ENVIRONMENTAL GEOLOGY

Dating Methods

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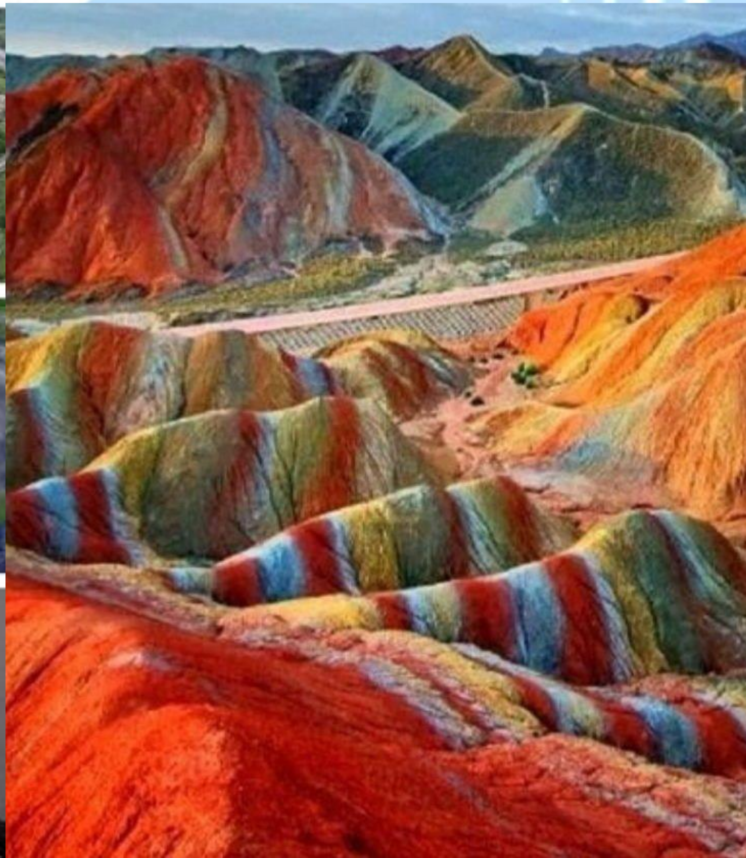

Dating Methods:

There are two primary methods to determine the age of rocks and events in Earth's history:

- **Relative Dating:**
  - This method involves comparing the ages of objects or events. For instance, you are younger than your parents, but you don't need to know their exact age, just that one is older than the other.
  - Relative dating allows geologists to quickly reconstruct a sequence of geological events based on features such as rock types, environmental indicators, or fossils.

- **Absolute Dating:**
  - This method determines the exact age of rocks or events by analyzing specific materials in the rocks, such as minerals or radioactive isotopes.
  - Absolute dating is the only method that can provide a precise age for a rock or an event.
- **Relative time**: Orders events chronologically.
- **Absolute time**: Provides specific dates for geological events.

Characteristics of Both Dating Methods:

- **Relative Dating:**
  - It’s cost-effective, quick, and can be used in the field.
  - It is versatile and can be applied to many different types of rocks.
- **Absolute Dating:**
  - Provides a precise age for rocks and events.
- It is limited to certain materials or minerals that can be dated accurately.

Development of the Geologic Time Scale:

- As scientists studied rocks and their features, they were able to piece together a timeline of Earth's history, which led to the creation of the **Geologic Time Scale**.
- This scale organizes geological events into eons, eras, periods, and epochs based on rock formations and fossil evidence.
- The age of Earth was eventually determined to be around 4.54 billion years, and this discovery has helped scientists develop a more detailed understanding of Earth's history.

Geologic Time Scale

EON	ERA	PERIOD		EPOCH	
					Present
Phanerozoic	Cenozoic	Quaternary		Holocene	0.01
Phanerozoic	Cenozoic	Quaternary		Pleistocene	2.6
Phanerozoic	Cenozoic	Tertiary	Neogene	Pliocene	5.3
Phanerozoic	Cenozoic	Tertiary	Neogene	Miocene	23.0
Phanerozoic	Cenozoic	Tertiary	Paleogene	Oligocene	33.9
Phanerozoic	Cenozoic	Tertiary	Paleogene	Eocene	55.8
Phanerozoic	Cenozoic	Tertiary	Paleogene	Paleocene	65.5
Phanerozoic	Mesozoic	Cretaceous			145.5
Phanerozoic	Mesozoic	Jurassic			199.6
Phanerozoic	Mesozoic	Triassic			251
Phanerozoic	Paleozoic	Permian			299
Phanerozoic	Paleozoic	Carboniferous	Pennsylvanian		318
Phanerozoic	Paleozoic	Carboniferous	Mississippian		359.2
Phanerozoic	Paleozoic	Devonian			416
Phanerozoic	Paleozoic	Silurian			443.7
Phanerozoic	Paleozoic	Ordovician			488.3
Phanerozoic	Paleozoic	Cambrian			542
Precambrian	Proterozoic				2500
Precambrian	Archean				4000
Precambrian	Hadean				

Absolute Time

What is Absolute Time?

Absolute time helps us figure out the exact age of a rock or object. This is different from relative time, which only tells us if something is older or younger than something else. In absolute time, we use **radioactive isotopes** to get a precise age.

Atoms and Isotopes

Let's start by understanding atoms. Atoms are made of three main particles:

1. **Protons** – these define the element (for example, carbon, oxygen, etc.).
2. **Electrons** – they control how the element bonds with other elements to form compounds.
3. **Neutrons** – these affect the atomic weight of the element.

Now, **isotopes** are forms of the same element, but with different numbers of neutrons. For example, carbon-12 and carbon-14 are isotopes of carbon. If an atom has too many or too few neutrons, it becomes **unstable**. When an atom is unstable, it undergoes a process called **radioactive decay**.

Radioactive Decay

Radioactive decay is when an unstable atom (called the **parent atom**) releases a particle and transforms into another element, known as the **daughter atom**. Over time, this decay happens at a steady rate, which we can measure in a laboratory.

Half-Life and Radiometric Dating

Every radioactive isotope decays at a specific rate, which is defined by its **half-life**. A half-life is the time it takes for half of the parent atoms in a sample to decay into daughter atoms.

Here's something important to understand: the half-life is **constant**. It doesn't change depending on how many atoms you have. So, if you start with 100% of the parent isotope, it will take one half-life to decay to 50%. After another half-life, 50% will turn into 25%, and so on.

By knowing the **half-life** of a specific isotope and measuring the amount of parent and daughter isotopes in a rock, we can calculate the age of the rock. This process is called **Radiometric Dating**.

Dating Systems: Types of Radiometric Dating

There are several different **radiometric dating systems**, each using different isotopes and applicable to specific types of materials and time frames. Let’s go over the most common systems:

1. **Carbon-14 Dating**

   Carbon-14 has a short half-life of **5,730 years**, so it is only useful for dating materials that are less than about **70,000 years old**. This makes it ideal for dating recent materials but not useful for ancient rocks.

2- Uranium Dating

- Uranium decays in a series of steps until it becomes **non-radiogenic lead**.
- Uranium has a very long half-life of **4.5 billion years**, which makes it perfect for dating very old rocks. However, it’s only reliable for rocks that are at least **1 million years old**.

3- Potassium-Argon Dating

The half-life of Potassium is **702 million years**, making it useful for dating older rocks, like those that are millions or billions of years old.

Calculating the Age of a Rock

Now, let’s look at how to calculate the age of a rock using radiometric dating. The basic formula is:

$$Age = -(t_{1/2} / \ln 2) \ln(P)$$

Where:

- $t_{1/2}$ = The length of the half-life in years.
- P = The amount of the parent remaining in decimal form. For example, if there is 50% of the parent remaining it would equal 0.5.

Let's work through an example using the equation. You have a sample of bone with 25% of the Carbon-14 (half-life = 5730 years) remaining. How old is the sample?

We can answer this question in two ways:

1. We know that if there is 25% remaining, two half-lives have passed and with each half-life being 5730 the bone would be 11,460 years old.

2. We could use the above equation and insert both the length of the half-life and the amount of the parent remaining:

$$\text{Age} = -(t_{1/2} / 0.693) \ln(P)$$

$$\text{Age} = -(5730 / 0.6931472) \ln(0.25)$$

You will get 11,460 as well.

In brief:

Absolute Time allows us to determine the exact age of a rock or object through **radiometric dating**.

Different **dating systems**, like **Carbon-14**, **Uranium**, and **Potassium-Argon**, are used for different types of materials and time frames.

By studying the decay of isotopes and knowing their half-lives, we can measure the passage of time and understand the history of our planet in a detailed and precise way.

Thank You for Listening

Any Questions?