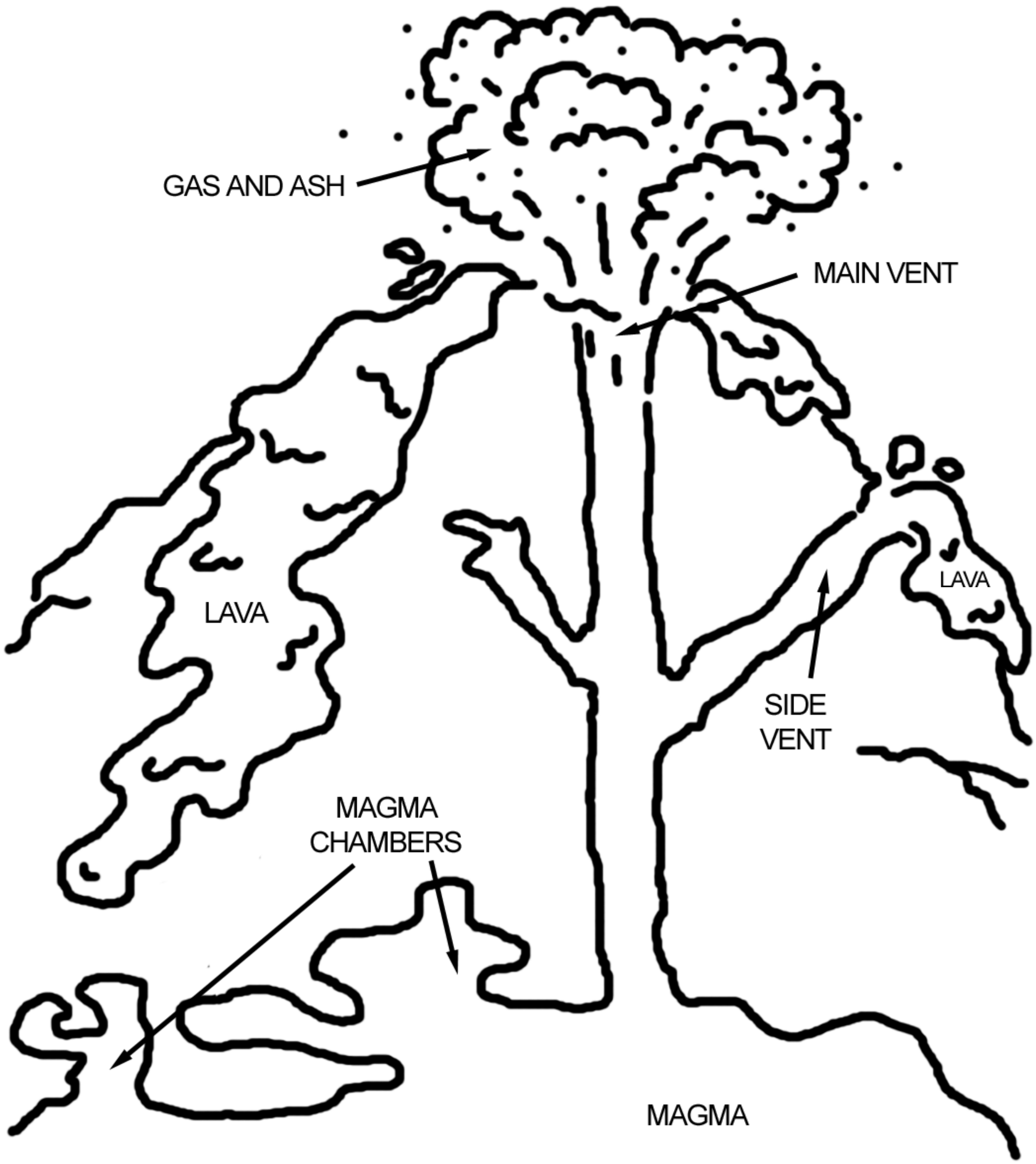
8. **Extra Credit**

Remember; on Earth's surface, individual fault do not exist all by themselves. With one or more of your classmates, combine your models to show how a fault-block mountain range or a rift valley could form. (*Hint*: Both involve normal faults.) How could you combine your models to show how reverse fault produce a mountain range.

The model demonstrates actual rock movement. The model's fault is much more regular and smoother than real fault between rock surfaces, so the model's movements involve far less friction and less abrupt and "jerky." The model enables you to see block movements that are hidden underground in real faulting.

Appendix F

Inside a Volcano Model



Appendix G

Volcano Eruption Checklist

Student	Contributes to group	Focuses on task at hand	Works well with others

Appendix H

Volcano Paragraph Rubric

Teacher Name:

Student Name: ____

CATEGORY	4	3	2	1
Grammar & Spelling	Writer makes no errors in grammar or spelling that distracts the reader from the content.	Writer makes 1-2 errors in grammar or spelling that distract the reader from the content.	Writer makes 3-4 errors in grammar or spelling that distract the reader from the content.	Writer makes more than 4 errors in grammar or spelling that distracts the reader from the content.
Sentence Structure	All sentences are well-constructed with varied structure.	Most sentences are well-constructed with varied structure.	Most sentences are well-constructed but have a similar structure.	Sentences lack structure and appear incomplete or rambling.
Focus on Topic	There is one clear, well-focused topic. Main idea stands out and is supported by detailed information.	Main idea is clear but the supporting information is general.	Main idea is somewhat clear but there is a need for more supporting information.	The main idea is not clear. There is a seemingly random collection of information.
Recognition of Reader	The reader's questions are anticipated and answered thoroughly and completely.	The reader's questions are anticipated and answered to some extent.	The reader is left with one or two questions. More information is needed to "fill in the blanks".	The reader is left with several questions.
Sequencing	Details are placed in a logical order and the way they are presented effectively keeps the interest of the reader.	Details are placed in a logical order, but the way in which they are presented/introduced sometimes makes the writing less interesting.	Some details are not in a logical or expected order, and this distracts the reader.	Many details are not in a logical or expected order. There is little sense that the writing is organized.

Teacher Comments: Total ______/20

Appendix I

Compare and Contrast

Teacher Name:

Student Name: ____

CATEGORY	4	3	2	1
Support for Topic	Relevant, telling, quality details give the reader important information that goes beyond the obvious or predictable.	Supporting details and information are relevant, but one key issue or portion of the storyline is unsupported.	Supporting details and information are relevant, but several key issues or portions of the storyline are unsupported.	Supporting details and information are typically unclear or not related to the topic.
Flow & Rhythm	All sentences sound natural and are easy-on-the-ear when read aloud. Each sentence is clear and has an obvious emphasis.	Almost all sentences sound natural and are easy-on-the-ear when read aloud, but 1 or 2 are stiff and awkward or difficult to understand.	Most sentences sound natural and are easy-on-the-ear when read aloud, but several are stiff and awkward or are difficult to understand.	The sentences are difficult to read aloud because they sound awkward, are distractingly repetitive, or difficult to understand.
Sequencing	Details are placed in a logical order and the way they are presented effectively keeps the interest of the reader.	Details are placed in a logical order, but the way in which they are presented/introduced sometimes makes the writing less interesting.	Some details are not in a logical or expected order, and this distracts the reader.	Many details are not in a logical or expected order. There is little sense that the writing is organized.
Introduction	The introduction is inviting, states the main topic and previews the structure of the paper.	The introduction clearly states the main topic and previews the structure of the paper, but is not particularly inviting to the reader.	The introduction states the main topic, but does not adequately preview the structure of the paper nor is it particularly inviting to the reader.	There is no clear introduction of the main topic or structure of the paper.
Conclusion	The conclusion is strong and leaves the reader with a feeling that they understand what the writer is "getting at."	The conclusion is recognizable and ties up almost all the loose ends.	The conclusion is recognizable, but does not tie up several loose ends.	There is no clear conclusion, the paper just ends.

Teacher comments: Total______/20

The Structure of the Earth
Summaritive Evaluation

Name_______________ Date____________________

Section I. (each question worth one point, with a total of 10 points) Match the word in the first column with its definition in the second column.

1. _______ fossil	**a. a mixture of gases and hot molten rock**
2. _______ plate tectonics	**b. liquid magma that reaches the surface**
3. _______ fault	**c. a break in Earth's crust where slabs of rock slip past each other**
4. _______ core	**d. a devise that records ground movements caused by seismic waves as they move through Earth**
5. _______lava	**e. the name of the single landmass that broke apart 200 million years ago and gave rise to today's continents**
6. _______ lithosphere	**f. a trace of an ancient organism that has been preserved in rock**
7. _______ geology	**g. the Earth's solid outer shell**
8. _______ magma	**h. the geological theory that states that pieces of the Earth's lithosphere are in constant, slow motion, driven by currents in the mantle.**
9. _______ Pangea	**i. Earth's super-hot center**
10. ______ seismograph	**j. the study of the Earth's origin, history, and structure**

Section II: (each question worth 4 points, with a total of 8 points)
Directions: Draw and label the diagrams

11. Draw and label a diagram of the inside of a volcano.

12. Draw and label a diagram showing the four layers of the Earth.

Section III: (each question worth two points, with a total of eight points)
Directions: Write short answers to the following questions…

13. What is the theory of plate tectonics?

14. What was Wegener's theory of continental drift?

15. What are the three main types of faults?

16. Compare and contrast a geyser and a volcano

Section IV: (worth 10 points)

Imagine that Alfred Wegener is alive today to defend his theory of continental drift. Write a short interview that Wegener might have on a daytime talk show. You may use humor. You may write on the back of this paper.

The Structure of the Earth
Summaritive Evaluation
Answer Key

Name_______________ Date____________________

Section I. (each question worth one point, with a total of 10 points) Match the word in the first column with its definition in the second column.

1. __f____ fossil
2. __h____ plate tectonics
3. __c____ fault
4. __i____ core
5. __b____ lava
6. __g____ lithosphere
7. __j____ geology
8. __a____ magma
9. __e____ Pangea
10. __d____ seismograph

a. a mixture of gases and hot molten rock
b. liquid magma that reaches the surface
c. a break in Earth's crust where slabs of rock slip past each other
d. a devise that records ground movements caused by seismic waves as they move through Earth
e. the name of the single landmass that broke apart 200 million years ago and gave rise to today's continents
f. a trace of an ancient organism that has been preserved in rock
g. the Earth's solid outer shell
h. the geological theory that states that pieces of the Earth's lithosphere are in constant, slow motion, driven by currents in the mantle.
i. Earth's super-hot center
j. the study of the Earth's origin, history, and structure

Section II: (each question worth 4 points, with a total of 8 points)
Directions: Draw and label the diagrams

17. Draw and label a diagram of the inside of a volcano.

Drawings may vary. Just make sure that they have the main vent, lava, magma, and gas and ash labeled correctly. Take off one point for each label that they are missing.

18. Draw and label a diagram showing the four layers of the Earth.

Drawings may vary. Just make sure that the outer label is labeled crust, second layer is the mantle, third layer is the outer core, and the center is the inner core. Take off one point for each labeled incorrectly.

Section III: (each question worth two points, with a total of eight points)
Directions: Write short answers to the following questions…

19. What is the theory of plate tectonics?

The theory of plate tectonics explains the formation, movement, and subduction of Earth's plates.

20. Earthquakes, volcanoes, ocean trenches, and mountains are produced by the movement of what?

Plates along the Earth's mantle

21. What are the three main types of faults?

Strike-slip fault, normal fault, and reverse fault

22. Compare and contrast a geyser and a volcano.

Answers may vary. Similarities might include…they are both caused from the movement of Earth's plates, both can be active, dormant, or extinct, both erupt at weak spots in the Earth, or both are caused by pressure. Differences might include…geysers do not involve the eruption of lava, may not travel as far as a volcano, or are not built from lava.

Section IV: (worth 10 points)

Imagine that Alfred Wegener is alive today to defend his theory of continental drift. Write a short interview that Wegener might have on a daytime talk show. You may use humor. You may use the back of this paper.
Answers may vary. A typical interview should include mention of a variety of evidence that supports Wegener's theory, including evidence from landforms, fossils, and climate. Students should also mention evidence for the more modern theories of sea-floor spreading and plate tectonics.