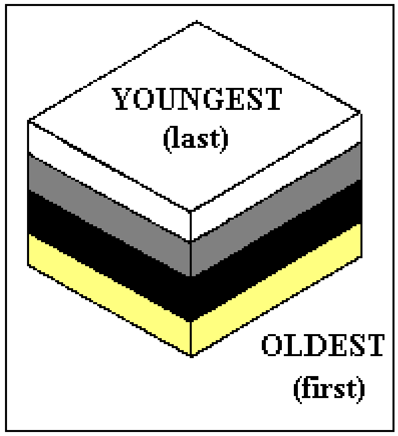
GEOLOGIC TIME	
RELATIVE TIME (DATING)	▪ **List the order in which events occurred, without regard to the amount of time separating them.** ▪ **Refers to the age of a rock in relation to other rocks** ▪ **Places events or rocks in sequential order** ▪ **IT DOES NOT ASSIGN A NUMERIC AGE IN YEARS**
ABSOLUTE TIME (DATING)	▪ **Tells both the order in which events occurred and the amount of time separating them** ▪ **Places a rock or event as having occurred at a specific number of years ago.** ▪ **Calibrated to external processes that record the passage of time. (Radiogenic isotopes)**

GEOLOGIC EVENTS	
DEPOSITION OF SEDIMENTS	**SEDIMENTARY ROCKS**
EXTRUSION	**IGNEOUS ROCKS**
INTRUSION	
METAMORPHISM	**METAMORPHIC ROCKS**
DEFORMATION	**FAULTING**
	FOLDING
	TILTING
UPLIFT	
EROSION	
SUBSIDENCE	

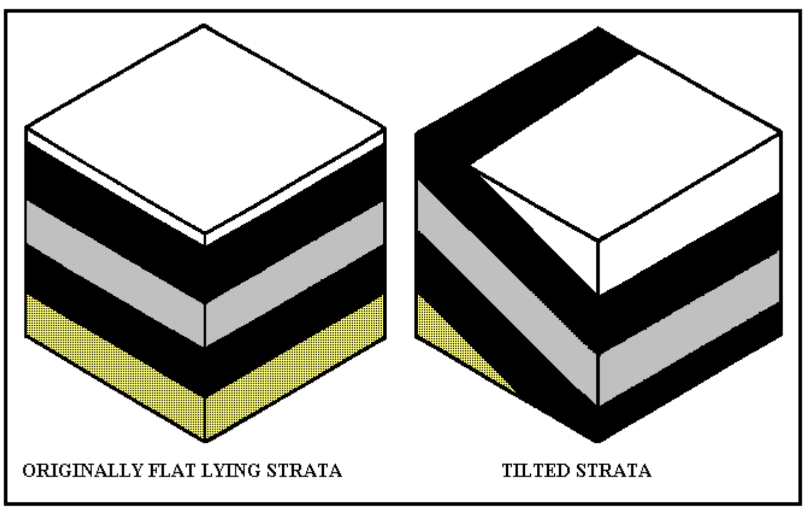
RELATIVE DATING

Principles related to the deposition of sedimentary sequences.

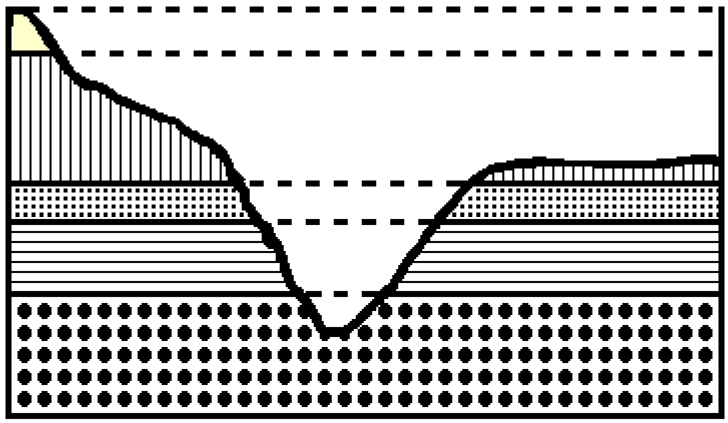
PRINCIPLE OF SUPERPOSITION. In an undisturbed unit of sedimentary rocks, the layer on the bottom formed first, and the layers on top successively later.
Also applied to LAVA FLOWS



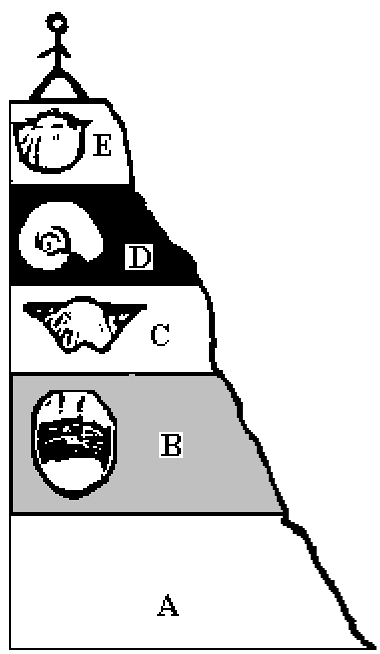
PRINCIPLE OF ORIGINAL HORIZONTALITY. Sediments are deposited in flat, horizontal layers (any tilting, folding or other deformation must have occurred after the beds were formed).
Also applied to LAVA FLOWS



PRINCIPLE OF ORIGINAL LATERAL CONTINUITY. Sediments are deposited over a large area in continuous sheets.

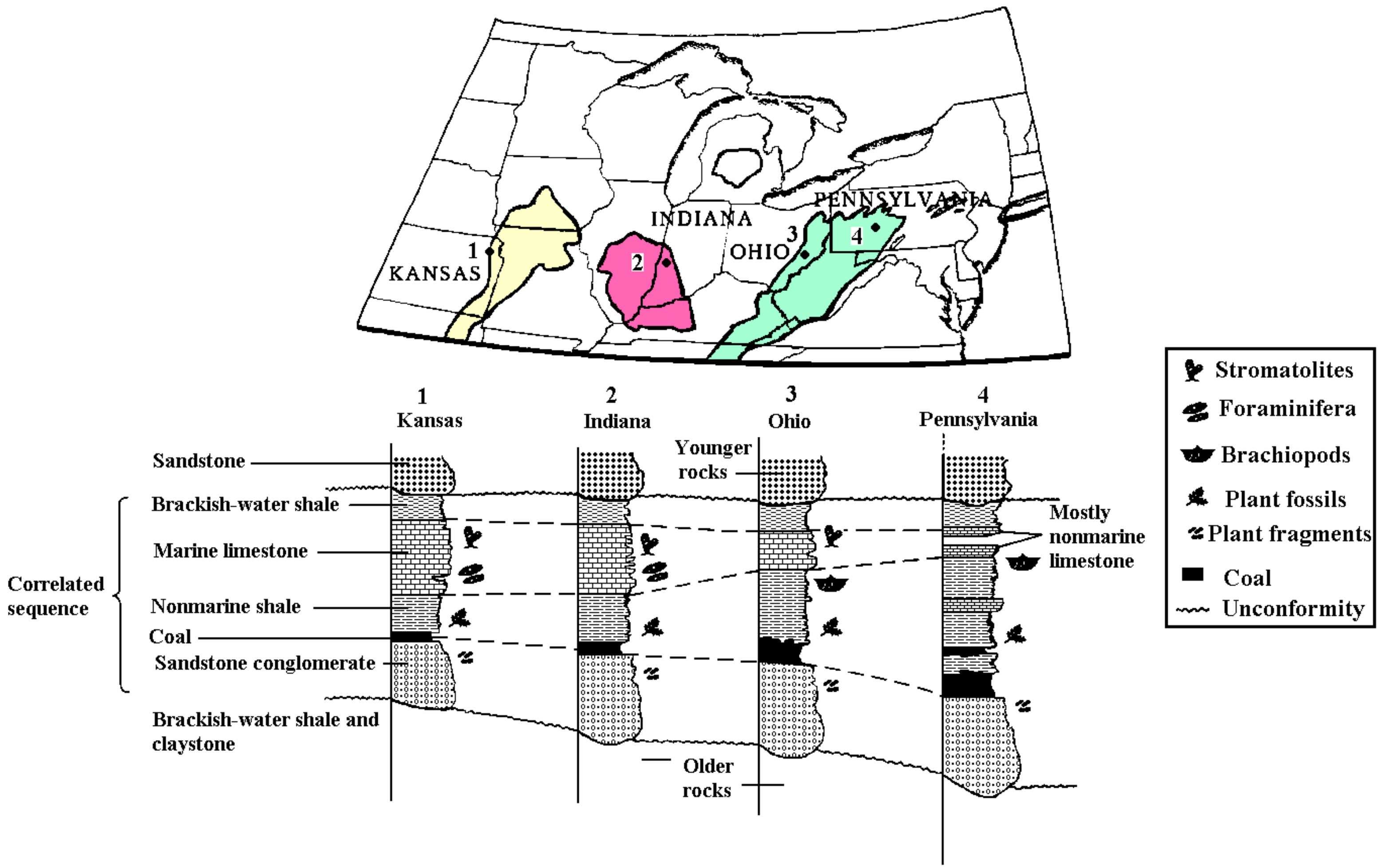


PRINCIPLE OF FAUNAL SUCCESSION. Fossils occur in a consistent vertical order in sedimentary rock all over the world. –The result of the natural appearance and disappearance of species through time.



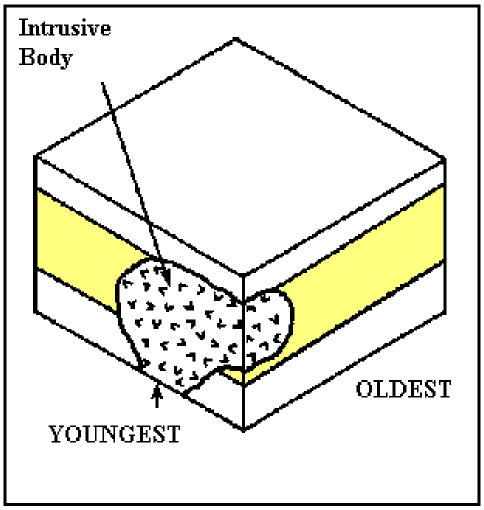
CORRELATION OF SEDIMENTARY UNITS.

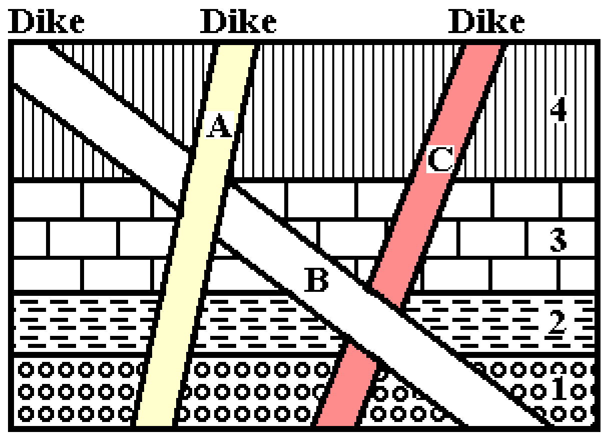
Determination of age equivalence between geographically distant rock units.

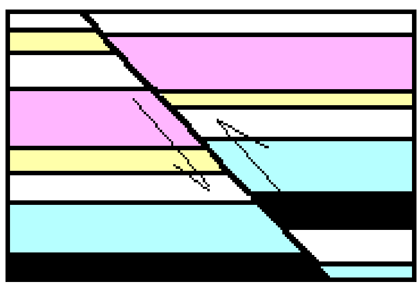


Principles related to extrusion or intrusion,

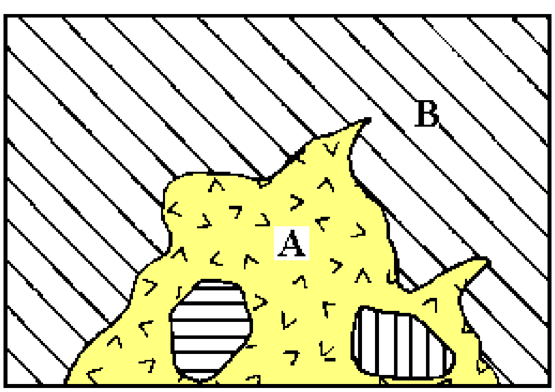
PRINCIPLE OF CROSS-CUTTING RELATIONSHIPS. Intrusions are younger than the rock they cut (also applied to faults [cracks across rocks along which there has been relative movement]).

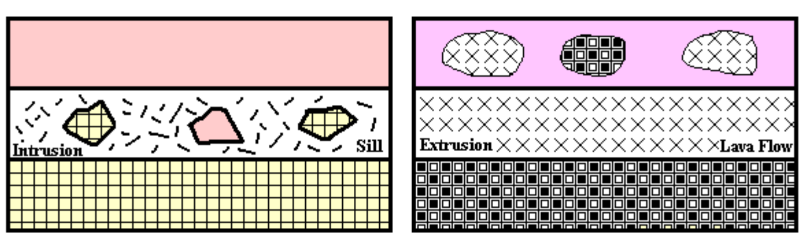






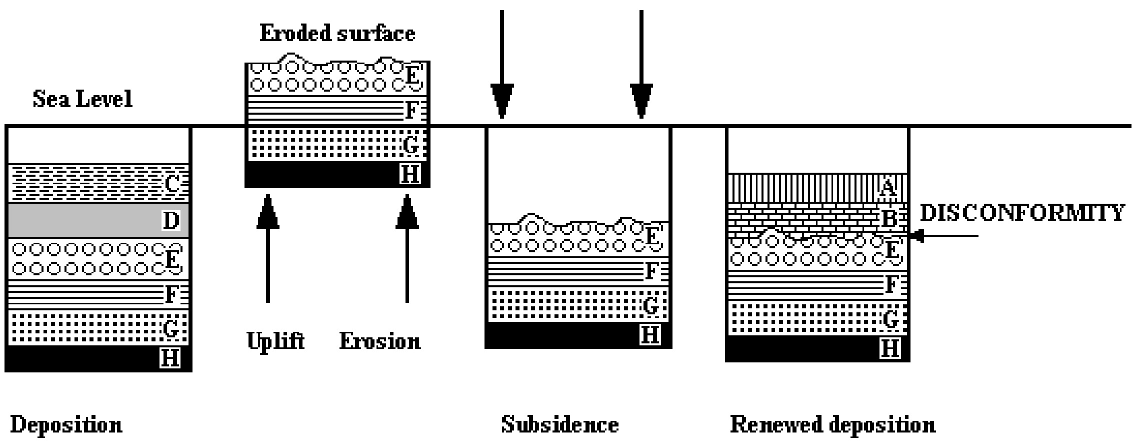
PRINCIPLE OF INCLUSIONS or COMPONENTS. Rocks fragments within either igneous units (xenoliths) or sedimentary units (clasts) are older than their hosts.



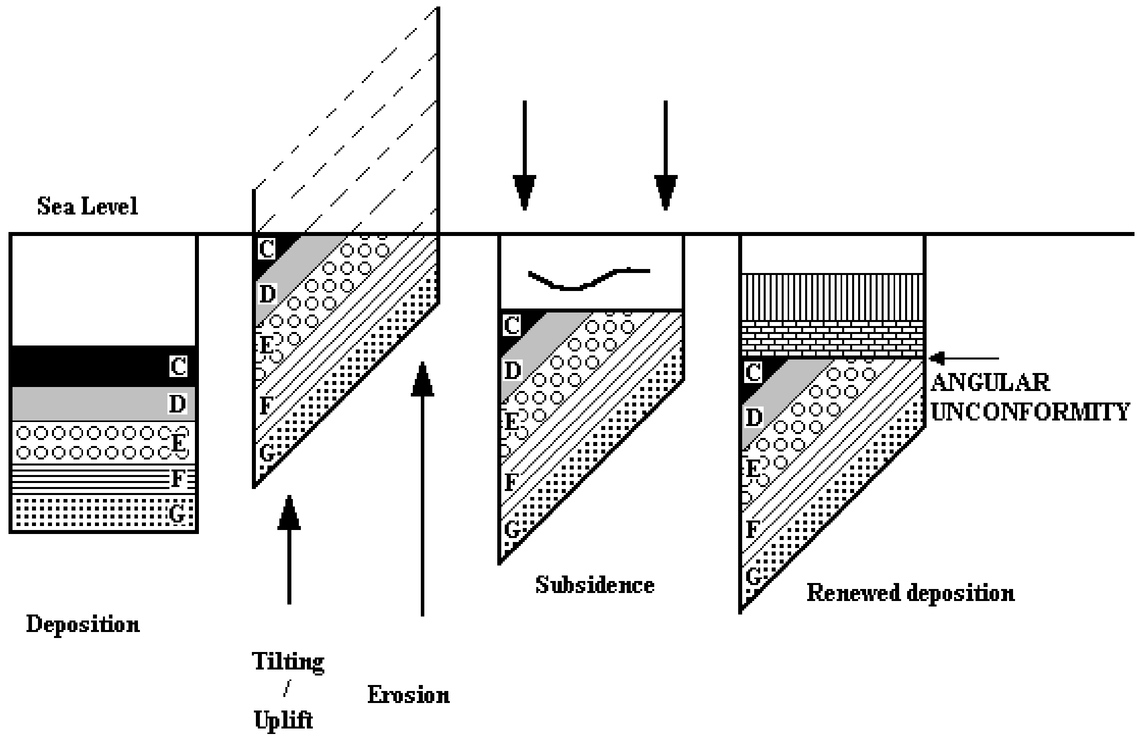


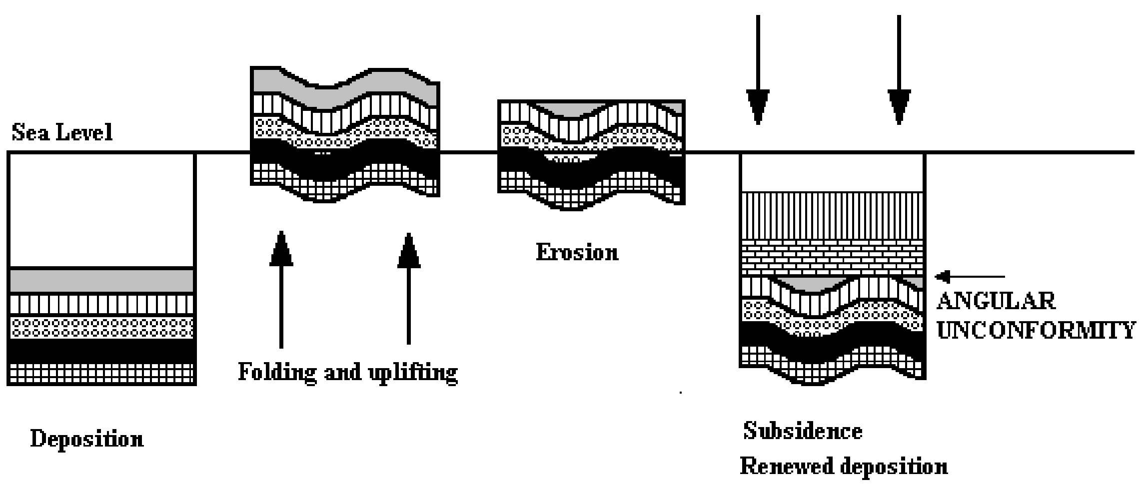
UNCONFORMITY. A surface along which a portion of the geologic record is missing. They represent a break in the geological record.

1. DISCONFORMITY. Rocks above and below the eroded surface have similar attitudes (orientation)

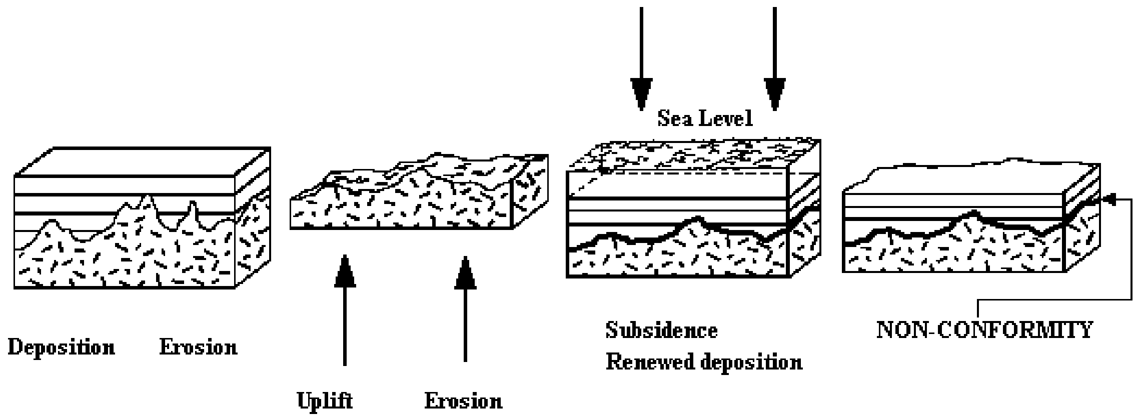


2. ANGULAR UNCOFORMITY. Rocks above and below the eroded surface have different attitudes.





3. NON-CONFORMITY.

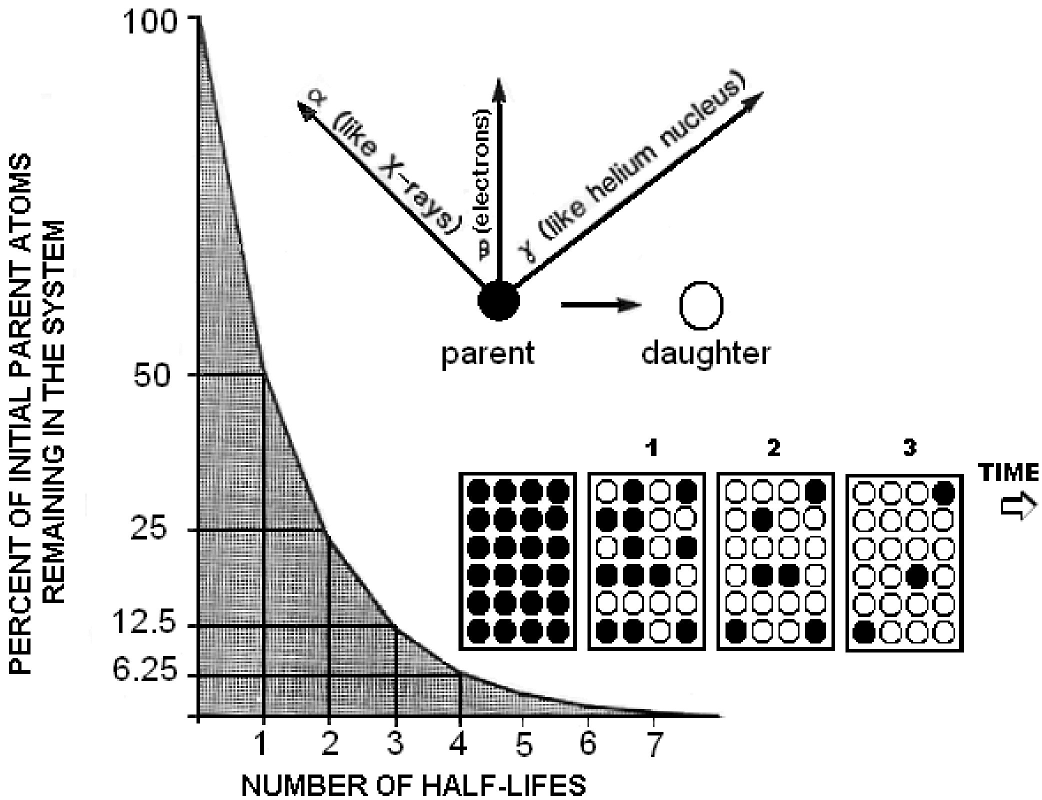

Sea Level
Deposition
Erosion
Uplift
Erosion
Subsidence
Renewed deposition
NON-CONFORMITY

ABSOLUTE AGE

ISOTOPES: Each element has a fixed number of positively charged protons in its nucleus and an equal number of electrons orbiting the nucleus. The nucleus contains both protons and neutrons. An element has a **fixed number of protons** but may exist with **various numbers of neutrons**.

Isotopes are atoms of the same element with different number of neutrons. They have the same chemical properties but different weights (mass number).

RADIOMETRIC DATING. Measures absolute time, based on the decay of a radioactive parent isotope to a daughter isotope, at a constant, known rate (half-life of the parent ½-life).



Radioactive isotopes decay to stable daughther isotopes while emmiting radiation or particles or both. The rate of decay is expressed as the half-life, the time it takes half of the parent isotope to decay to the daughter isotope. The rate is exponential, as can be seen on the decay curve above. The curve at first drops very rapidly, then much slowly.

DECAY PARAMETERS				
% of P	**% of D**	**P/D**	**t ½ ELAPSED**	**AGE**
99.220	0.780	127.205	1/64	1/64 x t ½
98.440	1.560	63.103	1/32	1/32 x t ½
96.880	3.120	31.051	1/16	1/16 x t ½
93.750	6.250	15.00	1/8	1/8 x t ½
87.500	12.500	7.00	1/4	1/4 x t ½
75.000	25.000	3.000	1/2	1/2 x t ½
50.000	50.000	1.00	1	1 x t ½
37.500	62.500	0.600	1 1/2	1 1/2 x t ½
25.000	75.000	0.333	2	2 x t ½
12.500	87.500	0.143	3	3 x t ½
6.250	93.750	0.067	4	4 x t ½
3.125	96.875	0.032	5	5 x t ½
1.563	98.438	0.016	6	6 x t ½

SOME ISOTOPES USED IN RADIOMEDRIC DATING				
P	**D**	**t ½ OF PARENT**	**DATING RANGE**	**MATERIALS USED**
^{87}Rb	87Sr	48.8 b.y.	10 - 4.6 billion	Muscovite Biotite K-feldspar Whole metamorphic or igneous rock
^{40}K	^{40}Ar ^{40}Ca	1.3 b.y.	50,000 - 4.6 billion	Muscovite Biotite Hornblende Whole volcanic rock
^{238}U ^{235}U ^{232}Th	^{206}Pb ^{207}Pb ^{208}Pb	4.5 b.y. 710 m.y. 14 b.y.	10 million – 4.6 billion	Zircon Uraninite Pitchblende
^{14}C	^{14}N	5,730 y.	100 - 70,000 (geologically very young!)	Wood Charcoal Peat Bone tissue Shell and other $CaCO_3$ Groundwater, ocean water, glacier ice containing dissolved CO_2

Assumptions of radiometric dating:
1) The rock or mineral must be a "closed system."
2) We must be able to accurately determine a value for the initial daughter atoms if they were present in mineral or rock sample being dated.
3) The value of the decay constant (λ) must be known accurately.
4) The measurements of the parent and daughter atoms must be accurate and representative of the rock or mineral to be dated.

Limitations:
Mineral grains must have formed when the rock formed)
Rock needs measurable amounts of P and D.
Ages are reported with an estimated error.
Weathered or altered minerals should not be used.