

## Geologic Time - Water, W.PA, 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

**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, Pennsylvanian period, Permian period, Mesozoic era, Cenozoic era, topography, bedrock, sedimentary rocks, lithified, orogeny, till.

**RELATED MODULE RESOURCES:**

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

**MATERIALS (INCLUDED IN MODULE):**

- Two 2 tape measures to use as timeline
- Clothespins and binder clips
- Green and blue timeline event tags

**ADDITIONAL MATERIALS (NOT INCLUDED IN MODULE):**

- Art paper
- Markers, colored pencils, crayons

**ACADEMIC STANDARDS:**

*STEELS- 3.1 Life Science*

**6-8 Grade**

3.1.6-8.K Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem

3.1.6-8.O Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past

*STEELS- 3.3 Earth and Space Science*

**6-8 Grade**

3.3.6-8.D 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

3.3.6-8.E Construct an explanation based on evidence of how geoscience processes have changed Earth's surface at varying time and spatial scales.

**9-12 Grade**

3.3.9-12.H Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.

**OVERVIEW SUMMARY:**

By constructing a timeline 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 the Earth is always changing.

### **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 multi celled 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

### **BACKGROUND CONTINUED:**

organisms began to appear. Insects and plants inhabited the land and amphibians evolved and diversified quickly. By the **Pennsylvanian 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.

### **BACKGROUND CONTINUED:**

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 breakup 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.

### **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 timeline 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 timeline (10 m) and attach the blue "Present Day" card to the right end of the Earth timeline. On the expanded timeline (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 timelines. *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/Activity:*

1. All blue tags are for the Earth timeline. All green tags are for the expanded timeline. 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 timelines, so students will have several tags each.

### **PROCEDURE CONTINUED:**

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 timeline. Some event tags may need to be attached to each other under the proper spot on the timeline. 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 timeline has a scale of 1 cm = 5 million years, while the green expanded timeline has a scale of 1 cm = 1 million years.
  
5. \*NOTE  
On the Earth timeline:  
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 timeline:  
1 centimeter = 1 million years

### DISCUSSION:

- Is this what you expected to see on the timelines? *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 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 affected 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 & 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 leave suggestions you have for Teachers using this activity in the future):**





# Geologic Time - Stream Geology Module

## Teacher Help Sheet

### Entire Earth and Extended Timelines - *Geological Time - Water, W. PA, and World*

All blue event tags should hang on the earth timeline (4.5 billion years covered)- 1 cm = 5 million years and you use 9.2 meters of the tape measure.

All green event tags should hang on the extended (Paleozoic era - present) timeline - 1 cm = 1 million years and you use 5.7 meters of the tape measure.

- Light blue = water-related
- Light green = biology-related
- Orange = rock and mineral creation
- Yellow = geography-related
- Red = landform development

**\*\*Italicized events are Pennsylvania specific\*\***

TIME PERIOD and EVENT CARDS in activity	Placement location on the BLUE entire Earth timeline 1cm=5 million yr	Placement location on the GREEN expanded Paleozoic era - present timeline 1cm = 1 million yr
<p><b><u>Precambrian era</u></b>  <b>(4.5 billion to 570 million years ago)</b></p> <p><b><u>Hadeon eon (4.5-3.9 billion)</u></b></p> <ul style="list-style-type: none"> <li>■ Water appears with the formation of the atmosphere</li> </ul> <p><b><u>Archean eon (3.9-2.5 billion)</u></b></p> <ul style="list-style-type: none"> <li>■ First life appears (bacteria)</li> <li>■ Ocean basins form</li> <li>■ Earliest known fossils</li> </ul> <p><b><u>Proterozoic eon</u></b>  <b>(2.5 billion to 570 million)</b></p> <ul style="list-style-type: none"> <li>■ Blue-green algae and worms appear</li> <li>■ Oldest rocks in Pennsylvania are formed (3.2m)</li> </ul> <p><b><u>Paleozoic era</u></b>  <b>(570 million to 250 million)</b></p> <p><b><u>Cambrian period (570 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Transgression of the sea</li> <li>■ <i>**Pennsylvania covered with shallow water. Western Pennsylvania has a sandy bottom. Eastern Pennsylvania has a carbonate bottom.</i></li> <li>■ First trilobites appear</li> </ul>	<p>9.2 m</p> <p>7.8 m</p> <p>5.0 m</p> <p>1.14m</p>	<p>No</p> <p>No</p> <p>No</p> <p>5.7m</p>

TIME PERIOD and EVENT CARDS in activity	Placement location on the BLUE entire Earth timeline 1cm=5 million yr	Placement location on the GREEN expanded Paleozoic era - present timeline 1cm = 1 million yr
<p><b><u>Ordovician period (500 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Taconic orogeny develops the Appalachian basin</li> <li>■ <i>Water covering Pennsylvania drains</i></li> <li>■ First mollusks and fish</li> </ul>	1.0 m	5.0 m
<p><b><u>Silurian period (430 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Erosion of mountains</li> <li>■ Deposition of sand and mud by streams and rivers</li> </ul>	86 cm	4.3 m
<p><b><u>Devonian period (405 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Acadian orogeny</li> <li>■ First amphibians, insects, and land plants appear</li> <li>■ Oil gathers within sandstone deposits</li> <li>■ <i>Dunkleosteus, a large fish, inhabited Pennsylvania in the regions now known as Crawford, Warren, and Erie counties</i></li> <li>■ <i>During this period, the following rocks formed in Pennsylvania: red sandstone, gray/black shale, limestone, and chert</i></li> <li>■ <i>Oldest bedrock in Western Pennsylvania formed</i></li> </ul>	81 cm	4.05 m
<p><b><u>Mississippian period (365 million)</u></b></p> <ul style="list-style-type: none"> <li>■ First trees and ferns appear</li> <li>■ The shoreline of what we know as present day North and South America advances eastward</li> <li>■ Coal and fossils begin to form due to peat bogs</li> <li>■ <i>During this period, the following rocks formed in Pennsylvania: red/gray sandstone, shale, and limestone</i></li> </ul>	73 cm	3.65 m



## Geologic Time - Stream Geology Module

TIME PERIOD and EVENT CARDS in activity	Placement location on the BLUE entire Earth timeline 1cm=5 million yr	Placement location on the GREEN expanded Paleozoic era - present timeline 1cm = 1 million yr
<p><b><u>Pennsylvanian period (323 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Other plants begin to take hold</li> <li>■ First air breathing mollusks and reptiles appear</li> <li>■ <i>Anthracite (coal) forms in eastern Pennsylvania</i></li> <li>■ <i>During this period, the following rocks formed in Pennsylvania: sandstone, red/gray shale, conglomerate, clay, and limestone</i></li> </ul> <p><b><u>Permian period (290 million)</u></b></p> <ul style="list-style-type: none"> <li>■ <i>Alleghanian orogeny forms the Appalachian mountains through collisions between North America and Africa</i></li> <li>■ Much erosion takes place</li> <li>■ Extinction of trilobites and many other marine animals</li> <li>■ <i>During this period, the following rocks formed in Pennsylvania: shale, sandstone, limestone, and bituminous (coal)</i></li> </ul>	65 cm	3.23 m
<p><b><u>Mesozoic era (245-65 million)</u></b></p> <p><b><u>Triassic period (245 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Gradual separation of North America from Africa. Pangaea begins to break up</li> <li>■ <i>Pennsylvania begins to move from the equator into the Northern Hemisphere</i></li> <li>■ First dinosaurs appear and become the dominant life species on Earth</li> <li>■ First mammals appear</li> </ul>	58 cm	2.9 m
<p><b><u>Jurassic period (208 million)</u></b></p> <ul style="list-style-type: none"> <li>■ The Atlantic Ocean begins to open.</li> <li>■ First birds appear</li> </ul>	49 cm	2.45 m
<p><b><u>Cretaceous period (145 million)</u></b></p> <ul style="list-style-type: none"> <li>■ <i>Much erosion and weathering of the Appalachian mountains occurs, forming the landscape of today</i></li> <li>■ First flowering plants appear</li> <li>■ Sevier orogeny</li> <li>■ Dinosaurs become extinct</li> </ul>	41 cm	2.08 m
	21 cm	1.45 m

TIME PERIOD and EVENT CARDS in activity	Placement location on the BLUE entire Earth timeline 1cm=5 million yr	Placement location on the GREEN expanded Paleozoic era - present timeline 1cm = 1 million yr
<p><b><u>Cenozoic Era (65 million to present day)</u></b></p> <p><b><u>Tertiary period (65-5.3 million)</u></b></p> <p><b><u>Paleocene epoch (65 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Laramid orogeny</li> </ul> <p><b><u>Eocene epoch (57.8 million)</u></b></p> <ul style="list-style-type: none"> <li>■ First primates, horses, monkeys, and whales appear</li> <li>■ Himalayas and Andes form.</li> <li>■ Global cooling begins.</li> </ul> <p><b><u>Oligocene epoch (36.6 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Ice cap forms on Antarctica</li> <li>■ First apes appear</li> </ul> <p><b><u>Miocene epoch (23.7 million)</u></b></p> <ul style="list-style-type: none"> <li>■ <i>The landscape of today is sculpted</i></li> <li>■ <i>The rivers, creeks, and rivulets of Pennsylvania form</i></li> </ul> <p><b><u>Quaternary period (5.3 million-present day)</u></b></p> <p><b><u>Pliocene epoch (5.3-1.6 million)</u></b></p> <ul style="list-style-type: none"> <li>■ Ice sheets form in the Northern Hemisphere</li> </ul> <p><b><u>Pleistocene epoch (1.6-present day)</u></b></p> <ul style="list-style-type: none"> <li>■ The Ice Age occurs (much glaciation)</li> <li>■ First Homo erectus appears, followed by Neanderthals and Homo sapiens</li> <li>■ <i>Sand, silt, clay, and gravel (glacial till) are deposited in NW Pennsylvania</i></li> <li>■ <i>Glacial till creates a vast groundwater aquifer in NW Pennsylvania containing calcium carbonate, which buffers acid precipitation</i></li> <li>■ <i>The waterways of Pennsylvania change to how they are now, from feeding Lake Erie to feeding the Ohio River due to glacial retreat and deposited glacial till</i></li> <li>■ Coal mining begins</li> <li>■ <i>Oil is discovered in sandstones that were formed during the Devonian period</i></li> <li>■ <i>Creek Connections started at Allegheny College</i></li> </ul>	<p>13 cm</p> <p>11.2 cm</p> <p>7.2 cm</p> <p>4.5 cm</p> <p>1.3 cm</p> <p>0.2 cm</p>	<p>65 cm</p> <p>57.8 cm</p> <p>36.6 cm</p> <p>23.7 cm</p> <p>5.3 cm</p> <p>1.6 cm</p>