Exploring Plate Tectonics

Content Area: **Science**
Course(s): **Science 6**
Time Period: **Trimester 2**
Length: **14 Lessons**
Status: **Published**

Unit Overview

In this unit, students investigate the structure of earth's interior and crust based on the manipulation of simple models and on the identification of patterns they observe from maps. As students progress through the unit, they compile, through a series of experiences, evidence for the theory of plate tectonics, including patterns of earthquakes, shapes of continents, paleomagnetism, the fossil record, and convection in the mantle. Students also investigate how volcanoes are formed and the different types of volcanoes found on earth. This unit gives students many opportunities to analyze, record, and communicate results and to apply the results to previous experiments to predict outcomes in new situations. As students progress through the unit, they take greater responsibility for their own learning, eventually planning and conducting their own procedures, devising their own data tables, and analyzing the results they obtain. This unit consists of both laboratory excercises and pointed reading selections.

This unit is mostly laboratory and project based. However, there are many important reading selections from both the STC and Pearson publications. The Pearson Interactive Science series listed in the bibliography is used mainly as a reinforcement for the lab activities and as an additional source of readings, vocabulary, and diagrams. In addition, many other sources of reading materials, videos, and other media are used to enhance the lesson, such as *National Geographic, Smithsonian Magazine, Science Scope* (NSTA), *BrainPop, YouTube, Science Illustrated,* and other relevant books and current events.

This unit will be learned in the second trimester.

Essential Questions

How do people figure out that the Earth and life on Earth have changed over time?

How does the movement of tectonic plates impact the surface of Earth?

How do the materials in and on Earth's crust change over time?

How does water influence weather, circulate in the oceans, and shape Earth's surface?

How can natural hazards be predicted?

Content

History of Earth:

The history of planet Earth: Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth's history.

Earth's Systems:

Earth materials and systems: Energy flows and matter cycles within and among Earth's systems, including the sun and Earth's interior as primary energy sources. Plate tectonics is one result of these processes.

Plate tectonics and large-scale system interactions: Plate tectonics is the unifying theory that explains movements of rocks at Earth's surface and geological history. Maps are used to display evidence of plate movement.

The roles of water in the Earth's surface processes: Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.

Skills

- Perform experiments related to earthquakes, volcanoes, and plate tectonics.
- Describe the results of investigations related to earthquakes, volcanoes, and plate tectonics.
- Discuss and explain the effect of the variables of depth and magnitude in explaining movement in the earth's crust.
- Communicate results through writing, graphs, maps, and charts.
- Reflect on experiences related earthquakes, volcanoes, and plate tectonics through writing and discussion.
- Use the results of previous investigations on the variables of different types of plate movements to predict outcomes in new investigations.
- Apply previously learned concepts and skills to decrease the mitigation of catastrophic earthquakes and volcanoes.
- Read and use technology to obtain knowledge about the earth's interior, earthquakes, volcanoes, and plate tectonics.

Assessments

The majority of this unit is an inquiry-based hands-on approach to learning. It consists of laboratory activities which vary in their intensity, approach, skill, and evaluative measurements. For example, some of the lab activities are "walk-through" labs, where the student is guided through a procedure and a process, and is asked to make connections among the main concepts presented in the activity and associated readings. Other lab activities consist of a problem that is presented to the student, which he or she must solve by designing an experiment (which is then peer and teacher evaluated before proceeding with the lab activity) and collecting data. Regardless of the lab activity, students are evaluated based on the quality and presentation of the collected data in graphic organizers; the efficacy and accuracy of the experimental design; the connections made between the experimental design, the data collected, and the conclusion of the laboratory report- i.e. "tying it all together to see the big picture"; and lab etiquette and adherence to safety rules. Other evidence for learning includes several short 5-10 question quizzes, and end-of-unit lab practical (hands-on) test, end-of-unit paper test based on the labs, and several creative projects, which may include posters, skits, songs and poems, and presentations.

Lessons/Learning Scenarios

Lesson 1: "Introducing Earthquakes"

Objectives:

- Brainstorm possible causes and effects of earthquakes and techniques for monitoring and predicting them
- Use a world map to plot the areas where student believe earthquake occur
- View a video of actual earthquakes and discuss the destruction that earthquakes can cause
- Develop observation and descriptive writing skills
- Work cooperatively with a lab partner
- Practice safe and appropriate laboratory techniques

Learning Activities:

- Draw a concept map in their science notebooks and then with their groups to express their understanding of the following regarding earthquakes: cause and effect; how seismologists monitor and predict earthquakes; and how people prepare for and protect themselves from earthquakes.
- Use a map to identify where they believe earthquakes occur.
- Discuss why earthquakes occur in particular areas.
- View video footage of an earthquake and document their observations and predictions regarding earthquakes.

Concepts:

- Processes within the earth cause earthquakes, which can change or destroy human and wildlife habitats
- Some locations on earth are more prone to earthquakes than others
- Earthquakes are natural catastrophic events that can present risks to humans
- Earthquakes can be monitored, measured, and maybe someday predicted with technology

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 2: "When the Earth Shakes"

Objectives:

- Observe the formation and movement of waves in water
- Conduct a controlled investigation
- Use a spring to simulate different kinds of waves
- Relate wave movement in a spring to earthquake waves
- Use a spring to model possible damaging effects of earthquake waves
- Read about how buildings can be designed to withstand earthquakes

Learning Activities:

- Observe water waves moving out in concentric circles when water in a shallow pan is disturbed
- Relate observations of these water waves to the earthquake motions they saw in Lesson 1
- Use steel springs to simulate body waves of a model earthquake
- Control the initial energy added to the system and observe that P-waves travel more slowly than S-waves

- Use tape to model the motion of buildings at the earth's surface

Concepts:

- A wave is one or more of a series of movements passing along a surface or through a substance
- A wave originates at one point and travels outward in all directions
- Earthquakes release energy that travels in waves
- A controlled investigation answers a scientific question by testing on variable and controlling all other variables
- Earthquake waves can be modeled using a steel spring: push and pull waves (P-waves) or side-to-side waves (S-waves)
- Surface waves form after body waves reach the surface, and cause damage to manmade structures
- P-waves and S-waves, modeled using a stretched spring, take different times to travel

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 3: "Recording Earthquake Waves"

Objectives:

- Discuss earthquake waves and how scientists record and study them
- Record vibrations using a model seismograph
- Analyze earthquake wave patterns on an actual seismograph
- Locate the epicenter of an earthquake using data from three seismograph stations

Learning Activities:

- Students are introduced to seismographs and seismograms
- Students review their understanding of the nature of waves moving out in all directions
- Students manipulate a model seismograph that shows that waves from different directions, with different strengths or forces, and from different distances, leave different signatures on seismographs
- Students use an actual seismogram to determine information about the earthquake, including when it happened, how far away it was, and how many aftershocks accompanied it
- Students use data from three seismic stations of an actual earthquake to plot the location of the epicenter

Concepts:

- Earthquake waves radiate outward in all directions from the earthquake source
- Vibrations from an earthquake can be recorded with a seismograph; a seismogram is the recording made by a seismograph
- Scientists construct models to help them understand how complex systems behave
- Different earthquake waves travel at different speeds and therefore arrive at seismograph stations at different times
- The epicenter of an earthquake is the point on the earth's surface directly above the focus, or point of origin, of the earthquake
- Scientists can use data from seismograms recorded at several locations to pinpoint the epicenter of an

earthquake

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 4: "Plotting Earthquakes"

Objectives:

- Brainstorm about where earthquakes occur and why
- Plot on a world map the locations, depths, and magnitudes of some the earthquakes that occurred during the 1990s
- Analyze the locations, depths, and magnitudes of earthquakes around the world
- Identify the perimeter of the Pacific Ocean, the Mid-Atlantic Ridge, and the Mediterranean-Himalayan Belt as areas of intense earthquake activity
- Understand the difference between magnitude and intensity
- Hypothesize about the reasons for patterns in the locations of earthquakes

Learning Activities:

- Students revisit their original thoughts on earthquake causes, effects, and locations
- Students begin to formulate the reasons earthquakes are located where they are
- Students plot a set of earthquake data on a world map. The data includes information on each earthquake's magnitude and depth. They then analyze the data by relating the location of these earthquakes to other geologic features, such as mountain ranges and continental coasts.

Concepts:

- Major geological events, such as earthquakes, volcanic eruptions, and mountain building, are clustered in particular locations on earth that correspond to plate boundaries.
- The Ring of Fire is a zone of intense earthquake and volcanic activity that encircles the Pacific Ocean basin.
- The Mid-Atlantic Ridge is a zone of intense earthquake and volcanic activity that runs down the middle of the Atlantic Ocean floor.
- The Mediterranean-Himalayan Belt of earthquakes and volcanic activity extends from west of Indonesia through the Himalayas in Asia and the Mediterranean region.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 5: "Using Earthquakes to Study the Earth's Interior"

Objectives:

- Examine the interior structure of some common objects
- Discuss how scientists study the structure of the earth's interior

- Recognize that an understanding of the motion of earthquake waves can help scientists formulate hypotheses about the earth's interior
- Use computer images to identify and describe the layers of the earth
- Plot the locations of volcanoes, and compare these locations with those of earthquakes

Learning Activities:

- Students examine some common food items and discuss how could discover the internal structure
- Students begin to relate their ideas about these layered objects to the study of the structure of the earth
- Students view waves in a pan of water, and then see what happens to the waves when a can is placed in the middle of the pan
- Students view images from a CD-ROM to examine lines of evidence for understanding the internal structure of the earth. This is a lesson that will take some very concrete ideas and apply them in an abstract manner. We have not been deeper than 12 km into the earth's crust, yet we know an immense amount about the earth's interior
- Students plot volcanoes on a world map and compare their locations with those from previous earthquake data

Concepts:

- Earthquake waves travel through some substances, but not others, and travel at different speeds depending on the substance.
- Patterns of earthquakes and their waves provide information about plate boundaries and the interior structure of the earth.
- Major geologic events, such as earthquakes, volcanic eruptions, and mountain building, can result from plate movement.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 6: "Investigating Plate Movement"

Objectives:

- Review Student Sheet 5:1: Plotting Volcanic Activity
- Describe what a model is and distinguish models from real objects or events
- Use models to simulate the movement of lithospheric plates as they collide, separate, and slide past one another
- Use a globe and a map to find evidence of plate movement and to identify landforms that result from plate movement

Learning Activities:

- Students are introduced to three models to deepen their understanding of the structure and behavior of the earth's crustal plates
- Students view "The Theory of Plate Tectonics" CD-ROM and elaborate on the relationship of plate movements to earthquakes, volcanoes, mountains, and trenches
- Students use foam pads of differing densities to discover the different ways the plate of crust interact. They are also able to infer how this relates to the actual ocean and continental crusts

- Students examine a 3-dimensional model of crustal plates spreading apart or colliding. This is an interactive demonstration that can lead to further explanation for students who are helped by having 3-dimensional models
- Oreo Lab to demonstrate 3 different plate boundaries

Concepts:

- Lithospheric plates on the surface of the earth slide past one another, collide, and separate at the rate of 2 to 20 cm per year.
- Landforms – mid-ocean ridges, trenches, and mountains – form as a result of plate movement.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 7: "Investigating Faults"

Objectives:

- Classify materials as either "brittle" or "ductile"
- Design an investigation
- Investigate the effects of applying a force to a model of a fault
- Relate the interaction of forces at boundaries to the occurrence of earthquakes

Learning Activities:

- Students examine the properties of a set of materials and classify them as "brittle" or "ductile"
- Students use a model fault system and vary the friction along the fault to investigate the effect of friction on the force required to cause an earthquake. They alse measure how increasing friction increases the size of the earthquake

Concepts:

- Rock responds to the forces caused by plate movement by either folding (bending) or fracturing (breaking).
- Faults are fractures in the earth's crust and upper mantle along which measureable movement of rock has occurred.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 8: "Convetion in the Mantle"

Objectives:

- Recall previous experiences students have had with convection
- Use a flow indicator, Carolina Convection Fluid, to model convection currents in the mantle

- View computer images of the earth's interior to observe convection in the mantle
- Use appropriate vocabulary when communicating ideas about the earth's interior layers
- Identify movement in the earth's mantle as one cause of plate movement, earthquakes, and volcanoes

Learning Activities:

- Students brainstorm what they know about plate tectonics and review any prior knowledge of convection
- Students use Carolina Convection Fluid in bottles to model convection in the mantle

Concepts:

- Uneven heat causes convection to occur in a gas or a liquid.
- The earth has a rigid lithosphere that covers a hot, convective mantle.
- Convection in the earth's mantle can be modeled by heating a convective fluid in a jar.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 9: "Introducing Volcanoes"

Objectives:

- Create a concept map based on what students know about volcanoes
- Plot the locations of volcanoes on a world map
- Analyze the causes and effects of volcanic eruptions by watching a video
- Analyze scientists' ability to forecast volcanic activity, and explore the challenges they face in making such forecasts.
- Identify other plate tectonics related to volcanoes
- Classify the effects of volcanic eruptions as either destructive or constructive
- Brainstorm what students know and want to learn about volcanoes

Learning Activities:

- Students construct a concept map to reveal their current understanding of volcanoes and the relationship of volcanoes to other catastrophic events, and to reveal what they know volcanoes tell us about the earth
- Students watch two videos that reveal the constructive and destructive effects of volcanoes. They then complete a set of questions related to the risk assessment of volcanic eruptions. Finally, they revisit their concept maps and focus on additional constructive effects of volcanoes and write a definition of "volcano."

Concepts:

- Volcanoes are evidence of the heat within the earth that drives plate tectonics.
- Volcanoes cause destructive and constructive changes to the earth's surface.
- Scientists use special tools and methods to look for signs of impending volcanic activity.
- Scientific data are used to help communities reduce or eliminate risks from volcanoes.
- Even today, scientists are challenged to accurately forecast the timing and effects of catastrophic

events.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 11: "Volcanoes Change the Landscape"

Objectives:

- Brainstorm what students know and want to learn about magma and lava
- Model the movement of molten rock through fractures in the lithosphere
- Model the movement of molten rock over the earth's surface and under water
- Identify in photographs landforms created by molten rock
- Devise working definitions for the terms "magma" and "lava"

Learning Activities:

- Students brainstorm what they know and want to learn about magma and lava
- Students simulate the movement of magma as it rises through fractures and change the shape of the surface of the earth
- Students use melted wax to investigate how cooling lava forms new land both in and out of water. The investigations prepare students for Lesson 12, in which they will investigate the effect of lava viscosity on the type of volcano that forms.
- Students create working definitions of the words "magma" and "lava"

Concepts:

- Volcanic eruptions create landforms by adding new material to the earth's surface.
- Magma is molten rock beneath the earth's surface.
- Lava is magma that has reached the earth's surface.
- Lava flows, cools, and hardens on land and under water, forming layers of new rock.
- Signs that magma is intruding into a volcano include earthquakes, building lava domes, and steam blasts.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 12: "Viscosity and Volcano Types"

Objectives:

- Classify images of volcanoes on the basis of observable properties, including shape and size
- Identify and compare how three different liquid flows
- Observe changes in how two liquids flow when they are mixed with a solid
- Observe changes in how two liquids flow when they are heated
- Develop a working definition for the word "viscosity"

- Relate the viscosity of lave to the type of volcano formed, and model the formation of each type

Learning Activities:

- Students review their understanding of magma and lava
- Students are introduced to the concept that the materials ejected determine the shape and size of a volcano
- Students classify a set of volcano cards based on their observable properties of shape and size
- Students design a controlled investigation to test the variables that affect the viscosity of fluids: type of liquid, temperature of liquid, and presence of solids in the liquid. Students then apply their new understanding of viscosity by reclassifying the volcano cards into three categories.

Concepts:

- The shape of a volcano depends on several factors, such as the properties of the volcanic material ejected and the sequence and variety of the eruptions.
- One of the characteristic properties of a liquid is viscosity; or the tendency to resist flow.
- Viscosity mostly depends on the composition and temperature of the liquid.
- The viscosity of lava affects the type of volcano that forms.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 13: "Viscosity and Volcano Types"

Objectives:

- Observe the properties of peridotite
- Observe the properties of five igneous rocks
- Sort and classify igneous rocks on the basis of color, mineral composition, and texture

Learning Activities:

- Students observe one rock sample to generate a list of observations they can make about rocks in general
- Students develop a working definition of "rock"
- Students examine five samples of different igneous rocks and classify them based on texture and composition using they observable properties of crystal size and color
- Students begin to infer how these observable properties of rocks allow us to identify the conditions by which the rocks formed

Concepts:

- All rocks are made of minerals
- The melting caused by volcanic activity can change mineral compositions to form new rocks.
- Igneous rocks are formed by cooling magma or lava.
- The color of an igneous rock indicates its mineral composition, and the texture indicates its crystal size.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 14: "Volcanic Ash"

Objectives:

- Observe the properties of two igneous rock samples and their fragments
- Brainstorm ideas about volcanic ash and how it forms
- Model an ash fall and investigate how different-sized volcanic particles, such as ash, erupt into and settle out of the air
- Determine how the size of airborne materials affects where and how fast they settle
- Draw conclusions about how weather conditions, such as wind, affect the direction and speed at which ash moves
- Identify the constructive and destructive effects of ash fall
- Understand the atmospheric and geologic changes caused by volcanic eruptions can occur quickly and slowly over geologic time

Learning Activities:

- Students examine samples of pumice, tuff, breccias, and their fragments. Students hypothesize how these rocks formed
- Students use simple materials to model an ash fall and investigate how different-sized volcanic materials erupt into and settle out of the air

Concepts:

- Volcanic ash is made up, in part, of fine fragments of rock.
- Magma erupted from a volcano may shatter into an ash of tiny fragments of rocks, minerals, and glass.
- Volcanic ash may settle over large areas and impact people and wildlife.
- The size of airborne volcanic materials affects how they move into and settle out of the air.

Assessments:

- Laboratory Report, including data tables, charts, diagrams, and graphs, where applicable
- Class Discussion (Pre-lab, Post-lab)
- Reading selection discussion

Lesson 15: "Exploring Plate Tectonics Assessment"

Objectives:

- Review the concepts and skills learned in this unit
- Design and conduct an experiment to investigate the effect of loose soil verse packed soil on the way model buildings respond to shaking
- Use knowledge and skills acquired in this unit to answer questions related to plate tectonics
- Review correct responses to both parts of the assessments

Learning Activities:

- Students use the review materials to revisit the concepts that they encountered in the unit
- Students complete a performance-based assessment
- Students complete a set of multiple-choice and short-answer questions
- The teacher reviews the assessment with the students and discusses the results with them
- Students add to their group concept maps

Concepts:

- Concepts and skills of units

Assessments:

- Performance-Based Assessment
- Written Assessment

Standards

SCI.6-8.MS-ESS1-4	Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.
SCI.6-8.MS-ESS2-2	Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.
SCI.6-8.MS-ESS3-1	Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
SCI.6-8.MS-ESS2-1	Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.
SCI.6-8.MS-ESS2-4	Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
SCI.6-8.MS-ESS2-3	Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.

Resources

Smithsonian Institution - National Science Resources Center: *Exploring Plate Tectonics. The STC Program, 2014* .