

SCIENCE AT HOME

GEOLOGIC DATING

GRADE: **12**

SES4U

SUBJECT: EARTH AND SPACE SCIENCE
STRAND: PLANETARY SCIENCE; RECORDING EARTH'S GEOLOGIC HISTORY

TOPIC: RELATIVE AND ABSOLUTE DATING

EXPECTATIONS: C.1.2, C1.2, D.2, D2.4, D2.6, D.3, D3.4, D3.5, D3.7, E2.2

VIDEO: youtu.be/Sq9GYhgyDi0

INTRODUCTION:

Have you ever held a rock or seen a fossil and wondered how old it was? Some are hundreds of millions of years old. How do we know that? There are two main methods geologists use: "relative dating" and "absolute dating." Relative dating roughly compares the age of one rock or fossil to another through visual inspection — the same way you can tell a child is younger than an adult without pinpointing their exact ages. Absolute dating assigns a numerical age based on the object's natural radioactive decay. The two methods are often used in conjunction to determine geologic age.

ACTIVITY: Build a stratigraphy box

Explore relative dating by making your own rock layers and watching how a simulated geologic event affects them.

TIME: 15 minutes

SAFETY:

Don't consume any materials used in the experiment.

WHAT YOU NEED:

- Large, clear, rectangular plastic container
- Square piece of cardboard or rigid plastic
- Granular solids (sand, flour, baking soda, rice, cocoa powder, coloured beads)

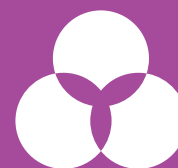


WHAT YOU DO:

- Cut the cardboard so that it fits snugly inside the container but is 10 centimetres taller.
- Place the cardboard or plastic piece inside the container against one side.



- Pour your first layer of granular solid (it can be any of them) into the container so that it fully covers the bottom.
- This layer and all subsequent layers should be between two and five centimetres thick.
- Add your next layer by pouring a different granular solid on top of the first. This solid should be a different colour from the first so they're visually distinct.
- Add layers of different colours at least three more times or until your container is half full.



ONTARIO
**SCIENCE
CENTRE**

An agency of the
Government of Ontario

SCIENCE AT HOME

GEOLOGIC DATING

GRADE: **12**

SES4U

SUBJECT: EARTH AND SPACE SCIENCE
STRAND: PLANETARY SCIENCE; RECORDING EARTH'S GEOLOGIC HISTORY

TOPIC: RELATIVE AND ABSOLUTE DATING

EXPECTATIONS: C.1.2, C1.2, D.2, D2.4, D2.6, D.3, D3.4, D3.5, D3.7, E2.2

VIDEO: youtu.be/Sq9GYhgyDi0

WHAT YOU DO (continued):

- Look from the side. What do you see?
- You are now going to simulate a geologic event in which a piece of the Earth pushes against rock layers. (In the real world, this happens where tectonic plates collide.) Slowly push your piece of cardboard or plastic from one side to the other. What happens to your layers?
- Is the last layer you added to your container still on top?

UNPACKING WHAT HAPPENED:

If you've ever driven on the highways of northern Ontario, you may have noticed beautiful rock formations. These rocks are made of multiple horizontal layers, known as "strata." The study of how they're formed is known as "stratigraphy."

The granite layers you see in northern Ontario are igneous rock, formed by the gradual cooling of molten rock beneath Earth's surface. The layers you see in the Niagara Escarpment, on the other hand, are sedimentary rock, formed when sediments like sand or clay are deposited in water and then solidify over time. Either way, geologists can rely on the principles of stratigraphy to date the layers.

One of the most important dating principles is the Law of Superposition. This law states that, within horizontal strata, younger rock layers are deposited on top of older ones. An easy way to envision this is to think about a lasagna: you know the bottom layer had to be first, and that each additional layer came after, with the melted cheese on the top.



Sedimentary rock layers in the Niagara region

But geologic events, like the shifting cardboard, can often alter strata, changing once-horizontal layers into a series of folded layers. If events like these occur multiple times within a rock layer, older layers may be pushed to the top, invalidating the Law of Superposition. In such cases scientists often turn to absolute dating to determine the age of the rocks.

TAKING IT FURTHER: Stratigraphy

What other materials could you add to your stratigraphy box? We used only dry materials. What about wet materials — like pudding — to mimic swamps and other wetlands? You can also add other solids to your containers to mimic magma plumes that have solidified underground, large boulders or even fossils.



**ONTARIO
SCIENCE
CENTRE**

An agency of the
Government of Ontario

SCIENCE AT HOME

GEOLOGIC DATING

GRADE: **12**

SES4U

SUBJECT: EARTH AND SPACE SCIENCE
STRAND: PLANETARY SCIENCE; RECORDING EARTH'S GEOLOGIC HISTORY

TOPIC: RELATIVE AND ABSOLUTE DATING

EXPECTATIONS: C.1.2, C1.2, D.2, D2.4, D2.6, D.3, D3.4, D3.5, D3.7, E2.2

VIDEO: youtu.be/Sq9GYhgyDi0

ACTIVITY: Measure the half-life of milk foam

Build a model to determine the half-life of a decaying material – milk bubbles – to better understand absolute dating.

TIME: 30 minutes

WHAT YOU NEED:

- 100 to 500 mL of milk or chocolate milk (skim, almond and soy milk are too thin for this activity)
- Tall, clear measuring cup
- Straw or frother
- Stopwatch
- Pen
- Paper (or digital spreadsheet)

WHAT YOU DO:

- Pour the milk into the measuring cup.
- Use the straw to blow bubbles into the milk for 30 seconds, or use a frother.
- Once the volume of bubbles is equal to the volume of liquid in the measuring cup – that is, once the total volume has doubled – record in millilitres where the bubbles have reached.



- Record the height of the bubbles every 10 seconds, using the stopwatch.
- After all the bubbles have popped – about two minutes – graph your results. Put time in seconds on the x-axis and volume in millilitres on the y-axis.
- What do you notice about your graph? Do the values represent a linear decay over time?

UNPACKING WHAT HAPPENED:

As you may have noticed, the bubbles pop quickly at first and then appear to pop more slowly as the experiment continues. This is an example of "exponential decay." Say you started with 100 bubbles, and after one minute, there are 50 left. That would mean one minute is the "half-life" of the bubbles: the time it takes for half the bubbles to disappear. Exponential decay tells you that after another minute, or a second half-life, the number of bubbles will again be cut in half. If you had 50 bubbles after one minute, you'd be left with 25 after two minutes.



**ONTARIO
SCIENCE
CENTRE**

An agency of the
Government of Ontario

SCIENCE AT HOME

GEOLOGIC DATING

GRADE: **12**

SES4U

SUBJECT: EARTH AND SPACE SCIENCE
STRAND: PLANETARY SCIENCE; RECORDING EARTH'S GEOLOGIC HISTORY

TOPIC: RELATIVE AND ABSOLUTE DATING

EXPECTATIONS: C.1.2, C1.2, D.2, D2.4, D2.6, D.3, D3.4, D3.5, D3.7, E2.2

VIDEO: youtu.be/Sq9GYhgYDi0

If you know both the half-life and the volume of bubbles you started with, you can calculate how much bubble-froth there will be after a certain amount of time. But if you know the half-life, the volume of bubbles you started with and the current amount, you can actually work backwards and calculate how much time has passed. This is the basis of absolute dating.

WHY THIS MATTERS:

Absolute dating uses the principles of exponential decay and half-lives to determine the age of rocks, fossils and artifacts. The objects being dated are incredibly old, so you can't use something like bubbles, as they disappear far too quickly. That's why scientists use "radioactive isotopes," or "radioisotopes," which are unstable atoms that slowly decay into stable ones. The most famous radioisotope is Carbon-14. Most carbon atoms have six protons and six neutrons, but Carbon-14 has six protons and eight neutrons (for a total atomic weight of 14). Carbon-14 is an unstable isotope: over time, it decays into Nitrogen-14, a much more stable atom. Scientists have determined that the half-life for this process is 5730 years.

If it takes 5730 years for half of the Carbon-14 atoms to become Nitrogen-14, archaeologists can work backwards to calculate an artifact's age in a process called "radiometric dating" or "carbon dating." Put simply, if an artifact started with 100 grams of Carbon-14, and now there are only 50 grams left, you can conclude that the artifact is 5730 years, or one half-life, old. (Obviously, carbon dating is a bit more complicated than that, but this is essentially how it works.)

With its half-life of 5730 years, Carbon-14 dating works best for things that are roughly 50,000 years old or younger. For rocks, which may be billions of years old, however, you need to use radioisotopes with a much longer half-life. Potassium-40 — a potassium isotope with an atomic mass of 40 — decays into Argon-40, and the half-life of the process is about 1.25 billion years. Using Potassium-40 radiometric dating, geologists have estimated that Canada's oldest rocks, the Acasta Gneiss in Northwest Territories, are between 3.5 and 4 billion years old!

TAKING IT FURTHER: Half-Life

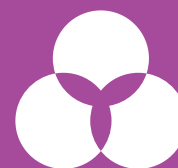
What other liquids could you use in the milk foam experiment? Do you think the viscosity of a liquid would alter its half-life? Try experimenting with more viscous liquids like syrup or less viscous liquids like water.

MORE ONLINE:

Harnessing Half-Life
<https://rps.nasa.gov/resources/20/harnessing-half-life/>

How Does Radiocarbon Dating work? Instant Egghead #28
https://www.youtube.com/watch?v=phZeE7Att_s

Dating Rocks and Fossils Using Geologic Methods
<https://www.nature.com/scitable/knowledge/library/dating-rocks-and-fossils-using-geologic-methods-107924044/>



ONTARIO
**SCIENCE
CENTRE**

An agency of the
Government of Ontario