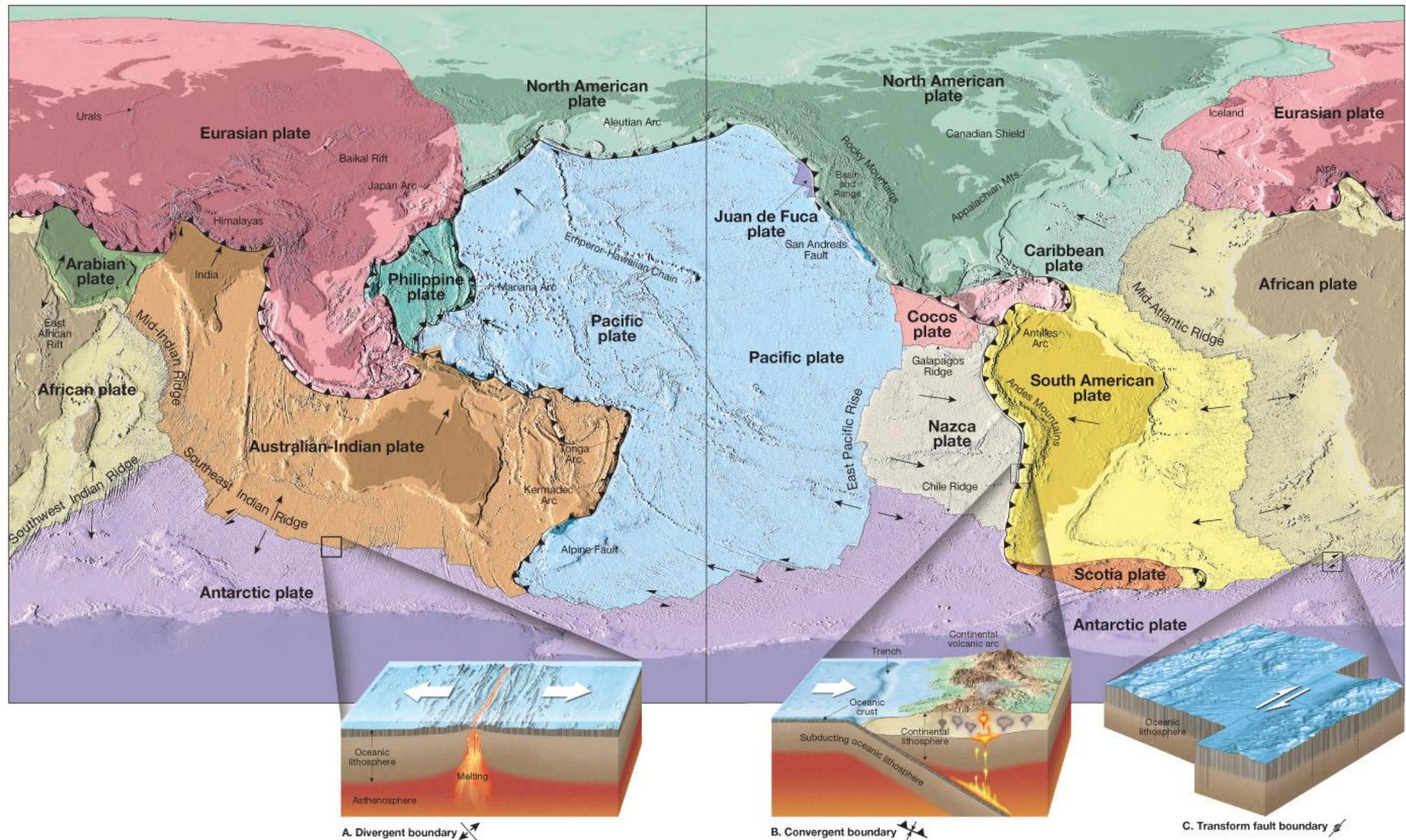


# **GY4051 Earth Science and Society**

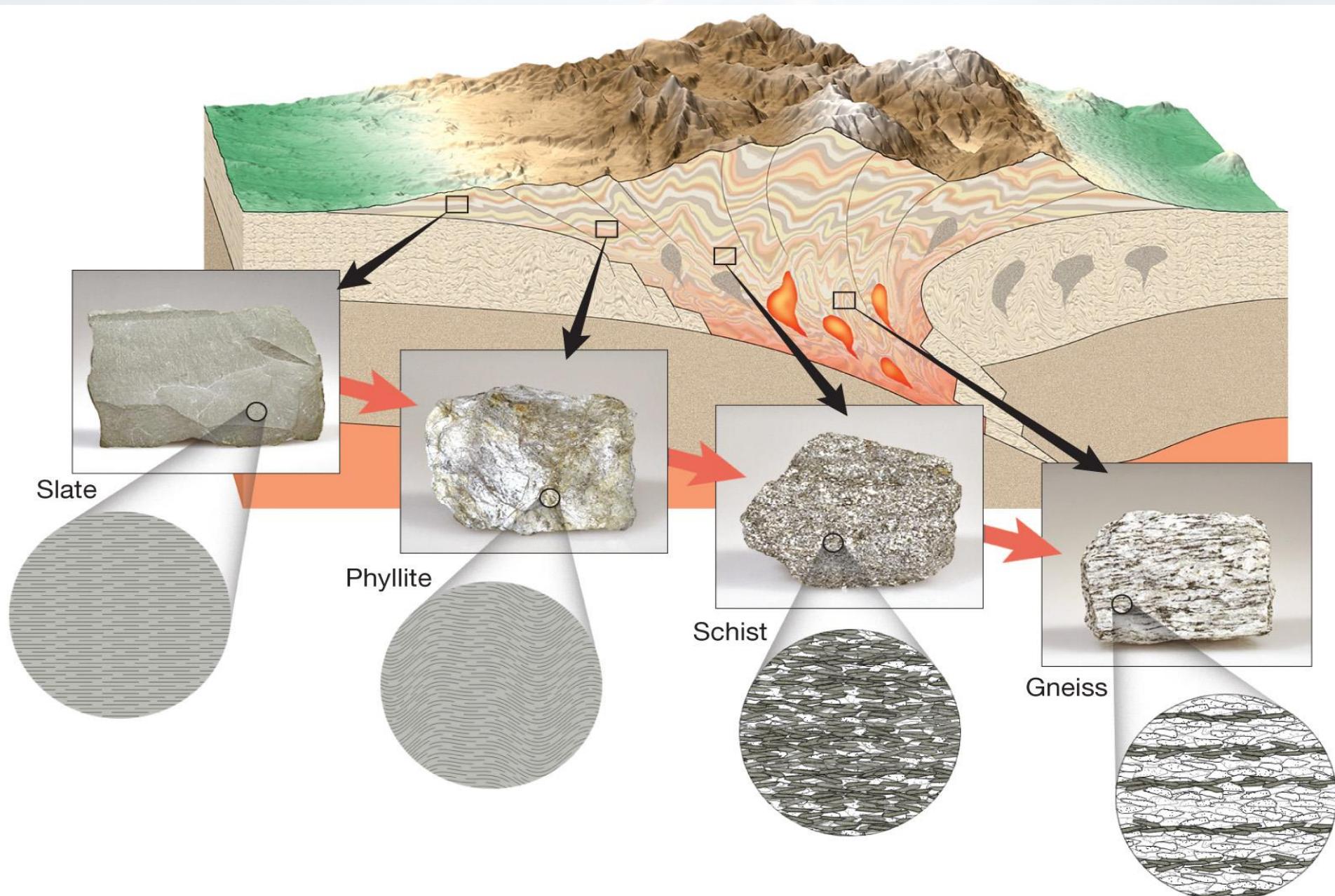
*Recent Ireland*















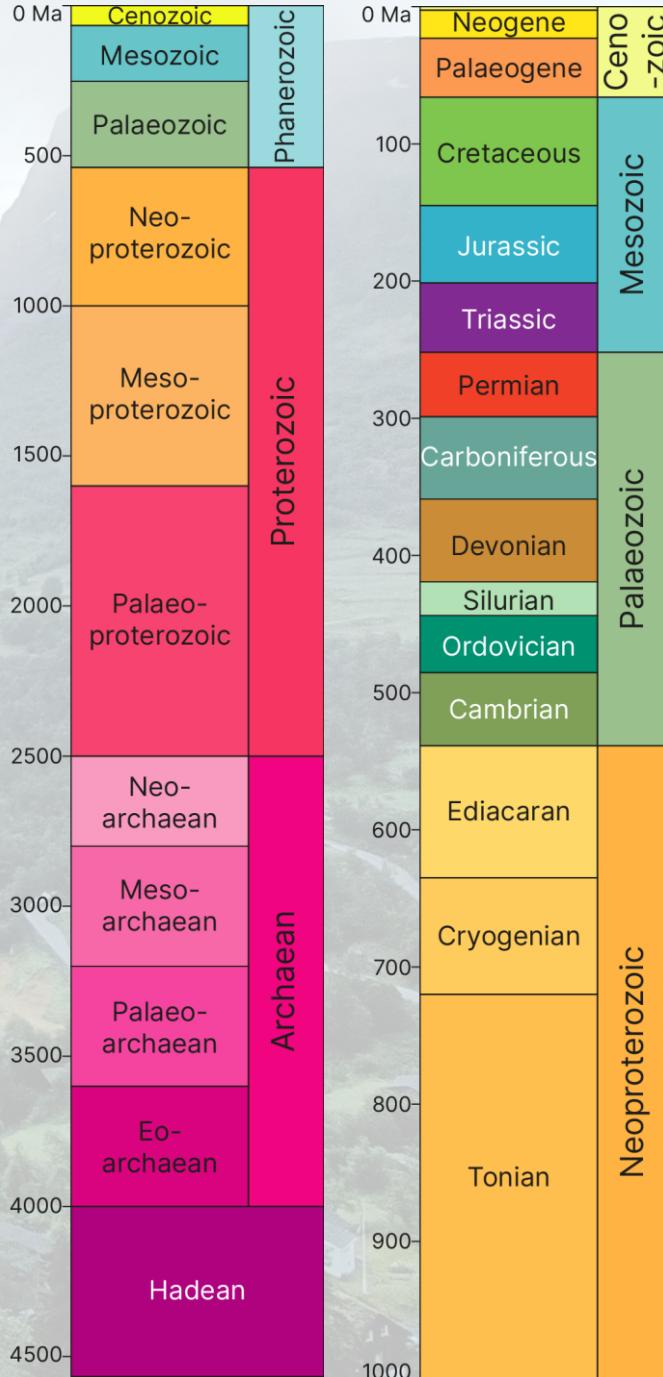
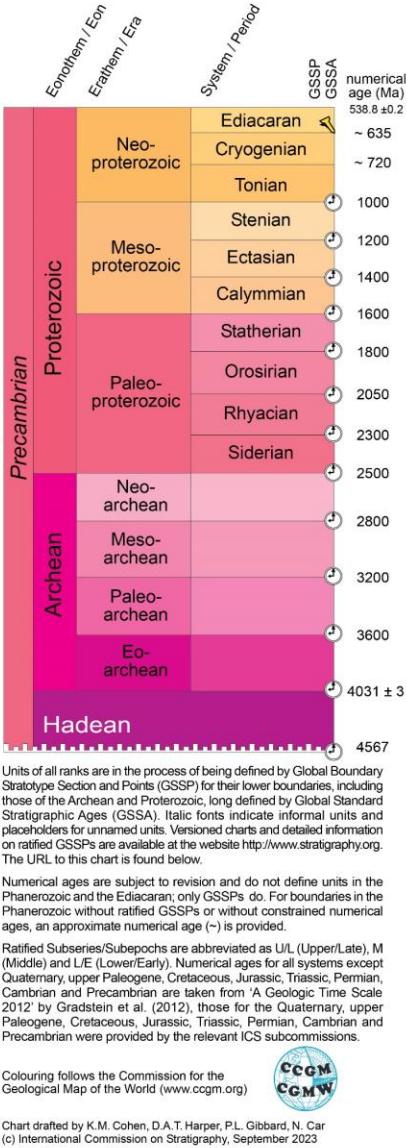
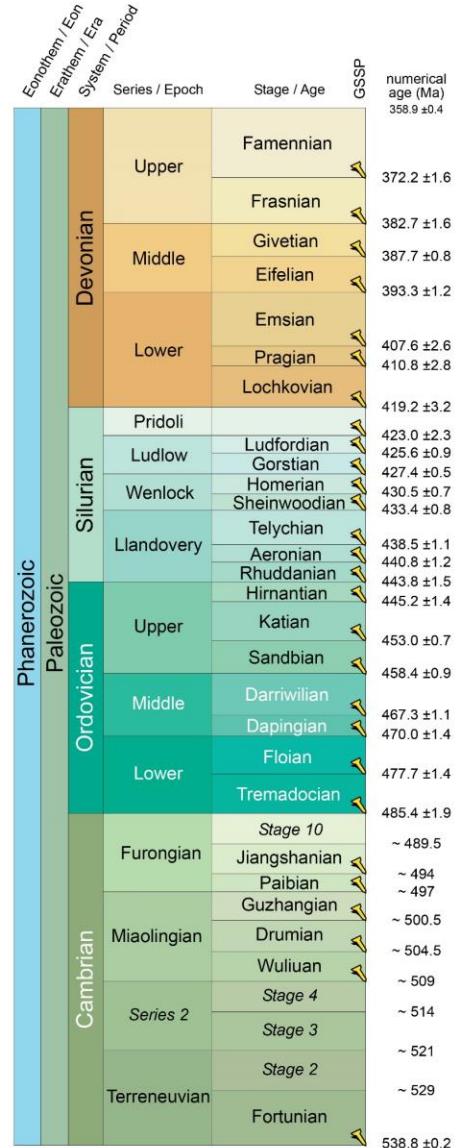
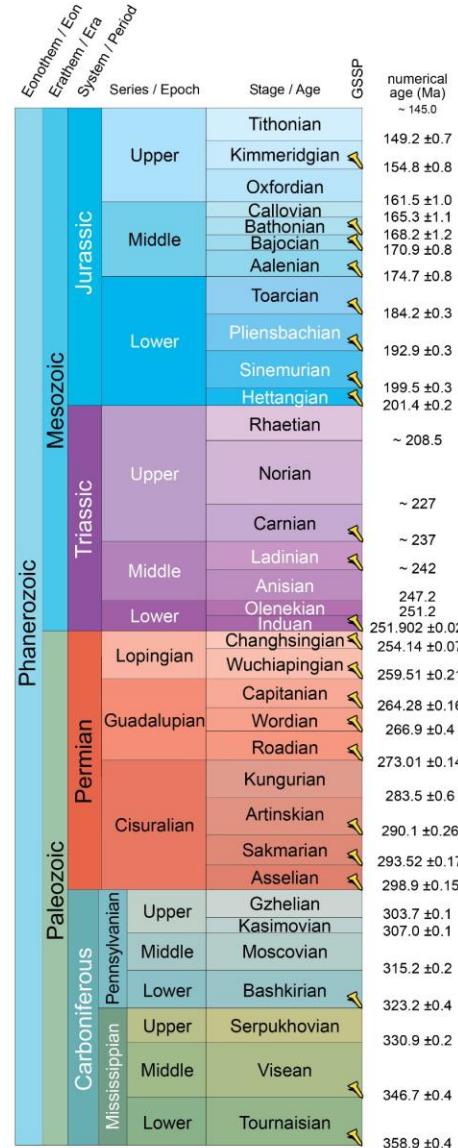
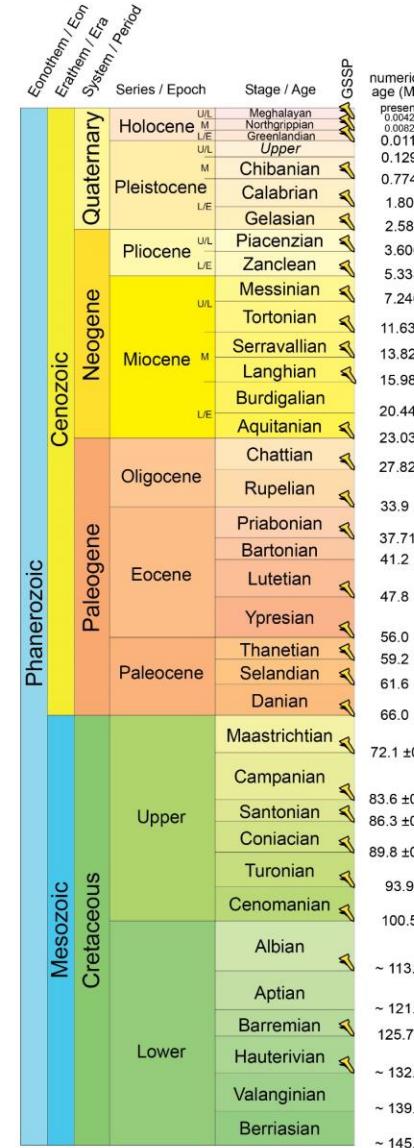


## INTERNATIONAL CHRONOSTRATIGRAPHIC CHART

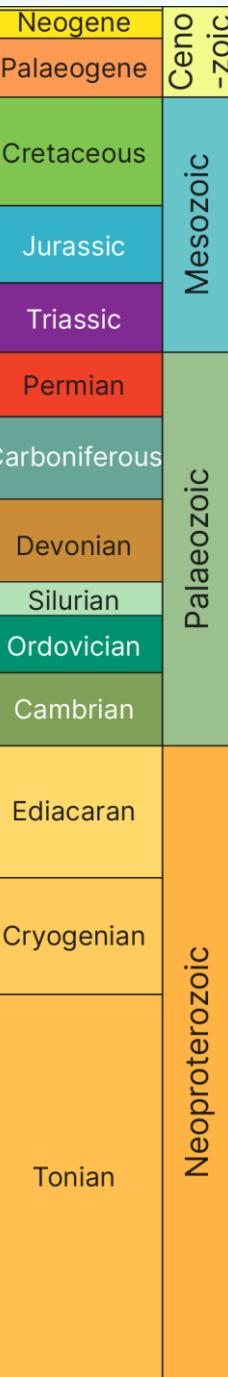
[www.stratigraphy.org](http://www.stratigraphy.org)

International Commission on Stratigraphy

v 2023/09



GY4051



Units of all ranks are in the process of being defined by Global Boundary Stratotype Section and Points (GSSPs) for their lower boundaries, including those of the Archean and Proterozoic, long defined by Global Standard Stratigraphic Ages (GSSA). Italic fonts indicate informal units and placeholders for unnamed units. Versioned charts and detailed information on ratified GSSPs are available at the website <http://www.stratigraphy.org>. The URL to this chart is found below.

Numerical ages are subject to revision and do not define units in the Phanerozoic and the Ediacaran; only GSSPs do. For boundaries in the Phanerozoic without ratified GSSPs or without constrained numerical ages, an approximate numerical age (~) is provided.

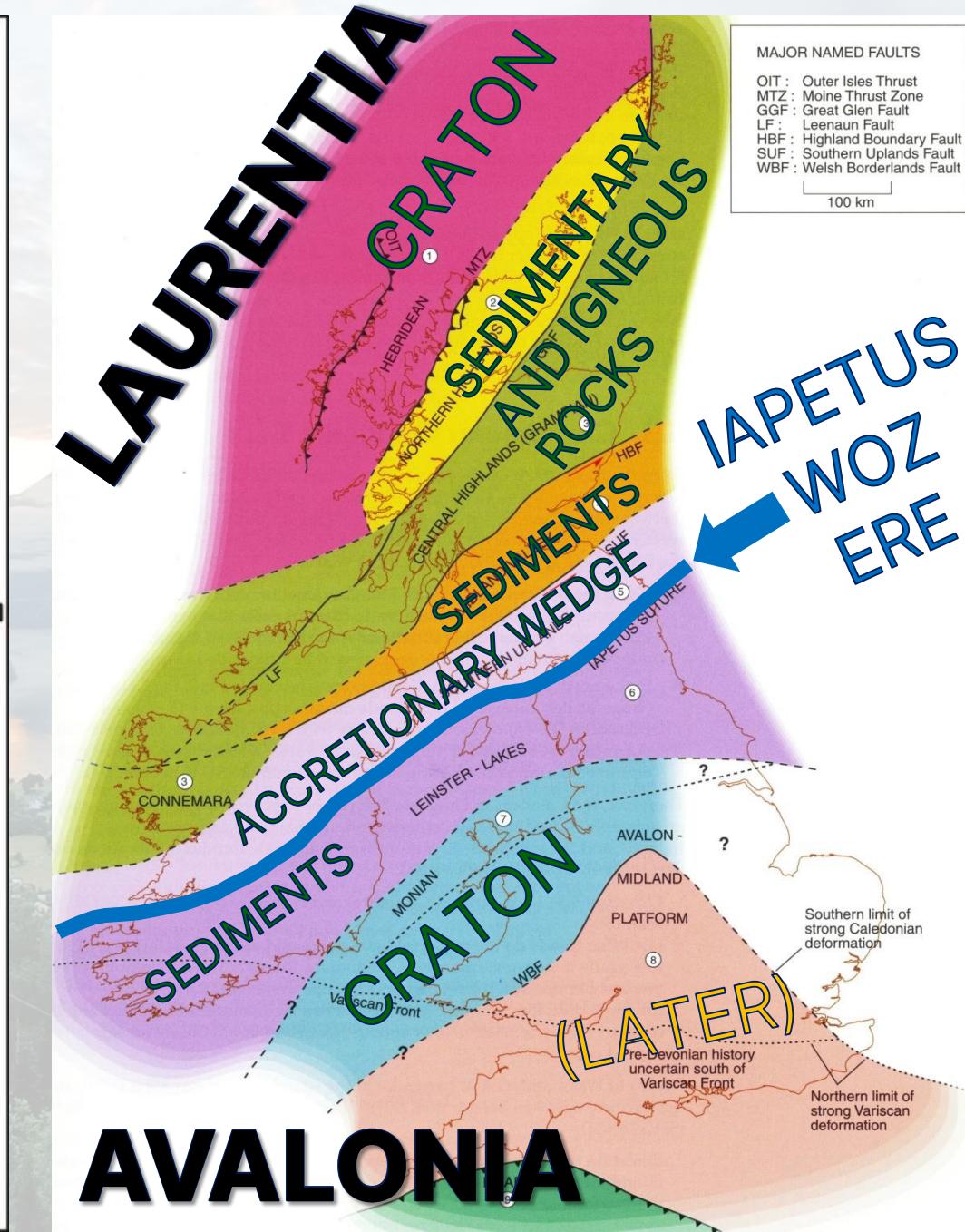
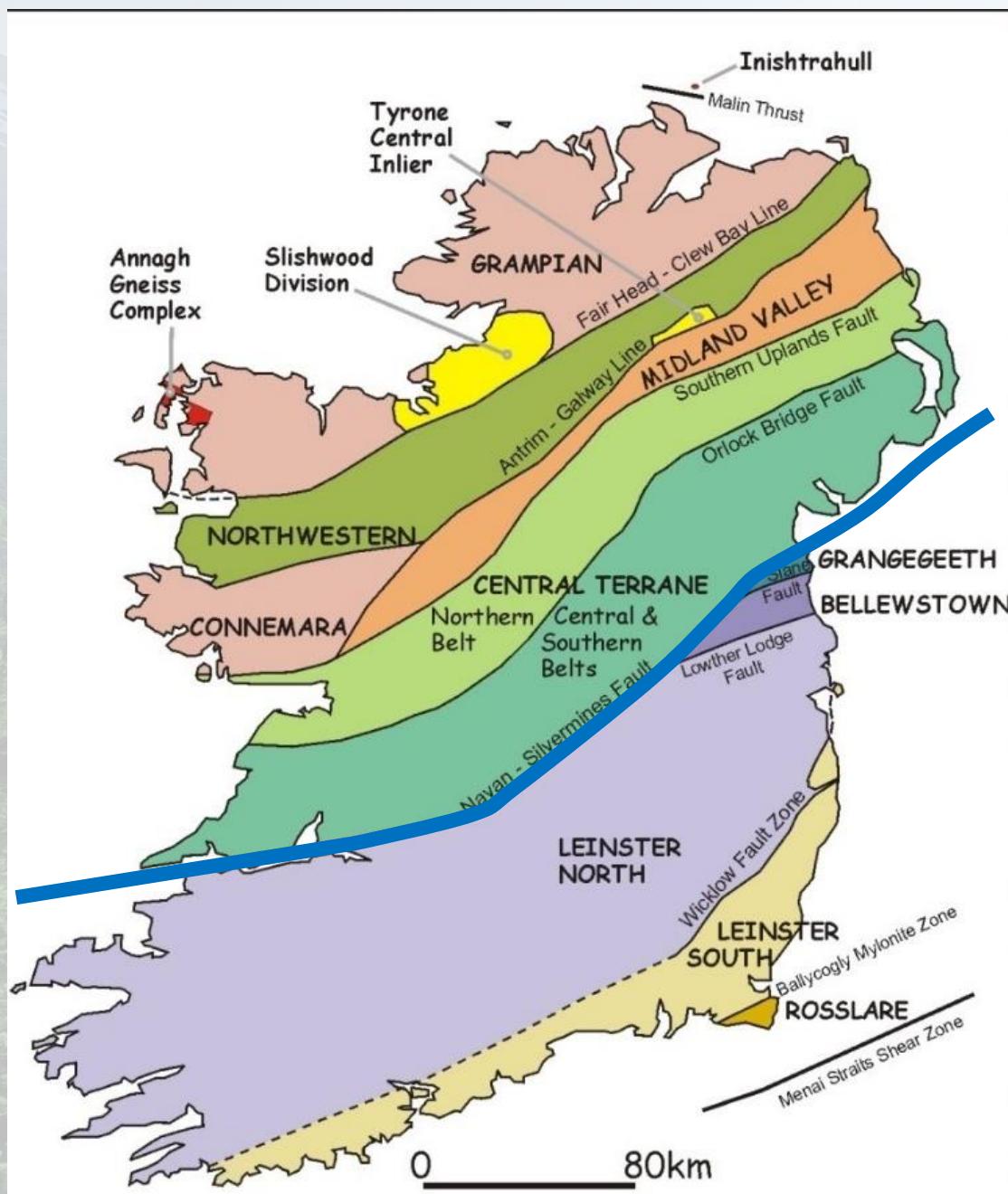
Ratified Subseries/Subepochs are abbreviated as U/L (Upper/Late), M (Middle) and L/E (Lower/Early). Numerical ages for all systems except Quaternary, upper Paleogene, Cretaceous, Jurassic, Triassic, Permian, Cambrian and Precambrian are taken from 'A Geologic Time Scale 2012' by Gradstein et al. (2012), those for the Quaternary, upper Paleogene, Cretaceous, Jurassic, Triassic, Permian, Cambrian and Precambrian were provided by the relevant ICS subcommissions.

Colouring follows the Commission for the Geological Map of the World ([www.cgmw.org](http://www.cgmw.org))

Chart drafted by K.M. Cohen, D.A.T. Harper, P.L. Gibbard, N. Car (c) International Commission on Stratigraphy, September 2023

To cite: Cohen, K.M., Finney, S.C., Gibbard, P.L. & Fan, J.-X. (2013; updated) The ICS International Chronostratigraphic Chart. Episodes 36: 199–204.

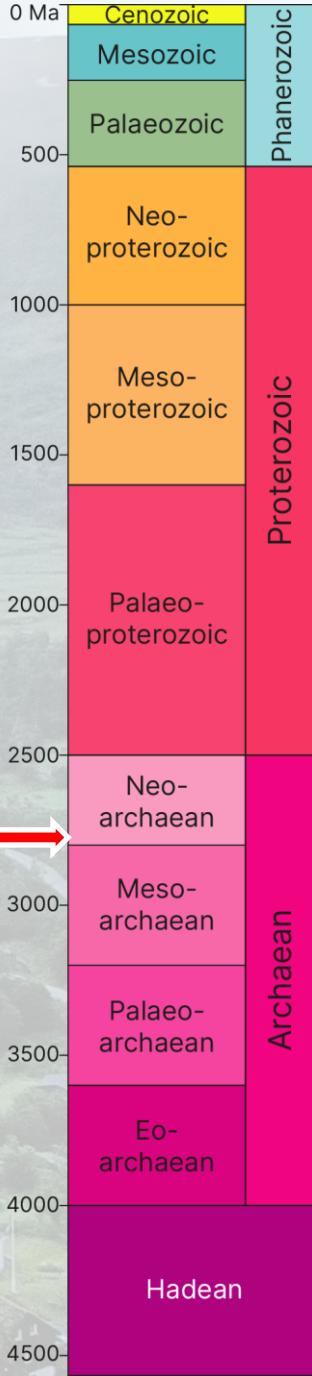
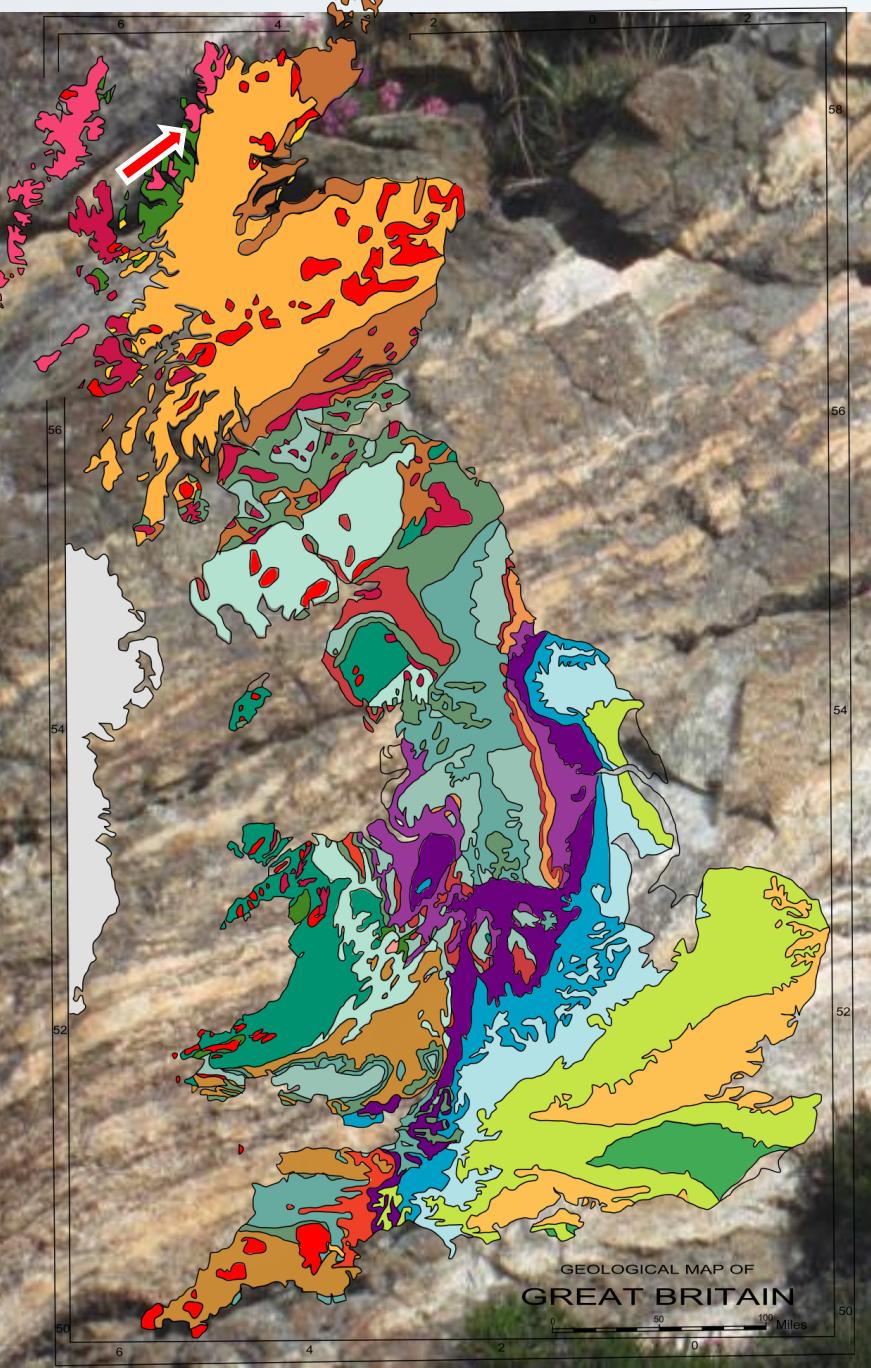
URL: <http://www.stratigraphy.org/ICSChart/ChronostratChar2023-09.pdf>



# Laurentia, Avalonia and the Iapetus Ocean | The Laurentian Craton

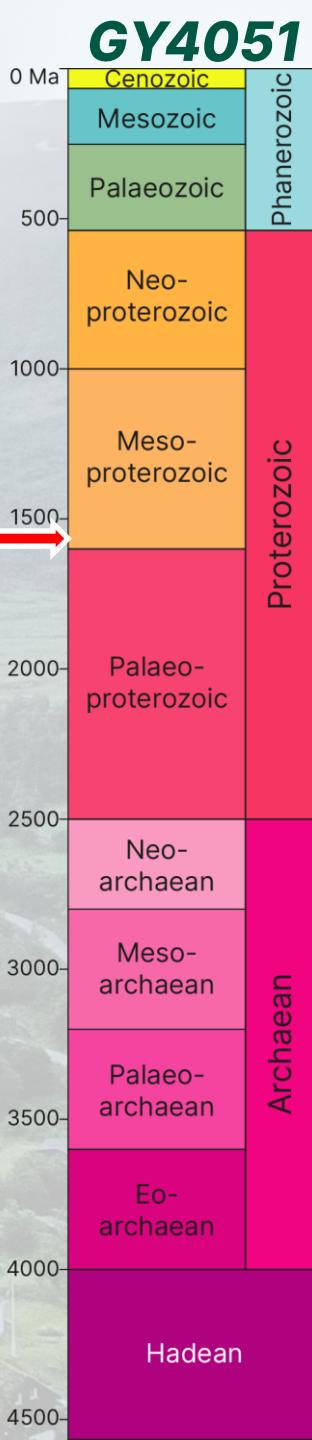
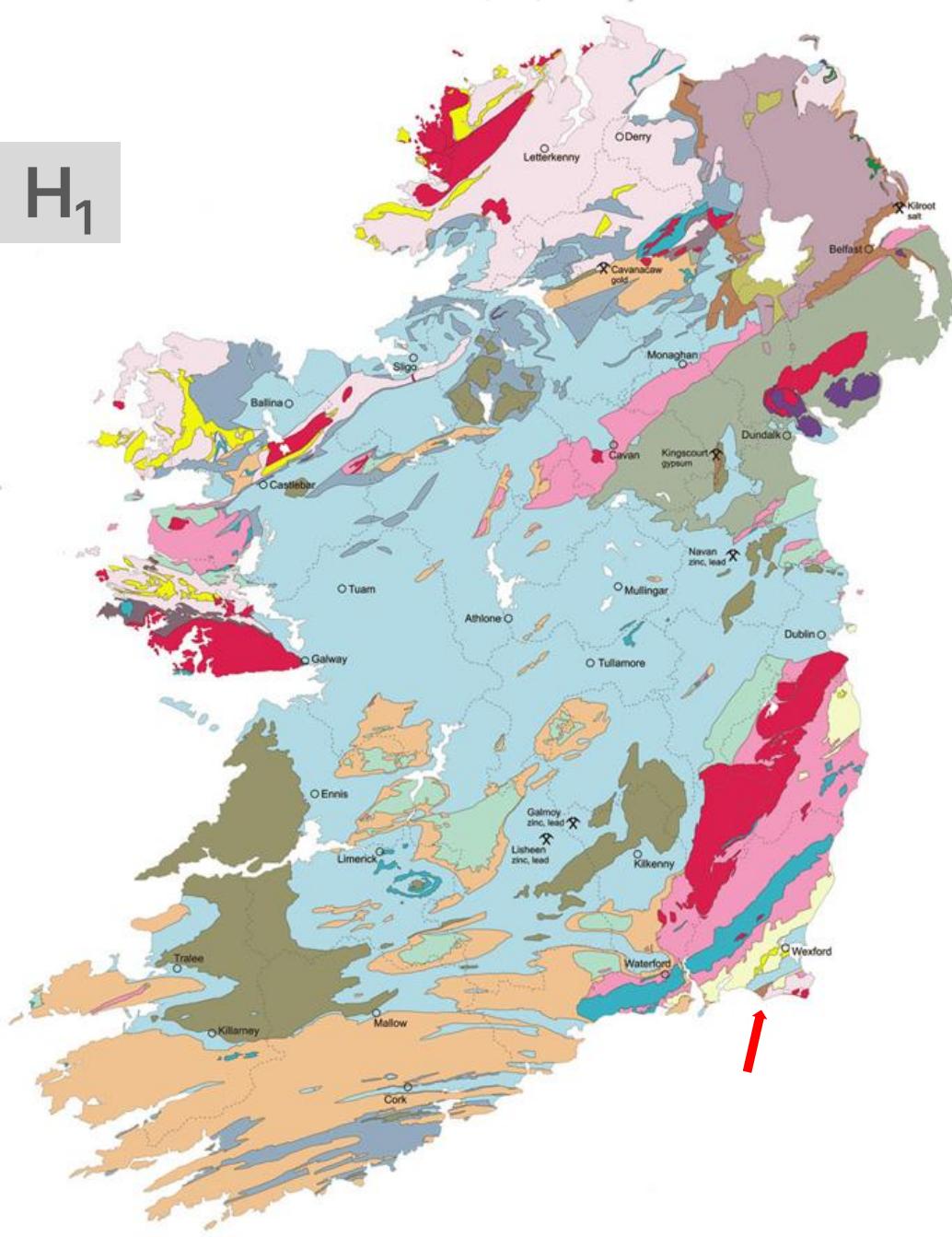
GY4051

H<sub>2</sub>



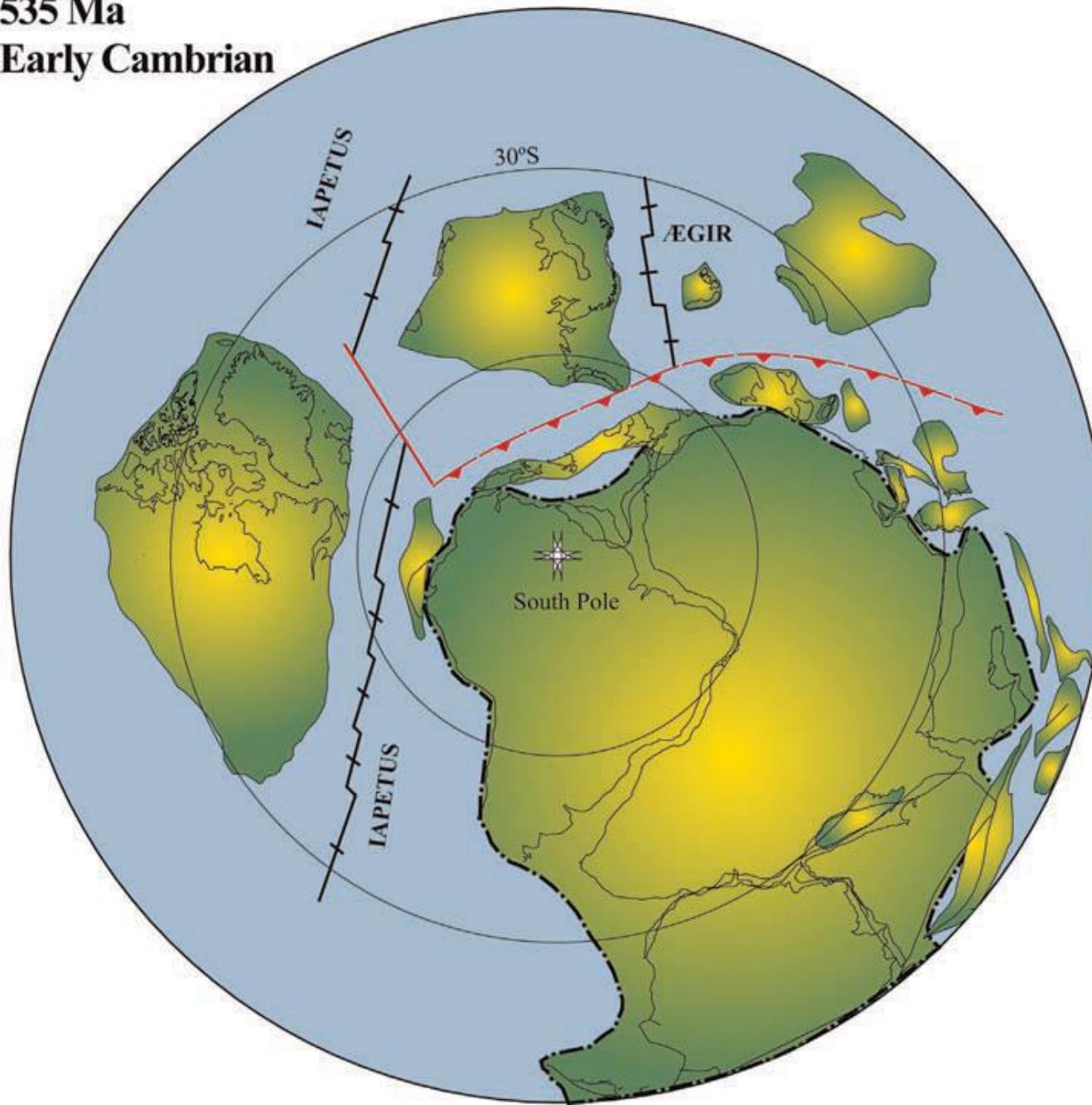
# Laurentia, Avalonia, and the Iapetus Ocean | The Avalonian Craton

H<sub>1</sub>



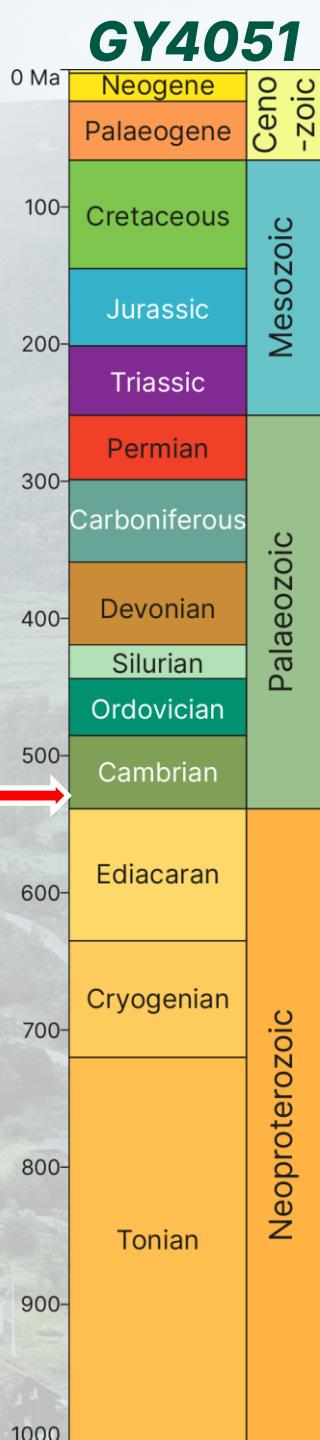
535 Ma

## **Early Cambrian**



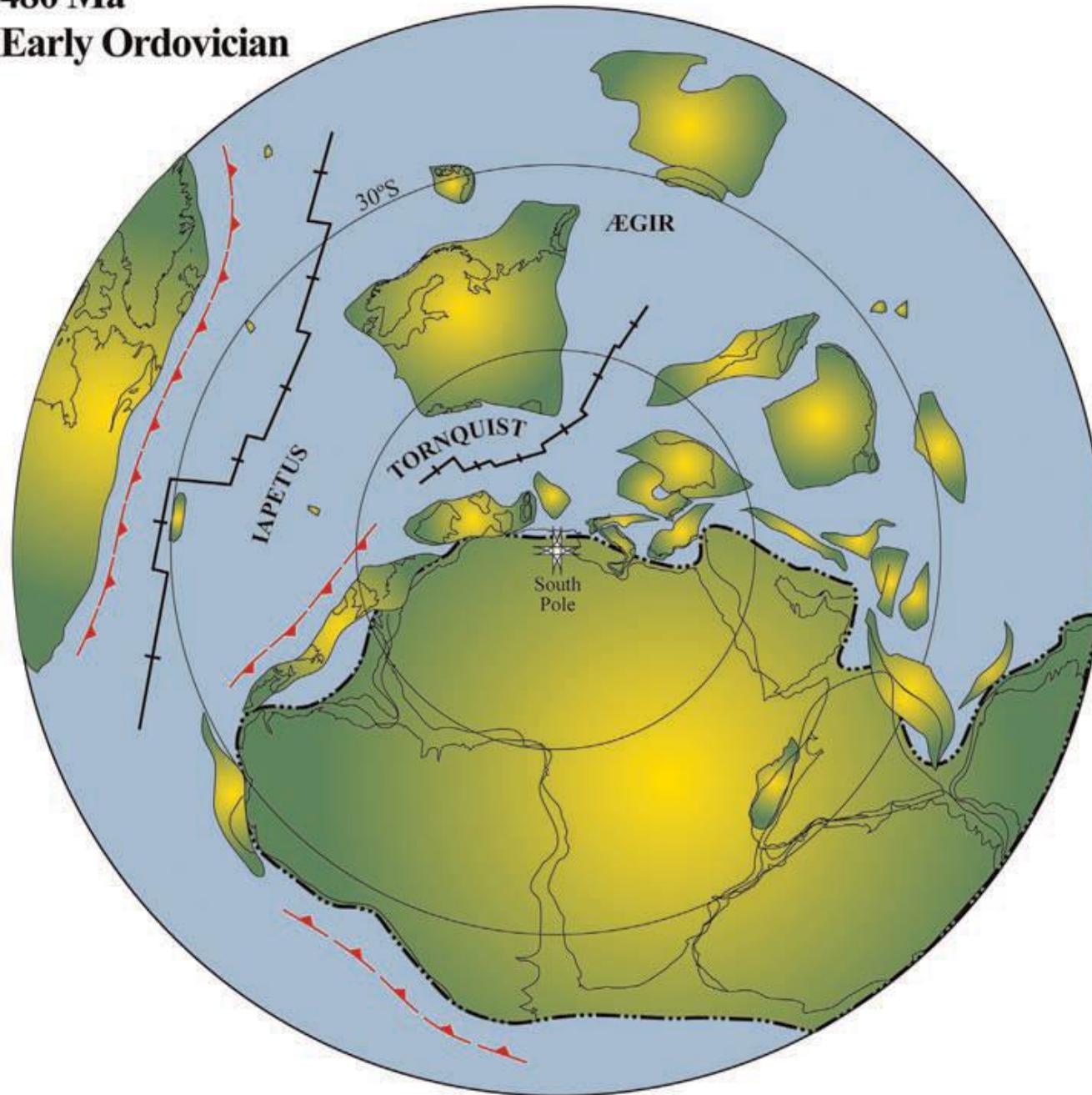
# Rifting of Rodinia

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



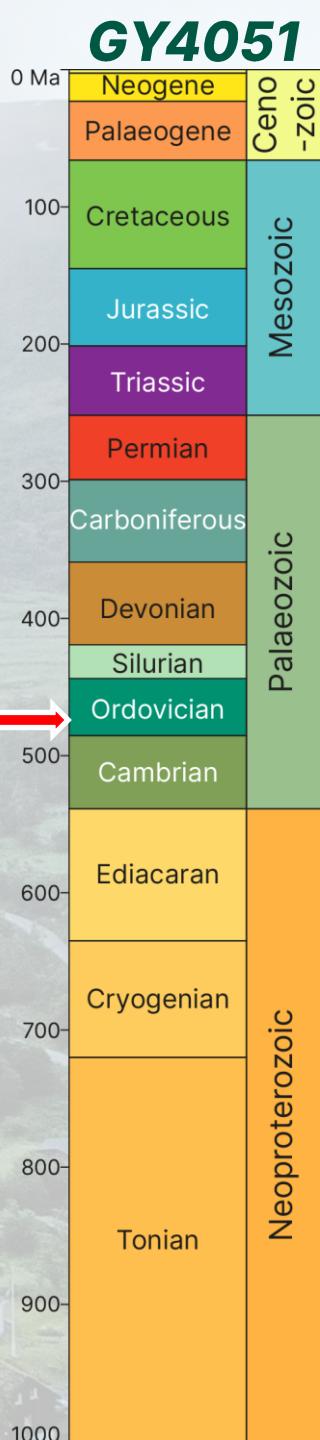
480 Ma

Early Ordovician



## Iapetus Ocean starts to close

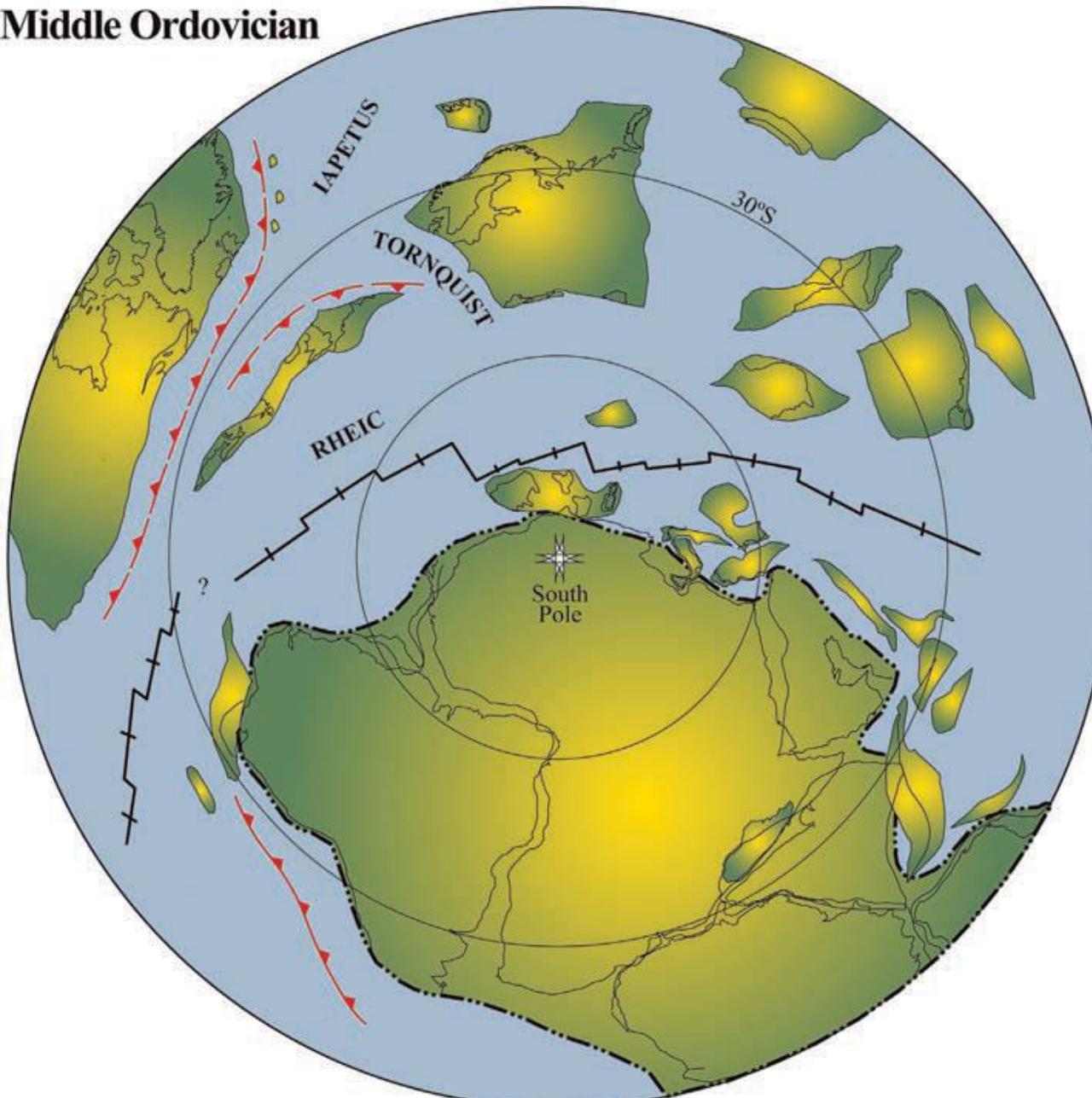
- Southern Britain and Ireland starts to rift from Gondwana
- Becomes microcontinent of Avalonia



**Laurentia, Avalonia, and the Iapetus Ocean** | Middle Ordovician

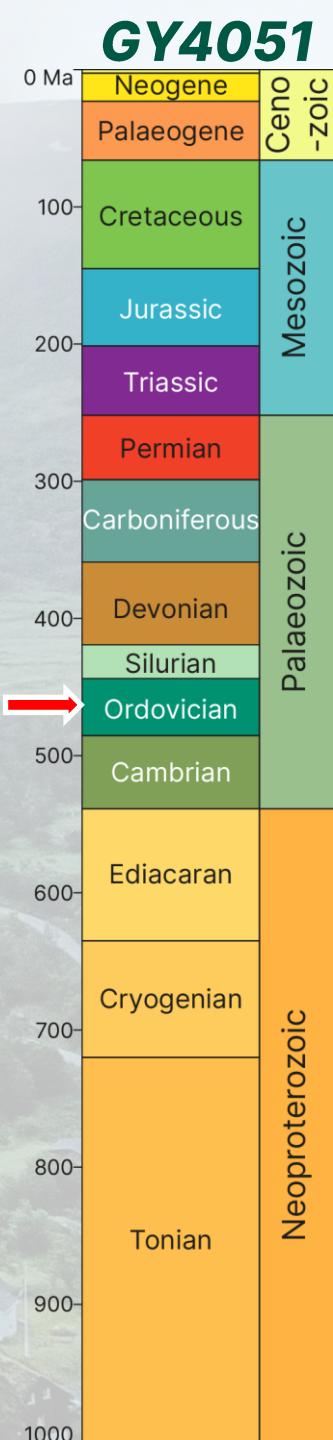
460 Ma

## Middle Ordovician



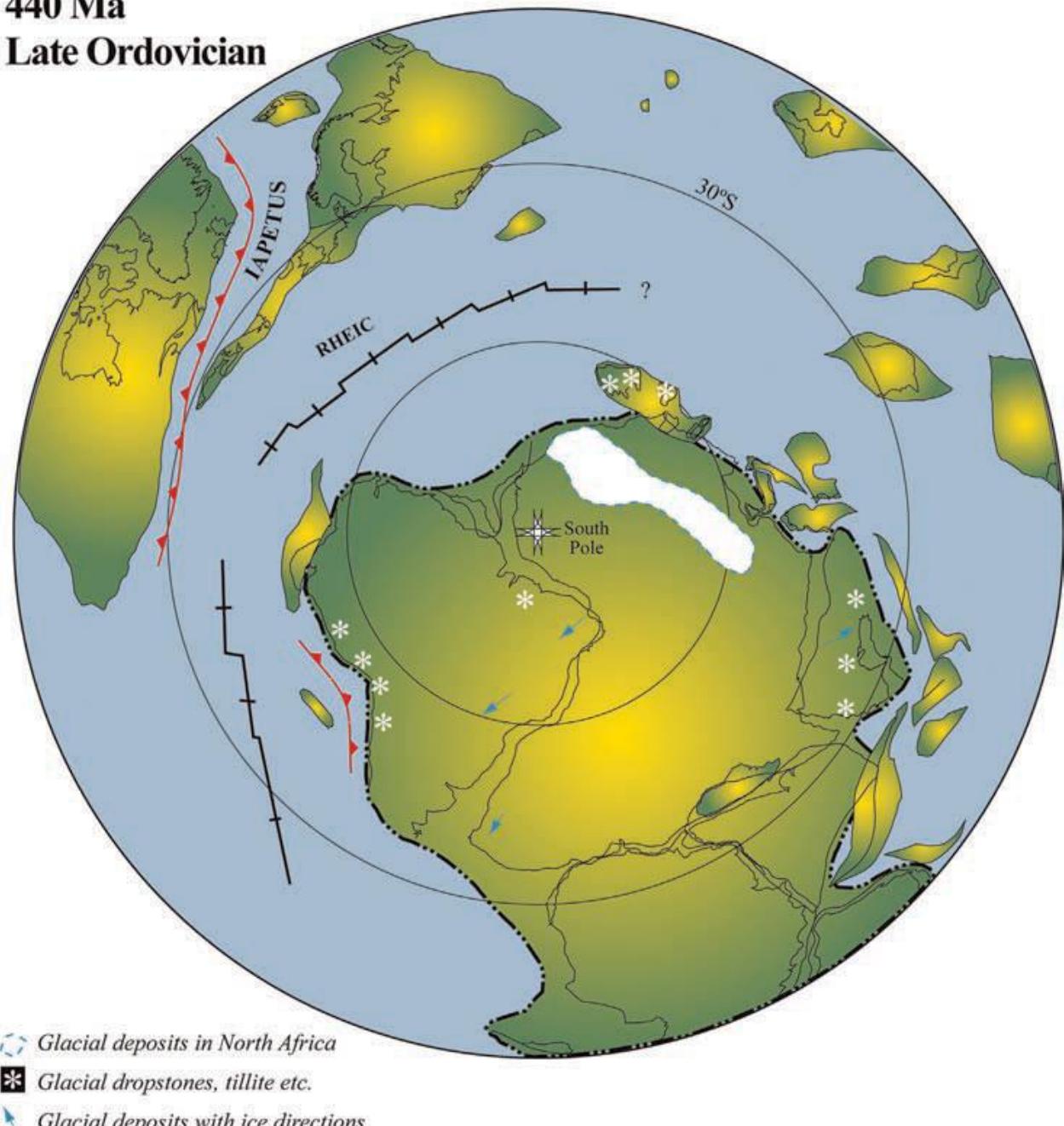
# Lapetus Ocean continues to close

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



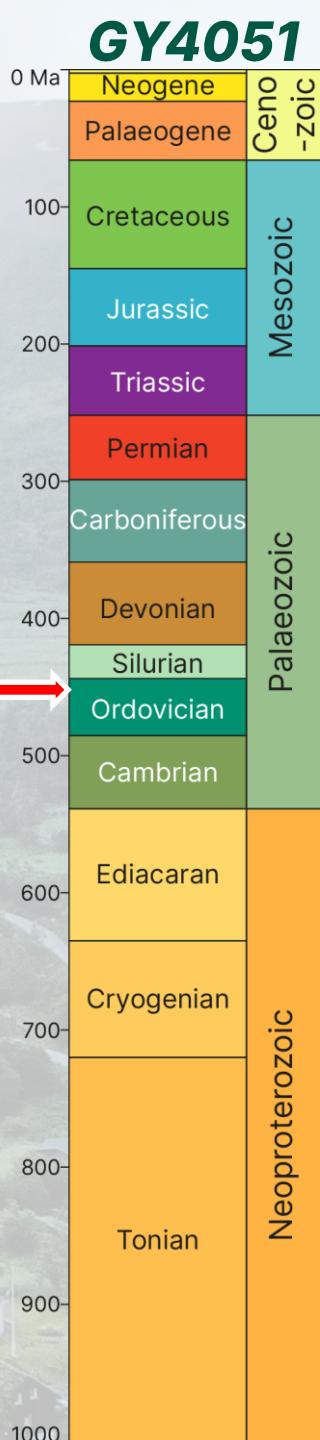
440 Ma

Late Ordovician



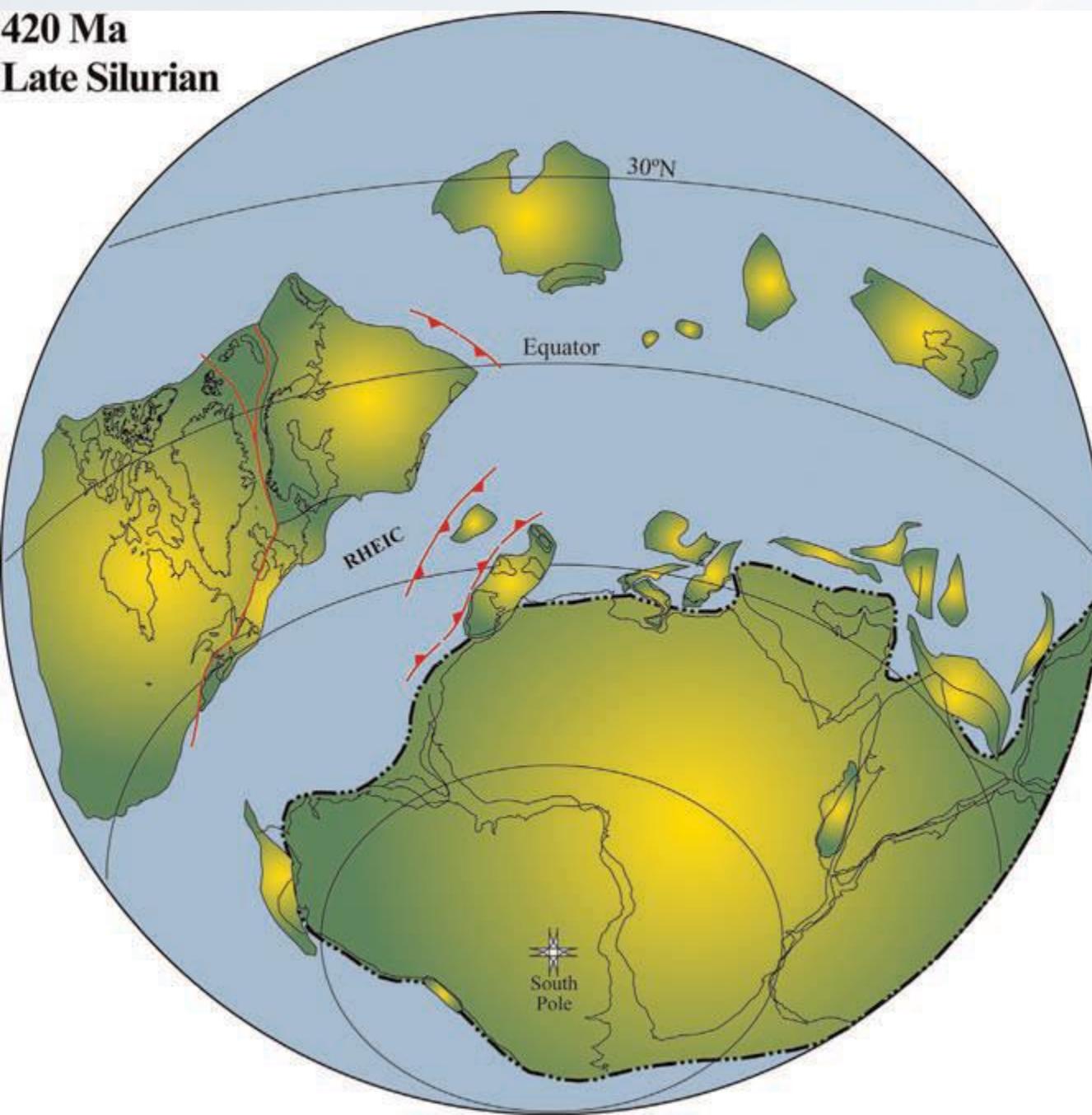
## Iapetus Ocean nears the end

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



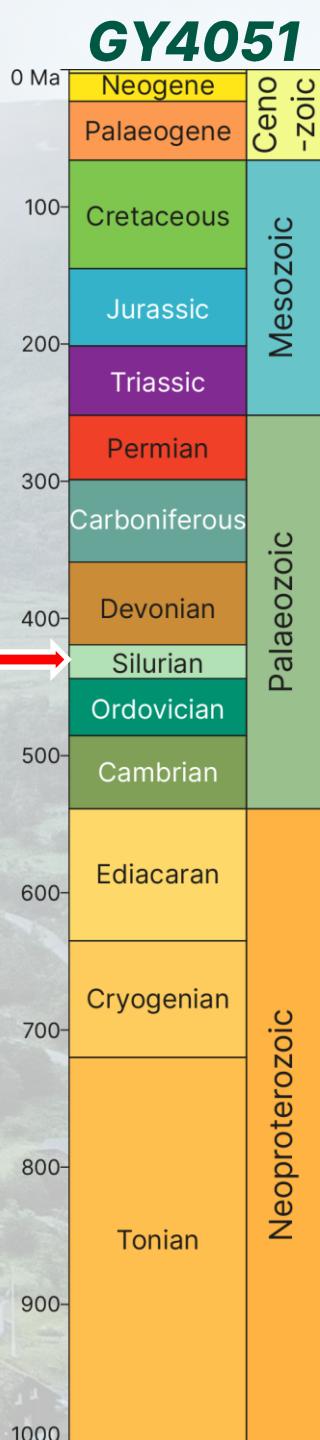
# Laurentia, Avalonia, and the Iapetus Ocean | Late Silurian

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

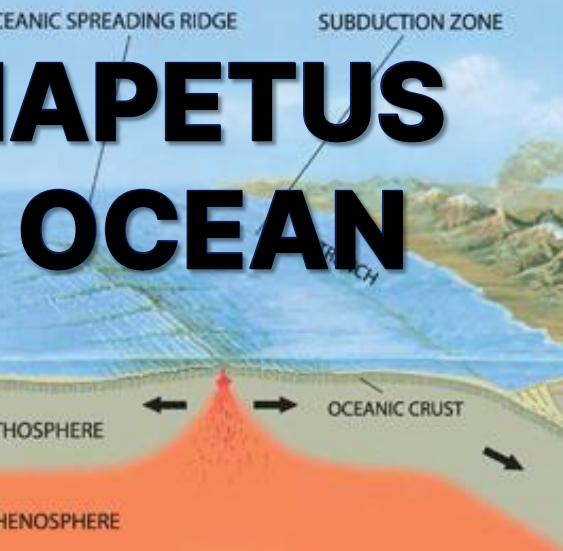
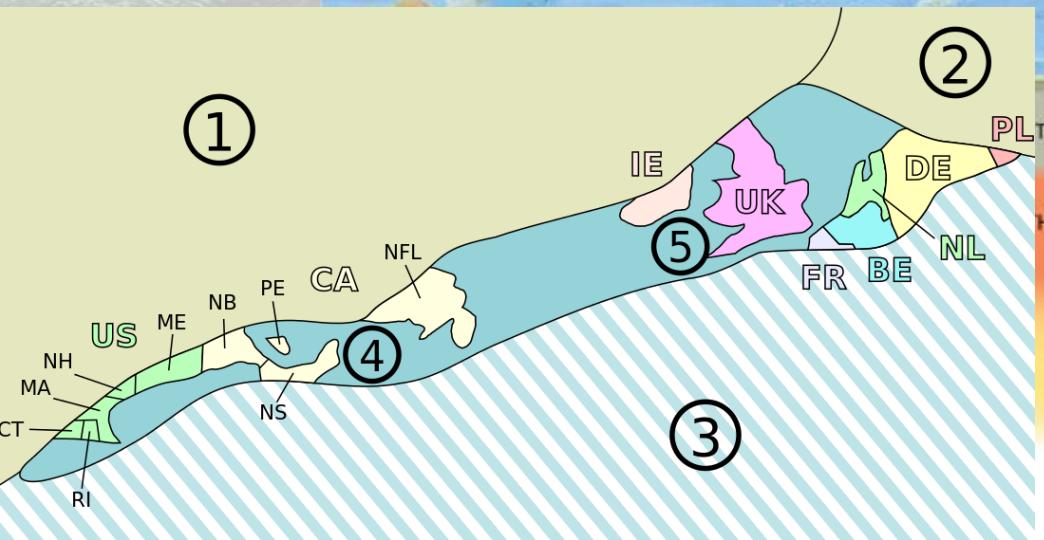
SUBDUCTION ZONE

# IAPETUS OCEAN

# LAURENTIA

RIFT ZONE

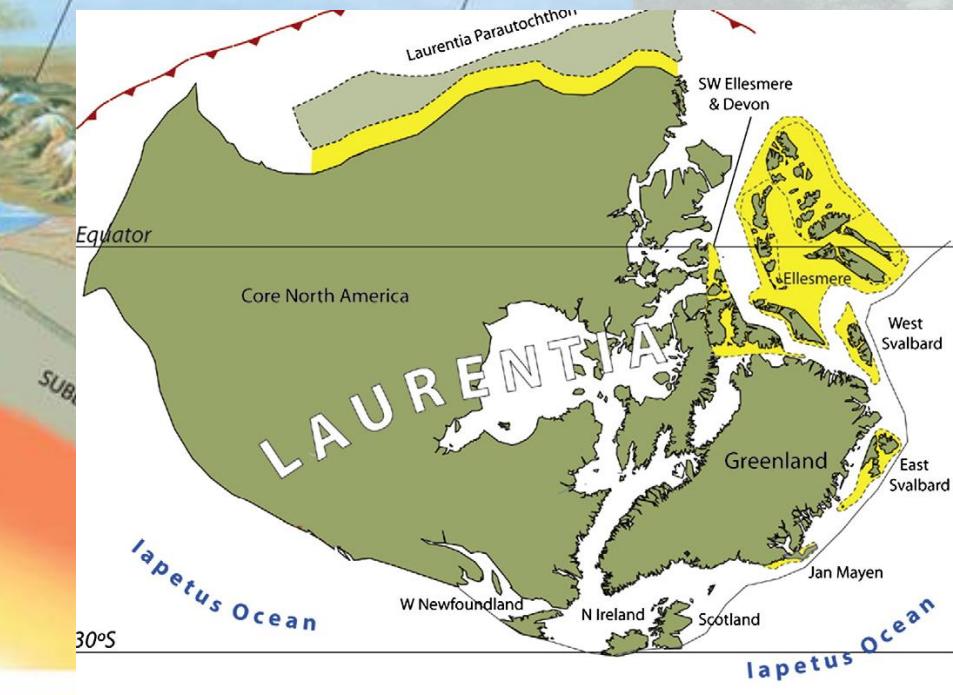
VOLCANIC ARC

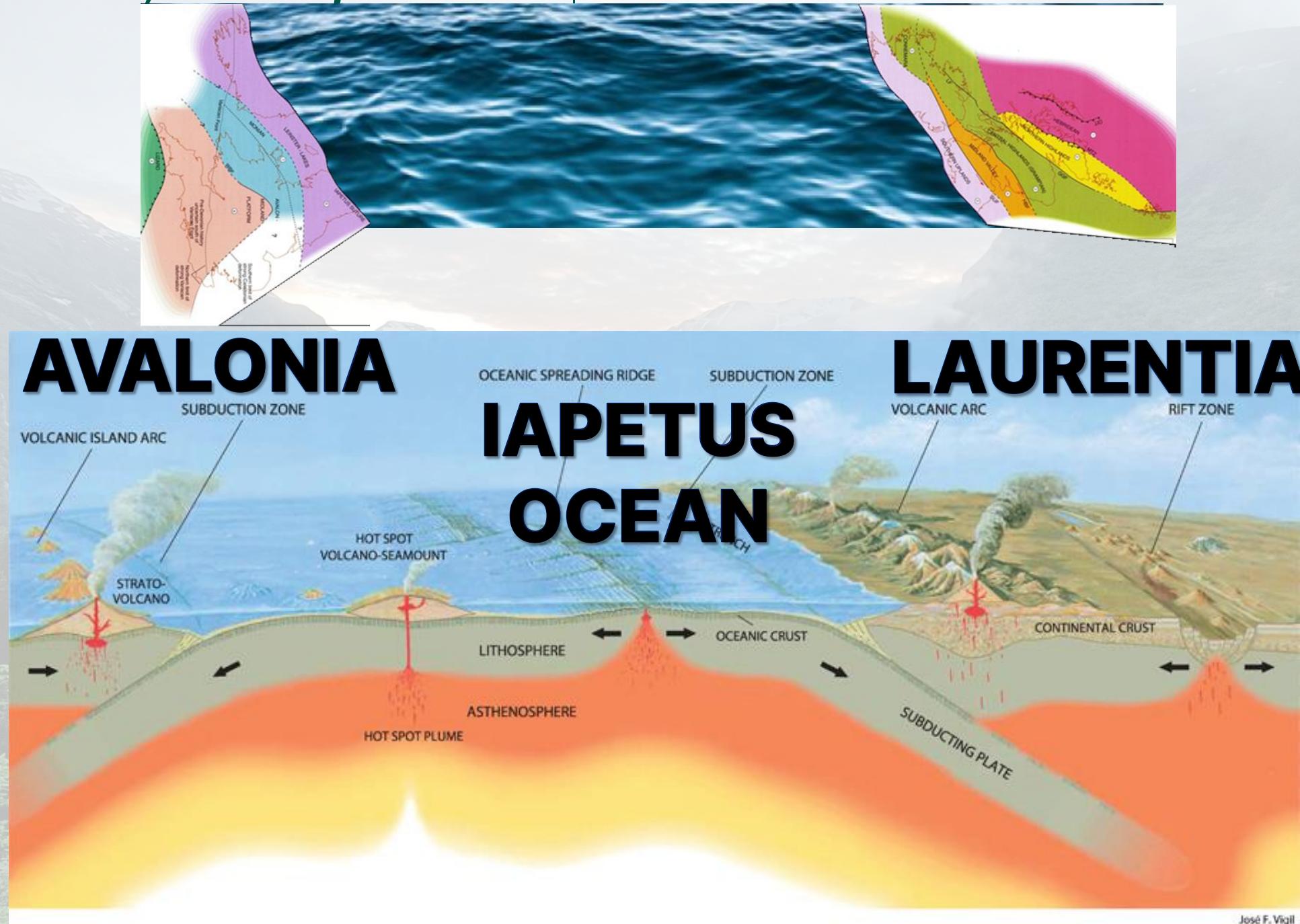


# LAURENTIA

RIFT ZONE

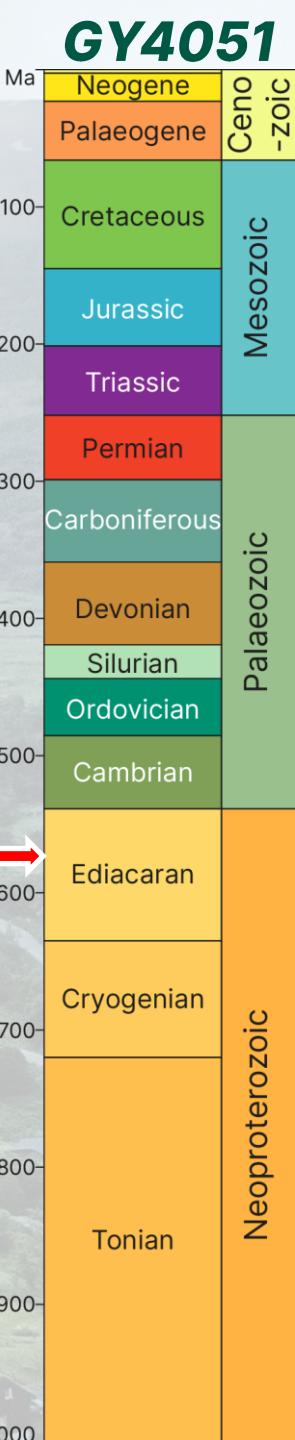
VOLCANIC ARC



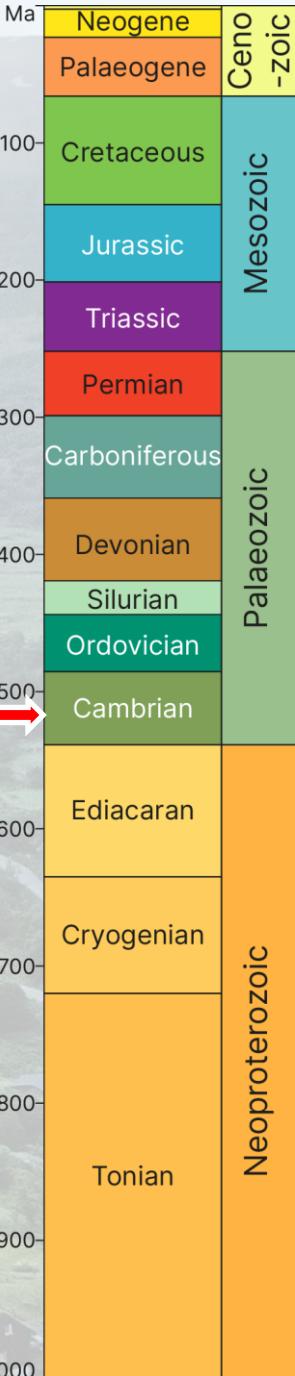
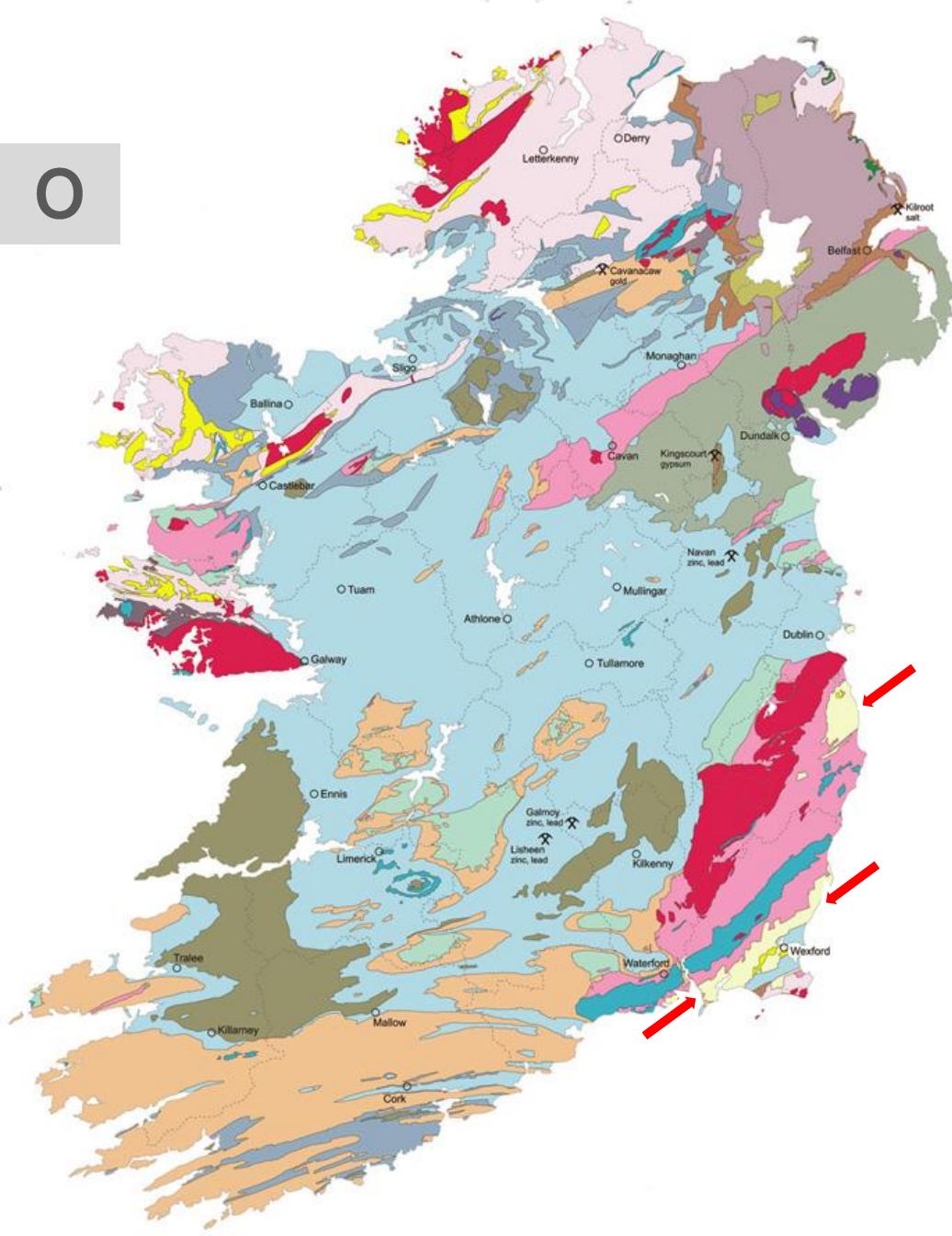


# **Laurentia, Avalonia, and the Iapetus Ocean** | The Laurentian margin

G<sub>1</sub> M<sub>1</sub>  
G<sub>2</sub>  
I

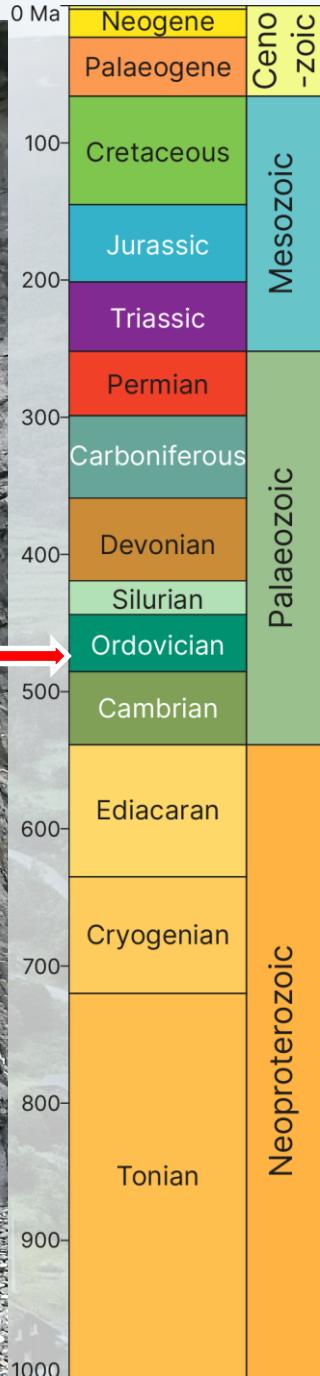


O



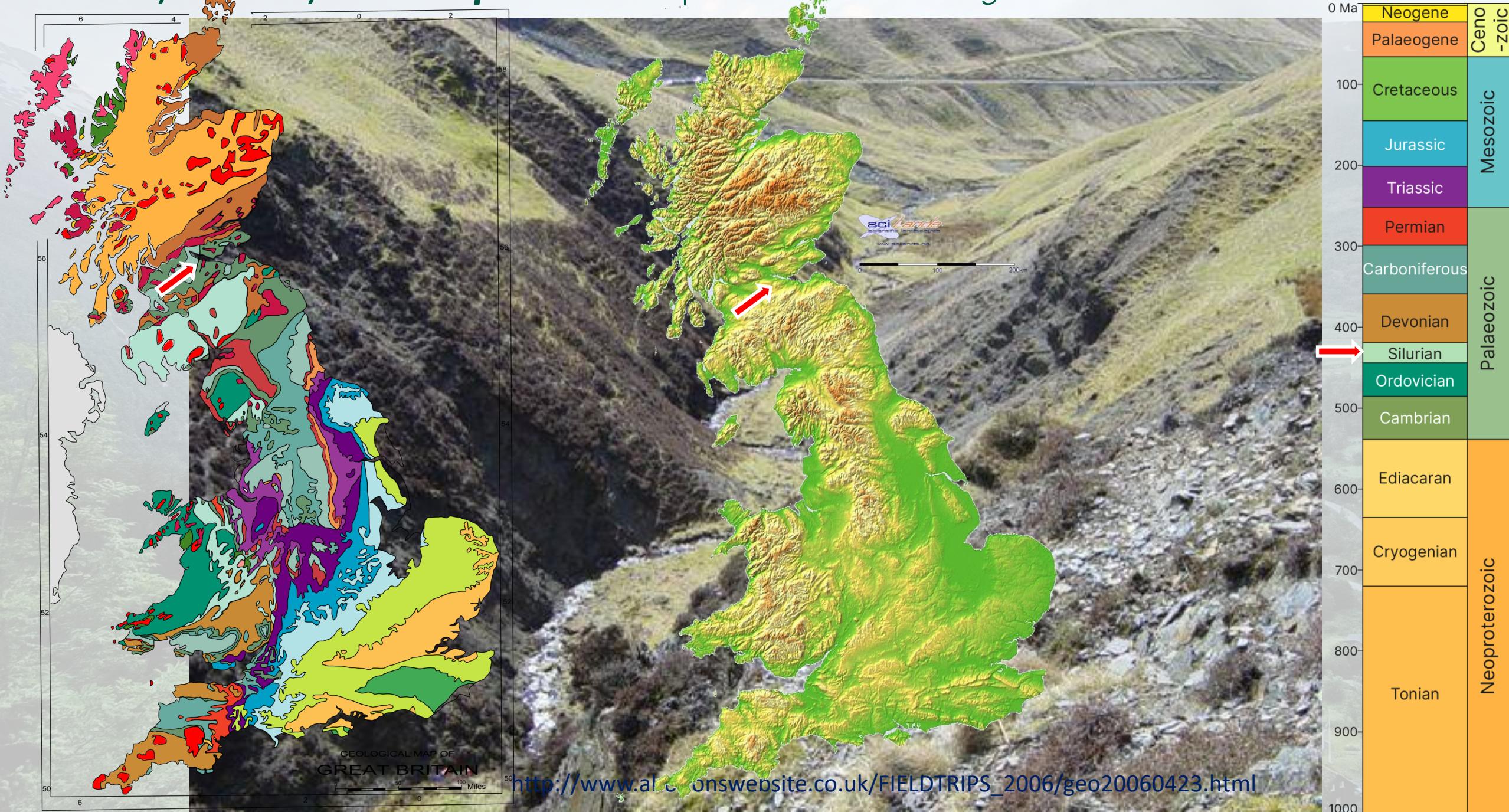
# Laurentia, Avalonia, and the Iapetus Ocean | Ordovician – Subduction volcanism

GY4051



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

GY4051

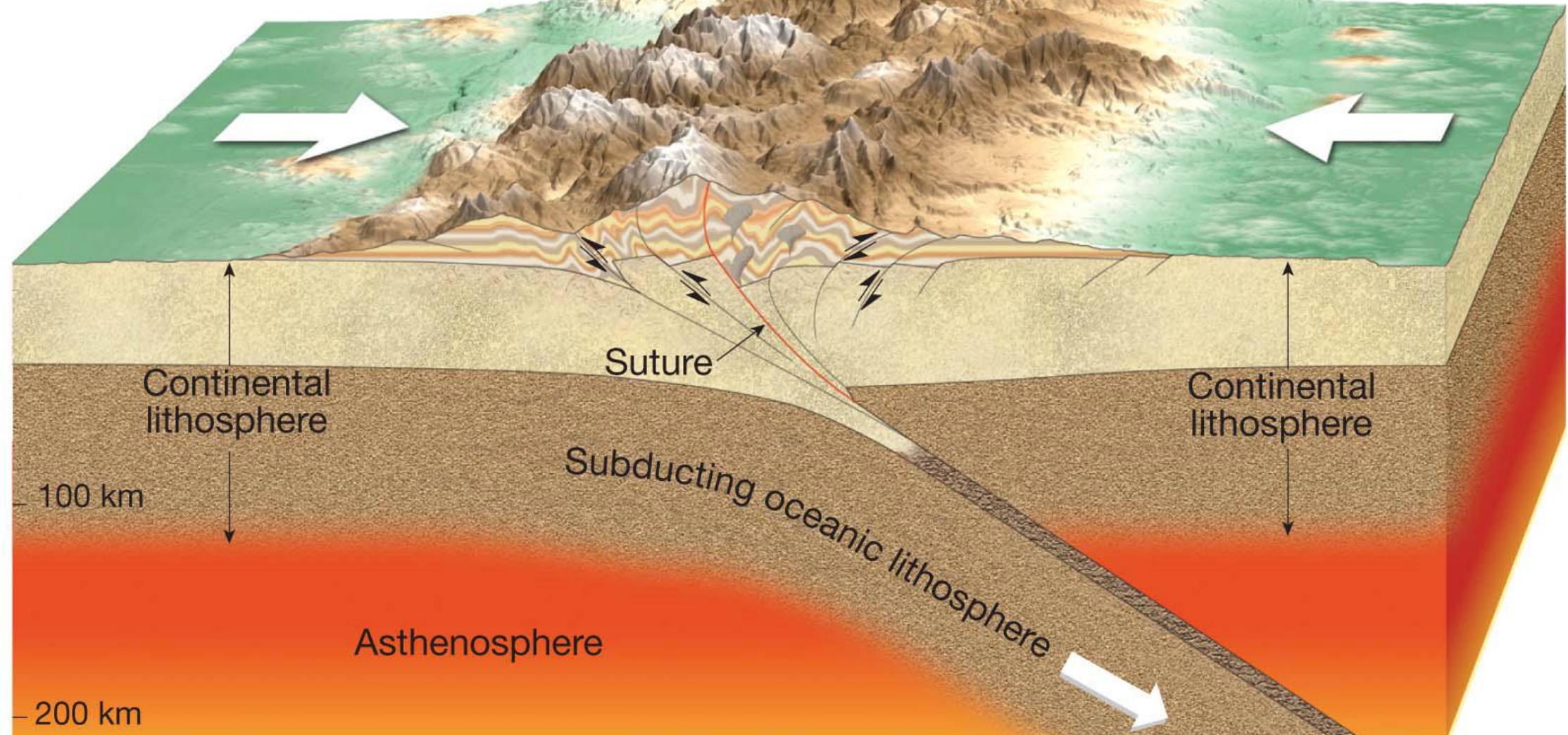


# Rise and Fall of The Caledonian Mountains | The Caledonian Mountains

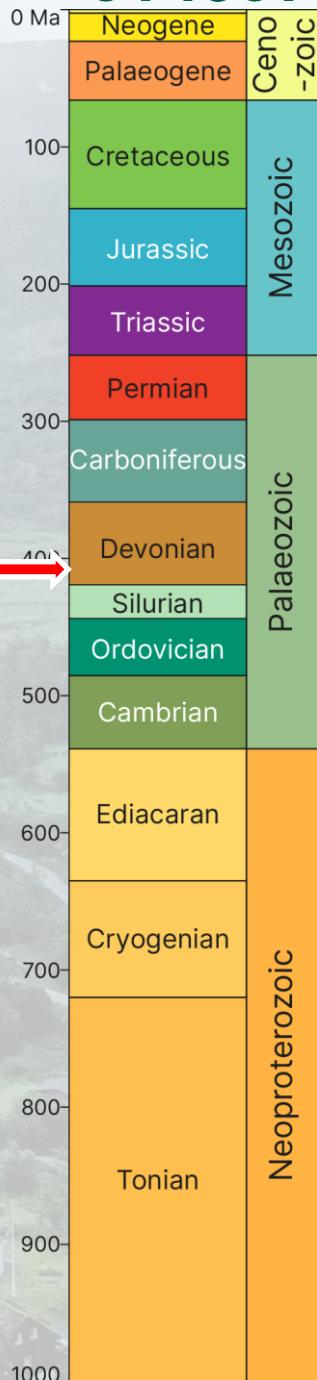
## AVALONIA

Collision mountains

## LAURENTIA



**GY4051**

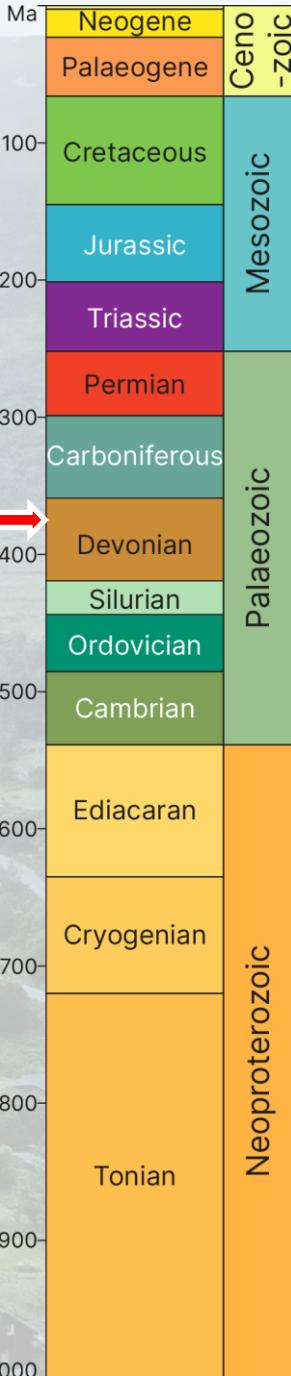


**C.**



# Rise and Fall of The Caledonian Mountains | Devonian of Ireland

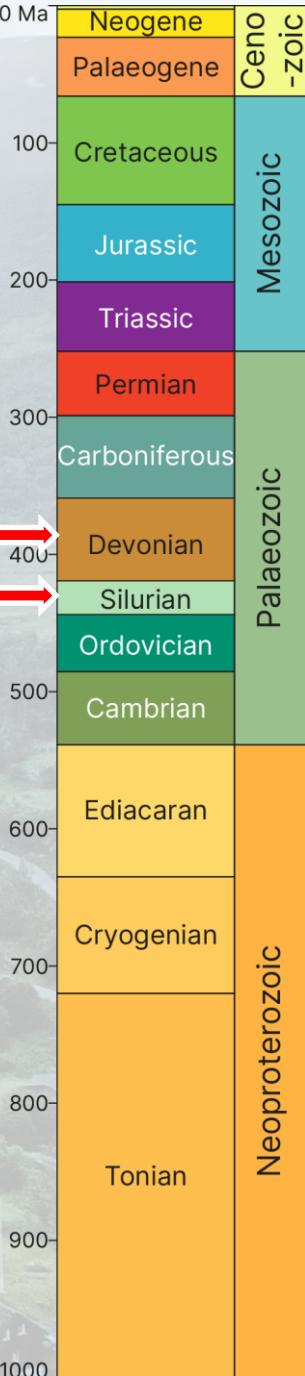
GY4051



# Rise and Fall of The Caledonian Mountains | Caledonian Granites

GY4051

C<sub>1</sub>

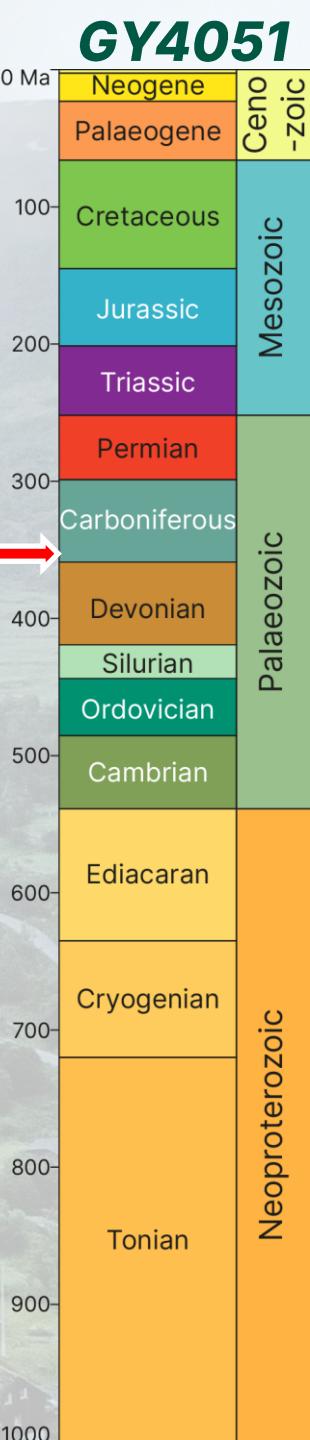


# Rise and Fall of The Caledonian Mountains | Marine Transgression

GY4051



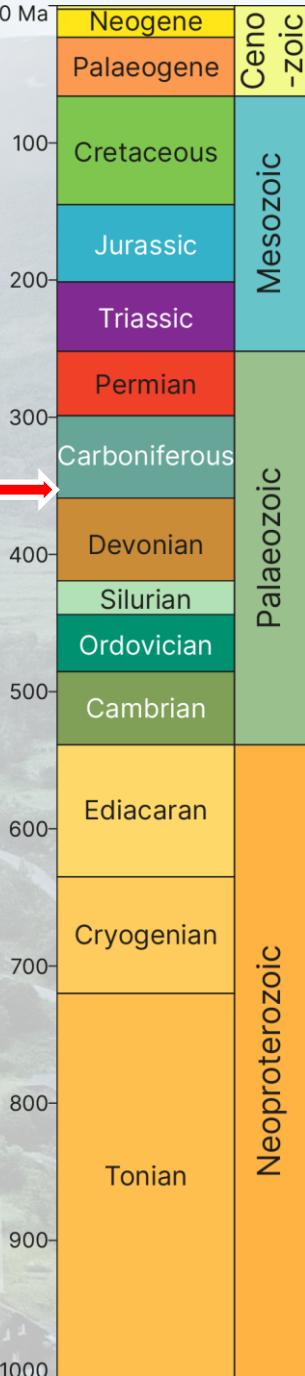
# Tropical Ireland | Insert witty joke about the weather here



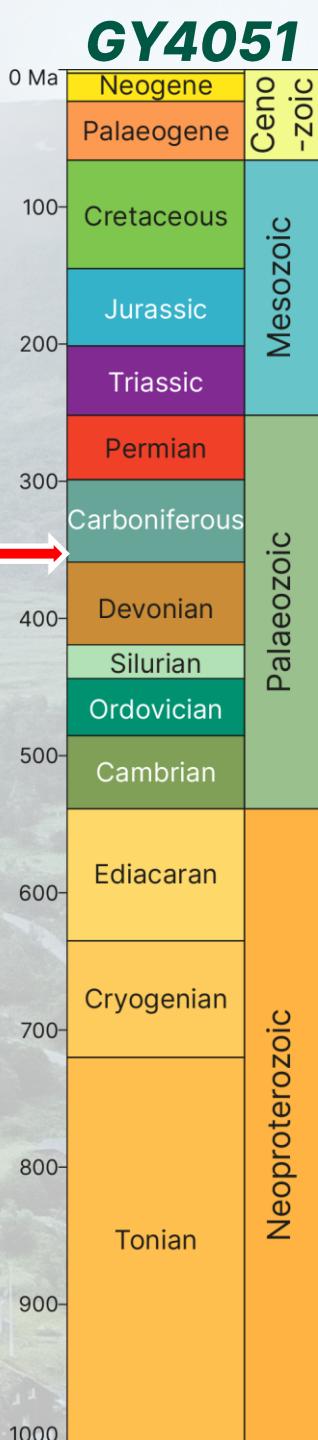
# Tropical Ireland | Early Carboniferous

GY4051

P



# Tropical Ireland | Shelf Limestones – LEAD AND ZINC



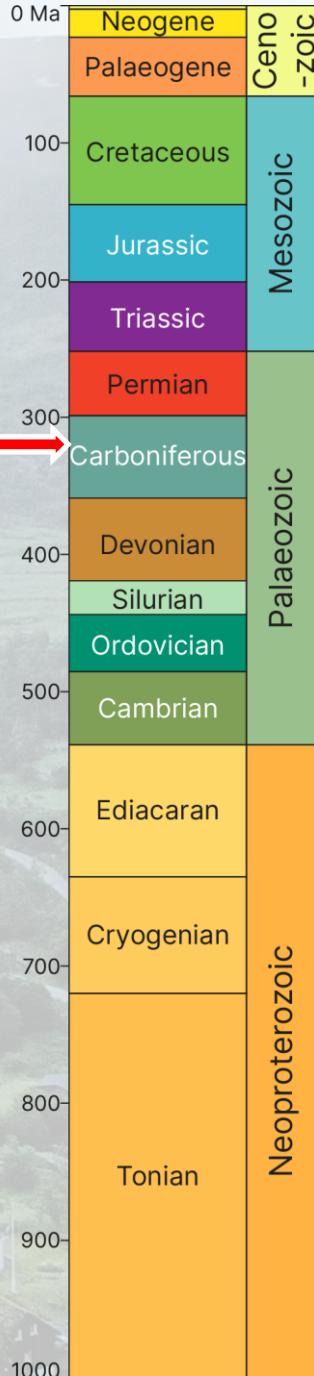
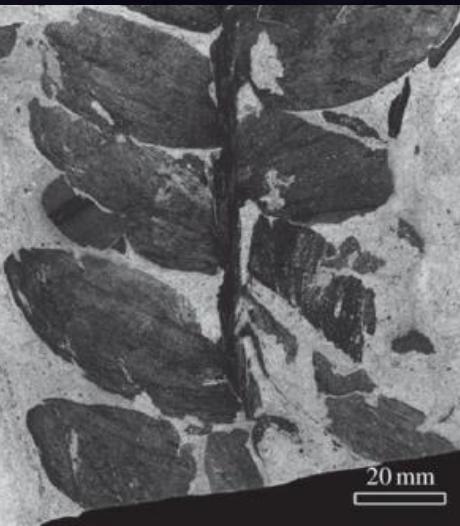
# Tropical Ireland | Deltas – the Cliffs of Moher

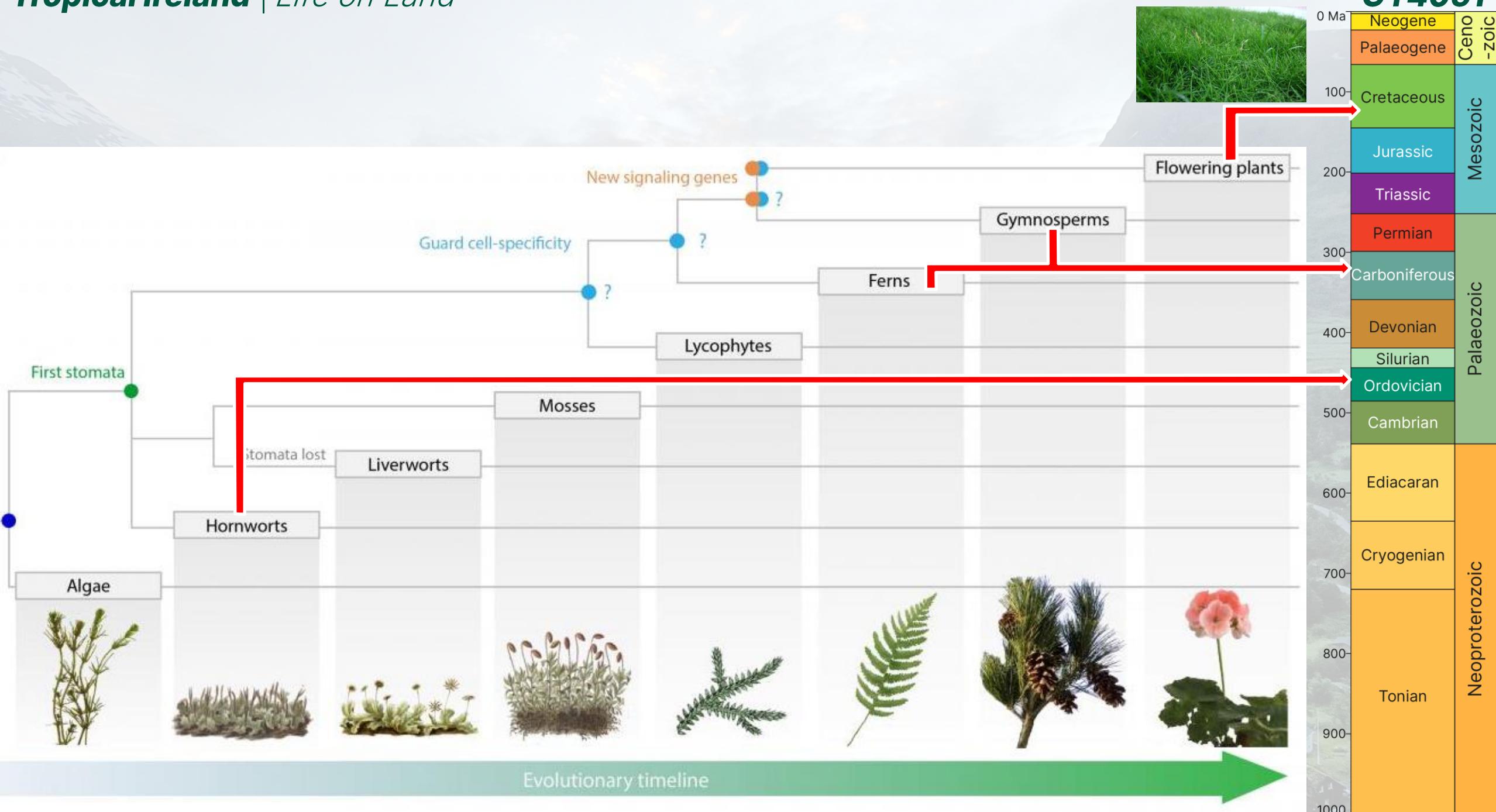
GY4051



# Tropical Ireland | Carboniferous Life on Land

GY4051

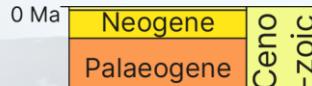




# Osteichthyes: Bony fish

## 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

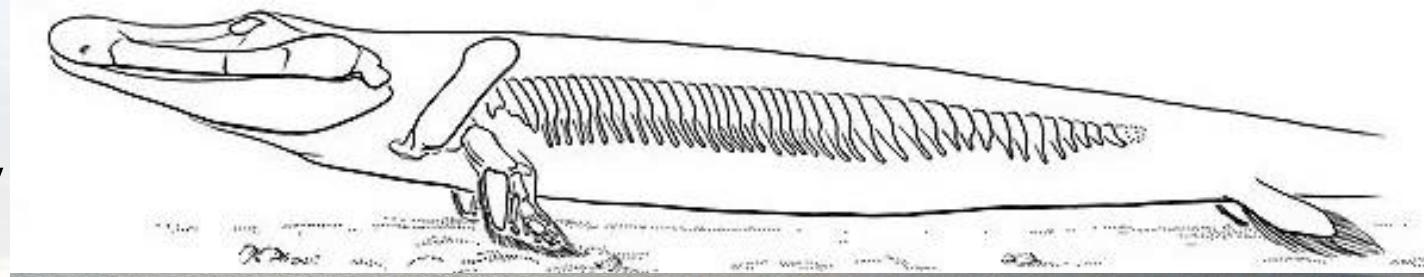
- Lobe-finned fish
- Late Devonian
- Fins are **fleshy**, and **bony**
- Four fins – but no digits
- Lived entirely in water



# 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

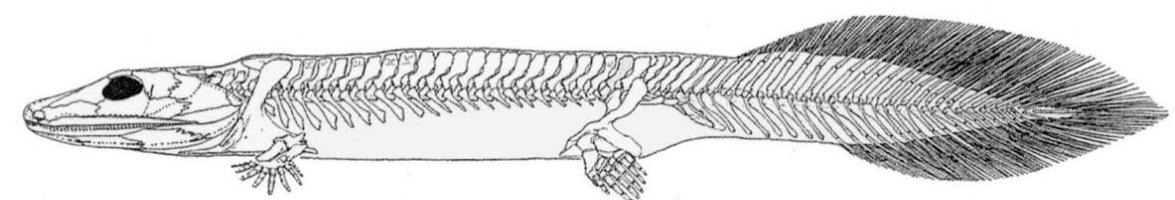


Nobu Tamura  
(<http://spinops.blogspot.com>)

# 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

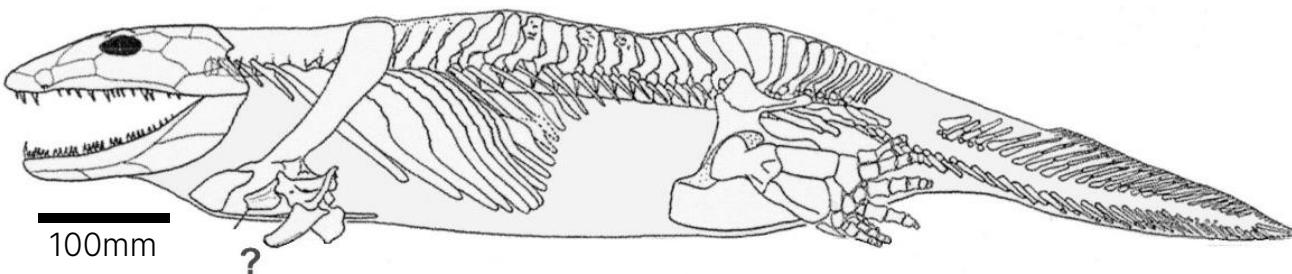
Acanthostega



# 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

Carboniferous

400-500  
Devonian

Silurian

Ordovician

Cambrian

600-700  
Ediacaran

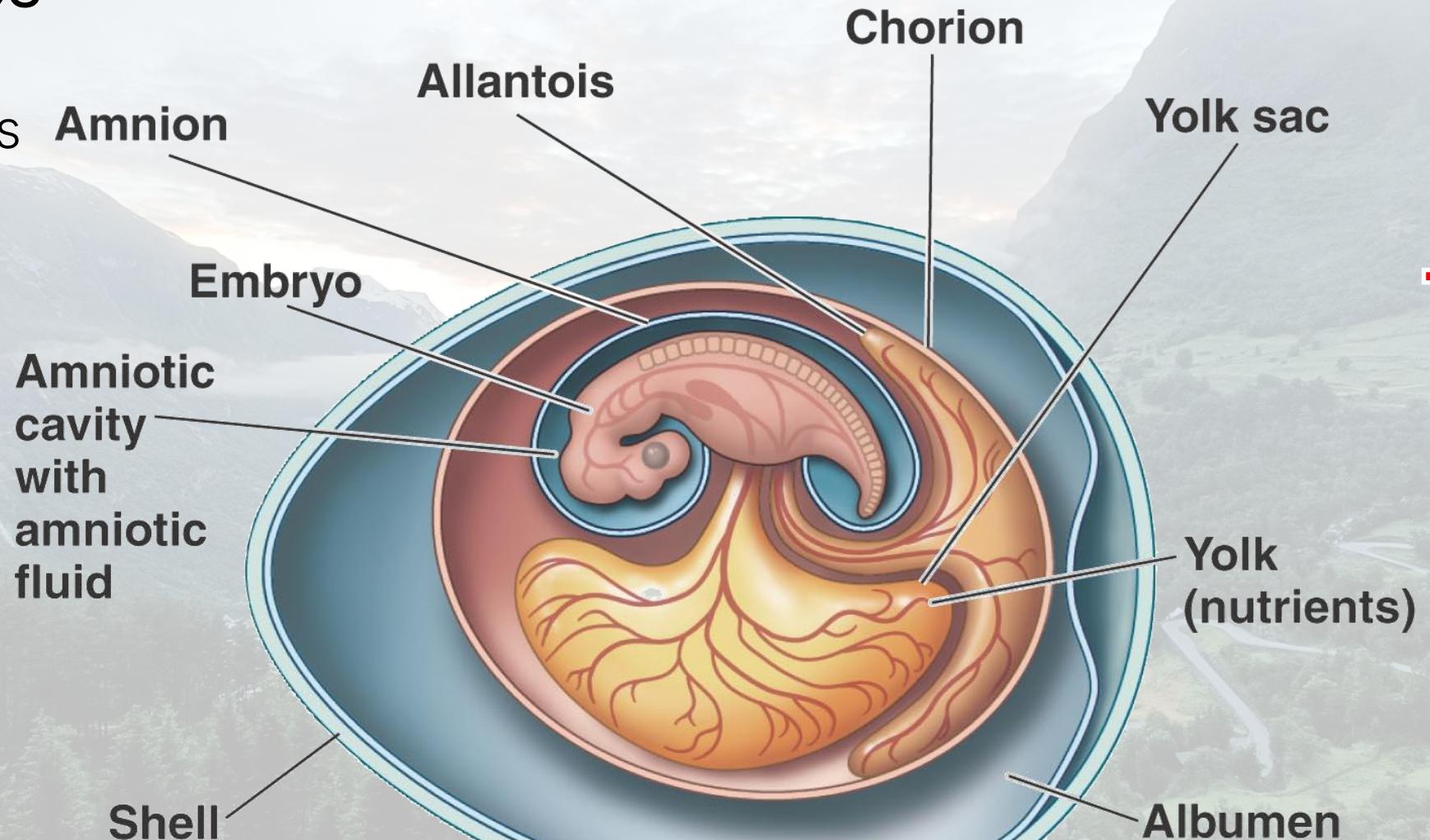
Cryogenian

700-800  
Tonian

900-1000  
Neoproterozoic

# 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

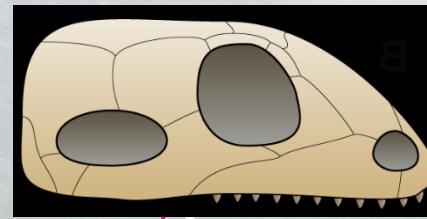
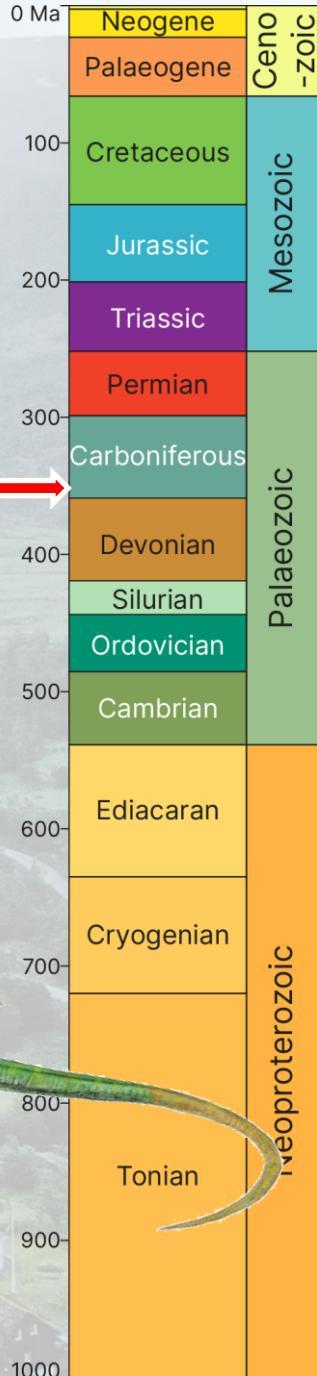
900

1000

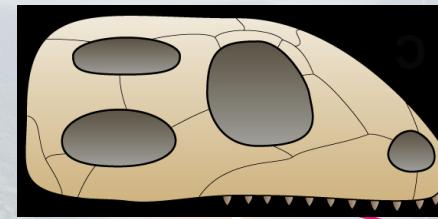
Palaeozoic

Mesozoic

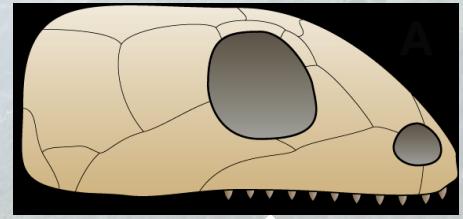
Ceno-zoic



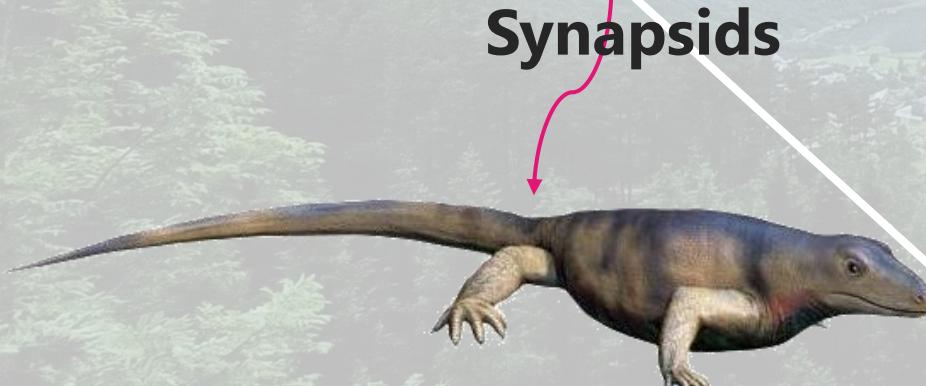
**Synapsids**



**Diapsids**

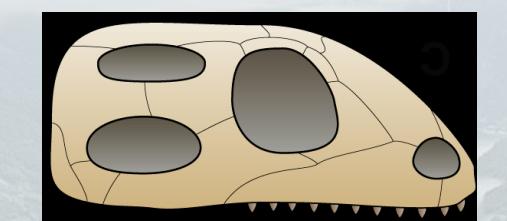
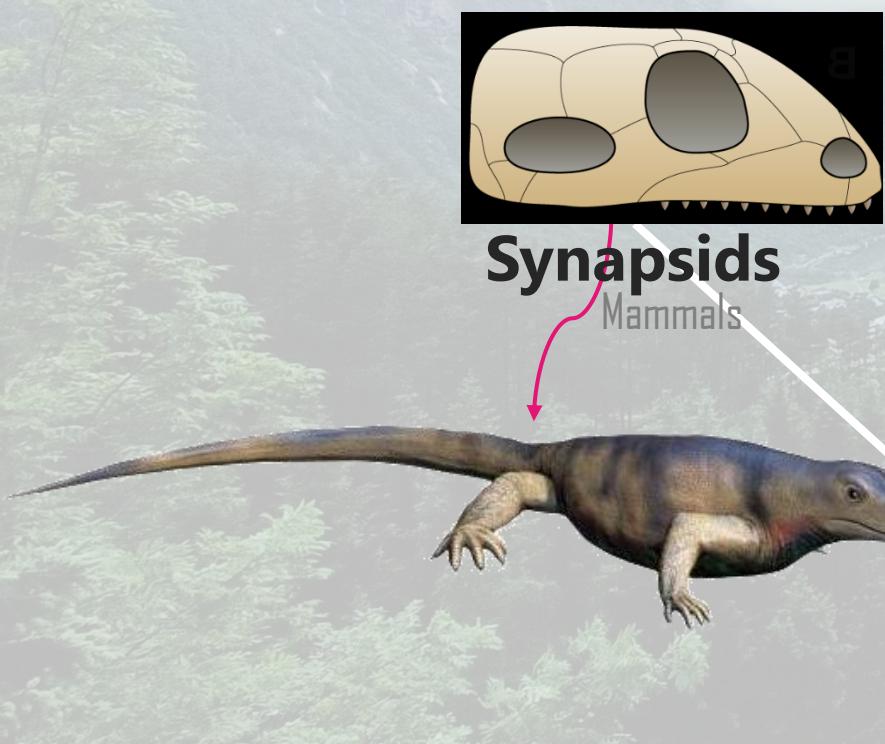
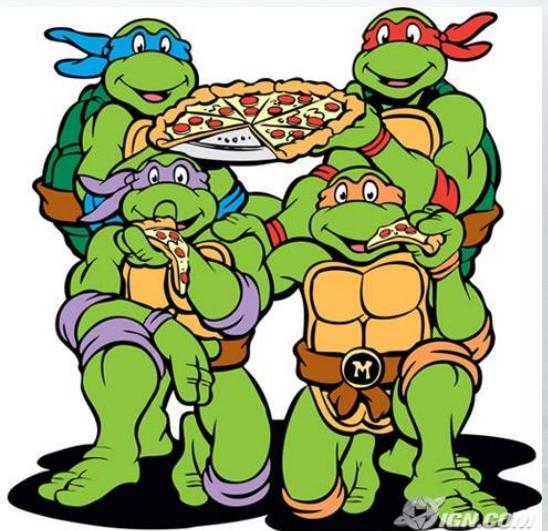


**Anapsids**



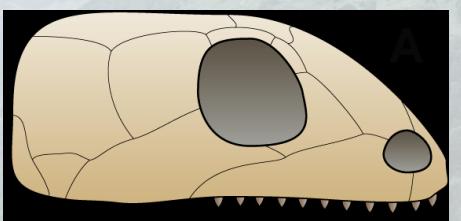
**Amniota**  
**Amniotic egg**





**Diapsids**

Modern reptiles, birds

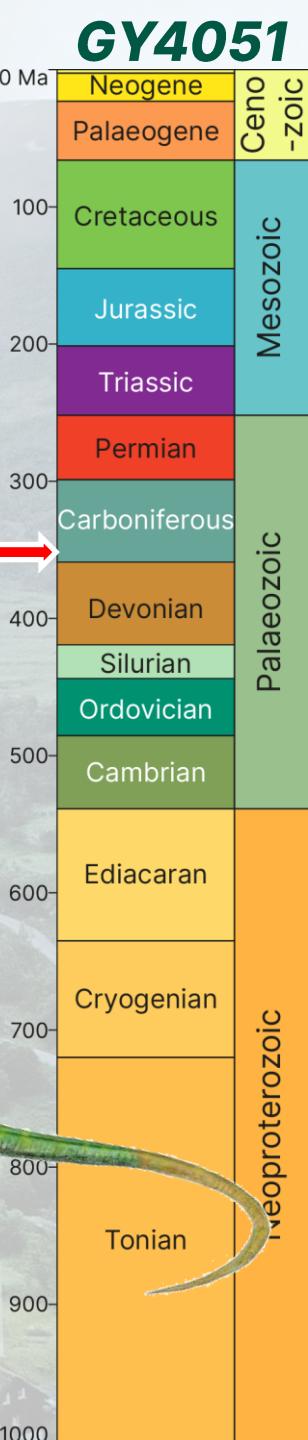


**Anapsids**

Turtles



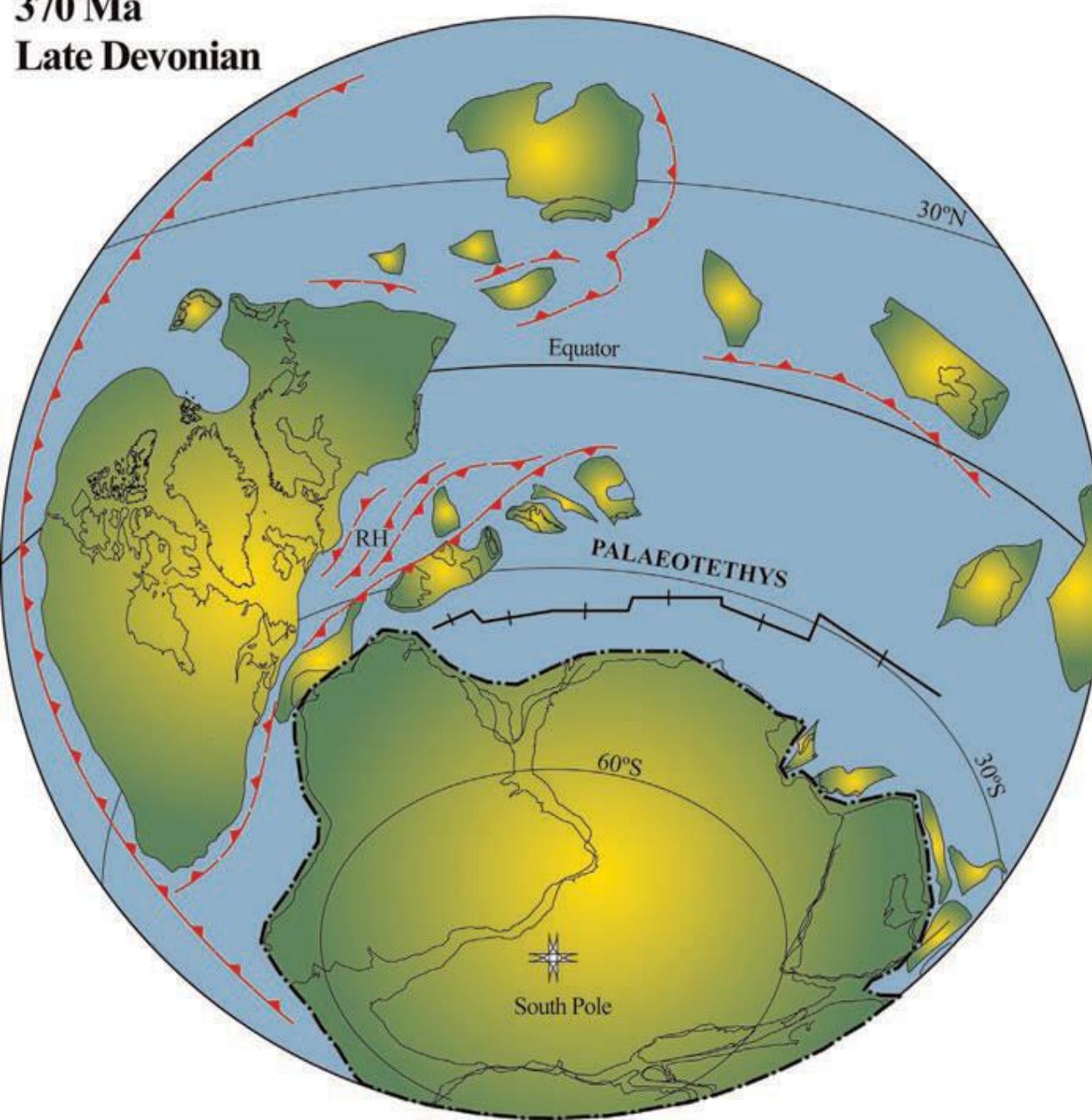
**Amniota**  
**Amniotic egg**



# Rise and Fall of The Caledonian Mountains | Late Devonian

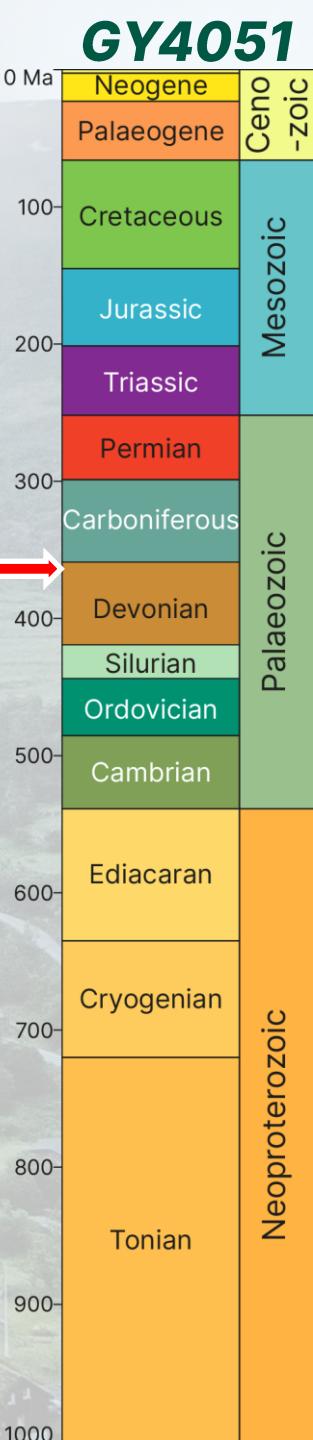
370 Ma

Late Devonian



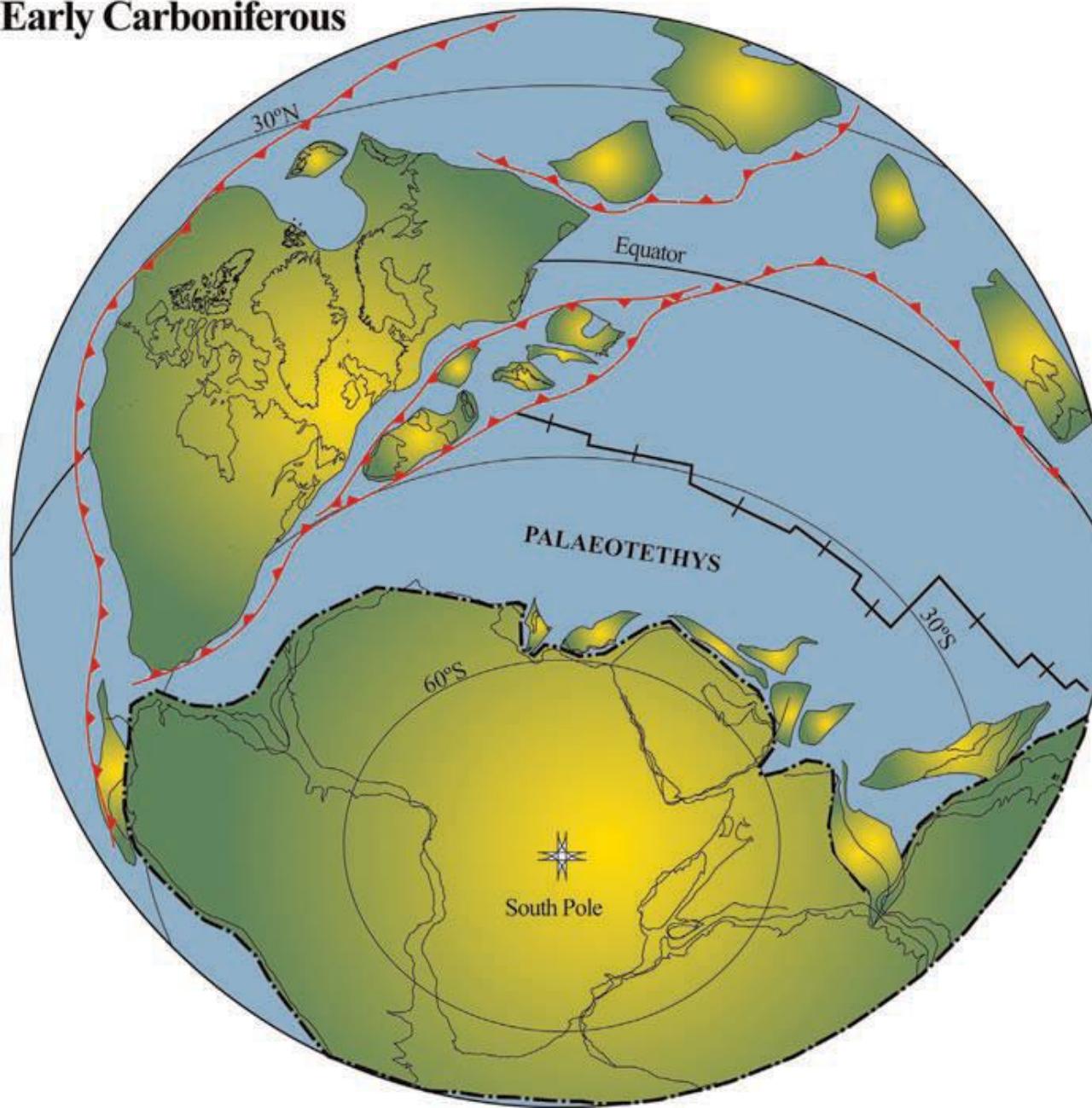
## Tethys Ocean continues to open

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



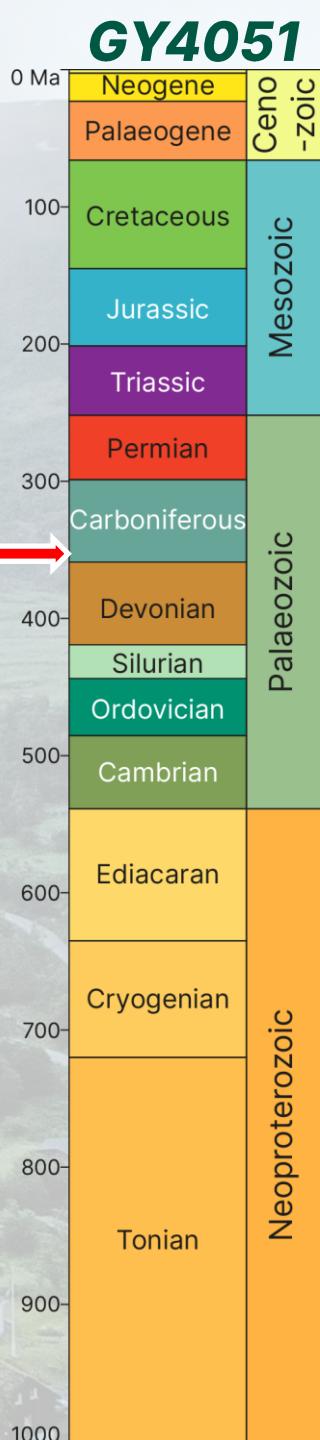
340 Ma

Early Carboniferous



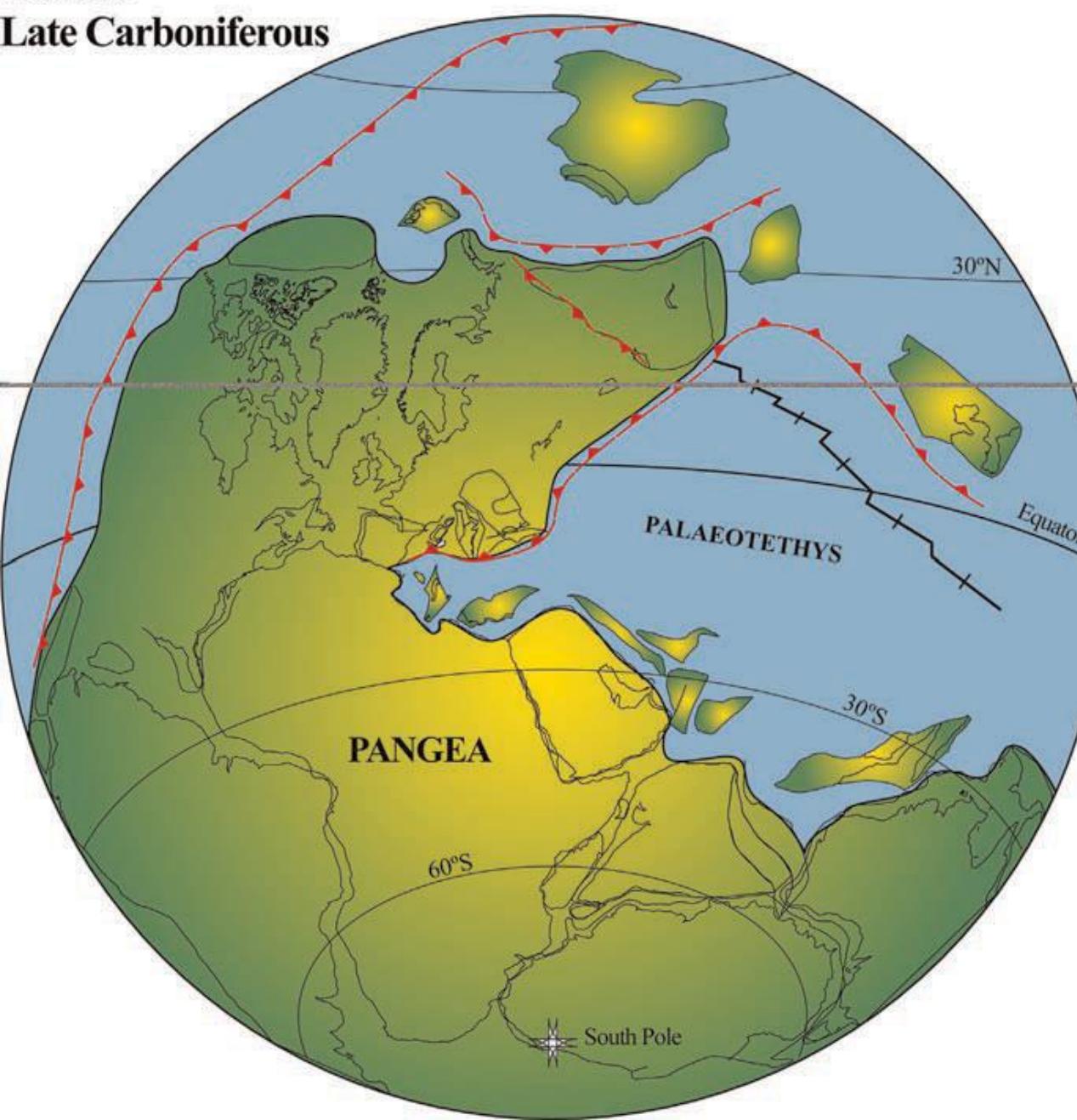
## Rheic Ocean almost closed

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



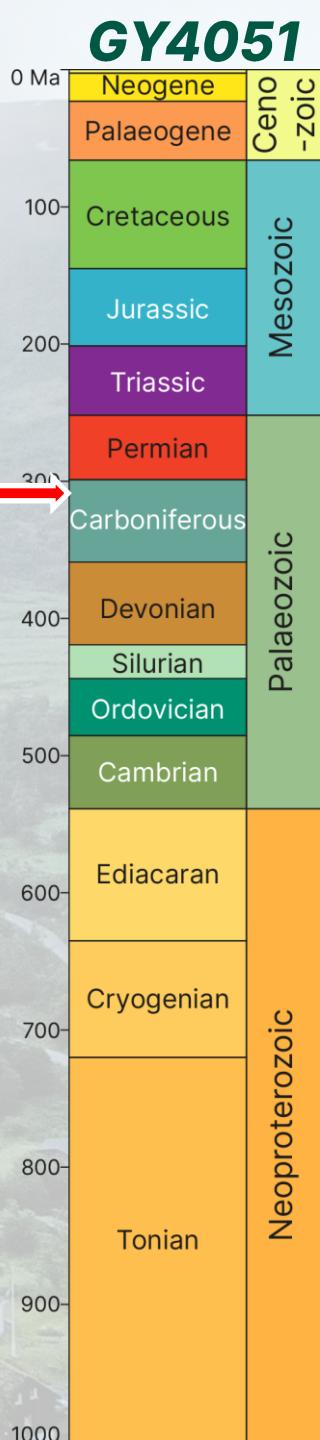
310 Ma

Late Carboniferous

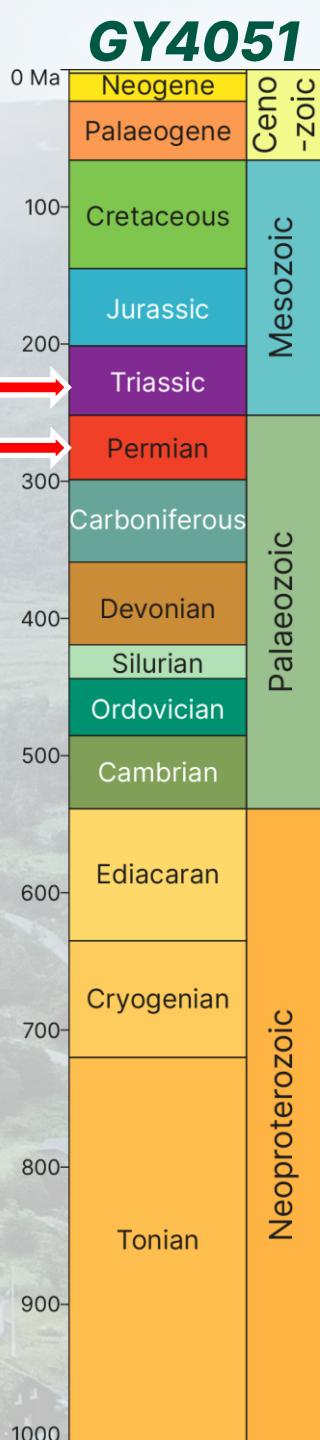


## Variscan Orogeny

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



Desert sandstone | Belfast, Co. Antrim





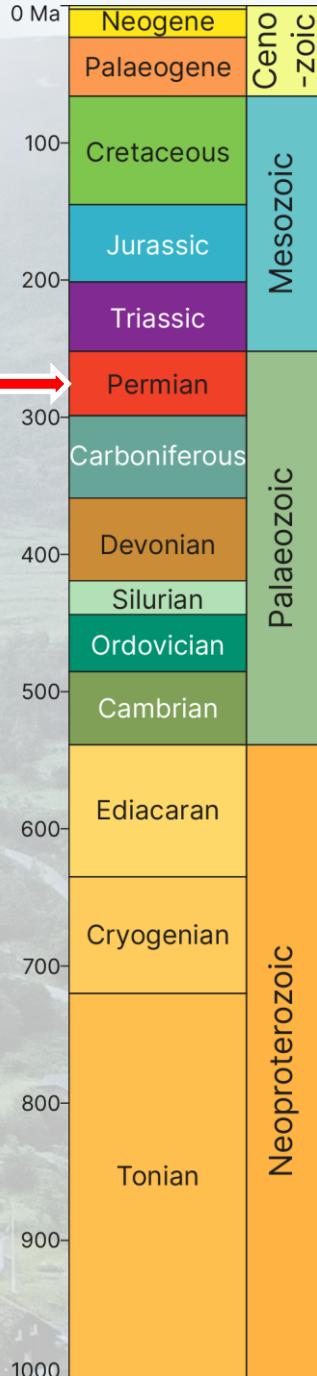
# Synapsids

## Cynodonts

- Ancestral to Mammals



*Procynosuchus*

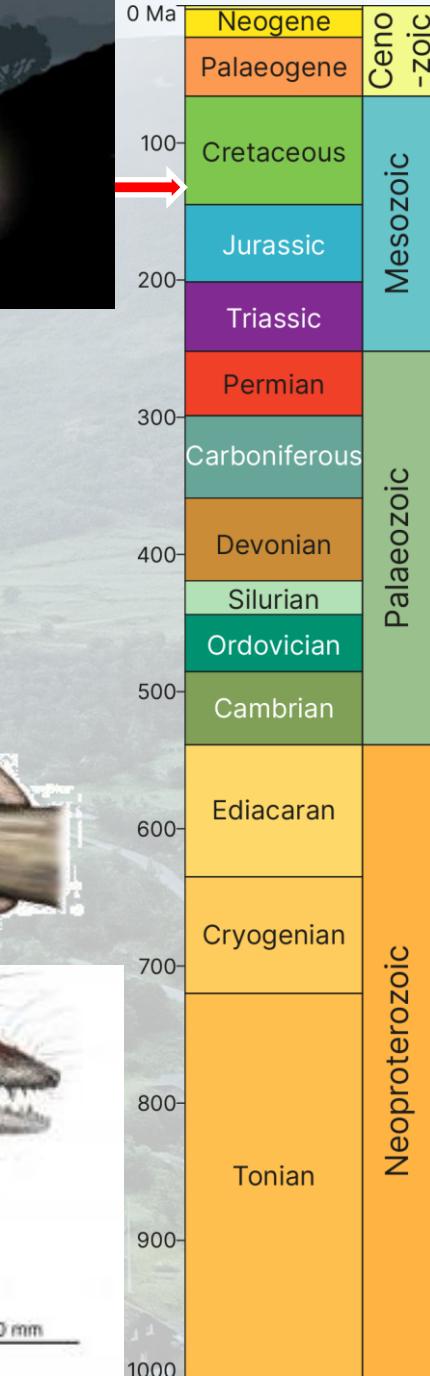
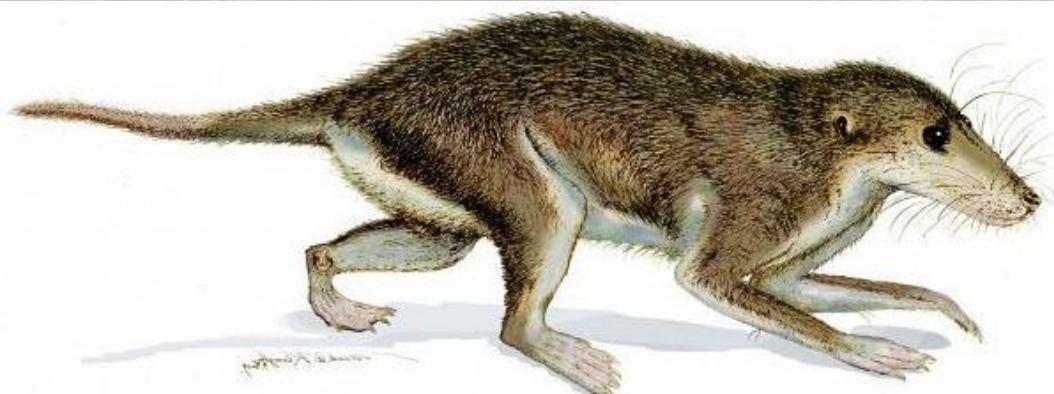
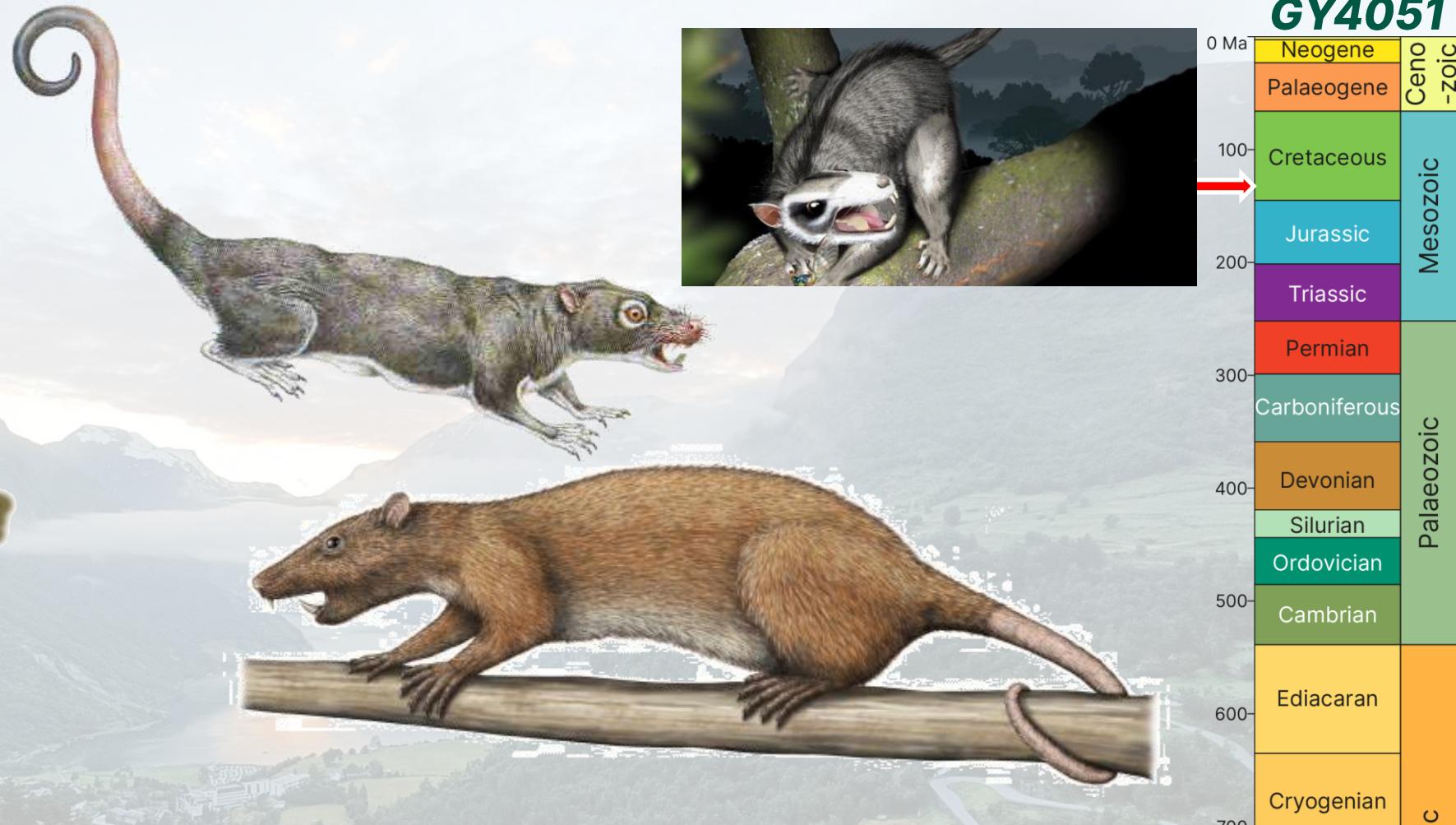


# Synapsids

## Mammalia



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



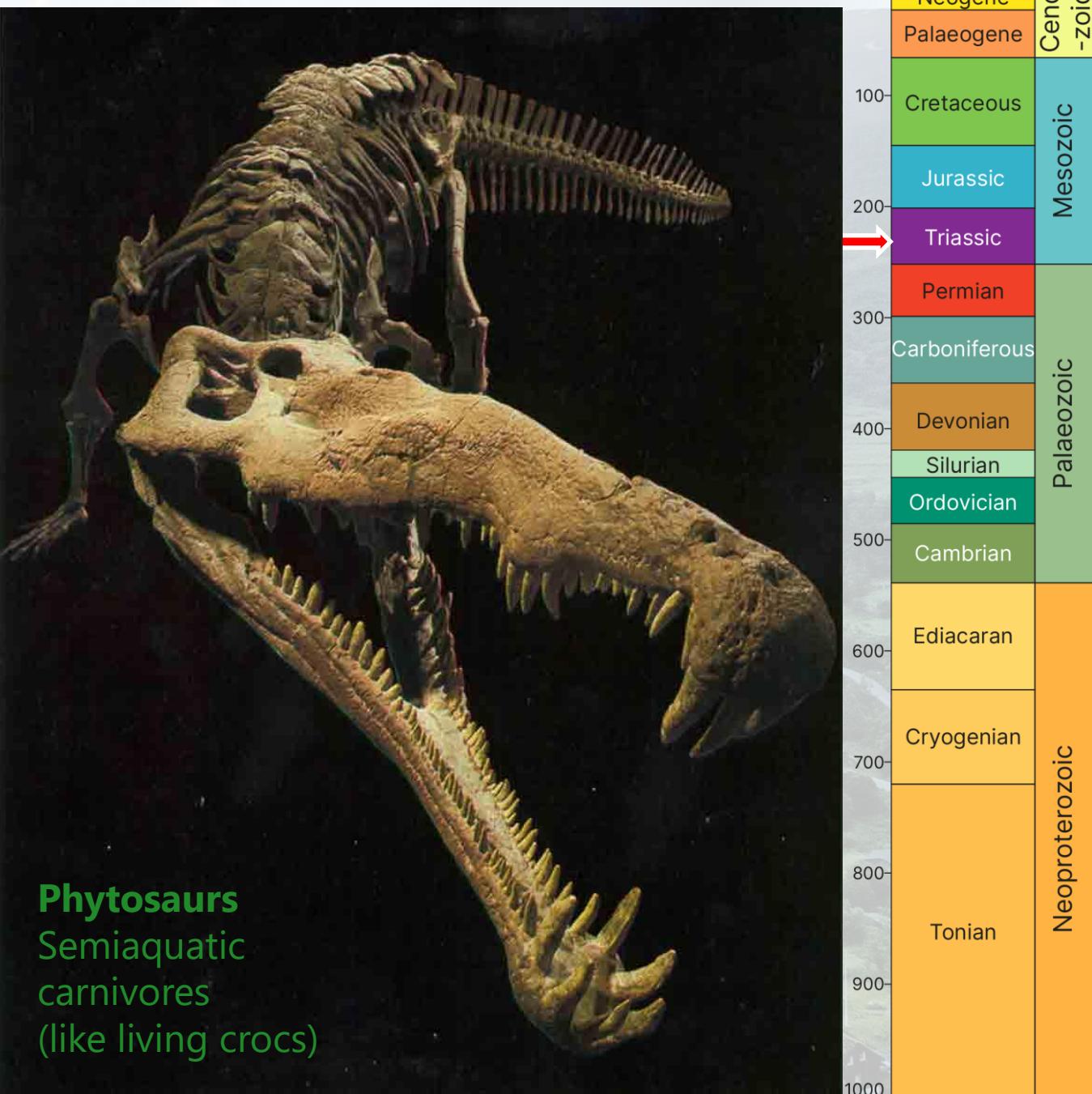
# Diapsids

## Crurotarsans

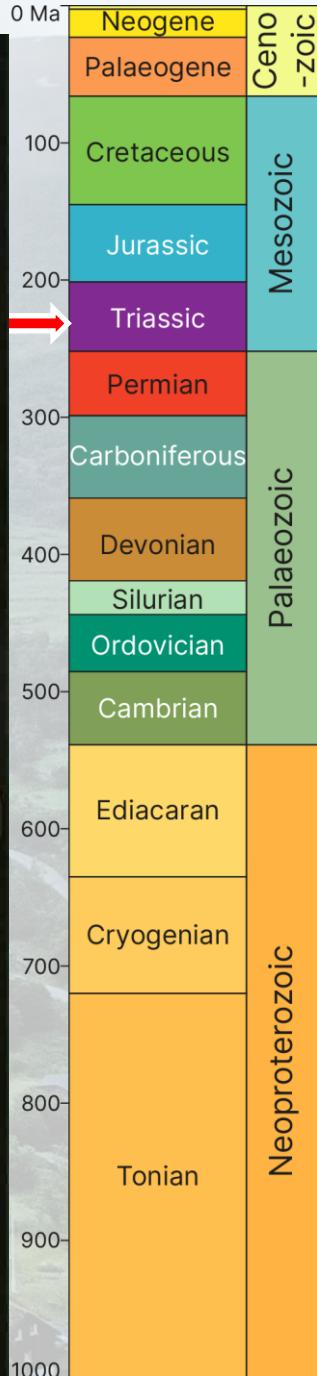


### Rauisuchians

quadrupedal predators  
(top carnivores in  
Triassic)

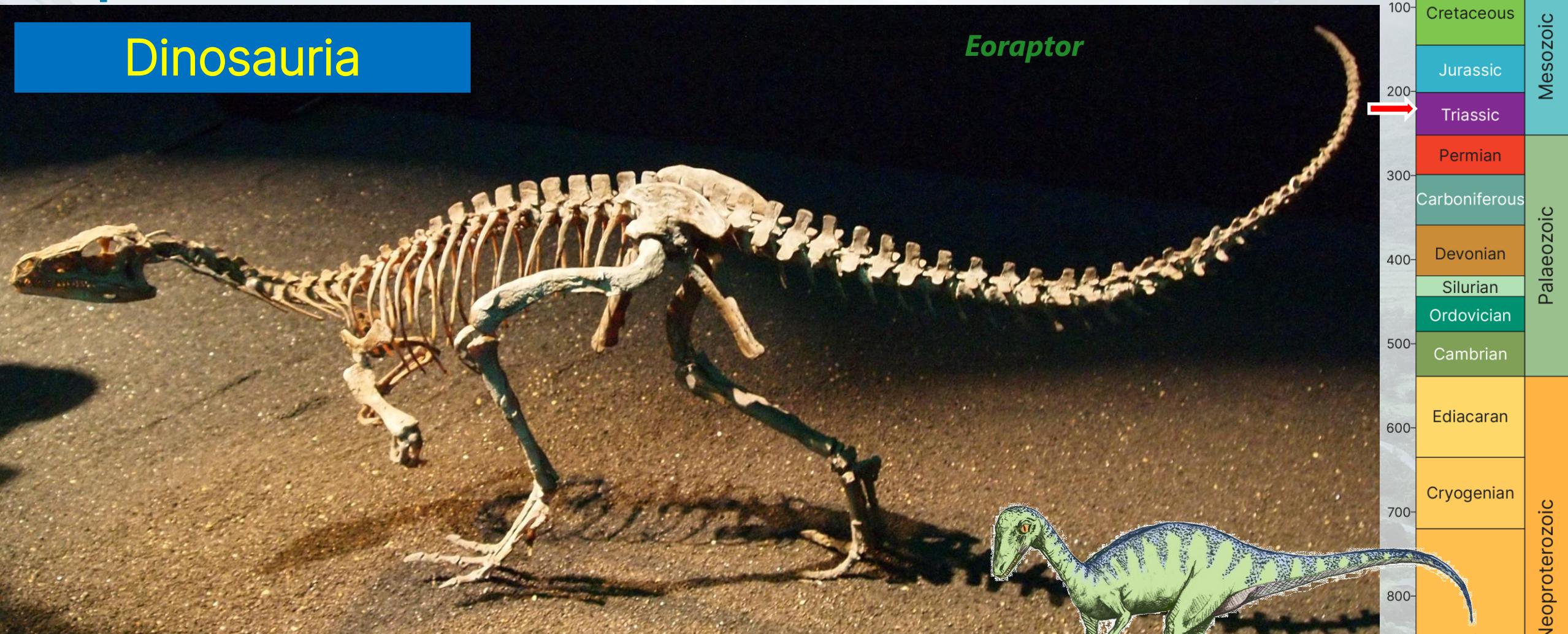


**Phytosaurs**  
Semiaquatic  
carnivores  
(like living crocs)



# Diapsids

Dinosauria



*Eoraptor*

0 Ma  
Neogene  
Palaeogene

Ceno-  
zoic

100  
Cretaceous

Mesozoic

200  
Jurassic

300  
Triassic

400  
Permian

500  
Carboniferous

600  
Devonian

700  
Silurian

800  
Ordovician

900  
Cambrian

1000  
Ediacaran

1100  
Cryogenian

1200  
Tonian

# Diapsids

## Dinosauria

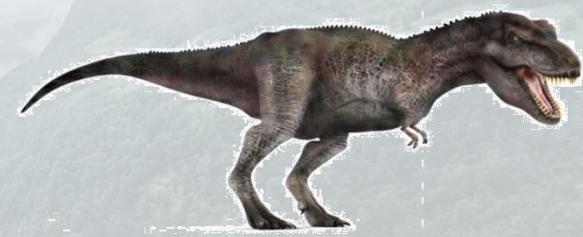
Ornithischians



Sauropodomorphs

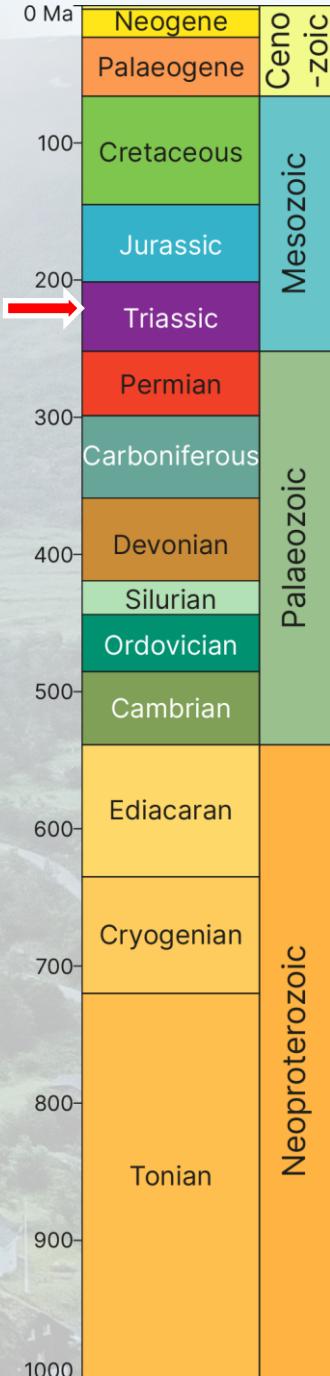


Theropods



Saurischia

Dinosauria

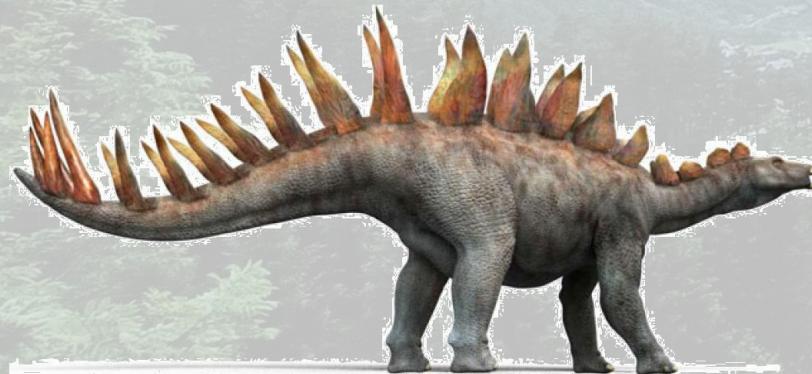


# Dinosauria

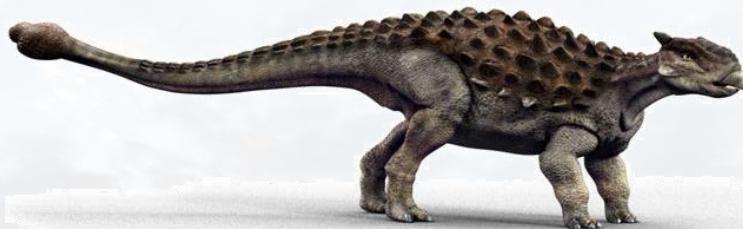
## Ornithischia



**Ceratopsians—horned dinosaurs**



**Stegosaurs—plated dinosaurs**



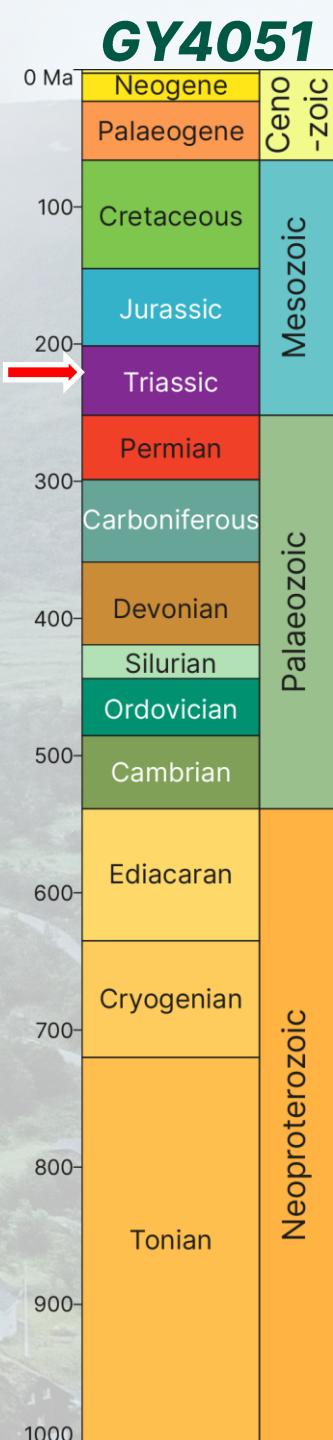
**Ankylosaurs—armoured dinosaurs**

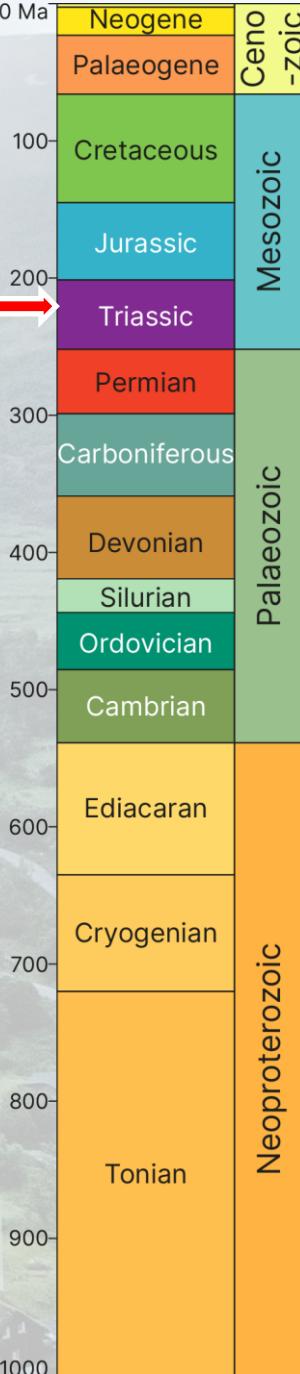


**Hadrosaurs—duck-billed dinosaurs**



**Pachycephalosaurs—dome-headed dinosaurs**



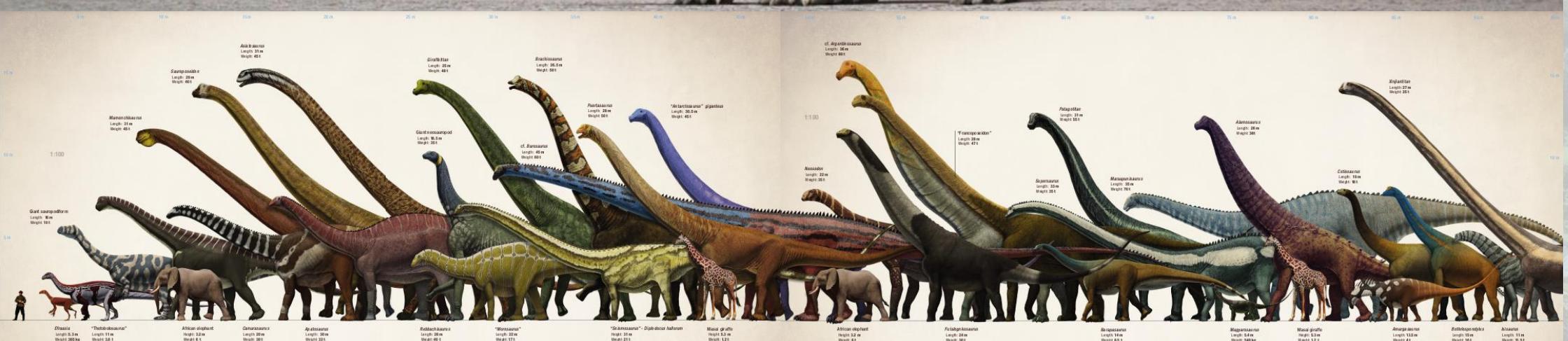


# Saurischian Dinosauria

## Sauropoda

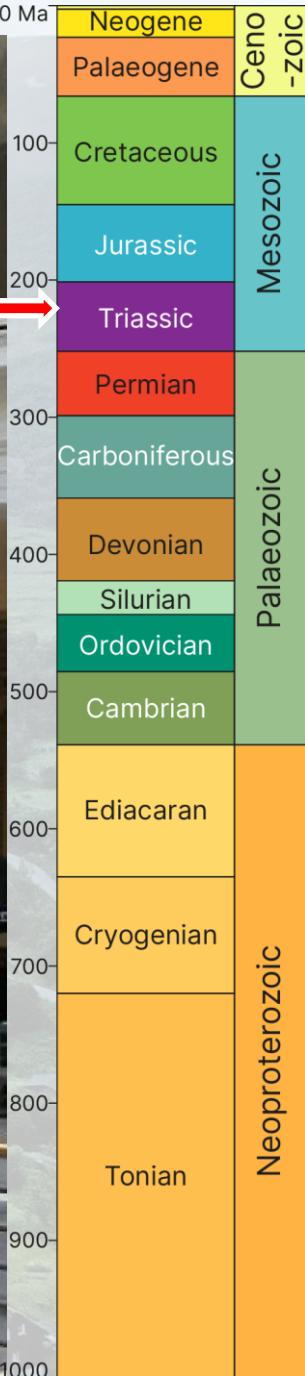


- Largest terrestrial animals ever – up to ~40m, 80t
- Small head, long neck, long tail, quadrupedal limbs



# Saurischian Dinosauria

## Theropoda



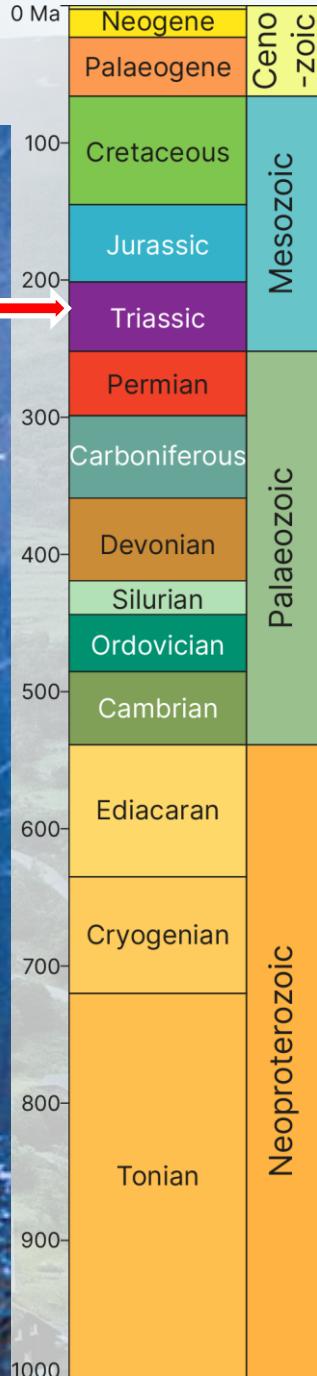
- Ruled the Earth Late Triassic to end Cretaceous

# Saurischian Dinosauria

## Theropoda

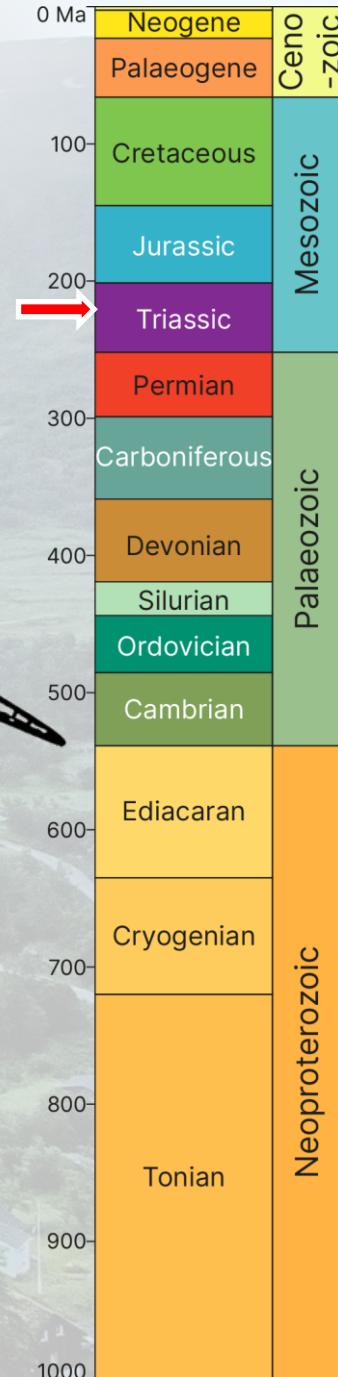
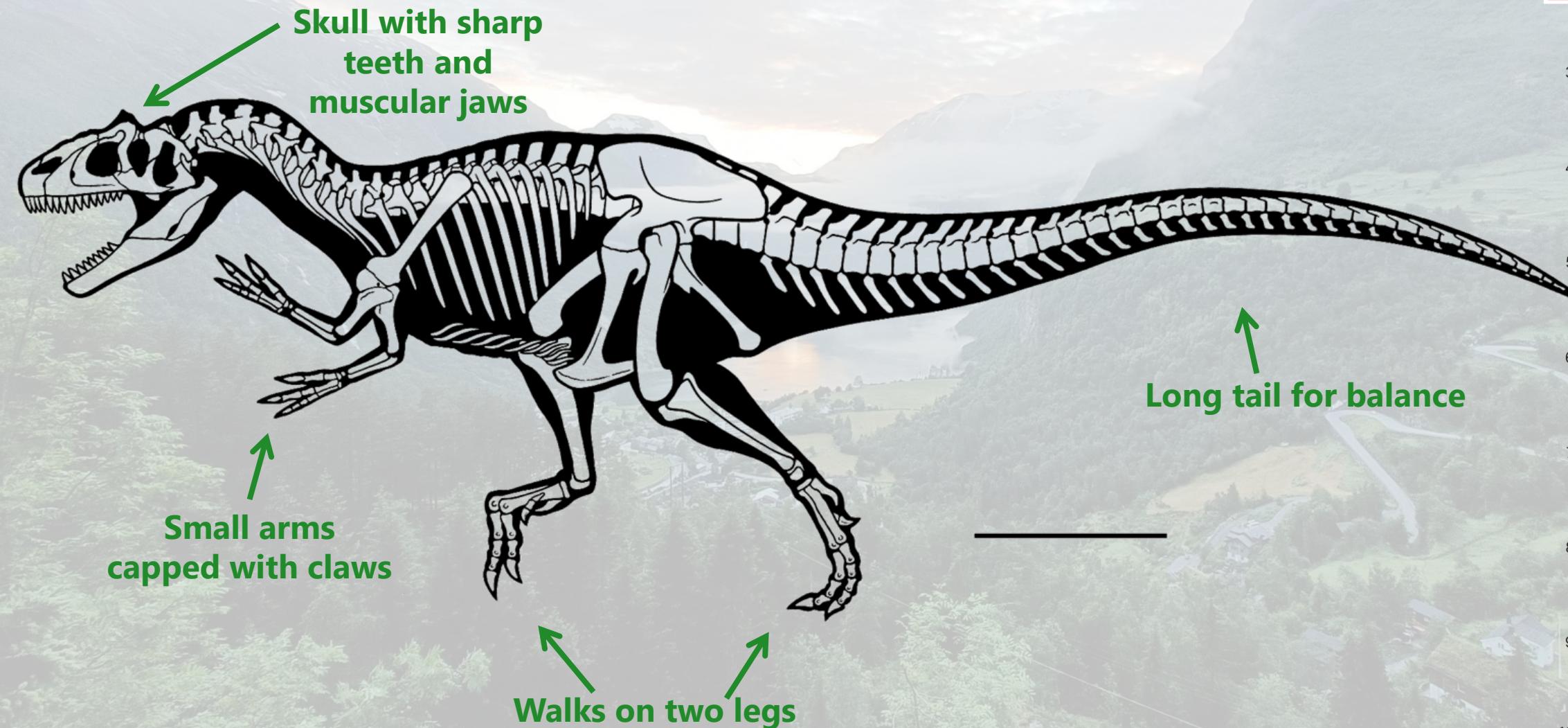


- *Tyrannosaurus rex* reached up to 13m long
- Ruled the Earth Late Triassic to end Cretaceous



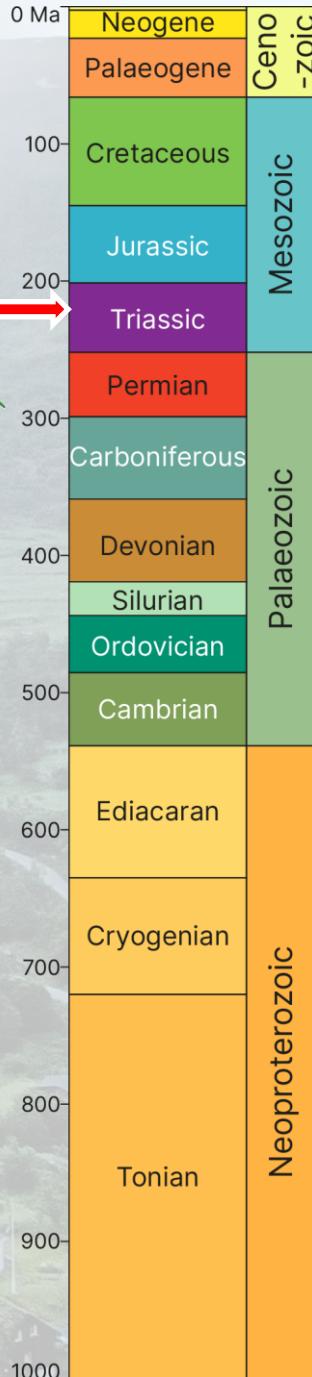
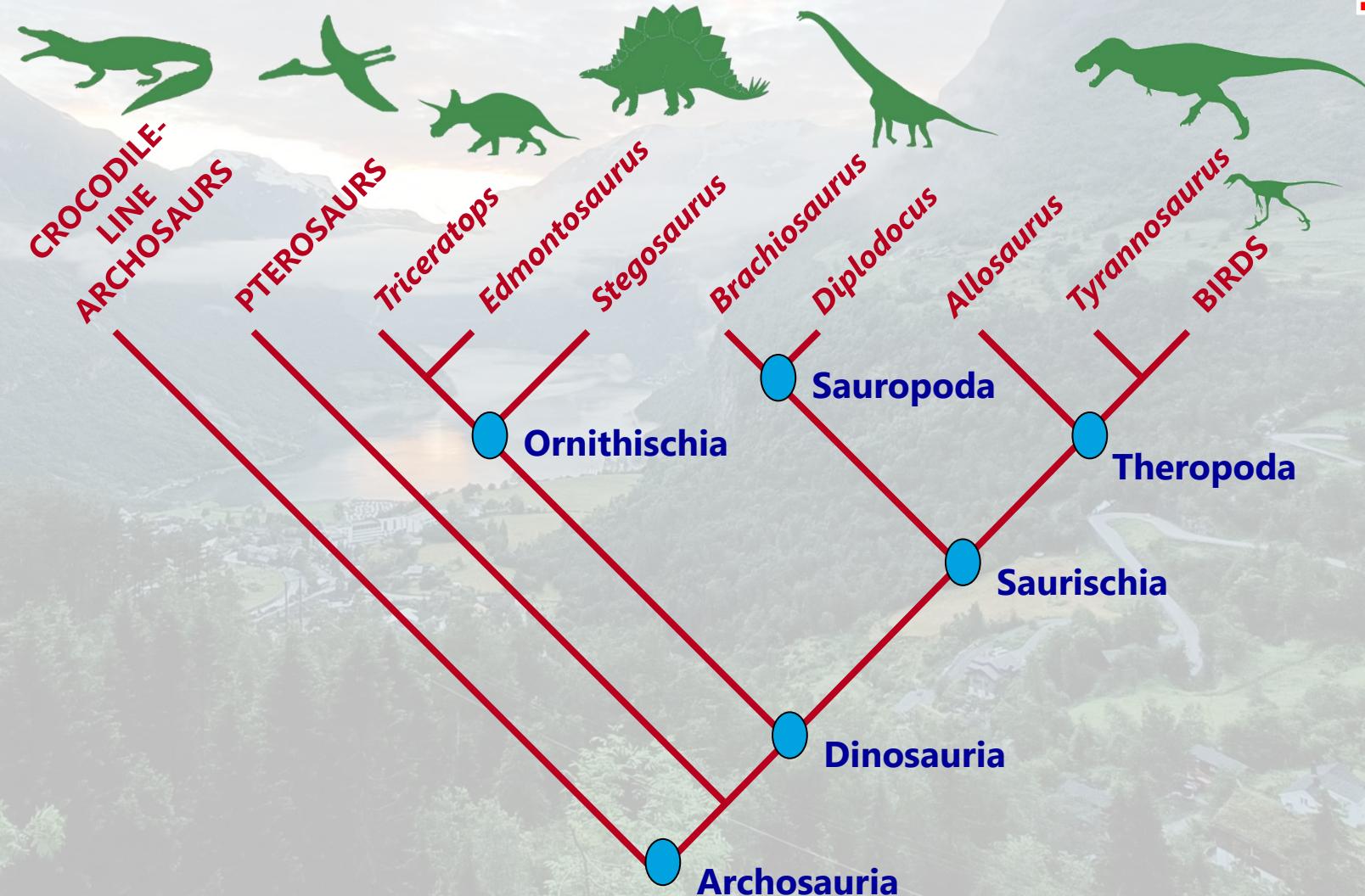
# Saurischian Dinosauria

## Theropoda



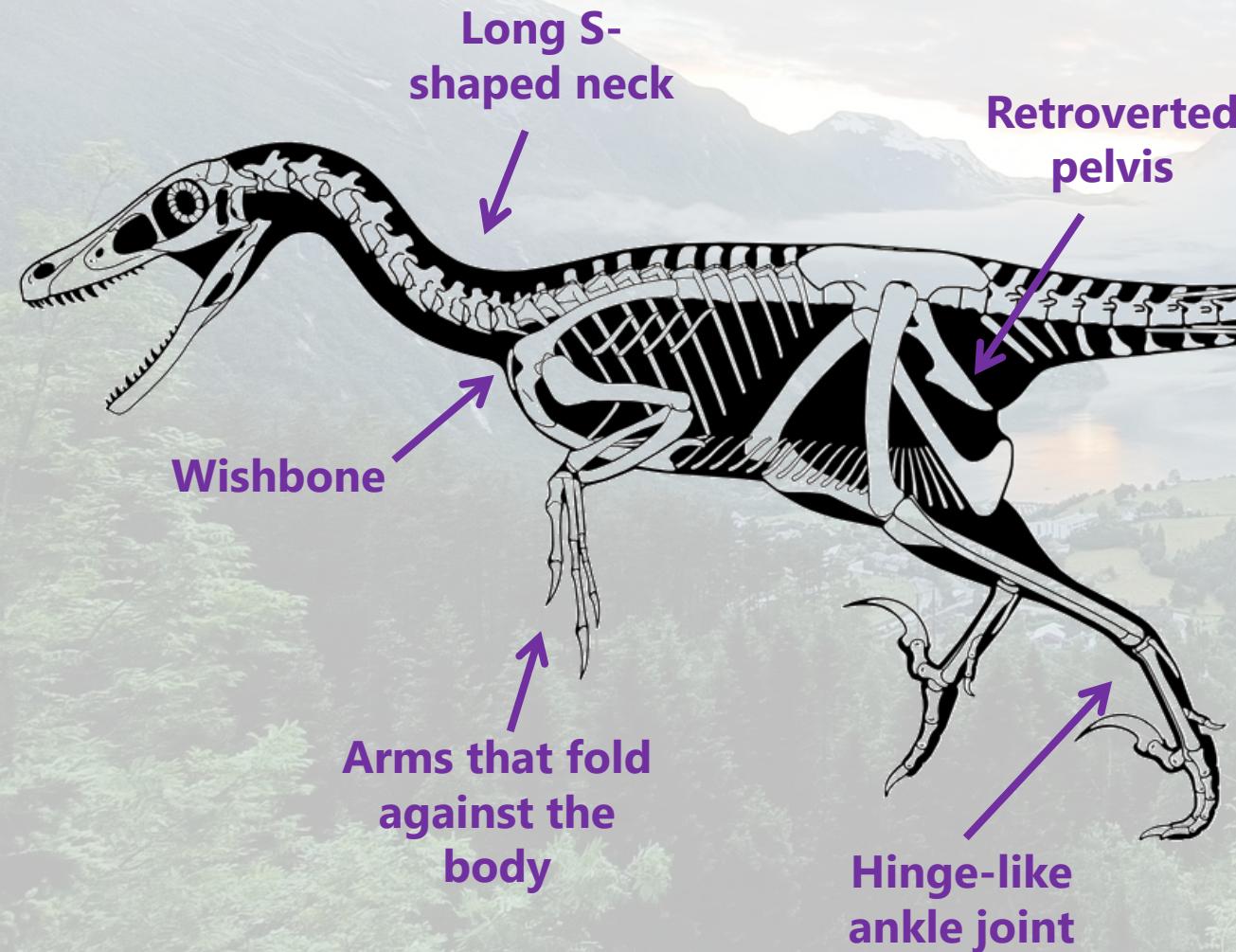
# Saurischian Dinosauria

## Theropoda



# Saurischian Dinosauria

## Theropoda



## *Velociraptor*



# Saurischian Dinosauria

## Theropoda



① *Microraptor gui*

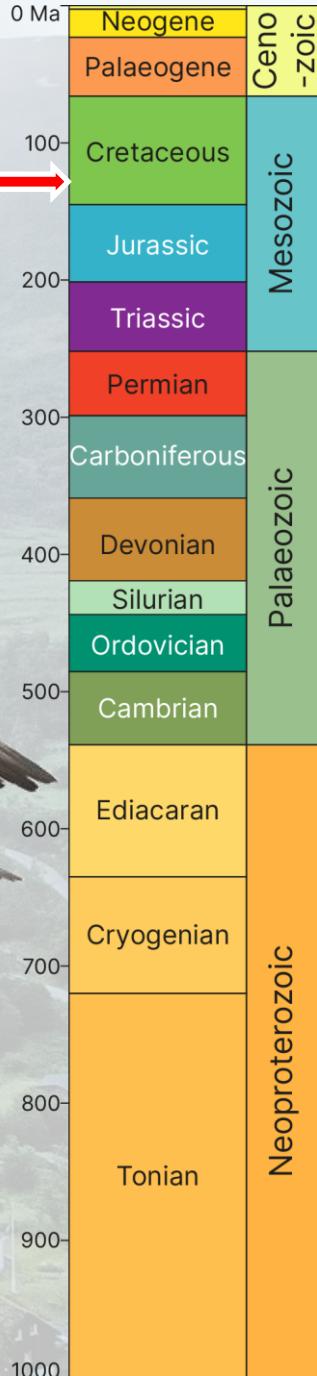
② *Velociraptor mongoliensis*

③ *Austroraptor cabazai*

④ *Dromaeosaurus albertensis*

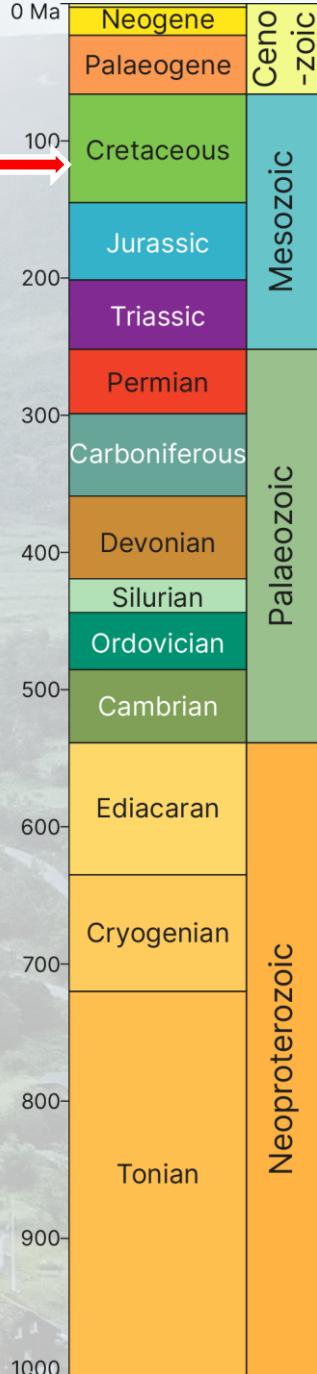
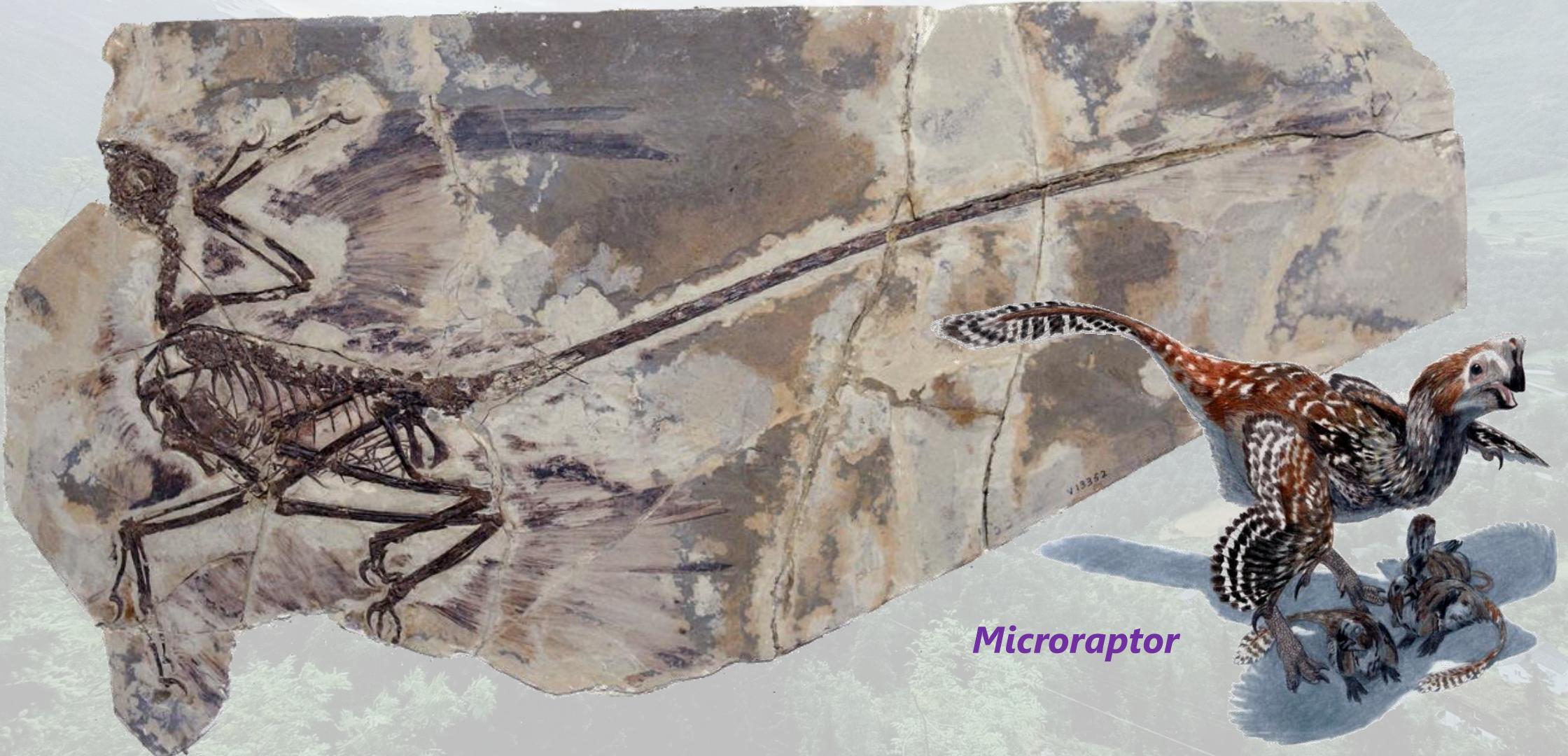
⑤ *Utahraptor ostrommaysorum*

⑥ *Deinonychus antirrhopus*



# Saurischian Dinosauria

## Theropoda

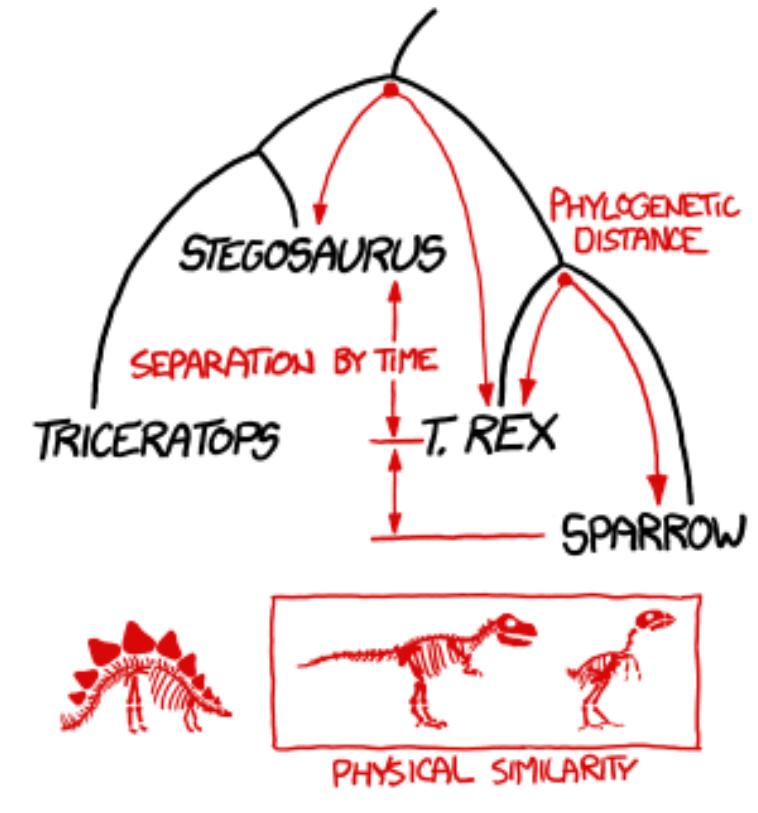


# Saurischian Dinosauria

## Theropoda



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



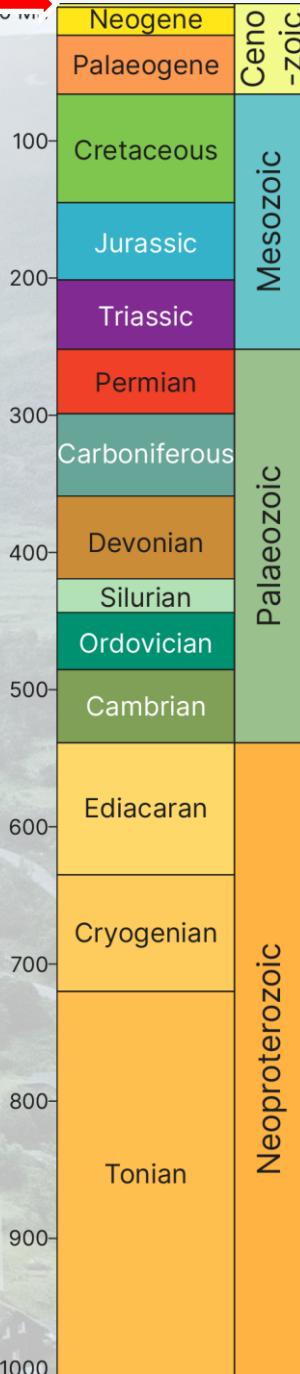
BIRDS AREN'T DESCENDED FROM DINOSAURS,  
THEY ARE DINOSAURS.

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.

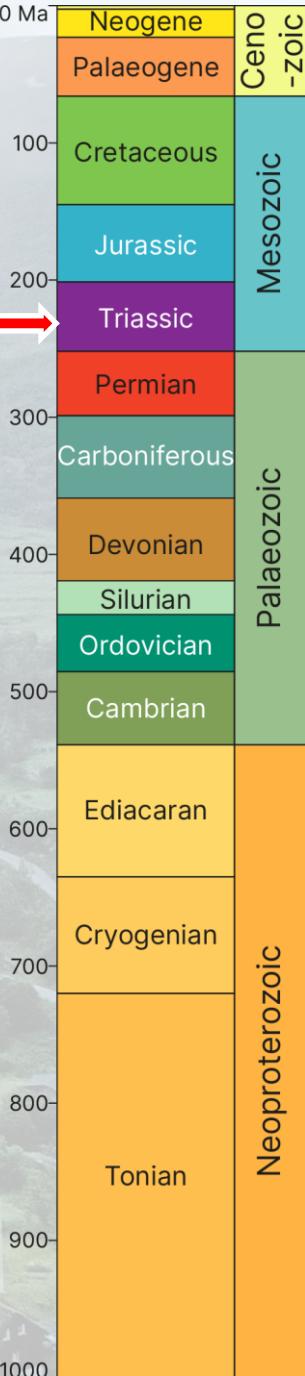
THIS IS A GOOD WORLD.





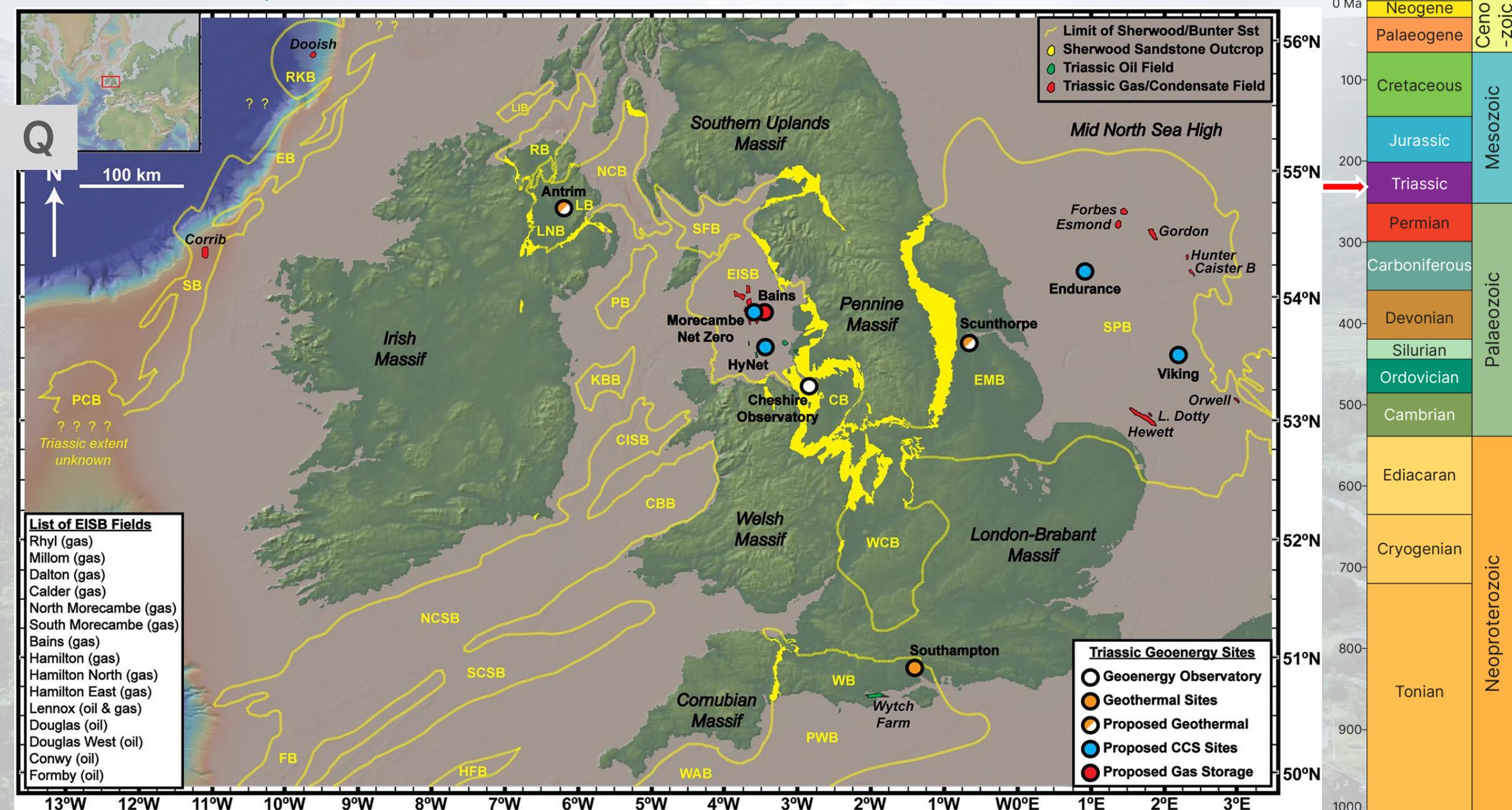
Desert sandstone | Merseyside, England

Q



**Tropical Ireland** | Permian and Triassic – New Red Sandstone

**GY4051**



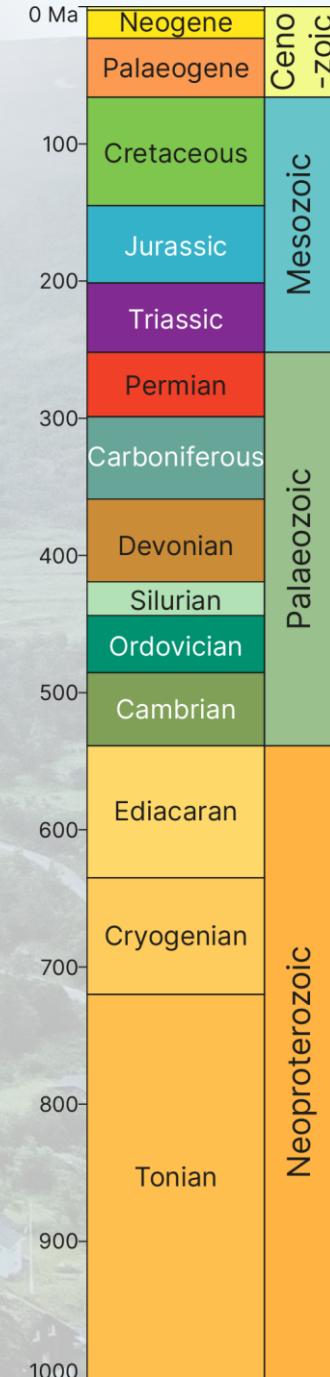
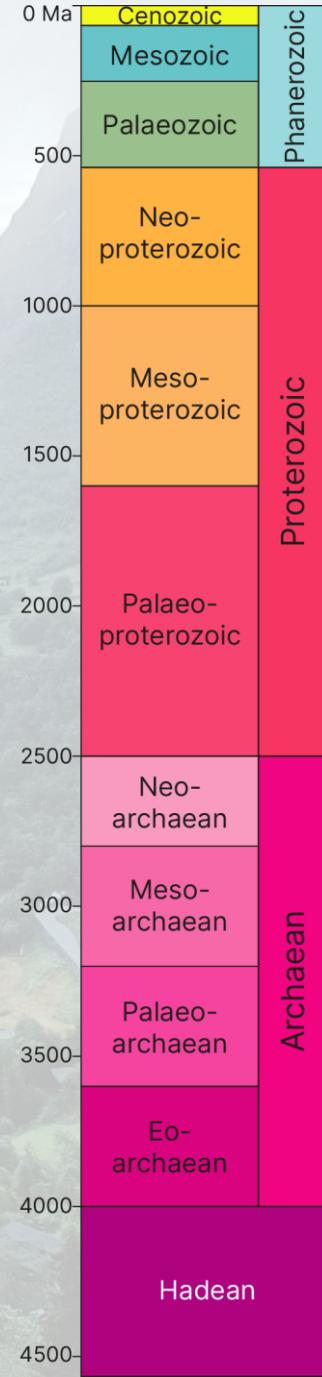
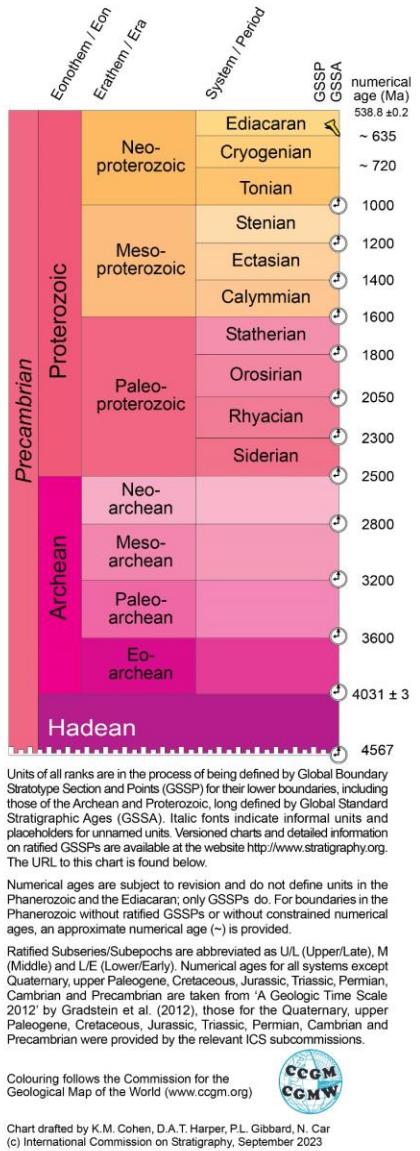
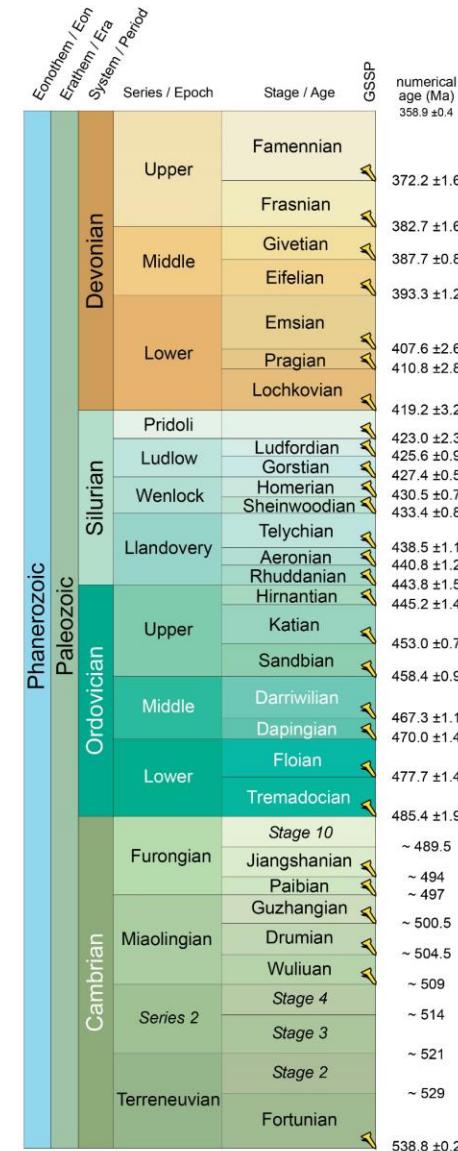
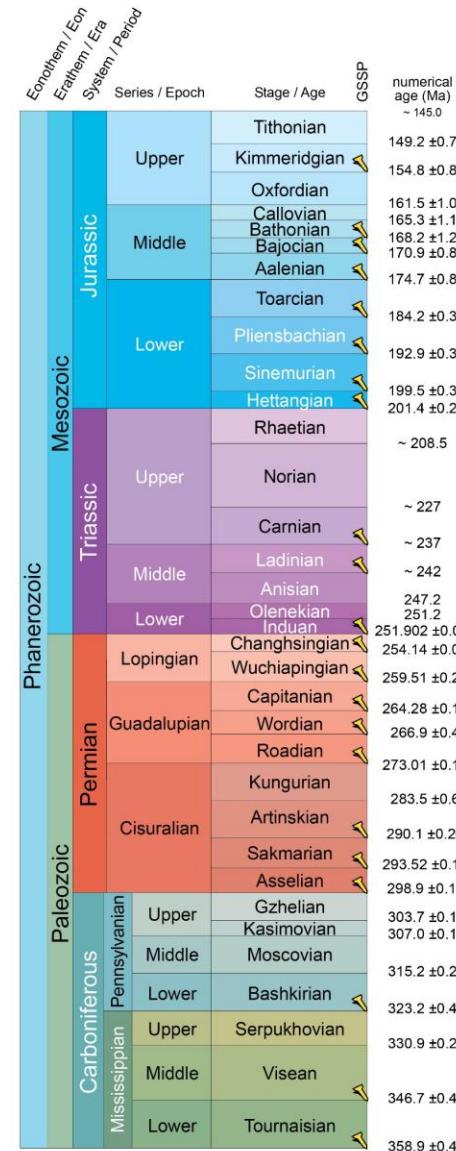
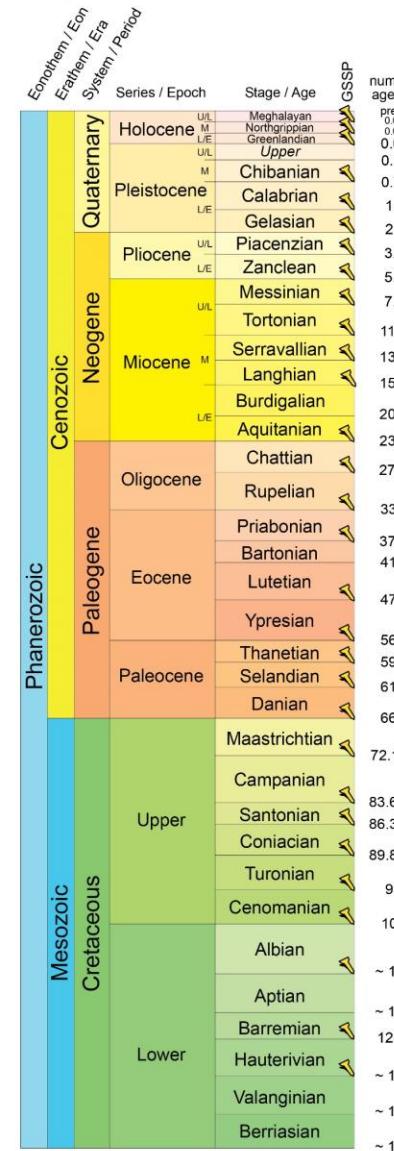


IUGS

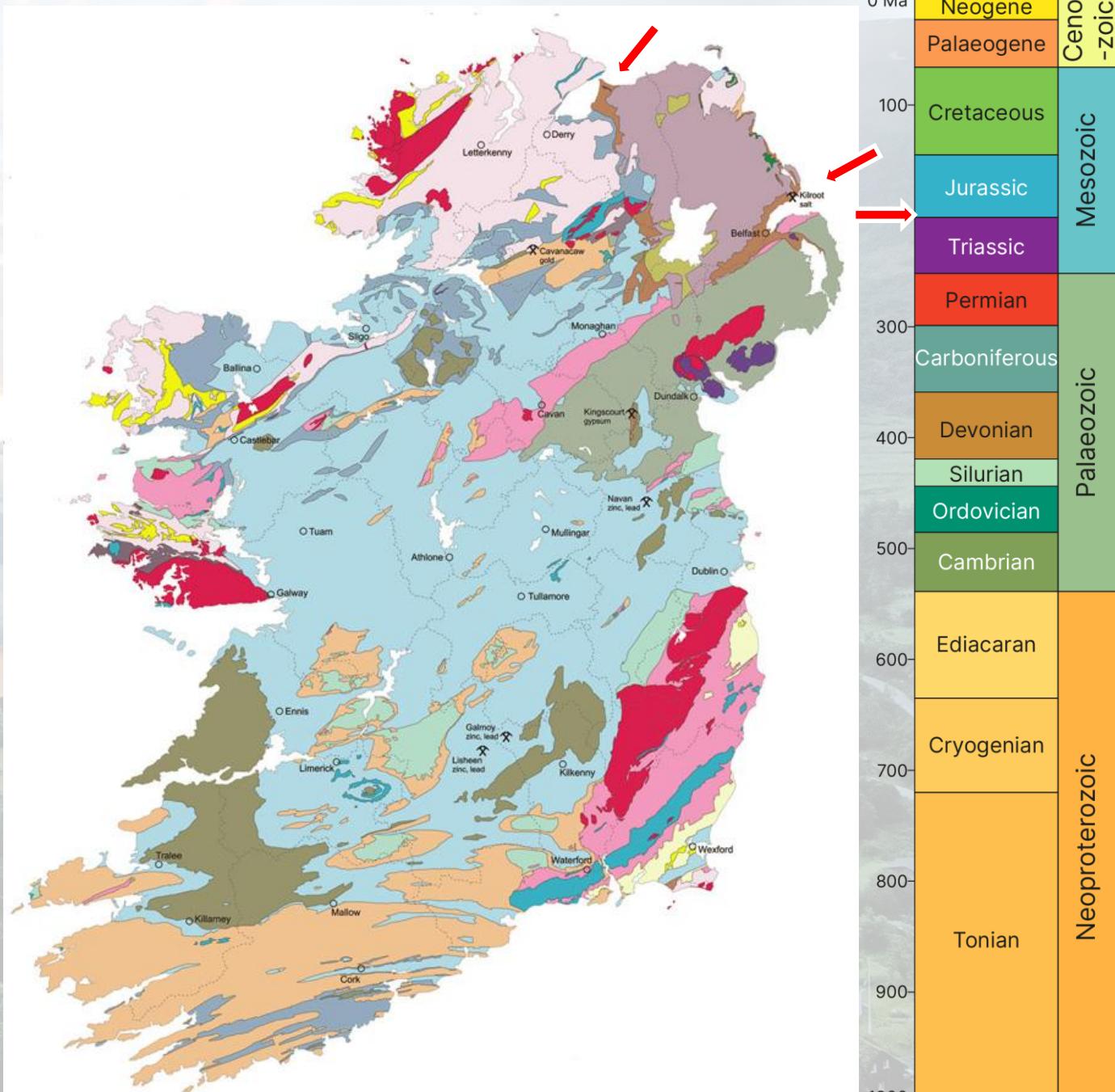
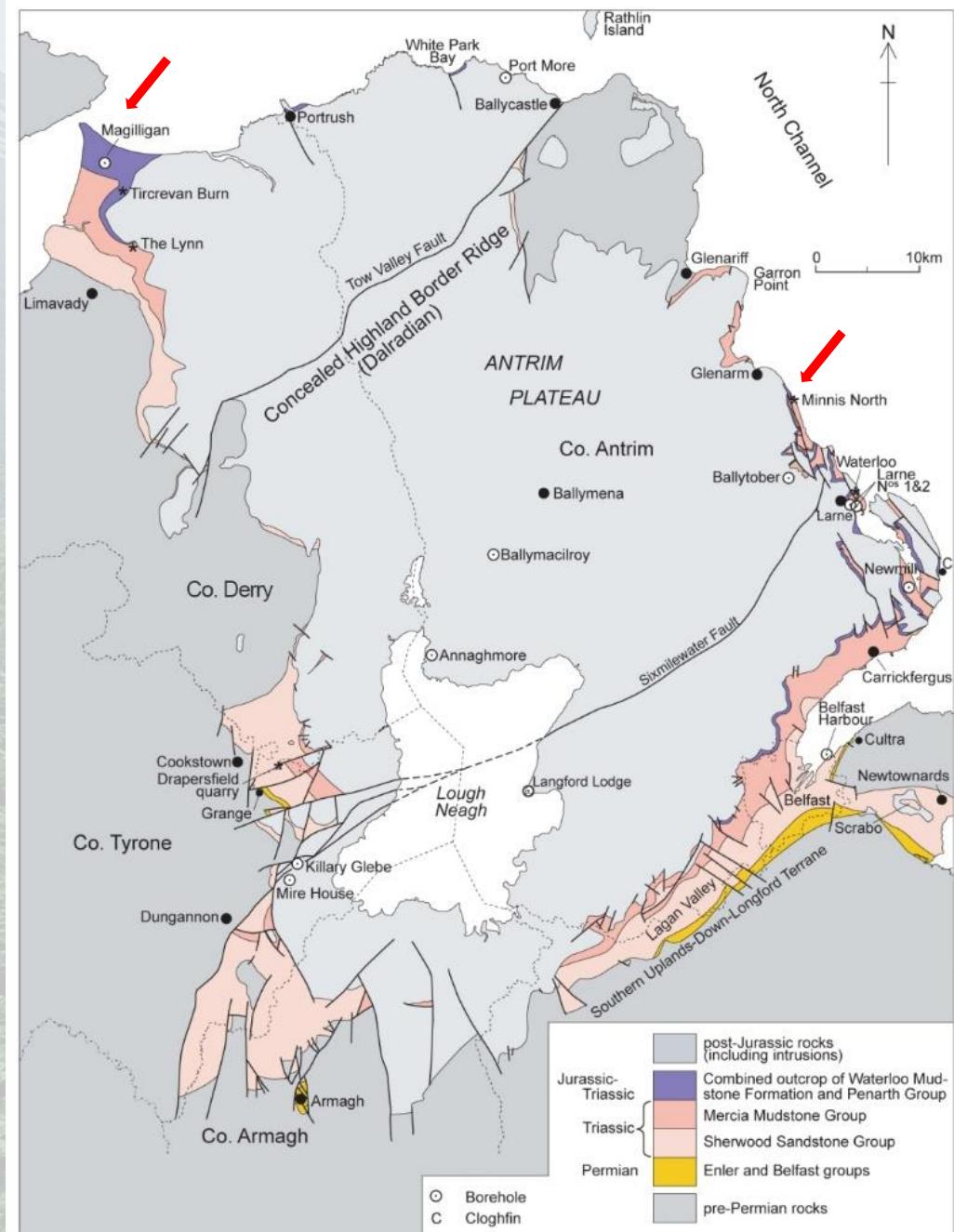
[www.stratigraphy.org](http://www.stratigraphy.org)

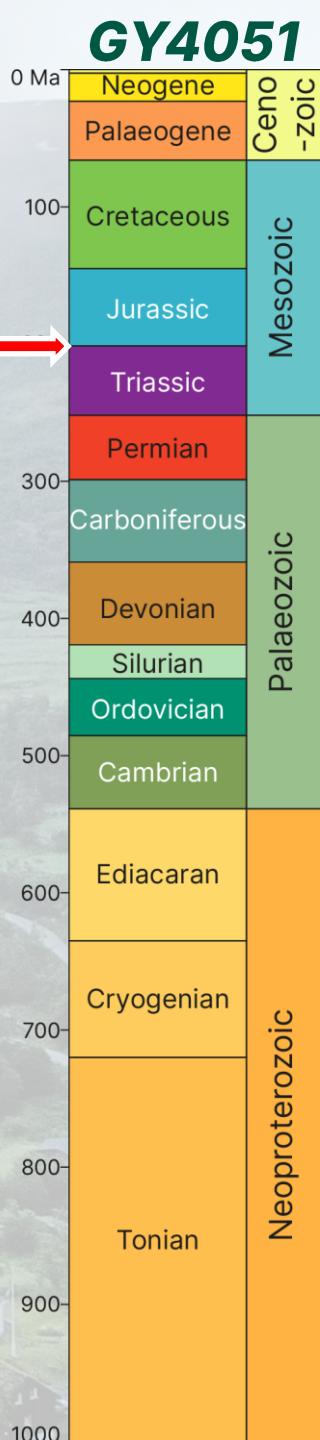
International Commission on Stratigraphy

v 2023/09

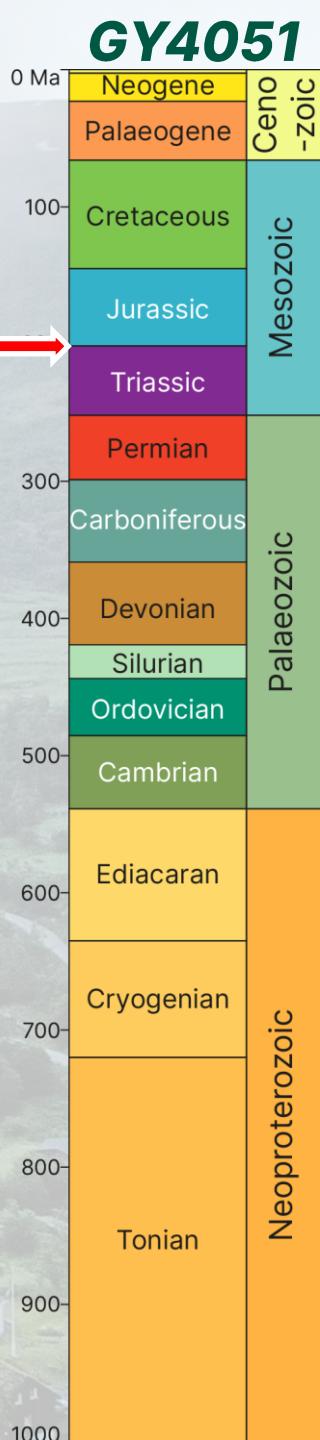


# **Recent Ireland** | Triassic and Jurassic

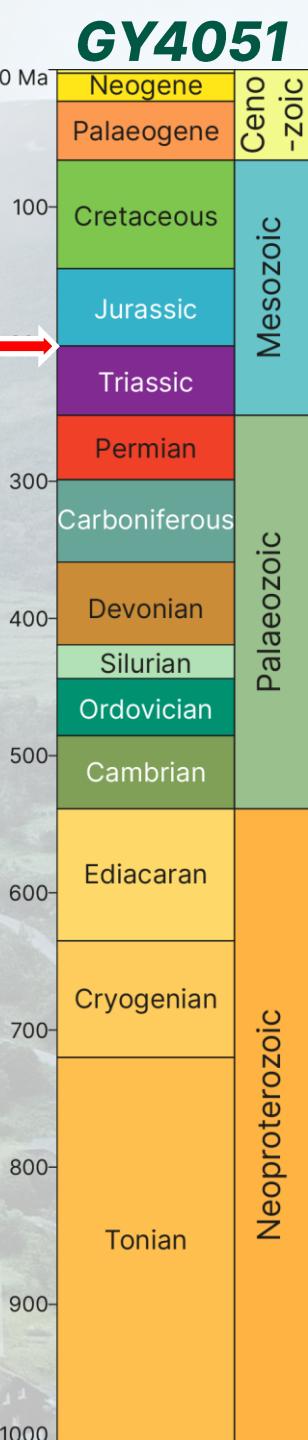
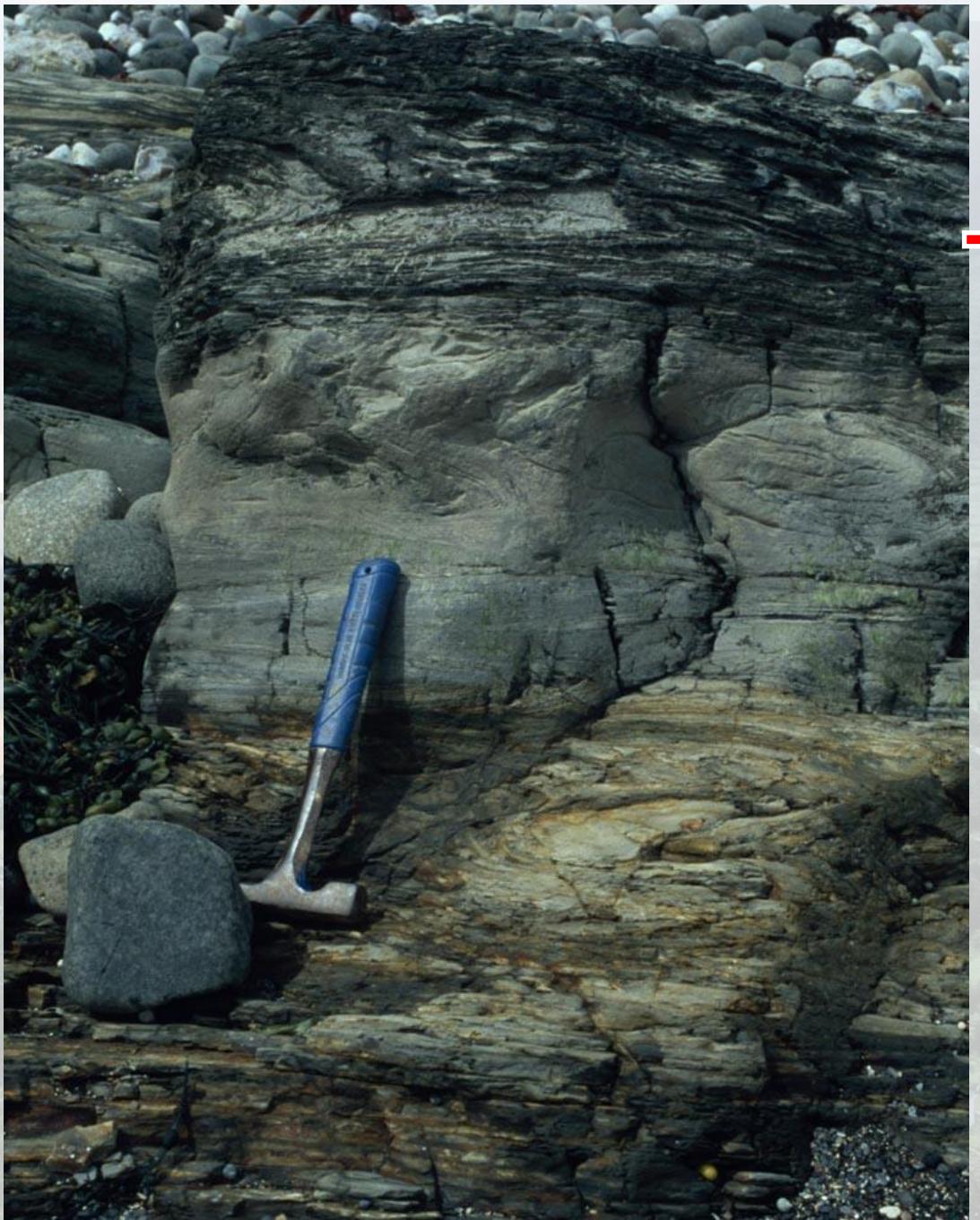




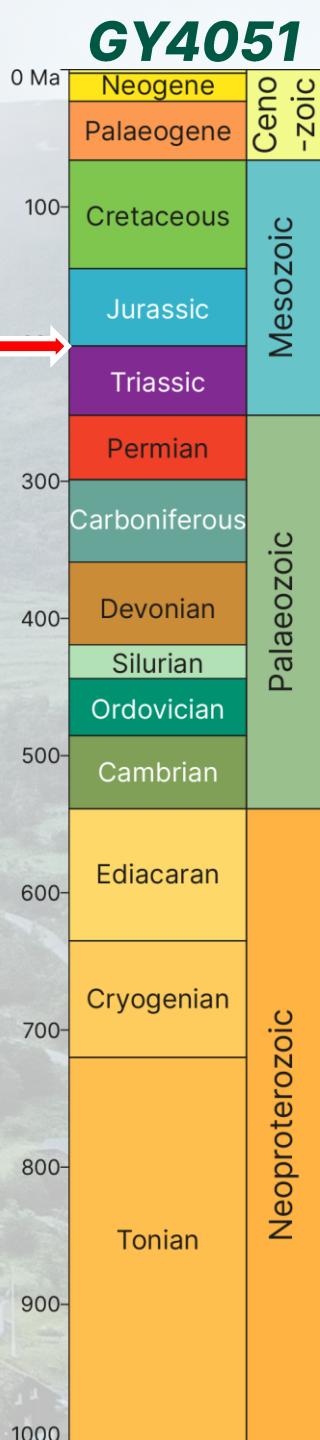
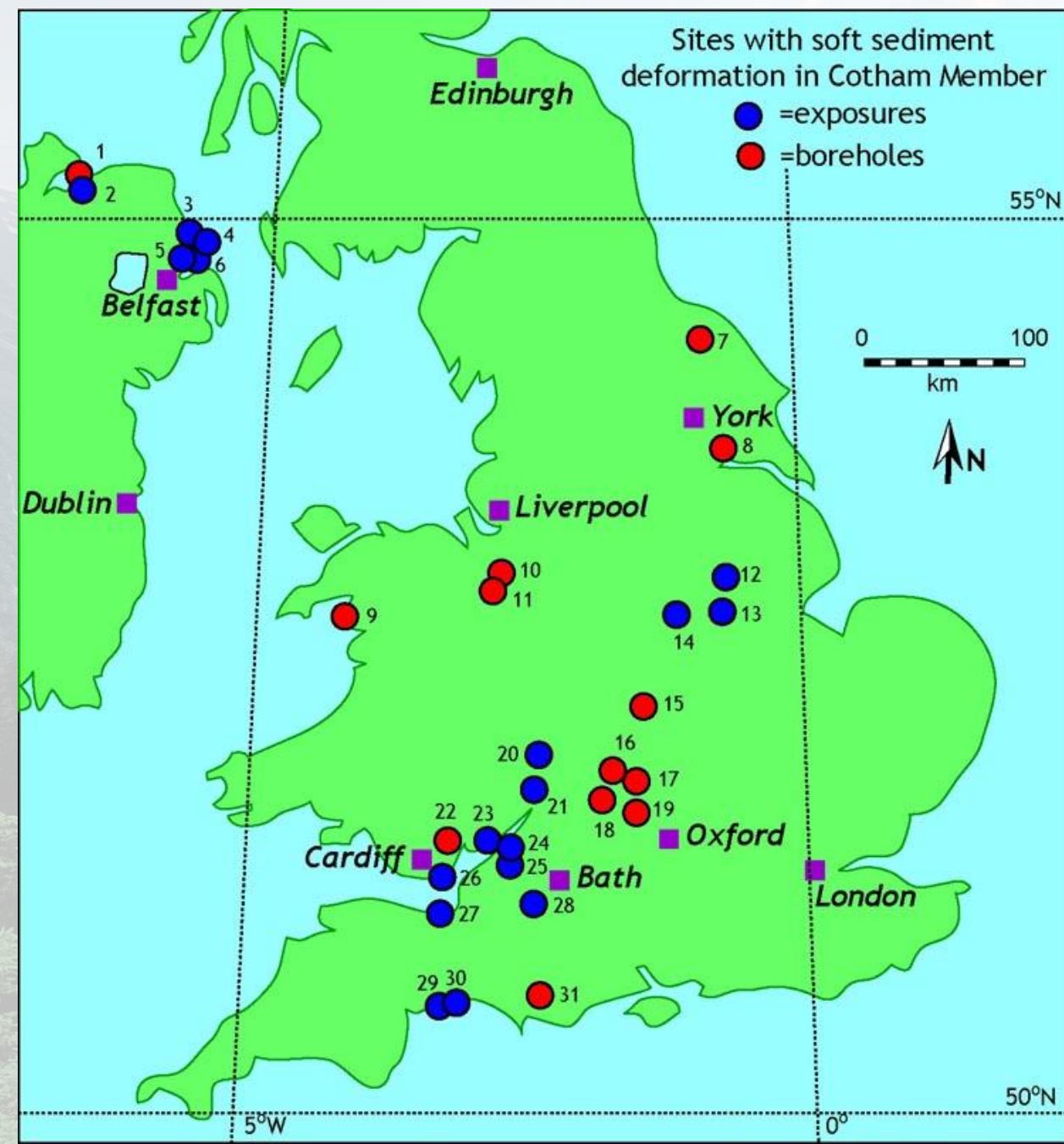
Marine again | Larne, Co. Antrim



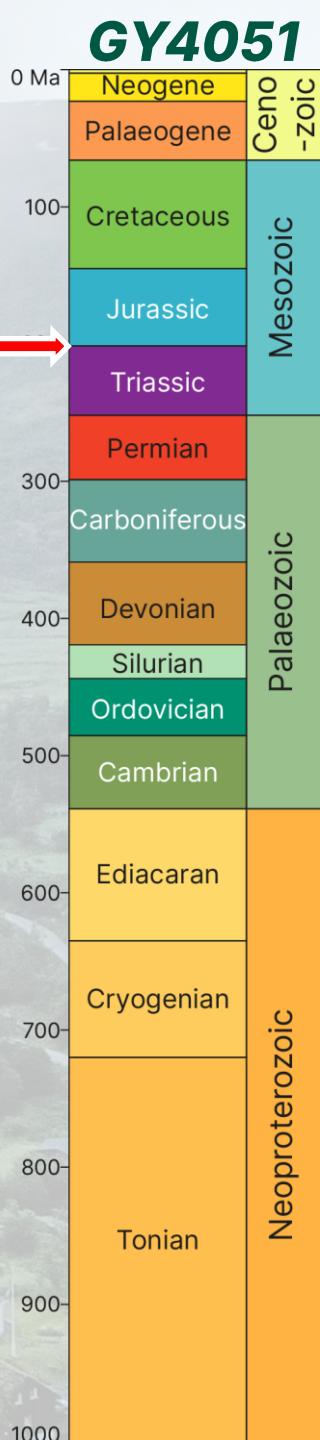
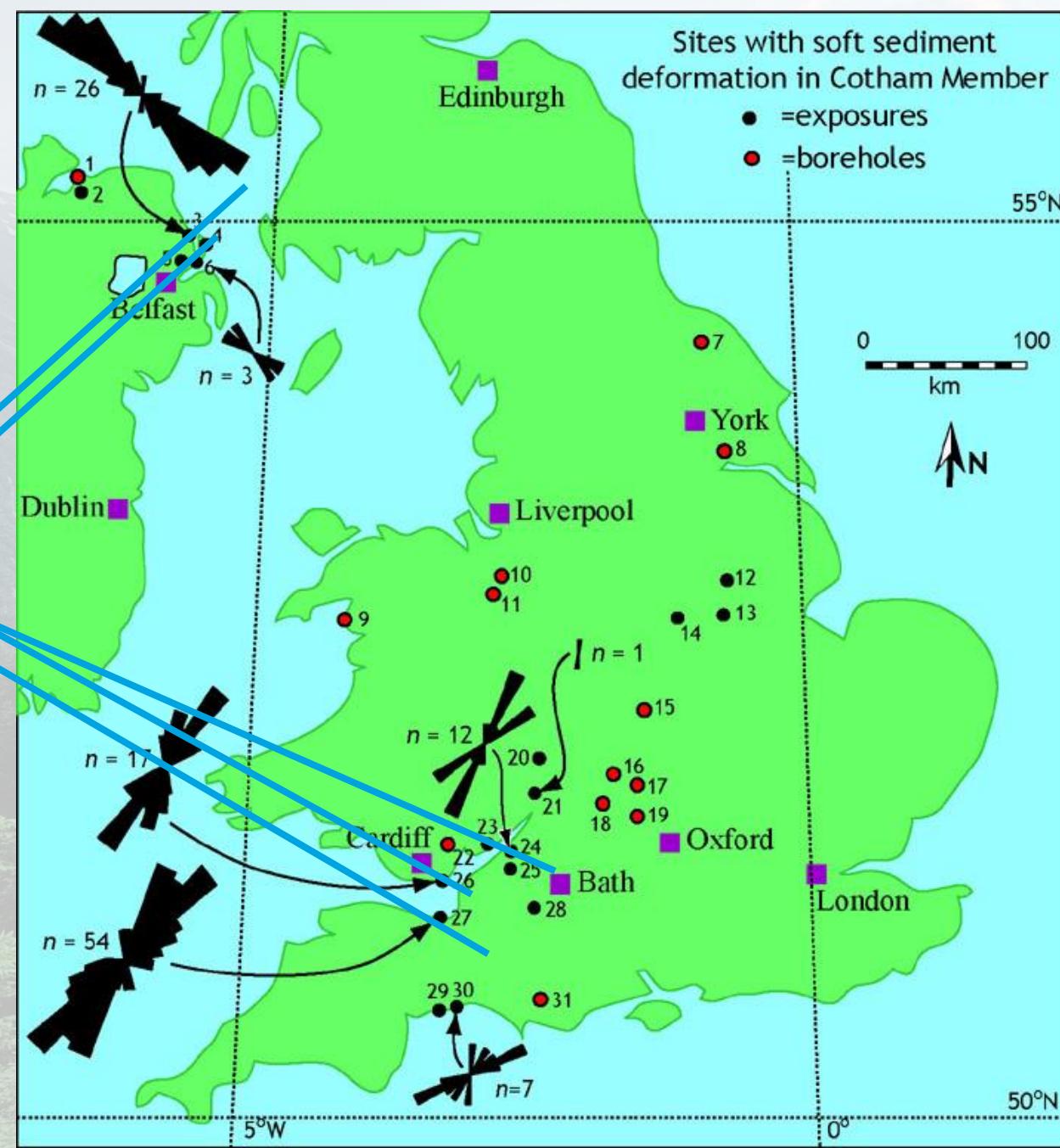
# Recent Ireland | Early Jurassic

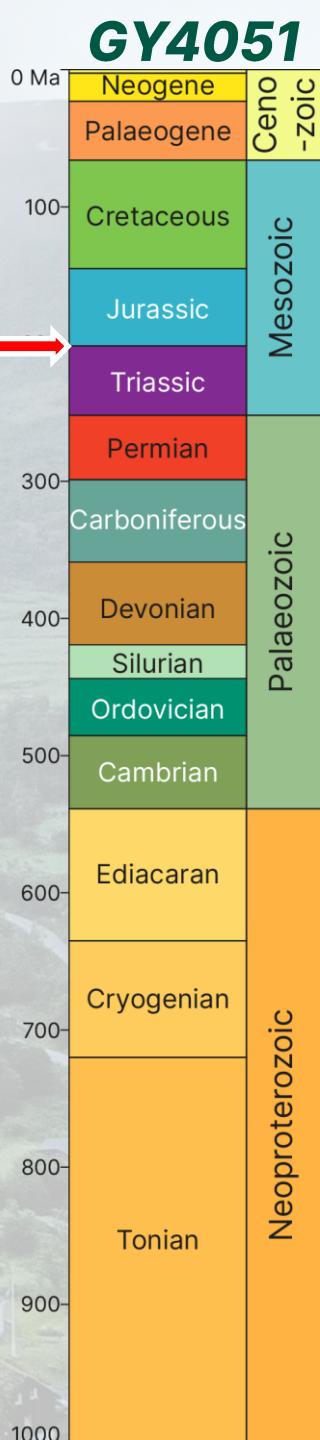


# Recent Ireland | Early Jurassic



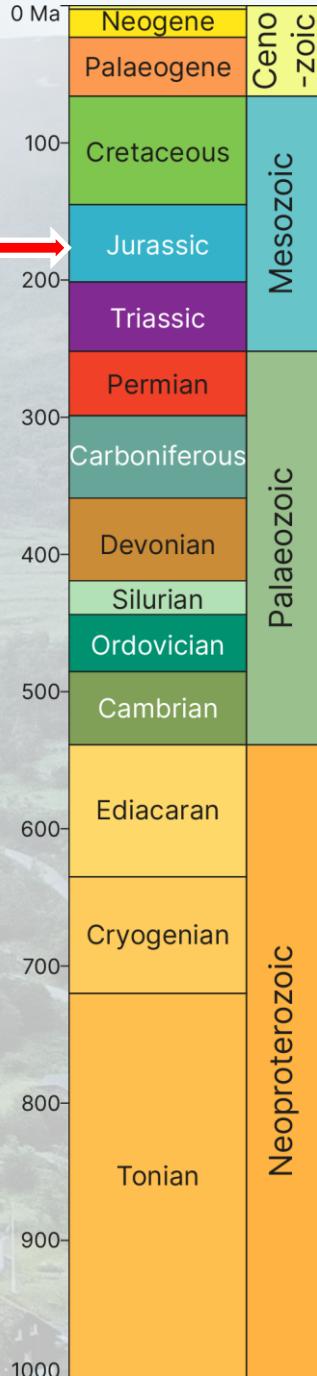
## **Recent Ireland** | Early Jurassic



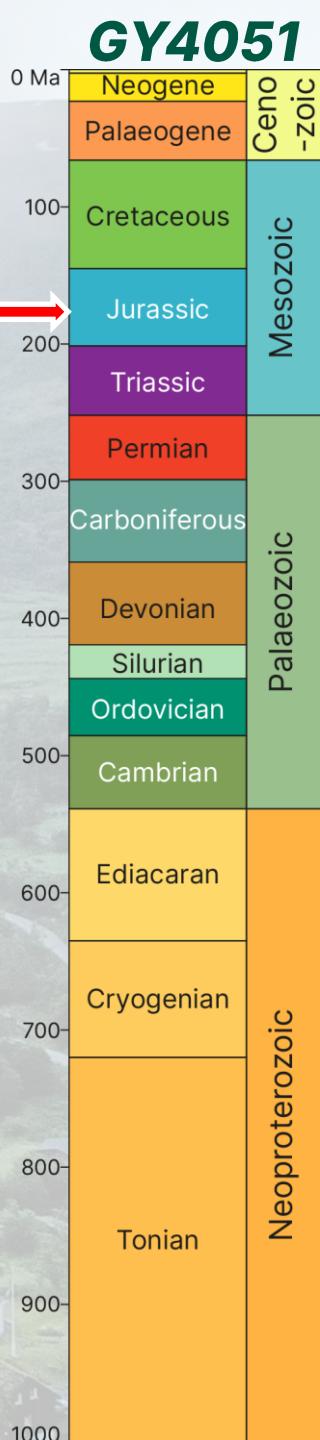
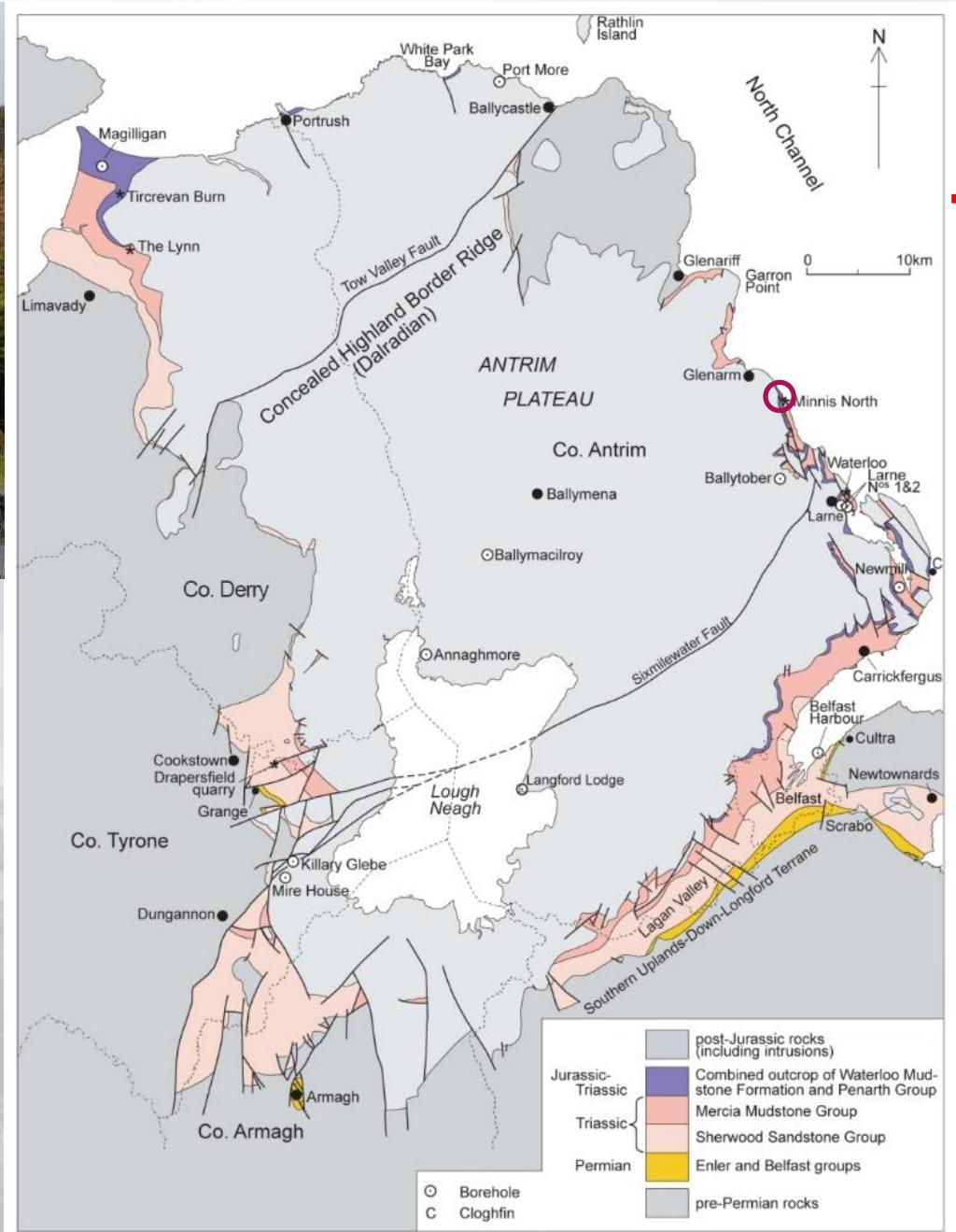


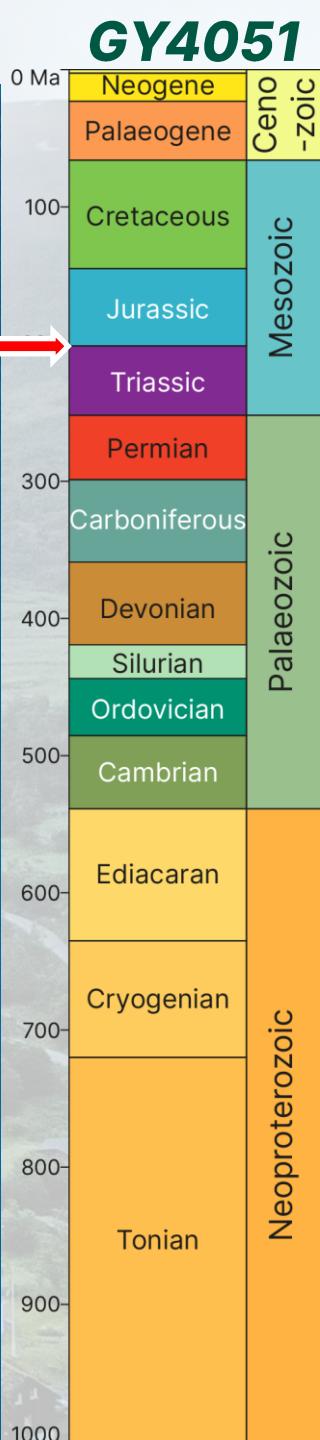
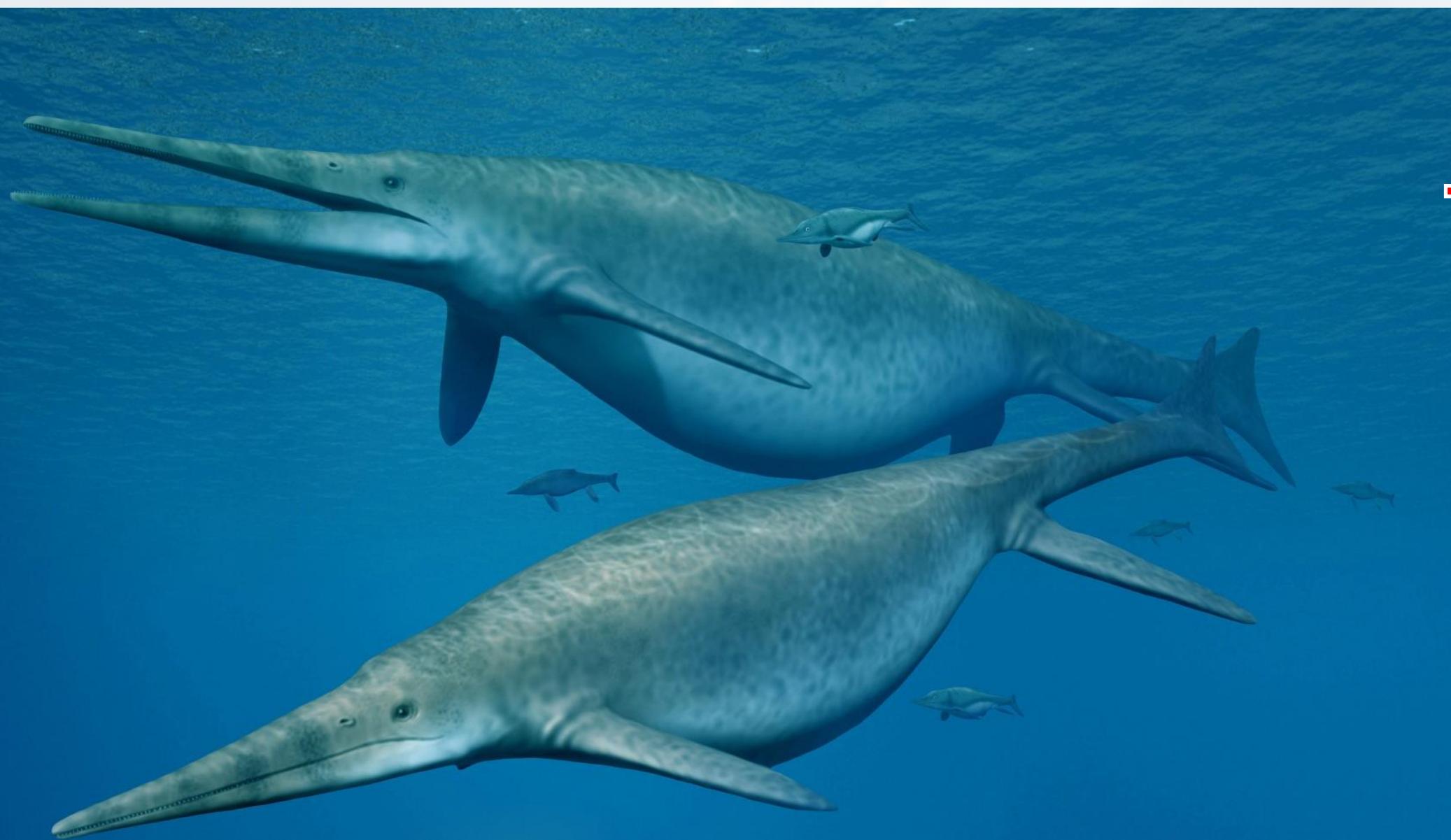
# Recent Ireland | Early Jurassic

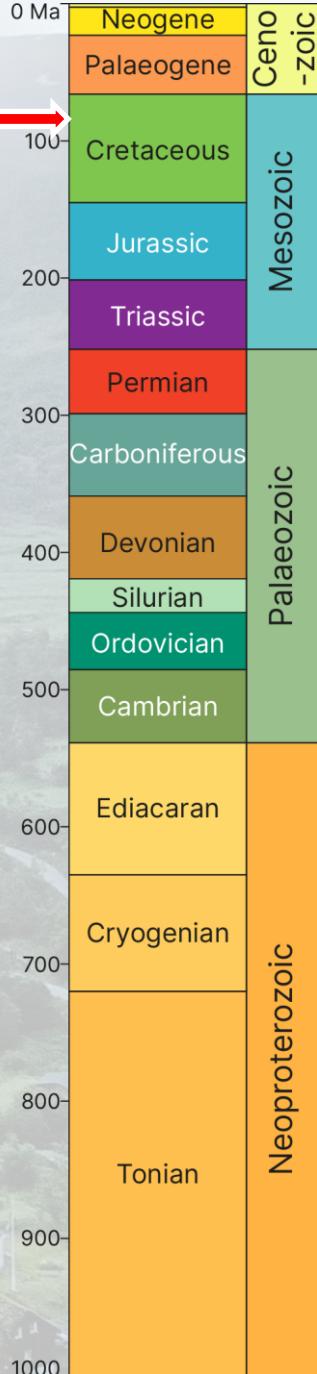




# Recent Ireland | Jurassic

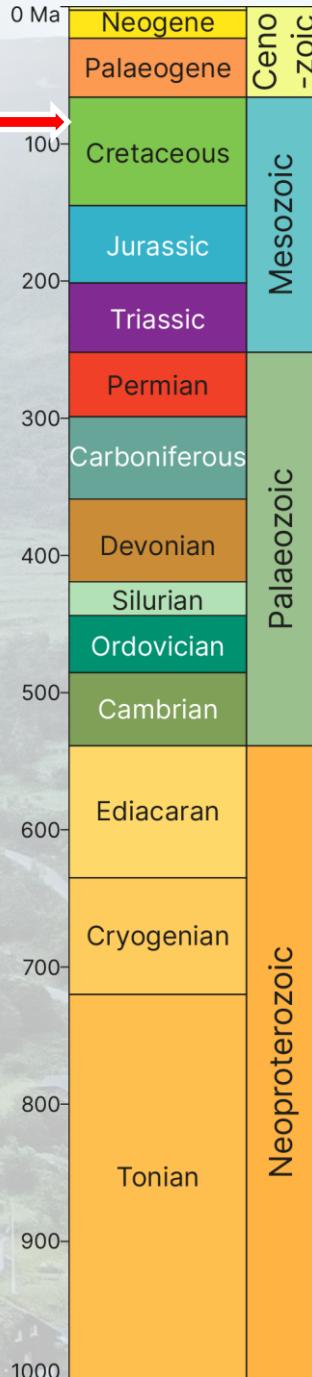
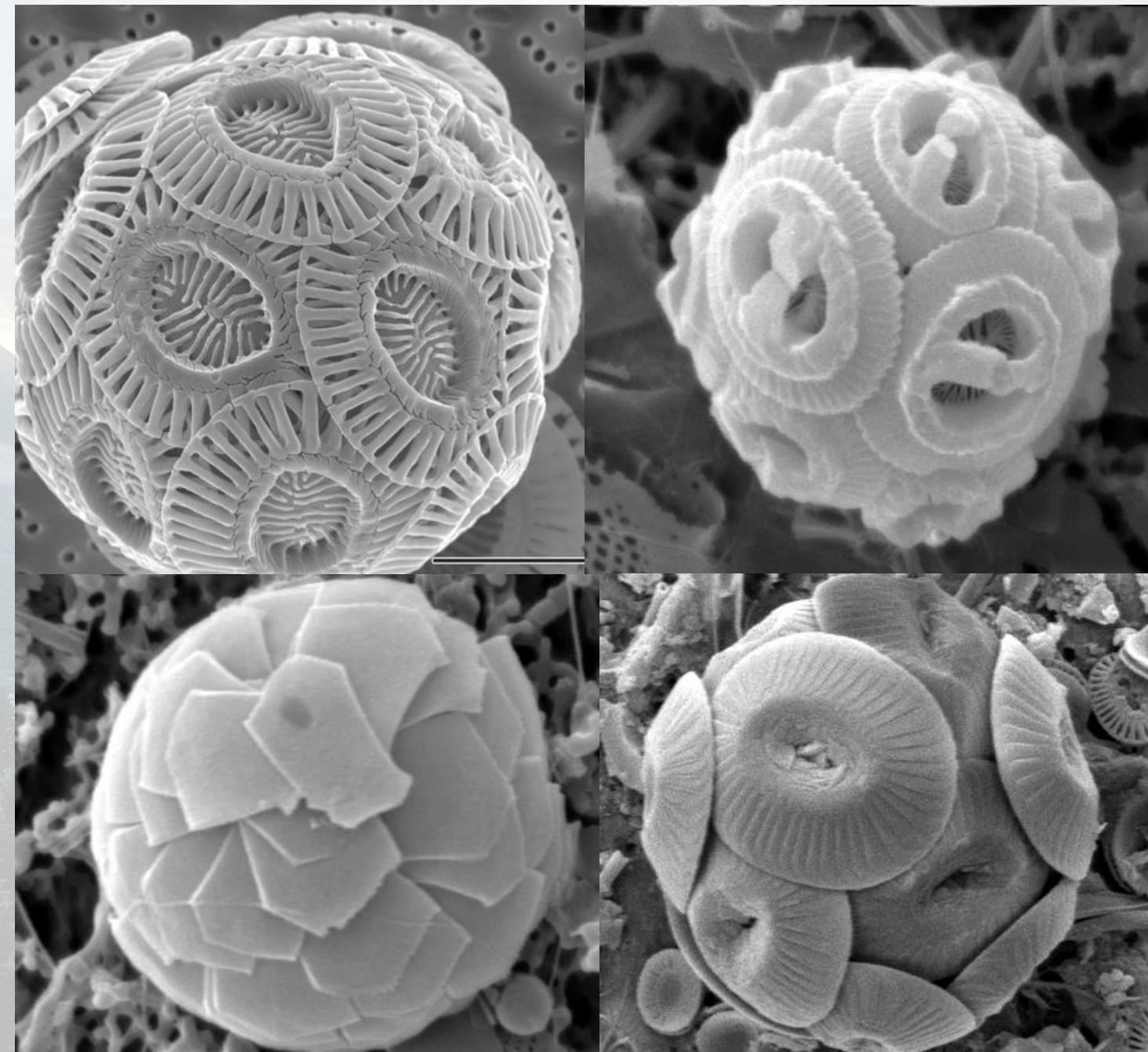




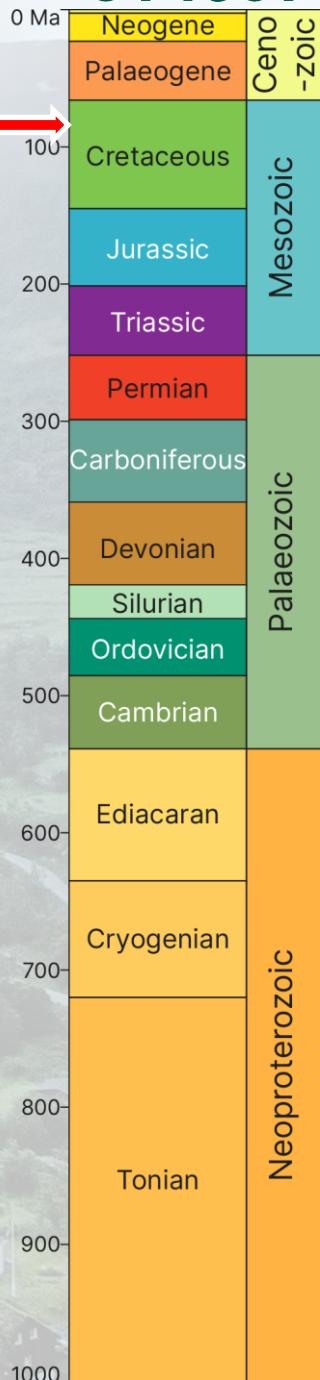


# Coccolithophores

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

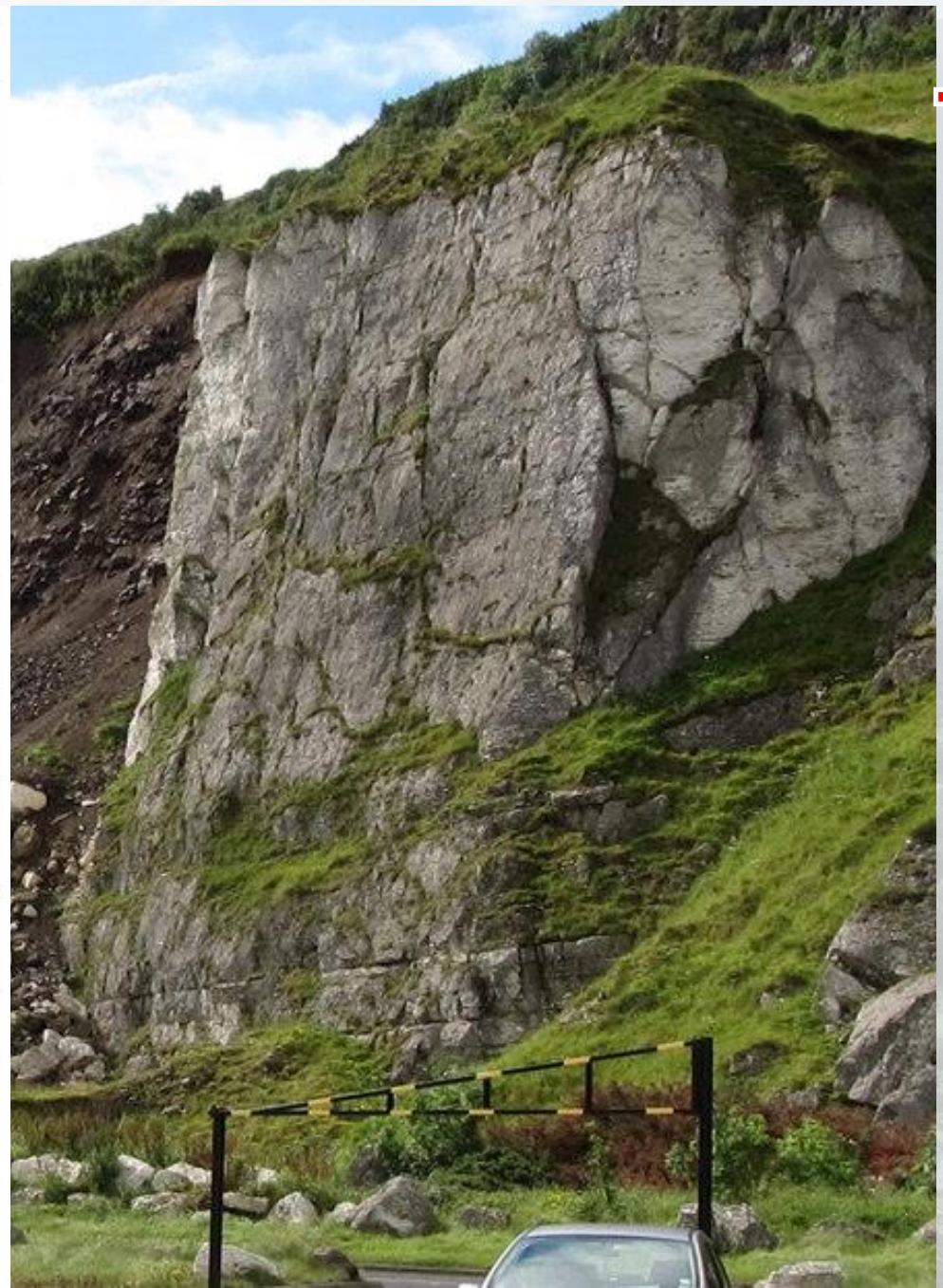
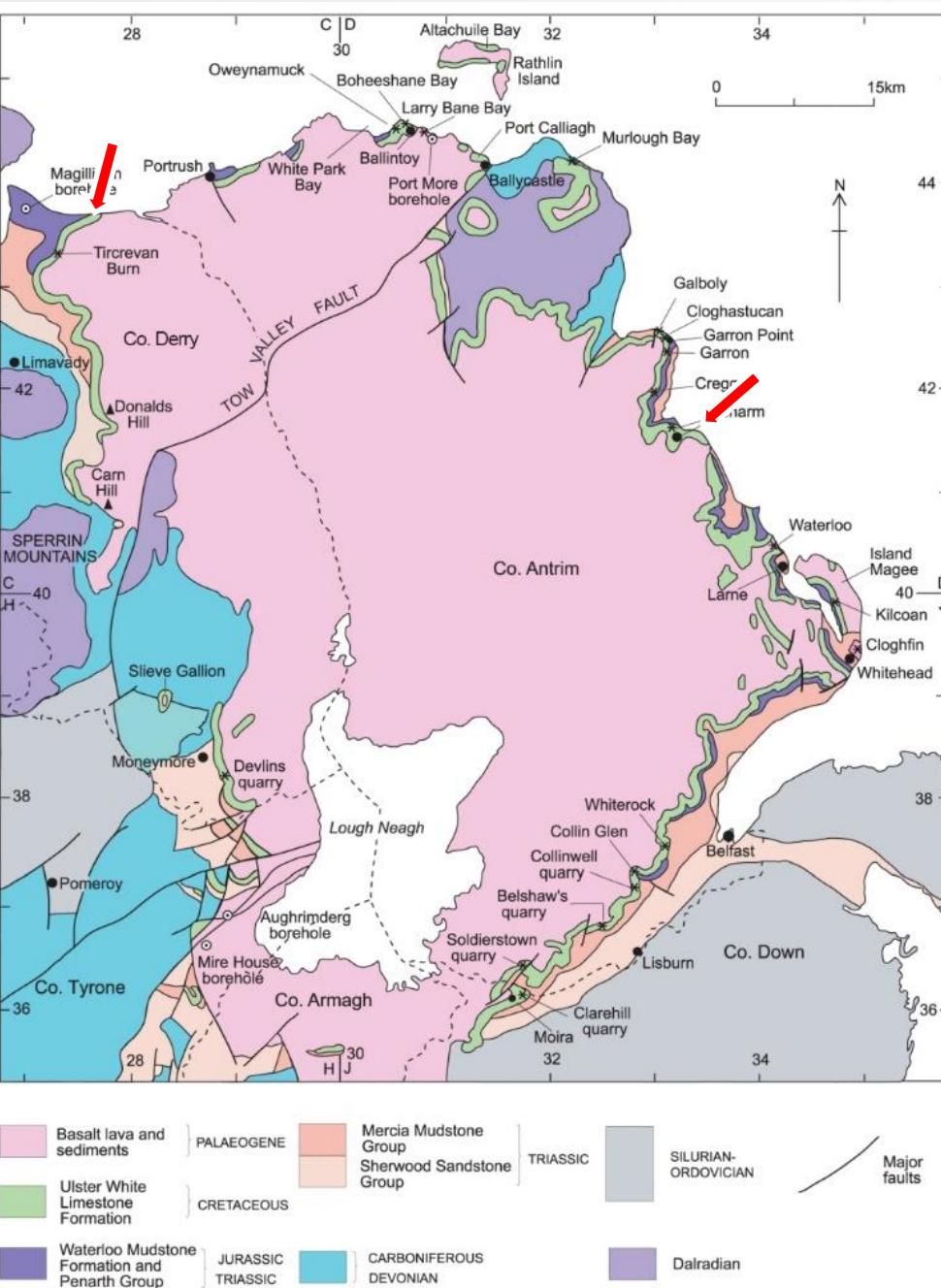
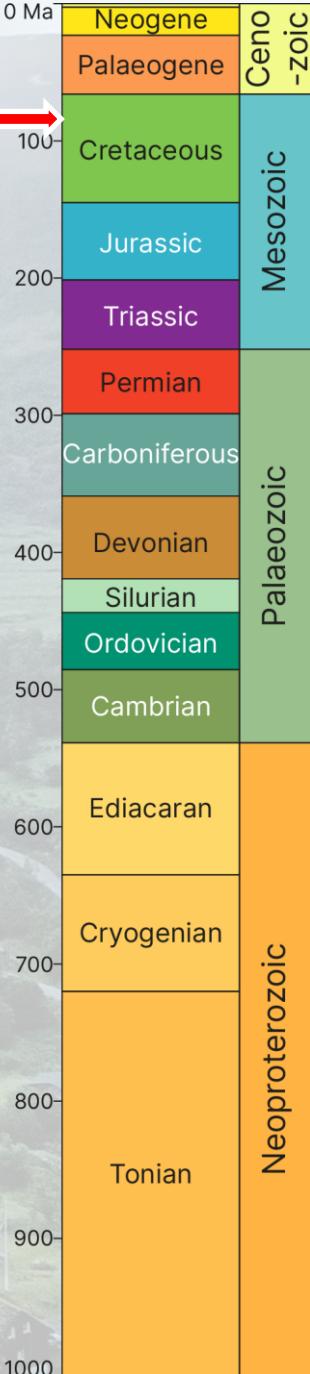


S



# Recent Ireland | Cretaceous

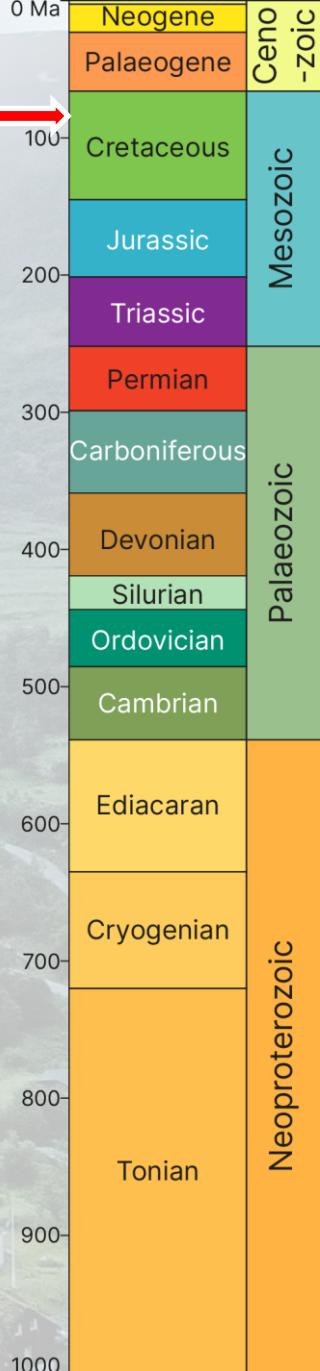
**GY4051**



S

# Recent Ireland | Cretaceous

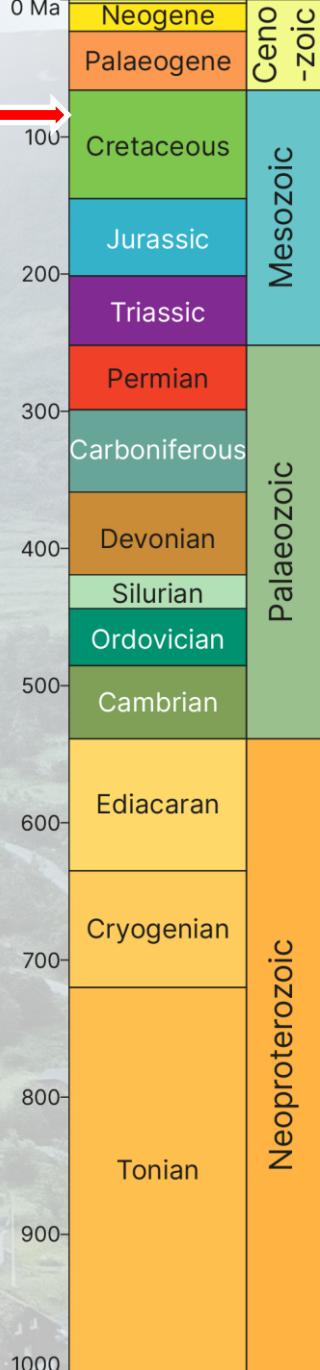
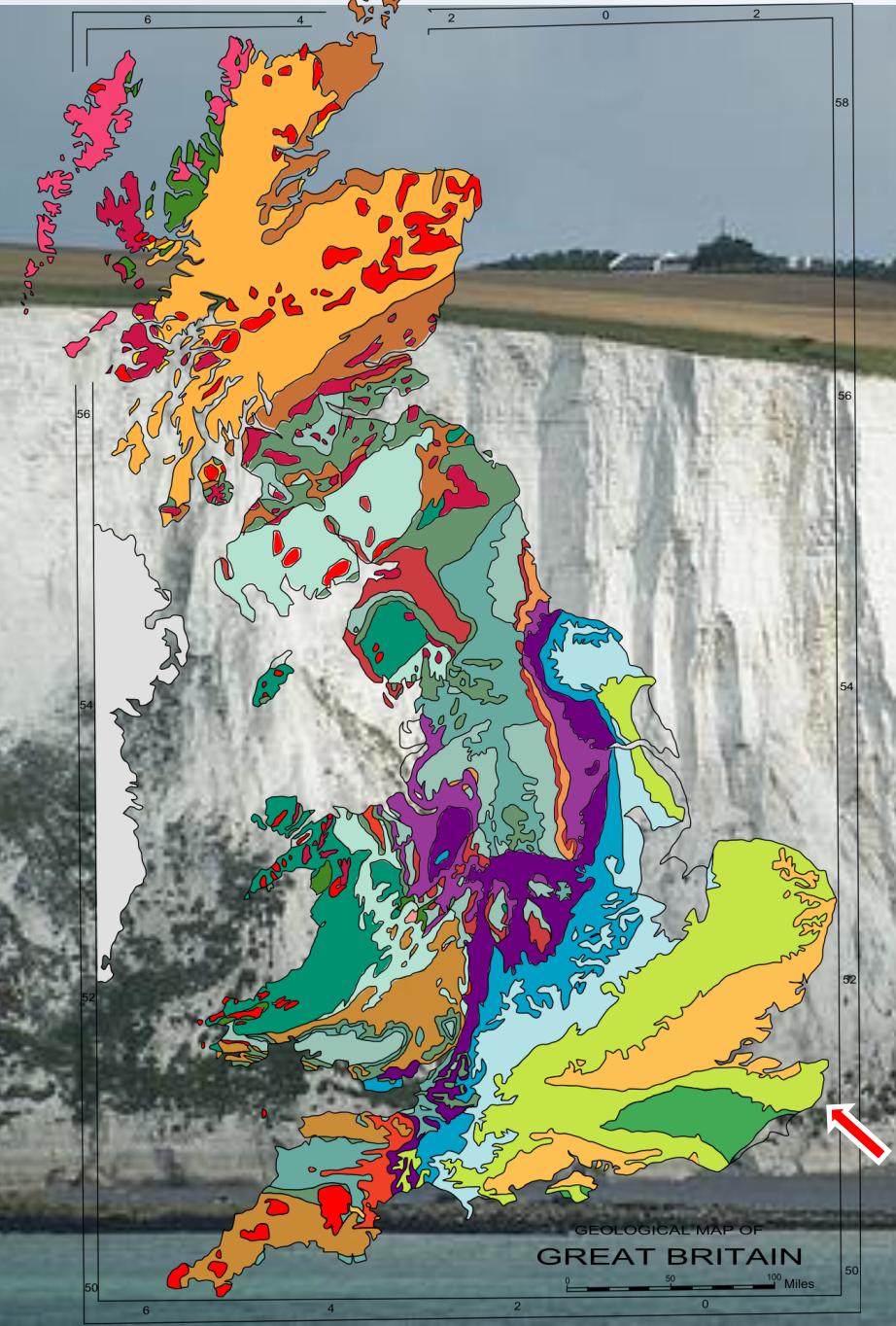
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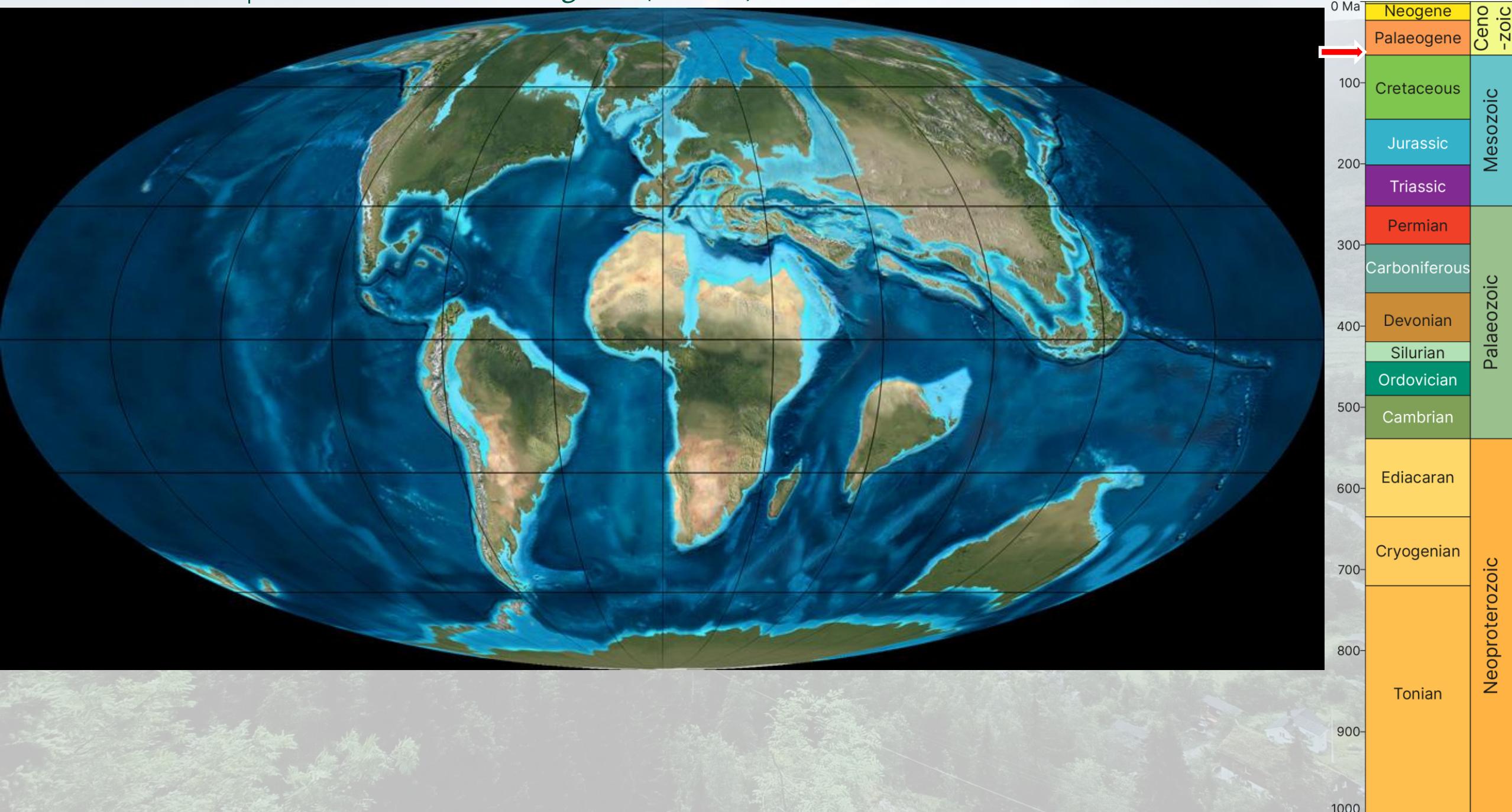


**Recent Ireland**

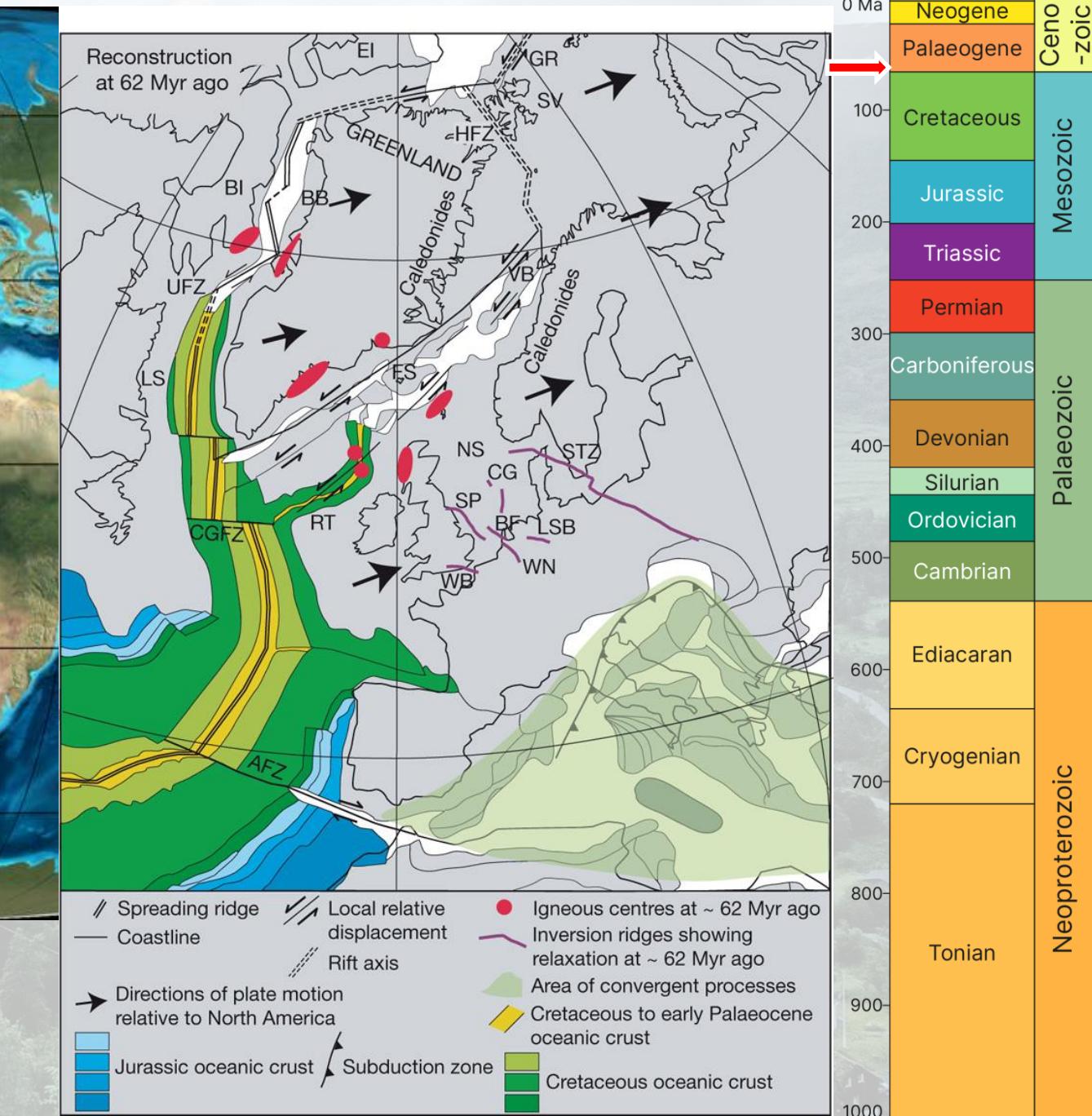
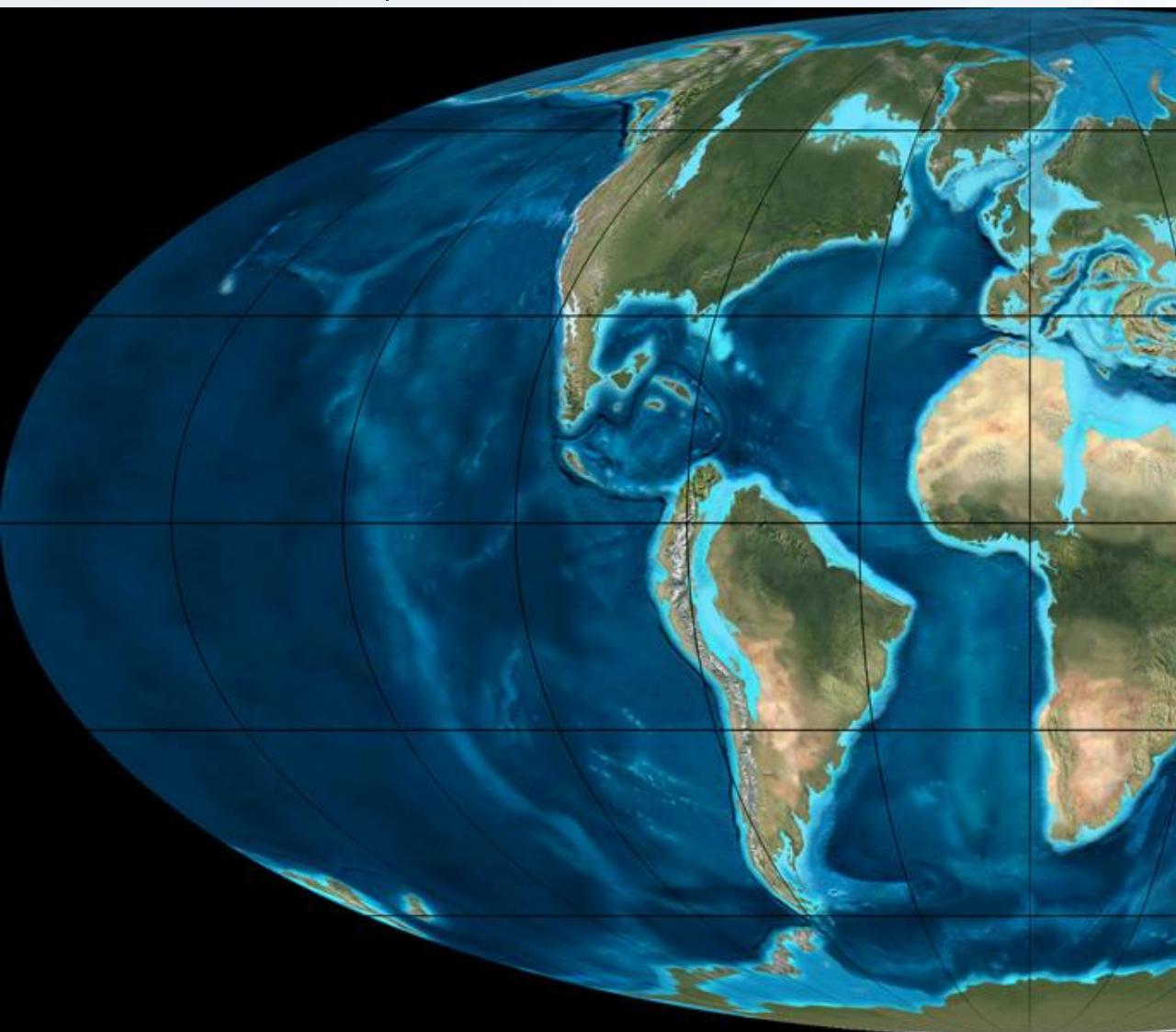
*Cetaceous*

**GY4051**

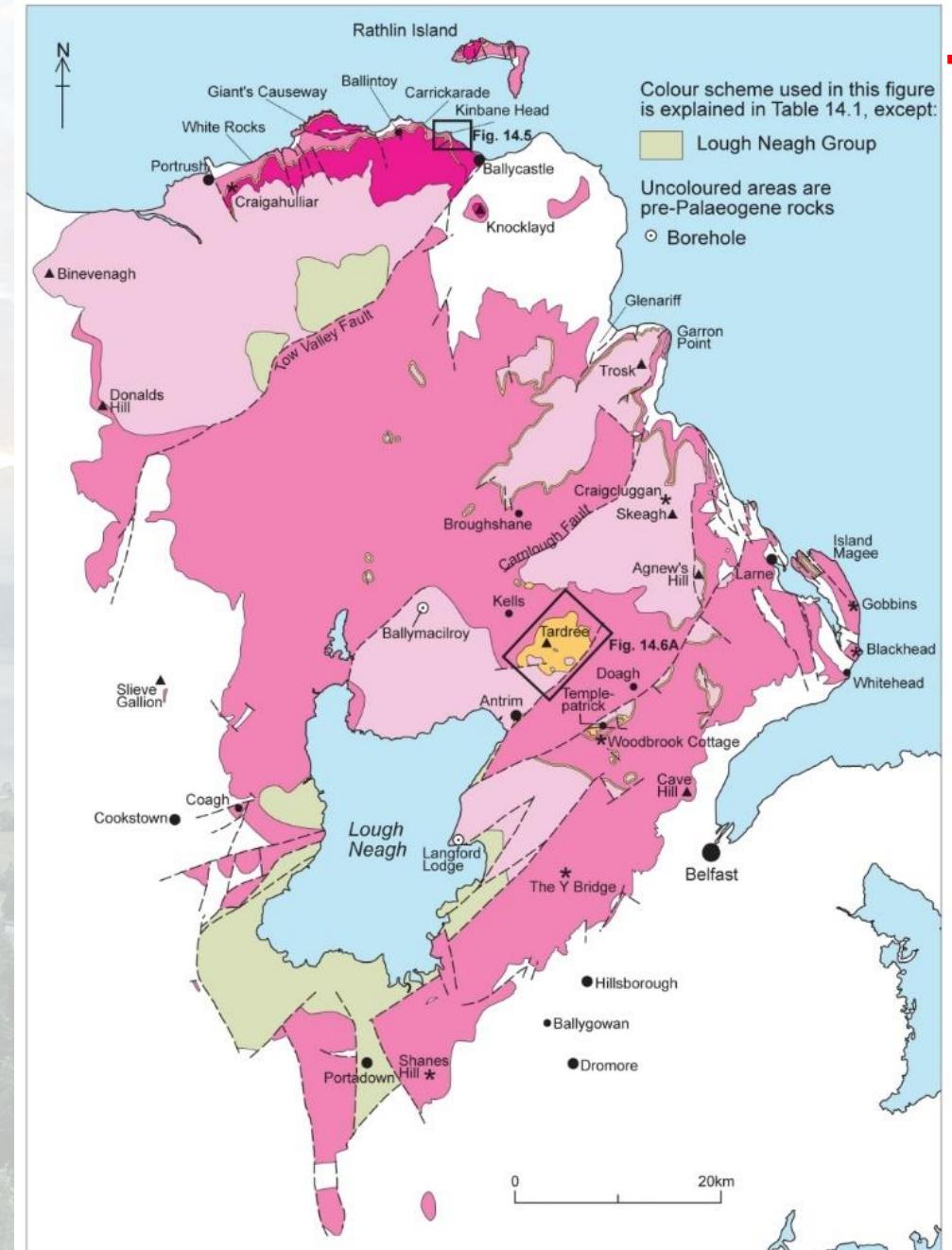
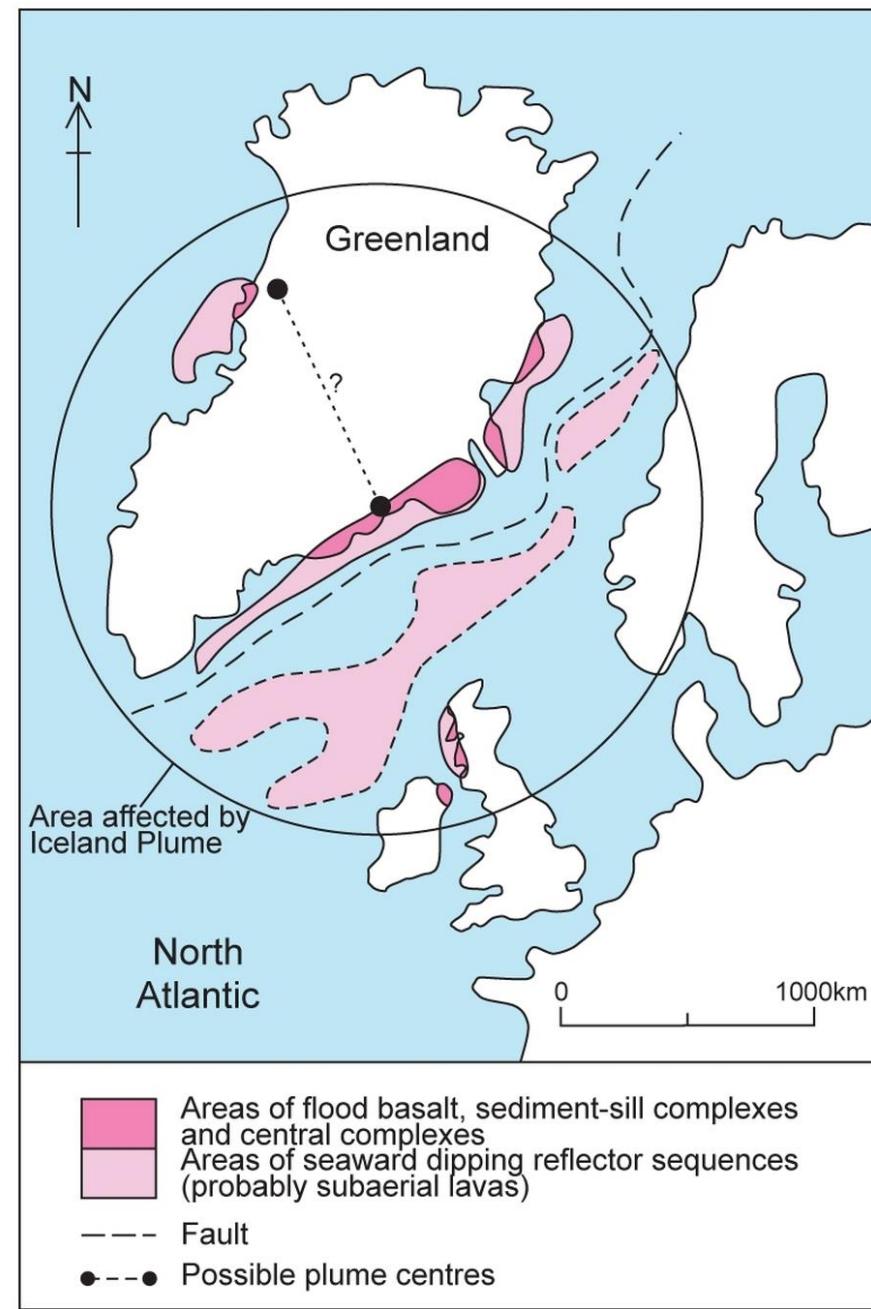




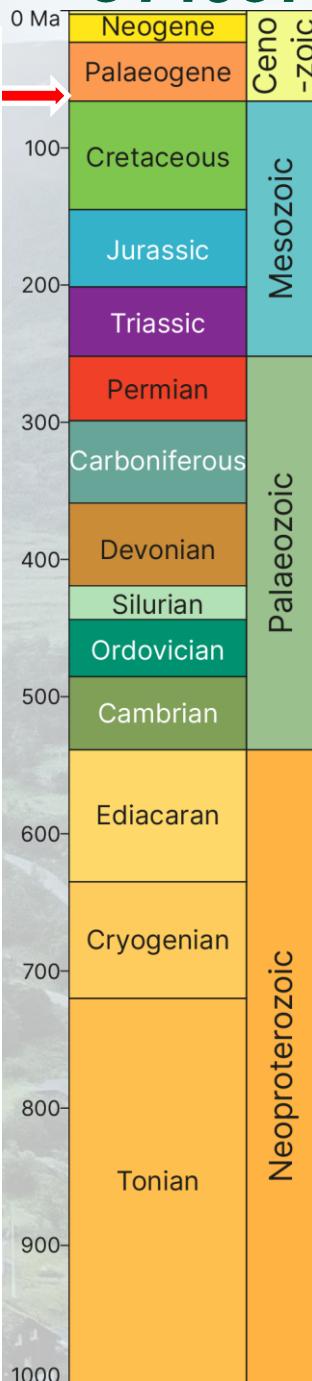
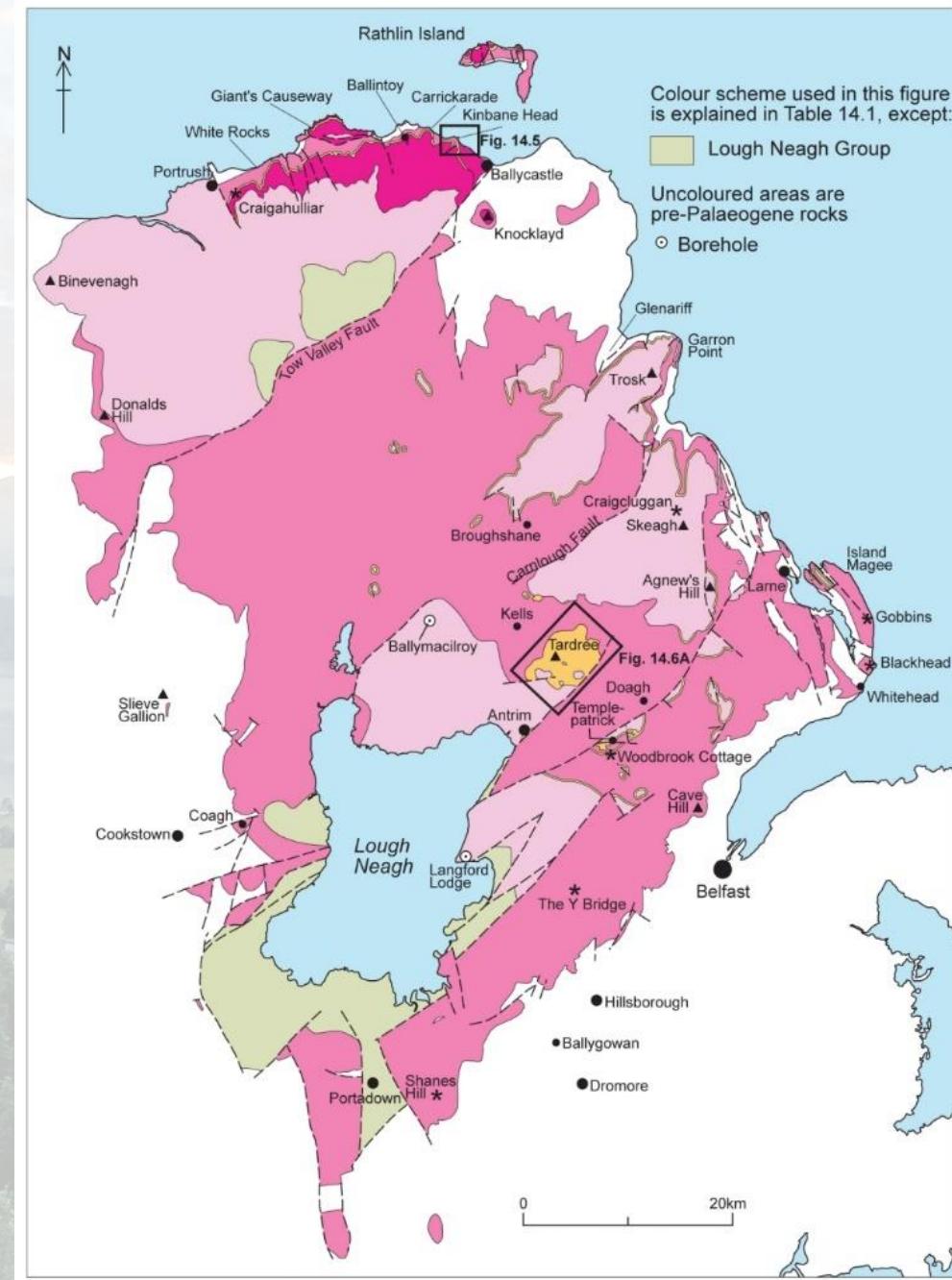
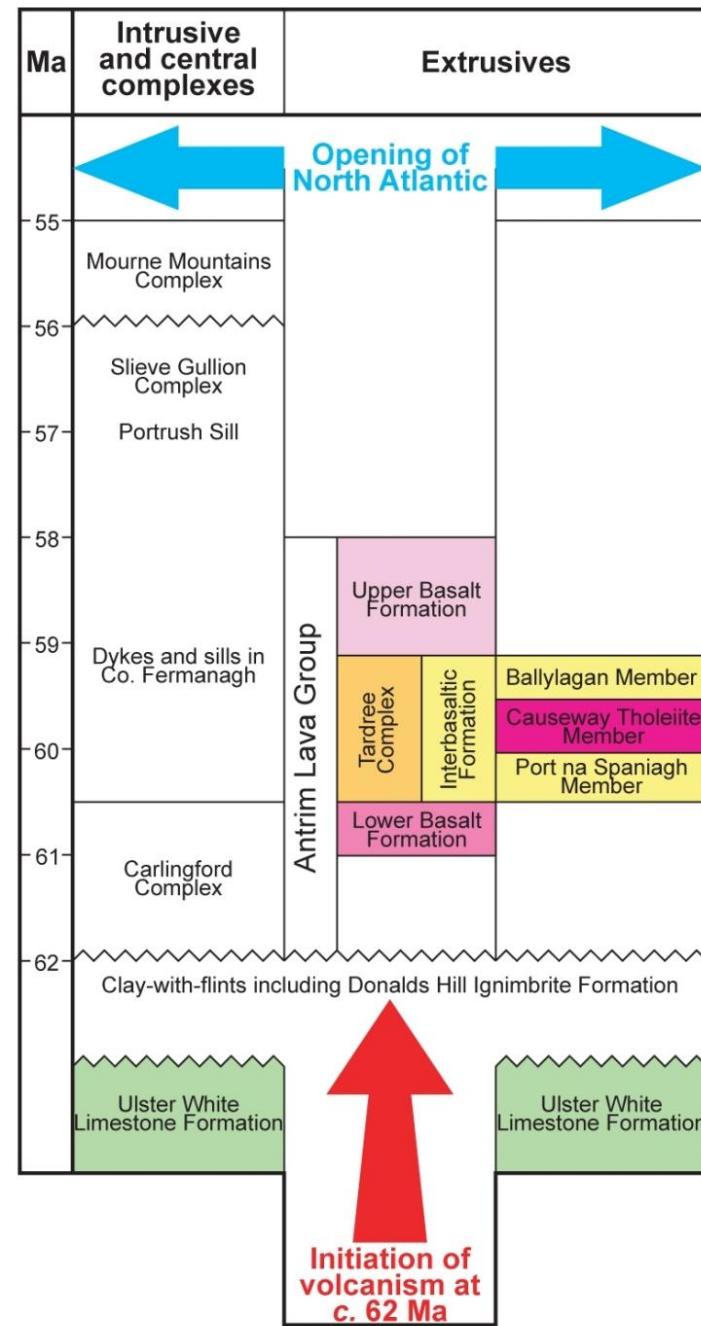
# Recent Ireland | The Atlantic Ocean Opens



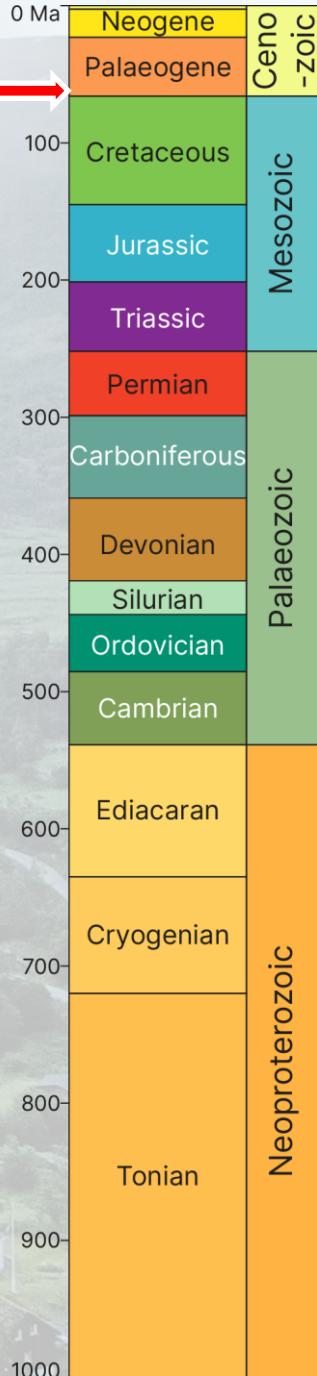
# Recent Ireland | The Iceland Plume



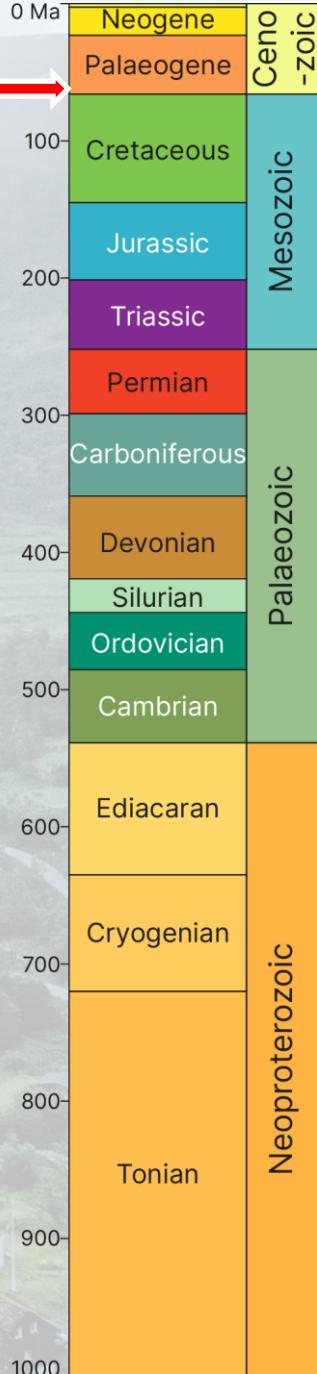
**Recent Ireland** | The Antrim Plateau



B<sub>1</sub>

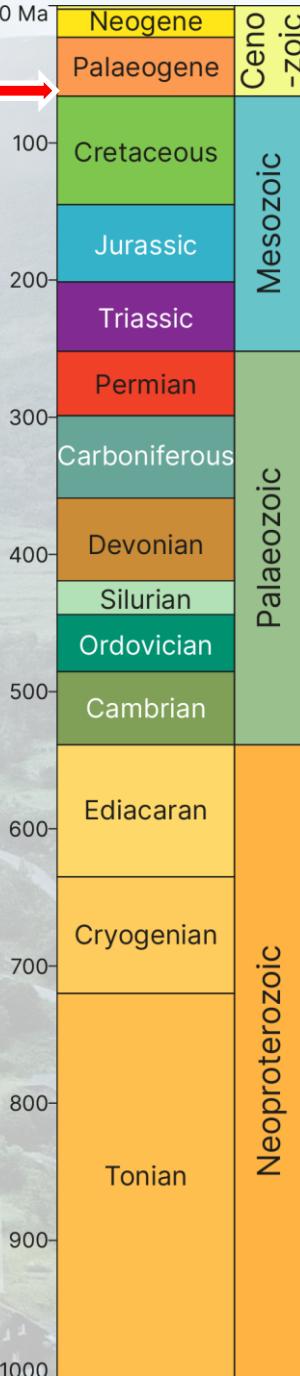
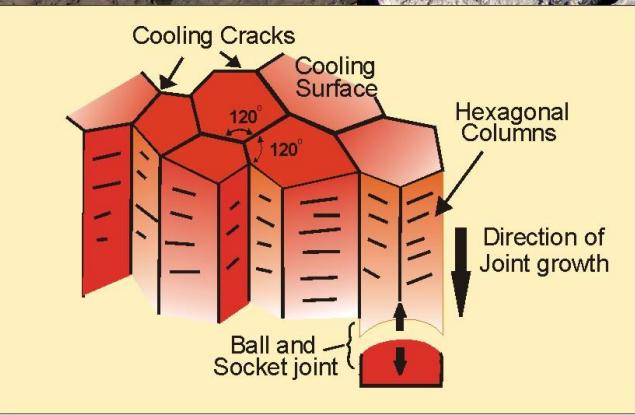
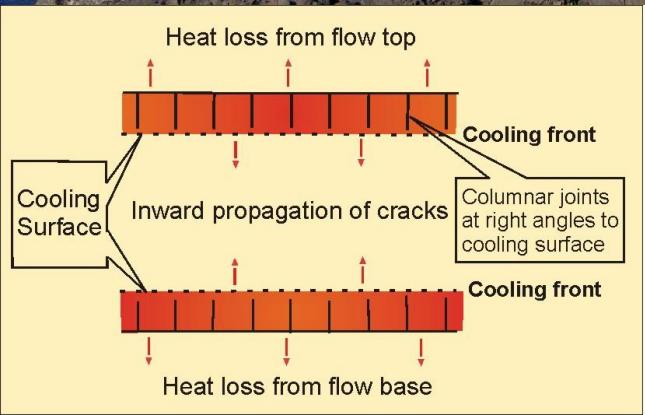


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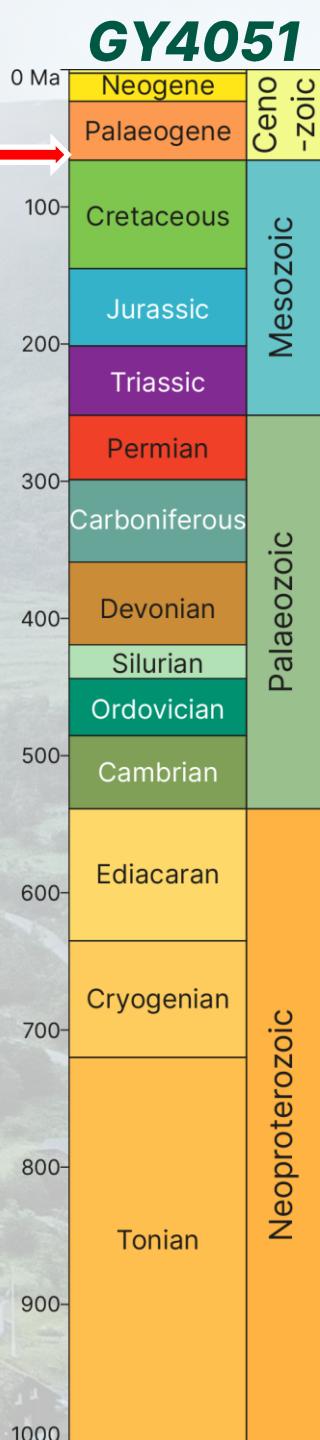


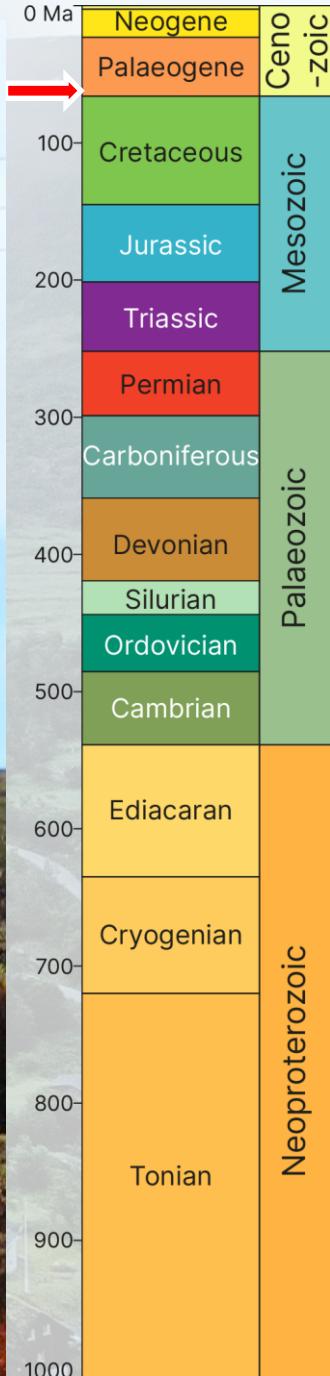
**B<sub>1</sub>**



B<sub>1</sub>

B<sub>1</sub>

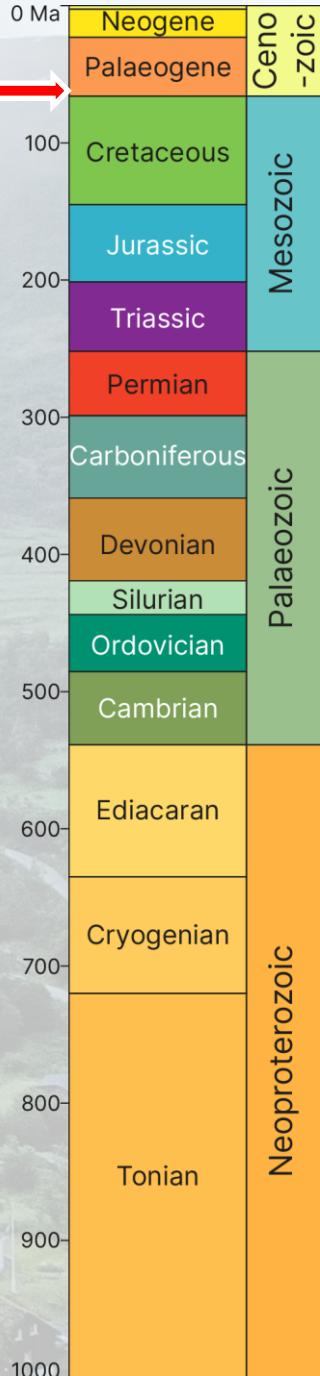


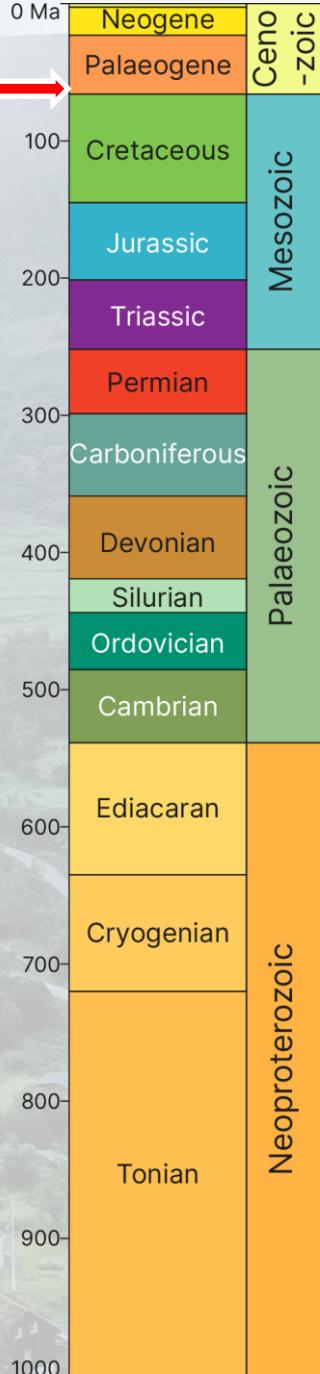


**A**



A

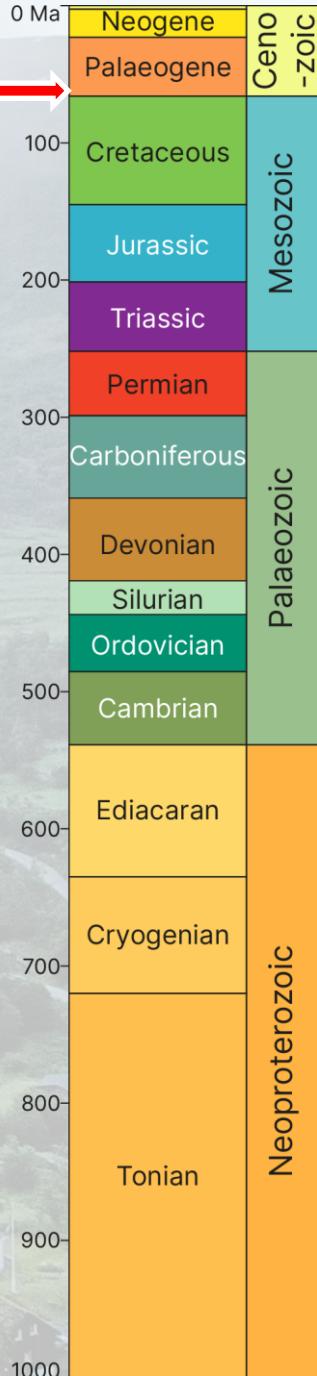




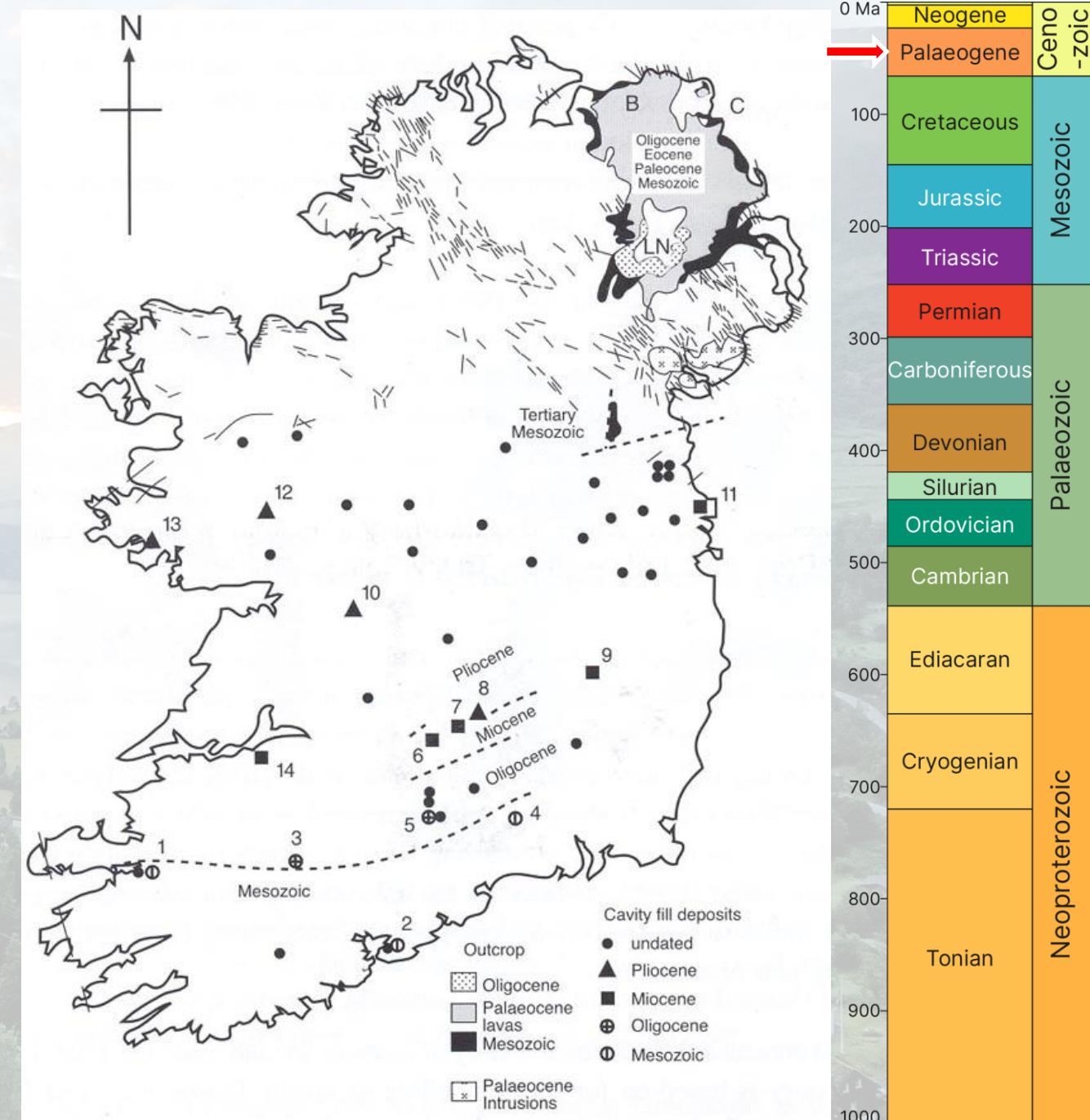


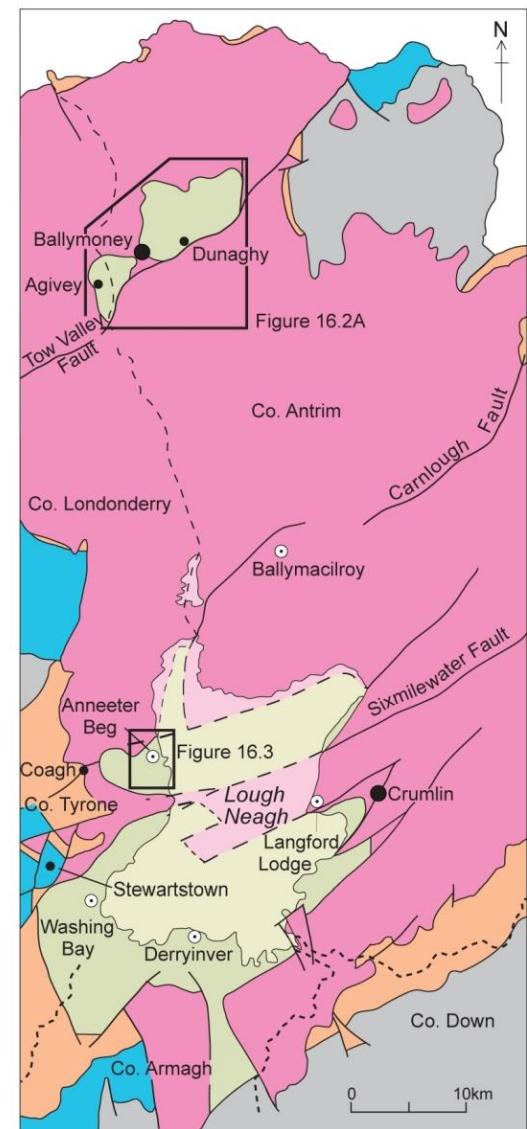
In the vicinity of Newry (from Slieve Gullion to Slieve Croob), the basement rocks comprise a sequence of **granite** masses, several kilometres deep, which were emplaced into the Ordovician and Silurian rocks about 400 million years ago. These Newry Igneous Complex rocks range from **granodiorite**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



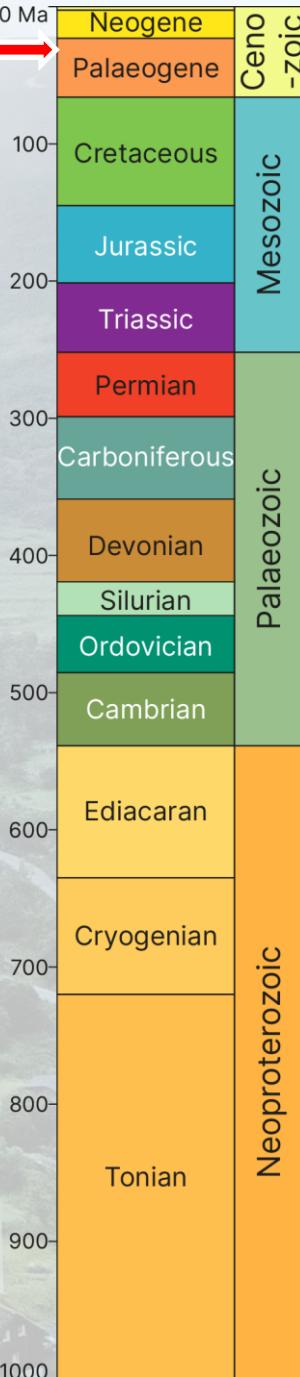
Nothing to see here...

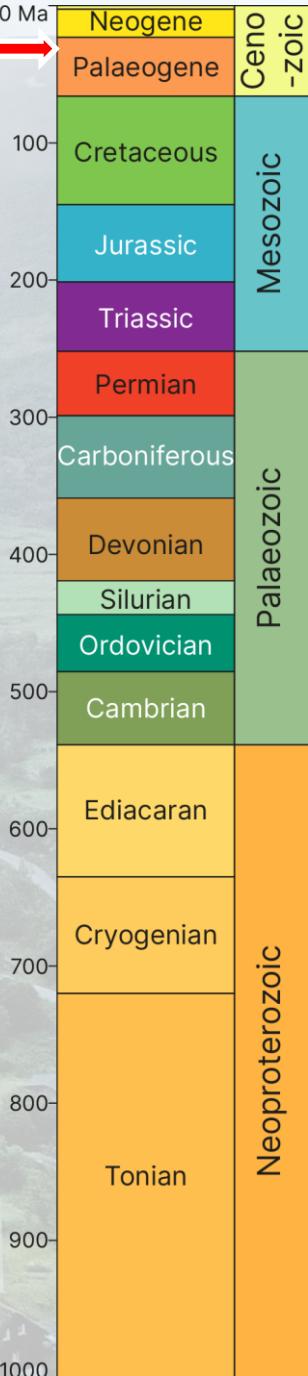


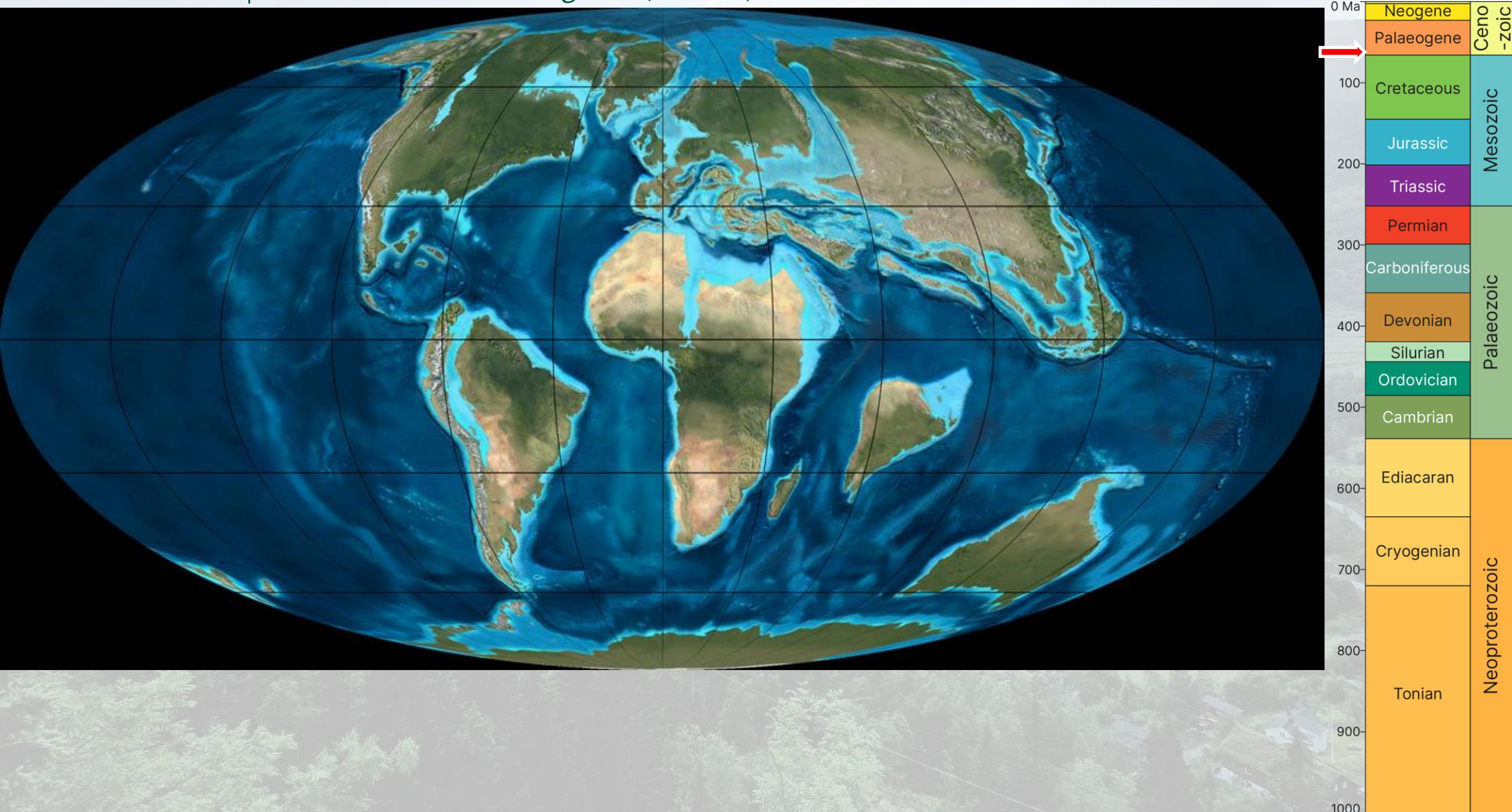


Lough Neagh Group	Beneath Lough Neagh Exposed	Cretaceous-Triassic-Permian
Antrim Lava Group	Beneath Lough Neagh Exposed	Carboniferous

● Borehole

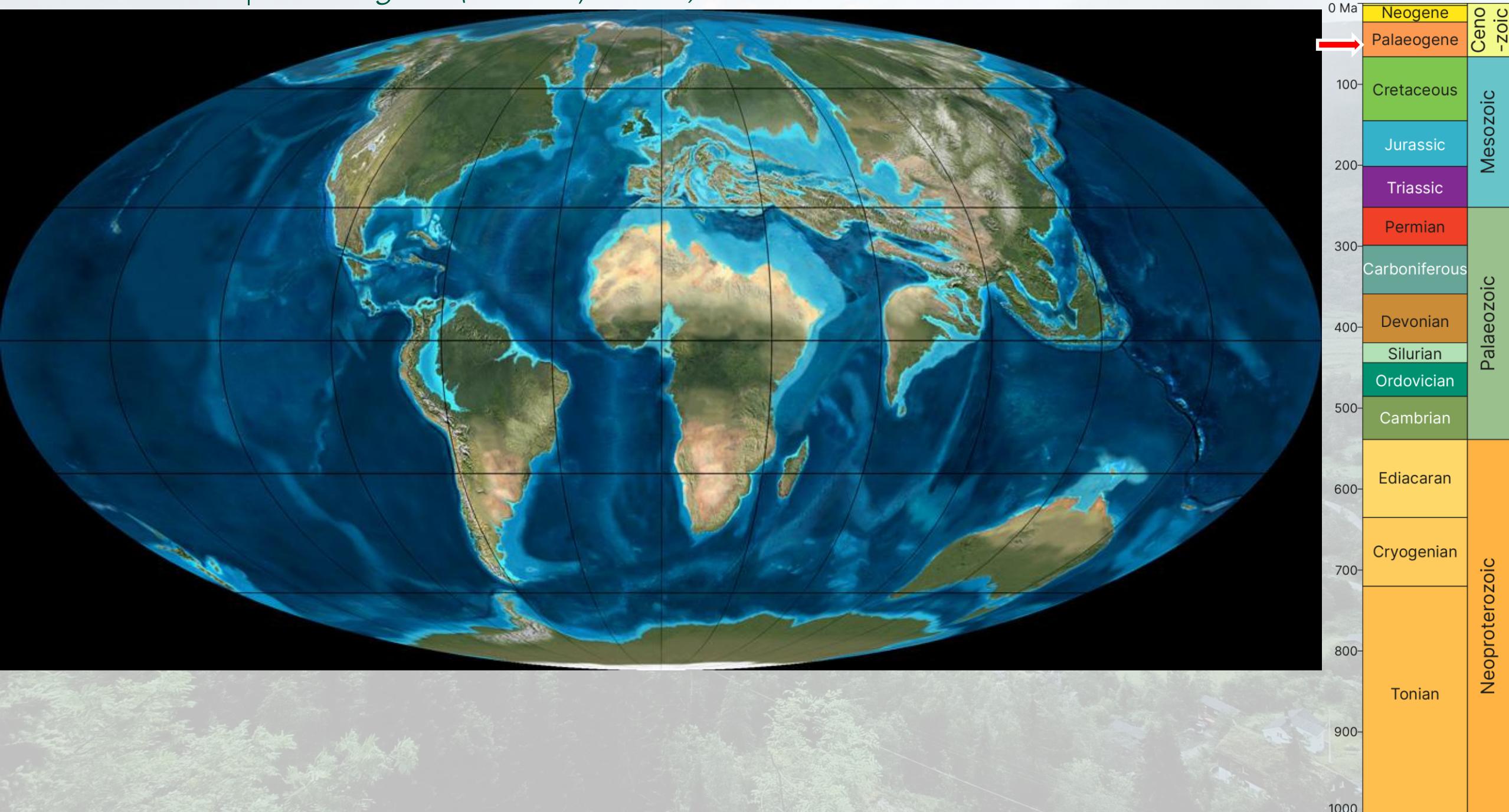






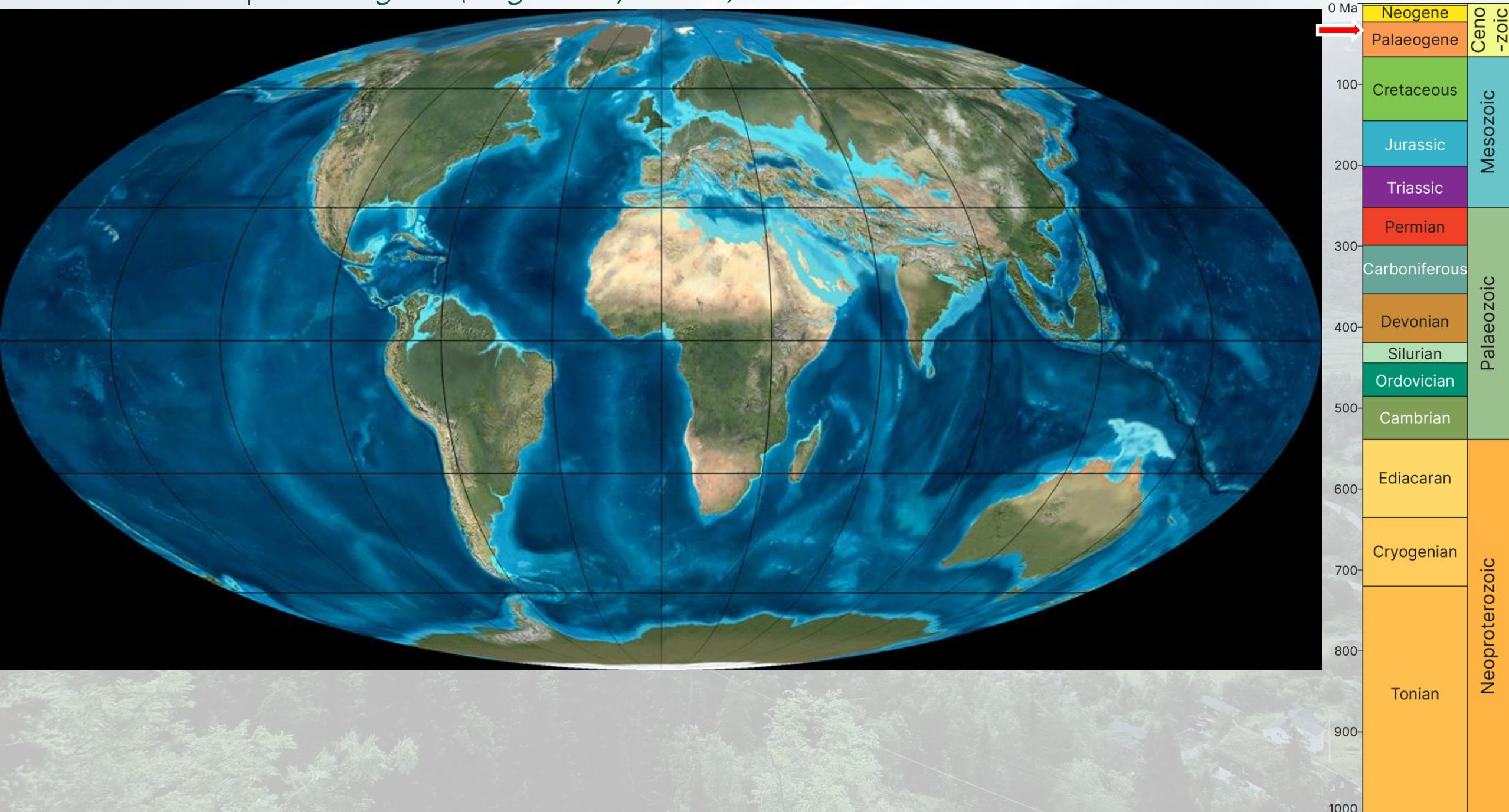
# Recent Ireland | Palaeogene (Eocene, 50 Ma)

GY4051



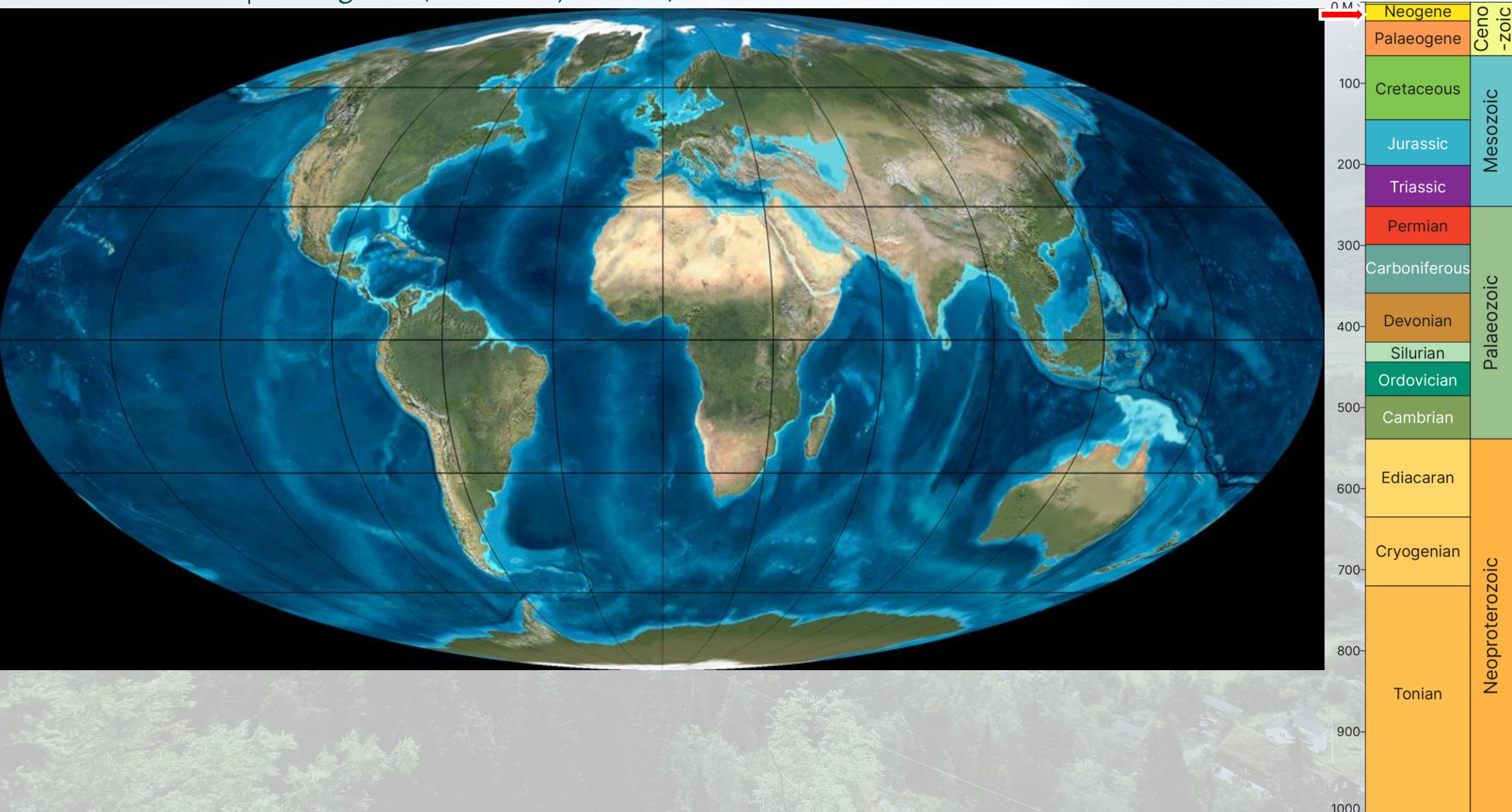
# Recent Ireland | Palaeogene (Oligocene, 35 Ma)

GY4051



# Recent Ireland | Neogene (Miocene, 20 Ma)

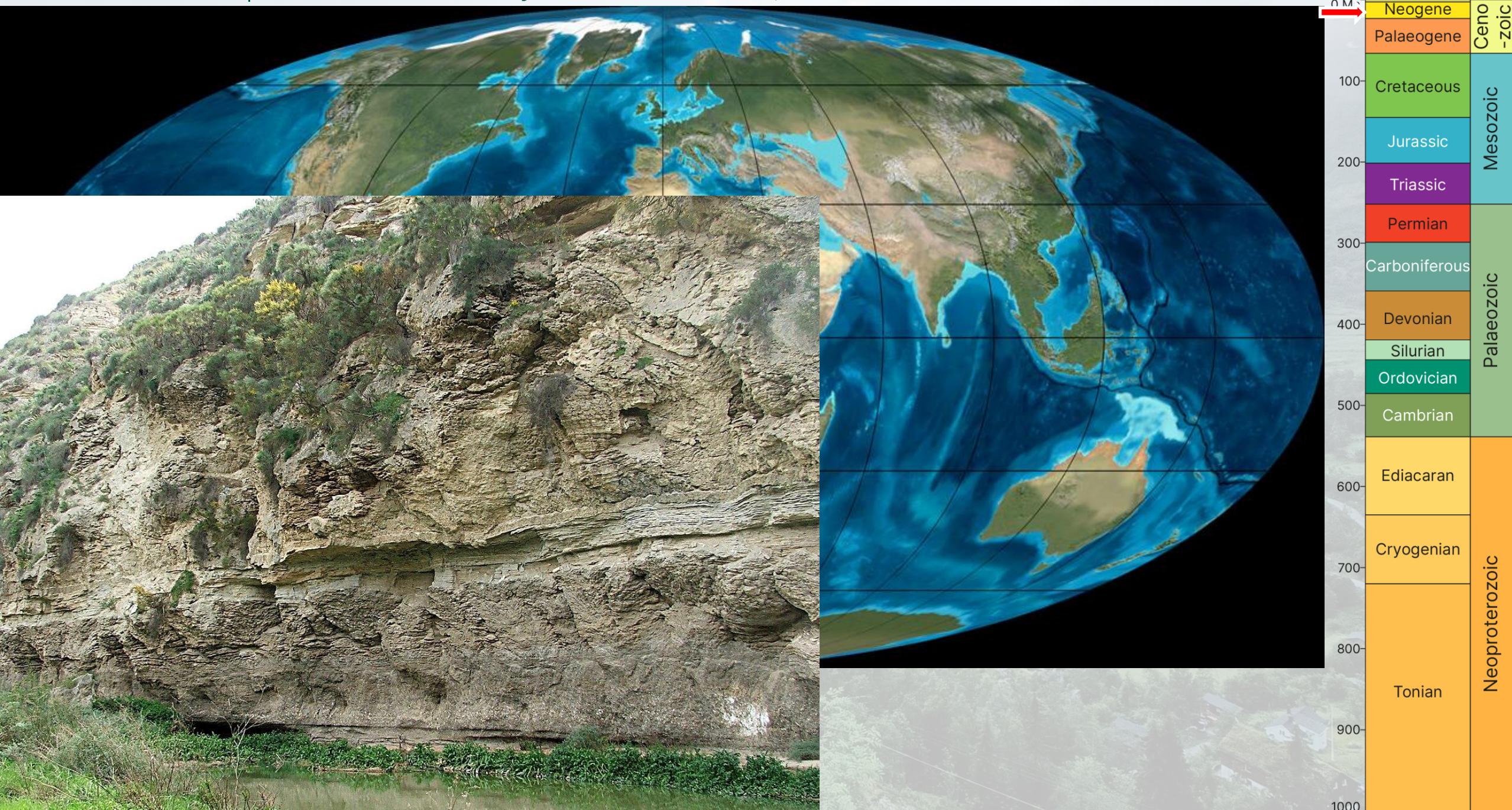
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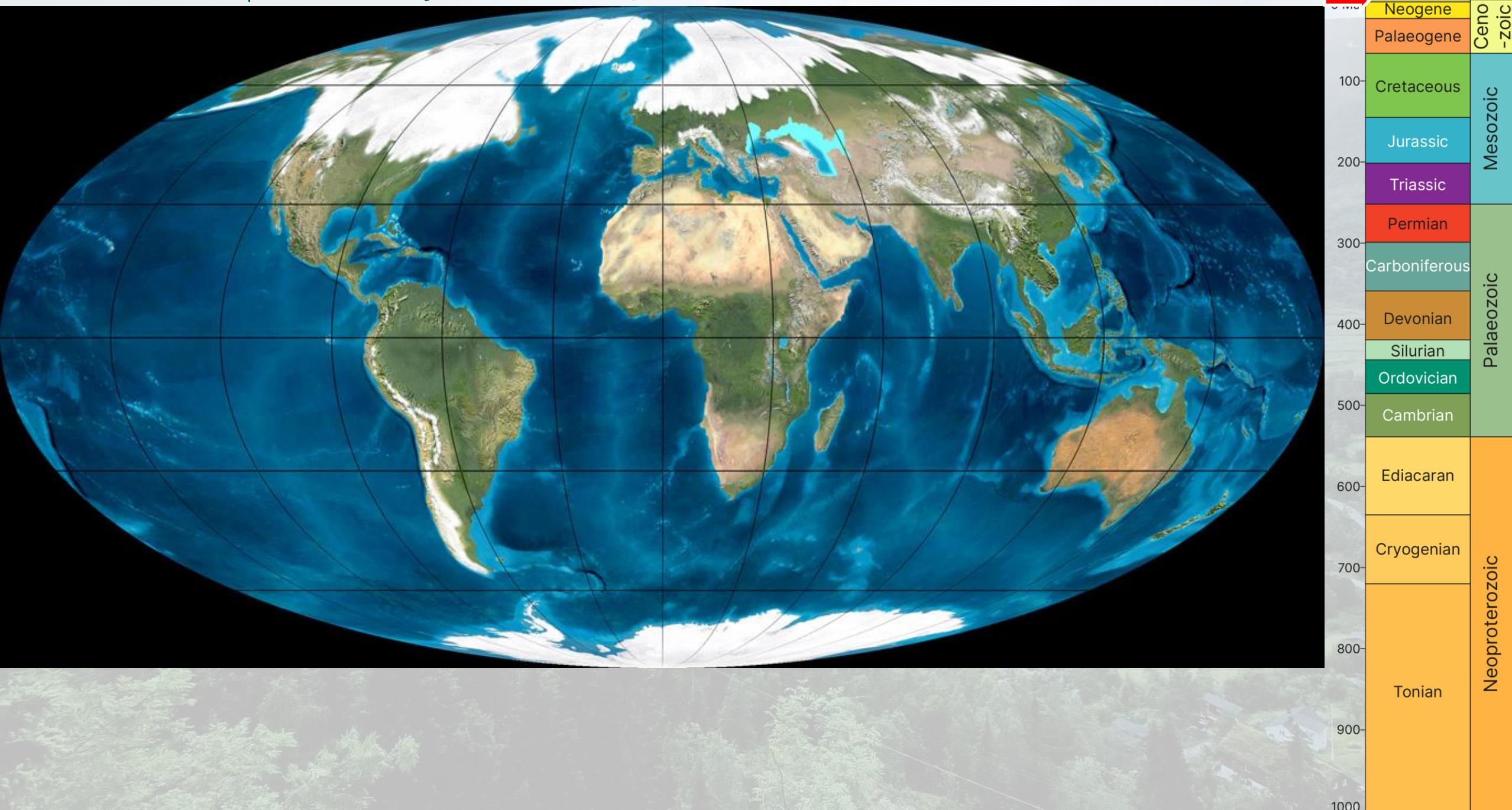
# Recent Ireland

## Messinian Salinity Crisis (Miocene, 5 Ma)

GY4051

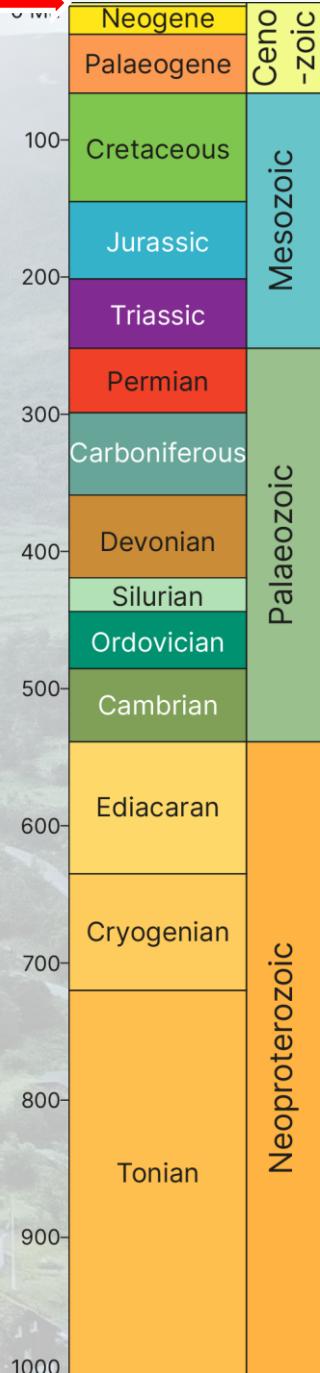
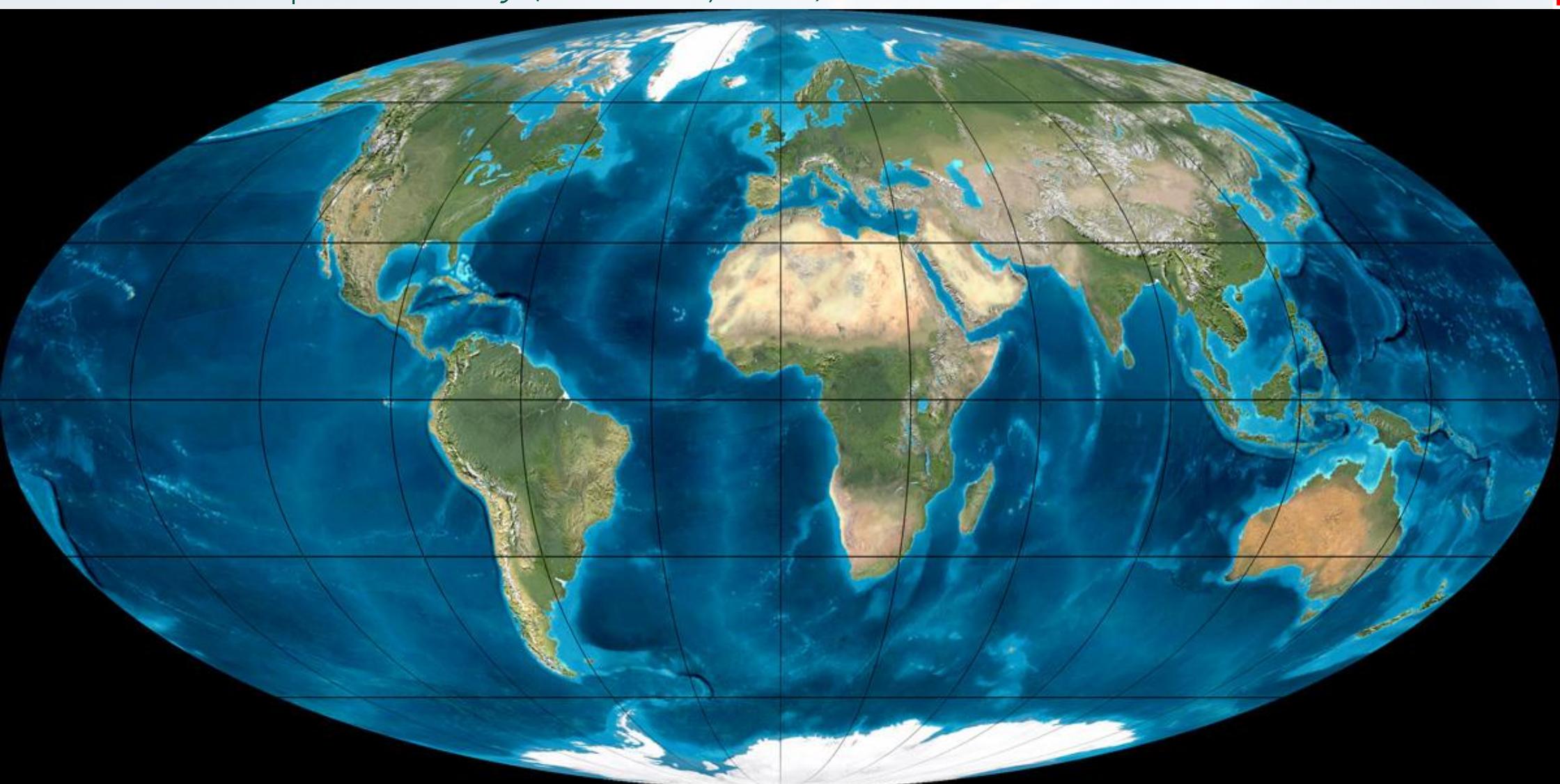


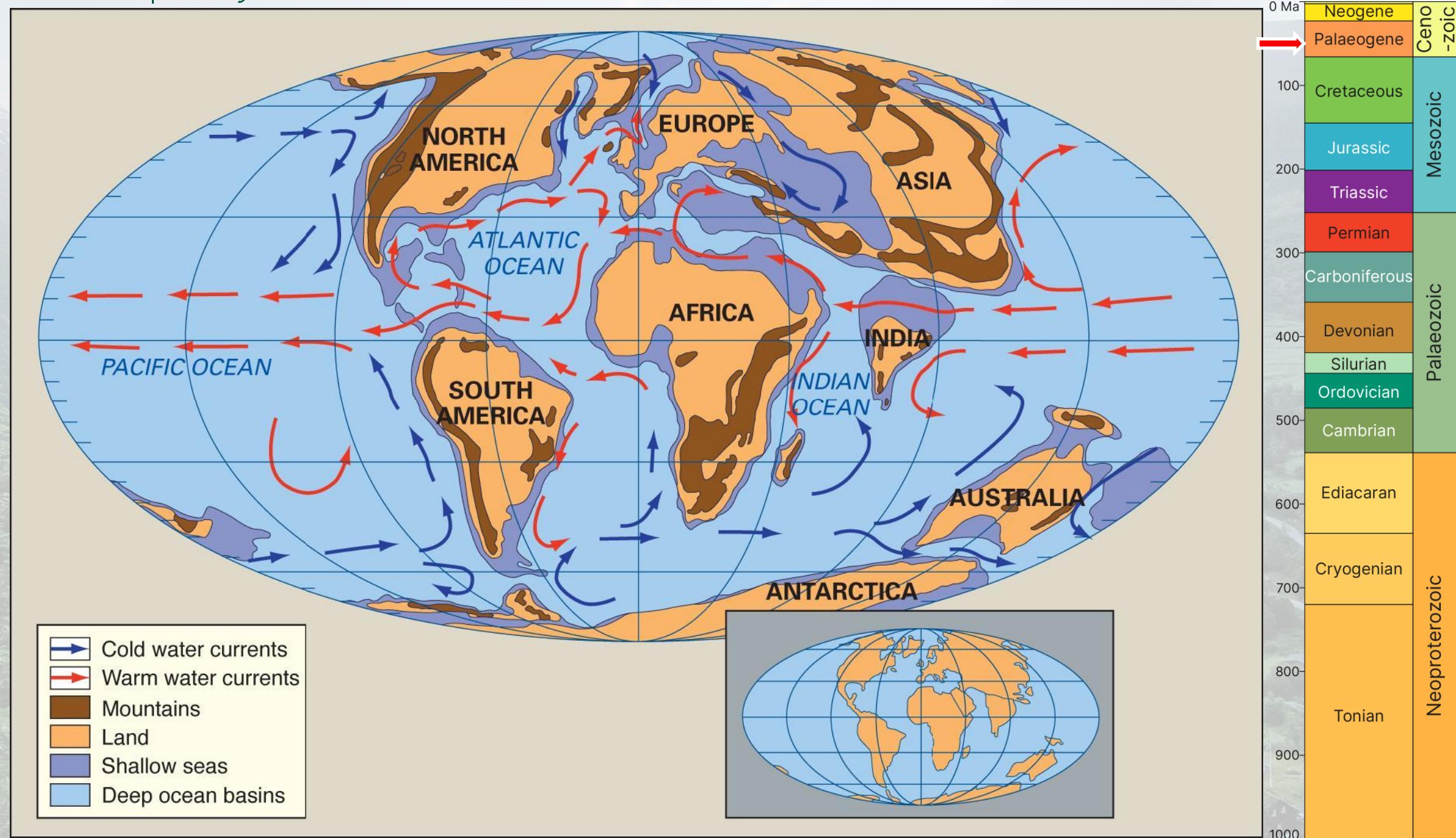
# Recent Ireland | Quaternary (Pleistocene, 1 Ma)

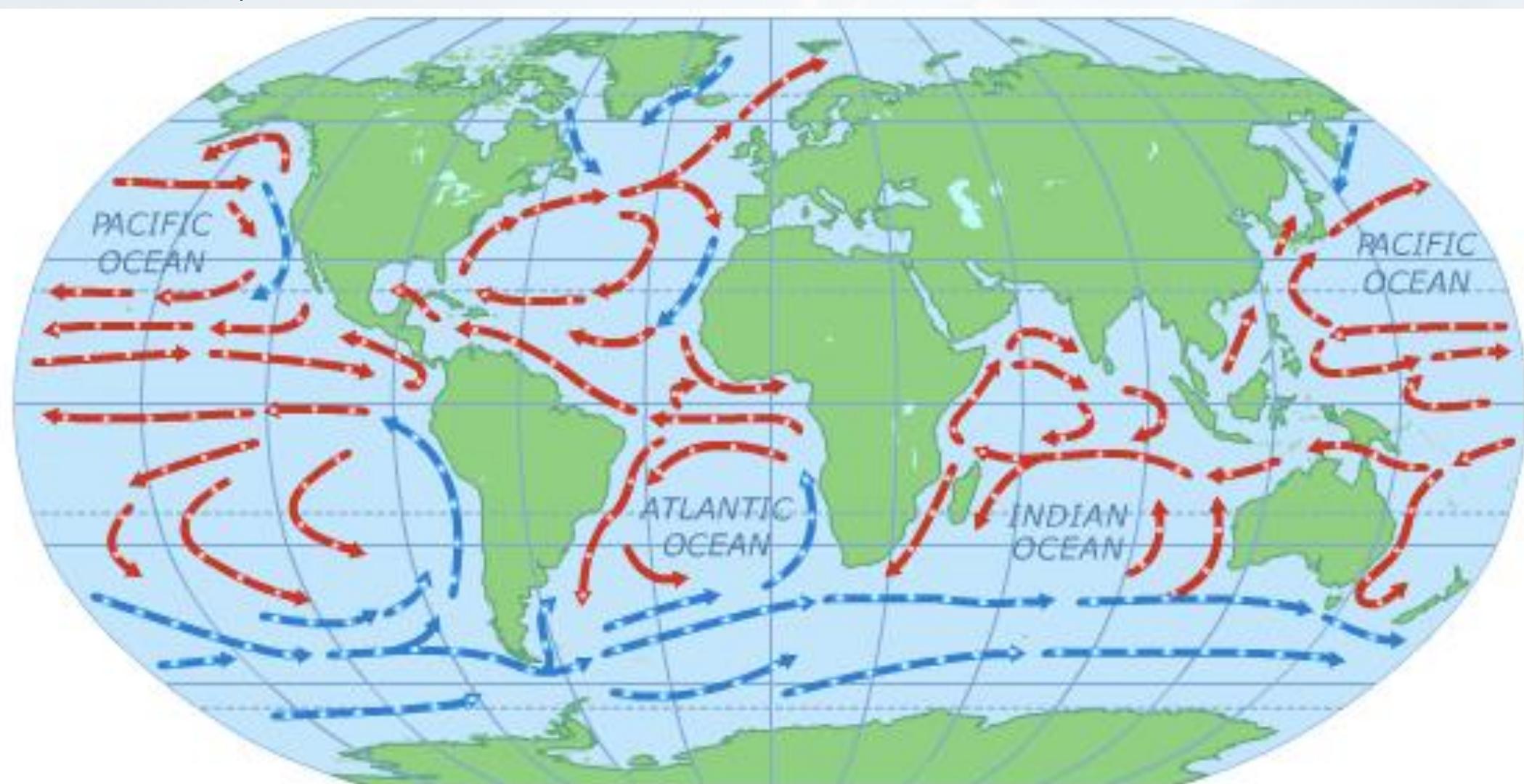


# Recent Ireland | Quaternary (Holocene, 0 Ma)

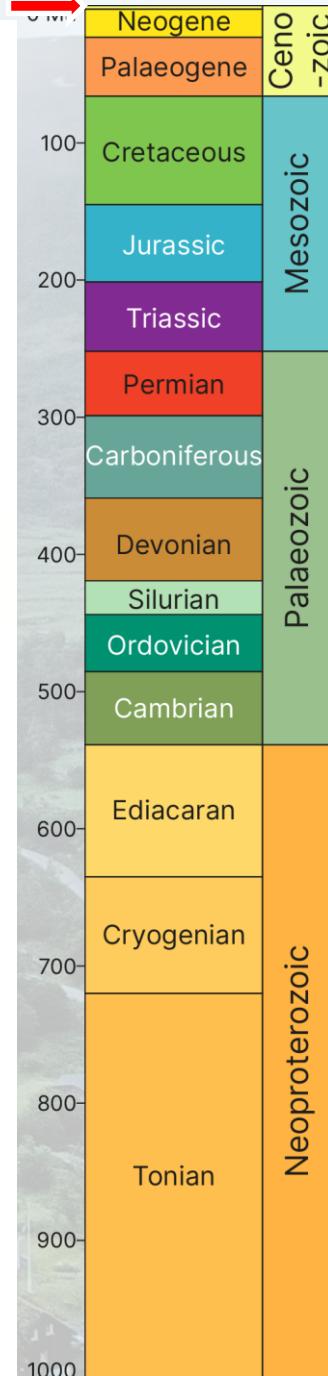
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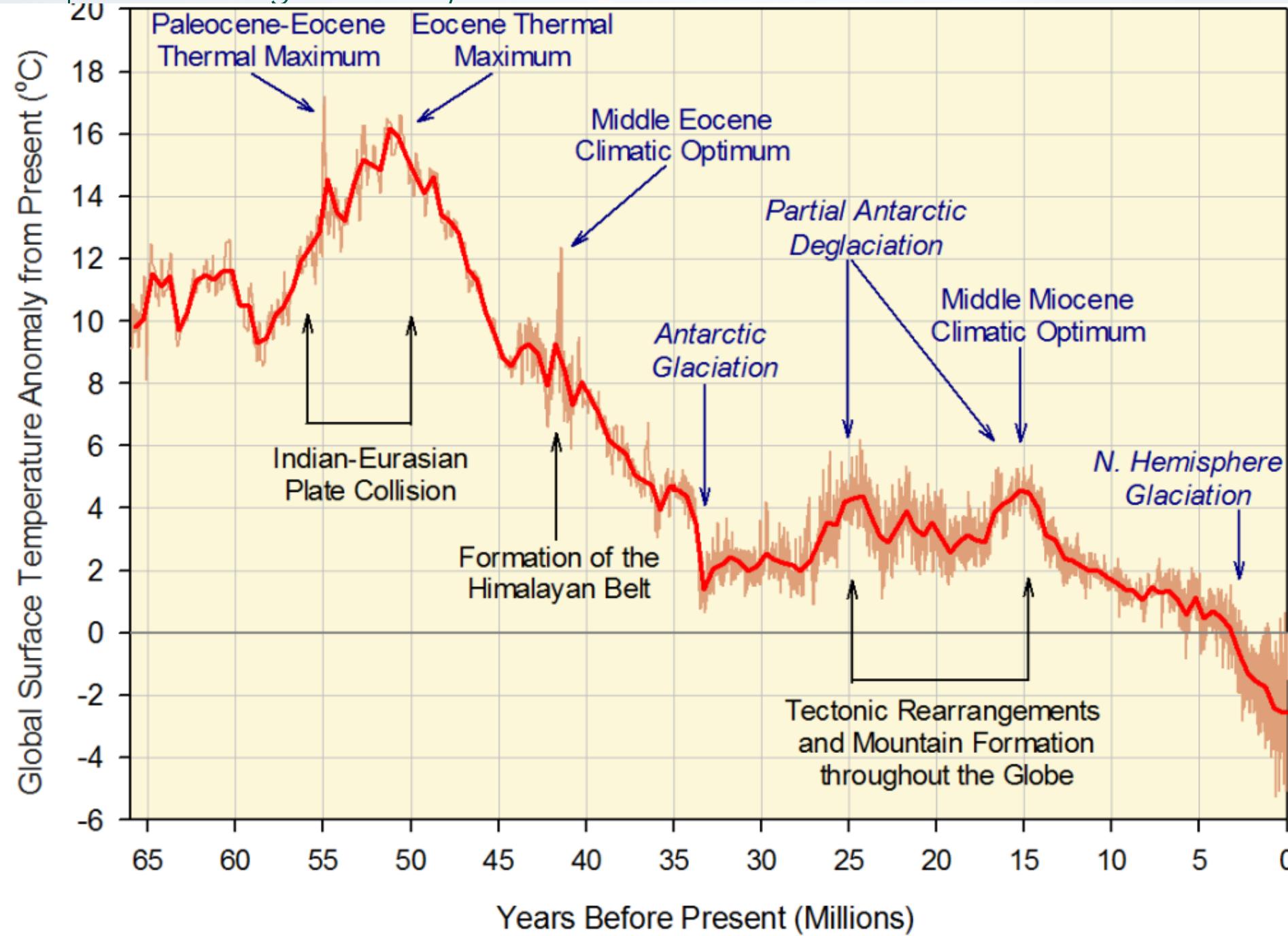




**Ocean Currents:**

- Warm currents
- Cool currents

**Global Winds:**





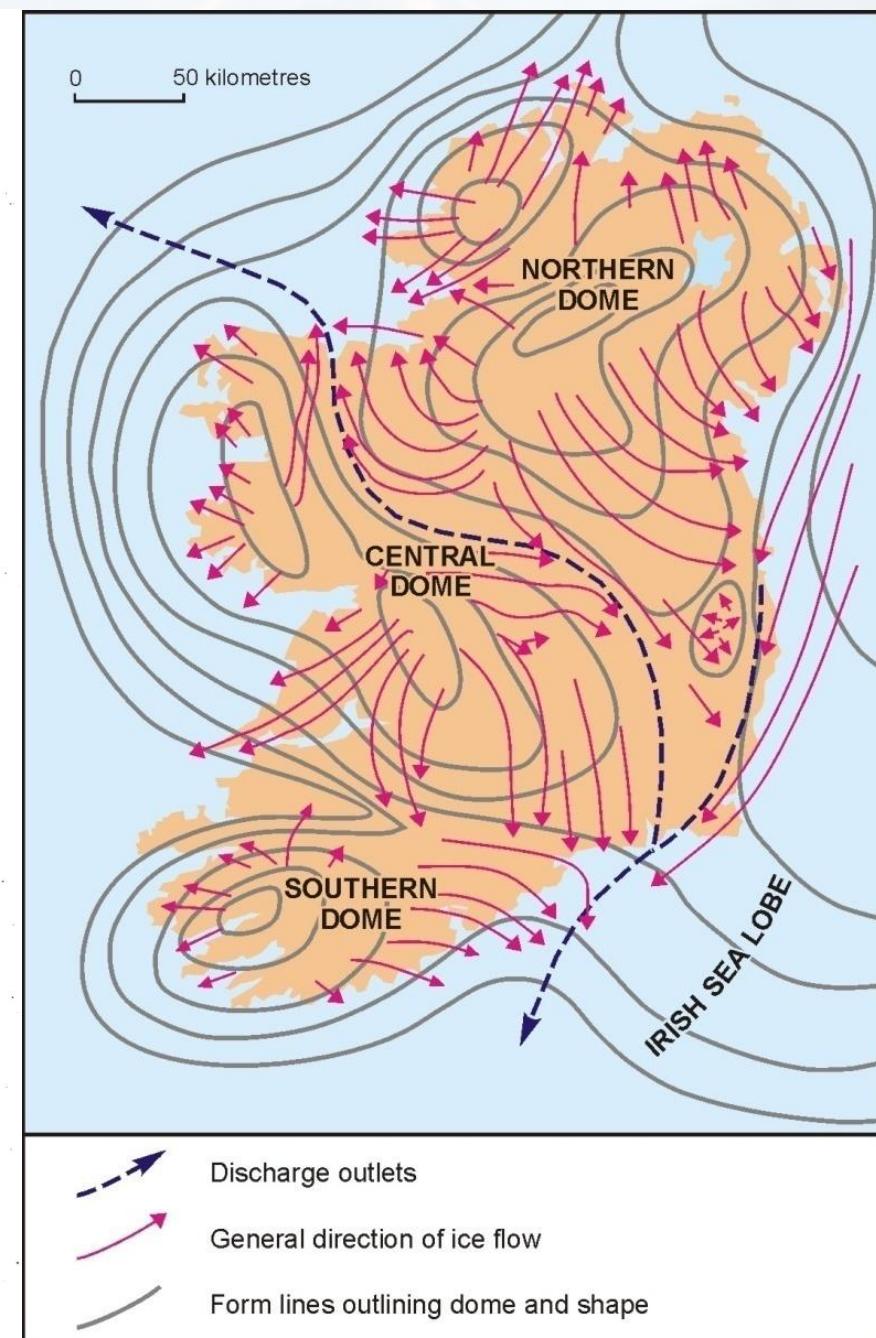
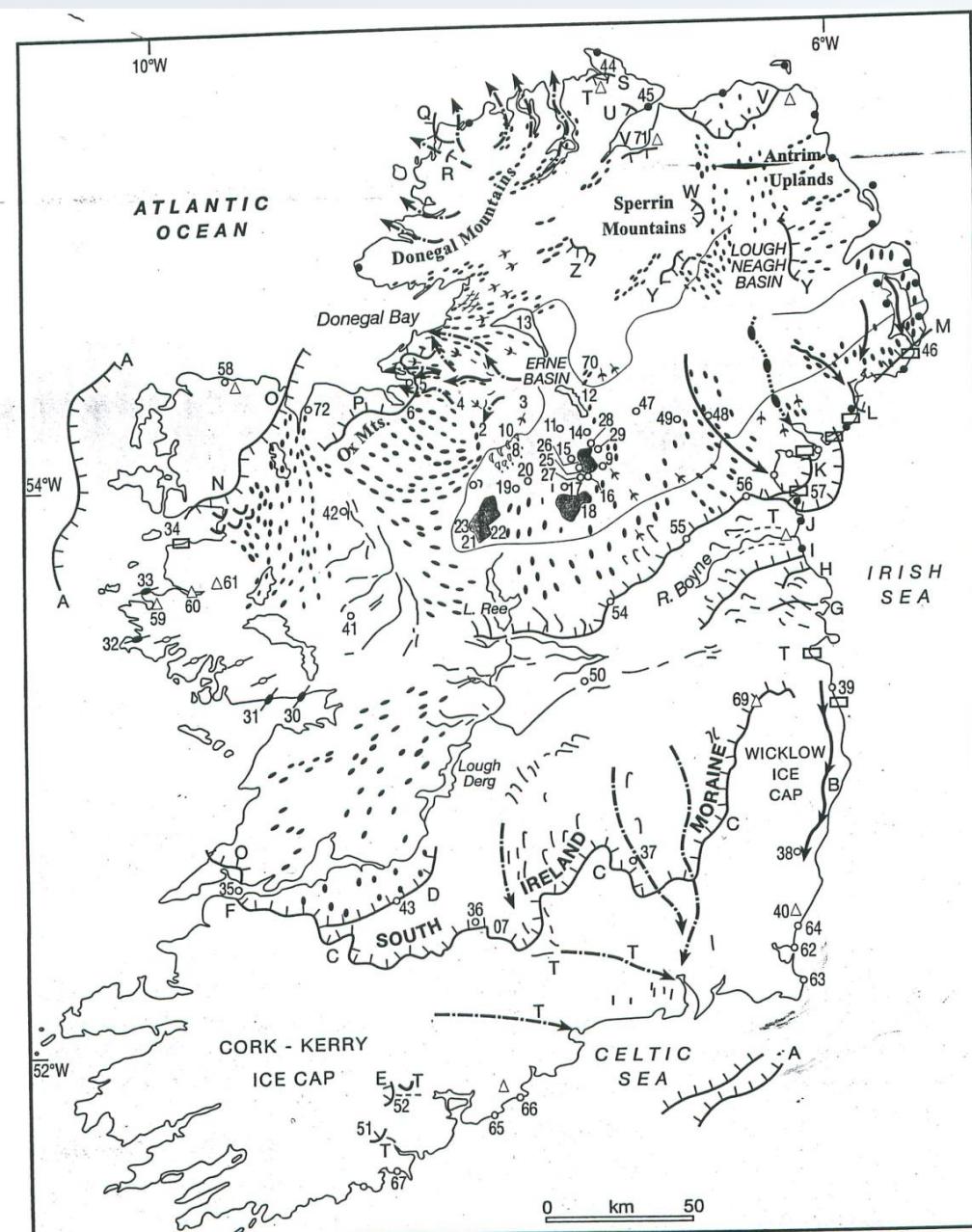












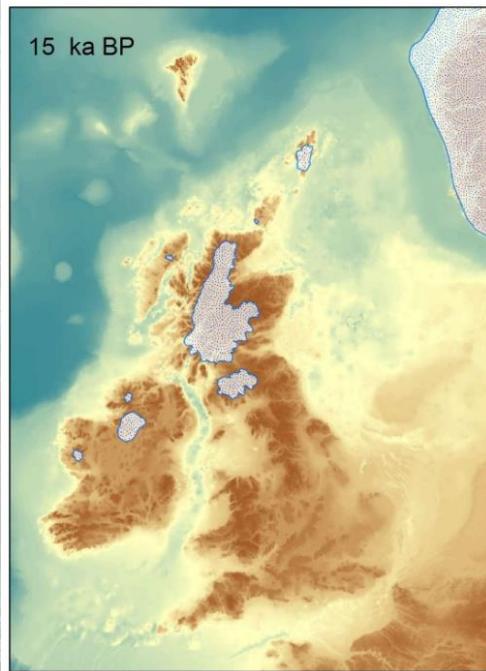
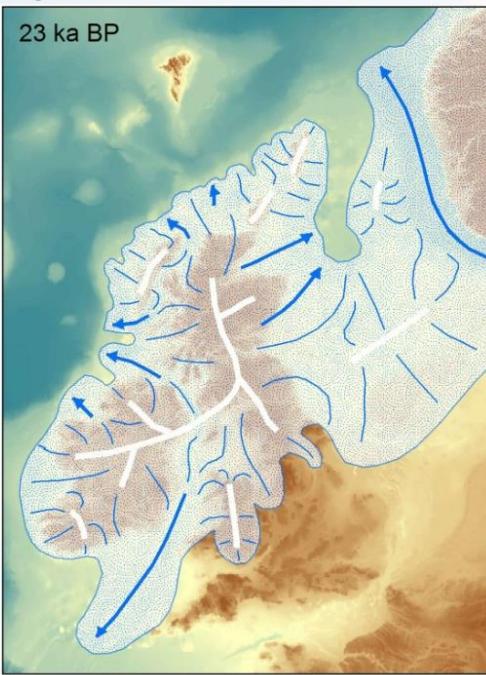
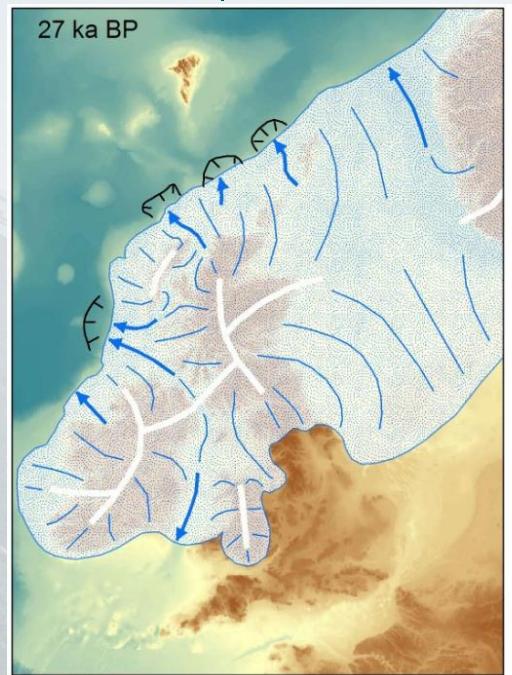
3 main phases recorded

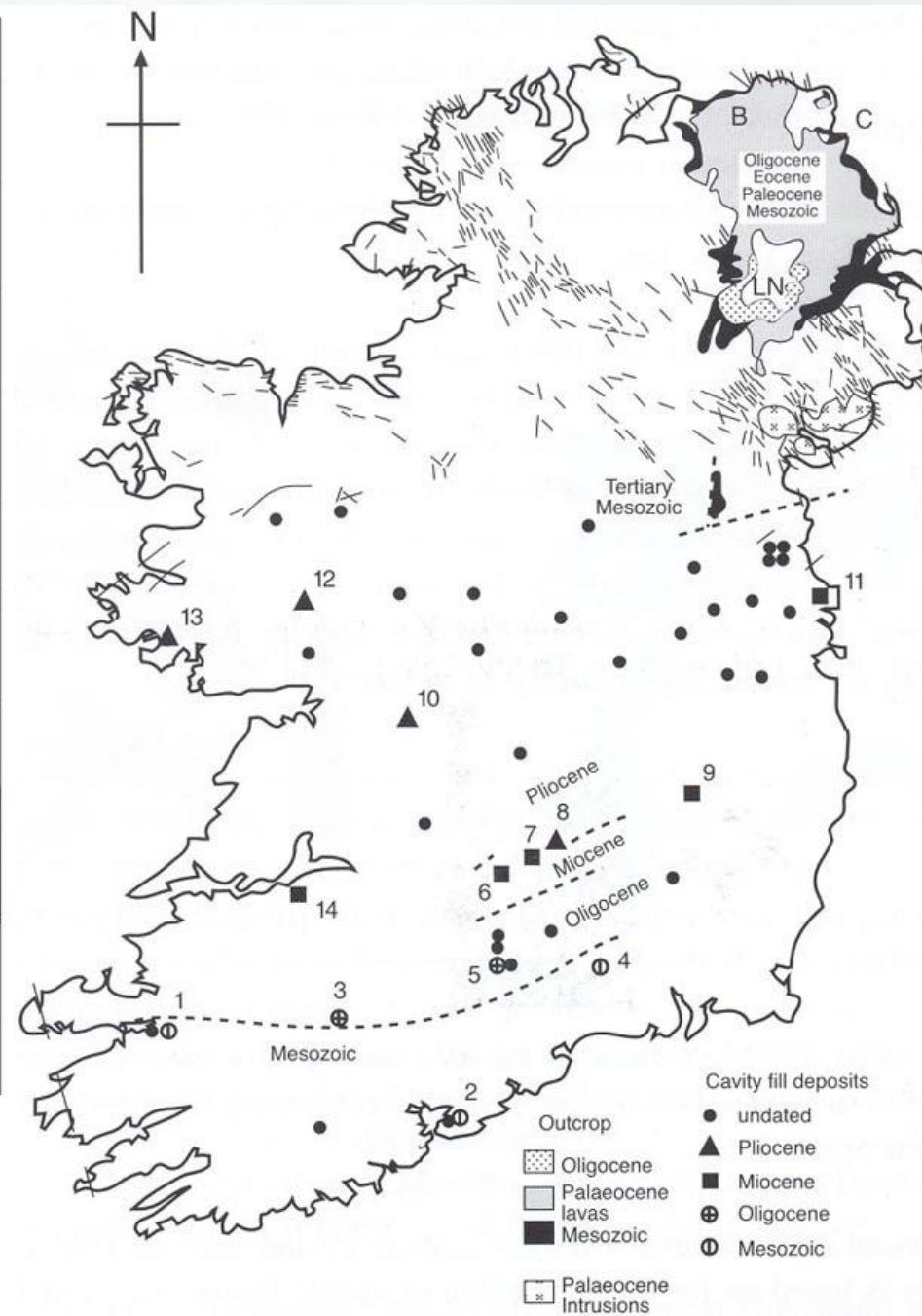
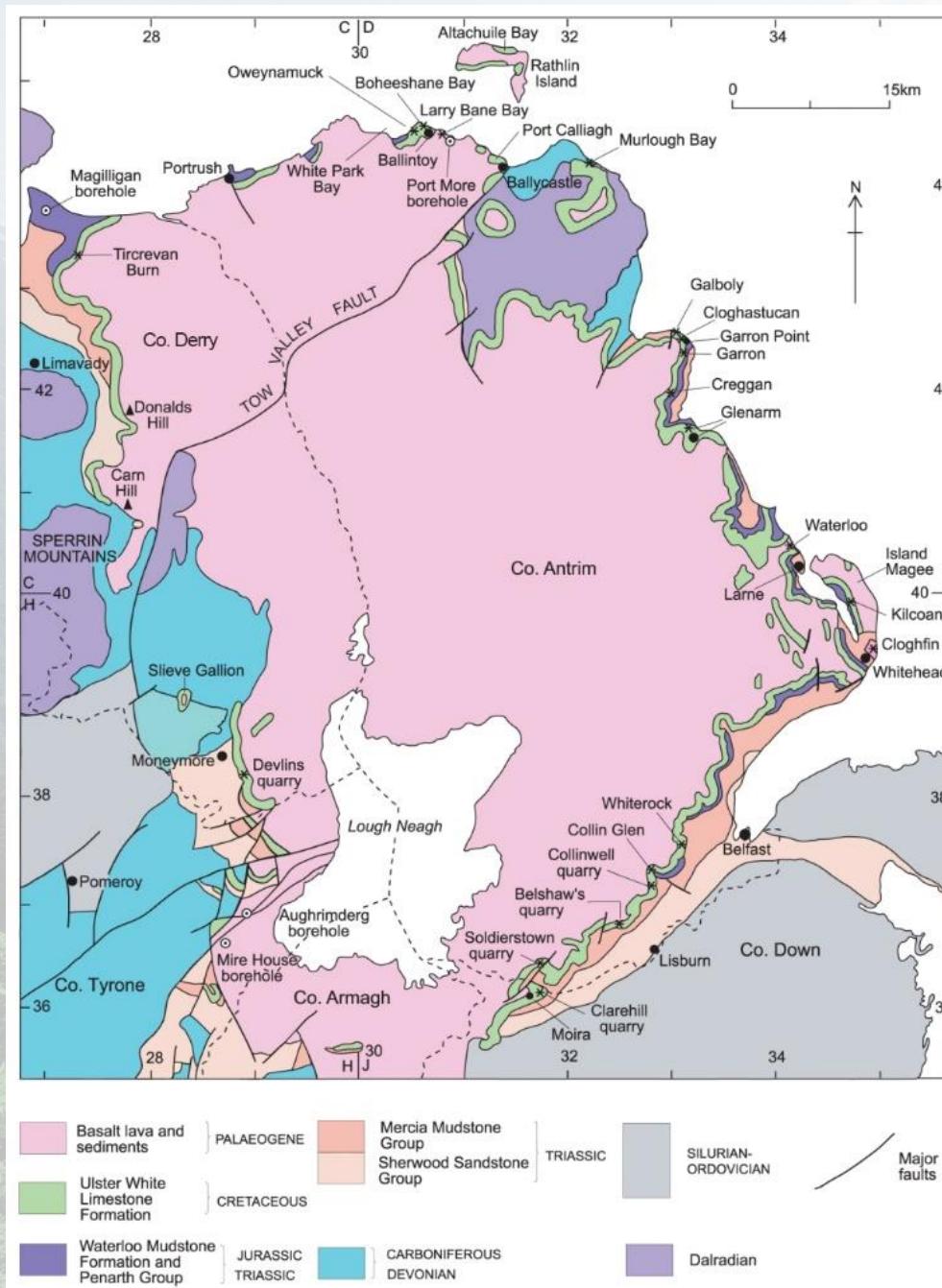
- Anglian (450 Ka)
- Munsterian (Wolstonian) (300-130 Ka)
- Midlandian (Devensian) (80-10 Ka)
- Ended around 10 Ka
- There may have been older ice ages; but if so, the evidence has been removed by these later glacial phases

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, Solas and Stephens. See Keys on opposite page.

6



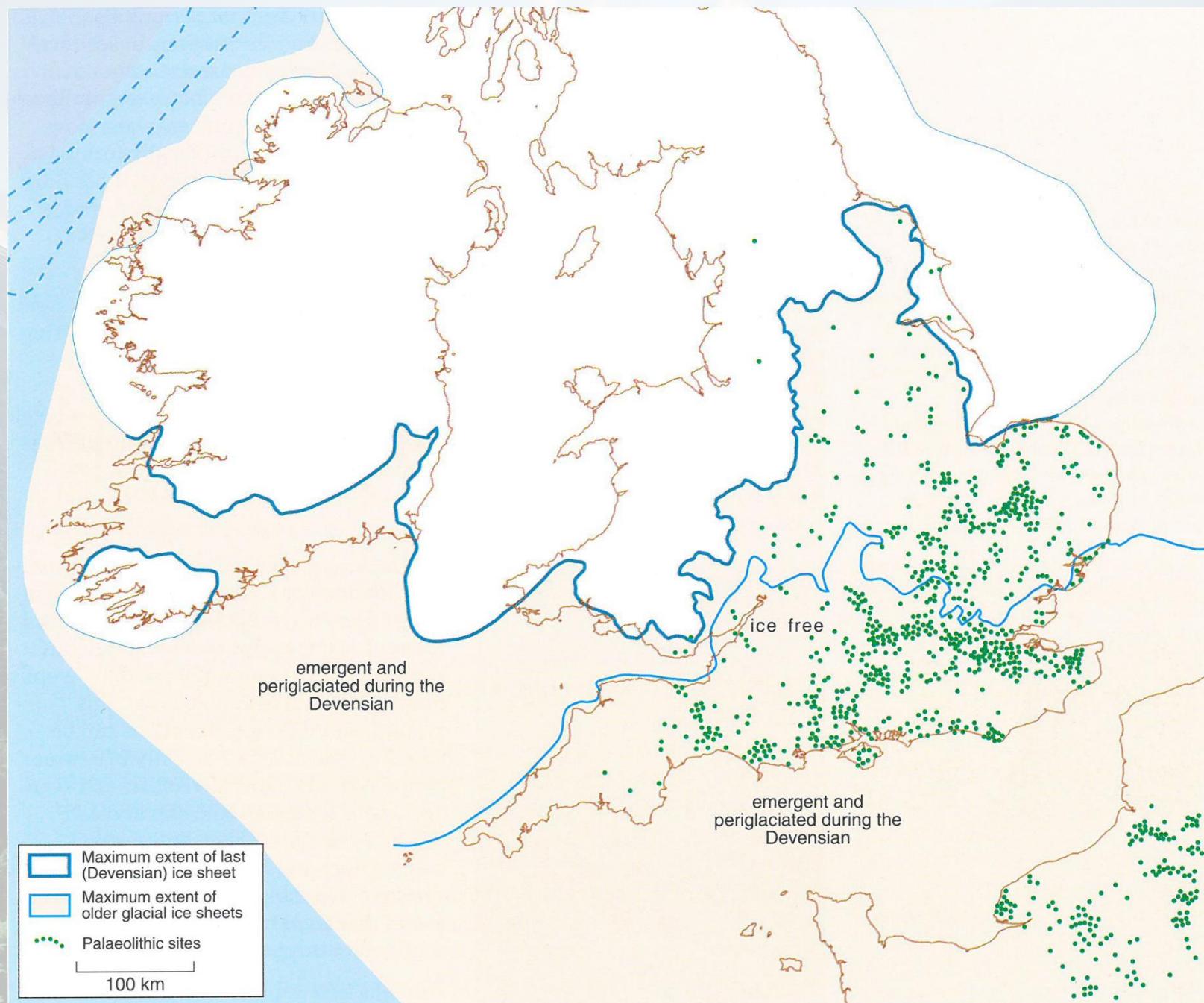






## Humans!

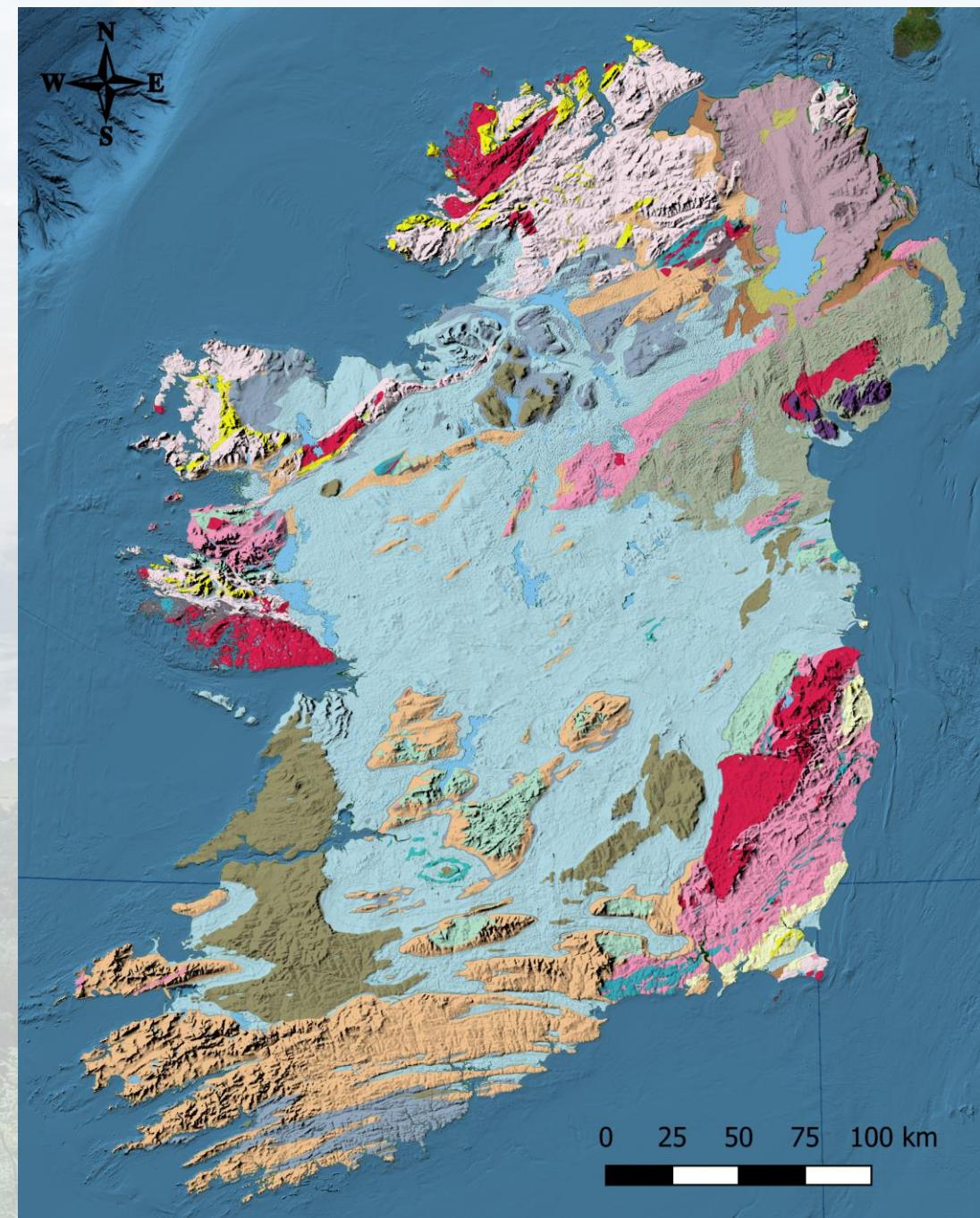
- Evidence of humans in Britain dates as far back as 700-950 Ka stone tools
- Neanderthals 400-50 Ka
- *Homo sapiens* lived in Britain from 40 Ka, but continuously only since 12 Ka
- Oldest complete skeleton: Cheddar Man, from Gough's Cave, Cheddar Gorge, England





## 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