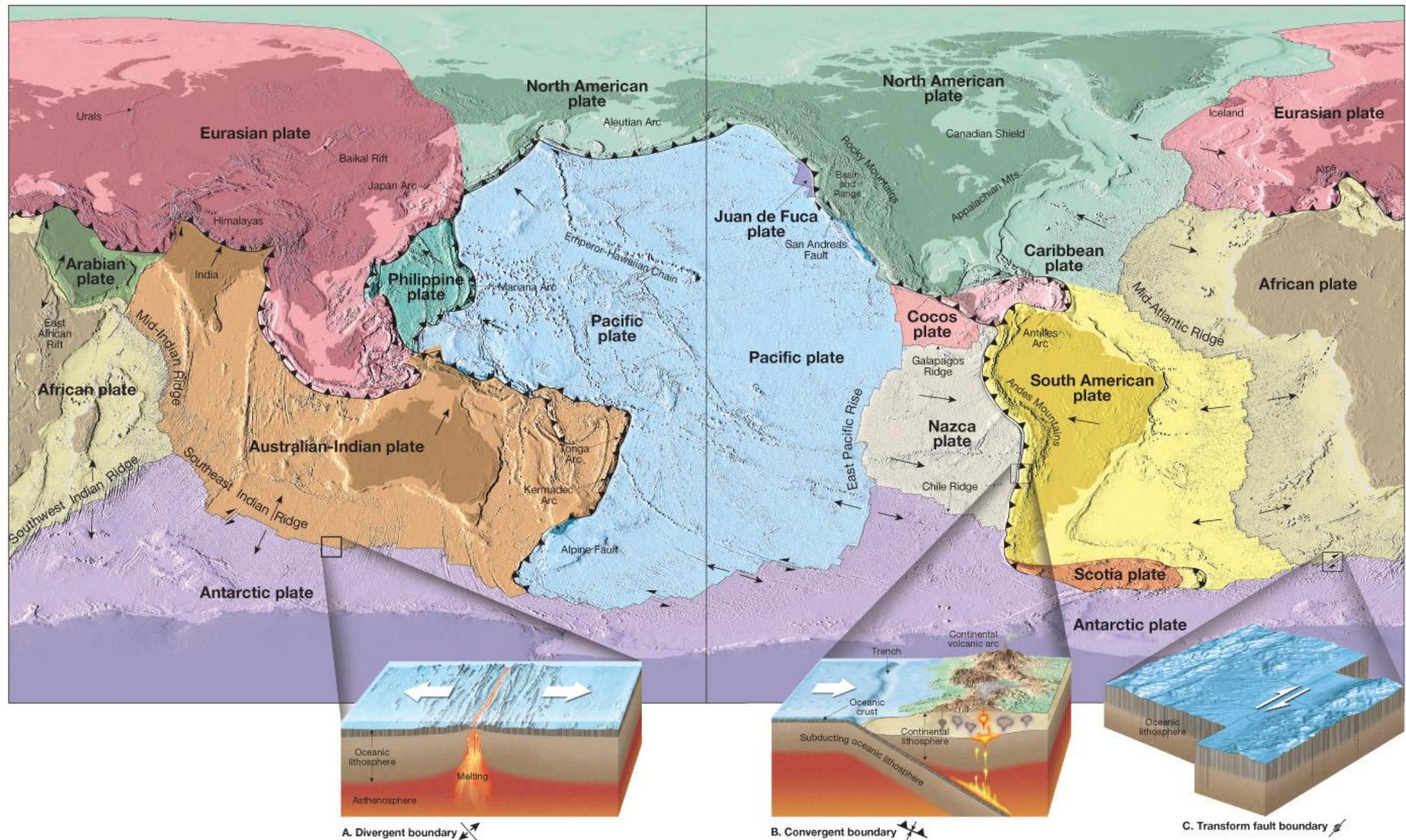


GY4051 Earth Science and Society

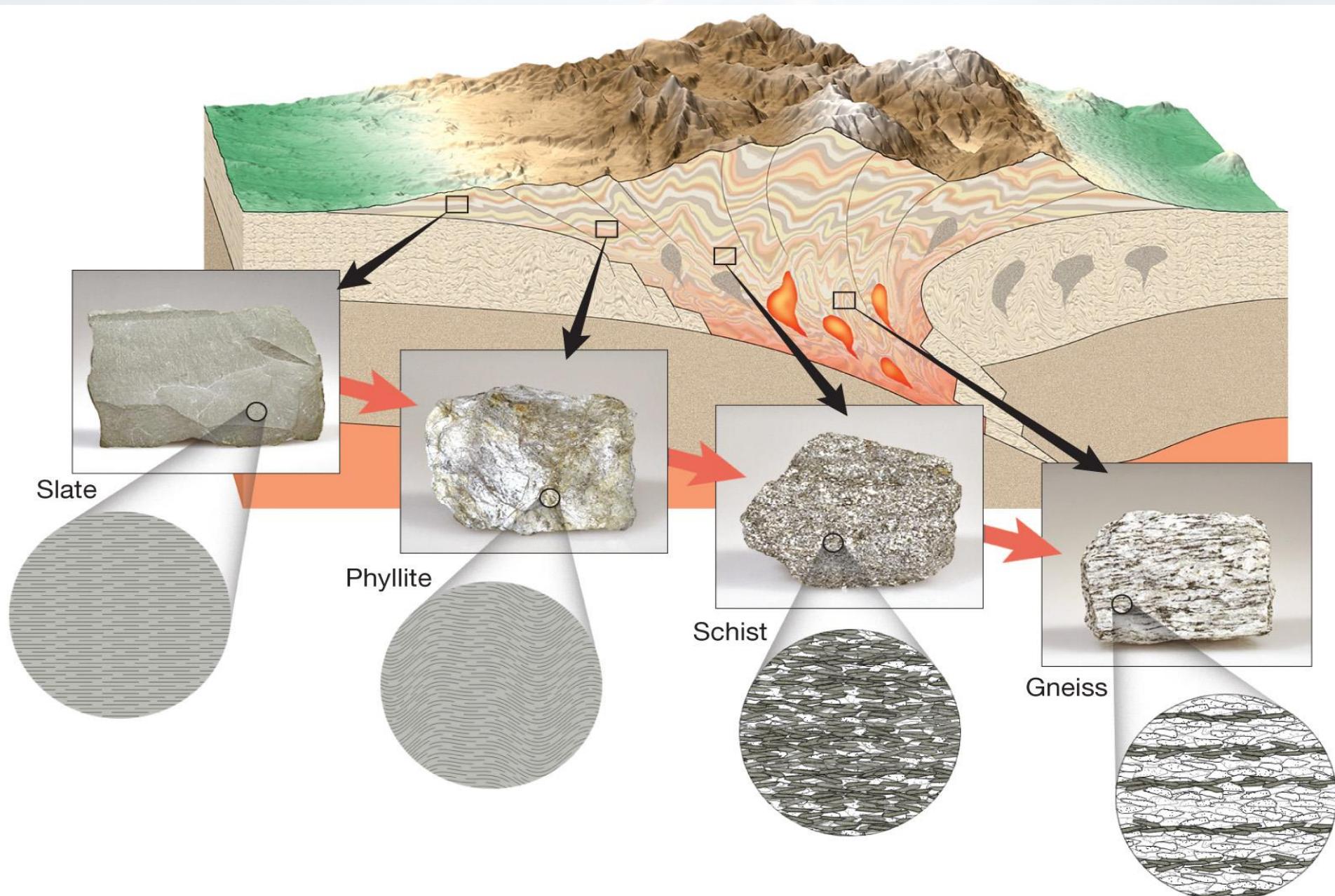
Recent Ireland















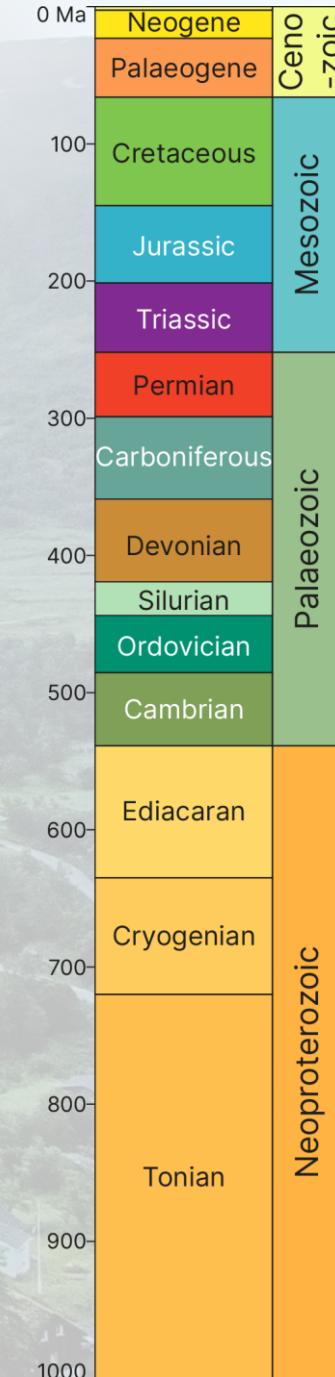
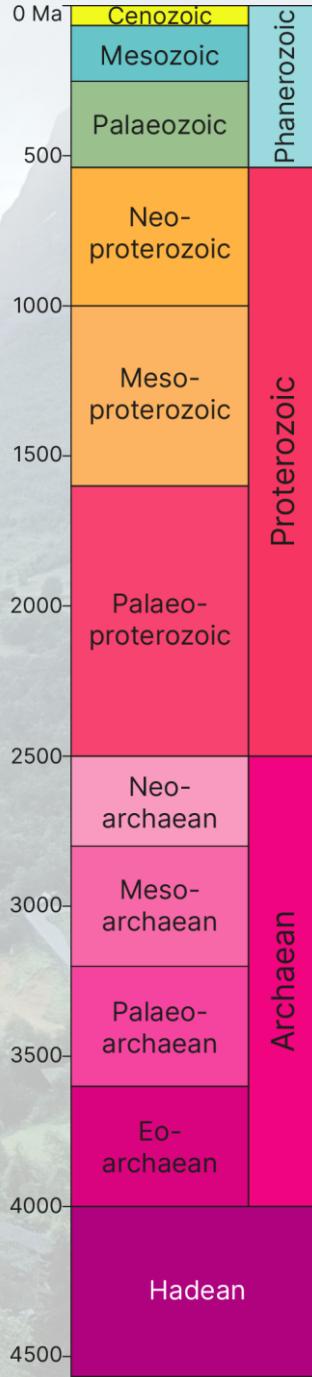
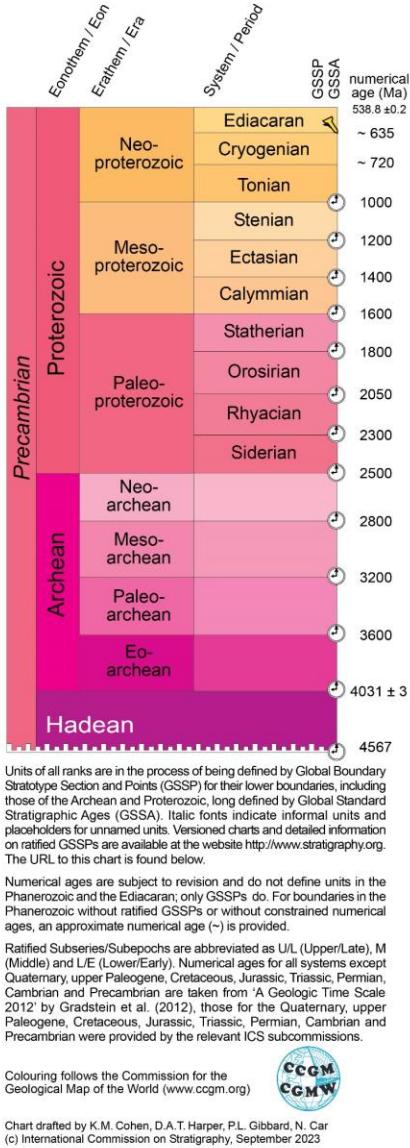
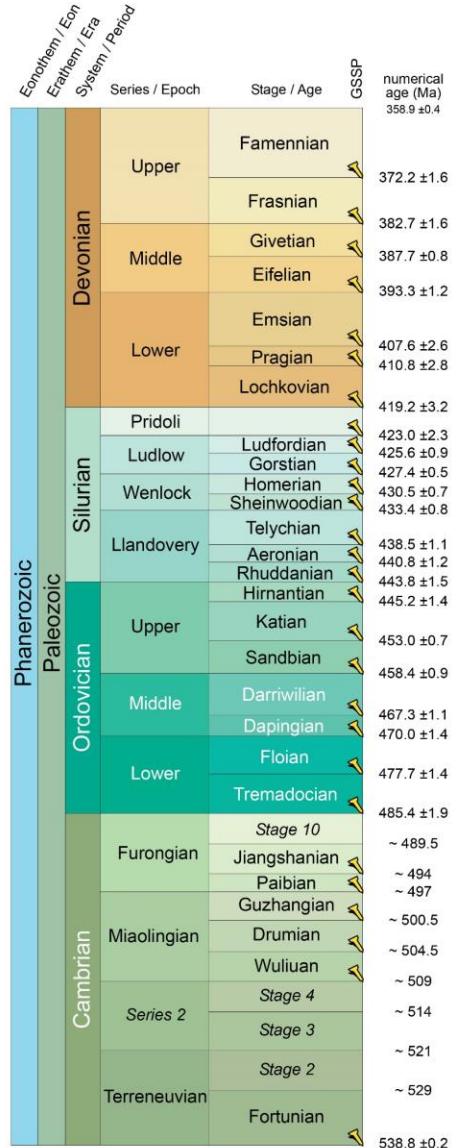
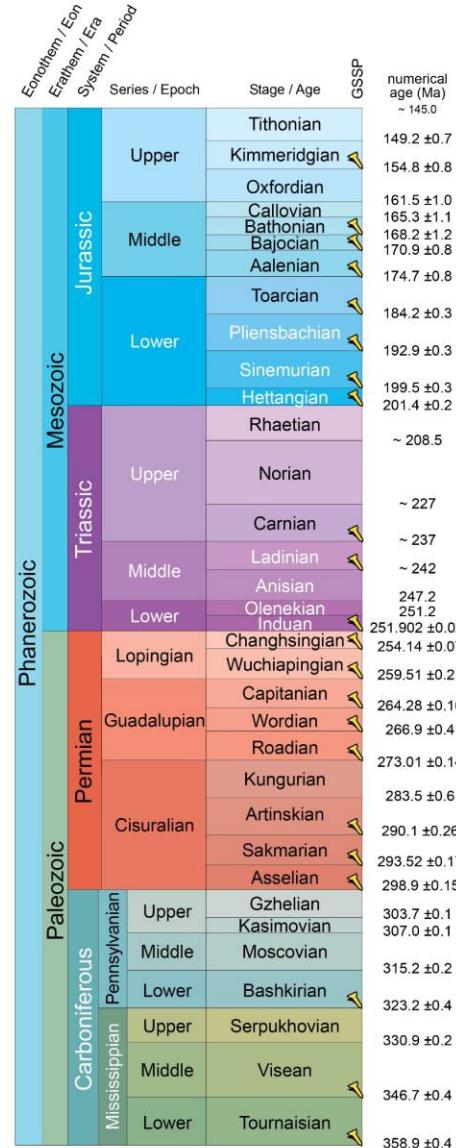
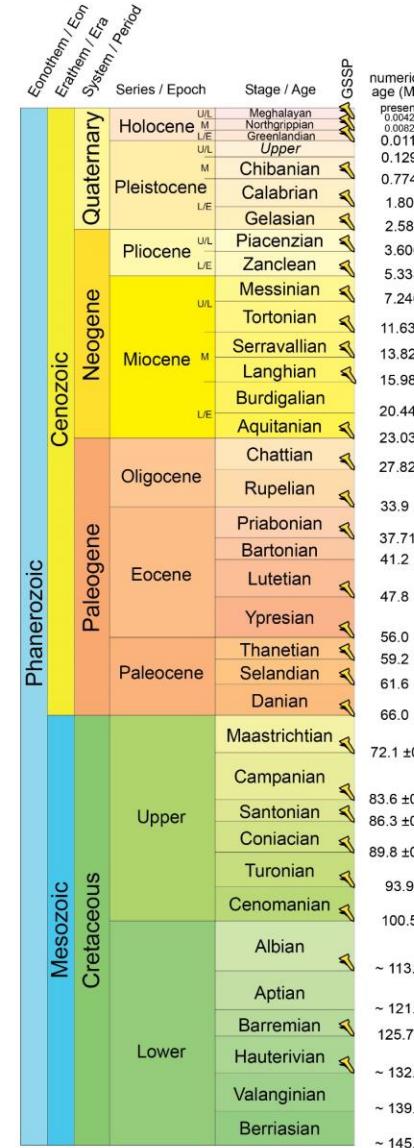


INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

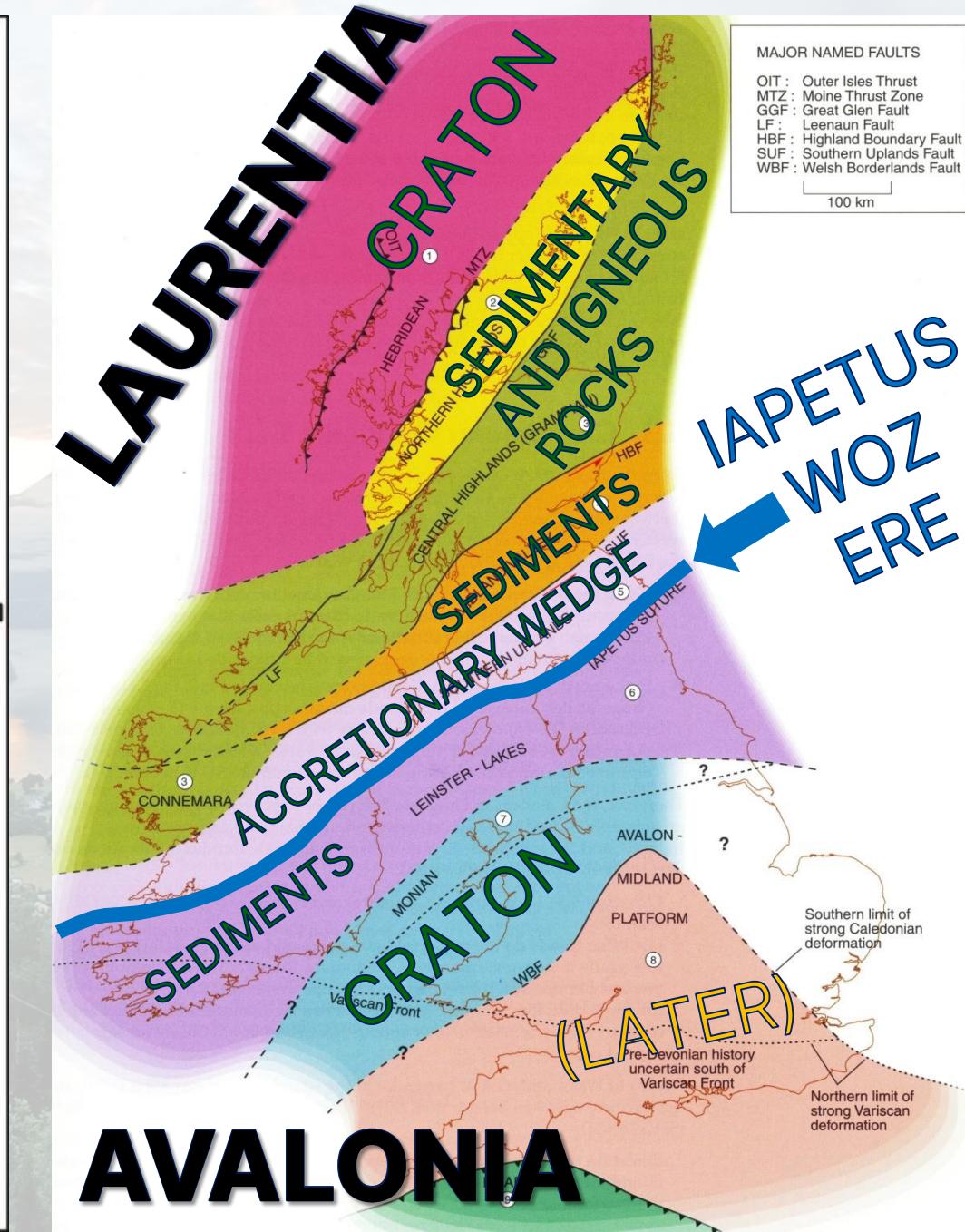
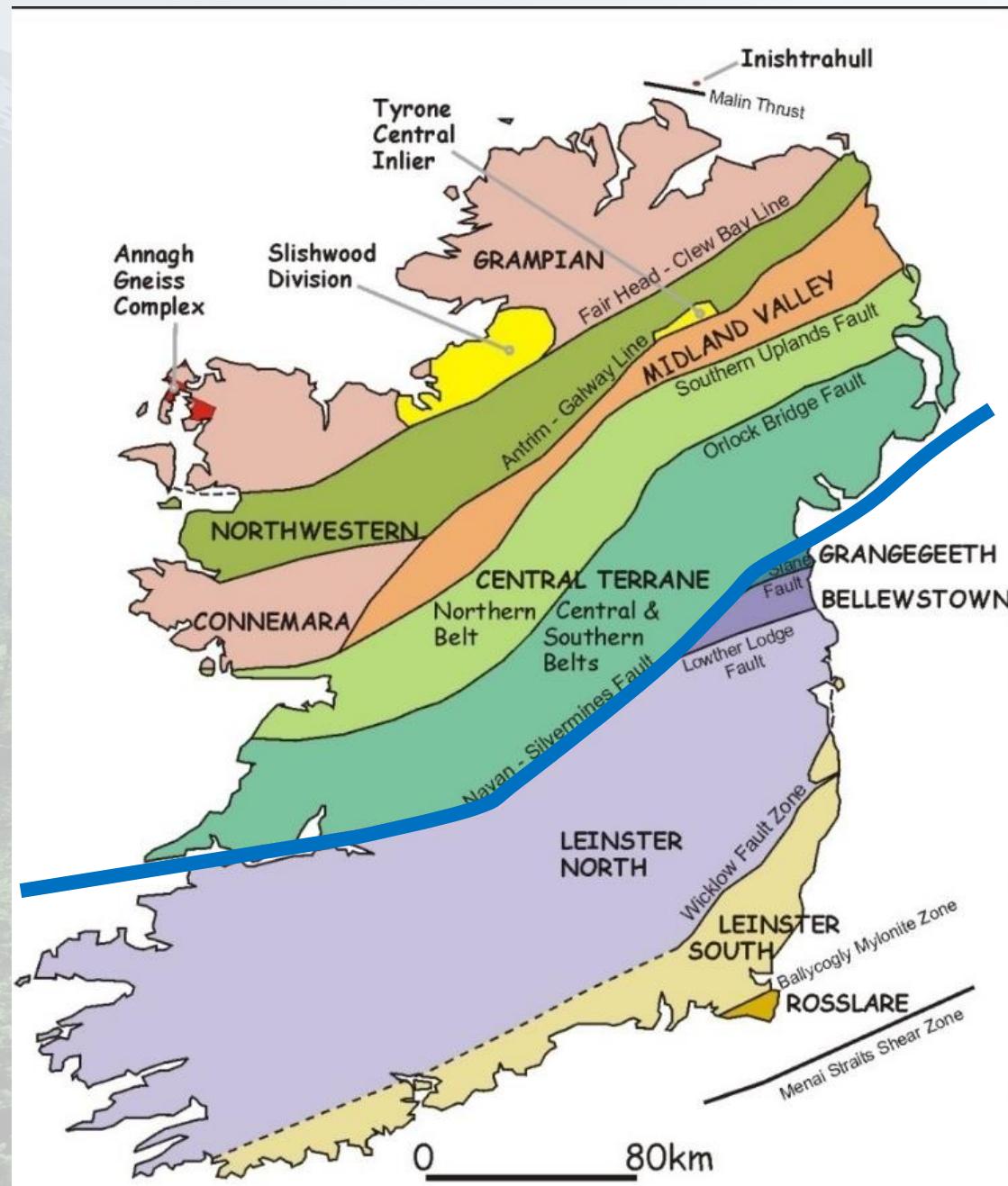
www.stratigraphy.org

International Commission on Stratigraphy

v 2023/09

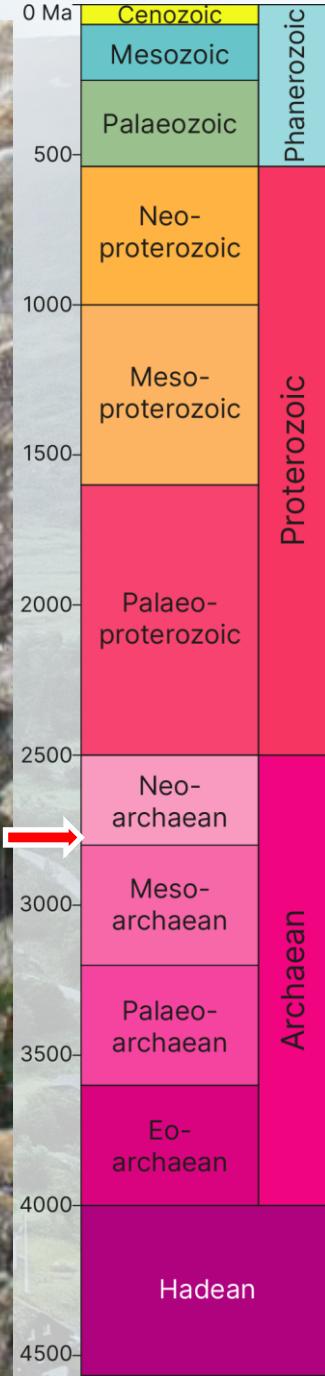
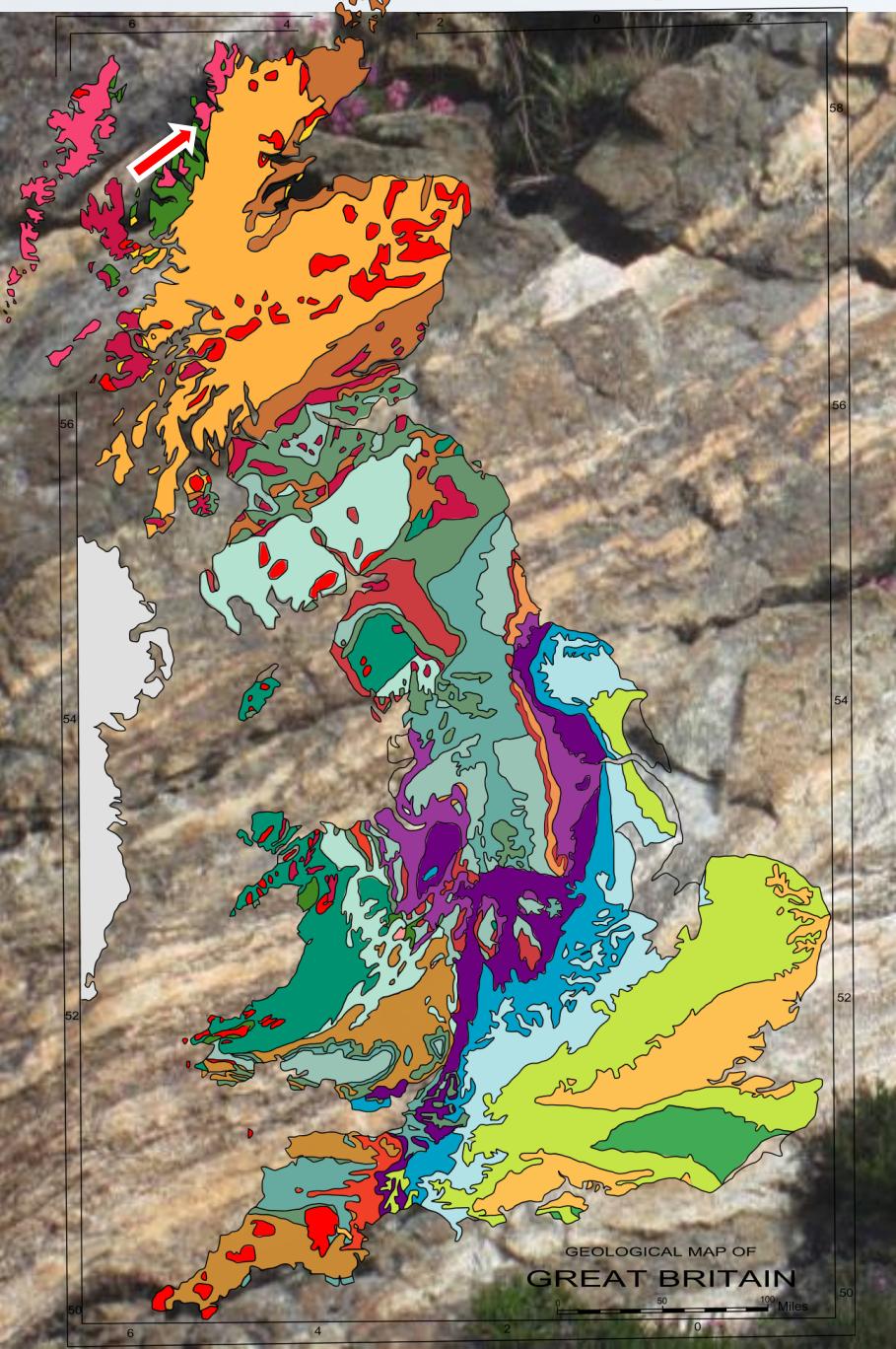


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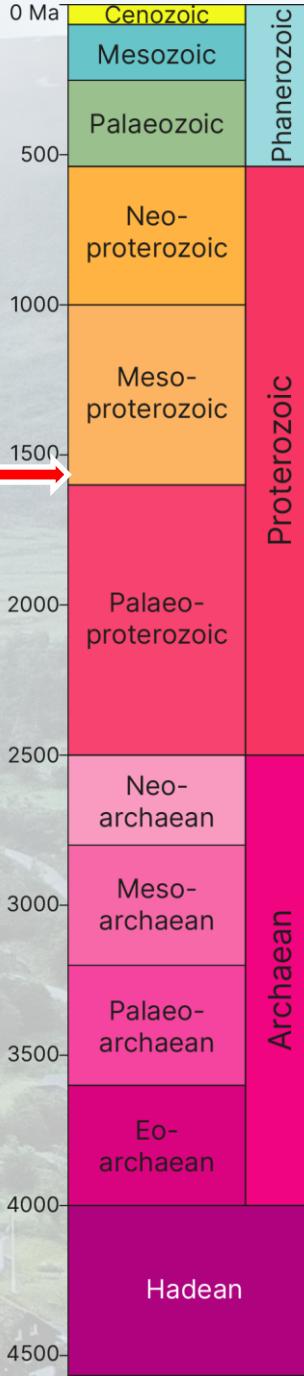
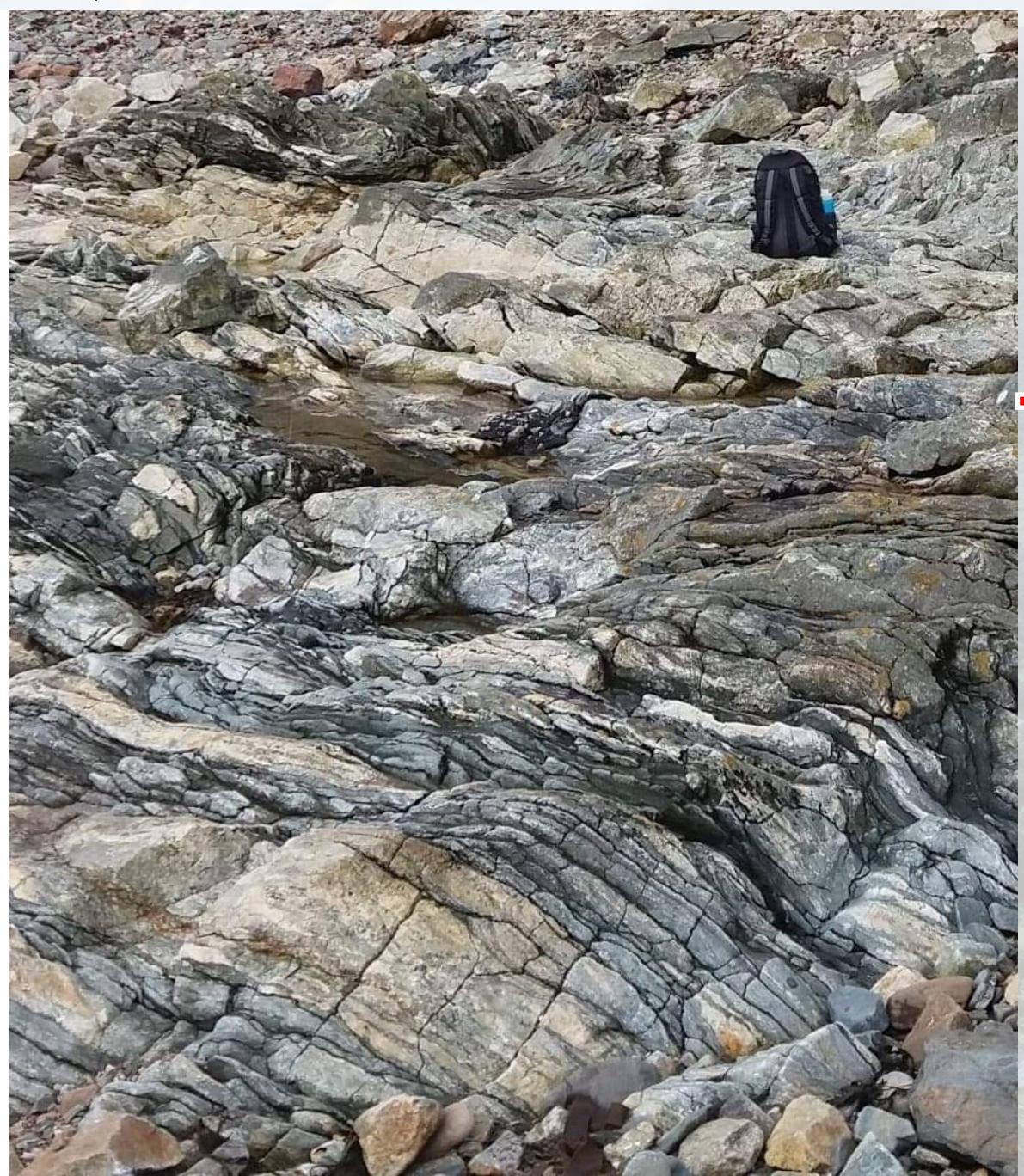
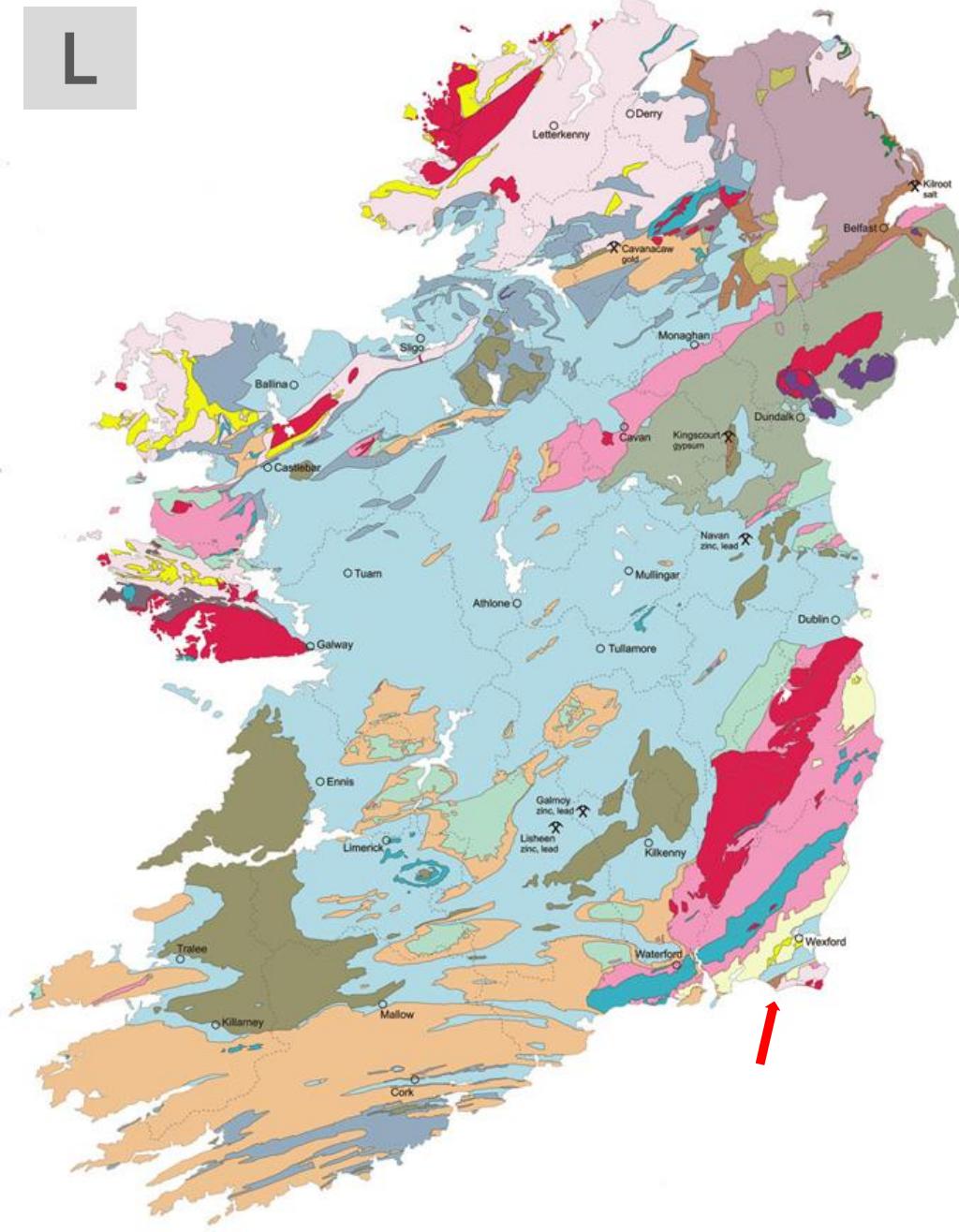
Laurentia, Avalonia and the Iapetus Ocean | The Laurentian Craton

GY4051



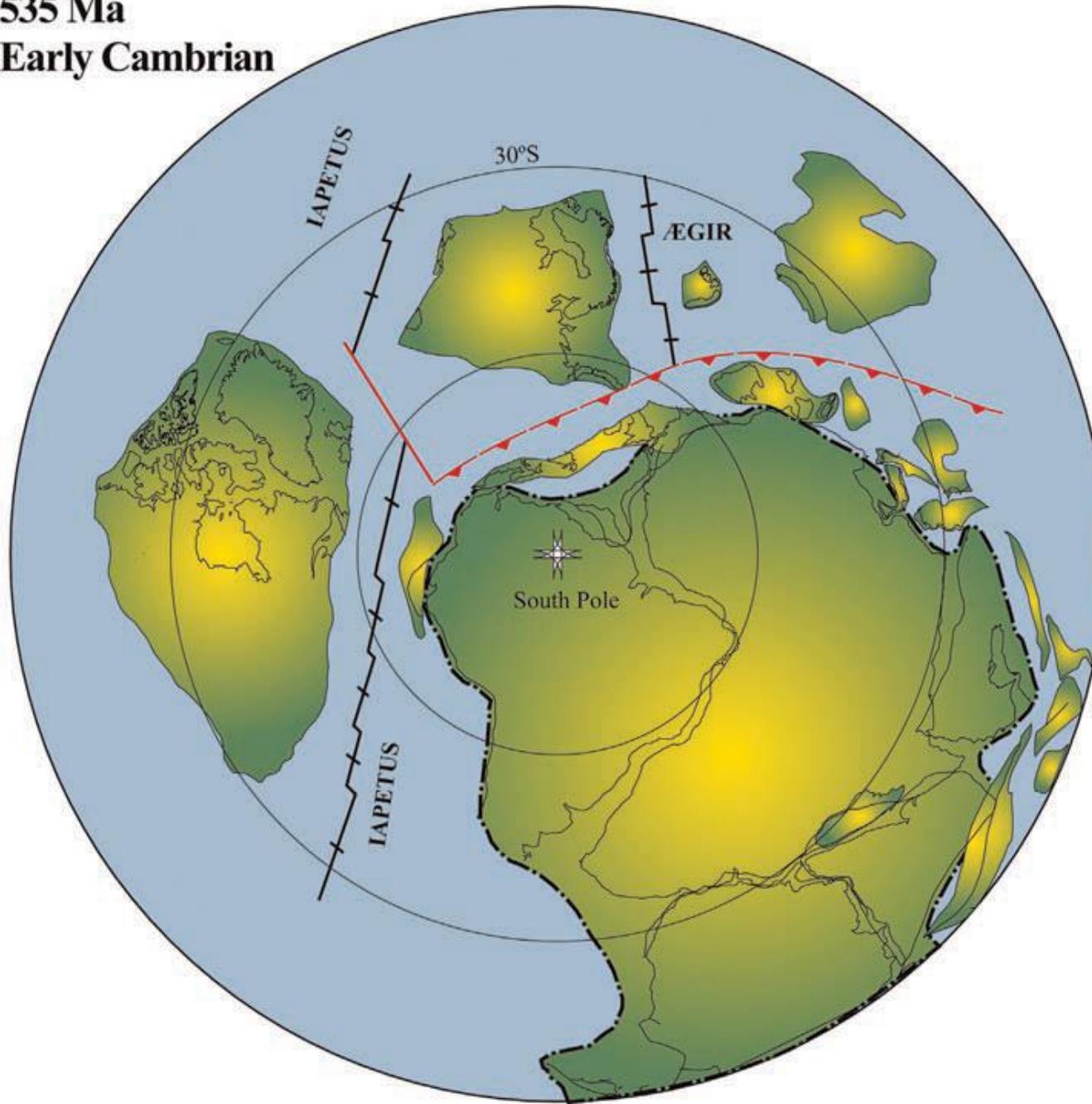
Laurentia, Avalonia, and the Iapetus Ocean | The Avalonian Craton

GY4051



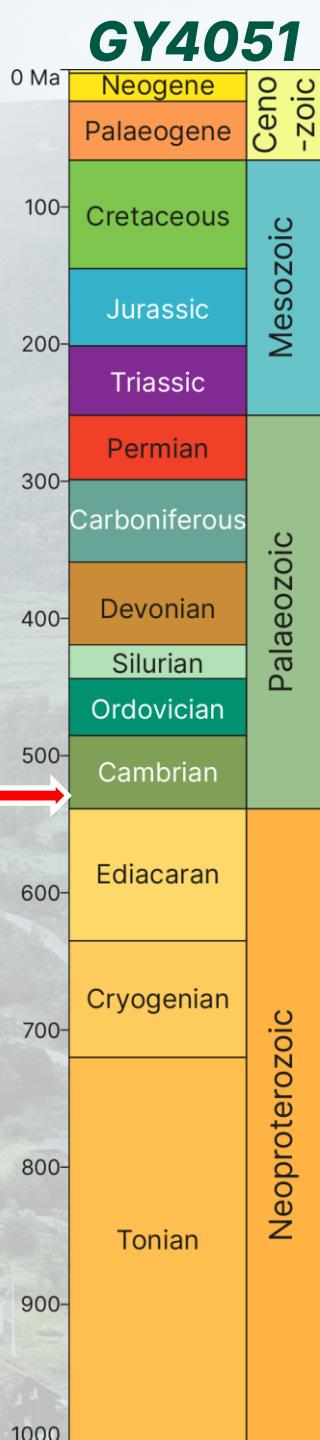
535 Ma

Early Cambrian



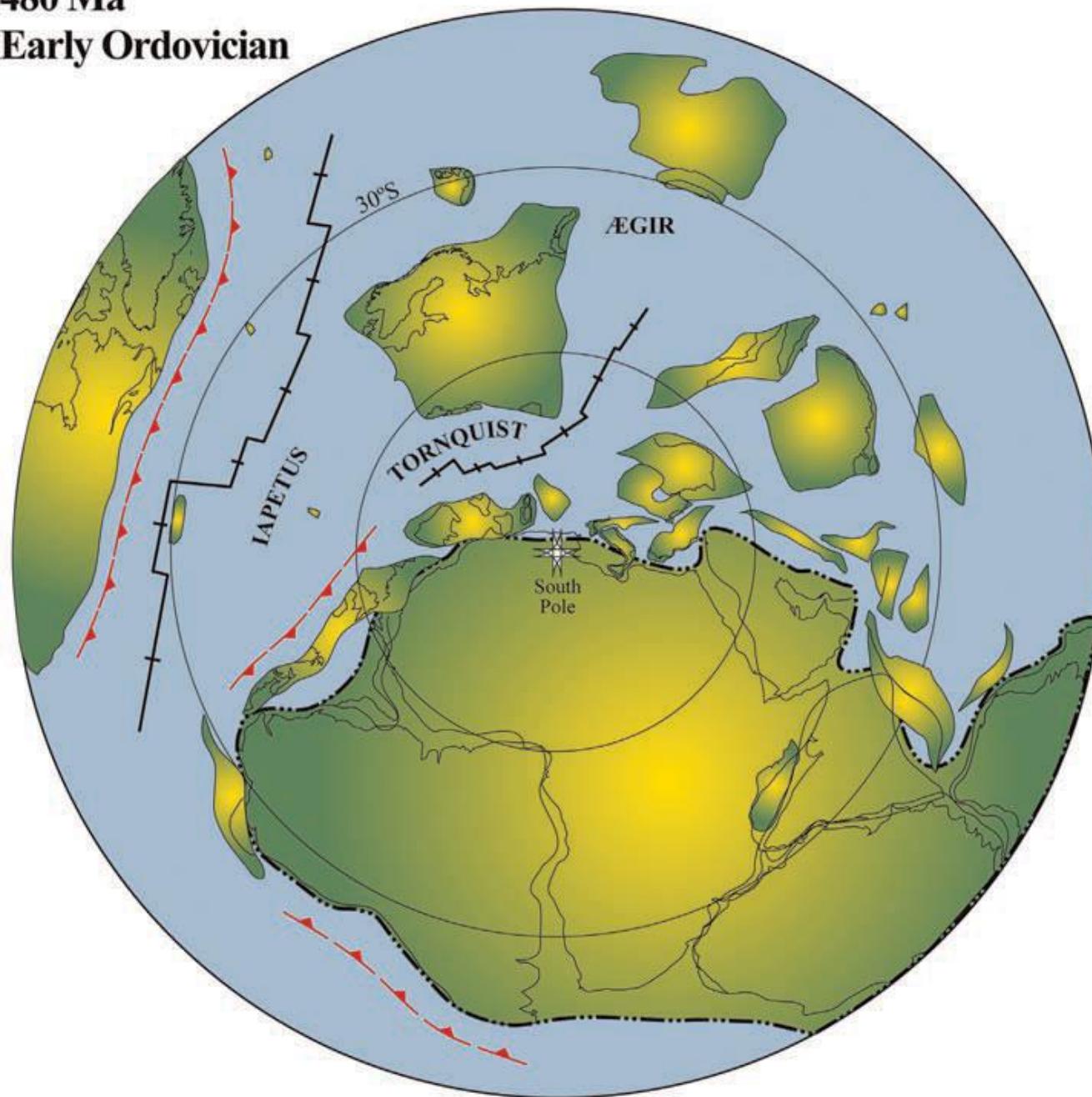
Rifting of Rodinia

- Iapetus Ocean opening
- Northern Britain and Ireland part of Laurentia
- Southern Britain and Ireland still part of Gondwana



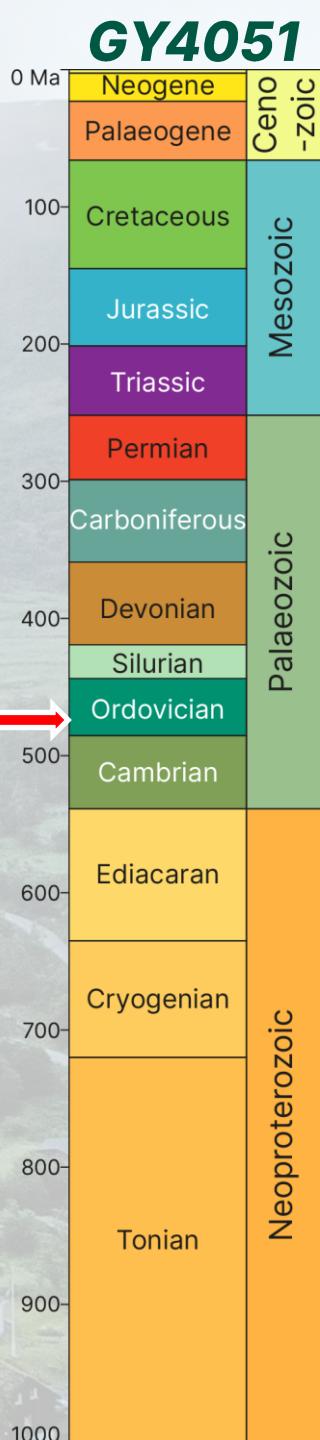
480 Ma

Early Ordovician



Iapetus Ocean starts to close

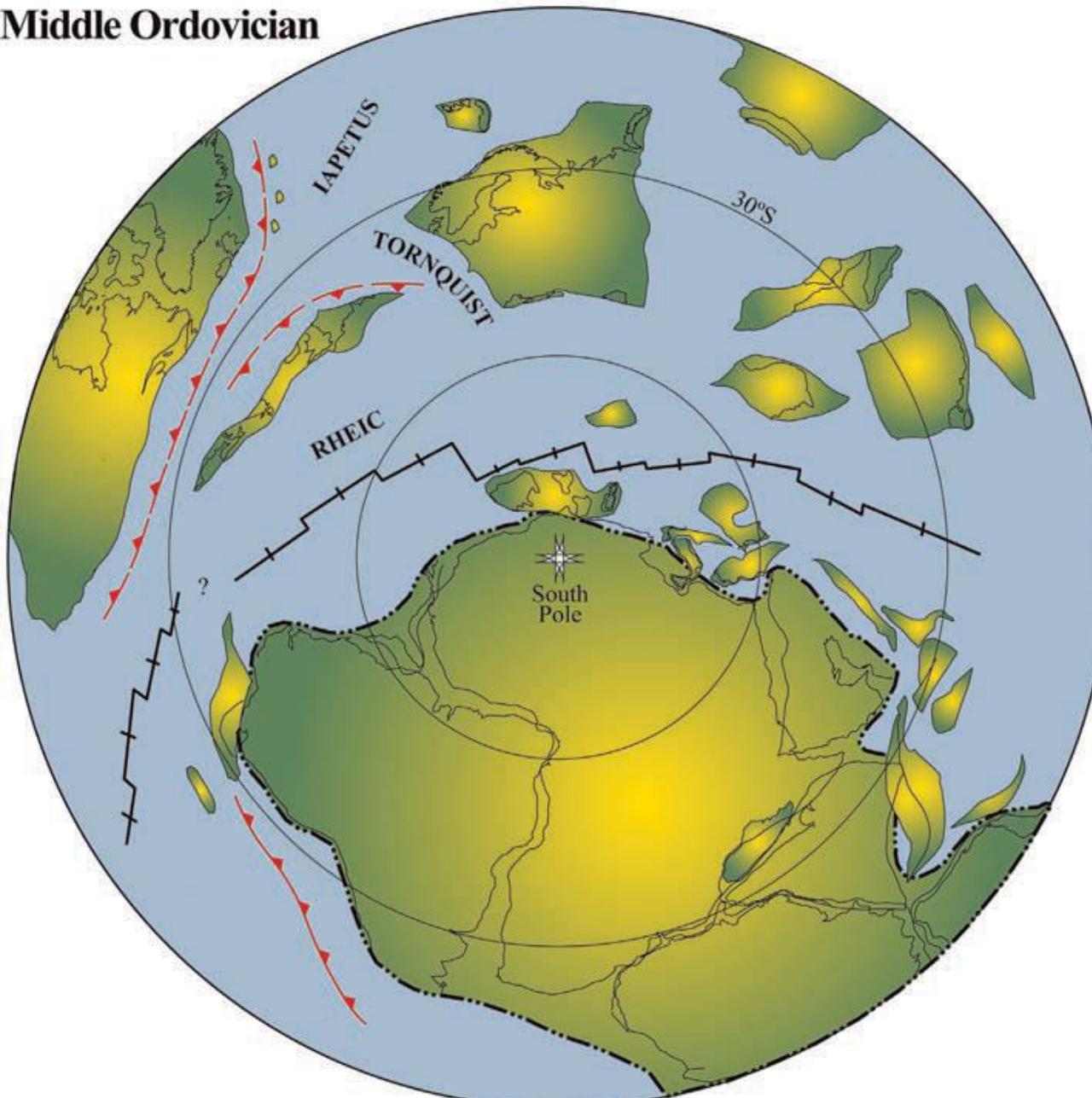
- Southern Britain and Ireland starts to rift from Gondwana
- Becomes microcontinent of Avalonia



Laurentia, Avalonia, and the Iapetus Ocean | Middle Ordovician

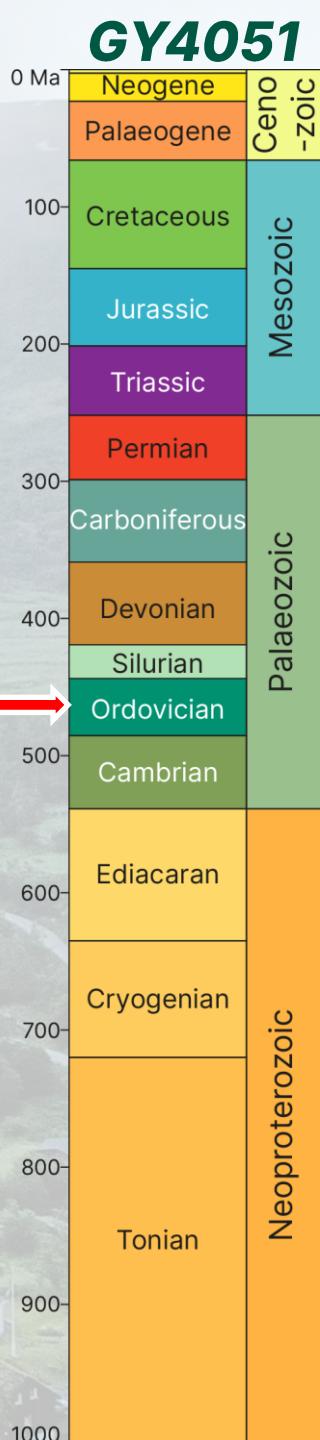
460 Ma

Middle Ordovician



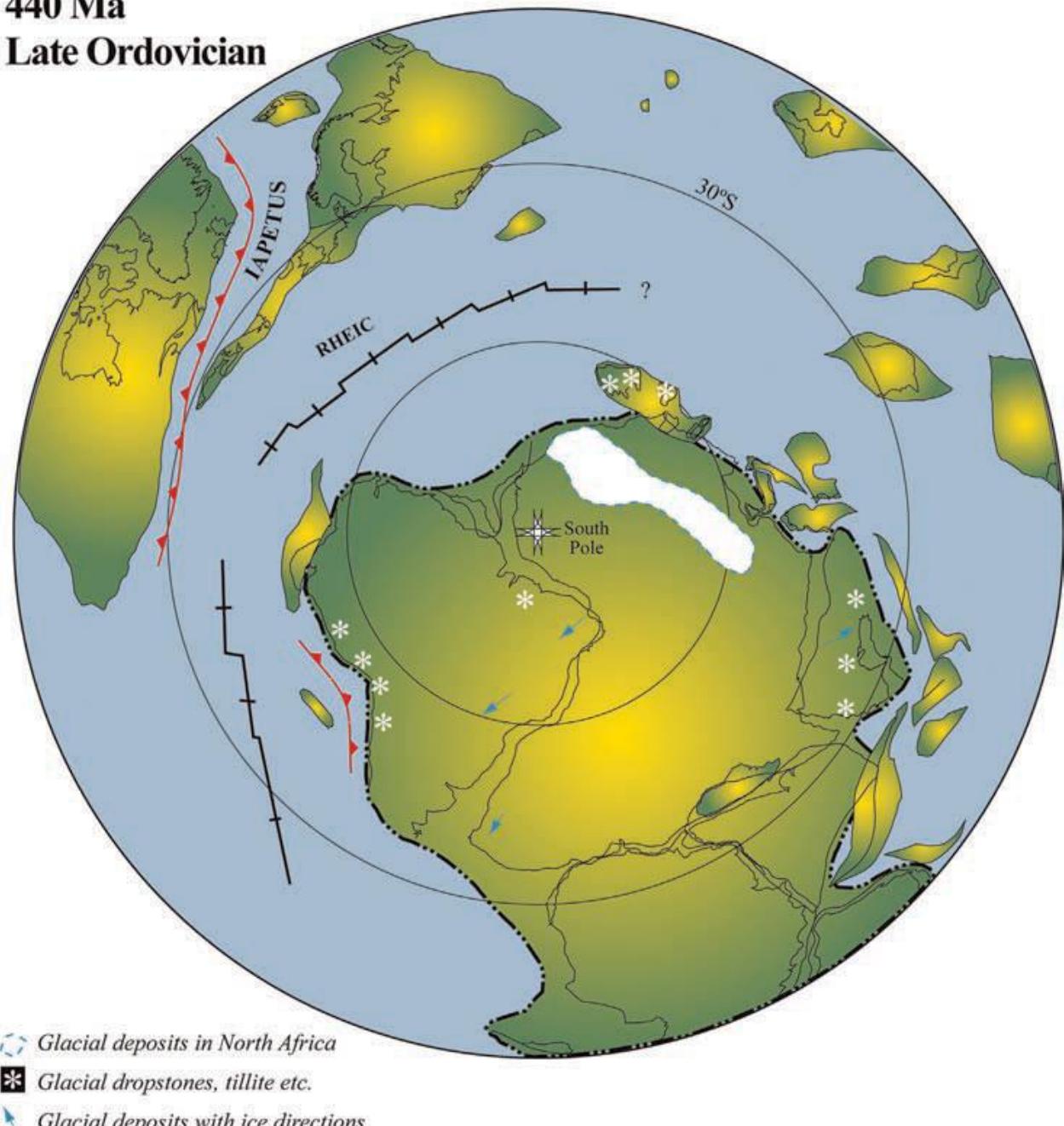
Iapetus Ocean continues to close

- Rheic Ocean opening between Avalonia and Gondwana
- Avalonia moving north towards Laurentia as Iapetus narrows



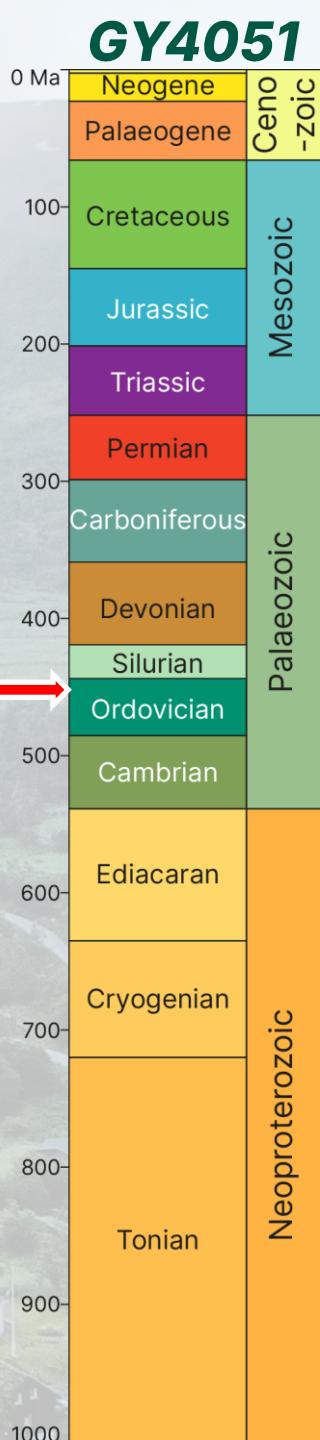
440 Ma

Late Ordovician



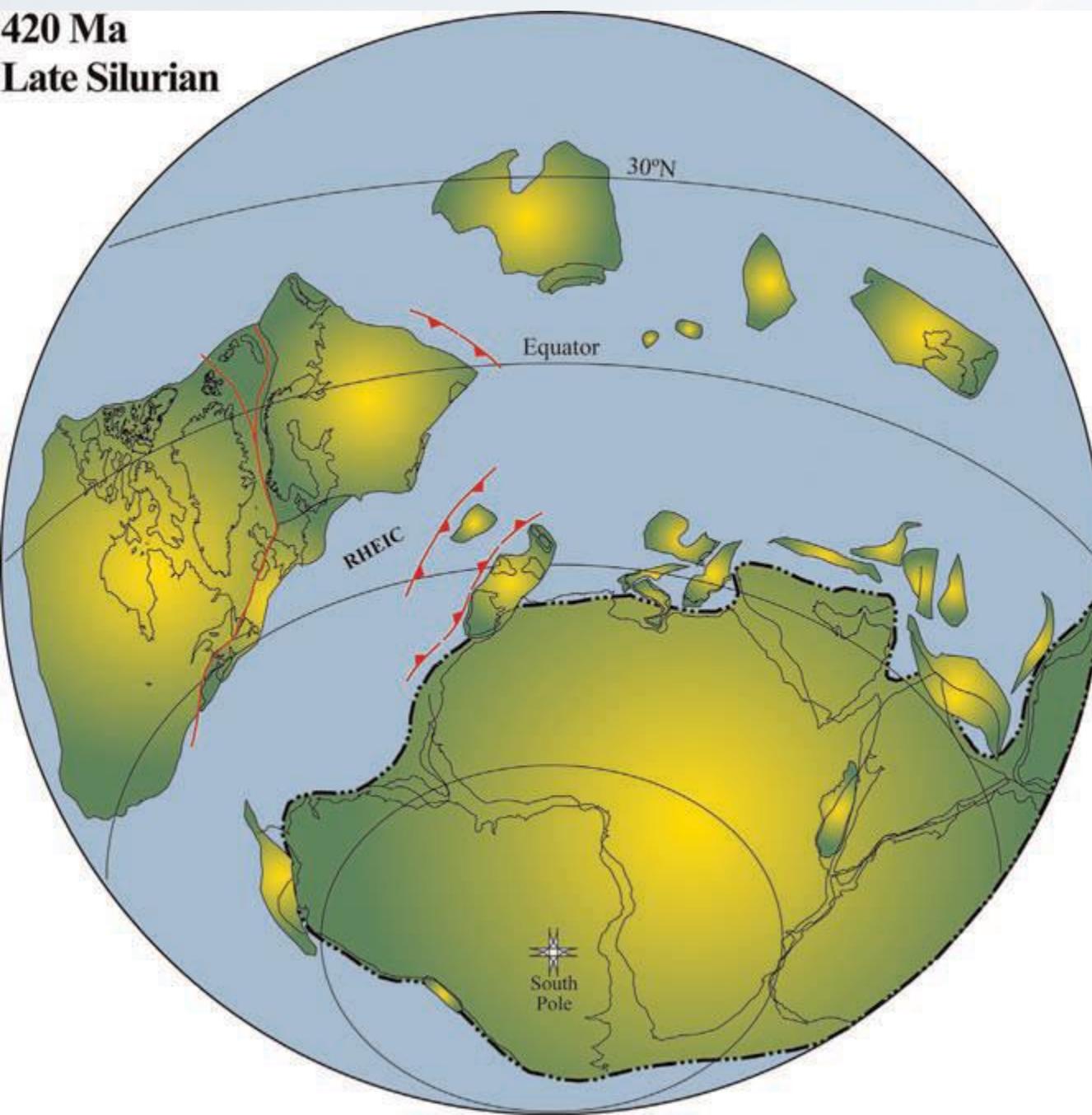
Iapetus Ocean nears the end

- Two halves of Britain and Ireland very close
- Baltica starts to collide with Eastern Avalonia
- Rheic Ocean widening



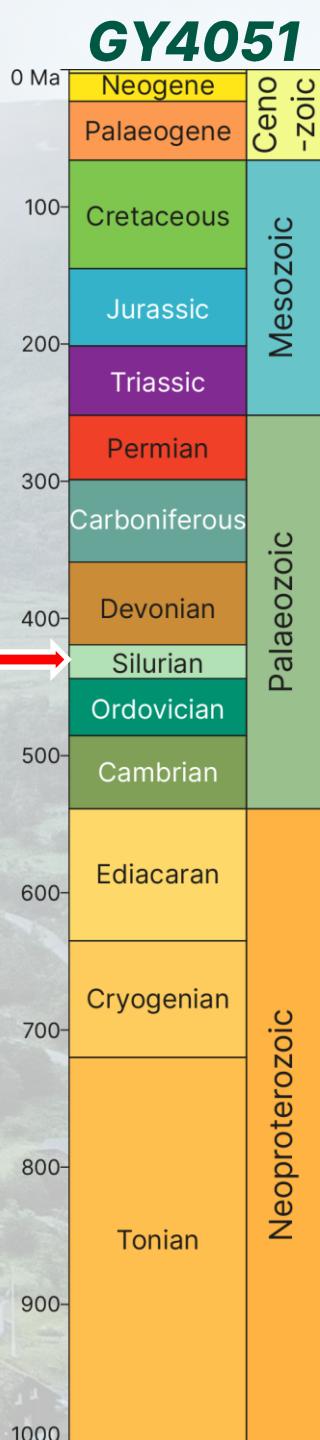
Laurentia, Avalonia, and the Iapetus Ocean | Late Silurian

420 Ma
Late Silurian



Iapetus Ocean is gone

- Avalonia has collided with Laurentia and Baltica in the Caledonian Orogeny
- Continent of Laurussia
- Britain and Ireland joined, separated from Gondwana by the Rheic Ocean





AVALONIA

SUBDUCTION ZONE

VOLCANIC ISLAND ARC

SUBDUCTION ZONE

OCEANIC SPREADING RIDGE

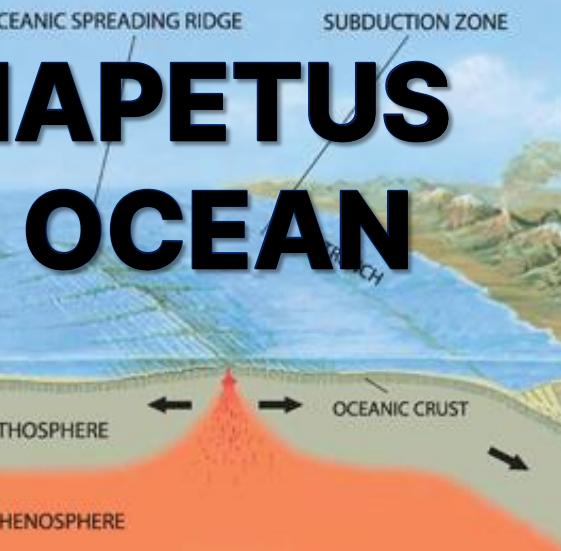
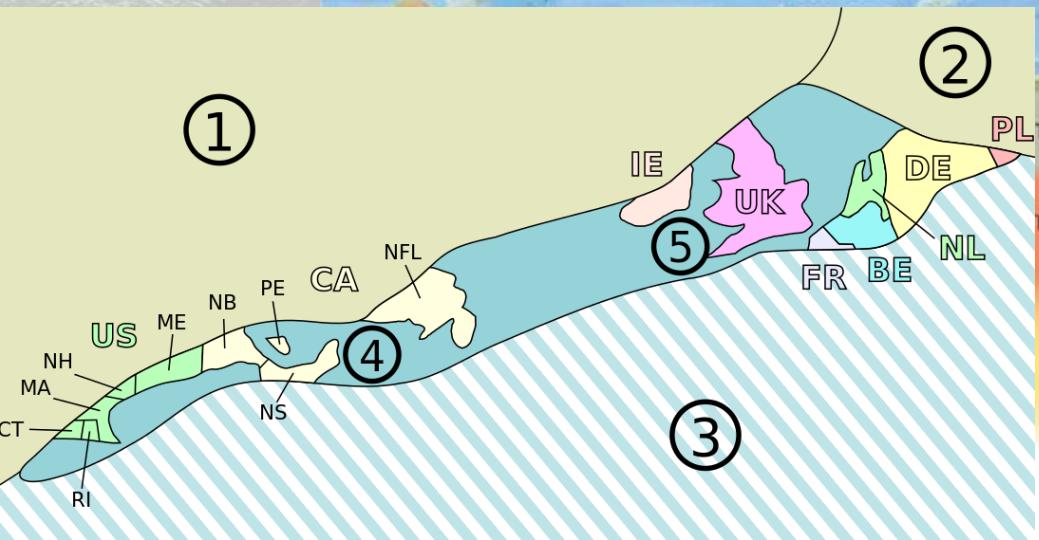
SUBDUCTION ZONE

IAPETUS OCEAN

LAURENTIA

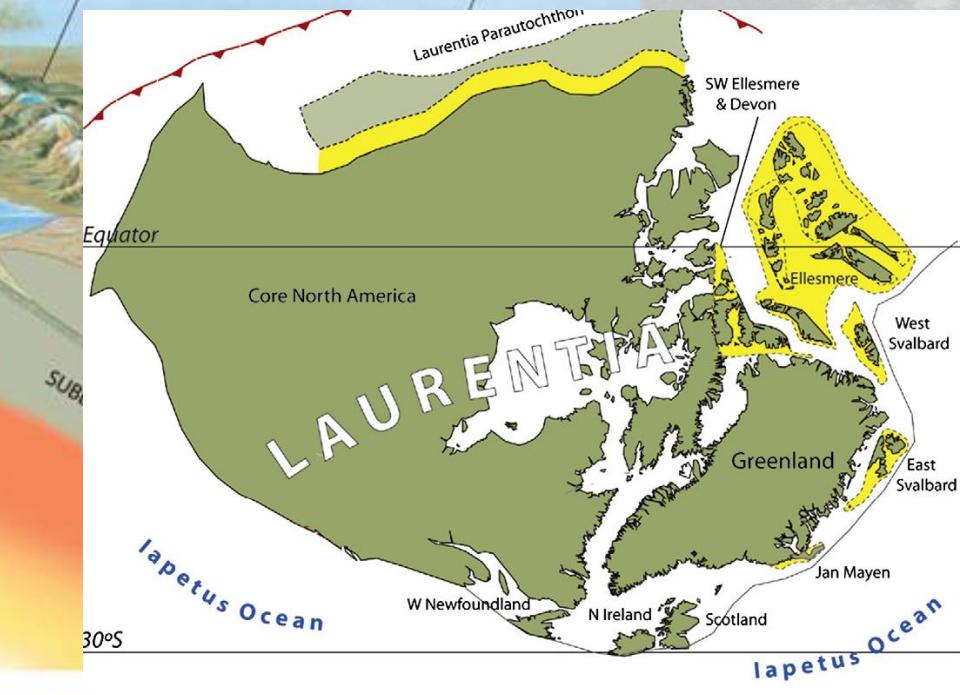
RIFT ZONE

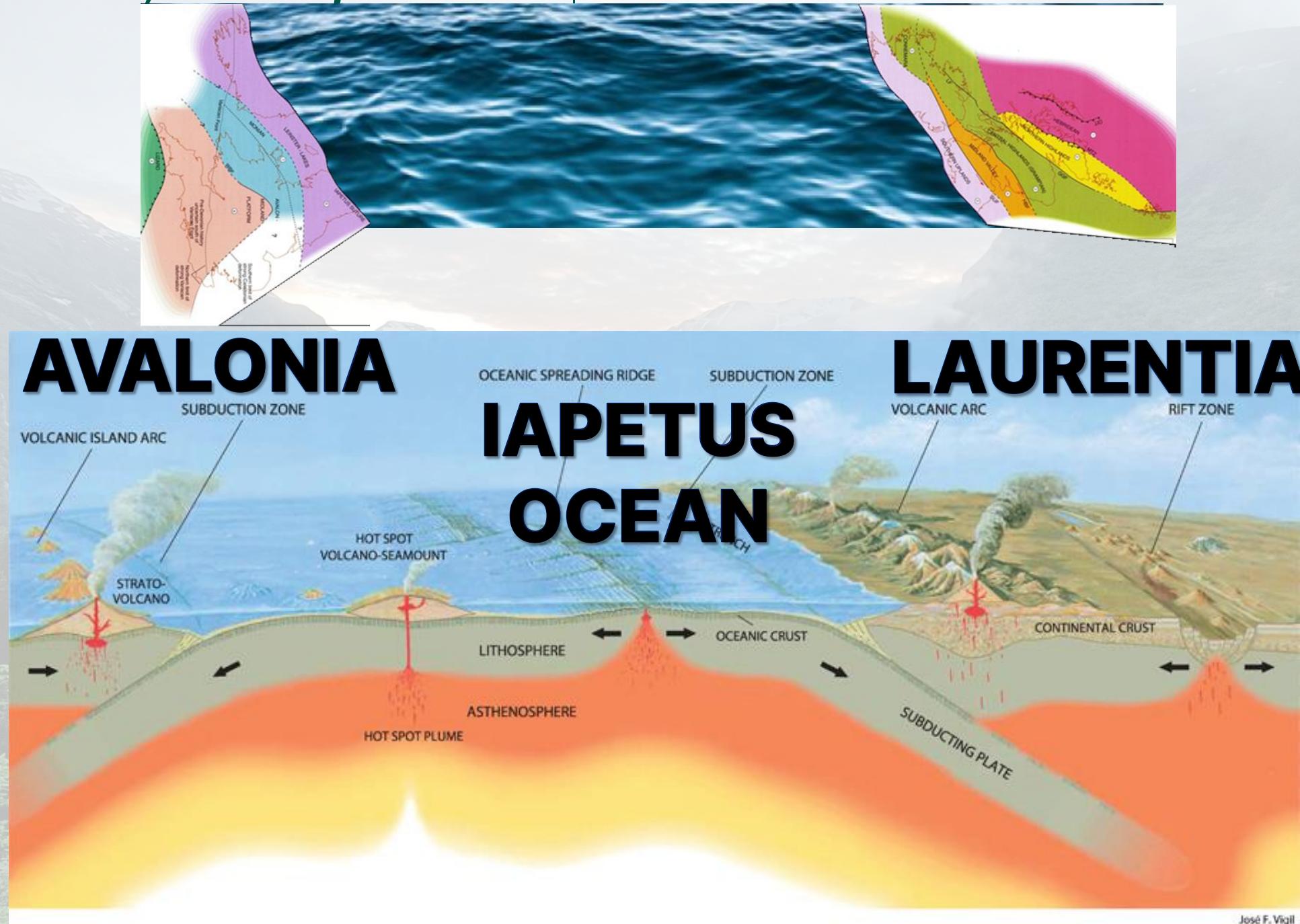
VOLCANIC ARC



LAURENTIA

RIFT ZONE

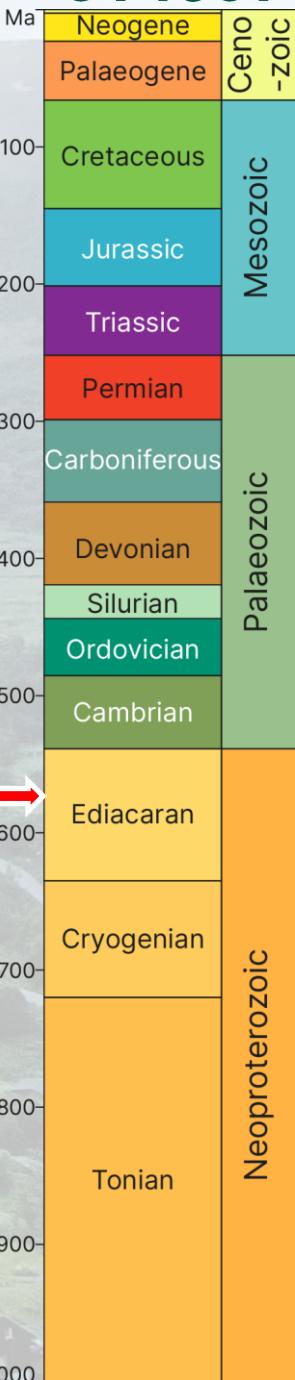




Laurentia, Avalonia, and the Iapetus Ocean | The Laurentian margin

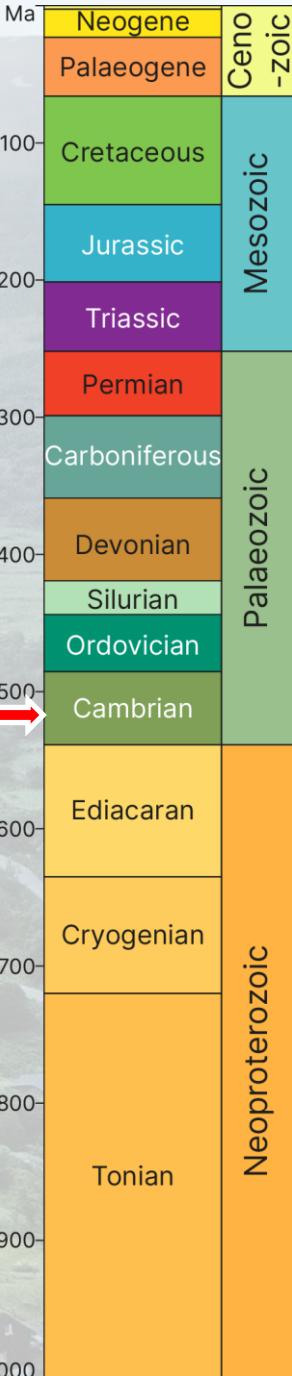
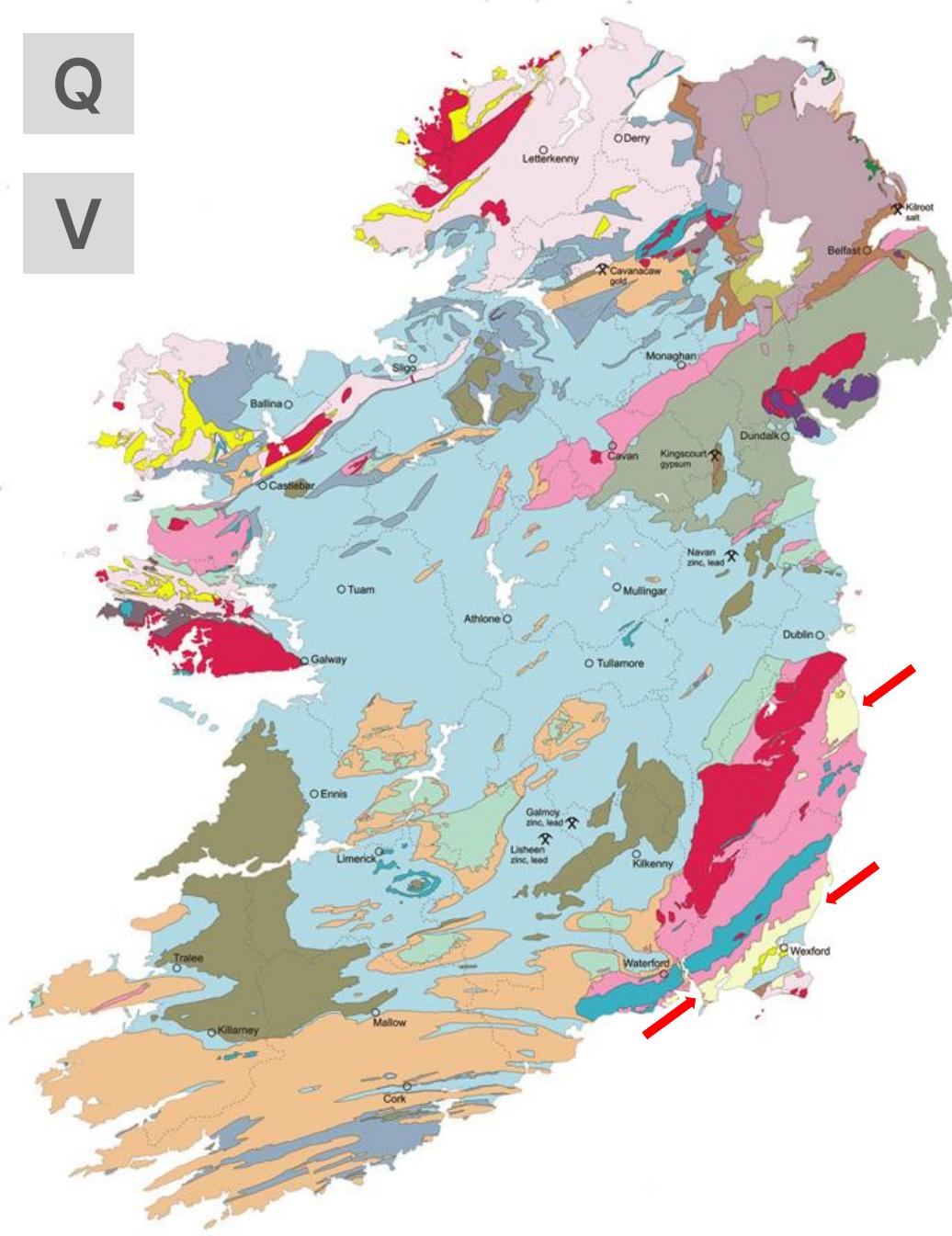
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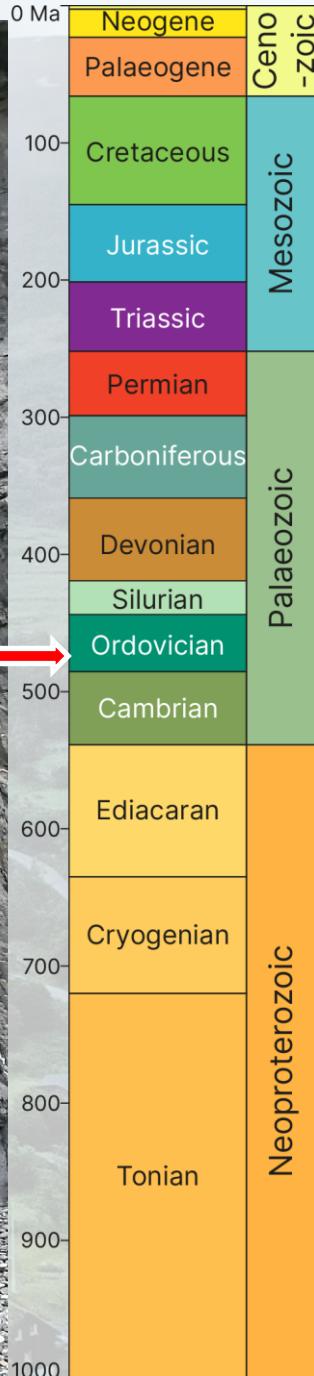
V



Laurentia, Avalonia, and the Iapetus Ocean | Ordovician – Subduction volcanism

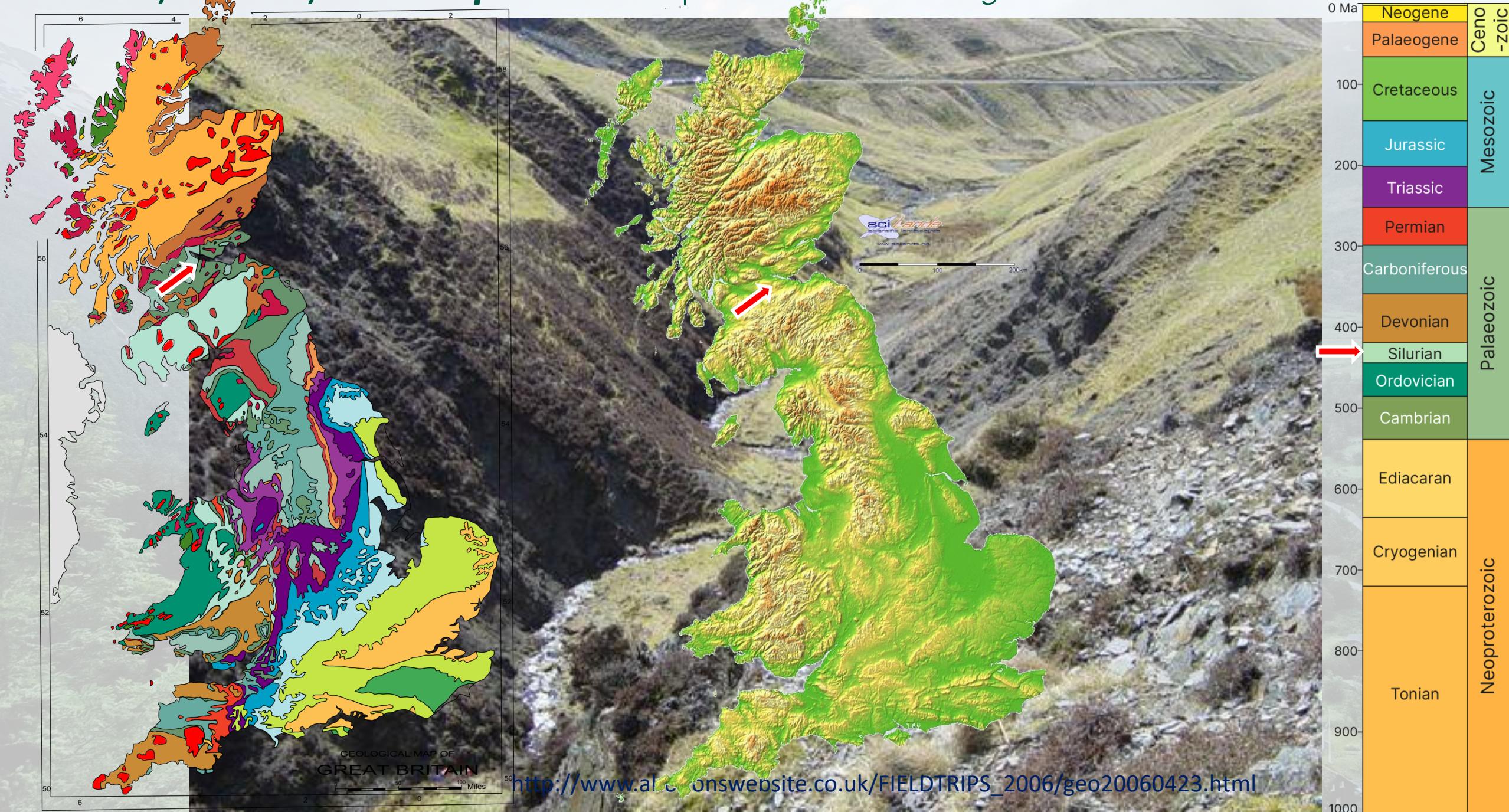
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F



Laurentia, Avalonia, and the Iapetus Ocean | The Laurentian margin

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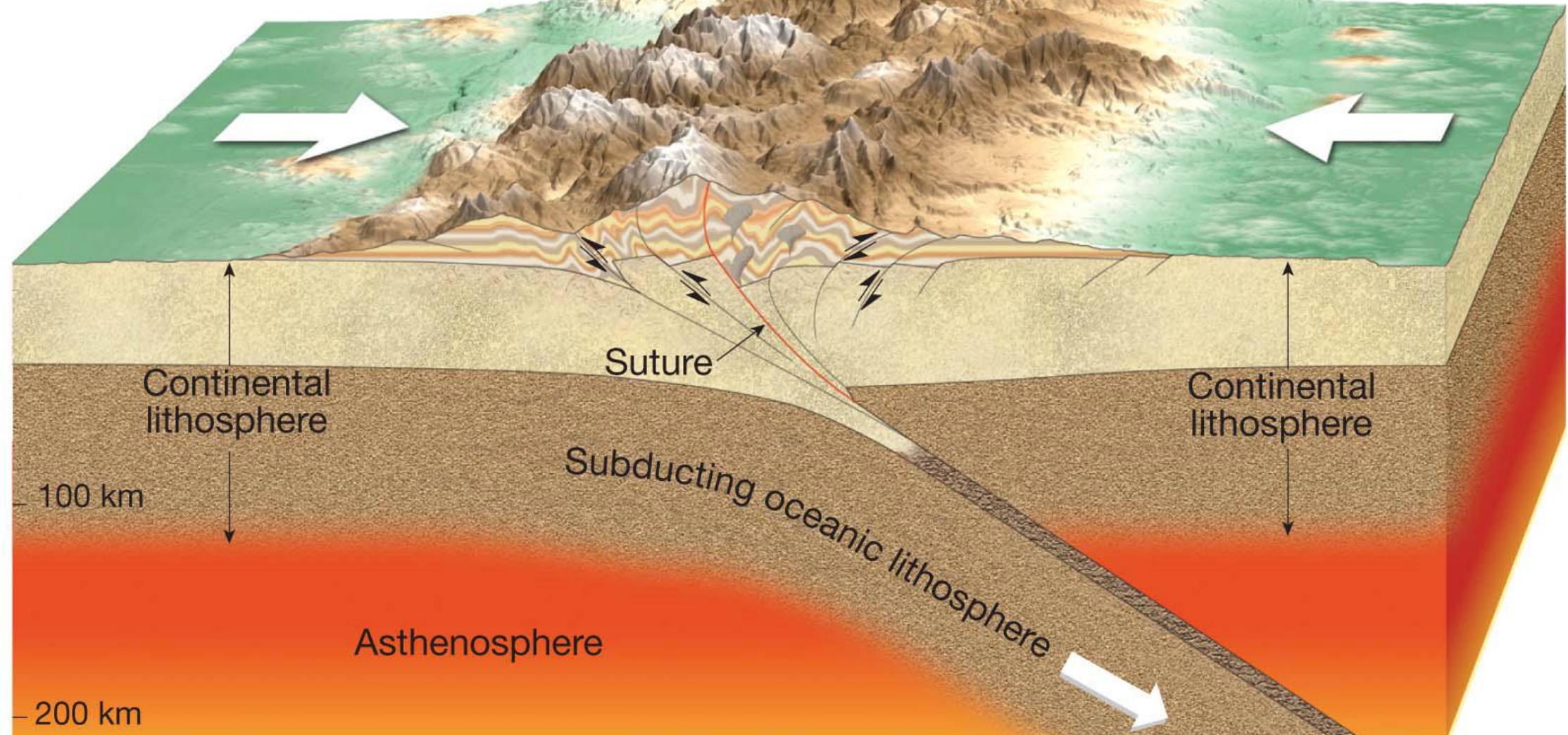


Rise and Fall of The Caledonian Mountains | The Caledonian Mountains

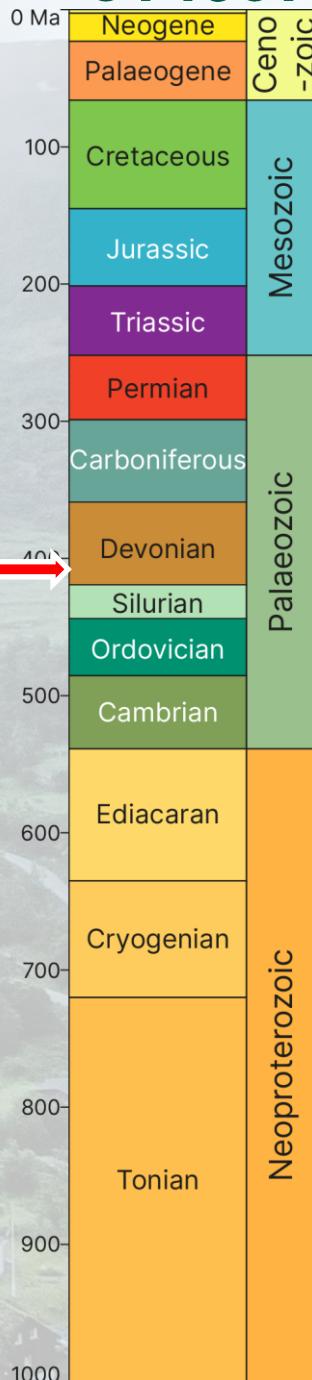
AVALONIA

Collision mountains

LAURENTIA



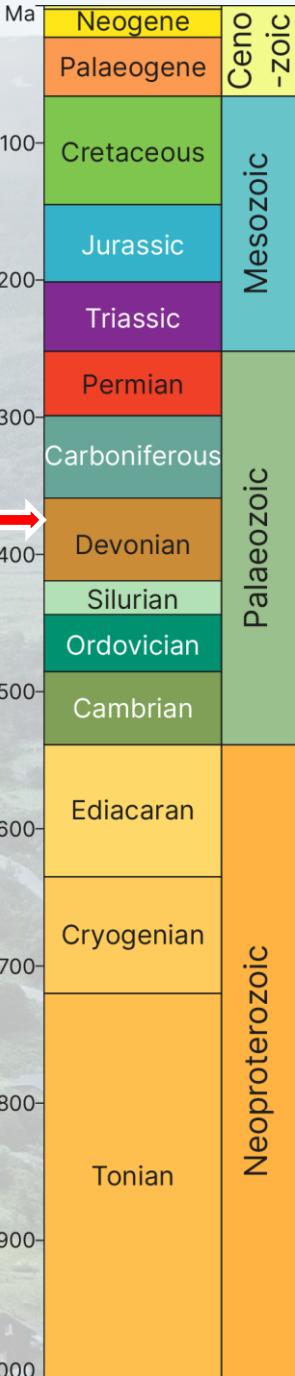
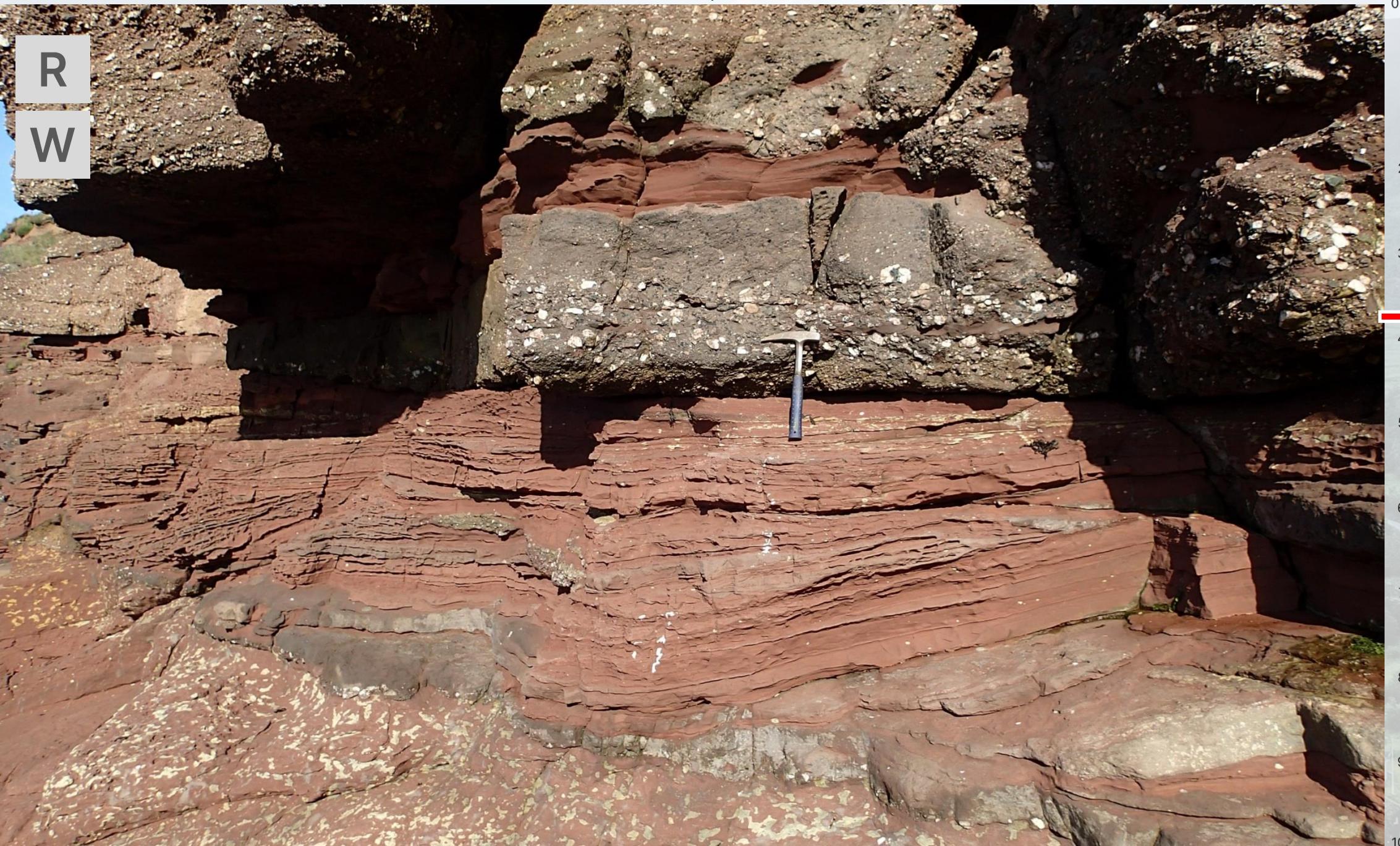
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Rise and Fall of The Caledonian Mountains | Devonian of Ireland

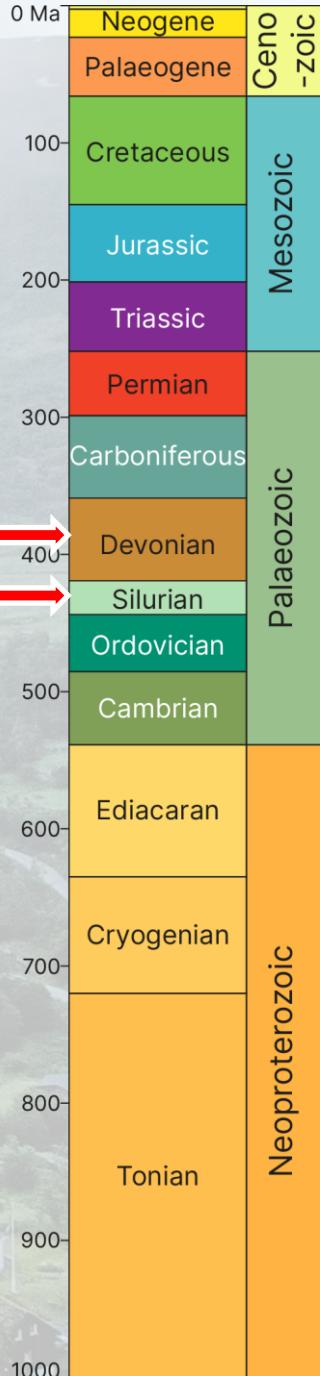
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Rise and Fall of The Caledonian Mountains | Caledonian Granites

GY4051

C

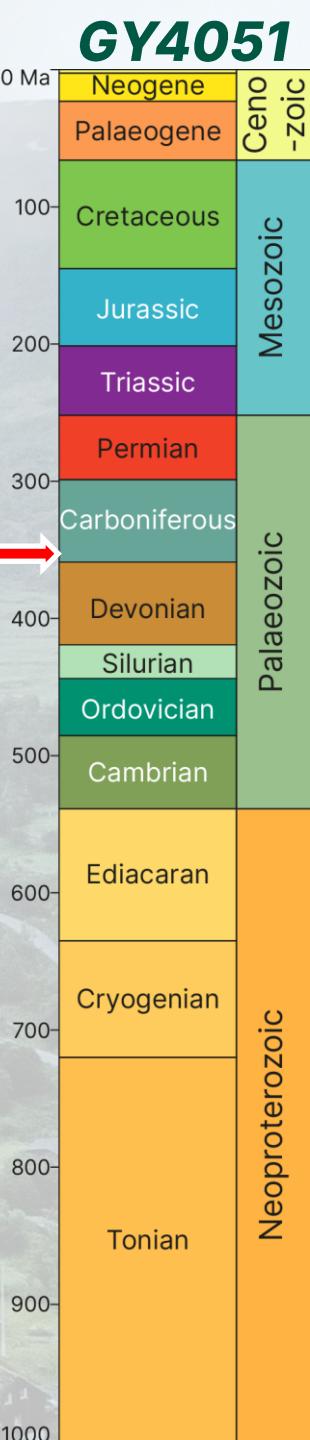


Rise and Fall of The Caledonian Mountains | Marine Transgression

GY4051



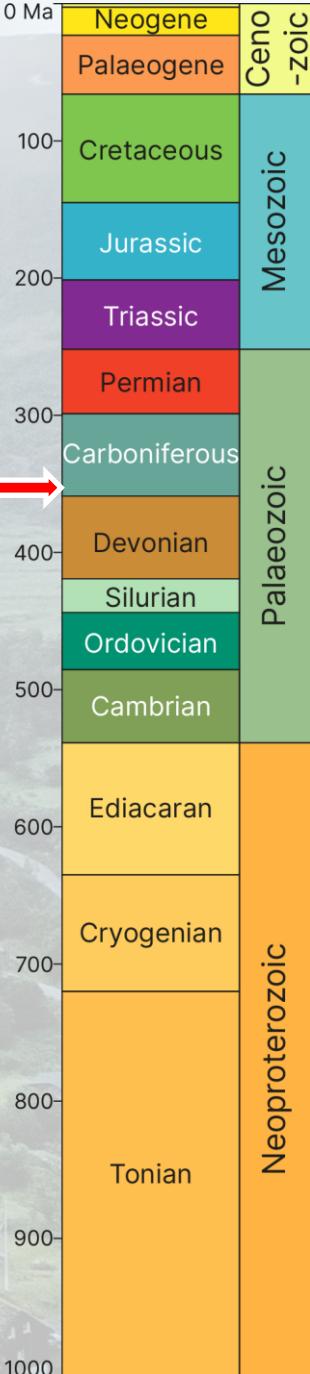
Tropical Ireland | Insert witty joke about the weather here



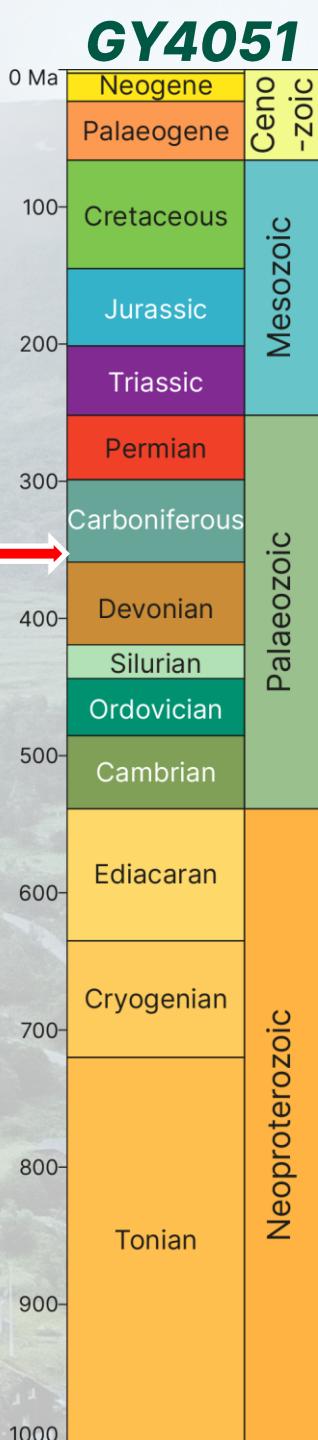
Tropical Ireland | Early Carboniferous

GY4051

AC



Tropical Ireland | Shelf Limestones – LEAD AND ZINC



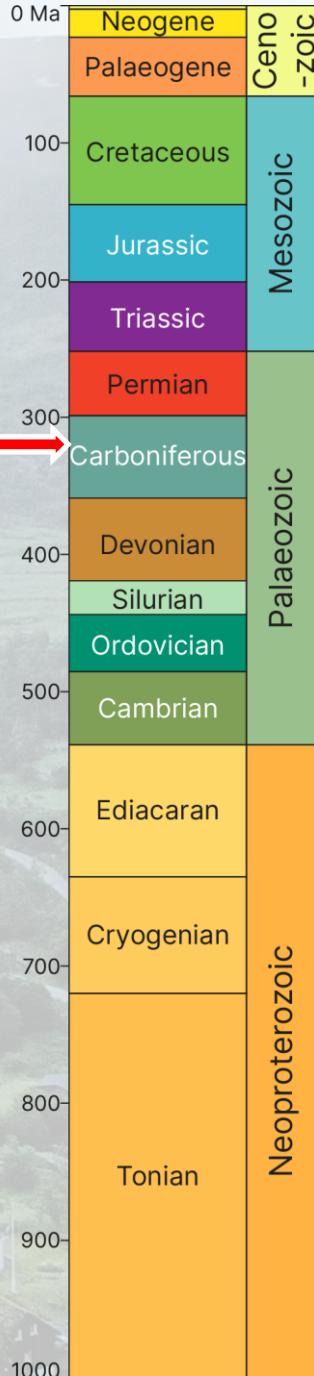
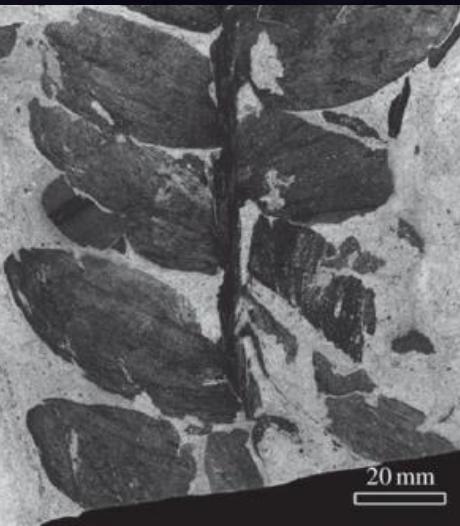
Tropical Ireland | Deltas – the Cliffs of Moher

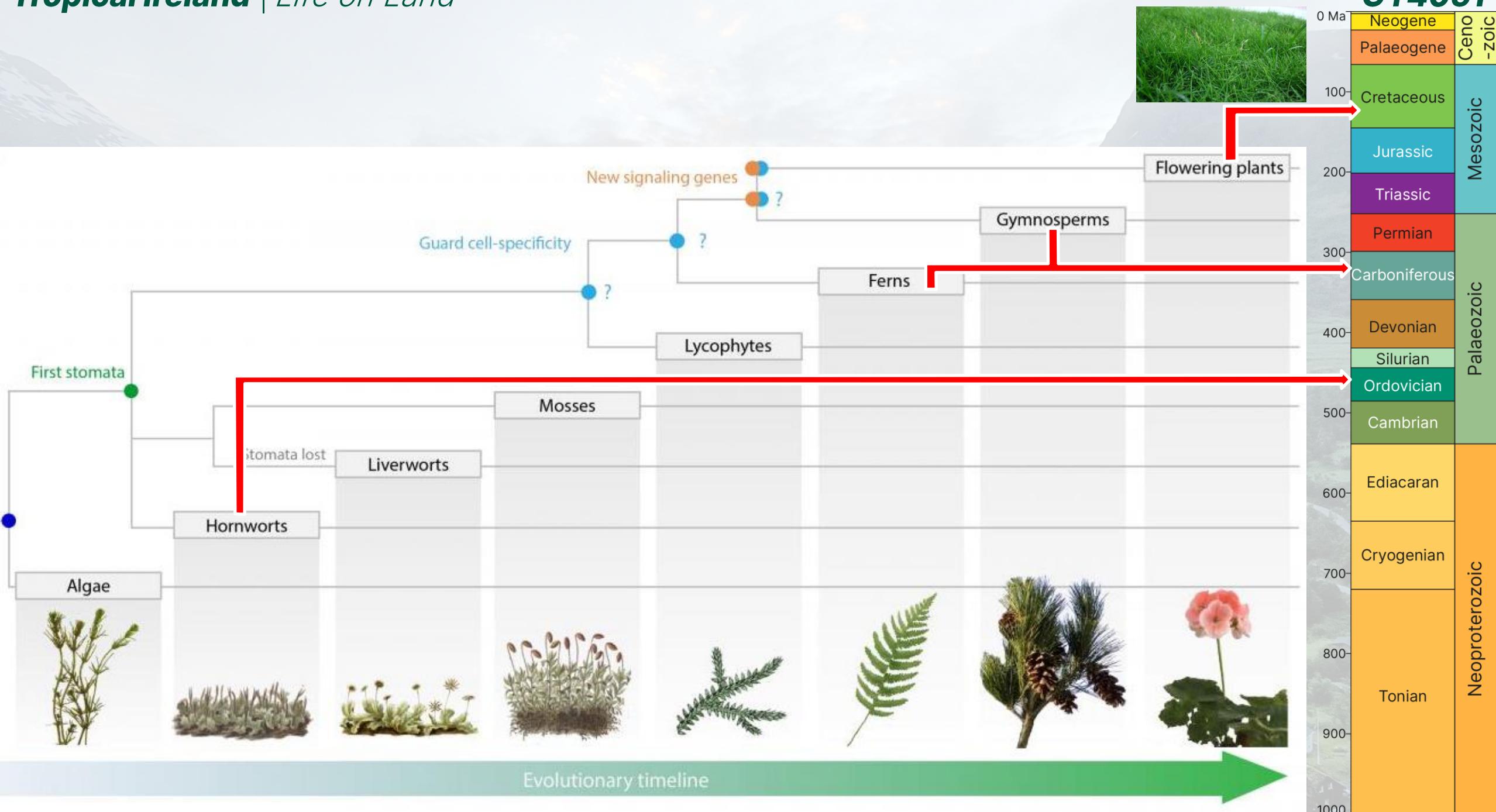
GY4051



Tropical Ireland | Carboniferous Life on Land

GY4051





Osteichthyes: Bony fish

Actinopterygii

- Ray-finned fish
- Appeared in the Silurian
- Fins are webs of skin supported by bony or horny spines
- Most dominant vertebrates on Earth – 99% of fish
- All aqueous settings



Osteichthyes: Bony fish

Sarcopterygii

- **Lobe-finned** fish
- Appeared in the **Silurian**
- **Fins are fleshy**, connected to the body by a single **bone**
- Not common in modern oceans*
- Includes **lungfish**, **coelacanths**, and...

*This is precisely worded...



Tetrapodomorph Osteichthyes

Panderichthys

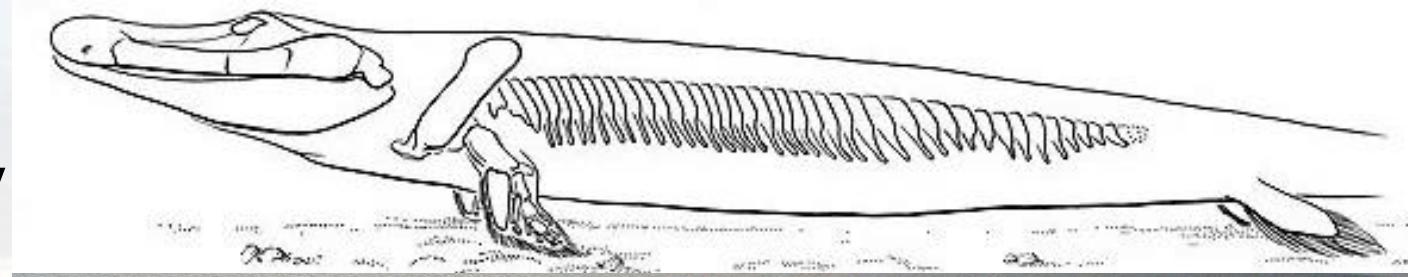
- Lobe-finned fish
- Late Devonian
- Fins are **fleshy**, and **bony**
- Four fins – but no digits
- Lived entirely in water



Tetrapodomorph Osteichthyes

Tiktaalik

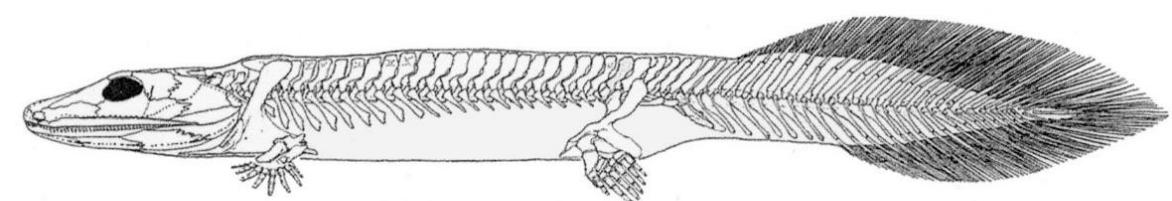
- Fins are **fleshy**, and **bony**
- Four fins – but no digits
- Fish gills and scales
- Flattened head
- Rib bones and lungs
- May not have lived entirely in water



Tetrapodomorph Osteichthyes

Acanthostega

- Fins are **fleshy**, and **bony**
- **Four** fins – each with 8 digits
- Fish gills and scales
- Flattened head
- Rib bones and lungs
- May have lived in shallow swamps



100mm

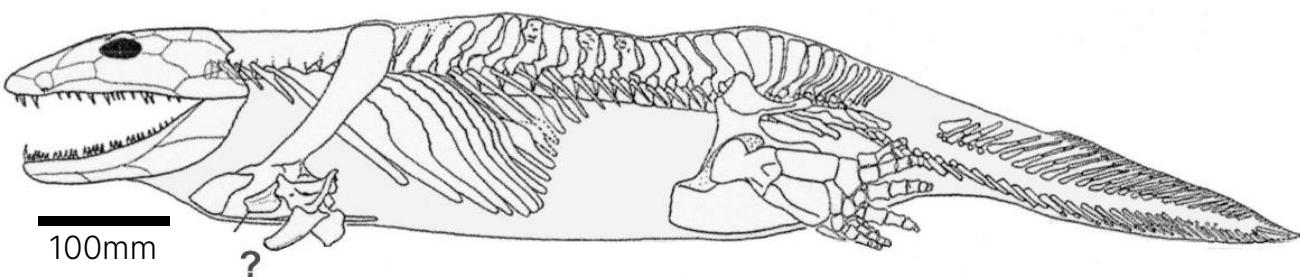
Acanthostega



Tetrapodomorph Osteichthyes

Icthyostega

- Fins are **fleshy**, and **bony**
- **Four** fins – each with 7 digits
- Fish gills
- Flattened head
- Strong forelimbs
- Strong ribcage and lungs
- Could swim and walk (ish) on land





Tetrapods

Amphibians

- Limbs with **elbows/knees** and **ankles/wrists**
- Four limbs – each **pentadactyl**, with 5 digits
- Some still have gills
- Strong ribcage and lungs
- Could swim and walk on land
- Laid eggs in water



Colosteus

Greererpeton



Balanerpeton: One of the oldest temnospondyls

0 Ma
Neogene
Palaeogene

Ceno-
zoic

100
Cretaceous

Mesozoic

200
Jurassic

300
Triassic

300-400
Permian

400-500
Carboniferous

400-500
Devonian

500-600
Silurian

500-600
Ordovician

600-700
Cambrian

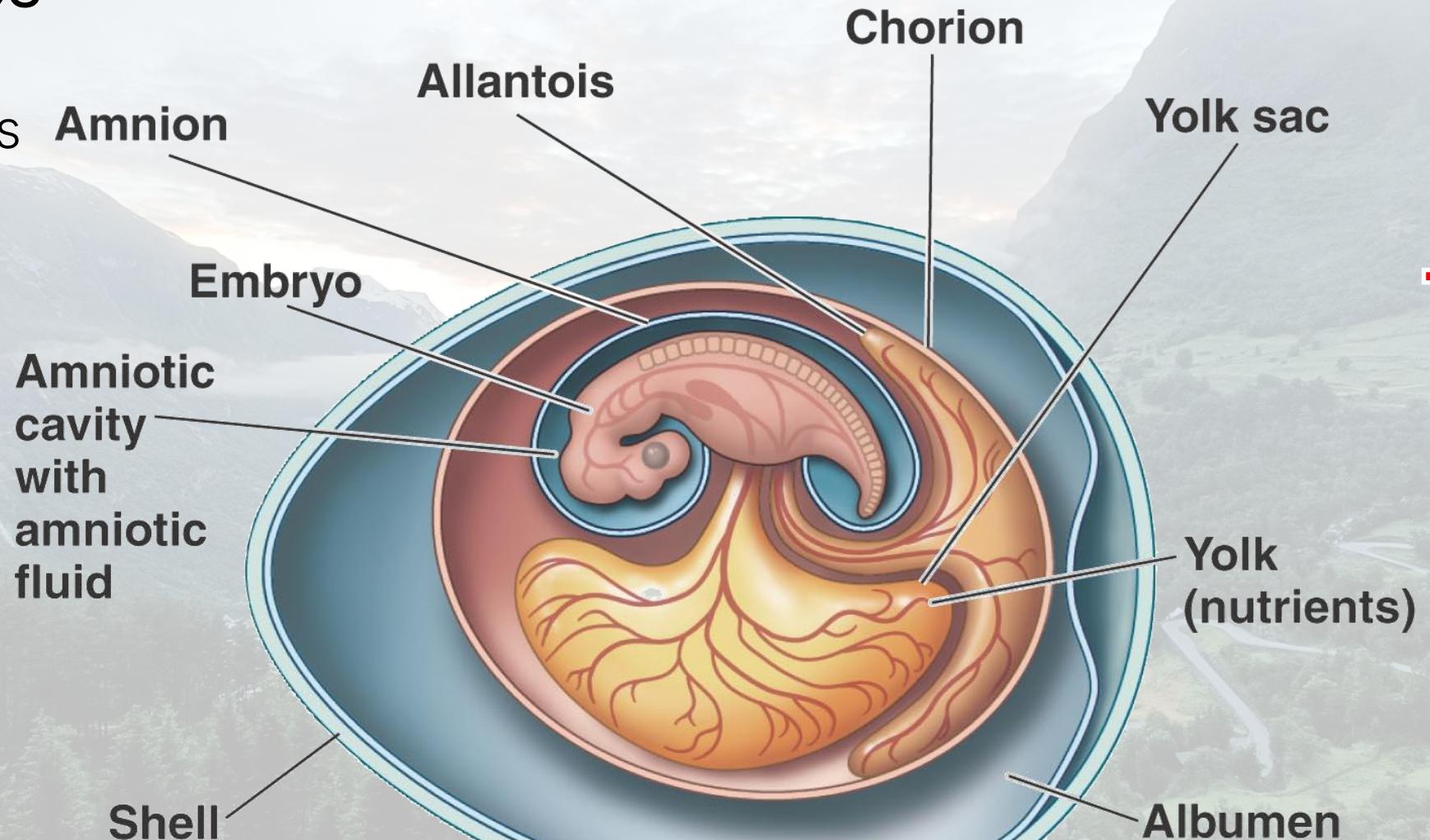
700-800
Ediacaran

800-900
Cryogenian

1000
Tonian

Amniotic Eggs

Major
Carboniferous innovation



0 Ma
Neogene
Palaeogene

Ceno-zoic

100
Cretaceous

200
Jurassic

300
Triassic

300
Permian

300
Carboniferous

400
Devonian

500
Silurian

500
Ordovician

600
Cambrian

600
Ediacaran

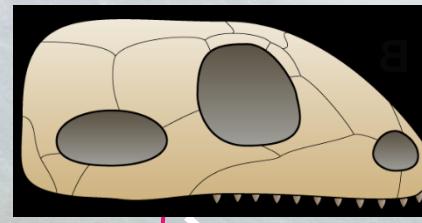
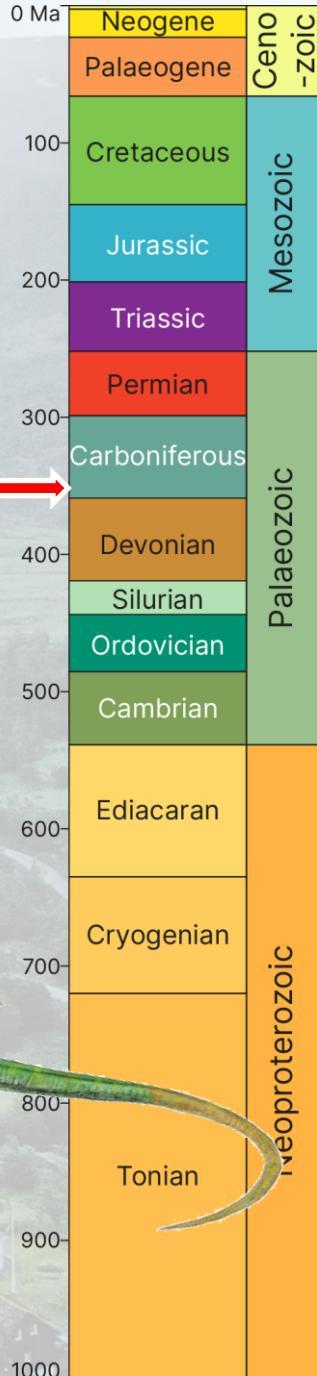
700
Cryogenian

800
Tonian

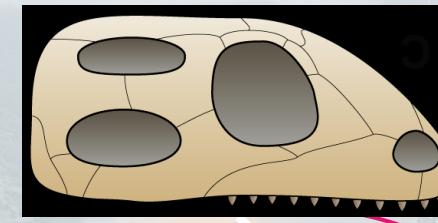
Neoproterozoic

900

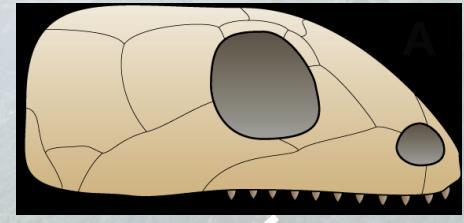
1000



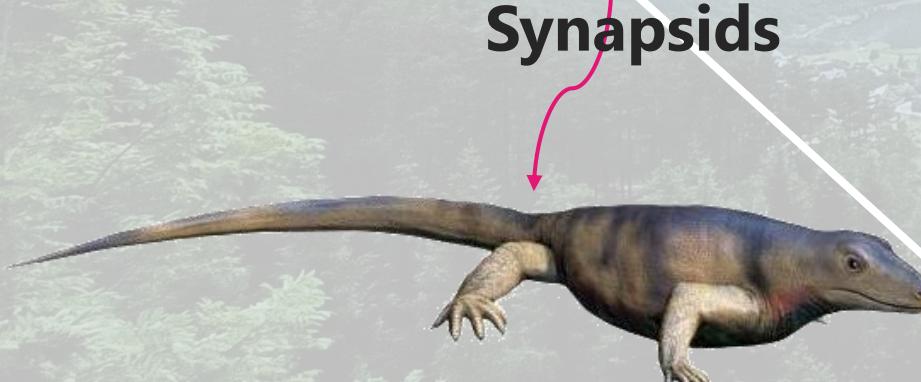
Synapsids



Diapsids

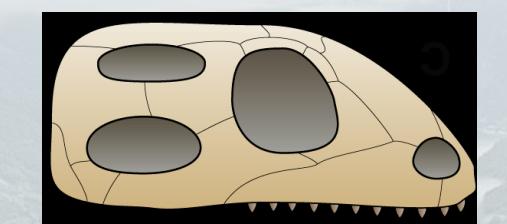
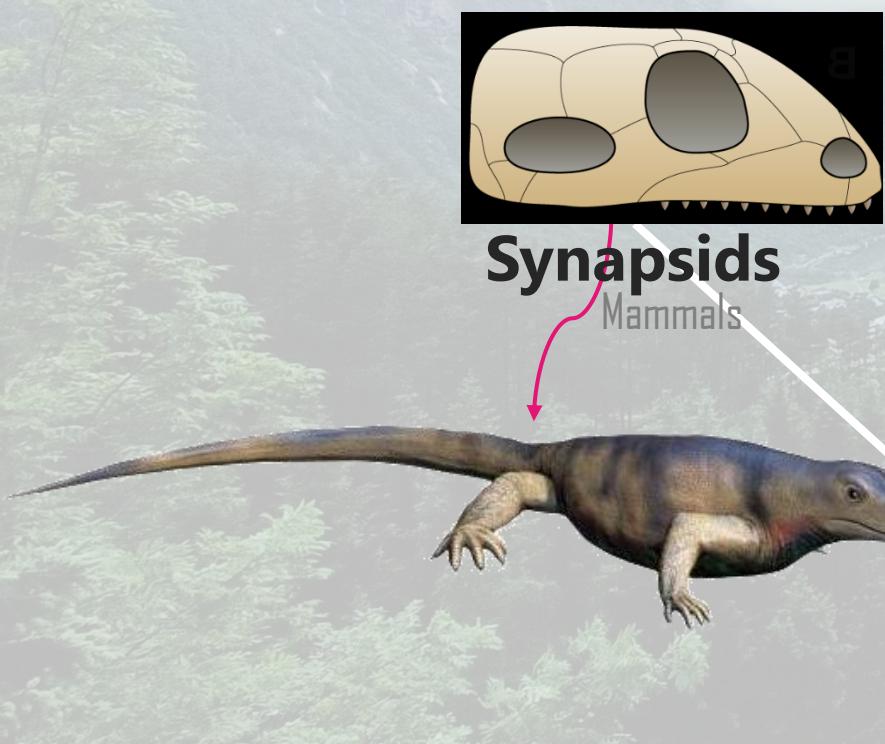
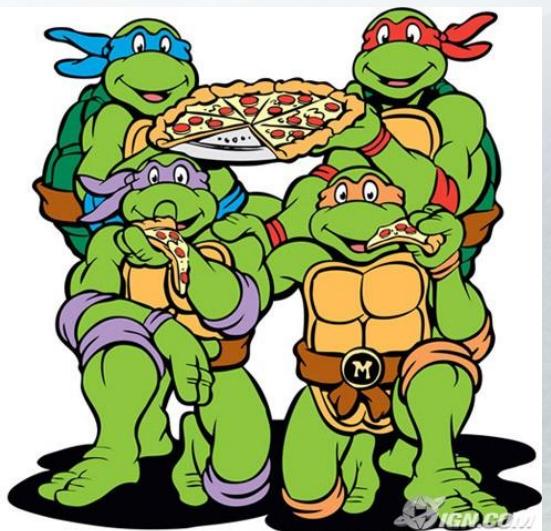


Anapsids

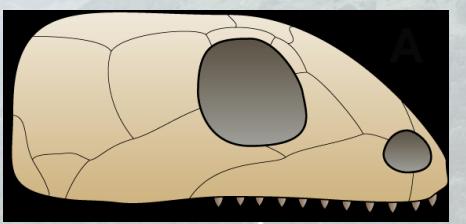


Amniota
Amniotic egg

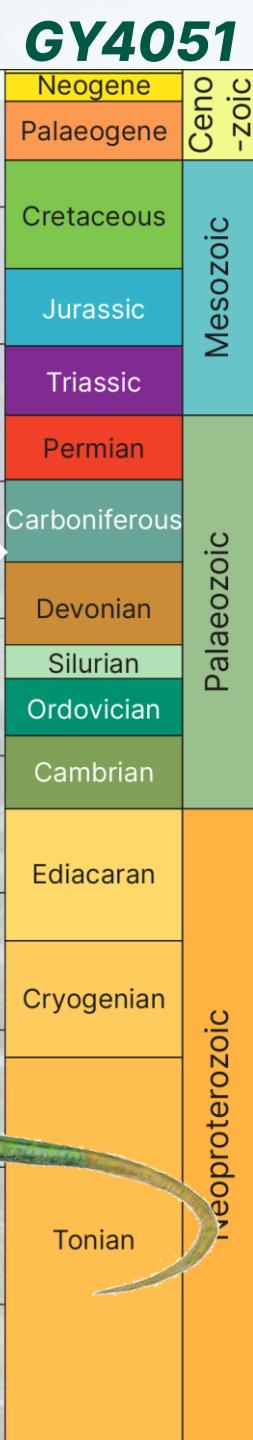




Diapsids
Modern reptiles, birds



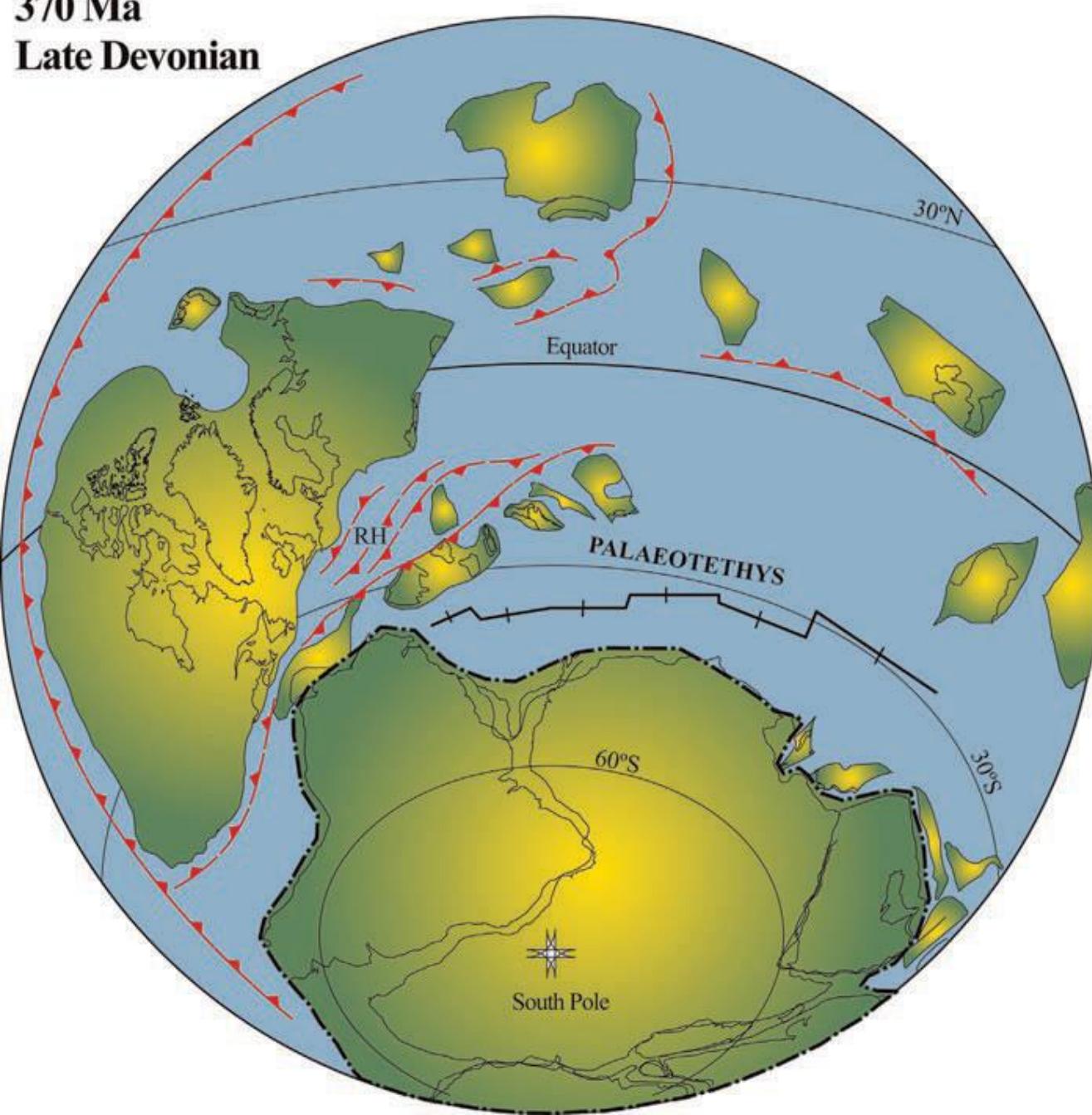
Anapsids
Turtles



Rise and Fall of The Caledonian Mountains | Late Devonian

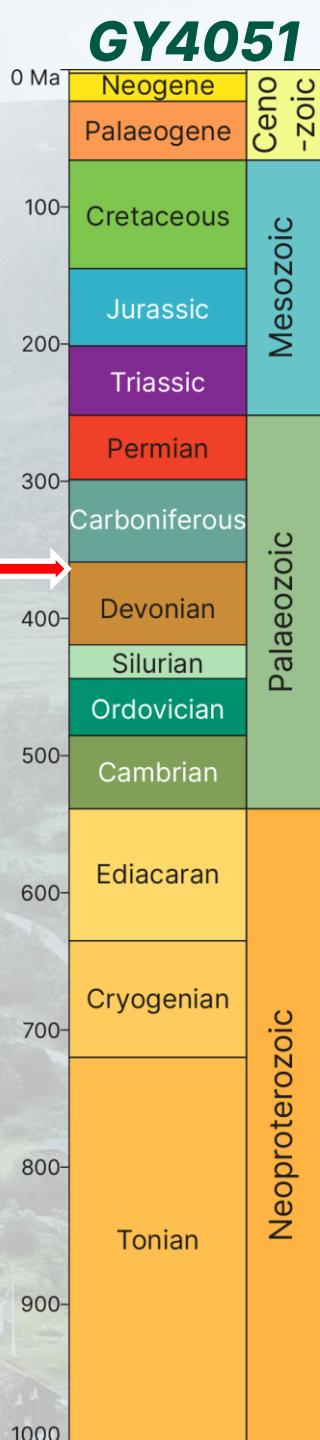
370 Ma

Late Devonian



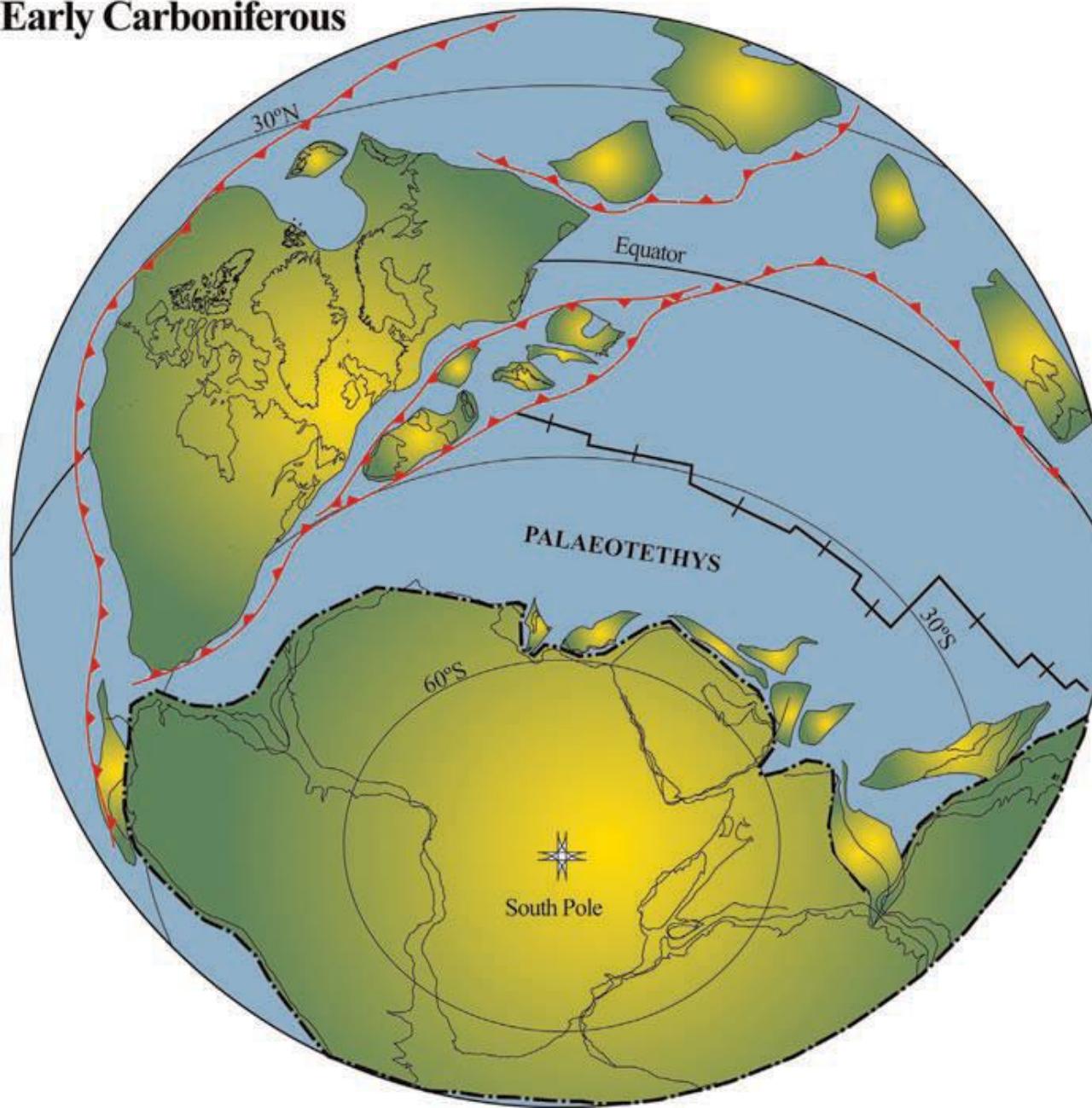
Tethys Ocean continues to open

- Rheic Ocean is nearly gone
- European microcontinents approaching Britain and Ireland



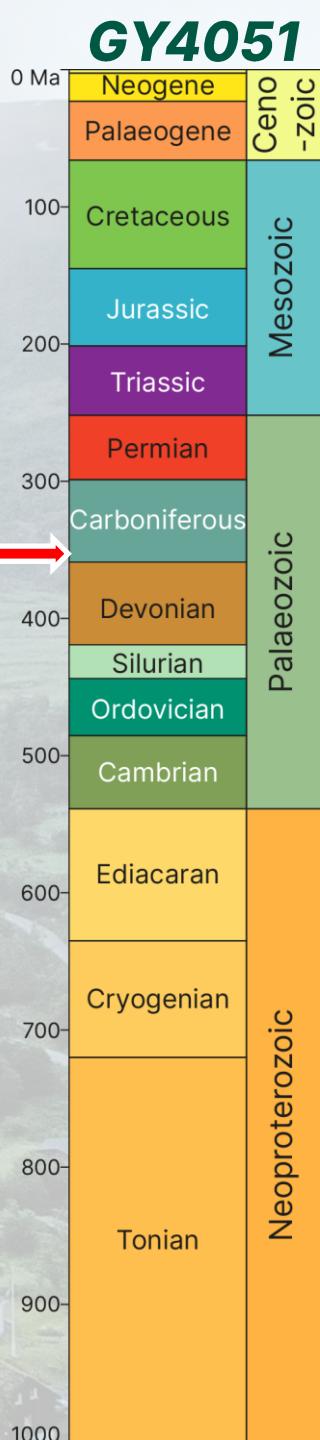
340 Ma

Early Carboniferous



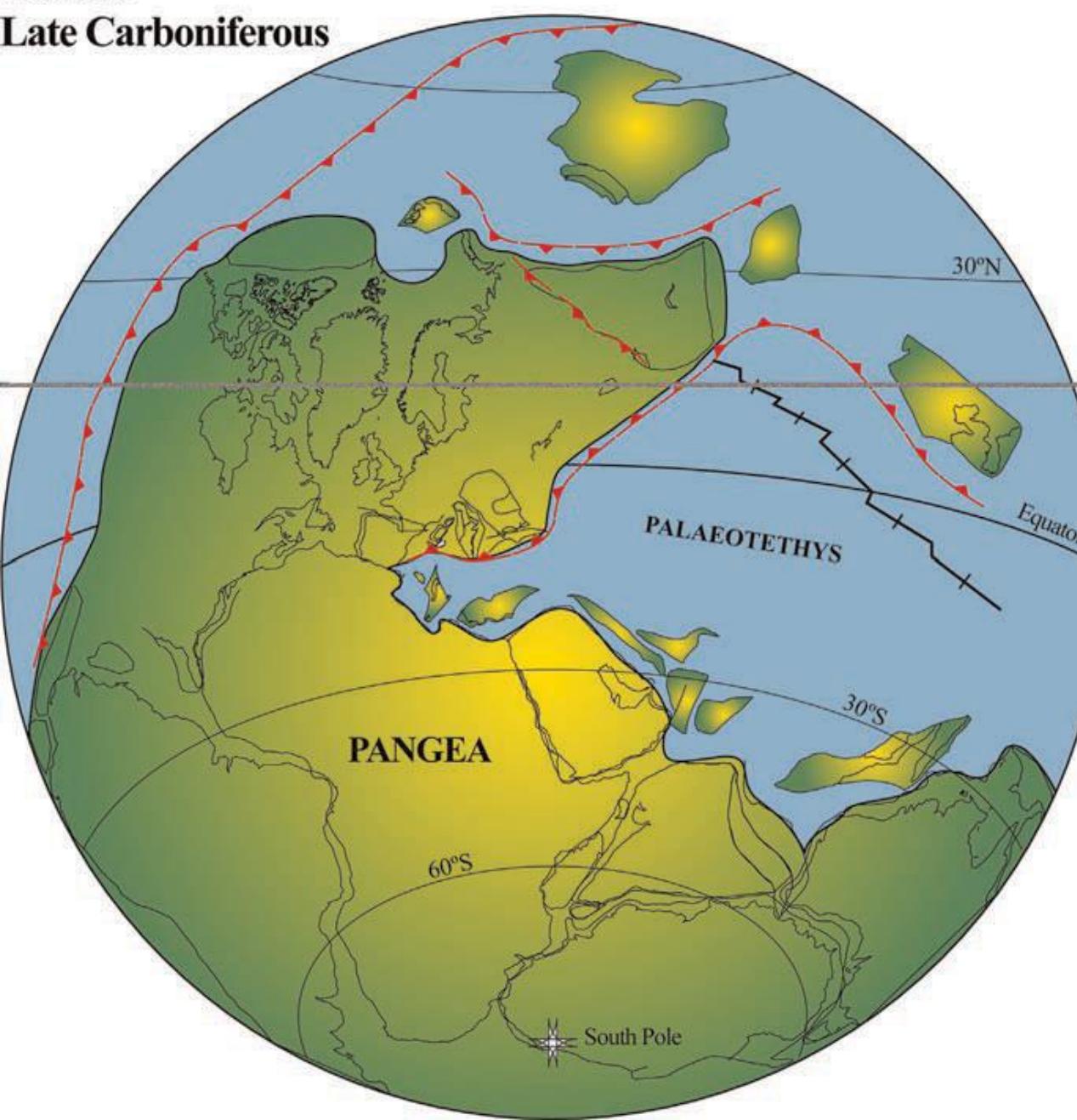
Rheic Ocean almost closed

- Tethys Ocean very wide
- Britain and Ireland tropical
- Gondwana closing on Laurussia



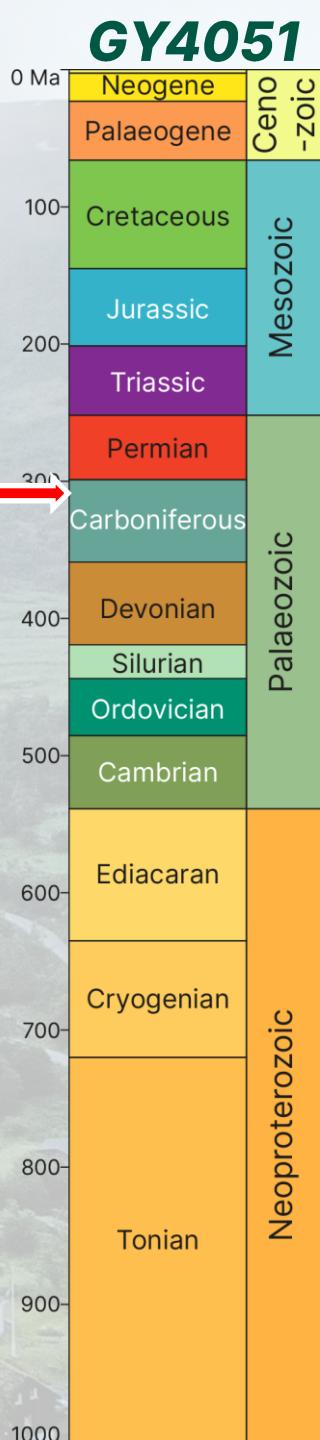
310 Ma

Late Carboniferous

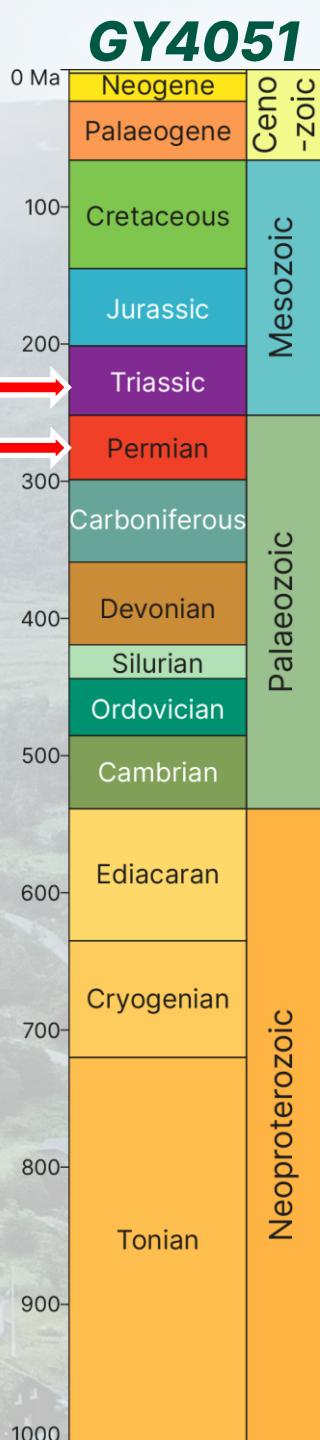


Variscan Orogeny

- Gondwana collided with Laurussia
- European microcontinents collided with Laurussia
- Supercontinent of Pangaea



Desert sandstone | Belfast, Co. Antrim





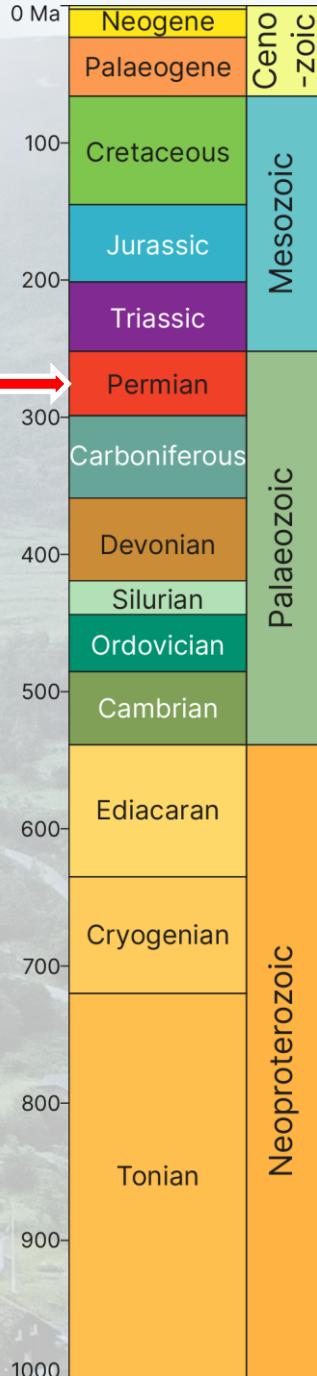
Synapsids

Cynodonts

- Ancestral to Mammals



Procynosuchus

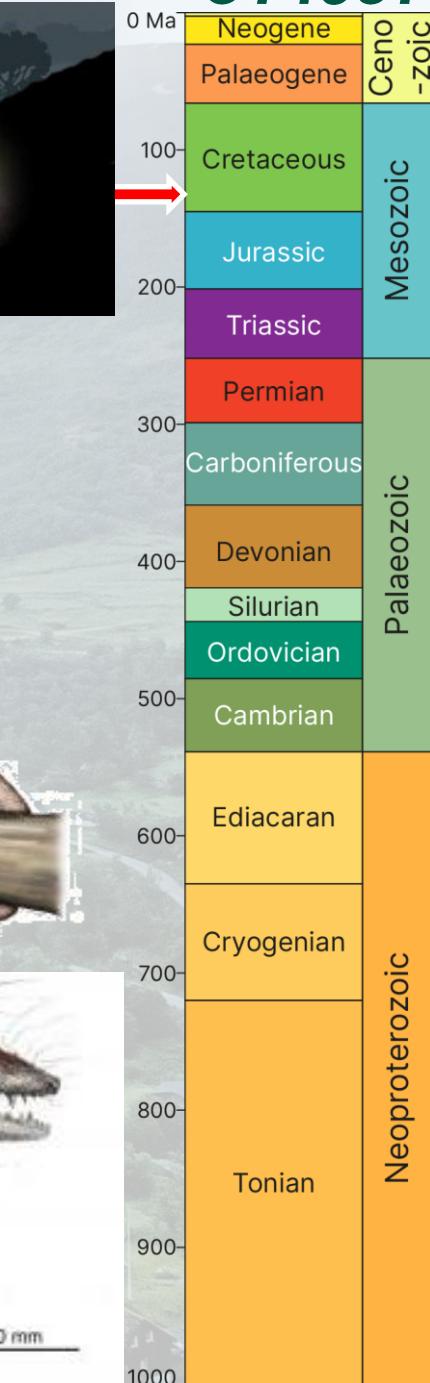
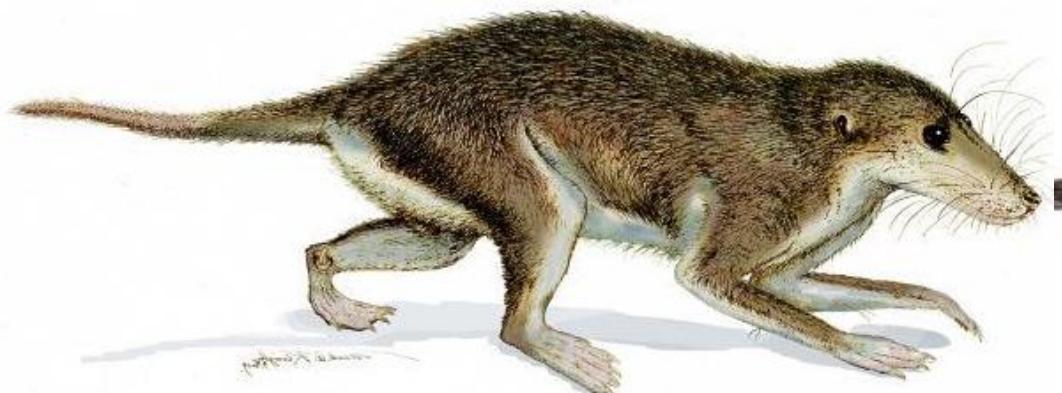
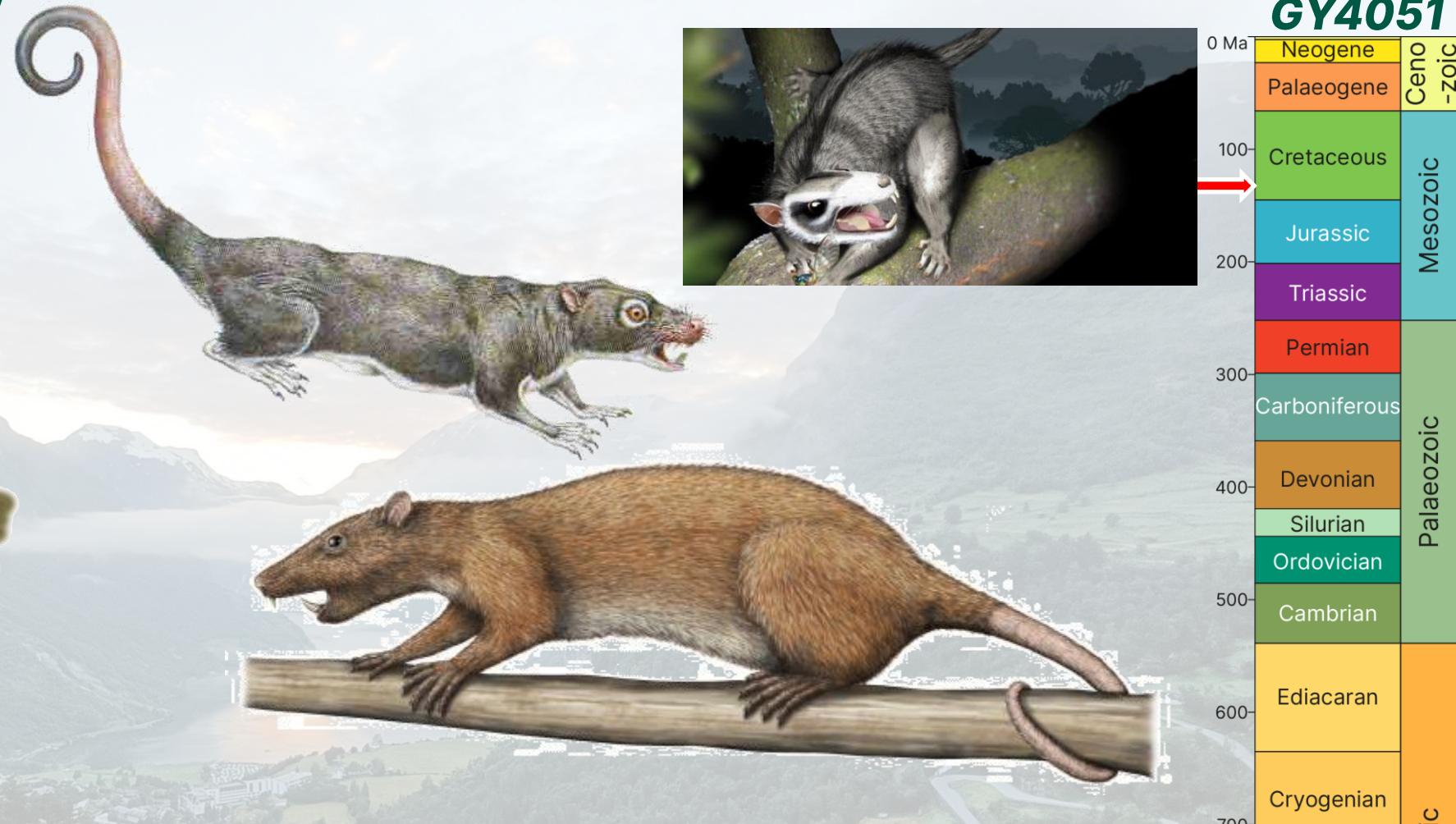


Synapsids

Mammalia



As big as they got:
Repenomamus: ~1 meter long
and ~15 kilograms



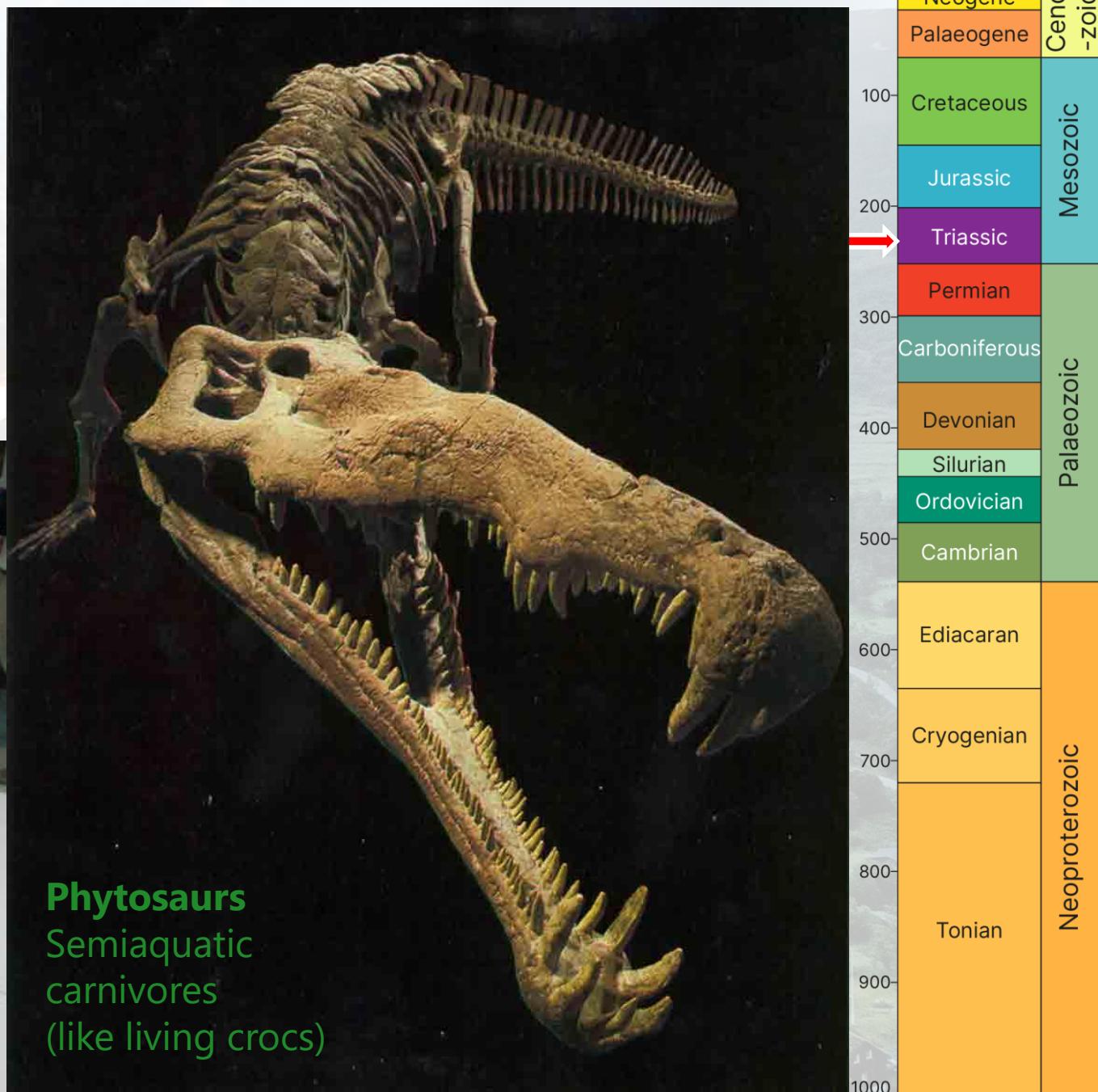
Diapsids

Crurotarsans

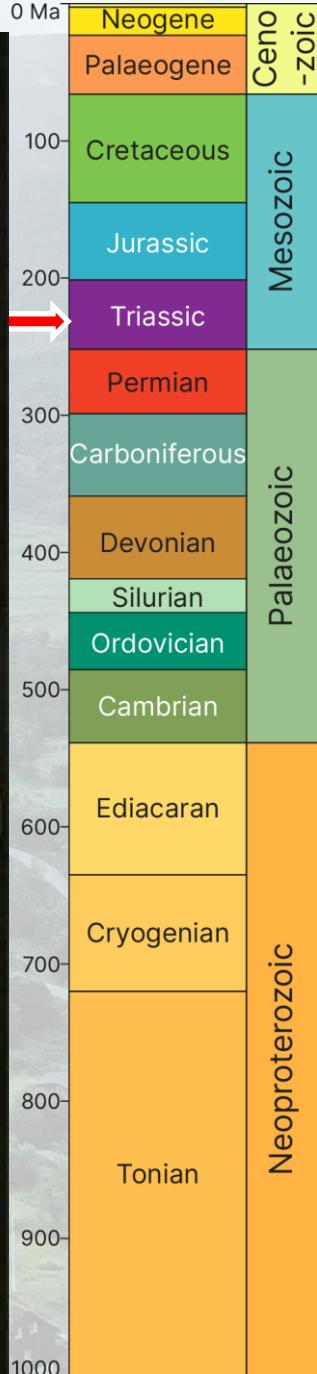


Rauisuchians

quadrupedal predators
(top carnivores in
Triassic)

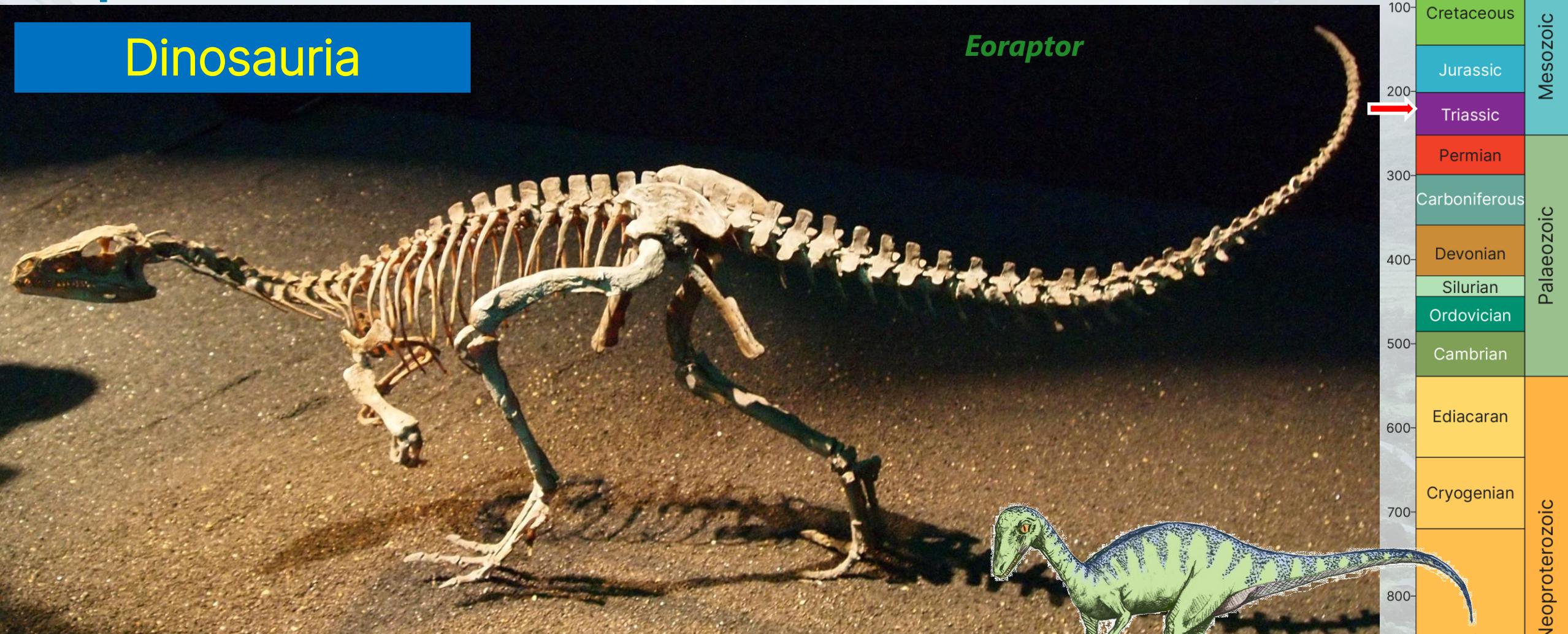


Phytosaurs
Semiaquatic
carnivores
(like living crocs)



Diapsids

Dinosauria



Eoraptor

0 Ma
Neogene
Palaeogene

Ceno-
zoic

100
Cretaceous

Mesozoic

200
Jurassic

Triassic

Permian

Carboniferous

Devonian

Silurian

Ordovician

Cambrian

Ediacaran

Cryogenian

800
Tonian

900

1000

Diapsids

Dinosauria

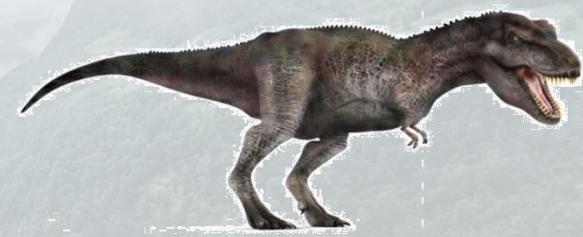
Ornithischians



Sauropodomorphs

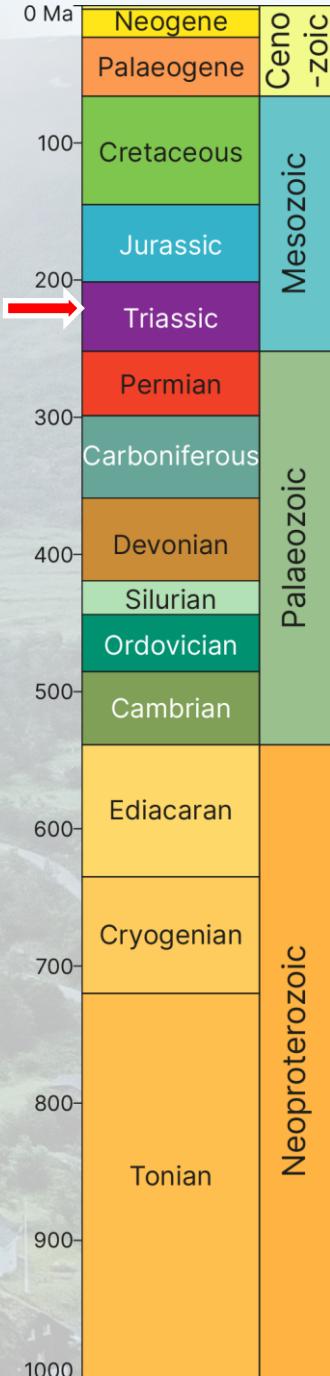


Theropods



Saurischia

Dinosauria

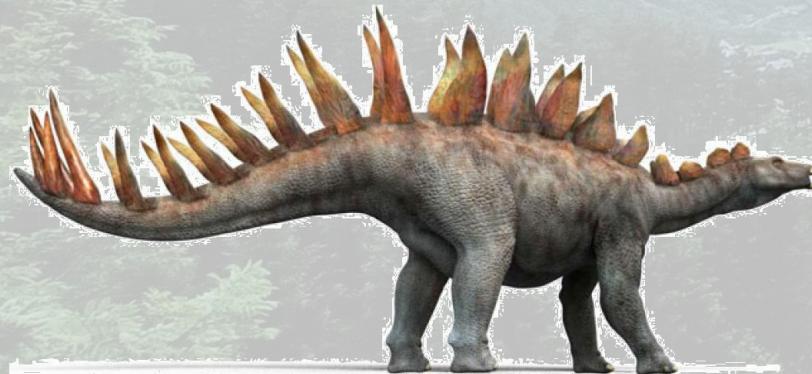


Dinosauria

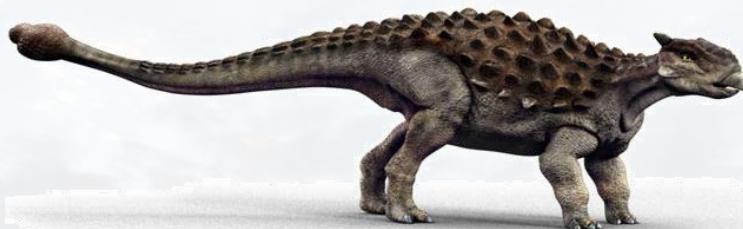
Ornithischia



Ceratopsians—horned dinosaurs



Stegosaurs—plated dinosaurs



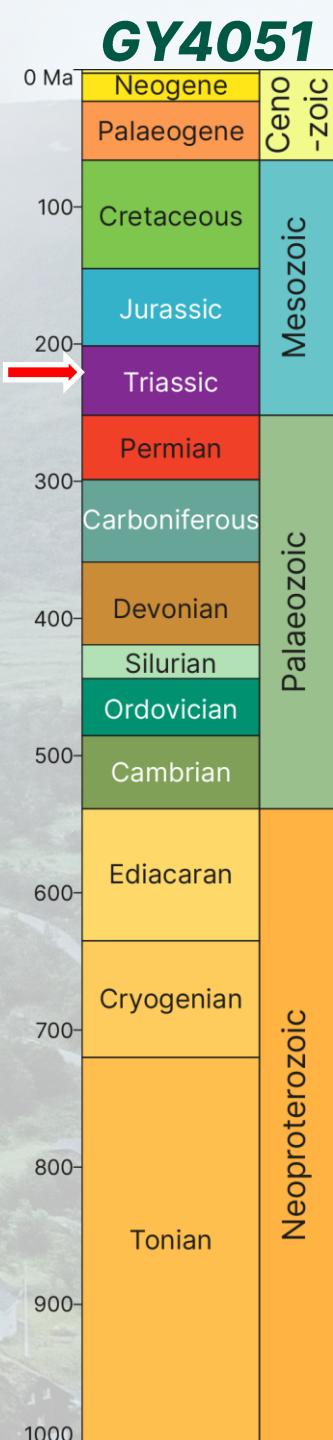
Ankylosaurs—armoured dinosaurs

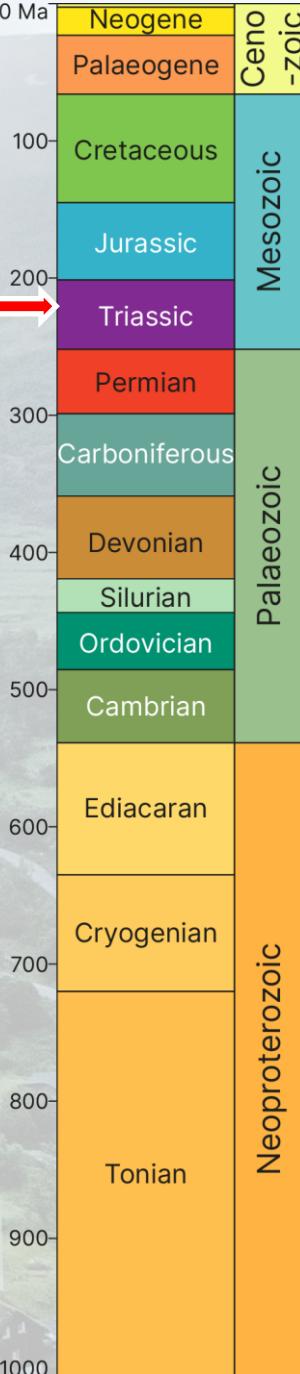


Hadrosaurs—duck-billed dinosaurs



Pachycephalosaurs—dome-headed dinosaurs



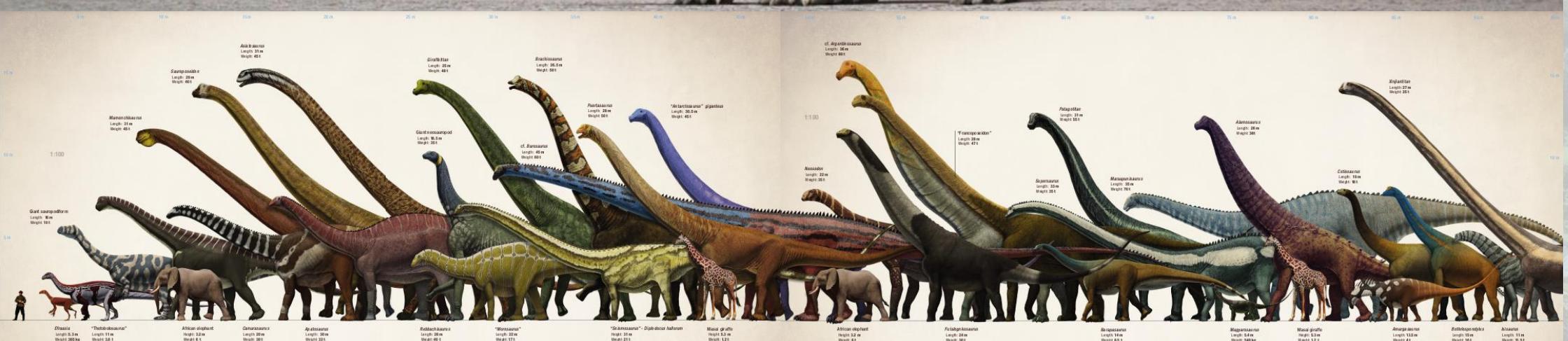


Saurischian Dinosauria

Sauropoda

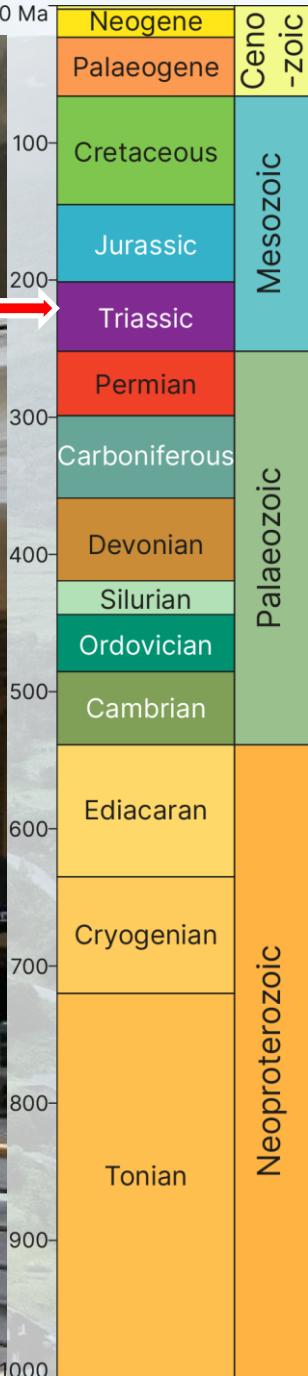


- Largest terrestrial animals ever – up to ~40m, 80t
- Small head, long neck, long tail, quadrupedal limbs



Saurischian Dinosauria

Theropoda



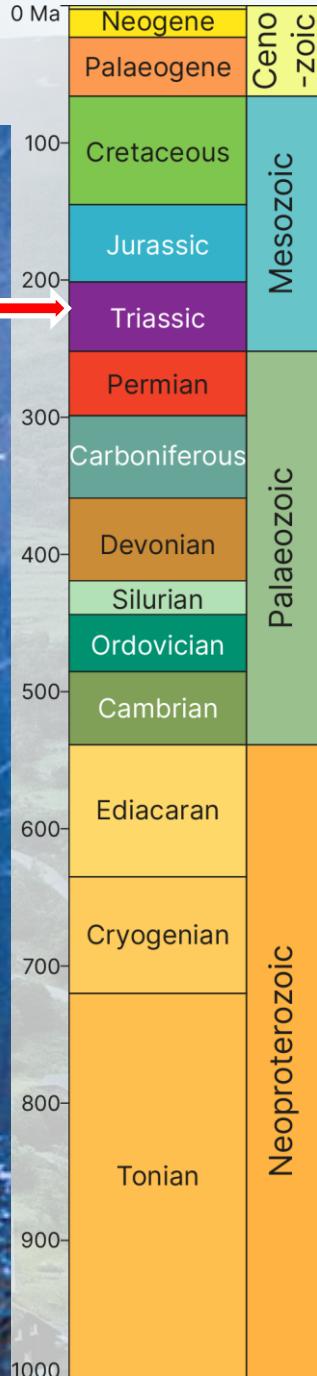
- Ruled the Earth Late Triassic to end Cretaceous

Saurischian Dinosauria

Theropoda

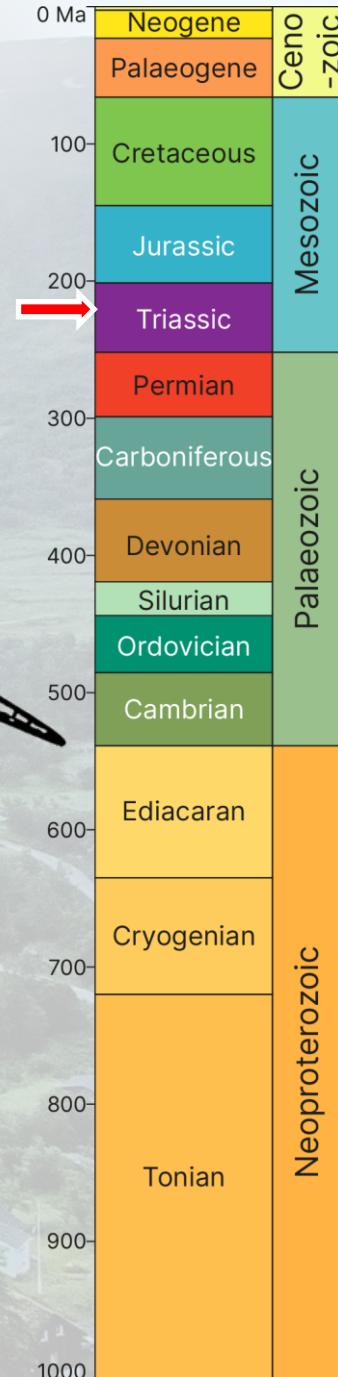
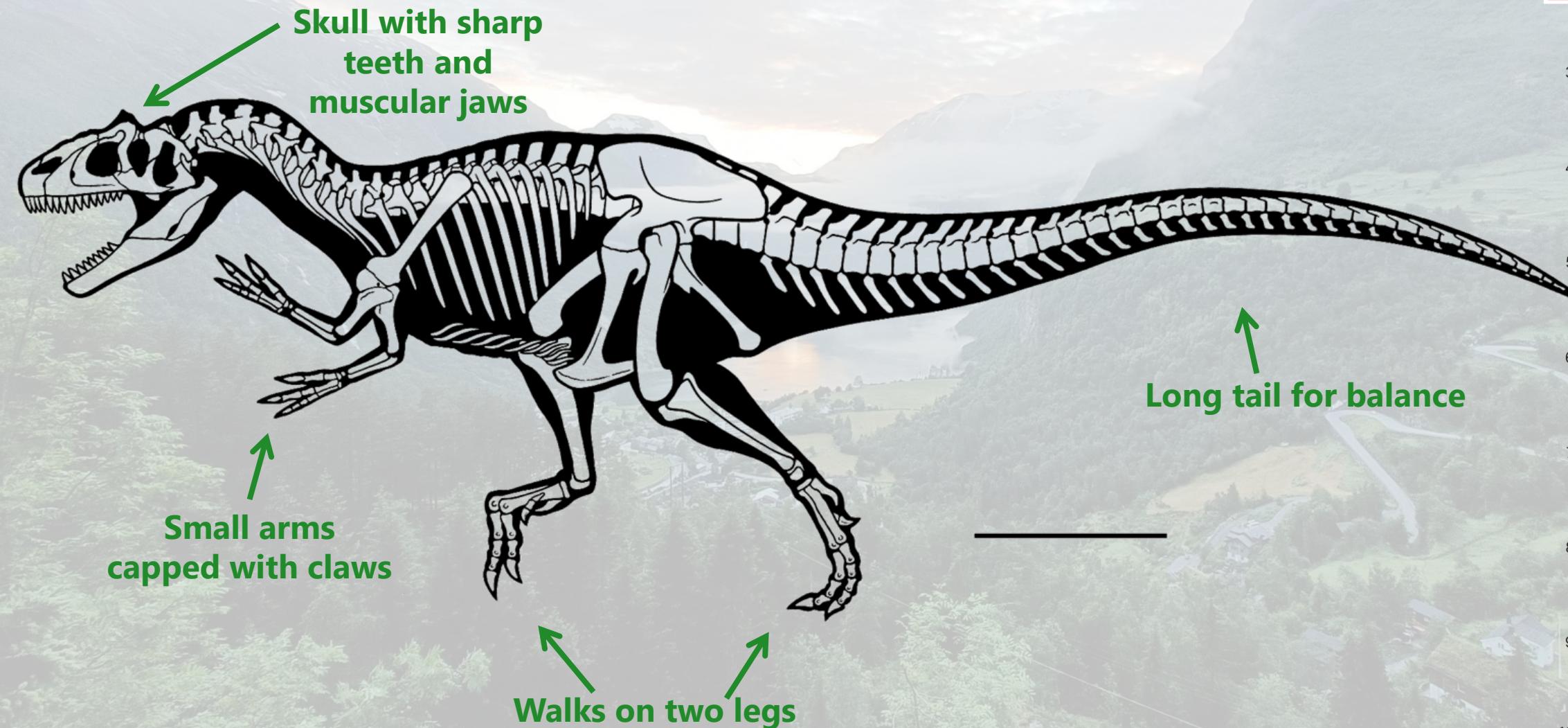


- *Tyrannosaurus rex* reached up to 13m long
- Ruled the Earth Late Triassic to end Cretaceous



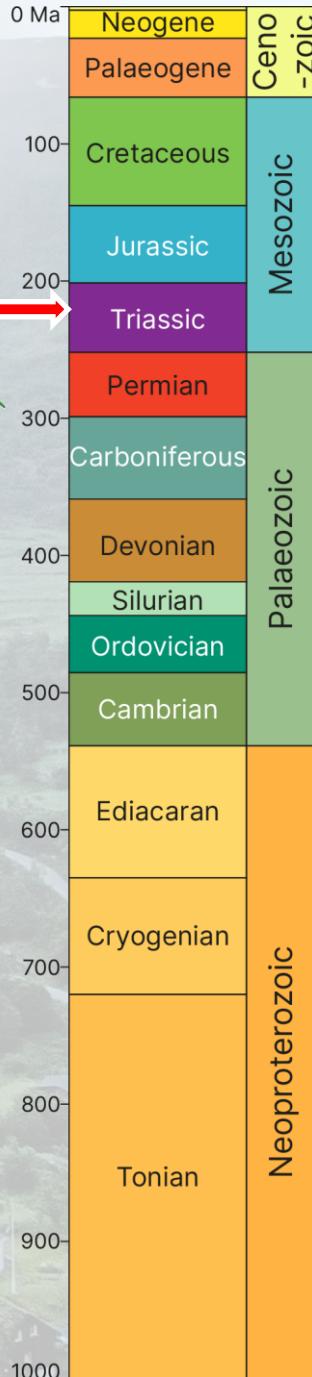
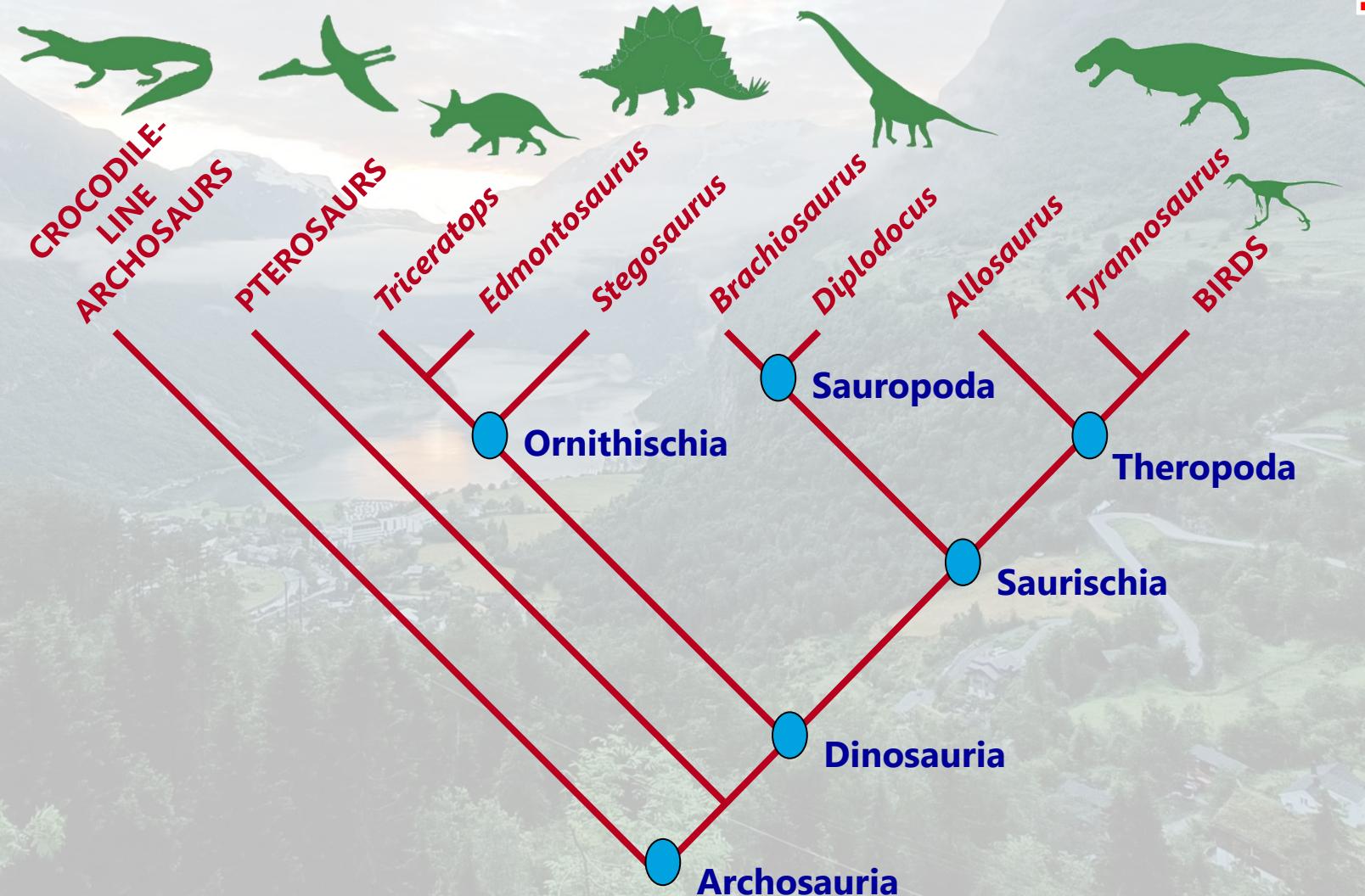
Saurischian Dinosauria

Theropoda



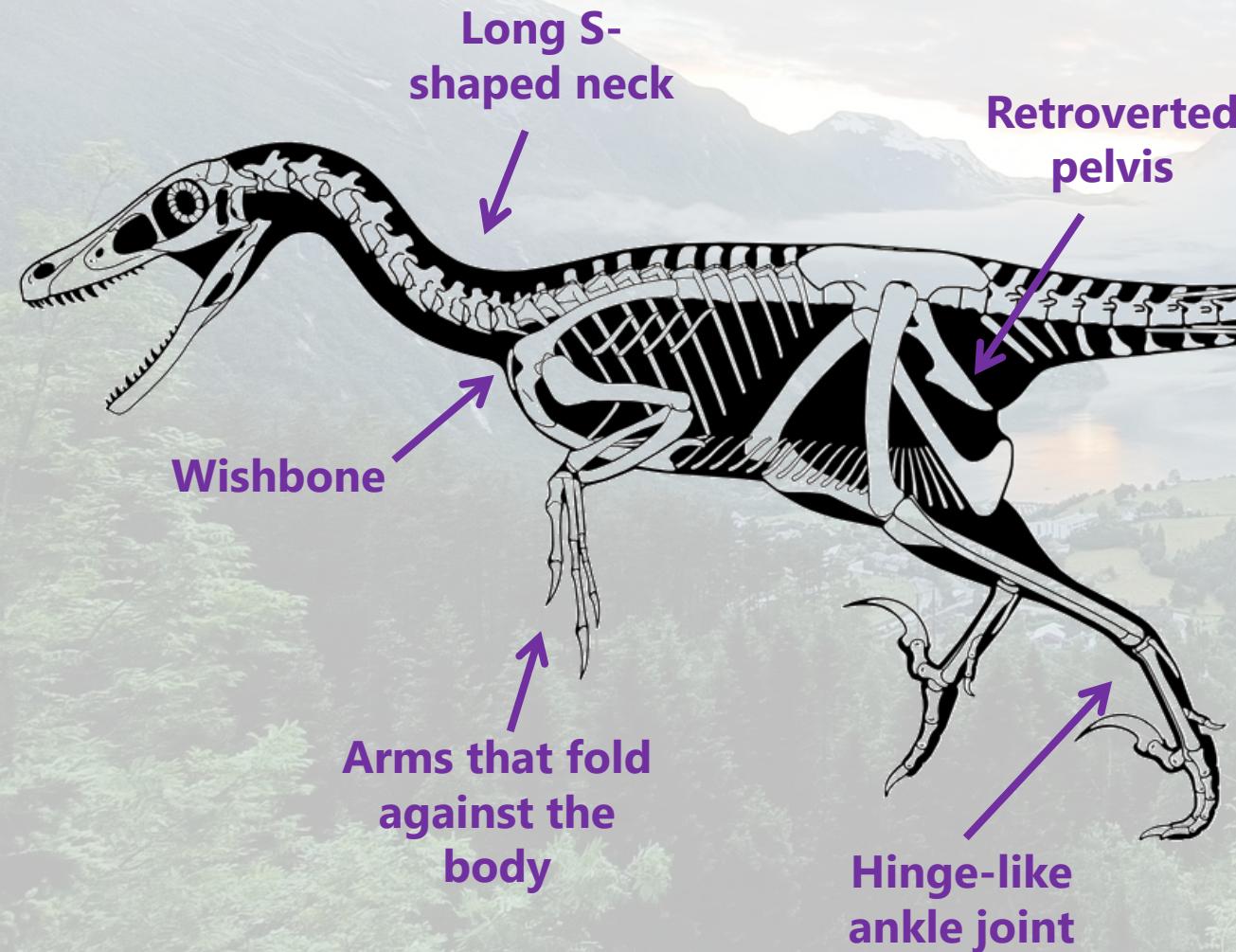
Saurischian Dinosauria

Theropoda



Saurischian Dinosauria

Theropoda



Velociraptor



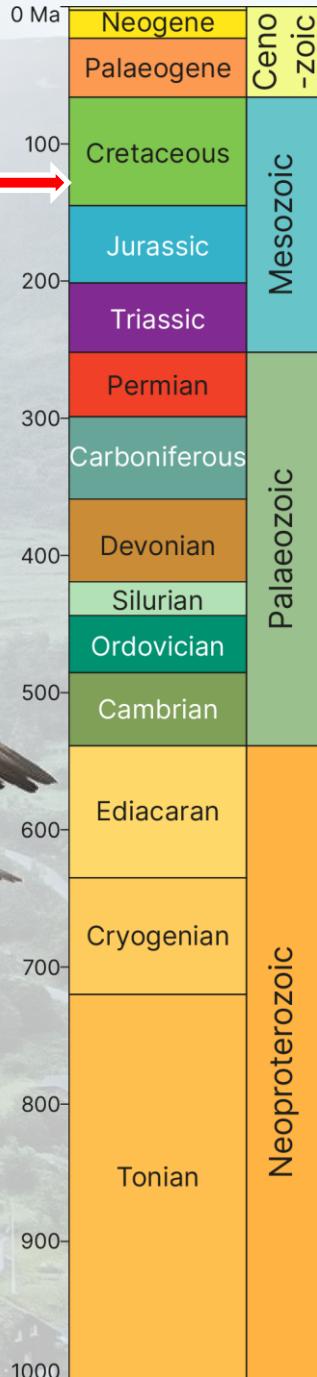
Saurischian Dinosauria

Theropoda



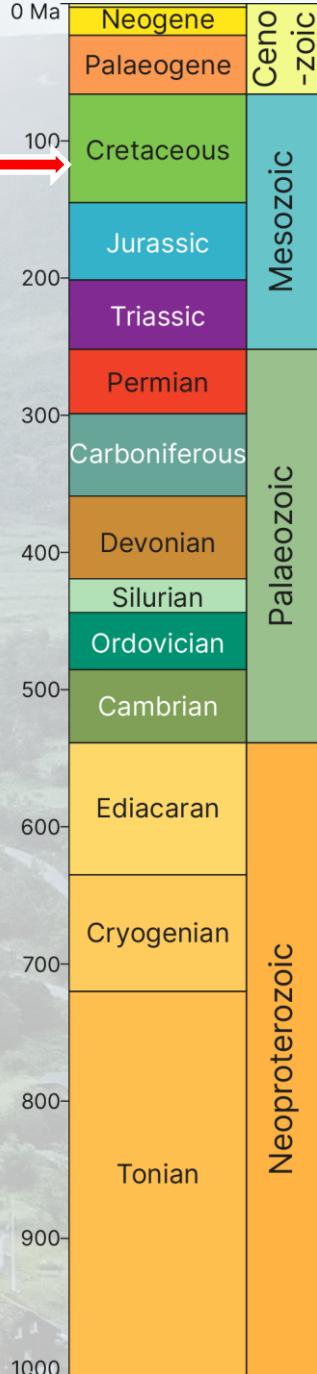
- ① *Microraptor gui*
- ② *Velociraptor mongoliensis*
- ③ *Austroraptor cabazai*

- ④ *Dromaeosaurus albertensis*
- ⑤ *Utahraptor ostrommaysorum*
- ⑥ *Deinonychus antirrhopus*



Saurischian Dinosauria

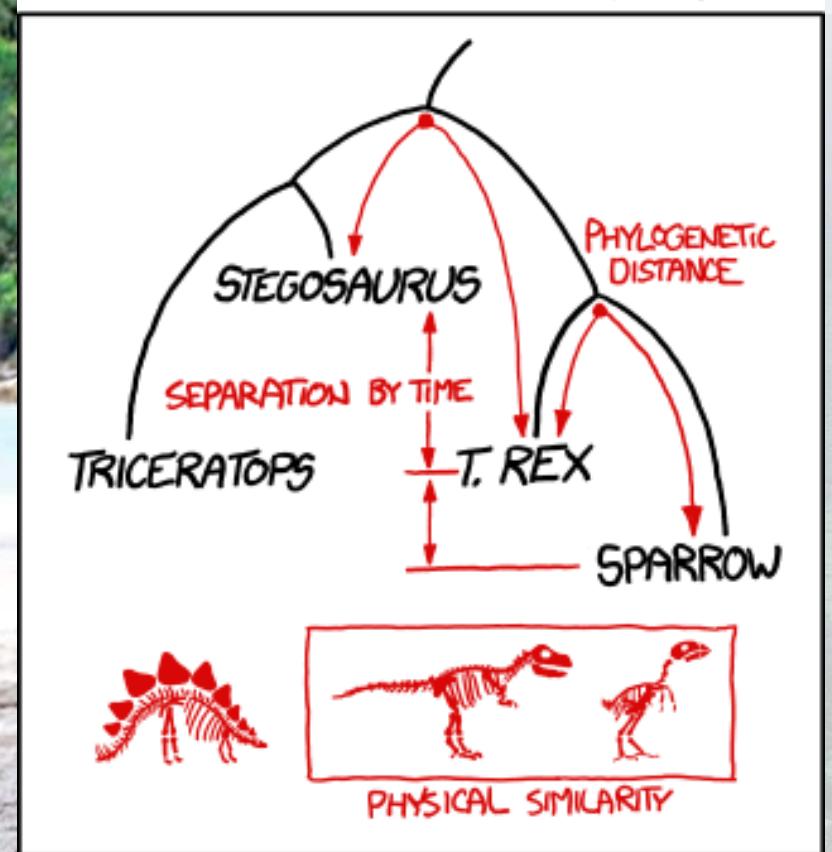
Theropoda



BY ANY REASONABLE DEFINITION, T. REX IS MORE CLOSELY RELATED TO SPARROWS THAN TO STEGOSAURUS.

Saurischian Dinosauria

Theropoda



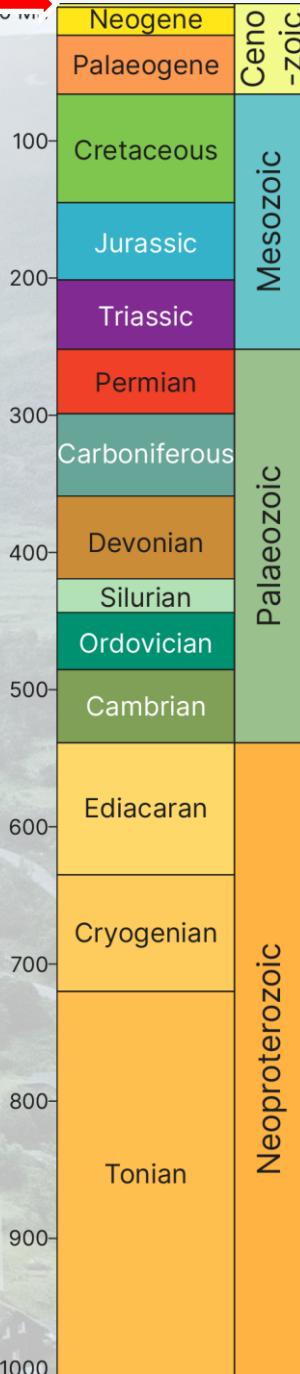
BIRDS AREN'T DESCENDED FROM DINOSAURS,
THEY ARE DINOSAURS.

WHICH MEANS THE FASTEST ANIMAL ALIVE TODAY IS
A SMALL CARNIVOROUS DINOSAUR, *FALCO PEREGRINUS*.



IT PREYS MAINLY ON OTHER DINOSAURS, WHICH
IT STRIKES AND KILLS IN MIDAIR WITH ITS CLAWS.

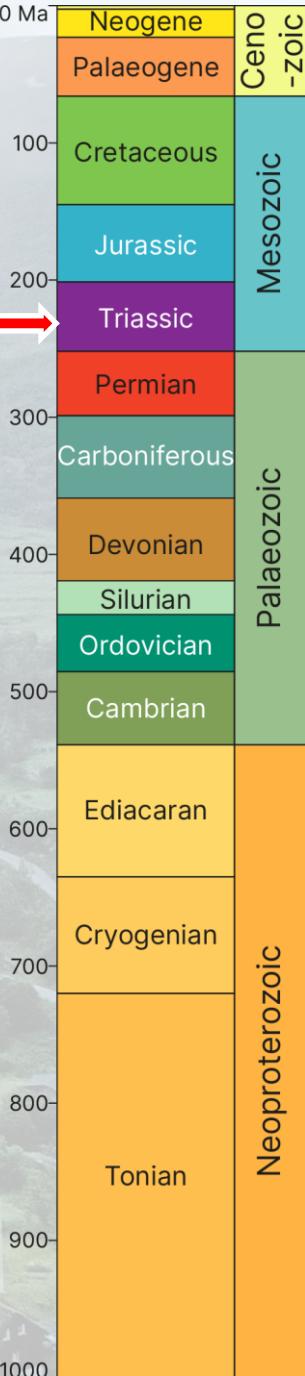
THIS IS A GOOD WORLD.





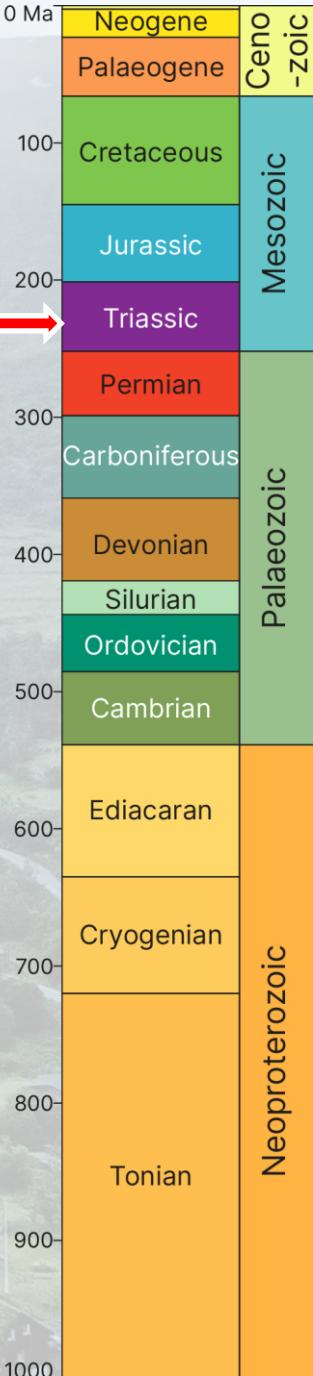
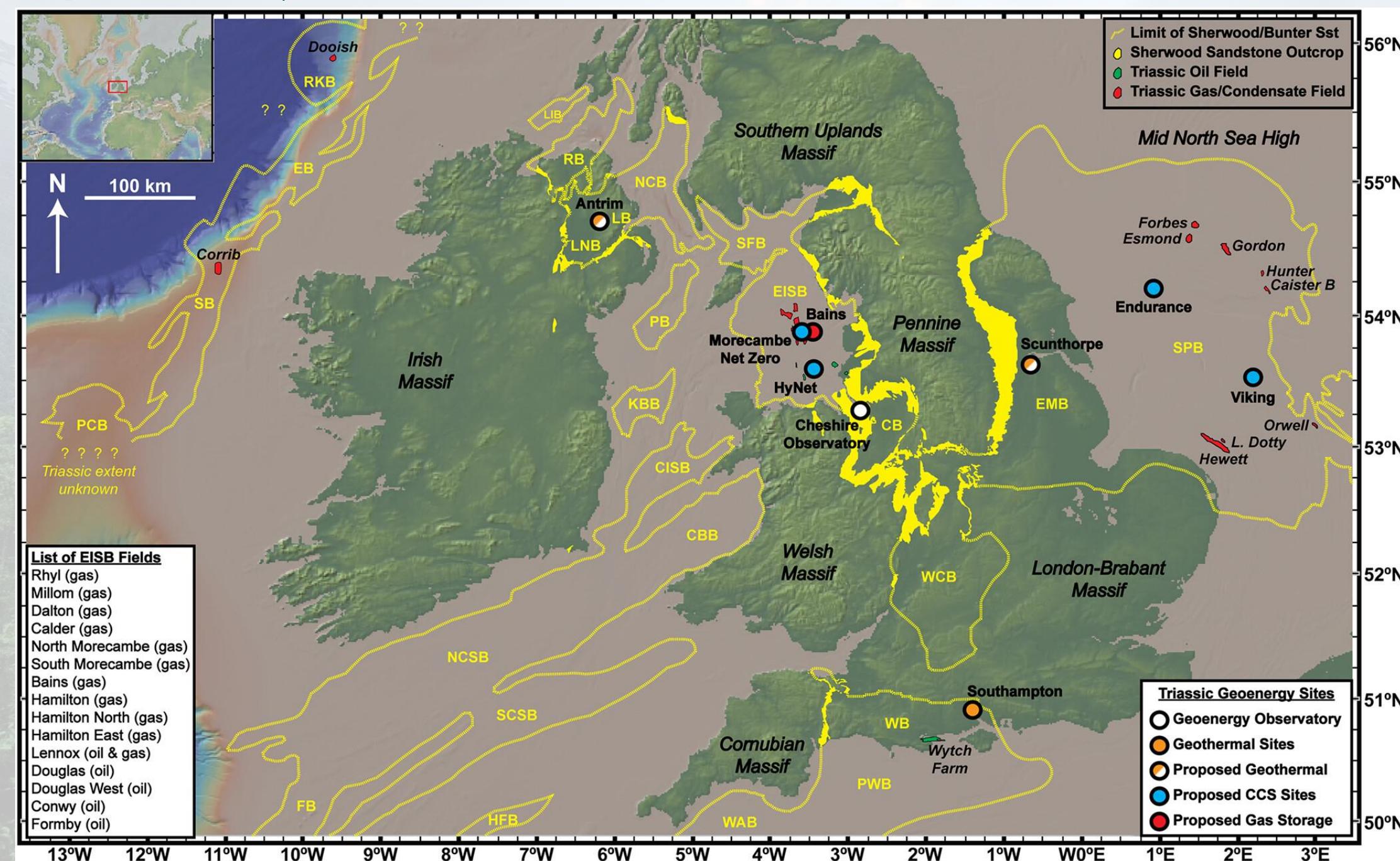
T

Desert sandstone | Merseyside, England



Tropical Ireland | Permian and Triassic – New Red Sandstone

GY4051



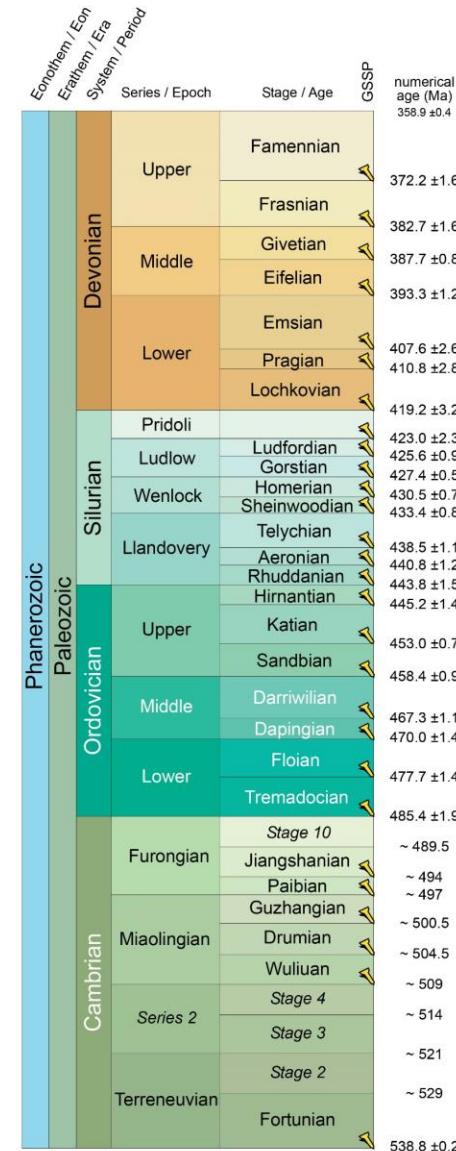
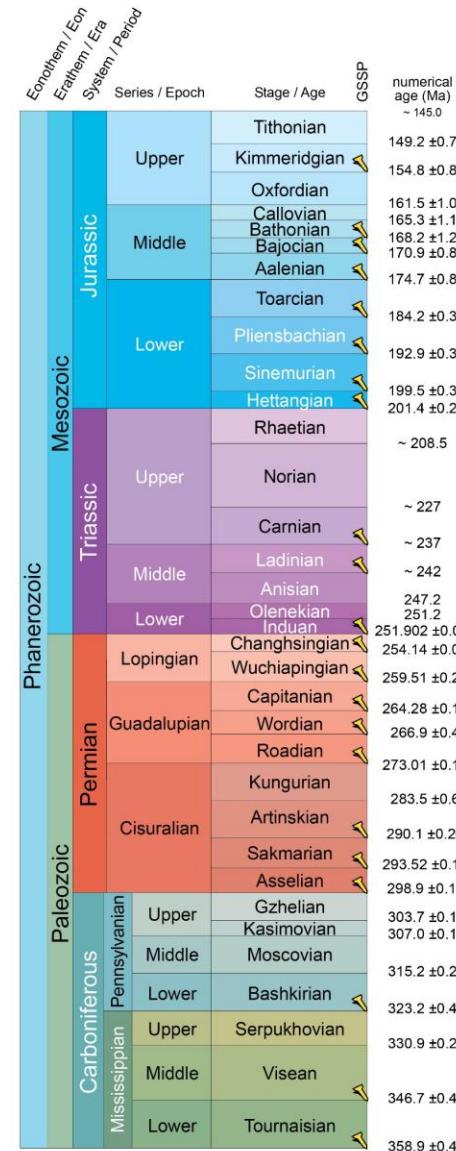
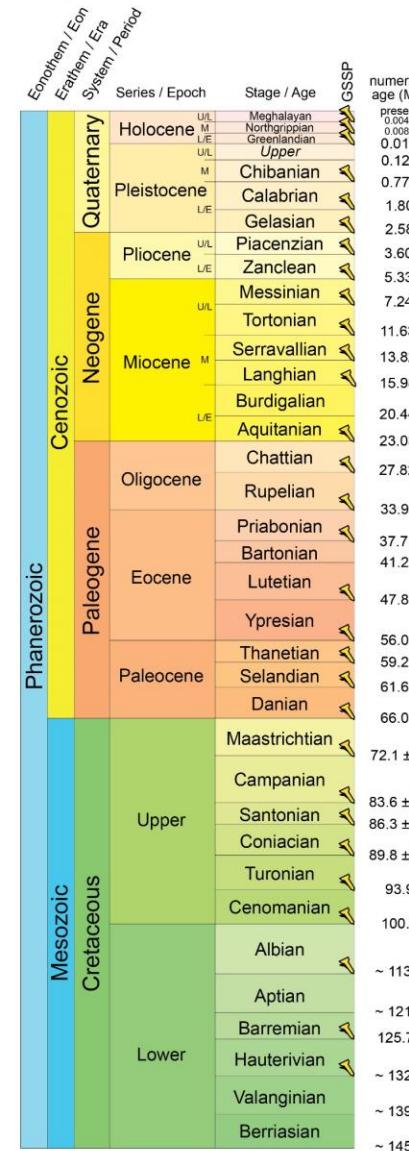


INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

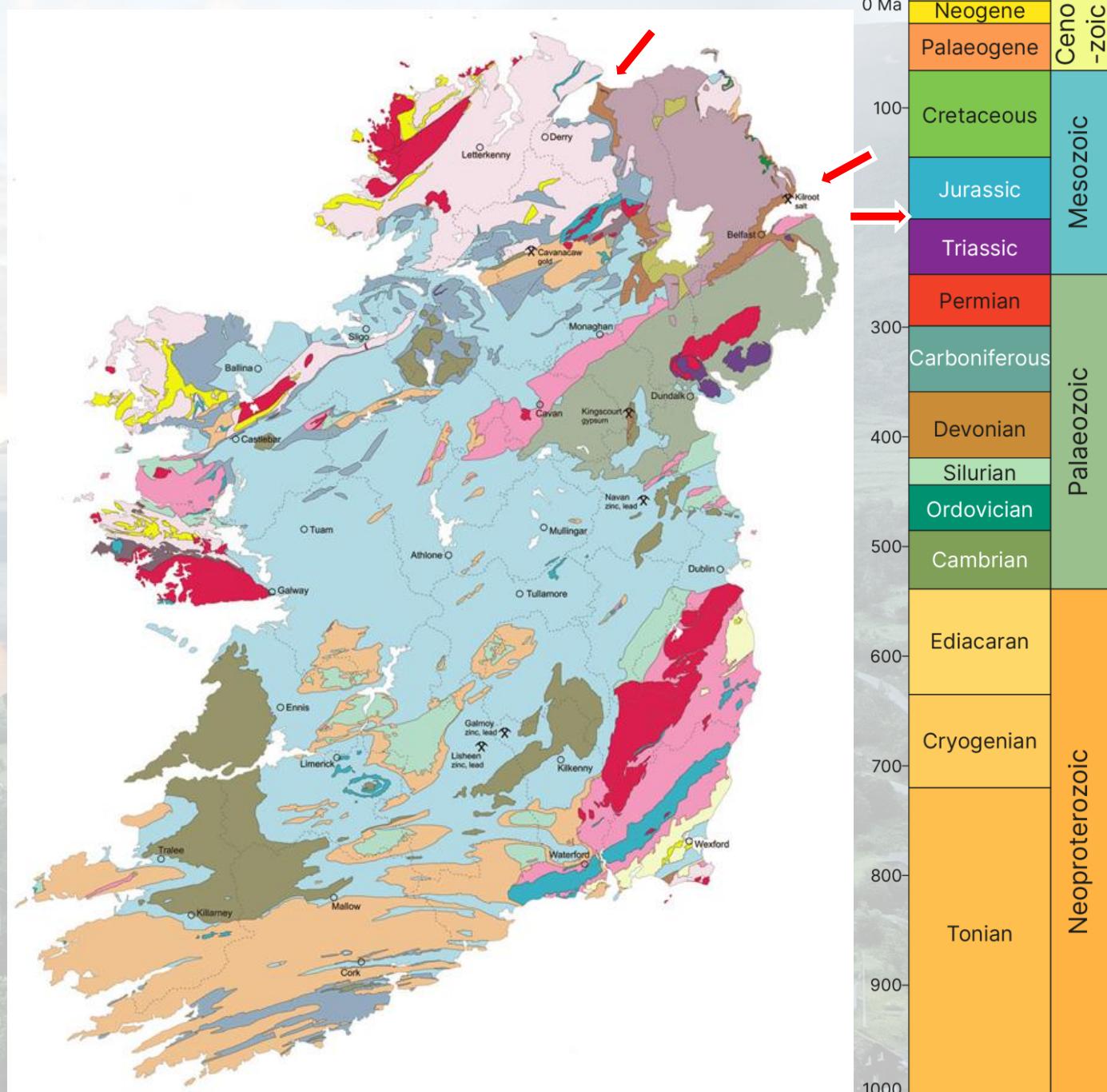
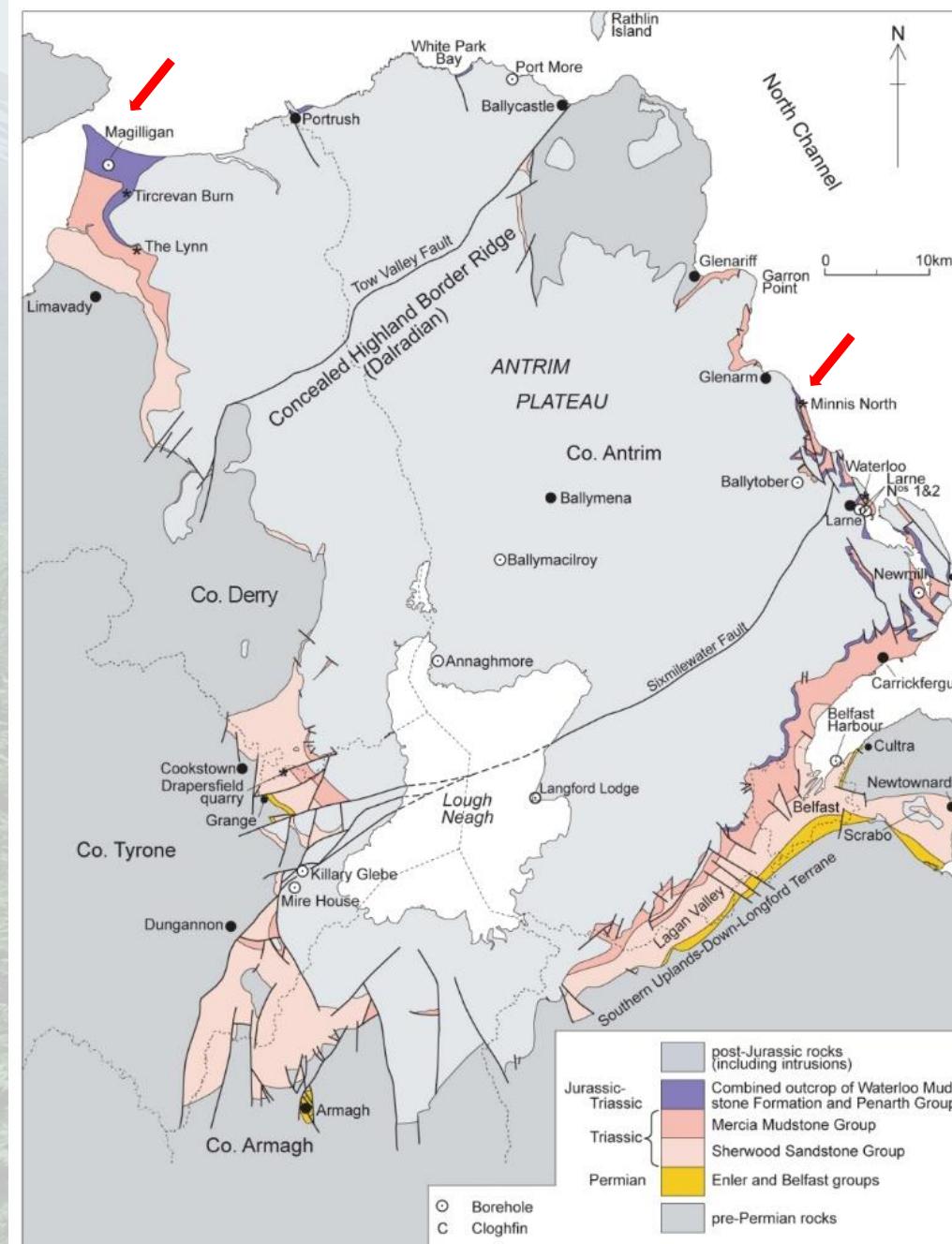
www.stratigraphy.org

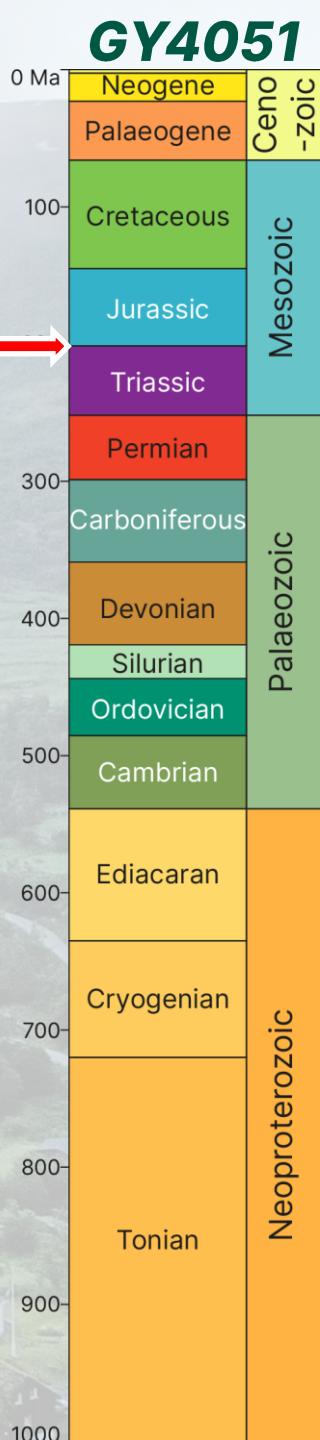
International Commission on Stratigraphy

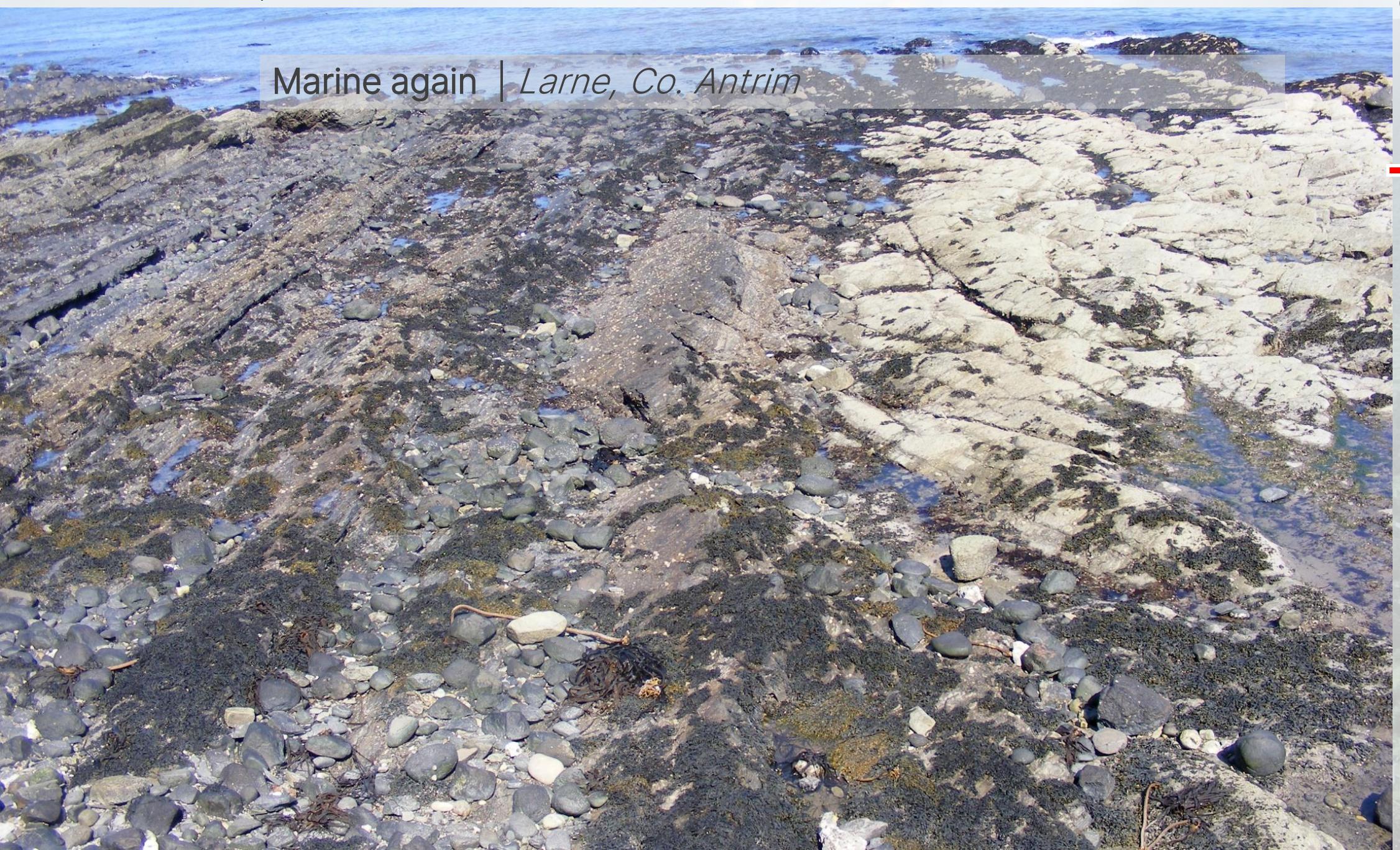
v 2023/09



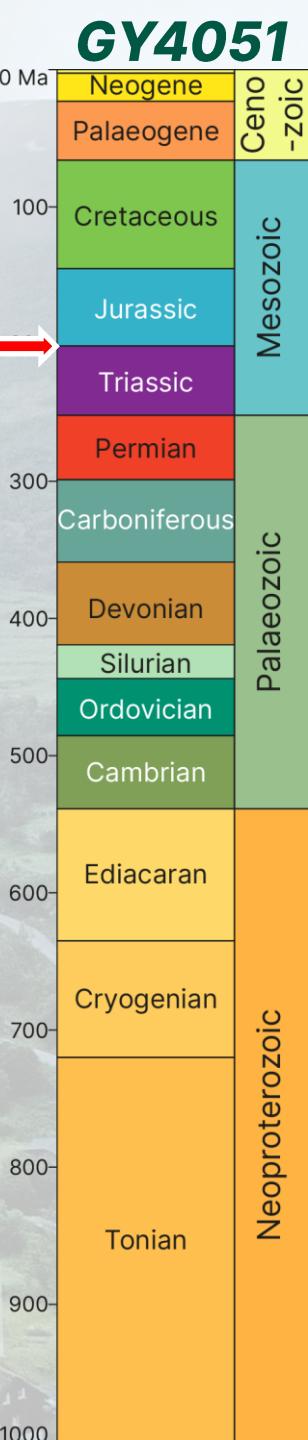
Recent Ireland | Triassic and Jurassic



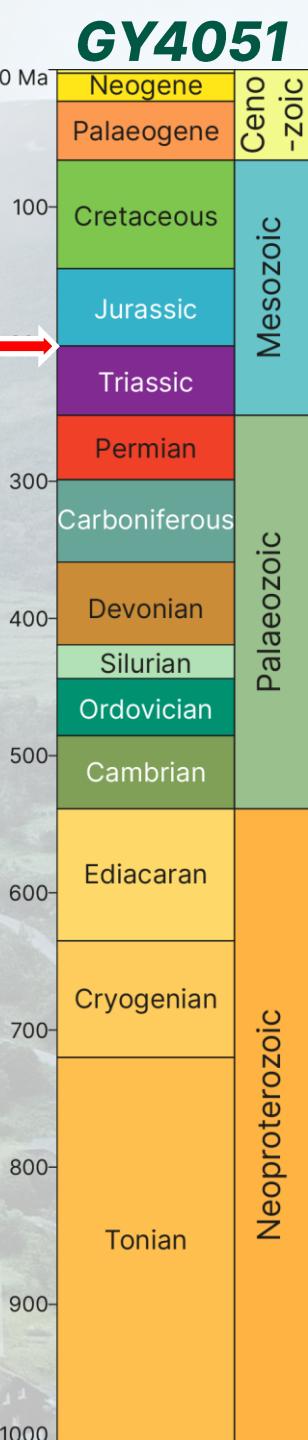
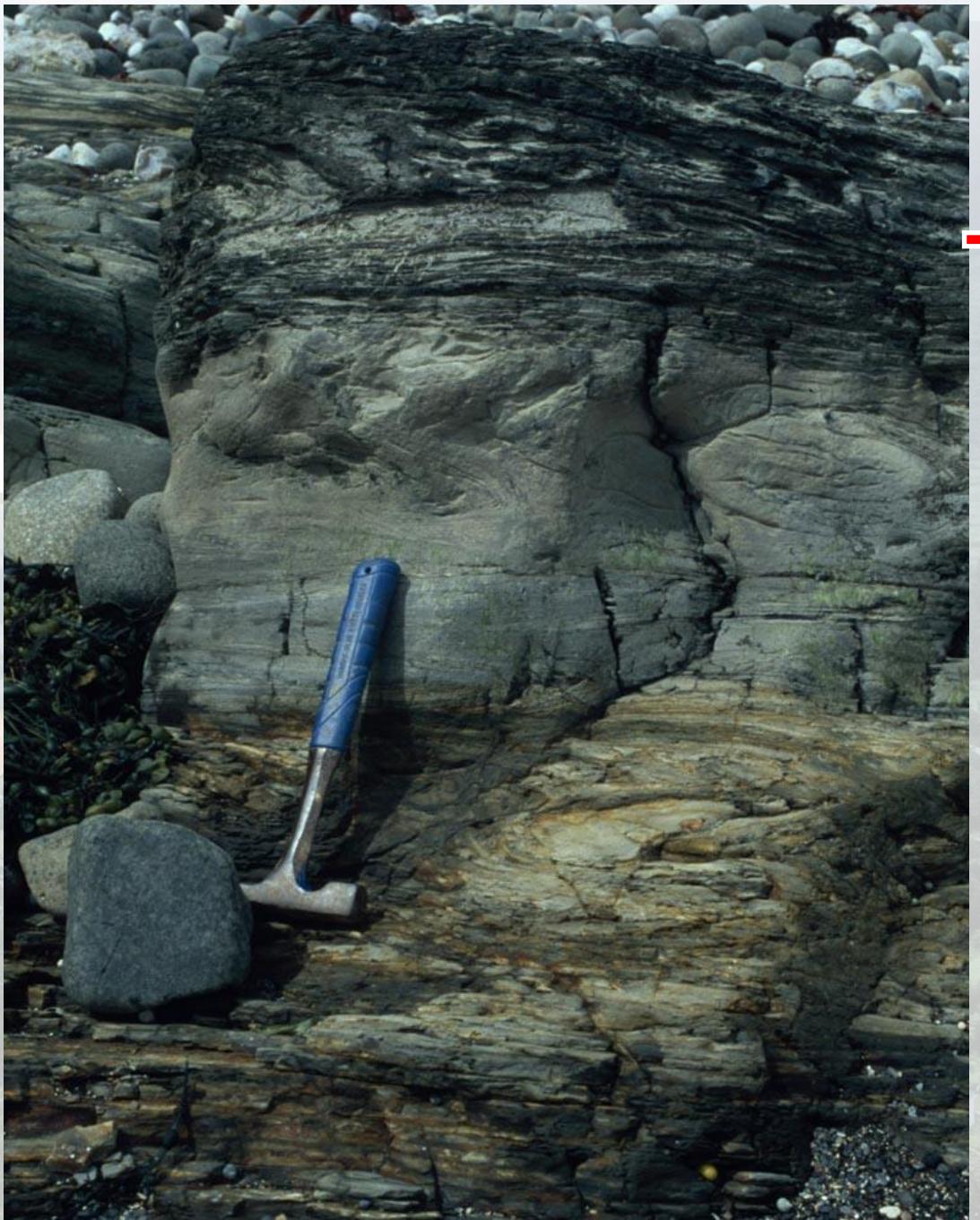




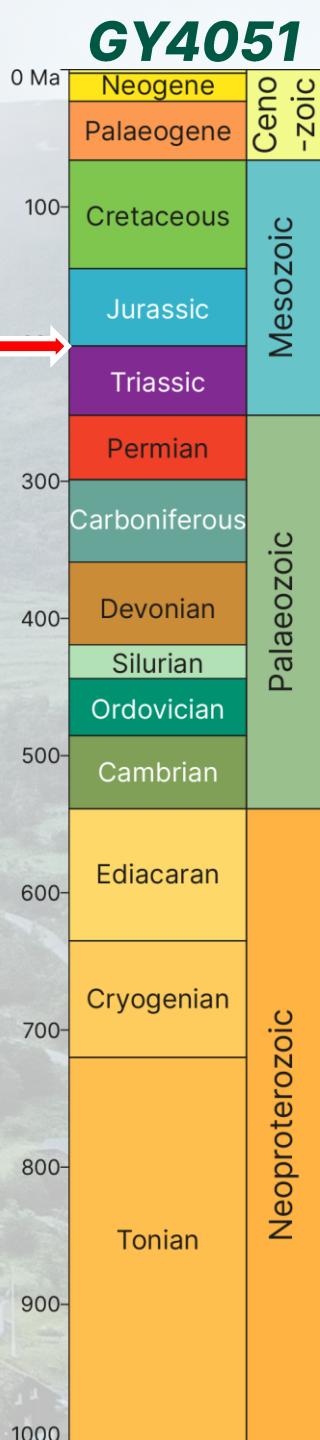
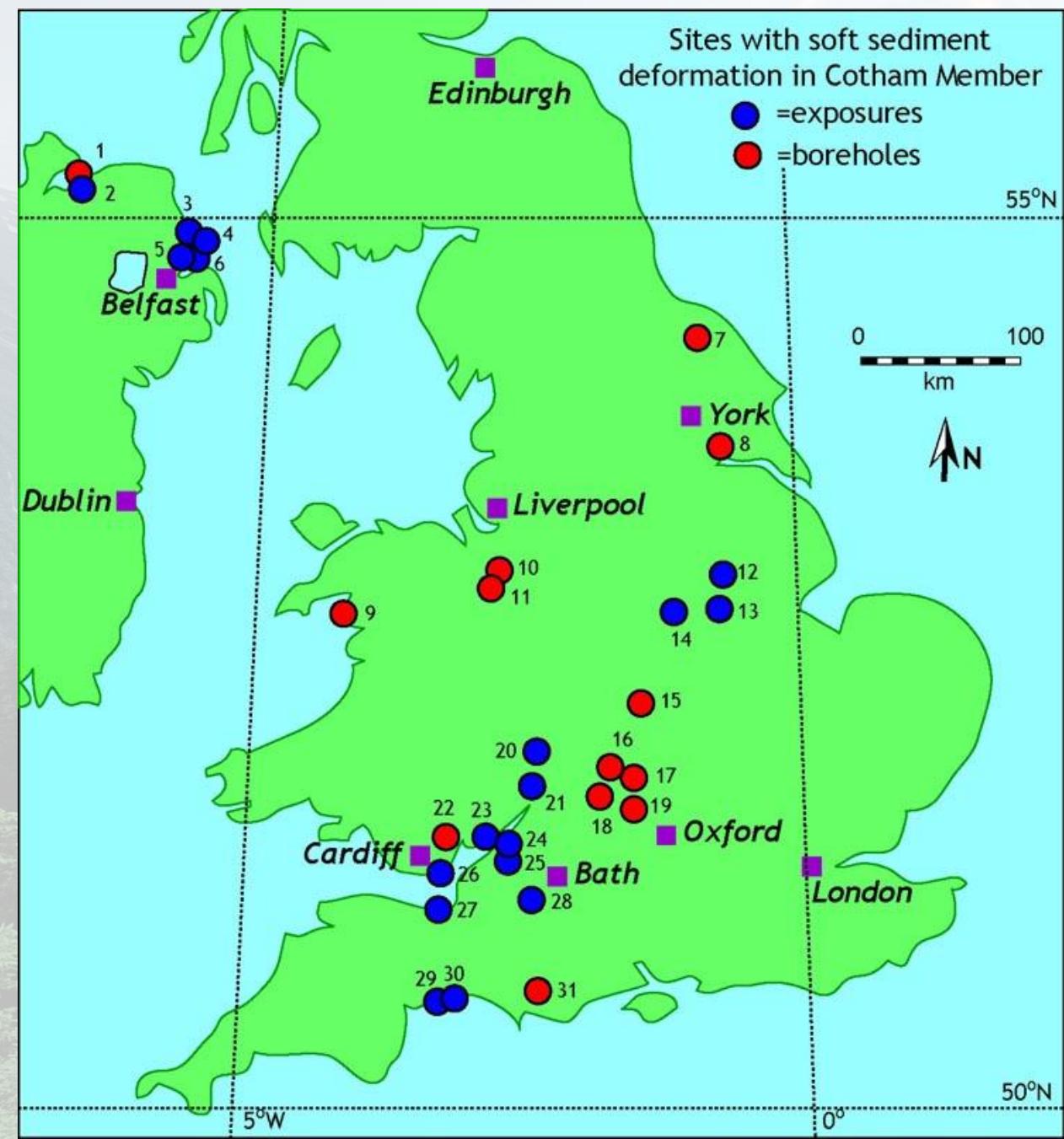
Marine again | Larne, Co. Antrim



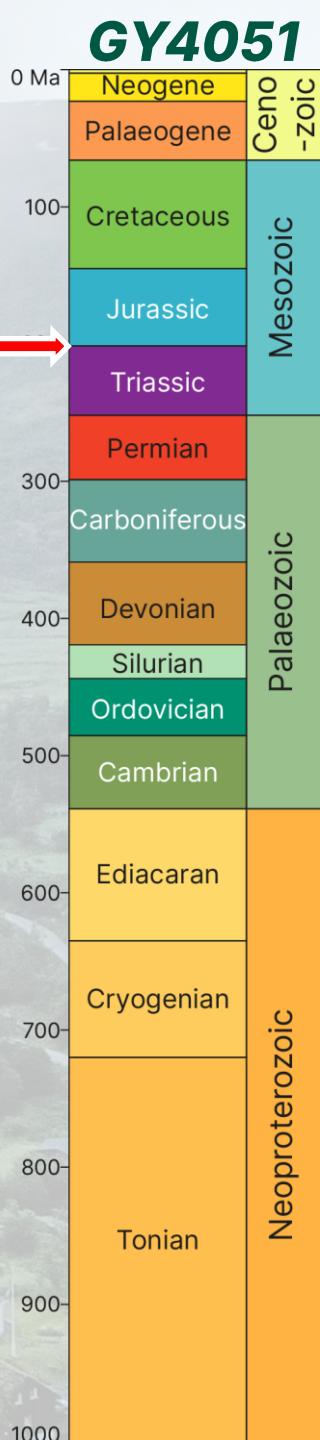
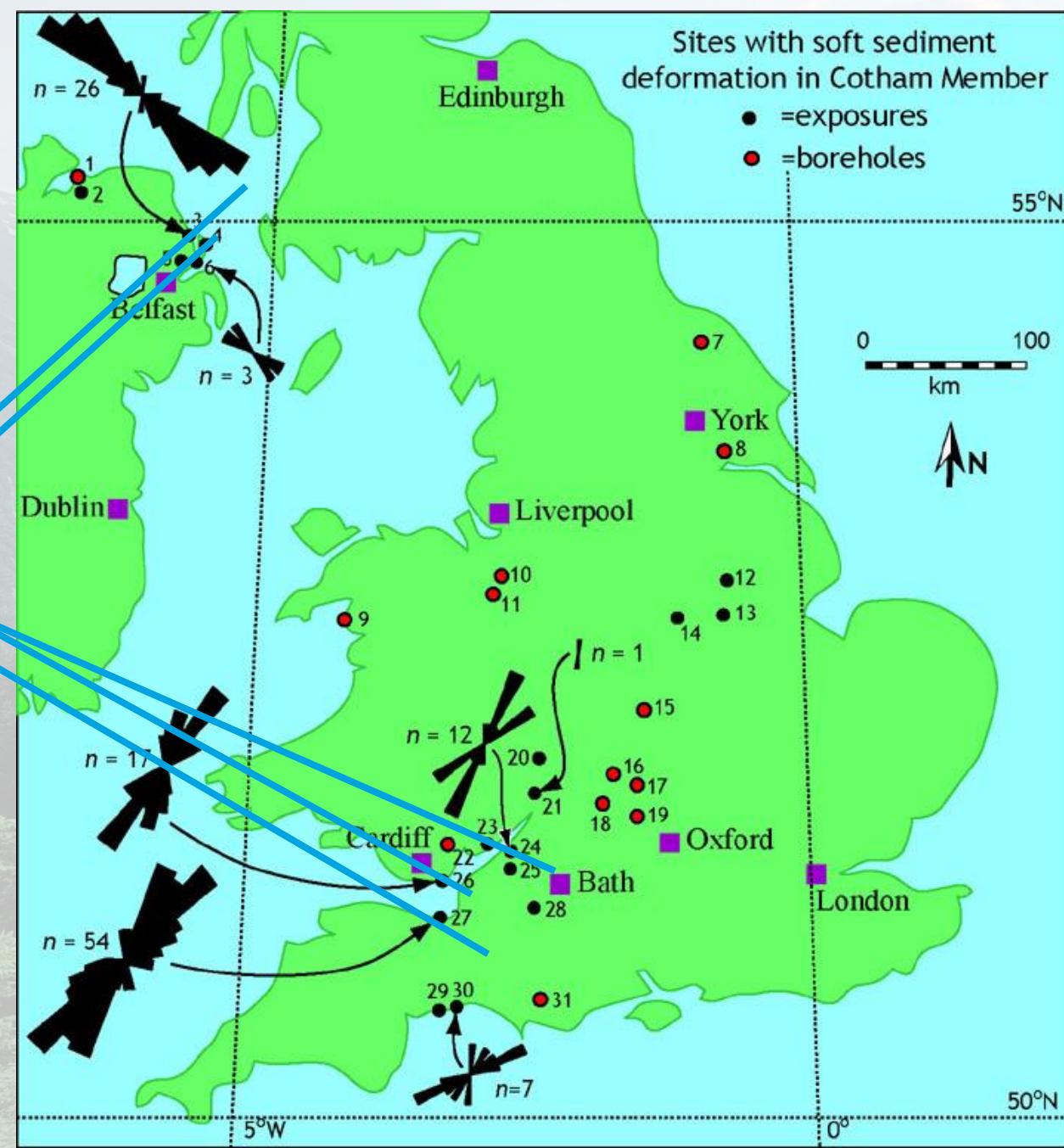
Recent Ireland | Early Jurassic

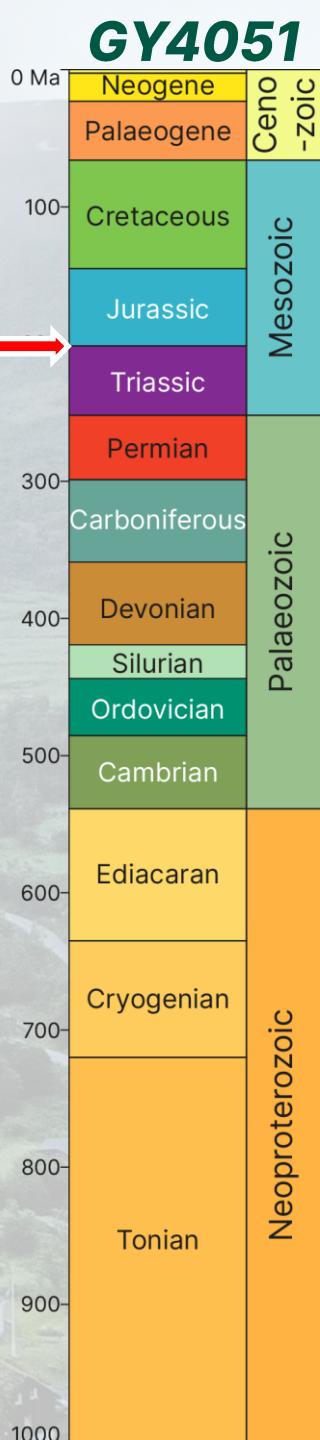


Recent Ireland | Early Jurassic

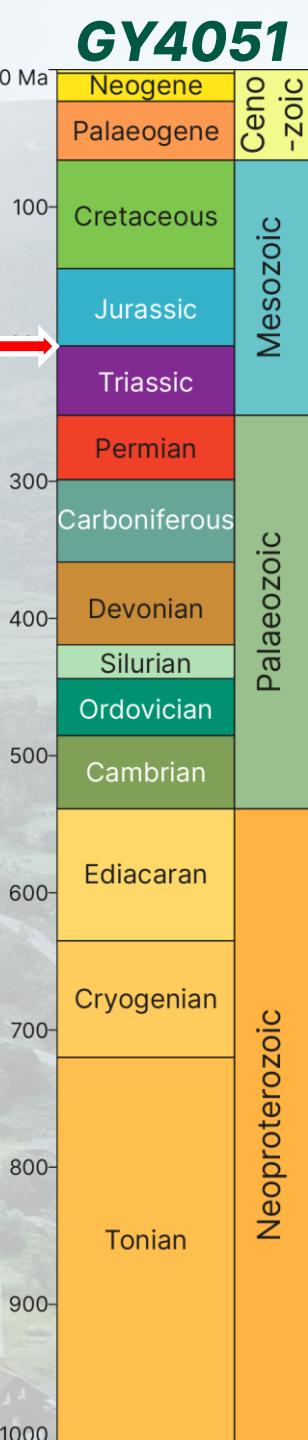


Recent Ireland | Early Jurassic

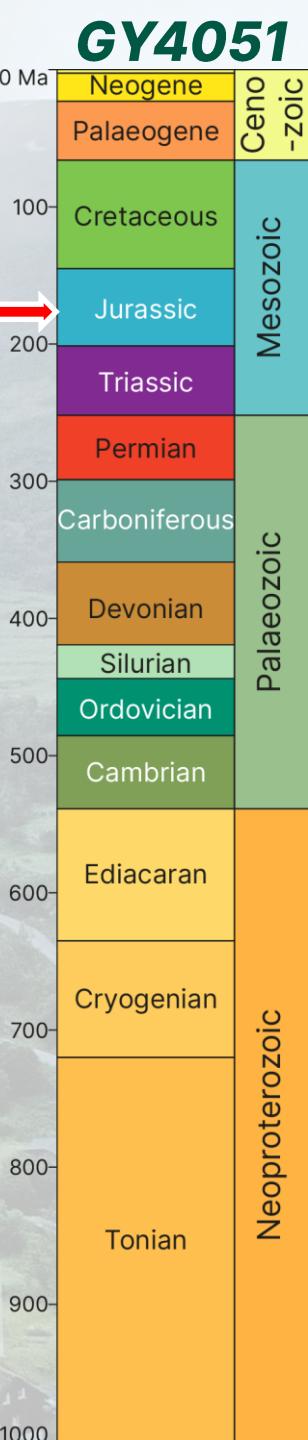




Recent Ireland | Early Jurassic



7



0 Ma
Neogene

Palaeogene

Ceno-
zoic100
Cretaceous200
Jurassic

Triassic

Permian

300
Carboniferous400
Devonian

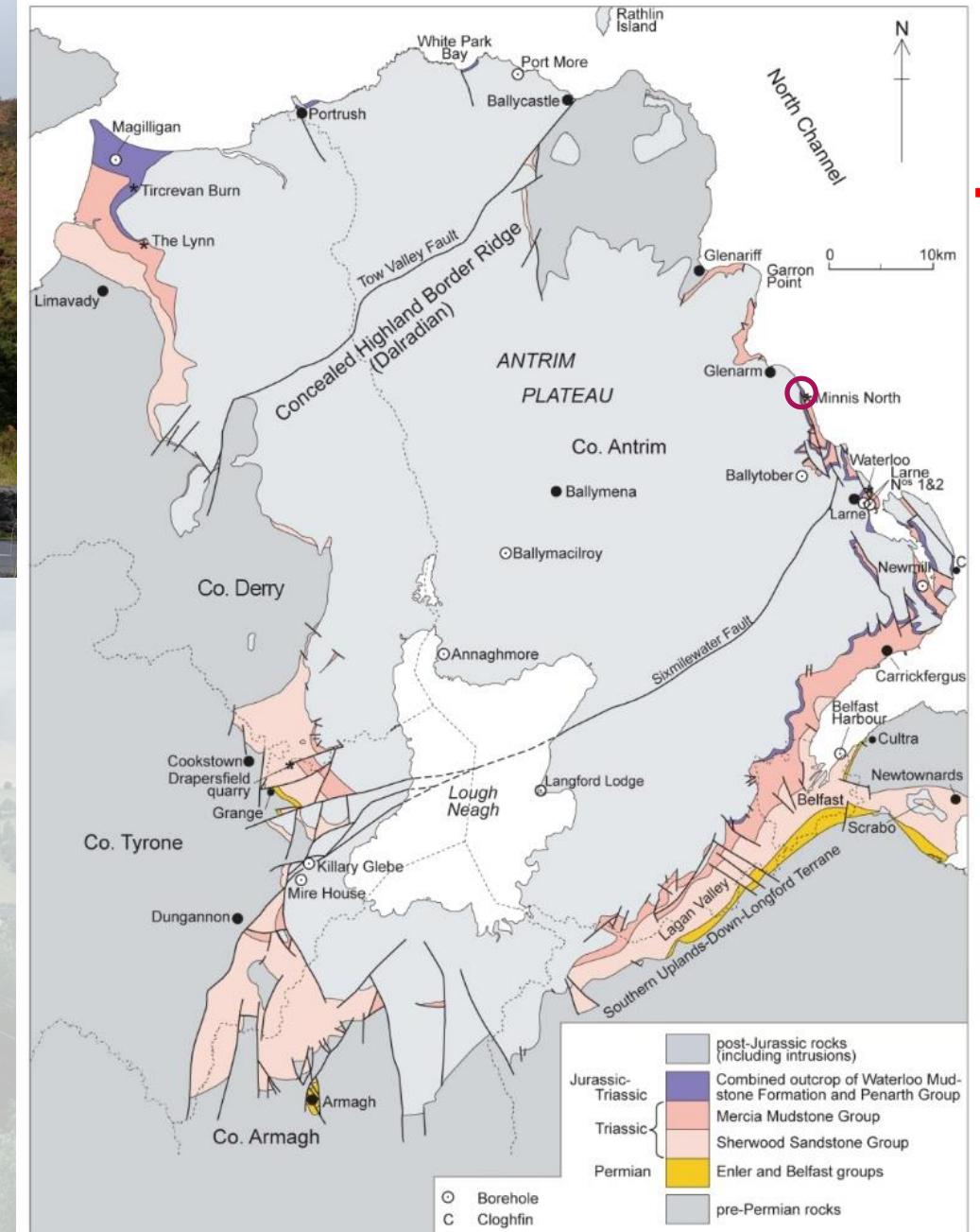
Silurian

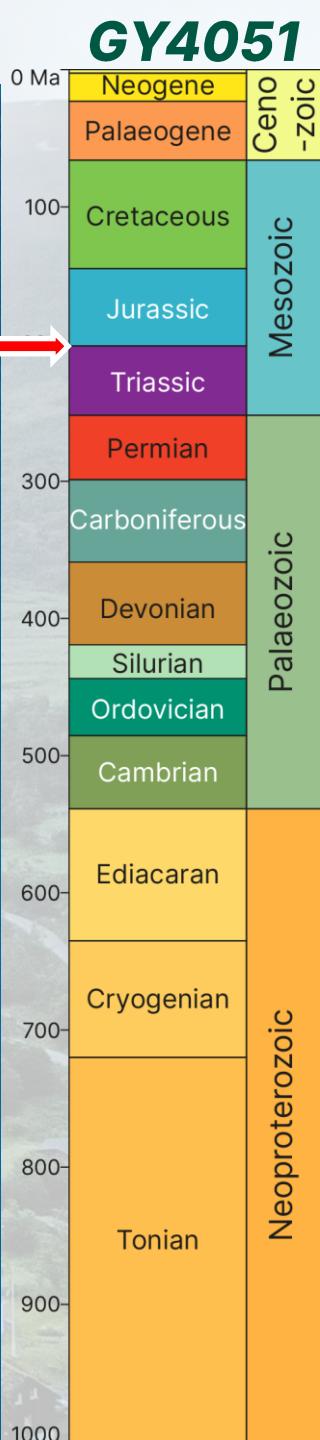
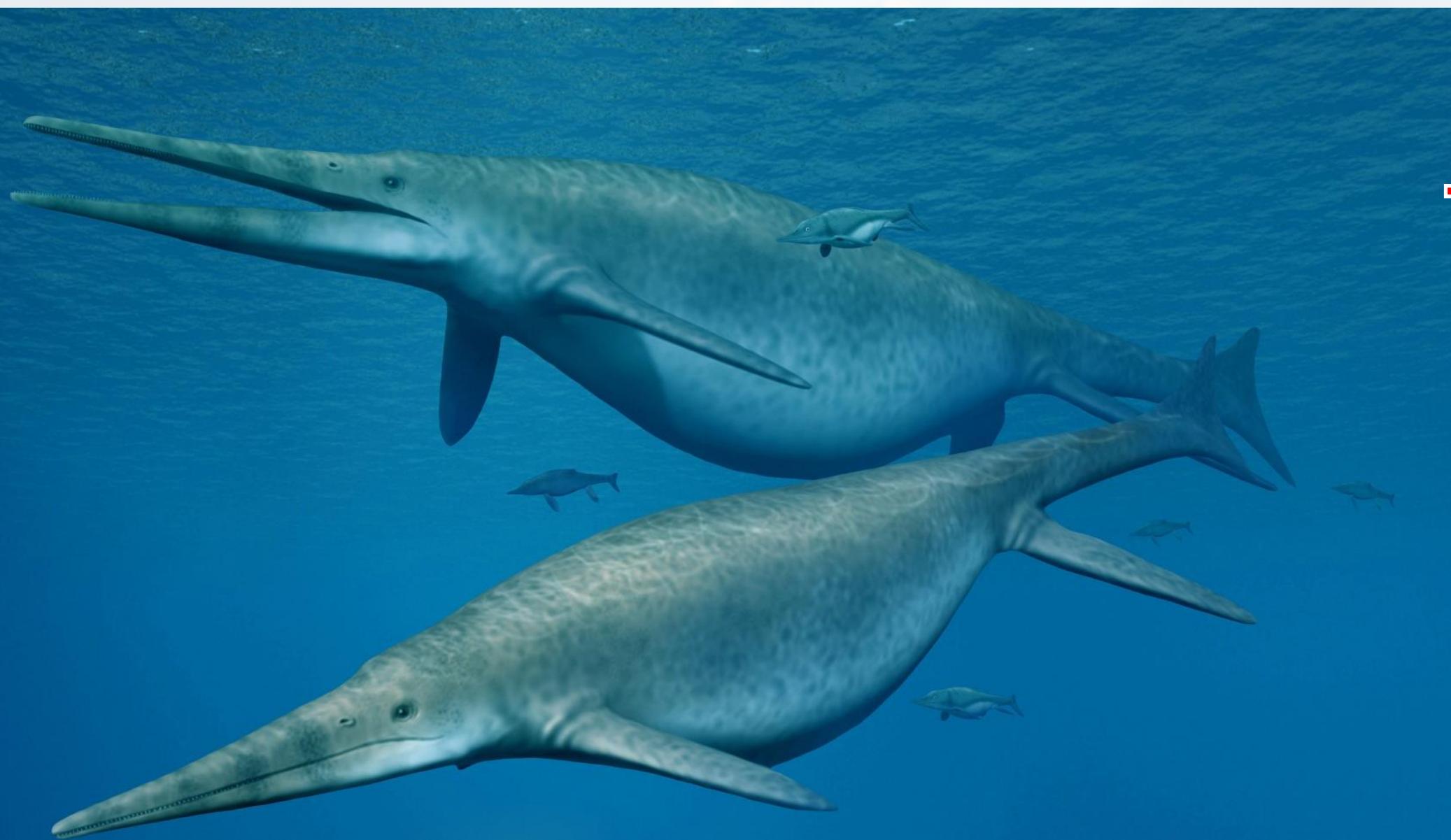
500
Ordovician

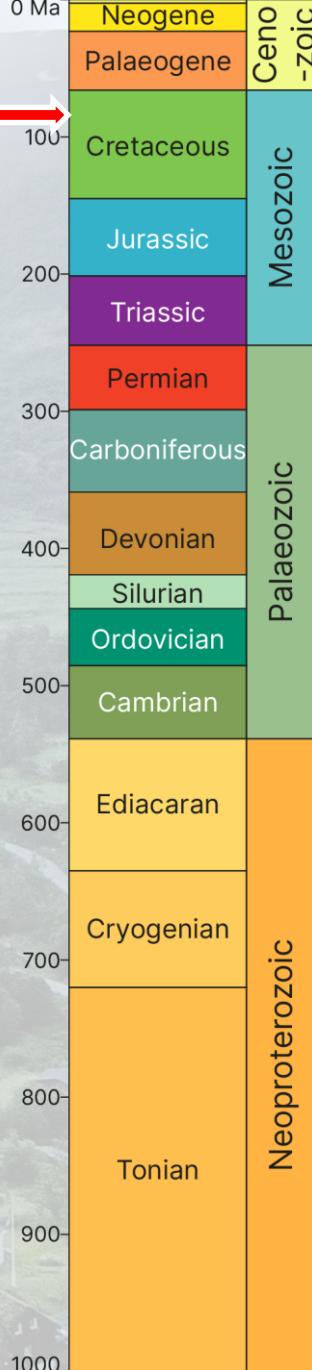
Cambrian

600
Ediacaran700
Cryogenian800
Tonian

Neoproterozoic

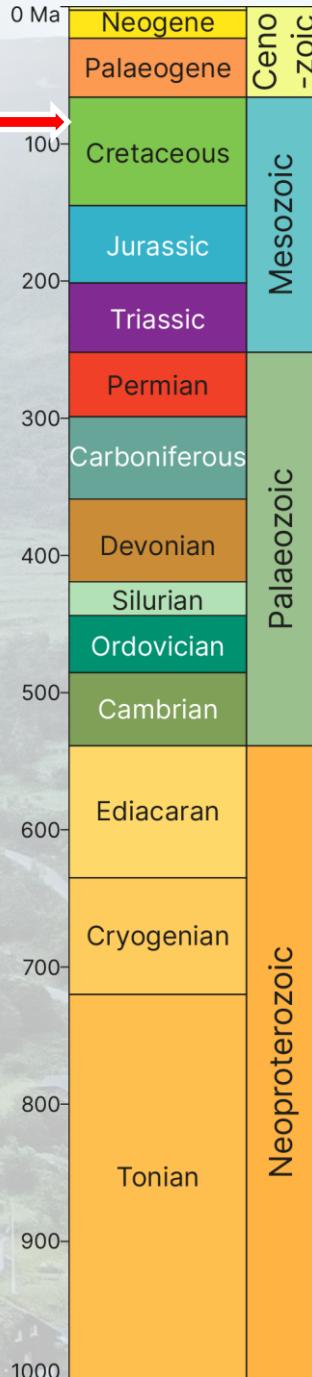
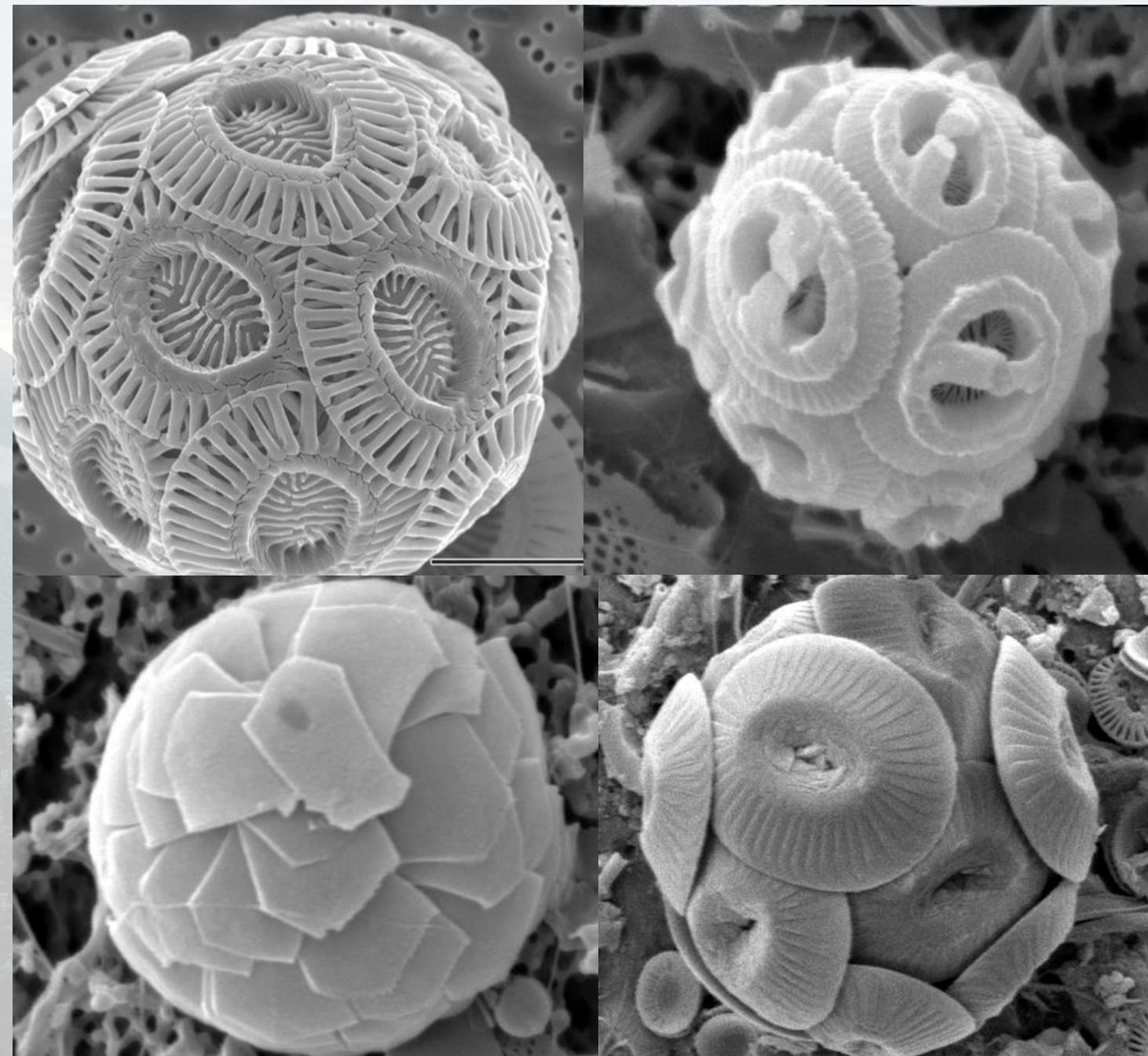




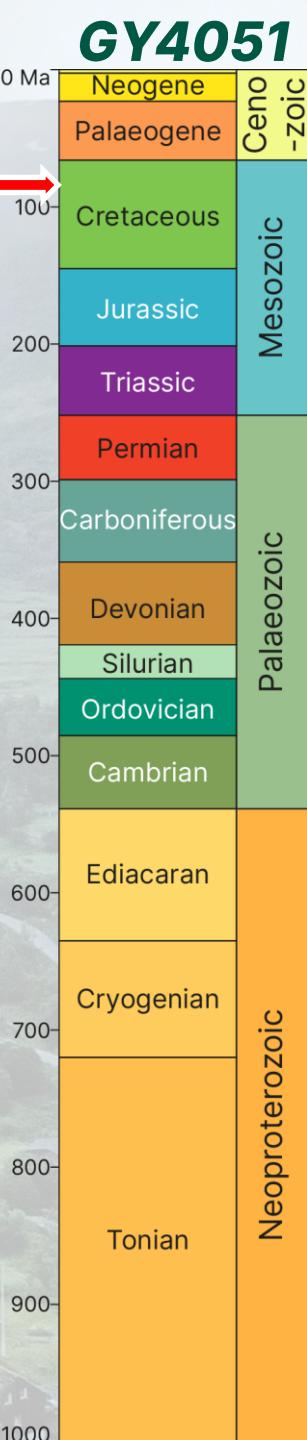


Coccolithophores

- Haptophyte Protists (single-celled organisms)
- Phytoplankton - photosynthetic
- Spherical cell enclosed by plates called coccoliths
- Component of deep sea calcareous ooze

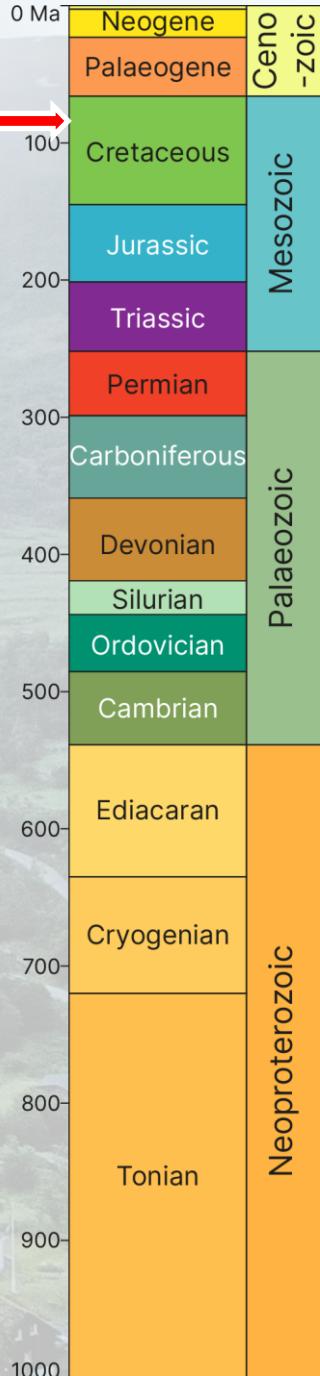
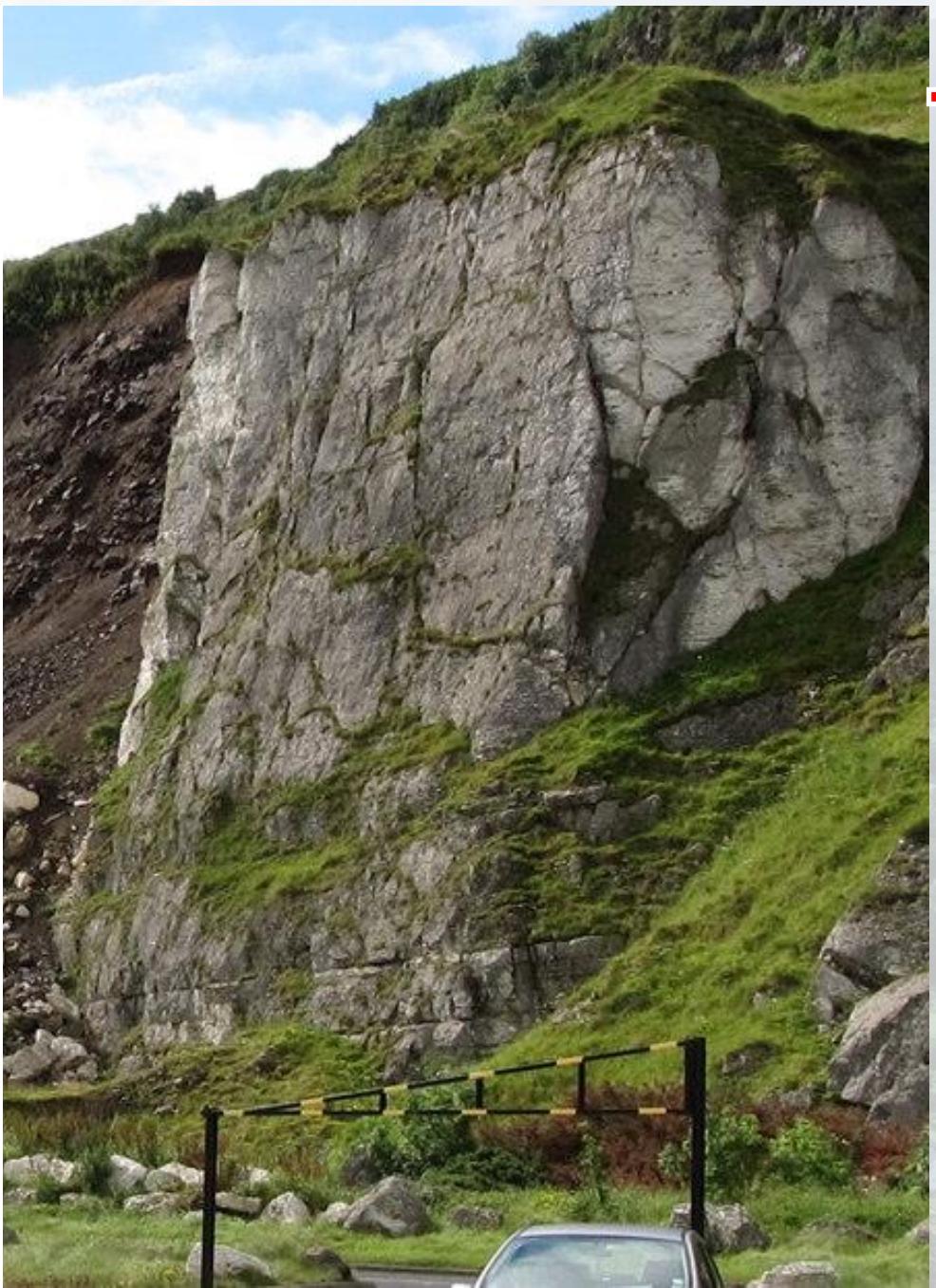
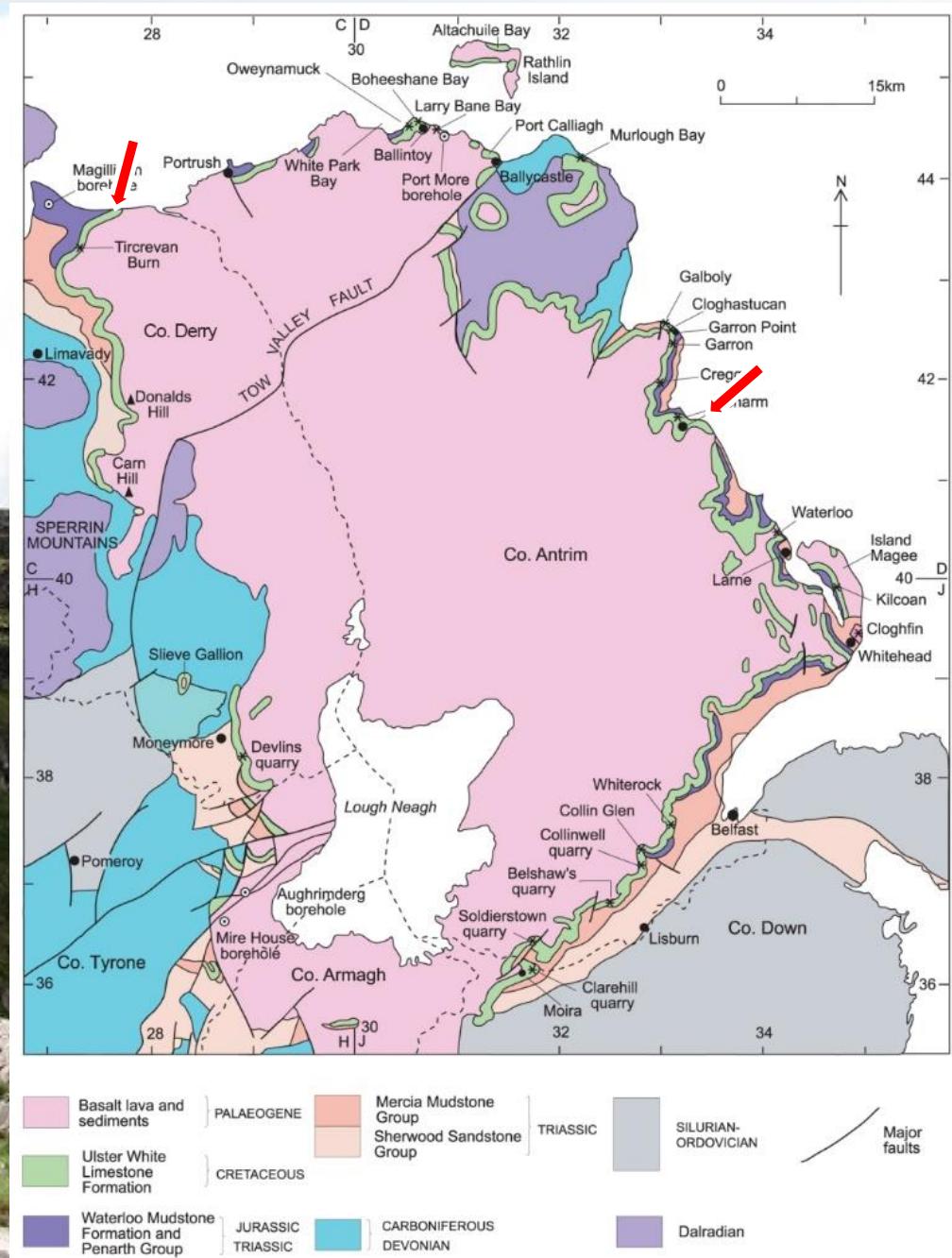


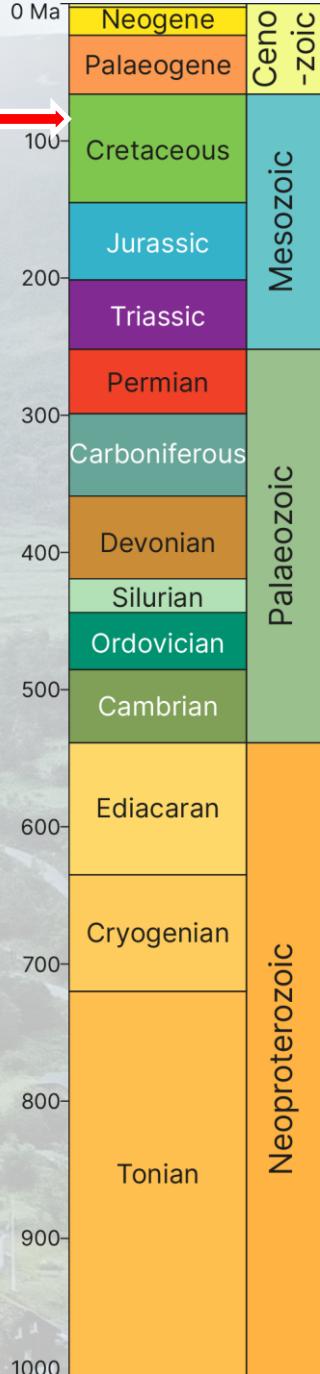
AD



Recent Ireland | Cretaceous

AD

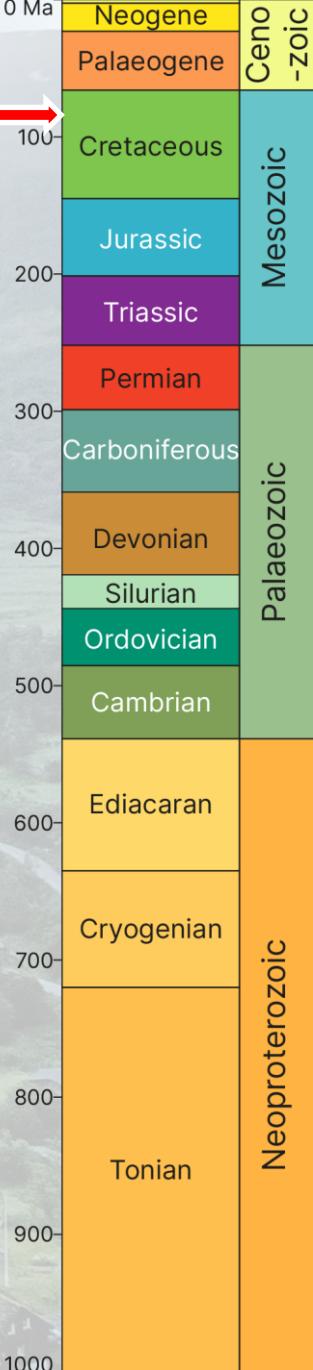
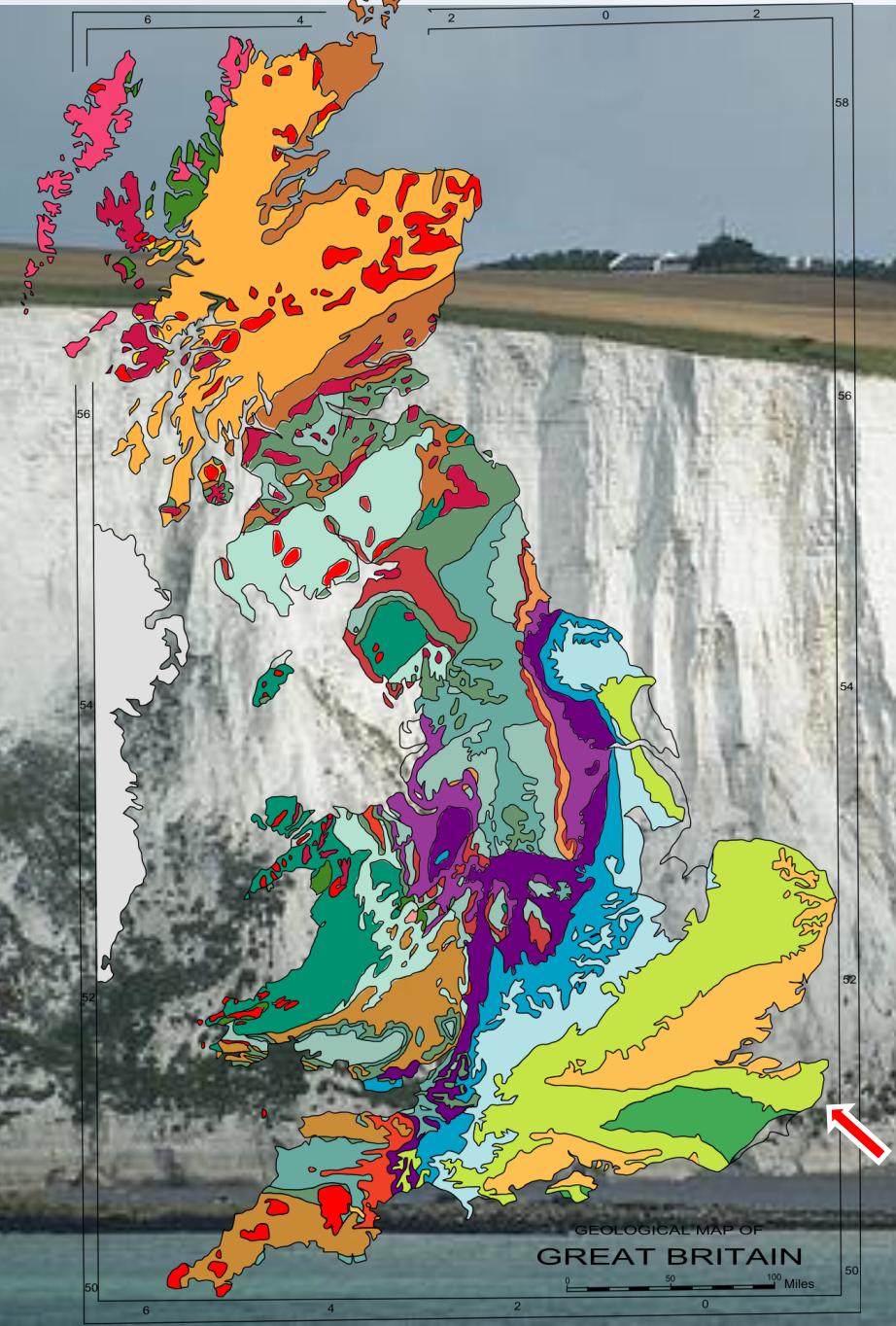


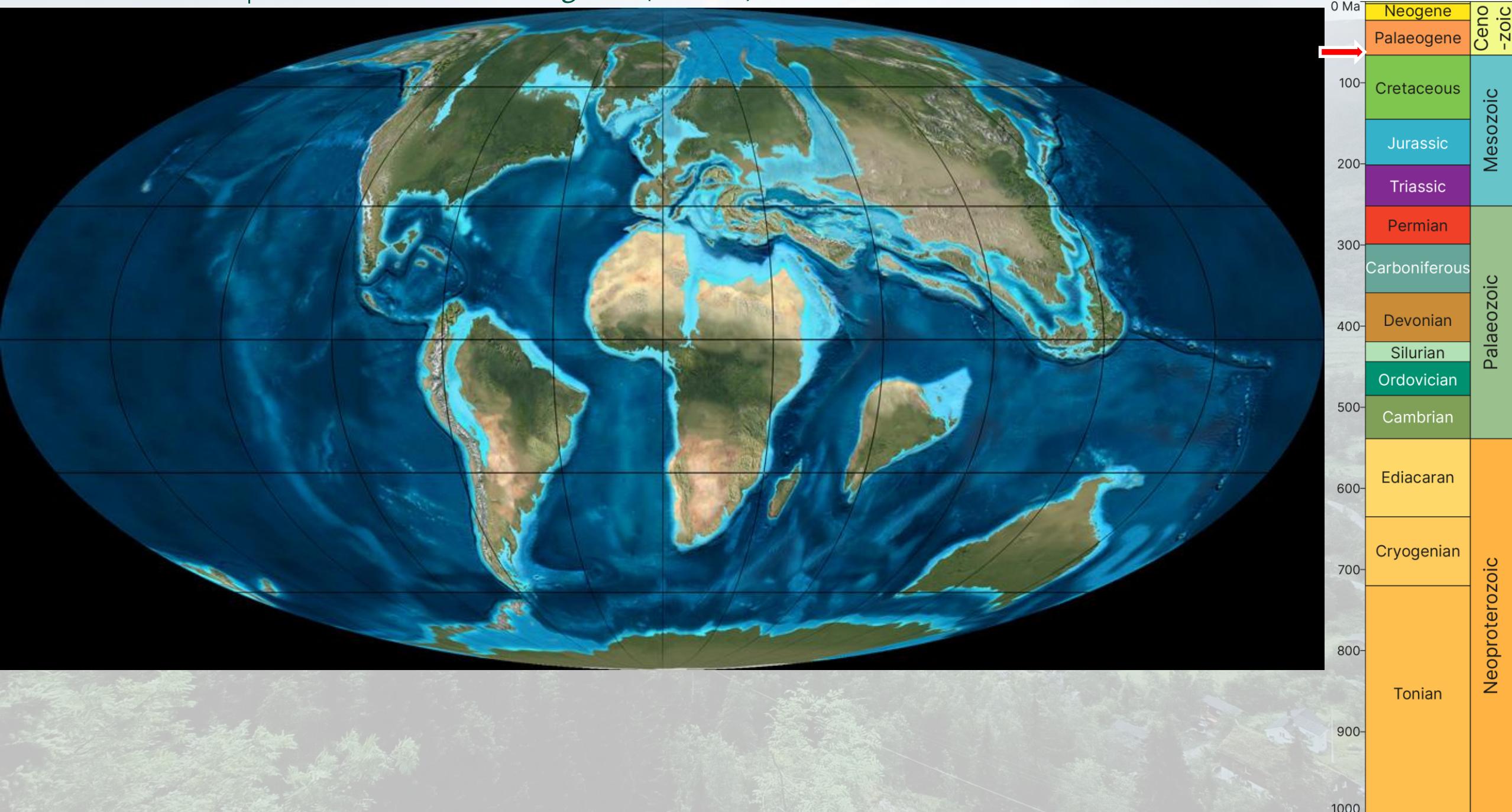


Recent Ireland

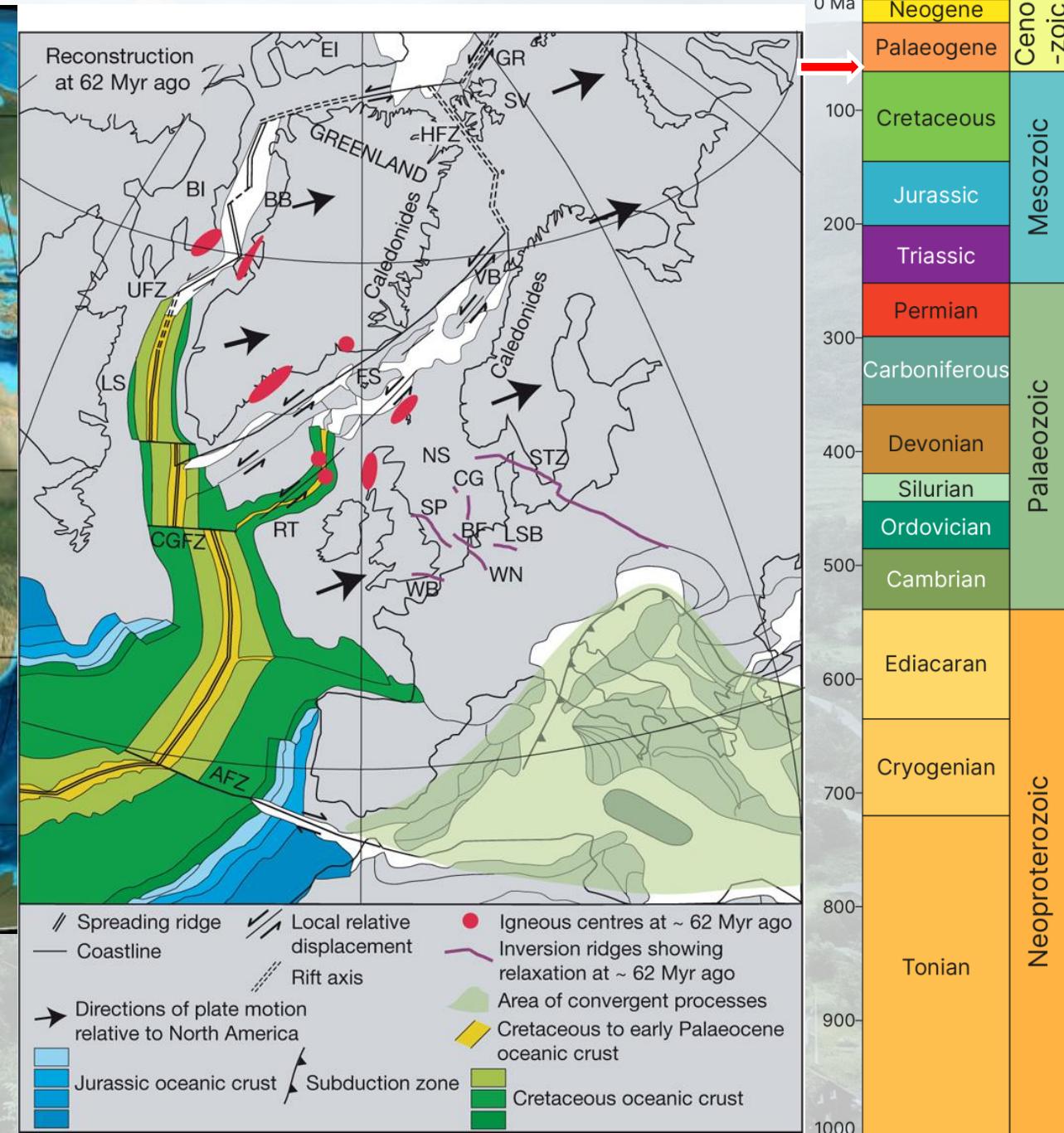
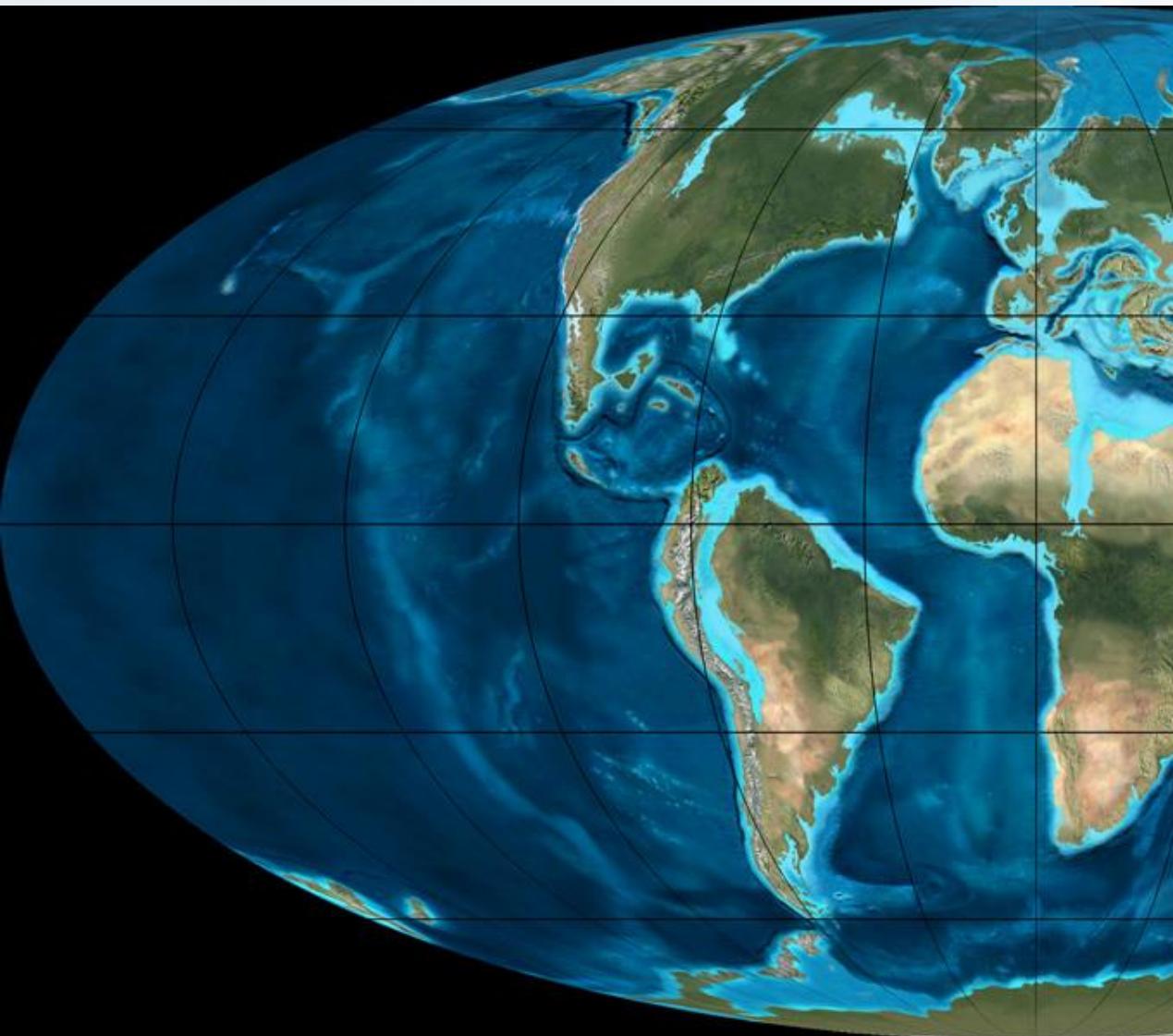
Cetaceous

GY4051

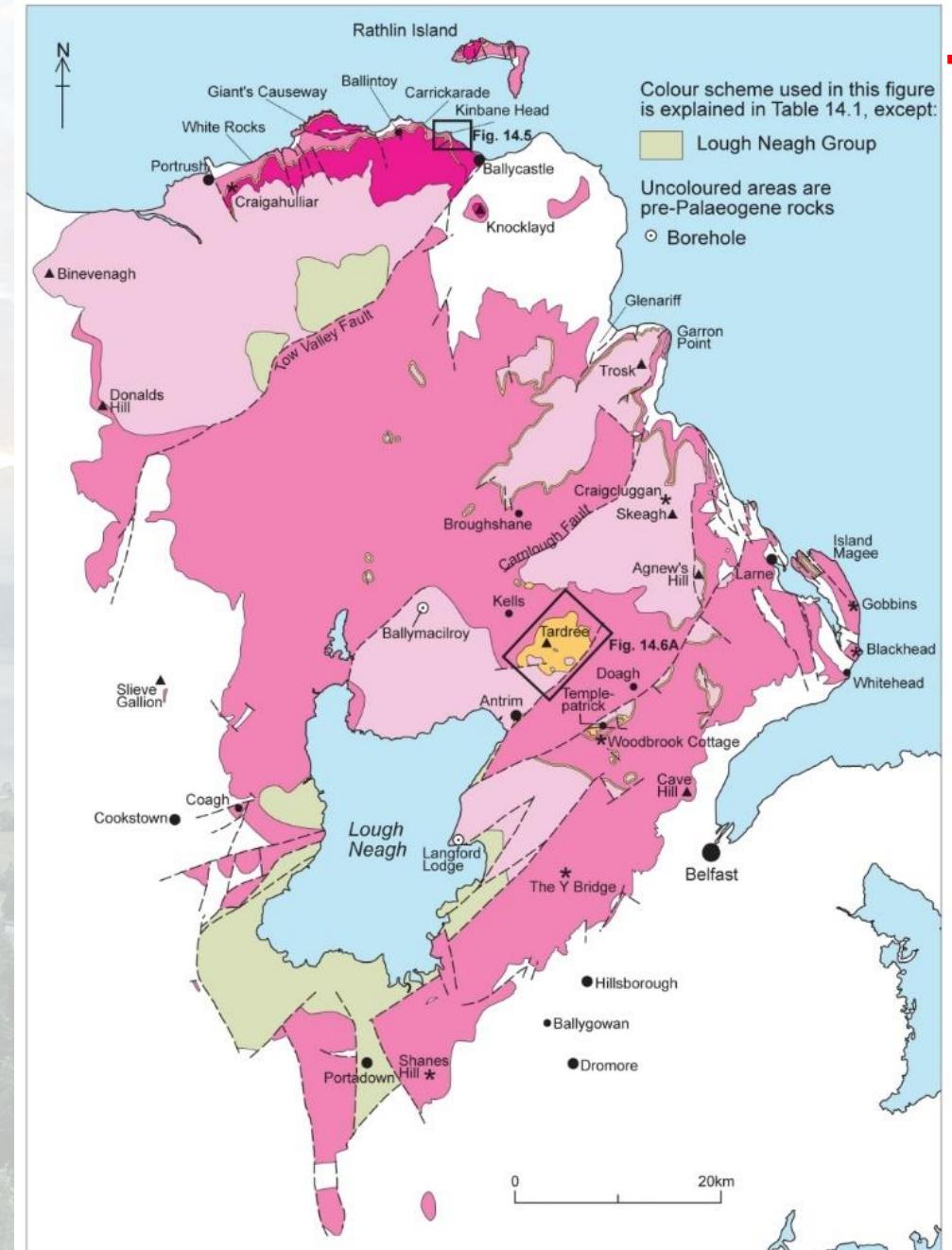
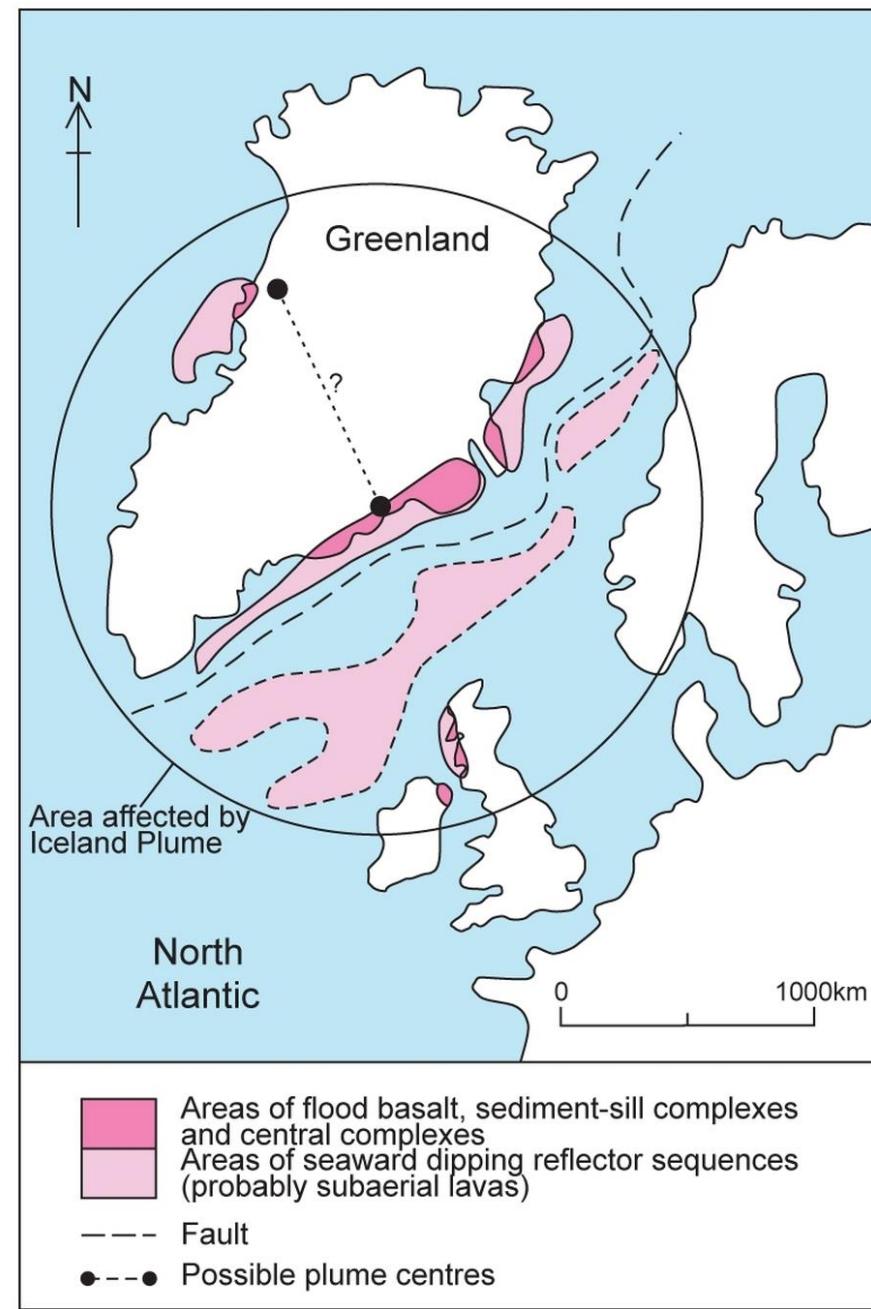




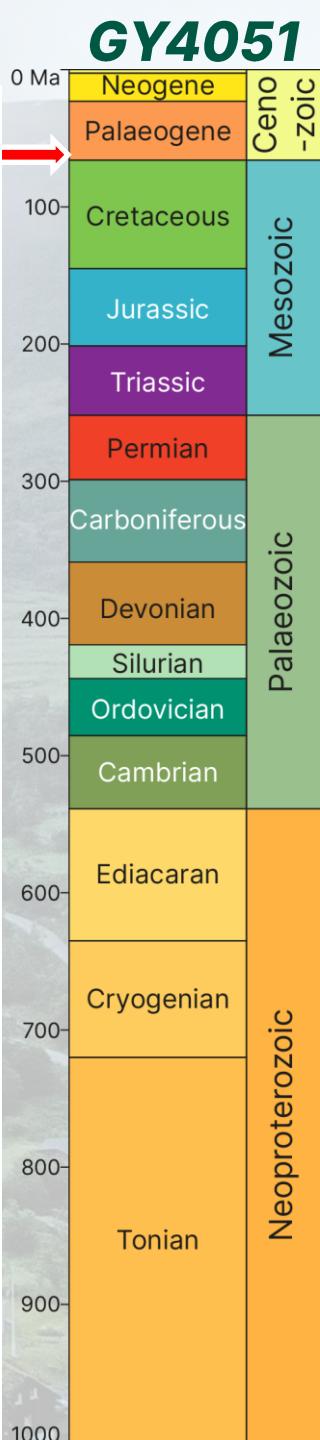
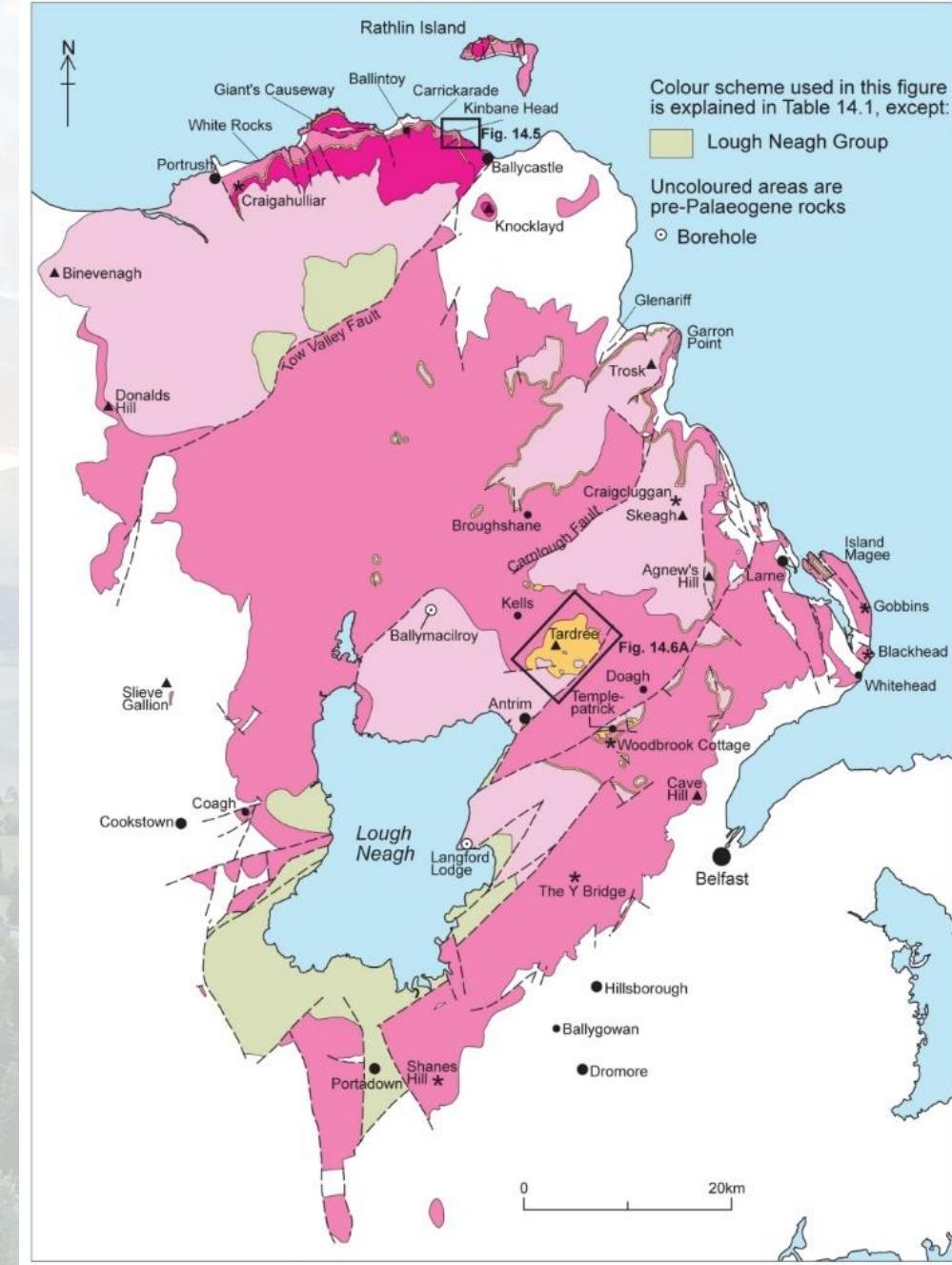
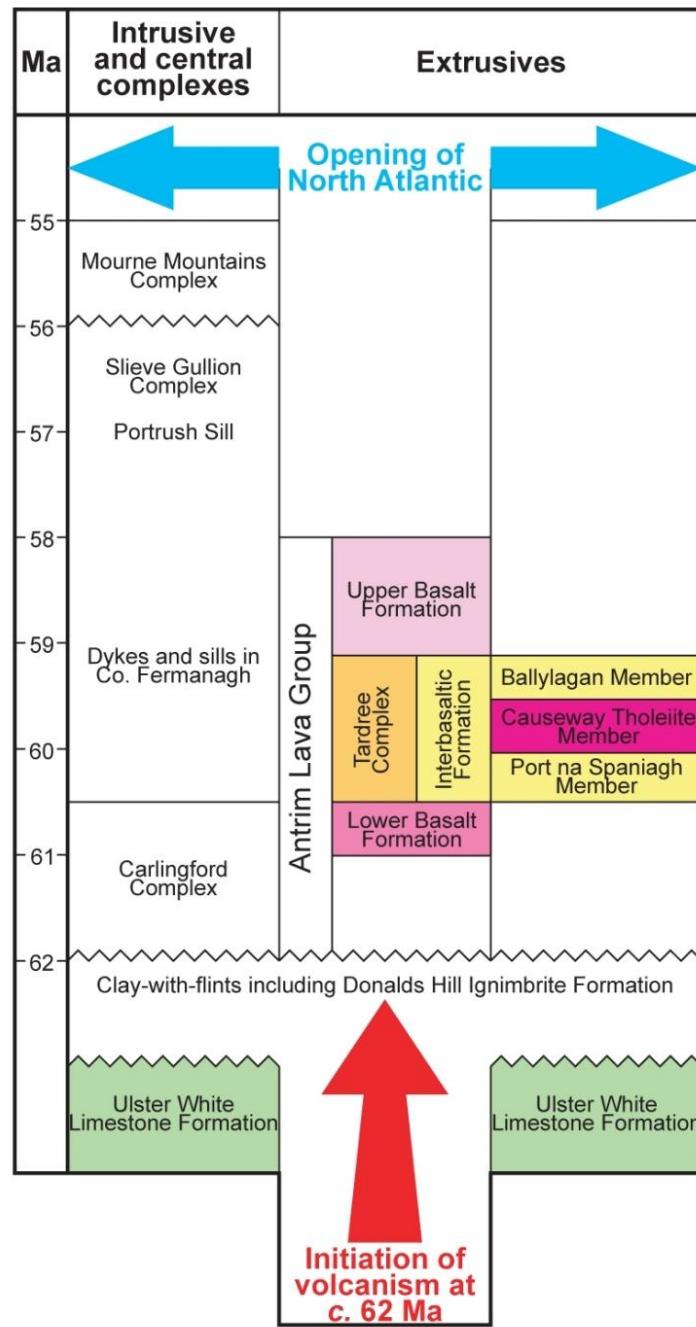
Recent Ireland | *The Atlantic Ocean Opens*



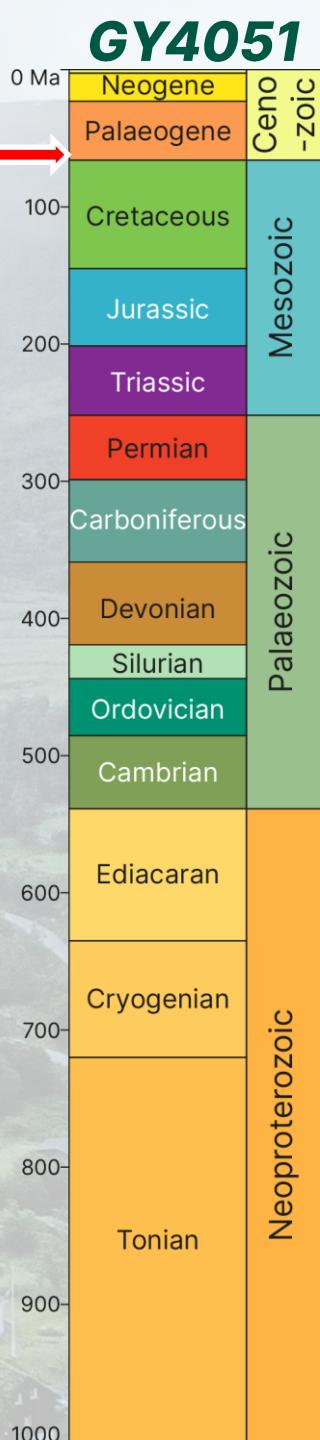
Recent Ireland | The Iceland Plume



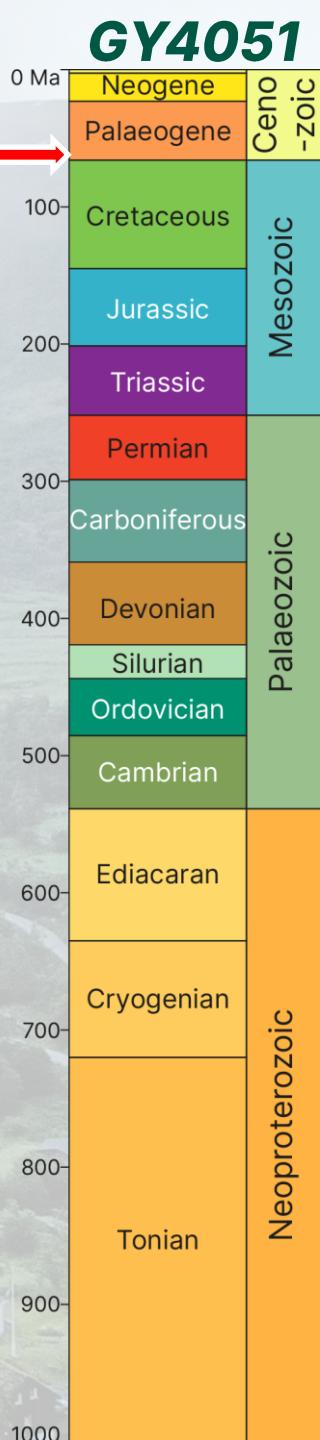
Recent Ireland | The Antrim Plateau



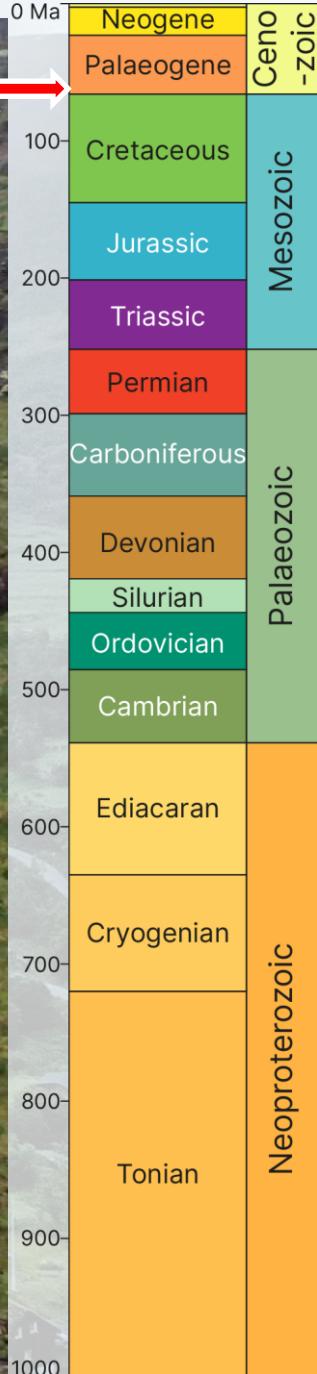
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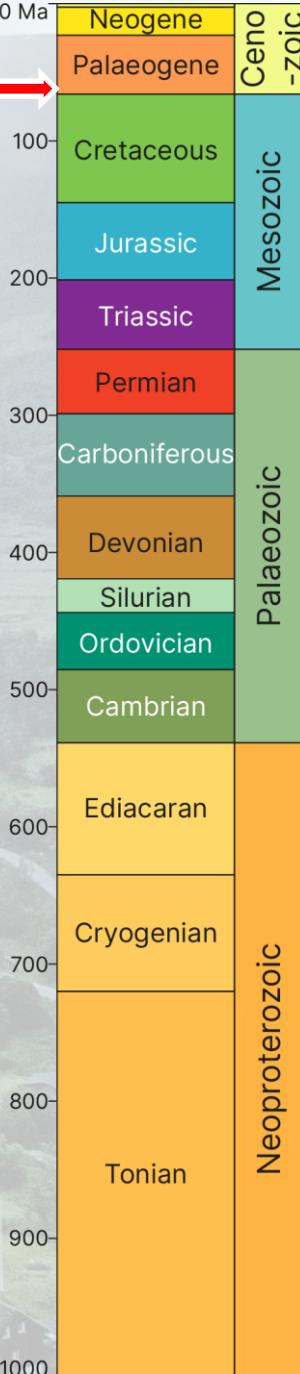
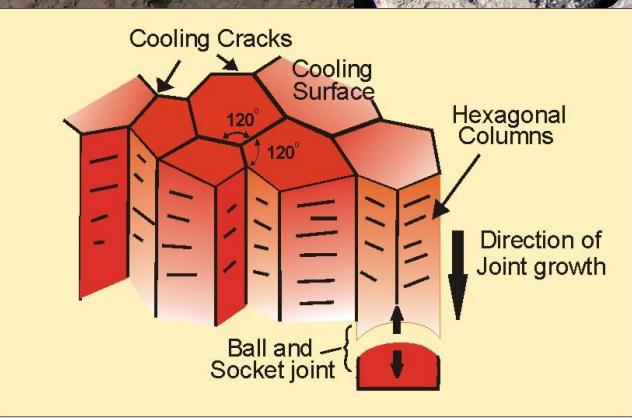
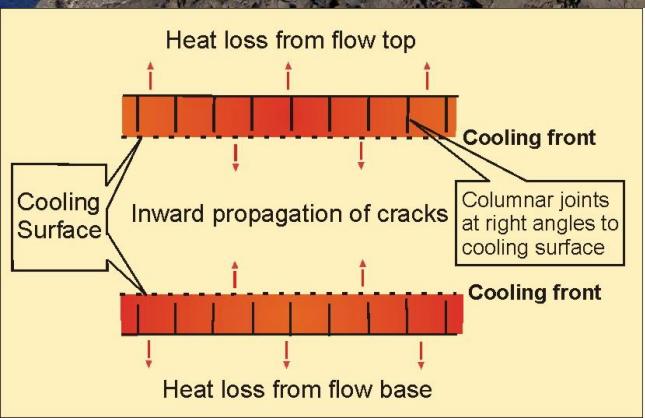
D

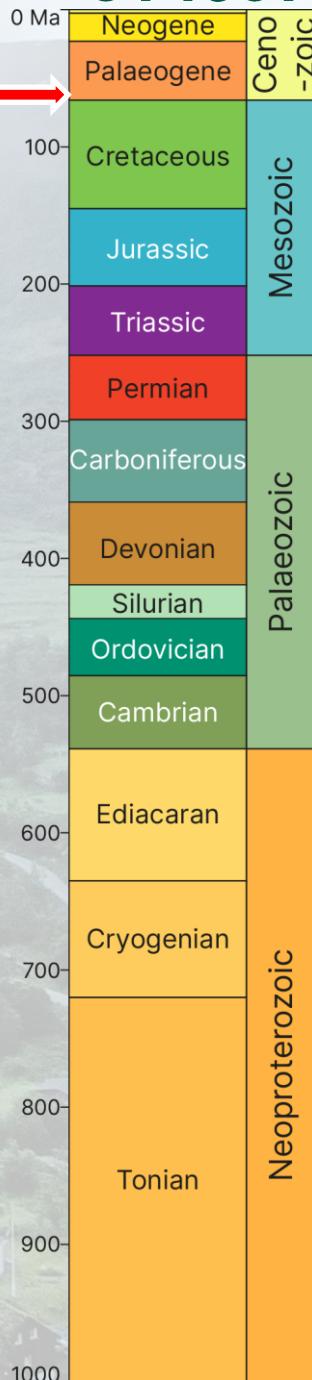


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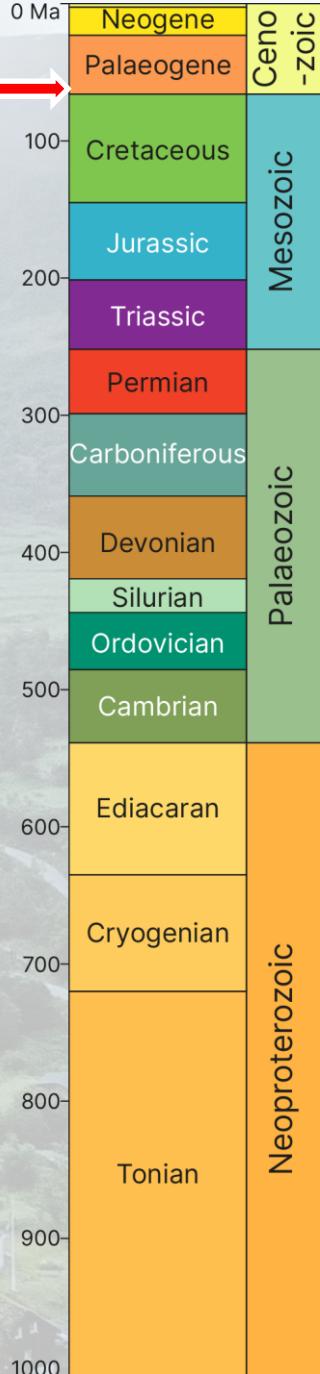


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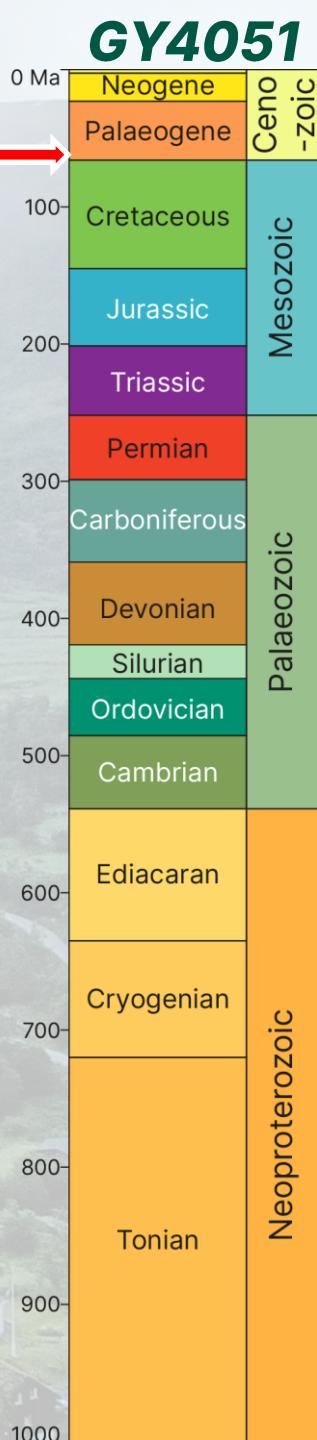


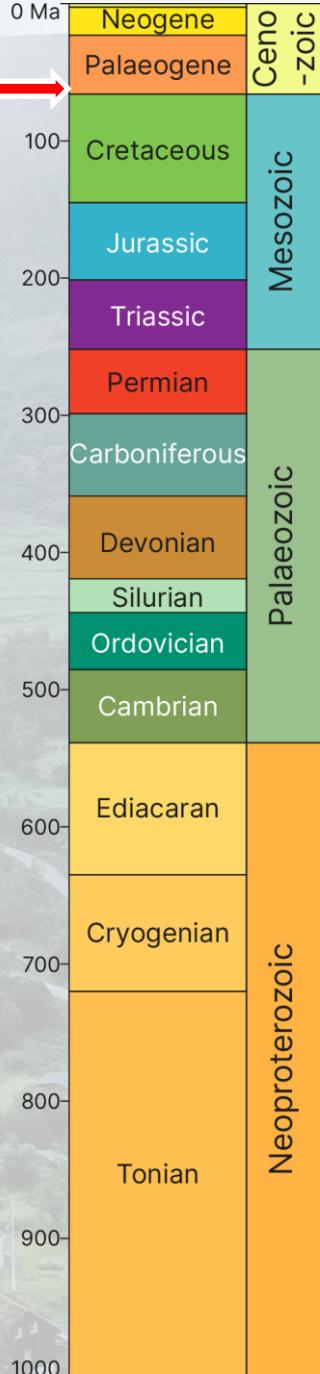


B



B

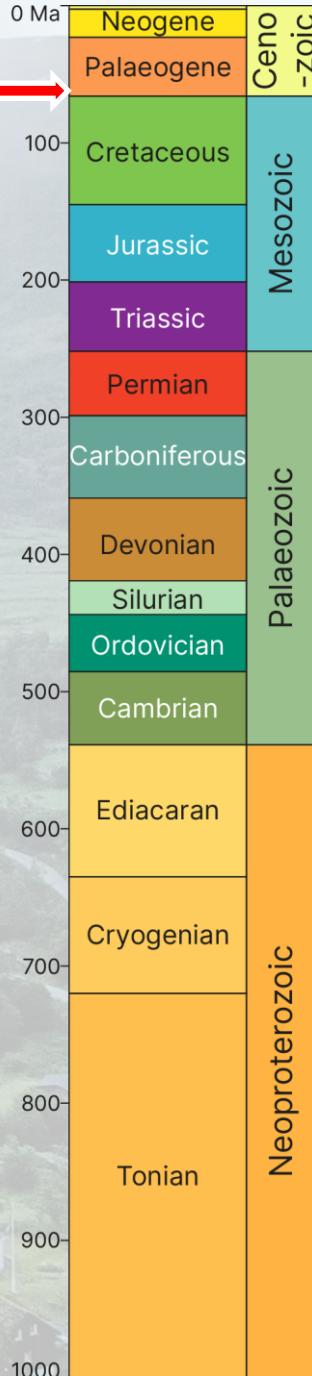




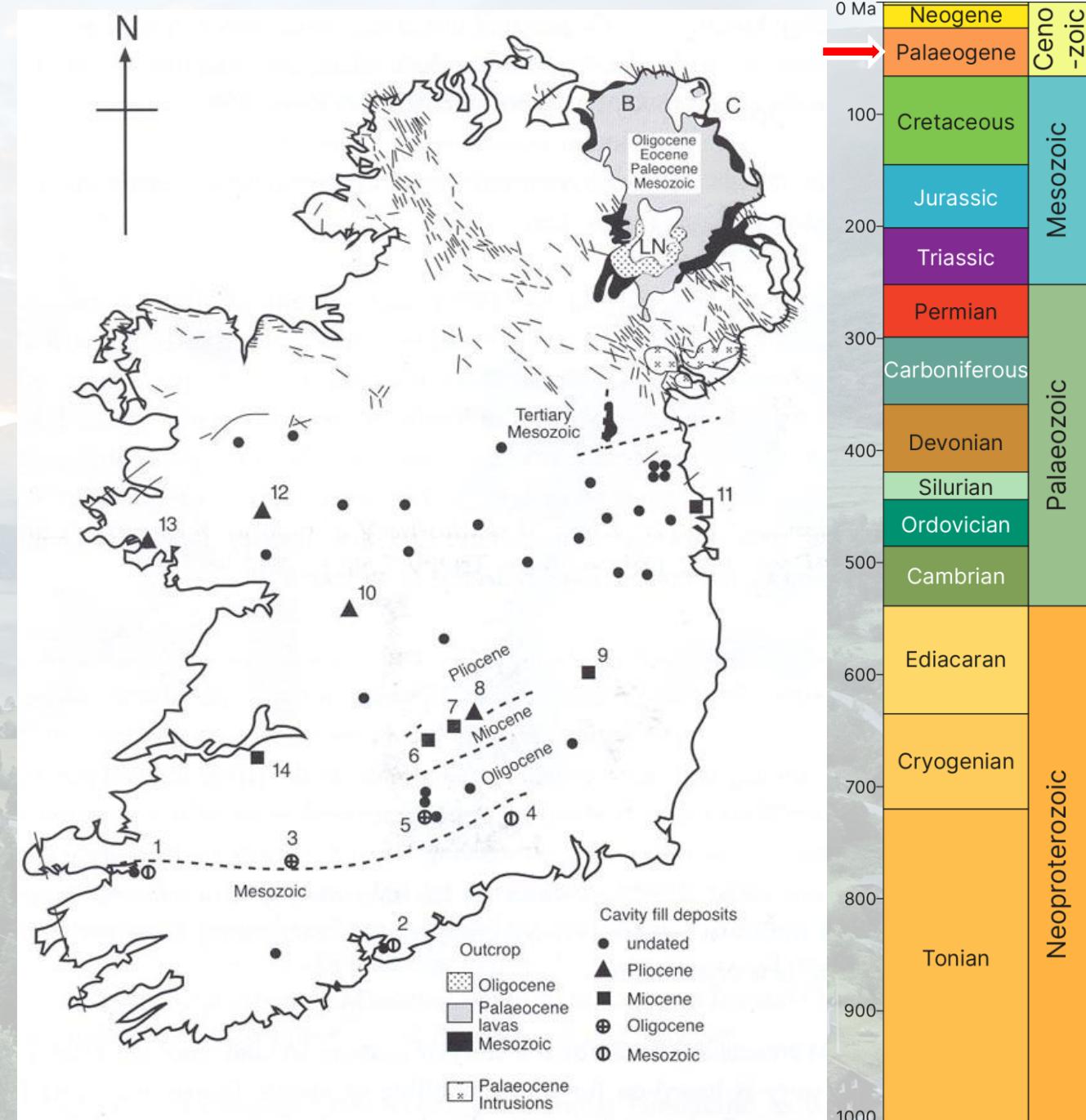


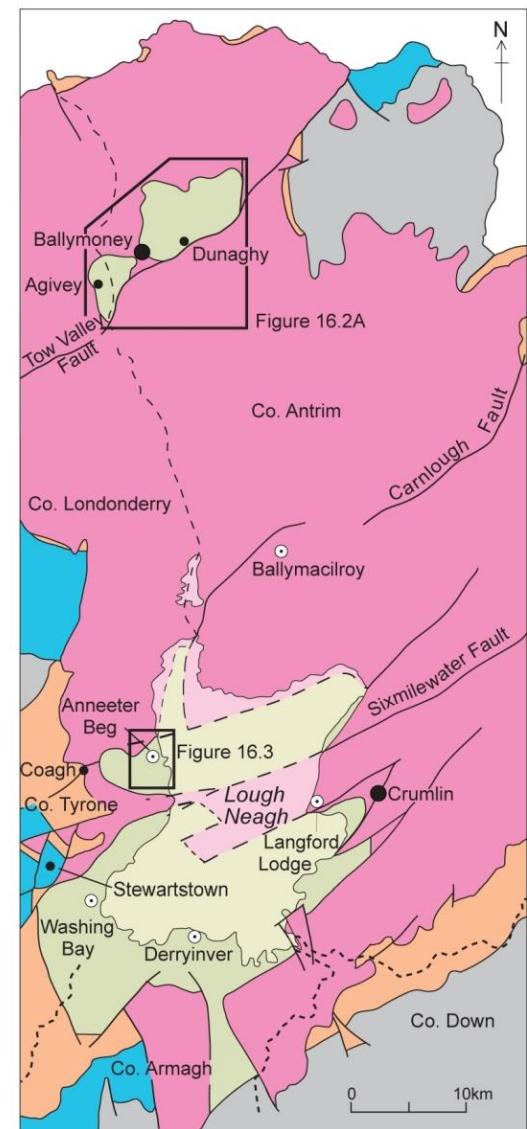
In the vicinity of Newry (from Slieve Gullion to Slieve Croob), the basement rocks comprise a sequence of granite masses, several kilometres deep, which were emplaced into the Ordovician and Silurian rocks about 400 million years ago. These Newry Igneous Complex rocks range from granodiorite to granite and are potential HSR host rocks.

The younger igneous rocks in this subregion comprise the granite and related rocks of the Mourne Mountains and Slieve Gullion Complex which were formed as large masses hundreds of metres thick from the solidification of molten rock below ancient volcanoes about 55 to 60 million years ago. The total thickness of the Mourne Mountains Complex is uncertain, however a borehole located in Silent Valley passed through approximately 600m of granite without reaching the base. These younger igneous rocks are potential HSR host rocks.



Nothing to
see here...





Lough Neagh Group
Beneath Lough Neagh Exposed

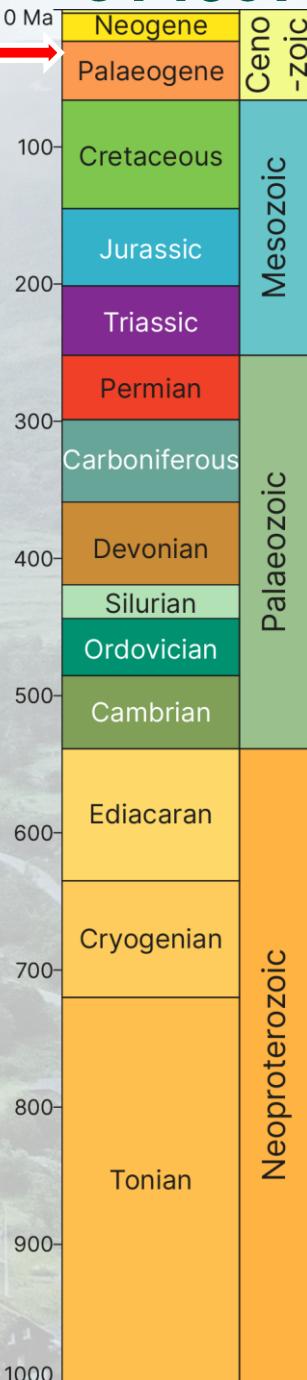
Antrim Lava Group
Beneath Lough Neagh Exposed

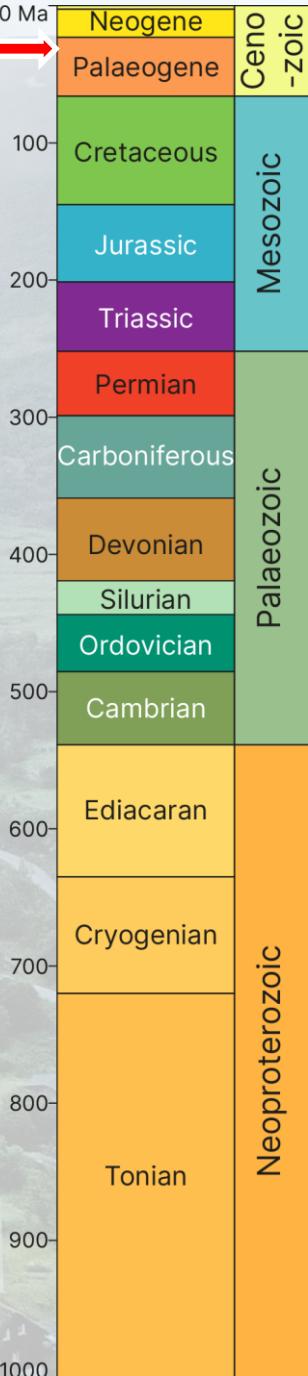
Cretaceous-Triassic-Permian

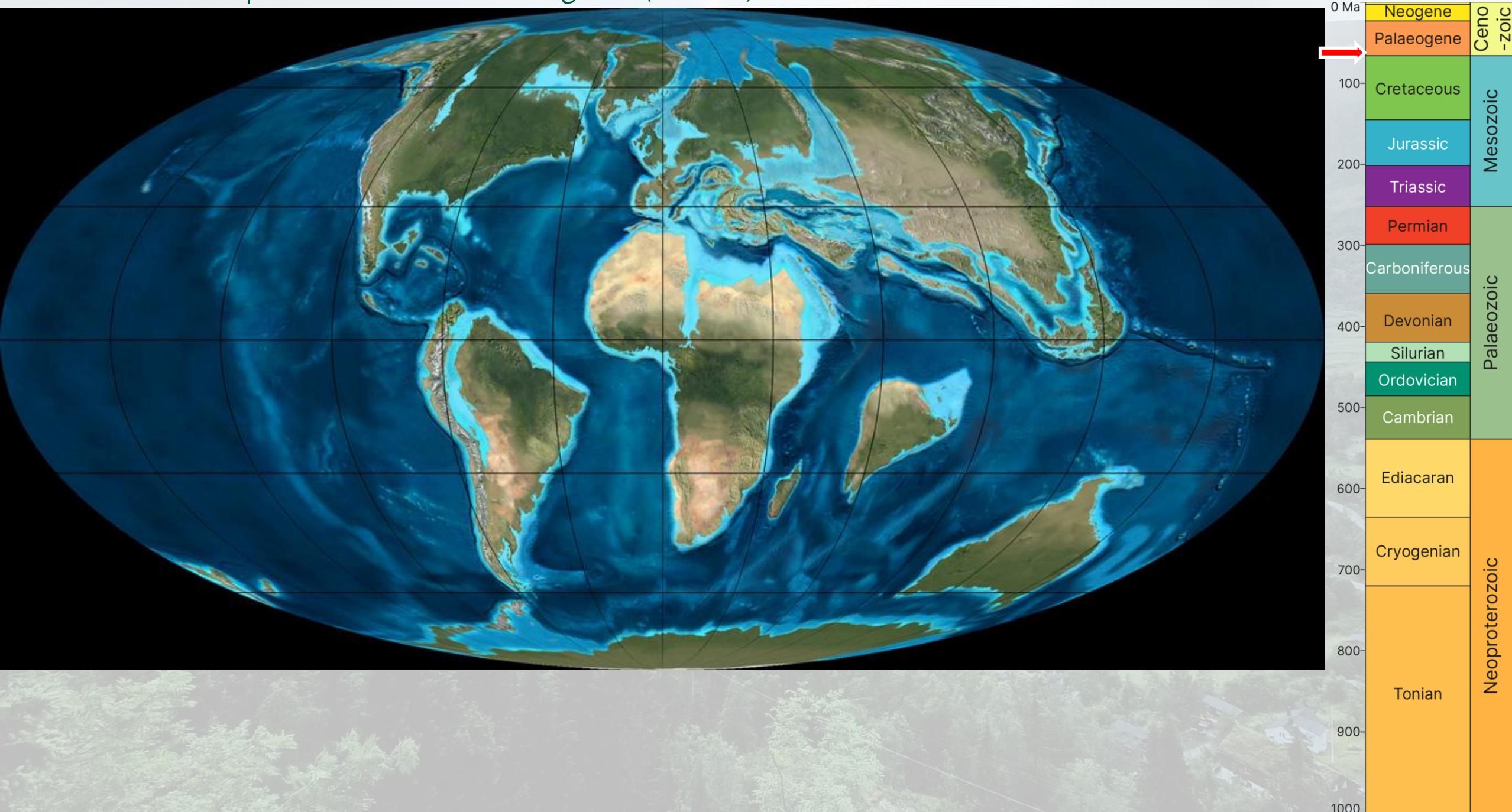
Carboniferous

pre-Carboniferous

Borehole

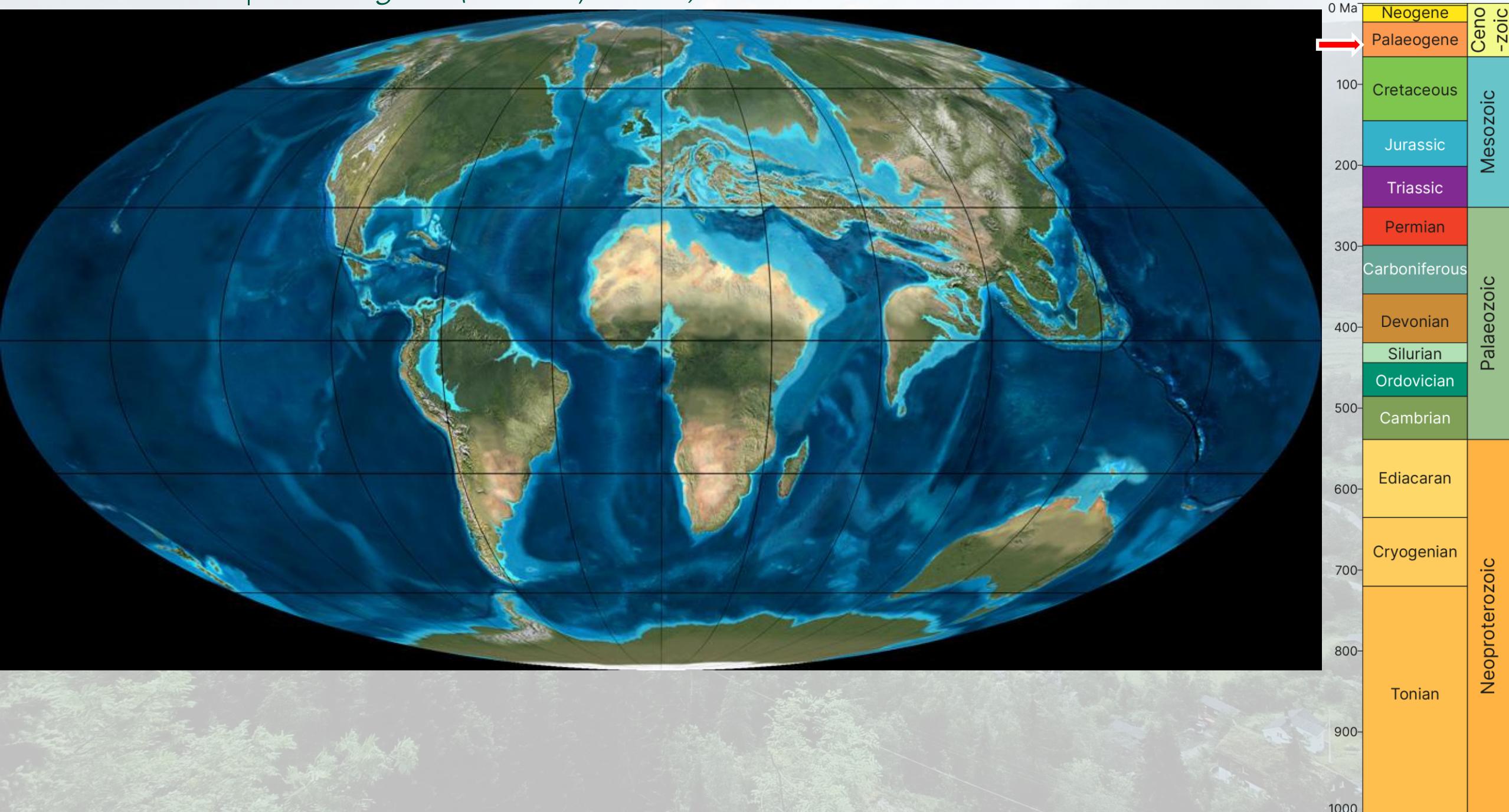






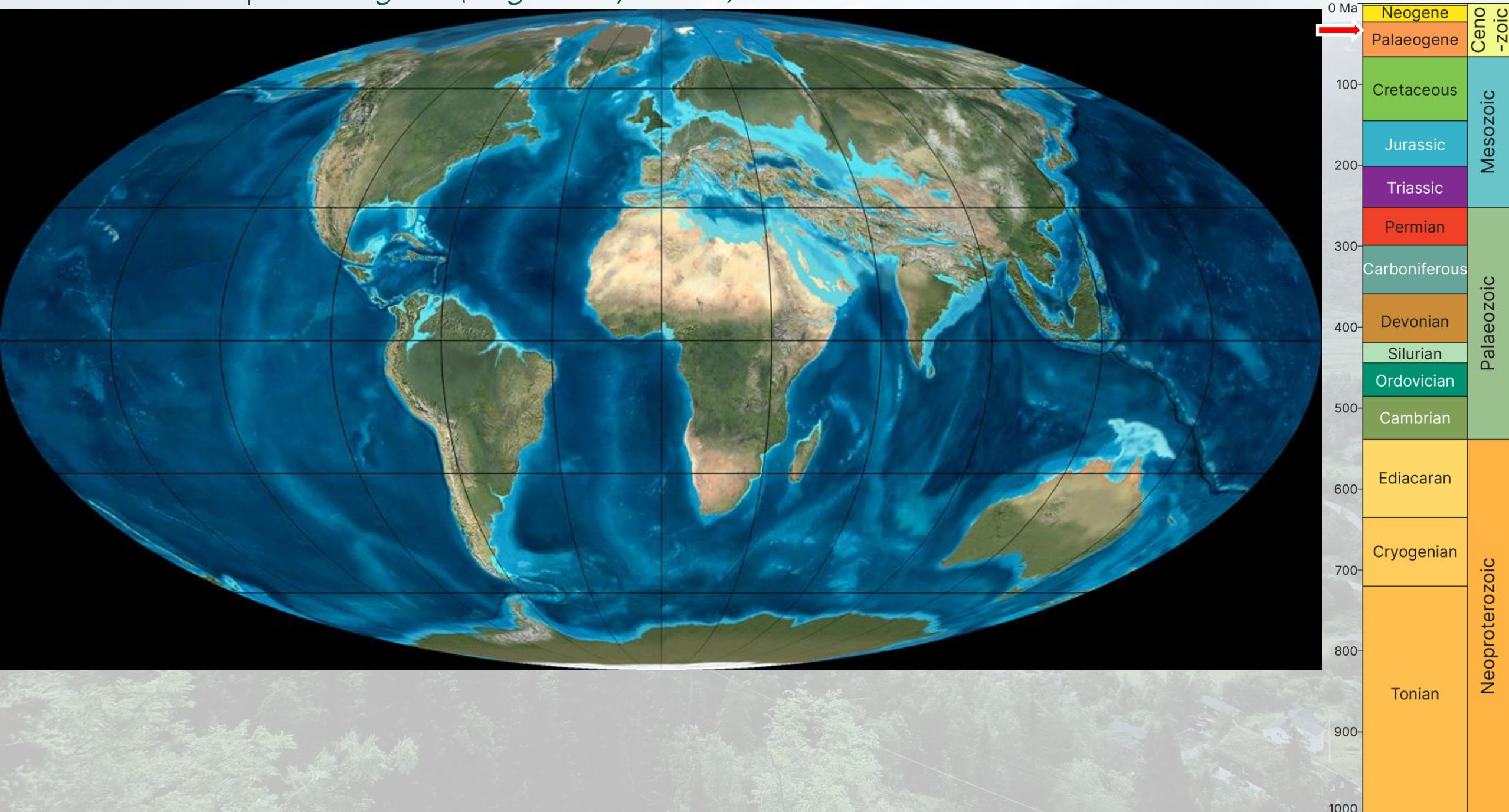
Recent Ireland | Palaeogene (Eocene, 50 Ma)

GY4051



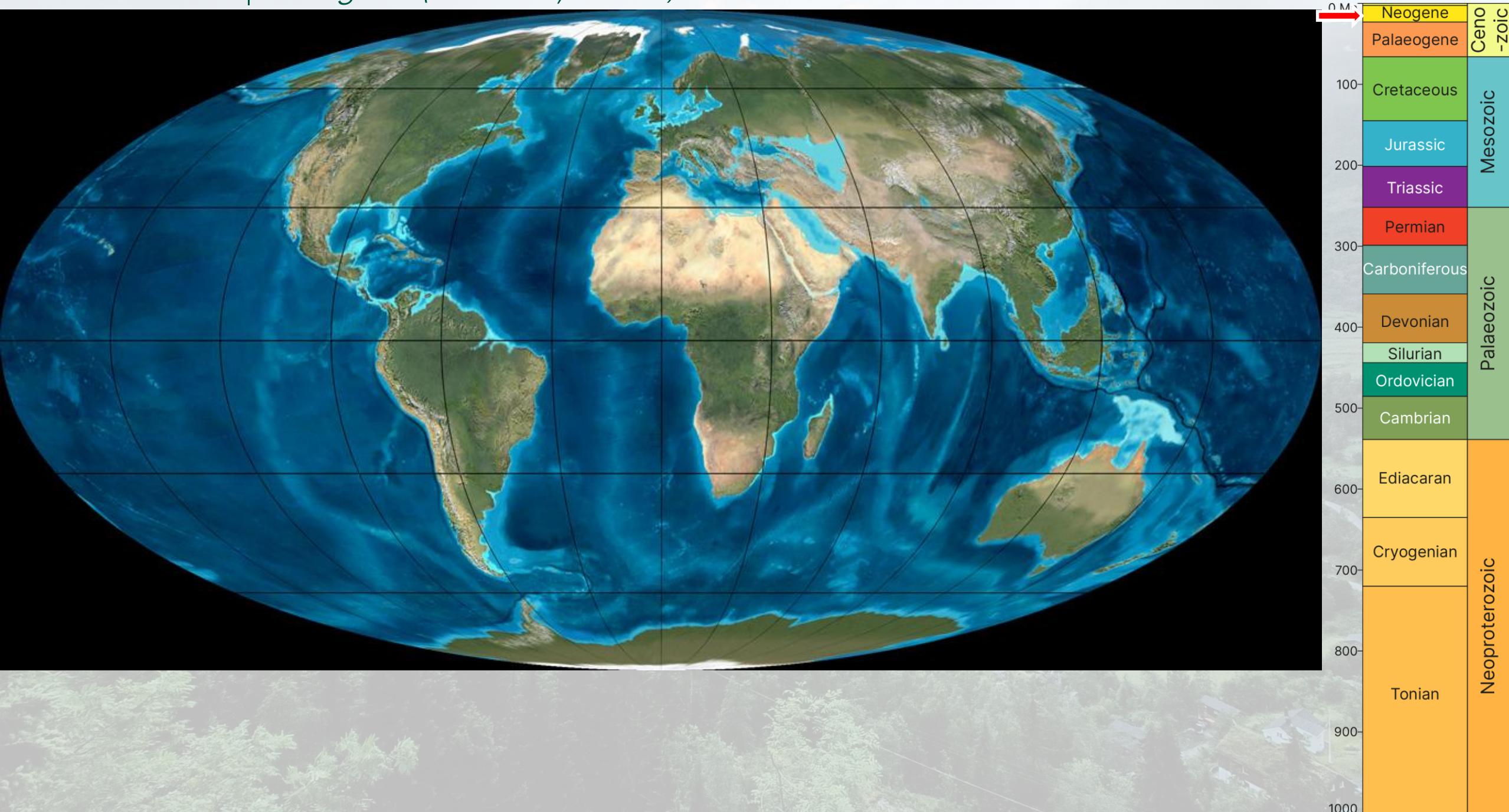
Recent Ireland | Palaeogene (Oligocene, 35 Ma)

GY4051



Recent Ireland | Neogene (Miocene, 20 Ma)

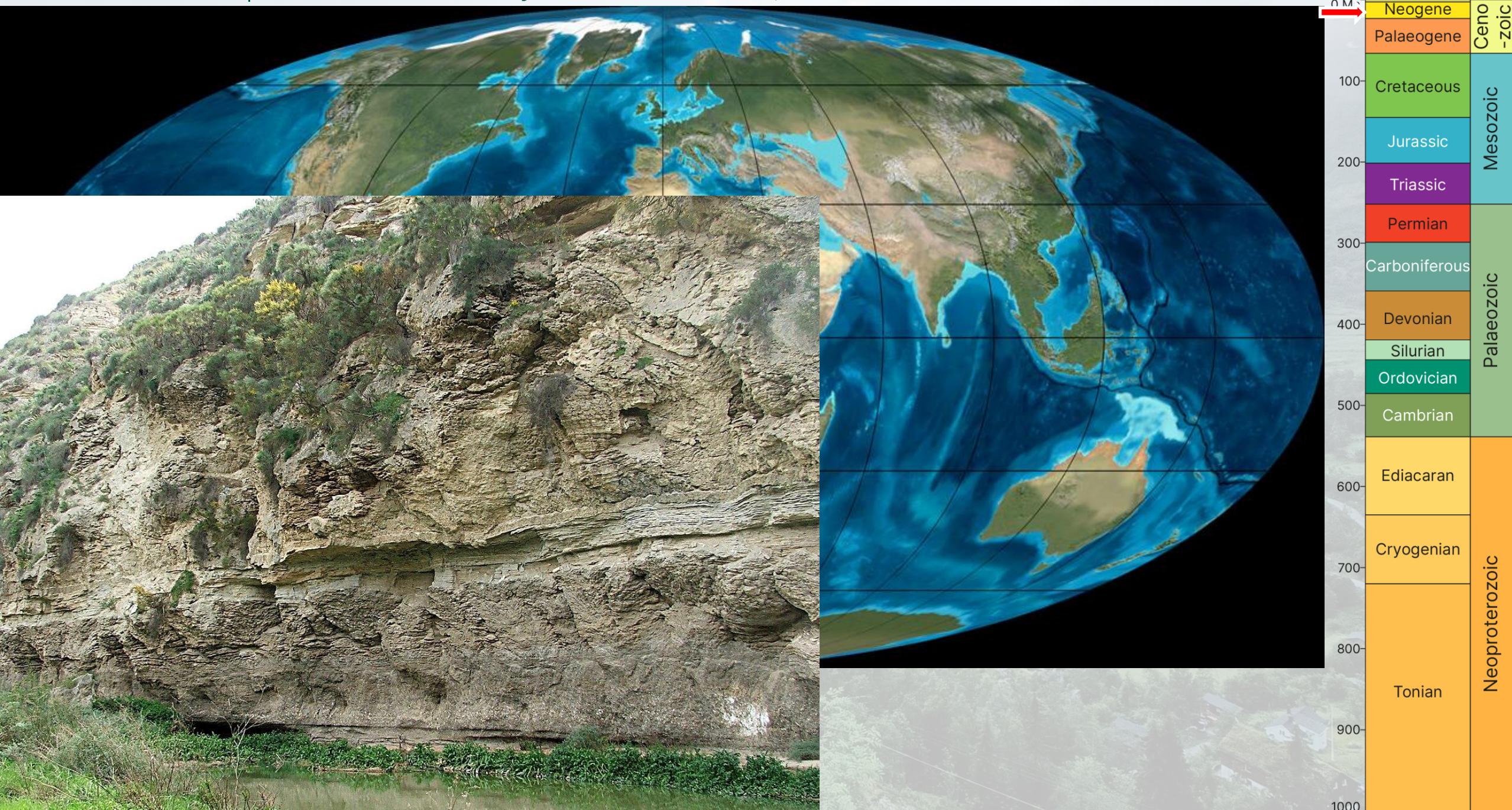
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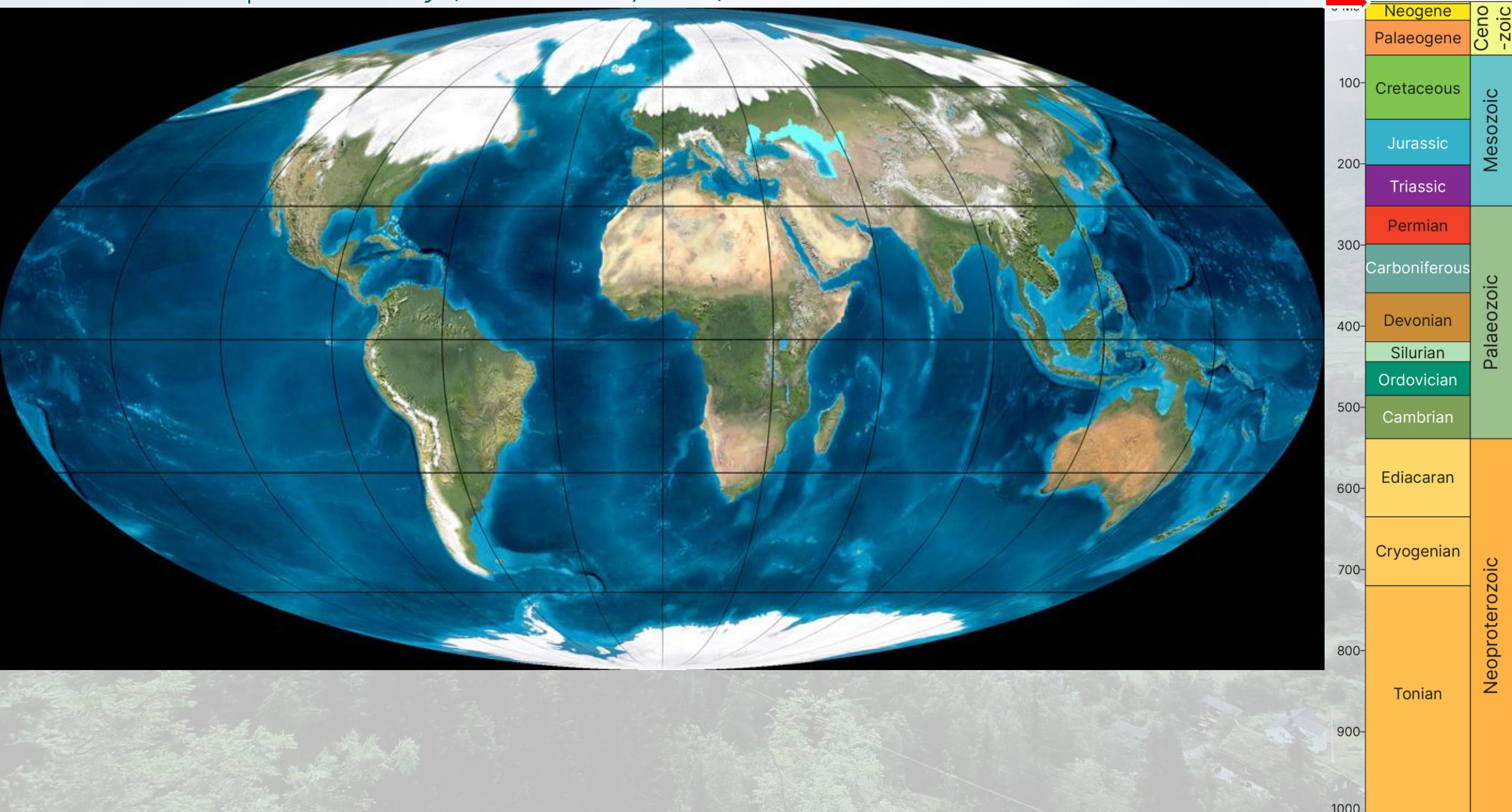
Recent Ireland

Messinian Salinity Crisis (Miocene, 5 Ma)

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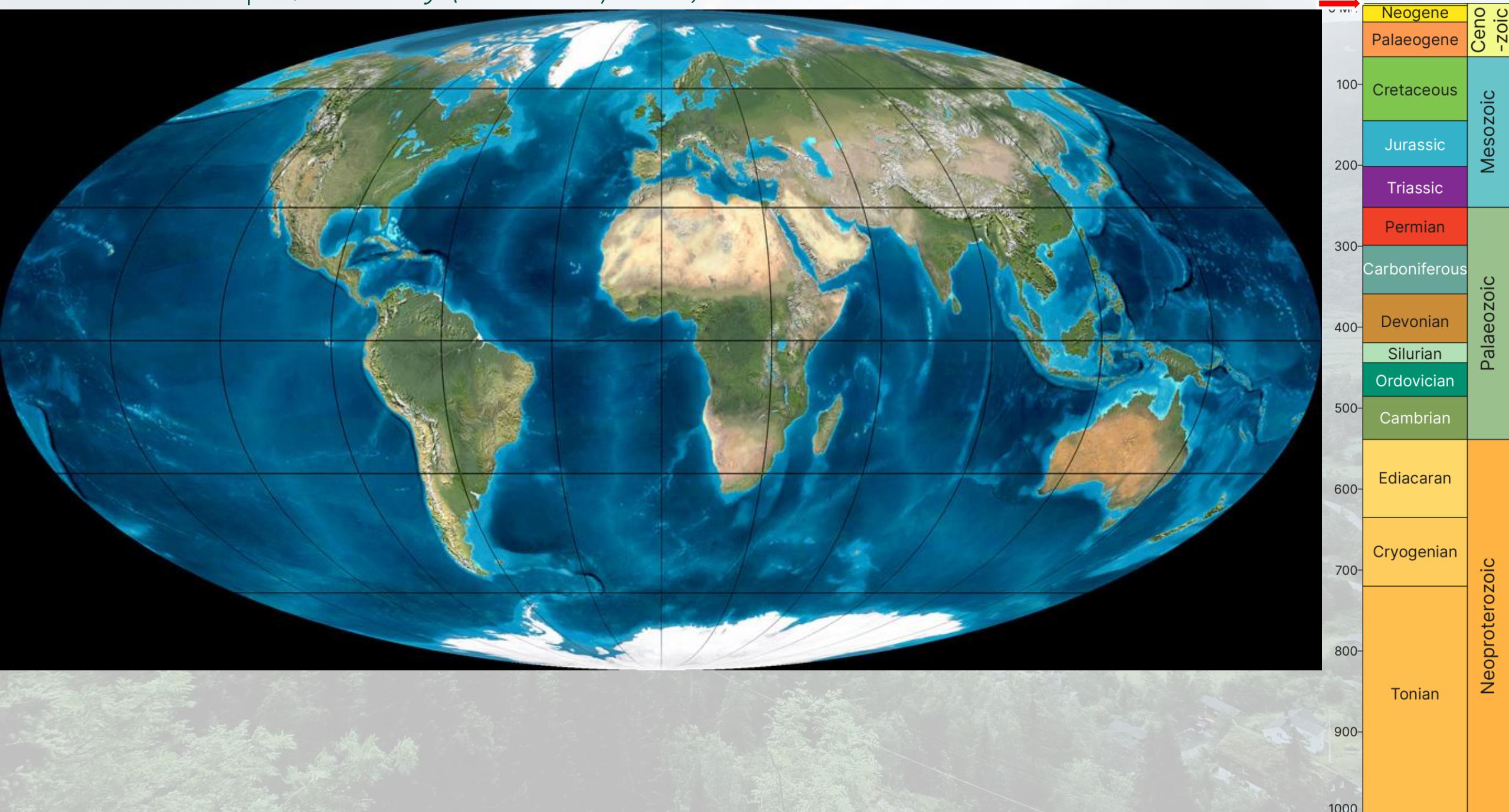


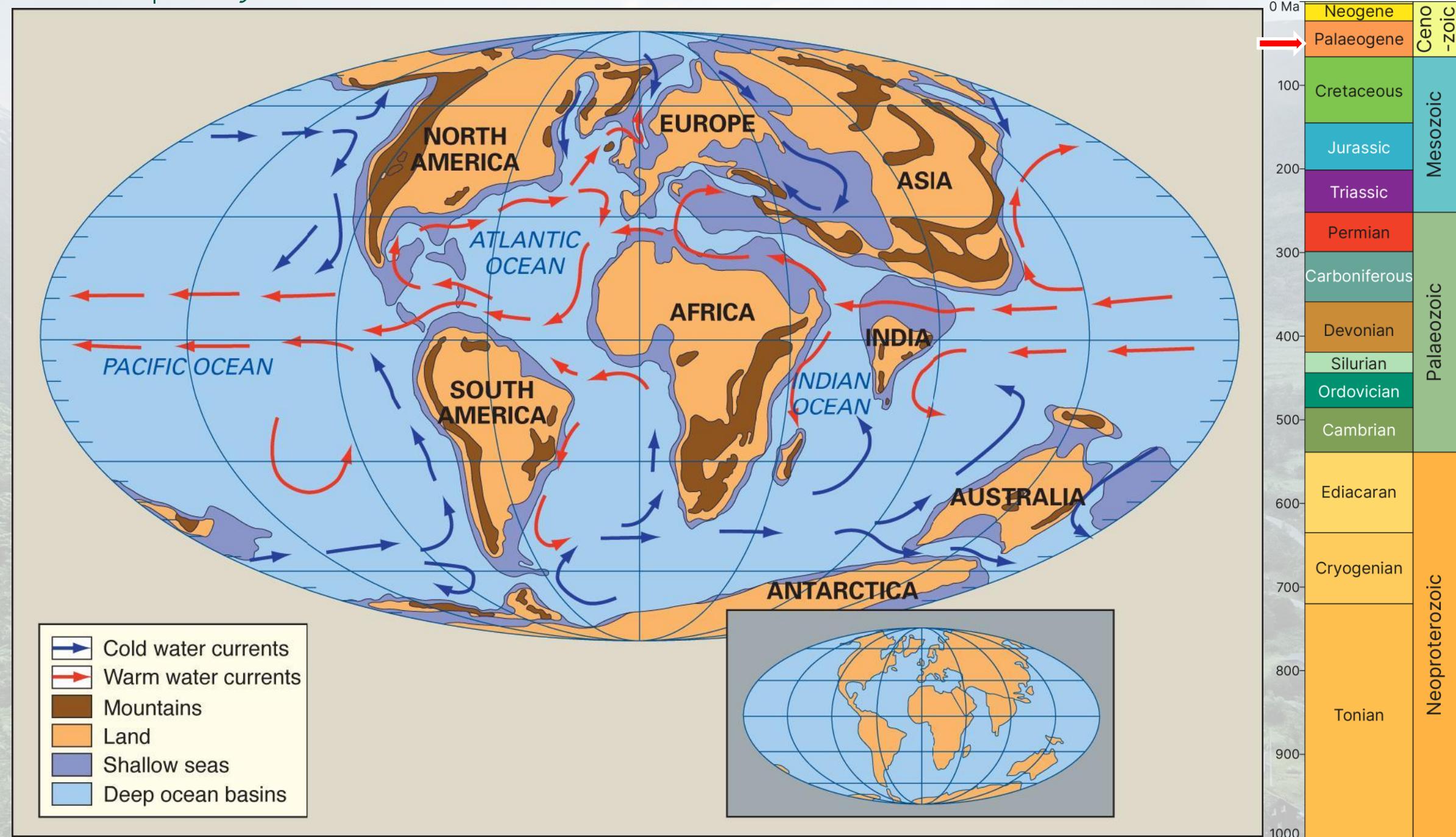
Recent Ireland | Quaternary (Pleistocene, 1 Ma)

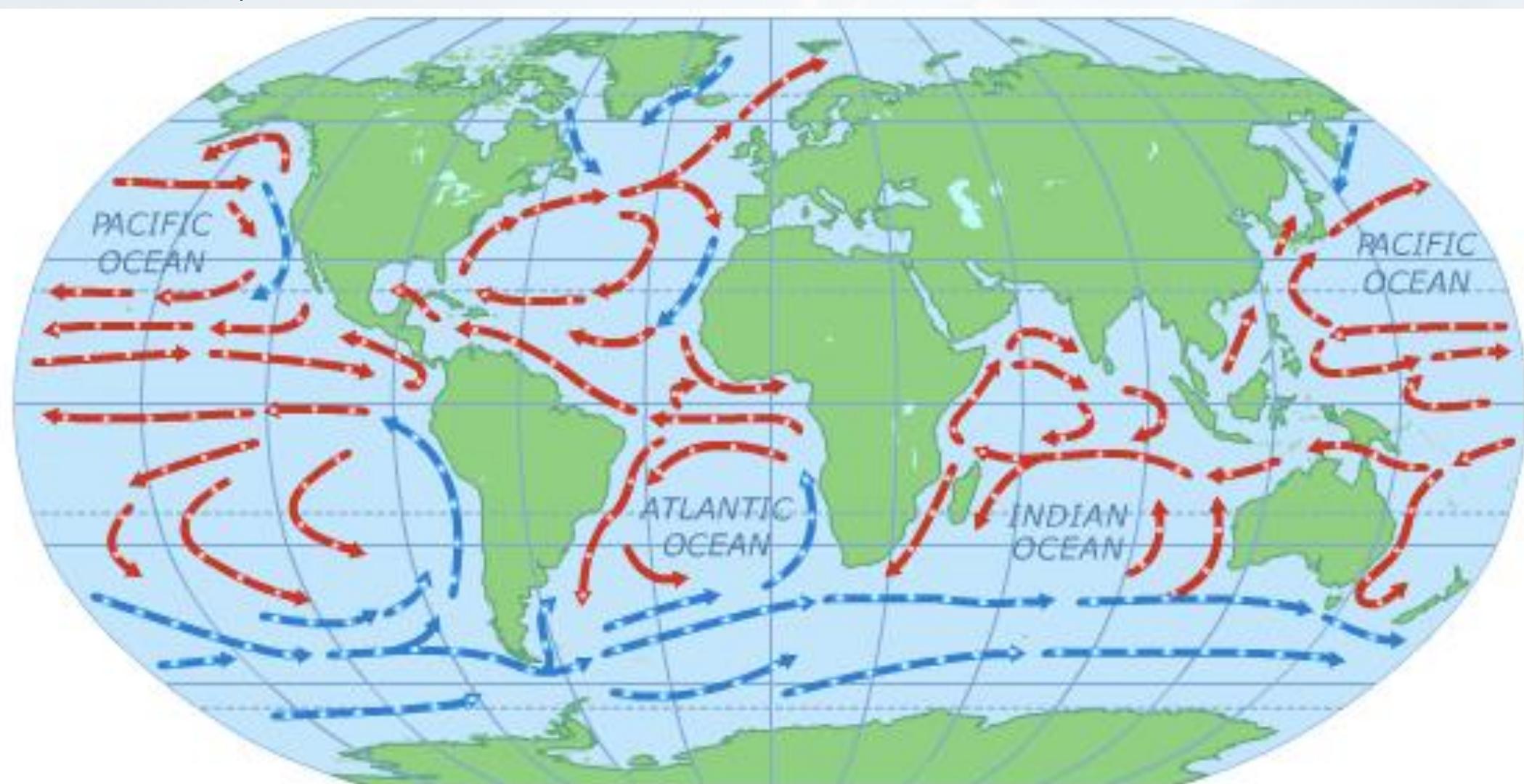


Recent Ireland | Quaternary (Holocene, 0 Ma)

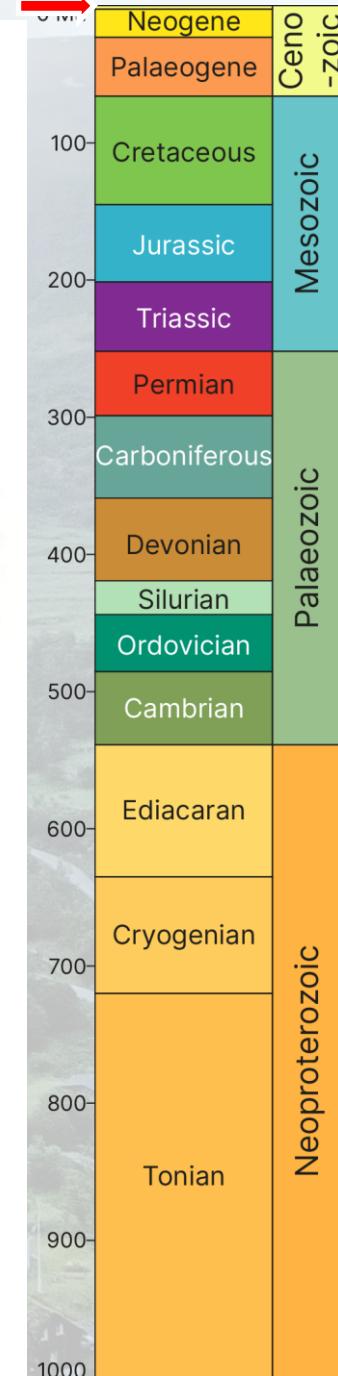
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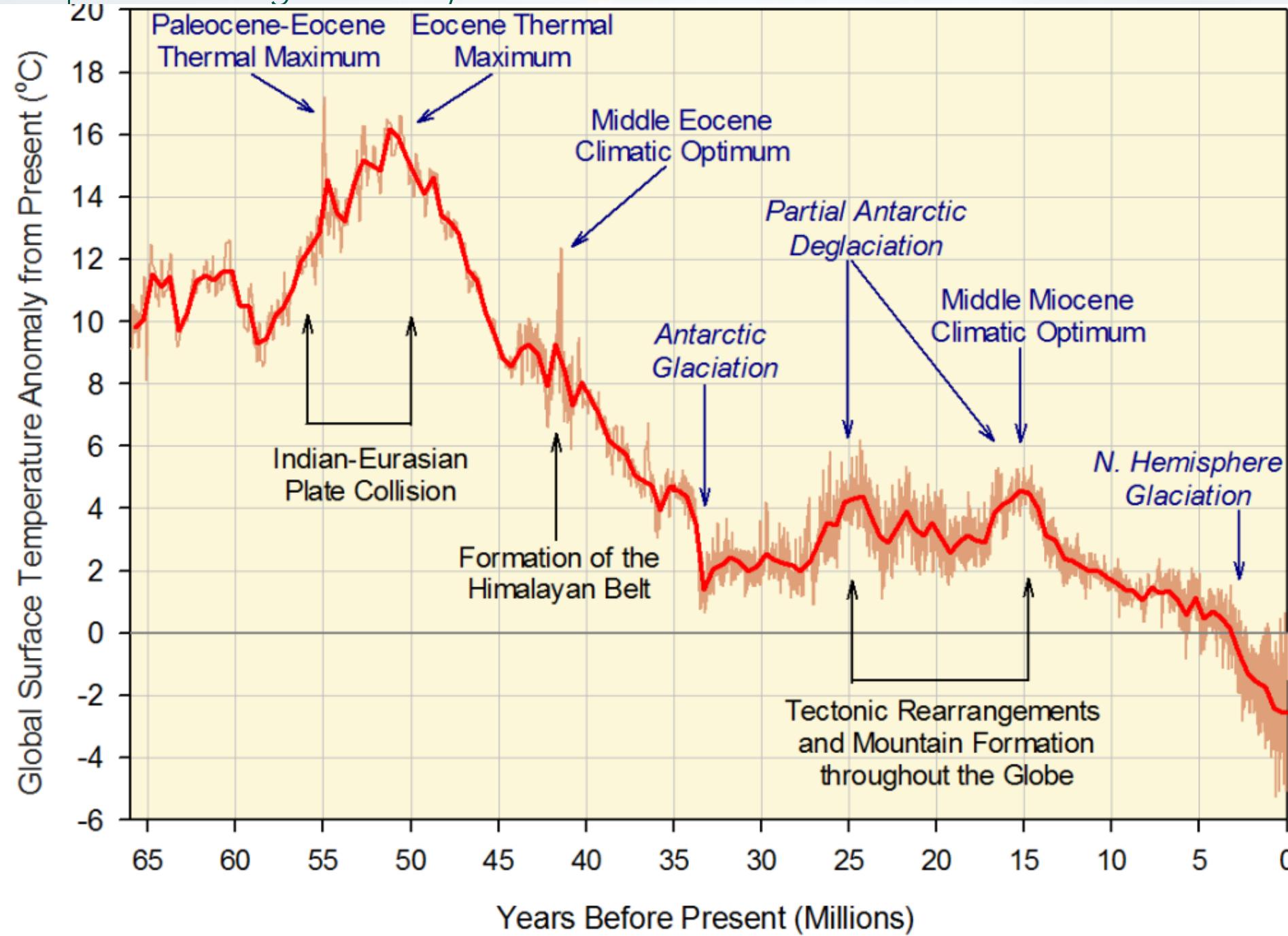




**Ocean Currents:**

- Warm currents
- Cool currents

Global Winds:





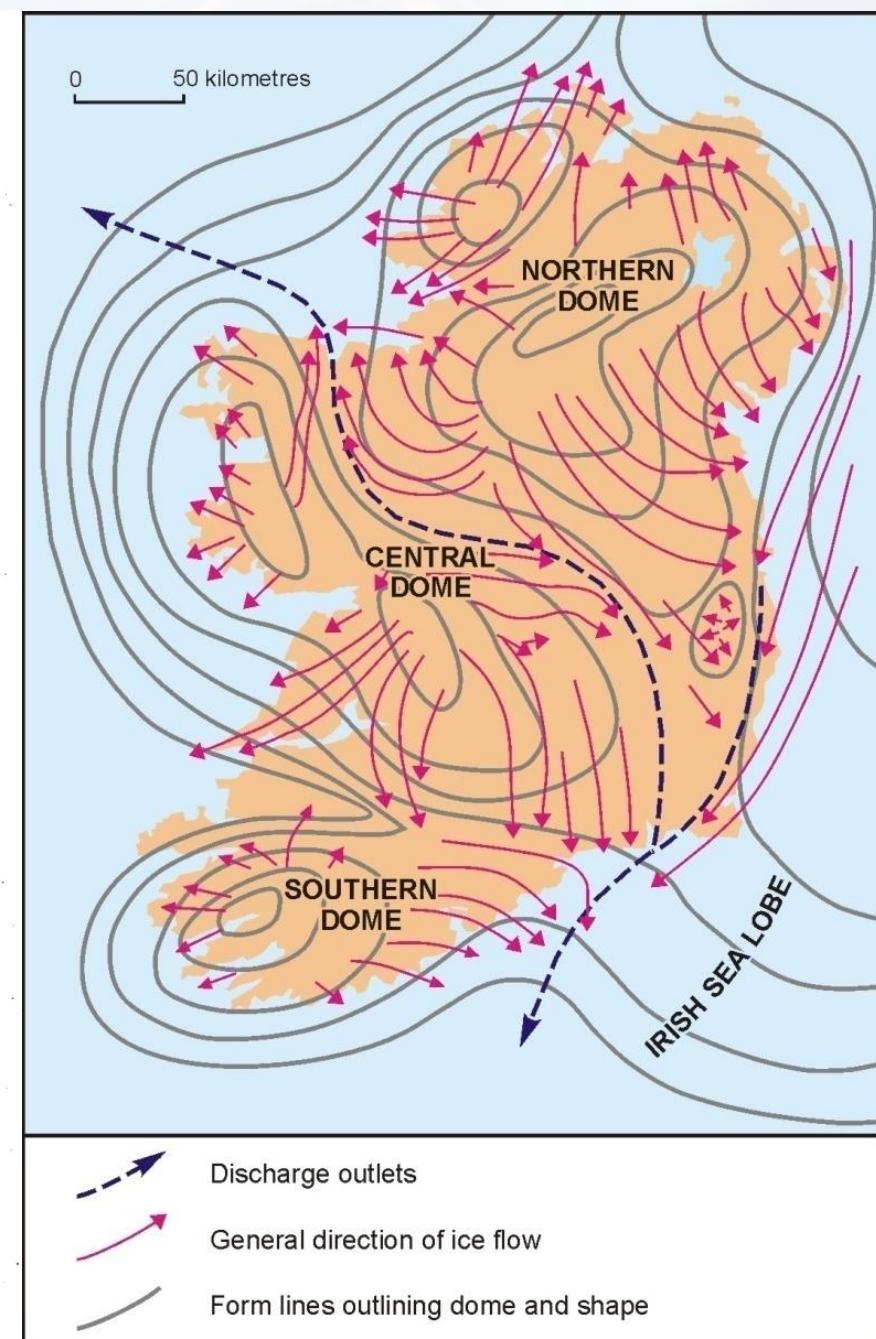
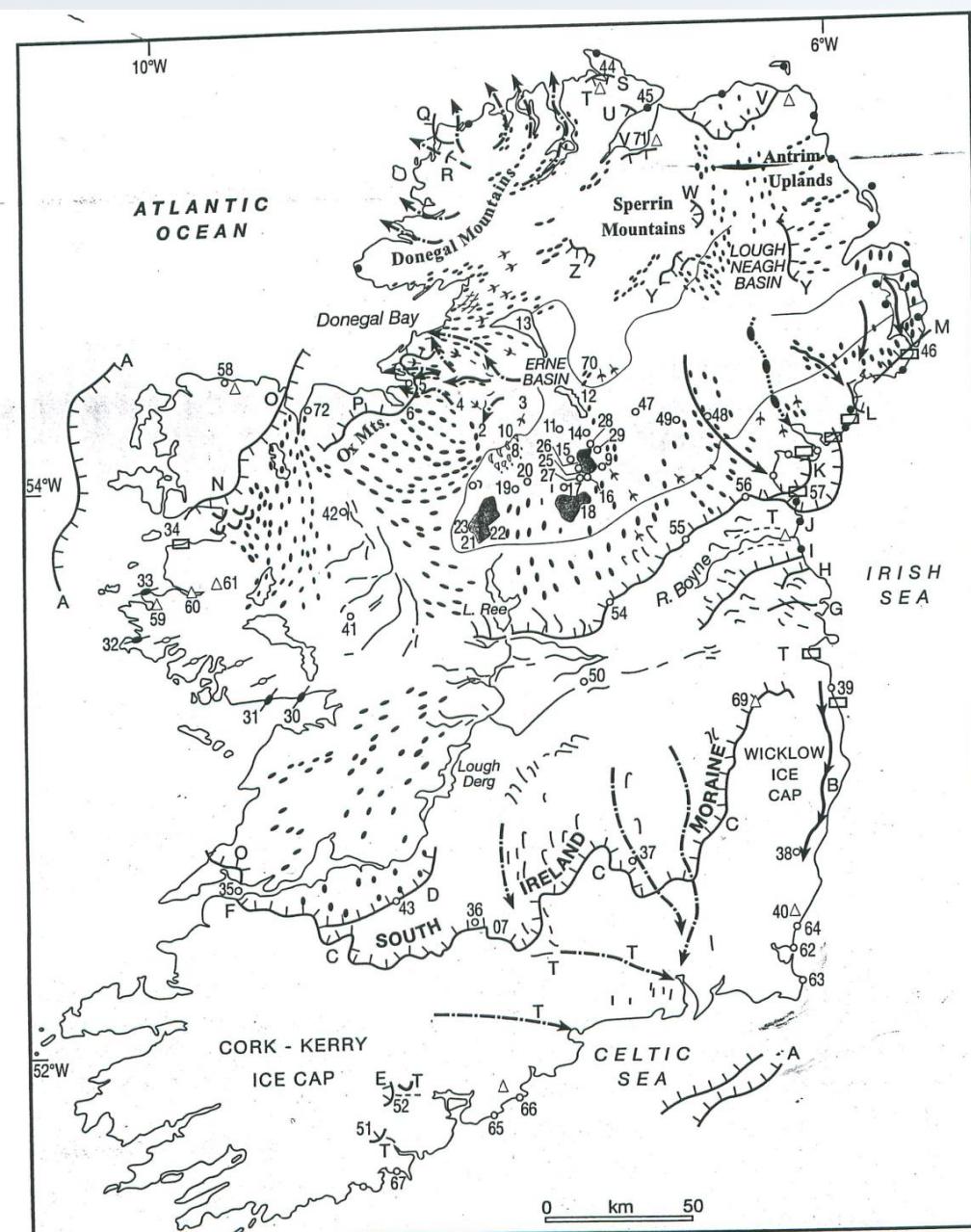












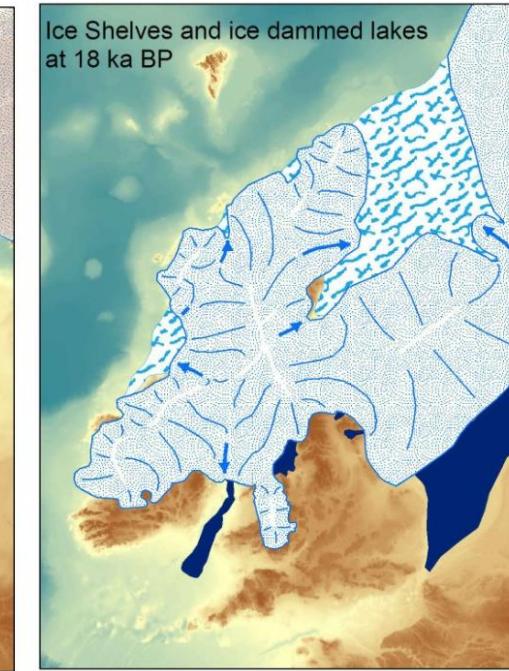
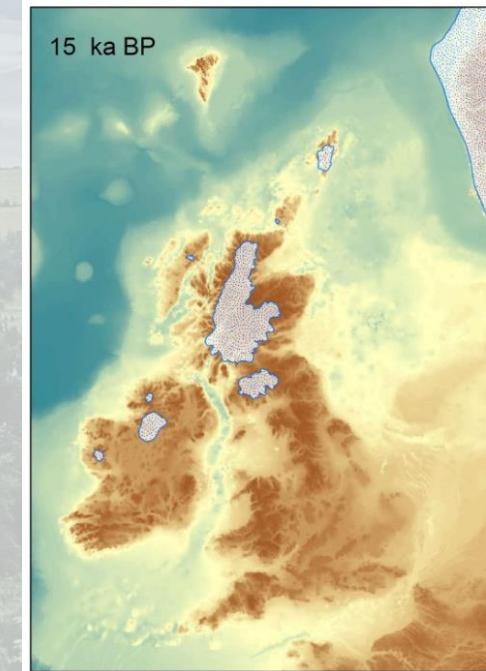
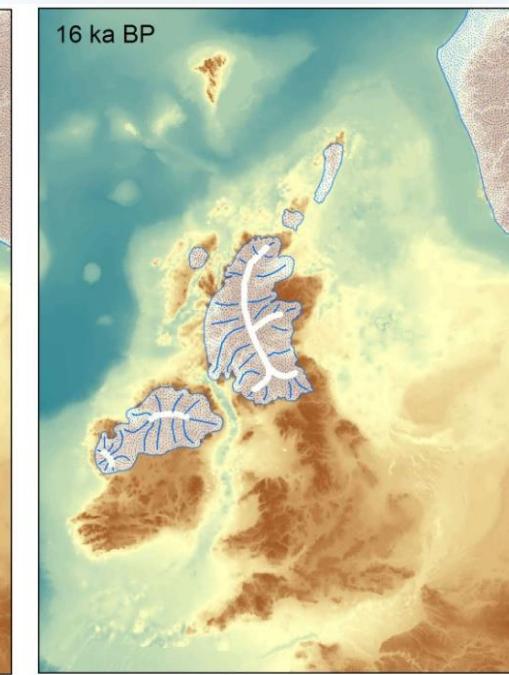
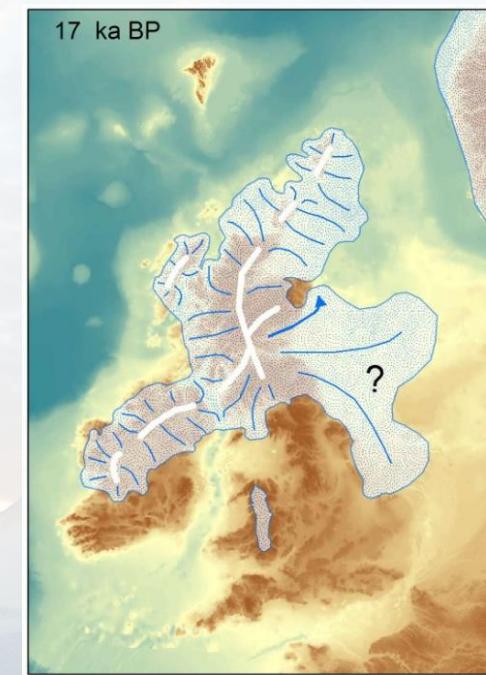
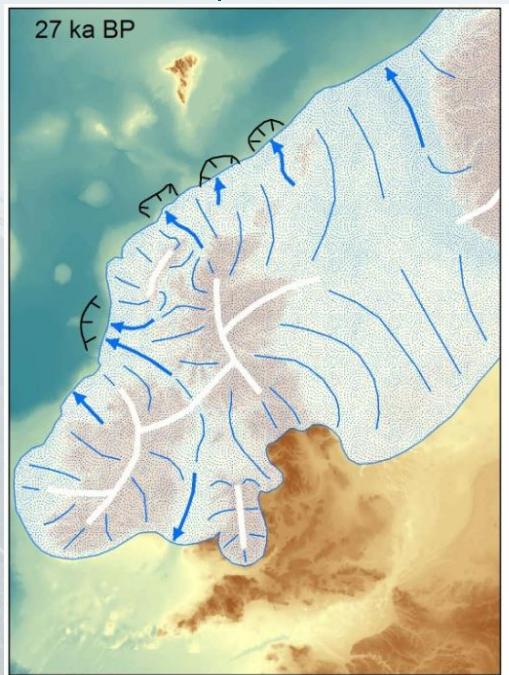
3 main phases recorded

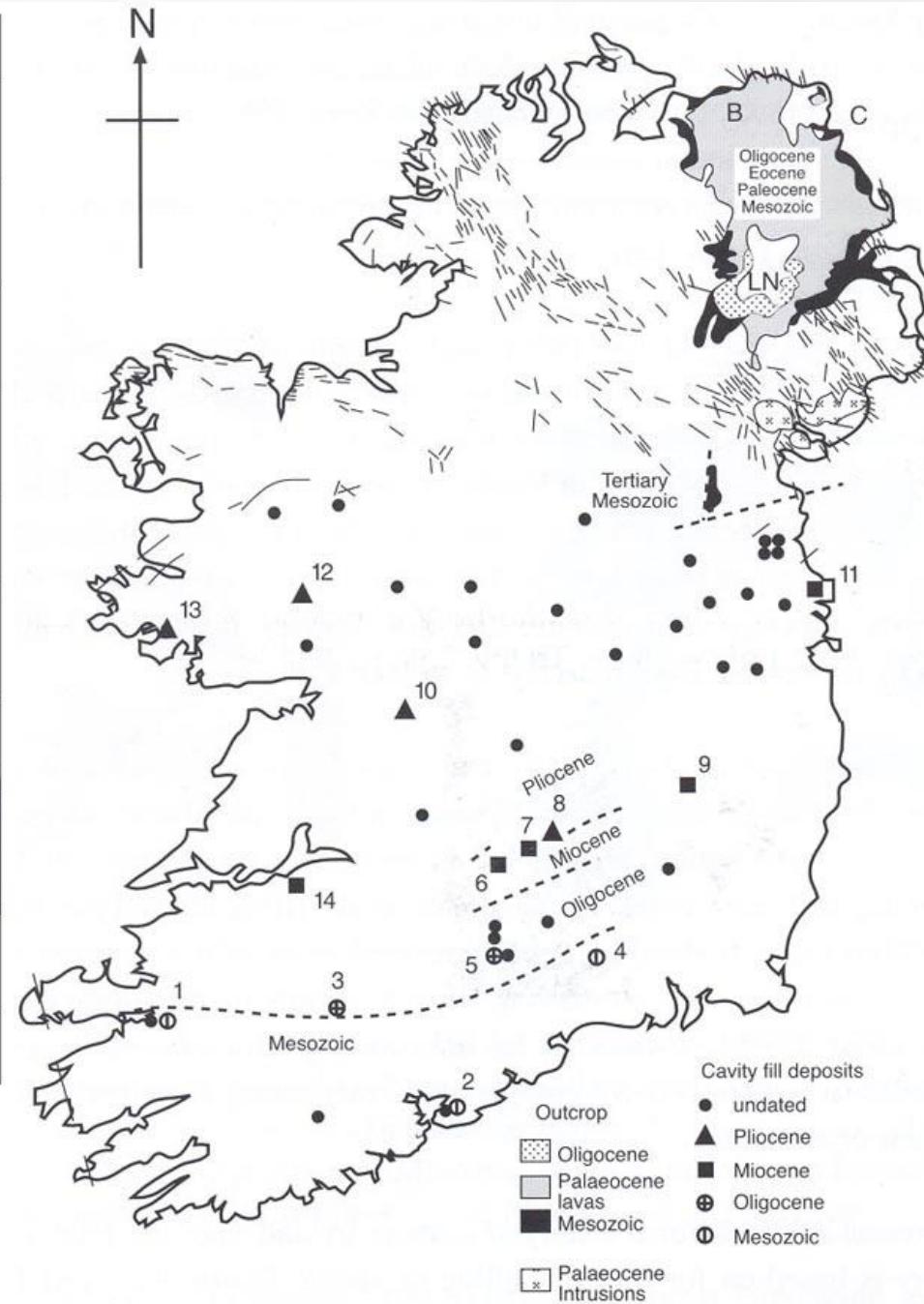
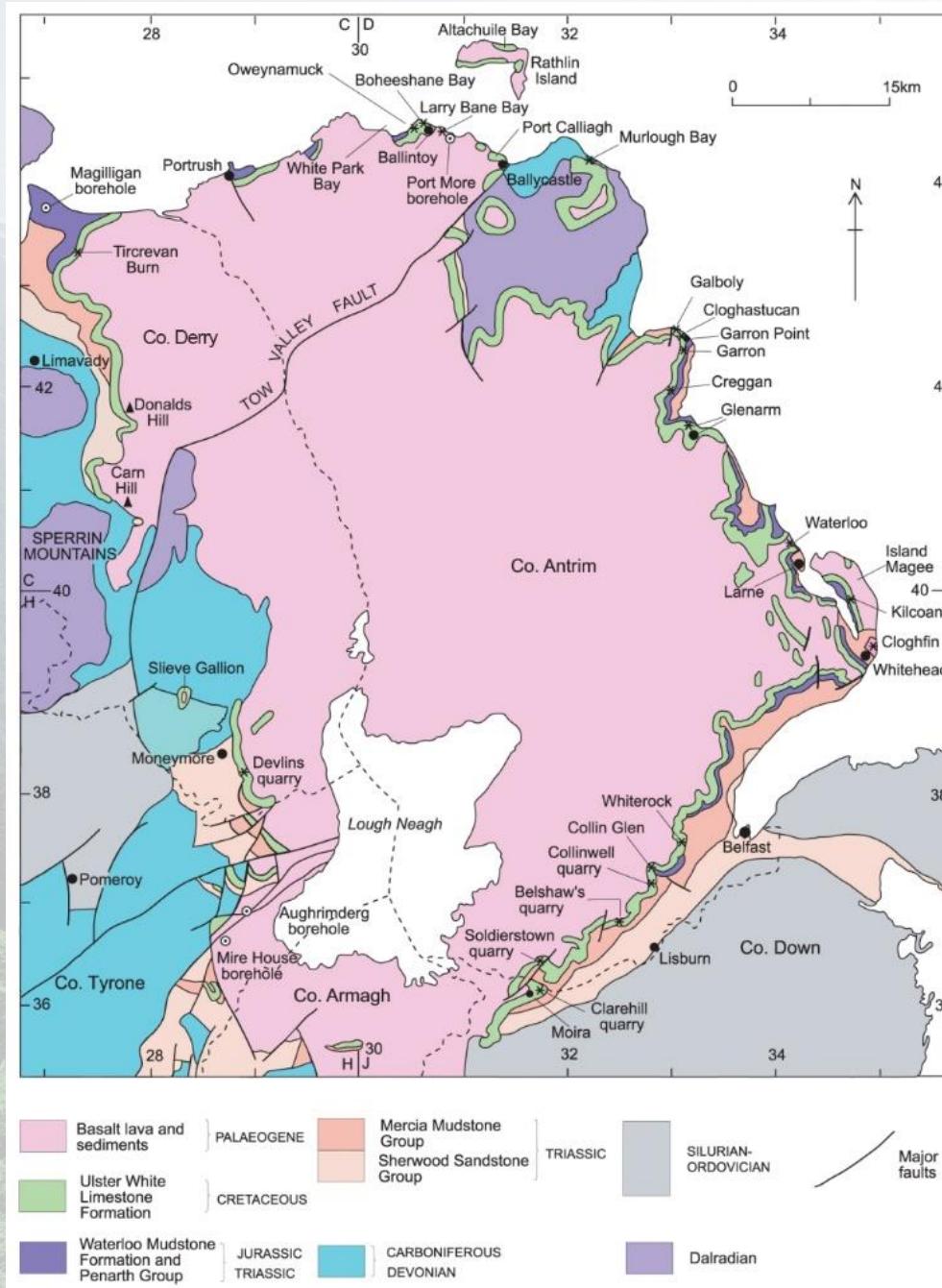
- Anglian (450 Ka)
- Munsterian (Wolstonian) (300-130 Ka)
- Midlandian (Devensian) (80-10 Ka)
- Ended around 10 Ka
- There may have been older ice ages; but if so, the evidence has been removed by these later glacial phases

Fig. 1.4 Distribution of the main glaciogenic landforms in Ireland and critical sites/exposures discussed in the text. Based on Syng (1970a) and published records of Charlesworth, Colhoun, Coxon, Farrington, McCabe, Sollas and Stephens. See Keys on opposite page.

5



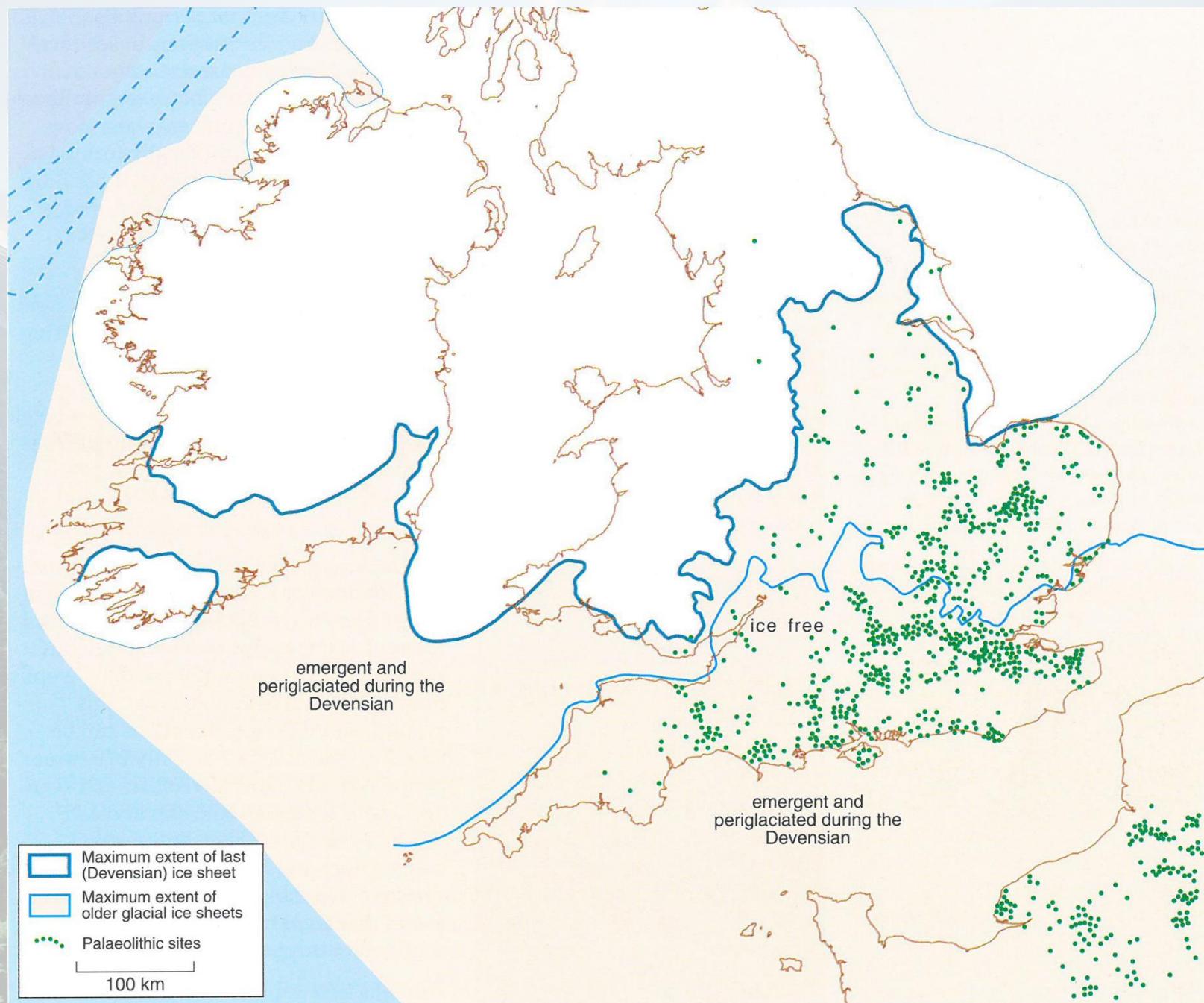






Humans!

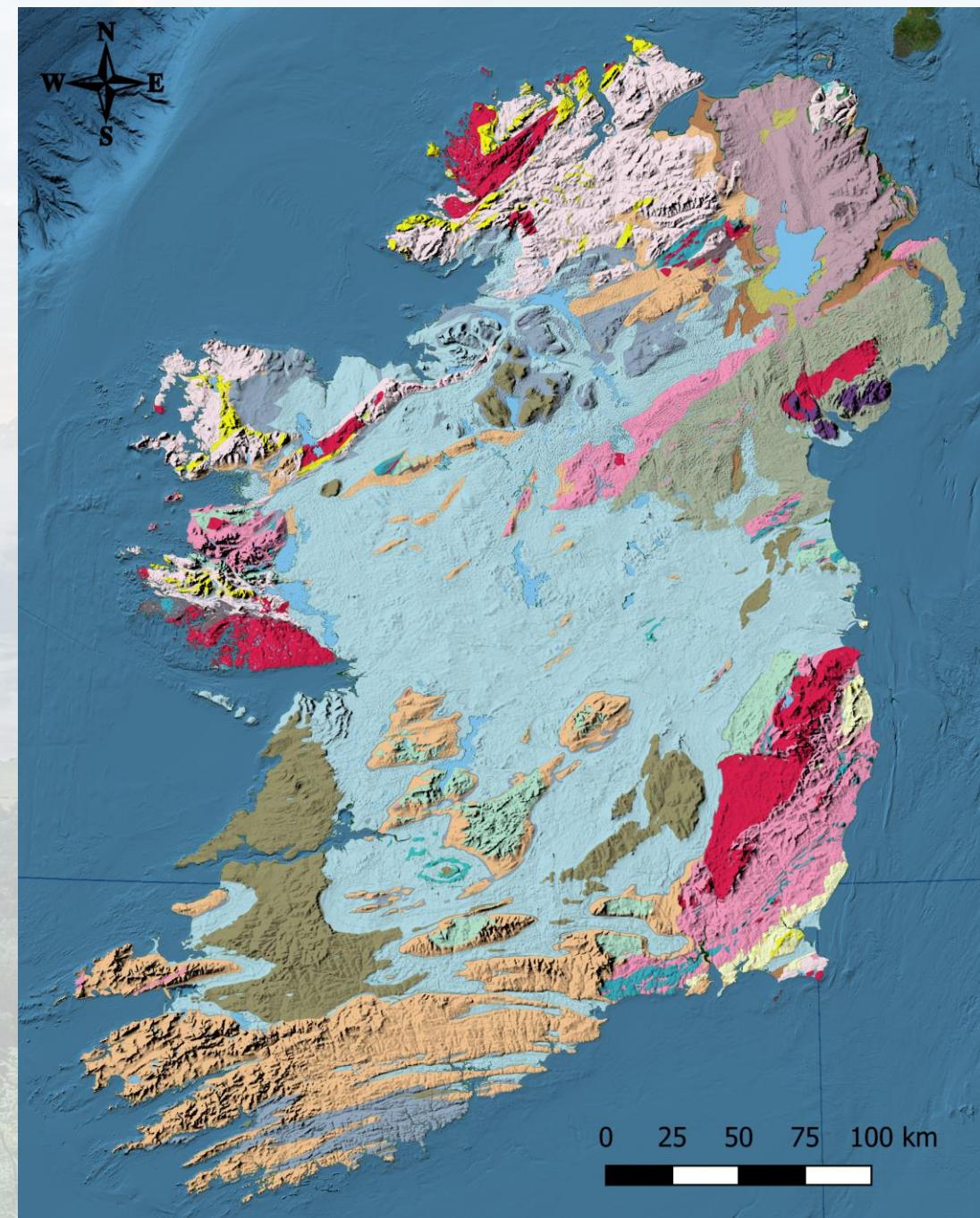
- Evidence of humans in Britain dates as far back as 700-950 Ka stone tools
- Neanderthals 400-50 Ka
- *Homo sapiens* lived in Britain from 40 Ka, but continuously only since 12 Ka
- Oldest complete skeleton: Cheddar Man, from Gough's Cave, Cheddar Gorge, England





Humans!

- Evidence of humans in Ireland dates only to 12,500 years ago
- No Neanderthals
- *Homo sapiens* from 10 Ka
- Mesolithic settlement at Mount Sandel near the Derry-Antrim border
- Rathjordan in Limerick also Mesolithic



1. Why is Ireland a major supplier of lead and zinc, with some gold, and previously copper, but not the rare earth elements used in modern electronics? **L9 & L11**
2. Why were Game of Thrones, Harry Potter, and Star Wars filmed (partially) in Ireland? **L11 & L12**
3. Why is the A2 Coast Road in Co. Antrim arguably the most repaired road in Ireland? **L12**
4. Why was Co. Down considered as a location for the disposal of spent nuclear fuel? **L9**
5. Oliver Cromwell famously said “To hell or to Connacht”. Why Connacht? **L5 & L11**
6. Why did the Industrial Revolution start in England? **L11**
7. Why is Scotland far less dependant on imported energy than Ireland? **L6 & L11**
8. Modern humans have existed for around 300,000 years. Why is the oldest evidence for humans in Ireland only 12,500 years ago? **L12**

Also considered: Volcanic hazards, drinking water, water and land use, quarrying of millstones to make flour, mining of slate and salt, impact of mining on communities and regions, and oil and gas geopolitics