

# Geologic Time and Earth's Evolution



# Geologic Time and Earth's Evolution.

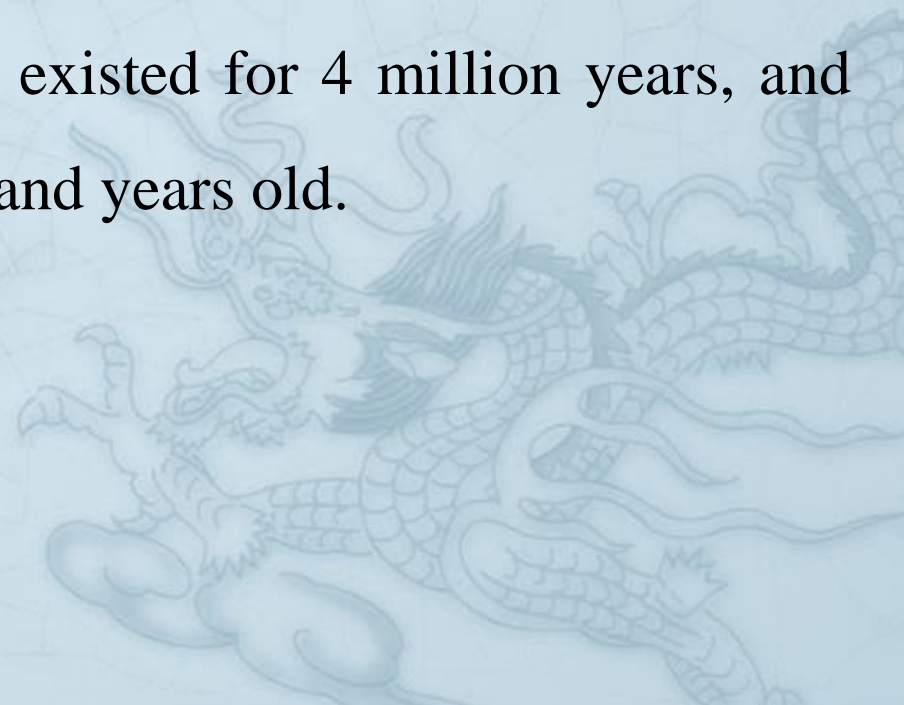
Geologists commonly study events that occurred in the past. They observe rocks and landforms and ask questions such as;

- When and how the Earth came into existence?
- What geologic processes shaped that mountain range?
- When did the mountains rise and erode?

# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

While most of us think of time in terms of days or years, geologists commonly refer to events that happened millions or billions of years ago. The Earth is approximately 4.6 billion years old. Yet humans and our human-like ancestors have existed for 4 million years, and recorded history is only a few thousand years old.



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **Geologic Time Scale: Its History and Development:**

Scottish geologist James Hutton (1726-1797) set the stage for the development of the geologic time scale in the late 18th century with the publication of his *Theory of the Earth* (1785). In it, Hutton advanced "uniformitarianism," a geological doctrine which basically assumes that current geologic processes, occurring at the same rates observed today, in the same manner, account for all of Earth's geological features, a principle later championed by British geologist Sir Charles Lyell (1797-1875). Next, British civil engineer, surveyor and geologist William Smith (1769-1839) made the discovery that fossils are found buried in a definite order. The geologic time scale was developed shortly thereafter.

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## GEOLOGIC TIME:

The geological time scale (GTS) is a system of chronological dating that relates geological strata (**Stratum** (plural; strata) is a layer of sedimentary rock or soil with internally consistent characteristics that distinguish it from other layers.) to time, and is used by geologists, paleontologists, and other Earth scientists to describe the timing and relationships of events that have occurred during Earth's history. The table of geologic time spans agrees with the nomenclature, dates and standard color codes set forth by the International Commission on Stratigraphy

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## **GEOLOGIC TIME:**

### **Chronological dating:**

Chronological dating, or simply dating, is the process of attributing to an object or event a date in the past, allowing such object or event to be located in a previously established chronology.



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

Evidence from radiometric dating indicates that Earth is about 4.54 billion years old. The geology or deep time of Earth's past has been organized into various units according to events which took place in each period. Different spans of time on the GTS are usually marked by changes in the composition of strata which correspond to those, and indicate major geological or paleontological events, such as mass extinctions.



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## **GEOLOGIC TIME:**

### **Terminology**

The largest defined unit of time is the *SUPEREON*, composed of *Eons*. *Eons* are divided into *Eras*, which are in turn divided into *Periods*, *Epochs* and *Ages*.

The terms "eonothem", "erathem", "system", "series", and "stage" are used to refer to the layers of rock that correspond to these periods of geologic time in Earth's history.

**Table 9-2 • THE GEOLOGIC COLUMN AND TIME SCALE\***

TIME UNITS OF THE GEOLOGIC TIME SCALE

Eon	Era	Period	Epoch	DISTINCTIVE PLANTS AND ANIMALS			
Phanerozoic Eon ( <i>Phaneros</i> = "evident"; <i>Zoon</i> = "life")	Cenozoic Era	Quaternary	Recent or Holocene	"Age of Mammals"	Humans		
			Pleistocene		Mammals develop and become dominant		
		Tertiary	Pliocene			Extinction of dinosaurs and many other species	
			Neogene				Miocene
							Oligocene
		Paleogene	Eocene				
			Paleocene				
			66				
	Mesozoic Era	Cretaceous	"Age of Reptiles"	First flowering plants, greatest development of dinosaurs			
		Jurassic		First birds and mammals, abundant dinosaurs			
		Triassic		First dinosaurs			
	Paleozoic Era	Carboniferous	Permian	"Age of Amphibians"	Extinction of trilobites and many other marine animals		
			Pennsylvanian		Great coal forests; abundant insects, first reptiles		
			Mississippian		Large primitive trees		
		Devonian	"Age of Fishes"	First amphibians			
		Silurian		First land plant fossils			
		Ordovician	"Age of Marine Invertebrates"	First fish			
		Cambrian		First organisms with shells, trilobites dominant			
Proterozoic		Archean	Hadean	Sometimes collectively called Precambrian	First multicelled organisms		
	First one-celled organisms						
	Approximate age of oldest rocks						
4600±		Origin of the Earth					

\*Time is given in millions of years (for example, 1000 stands for 1000 million, which is 1 billion). The table is *not* drawn to scale. We know relatively little about events that occurred during the early part of the Earth's history. Therefore, the first 4 billion years are given relatively little space on this chart, while the more recent Phanerozoic Eon, which spans only 538 million years, receives proportionally more space.

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## **GEOLOGIC TIME:**

### **How to remember the geological time scale?**

Geologists divide all of geologic time into smaller units for convenience. Just as a year is subdivided into months, months into weeks, and weeks into days, large geologic time units are split into smaller intervals. The units are named, just as months and days are. The largest time unit **SUPEREON** are divides into Eons, which are divided into Eras. Eras are subdivided, in turn, into Periods, which are further subdivided into Epochs.

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## **GEOLOGIC TIME:**

**How to remember the geological time scale?**

➤ **To memorize the Eras:**

*Precambrian, Paleozoic, Mesozoic, Cenozoic:*

Pizza places make chicken.

➤ **To memorize the Periods:**

*Cambrian, Ordovician, Silurian, Devonian, Mississippian,  
Pennsylvanian, Permian, Triassic, Jurassic, Cretaceous, Tertiary,  
Quaternary:*

Come over some day, maybe play poker. Three jacks can take queens

➤ **To memorize the Epochs of Cenozoic Era:**

*Paleocene, Eocene, Oligocene, Miocene, Pliocene, Pleistocene,  
Holocene (or Recent):*

Put Eggs On My Plate Please Homer

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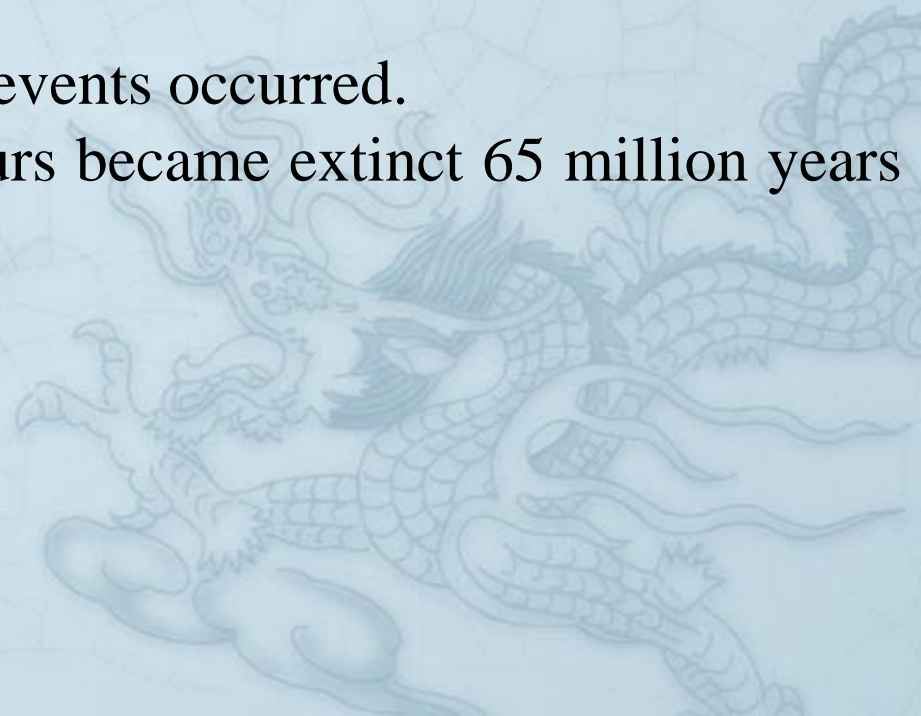
## **GEOLOGIC TIME:**

**How geologist measures the Geologic time?**

Geologists measure geologic time in two different ways.

***Relative Age:*** lists the order in which events occurred.

***Absolute Age*** is age in years. Dinosaurs became extinct 65 million years ago.



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

**How geologist measures the Geologic time scale?**

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*Absolute Age* is age in years. Dinosaurs became extinct 65 million years ago.

*Let's discuss with detail.*

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## **GEOLOGIC TIME:**

### **RELATIVE GEOLOGIC TIME:**

Absolute age measurements have become common only in the second half of this century. Prior to that time, geologists used field observations to determine relative ages. Even today, with sophisticated laboratory processes available, most field geologists routinely use relative ages. Geologists use a combination of common sense and a few simple principles to determine the order in which rocks formed and changed over time.



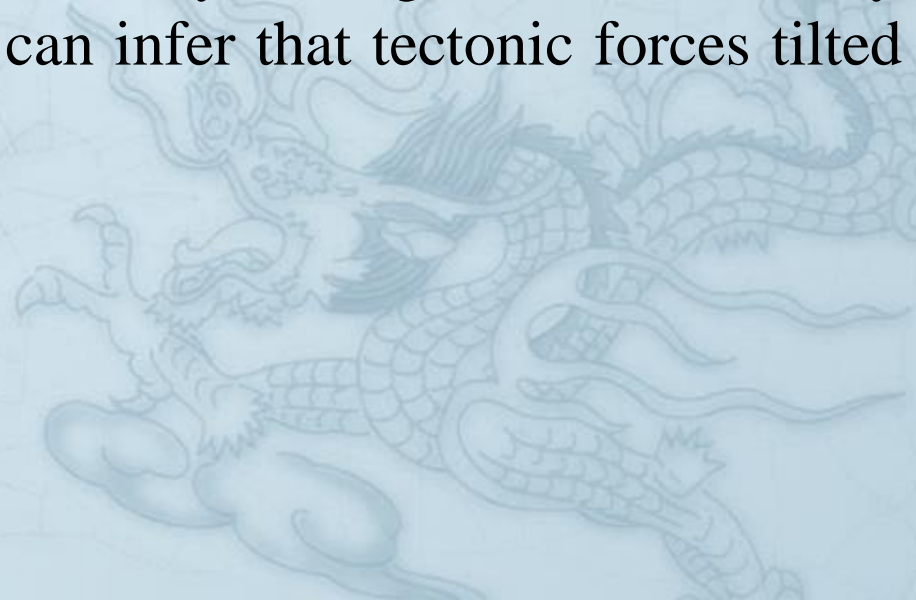
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## **GEOLOGIC TIME:**

### **RELATIVE GEOLOGIC TIME:**

#### *1. Principle Of Original Horizontality:*

The principle of original horizontality is based on observation that sediment usually accumulates in horizontal layers (Fig.1). If sedimentary rocks lie at an angle (as in Fig.2) we can infer that tectonic forces tilted them after they formed.



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**Fig.1** The principle of original horizontality tells us that most sedimentary rocks are deposited with horizontal bedding



**Fig.2** When we see tilted rocks, we infer that they were tilted after they were deposited.

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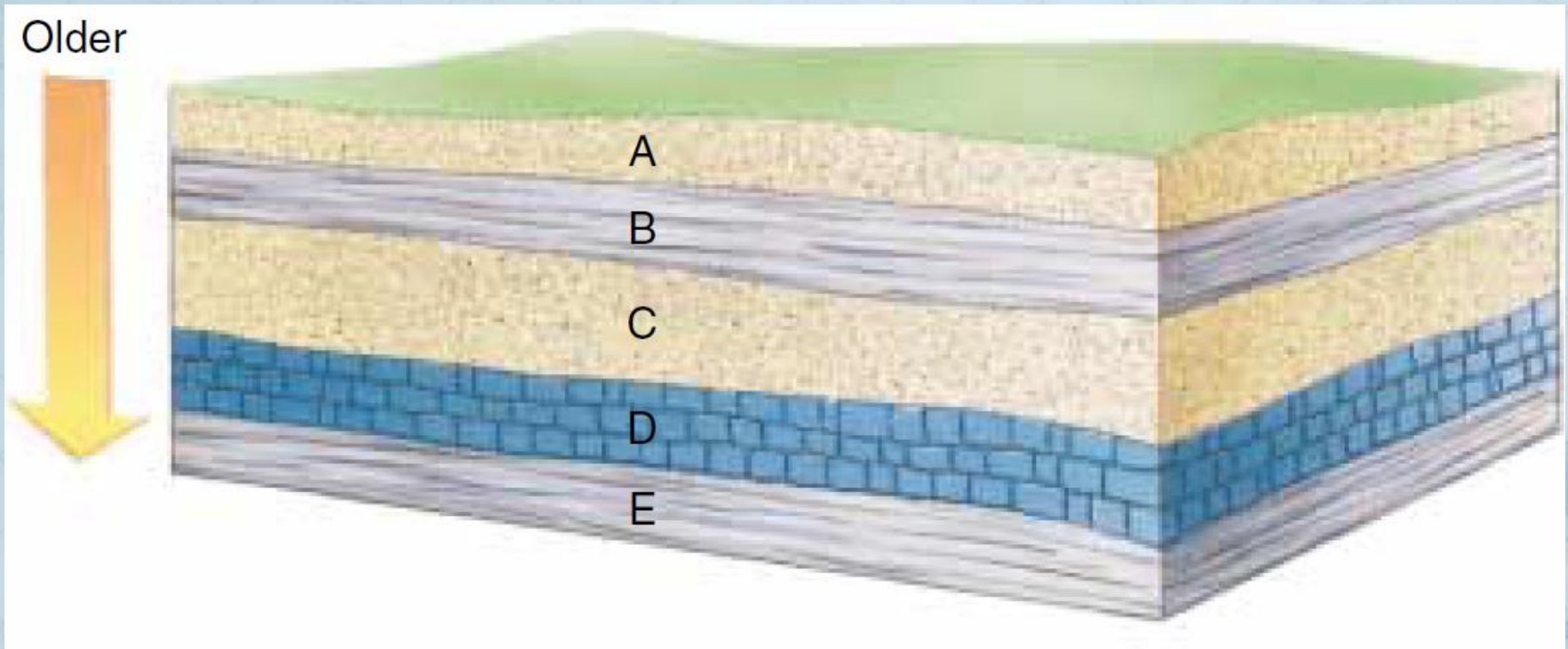
## **GEOLOGIC TIME:**

### **RELATIVE GEOLOGIC TIME:**

#### *Principle Of Superposition:*

The principle of superposition states that sedimentary rocks become younger from bottom to top (as long as tectonic forces have not turned them upside down). This is because younger layers of sediment always accumulate on top of older layers. In Figure 9–3, the sedimentary layers become progressively younger in the order E, D, C, B, and A.

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In a sequence of sedimentary beds, the oldest bed is the lowest, and the youngest is on top. These beds become older in the order A, B, C, D, E.

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## **GEOLOGIC TIME:**

### **RELATIVE GEOLOGIC TIME:**

#### *Principle Of Crosscutting Relationships:*

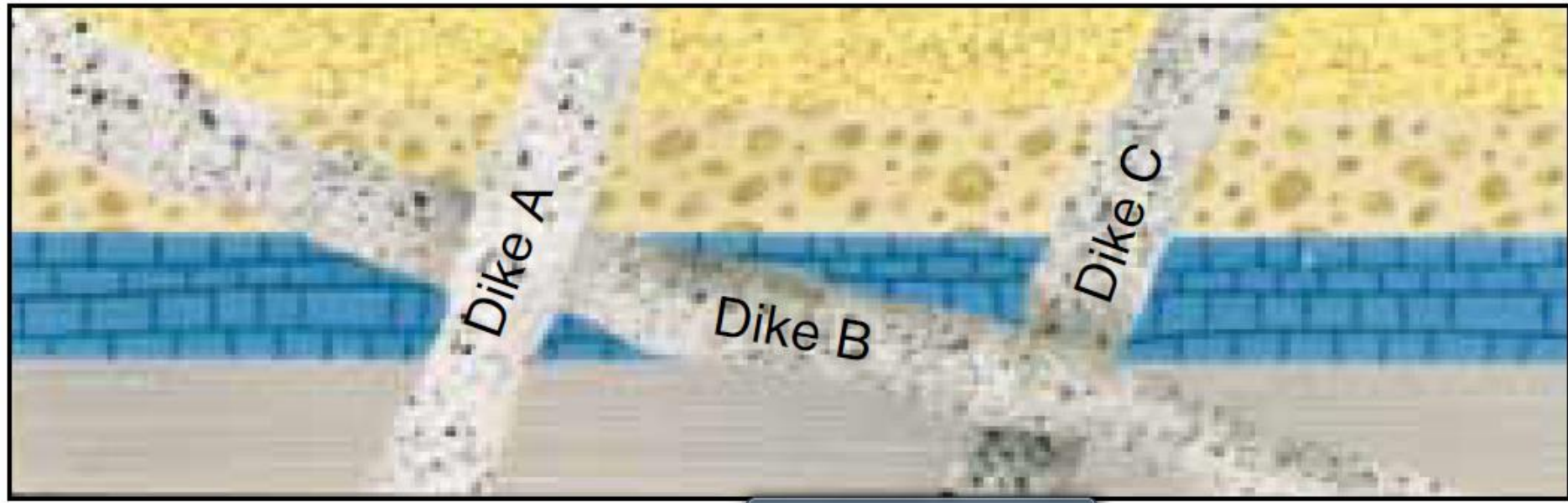
The principle of crosscutting relationships is based on the obvious fact that a rock must first exist before anything can happen to it. Clearly, the country rock must be older than the dikes. Figure A shows sedimentary rocks intruded by three granite dikes. Dike B cuts dike C, and dike A cuts dike B, so dike C is older than B, and dike A is the youngest. The sedimentary rocks must be older than all of the dikes.

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Figure shows light granite dikes cutting through older country rock.

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Three granite dikes cutting sedimentary rocks. The dikes become younger in the order C,B , A. The sedimentary rocks must be older than all three dikes

# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **FOSSILS AND FAUNAL SUCCESSION:**

Paleontologists study fossils, the remains and other traces of prehistoric life, to understand the history of life and evolution. *Fossils also provide information about the ages of sedimentary rocks and their depositional environments.* The oldest known fossils are traces of bacteria-like organisms that lived about 3.5 billion years ago. A much younger fossil consists of the frozen and mummified remains of a Bronze Age man recently found frozen in a glacier near the Italian-Austrian border (As shown in Fig).



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# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **FOSSILS AND FAUNAL SUCCESSION:**

#### **Interpreting Geologic History From Fossils:**

Fossils allow geologists to interpret geologic history. The *theory of evolution* states that life forms have changed throughout geologic time. Fossils are useful in determining relative ages of rocks because different animals and plants lived at different times in the Earth's history. For example, trilobites lived from 535 million to 245 million years ago, and the first dinosaurs appeared about 220 million years ago.

# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **FOSSILS AND FAUNAL SUCCESSION:**

#### **Interpreting Geologic History From Fossils:**

#### **Principle Of Faunal Succession:**

The principle of faunal succession states that fossil organisms succeeded one another through time in a definite and recognizable order and that the relative ages of rocks can therefore be recognized from their fossils.



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **FOSSILS AND FAUNAL SUCCESSION:**

#### **Interpreting Geologic History From Fossils:**

##### **Index Fossils:**

An index fossil indicates the age of rocks containing it. To be useful, an index fossil is produced by an organism that

- I. is abundantly preserved in rocks
- II. was geographically widespread
- III. existed as a species or genus for only a relatively short time, and
- IV. is easily identified in the field.

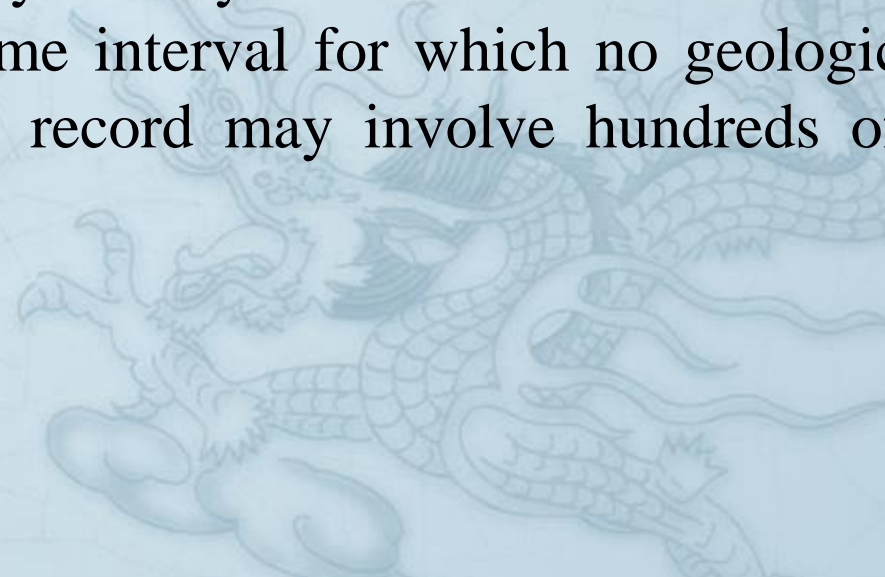
Floating or swimming marine animals that evolved rapidly make the best index fossils.

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## **GEOLOGIC TIME:**

### **UNCONFORMITIES :**

Layers of sedimentary rocks are conformable if they were deposited without interruption. An unconformity represents an interruption in deposition, usually of long duration. During the interval when no sediment was deposited, some rock layers may have been eroded. Thus, an unconformity represents a long time interval for which no geologic record exists in that place. The lost record may involve hundreds of millions of years.



# Geologic Time and Earth's Evolution.

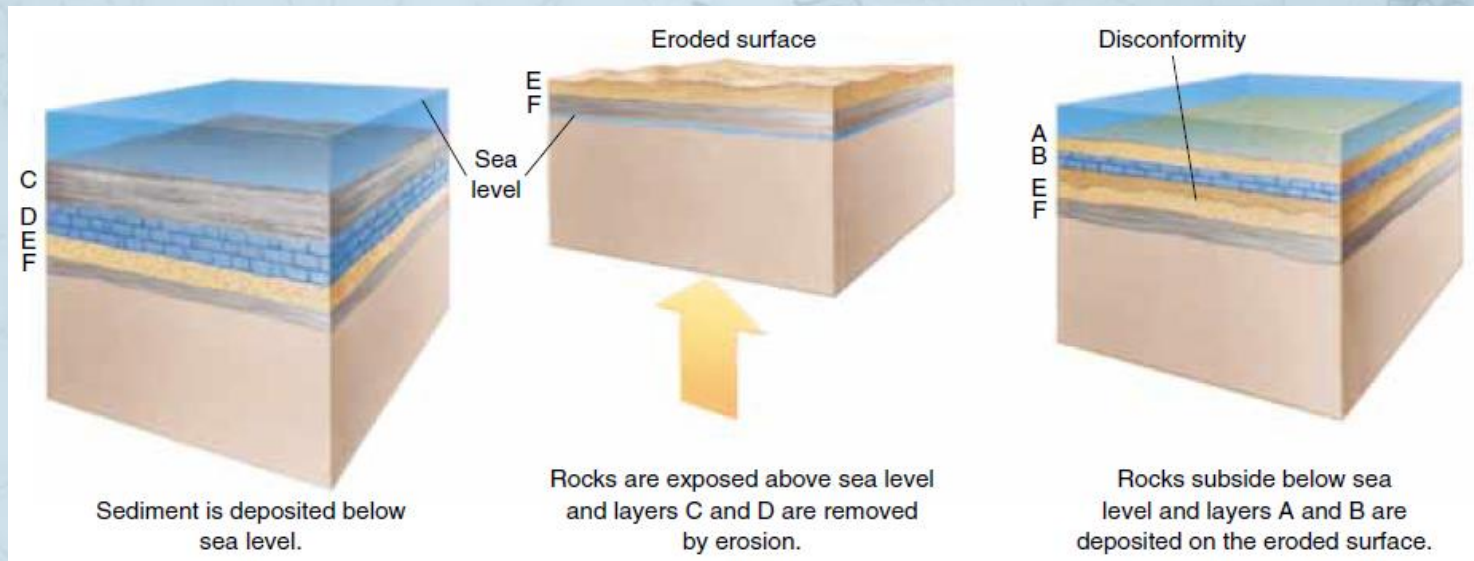
## GEOLOGIC TIME:

### UNCONFORMITIES :

Several types of unconformities exist.

### Disconformity:

In disconformity, the sedimentary layers above and below the unconformity are parallel.



# Geologic Time and Earth's Evolution.

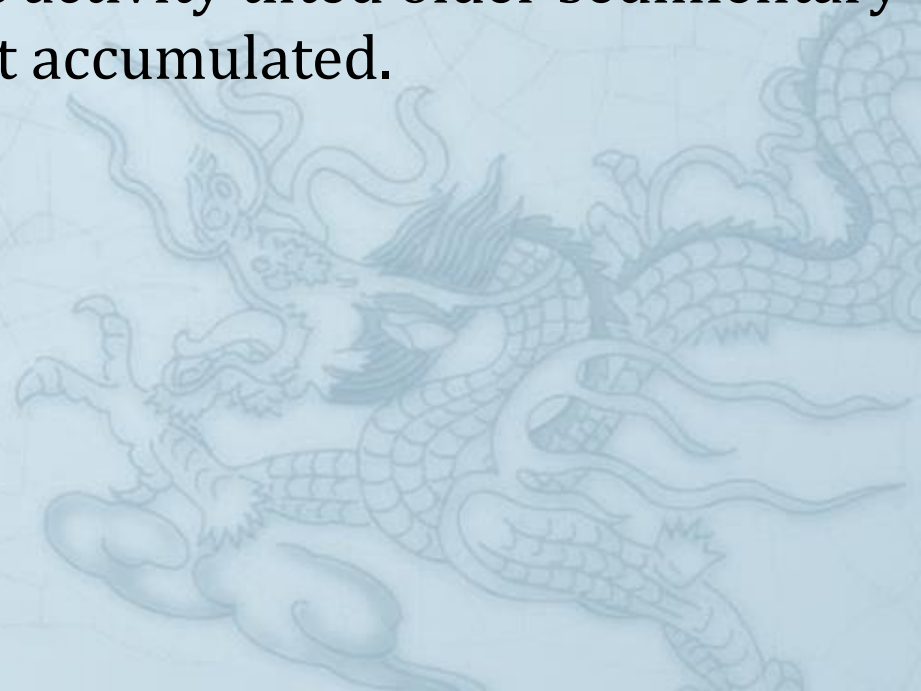
## **GEOLOGIC TIME:**

### **UNCONFORMITIES :**

Several types of unconformities exist.

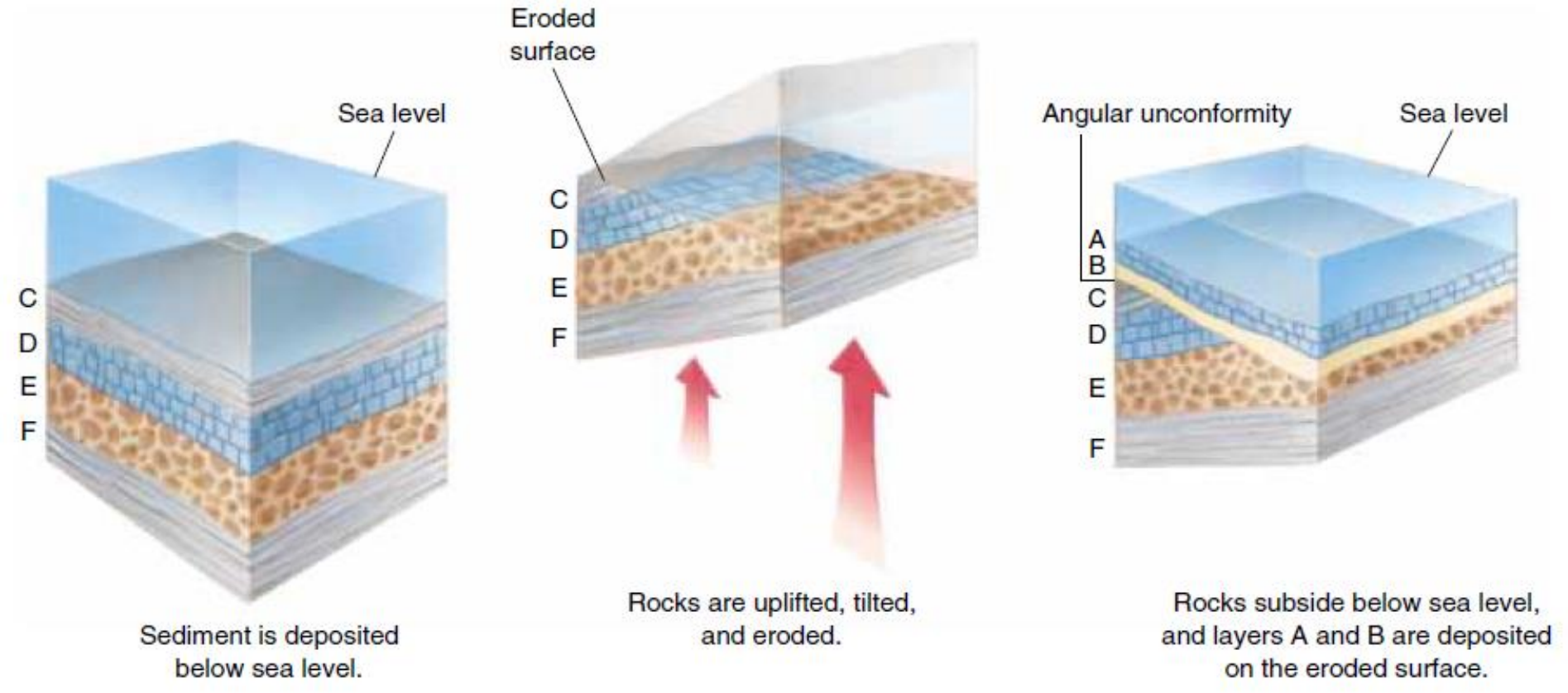
#### **Angular Unconformity:**

In an angular unconformity, tectonic activity tilted older sedimentary rock layers before younger sediment accumulated.



# Geologic Time and Earth's Evolution.

## GEOLOGIC TIME:



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## **GEOLOGIC TIME:**

### **UNCONFORMITIES :**

Several types of unconformities exist.

#### **Nonconformity :**

A nonconformity is an unconformity in which Sedimentary rocks lie on igneous or metamorphic rocks.



# Geologic Time and Earth's Evolution.

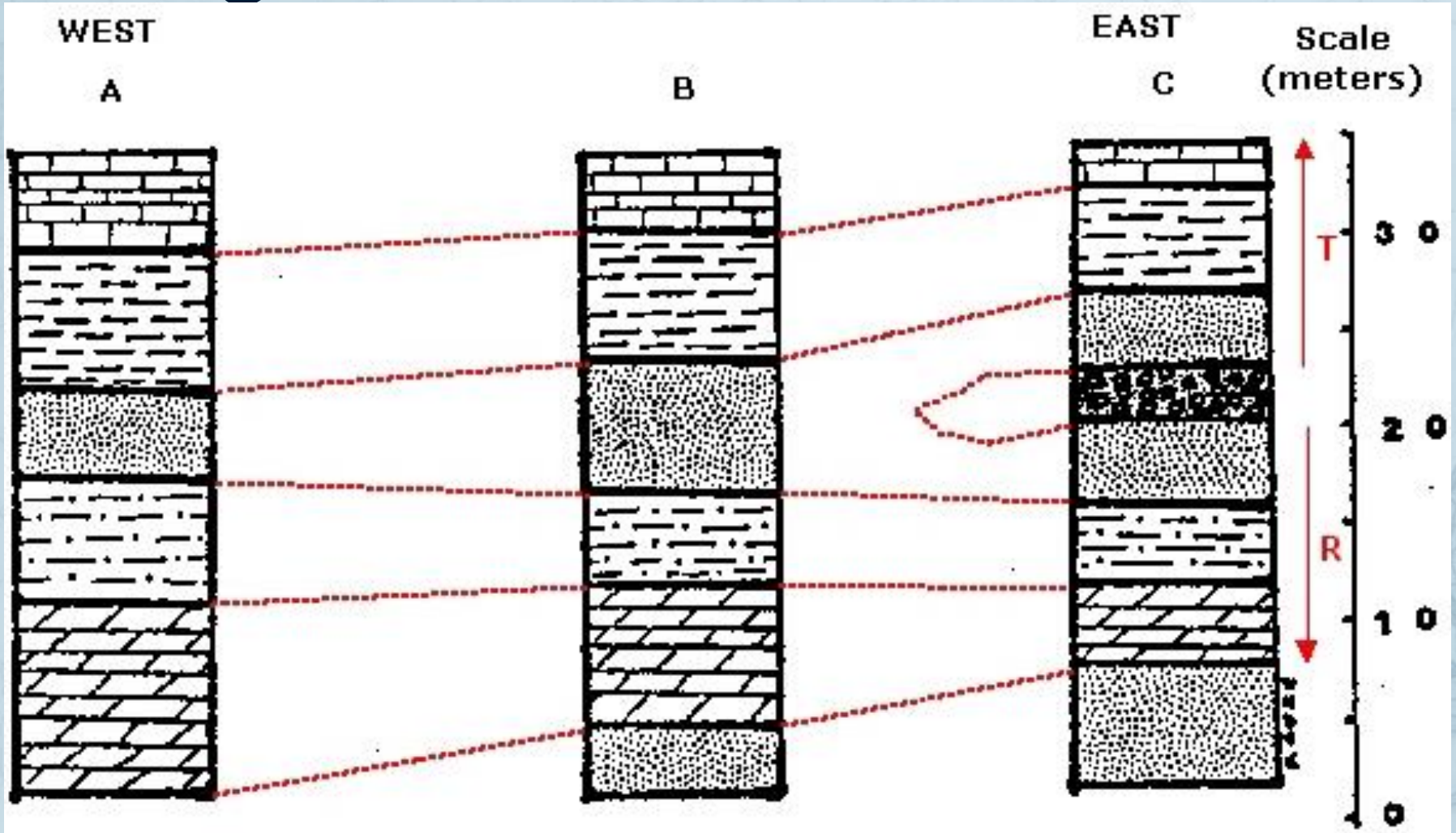
## **GEOLOGIC TIME:**

### **CORRELATION:**

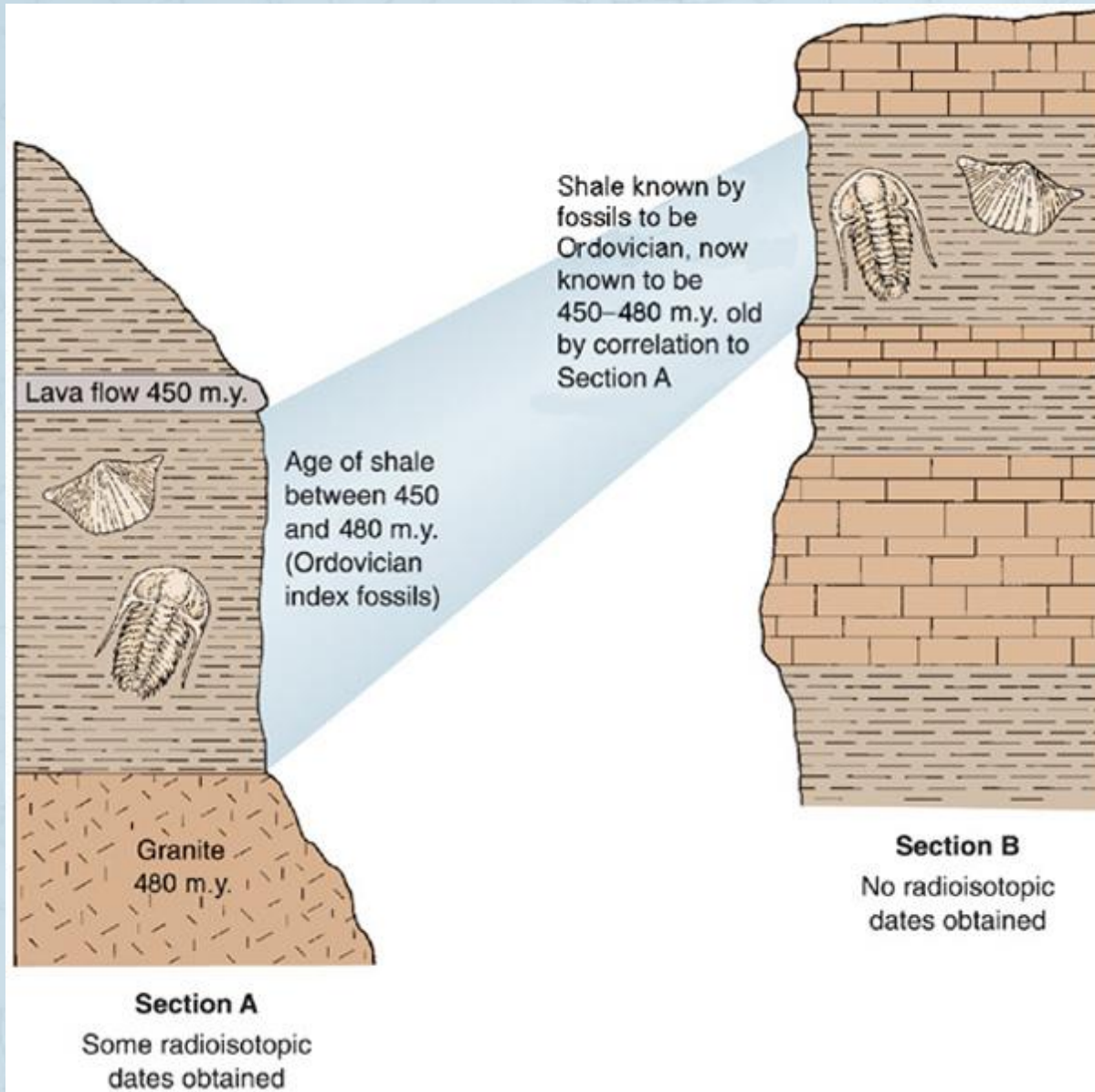
In geology, the term correlation refers to the methods by which the age relationship between various strata of Earth's crust is established. Such relationships can be established, in general, in one of two ways:

- by comparing the physical characteristics of strata with each other (physical correlation)
- by comparing the type of fossils found in various strata (fossil correlation).

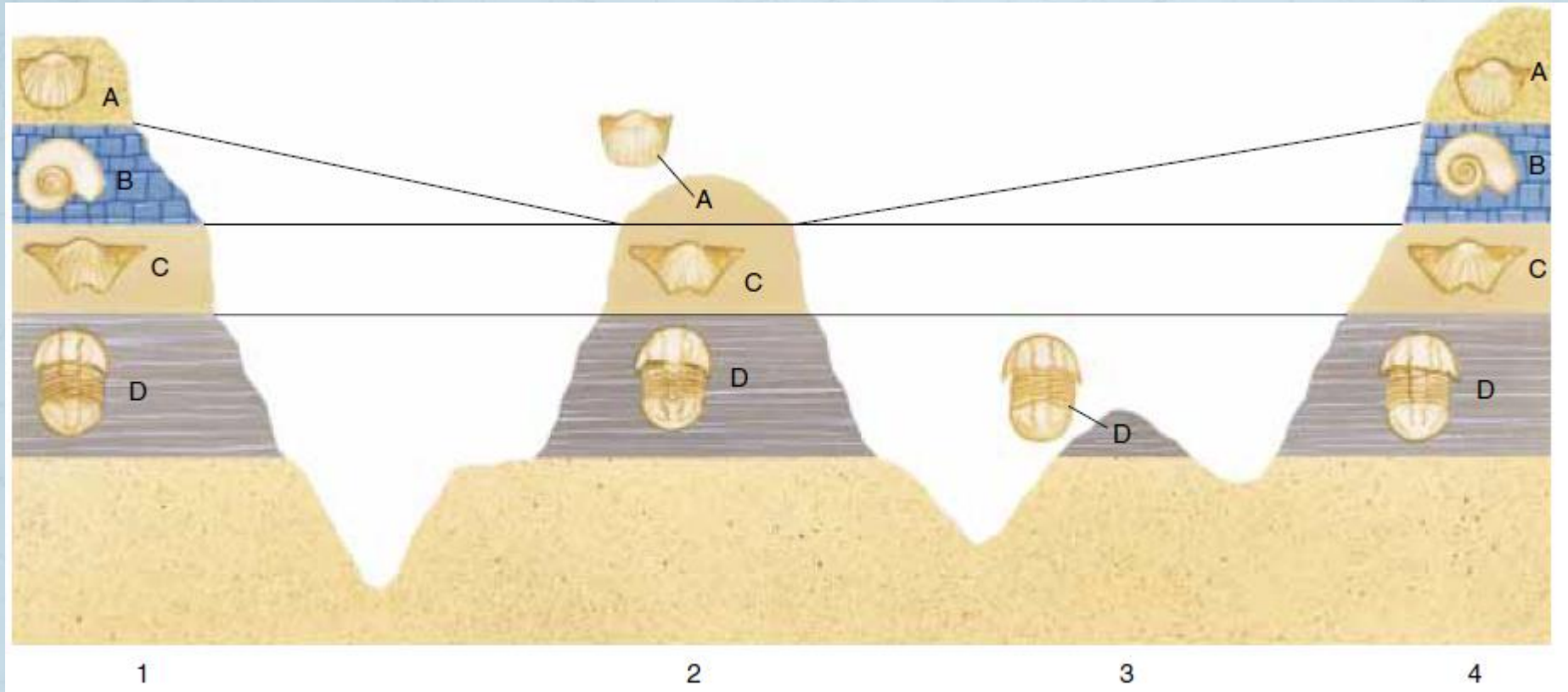
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# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

Absolute age measurement depends on two factors:

- A process that occurs at a constant rate (e.g., the Earth rotates once every 24 hours)
- Some way to keep a cumulative record of that process (e.g., marking the calendar each time the Sun rises).

Geologists have found a natural process that occurs at a constant rate and accumulates its own record: It is the radioactive decay of elements that are present in many rocks.

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## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

#### **Radioactivity:**

Isotopes are atoms of the same element with different numbers of neutrons. For example, all isotopes of potassium have 19 protons, but one isotope has 21 neutrons and another has 20 neutrons. Each isotope is given the name of the element followed by the total number of protons plus neutrons in its nucleus. Thus, potassium-40 contains 19 protons and 21 neutrons. Potassium-39 has 19 protons but only 20 neutrons.

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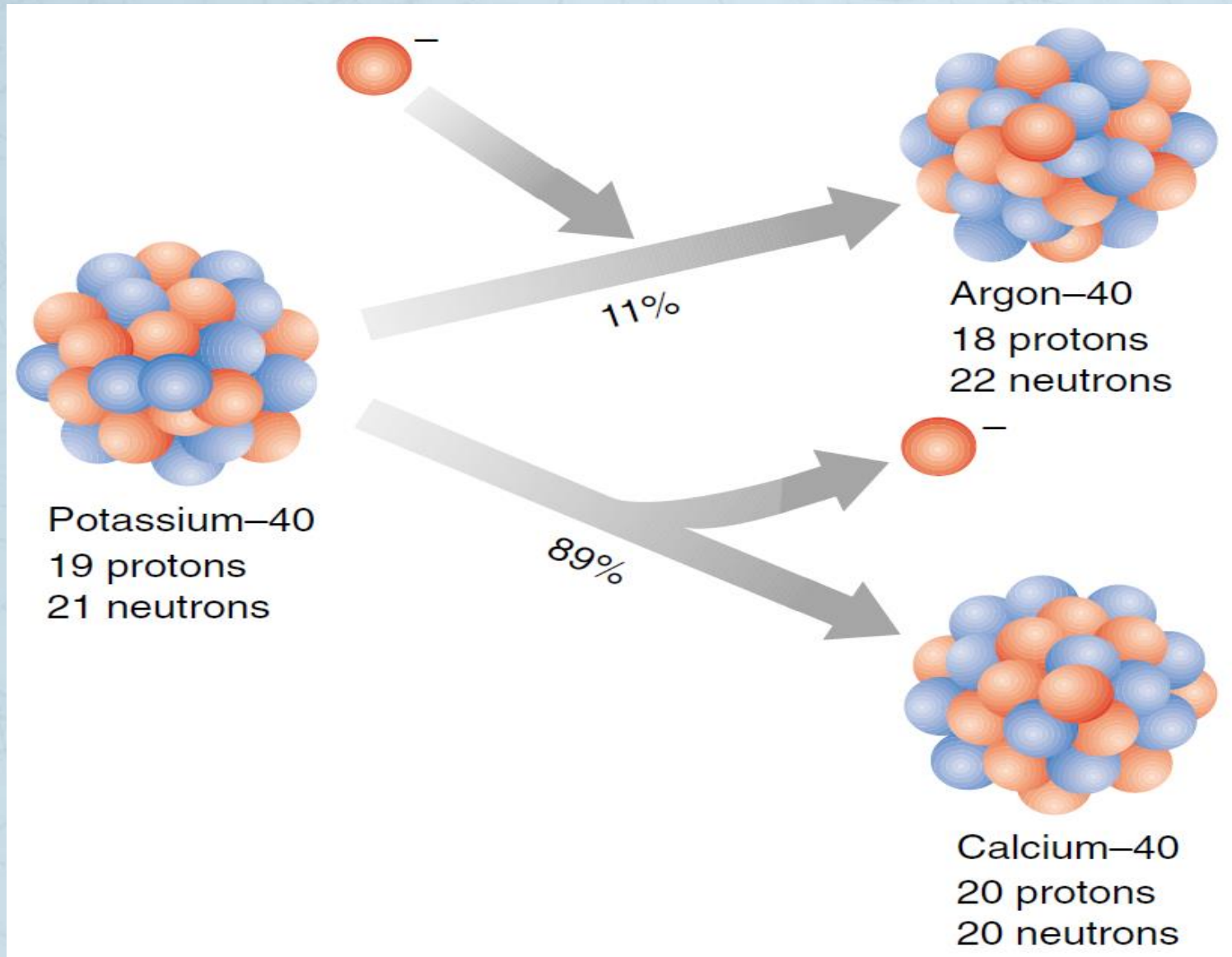
## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

#### **Radioactivity:**

Many isotopes are stable and do not change with time. If you studied a sample of potassium-39 for 10 billion years, all the atoms would remain unchanged. Other isotopes are unstable or radioactive. Given time, their nuclei spontaneously break apart. Potassium-40 decomposes naturally to form two other isotopes, argon-40 and calcium-40 (Fig). A radioactive isotope such as potassium-40 is known as a parent isotope. An isotope created by radioactivity, such as argon-40 or calcium-40, is called a daughter isotope.

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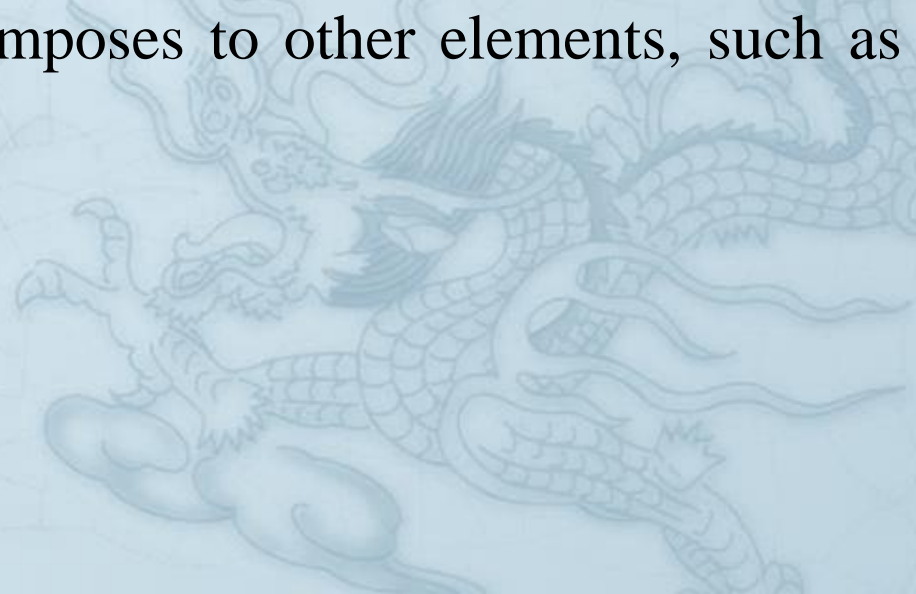
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## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

#### **Radioactivity:**

Many common elements, such as potassium, consist of a mixture of radioactive and nonradioactive isotopes. With time, the radioactive isotopes decay, but the nonradioactive ones do not. A few elements, such as uranium, consist only of radioactive isotopes. The amount of uranium on Earth slowly decreases as it decomposes to other elements, such as lead.



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

#### **Radioactivity And Half-life:**

The half-life is the time it takes for half of the atoms in a sample to decompose. The half-life of potassium-40 is 1.3 billion years. Therefore, if 1 gram of potassium-40 were placed in a container, 0.5 gram would remain after 1.3 billion years, 0.25 gram after 2.6 billion years, and so on. Each radioactive isotope has its own half-life; some half-lives are fractions of a second and others are measured in billions of years.

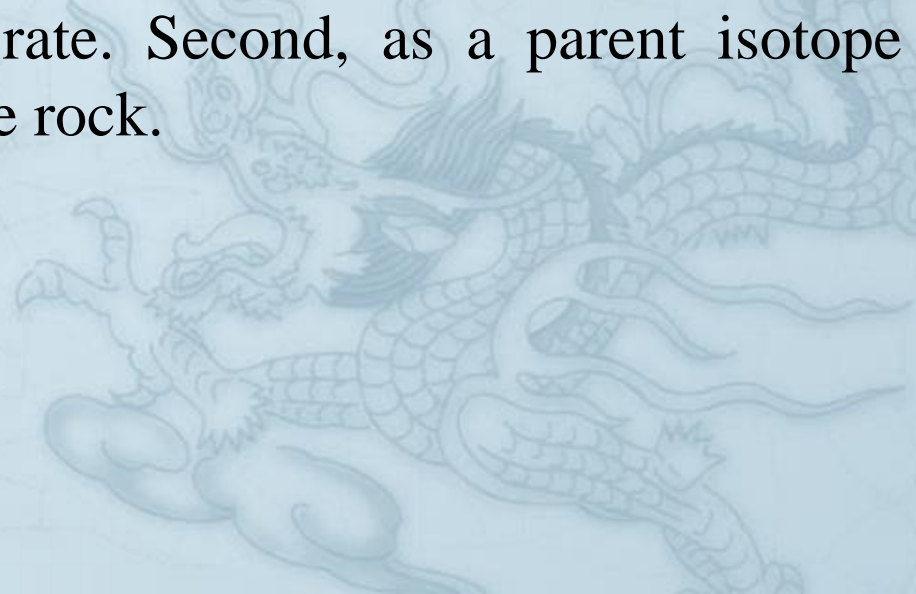
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## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

#### **The basis of radiometric dating :**

Two aspects of radioactivity are essential to the calendars in rocks. First, the half-life of a radioactive isotope is constant. It is easily measured in the laboratory and is unaffected by geologic processes. So radioactive decay occurs at a known, constant rate. Second, as a parent isotope decays, its daughter accumulates in the rock.



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## **GEOLOGIC TIME:**

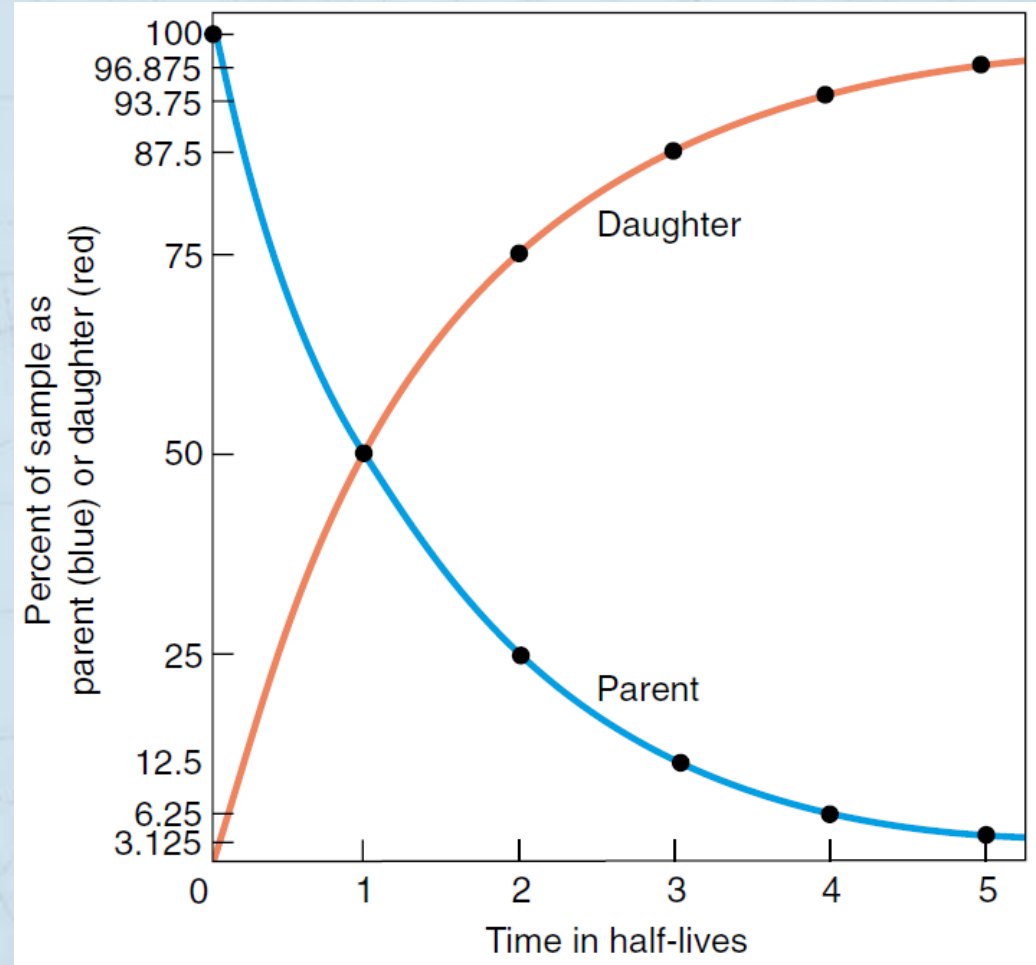
### **ABSOLUTE GEOLOGIC TIME:**

#### **Radiometric dating:**

Radiometric dating is the process of determining the ages of rocks, minerals, and fossils by measuring their parent and daughter isotopes. Fig shows the relationships between age and relative amounts of parent and daughter isotopes. At the end of one half-life, 50 percent of the parent atoms have decayed to daughter. At the end of two half-lives, the mixture is 25 percent parent and 75 percent daughter. To determine the age of a rock, a geologist measures the proportions of parent and daughter isotopes in a sample and compares the ratio to a similar graph.

# Geologic Time and Earth's Evolution.

As a radioactive parent isotope decays to a daughter, the proportion of parent decreases (blue line), and the amount of daughter increases (red line). The half-life is the amount of time required for half of the parent to convert to daughter. At time zero, when the radiometric calendar starts, a sample is 100 percent parent. At the end of one half-life, 50 percent of the parent has converted to daughter. At the end of two half-lives, 25 percent of the sample is parent and 75 percent is daughter. Thus, by measuring the proportions of parent and daughter in a rock, its age in half-life can be obtained. Because the half-lives of all radioactive isotopes are well known, it is simple to convert age in half-life to age in years.



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **ABSOLUTE GEOLOGIC TIME:**

#### **Radiometric dating:**

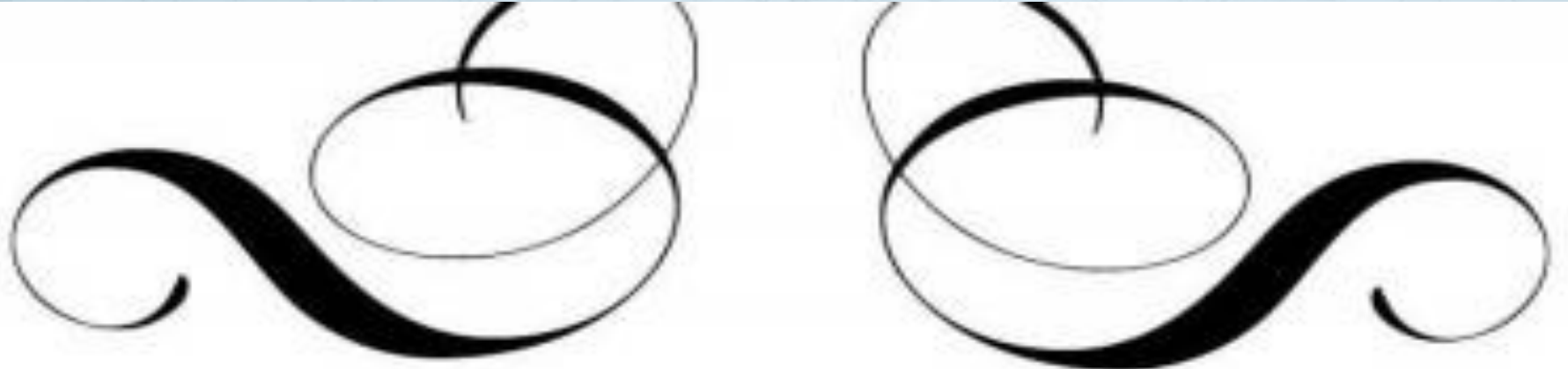
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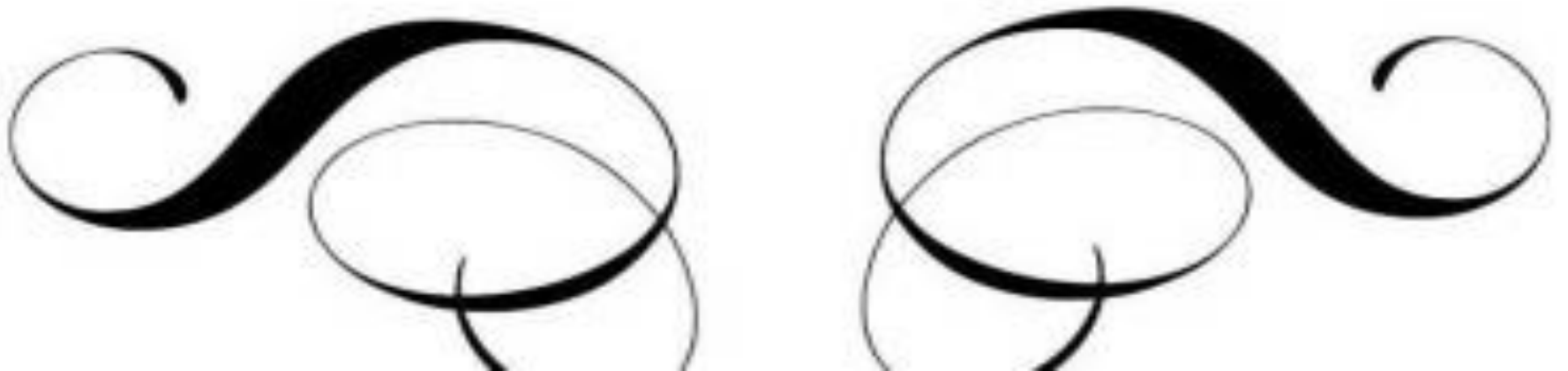
**Table 9-1 • THE MOST COMMONLY USED ISOTOPES IN RADIOMETRIC AGE DATING**

ISOTOPES		HALF-LIFE OF PARENT (YEARS)	EFFECTIVE DATING RANGE (YEARS)	MINERALS AND OTHER MATERIALS THAT CAN BE DATED
Parent	Daughter			
Carbon-14	Nitrogen-14	5730 ± 30	100–70,000	Anything that was once alive: wood, other plant matter, bone, flesh, or shells; also, carbon in carbon dioxide dissolved in ground water, deep layers of the ocean, or glacier ice
Potassium-40	Argon-40 Calcium-40	1.3 billion	50,000–4.6 billion	Muscovite Biotite Hornblende Whole volcanic rock
Uranium-238	Lead-206	4.5 billion	10 million–4.6 billion	Zircon Uraninite and pitchblende
Uranium-235 Thorium-232	Lead-207 Lead-208	710 million 14 billion		
Rubidium-87	Strontium-87	47 billion	10 million–4.6 billion	Muscovite Biotite Potassium feldspar Whole metamorphic or igneous rock

# Geologic Time and Earth's Evolution.



*Thank You*



# Geologic Time and Earth's Evolution.

## **GEOLOGIC TIME:**

### **Questions:**

1. Who was the inventor of Geological time scale (GTS)? And when he invent it?
2. What is the chronological dating?
3. How many periods are in GTS? Write down their names in sequence
4. Briefly describe the principles used in relative age?
5. What is meant by Index Fossil?
6. Describe radiometric dating?
7. What are the daughter elements of Potassium<sup>40</sup>?