Cave of the Winds Activity Ten: Relative and Absolute Dating of Geologic Materials

Lesson for Grades 9-12
One lab of about 50 minutes

Satisfies Colorado Model Content Standard for Science, Standard 4, Benchmark #6 for grades 9-12: Evidence is used (for example: fossils, rock layers, ice cores, radiometric dating) to investigate how Earth has changed or remained constant over short and long periods of time (for example: Mount St. Helen's eruption, Pangaea, and geologic time). Prerequisite: some knowledge of elements

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It's Not Your Average Friday Night: Relative and Absolute Dating of Geologic Materials

Objectives

The learner will:

1. Understand the difference between relative dating and absolute dating techniques used to determine the age of geologic deposits.
2. Recognize some of the ways each dating technique may be used at Cave of the Winds or other spots in our region.

Vocabulary

Radiometric dating, half-life, geologic laws, cross-cutting relationships, billions of years, Uranium/Thorium dating, Potassium/ Argon dating, luminescence dating, electron-spin resonance dating, absolute dating, cultural materials, Law of Horizontality, Law of Superposition, Law of Uniformitarianism, crosscutting relationships, biomarkers, volcanic ash, parent material, daughter product, elements, radioactive decay, half-life, radiocarbon, biomarkers, ash, timeline, schematic diagram, cross-section, exponential decay, x-y graph, results, constant decay curve, average, unconformity.

Background Information

Geologists determine the age of rocks through two different methods: relative dating and absolute dating. Relative dates of rocks are determined using standard geologic laws (Law of Horizontality, Law of Superposition, and Law of Uniformitarianism), crosscutting relationships, fossils, and cultural materials to tell "relative ages" from one geologic unit relative to another. The Law of Horizontality suggests that layers of rock are deposited horizontally and those that are not horizontal have been subjected to later movement. The Law of Superposition states that the lower layers of rock are older than those deposited above them. And the Law of Uniformitarianism suggests that Earth processes that occur today occurred in the past and produced similar geologic features. Crosscutting relationships look at how rocks and sediments are deposited in relation to each other (if a river erodes a previous river deposit and then the new river deposits sediment, the younger deposit versus older layer may be deciphered. As organisms and humans have evolved through time, fossils and archaeological sites may also give a relative age to the rock in which they are found. Any of these relative dating techniques or a combination of several of them enable geologists to determine that "rock layer X is older than the layer below it, rock layer Y," but they do not allow geologists to attach an age number to the rocks.

For determining the age of a rock in more specific numbers, geologists need to absolutely date the rocks. While there are different methods of absolute dating techniques that cover different time spans (it is hard to determine the age of rocks that are billions of years old!), the most common way of determining absolute ages is with radiometric dating. Radiometric dating can be performed on minerals within the rocks because certain elements within the minerals decay through time at a known rate. Radiocarbon dating, a form of radiometric dating that is performed on carbon materials, may date carbon material grown the last 40,000 years. Radiocarbon dating is useful in determining the age of archaeological material as well as other carbon and carbon dioxide, such as that found in carbonates and groundwater. Most cave

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decorations or speleothems are dated with Uranium series (U-Th dating) techniques, another radiometric dating technique however. In this lesson, students will learn absolute dating techniques through a hands-on activity.

Pre-activity Thought Questions

How can you tell the age of objects? Rocks? Landscapes?

Activity: Absolute Dating

Materials needed:
M&Ms or pennies (100 each group)
Plastic containers with lids
Graph paper

The teacher will:

1. Define absolute dating and discuss several types.
2. Give students, separated in groups, a plastic container filled with 100 pennies or M&Ms.
3. Have them turn the pennies or M&Ms face up (either heads up or with the Ms showing, respectively). X-Y graphs should be discussed because this experiment should be plotted on the graph paper with number of shakes on the x-axis and the number of heads/Ms remaining face-up on the y-axis.
4. The students should shake the plastic container (with the lid on) just once and remove the pennies or M&Ms facing downward and count the number of remaining heads or Ms face up. Again, students should plot results after each shake.
5. Continue the process until all the pennies or M&Ms have faced down and have been removed from the container. Students should produce exponential decay curves representing the exponential decay of elements, which is measured in the laboratory to produce a "constant decay rate" that is used in absolute dating.

Follow-up questions

In what instances would you use relative dating? Where would you use absolute dating?

Alternative Assessments

1. Have students research specific radiometric dating techniques (i.e. radiocarbon, electron spin resonance, luminescence dating, Uranium-Thorium dating, Potassium-argon dating, etc.)—be sure they include the type of material that is dated, the half-life of the element, and the time span applicable.
2. Research the specific dating controls used in a National Park in Colorado.

Bibliography

Marshak, S. ***Earth, Portrait of a Planet.*** New York: W.W. Norton & Co. 2001.
USGS geologic time web page: **http://pubs.usgs.gov/gip/geotime/**

Additional Reading and Other Resources

Minnesota State University Archaeology Department web page:
http://emuseum.mnsu.edu/archaeology/dating/index.shtml
Montana State University Dating Vocabulary:
http://btc.montana.edu/nten/trc/lesson5/vocab5_text.shtml

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