Item Numbers
Carolina Investigations™ for AP* Environmental Science: Tectonic Plates
Teacher's Manual and Student Guide

Carolina Investigations™ for AP* Environmental Science: Tectonic Plates
Table of Contents
Teacher's Manual

Student Guide*

*Photocopy the Student Guide as needed for use in your classroom.

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Overview
In this kit, students will learn about the earth science concept of plate tectonics. They will study the structure of the earth, plate movement, and the effects of this movement, including the formation of volcanoes and seismic activity. During the first activity, students will create convection cells using warm water and food coloring. In the last activity, students will plot earthquake and volcano activity, along with landform positions on an alternate planet to predict tectonic plate boundaries and relative motion of these plates. The 1-station kit is designed for one group of 4 students. The 8-station kit is designed for a class of 32 students working in eight groups of 4.

Objectives
Students will
- learn about the layers of the earth and how they relate to plate movement.
- study the three types of plate boundaries and their corresponding characteristics.
- create convection cells.
- map longitudinal and latitudinal coordinates of earthquakes, volcanoes, and landforms.
- predict plate location and direction based on the presence of earthquakes, volcanoes, and landforms.

Content Standards
This kit is appropriate for Advanced Placement high school students and addresses the following AP® Environmental Science topics:

I. Earth Systems and Resources
    A. Earth Science Concepts

This kit addresses the following National Science Content Standards:

Grades 9–12

Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Earth and Space Science
- Energy in the Earth System
- The Origin and Evolution of the Earth System

Time Requirements

Preparation	10 minutes
Activity 1	20 minutes
Activity 2	40 minutes

Materials

Included in the kit:	**8-station kit quantity**	**1-station kit quantity**
10 oz cups	32	4
vials	8	1
plastic containers	8	1
pipets	16	2

red food coloring	2	1
blue food coloring	2	1
measuring cups	16	2
Earthquake and Volcano Data Points Sheet, master	1	1
Laminated maps	16	2
Teacher’s Manual and reproducible Student Guide	1	1

Needed, but not supplied:
- glass beaker, 1000 mL
- hot plate
- thermal gloves or hot pad
- water
- dry erase markers

*Included in 8-station refill kit

Safety

Ensure that students understand and adhere to safe laboratory practices when performing any activity in the classroom or lab. Demonstrate the protocol for correctly using the instruments and materials necessary to complete the activities, and emphasize the importance of proper usage. Use personal protective equipment such as safety glasses or goggles, gloves, and aprons when appropriate. Model proper laboratory safety practices for your students and require them to adhere to all laboratory safety rules.

Be vigilant when working with heat sources. Use thermal gloves or a hot pad to handle the beaker of water after heating. When pouring the hot water, wear proper safety equipment to avoid steam burns. Direct students to use thermal gloves or hot pads if they move vials filled with 70-80°C water.

Carolina’s Approach

Carolina Investigations™ for AP Environmental Science are designed to facilitate student understanding of the topics in the College Board’s AP Environmental Science Course Description. The students conduct experiments using appropriate techniques, analyze their data, and evaluate their conclusions, while relating their findings to real-world environmental concepts or problems. Follow-up discussion questions, modeled after the AP exam’s free-response questions, require critical thinking and, often, the application of mathematics.

Background Information

In addition to the background information found in the Student Guide, you also need to be aware of the following information.

The majority of volcanoes and seismic activity on earth are found in the Pacific Ring of Fire. This is an area created by tectonic plate boundaries that arch around the Pacific Ocean. However, volcanoes are not only found at convergent and divergent plate boundaries. Some are found on the interior of tectonic plates. An area where volcanism has occurred for a long time but may or may not be at a plate boundary is called a hot spot. Here, a volcano is formed and as the tectonic plate moves over the hot spot, more volcanoes are born, creating island chains. This is how the Hawaiian island chain formed. There is much debate among scientists as to why these hot spots are formed but some theories include the existence of mantle plumes and/or lithosphere thinning.

Student Prior Knowledge

Before beginning this activity, students should be familiar with

- mapping using longitudinal and latitudinal data.

Preparation

1. Make 16 copies of the Earthquake and Volcano Data Points Sheet.
2. Put 10-15 drops of red food coloring in 8 of the measuring cups.
3. Put 20-25 drops of blue food coloring in 8 of the measuring cups
4. Distribute the needed materials to each lab stations. Each group needs the following:
    - 4 cups, 10 oz
    - 1 vial
    - 1 plastic container
    - 2 pipets
    - 1 measuring cup of red food coloring
    - 1 measuring cup of blue food coloring
    - water
    - dry erase markers
    - 2 Earthquake and Volcano Data Points Sheet
    - 2 laminated maps
5. In a glass beaker, heat 700 milliliters of water to 70-80°C.
6. Photocopy the Student Guide for each student. If paper supplies are limited, a single copy for each group should be sufficient, although students will need to read and review the content cooperatively. You may wish to have students answer the questions cooperatively, or answer them independently in their lab notebooks.

Procedure

1. Divide the class into eight groups. Modify the size of the groups according to your class size.
2. Distribute one Student Guide to each student or group, allowing them to read over the background information and procedure. Allow time to address any questions or concerns with the information or laboratory procedure.
3. Use thermal gloves or a hot pad when filling the vials with the 70-80°C water. You may choose to carry the vials back to the student lab stations or supply students with thermal gloves or hot pads.
4. Ensure that students are releasing the food coloring only on the bottom of the containers, minimizing the amount of food coloring being distributed into the surrounding water.
5. After completing Activity 1, direct students to pour the water and food coloring in the container down the sink and clean up used materials.
6. Indicate longitudinal and latitudinal lines on the laminated map.
7. Direct students to answer all Laboratory Questions.
8. Administer the Discussion Questions to test student understanding of the concepts addressed in the laboratory.

Answers to Questions in the Student Guide
Laboratory Questions
Activity 1: Convection Cells

1. Describe the movement of red and blue food coloring. Explain the process that is causing the food coloring to move.
   The red food coloring in the center divot moved upward and then out. The blue food coloring on the sides of the container moved along the bottom of the container toward the center divot and then it moved up and out like the red. The red food coloring in the water in the center divot became warm from placing the hot water directly below it. Warm water is less dense than cold water so the warm, red water rose. Cool water from the sides of the container, indicated by the blue food coloring, came in to replace the rising warm water. As it was warmed, it rose also. As the warm water that rose, cools again, it sinks on the periphery of the container, creating circular cells of movement over the heat source.

2. Explain how this model relates to the tectonic plate movement on earth.
   The water within the container represents the flowing asthenosphere. Heat from the core, represented by the vial filled with hot water, creates convection cells within the asthenosphere. The movement of these convection cells causes the lithosphere, the layer on top of the asthenosphere that is made up of earth's tectonic plates, to move.

3. What type of plate boundary occurs at the upwelling of a convection cell? Explain the motion of the asthenosphere.
   A divergent boundary would occur between plates. The warmed asthenosphere would move upward until it reached the boundary between itself and the lithosphere. It would then have to move horizontally away from the center of the convection cell, carrying the two plates in opposite directions, creating a divergent boundary.

Activity 2: Plate Boundaries

1. There is a line of seismic and volcanic activity in the northwest quadrant of the planet. What has caused this line of activity? Explain.
   A convergent boundary between oceanic and continental crust is responsible for this line of seismic and volcanic activity. The denser oceanic crust is subducting beneath the less dense continental crust. As the oceanic crust subducts, it melts and becomes part of the mantle. Molten magma then rises to the surface, creating the volcanic mountains we see on the continental crust. Strain on the tectonic plates during subduction also cause earthquakes.

2. What is happening to the horseshoe-shaped island in the northeast quadrant of the planet? Explain. What will occur if the plates continue to move as they are?
   Two tectonic plates are diverging in the middle of the island, creating a rift valley. As this rift valley has widened, seafloor spreading has occurred, creating an ocean basin in the middle of the island. If the plates continue to diverge and the ocean basin grows, the island will eventually be separated into two islands.

3. If there was a convergent boundary dividing a continent, what type of landform would you expect to see at this boundary? Explain. How would this be different if the boundary was dividing the seafloor?

At a convergent boundary between continental crusts, I would expect to see mountains. This is because the two crusts have a similar density, so as they converge, they crumple and uplift creating mountain ranges. Oceanic crusts, however, would not crumple and rise to create mountains. Instead, because of the immense pressure of the ocean, one of the oceanic crusts would subduct beneath the other. Here, I would expect to see a deep ocean trench. The subducting plate would melt and the molten magma would then rise also creating volcanic mountains. If these volcanoes rose above sea level, volcanic islands may also be visible where oceanic crusts converge.

4. Seafloor spreading occurs at divergent boundaries. Does this mean the earth is growing in diameter? Explain.
   No, this does not mean the earth is growing in diameter. It is true that diverging plates cause seafloor spreading and add new materials from the asthenosphere to the two tectonic plates. However, as these two tectonic plates diverge from each other, they are converging or moving past plates on their other sides. Therefore, tectonic plates move in relation to each other on the earth's surface, preserving earth's fixed diameter.

Discussion Questions

1. In the early 1900s, a German scientist named Alfred Wegener theorized that the present-day continents were once connected as a single, large landmass or supercontinent that he called Pangaea. Using paleontological, geologic, and climatic data, he proposed that 200 million years ago Pangaea began to break apart into individual continents that drifted to their current positions. This theory is called Continental Drift. Explain how Continental Drift, or the movement of tectonic plates, has contributed to the evolution of new species.
   As tectonic plates shifted, continents were split apart. Species that were once part of a large population on Pangaea were isolated from each other. As the continents moved to their present day locations, climates of the moving landmasses changed. In order to survive in the shifting climates on the landmasses, species began to adapt. Adaptation to different environments led to the evolution of new species. If species were unable to adapt the new environmental conditions, extinction would occur.

2. Volcanoes and earthquakes are most commonly associated with tectonic plate boundaries. Explain three environmental impacts of volcanoes.
   Answers will vary. Samples answer: Erupting volcanoes deposit lava and rocks that are rich in minerals. After weathering, fertile soil is created for the surrounding environment that is ideal for farming. Volcanoes, however, can also be destructive in that the hot lava flows devastate established habitats and destroy populations in the area. Gases emitted from volcanoes also influence global climate. Carbon dioxide and water vapor emitted during volcanic eruptions contribute to global warming as they are both greenhouse gases. Sulfur dioxide may also be emitted during volcanic eruptions. Sulfur dioxide can lead to acid rain and air pollution downwind from the eruption point. Furthermore, in the stratosphere, sulfur dioxide reacts with water to form sulfuric acid droplets that reflect solar radiation. Layers of sulfuric acid along with volcanic ash reflect solar radiation that cool the earth's atmosphere.

Helpful Hints

- If students are getting too much food coloring into the water column, direct them to gently wipe the outside of the pipets containing the food coloring with a paper towel before submerging them into the cool water. They should not squeeze the bulb of the pipet until the tip of the pipet is touching the bottom of the container.
- Students may have trouble plotting data points because the grid becomes hard to follow. Direct them to use a ruler or index card to follow the longitudinal and latitudinal lines from the outside to the correct position on the map.

Extension Activities

1. Using a world map, have students trace the boundaries of the earth's tectonic plates. Have them label major landforms associated with plate boundaries and explain the type of boundary that exists.
2. Using earthquake data on the U.S. Geological Survey National Earthquake Information Center website (http://neic.usgs.gov/neis/epic/epic_global.html), direct students to plot earthquake activity over the past 5 years. Have them report any trends and postulate tectonic plate boundary types.
3. Have student groups create their own tectonic plates map. Direct them to create longitudinal and latitudinal points for earthquakes, volcanoes, oceanic trenches, ridges, etc. to imply plate boundaries and the direction of movement. Instruct groups to trade data points and construct tectonic plate locations and movements based on another group's data.

Resources

Web Sites

At the time of this printing, the Web sites given below were active. You may wish to perform an independent search for similar sites.

This Dynamic Planet. ©Smithsonian
This interactive map allows students to explore earth's tectonic plates. By adding layers, students can view sites of volcanoes and earthquakes. The plate boundaries along with the type of boundary and its direction of movement can be viewed.
http://mineralsciences.si.edu/tdpmap/

This Dynamic Earth: The Story of Plate Tectonics. ©USGS
This website contains abundant information about earth's plate tectonics. It includes information about the theory of continental drift, the three boundary types, and how tectonic movement affects populations.
http://pubs.usgs.gov/gip/dynamic/dynamic.html

Plate Tectonic Movement Visualizations. ©SERC at Carleton College
This website contains links to an array of visualizations that depict tectonic plate movement. It includes links to visualizations of the boundary types, plate movement through time, data used to determine plate movement, and other supplements that can be used when teaching this concept.
http://serc.carleton.edu/NAGTWorkshops/geophysics/visualizations/PTMovements.html

Related Products

Following is a list of related items available from Carolina Biological Supply Company. For more information, please refer to the most recent *Carolina*™ *Science* catalog, call toll free 800-334-5551, or visit our Web site at **www.carolina.com**.

RN-959115	Carolina™ Modeling Tectonic Plate Boundaries Kit
RN-GEO779	Carolina™ Tectonic Sandbox
RN-GEO457	Pangaea Puzzle Kit

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Earthquake and Volcano Data Points Sheet

Earthquakes	
Latitude	**Longitude**
84.32	-73.47
82.54	-72.65
81.21	-74.14
68.98	-74.14
52.03	-72.39
10.44	-69.04
3.60	-65.65
1.31	-64.24
-5.01	-60.12
-6.78	-68.07
-2.95	-95.31
-1.32	-97.64
-7.74	-107.17
-7.60	-110.67
-7.34	-111.47
-19.14	-144.16
-17.85	-146.79
-13.32	-150.39
-11.01	-154.64
-11.98	-159.98
-10.64	-60.00
-18.97	-58.07
-23.07	-55.65
-22.54	-65.25
-25.47	-74.95
-27.30	-76.47
-27.56	-81.32
-34.64	-102.78
-40.02	-115.07
-41.92	-117.45
-45.01	-131.98
-59.44	-151.54
-63.37	-154.47
-79.79	-171.64
-84.28	-179.54
-39.94	-6.38
-42.65	-3.01
-51.47	22.02
-55.79	23.52
-57.32	25.32
-65.01	32.31
-68.24	37.78
-70.32	43.04
-72.07	47.31
-80.38	87.47
-81.32	87.28
-85.89	97.43
-38.04	23.78
-21.34	37.64
-18.65	41.88
1.07	57.68
16.65	70.01
18.24	74.07
34.01	90.14
42.01	100.22
57.93	112.65
67.47	122.47
71.41	125.54
87.65	137.32

Volcanoes	
Latitude	**Longitude**
75.02	-73.82
73.00	-73.87
70.11	-73.85
7.27	-67.34
-2.55	-62.50
-13.42	-58.72
-27.25	-90.01
-30.27	-94.98
-44.41	-125.01
-5301	-132.82
-48.27	-141.92
-55.92	-146.78
-59.72	-156.16
-65.92	-158.47
-71.02	-161.84
-83.27	-176.42
80.09	132.17
50.01	107.27
48.72	106.19
45.11	105.00
27.34	83.72
25.27	80.04

[<u>Designer:</u> Please insert Earthquake and Volcano Data Points Sheet. Include the 2 tables found in EarthquakesVolcanoes.doc Please make it one page.]

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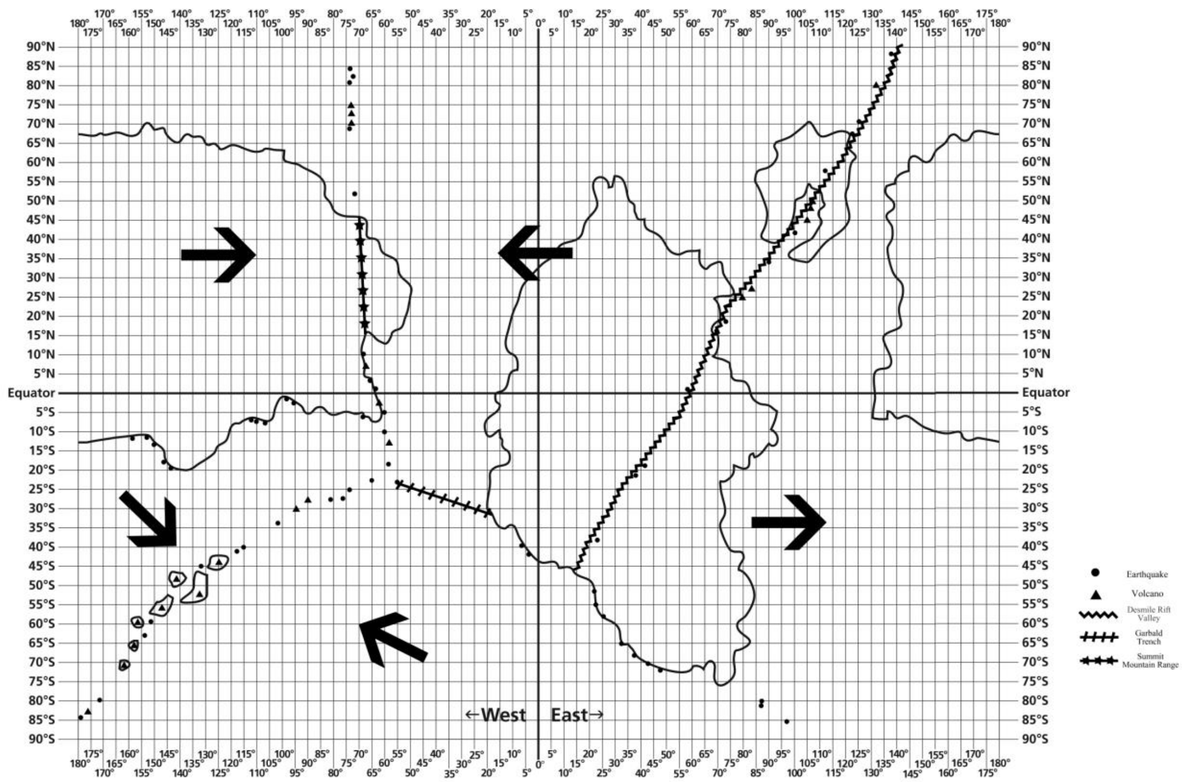
Map Key



[<u>Designer:</u> Please insert map key in the center of the manual if possible. The image is FINAL New World Grid Key.jpg]

Name ______________________ **Student Guide**
Date _______________________

Background

Mountain climbers from all over the world flock to Mount Everest to earn the distinction and ability to say that they have scaled the mountain with the highest elevation in the world (8,850 meters). However, if they do reach Mount Everest's summit, as time progresses, the climbers can no longer claim their fame saying they climbed to the highest elevation in the world. This is because the Himalayan Mountains, where Mount Everest is found, are growing at a rate of more than 1 centimeter per year. So how do mountains continue to grow? The answer is plate tectonics.

Tectonics is the study of the forces that affect, move, and change the surface of the earth. The earth is divided into three distinct layers based on composition−the core, the mantle, and the crust. When examining the earth's physical properties, however, scientists describe the layers of the earth in five layers−the solid inner core, the liquid outer core, the thick mesosphere, the flowing asthenosphere, and the rigid lithosphere.

The lithosphere forms the thin outer shell of the earth and is made up of the crust and the rigid upper mantle. The crust of the lithosphere may be continental or oceanic. Oceanic crust is made of basalt, a very dense, heavy material that has its origin as magma extruded from the mantle. As this magma comes in contact with cold seawater at rift zones, it solidifies as basalt. Continental crust, composed mainly of granitic material, is thicker yet less dense than the oceanic crust. It makes up the landmasses of earth. These two types of crusts are divided into major sections called tectonic plates. A plate may consist of oceanic crust, continental crust, or a combination of the two.

Beneath the lithosphere is the asthenosphere, a soft layer of rock that flows slowly under pressure. Over millions of years, pressure in the asthenosphere has caused the lithosphere to crack and divide into many different plates, like the pieces of a jigsaw puzzle. As heat from the core radiates toward the surface, it deforms and moves the asthenosphere, creating areas of heat circulation known as convection cells. The tops of the convection cells function like conveyor belts under the lithosphere, slowly moving the tectonic plates.

Imagine a pond with a frozen surface. If someone were to take a sledgehammer and break the ice into several large sections, the ice floating on top of the pond would still cover the entire surface, but it would have cracks in it. Each piece might move, but only slightly, until it bumps into the next piece. This is similar to the plates of the earth's crust.

What makes the plates move? If the water at the bottom of the pond with the broken pieces of ice on it were heated, the warmer water would rise because it is less dense than cold water. The upwelling water would push up between the pieces of ice and push them apart. This would cause them to collide with other ice pieces. The pushing and colliding would affect all the pieces of ice, but they would not move in the same direction. Some would move apart from each other, others toward each other, and others would slide alongside each other.

The plates that make up the earth's crust are slowly moving in different directions as well. These movements affect the earth's lithosphere (the earth's crust and the upper mantle) at the zones where the plates meet. These areas are known as tectonic boundaries. Three basic types of boundaries occur based on the interaction between adjacent plates: convergent, divergent, and transform boundaries. More than one type of boundary may be present between adjacent plates. The type of crust present at the plate boundary (oceanic or continental), the shape, and the movement of the plates influence the kind of boundary present.

Convergent Boundary

At a convergent boundary, two plates collide. The plates may buckle and form mountains, or one plate may slide under the other and form a subduction zone. Earthquakes and volcanic activity are common at subduction zones. Pressure and friction as the denser plate subducts beneath the less dense plate causes earthquakes. Volcanoes are formed as the subducting plate melts and the magma then rises to the surface of the plate. There are three types of collisions that may occur at convergent boundaries based on the type of crusts present on adjacent plates:

[Designer: Please insert an illustration of the convergent boundary. It can be found on page S-1 of the Carolina Tectonic Sandbox manual (CB660290709).]

Oceanic crust converging with continental crust

The dense ocean crust is forced, or subsides, under the less dense, or more buoyant, continental crust. The boundary where one plate moves under another is known as a subduction zone and an oceanic trench is formed at the plate boundary. As the oceanic crust is pushed down onto the asthenosphere, it melts and becomes part of the mantle. Some of that molten magma rises to the surface, creating volcanic mountains. The oceanic Nazca plate is subducting under the continental South American plate. This subduction has led to the formation of the volcanic Andes Mountains in South America and associated Peru-Chile Trench in the Pacific Ocean.

Continental crust converging with another continental crust

During this type of collision, neither plate subsides. Both plates are similarly dense and are pushed up at the boundary. As the two plates continue to push against each other, they crumple and rise, creating mountain ranges that parallel the convergent boundary. One example of the mountain-forming type is found at the Indian/Eurasia convergent boundary. India broke free from Africa about 200 million years ago and began drifting toward the Eurasia plate. Where the two plates collided, the land began to lift, creating the Himalayan mountain range. India is still pushing into the Eurasian plate, and the Himalayas continue to grow higher.

Oceanic crust converging with another oceanic crust

Unlike a continental-continental plate collision, an oceanic-oceanic collision results in one plate subsiding under the other. Although both plates are similar in density, even a slight difference results in an unequal effect from the immense pressure of the ocean water. The plate that is slightly denser is pushed under the other, resulting in the formation of a deep ocean trench along the boundary, as seen with the Mariana Trench. As the subducted plate melts, some of the molten rock pushes upward, forcing the crust to bulge, creating volcanoes, which may remain underwater or protrude and form islands, such as the Aleutian Islands of Alaska.

Divergent Boundary

As the earth's core heats the mantle, the less dense molten rock rises to the surface. Under the pressure of the rising magma, the earth's crust cracks and breaks, and the upflow of magma pushes the plates apart. As the magma fills in the gap, or rift valley, that forms between the plates, it cools and becomes part of the crust. This process continues pushing the plates apart and reforming the earth's crust. Earthquakes and submarine volcanic activity are common at these boundary types. Most divergent plate boundaries are formed on the ocean floor. An example of this is the Mid-Atlantic Ridge, formed about 200 million years ago. Divergent boundaries can also occur between two continental crusts, as seen in Africa's Great Rift Valley. These boundaries lead to seafloor spreading and the extension of oceans.

[Designer: Please insert an illustration of the divergent boundary. It can be found on page S-2 of the Carolina Tectonic Sandbox manual (CB660290709).]

Transform Boundary

The third type of boundary occurs where two plates slide along each other in opposite directions. Since the edges of plates are not perfectly smooth or straight, as these plates move they sometimes catch against each other. Pressure then builds up behind each plate until the caught edges break loose. The resulting sudden and dramatic movement of both plates results in an earthquake. This type of boundary is most common on the ocean floor and may be associated with divergent boundaries. This is because diverging plates create a zigzag pattern as the plates separate at their weakest points. As plates diverge, sections of the plates slip past one another because of this zigzag characteristic, forming transform boundaries. Transform boundaries may also occur between continental crusts. The San Andreas Fault that runs through west-central California is an active transform boundary.

[Designer: Please insert an illustration of the transform boundary. It can be found on page S-2 of the Carolina Tectonic Sandbox manual (CB660290709).]

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Activity 1: Convection Cells

Materials

- 4 cups, 10 oz
- 1 vial
- 1 plastic container
- 2 pipets
- 1 measuring cup of red food coloring
- 1 measuring cup of blue food coloring
- water
- hot plate
- thermal gloves or hot pad

Procedure

1. Fill three fourths of the plastic container with cool water.

2. Create a pedestal for the container with the four 10 oz cups. Place them upside down in a square configuration and put the corners of the container of water on the bottoms of the four cups.
3. Have your teacher fill the vial with hot water ½ centimeter below the lip.
4. Using thermal gloves or a hot pad, place the vial beneath the middle of the container, below the small center divot. You may have to lift the side of the container slightly to get the vial directly below the divot.
5. Fill a pipet with blue food coloring to the second ledge before the graduations begin.
6. Submerge the pipet into the water in the center of the far right hand edge of the container.
7. Release the food coloring onto the bottom of the container and remove the pipet. Try not to release the food coloring into the surrounding water.
8. With the same pipet, repeat steps 5-7 in the center of the far left hand edge of the container.
9. Fill a different pipet with red food coloring to the 0.25 mL graduation.
10. Submerge the pipet into the water to the bottom of the center divot.
11. Carefully release the red food coloring into the water in the center divot of the container. Try not to release the food coloring into the surrounding water.
12. Observe for 5 minutes and answer the associated laboratory questions.

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Activity 2: Plate Boundaries

In this activity you will use longitudinal and latitudinal coordinates of earthquakes, volcanoes, and other landforms to predict plate boundaries on a hypothetical planet. This planet is much like earth in that convection cells move the tectonic plates of the lithosphere. For simplicity, imagine that the plates do not wrap around the planet, but instead a distinct line separates them, represented by the outer vertical lines of the map.

Materials

Earthquake and Volcano Data Points Sheet
laminated map
dry erase markers

Procedure

1. Within your group, divide into pairs.
2. Using the longitude and latitude coordinates on the Earthquake and Volcano Data Points Sheet, plot the points where each occur on the laminated map. Use circles to indicate locations of earthquakes and triangles to indicate locations of volcanoes. Use dry erase markers.
   Note: Positive numbers indicate north latitudinal and east longitudinal lines. Negative numbers indicate south latitudinal and west longitudinal lines.
3. Plot the following landforms on your map. Use symbols to represent each landform. Use dry erase markers.
   a. The Desmile Rift Valley runs from -46.02, 14.98 to 90, 140.02.
   b. The Garbald Trench runs from -24.25, -55.87 to -32.45, -17.09.
   c. The Summit Mountain Range run from 45.98, -69.58, to 15.65, -68.92
4. Create a key in the bottom right corner of the map.

5. Using dashed lines, predict the tectonic plate boundaries on the map.
6. Use arrows to indicate the direction of movement of each tectonic plate.
7. Answer all associated laboratory questions.

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Laboratory Questions

Activity 1: Convection Cells

1. Describe the movement of red and blue food coloring. Explain the process that is causing the food coloring to move.

2. Explain how this model relates to the tectonic plate movement on earth.

3. What type of plate boundary occurs at the upwelling of a convection cell? Explain the motion of the asthenosphere.

Activity 2: Plate Boundaries

1. There is a line of seismic and volcanic activity in the northwest quadrant of the planet. What has caused this line of activity? Explain.

2. What is happening to the horseshoe-shaped island in the northeast quadrant of the planet? Explain. What will occur if the plates continue to move as they are?

3. If there was a convergent boundary dividing a continent, what type of landform would you expect to see at this boundary? Explain. How would this be different if the boundary was dividing the seafloor?

4. Seafloor spreading occurs at divergent boundaries. Does this mean the earth is growing in diameter? Explain.

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Discussion Questions

1. In the early 1900s, a German scientist named Alfred Wegener theorized that the present-day continents were once connected as a single, large landmass or supercontinent that he called Pangaea. Using paleontological, geologic, and climatic data, he proposed that 200 million years ago Pangaea began to break apart into individual continents that drifted to their current positions. This theory is called Continental Drift. Explain how Continental Drift, or the movement of tectonic plates, has contributed to the evolution of new species.

2. Volcanoes and earthquakes are most commonly associated with tectonic plate boundaries. Explain three environmental impacts of volcanoes.

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Note to Advisory Panel: The laminated maps will look like the map below except it will be printed on an 11 x 17 piece of paper.