Cupcake Drilling

Lesson Plans and Activities

Targeted Age:

Elementary to High School

Activity Structure:

Individual Activity

Indiana Standards and Objectives:

K.PS.1, 2.PS.1, 3.ESS.3, 4.ESS.3, 7.ESS.2, 7.ESS.3, 7.ESS.4, ES.5.3, ES.5.4, ES.5.5, Env.2.11, Env.3.1, SEPS.1, SEPS.2, SPES.3, SEPS.4,SEPS.6

MATERIALS NEEDED

- 1:500,000-scale bedrock map (MM48)
- 1:500,000-scale surficial map (MM49)
- White cake mix
- Frosting
- Food coloring
- Foil baking cups (must be opaque)
- Cupcake or muffin pan
- Plastic cutlery
- Clear plastic straws (large straws from Arby's are the best)
- Crayons, markers, or colored pencils

Introduction

In this lesson, students will model geologic drilling using layered cupcakes to learn about rocks below the Earth's surface. Students will locate features on a geologic map and observe cupcake cores to evaluate the scientific techniques used in the study of Indiana's subsurface geology.

Background Information

The study of Indiana's geology is commonly divided into the study of bedrock and unconsolidated sediment. Indiana's bedrock, deposited 540 to 300 million years ago, is composed of layers of sedimentary rock that occur at or below the Earth's surface. The bedrock forms a broad anticline, or arch, that plunges slightly to the northwest. In the southeastern part of Indiana, this arch is known as the Cincinnati Arch, and in the northwestern part of the state it is called the Kankakee Arch. The youngest bedrock in Indiana is found in the southwest, while the oldest rocks are exposed in the southeast and northwest along the axis of the anticline. Indiana also contains several named faults, such as the Mt. Carmel Fault that extends from Morgan County south through Monroe and Lawrence Counties into Washington County. A concentrated area of faults in the southwestern part of the state is known as the Wabash Valley Fault System. The spatial distribution of rock types and their ages, as well as the faults and folds that occur in the

subsurface can be found on the Bedrock Geologic Map of Indiana (MM48).

Indiana's bedrock is exposed only in outcrop and along river valleys in the south-central and central parts of the state. The majority of the bedrock surface is covered by up to 500 feet of unconsolidated sediment. These sediments, deposited during the advances and retreats of Pleistocene-age glaciers (2.6 million–12,000 years ago), are stacked atop one another and interlaterally woven over the bedrock surface. Till forms flat to hummocky plains that are found in the central portion of the state, punctuated by subtle recessional moraines in northeastern Indiana. Outwash is prevalent in northern Indiana and along major river valleys that once served as meltwater drainages, notably the Eel, Kankakee, Whitewater, Wabash, White, and Ohio Rivers. Outwash deposits form broad fans, mounds, and sinuous ridges and line valley bottoms. These deposits provide commercially viable sand, gravel, and groundwater resources for Indiana. The distribution of surficial geologic materials can be found on the Quaternary Geologic Map of Indiana (MM49).

Geologists have gained a great deal of information about Indiana's geology through geologic drilling. Geologic drilling is the creation of small holes in the earth's subsurface to sample sediment, rock, or groundwater. These samples of rock or sediment are called cores and are invaluable to the creation of geologic maps. Because exposures of rock and sediment are scarce (especially in the northern two-thirds of the state) and geophysical methods generally cannot identify rock type, geologists must drill into the earth to study the subsurface. The Bedrock Geologic Map of Indiana, for example, was created through detailed analysis of tens of thousands of drill holes! Geologic maps provide valuable information on the locations of geologic hazards (earthquakes, landslides), energy and mineral resources (coal, oil, gas, sand, gravel, stone), and environmental resources (groundwater). Scientists, government agencies, and the general public can use geologic maps to make informed decisions regarding the wise use and stewardship of Indiana's natural resources.

Vocabulary

Bedrock – solid rock at or below the Earth's surface
Core – a cylindrical sample of rock or sediment produced by drilling into the Earth
Geological Drilling – the creation of holes in the Earth's subsurface to sample sediment, rock, or groundwater
Geologic Map – a map that represents the distribution of rock and/or unconsolidated deposits, as well as the locations of geologic structures such as faults or folds
Subsurface – layers below the earth's surface
Unconsolidated Sediment – loose sediments that lay on top of the bedrock surface; are not generally cemented or bound together

Procedure

1. Prepare layered cupcakes prior to beginning the lesson. See baking instructions below.

   Mix the batter according to cake mix directions. Separate the batter into three bowls and add drops of food coloring to each bowl until desired color is achieved. Line a cupcake pan with foil baking cups. Spoon one tablesoon of each colored batter into the foil cup; order of color does not matter, and layers do not need to be smooth or uniform. Continue adding batter until the foil cup is half full. Bake according to cake mix instructions. Mix green (for grass) or brown (for soil) food coloring into the frosting. Once the cupcakes have baked and cooled, ice the top so that no part of the cupcake is showing.

2. Distribute a cupcake, plastic cutlery, three straws, and student data sheets to each student. Instruct students to not touch or eat the cupcake until told to do so.

Figure 1: Colored layers of a cupcake for student activity

3. Review the vocabulary terms and surficial and bedrock maps of Indiana. Explain that each cupcake represents a small part of the Earth.

4. Ask the class what techniques could be used to determine what the cupcake looks like inside. Common answers include:

   - Scrape back the icing- This will show the cupcake's surface, much like a bulldozer is used to expose rock, but it does not expose rocks at depth.

   - Cut or bite into the cupcake: This would work similiar to man-made outcrops (quarries, pits, roadcuts) or natural outcrops (river valleys). Unfortunately, outcrops are scarce, not always located where information is needed, and limited in depth below the surface.

   - Use an "X-ray machine": This is similiar to ground-penetrating radar and seismic shockwaves that allow geologists to image the earth below their feet. However, this approach does not tell geologists what type or age the rocks are, only how they are arranged.

   - Use the straw to drill into the cupcake: Correct answer! The straw can drill into the cupcake to reveal the layers below the surface. Geologists call these samples a core. Tens of thousands of cores were analyzed to produce the bedrock geologic map of Indiana.

Procedure Continued

5. Instruct students to use one straw to drill a hole directly into the center of their cupcake. Hold the straw upright and rotate it *slowly* until it reaches the bottom of the cupcake. Pull the straw out to reveal the colored layers of the core.

6. Instruct students to draw the colored layers of their core on their data sheet.

7. Using a clean straw, drill a second hole into the cupcake and draw the colored layers of the core on the data sheets. Repeat until all three cupcake cores are drilled and drawn.

8. Students will connect the contacts between the colored layers of the three cores to create a cross section of their cupcake. Ask students to make an inference on what the interior of cupcake looks like based on their core observations.

9. Use the plastic cutlery to cut the cupcake in half. Students should cut through their core holes in a straight line.

10. Instruct students to draw the cupcake interior once it is cut open. Compare the student's cross section to the actual cupcake layers.

Figure 2: Students modeling geologic drilling with layered cupcakes

Figure 3: Cupcake interior

If most of Indiana's bedrock is covered with unconsolidated sediment, how do geologists determine what is below the surface?

Cupcake Drilling

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Name:

_____

Class Period:

_____

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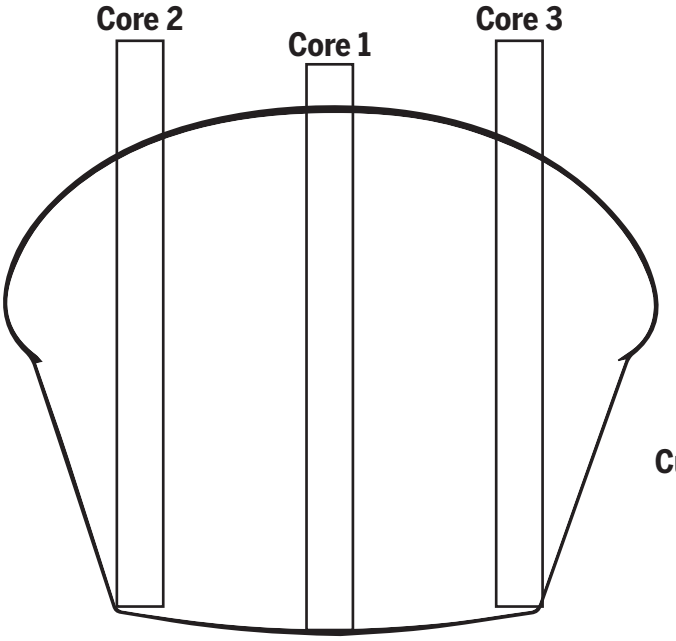
Student Data Sheet

1. Use a straw to drill a hole directly into the center of your cupcake. Pull the straw out and draw the colored layers in Core 1 below.

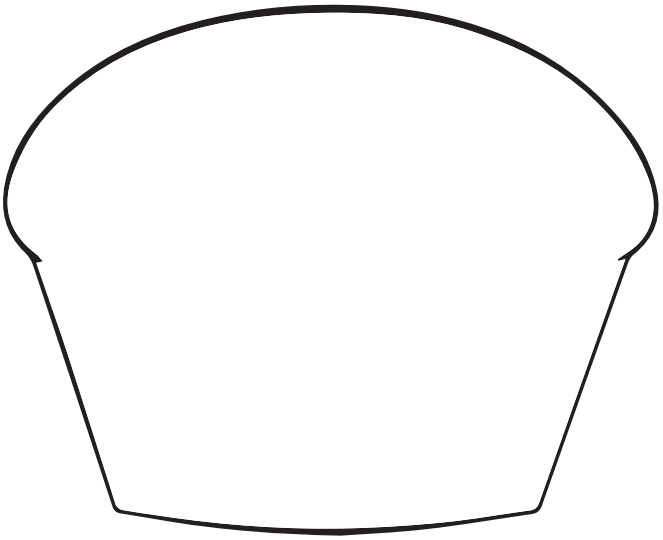


Cupcake cores and cross section

2. Use new straws to drill Core 2 and Core 3. Draw your cores in the spaces above.

3. Connect the contacts between the colored layers of the cores to create a cross section in the space above. Use your observations of the core to make an inference of what the cupcake looks like inside.

4. Cut the cupcake in half. Draw the inside layers of the cupcake in the space below.



Actual cupcake interior

Reflection Questions

1. Compare your cupcake cores to the cupcake that you cut open. What are the differences between your cross section and the actual cupcake interior?

2. What could you have done to make a more accurate cross section? Explain your answer.

3. Describe the difference between bedrock and unconsolidated sediment.

4. Why do geologists study the subsurface? List 3 reasons why someone would need to know what rocks and sediment are below the surface.