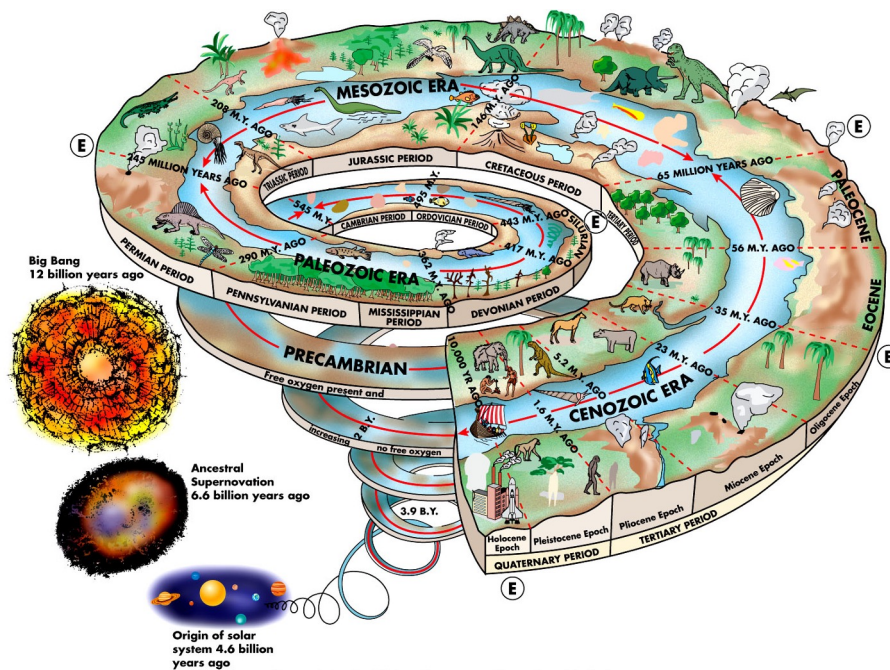# Earth's History

How old is the Earth?
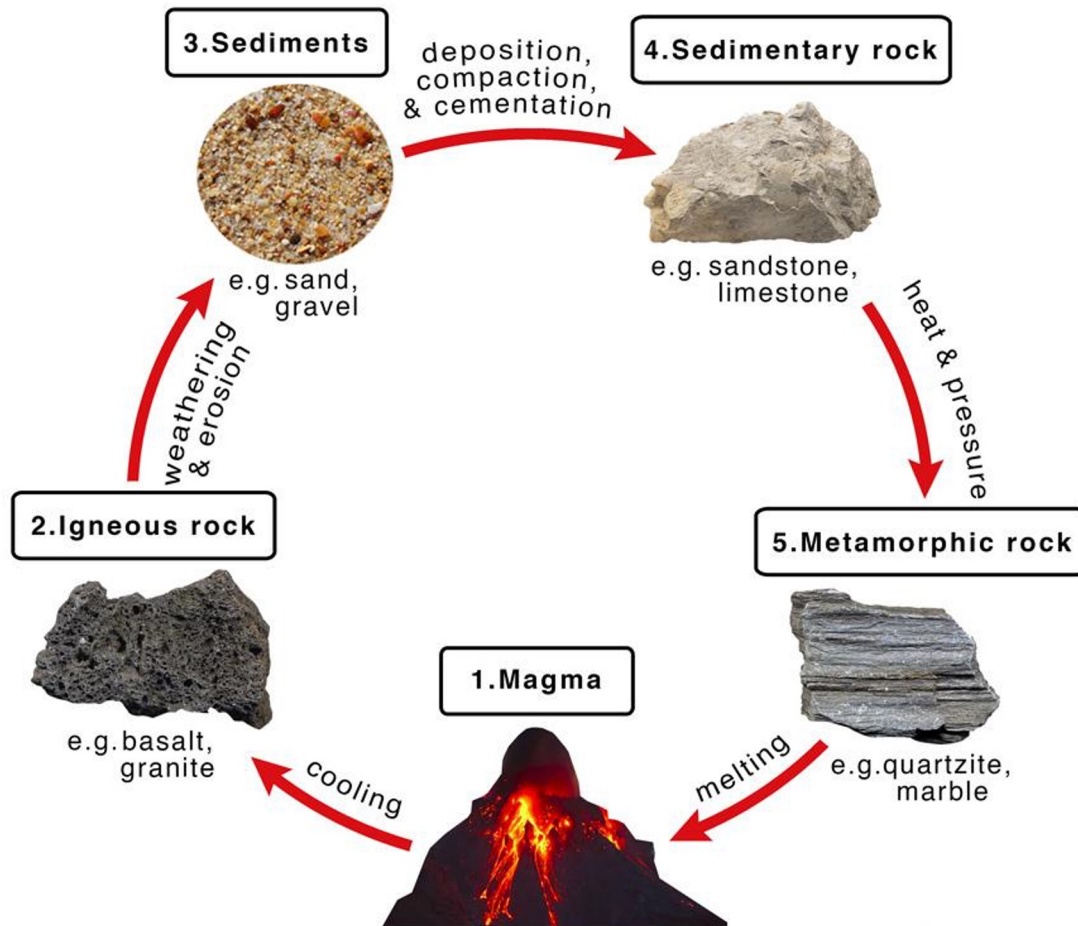
Planet Earth is approximately <mark>4.6 billion</mark> years old

How do we know?
You are about to find out!

Rock Cycle – 3 types of Rock

Steps of the Rock Cycle

3.Sediments — deposition, compaction, & cementation → 4.Sedimentary rock

e.g. sand, gravel

e.g. sandstone, limestone

weathering & erosion

heat & pressure

2.Igneous rock

5.Metamorphic rock

e.g. basalt, granite

1.Magma

cooling

melting

e.g. quartzite, marble

ScienceFacts.net

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There are two types of Geologic Dating

- **Relative**
  - Used to determine if one thing is younger or older than another
- **Absolute**
  - Determines approximately how many years old something is.
    - (Usually, a range of millions of years)

Tools used to determine

Relative Dating

- Law of superposition
- Use of index fossils
- Correlation of rock layers

Absolute Dating

- Radiometric Dating
  - Carbon 14 Dating
  - Potassium-Argon Dating
  - Uranium-Series Dating
  - Uranium-Lead Dating

These two methods are used together to put together the puzzle that is the History of our Earth.
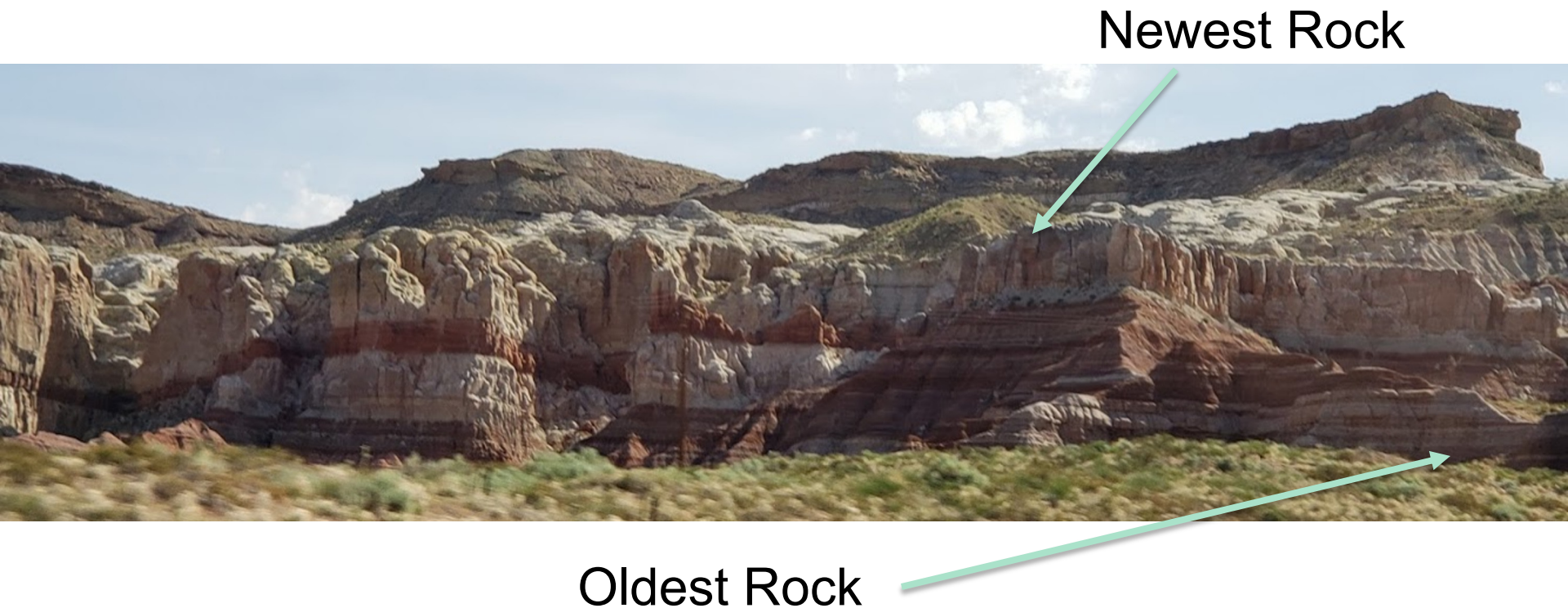
Relative Dating

- Definition: <mark>A method of dating rock layers and fossils by comparing them to each other.</mark>

We can only determine what is older and what is younger using this method.

Law of Superposition

- Definition: ==Sedimentary rock layers form in flat layers with the oldest on the bottom and the newest on the top.==
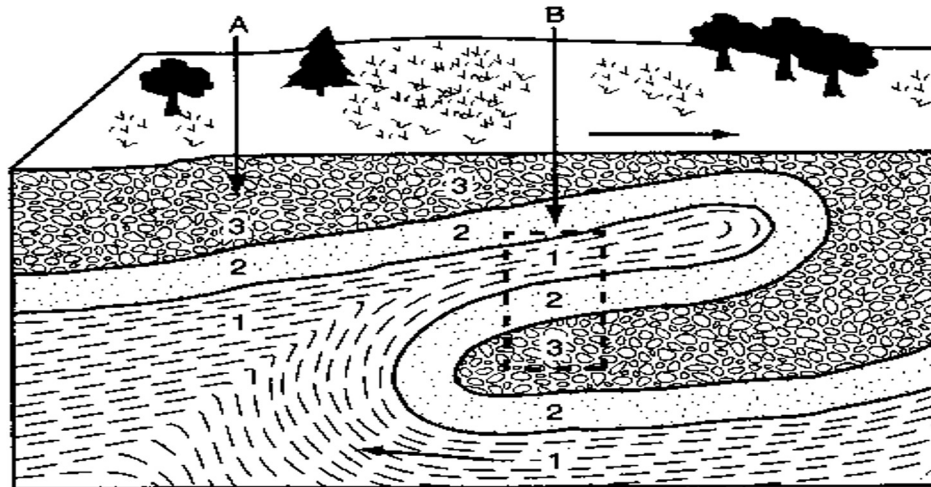
Newest Rock

Oldest Rock

What if the rock isn't flat?!

- Rock Folds
- Rock Faults
- Lava cutting through rocks
- Rocks in Rocks
- Eroding rocks
- Earthquakes

Rock Folds

- **Rock layers are older than folds found in them**
  - Layers were there before they were folded.

 This means the rock layers formed flat and then were folded.

Undisturbed Strata   Recumbent Fold

The dotted boxes show where superposition does not apply.

Faults

- Definition: <mark>a crack or fracture in the Earth's crust where rocks on either side have moved past each other</mark>.

  - Rock layers are older than faults found in them.

  - This means the rock layers formed first, then an earthquake happened and broke the rock layers causing the fault.
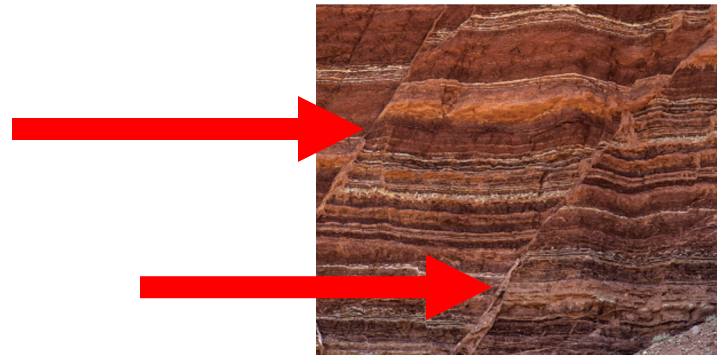
Law of Cross Cutting

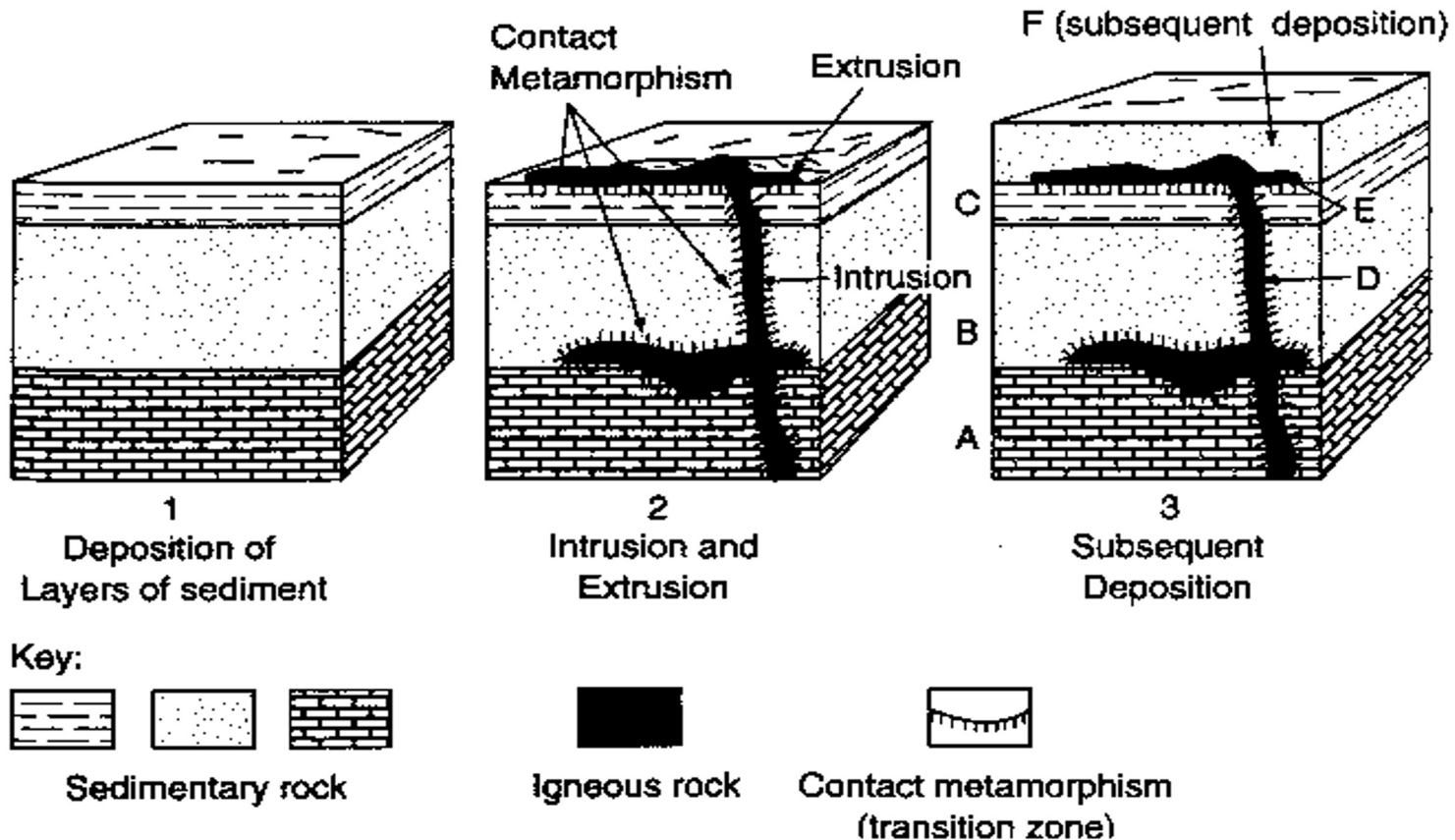- Anything that cuts through the rock layers is younger than the rock layers they cut through.
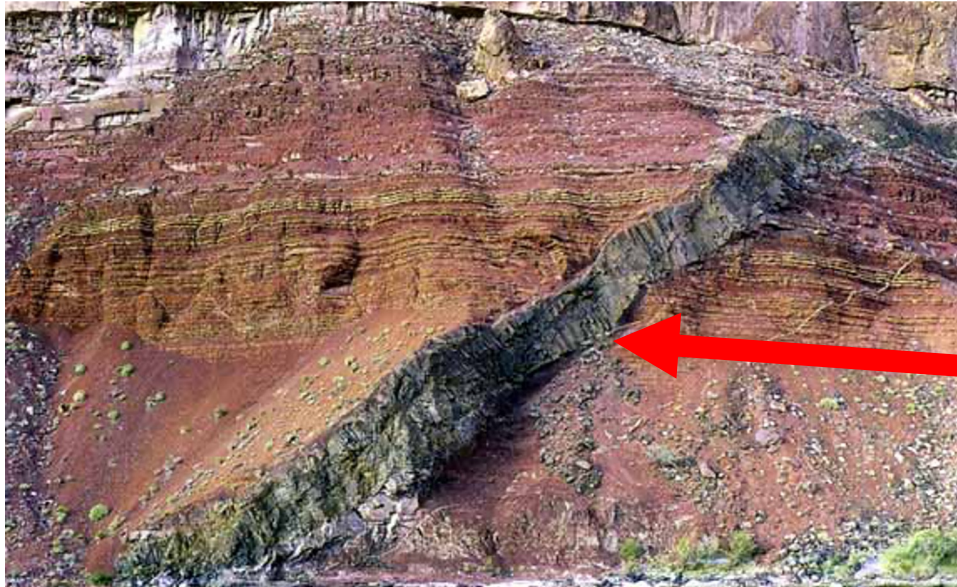
Lava burns through the rock layers from the Earth's mantle.

This example is called an Igneous Intrusion.

Igneous Intrusions vs. Extrusions

- Igneous intrusions <mark>cut through the rock</mark>.
- Igneous Extrusions <mark>spreadout on top</mark>.

Contact Metamorphism   Extrusion   F (subsequent deposition)

Intrusion

C

E

B

D

A

1
Deposition of
Layers of sediment

2
Intrusion and
Extrusion

3
Subsequent
Deposition

Key:

Sedimentary rock

Igneous rock

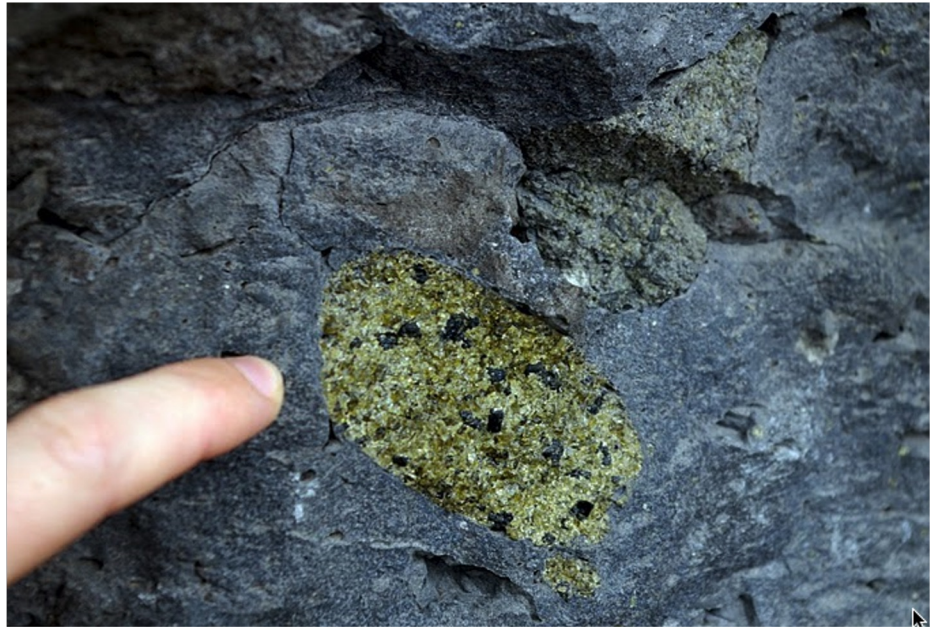Contact metamorphism
(transition zone)

Law of Inclusion

- Definition: Rocks found within the layers of other rocks, are older than the rock that surrounds them.
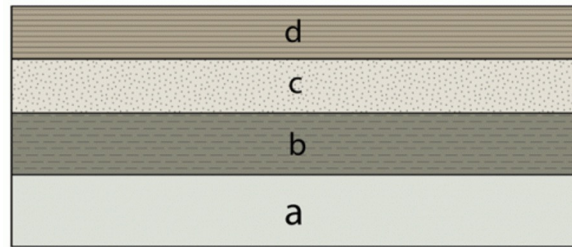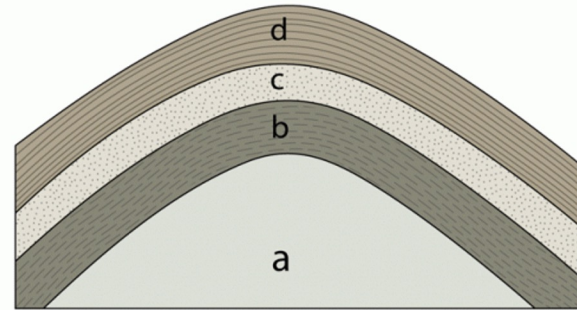
Granite
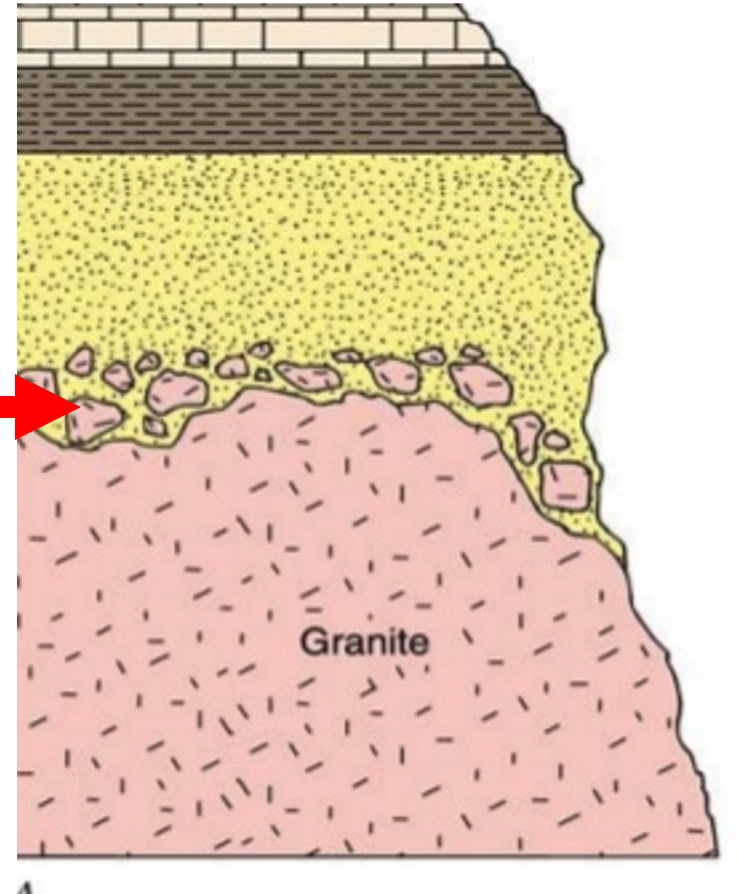
Law of Inclusion

Unconformity

- Definition: <mark>When a new sedimentary rock layer is formed on top of an eroded surface</mark>

Evolution of an Angular Unconformity

1. Deposition
2. Deformation
3. Erosion
4. Renewed deposition
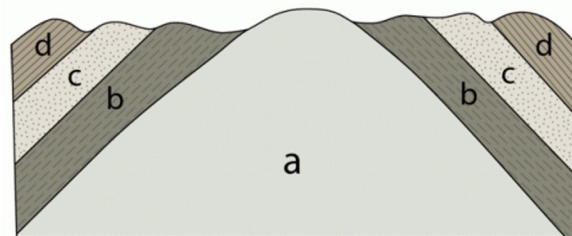
Unconformity

Practice: what happened here?
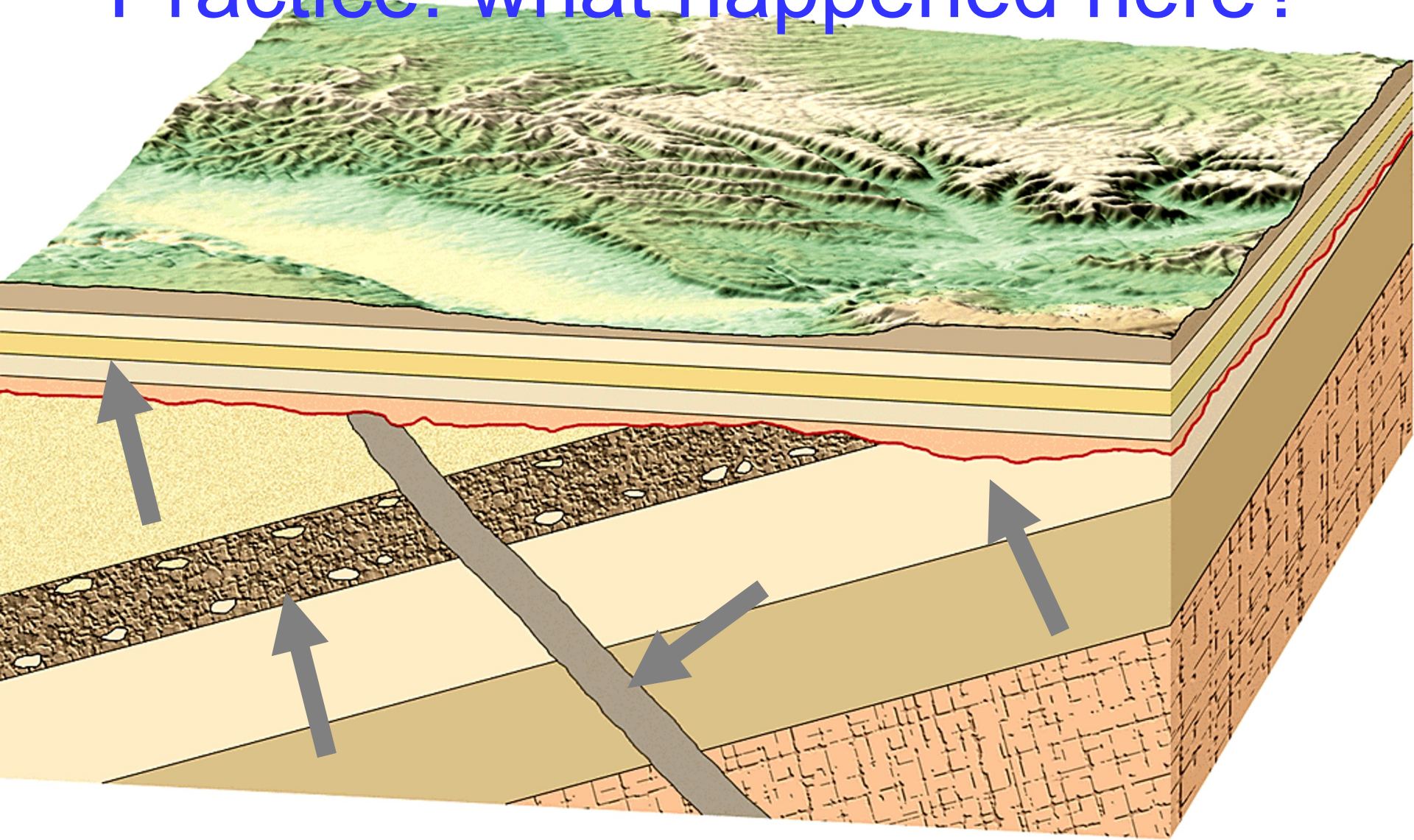
Absolute Dating

Definition: ==A method used to determine how old something is using the atoms in the rock or fossil==.

- Uses ==numbers== (in millions of years, mya)
- Only works for ==Igneous== Rocks and some ==fossils==

Numerical dating

495 mya

510 mya

dating of volcanic ash

520 mya

545 mya
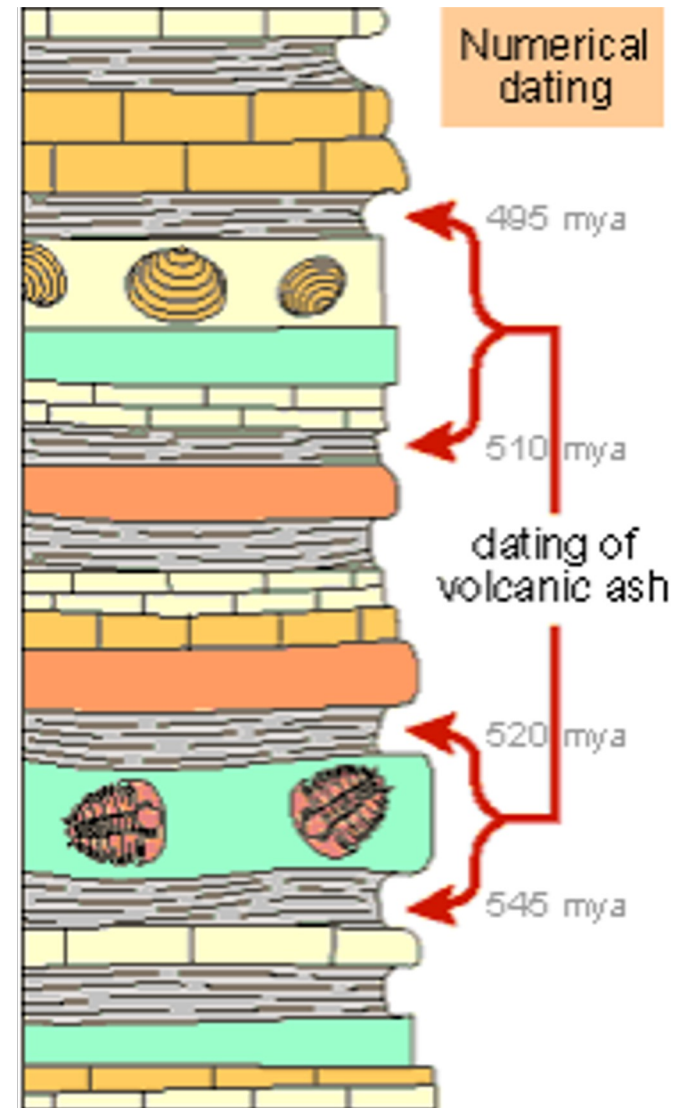
Absolute Dating

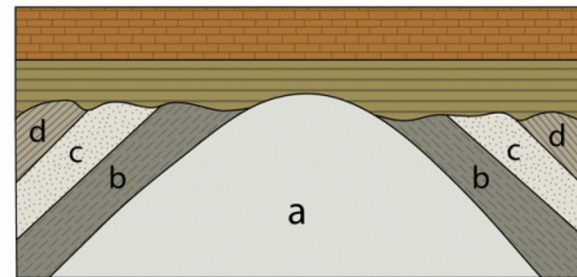- Determines the specific age of a ==fossil==
- Looks at ==chemical== properties
- Many different types:
  - Carbon-14 (radiocarbon)
  - Potassium-Argon
  - Uranium Series Dating
  - Uranium Lead Dating
- And more!

How Absolute Dating Works

- When <mark>magma/lava</mark> cools, radioactive elements are incorporated into the minerals

- Examples:
  - Potassium 40
  - Uranium 235
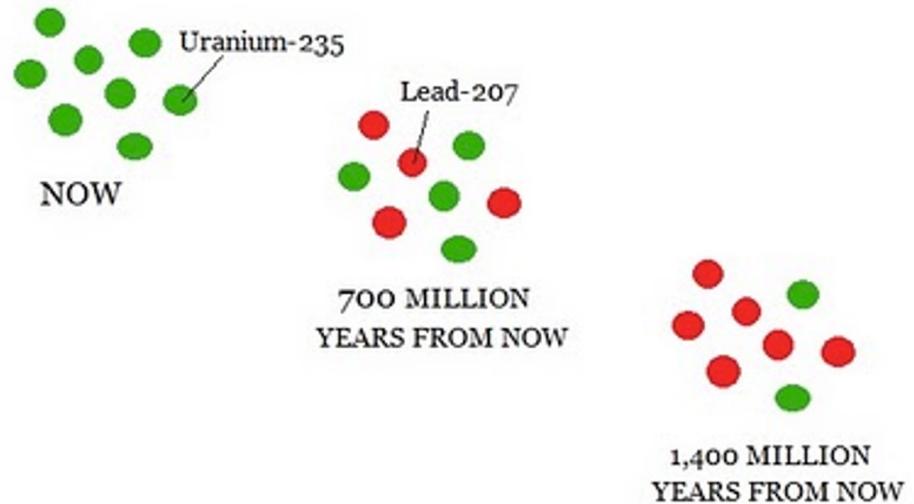
How Absolute Dating Works

- These elements begin to ==decay== at a known rate starting when the rock cools

- We can ==measure== how much of the element is left

- Tells us how much ==time== has passed since the rock ==formed==.

Carbon-14 Dating

- Also known as Radiocarbon dating
- Used to date organic substances
- Scientists measure the radiocarbon in the fossil to determine its age
- Can only date specimens up to about 60,000 years old

Potassium-Argon Dating

- Scientists determine the ==age== of the rock surrounding the ==fossil== to determine the fossil's age.

- Used only for ==inorganic== substances (rocks and minerals)

- Scientists measure the amount of argon in the rock to determine its age

- Dates rock ==60,000 years old and older==

Uranium-Series Dating

- This method can be used to date calcium carbonate deposits, such as those in caves or the shells of some marine fossils.

- Can provide age estimates for materials that range from a **few thousand years to several hundred thousand years**, depending on the specific isotopes being measured.

Uranium-Lead Dating

- **U-238** dating is often used for dating rocks and minerals with ages in the billions of years, such as the age of Earth itself and the age of the Moon's surface.

- **U-235** dating is employed for materials with ages ranging from **tens of millions to billions of years.**

- Used to date igneous rock most frequently

Using Relative and Absolute Dating Together

- Fossils
  - Relative Dating: Index Fossils, Correlation
  - Absolute: Radioactive Dating

What is a Fossil?

Fossil

The evidence in rock of the presence of a plant or animal from an earlier period in time

Each type of fossil provides unique information about past life forms and the history of the Earth, contributing to our understanding of evolution, paleoecology, and geology.

Fossils

- Generally found in sedimentary rock layers

- Why don't fossils exist in most igneous or metamorphic rock?

Key to rock types

- Limestone
- Shale
- Sandstone
- Conglomerate
- Basalt
- Schist
- Contact Metamorphism

Key to Fossils

- Mastodont
- Condor
- Figlike leaf
- Dinosaur
- Brachiopod
- Ammonite

Location A

Location B
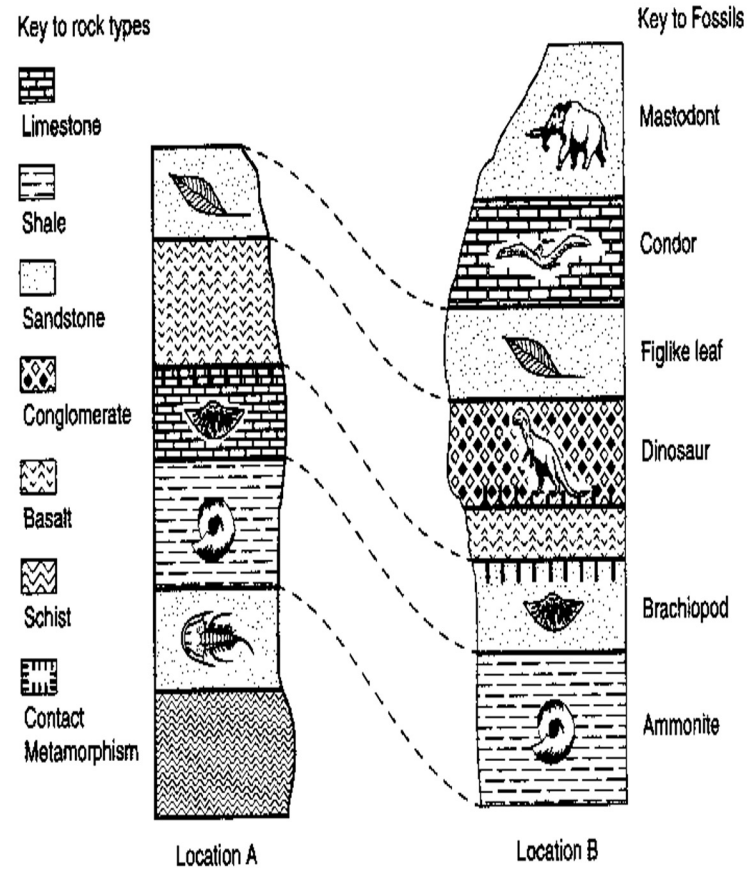
Types of Fossils

- **Body Fossils:** These fossils are the preserved remains of the actual body parts of ancient organisms.

  – Examples: Bone, teeth, shell and in rare cases soft tissues fossils.
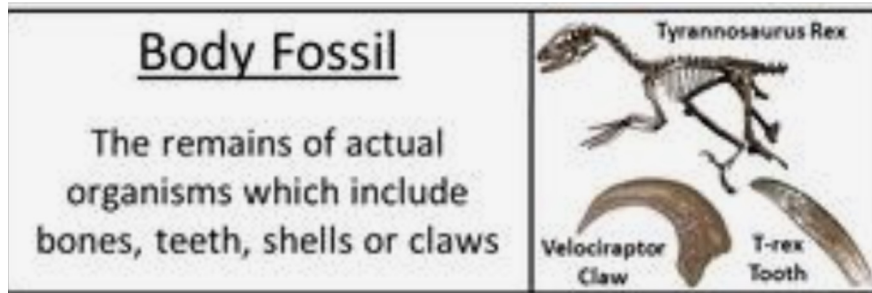
Psittacosaurus preserved with
 fossilised skin (Soft Tissue)

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Types of Fossils

- **Plant Fossils:**
  - Examples: petrified wood, leaves, and flowers.
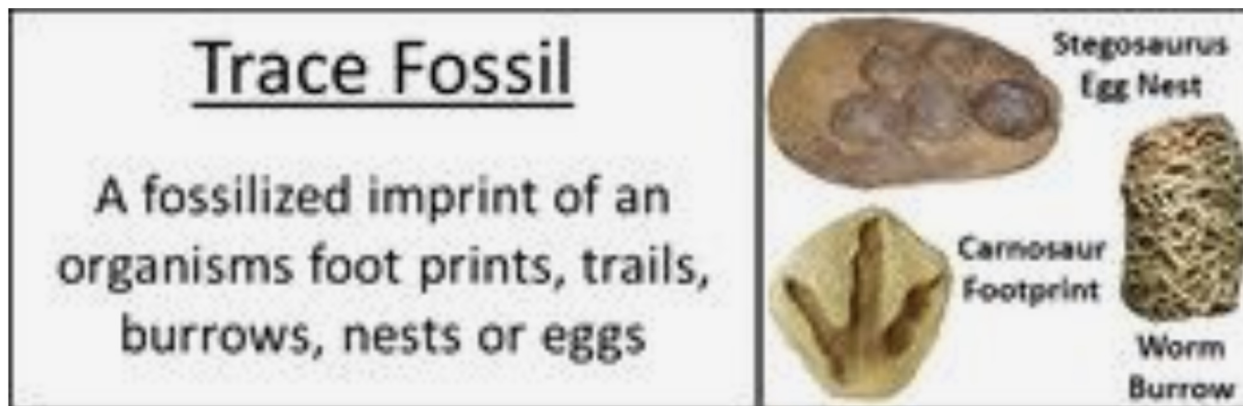
Types of Fossils

- **Trace Fossils:** These fossils are not the actual remains of an organism but rather evidence of their activities.
  - Examples: Footprints, tracks, burrows, feces, nests, and eggs.

Trace Fossil

A fossilized imprint of an organisms foot prints, trails, burrows, nests or eggs

Stegosaurus Egg Nest

Carnosaur Footprint

Worm Burrow

Types of Fossils

Molds and Casts: When an organism's remains dissolve, they can leave behind a cavity or mold in the surrounding rock.

The fossil begins to weather and erode as water moves through the rock layers.

The fossil has been eroded away; the harder rocks once surrounding it form a mold.

Sediments are carried into the mold and deposited.

A cast is formed.

More types of fossils
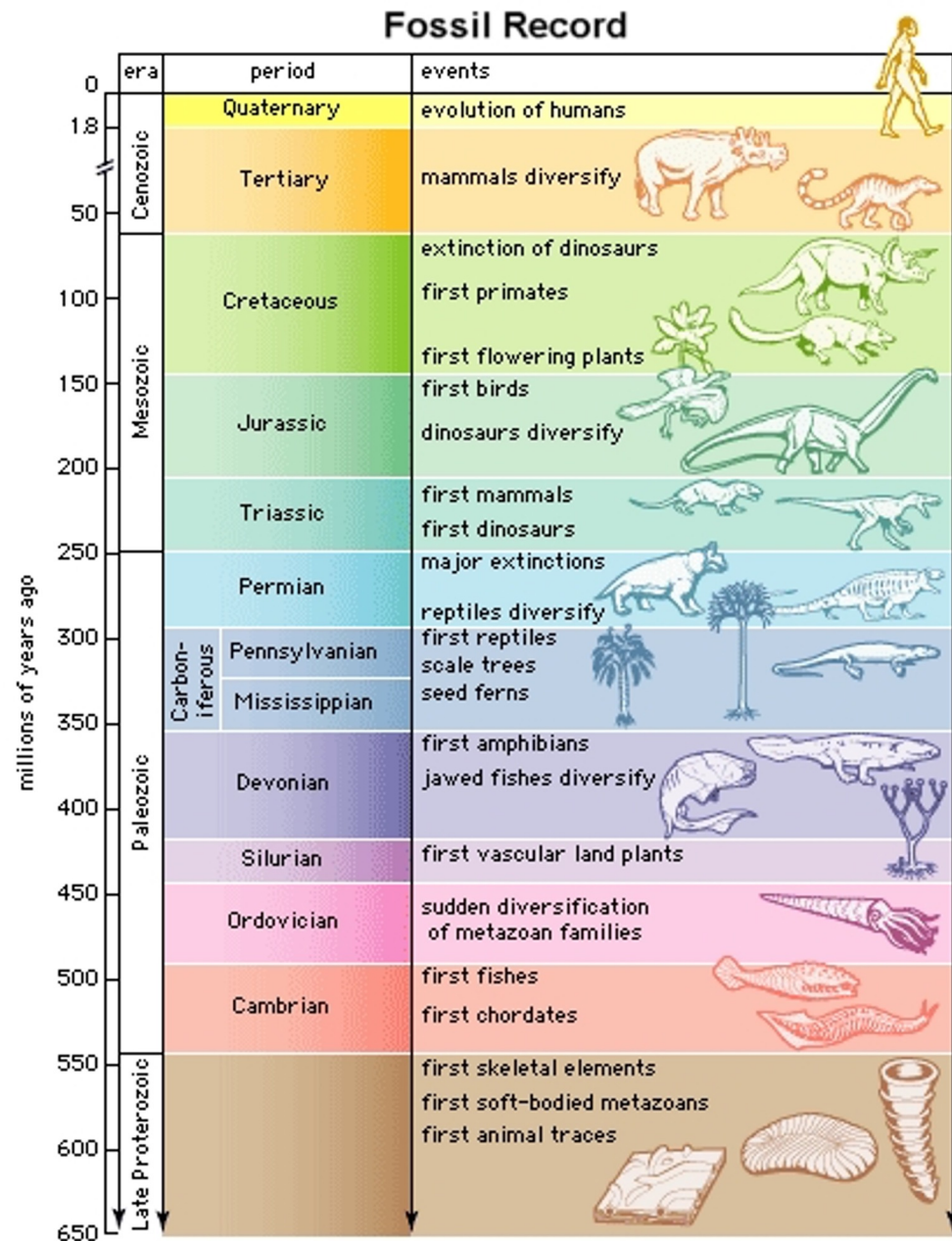

Tar Fossils

Amber Fossils

Microfossils

Ice Fossils

Fossil Record

Definition: ==A record of all known fossils and their relative ages.==

This is what Scientists use to keep track of what has been discovered.

Fossil Record

era	period	events
Cenozoic	Quaternary	evolution of humans
	Tertiary	mammals diversify
Mesozoic	Cretaceous	extinction of dinosaurs; first primates; first flowering plants
	Jurassic	first birds; dinosaurs diversify
	Triassic	first mammals; first dinosaurs
Paleozoic	Permian	major extinctions; reptiles diversify
	Pennsylvanian (Carboniferous)	first reptiles; scale trees; seed ferns
	Mississippian (Carboniferous)	
	Devonian	first amphibians; jawed fishes diversify
	Silurian	first vascular land plants
	Ordovician	sudden diversification of metazoan families
	Cambrian	first fishes; first chordates
Late Proterozoic		first skeletal elements; first soft-bodied metazoans; first animal traces

millions of years ago: 0, 1.8, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650

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Index Fossils

- Definition: a fossilized organism that is used to help determine the ==age== of rock layers or geological strata. These fossils are particularly useful for relative dating because they are:

Things that make a good index fossil:

- ==Widespread== – you can find them all over the world.

- ==Abundant== – there were a lot of them when they lived.

- ==Distinctive== – they are easy to recognize even when you just find small pieces.
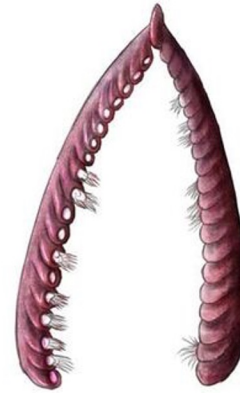
- they were around for a *geographically short amount of time*

Examples of Index Fossils
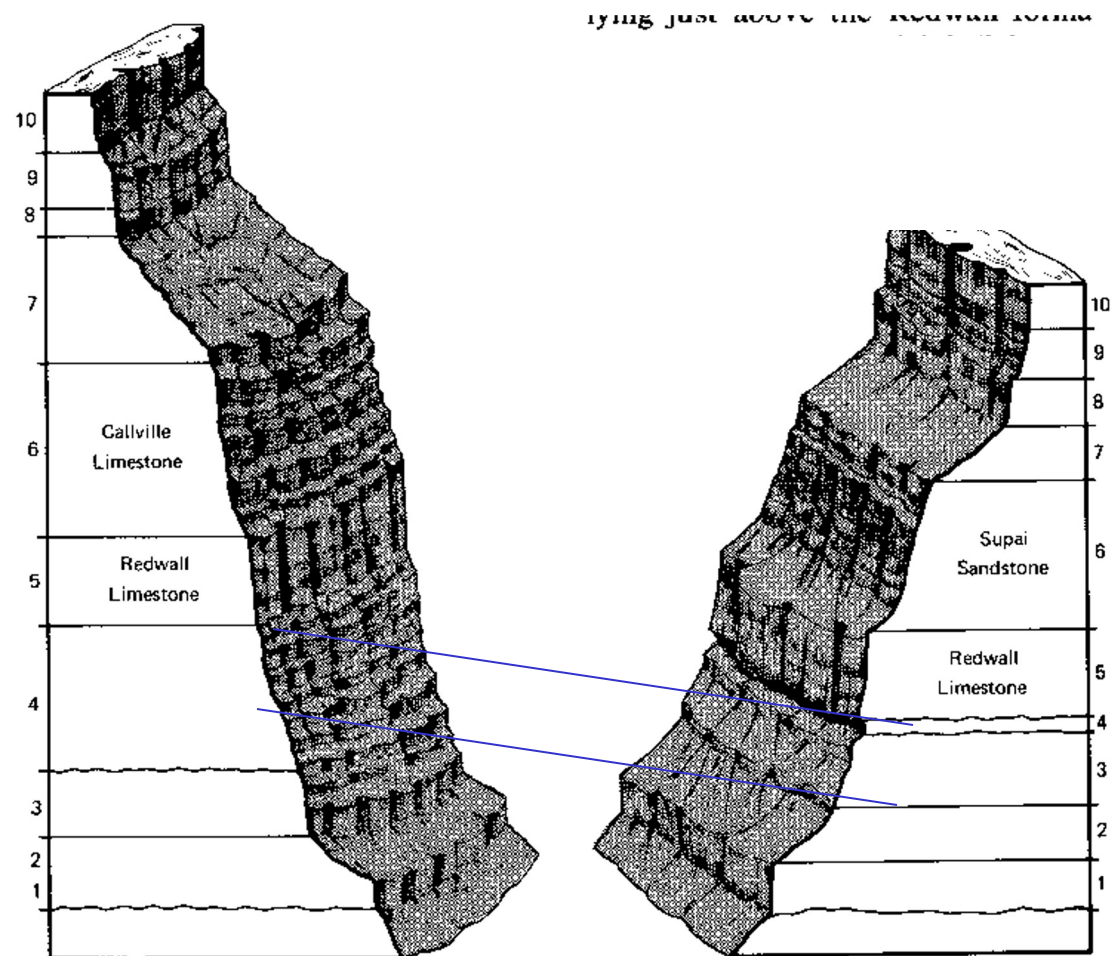
Trilobite

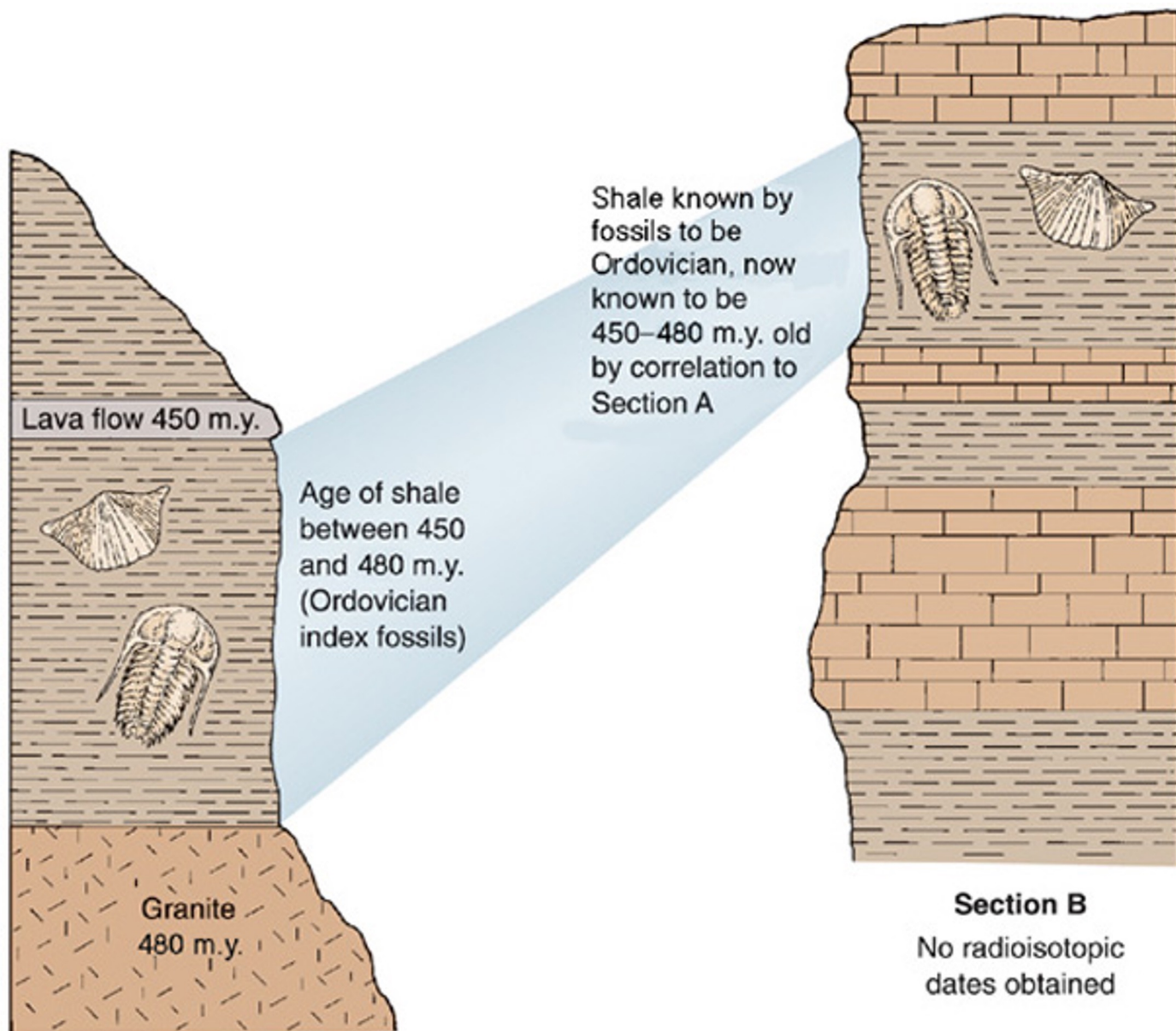Echinoid

Graptolite

Coral

Brachiopods

Which fossil makes a good index fossil?

Correlation

- Definition: ==Matching== similar rock layers in different locations to see if they ==formed== at the ==same== time

Shale known by
fossils to be
Ordovician, now
known to be
450–480 m.y. old
by correlation to
Section A

Lava flow 450 m.y.

Age of shale
between 450
and 480 m.y.
(Ordovician
index fossils)

Granite
480 m.y.

Section A
Some radioisotopic
dates obtained

**Section B**
No radioisotopic
dates obtained
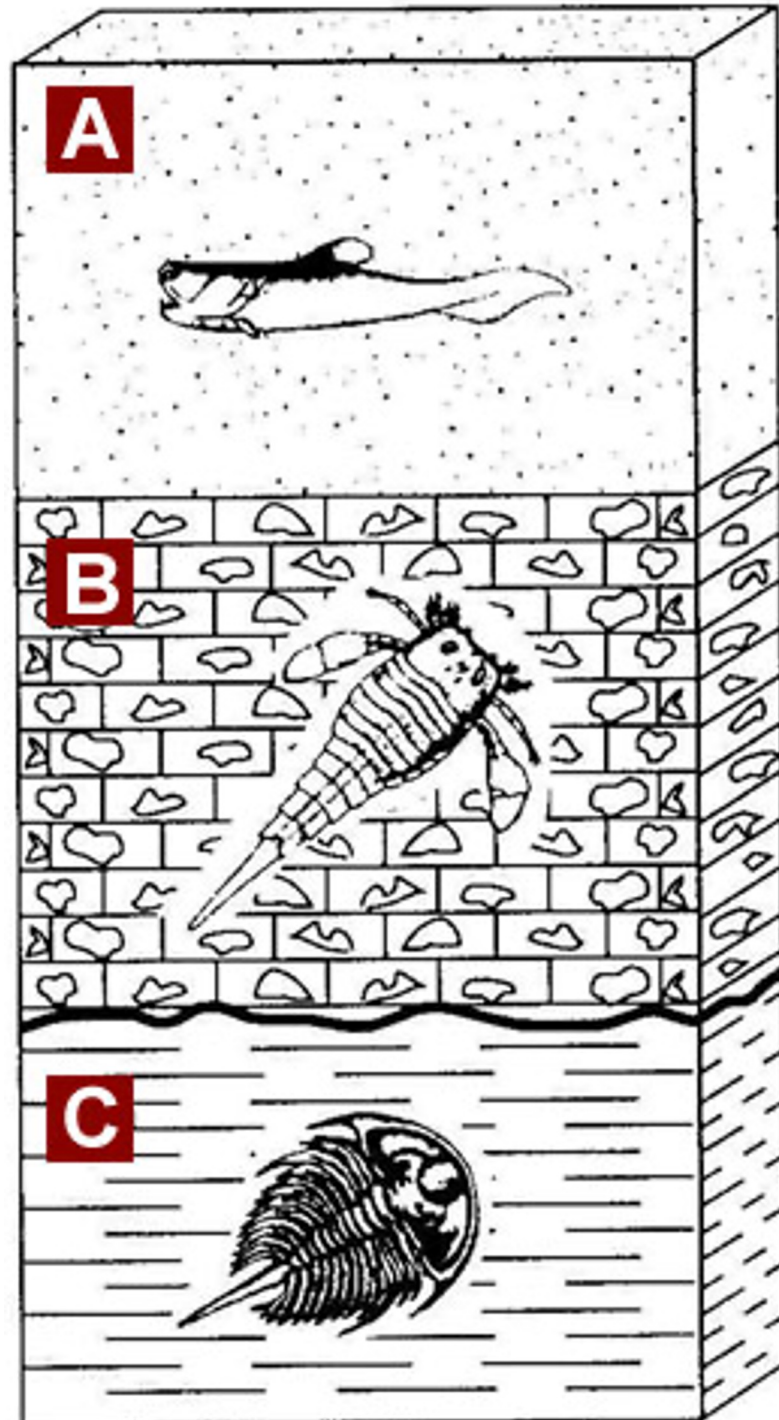
Volcanic Ash Falls

Can also be used to correlate rock layers over a large area

- Ash is a good indicator because:
  - The ash from one explosion has distinct characteristics
  - ash can be deposited around the globe
  - The event occurs at one, geologically brief, time
  - Some can be dated using radiometric dating.

Let's practice

Geologist
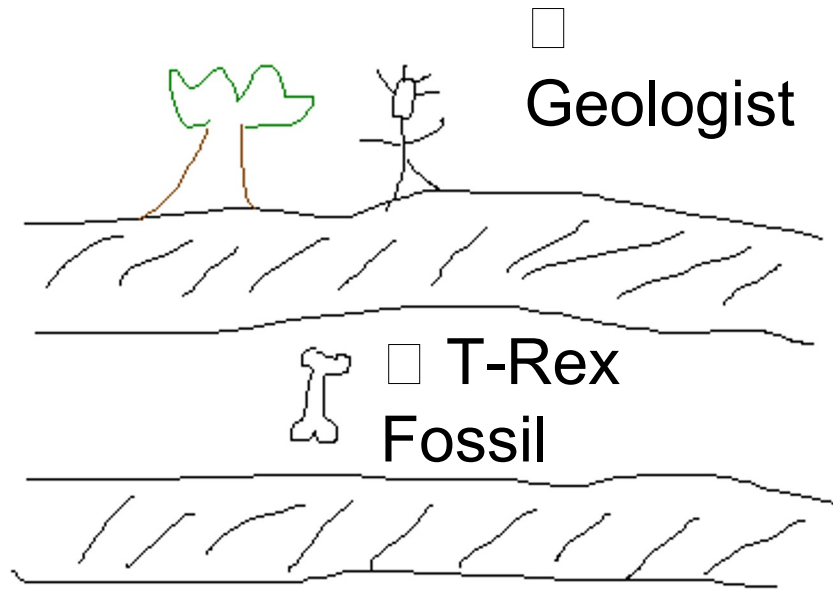
Basalt, dated to 80 mya

T-Rex Fossil

Sandstone

Basalt flow, dated to 100 mya

So when did this T-Rex live?

Between 100 and 80 mya