Earth Science

Chapter 8 – The Rock Record

Section 2 – Determining Absolute Age

E.Q.: *What are the characteristics of the five methods used to determine Absolute Age in rock formations?*

STANDARDS:

SES4. Students will understand how rock relationships and fossils are used to reconstruct the Earth's past.

    a. Describe and apply principles of relative age (superposition, original horizontality, cross-cutting relations, and original lateral continuity) and describe how unconformities form.

    b. Interpret the geologic history of a succession of rocks and unconformities.

    c. Apply the principle of uniformitarianism to relate sedimentary rock associations and their fossils to the environments in which the rocks were deposited.

    d. Explain how sedimentary rock units are correlated within and across regions by a variety of methods (e.g., geologic map relationships, the principle of fossil succession, radiometric dating, and paleomagnetism).

    e. Use geologic maps and stratigraphic relationships to interpret major events in Earth history (e.g., mass extinction, major climatic change, tectonic events).

Objectives

- Summarize the limitations of using the rates of erosion and deposition to determine the absolute age of rock formations.
- Describe the formation of varves.

- Explain how the process of radioactive decay can be used to determine the absolute age of rocks.

Absolute Dating Methods

absolute age - the numeric age of an object or event, often stated in years before the present, as established by an absolute-dating process, such as radiometric dating

- Scientists use a variety of ways to determine absolute age, or the numeric age, of a rock formation.

Rates of Erosion

- One way scientists use to estimate absolute age is to study rates of erosion.
- Studying the rates of erosion is practical only for geologic features that formed within the past 10,000 to 20,000 years.
- For older surface features, the method is less dependable because rates of erosion can vary over millions of years.

Rates of Deposition

- Scientists can also estimate absolute age by calculating the rate of sediment deposition.
- By using data collected over a long period of time, geologists can estimate the average rates of deposition for common sedimentary rocks.
- This method is not always accurate because not all sediment is deposited at an average; therefore it provides only an estimate of absolute age.

Varve Count

varve - a banded layer of sand and silt that is deposited annually in a lake, especially near ice sheets or glaciers, and that can be used to determine absolute age.

- Some sedimentary deposits show definite annual layers, called varves.

- The varves can be counted much like tree rings to determine the age of the sedimentary deposit.

<u>Reading check</u>

How are varves like tree rings?

Varves are like tree rings in that varves are laid down each year. Thus, counting varves can reveal the age of sedimentary deposits.

<u>Radiometric Dating</u>

<u>radiometric dating</u> - a method of determining the absolute age of an object by comparing the relative percentages of a radioactive (parent) isotope and a stable (daughter) isotope.
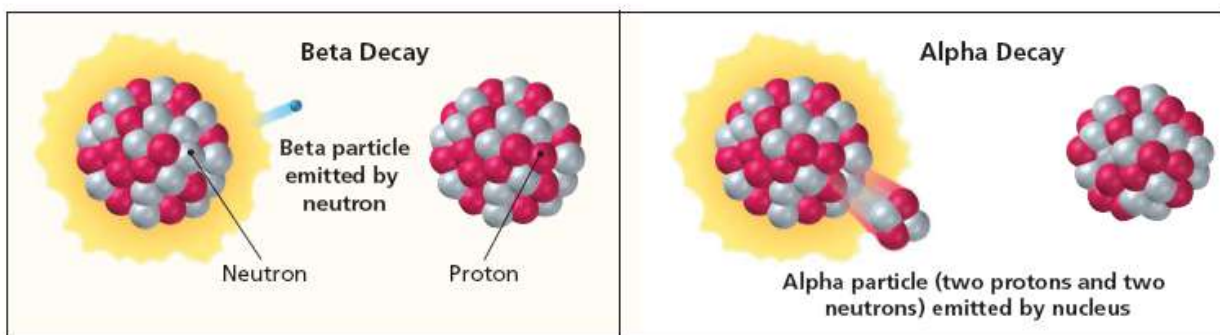
- Rocks generally contain small amounts of radioactive material that can act as natural clocks.
- Atoms of the same element that have different numbers of neutrons are called *isotopes.*
- *Radioactive isotopes* can be used to determine age.
- Radioactive isotopes have nuclei that emit particles and energy at a constant rate regardless of surrounding conditions.
- Scientists use the natural breakdown of isotopes to accurately measure the absolute age of rock, which is called radiometric dating.
- To do this, scientists measure the concentration of the *parent isotope* or original isotope, and of the newly formed *daughter isotopes.* Then, using the known decay rate, they can determine the absolute age of the rock.

<u>Half-Life</u>

<u>half-life</u> - the time required for half of a sample of a radioactive isotope to break down by radioactive decay to form a daughter isotope.

- Scientists have determined that the time required for half of any amount of a particular radioactive isotope to decay is always the same and can be determined for any isotope.
- By comparing the amounts of parent and daughter isotopes in a rock sample, scientists can determine the age of the sample.
- The greater the percentage of daughter isotopes present in the sample, the older the rock is.

Radioactive Decay

Beta Decay

Beta particle emitted by neutron

Neutron   Proton

Alpha Decay

Alpha particle (two protons and two neutrons) emitted by nucleus

Half-Life

Parent isotope

Daughter isotope

Before decay begins | After 1 half-life | After 2 half-lives | After 3 half-lives | After 4 half-lives

Radioactive Isotopes
- Uranium-238, or ^{238}U, is an isotope of uranium that has an extremely long half-life, and is most useful for dating geologic samples that are more than 10 million years old.
- Potassium-40, or ^{40}K, has a half-life of 1.25 billion years, and is used to date rock that are between 50,000 and 4.6 billion years old.
- Rubidium-87 has a half-life of about 49 billion years, and is used to verify the age of rocks previously dated by using ^{40}K.

Reading Check

How does the half-life of an isotope affect the accuracy of the radiometric dating method?

An isotope that has an extremely long half-life will not show significant or measurable changes in a young rock. In a very old rock, an isotope that has a short half-life may have decayed to the point at which too little of the isotope is left to give an accurate age measurement. So, the estimated age of the rock must be correlated to the dating method used.

Carbon Dating

- Younger rock layers may be dated indirectly by dating organic material found within the rock.
- Organic remains, such as wood, bones, and shells that are less than 70,000 years old can be determined by using a method known as *carbon-14 dating*, or *radiocarbon dating*.
- All living organisms have both the carbon-12 and carbon-14 isotope.
- To find the age of a sample of organic material, scientists compare the ratio of ^{14}C to ^{12}C and then compare this with the ratio of ^{14}C to ^{12}C known to exist in a living organism.
- Once a plant or animal dies, the ratio begins to change, and scientist can determine the age from the difference between the ratios of ^{14}C to ^{12}C in the dead organism.