Absolute Age Dating

Geological dating techniques are illustrated by the following example from New Mexico. Please work through the exercise which follows.

Figure 1 is a geologic cross-section through an area in northern New Mexico where two dikes cross-cut a number of sedimentary strata. The dikes are basaltic in composition and contain very small, but geologically significant amounts of radioactive minerals. The radioactivity of the minerals is caused by decay of unstable isotopes such as uranium (U) and potassium (K). These parent isotopes give off energy as they decay slowly through time into more stable daughter products. For example, radioactive uranium isotopes decay slowly through time into lead (Pb). Likewise, radioactive potassium isotopes decay into argon gas (Ar). Decay rates are measured in the laboratory and differ for each reaction (potassium to argon, etc.). A decay curve can then be constructed by plotting the abundance of the parent isotope in a sample versus time (Figure 2). In the ideal situation, an absolute age estimate for a rock can be read from the appropriate decay curve once the proportion of parent-to-daughter isotopes has been measured in a radiogenic mineral contained within the rock.

For the radioactive minerals contained in the dikes shown in Figure 1, a simplified decay curve has been plotted (Figure 2). The parent isotope, X in this problem, decays to the daughter product Y. Therefore, when the amount of X remaining is 50 percent, exactly one half of the parent (X) has decayed into its daughter (Y). This value (follow the 50% line to the curve, then extend a vertical line downward to the time axis) is called the half-life of the parent.

Using the two figures determine the following:

1) The half-life of parent X

2) The date of metamorphism of the schist

3) The date of intrusion of dike A

4) The date of intrusion of dike B
Please answer questions (5) and (6) in both million years before present (m.y.) and in terms of the corresponding geological time periods (refer to your text for the geological time scale, p. 17).

5) Range of possible ages for beds 1-4

<table>
<thead>
<tr>
<th>Million Years</th>
<th>Geologic Interval (period)</th>
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6) Range of possible ages for beds 5-9

<table>
<thead>
<tr>
<th>Million Years</th>
<th>Geologic Interval (period)</th>
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7) What is the oldest period of geologic time that bed 10 could belong to?


8) Outline the geologic history of the area using both absolute and relative timing constraints.
Figure 1.

Figure 2.
Measuring Radioactive Decay

Using a Geiger counter, we can measure the particles (alpha, beta, and gamma) which are emitted by the process of radioactive decay. In this example, we will measure the emissions using samples of uraninite, a uranium ore, and granite, a common rock found in Earth’s crust. In the uraninite, $U^{238}$ decays to $Pb^{206}$ and the half-life of this decay is 4.5 billion years.

To determine the amount of radioactive decay in our samples, we first attempt to determine the background radiation present in the room, by recording the number of counts in the time span of a minute.

background level \[\text{___________}/\text{min}\]

Next we measure the amount of radiation using the uraninite sample, holding the Geiger counter at a distance where the rate of triggering is reasonable to assess. For example, what is the rate at 300 cm from the sample? Determine the uraninite rate by subtracting the background rate.

\[\text{background } + \text{uraninite rate } \text{___________}/\text{min}\]

\[\text{uraninite rate } \text{___________}/\text{min}\]

The Geiger counter only catches a very small fraction of the particles emitted. To compensate for this, we need to multiply the amount of radiation we record by the ratio of the area of a spherical shell around the sample to the area of the Geiger counter. To compute the ratio, divide the area of a three dimensional spherical shell with radius 300 cm ($A=4\pi r^2$) by the surface area of the Geiger counter. Then, multiply the uraninite rate by the ratio. What is the total rate?

\[\text{total uraninite rate } \text{___________}/\text{min}\]

Next, we would like to extrapolate for the number of particles emitted in a year, using the number of minutes in a year. How many counts per year?

\[\text{annual uraninite rate } \text{___________}/\text{yr}\]

How does the radioactivity of granite compare with the uranium ore?