Rocks and Rain

A Geomorphology of the British Isles
Part 1 of 2

How on Earth did that happen?

We are all used to seeing beautiful landscapes in picture postcards but did you ever ask yourself how these landscapes came to be?

It’s quite simple!

Landscape

Geomorphic processes

Environmental factors

How Old?

Until modern times (1860s) it was thought that the Earth was around 6,000 years old. This was based on studies of the Bible by James Ussher in the 17th century.

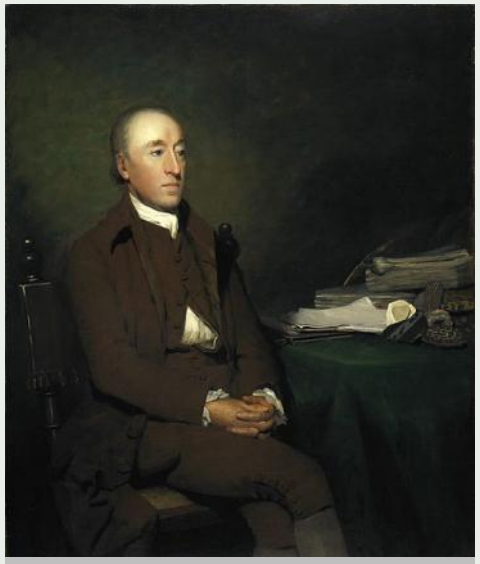
More recently, radiometric age dating of meteorites has determined that the age of the Earth is around...

4,600 million years

Wikipedia: James Ussher

How Long is 4.6 Billion Years?

- It's unimaginably long…
- In fact, it's so long that up until 200 years ago, no one believed the Earth could be so old.
- In 1785, **James Hutton** developed the theory of **Deep Time** after looking at ancient rocks and considering the speed of contemporary natural processes of erosion and deposition.
- This, in turn led to his theory of **Uniformitarianism**, which states that the processes we see on the Earth today are the same as those acting upon the Earth in the distant past.
- The theory was popularised by **Charles Lyell** in his *Principles of Geology* of 1830.

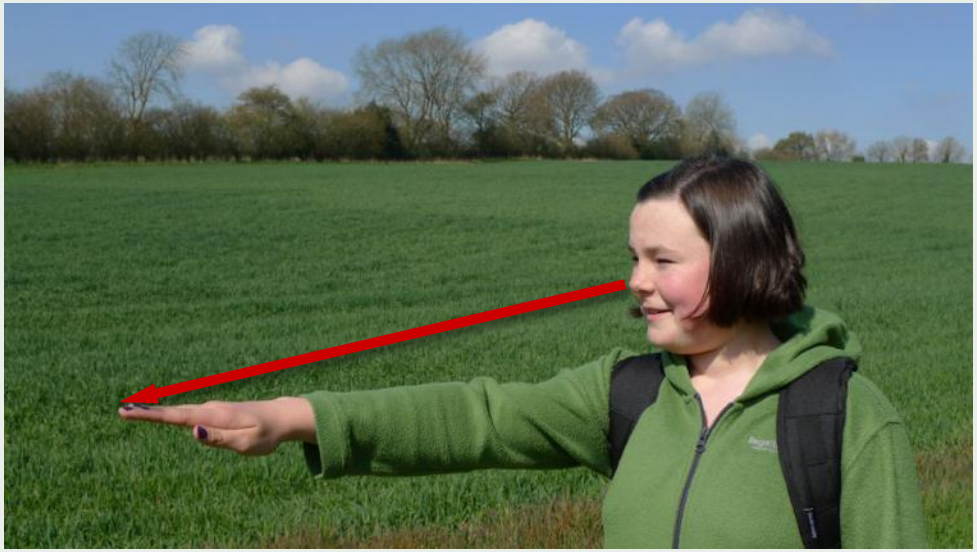


James Hutton 1726-1797

Wikipedia: James Hutton, Deep Time, Uniformitarianism, Charles Lyell

Deep Time

- Such enormous spans of geological time are difficult for us to comprehend – our own lives are measured in decades.
- In his book, *Basin and Range* (1981), John McPhee used the following analogy to explain the enormity of geological time…
- We are going to use a slightly different analogy, based on an idea from Ian Vince's book *The Lie of the Land* (2011)…



…if the history of the Earth is the distance from the tip of your nose to the tip of your outstretched fingers, the whole of human history would be erased by a single stroke of a nail file.

Time Travel

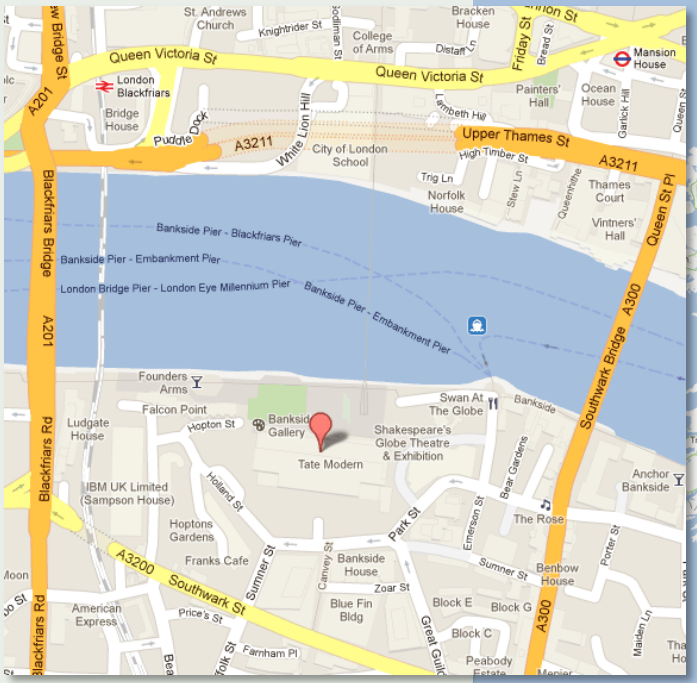
The oldest rocks on the British mainland are the [Lewisian Gneises](#) at Cape Wrath. They are around 3 Billion years old and are *Metamorphic* rocks.

Time Travel

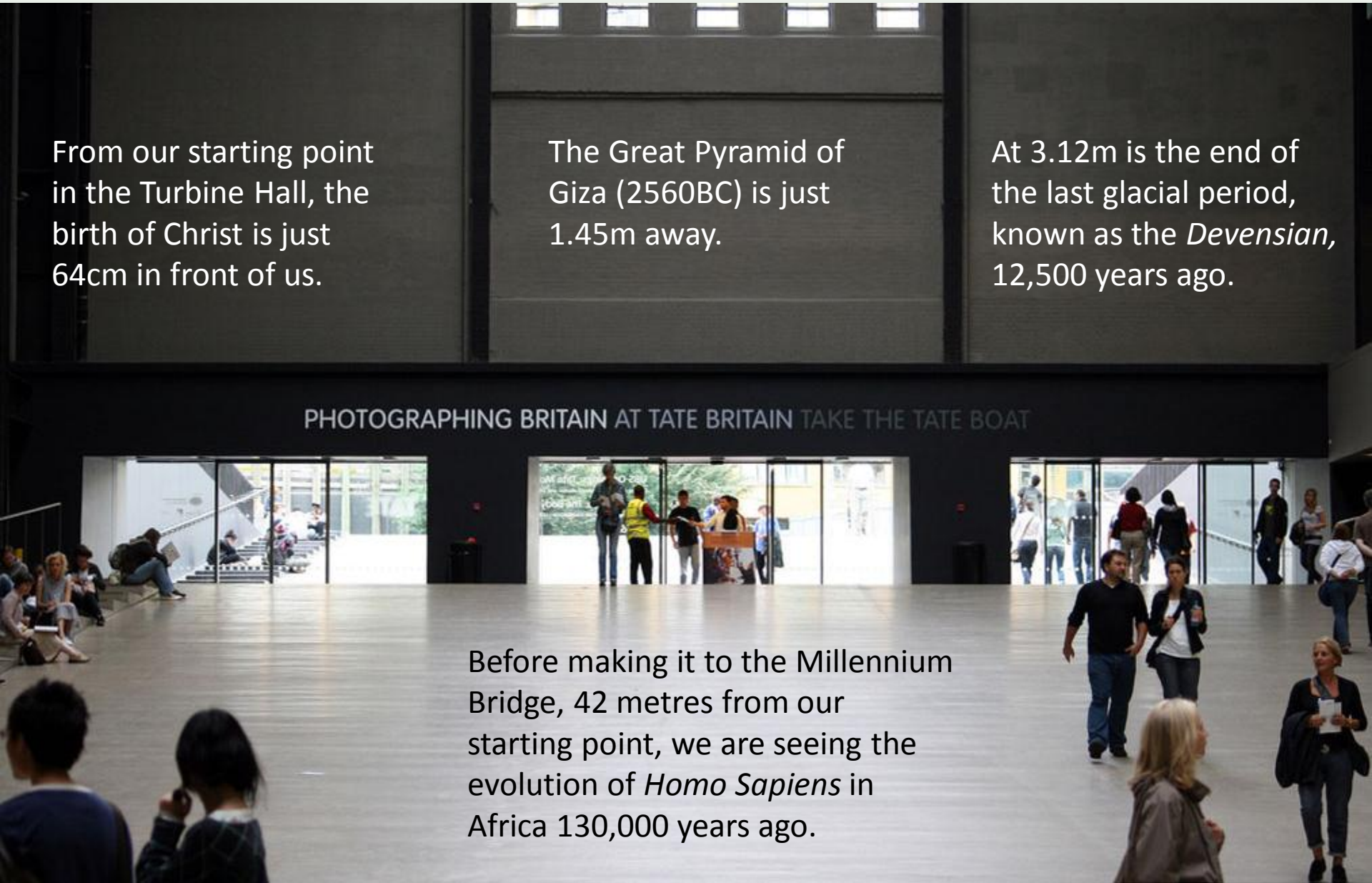
The youngest “rocks” are the sands and clays of the London Basin, which are around 50 million years old. They are mostly overlain with younger “drift” material.

Time Travel

If we were to make a journey of 3 billion years from London to Cape Wrath, we might begin at the Tate Modern.



Time Travel



From our starting point in the Turbine Hall, the birth of Christ is just 64cm in front of us.

The Great Pyramid of Giza (2560BC) is just 1.45m away.

At 3.12m is the end of the last glacial period, known as the *Devensian,* 12,500 years ago.

Before making it to the Millennium Bridge, 42 metres from our starting point, we are seeing the evolution of *Homo Sapiens* in Africa 130,000 years ago.

Time Travel

13 miles into our journey, we hit the M25 at Potters Bar and the end of the age of the dinosaurs at 65Ma, a geological period known as the *Cretaceous*.

An artists impression of the M25

Wikipedia: [Cretaceous]

13 miles

Time Travel

At only 100 miles from our start point, we are at the very beginning of multicellular life on Earth, the Cambrian/Precambrian boundary.

Fossil Trilobites, 540Ma

Wikipedia: [Trilobites]

At **Derby**, roughly 540 million years ago, is the earliest fossil record of *Trilobites*.

Milton Keynes where the earliest dinosaurs evolved 230 Ma

Luton, where flowering plants evolved between 140 and 130 Ma

Time Travel

Our journey back to Britain's oldest rocks is 3 billion years, shown by A and B on the map but the history of Earth goes back another 1.6 billion years, C on the map. Each of these periods of time can be characterised as follows:

A = we know a fair bit about what happened because there are lots of fossils.

B = we know very little about what happened because there are no fossils.

C = we know nothing.

Geological Time

The part of geological history that we have enough evidence to allow for an accurate chronology accounts for only 10% of the history of the Earth.
The *Phanerozoic* eon is divided into eras and each era into periods.
The relative order of rocks has been determined with reference to the evolution of fossil organisms (visible life) and this gives rise to the *Litho-Stratigraphic column*. During the *Cryptozoic* there is very little evidence of life (hidden life), making relative dating of rocks almost impossible.

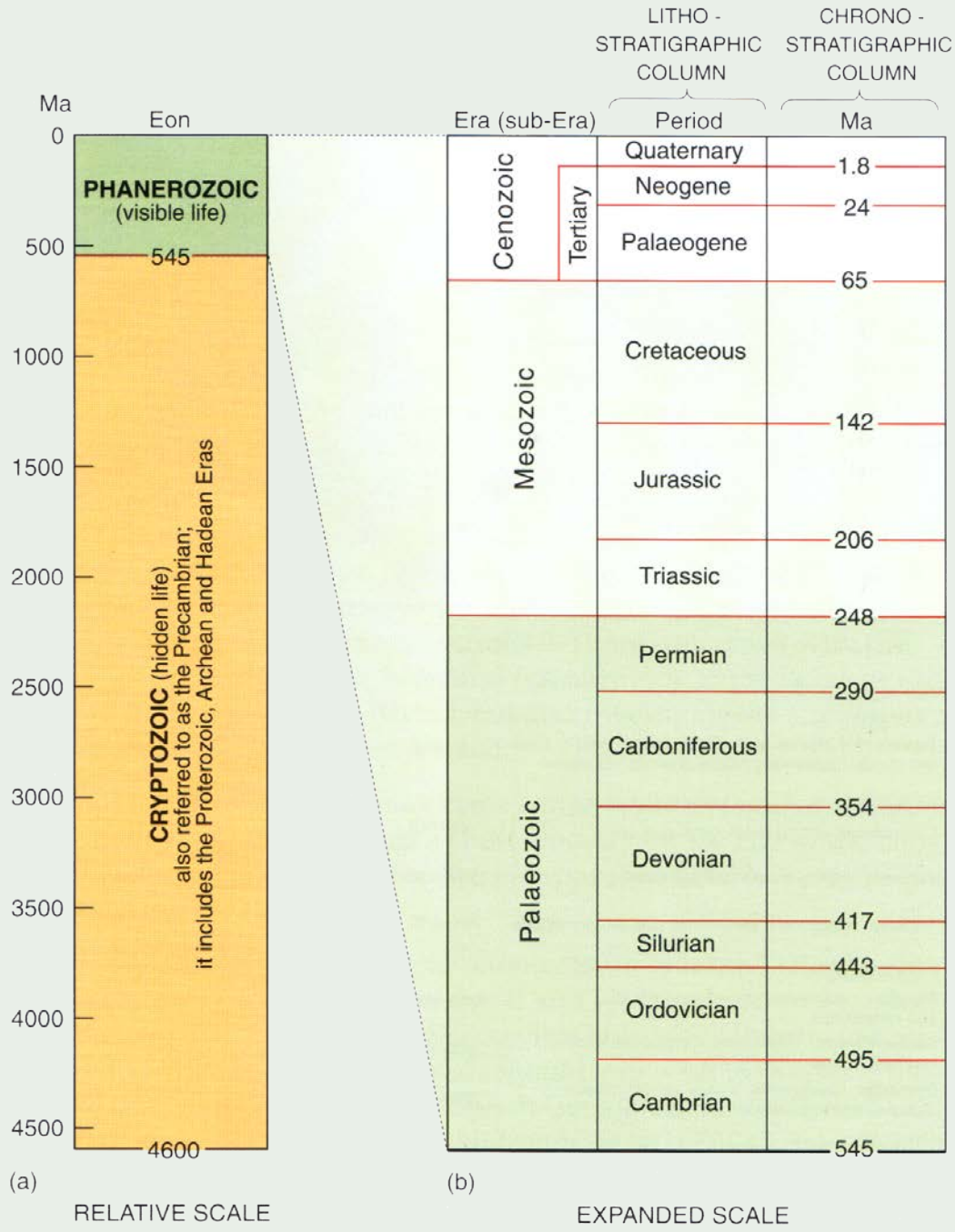


Illustration from the book *The Geological History of the British Isles* by Arlëne Hunter & Glynda Easterbrook

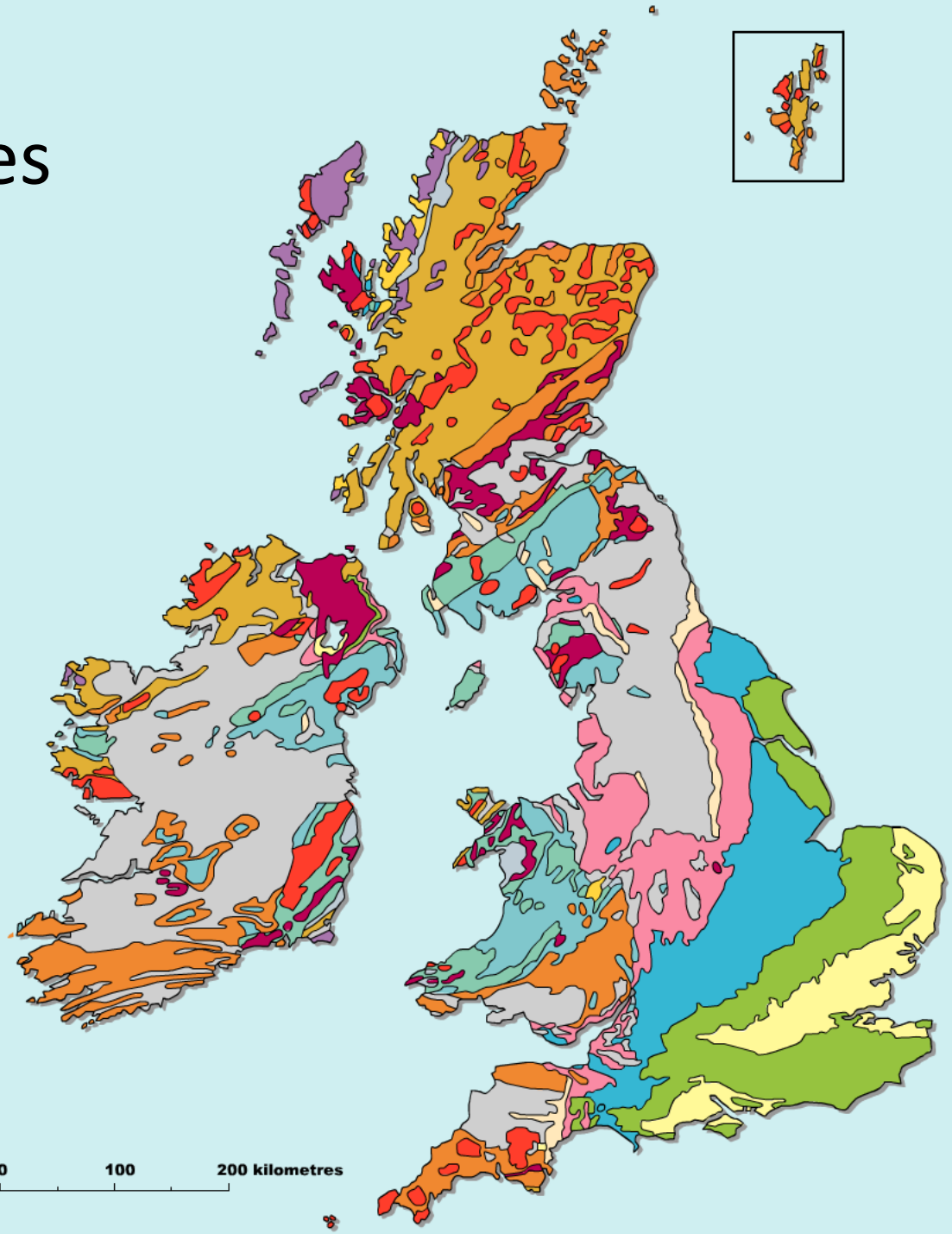
The Classification of Rocks

- Rocks are divided into 3 broad groups:
- **Igneous** rocks are formed from the cooling of magma or lava (intrusive or volcanic molten rock). Examples include, Granite (intrusive) and Basalt (volcanic)
- **Sedimentary** rocks are those formed by the deposition of sediments, often characterised by layers or *strata*. Examples include, Sandstone, Limestone and Chalk.
- **Metamorphic** rocks are igneous or sedimentary rocks that have been altered by heat or by pressure. Examples include, Slate and Gneiss.
- All 3 rock types exist in Britain and are used as materials by landscape architects, although much is now imported.

Wikipedia: Igneous, Sedimentary, Metamorphic

Geology of the British Isles

Rocks are classified by their type and their age. This map shows the distribution of the broad rock types in the UK. Each colour represents a different geological period, except for igneous rocks, which are shown in scarlet. The first geological map was created by **William Smith** in 1801.



How did this happen?

The story of how the landscape of Britain came to look the way it looks today can only be told with reference to two global and universal processes:

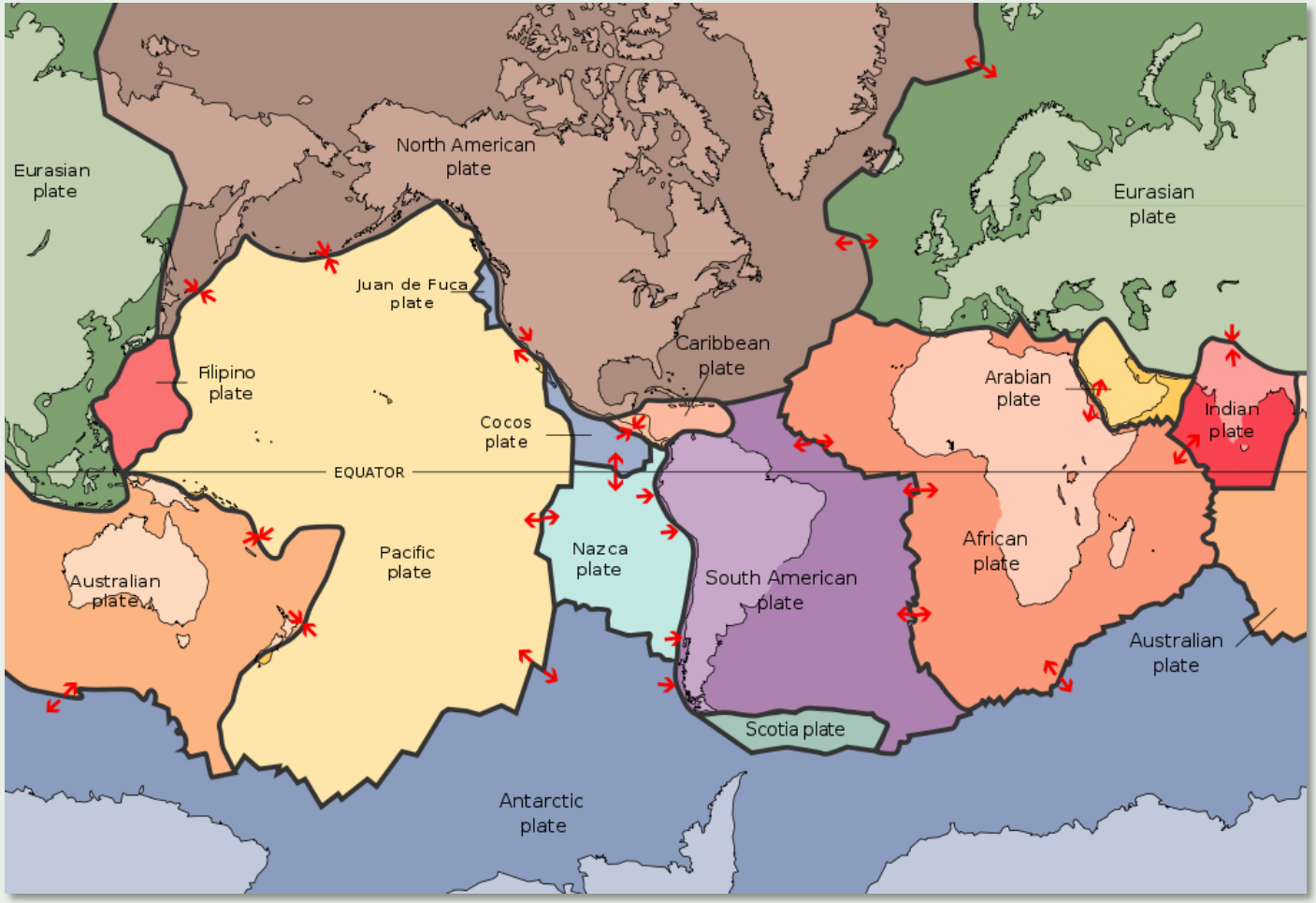
1. **Plate Tectonics**
2. **Uplift, Erosion and Deposition**

Although the cycle of uplift, erosion and deposition has been understood for 200 years, the acceptance of plate tectonics is less than 50 years old.

Stair Hole at Lulworth Cove in Dorset is one of the best examples of folded limestone strata in Britain.

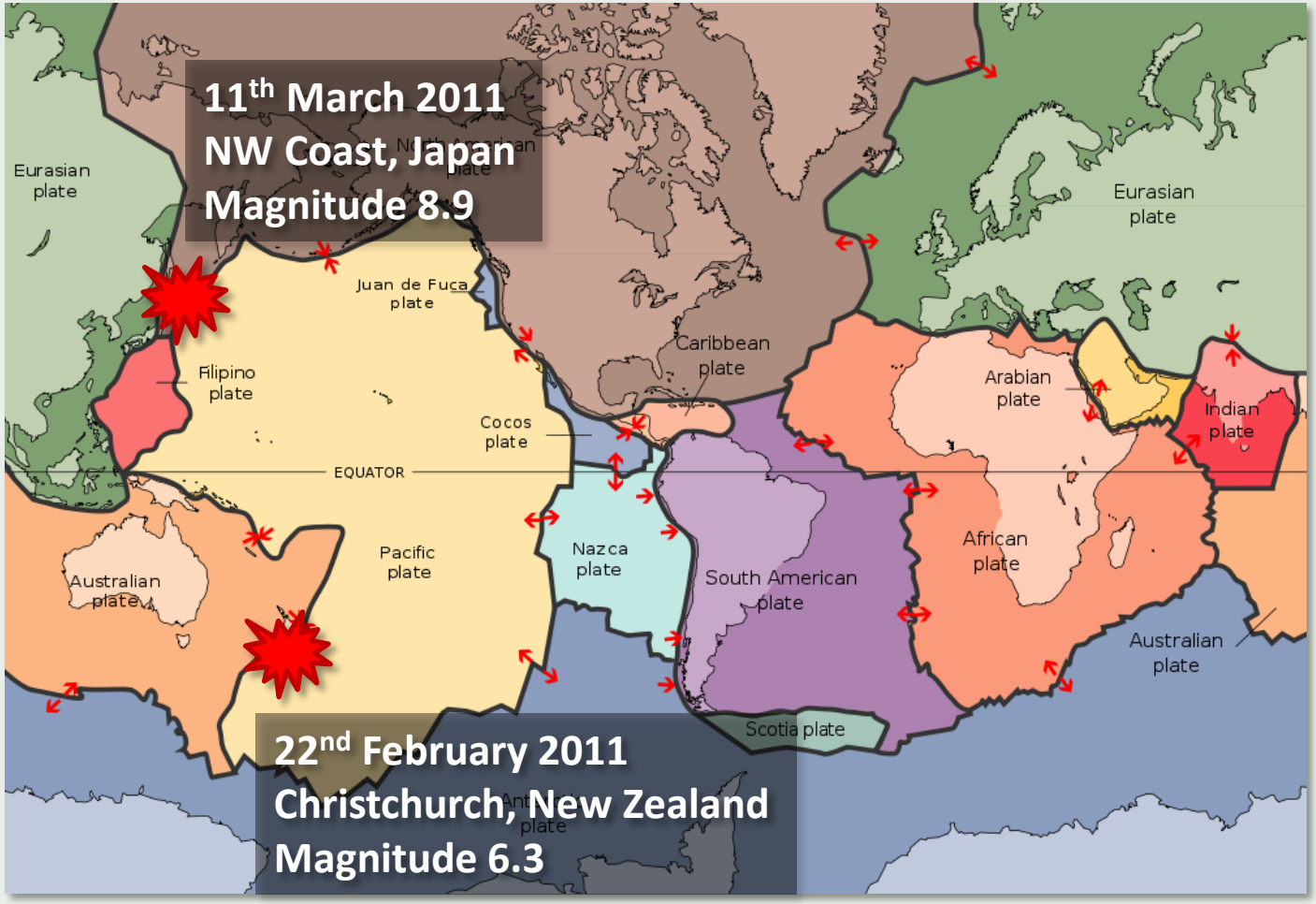
Wikipedia: Stair Hole

Plate Tectonics



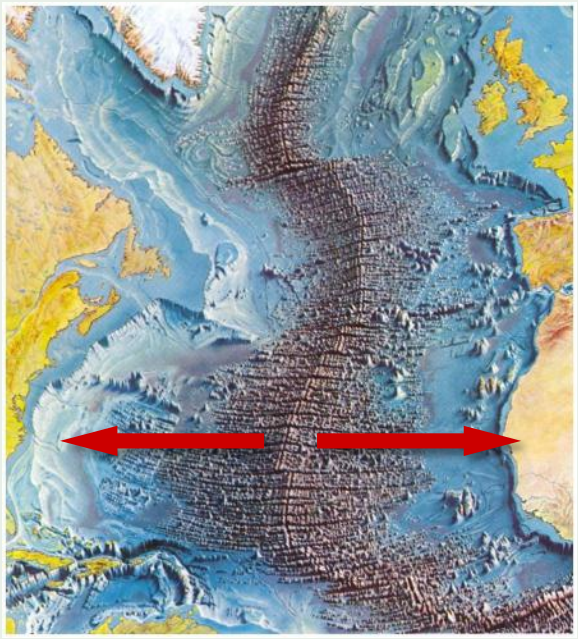
Wikipedia: [Plate Tectonics]

Plate Tectonics

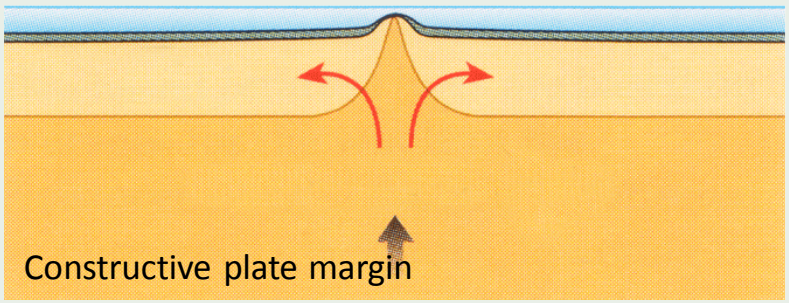


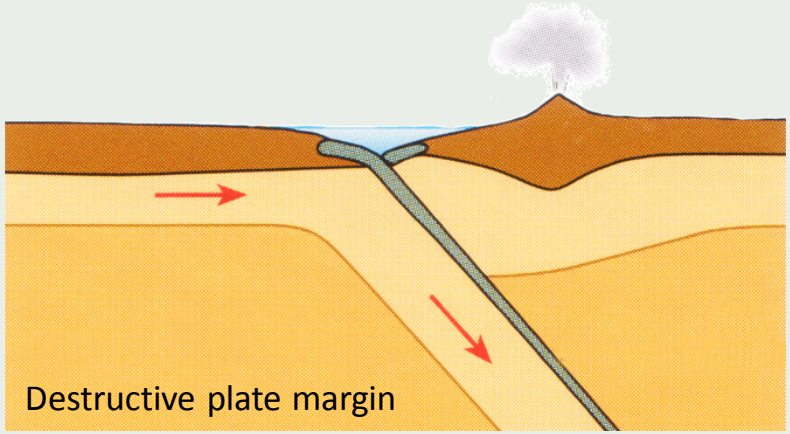
BBC: [History of Deadly Earthquakes]

Seafloor Spreading



Convection within the Earth creates mid-ocean ridges as volcanic material is added to the crust. Plates move apart as the ridge widens. The Atlantic ridge is moving apart at a rate of 8cm per year. Mid-ocean ridges are constructive plate margins where plates are moving apart. Destructive plate margins form where plates collide, causing earthquakes and volcanic activity.

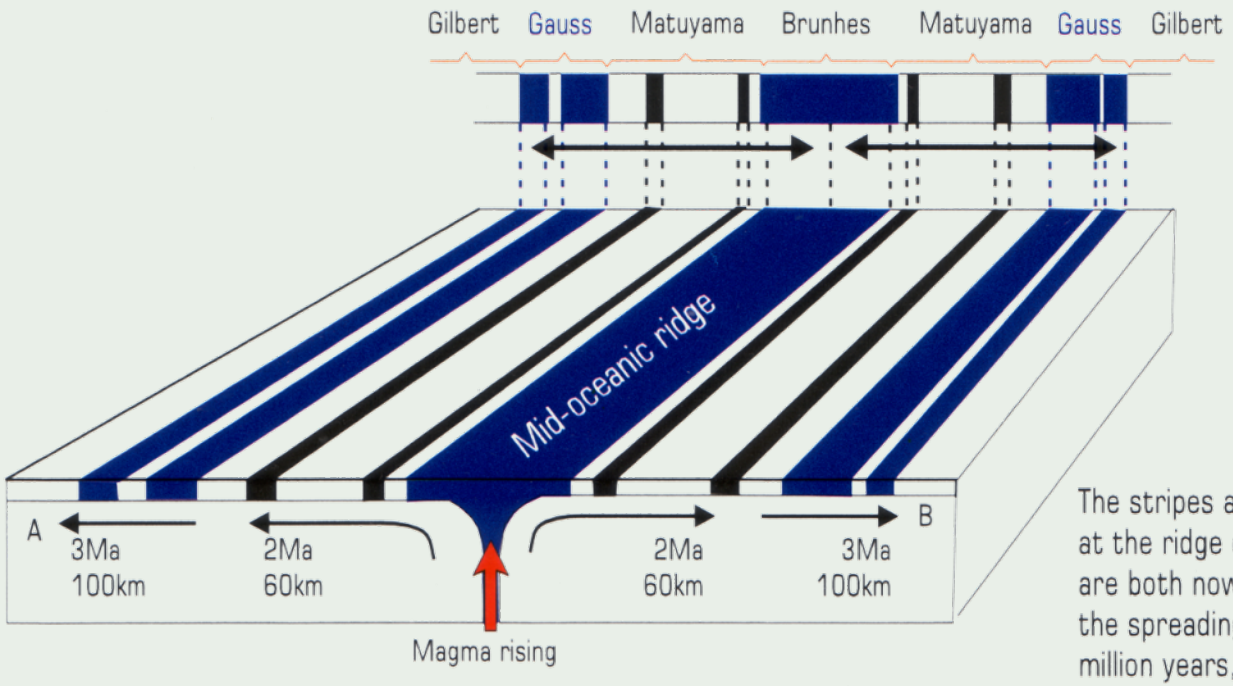




Wikipedia: Seafloor Spreading

Earth, the power of the planet (BBC): Plate Tectonics

Geomagnetic Reversal



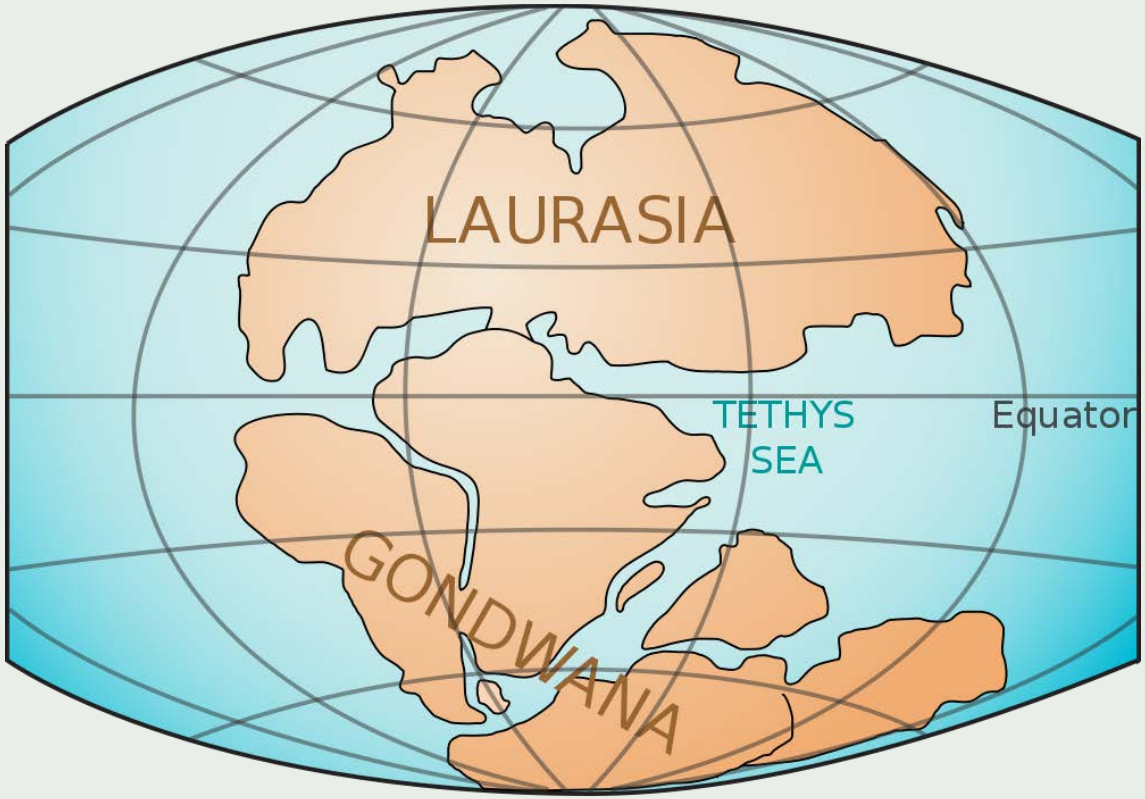
The stripes at localities A & B were both produced at the ridge crest three million years ago. As they are both now 100 km away from the ridge crest the spreading rate has been 100 km in three million years, or 3 cm/yr

When studying the rocks formed at mid-ocean ridges, geologists noticed that some of them had formed with reversed polarity. A pattern emerged of a mirror image of normal and reversed polarity stripes either side of the ridge. It is now known that the Earth's polarity has changed a number of times in the past. The last reversal , known as the *Brunhes-Matuyama* reversal took place about 780,000 years ago.

Wikipedia: Geomagnetic Reversal

Illustration from the book *The Geology of Britain: An Introduction* by Peter Toghill

Ancient Continents



TRIASSIC
200 million years ago

YouTube: [Earths history in the last 600 million years]

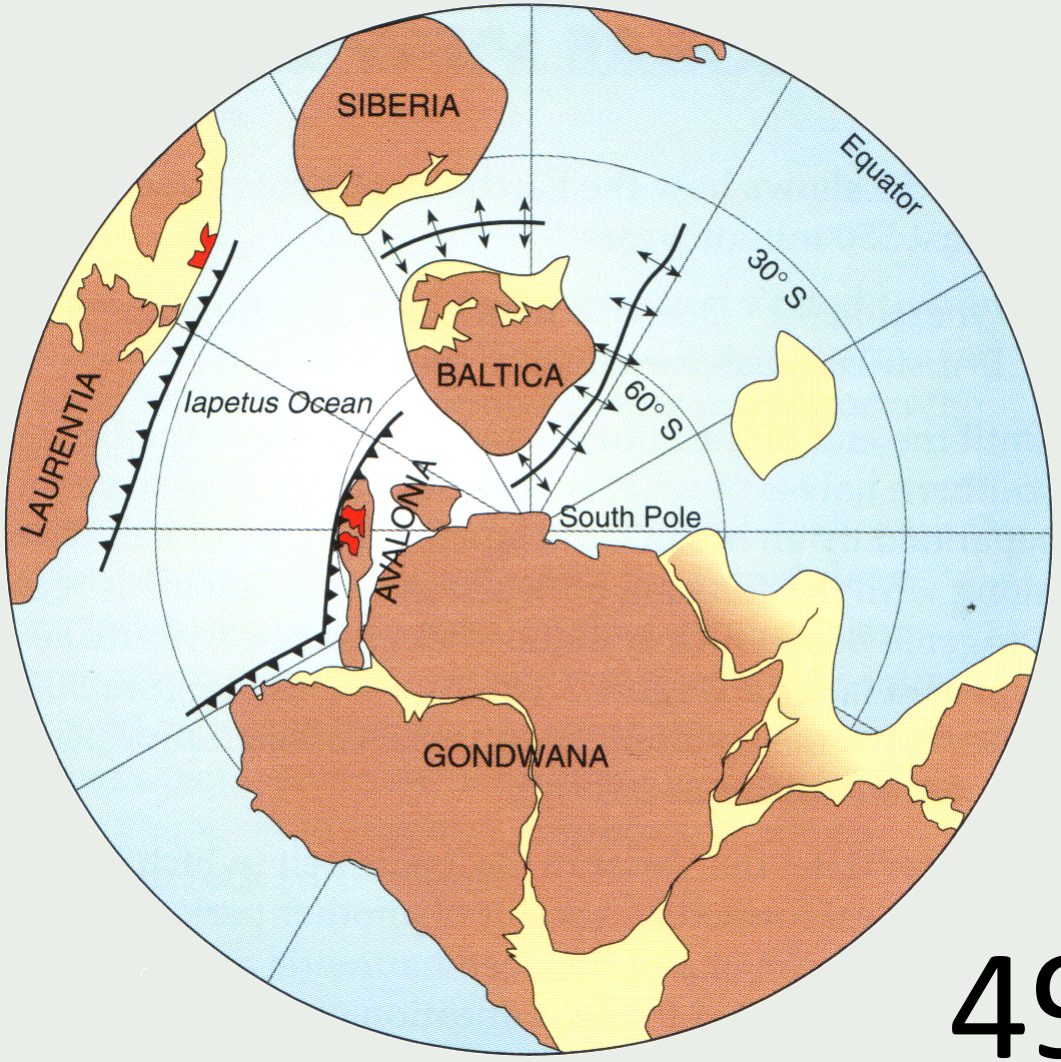
Drift across the Globe

550 Ma

Late Proterozoic (Precambrian)

Illustration from the book *The Geological History of the British Isles* by Arlëne Hunter & Glynda Easterbrook

Drift across the Globe

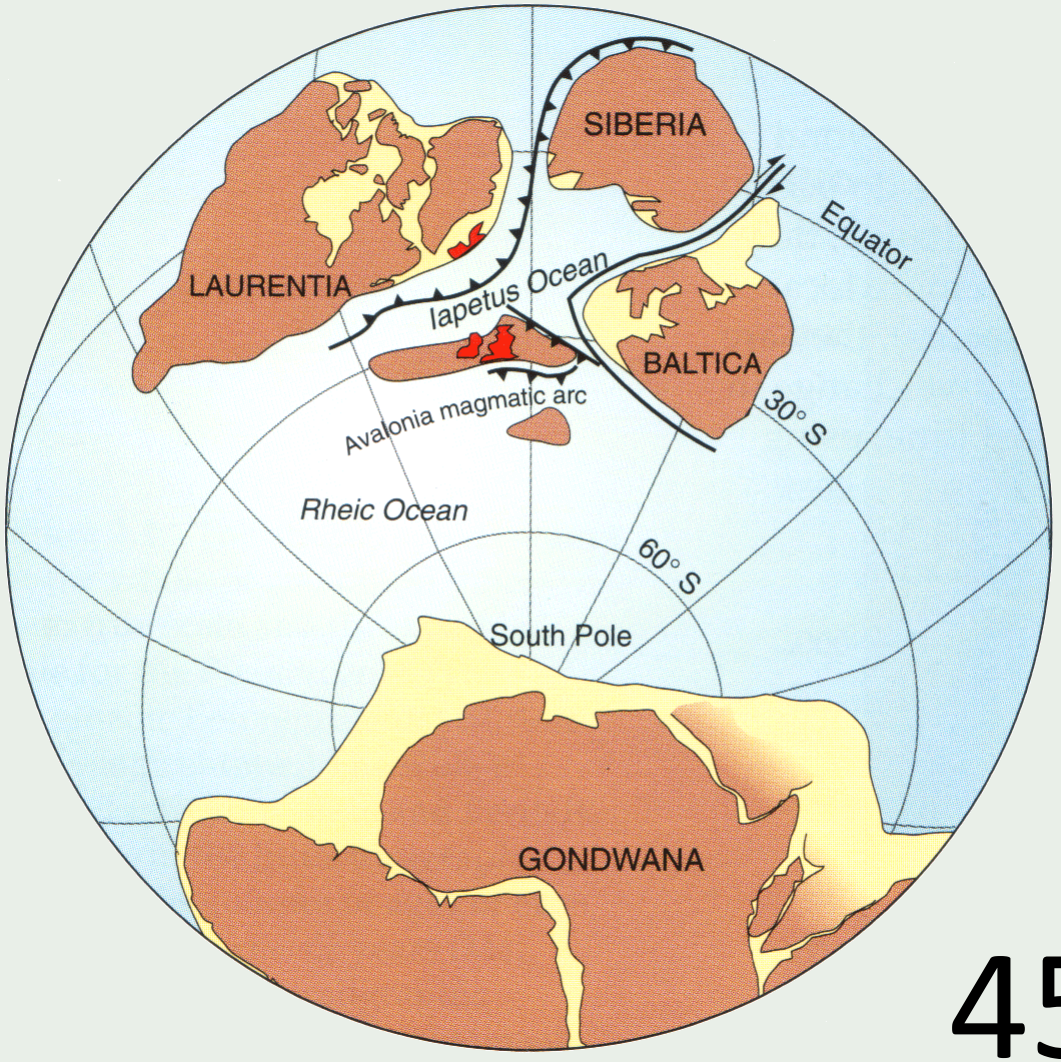


490 Ma

Early Ordovician

Illustration from the book *The Geological History of the British Isles*
by Arlëne Hunter & Glynda Easterbrook

Drift across the Globe



450 Ma

Late Ordovician – Early Silurian

Illustration from the book *The Geological History of the British Isles* by Arlëne Hunter & Glynda Easterbrook

Drift across the Globe

375 Ma

Mid Devonian

Illustration from the book *The Geological History of the British Isles*
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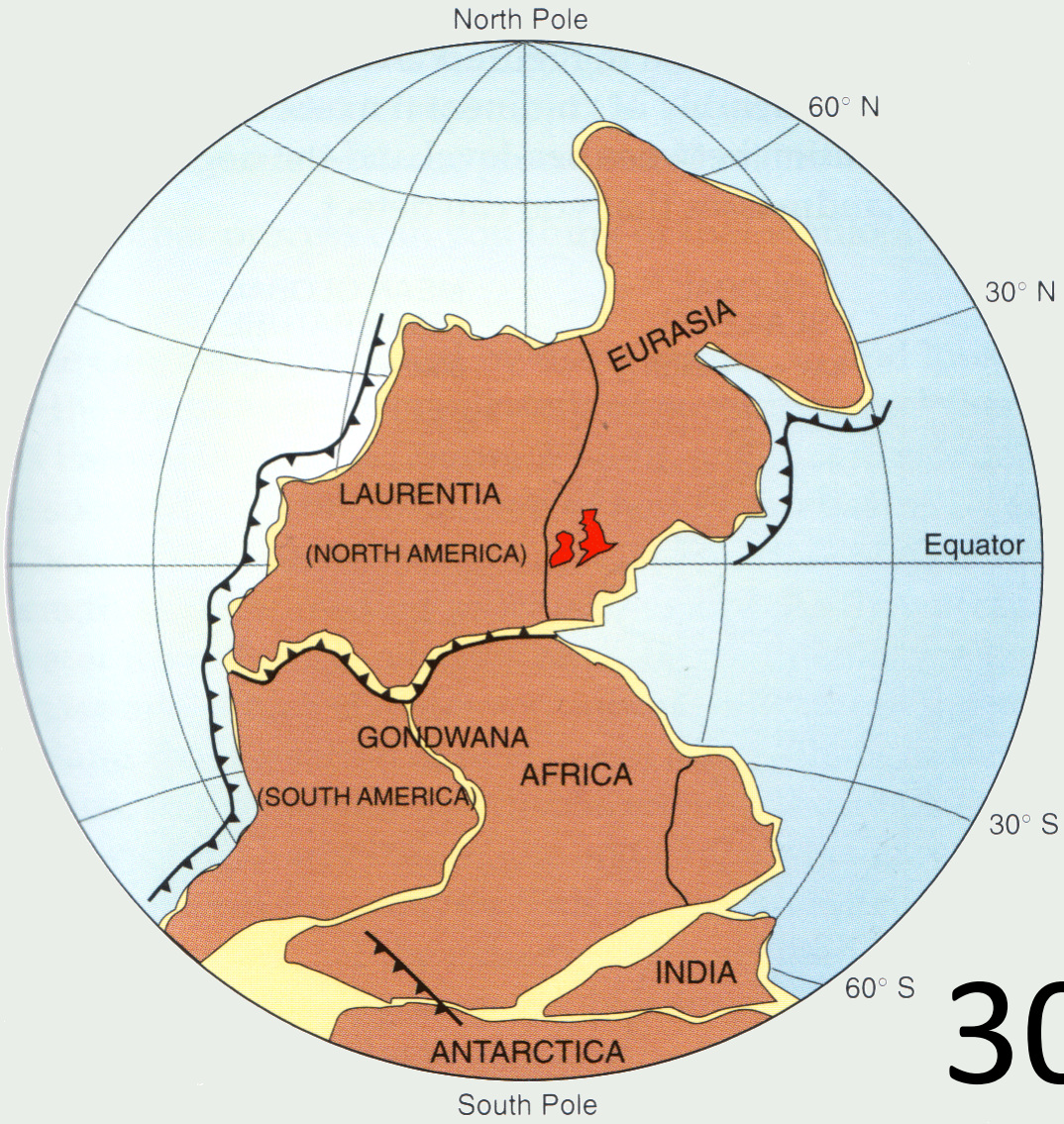
Drift across the Globe



302 Ma

Carboniferous

Illustration from the book *The Geological History of the British Isles*
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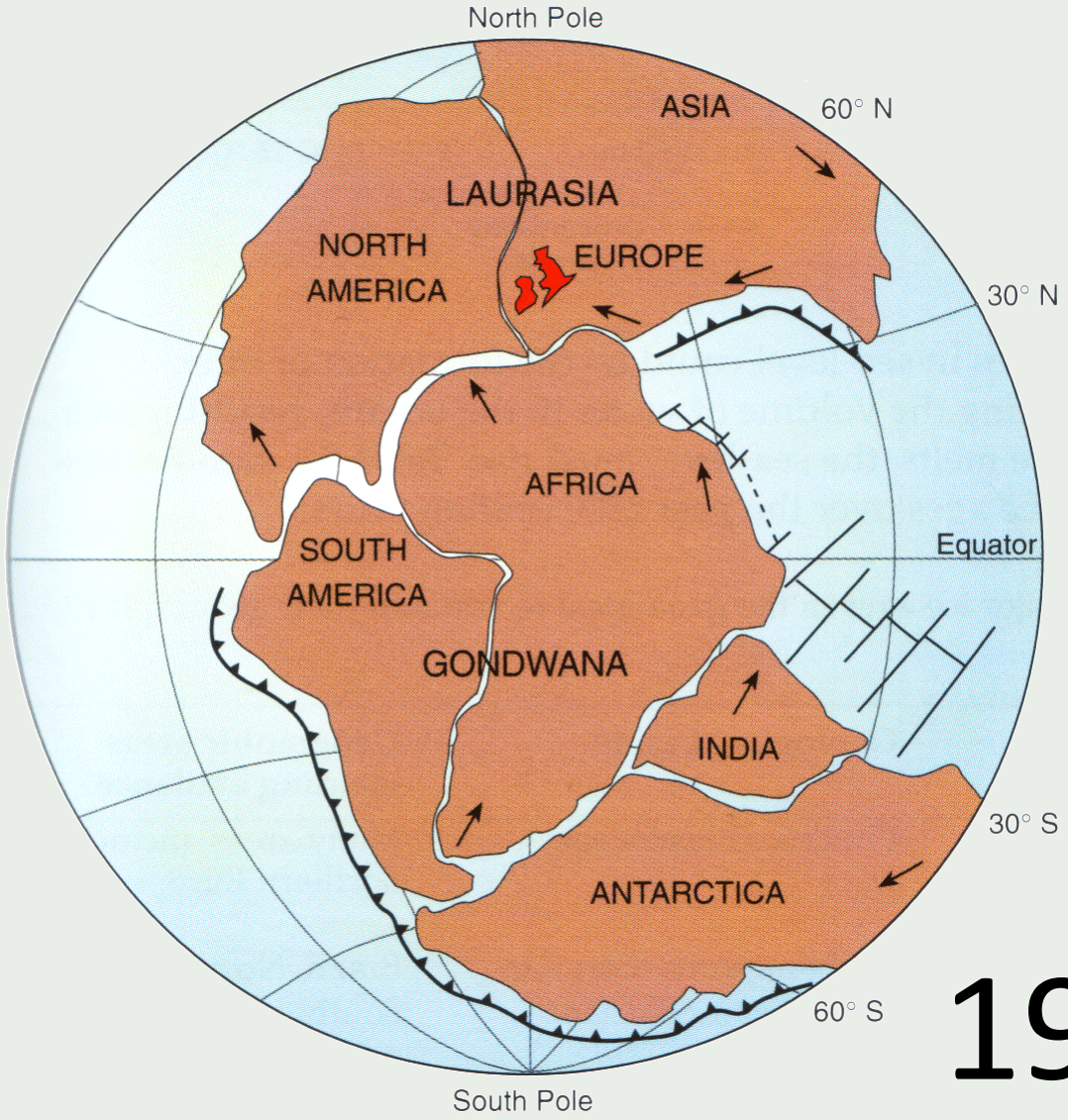
Drift across the Globe

237 Ma

Triassic

Illustration from the book *The Geological History of the British Isles*
by Arlëne Hunter & Glynda Easterbrook

Drift across the Globe

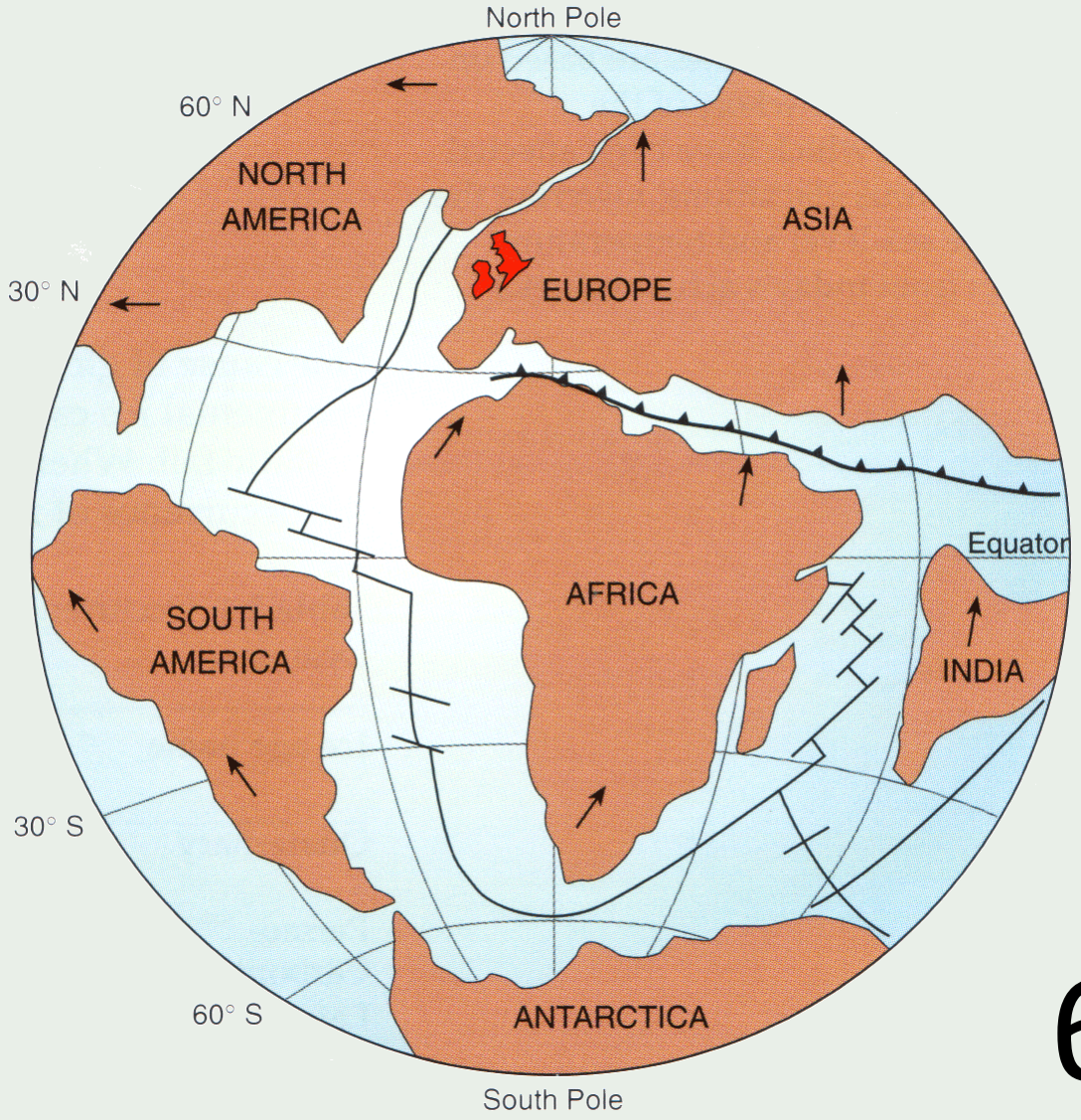


195 Ma

Jurassic

Illustration from the book *The Geological History of the British Isles* by Arlëne Hunter & Glynda Easterbrook

Drift across the Globe



65 Ma

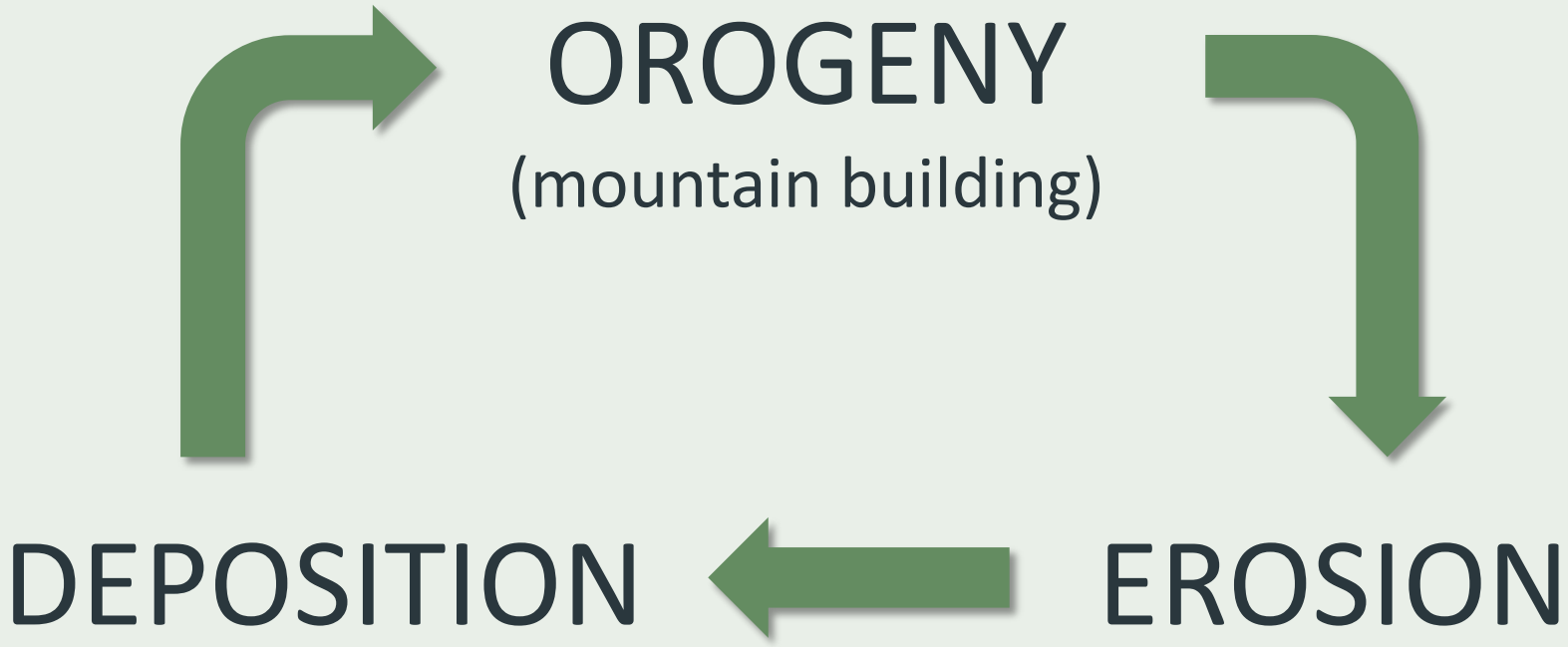
Late Cretaceous – Early Tertiary

Illustration from the book *The Geological History of the British Isles* by Arlëne Hunter & Glynda Easterbrook

Britain through time

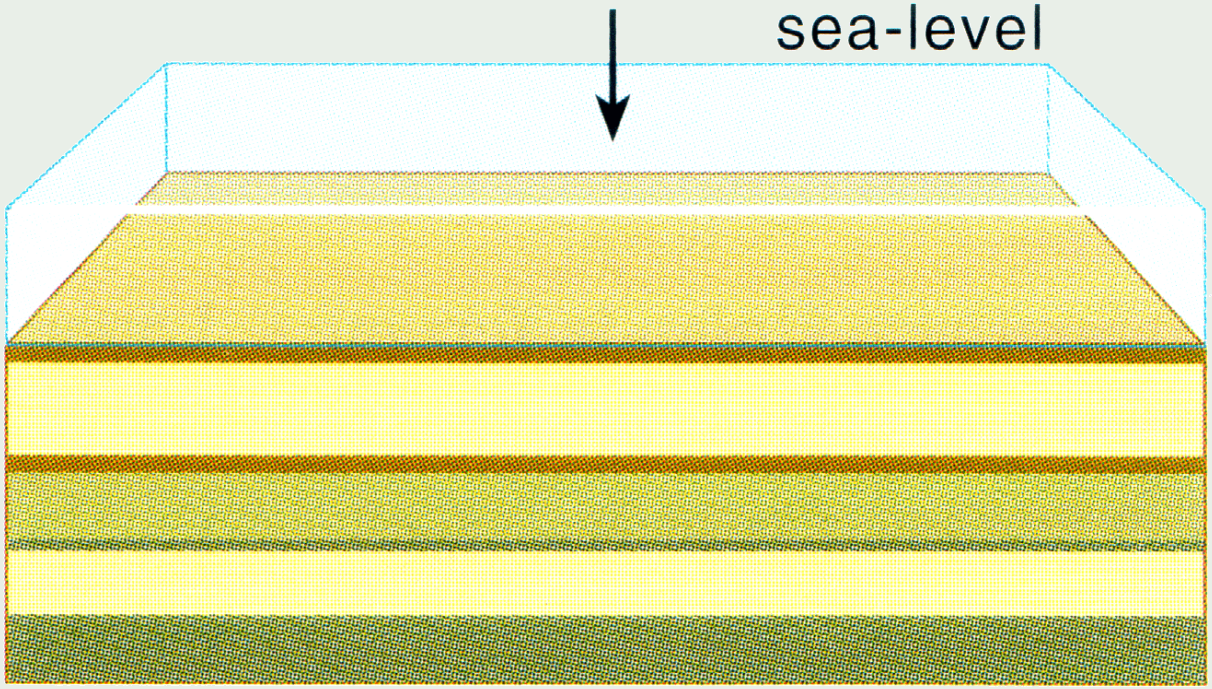
As continents shifted over millions of years, the area that was to become the British Isles went through many changes. At times it was desert land (Permian) at other times it was a large river delta (Carboniferous) and at other times it was completely submerged (Cretaceous) or under ice (Quaternary).

Uplift, Erosion and Deposition



The origins of all rocks are igneous (intrusive and volcanic) but over millions of years, these rocks are eroded and deposited as sedimentary "strata" in deep lakes and oceans. These sediments may then be uplifted by orogenesis, only to be eroded once more and deposited. The study of strata is known as stratigraphy.

Deposition and Burial



(a) DEPOSITION AND BURIAL

Illustration from the book *The Geological History of the British Isles*
by Arlëne Hunter & Glynda Easterbrook

Orogeny and Erosion

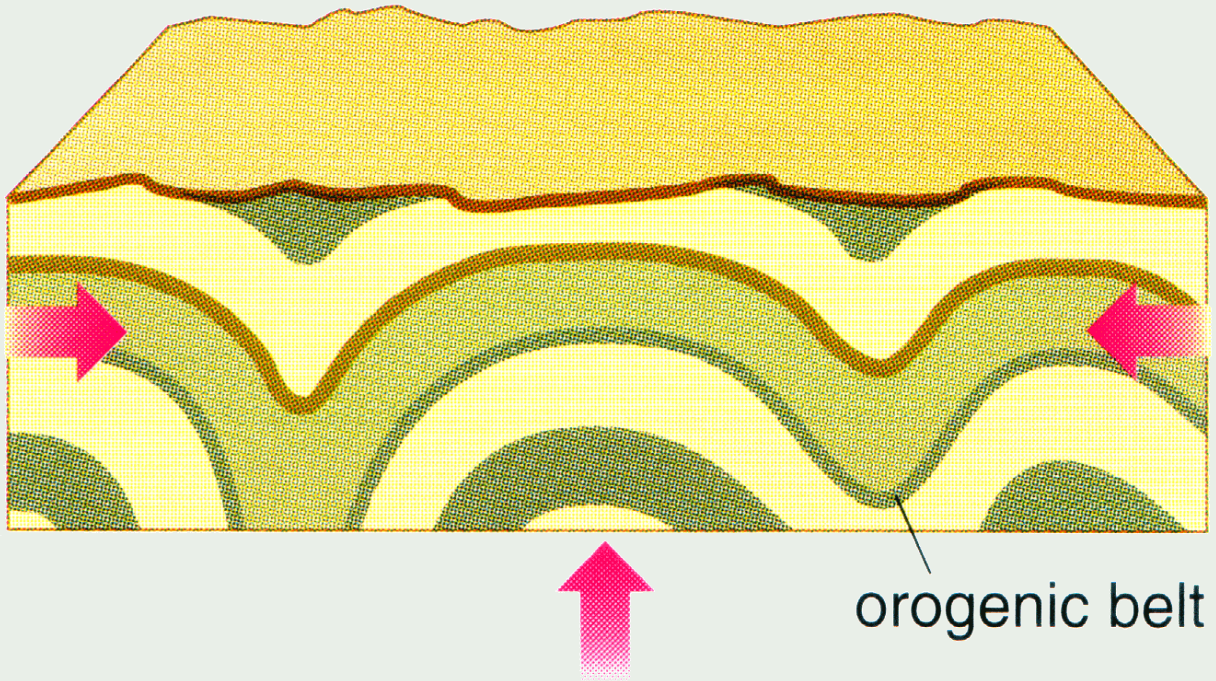


Illustration from the book *The Geological History of the British Isles*
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Transgression

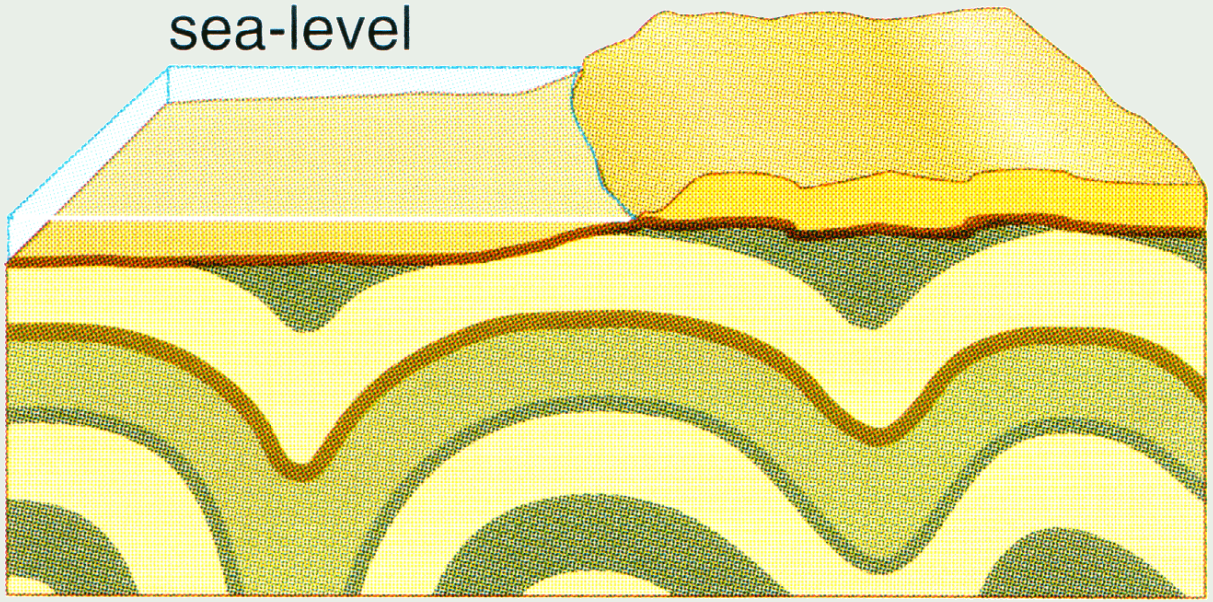

Illustration from the book *The Geological History of the British Isles*
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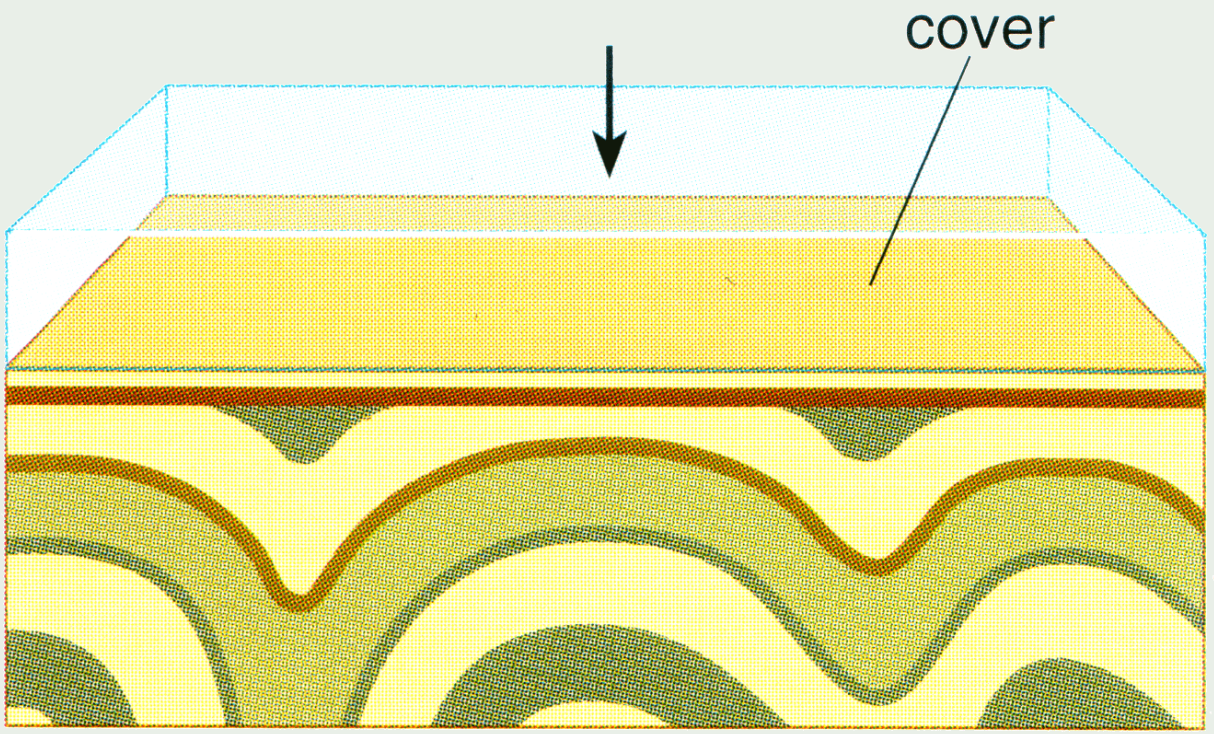
Deposition

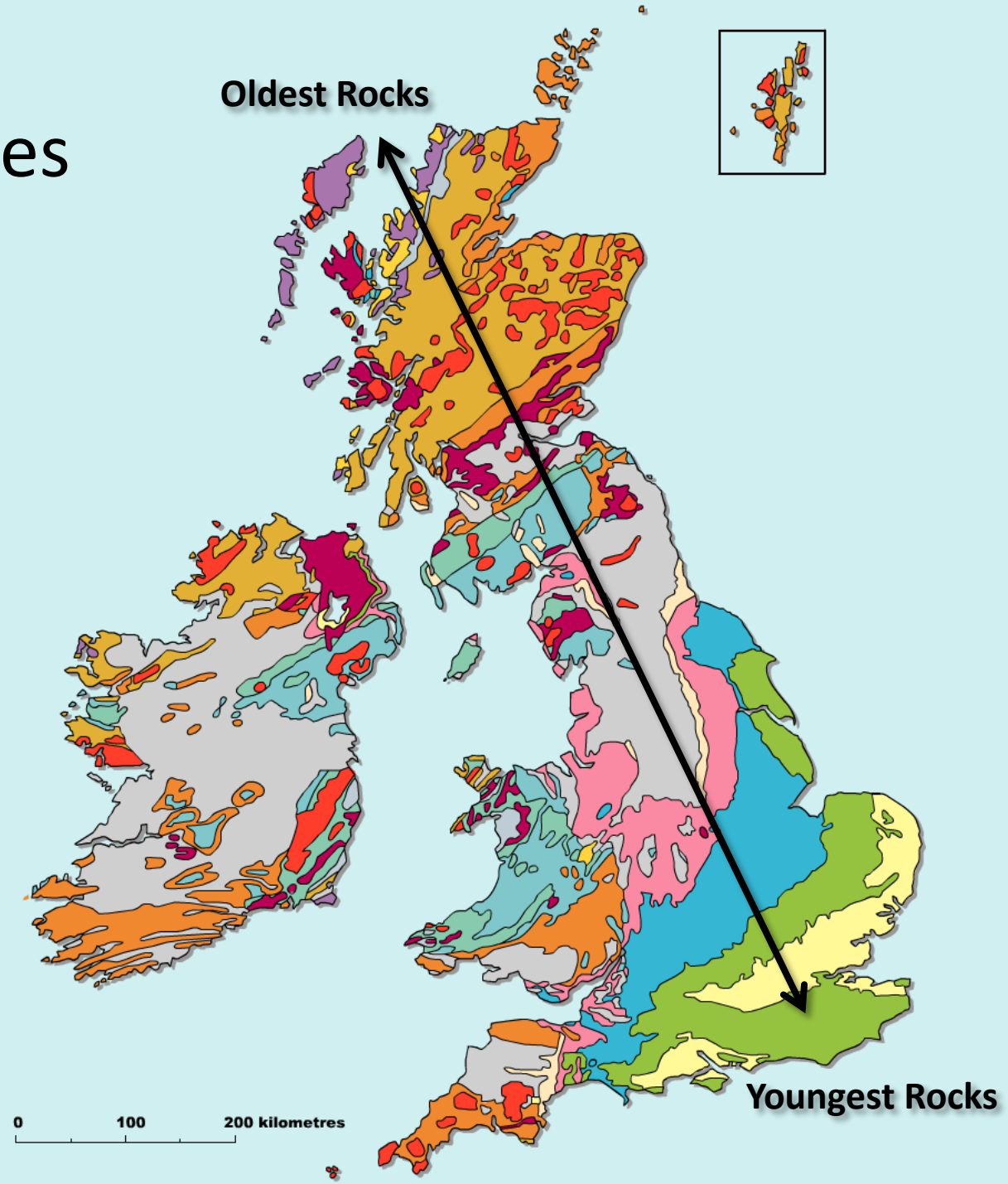


(d) DEPOSITION

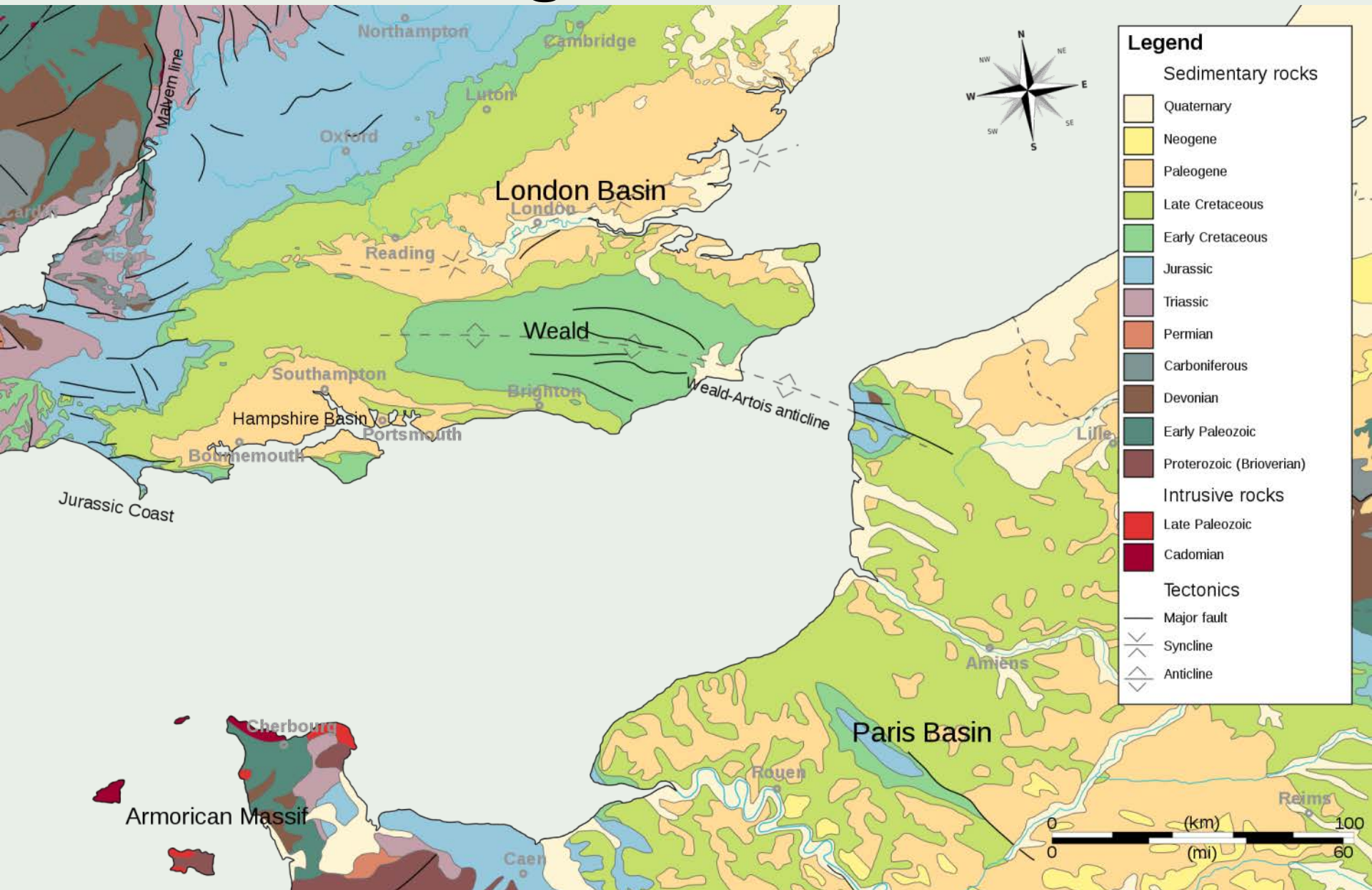
Illustration from the book *The Geological History of the British Isles*
by Arlëne Hunter & Glynda Easterbrook

Geology of the British Isles

The pattern of rocks in Britain is the result of billions of years of tectonic plate movement, causing uplift of ridges and formation of basins. Ridges are eroded and material deposited in basins, only to be uplifted again in a continuing cycle. But this crude mapping of rock types is only the start; geologists have mapped the landscape in much greater detail…

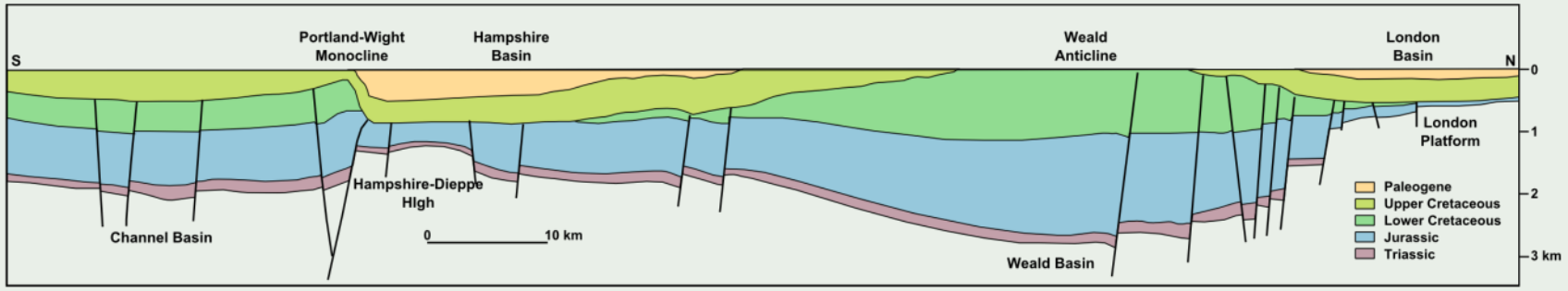


Geological Structures



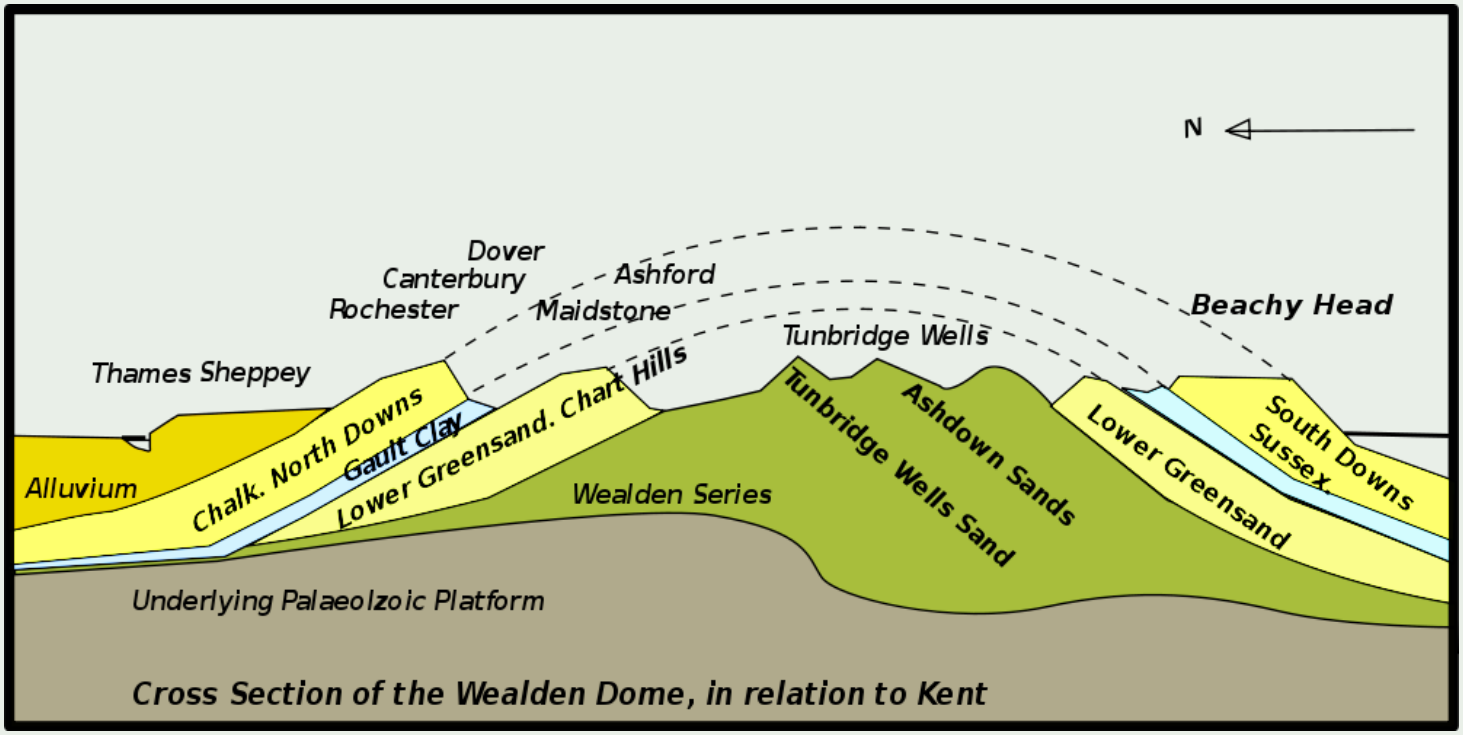
Weald-Artois Anticline

Geologists not only map the distribution of rocks at the surface but can also determine sub-surface structure. This allows for a greater understanding of how the present landscape was formed. Below is a section across the *Weald-Artois Anticline*, which resulted in the formation of the North and South Downs.



Wikipedia: [Weald Basin]

Formation of the Downs



Chalk was formed in the Weald Basin from the shells of billions of tiny creatures laid down in shallow, tropical seas during the Cretaceous period (142 – 65Ma). It was then uplifted into an anticline during the Alpine Orogeny caused by the African tectonic plate moving north and colliding with the Eurasian plate. Over millions of years, the anticline was eroded, leaving the North and South Downs chalk escarpments.

Rocks and Rain

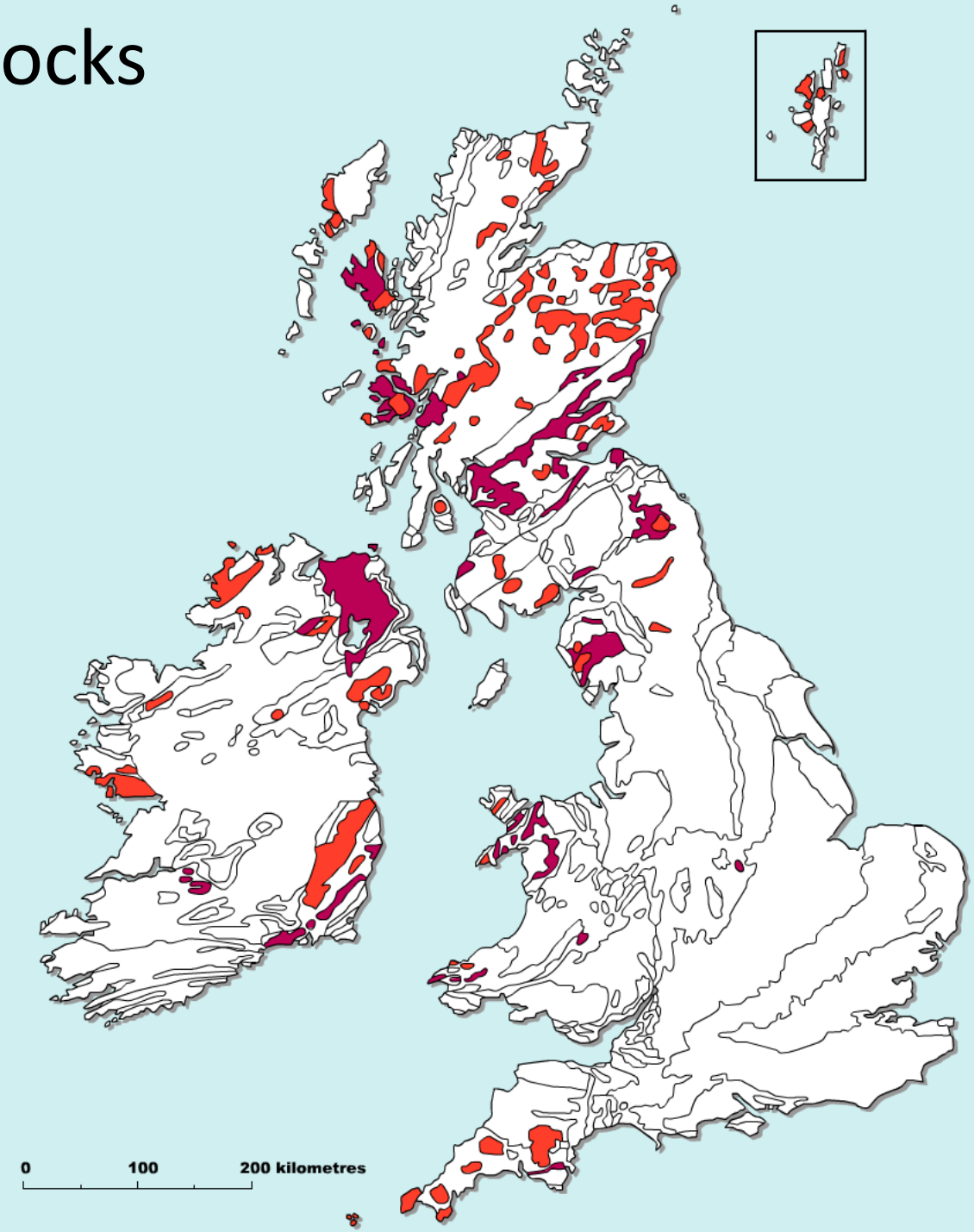
A GEOLOGICAL TOUR

Igneous Rocks

Various ages

Intrusive

Volcanic



Edinburgh Castle

A volcanic plug formed in Carboniferous times.

Torr on Dartmoor

Dartmoor is formed from plutonic magma which cooled to form granite during the Carboniferous.

Strumble Head

Pillow lava at Strumble Head

Lava flow during the Ordovician forming Pembrokeshire headland and ideal location for lighthouse.

Giants Causeway

A lava flow in Paleogene times, forming Basalt columns.

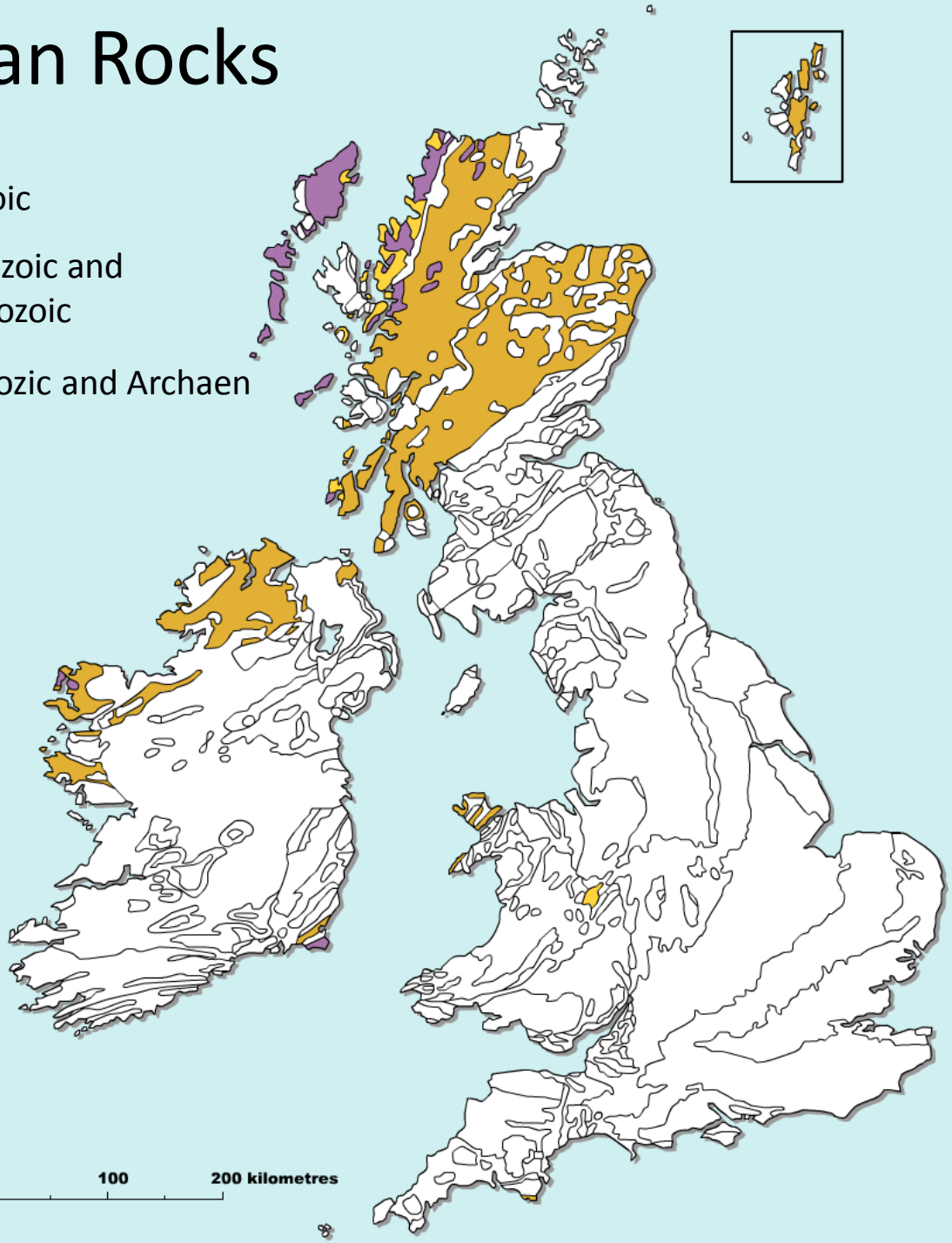
Precambrian Rocks

Older than 545Ma

Neoproterozoic

Lower Palaeozoic and Upper Proterozoic

Lower Proterozic and Archaen



Scottish Highlands

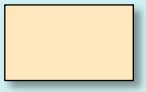
The ancient metamorphic rocks of the Scottish Highlands have been rounded and smoothed by erosion and shaped by ice.

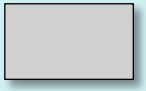
Long Mynd

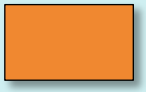
The Long Mynd in Shropshire is a rare example of Precambrian rock in England. It forms a ridge of ancient, hard rock.

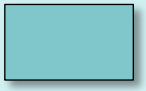
Palaeozoic Rocks

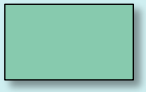
248 to 545Ma

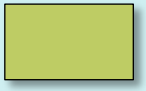

Permian

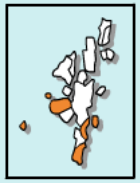

Carboniferous


Devonian


Silurian


Ordovician


Cambrian



Rhinogydd

Rhinog Fach and Y Llethr form part of the feature known as the “Harlech Dome”, and composed of Cambrian rocks. This range of welsh mountains is known as the Rhinogydd.

Harlech Dome

The Rhinogydd are formed of hard sedimentary rocks of Cambrian age which occur as a major anticlinal structure known to geologists as the Harlech Dome. This structure which originated during the Caledonian Orogeny extends from Cadair Idris in the south to Blaenau Ffestiniog in the north. Its erosion by successive ice ages has left the valleys and peaks of the Rhinogydd visible today.

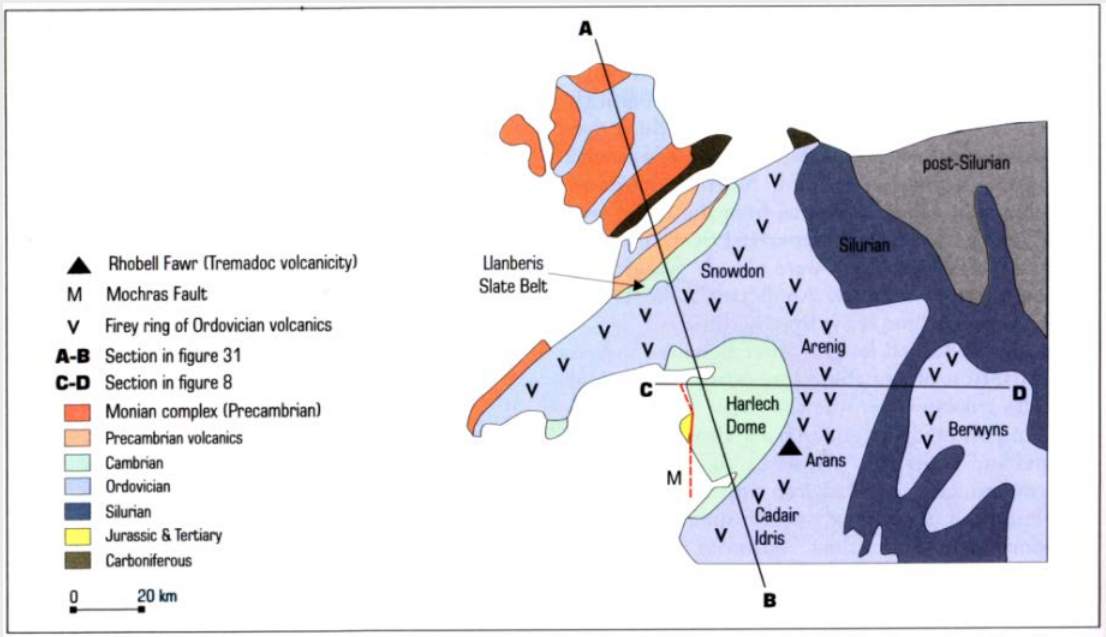


FIG. 29. *Geological sketch map of North Wales. Cross-sections from A to B and C to D are shown in figs. 30 and 8.*

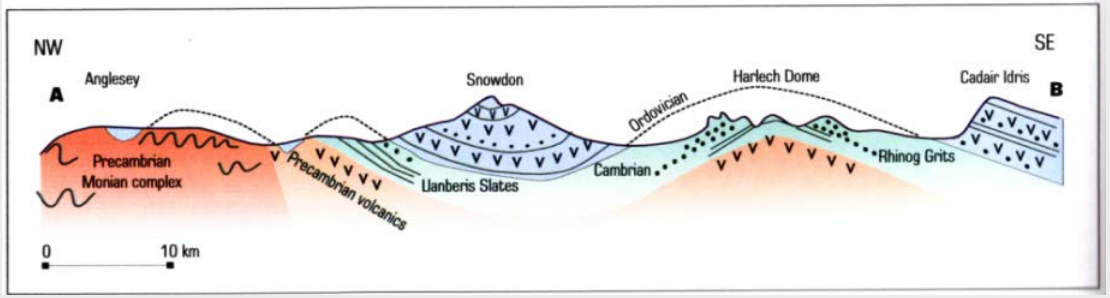


FIG. 30. *Cross-section through part of North Wales, section A to B on fig. 29, showing distribution of Cambrian and Ordovician rocks.*

Wikipedia: [Rhinogydd]

Illustration from the book *The Geology of Britain: An Introduction* by Peter Toghill

Malham

Carboniferous Limestone is eroded by solution and results in poor, thin soils or “limestone pavements”. Yorkshire Dales National Park.

Ingleborough

Hard Carboniferous Millstone Grit alternates with softer limestone to form the plateau top to Ingleborough in the Yorkshire Dales National Park.

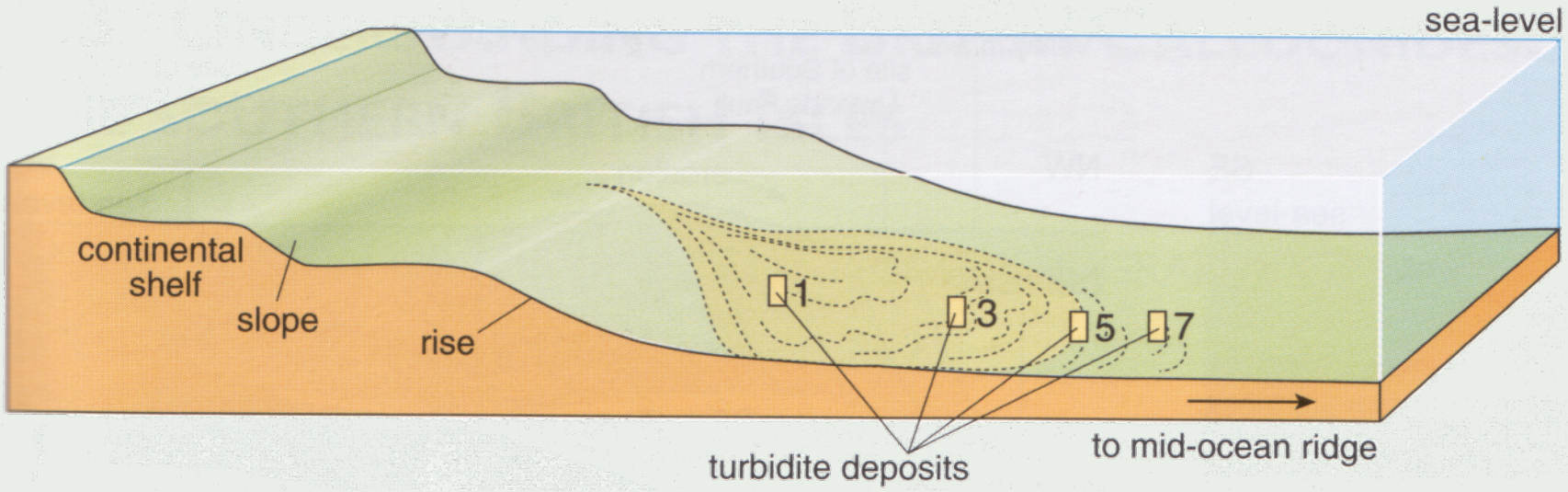
Brecon Beacons

The Brecon Beacons are formed by the Devonian Old Red Sandstone.

Aberystwyth

The Silurian grits that form the landscape around Aberystwyth on the coast of Cardigan Bay are dark grey, resulting in grey beaches. These grits were laid down by turbid currents in shallow oceans.

Turbid Flows



The Aberystwyth grits were laid down as turbid flows (avalanches of silt) from the continental shelf to the deep ocean floor. The resulting rocks are known as “turbidites”.

Wikipedia: Turbidite

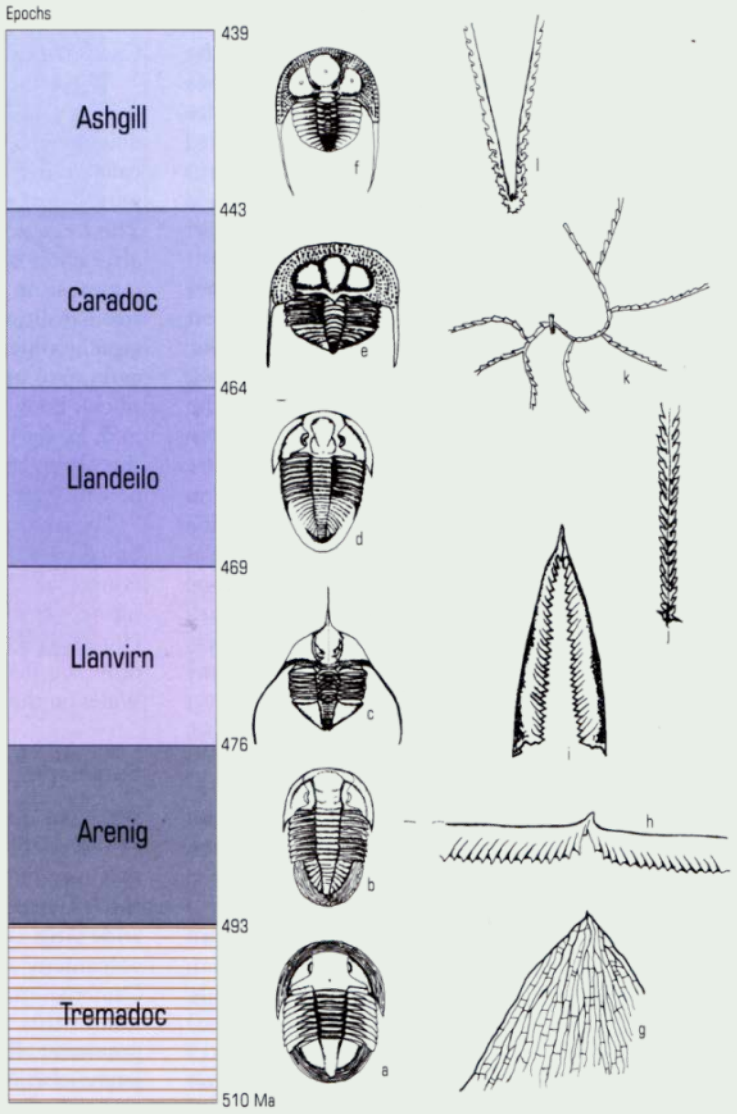
Illustration from the book *The Geological History of the British Isles* by Arlëne Hunter & Glynda Easterbrook

Whitesands Bay

Low coastal cliffs formed from Cambrian and Ordovician shales.

Ordovician Fossil Record

Before the advent of modern radiometric dating techniques, it wasn't possible for geologists to date rocks. However, it was important to know the order in which rocks were formed in order that they could be correctly mapped. The location and orientation of rocks is no guide because they may have been folded and appear in reverse order. Geologists discovered that the relative age of rocks could be determined using fossils. This study is known as "stratigraphy". Ordovician rocks are identified by the presence of different trilobite and graptolite fossils.



Wikipedia: Stratigraphy

Illustration from the book *The Geology of Britain: An Introduction* by Peter Toghill

Devon Farmland

Permian (New Red Sandstone) forms deep, rich red soils.

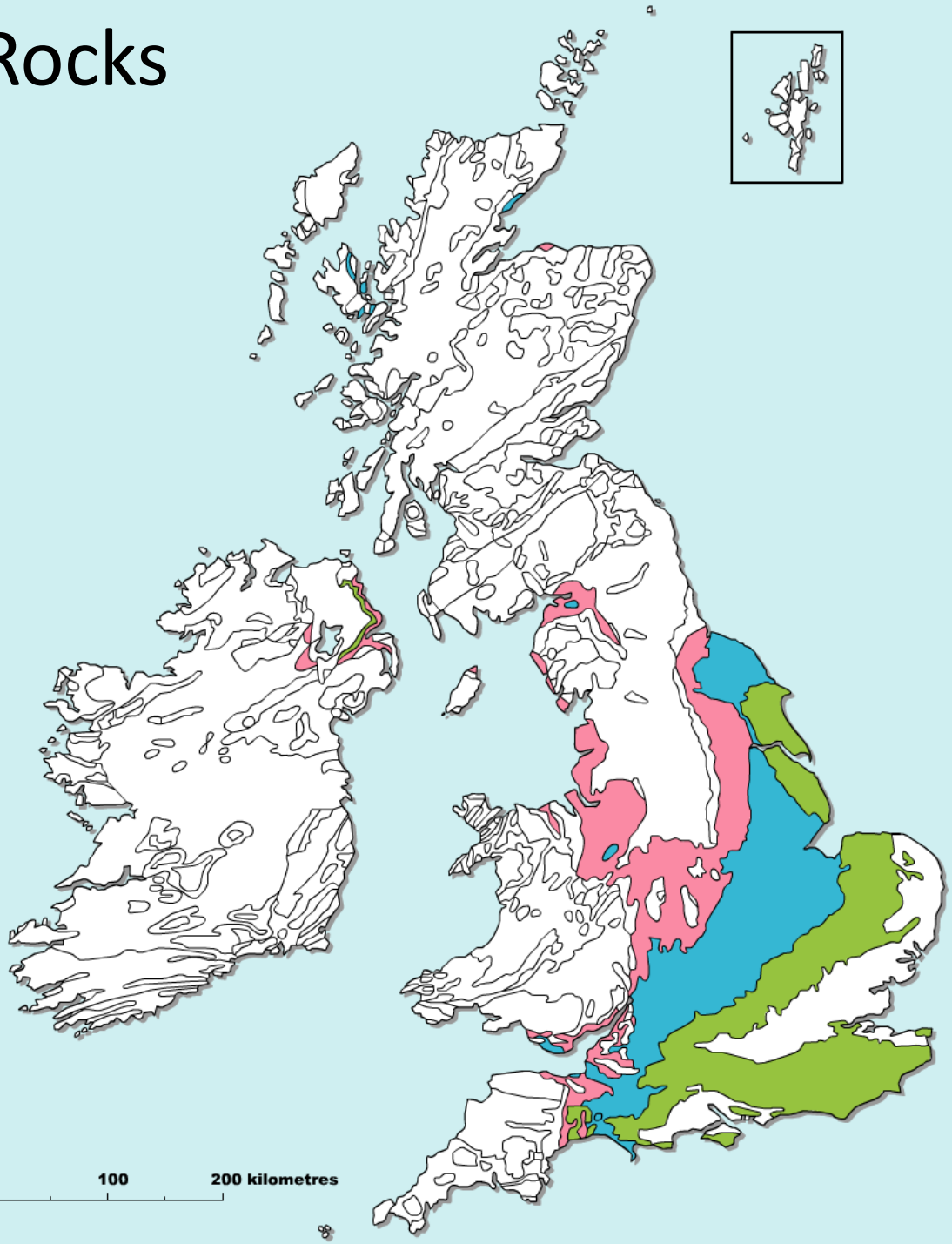
Mesozoic Rocks

248 to 65Ma

Cretaceous

Jurassic

Triassic



Alderly Edge

The Triassic sandstone of Alderly Edge escarpment which gives views across the Cheshire Plain towards the Pennines.

Jurassic Coast

A fossil-rich sequence of rocks, now a world heritage site.
The Jurassic was the age of the dinosaurs.

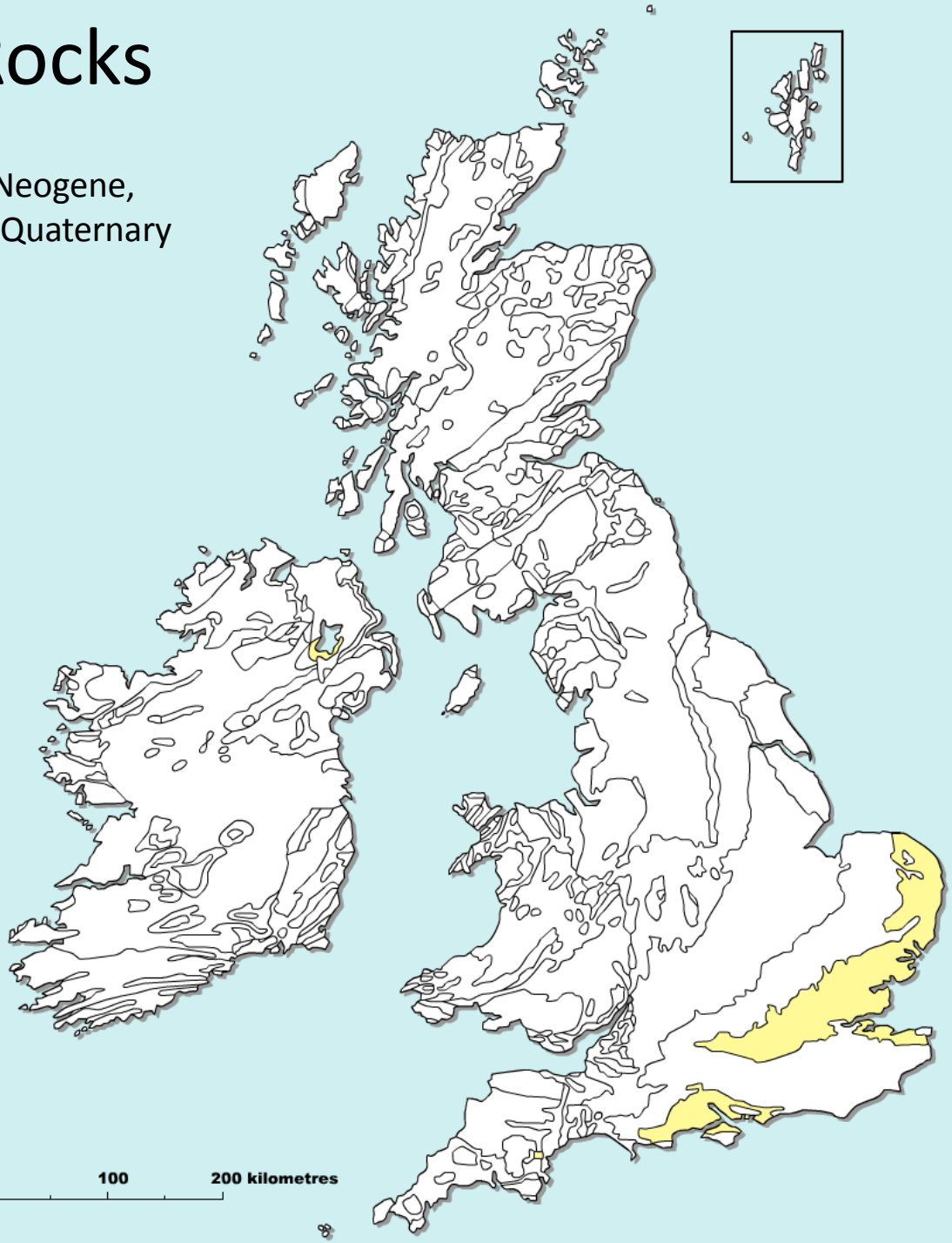
Beachy Head

Cretaceous chalk formed by countless billions of microscopic shells of ancient sea creatures. The Cretaceous is the longest of all the geological periods since the Precambrian.

Cenozoic Rocks

Younger than 65Ma

Palaeogene, Neogene, Pliocene and Quaternary



Rainham Marshes

London Clay forming low, undulating scenery.

Suffolk Coast

Quaternary “drift” forming low, unconsolidated cliffs. These houses near Southworld in Suffolk will soon fall into the sea as the cliffs are eroded.

Landscape Character

The landscape character map of England shows the National Character Areas (NCAs) and a remarkable but not surprising similarity to the geological map of England.


Ammonite fossil, Kilve Beach, Somerset

End of Part One…

www.coursestuff.co.uk/BUIL1164/Rocks-and-Rain.pdf