

Activity Overview

Students create a series of maps showing how the positions of the continents have changed over time and also how they may appear 250 million years into the future. Content reading follows the development of the theory of plate tectonic, from early discoveries in the late 1800s to the studies of Alfred Wegener in the early 1900s. Reading reviews the evidence that has been used to support Wegener's theory of continental drift, including the fit of the continents together like a puzzle and the magnetic record of the sea floor.

Preparation and Materials Needed

Each student will need four copies of the continents and three blank sheets of paper as well as a pair of scissors and tape. This activity should be completed by each student. Students can then work in groups and discuss the problem. Remind students that they should rely on their own ideas and that there are only more or less defensible answers, not “right” or “wrong” answers.

Materials

- 4 copies of the continents (**Blackline Master**)
- Scissors
- 3 blank sheets of paper
- Tape

Think about It

Take a sheet of a daily newspaper and tear it into irregular pieces small enough to fit into an envelope without folding. You might consider placing a piece from another paper in with all the matching pieces to get students to think about what to do when evidence “doesn't fit.” Students will readily appreciate that if they can successfully assemble the pieces into an intelligible page, as with a jigsaw puzzle, then the pieces all came from the same page. If some pieces are left over after the page is complete, they must have come from a different page. If the students are not able to assemble the pieces into a page, either the puzzle is “too complicated” (but still might have come from the same page) or the pieces really didn't come from the same page.

Assessment Tool

Think about It Evaluation Sheet

The **Think about It Evaluation Sheet** will help students to understand and internalize basic expectations for the warm-up activity.

Investigate

Teaching Tip

Circulate among students asking leading questions as the students progress through the activity. Some students may need to be reminded about proper use and safety when using scissors. Encourage individual ideas if backed by the evidence.

1. a) The pieces should be cut at the boundary between the continental and oceanic crust because that is the actual boundary of the continent. Sea level has varied through geologic time by as much as hundreds of meters, and because of the usually gentle slopes of coastal areas (coastal plains, on land, and continental shelves, under the ocean), the shoreline has shifted back and forth by hundreds of kilometers. The present position of the shoreline has no relevance to the actual edge of the continental crust.

Teaching Tip

If you are pressed for time, you may want to make photocopies of the continents, laminate the copies, and then cut them out and provide them to the students in an envelope. This way, the students will still have the opportunity to put the continents into the different configurations, but will not spend a great deal of time cutting them out.

- b) Answers will vary. Most areas of the United States are in the mid-latitude region, but that is not true of Alaska or the peninsula of Florida.
 - c) Coal deposits are not especially common in areas that are currently tropical or subtropical.
 - d) Mountain belts similar in structure to the Appalachian Mountains are found in northwestern Europe, eastern Greenland, northwestern Africa, and northeastern South America.
 - e) Rock formations similar to those in South America are found in southern Africa, Antarctica, Australia, and India.
 - f) *Glossopteris* is found in South America, Africa, India, Australia, and Antarctica.
 - g) *Mesosaurus* is found in South America and southern Africa.
2. Students may find it easier to draw the lines (Equator, etc.) first and use them to help arrange the modern continents. This should closely match any modern Mercator (cylindrical) projection of the world.

Assessment Tool

EarthComm Notebook Entry-Checklist

Refer students to the *EarthComm* Notebook Entry-Checklist to remind them of the criteria against which they will be assessed. The checklist also provides a quick guide for student self-assessment and also provides you with an opportunity to quickly score student work.

3. Don't let students be discouraged if their map is different from the one on page 110. The task of assembling Pangea involves many uncertainties and complexities, and the accepted reconstruction is based on extensive research by many geoscientists.

4.
 - a) South America and Africa fit together best.
 - b) Erosion and sedimentation along coastlines, and outbuilding of the continental shelves by sedimentation, during the last 250 million years since the continents were joined causes them to not fit together exactly.
 - c) Answers may vary.
 - d) Answers will vary. Students might infer a different latitude based on the evidence in the rocks.
 - e) The coal deposits were formed nearer to the Equator than they are now found. That makes sense if the continents have “drifted” since that time.
 - f) The Appalachian Mountains line up with those they resemble. The most obvious match is with the mountain belts of western and northwestern Europe.
 - g) Rock formations in South America line up with those they resemble.
 - h) Movement of the plates would explain why *Glossopteris* appear to have migrated.
 - i) There was no intervening sea at the time that *Mesosaurus* migrated because the continents were joined.

5.
 - a) Oceans will fill the empty spaces between the continents in the future.
 - b) The Mediterranean Sea will probably continue to close up, although a number of smaller residual basins, like the Black Sea, will probably be left over because of the irregular outlines of the continents that are converging. Mountains (even more than now) will be formed in the Mediterranean area.
 - c) The southern coast of California will be near Alaska if plate movements continue as they are now.
 - d) Answers will vary.
 - e) Answers will vary.
 - f) Plates can vary in direction and speed of movement over long periods of time.

(Remind students of **Activity 1**, in which they examined the changes in the speeds and direction of plates using GPS time series.)

Reflecting on the Activity and the Challenge

Use this opportunity to return student thinking to the **Chapter Challenge** as they share maps in a class discussion. Of particular interest to the challenge is that there may be differences between students' maps. This is consistent with the nature of science, whereby scientists come to different understandings and interpretations of data and work out the differences in ideas and interpretations through a discussion based on consistency with evidence.

Digging Deeper

Assign the reading for homework. The questions in **Check Your Understanding** on page 118 can be assigned for homework.

Assessment Tool

Check Your Understanding Notebook Entry-Evaluation Sheet

This evaluation sheet is used to help you evaluate the extent to which students understand the key concepts explored in the activity and explained in the **Digging Deeper** reading section.

Check Your Understanding

1. By wrinkling of the outermost part of the Earth during cooling and contraction of the Earth.
2. Many mountain ranges show geological evidence of extreme horizontal compression and movements. That is not consistent with simple cooling and contraction. Also, the discovery of radioactive heating makes the idea of a contracting Earth much less plausible.
3. The good fit of the continents when they are pieced together like a jigsaw puzzle, and the similarity of rocks, geologic structures, and fossils on opposite sides of the Atlantic Ocean, now far apart but likely close together when first formed.
4. By slow fluid flow of the material beneath the Earth's lithosphere.
5. Most plants and animals inhabit a geographically restricted area of the world. Many fossil plants and animals are now found in areas that are now widely separated by oceans. If the continents are assembled together in one continuous piece, these widely separated areas become contiguous.

Understanding and Applying What You Have Learned

1. Students may invoke several kinds of evidence that might be useful, including more detailed information about the types of rocks and fossils present in their community.
2. Specific information about the ecological zones that particular organisms (plants and animals) inhabited during that time would be helpful in developing a better sense of past climates. Evidence for the past existence of deserts and of continental glaciers is common in sedimentary rocks.
3. Wegener lacked a plausible mechanism to account for the movement of the continents. Although he amassed a lot of evidence that suggested that continents had moved, he was not able to propose a suitable mechanism for moving them.
4. Modern discoveries that helped scientists begin to accept plate tectonics included paleomagnetic data (sea-floor striping) and the increasing age and thickness of sea-floor sediments and rocks away from ocean ridges, and in very recent times, GPS data on actual movements of the continents. The technologies and tools for gathering and analyzing this data did not exist in Wegener's time.

5. Most scientists are naturally skeptical of new ideas and resistant to changing their way of thinking without solid evidence and reasoning. For most people, including scientists, “business as usual” is easier and more comfortable than taking great risks.
6. Plate tectonics states that continents do not plow through solid ocean floor (as was thought during Wegener’s time) but instead are the tops of moving plates of material that move as part of large-scale convection cells that involve the entire mantle.
7. All of the lithosphere under the Atlantic Ocean has formed within the last 200 million years. Before then, the continents were joined, and there was no Atlantic Ocean. The lithosphere under the Pacific Ocean continues to be produced, but at the present time the rate of consumption of Pacific lithosphere is greater than the rate of production, so the Pacific Ocean is becoming smaller.

Preparing for the Chapter Challenge

Depending upon the time available and the resources you and your students have at your disposal, this inquiry will enable your students to present the local significance of the theory of plate tectonics to local middle-school students. If rocks of older ages are present, earlier time periods can also be assigned back to the Proterozoic Era, about 550 million years before the present.

Inquiring Further

1. History of science

Through the routine acquisition of oceanographic data during naval and oceanographic cruises, mainly in the years after World War II. Magnetometers are routinely towed behind ships to measure the local magnetic field strength. This data was the basis for the revolutionary idea of sea-floor spreading that was proposed in the early 1960s.

Excellent web sites for helping students to get started on this inquiry are provided on the *EarthComm* web site

2. Plate tectonics and the Earth system

This is a very open-ended task. Some effects are obvious: most major earthquakes and volcanic activity would cease. Another very significant effect, but one that is less obvious, is that uplift of the lithosphere to form plateaus and mountains would also cease, and the continents would gradually wear down to low-lying plains.