Cambridge Core Science Series: GeoBasics

PLATE TECTONICS

Cambridge Educational

Introduction

This Teacher's Guide provides information to help you get the most out of *Plate Tectonics,* Part 2 of the *GeoBasics* series. The contents in this guide will allow you to prepare your students before they use the program, assist them as they navigate through the program, and present follow-up activities to reinforce the program's key learning points.

The *GeoBasics* series is intended to excite young people about science and teach them concepts that meet national educational standards for science literacy. Science, in its multiple disciplines, is inherently fascinating and helps explain the world around us. In addition to fulfilling our natural curiosity, studying science and learning critical thinking skills provides numerous practical benefits, including helping us make informed and reasoned decisions, solve problems, think creatively, and continue to learn.

This 20-minute video provides students in grades 7 through 12 with an introduction to the size, composition, age, and history of our planet, but the program is not limited to usage by this audience. Because science literacy is important for all people, the information presented in *Plate Tectonics* could also be presented to vocational/technical schools or in adult education courses that focus on science.

Learning Objectives

After watching *Plate Tectonics*, students will understand how to:

- Define continental drift and relate how it has changed the shape of our planet.
- Demonstrate an understanding of how ocean floor mapping, magnetic striping and polar reversals, seafloor spreading, and geodesy relate to plate tectonics.
- Describe the benefits of plate tectonics and its two major processes: spreading and subduction.
- Recognize the four types of plate boundaries—divergent boundaries, convergent boundaries, transform boundaries, and collisional boundaries—and describe the characteristics of each.
- Describe the three types of earthquake waves—P (push or primary) waves; S (shear or secondary) waves;
  and L, or surface waves—and describe the measurement systems and prediction methods used to record earthquakes.
- Demonstrate an understanding of the various ways volcanic eruptions can occur.
- Recognize what causes tsunamis, and how scientists predict them and warn people about them.

Educational Standards

The *Plate Tectonics* video program correlates with the following Standards: the National Standards of the National Academy of Sciences National Science Education, International Society for Technology in Education (ISTE), National Educational Technology Standards (NETS), and National Council of Teachers of English; and the State Standards of Florida, California, and Ohio for Earth and Space Sciences, Processes that Shape the Earth; How Living Things Interact with Their Environment; and Listening, Viewing, and Speaking.

- Develops an understanding of energy in the earth system, geochemical cycles, origin and evolution of the earth system, and origin and evolution of the universe. *(National Academy of Sciences National Science Education Standards, Earth and Space Science Standards: Grades 9-12)*

- Recognizes that processes in the lithosphere, atmosphere, hydrosphere, and biosphere interact to shape the Earth. *(Florida State Standards: Processes that Shape the Earth; How Living Things Interact with their Environment; Listening, Viewing, and Speaking)*

- Demonstrates an understanding about how earth systems and processes interact in the geosphere resulting in the habitability of Earth; and understands historical perspectives, scientific approaches, and emerging scientific issues associated with Earth and space sciences. *(Ohio State Earth and Space Science Standards)*

- Knows that plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on Earth's surface. *(California State Earth Sciences Standards)*

Program Overview

The *Cambridge Core Science* series is a 40-part series composed of subsets of programs addressing Life Science, Earth Science, Physical Science, Human Body Systems, and Space Science. The series is designed as a whole to give high school and some college students a basic scientific understanding of themselves and the world around them.

The *GeoBasics* video program series consists of eight titles:

- Our Planet Earth
- Plate Tectonics
- Rocks and Minerals
- Oceans and Seas
- Geocycles
- Atmosphere, Climate, and Weather
- Energy and Resources
- Environmental Issues and Human Impact

The second title of the series, *Plate Tectonics,* focuses on continental drift—plate tectonics. It introduces the viewer to the concept, explains its various plate motions and major processes, then describes how plate tectonics affects people through the byproducts of earthquakes, tsunamis, and volcanoes. It concludes by taking a look at the plethora of unanswered questions about plate tectonics, the importance of which is crucial to life as we know it, given the number of major cities built along tectonic plates.

Main Topics

Topic 1: Introduction
The program begins with an introduction to plate tectonics and the theory of continental drift, demonstrating what Pangaea might have looked like 250 million years ago. It continues by presenting the concepts of magnetic striping and seafloor spreading.

Topic 2: Earth's Tectonic Plates
In the second topic, the anatomy of the Earth is explored, from its compositional layers to its mechanical layers. Earth's major plates are named and the contents of plate edges are explained.

Topic 3: Forces, Measurements, and Causes
The forces that change Earth over time are discussed, as are the ways scientists measure the movement of tectonic plates over time. The topic concludes with an exploration of what causes continental drift, highlighting the process of convection.

Topic 4: Mountains, Earthquakes, Tsunamis, and Volcanoes
The awe-inspiring and oftentimes disastrous byproducts of plate tectonics are explored in relation to the three types of plate boundaries that cause them; mountains, earthquakes, tsunamis, and volcanoes are all paired with their corresponding divergent, convergent, or transform plate boundaries. Also discussed are the types of earthquake waves and how they are measured and recorded, as well as the types and locations of volcanoes on our planet.

Topic 5: Conclusion
The program wraps up by emphasizing how plate tectonics continues to shape today's world and what it could mean for the future to have better forecasting methods and warning systems for earthquakes and tsunamis.

Fast Facts

- Plate tectonics sets Earth apart from the other planets. Unlike the other terrestrial planets, Earth is the only one with a crust that is divided into several solid plates that float around independently on top of the hot mantle below.

- In recent years, the study of terranes (also called terrane tectonics or terrane analysis) has become a specialized field within plate tectonics research. Such studies suggest that plate tectonics have been operating in some fashion since perhaps as early as 3.8 billion years ago. An intriguing, but sketchy, picture theorizes that there have been several cycles of supercontinent formation, each followed by break-up and subsequent drifting of the fragmented parts. Pangaea itself may have been formed by the aggregation of separate continents that drifted back together after the break-up of an older supercontinent that existed about 550 million years ago.

- At irregular intervals, averaging about 200,000 years, the Earth's magnetic field reverses; this means that if today, the end of a compass needle points to the north ("normal orientation"), after a reversal, it will instead point to the south in a "reversed orientation." The oceanic plates act as a giant tape recorder, preserving in their magnetic minerals the orientation of the magnetic field present at the time of their creation.

- The late 1970s witnessed the rapid growth of space geodesy, a term applied to space-based techniques for taking precise, repeated measurements of carefully chosen points on the Earth's surface separated by hundreds to thousands of kilometers. The three most commonly used space-geodetic techniques are Very Long Baseline Interferometry (VLBI), Satellite Laser Ranging (SLR), and the Global Positioning System (GPS).To date, the GPS's twenty-four satellites are the most useful for studying the Earth's crustal movements.

- Over geologic time, plate movements, in concert with other geologic processes, have created some of nature's most magnificent scenery, such as the Himalayas, Swiss Alps, and Andes. Yet violent earthquakes caused by plate tectonics have resulted in terrible catastrophes, such as the magnitude-7.7 earthquake that struck China in 1976 and killed as many as 800,000 people. Another example is the 2004 Indian Ocean earthquake, the fourth largest earthquake in the world since 1900. Its 9.0 magnitude triggered a series of lethal tsunamis that killed over 283,100 people, making it the deadliest tsunami in recorded history.

- Tsunamis are often mistakenly called "tidal waves" when, in fact, they have nothing to do with tidal action. Rather, tsunamis are seismic sea waves caused by earthquakes, submarine landslides, and, infrequently, by eruptions of island volcanoes, which race across the ocean at speeds of more than 800 (500 miles) km per hour.

- The "Ring of Fire" (also called the Circum-Pacific belt) is a zone surrounding the land areas that ring the Pacific Ocean, wherein volcanic and seismic activity occurs. Approximately 90% of the world's earthquakes and approximately two-thirds of the world's active volcanoes occur there.

- Three-quarters of all lava eruptions on Earth take place unseen beneath the ocean, mostly along the oceanic spreading centers, such as the Mid-Atlantic Ridge and the East Pacific Rise.

- Since 1600 A.D., nearly 300,000 people have been killed by volcanic eruptions. The greatest hazards to civilizations and the ones that have caused the most deaths are the explosive eruptions of subduction-zone volcanoes and their accompanying pyroclastic flows and mudflows.

- Some 500,000 recordable earthquakes take place each year, approximately 1,370 per day. The release of energy in an earthquake increases by a factor of 30 for each point on the Richter scale. Thus, a magnitude 4 tremor releases thirty times as much energy as a magnitude 3. Earthquakes are classified as "major" earthquakes if they achieve a Richter magnitude of 6, or as "great" earthquakes if their magnitude is 8 or more.

Vocabulary Terms

asthenosphere: The region of the Earth below the surface that is the weak or "soft" zone in the upper mantle. It lies just below the lithosphere, which is involved in tectonic plate movements.

continental drift: The movement, formation, or re-formation of continents described by the theory of plate tectonics.

convection: The transfer of heat by a circulatory motion that occurs in a fluid at a non-uniform temperature, due to the variation of its density and the pull of gravity.

convergent (destructive) boundary: The boundary where a dense oceanic plate collides with a less-dense continental plate, causing the oceanic plate typically to be thrust underneath, forming a subduction zone.

core: The central portion of the Earth below the mantle, beginning at a depth of about 1,800 miles and probably consisting of iron and nickel. It is made up of a liquid outer core and a solid inner core.

crust: The outer layer of the Earth.

divergent (constructive) boundary: Where two plates move apart from each other. The space that this creates is filled with new crustal material sourced from molten magma that forms below.

earthquake: A sudden movement of the Earth's crust caused by the release of stress accumulated along geologic faults or by volcanic activity.

epicenter: The point of the Earth's surface directly above the focus of an earthquake.

fault: A fracture in the continuity of a rock formation caused by a shifting or dislodging of the Earth's crust, in which adjacent surfaces are displaced relative to one another and parallel to the plane of fracture.

focus: The point of origin of an earthquake.

geology: The scientific study of the origin, history, and structure of the Earth.

GPS (Global Positioning System): A system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

hot spot: An area of intense heat, radiation, or activity.

lithosphere: The solid outermost shell of the Earth, which includes the crust and the uppermost layer of the mantle.

magnetometer: An instrument for measuring the magnitude and direction of a magnetic field.

mantle: The layer of the Earth between the crust and the core.

Pangaea: A hypothetical supercontinent that included all the landmasses of the Earth before the Triassic Period. When continental drift began, Pangaea broke up into Laurasia (North America, Greenland, Europe, and Asia) and Gondwana (Antarctica, Australia, South America, Africa, and India).

P wave (primary or push wave): An earthquake wave in which rock particles vibrate parallel to the direction of wave travel. It can travel through solids and liquids.

Ring of Fire: An extensive zone of volcanic and seismic activity that coincides roughly with the borders of the Pacific Ocean.

seafloor spreading: In the theory of plate tectonics, the process by which new oceanic crust is formed by the convective upwelling of magma at mid-ocean ridges, resulting in the continuous lateral displacement of existing oceanic crust.

seismograph: An instrument for automatically detecting and recording the intensity, direction, and duration of a movement of the ground, especially of an earthquake.

subduction: A geologic process in which the edge of one crustal plate is forced below the edge of another.

S wave (secondary or shear wave): An earthquake wave in which rock particles vibrate at right angles to the direction of wave travel. It can travel through solids but not through liquids.

tectonic plate: Section of the Earth's crust that moves, floats, and sometimes fractures, whose interaction with other plates causes continental drift, earthquakes, volcanoes, mountains, and oceanic trenches.

transform (conservative) boundary: Where tectonic plates slide and grind against each other along a transform fault in a horizontal motion.

tsunami: A very large ocean wave caused by an underwater earthquake or volcanic eruption.

volcano: An opening in the Earth's crust through which molten lava, ash, and gases are ejected; or, a mountain formed by the materials ejected.

Pre-Program Discussion Questions

1. Why is it important to study plate tectonics? List some specific locations in the world where it is particularly crucial.

2. What do you think about the theory of continental drift? Do you think the continents will ever again become one solid landmass? Why or why not?

3. Discuss examples of plate tectonics that exist in your neighborhood or surrounding areas. Are there roads cut through mountains that exhibit geological strata? Have you ever been in an earthquake? If there are no local examples, then what stories have you heard about earthquakes, tsunamis, or volcanoes?

4. Have you ever used a GPS? Do you understand how it works? List the various ways it is currently used and propose ideas for how it could be used in the future.

5. If scientists can one day reach the Earth's core, what geologic forces do you think they'll find? Do you think they will uncover records of ancient climate change or undiscovered lifeforms? What potential benefits and risks could be derived by exploring the Earth's core?

Post-Program Discussion Questions

1. Name the various types of plate boundaries, and describe how the plates interact with each other for each type.

2. Now that you have a greater understanding of plate tectonics, think about any movies that you have watched about disasters created from plate tectonics. How realistic were they? How could they have been made more realistic or more informative to the viewing audience?

3. Create an earthquake scenario from start to finish, including the type of boundary on which it occurs, the focus, the epicenter, the name and sequence of earthquake waves, the earthquake's measured duration and corresponding placement on the Richter Scale, and the kind of devastation experienced.

4. Using video footage or newspaper clips, take your students step-by-step through the Indian Ocean earthquake and resulting tsunami from December 26, 2004.

5. We have discussed a lot of the devastation caused by plate tectonics, but what are its benefits? How does the study of tectonic plates assist humankind?

Internet Activities

Predicting Disaster
Choose a type of natural disaster—earthquake, volcano, or tsunami—and, using the Internet to research your findings, create a 5- to 7-page report on how they are predicted and monitored by various groups and methods, and what innovations have been created to warn people about the impending disaster.

Volcanic Activity
Research the Smithsonian's Global Volcanism Program and the US Geological Survey's Volcano Hazards Program and create a list of the 15 most recent volcanic eruptions, remembering to include the volcano's name, location, eruption date, the tectonic plates involved, and if possible, the associated type of plate boundary. Add any interesting details or characteristics of the eruption.

Group Activities

Measuring Earthquakes
Divide the class into small groups, assigning each group one of the following earthquake measurement systems or recording devices: seismographs, the Richter scale, the Mercalli intensity scale, creep meters, or stress meters. Have each group research and report on their topic by making a 5-minute presentation; then, compare and contrast the various methods and devices, showing how they can be used in conjunction with each other.

Shields, Supers, Cinders
Break the class into groups, assigning each a type of volcano: shield, cinder, composite, super, submarine, or mud. Ask each group to report on the size and shape, erupted material type, location, and characteristics of its particular volcano type and to present the findings to the rest of the class.

Ear to the Ground
Divide the class into pairs. Have student A place his or her ear at one end of a desk, and have student B very quietly scratch at the other end of the desk. Can student A hear the scratching? Then, repeat the exercise with student A lifting his head one inch above the table. Does the scratching sound travel better through the table or through the air?

Assessment Questions

Q1: What is plate tectonics?
A: Plate tectonics is the branch of geology studying the folding and faulting of the Earth's crust and the global distribution of geological phenomena such as seismicity, volcanism, continental drift, and mountain building due to the formation, destruction, movement, and interaction of the Earth's lithospheric plates.

Q2: What is the Theory of Continental Drift?
A: Stemming from the observation that the shapes of continents on either side of the Atlantic Ocean seemed to fit together (e.g., Africa and South America), the theory holds that all the continents had once been joined together in a supercontinent known as Pangaea.

Q3: True or false: The rigid asthenosphere floats on the lithosphere.
A: False. The reverse is true—the rigid lithosphere (the plates) floats on the asthenosphere.

Q4: How many major tectonic plates are there, and what are their names?
A: There are more than twelve major plates, called Eurasian, African, Indian-Australian, North American, South American, Antarctic, Pacific, Juan de Fuca, Cocos, Nazca, Scotia, Arabian, Philippine, and Caribbean.

Q5: True or false: You cannot measure the movement of tectonic plates.
A: False. You can measure tectonic plate movements directly with a Global Positioning System.

Q6: What are the three major types of plate boundaries?
A: Divergent, convergent, and transform.

Q7: There are three types of earthquake waves. What are the two major types?
A: P (primary waves), which can travel through solids and liquids, and S (secondary, shear waves), which can travel through solids but not through liquids.

Q8: How are earthquake waves recorded?
A: Earthquakes are recorded by seismographs, most often used at seismograph stations.

Q9: Of strato or shield, which volcano type tends to cause more destruction?
A: A strato volcano. Strato volcanoes occur along the Ring of Fire and can cause lots of destruction, while shield volcanoes have low viscosity, silicon content, and water content, so their effects are less devastating.

Q10: Are tsunamis tidal waves?
A: No. Tsunamis are very large ocean waves caused by underwater earthquakes or volcanic eruptions.

Additional Resources

USGS Education: Science for a Changing World
www.usgs.gov/education

Educypedia: The Educational Encyclopedia
http://users.pandora.be/educypedia/education/geology.htm

NASA's Science Mission Directorate Website
http://science.hq.nasa.gov

The Center for International Earth Science Information Network (CIESIN)
www.ciesin.org

The Earth Institute at Columbia University
www.earthinstitute.columbia.edu

The WWW Virtual Library: Earth Science
http://vlib.org/EarthScience

Earth Science Week
www.earthsciweek.org

National Earth Science Teachers Association
www.nestanet.org

Additional Resources at www.filmsmediagroup.com

Available from Films Media Group • www.filmsmediagroup.com • 1-800-257-5126

Earth Science I Video Library

- **VHS #30977**
- **VHS #30992—in Spanish**
- **DVD #30962**
- **Closed captioned**
- **Correlates to National Science Education Standards**
- **Includes a User's Guide**

Contains 18 video clips on the history of the Earth, fossils, paleontology, and mapping the Earth. Clips include *Introduction to Earth History, Thermal Features, Blue Hole, Extinction, Glaciers, Fossil Hunter, Fossil Voyage, Amber, Mammoth, Rhino Fossils, Fossil Tunnels, Early Maps, Remote Sensing, Global Positioning System, Mountains, Seafloor Maps, Measuring Latitude, Measuring Longitude*. A User's Guide is included, containing an overview; a numbered index of clips, with brief descriptions and lengths; time codes (VHS only); suggested instructional strategies; and a list of additional resources. A Discovery Channel/FFH&S Production. © 2003.

Earth Science II Video Library

- **VHS #30978**
- **VHS #30993—in Spanish**
- **DVD #30963**
- **Closed captioned**
- **Correlates to National Science Education Standards**
- **Includes a User's Guide**

The *Earth Science II Video Library* contains 24 video clips on volcanoes, earthquakes, oceans, seasons, weather, and climate. Clips include *Introduction to Volcanoes, Birth of a Volcano, Death and Destruction, Types of Volcanoes, Volcanology, Plate Tectonics, Earth in Motion, San Andreas Fault, Seismology, Earthquake-Proof, Earthquake Zone, Introduction to Oceans, Coral Reefs, Waves and Tides, Fish Harvesting, Currents, Introduction to Weather, Polar Weather, Man-Made Weather, Rain, Violent Weather, Heat and Weather, Weather Systems, Water Cycle*. A User's Guide is included, containing an overview; a numbered index of clips, with brief descriptions and lengths; time codes (VHS only); suggested instructional strategies; and a list of additional resources. A Discovery Channel/FFH&S Production. © 2003.

Earth Story

- **8-part series**
- **VHS/DVD-R #8503**
- **"Extremely well done!" —*Booklist***

Beginning with the first land formations that emerged from the ocean 4 billion years ago, this series explores how all geologic phenomena, from volcanoes to earthquakes, are intertwined. Journeying from the sea bottom to the highest peak in the Andes, the series presents theories on plate tectonics, earthquakes, volcanoes, land formations, and continental drift. An indispensable resource for teaching earth science and geology. A BBC Production. (50 minutes each)

The series includes *Dating the Earth, Journey to the Ocean Floor, Continental Drift: Legacy of Fire, Death of the Dinosaurs, Winds of Change, Noah's Children, Oxygen: The Poison Gas, The Earth and the Moon.*

Landforms

- **CD-ROM #6978 (Windows only)**

What causes volcanoes and earthquakes? Why do tsunamis and floods occur? How do river beds and coastlines change? And what challenges do the forces that shape the Earth pose for people? Using this highly interactive CD-ROM, students can freely explore the Geodome, a virtual laboratory of geologic landforms. Learning stations provide targeted opportunities to manipulate 3-D topographical models, conduct simulations of natural disasters, examine hundreds of slides, and watch video clips. Plus, info/quiz features offer additional background and test comprehension. Headline-making catastrophes and issues of geologic concern drive home the present-day relevance of earth science, geology, and physical geography. Plate tectonics and seismology, eruptions and erosion, landslides and sedimentation—this disc has it all.

The Life and Times of El Niño

- **VHS/DVD-R #34956**
- **Closed captioned**

It has been linked to famines, epidemics, even the fall of empires. This program follows El Niño's deadly path through human history and the progress science has made in understanding the once-mysterious phenomenon. The effects of El Niño are presented in detail, including an 1878 outbreak of yellow fever in Tennessee, a concurrent drought that ravaged much of China, and more recent calamities that have brought the true nature of this climatic occurrence to light. Focusing on high-tech advances in meteorology, the video outlines El Niño's significance in the global warming debate and illustrates the use of computer models that can predict its next appearance. A BBCW Production. (50 minutes) © 2005.

Man and the Biosphere

- **12-part series**
- **VHS/DVD-R #2333**
- ***Recommended by Science Books & Films***

Using an integrated interdisciplinary approach combining the natural and the social sciences, these videos look at the relationships between living beings and their environments. The work of botanists, biologists, geologists, and demographers is used to examine the realities of ecological concerns in the framework of political realities. From the tops of the Himalayas to the bottom of the sea, from empty deserts to overcrowded cities, these videos show life where it thrives and where it has died out. Based on UNESCO's ground-breaking Man and the Biosphere Program, they illustrate the problems and concerns of preserving life, including human life, on Earth, and demonstrate numerous environmental projects that have successfully met the needs of both humankind and nature. (28 minutes each)

The series includes *Life in Arid and Semi-Arid Lands; The Desert as Laboratory; Life at the Top*; *Equilibrium in a Mountain Habitat; The Tropical Rain Forest; Preserving the Rain Forest; Coastlines; Ecology of the Coral Reef; Lagoons; Wetlands and Pinelands; Urban Ecology; Toward a Livable City.*

BioBasics

- **8-part series**
- **VHS/DVD-R #33833**
- **Preview clip online at www.films.com (Search on 33833)**
- **Includes viewable/printable Teacher's Guide**

- **Correlates to National Academy of Sciences National Science Education Standards and the American Association for the Advancement of Science Benchmarks for Science Literacy**
- **"A welcome replacement for outdated life science programs."—*School Library Journal***

Use the comprehensive 8-part *BioBasics* series to excite your students about life science as you present the fundamental concepts they'll need for a firm foundation in biology. An engaging blend of computer graphics, interviews with scientists, and animations will hold their attention as they open their minds to a wide range of essential life science topics.

The series includes *Introduction to Life Science; Cells: The Building Blocks of Life;Genetics and Evolution; Organization and Diversity; Life Processes of Animals; Life Processes of Plants; Microorganisms; Interdependence of Life.* A Cambridge Educational Production. Viewable/printable teacher's guides are available at www.cambridgeeducational.com. (25 minutes each) © 2005.

For information on other programs

Visit our Website at
www.cambridgeeducational.com

2572 Brunswick Pike, Lawrenceville, NJ 08648

Toll Free: 1 800/468-4227
Fax: 1 800/FAX ON US

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