Geohistory Review

Things you need to know:

a) The earth and the solar system are 4.5 billion years old (4.5 X 10^9)
b) Law of original horizontality: Sedimentary rock layers are always deposited as horizontal strata. Any change from that position (tilting, folding, faulting) is evidence that they moved since their formation.
c) Law of superposition: The oldest rock layers are on the bottom unless overturning has ocurred.
d) Uniformitarianism: The processes that shaped the earth in the past are the same processes operating today. The key to understanding the past is to understand the present.
e) Relative age: How old one thing is when compared to something else. Bob is older than Sue. Sue is younger than Victoria. This allows comparisons but does not give an exact age.
f) Absolute age. The real age: Bob is 15. Sue is 12. Victoria is 19. Absolute age is almost always determined by radioactive dating.
g) Geologic time divisions are based on the predominant forms of life on earth during those times.

A) Determination of the relative age of rock layers:

1) Chronology of layers (oldest on bottom, youngest on top - unless overturning has occurred)

2) Igneous intrusions/extrusions: Rock layers through which the igneous rock intrudes had to be there first. Magma cannot intrude into rock that isn't there.

3) Contact metamorphism:

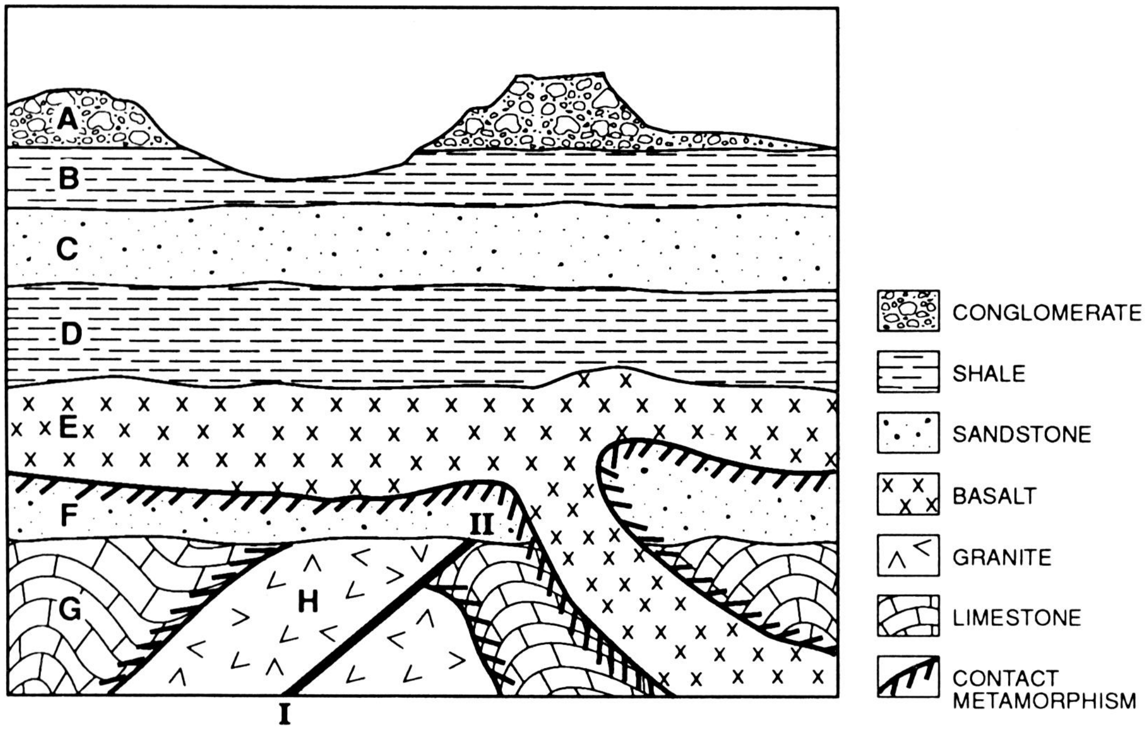
Igneous and sedimentary rock are in contact with one another if........

a) there is contact metamorphism between them, the sedimentary rock is older.

b) there is NO contact metamorphism between them, the igneous rock is older.

4) Faults: A fault is always younger than the rock in which it is found. The rock had to be there first in order to fault.

5) Unconformities aka buried erosional surfaces: A surface that was exposed to air and/or running water and which was eroded. An unconformity always means that ***part of the rock record is missing. The rock record is incomplete.*** You know that some rock is missing but there is no way to know how much.

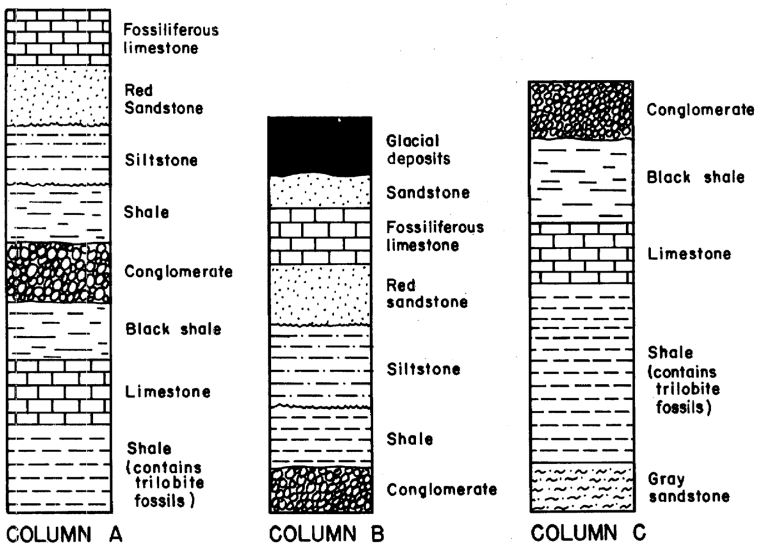


EXAMPLE: ANALYSIS OF GEOLOGIC CROSS SECTION

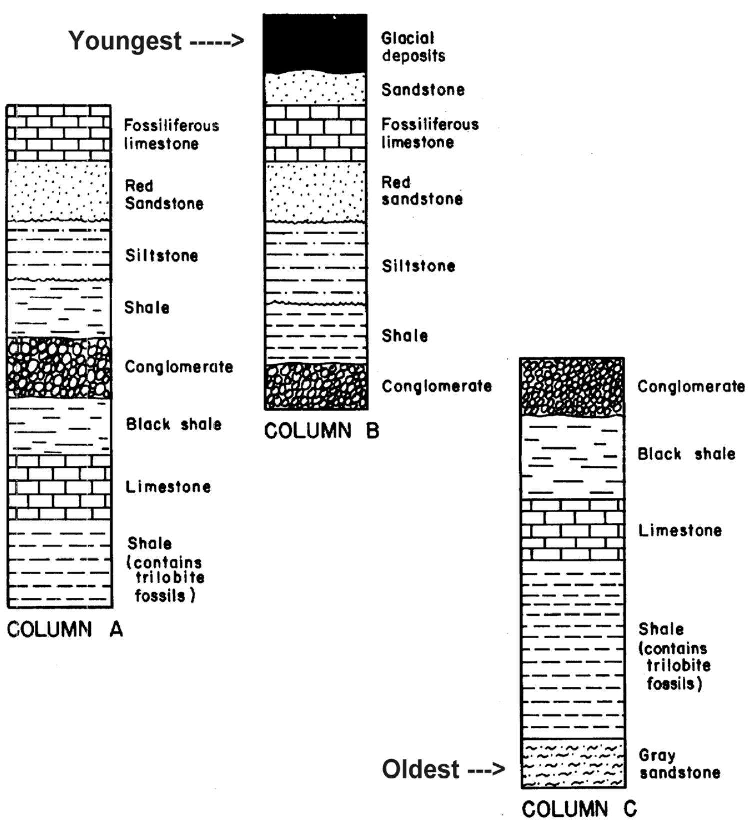
The following events are listed in chronological order, from first to most recent.

1) Layer ‘G’ is deposited (it’s on the bottom).
2) Layer ‘G’ is folded (it was originally deposited as a horizontal layer).
3) Igneous rock ‘H’ intrudes. Notice that there is NO contact metamorphism between ‘H’ and sandstone layer ‘F’. This means that ‘H’ had cooled long before ‘F’ was deposited.
4) Faulting along line I-II occurs. Notice that the fault runs through ‘H’ and ‘G’ but not through ‘F’. This means that ‘F’ had not yet been deposited when the faulting occurred.
5) Sandstone layer ‘F’ is deposited. ‘F’ must be older than igneous intrusion ‘E’ first because ‘E’ goes through ‘F’ and also because there is **contact** metamorphism between the two layers.
6) Igneous intrusion ‘E’ occurs. ‘E’ must have extruded onto the surface and cooled long before ‘D’ was deposited because there is no contact metamorphism between ‘D’ and ‘E’.
7) Layers ‘D’, ‘C’, ‘B’, and ‘A’ are deposited in that order (law of superposition).
8) Layers ‘A’ and ‘B’ undergo erosion. Material is removed.
9) It is ***possible*** that there were other layers on top of ‘A’ and that they have been completely eroded away. There is no indication that this is so, but it’s ***possible***.

6) Correlation of rock layers from widely separated regions. The object is to reconstruct the geologic history of separate areas and correlate them so that we can match rock layers in one area with similar layers that formed ***at the same time*** in another region. This can often be done by examining and comparing “columns’ from different areas.



These are columns (drill cores) from widely separated regions. They contain **<u>some</u>** of the same rocks but the columns are not identical because different geologic processes, erosion, sediment deposition, rock formation, were at work in each location. ***YOUR JOB*** is to reconstruct the geo-history by correlating these layers.



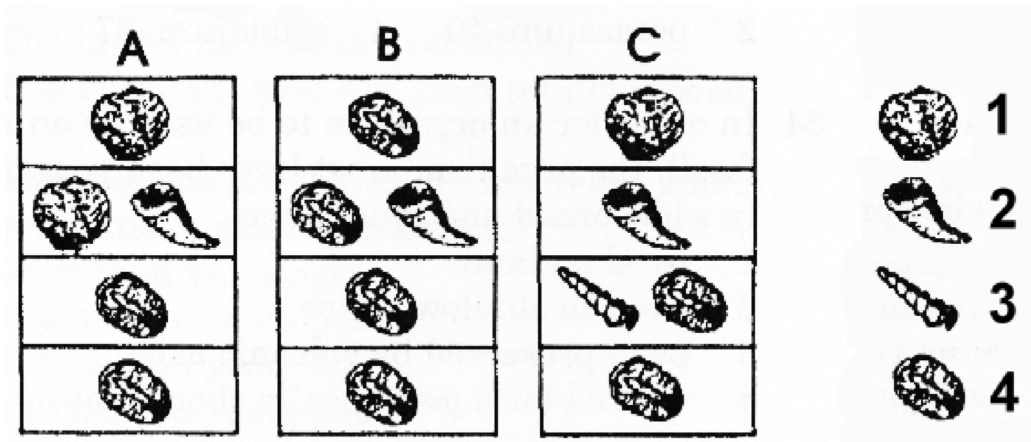
Here are the same columns rearranged and correlated. Since the glacial deposits are the uppermost layers they must be the youngest. Gray sandstone is on the bottom and must therefore be the oldest layer.

7) Index fossils:

a) Have wide distribution - found in many different parts of the earth.

b) Were found on earth for a relatively brief time (a few million years)

Since the organism was on earth for a brief time, if it is found in two widely separated rock layers they must have been formed during this same brief period.



Q: Which of these fossils (1 through 4) would make the best index fossil?
A: Fossil #2
Why? Because a) It is widely distributed. It is found in all 3 columns.

b) It existed for a brief period of time. Notice that it is found in only ***<u>one</u>*** rock layer whereas fossil #4, which is also widely distributed is useless as an index fossil because it existed for a long time and is found in all four layers.

8) Volcanic ash layers: Volcanoes broadcast ash over very large areas. The ash settles rapidly (a few days or weeks) and may form a thin layer in the geologic record. This ash layer becomes a time marker since it was deposited at the same time everywhere it is found.

B) Determination of ABSOLUTE AGE: <u>Radioactive dating</u>

Definitions:

1) Half-life: The time it takes for half of the radioactive material present in a sample to decay.

2) Isotope: Atoms of the **<u>same</u>** element that have different numbers of **<u>neutrons.</u>**
ex. C^{12} and C^{14} are both carbon atoms but they are isotopes because C^{14} has 2 extra neutrons.

3) Decay: A radioactive isotope spontaneously breaks down into another element.
ex. C^{14} will decay into N^{14}.

IMPORTANT NOTE: C^{14} can only be used to date things that were once alive. Such items include real (not fossilized) bone, teeth, wood, charcoal, cloth from cotton or wool, animal skins, etc. If you want to date rocks, you must use one of the other elements listed on page 1 of your reference tables.

# of Half Lives	% C^{14} remaining	% N^{14} remaining	Ratio C^{14} to N^{14}
0	**100%**	**0%**	**none**
1	**50%**	**50%**	**1:1**
2	**25%**	**75%**	**1:3**
3	**12.5%**	**87.5%**	**1:7**

Notice that with each additional half-life, the amount of C^{14} is half of what it was before. The amount that has decayed becomes N^{14} and that is added to the previous amount of N^{14}.

Problem 1: You find a sample of material that contains C^{14} to N^{14} in the ratio of 1:3. How old is it.

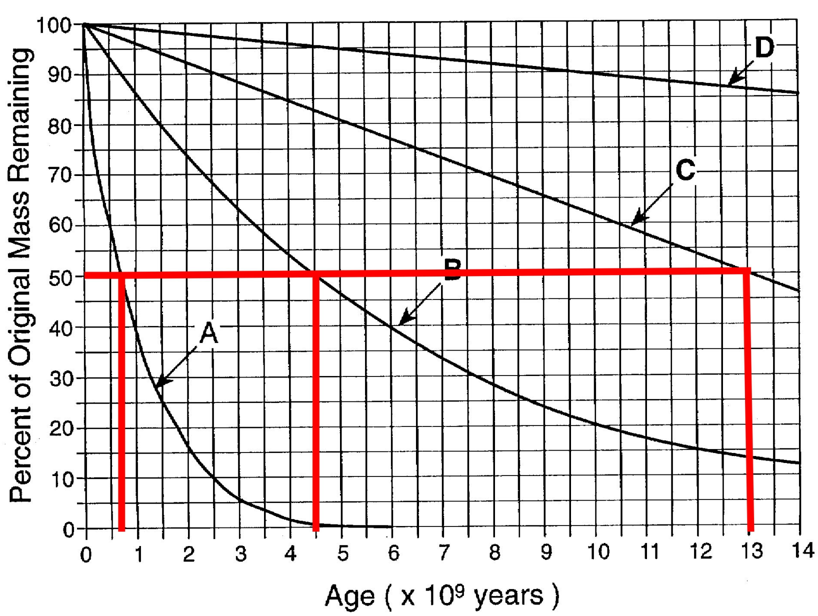
Solution: It takes 2 half-lives to reach a 1:3 ratio. You look up the half-life of C^{14} on page 1 of your reference table and find that it is 5.7×10^3 years (5,700). But since it will take ***2*** half-lives to reach this ratio, you must multiply 5,700 by 2. The sample is 11,400 years old.

Problem 2: How long will it take for 75% of the original C^{14} found in a sample to decay?

Solution: If 75% has decayed, you will have 25% remaining. You can see in the chart above that it will take 2 half-lives to reach 25% remaining. Since the half-life for C^{14} is 5,700 years, 2 half-lives is 11,400 years.

Problem 3: The ratio of U^{238} to Pb^{206} in a rock is 1:1. How old is the rock?

Solution: It will take 1 half-life to reach a 1:1 ratio ***but***, you must now find the half-life of uranium, not C^{14}. The half-life of U^{238} is 4.5×10^9 years. This is 4.5 billion years.



USING A HALF-LIFE GRAPH:

This graph shows the decay of 4 different radioactive elements. To find the half-life of any element simply find 50% on the vertical axis, go over to the line representing a specific element, element B for example, and drop straight down to read the half-life. The half-life of element B is 4.5 billion years.

Landscape Review

Landscapes form as the result of 2 opposing forces: Uplift (mountain building) and Leveling (erosion). Almost always one force is ***dominant*** over the other.
a) If uplift is dominant, the elevation of the landscape will increase.
b) If leveling forces (erosion) are dominant, the elevation will decrease.
c) If the two forces are in equilibrium, the elevation will remain constant.

1) PLATEAU - - - - - - - - - High elevation - - - - flat slopes - - - - horizontal bedrock

2) PLAINS (Lowlands) - - Low elevation - - - - flat slopes - - - - horizontal bedrock

3) MOUNTAINS - - - - - - High elevation - - - - steep slopes - - - tilted or folded bedrock

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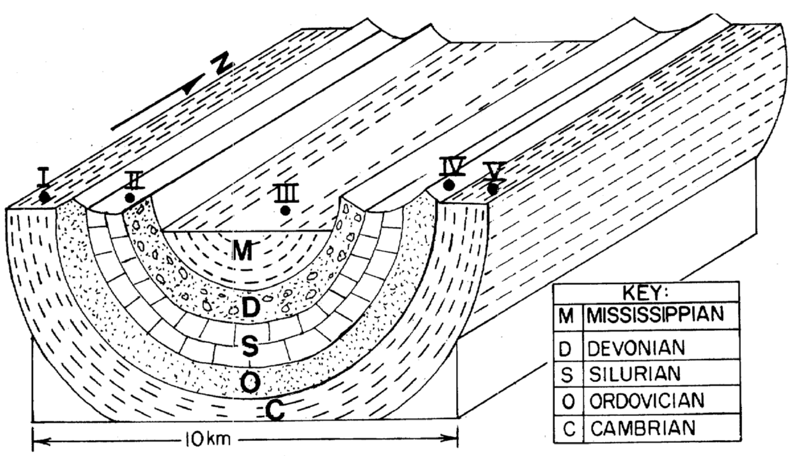
Effects of Climate:

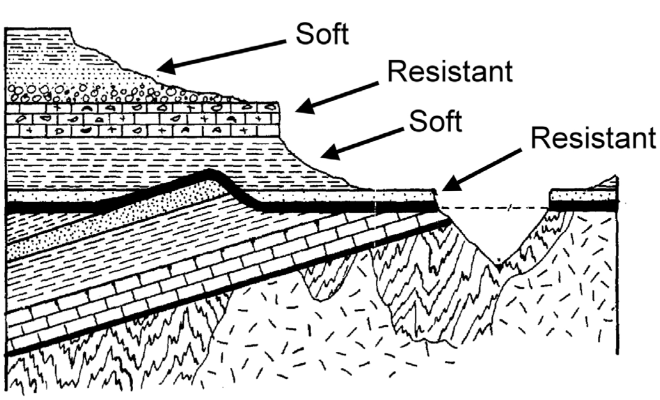
a) Arid (dry) climate = sharp angular features (mesas of the SW).
b) Humid climate = rounded features

Rock types: Differences in the ***resistance*** (hardness) of rock may result in the formation

of mountains, cliffs, and other features as soft rock is warn away leaving harder rock behind.

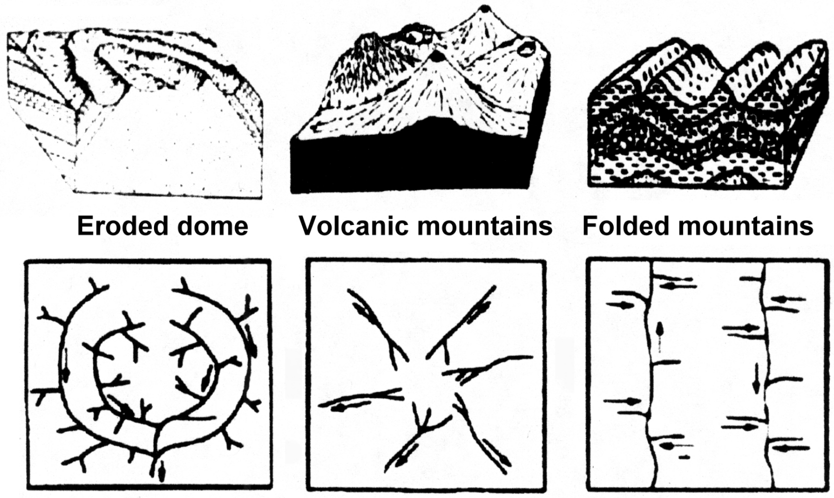


In this diagram of folded bedrock, layers D and O are resistant (hard) while layers C, S, and M are softer. The differences in resistance explains the long ridges of mountains formed by layers D and O.



The cliffs that have formed in this landscape region are the result of differences in the hardness of the rock. Soft rock is eroded away while harder, more resistant rock remains forming cliffs.

Landscapes & their Drainage Patterns



A meandering stream. This is characteristic of a very old sream or river with a nearly flat slope. Over time it has chaged course and produced a very wide river valley.

The views above show the landscape as it appears in the surface and in cross section. Below each diagram is the drainage or stream pattern associated with that landscape. Given any landscape, you must be able to select the stream pattern associated with it. If you are given a steam pattern, you must be able to identify the landscape in which that pattern would be found.

Also remember:

Stream or river valleys: V-shaped
Glacial valleys: U-shaped