

Relative Age

Putting earth's past in order

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SUMMARY

We know earth has been changing over time. How, though, do we determine when those changes happened? How do we know what happened first? Relative age determines the order of events in earth's history.

Layers of sedimentary rock show relative age.

- When we look at objects, we can tell which is older and which is younger. We may not know the specific age of each object. Yet, each object has characteristics that make it easy to determine which is older.
 - For example, if you look at a picture of a family, you can tell who is older and younger than whom.
- This idea, putting objects and events into the correct order, is called finding the relative age. The **relative age** is the age of an event or object in relation to another event or object.
 - This does not require knowing the actual age! You know that your parents are older than you and you are younger than them. Relative age is about comparisons between objects and events. It is find the correct **order**.
- Scientists are able to do determine the relative age to determine the order (not the age) of events in earth's past:
 - ↳ Ex: Determining which rock layer formed first.
 - ↳ Ex: Determining which fossils came first.
 - ↳ Ex: Determining if an eruption happened before or after another event.
- Until the 1900s scientists did not have a way to determine the absolute age (the approximate age) of rocks. So, why do we need to know relative age if we have ways to determine the absolute age of earth?
- We still use relative age for a variety of reasons:
 - ↳ We need to know relative age to determine which method of absolute age to use. (For example: would you measure your book in meters or centimeters?)
 - ↳ Sedimentary rocks do not easily reveal absolute age because they are made of other rocks. Finding the absolute age of a sedimentary rock would find the age of its sediments.
 - ↳ There are many parts of Earth's history that cannot be given exact ages due to their formation.
- Why do we look at sedimentary rock layers? Remember when we talked about uniformitarianism? It's the idea that states the natural process that happened in the past happen today in the same way. Essentially, sedimentary rock forms in a very specific way (the five step process). It is very uniform.

- We use sedimentary rocks to determine relative age because they form in a very specific way (the five steps) and in a specific order. Igneous rocks can form in many places. (Ex: They can form on top of older or younger igneous rocks. Sed. rock always forms on top of older sed. rock.)
- Why are the layers of sedimentary rock relative and not absolute? The order of sedimentary rock layers is relative because you cannot be sure when each layer formed. (We can make estimates using fossils and other evidence.) However, they make it easy to determine relative age!
- When horizontal layers of sedimentary rock are undisturbed, the youngest layer is always on the top and the oldest is always on the bottom.
 - ↳ This idea is simple, true, and universal.
 - ↳ Therefore it must be a law!
- This is the Law of Superposition: in undisturbed layers of rock, the oldest rock is on the bottom and the youngest is on the top.
- Notice a very important work in the law: undisturbed. Are earth's layers undisturbed? Some are. But imagine, over 4.6Ga earth has undergone a lot of change. We don't expect layers to be perfectly intact. So, how do we determine the relative age of its layers? We look at the clues in the layers.

The movement of earth's plates disturb sedimentary rock layers.

- Over millions of years, layers of rock can become shifted, turned, bent, cracked, or broken apart.
- This is caused by the movement of earth's plates. We'll focus on what happens when rock bends because it can seem to change the order of the layers (but it doesn't!)
- When rock bends (it makes a letter S), we call it a syncline or an anticline. Why two names? It depends where you are looking!
 - ↳ A **syncline** is a downward curve in the rock layers. (Think **syn**cline, it's sinks downward)
 - ↳ An **anticline** is an upward curve in rock layers.
- The order of the rock layers in a syncline is as follows:
 - ↳ The oldest layer is the outer most curved layer.
 - ↳ The youngest layer is the inner most curved layer.
- The order of rock layers in anticline is as follows:
 - The oldest layer is the inner most curved layer.
 - The youngest layer is the outer most curved layer.
- Notice how they are opposites of each other?

Igneous rock formation can disturb sedimentary rock layers.

- The formation of igneous rock can disturb the layers by forming through the layers and between them.
 - The idea is that these igneous layers form where they can. They don't have to follow a specific order.
- Under ideal conditions, igneous rock would form a layer on the surface of the earth. This is called an extrusion. In this case, the layer is younger than any layers below it. It's quite simply the law of superposition.

- But, how did this layer get here? It got there by a channel of magma rising to the surface. This is what is important to us now!
- This magma rising through the layers of sedimentary rock is called an intrusion. (Think of a person breaking into your house. They are an intruder. Magma cutting through rock is an intrusion.) If this magma reaches the surface of the earth and forms a layer on top it is called an extrusion.
 - Quite note: Intrusions are younger than the rock they cut through (see below). Extrusions are younger than the rock they form on top of (law of superposition).
- Magma can only rise up in the form of a column if there is rock around it. Therefore, the intrusion will be younger than any rock around it.
- This idea is called **the principle of cross cutting relationships**. If something (molten rock, faults, etc.) cuts through another layer, the layer is older than what cut it.
 - Think about it: you can't break a rock that isn't there! Magma can't cut through a rock that isn't there!
- Is it possible that the molten rock could form a layer between two layers of sedimentary rock? Absolutely! So what do we do in this case? How do we know which is older? We look inside the rock.
- If there are parts of other rocks in an igneous layer, called an inclusion, then those inclusions are older than the layer of igneous rock.
 - Example: we find pieces of sandstone inside a layer of granite. It is impossible for sandstone to form inside the granite. The only way it could have gotten inside the granite is if the sandstone existed first. When the granite was forming (still magma), the sandstone "fell in" and became trapped in the eventually-to-be granite.
- This gives us another principle. The **principle of inclusion** states that layers that contain parts of other layers are younger than the parts they contain.
 - In other words... If you find a layer of rock (LAYER C) that contains rock from the layers above (LAYER B) or below it (LAYER A), then layer C is younger than both layer B and A. This is because both layers A and B had to exist before. Otherwise, we couldn't find them inside layer C.

Faults and unconformities disrupt sedimentary rock layers.

- Earth's layers do not always stay perfectly horizontal.
- **Faults**, cracks or breaks in the rock, can disturb sedimentary layers by cross cutting them. This causes the layers to misalign (they slide apart such that layer A now touches layer C.)
- Because faults can only exist in a rock layer that already exists, faults are always younger than the layers they form in. Why? This is another example of the principle of cross cutting relationships.
 - Note: What happens if there are 10 layers and a fault only cuts through 8 of them? We assume that layers 9 and 10 hadn't formed yet.
- Unconformities can disturb sedimentary rock layers, too.
- Unconformities are where layers are missing or younger layers come in contact with older layers.
- Unconformities form in a variety of ways:

- Layers tilt from upright and movement of earth's plates. This causes them to angle. This is called an **angular unconformity**. You can identify it by looking for angled layers against a flat layer. It forms by:
 - Layers depositing
 - Layers are folded and uplifted by the movement of earth's plates.
 - Upper portion of layers are eroded.
 - New layers are deposited on top of the eroded parts.
- Layers eroding or layers not forming. This is called a **disconformity**. We identify this by looking for an uneven line between rock layers or a gap in the layers (ex: we don't find rock that is 100-120Ma). It forms by:
 - Layers depositing
 - Some layers are weathered and eroded exposing deeper layers. (Note: no folding occurs! Uplifting: yes!)
 - New layers deposit on top of older layers.

Index fossils help determine relative and absolute age.

- Fossil contained within sedimentary rock can offer clues about the age of the rock.
- An organism that was fossilized in a rock must have lived during the same time span in which the rock formed.
- Fossils or organisms that were common, that lived in many areas, and that existed only during specific spans of time are called index fossils.
- Index fossils reveal a lot about earth's layers:
 - **They can match rock layers (same of different type of layer) in different locations to the same time period.** If we find the same fossils in two different layers in two different locations, we can infer the layers were made at the same time because they contain the same fossils. (Hey, this is a great hypothesis to test!)
 - **They can reveal missing rock layers.** If we have two locations of layers each with several of the same layers and one location has a layer of fossils that the other does not, we can infer that this layer is missing from the other location.
 - **They can determine the approximate age of a rock layer.** If we know the time an organism existed, we know the age of the rock.
- Index fossils help us determine the age of a rock. How? If there are multiple fossils in a layer of rock and each fossil only lived for a specific period of time, we can figure out the age of the rock.
 - Example: In a rock layer we find two fossils. Fossil A lived from 4-7Ma and Fossil B lived from 3-5Ma. The rock layer must be between 4-5Ma. Why? Fossil A didn't exist before 4Ma and Fossil B didn't exist after 5Ma. There's our range!