

An Introduction to Geology: 2



How old is...?



...a human?
...a fossil?
...a pebble?
...a mountain?
...the Earth?

The Dating Game

Relative time
versus
Absolute time

Extreme relative dating!

James Ussher
(1581-1656)

Biblical chronology

= Sunday 23rd
October 4004 BC



Stratigraphy

The law of superposition



Chronostratigraphy

Layers of Time

Lithostratigraphy = rock layers

Biostratigraphy = fossil layers

Chemostratigraphy = chemical layers

Magnetostratigraphy = magnetic layers

The stratigrapher

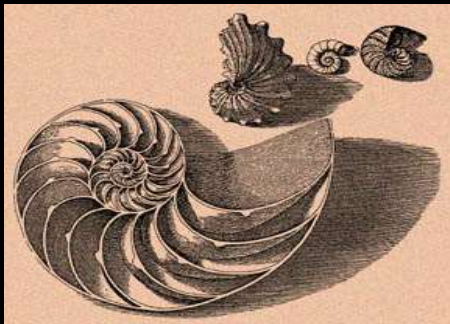
Niels Stensen
'Steno' (1638-86)

1. Superposition
2. Horizontality
3. Lateral continuity



The chrono-stratigrapher

Robert Hooke
(1635-1703)



“And tho’ it must be granted that it is very difficult to read [the rocks], and to raise a Chronology out of them, and to state the intervals of the Times wherein such or such Catastrophies and Mutations have happened; yet, tis not impossible”

The bio-stratigrapher

William Smith

Canal surveyor

The Law of Faunal
Succession



Using Fossils To Tell The Time

William Smith's
nephew
(1840-41)

Palaeozoic – 'old life'
Mesozoic – 'middle life'
Cainozoic – 'new life'



Life Time



Life-time

PALAEOZOIC:

Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian

MESOZOIC:

Triassic
Jurassic
Cretaceous

CAINOZOIC

Palaeogene
Neogene
Quaternary

The youngest
is the oldest

Giovanni Arduino
(1759):

Quaternary

Tertiary

Secondary

Primitive



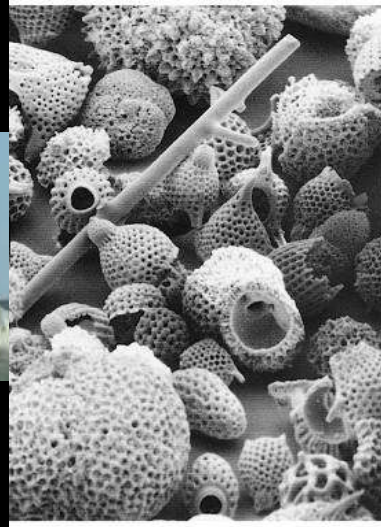
Carboniferous (1822)

“Coal-bearing”



Cretaceous (1822)

“Chalk-bearing”



Jurassic (1829)



Jura Mountains



Silurian (1833)



Silures



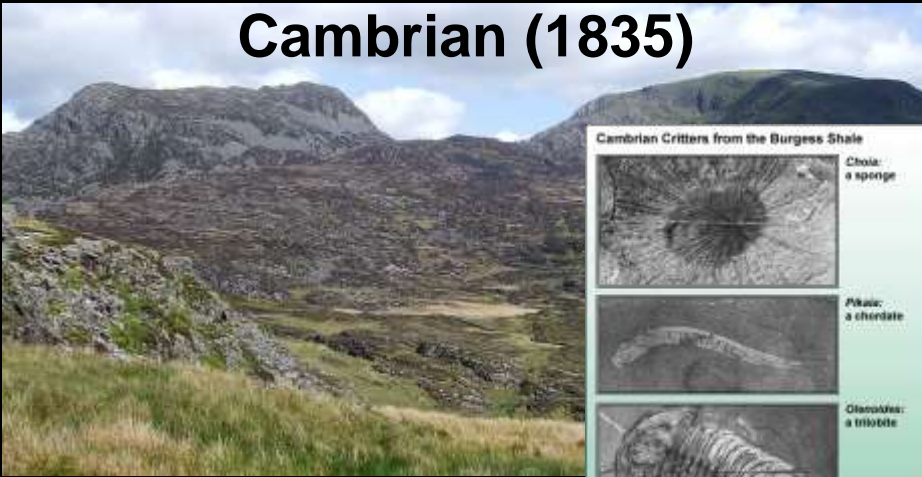
Triassic (1834)



A German triad:
Red sandstones
White limestones
Black shales

Friedrich von Alberti

Cambrian (1835)



Cymru

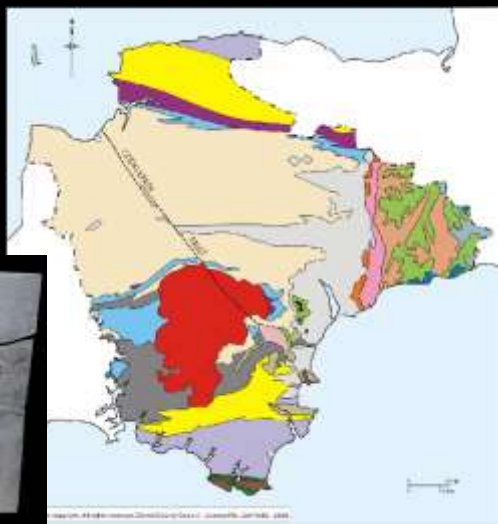
Cambrian Critters from the Burgess Shale

- Choia:** a sponge
- Pikaia:** a chordate
- Olanella:** a trilobite
- Ayscha:** a velvet worm

Four fossil specimens are shown in a vertical column. From top to bottom: a circular sponge-like organism (Choia), a small worm-like organism (Pikaia), a segmented trilobite (Olanella), and a segmented worm-like organism (Ayscha).

Devonian (1839)

Devon



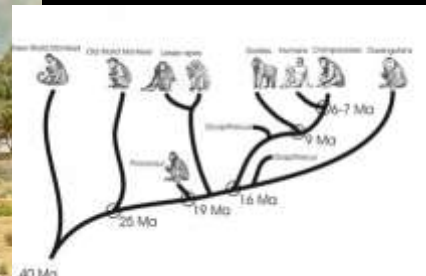
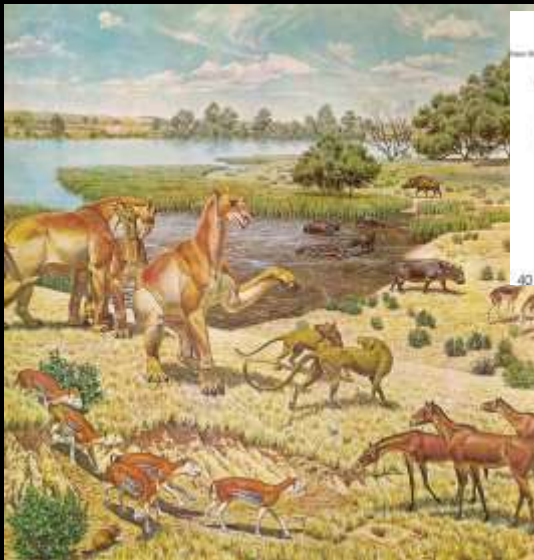
Permian (1841)



A Molotov rock tale



Neogene (1859)



“new born”
(modern animals)

Palaeogene (1866)



“old born”

Appearance of
mammals

Darwinius masillae –
early primate

Ordovician (1879)



Charles Lapworth &
the Ordovices

The oldest is the youngest

Ediacaran (2006)



Giving us:

The
Geological
Column



Geological Periods Mnemonic...

Ediacaran	Eating
Cambrian	Crisps
Ordovician	On
Silurian	Sundays
Devonian	Doubles
Carboniferous	Calorie
Permian	Points

...continued

Triassic	Thus
Jurassic	Jogging
Cretaceous	Can
Palaeogene	Prove
Neogene	Notably
Quaternary	Queasy

Make Your Own Mnemonic

Fabulous* prizes for the best ones

*Probably fossils

The Dating Game

Relative
versus
Absolute

Problems of relative dating



The absolute challenge

Q. How can we determine how old rocks are?



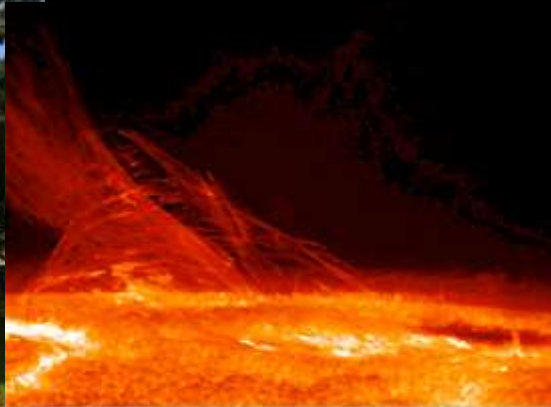
Sedimentation rates?

Phillips (1860) = 38-96 million years old



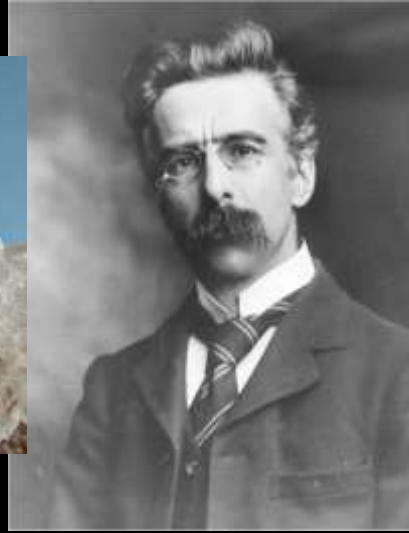
By heat loss?

Kelvin (1862-1897) = 20-40 million years old



By ocean saltiness?

Joly (1897-99) = 80-100 million years old



A. By radioactivity!

84 natural elements

339 isotopes

70 radioactive
isotopes

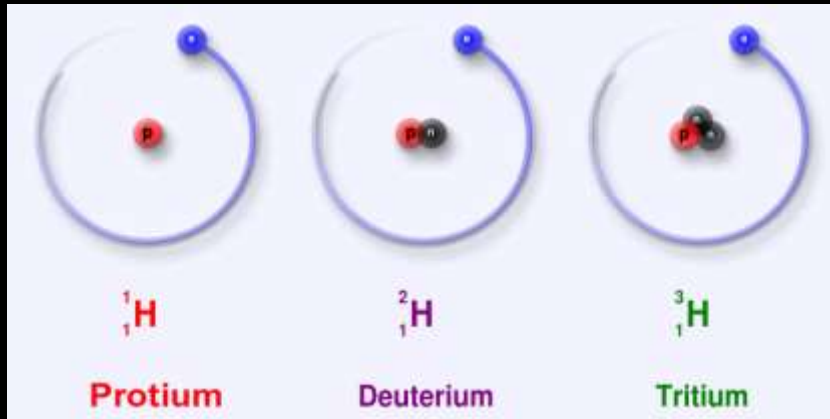
18 with long half
lives



Pierre & Marie Curie

Isotopes

Atoms of a chemical element can have different numbers of neutrons



Isotopes of hydrogen



Ernest Rutherford

Half-lives

Nuclei of radioactive atoms decay

Parents and daughters:

C-14 decays to N-14

K-40 decays to Ar-40

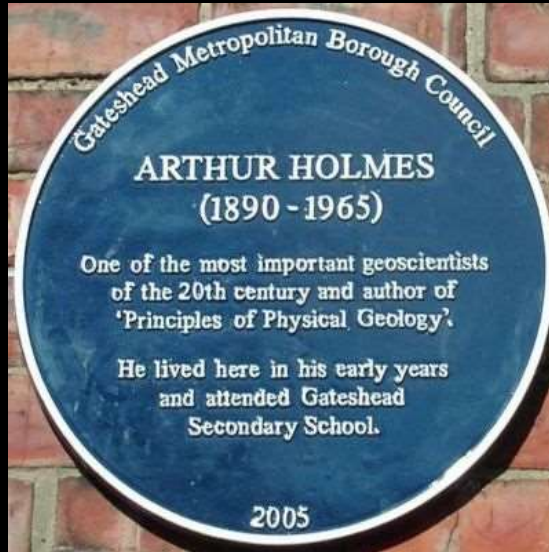
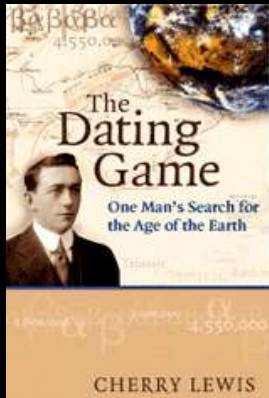
U-238 to Pb-206 (via a decay chain)

Constant decay rate:

Half-life = time to get 50:50 parent:daughter

Holmes: radioactive rock detective

Earth is billions
of years old



Combined chronology

ABSOLUTE

Radiometric analysis only possible for igneous (and some metamorphic) minerals

Expensive, difficult, slow

RELATIVE

Fossils widespread, common, cheap and fast to analyse

Next week: igneous rocks

