

Geological Time - Water, W.P.A, and World

Adapted from: Old Water Activity, Project WET Curriculum and Activity Guide. The Watercourse and Council for Environmental Education (CEE) 1995.

Grade Level: Intermediate

Duration: 60 minutes

Setting: Classroom or hallway

Summary: Students will create time lines of the geologic history of Earth and Pennsylvania.

Objectives: Understand the age of Earth, compare the amount of time that Earth has existed to the events that have taken place, understand the geologic history of Western Pennsylvania and its effects.

Vocabulary: Principle of Superposition, relative age, absolute dating, fossils, era, period, epoch, Precambrian era, Paleozoic, Gondwanaland, Laurasia, Pangaea, Pennsylvania period, Permian period, Mesozoic era, Cenozoic era, topography, bedrock, sedimentary rocks, lithified, orogeny, till.

Related Module Resources:

- The Pennsylvania Geological Survey Educational Series of books
- Geologic maps of Pennsylvania from the DCNR

Materials (Included in Module):

- Two tape measures to use as time line
- Clothespins and binder clips
- Green and blue time line event tags

Additional Materials (NOT Included in Module):

- Art paper
- Markers, colored pencils, crayons

ACADEMIC STANDARDS: SCIENCE & TECHNOLOGY

7th Grade

3.5A Describe earth features and processes that change the earth

- Describe the processes that formed Pennsylvania geologic structures and resources including mountains, glacial formations, water gaps, and ridges.
- Explain how the rock cycle affected rock formations in the state of Pennsylvania.

3.5B Recognize earth resources and how they affect everyday life

- Identify and locate significant earth resources (e.g., rock types, oil, gas, coal deposits) in Pennsylvania.
- Explain the processes involved in the formation of oil and coal in Pennsylvania.
- Compare the locations of human settlements as related to available resources.

10th Grade

3.5A Relate earth features and processes that change the earth

- Compare examples of change to the earth's surface over time as they related to continental movement and ocean basin formation (e.g., Delaware, Susquehanna, Ohio Rivers system formations, dynamics).
- Interpret topographic maps to identify and describe significant geologic history/structures in Pennsylvania.
- Evaluate and interpret geologic history using geologic maps.
- Explain several methods of dating earth materials and structures.

12th Grade

3.5A Analyze and evaluate earth features and processes that change the earth

- Apply knowledge of geophysical processes to explain the formation and degradation of earth structures (e.g., mineral deposition, cave formations, soil composition).
- Interpret geological evidence supporting evolution.

3.5B Analyze the availability, location, and extraction of earth resources.

- Describe how the location of earth's major resources has affected a country's strategic decisions.
- Compare locations of earth's features and country boundaries.
- Analyze the impact of resources (e.g., coal deposits, rivers) on the life of Pennsylvania's settlements and cities.

BACKGROUND:

The Earth is approximately 4.6 billion years old! During this time, mountains were formed, dinosaurs became extinct, oceans have become smaller, and the continents have changed positions. These changes took a long time to occur and the continents are still slowly moving everyday. People who study the Earth and the changes that it goes through are called geologists. These scientists examine rocks to get clues about the history of the Earth. Geologists use the **Principle of Superposition** to determine if one rock is older or younger than the other based upon the rock's location.

Usually older rocks are on the bottom of a layer and younger rocks are on the top of the layer. Think about when you make a pizza; the crust is the first layer, then the sauce, then cheese and other toppings. The crust is on the bottom (oldest) and the pepperoni is on the top (youngest). This principle does not determine an exact age of the rock, instead it tells you the **relative age** of the rock; whether it is older or younger than another rock based upon its position. To determine the exact age of a rock geologists use **absolute dating** methods. This dating technique uses the constant rates of decay of radioactive materials. **Fossils** are also important clues to the age of a rock and the environment where it formed. Geologists know that certain animals and plants existed during specific time periods, like dinosaurs. When you find a rock with a dinosaur fossil you can conclude that the rock is at least as old as the dinosaur.

The history of the Earth is divided into time periods. Just like United States history is divided into millennia (every 1000 years), centuries (every 100 years), and decades (every 10 years). Since the Earth is so old, larger time periods were established to organize historical events. Geologic history is divided into **eras, periods, and epochs**.

The **Precambrian Era** covers approximately the first 4 billion years of Earth's history. During this time the first one-celled organism appeared and later during the period the first multicelled organisms appeared. The most common Precambrian fossils are stromatolites, a type of material deposited by algae.

The next era is the **Paleozoic**; it covers approximately 300 million years. The first life with shells appeared. The southern continents, South America, Africa, Antarctica, and Australia were joined together to form **Gondwanaland**. Later in the era, North America collided with Africa and the landmass formed **Laurasia**. By the end of the Paleozoic, all the continents fused together to form **Pangaea**. While the continents were moving new organisms began to appear. Insects and plants inhabited the land and amphibians evolved and diversified quickly. By the **Pennsylvania period** of the Paleozoic era, large tropical swamps extended across North America. These swamps became the source of coal deposits we use today. The **Permian period** was the last period of the Paleozoic era. During this period 75% of the amphibian families disappeared, 80% to 95% of marine life disappeared. The exact cause of the extinction is uncertain. Many scientists feel that the climatic changes brought on by the moving continents were too great for many species to adapt to.

The **Mesozoic era** is most famous for the dominance of the dinosaurs. The first birds appeared along with the first flowering plants. The supercontinent Pangaea began to break apart and the Atlantic Ocean was formed. The end of the Mesozoic era is marked by another mass extinction. The most strongly supported hypothesis for this extinction is that a large meteorite (approximately 6.2 miles or 10 kilometers in diameter) collided with the Earth at a speed of about 43,400 miles (69,846 kilometers) an hour.

The **Cenozoic era** began 65 million years ago and continues today. It is known as the "age of mammals". During this era the present day **topography** (the set of physical

features, mountains, valleys, shapes of landforms, that make up a landscape) of the Earth was formed.

Western Pennsylvania has a unique geologic history. In Western Pennsylvania the age of the **bedrock** (solid mass of rock that makes up the Earth's crust) is between the Permian period (250-290 million years ago) to the Devonian period (365-405 million years ago). The primary classification of rocks in PA is sedimentary. **Sedimentary rocks** are formed from the weathering of pre-existing rocks and sediments. The weathered products such as gravel, sand, silt, and clay are transported, deposited, and **lithified** (hardened) into sedimentary rocks. This is a time consuming process (like most geologic processes) and requires great pressure from burial as new layers are deposited on top. The rocks in Western Pennsylvania were formed through a series of **orogenies** (mountain building events), erosion and deposition by moving water and shallow seas. Pennsylvania was located at the equator during the Cambrian period (Paleozoic Era). Throughout geologic time the continents collided and shifted positions. These collisions of continents formed mountains.

During the Ordovician period (480-443 million years ago) Eastern North America collided with a volcanic island chain. This caused the Earth's crust to uplift and fold, forming mountains. The mountains underwent erosion and weathering producing sediments. These sediments were transported westward by rivers then deposited and lithified to form sedimentary rocks. During the Devonian period (417-354 million years ago) another orogeny occurred. When these mountains began to weather the sediments were transported and buried in shallow seas in the central and southwestern part of PA. This became home to sources of oil and natural gas. The seas became shallower and by the Pennsylvanian period swamps covered most of the state. These swamps produced coal through the accumulation of sediments and plant material under great pressure. The last orogeny occurred during the Permian period (290-248 million years ago). North America and Africa collided and the supercontinent Pangaea was formed. Enormous mountains arose in central Pennsylvania. Erosion and weathering took place throughout the break up of Pangaea until present day.

The landscape of Western Pennsylvania was once again altered during the Pleistocene epoch (1.8 million years ago during the Quaternary period). At least three glaciers entered Pennsylvania from Canada. With each glacier's movement southward came the erosion of deposits of earlier glaciers. Glaciers and their meltwater have tremendous erosional and depositional capabilities. The glaciers from Canada brought a mud-rich mixture of gravel, sand, silt, and clay. This mixture is called **till** and large boulders as well as chunks of ice were included. The movement of the glaciers carved deep valleys in the topography and glacial sediments filled them in. The sedimentary bedrock of Pennsylvania is now mostly covered with glacial sediments. Major river valleys were eroded and then filled in with glacial sediments altering the drainage patterns in Western Pennsylvania from flowing north into Lake Erie to flowing south to the Ohio River Watershed. Between each glaciation the climate became similar to that of today. It is possible that we are currently between glacial periods and in the future a glacier will grow in Canada and move southward into Pennsylvania.

OVERVIEW:

By constructing a time line of geologic history students will understand the time it takes for geologic processes to occur in relation to the age of the Earth. Students will examine the geologic history of Pennsylvania and how it affects us today. Students will also understand that geologic processes are taking place everyday and that the Earth is always changing.

PROCEDURE:

Teacher Preparation:

1. You may choose to photocopy the background section and distribute it to students prior to the activity. If students are unfamiliar with historic geological events, the background will help them attain a better understanding of the physical evolution of the Earth and Western Pennsylvania. Other resources on geological history can also be used - some of which can be found in the module.
2. There are two fiberglass measuring tapes in Box 2 "Extra Stuff". One roll (use only 10 m of it) will represent the geologic time line of the entire Earth. The other roll (use only 6 m of it) will represent the expanded portion of the Paleozoic era to the present day. Hang both rolls in the classroom or hallway. For the best comparisons, hang the 6 m expanded Paleozoic era to present time line below the 10m geologic time line of entire Earth. For both, the 0 cm mark (present day) should be on the right end, and the tape should extend from right to left (oldest time in history).
3. Using clothespins, attach the blue "Formation of the Earth" card on the left end of the Earth time line (10 m) and attach the blue "Present Day" card to the right end of the Earth time line. On the expanded time line (6 m), attach the green "Paleozoic and Cambrian period begin here" card on the left end and attach the green "Present Day" card on the right end. Then hang the correct name and scale cards at either end of both time lines. *Optional: You may also want to hang the correct colored clothespins on their respective time lines to show time intervals. A teacher help sheet is attached to this activity that will make arranging tags easier.*

Student Experiment:

1. All blue tags are for the Earth time line. All green tags are for the expanded time line. Tags that have information specific to Pennsylvania are *italicized*. The tags with a light blue water drop comprise water-related events. The tags with a light green dinosaur, fish, and plant stand for biology-related events. The tags that have orange rocks with a pick on them stand for rock and mineral creation events. The tags with yellow pictures of continents show geography-related events. The tags with red mountains and a river explain landform development events.
2. Have students randomly draw tags from an envelope or distribute them as desired. There are roughly 100 total different tags to be placed on the time lines, so students will have several tags each.

3. Using the laminated geologic time scales, "The Geological Story of Pennsylvania" booklet, and the background information to research their events, students should adjust their tags into their proper places on the time line. Some event tags may need to be attached to each other under the proper spot on the time line. Tags with time period events should be in order and spaced according to the help sheet. Events need not be placed exactly where they occurred, as long as they are placed within the proper time period.
4. After students attach all the tags, help the students arrange the time lines to scale. The blue Earth time line has a scale of 1 cm = 5 million years, while the green expanded time line has a scale of 1 cm = 1 million years.
5. *NOTE
On the Earth time line:
10 meters = 33 feet = 5 billion years = approximate age of the Earth
3.2 meters = 10.5 feet = 1.6 billion years = Oldest rocks in Pennsylvania are formed
2 meters = 6.6 feet = 1 billion years
2 centimeters = $\frac{3}{4}$ inch = 10 million years

On the expanded time line:
1 centimeter = 1 million years

DISCUSSION:

Is this what you expected to see on the time lines? *Students may have thought that life appeared much earlier. Point out to the students that Pennsylvania is only half as old as the Earth. Stress the fact that a lot happen to the earth in a relatively short amount of time relatively recently in geologic time.*

In what ways have the glaciers made the waterways what they are today? *Glaciers have carved into the land and deposited large amounts of sediment in northwestern Pennsylvania. Much of the water in the Great Lakes is from the melting of the last glaciers. The last glaciers also changed the direction of the western Pennsylvania waterways from flowing north into Lake Erie to flowing south into the Ohio River. Glacial till also contributed to the calcium carbonate in Northwestern Pennsylvania's waterways, which is important to acid buffering.*

How have orogenies made the waterways what they are today? *Orogenies have created the mountains in Pennsylvania, including the Appalachians, giving structure to the watersheds of Pennsylvania.*

What is the evidence of glaciers in Pennsylvania? *Non-native rocks (igneous rocks), deep cut valleys, glacial till in rivers.*

How did peat bogs form fossils? Coal? *Plants and animals that died and were preserved in peat bogs became compacted in mud and decaying material, which hardened over*

time. After much time and pressure coal will form from peat, the dead plant material found in peat bogs.

How has the geology of Pennsylvania shaped the types of resources available? *Large amounts of oil, natural gas, and coal.*

Why are there so many discrepancies in dates among sources? *Dating will always vary among sources when dealing with such large amounts of time. Although they may differ by millions of years, most sources compliment each other. Even with the technology we have today, scientists cannot provide precise dates for events that occurred millions and billions of years ago. In the grand scheme of things, however, the relative order and spacing of the events in time will typically not be effected by several million years.*

EVALUATION:

- Create two columns on the chalkboard. Label one "Geologic History of the Earth" and the other column "Geologic History of Western Pennsylvania". Have each student list an event in each column.
- Create a list of geologic events and have students place the events in relative order.

EXTENSIONS AND MODIFICATIONS:

- Refer to the books *Coal in Pennsylvania* and *Geology of Pennsylvania's Oil and Gas*. Have the students skim through the books and pay special attention to the maps. Locate yourself on the maps. How has the geology of Pennsylvania affected your area?
- Examine rocks that contain fossils. Have the students identify the fossils and approximate an age of the rocks. What type of environment were the rocks formed in?
- Attach large pieces of art paper (the kind that comes on rolls) to the time lines and ask students to draw a large mural of what the Earth may have looked like. Include life forms (if there were any), terrain (mountains, seas, volcanoes), and events (volcanic eruptions, meteorite impact, glacier movement).
- Allow students to come up with and place their own events on the timelines.
- Using the rock kit and geologic map of PA #7 DCNR, have students identify the rocks that are native to Western PA, i.e. sedimentary rocks. Then have them identify types of rocks that came into PA with glaciers, i.e. igneous rocks.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

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