Teachers: Hand this out last

Solution and Relevance of Popcorn Analogy to Geologic Age Dating

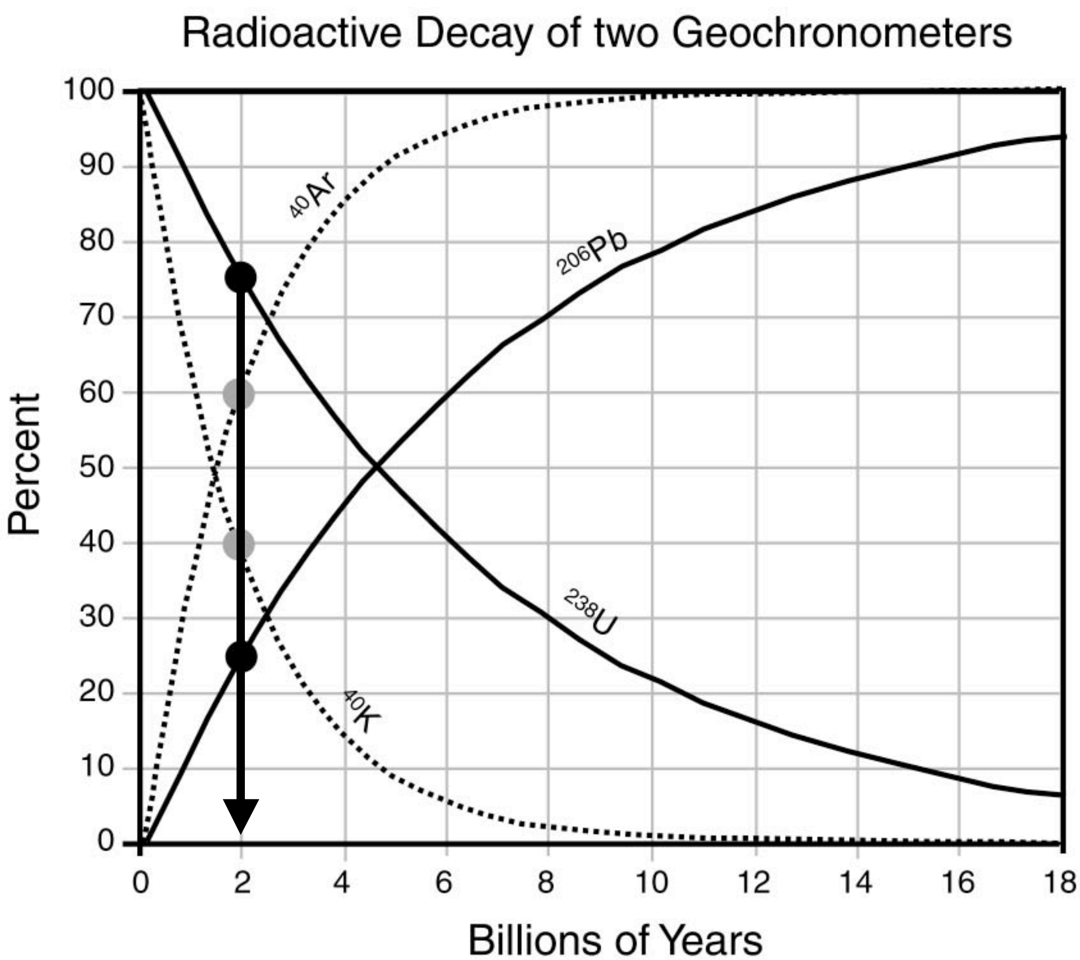
Geologists are faced with this exact same dilemma. They have two types of radioactive isotopes that are decaying at two different rates. No human was around to time them, so how do we know if we got the rate right?

What do you notice about the dots? They all fall on a vertical line that corresponds to the duration the corn was popped.

Each group's dots plotted at different times, because she did the experiment several times without keeping track of when she stopped popping.

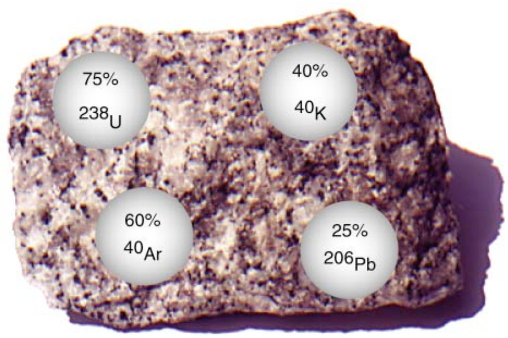
Remember that the curves are theoretical. She was testing them with an experiment. The experiment showed that the popcorn did indeed pop at the predicted rates.

What would happen to the dots if they were plotted on a set of incorrect popping curves? They would not line up vertically, which is not physically possible since both varieties of popcorn were popped for the same duration in the same pot. So the experiment is a valid way to test the validity of the rates of the two types of popcorn.



So how does this all relate to geology? It is a direct analogy. Instead of regular kernels we have ^{238}U and instead of regular popcorn we have ^{206}Pb. The radioactive isotope of uranium changes (decays) into an isotope of lead. Instead of 45 seconds, it takes billions of years. The green kernels are ^{40}K and the green popcorn is ^{40}Ar.

Geologists can easily measure the quantities of ^{238}U, ^{206}Pb, ^{40}K, and ^{40}Ar in a rock, just like you were able to count the contents of Lucille's pans. Lucille came up with the theoretical popcorn curves using simple laws of chemistry and physics. Geologists can also produce theoretical curves for the rates of decay of the isotopes. The test is the same. We count the isotopes present and see if they fall on a vertical line. Thousands of repeated experiments from rocks all over the earth have increased our confidence that the rate of decay of radioactive isotopes is well-understood and the same laws of physics apply to both short-lived and long-lived isotopes.



The radioactive isotopes in this rock have been decaying for 2 billion years, so the rock is 2 billion years old. As you may have guessed, the ratio of kernels to popcorn is the key measurement in geochronology.

Summary: Relative vs. Absolute Age Dating

Relative dating just tells you if a rock is older or younger than another rock. It is based on careful inspection of the rocks to determine which was deposited first, second, third, etc. Fossils occur in many sedimentary rocks. Knowing the order of the rocks allows geologists to figure out the order of appearance of each different type of fossil.

Absolute dating gives you an age in years before the present. The age is calculated by measuring the ratios of certain radioactive isotopes that are present in small quantities in most rocks. All you need to calculate the age is one ratio of isotopes such as $^{40}K/^{40}Ar$ and knowledge of the rate of decay of ^{40}K. The example discussed in this exercise used two ratios: $^{40}K/^{40}Ar$ and $^{238}U/^{206}Pb$. This was done to illustrate how the decay rates are determined with great confidence.

Now that the fossil record has been calibrated using radioactive isotope age dating of the rocks, we can use index fossils to give us a rough estimate of the age of a rock. This leads to some confusion, because it sounds to the lay person that the fossil is giving us an *absolute* age. The fossil is giving us a *relative* age that has been <u>calibrated</u> with an *absolute* age.