Determining the Age of Rocks and Fossils

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Relative and Absolute Age Dating

The age of fossils intrigues almost everyone. Students not only want to know how old a fossil is, but they want to know how that age was determined. Some very straightforward principles are used to determine the age of fossils. Students should be able to understand the principles and have that as a background so that age determinations by paleontologists and geologists don't seem like black magic.

There are two types of age determinations. **Geologists** in the late 18th and early 19th century studied rock layers and the fossils in them to determine relative age. We call this **relative age dating**. William Smith was one of the most important scientists from this time who helped to develop knowledge of the succession of different fossils by studying their distribution through the sequence of sedimentary rocks in southern England. It wasn't until well into the 20th century that enough information had accumulated about the rate of radioactive decay that the age of rocks and fossils in number of years could be determined through radiometric age dating or **absolute age dating**.

This packet on determining age of rocks and fossils is intended for upper middle school and high school students. It estimated to require four hours of class time, including approximately one hour total of occasional instruction and explanation from the teacher and two hours of group (team) and individual activities by the students, plus one hour of discussion among students within the working groups.

Purpose and Objectives

This packet will help students to have a better understanding of the basic principles used to determine the age of rocks and fossils. This activity consists of several parts.

Objectives of this packet are:

1. To have students determine relative age of a geologically complex area.
2. To familiarize students with the concept of **half-life** in radioactive decay.
3. To have students see that individual runs of statistical processes are less predictable than the average of many runs (or that runs with relatively small numbers involved are less dependable than runs with many numbers).
4. To demonstrate how the rate of radioactive decay and the buildup of the resulting decay product is used in radiometric dating of rocks.
5. To use radiometric dating and the principles of determining relative age to show how ages of rocks and fossils can be narrowed even if they cannot be dated radiometrically.

MOST*

VOCABULARY

Aboslute age dating
Fossil
Geologists
Half-life
Relative age dating

HELPFUL TERMS

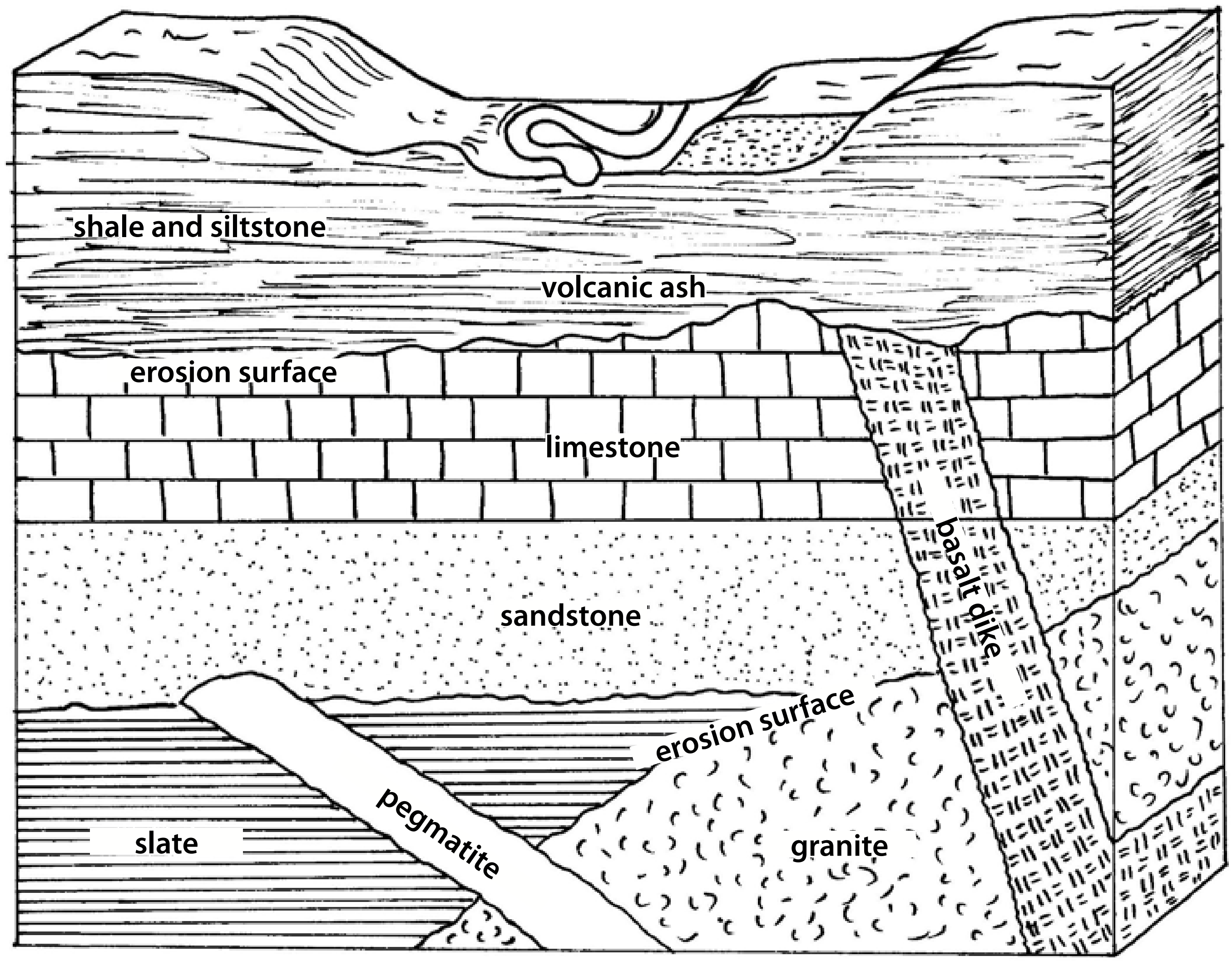
Paleontologists
Isotope
Radioactive decay

Inside This Packet

Activity: Relative Age of Rocks

What to do:

Each team of 3 to 5 students should discuss together how to determine the relative age of each of the rock units in the Relative Age of Rocks diagram. After students have decided how to establish the relative age of each rock unit, they should list them under the block, from most recent to oldest formation.



Most recent rock formed: ______________________

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Oldest rock: ______________________

List the rocks from oldest to most recently formed.

Activity: U-235 Half-lives

MATERIALS NEEDED

128 activity pieces

1 time card

Students should be able to:

Explain the term half-life

Calculate the age of an unknown given a model of half-lives

What to do:

1. To start, place all your activity pieces with U-235 facing up.
2. **First 2-Minute Period**
   During this period, turn over half of your pieces so that Pb-207 is now facing up. This represents one half-life of U-235.
   Team with Time Card 2 **STOP**.
3. **Second 2-Minute Period**
   During this time, turn over half of your remaining U-235 pieces so that Pb-207 is now facing up. This represents one more half-life of U-235.
   Team with Time Card 4 **STOP**.
4. **Third 2-Minute Period**
   During this time, turn over half of your remaining U-235 pieces so that Pb-207 is now facing up. This represents one more half-life of U-235.
   Team with Time Card 6 **STOP**.
5. **Fourth 2-Minute Period**
   During this time, turn over half of your remaining U-235 pieces so that Pb-207 is now facing up. This represents one more half-life of U-235.
   Team with Time Card 8 **STOP**.
6. **Final 2-Minute Period**
   During this time, turn over half of your remaining U-235 pieces so that Pb-207 is now facing up. This represents one more half-life of U-235.
   Team with Time Card 10 **STOP**.
7. Determine your Team's answers to the questions below.
8. Switch places with another team.
9. Determine the answers for the other Team's pieces and discuss the difference from your results.

Your Team's Results

How many half-lives did the U-235 experience?

____

The half-life of U-235 is 704 million years. How many million years are represented by the proporation of U-235 and Pb-207?

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Other Team's Results

How many half-lives did the U-235 experience?

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The half-life of U-235 is 704 million years. How many million years are represented by the proporation of U-235 and Pb-207?

____

Activity: Skittles Dating

MATERIALS NEEDED

Large cup or container

100 Skittles

Decay graph printout

Students should be able to:

Understand that the more repetitions of an experiment the greater the accuracy

Understand decay rates for a parent isotope

Graph their individual and group data accurately

What to do:

1. Place all your skittles candies with the "S" Facing up on a piece of notebook paper. These represent the parent isotopes. If there are any "S" missing on a piece of skittles request another piece so that you have 100 pieces with "S" on them to start the process.

2. Place all the candies in a large container and shake thoroughly. Then, pour all the candies out onto the notebook paper and spread them out. This first time of shaking represents one half life. The candies with "S" facing up are the parent isotope and those with the "s" facing down are the changed daughter isotope. They have lost neutrons to become stable.

3. Set aside ONLY the pieces with the "S" facing down or blank on top. These are the daughter, changed isotope. They will no longer be part of the process. Count the number of "S" facing up pieces (Parent Isotope).

4. These are the unchanged pieces or parent isotope. Record this number underneath your team number in Row 1 of the Decay Table Chart and report your number to your teacher.

5. Repeat steps 2-4 to find information for your Team for each row of the Decay Table chart. Each time shake only the parent isotopes that are left. Each shake represents another half life period.

6. Once you have finished gathering your research, plot your results on the Skittles Half Lives Chart and connect each point with a line.

7. On the same graph, your team should plot the Average Values of the whole class and connect those points with a darker line.

8. Also on the graph, each Team should plot points where, after each shake the starting numbers is divided by exactly two and connect these points with a differently colored line. (This line begins at 100; the next point is 100/2, or 50; the next point is 50/2, or 25 and so on.)

Answer these questions:

1. Why didn't each group get the same results?

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2. Which results follows the mathematically calculated line best: your single Team's results or the Class Average results?

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3. Was it easier to predict results when there were a lot of pieces of candy in the cup, or when there were fewer? Why?

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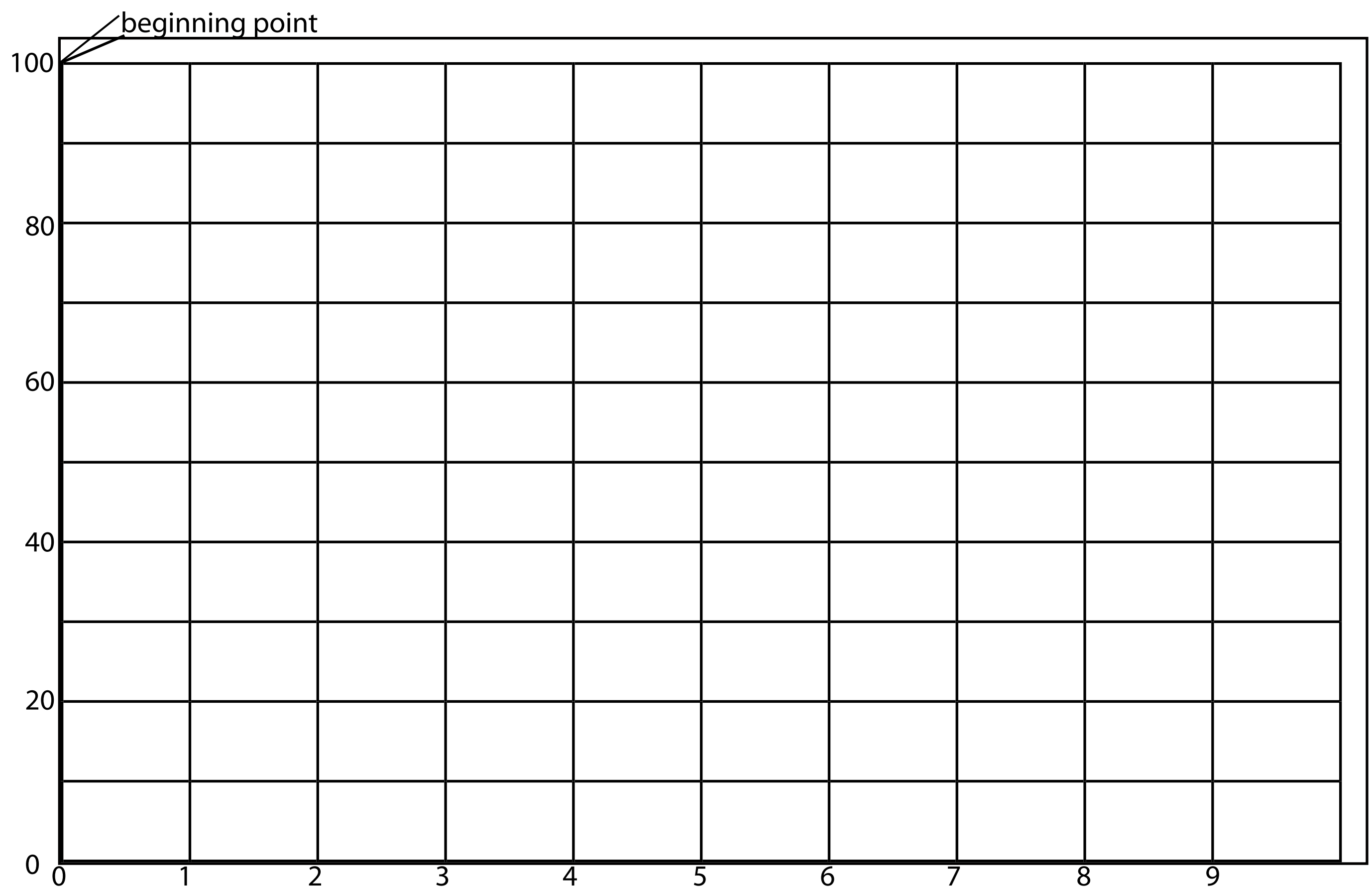
Activity: Skittles Dating Charts

Decay Table Chart

Run	Class Total	Number of "Unchanged" Pieces (parent isotope atoms)								Class Average
		Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7	Team 8	
1										
2										
3										
4										
5										
6										
7										
8										
9										

Skittles Half-Lives Chart



Absolute Age Dating

Some elements have forms (called isotopes) with unstable atomic nuclei that have a tendency to change, or decay. For example, U-235 is an unstable isotope of uranium that has 92 protons and 143 neutrons in the nucleus of each atom. Through a series of changes within the nucleus, it emits several particles, ending up with 82 protons and 125 neutrons. This is a stable condition, and there are no more changes in the atomic nucleus. A nucleus with that number of protons is called lead (chemical symbol Pb). The protons (82) and neutrons (125) total 207. This particular form (isotope) of lead is called Pb-207. U-235 is the parent isotope of Pb-207, which is the daughter isotope.

Many rocks contain small amounts of unstable isotopes and the daughter isotopes into which they decay. Where the amounts of parent and daughter isotopes can be accurately measured, the ratio can be used to determine how old the rock is, as shown in the activities.

Activity: Relative Age of Rocks

The teacher should tell the students that there are two basic principles used by geologists to determine the sequence of ages of rocks. They are:

Principle of superposition: Younger sedimentary rocks are deposited on top of older sedimentary rocks.
Principle of cross-cutting relations: Any geologic feature is younger than anything else that it cuts across.

Activity: U-235 Half Lives

For this activity you will need to create 128 pieces (for each team) with U-235 on one side and Pb-207 on the other. It is helpful if you use 2-sided construction paper or glue together 2 colors of paper . The time cards are pieces of paper marked TIME, on which is written either 2, 4, 6, 8, or 10 minutes.

At any moment there is a small chance that each of the nuclei of U-235 will suddenly decay. That chance of decay is very small, but it is always present and it never changes. In other words, the nuclei do not "wear out" or get "tired". If the nucleus has not yet decayed, there is always that same, slight chance that it will change in the near future.

Atomic nuclei are held together by an attraction between the large nuclear particles (protons and neutrons) that is known as the "strong nuclear force", which must exceed the electrostatic repulsion between the protons within the nucleus. In general, with the exception of the single proton that constitutes the nucleus of the most abundant isotope of hydrogen, the number of neutrons must at least equal the number of protons in an atomic nucleus, because electrostatic repulsion prohibits denser packing of protons. But if there are too many neutrons, the nucleus is potentially unstable and decay may be triggered. This happens at any time when addition of the fleeting "weak nuclear force" to the ever-present electrostatic repulsion exceeds the binding energy required to hold the nucleus together.

Very careful measurements in laboratories, made on VERY LARGE numbers of U-235 atoms, have shown that each of the atoms has a 50:50 chance of decaying during about 704,000,000 years. In other words, during 704 million years, half the U-235 atoms that existed at the beginning of that time will decay to Pb-207. This is known as the half life of U- 235. Many elements have some isotopes that are unstable, essentially because they have too many neutrons to be balanced by the number of protons in the nucleus. Each of these unstable isotopes has its own characteristic half life. Some half lives are several billion years long, and others are as short as a ten-thousandth of a second.