Keeping time

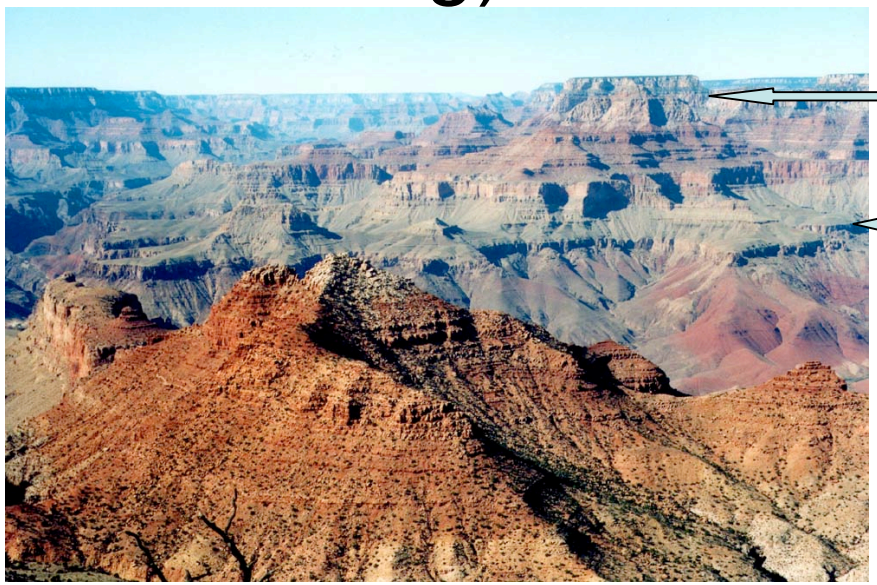
How do geologists determine the order of events?

How do geologists determine the age of a rock?

How do geologists determine the age of the Earth?

The Relative Order of Events

- Relative age = one thing is older or younger than another (versus “absolute age, which is establishing the date of something).



These layers are younger than..
these layers

Steno's Laws (you need to know these)

- Principle of Superposition - the layer of sediments on the bottom has to be older than the layer above it.
- Principle of Original Horizontality - layers of sediment are laid down flat
- Principle of Cross-Cutting Relationships - if sedimentary layers are cut by an intrusion or fault, the layers have to be older.
- Principle of Inclusions - if an igneous rock has pieces of another rock in it, the pieces have to per-date the rock that includes them.

Law of superposition

Layers at the top of a sequence have to be younger than the layers at the bottom

Law of original horizontality

Sediments are laid down horizontally. If the layers are tilted, the tilting happened after they were deposited

The sediments that are being deposited in the river are being laid down flat, not up the sides of the canyon

Law of lateral continuity

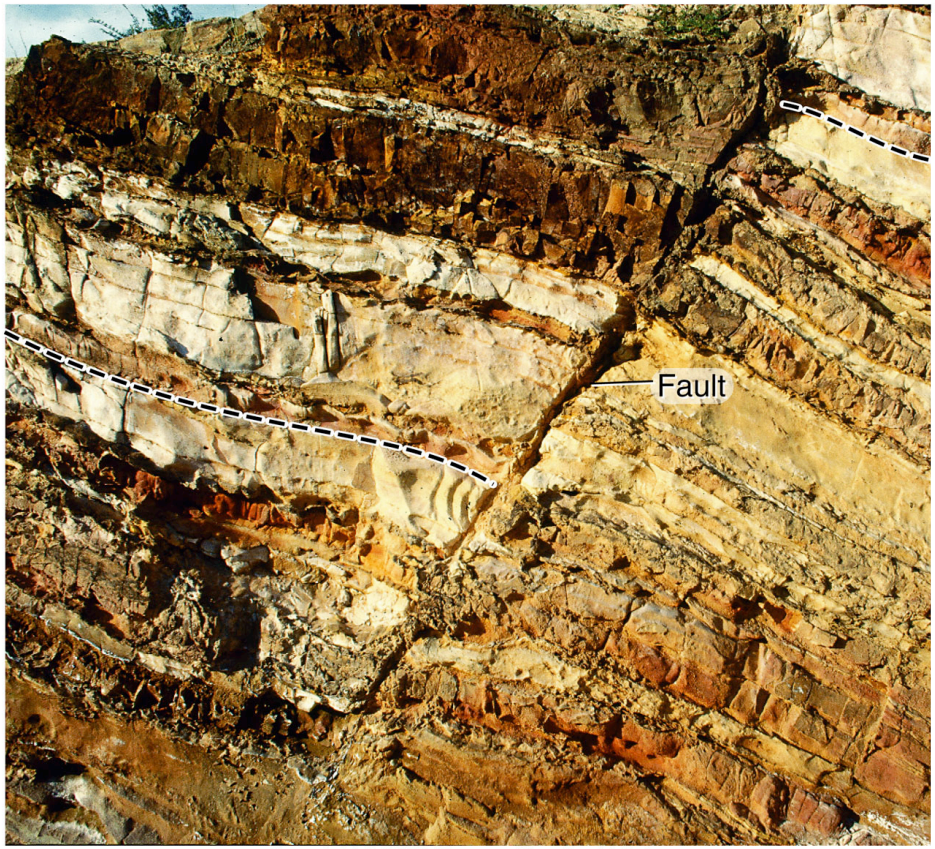
Sedimentary rock layers extend laterally until they gradually change to another rock type…they don't just "stop."

The sand on the shore of North Beach extends out into the lake until they gradually become smaller grains and become another type of sediment; the beach environment doesn't just end.

Law of inclusions

The clast of igneous rock has to be older than the sedimentary rock that contains it

Law of cross-cutting relationships



If rock layers are cut by faults or other rock types, the rock that is cut has to be older than what cuts through it.

(this is an igneous intrusion, or basalt dike, cutting through granite)

Which of Steno's Laws do you see "in action" in this photo?

Two more ways to establish relative ages:

Unconformities

Principle of Faunal Succession

A famous unconformity:

Scottish geologist James Hutton recognized that a huge amount of time must have lapsed between when the layers in the foreground were laid down flat, then tilted and the next layers were deposited, and both tilted.

Siccar Point, Scotland

An unconformity = a time when either no sediment was deposited, or it was deposited but then eroded (you need to know these definitions)

- Angular unconformity = the older layers were tilted and eroded before the next layers
- Nonconformity = the time between when an igneous or metamophic rock forms and it is then covered by sedimentary layers
- Disconformity = the time between deposition of sedimentary layers, which may involve erosion.

What type of unconformity is this? (the rocks are sedimentary)
Which of Steno's Laws can be applied?

1. First: lower layers are deposited flat

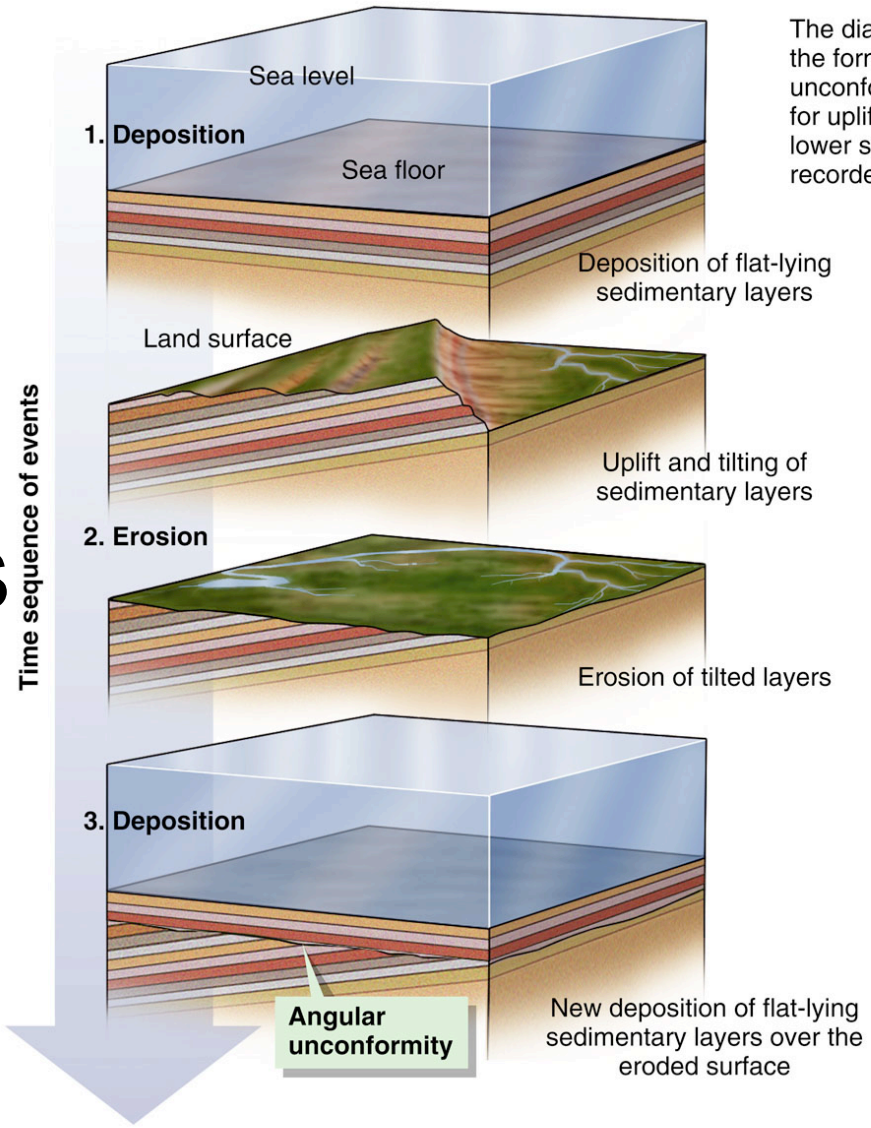
2. Lower layers are folded

3. Unconformity represents period of erosion

4. Upper layers are deposited

5. All layers gently tilted

There are 3 types of unconformites

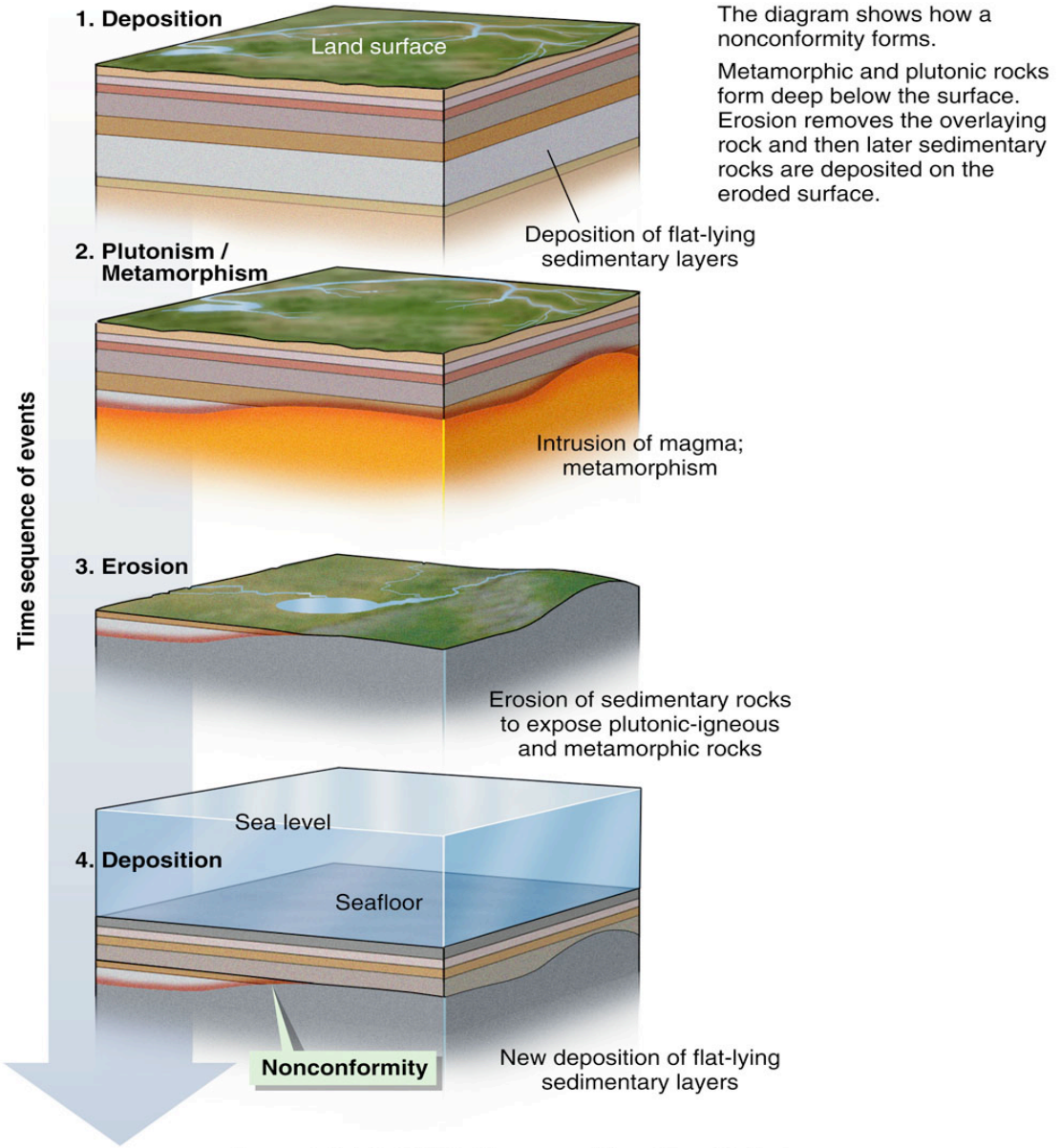


The diagram illustrates stages in the formation of an angular unconformity. The time required for uplift and erosion of the lower sedimentary layers is not recorded in rocks at this location.

1. Angular unconformity

2. nonconformitv

The black line
nonconformit
Canyon. Meta
plutonic-igneo
bottom of the
overlain by se
Approximatel
of Earth histo
the unconforr

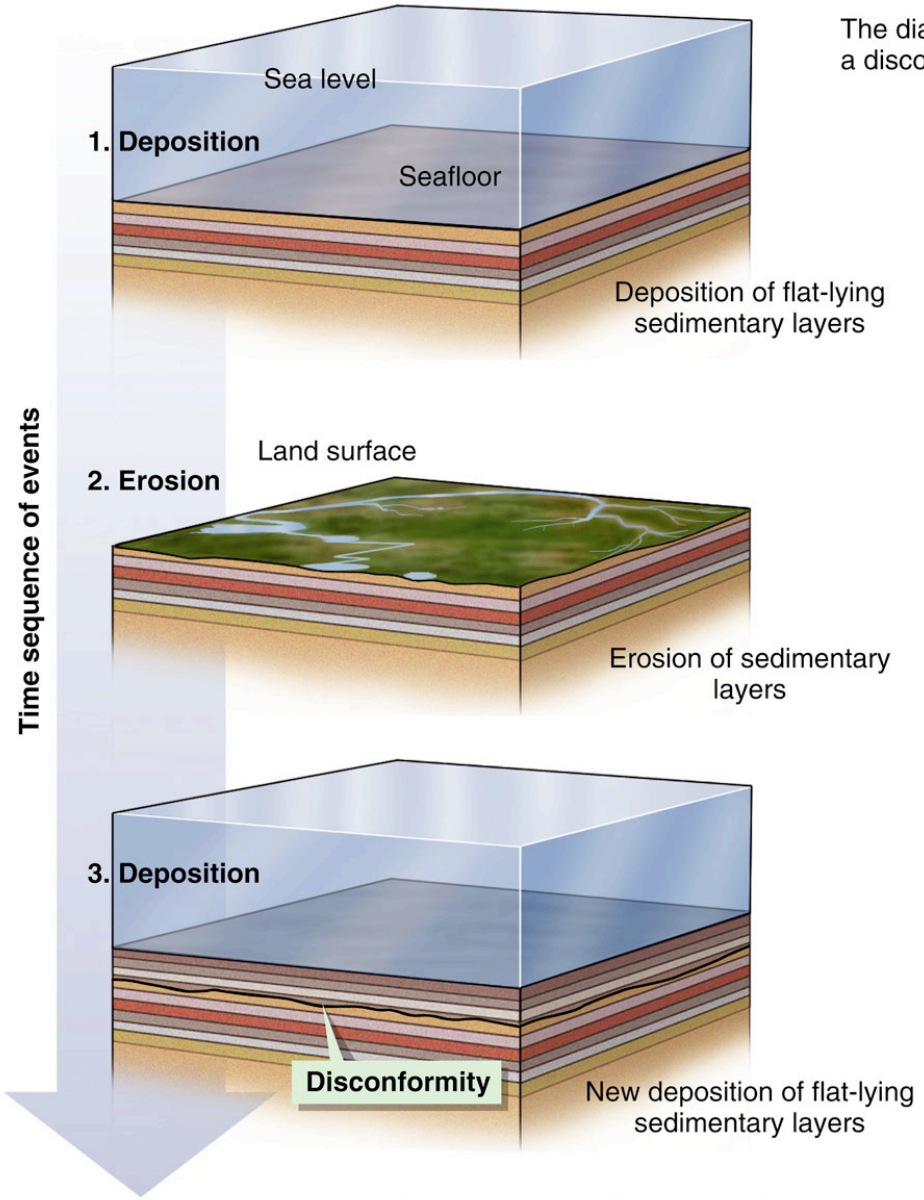


The diagram shows how a nonconformity forms.

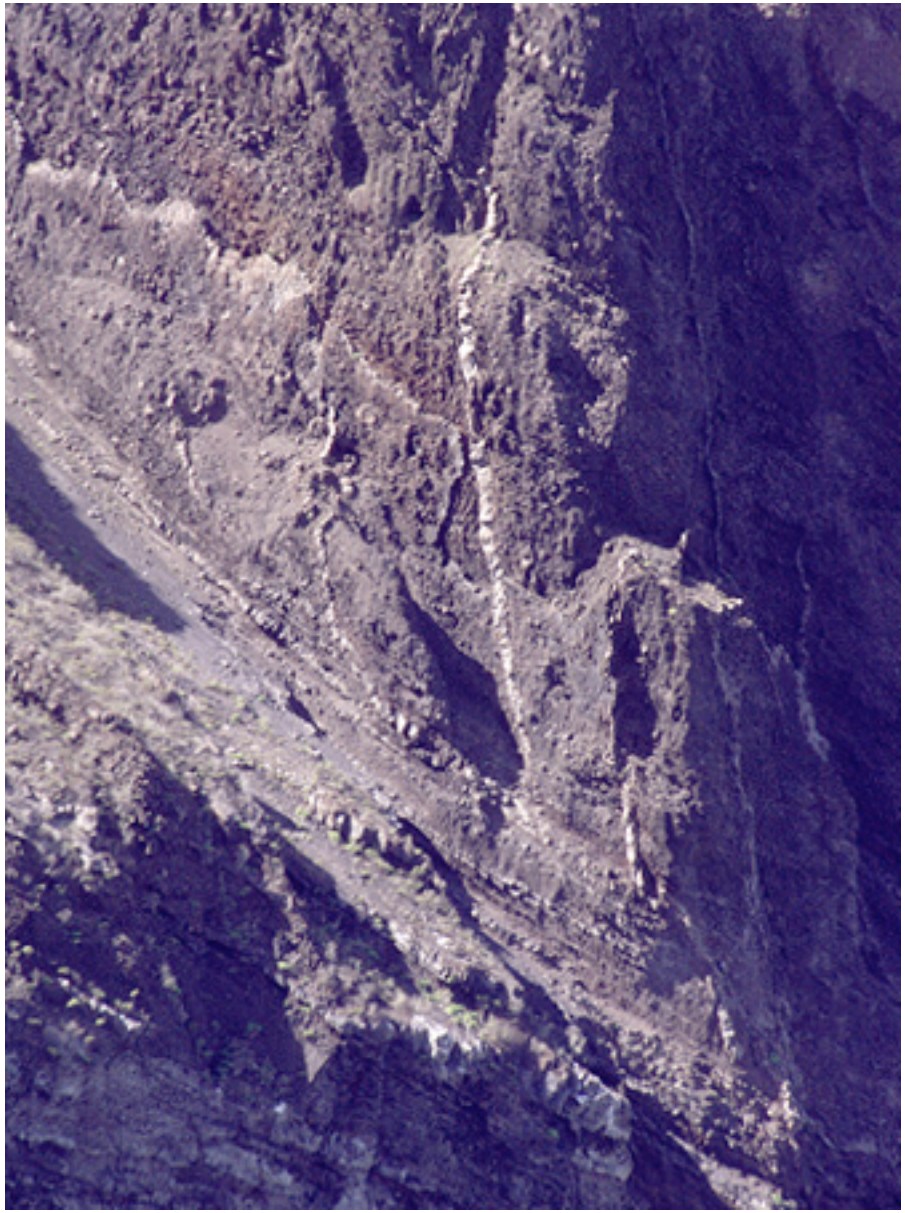
Metamorphic and plutonic rocks form deep below the surface. Erosion removes the overlaying rock and then later sedimentary rocks are deposited on the eroded surface.

3. disconformity

The hardest to see because the rock types above and below are the same (sedimentary) and both are flat lying



Apply Steno’s laws to establish a sequence of events, oldest to youngest

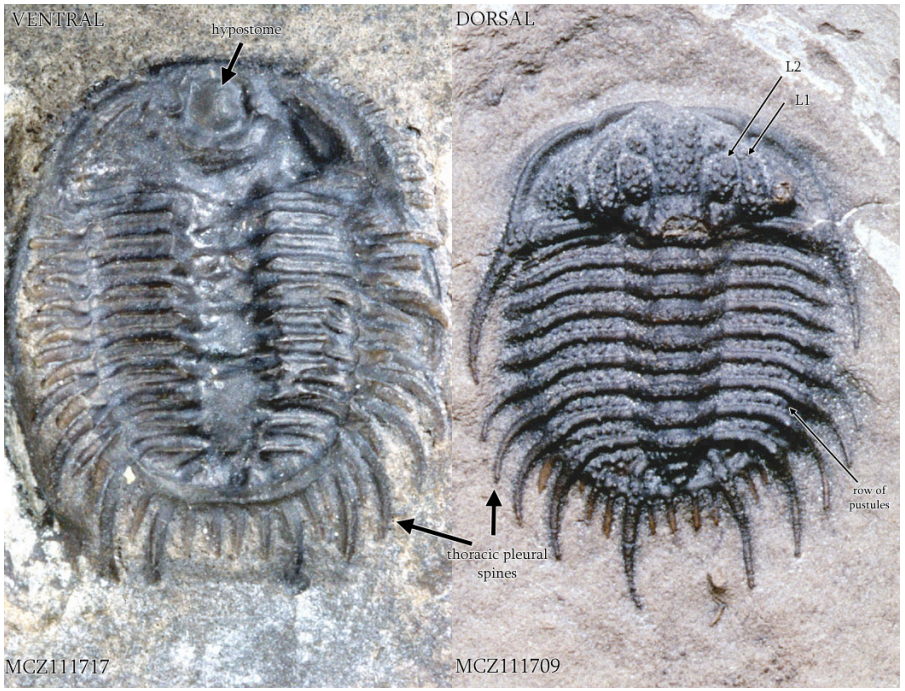


This is an example of which of Steno's laws?

All the rocks are sedimentary. The black line defines the contact. Is this an unconformity or not; how do you know?

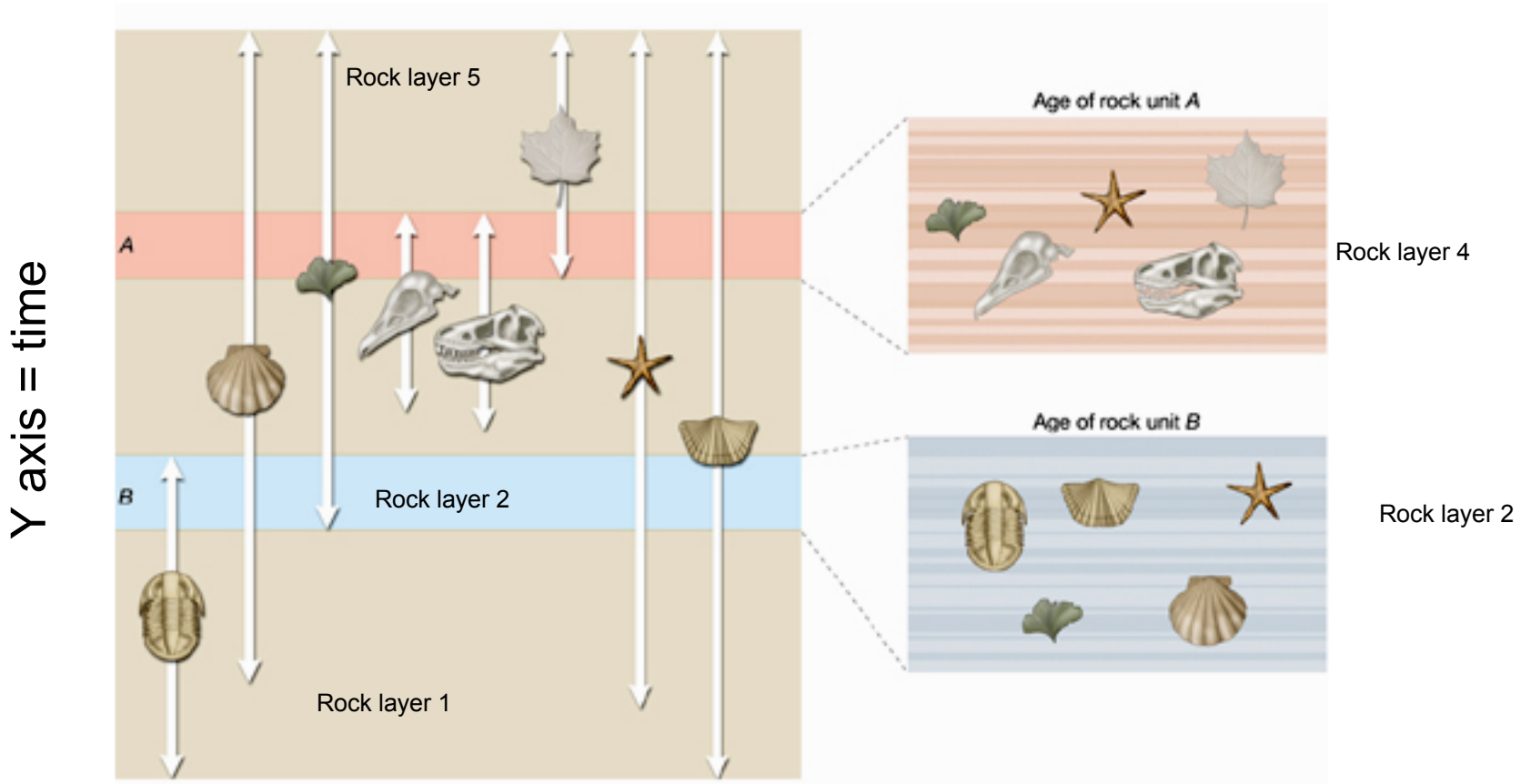
List the sequence of events, from oldest to youngest

Principle of Faunal Succession: fossil plants and animals appear in rocks in a definite succession that represents their evolution on Earth



Trilobites evolved before dinosaurs…so if a rock has trilobite fossils in it it must be older than a rock with dinosaur fossils

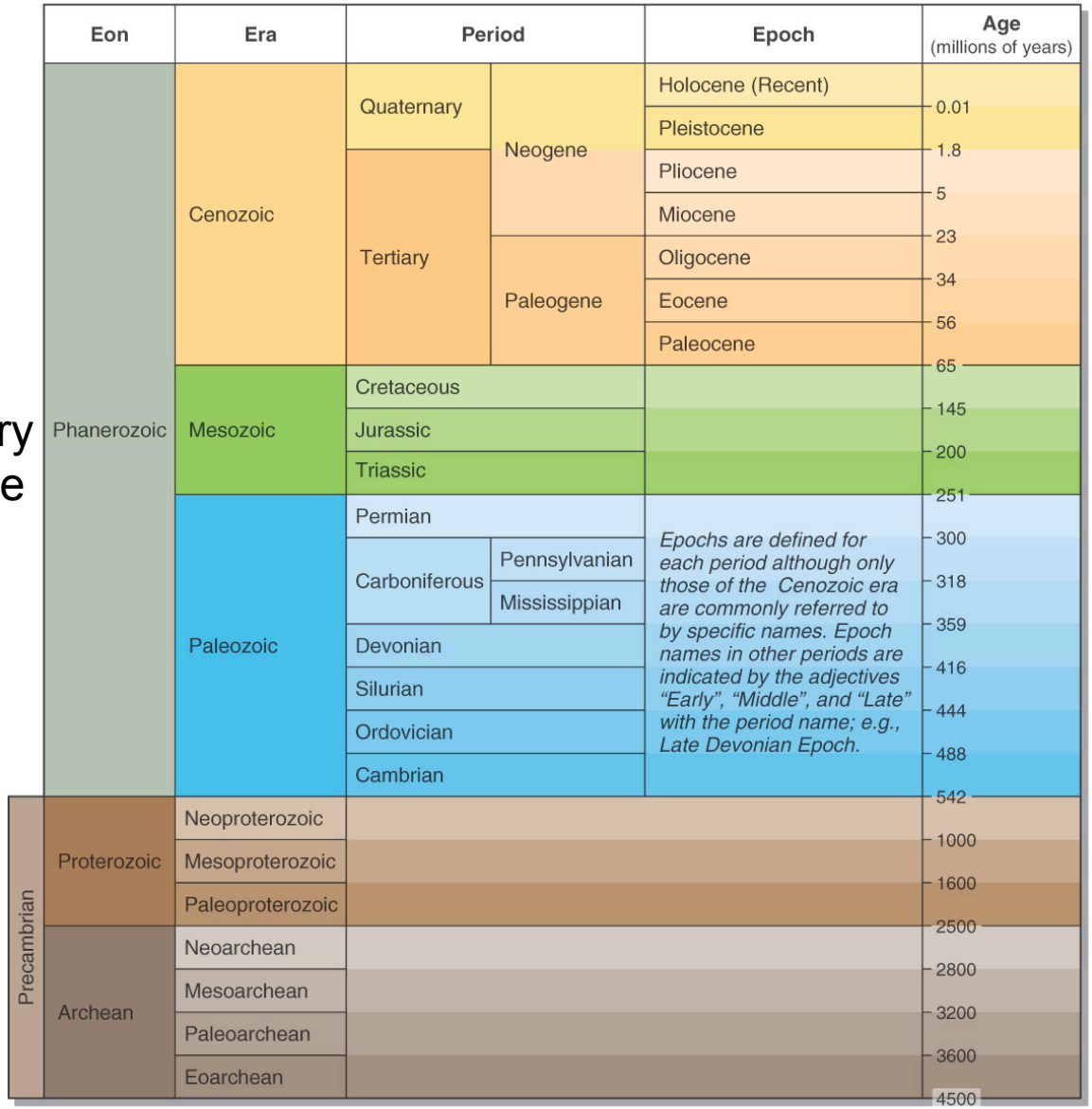
Application of the principle of faunal succession…figuring out the age of a sedimentary rock based on the fossils that are in it



X axis = different organisms that are present

Steno's Laws, unconformities and the Principle of Faunal Succession were synthesized to create the geologic time scale, name that we give to various intervals of time in Earth history

In order to put all the changes in Earth history in order, we need to be fluent in this sequence and the ages in millions of years that it represents



Deciphering the relative order of events: application of Steno's Laws

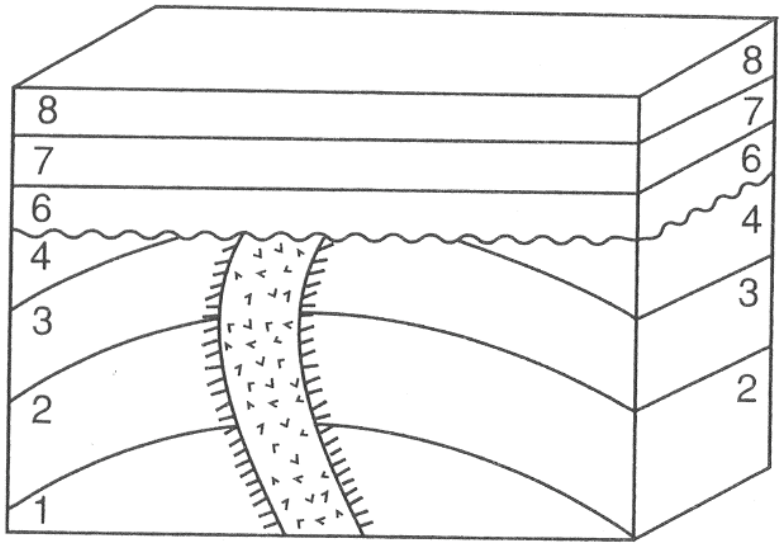


FIGURE Example of sequence of events.

F. Deposition of units 7 and 8.

E. Submergence and deposition of unit 6, with the development of an angular unconformity over units 1–4 and a nonconformity over the dike. (In geology, a wavy line, like that between units 4 and 6, is used to signify the presence of an unconformity.)

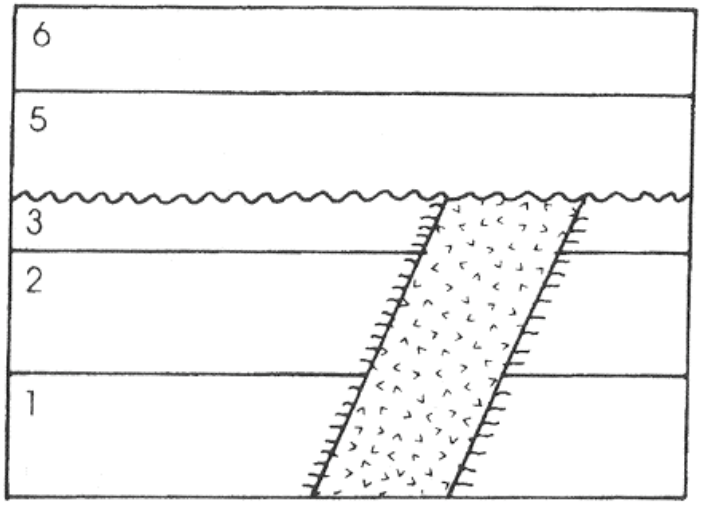
D. Episode of erosion.

C. Regional uplift and folding of preexisting units.

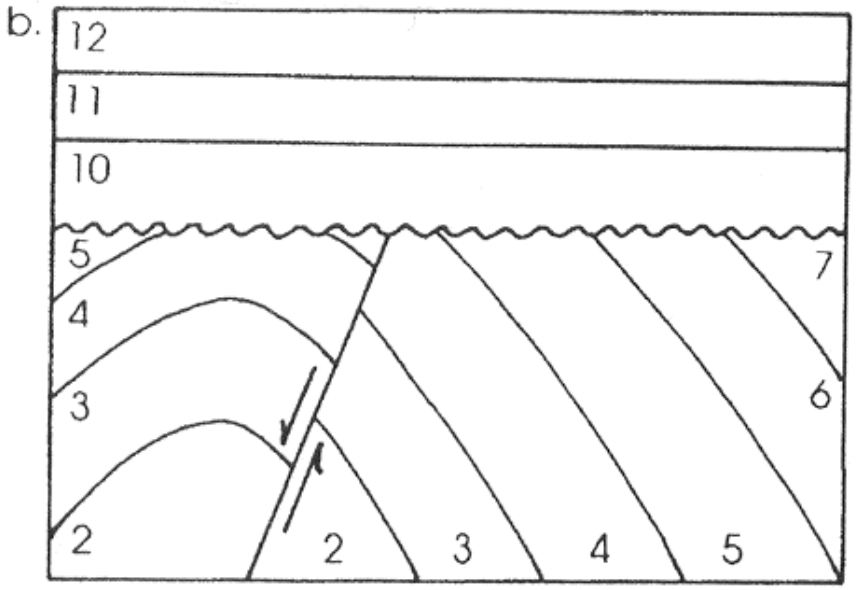
B. Injection of dike with contact metamorphism of units 1–4.

A. Deposition of units 1, 2, 3, and 4 and perhaps unit 5.

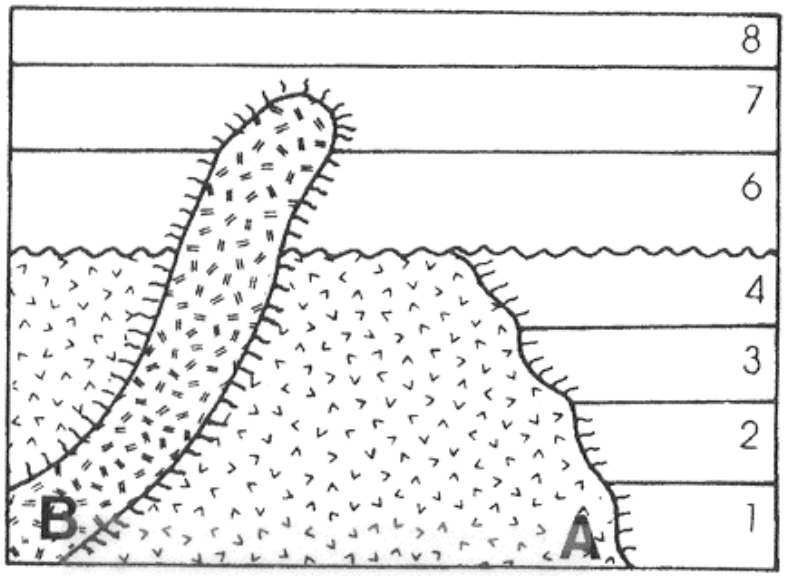
#1



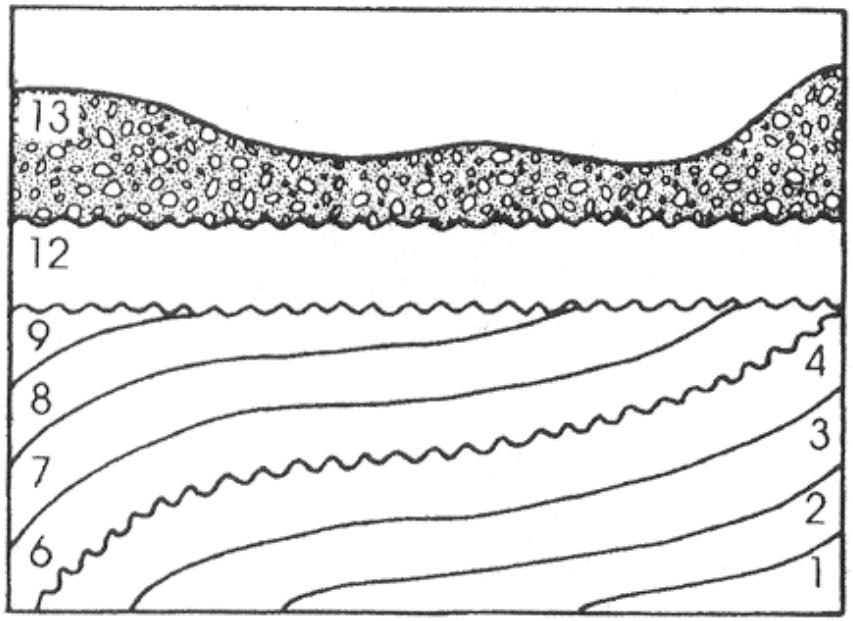
#2



#3

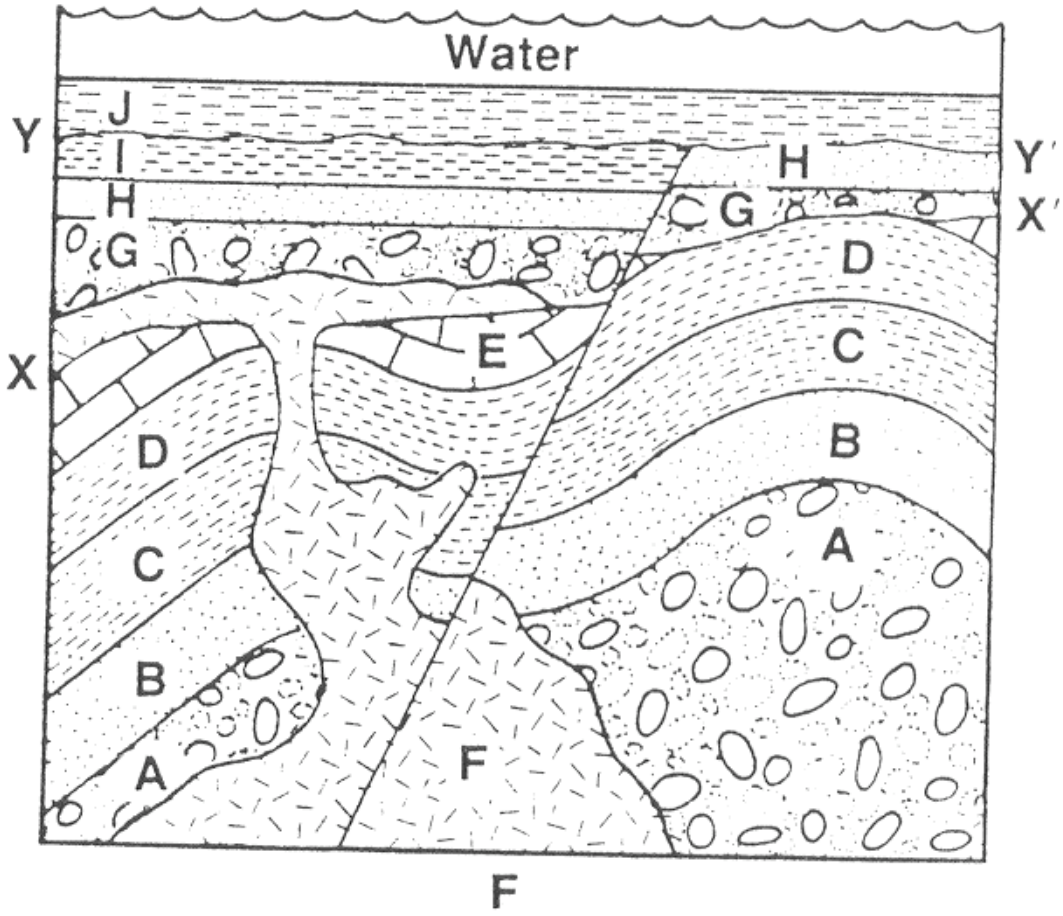


#4

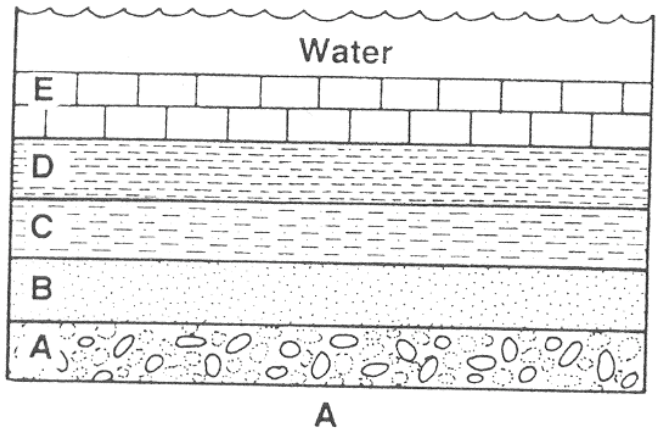


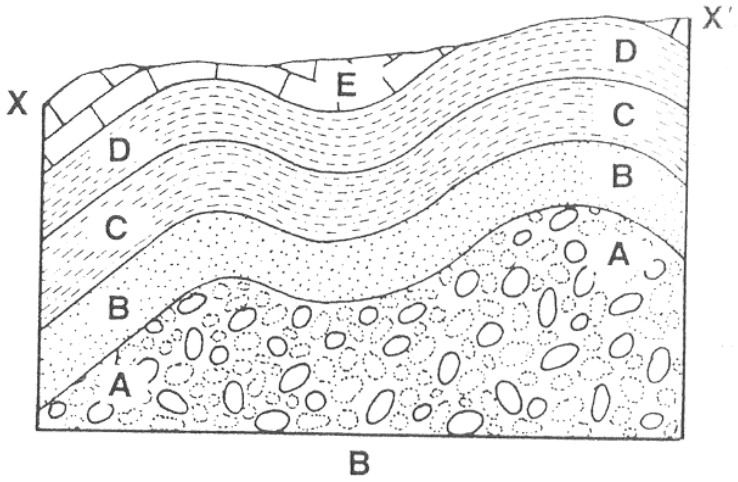
Deciphering complicated sequences…..

Where to start?????



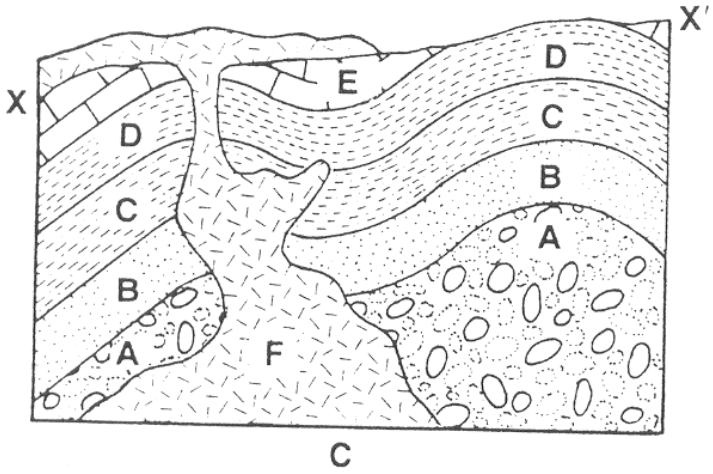
Layers were deposited flat-lying, oldest on bottom



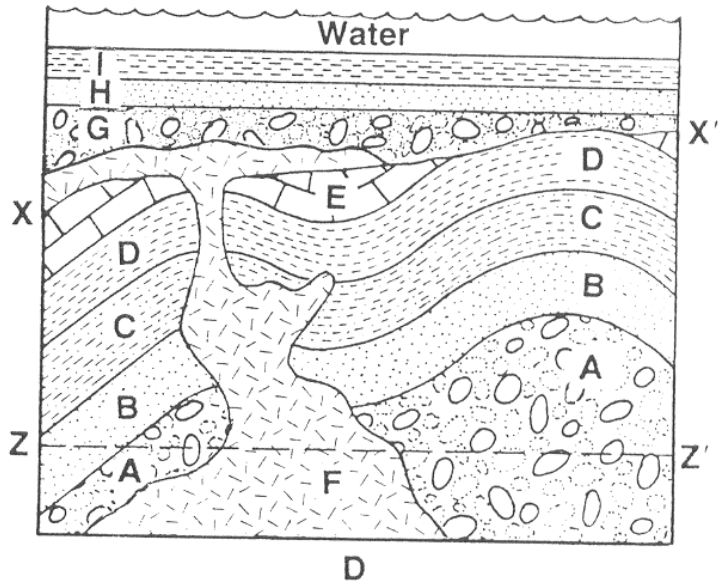


fold

Intrude igneous rock

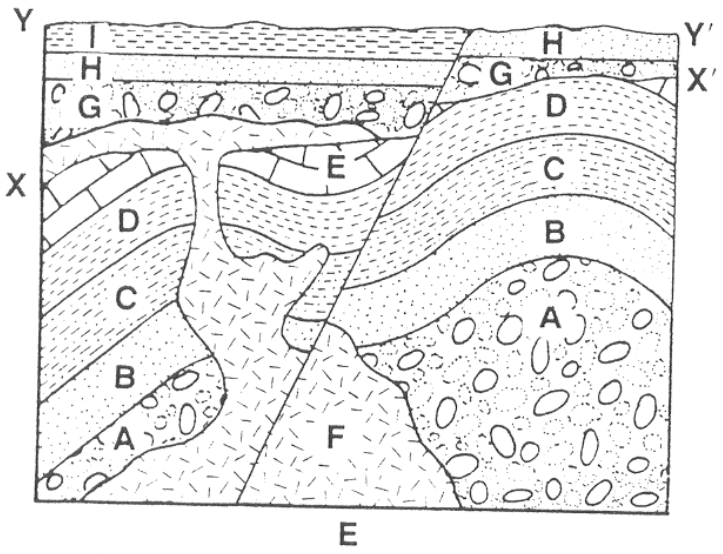


Unconformity over igneous rock and adjacent sedimentary rock, deposition of more layers



Yes, it's hard to tell if an igneous rock is folded or not, but the unconformity associated with it - the period of time when no sediment was deposited - is a key

Fault displaces everything



Deposition of last layers which post-date fault, since fault doesn't cut them