

COAL FORMATION AND TIMELINE

<input type="checkbox"/> Grade Level: Middle/High School	<input type="checkbox"/> Subject Areas: Chemistry, Environmental, Art, Social Studies	<input type="checkbox"/> Setting: Classroom
<input type="checkbox"/> Duration: 2 hours	<input type="checkbox"/> PA Academic Standards: 1.6.8A; 3.2.10A; 3.5.10A,B; 3.5.12B; 4.2.7A; 4.2.10A; 8.1.6A; 8.1.9A; 8.2.9C	<input type="checkbox"/> Keywords: Coal, mining, Pennsylvania, coal formation, heat, plants

SUMMARY

Students examine when coal was formed with the yarn timeline adapted from Project Wet and discuss how coal was formed. An exploration of what Pennsylvania looked like 300 million years ago will provide the background necessary for a hands on activity demonstrating the layering, decomposition, and pressure necessary for coal formation.

OBJECTIVES

- Given dates and materials, the student will work cooperatively to develop a timeline depicting the beginning of the earth to current day, emphasizing the formation of coal.
- Describe the plants that existed during the Pennsylvania period.
- Demonstrate how the inland sea assisted with the formation of coal.
- Using the timeline and class discussion, the student will explain how, when and where coal formed.

MATERIALS

- A. Timeline
 - a. 10 meters of yarn (5 Billion Years)
 - b. Index cards or slips of paper for each student to add to the timeline
 - c. Clothespins (Spring)
- B. Formation of Coal
 - a. Paint tray/Aluminum-baking pan – 30 if working individually, less if working in groups
 - b. Flour
 - c. Salt
 - d. Water
 - e. Food coloring (optional)
 - f. Sand/Sediment
 - g. Leaves and Twigs
 - h. Water
- C. Miscellaneous
 - a. Coal in Pennsylvania – Bureau of Topographic and Geologic Survey Education Series No. 7
 - b. The Geological Story of Pennsylvania – Bureau of Topographic and Geologic Survey Education Series No. 4

BACKGROUND

Over 300 million years ago, Pennsylvania was positioned near the equator and nearly flat with no ridges or mountains. The temperature and landscape of Pennsylvania was much different than today, the climate was tropical and there were no common trees like oak, pine, maple, and no grass. The area was covered with giant trees and ferns, up to 100 feet with large leaves, sometimes 30 inches to 3 feet long. Primitive animals, such as amphibians and reptiles were beginning to appear and insects, like dragonflies loved the lush swampy forests.

When the seas would rise, the sand would bury the decomposing plants, which contained carbon, hydrogen and oxygen. The sediment caused the decomposition to stop and the pressure from the sediment assisted in the coal formation. Also assisting with the formation of coal is heat, which is associated with the formation of mountains. Coal, the final product of all this decomposition, pressure and heat, has different classifications depending on the stage it is (peat, lignite, bituminous or anthracite coal) and the composition.

PROCEDURE

WARM UP

Show a piece of coal to the students and ask them:
How long did it take to make that piece of coal?
Who was the first person to discover King Coal?
How and why was it first used?

THE ACTIVITY – COAL TIME LINE

Coal Time Line (Adapted from Project WET – Old Water)

Create a yarn time line

1. Hang a 33-foot (10 meter) section of rope on the wall or across the room. – This represents 5 billion years – every 2 meters equals 1 billion years, every 2 cm equals 10 million years.
2. Attach index cards to label each end of the rope as “Earth formed” and “Now” respectively
3. Attach cards the following distances from “Now”:
 4. 7.5 meters - “Water on Earth”
 5. 7.0 meters - “Earliest forms of life”
 6. 60 cm - “Formation of Coal”
 7. 40 cm - “Dinosaurs Dominated the Earth”
 8. Hang the 4-foot piece of rope at the end marked “Now” so that it hangs vertically. At the top of this piece, draw a line on an index card that measures 2mm in length and label it “Existence of man” and hang it on “Now”.
9. Pass out index cards to each student and ask them to label key events in the Earth’s history to be placed on the time line. Also ask students to label events that have happened since the “Existence of man”. (Use the attached time line to show the formation of coal and mining.)

Some Coal Dates for NOW Time Period – All of Human History

1. 4th Cent. BC – Aristotle mentioned coal in his book, Meteorology
2. 13th Century – Coal used commonly in Europe
3. 1672 – Coal mentioned on Cape Breton Island, Canada
4. 1673 – Map by explorer Joliet shows coal location in Illinois
5. End of 17th Century – Long Wall Mining Discovered and Developed in Shirophshire, England
6. 1701 – Coal found along James River
7. 1752 – Coal found along the Kiskiminetas River by Joe Pattin
8. 1755 – Coal was utilized in U.S.
9. 1761 – Earliest record of actual coal mining in PA on “Plan of Fort Pitt and Parts Adjacent”
10. 1762 – First clear record of anthracite coal by John Jenkins Sr.
11. 1769 – First use of anthracite coal by the Gore Brothers in their blacksmith shop at Wilkes-Barre, PA
12. 1816 – Baltimore Maryland, first city to light streets with gas made from coal
13. 1830 – numerous small mining operations in U.S.
14. 1839 – Steam Shovel Invented
15. 1866 – Strip Mining Began – horse drawn plows
16. 1875 – Coal replaced charcoal as chief fuel for iron blast furnaces
17. 1896 – General Electric Company build first power plant
18. Late 18th Century – Coal Mining appeared in the US.
19. 1917 – Pennsylvania produced 278 million tons of coal worth \$705 million
20. 1990 – US Coal production 1 billion tons/year

Discuss that we know when coal was formed, but do we know how?

1. Was it formed when the earth was formed?
2. Did it appear when the continents shifted?
3. What was coal originally before it was converted into coal?

EXPLORE – How did Pennsylvania look 300 million years ago?

1. You can have the students search the Internet, use resources and other forms of material to discover what Pennsylvania looked like, especially Southwestern Pennsylvania.
 - Trees - 20 to 40 feet tall
 - Very humid tropical climate
 - No mountains, ridges or valleys.
 - PA land was low and flat with streams leading to coastal swamps and marshes in the west. East of Pennsylvania there was an inland sea covering the central states.
2. What elements are common constituents found in plants?
 - Carbon
 - Hydrogen
 - Oxygen

Discuss what the plants were like during this time. Use of the Bureau of Topographic and Geologic Survey Education Series No. 7 – Coal in Pennsylvania is very beneficial.

It is available at <http://www.dcnr.state.pa.us/topogeo/education/ed.htm>

- Lepidodendron – Very tall slender trees up to 100 feet high with narrow leaves up to 30 inches long.
- Cordaites – an ancestor of the modern pines and spruces, sometimes topping 100 feet, with large, straplike leaves up to 3 feet long.
- Calamites – a tree-like relative of the inconspicuous modern horsetails, grew to a height of 20 to 40 feet.
- Sphenophyllum – a low shrub that formed much of the underbrush of Pennsylvanian time.
- Ferns (True and Seed) – Pecopteris, Alethopteris, Odontopteris, Linoteris, Mاريوpteris, Neuropteris, up to 40 feet high

HANDS-ON - Have the students begin making a mock Pennsylvania with the homemade play dough made by them or by the teacher.

1. Use a pan, a disposable baking pan or plastic basin or paint tray will work.
2. Have the students begin developing what a section of Southwestern Pennsylvania would look like with the homemade play dough (see recipe in notes). Emphasizing that this was chosen because SW Pennsylvania has a great and rich coal history. (SHOW PICTURE FROM NRCS - COAL IN PENNSYLVANIA, Educational Series No.7.)
3. One side of the section should be partial inland sea, called the Appalachian Sea (preferably at the left of the pan, since SW PA was an inland sea), then a swampy area (where a beach would be in current times), and then the land with streams, but not high mountains...
 - Streams in Pennsylvania were braided and meandering.
 - Braided streams had many interconnected channels and deposited mainly sand and some gravel.
 - Meandering streams had a single channel wandering in a curved path and deposited sand, silt and clay.
4. At the swampy area and into the sea, place a layer of sand, then a layer of dirt.

The Decomposition of Leaves

1. Many of the swamp-like trees would loose leaves and die.
2. The leaves would settle to the bottom of the swamp and begin decomposing.
3. The decomposition is not complete because the stagnant water in the swamps stops the decaying process.
 - Who has a compost pile at home? If it is too wet, does the material decompose as quickly? No.
4. This partially decomposed material is peat, the beginning of coal.

HANDS-ON - Have the students add the following to their model.

1. Plants if you wish to have them create the look of the swamps in Southwestern Pennsylvania. They can be made from the play dough or use actual twigs.
2. Add crushed up leaves where there would be swamps.
3. Add water to the model to show a couple things:
 - Where the water will drain to – the inland sea
 - The swampy areas.
4. Have the students add more leaves and water to the swamps.

Explain how coastal erosion works (it is very similar to how coal is formed).

1. As waves near the shore or in this case the swamps, it breaks and releases stored energy, which causes erosion and the transport and deposition of sediments.
 - As the wave curls over, the sediment is pulled out into the sea with the undercurrent. Have the students think of the wave as a circle, it will curl over than continue on back out to sea.
 - Rivers can also supply new sediment to the coast.

Formation of Coal

1. Peat – The leaves fall into the swamps where, the bacteria and break down the cell structure and reduce the plant material to rotted wood and leaves or peat. How long the material is in this stage depends on how much the oxygen could work until the oxygen is cut off.
2. Burial of Peat – The peat is buried by the sediment, sand and mud in the swamp and the bacteria action will stop.
 - This can happen numerous times causing several layers of peat to accumulate underneath the ground.
 - 10 feet of peat produces a 1-foot coal seam. Therefore, the vegetation must have been immense to produce the large coal seams we have in the region.
3. Coal and Pressure –
 - The sediment buries the peat and the weight compacts the peat into a small fraction of its original thickness.
 - Mountain formation is also another source of pressure. As the mountain chains are pushed up, there is great force exerted.
4. Coal and Heat – When mountains are formed, the temperature usually increases due to the grinding and rubbing together of the rocks.

Hands-On

1. Using the mock Southwestern Pennsylvania coastal system.
2. Use a sprinkler bottle or other item to add water to the system to show students where the water would be.
3. The water should end up in the ocean and swamp.
4. Add leaves, twigs, and branches to the swamps and show the students that it will sink into the waters of the swamp where they grew, bacterial will break down the cell structure and reduce the plant material to rotted wood and leaves (peat).
5. Add sediment either sand or mud to bury the peat and cut off oxygen.

WRAP UP

Review

Was coal here from the beginning of the earth?

Coal wasn't here from the beginning of the earth; it was formed during the Pennsylvanian and Mississippian Periods from 290 – 354 million years ago.

What was Pennsylvania like during the Pennsylvanian and Mississippian Period? Southwestern Pennsylvania had an inland sea covering the entire region; it was very humid and tropical. Very large trees and no mountains like today.

What happened that caused the coal to be formed? Coal is formed from the peat, which comes from the decomposing plant material in the swamps. The peat is then buried with sediment, which applies pressure and compacts the decomposing material. Also assisting in the formation of coal is the heat that was produced during mountain formation.

Are we able to replace the coal that has been removed over the years? No, coal took millions of years to be formed, and the temperature, plants and landscape shaped the formation of coal. The current day Pennsylvania's climate, landscape and plant life are not the appropriate ingredients to coal formation.

ASSESSMENT

Evaluate the students understanding through their response to the questions and the design of their model.

- Teacher will visually assess the ability to work cooperatively and develop a timeline depicting the beginning of the earth to current day, emphasizing the formation of coal. **(Objective 1)**
- Teacher will use verbal checking to evaluate the student's knowledge of the plants that existed during the Pennsylvania period. **(Objective 2)**
- Teacher will evaluate the coal formation model developed by the student. **(Objective 3)**
- Teacher will test the student's knowledge about how, when and where coal formed through the use of a quiz. **(Objective 4)**

EXTENSIONS

Extensions: *Follow-up activities?*

1. Bottle Biology (ISBN – 084038601X)– The decomposition of leaves can be see with an activity in the Bottle Biology Book, but in contrast, it can also demonstrate what can happen when the leaves are left in stagnant water like in a swamp, the decomposition will not take place as rapidly, because it creates an anaerobic environment.
2. A visit to a Coal Mine – Tour Ed Mine in Tarentum, Pennsylvania, Seldom Seen Mine, Patton, Pennsylvania

CREDITS: (material used from)

Project Wet
DCNR Educational Series 4, 7

NOTES:

Play Dough

- 1 cup of salt
- 1 cup of flour
- 1/2 cup of water
- Food coloring (optional)

Directions

Put salt and flour in a deep unbreakable bowl. Mix the dry ingredients thoroughly with hands or a wooden spoon. Slowly add water. Continue to mix, and then knead dough until it is smooth and elastic without being sticky. Have students flour their hands to avoid a large mess. Add flour if necessary to produce a play dough like consistency.