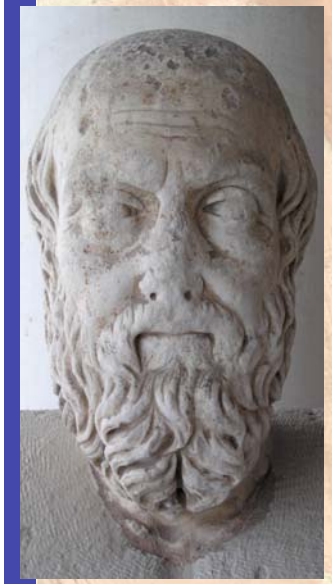
A Brief History of Geology



Herodotus
~500 BC

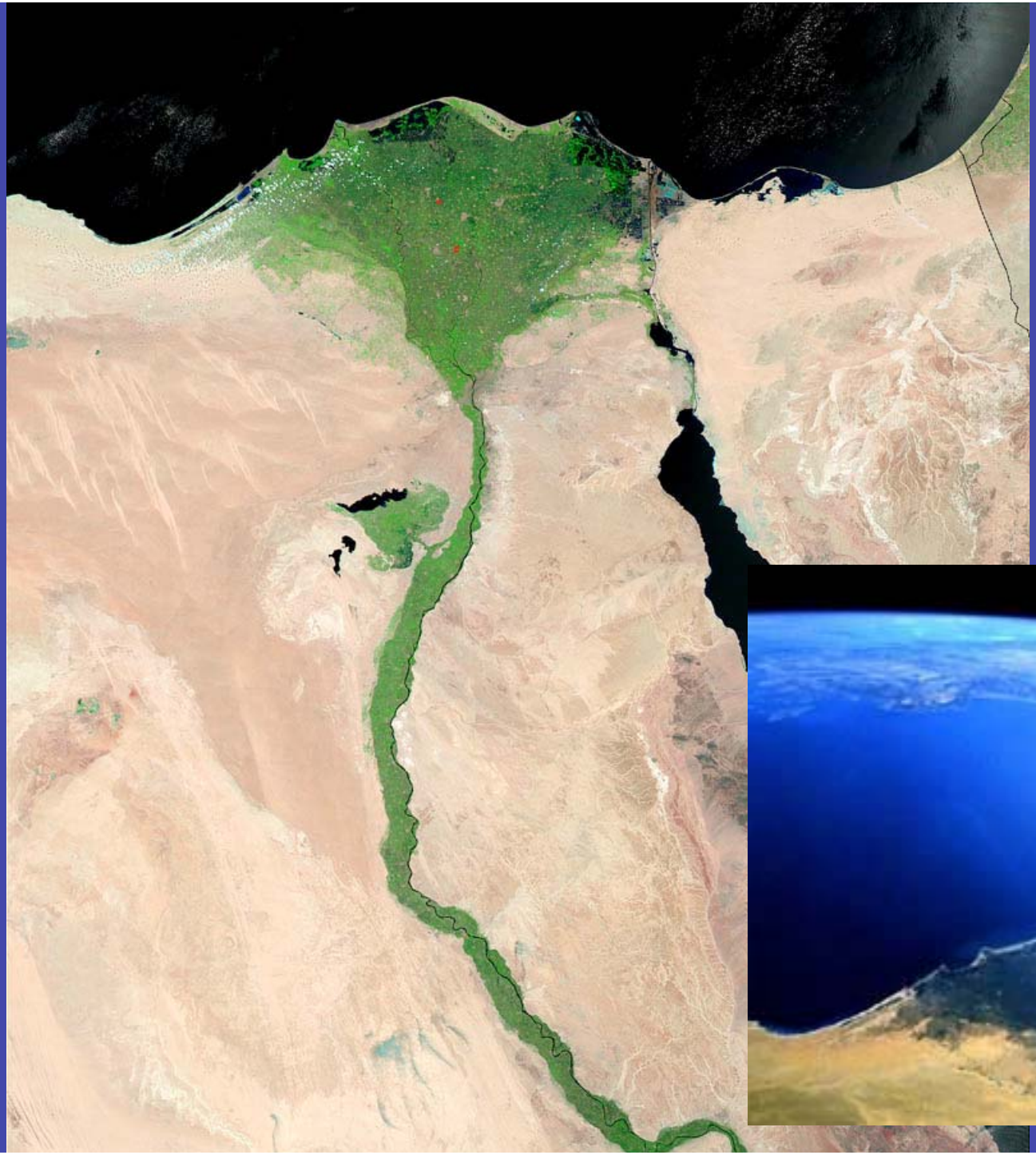




Long history of agriculture





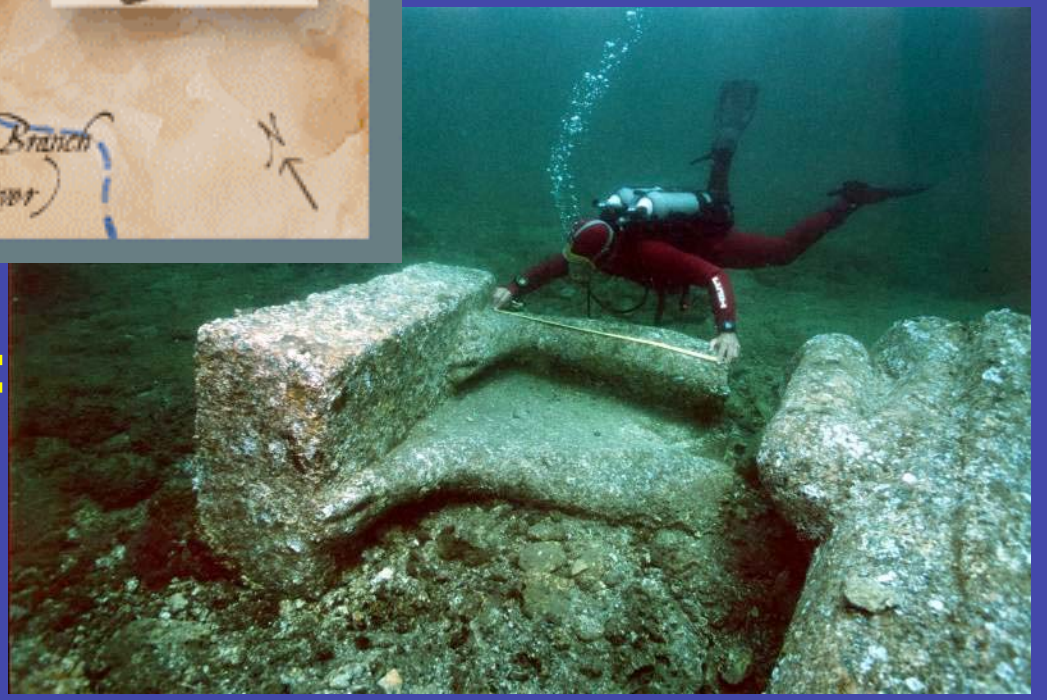


Annual flooding built Nile Delta



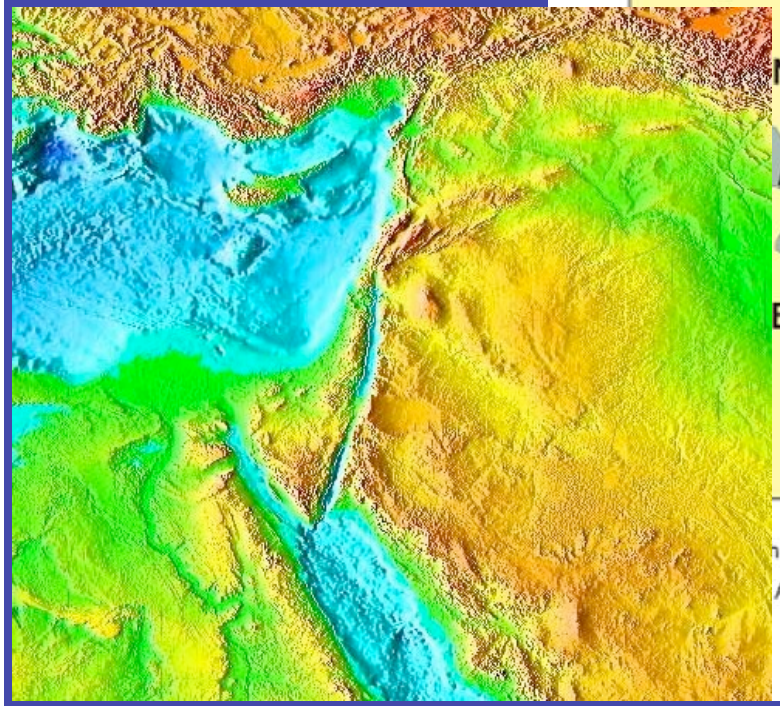


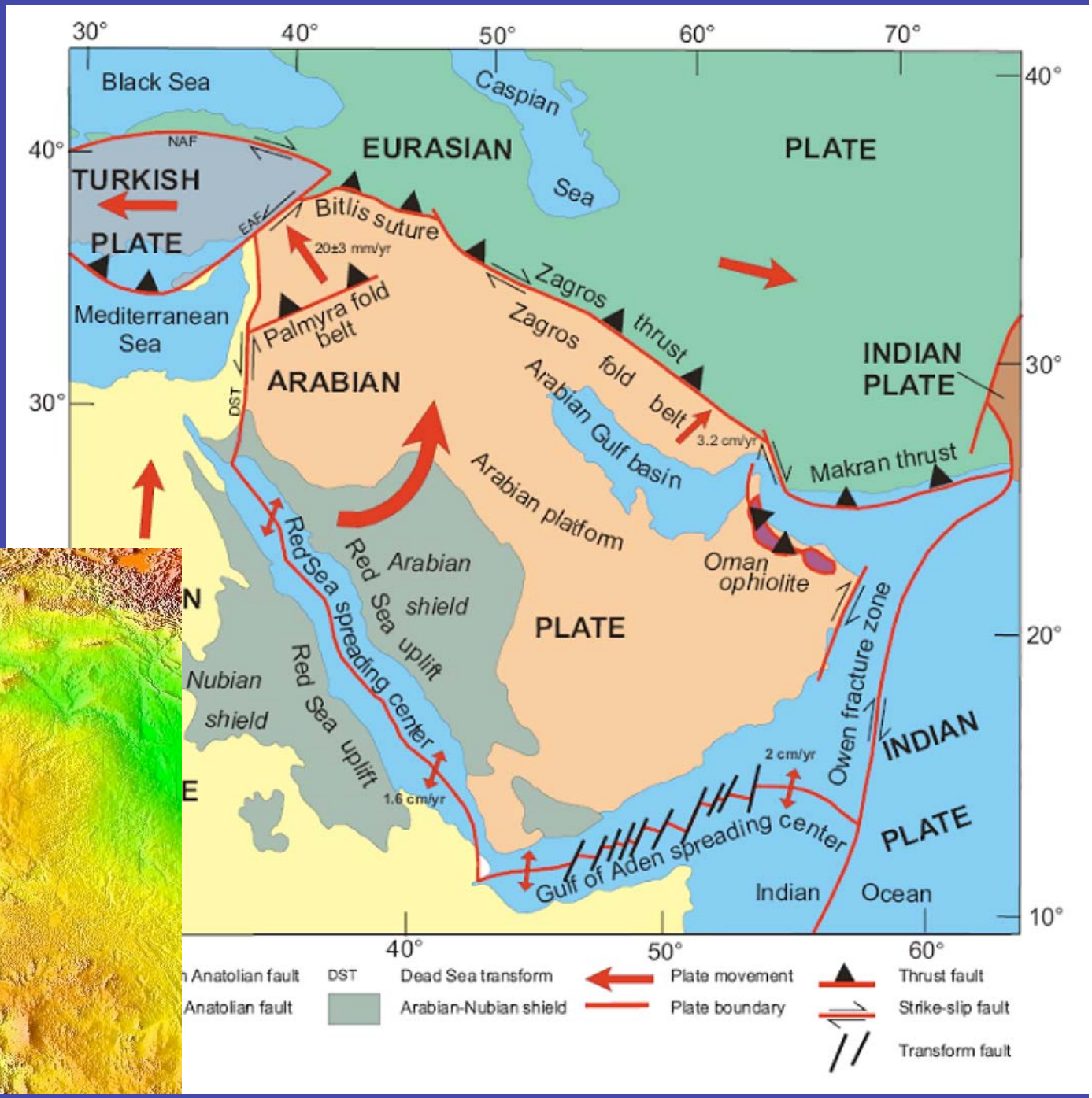




Sunken cities (~740 AD):
Herakleion
Menouthis

Dead Sea Transform











Positions of land and sea have changed



This must have happened over long timescales



What do these deposits represent?



How long would it take to accumulate river deposits of these thicknesses?



Recognized marine fossils, river deposits



Aristotle ~350 BC

But, believed Earth was center of the Universe


9539
Large fish









Theophrastus
314 BC

“Concerning Stones”

Did not recognize fossils as once-living organisms

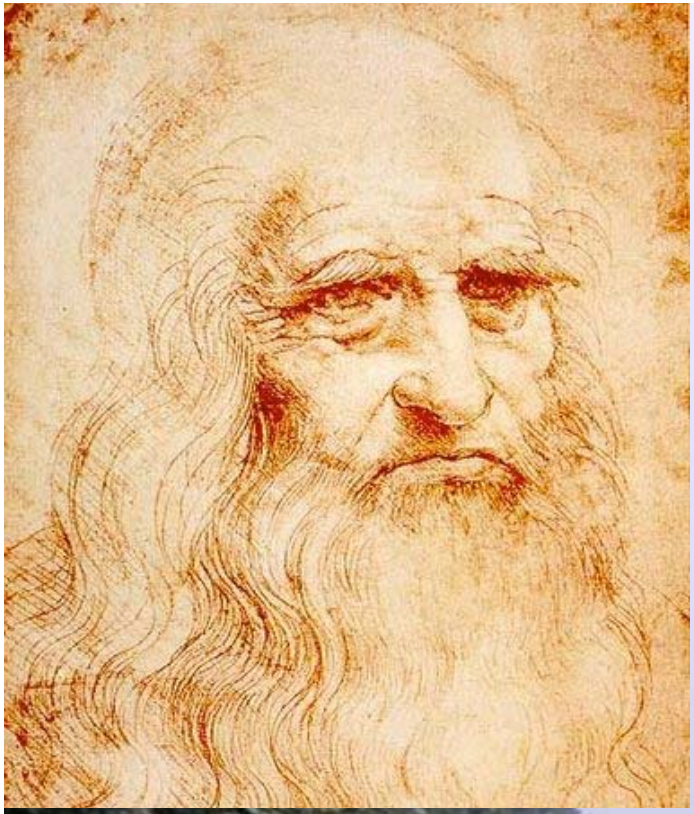


Rise of Christianity

~0 – 400 AD

Dark Ages

~400 AD – 1000 AD



Leonardo da Vinci
1452-1519

Po River Deposits

200,000 yrs old

therefore:

geologic time <u>much longer</u>

sedimentary uplift









James Ussher (1581–1656) Anglican Archbishop of Armagh and Primate of All Ireland



4004 BC - Creation
(at nightfall preceding 23 October)

2348 BC - The Great Flood
1921 BC - Yahweh's call to Abraham
1491 BC - The Exodus from Egypt
1012 BC - The founding of the Temple in Jerusalem
586 BC - The destruction of Jerusalem by Babylon and the beginning of the Babylonian Captivity
4 BC - The birth of Christ

Published 1650, therefore age of Earth assumed to be 5,654 yrs old.



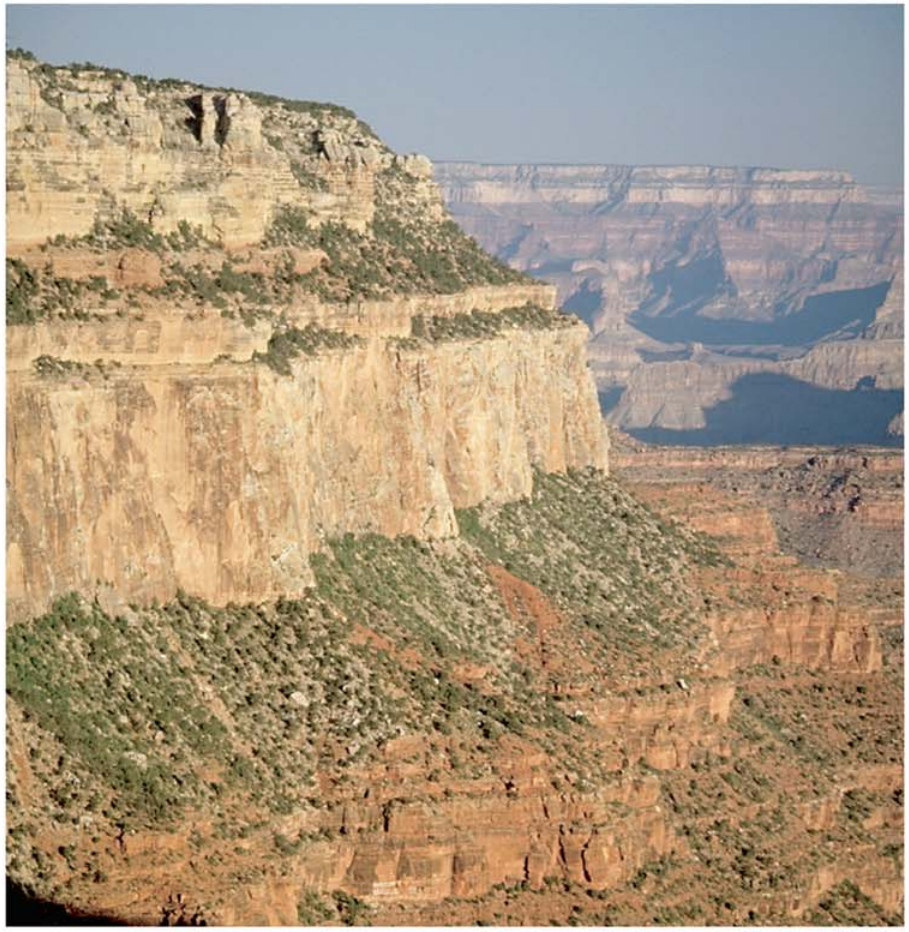


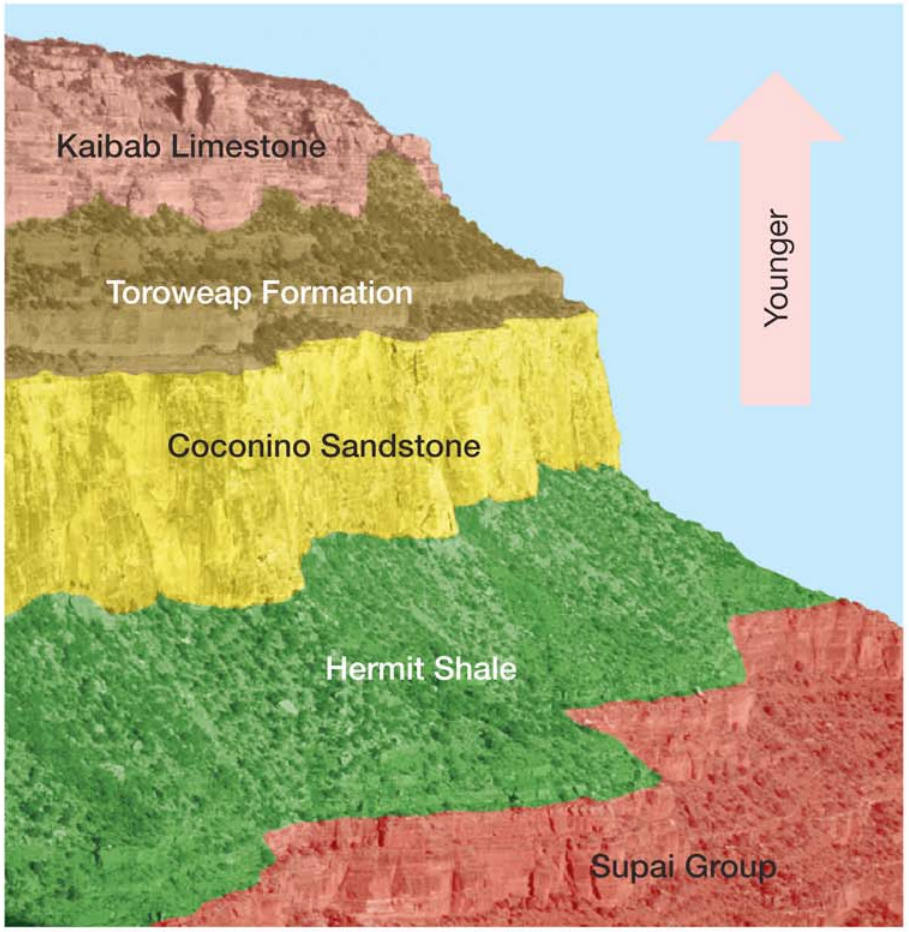
Nicolaus Steno (1638-1686)

Recognized shark teeth fossils



1) Law of Superposition








1) Principle of Original Horizontality



3) Principle of Lateral Continuity





“It is better to be humble than hung…”



Georges-Louis Leclerc,
Comte de Buffon
(1707 – 1788)

Age of Earth >75,000 years




350 feet high, 136 Mya



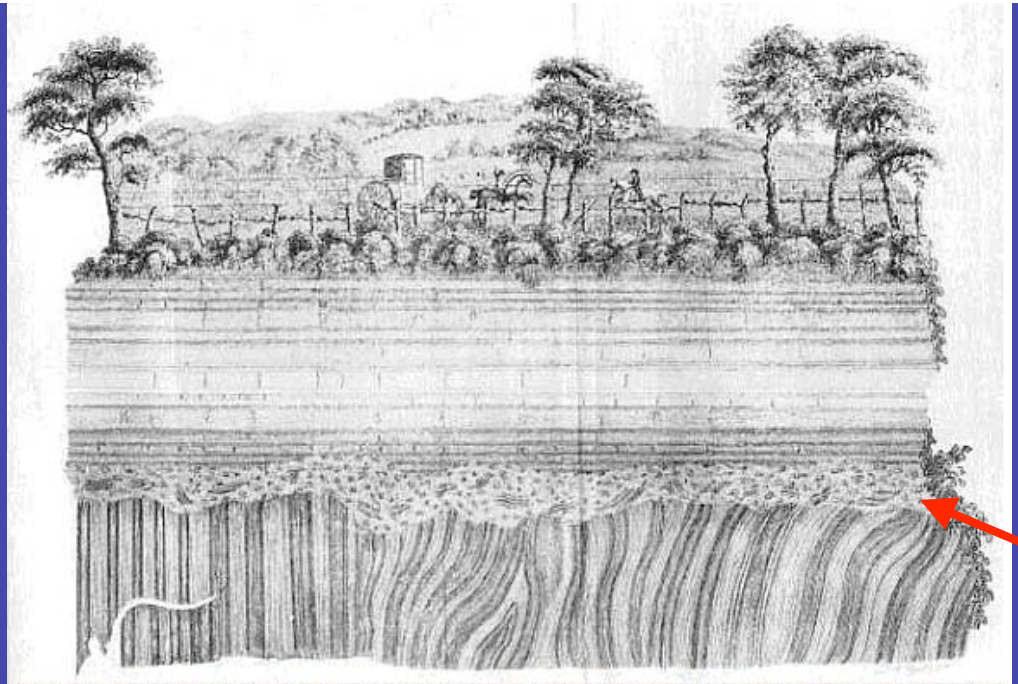
What can we infer about the environment of deposition?



Principle of Uniformitarianism
"present is the key to the past"

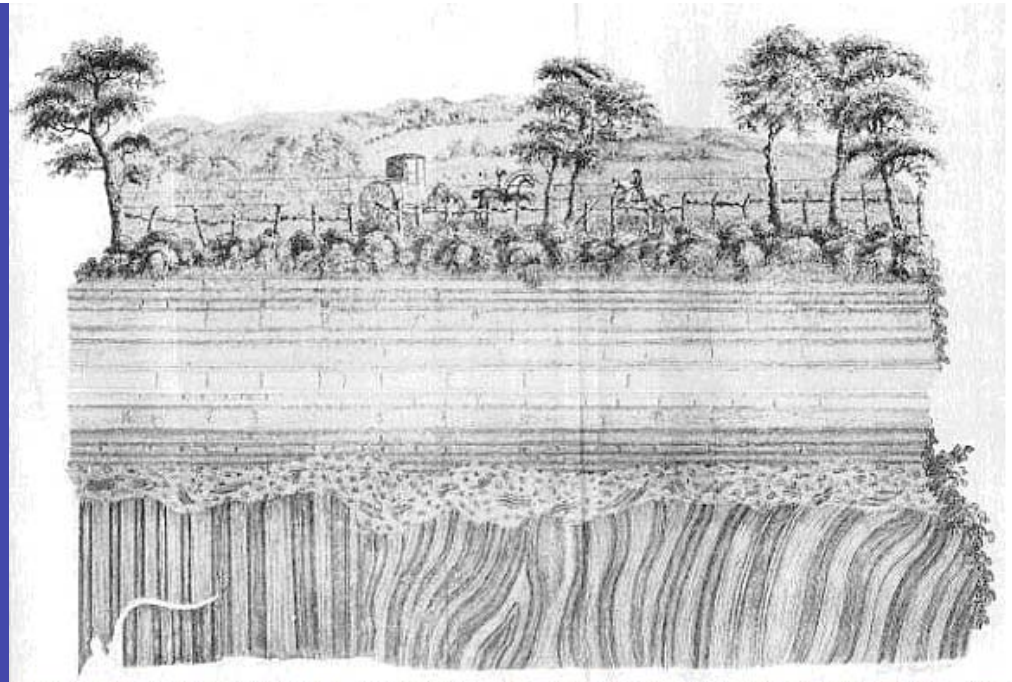
James Hutton
(1726-1797)


Igneous rocks were once molten
(they didn't precipitate
out of the ocean)

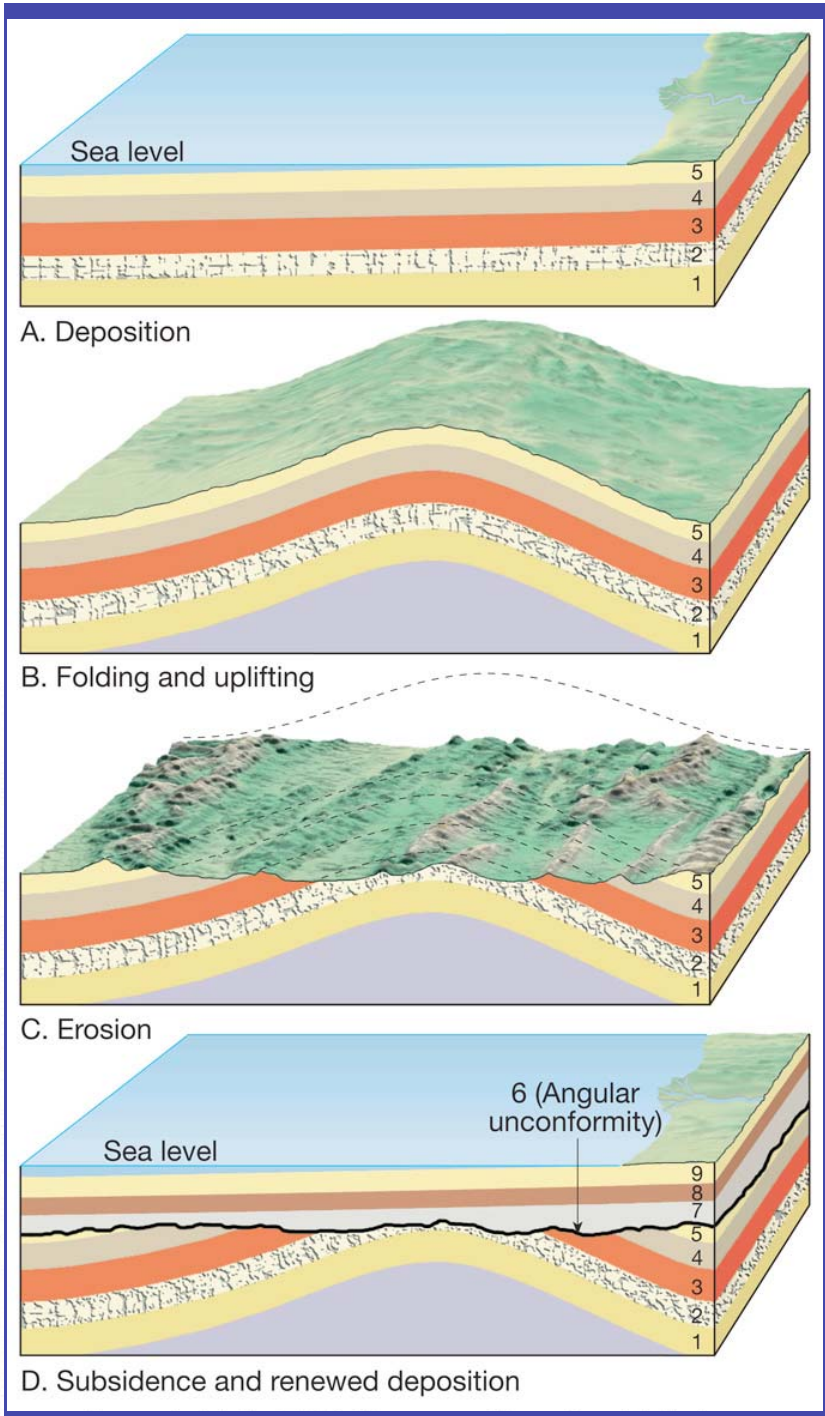




Hutton's Unconformity






Sea level
5
4
3
2
1
A. Deposition
5
4
3
2
1
B. Folding and uplifting
5
4
3
2
1
C. Erosion
6 (Angular unconformity)
Sea level
9
8
7
5
4
3
2
1
D. Subsidence and renewed deposition

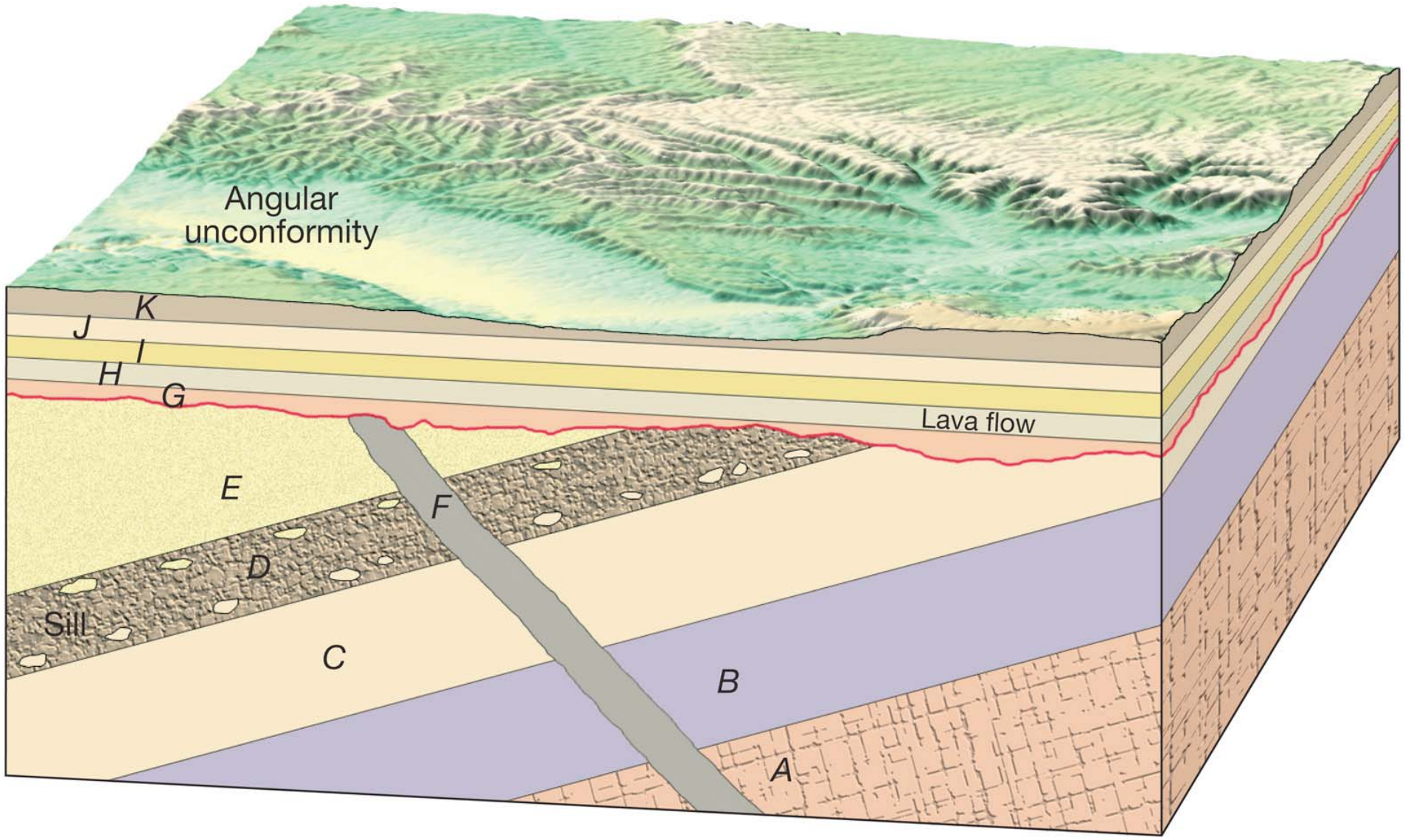

“the mind seemed to grow giddy by looking so far into the abyss of time” (1786)

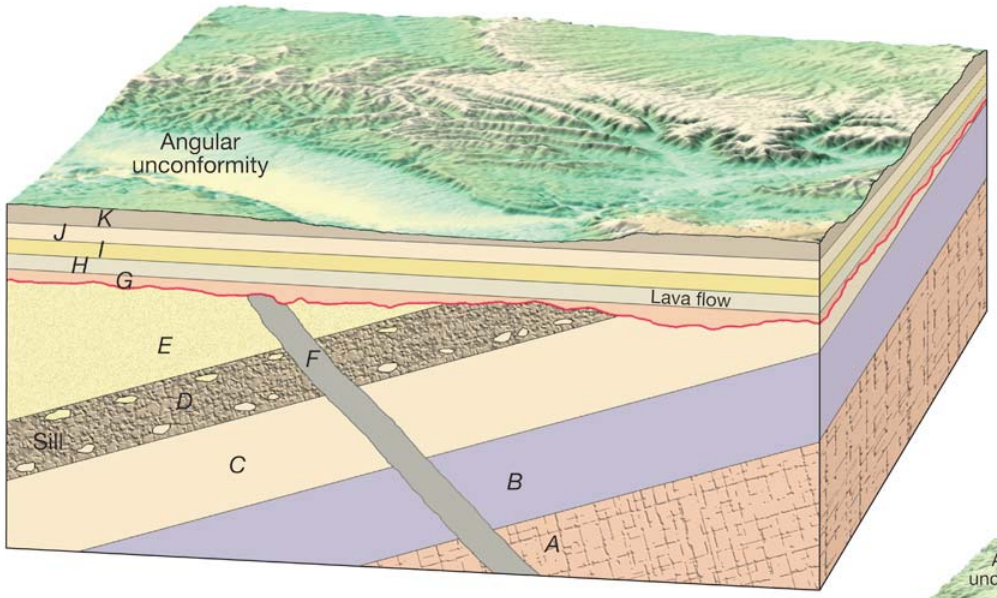




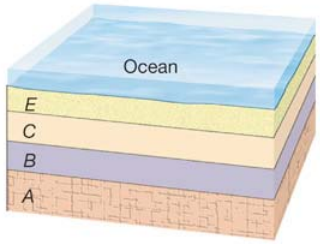
Principle of Cross-Cutting Relationships

Youngest material not cut (or overlain) by any other strata

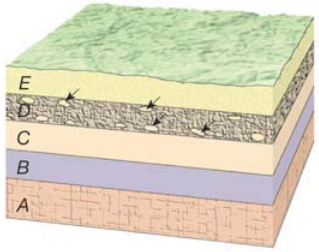




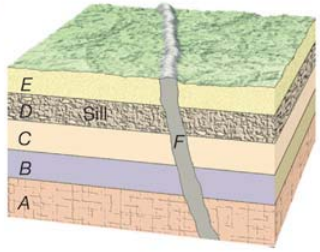
Interpretation:



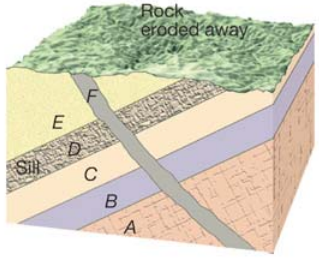
1. Applying the *law of superposition*, beds *A*, *B*, *C*, and *E* were deposited in that order.



2. Bed *D* is a sill (a concordant igneous intrusion). Evidence that sill *D* is younger than beds *C* and *E* are the *inclusions* in the sill of fragments from these beds. If this igneous mass contains pieces of adjacent strata, then the adjacent strata must have been there first.

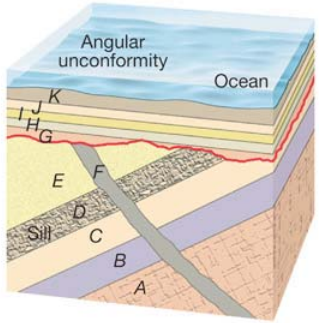


3. Following the intrusion of sill *D*, the intrusion of dike *F* occurred. Because the dike cuts through beds *A* through *E*, it must be younger than all of them (principle of cross-cutting relationships).

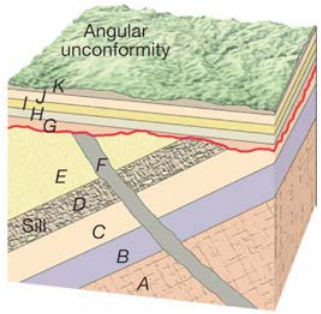


4. Next, the rocks were tilted and eroded. The tilting happened first because the upturned ends of the strata have been eroded. The tilting and erosion, followed by further deposition, produced an *angular unconformity*.

5. Beds *G*, *H*, *I*, *J*, and *K* were deposited in that order, again using the *law of superposition*. Although the lava flow (bed *H*) is not a sedimentary rock layer, it is a surface-deposited layer, and thus superposition may be applied.

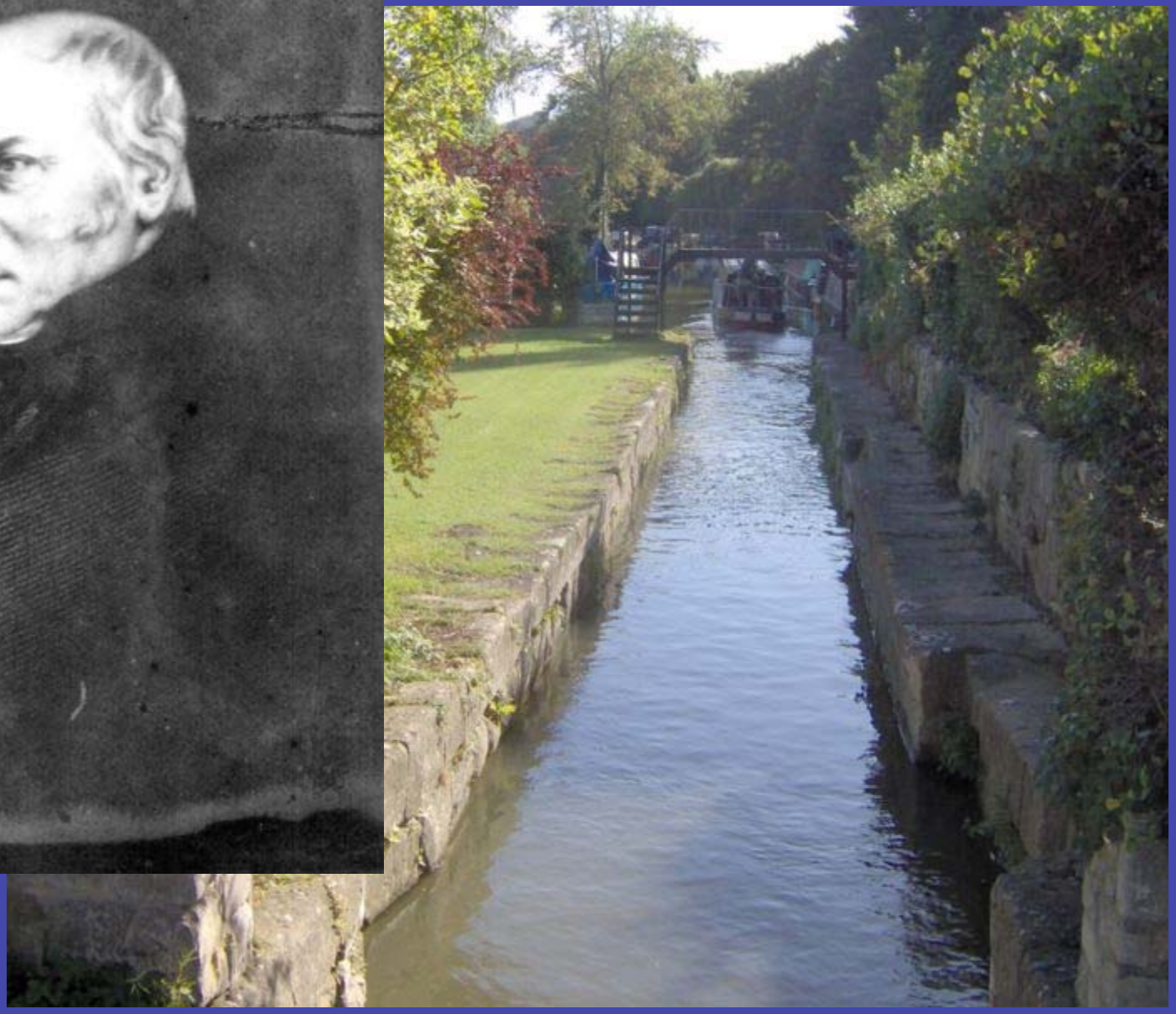


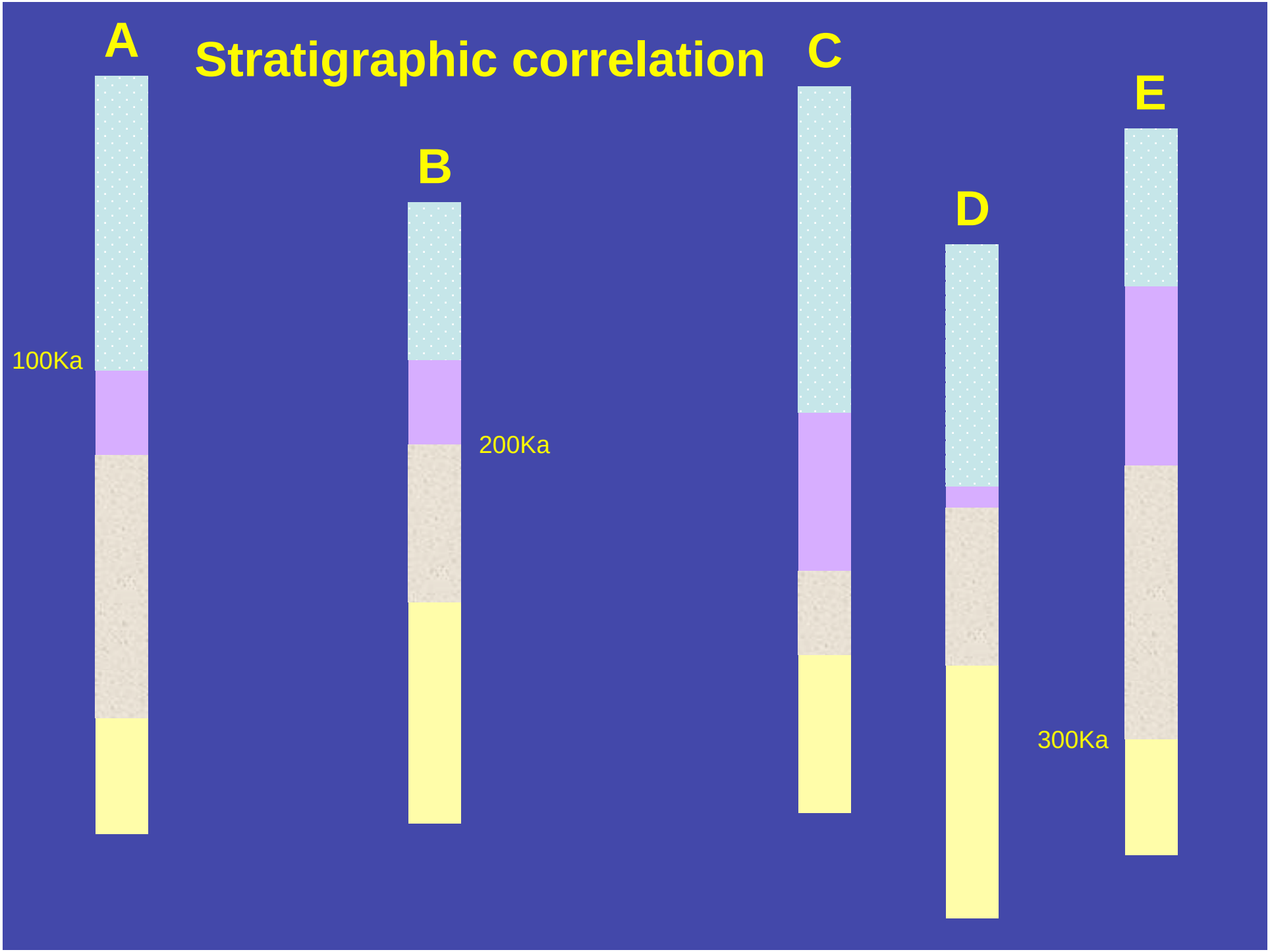
6. Finally, the irregular surface and the stream valley indicate that another gap in the rock record is being produced by erosion.

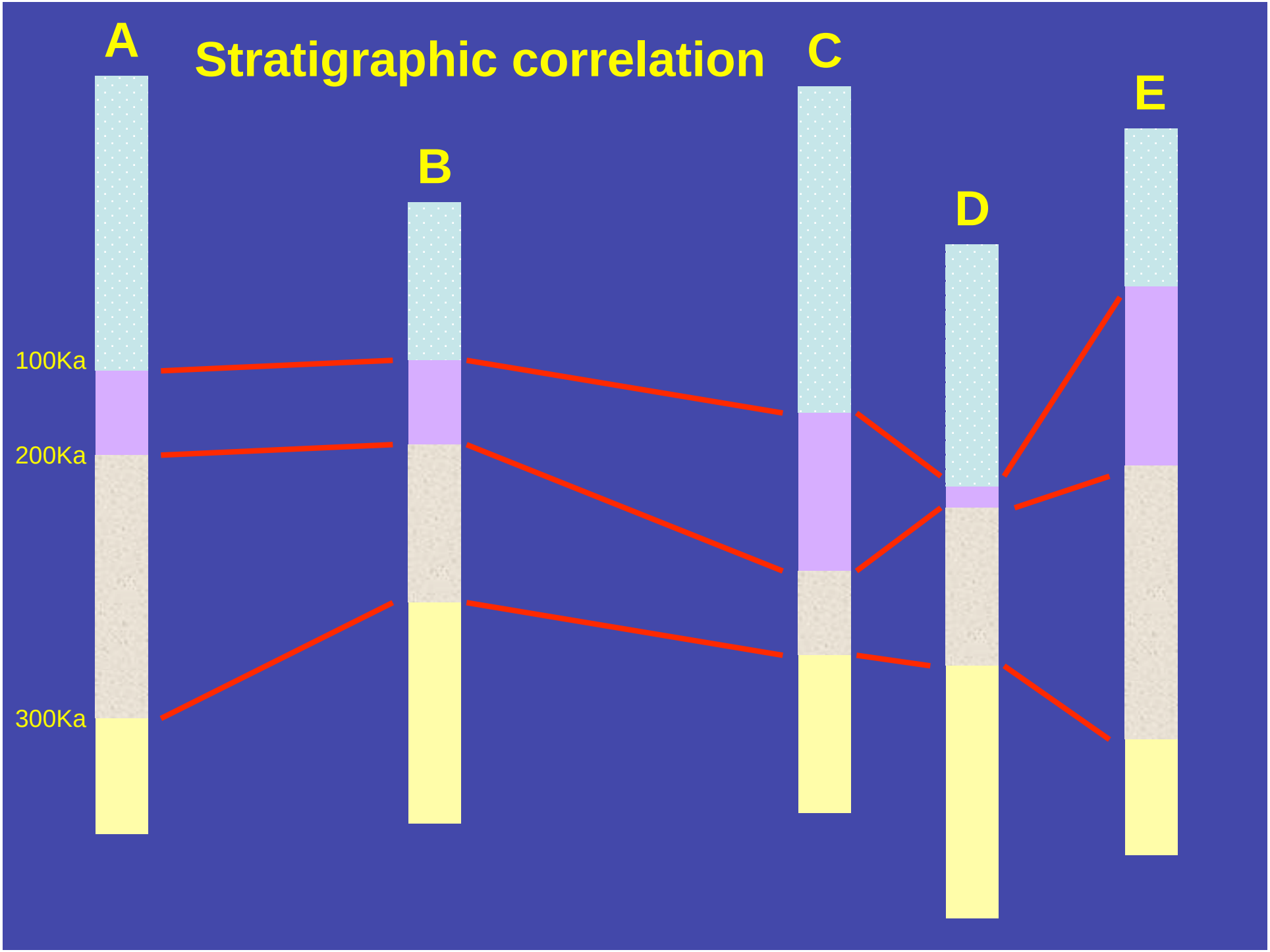


William “Strata” Smith (1769-1839)






Stratigraphic correlation
A
B
C
D
E
100Ka
200Ka
300Ka


Stratigraphic correlation
A
B
C
D
E
100Ka
200Ka
300Ka


Bryce Canyon

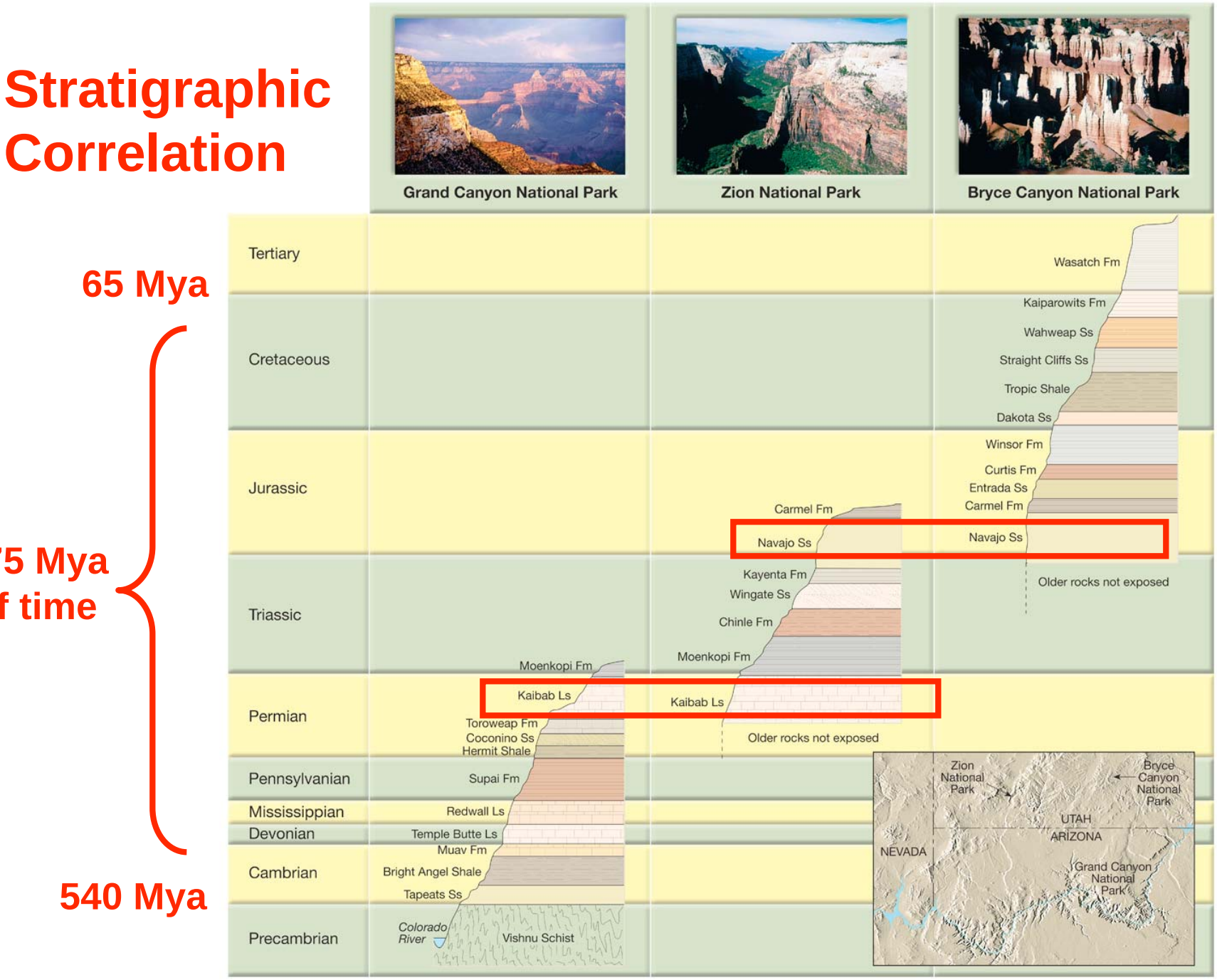
Stratigraphy:

The study of rock layering

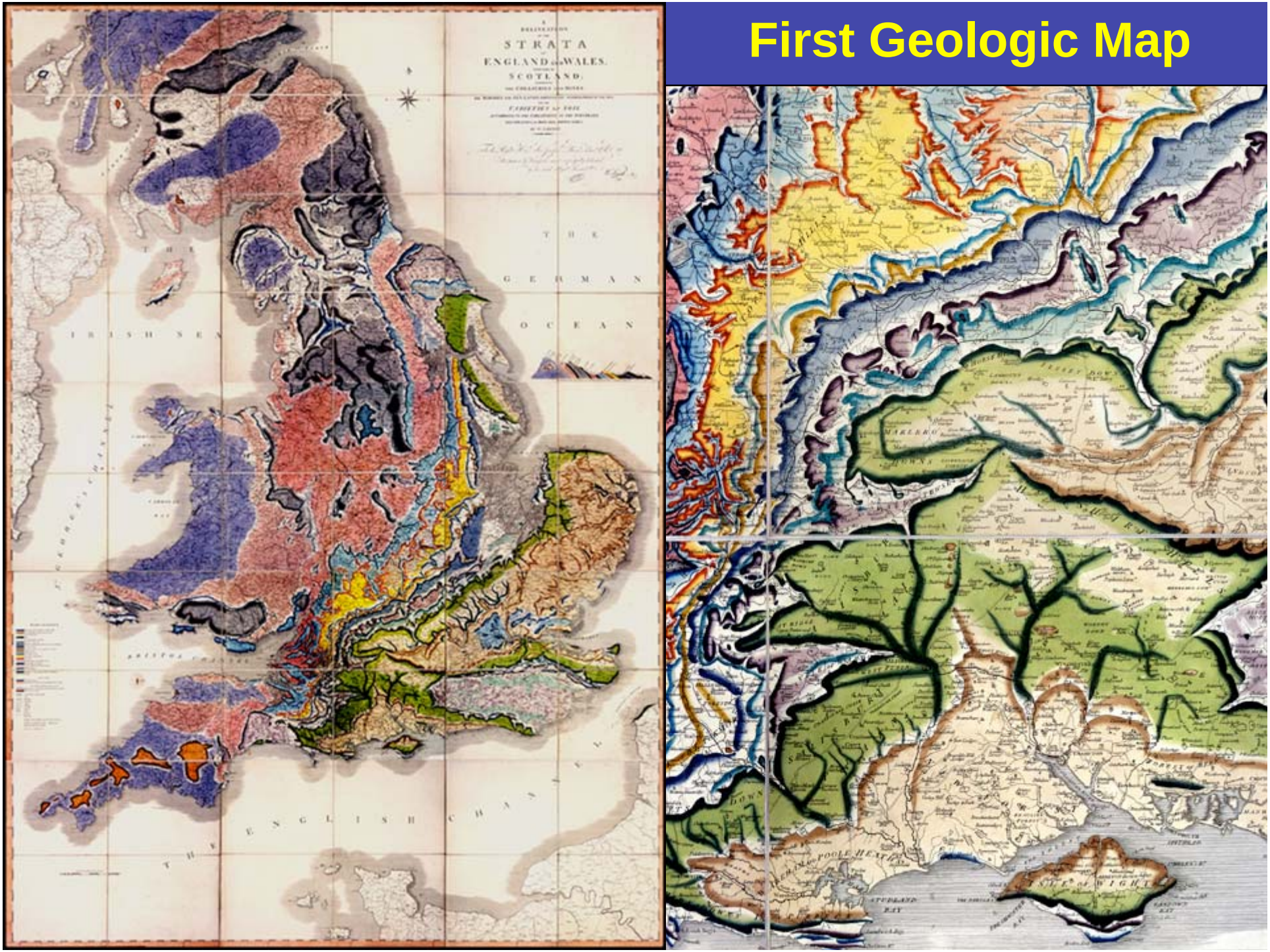

Grand Canyon

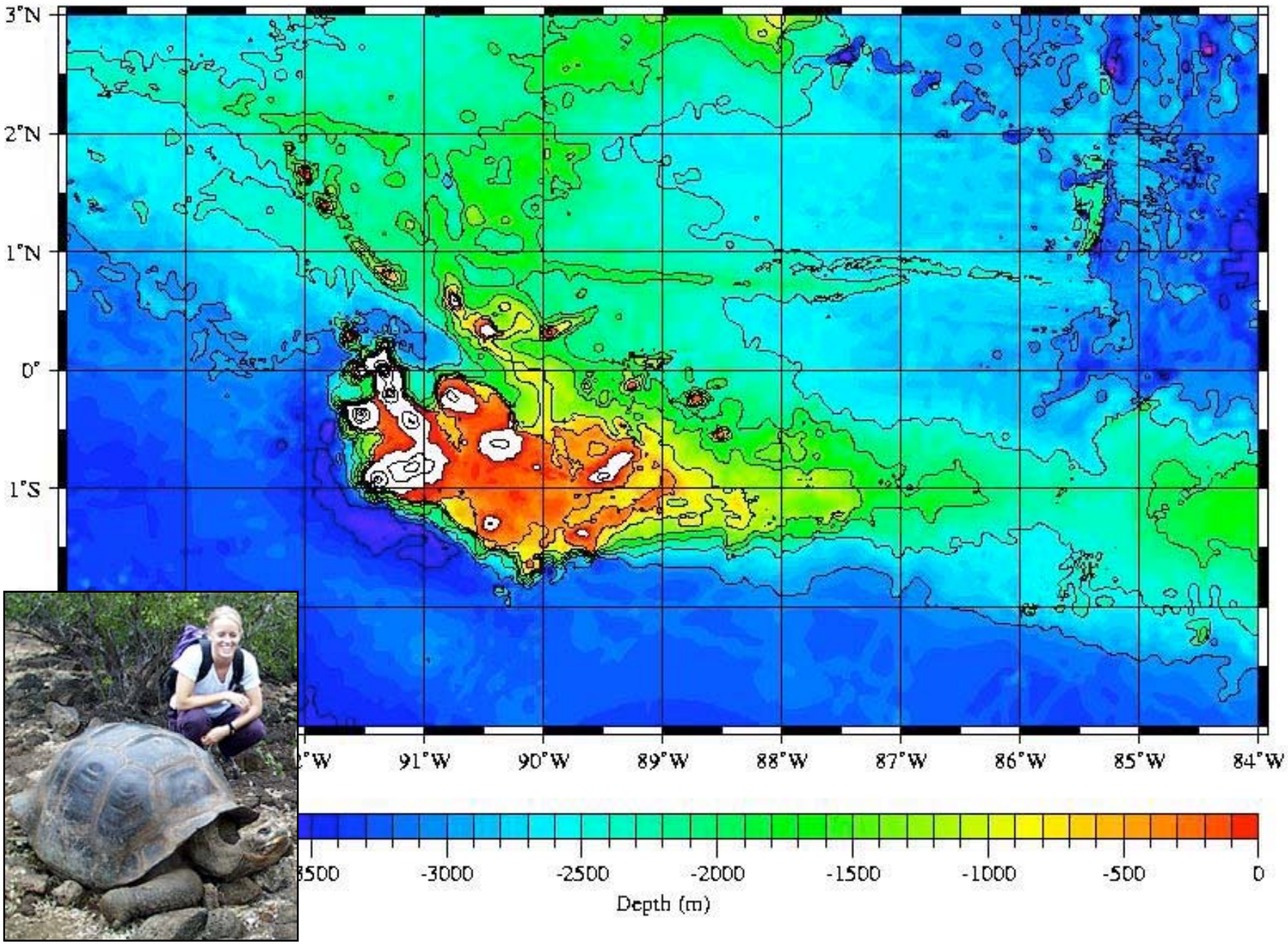

Zion

Stratigraphic Correlation



First Geologic Map




3°N
2°N
1°N
0°
1°S
91°W
90°W
89°W
88°W
87°W
86°W
85°W
84°W
-3000
-2500
-2000
-1500
-1000
-500
0
Depth (m)





Charles Darwin
(1809-1882)





Voyage of the HMS Beagle
(1831-1836)

Galápagos tortoise

Average age 150 years
Weights up to 660 pounds

















13 original subspecies
11 survive today



Harriet (1830-2006)

Collected by Darwin?

Lonesome George

Last Pinta Tortoise



Evolution & Natural Selection





"But with regard to the material world, we can at least go so far as this—we can perceive that events are brought about not by insulated interpositions of Divine power, exerted in each particular case, but by the establishment of general laws."

W. Whewell: *Bridgewater Treatise.*

"To conclude, therefore, let no man out of a weak conceit of sobriety, or an ill-applied moderation, think or maintain, that a man can search too far or be too well studied in the book of God's word, or in the book of God's works; divinity or philosophy; but rather let men endeavour an endless progress or proficience in both."

Bacon: *Advancement of Learning.*

Down, Bromley, Kent,
October 1st, 1859.

ON

THE ORIGIN OF SPECIES

BY MEANS OF NATURAL SELECTION,

OR THE

PRESERVATION OF FAVOURED RACES IN THE STRUGGLE FOR LIFE.

By CHARLES DARWIN, M.A.,

FELLOW OF THE ROYAL, GEOLOGICAL, LINNÆAN, ETC., SOCIETIES;
AUTHOR OF 'JOURNAL OF RESEARCHES DURING H. M. S. BEAGLE'S VOYAGE ROUND THE WORLD.'

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
1859.

The right of Translation is reserved.

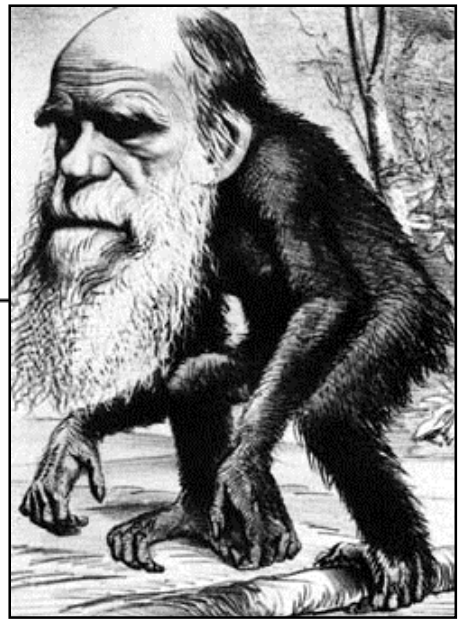




Do we share a common ancestry?







Pleistocene | Pliocene | Miocene

Split between human and chimpanzees using molecular clock, about 5 Ma

Sahelanthropus tchadensis

Genus Paranthropus

Age of bones found in Kenya, about 6 Ma

Orrorin tugenensis

P. robustus

P. boisei

P. aethiopicus

Genus Ardipithecus

Ar. kadabba

Ar. ramidus

A. anamensis

A. afarensis

A. bahrelghazali

A. africanus

A. garhi

Genus Australopithecus

H. habilis

H. floresiensis

H. georgicus

H. erectus

H. heidelbergensis

H. neanderthalensis

H. sapiens

Genus Homo

0 Years | 1e+06 | 2e+06 | 3e+06 | 4e+06 | 5e+06

What do evolution and natural selection imply about the passage of time?



Radioactivity:

Henri Becquerel (1896)
Marie & Pierre Curie (1898)



chalcolite



pitchblende







Marie Curie:

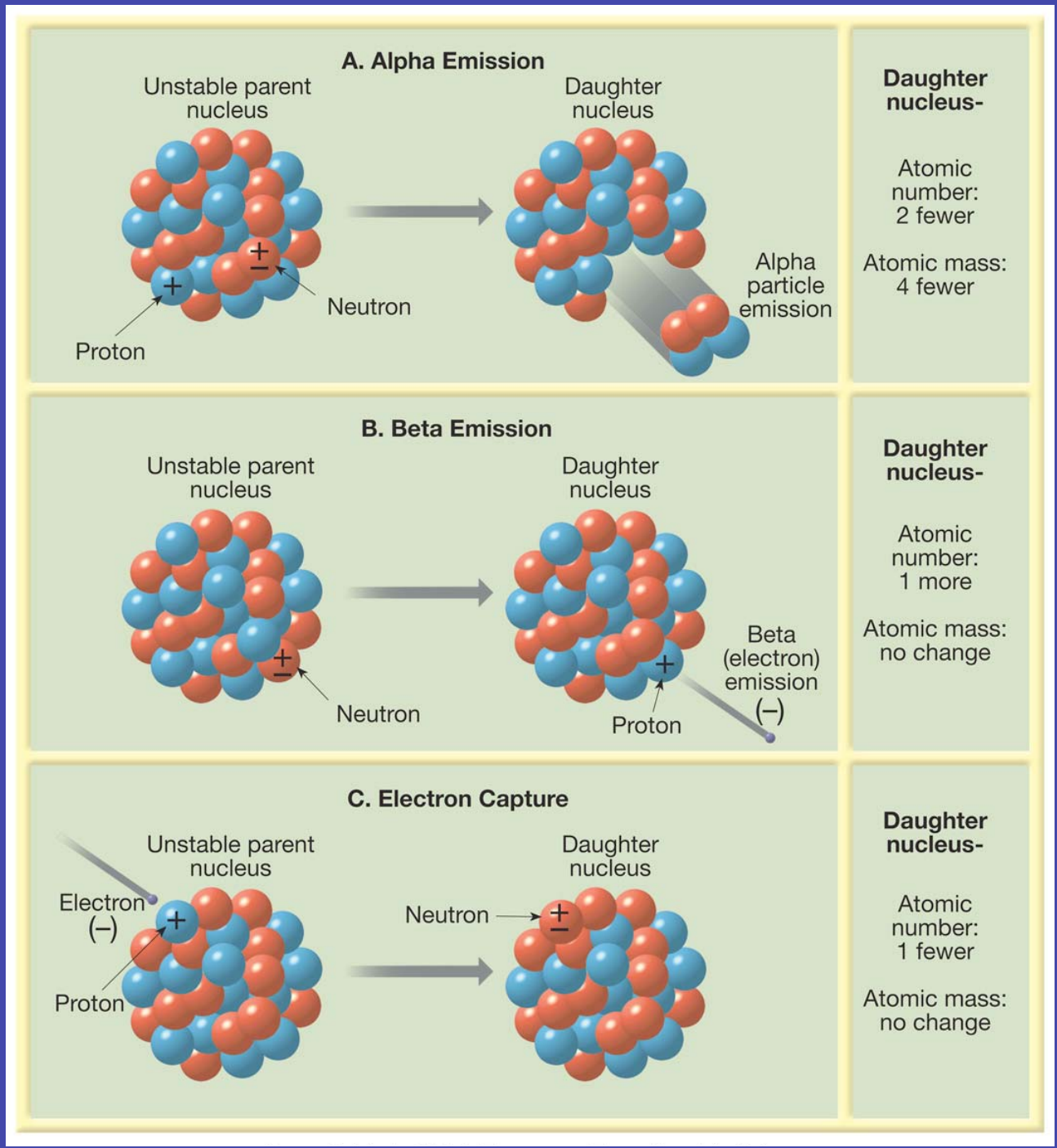
First in her undergraduate class at Sorbonne
First woman to receive a PhD in France
First woman to teach at Sorbonne
First woman to be awarded a Nobel Prize (1903)
First person/only woman to be awarded 2 Nobel Prizes (’03- Physics, ’11-Chemistry)
Died in 1934 from aplastic anemia (radiation)
Only woman buried under Panthéon in Paris
Eldest daughter, Irène Joliot-Curie, won a Nobel Prize for Chemistry in 1935

Isotope: same element, variable neutron number

Uranium isotopes:

	protons	neutrons
U-234	92	142
U-235	92	143
U-238	92	146





2 protons & 2 neutrons emitted

1 electron emitted

1 electron captured

Why do we care about radioactivity?

Why do we care?

1) Radioactivity produces HEAT energy
(i.e. not all of Earth's heat has to have come from the Sun)

2) Radioactive decay happens on a measurable timescale – this gives us a calendar for Earth materials

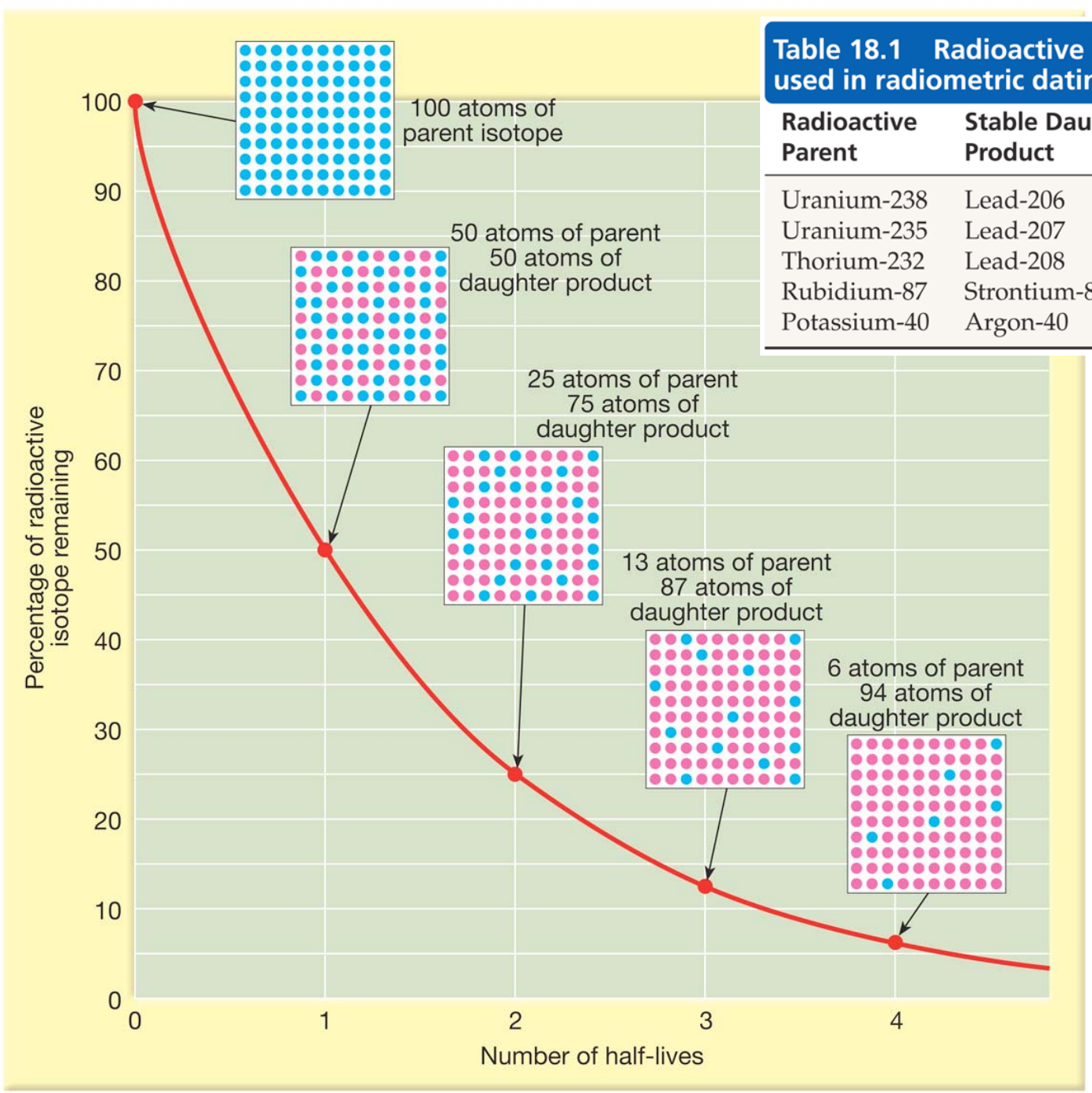
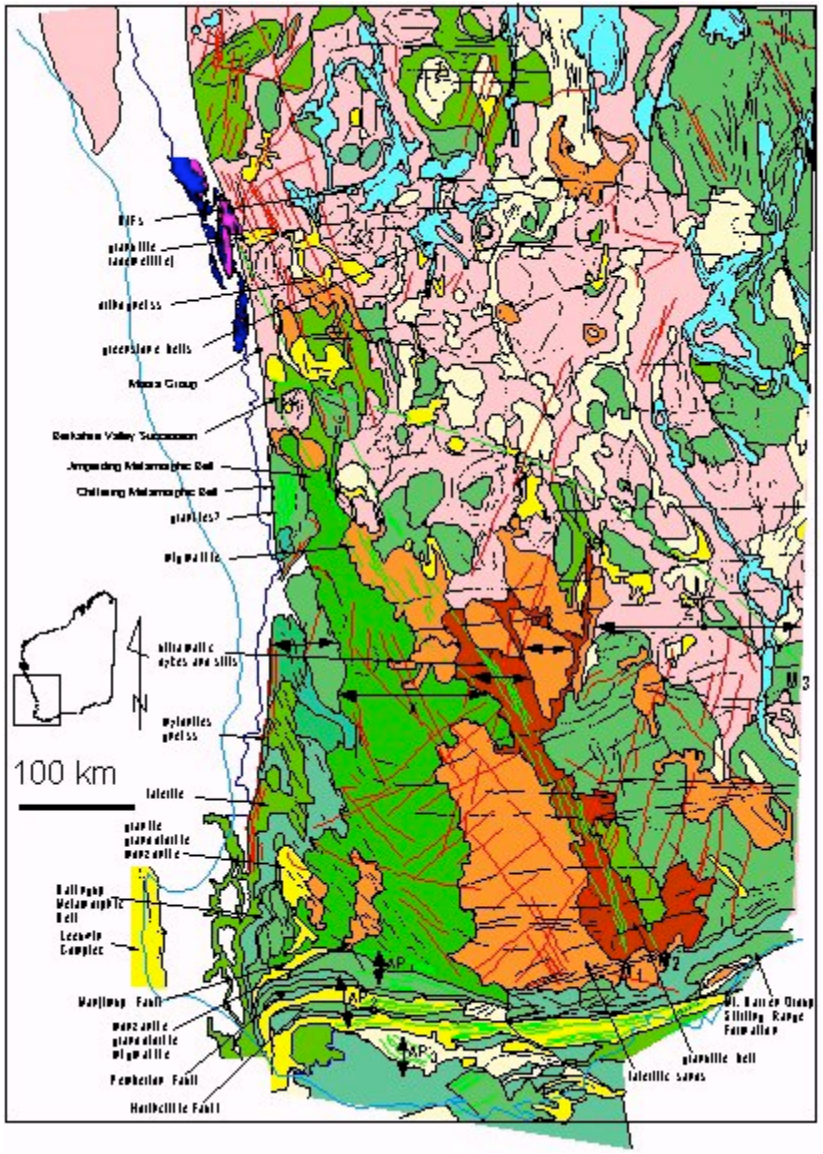


Table 18.1 Radioactive isotopes frequently used in radiometric dating.

Radioactive Parent	Stable Daughter Product	Currently Accepted Half-life Values
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
Potassium-40	Argon-40	1.3 billion years

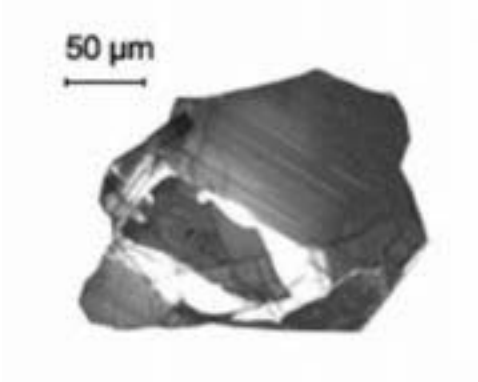
parent/ daughter ratio yields:

AGE

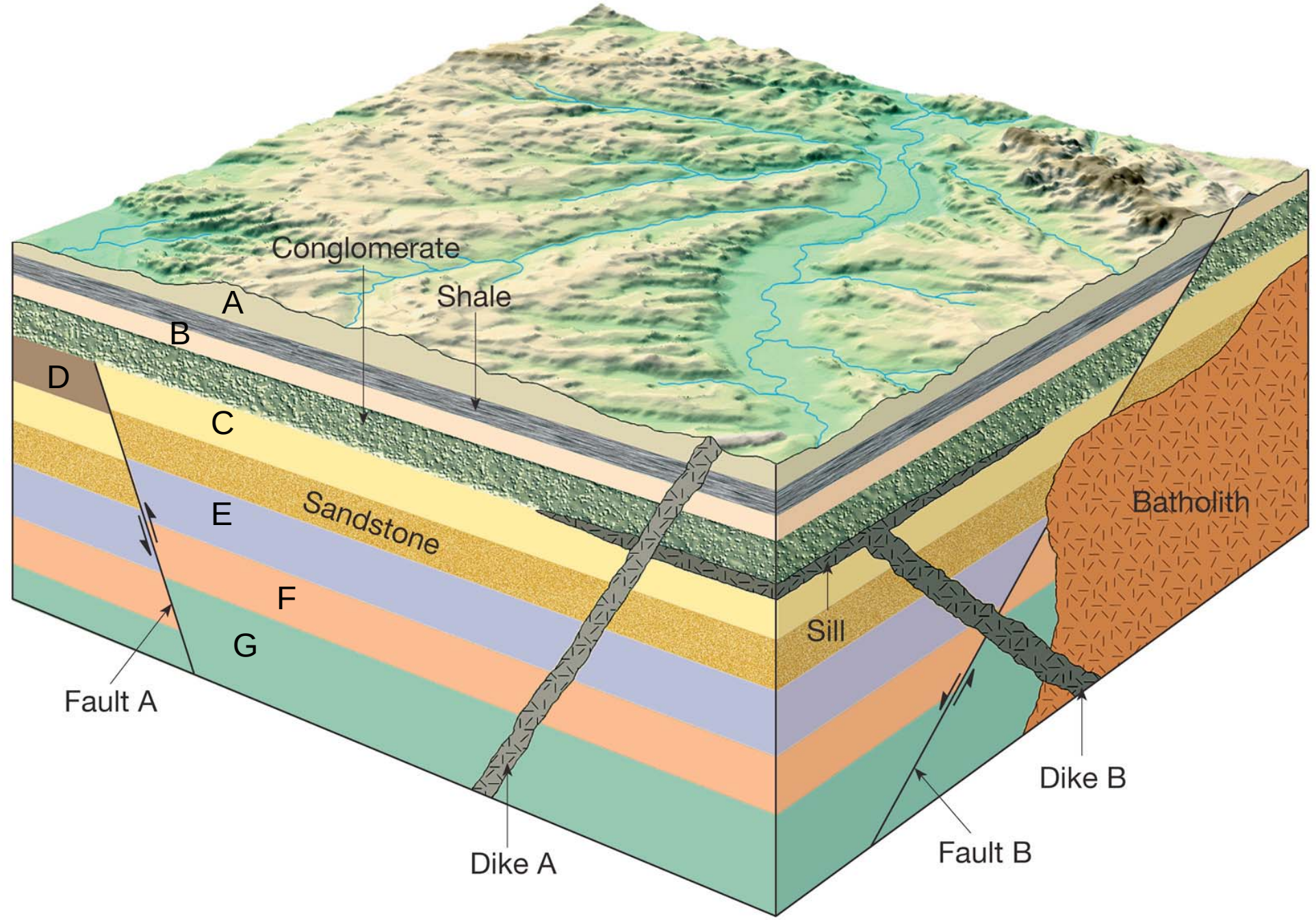




Oldest rock on Earth
4.404 Bya



Jack Hills, Western Australia


Conglomerate
Shale
A
B
D
C
E
Sandstone
F
G
Fault A
Dike A
Sill
Batholith
Dike B
Fault B