

Landscape evolution of southwest Wales: revelations of a dynamic Earth

PETER KOKELAAR

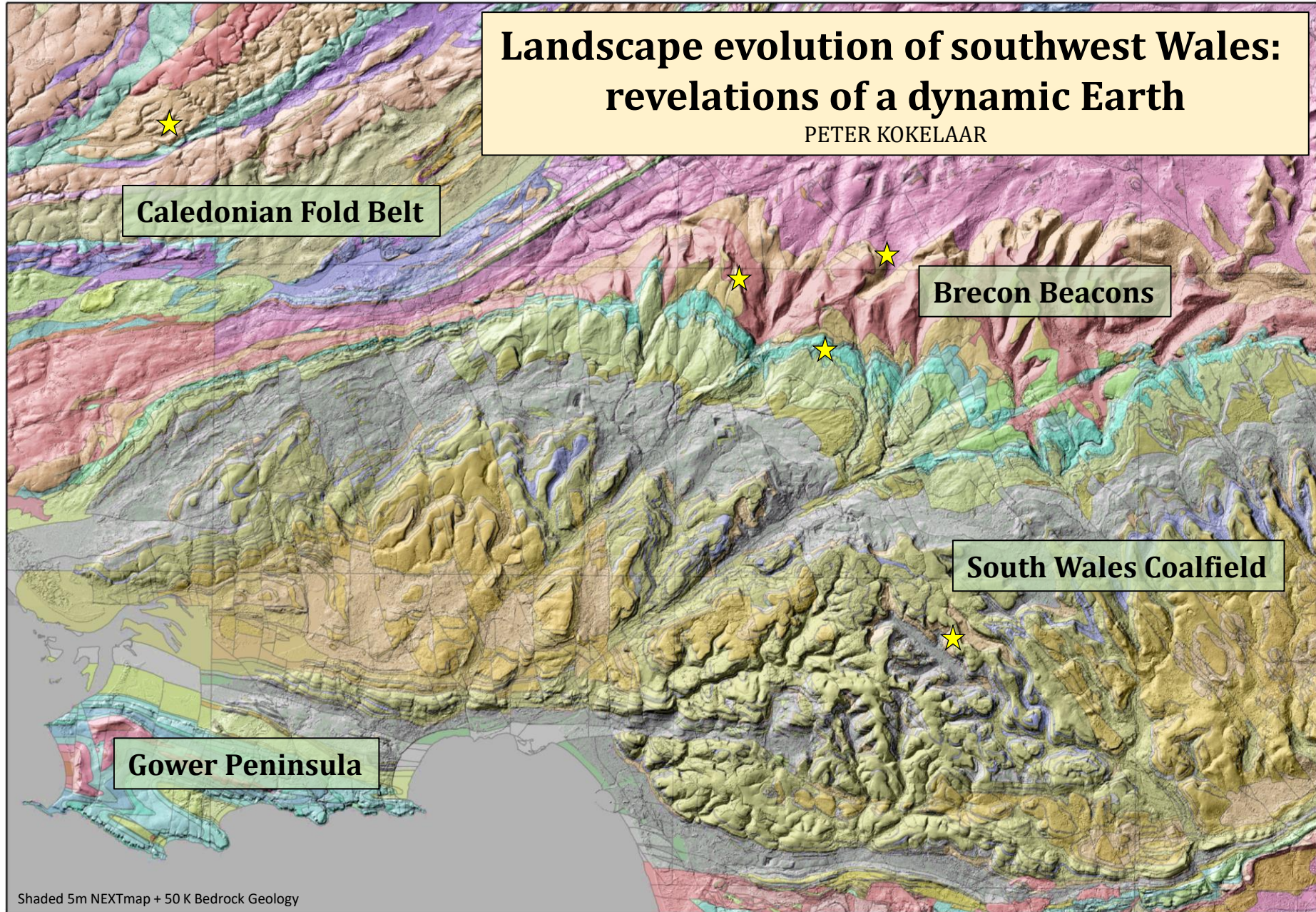
Caledonian Fold Belt

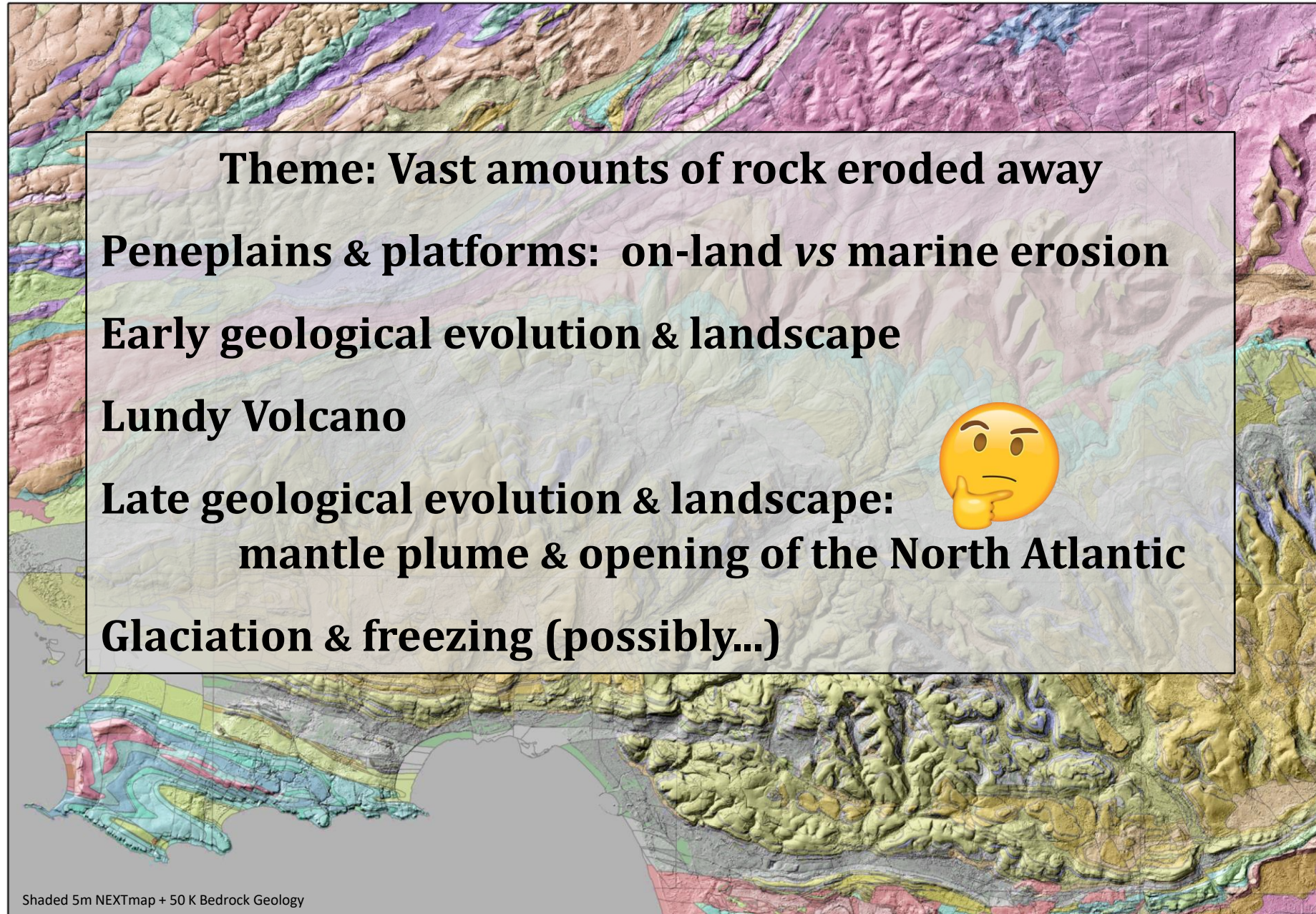
Brecon Beacons

South Wales Coalfield

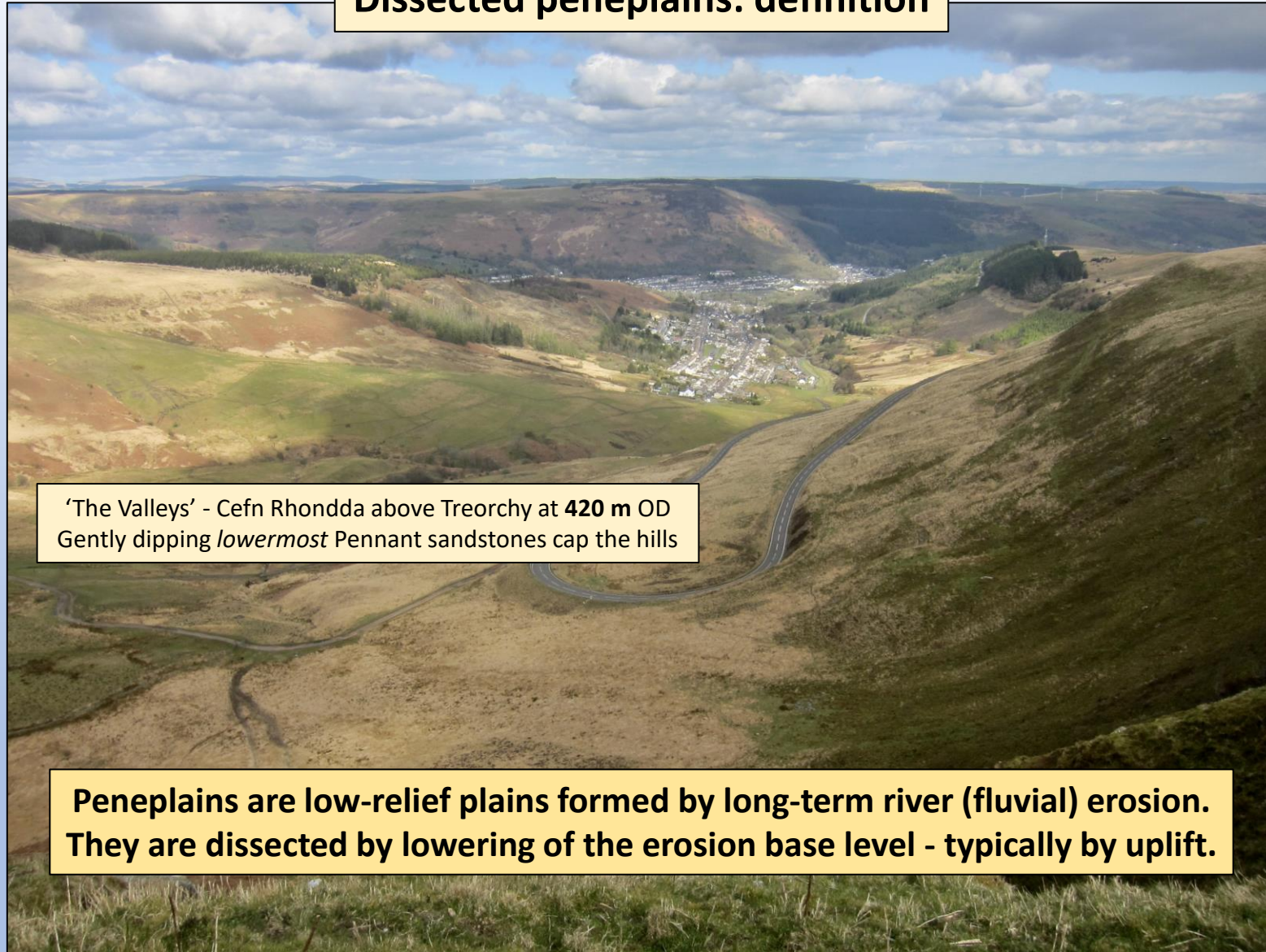
Gower Peninsula

Shaded 5m NEXTmap + 50 K Bedrock Geology



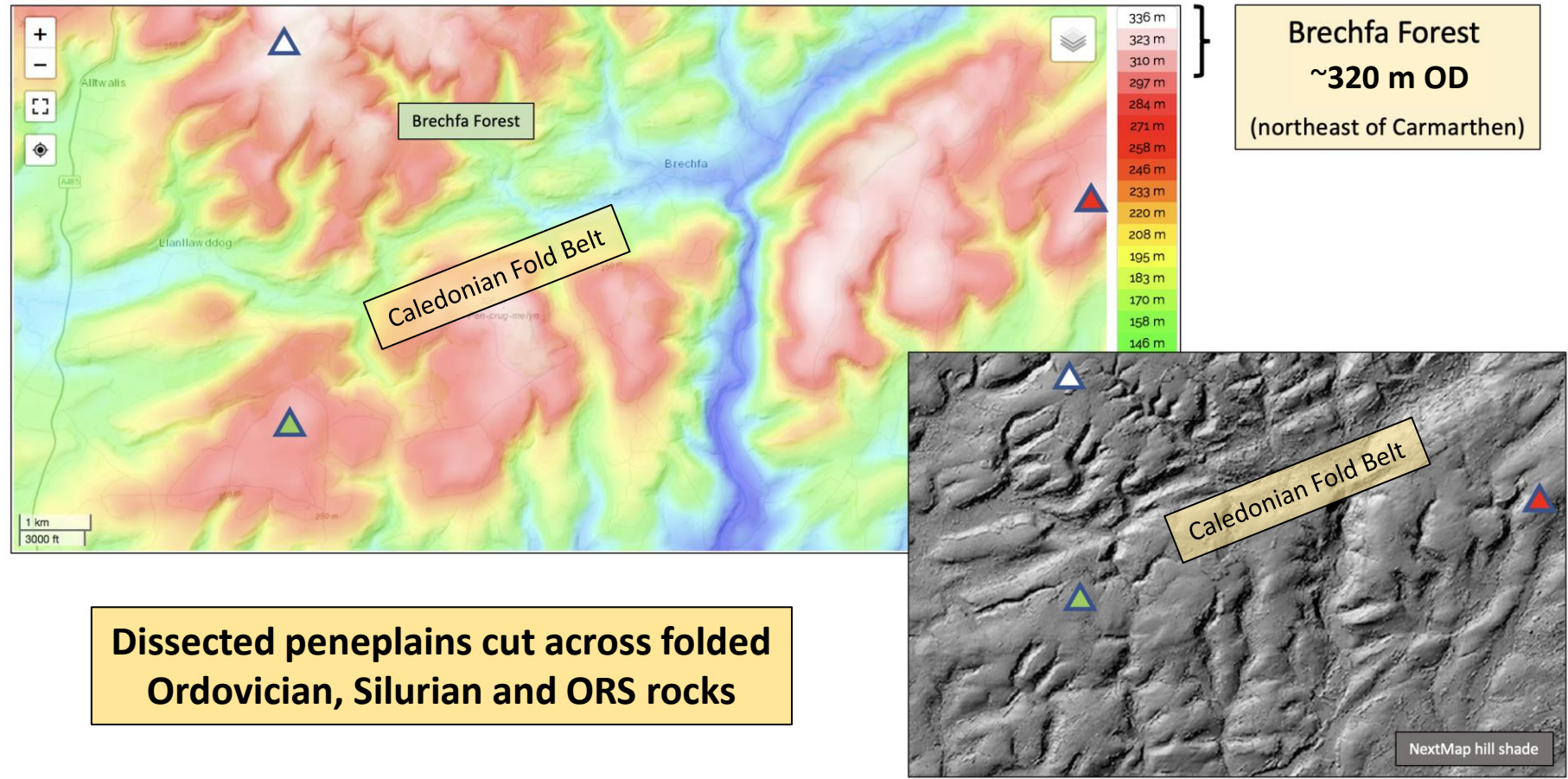


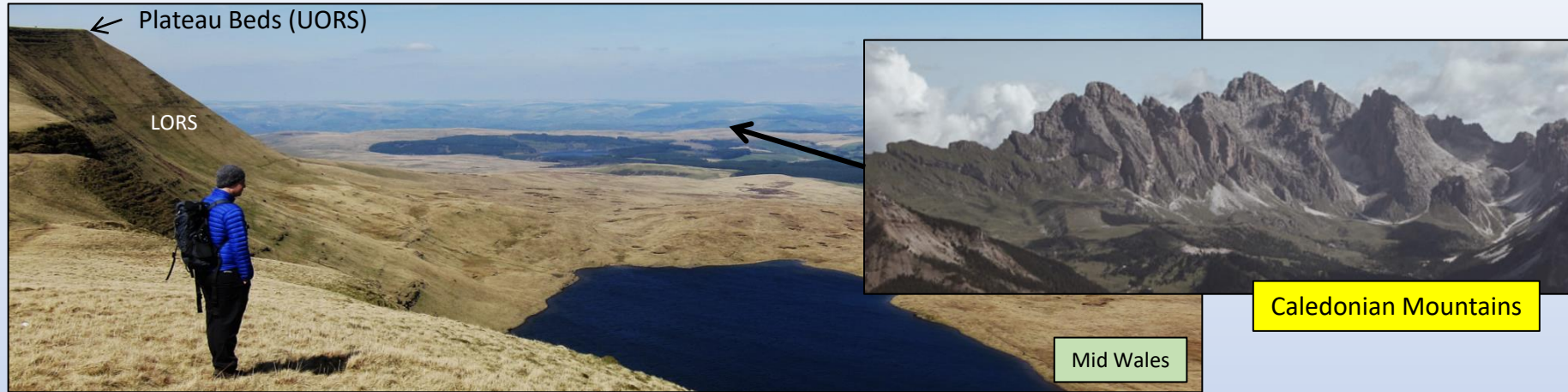
Dissected peneplains: definition



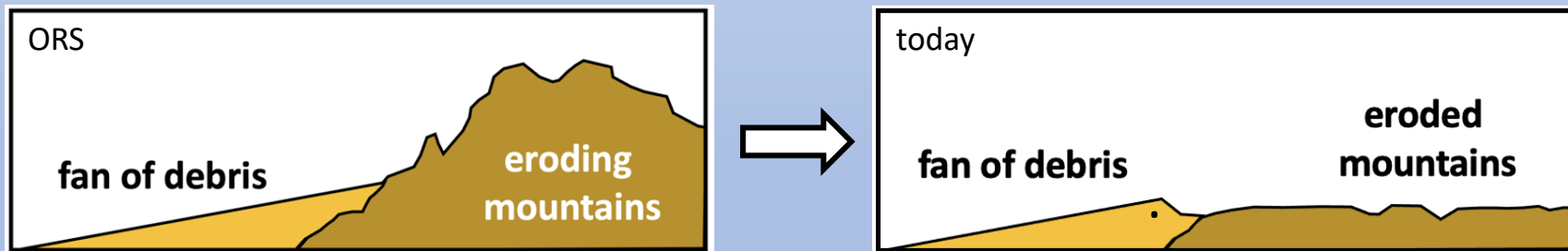
'The Valleys' - Cefn Rhondda above Treorchy at **420 m OD**
Gently dipping *lowermost* Pennant sandstones cap the hills

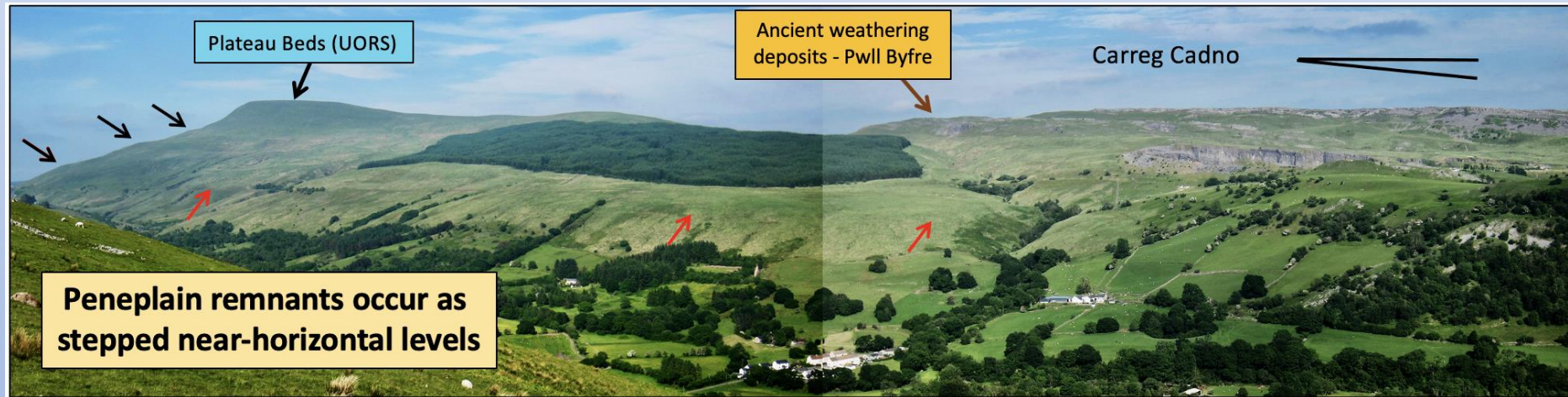
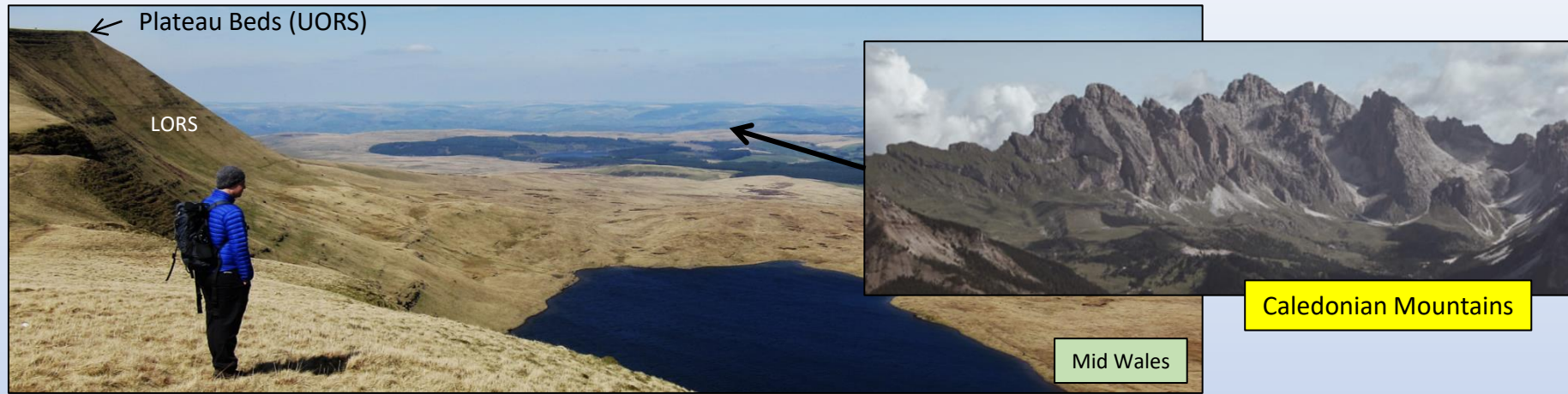
Peneplains are low-relief plains formed by long-term river (fluvial) erosion. They are dissected by lowering of the erosion base level - typically by uplift.

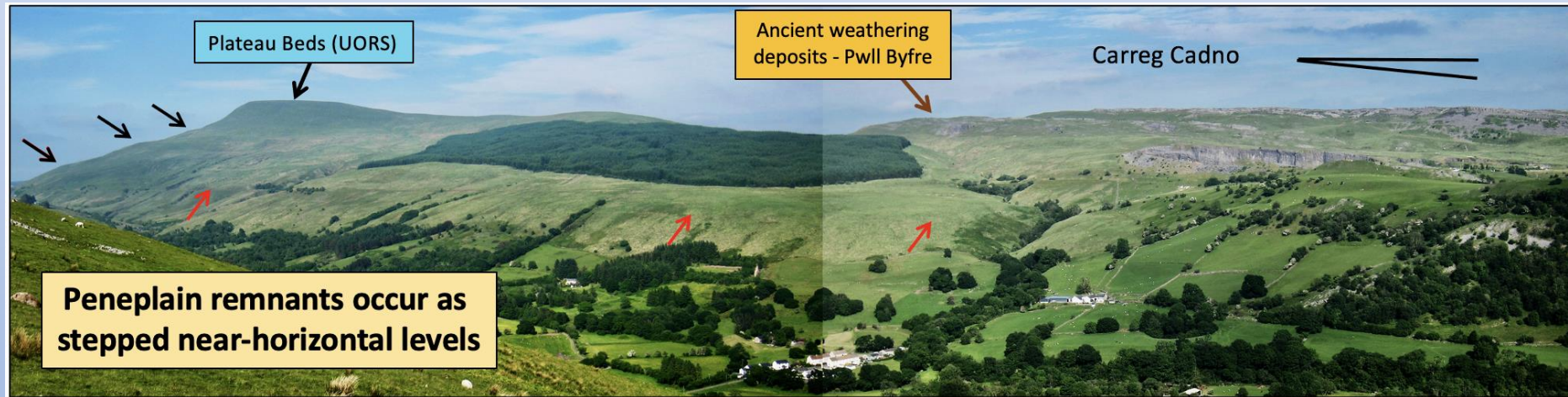
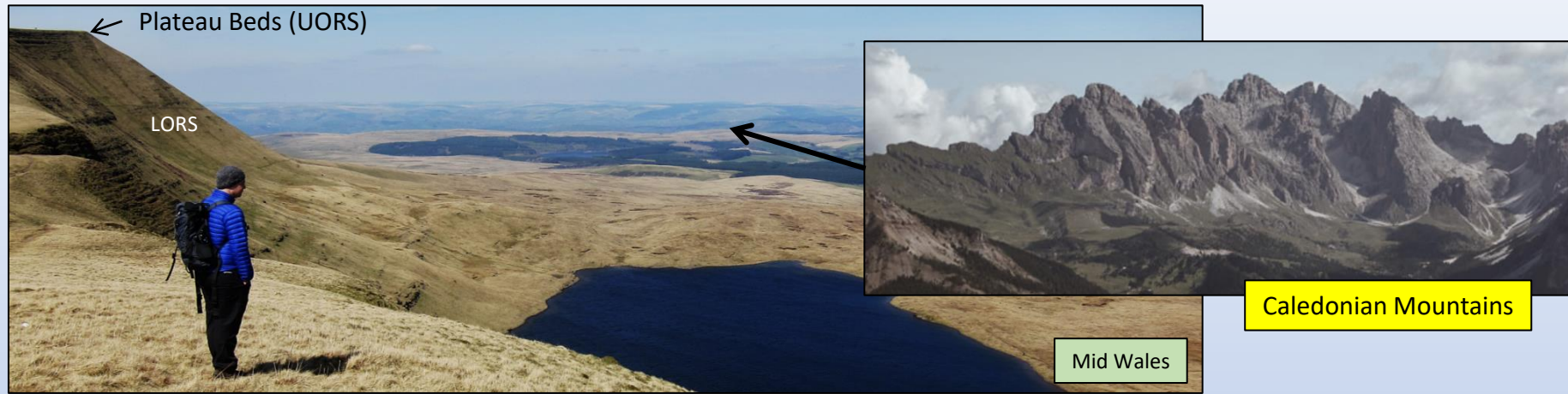




Vast volumes of rock have been eroded away

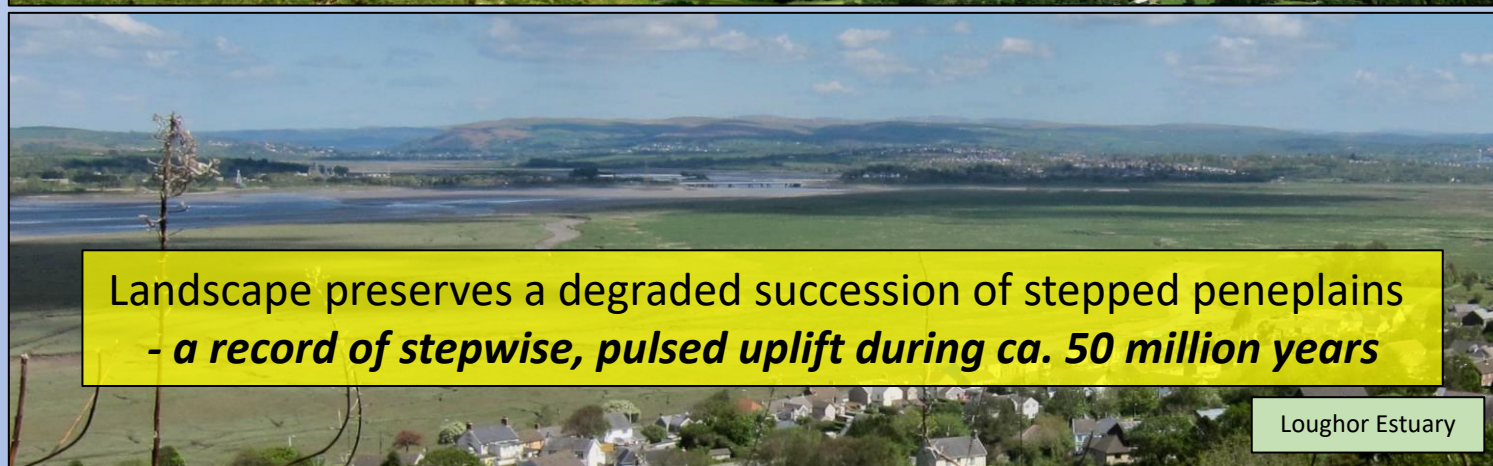


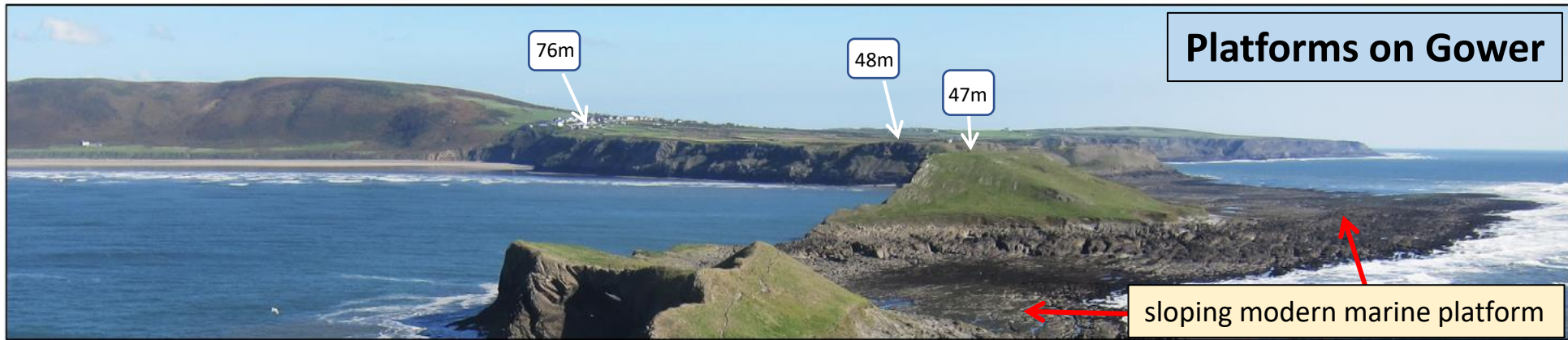




Vast volumes of rock have been eroded away *stepwise*

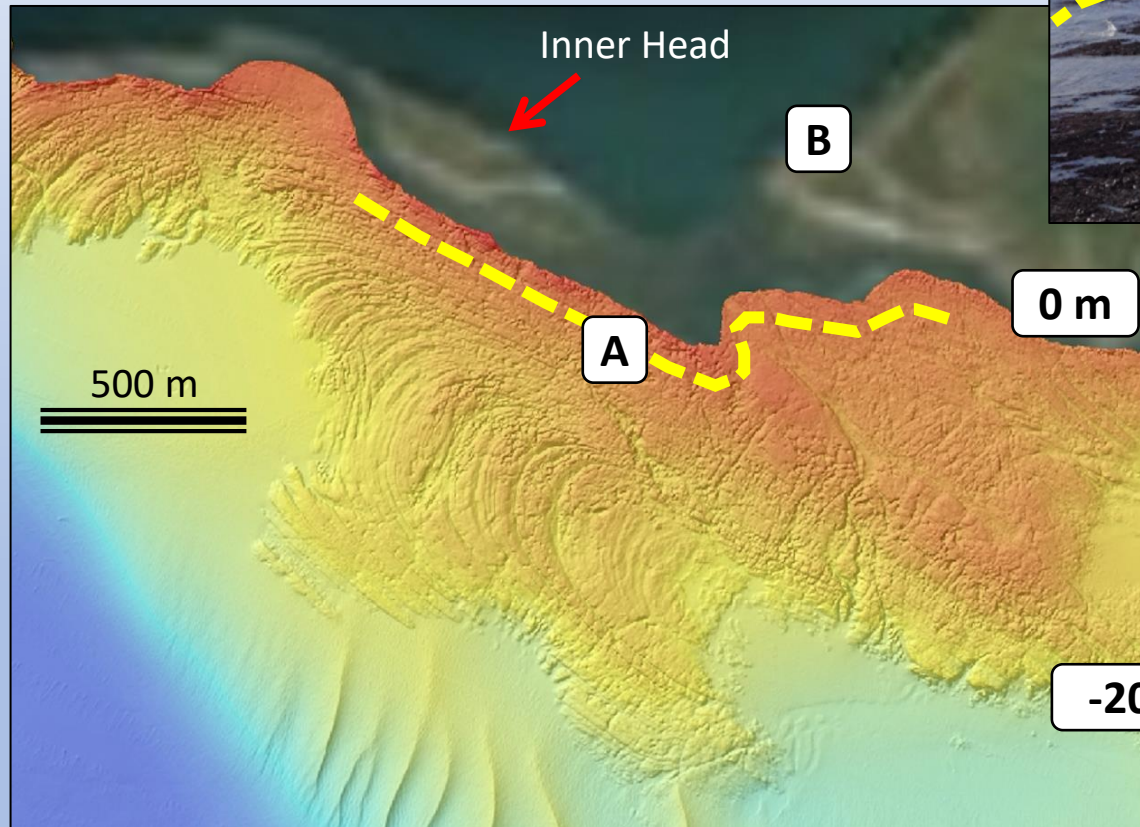
Dissected peneplains





Platforms on Gower

The modern platform slopes evenly across eroded rock strata



Exposed platform **A** to **B** is 500 m wide
Entire sloping platform is almost 1.5 km wide
extending down to a submerged cliff at
-20 to -25 m

Base image multibeam bathymetry from The Admiralty Marine Data Portal,
kindly processed and provided by Gareth Carter (BGS)

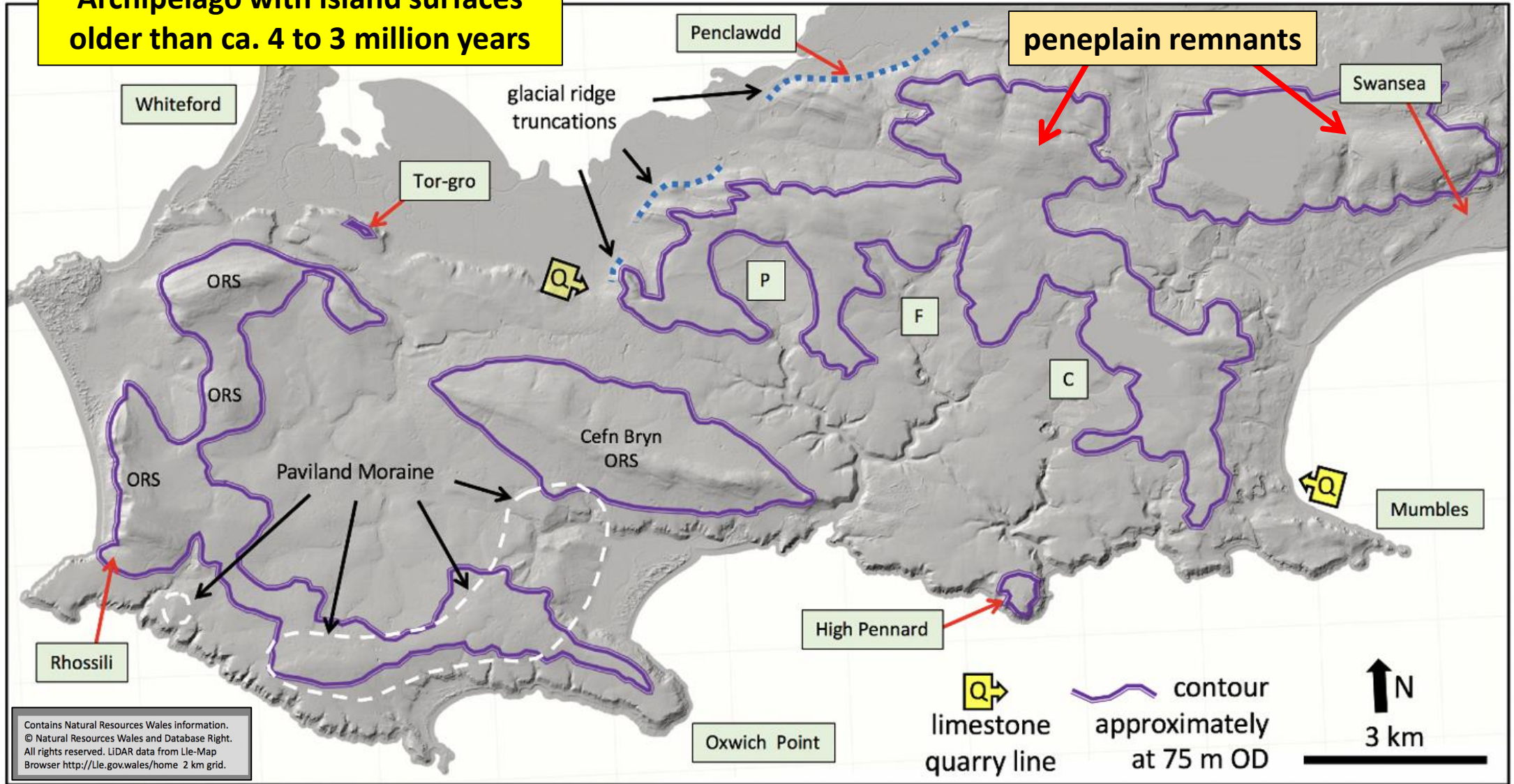
Platforms on Gower

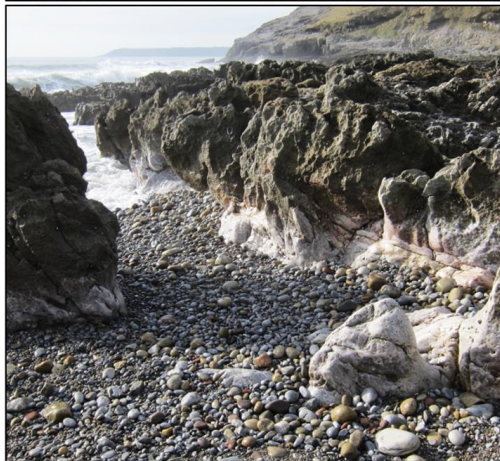


So-called '200 foot' (61 m) platform slopes up broadly northwards to ~75 m OD. It was cut by marine erosion ca. 4 to 3 million years ago

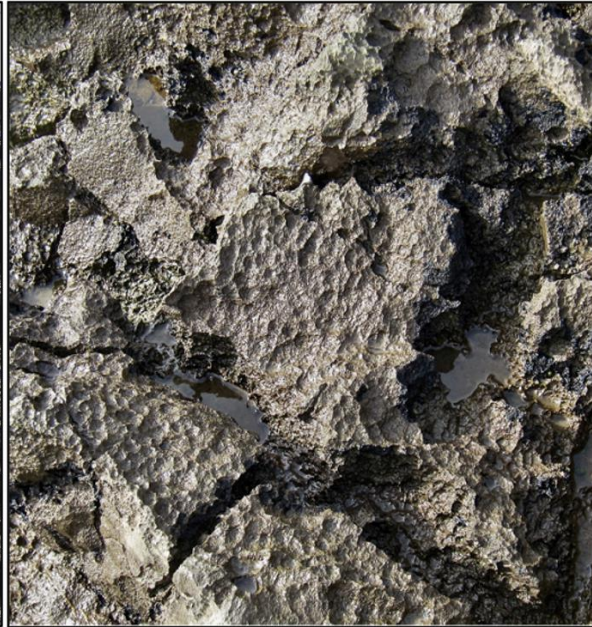


Archipelago with island surfaces older than ca. 4 to 3 million years



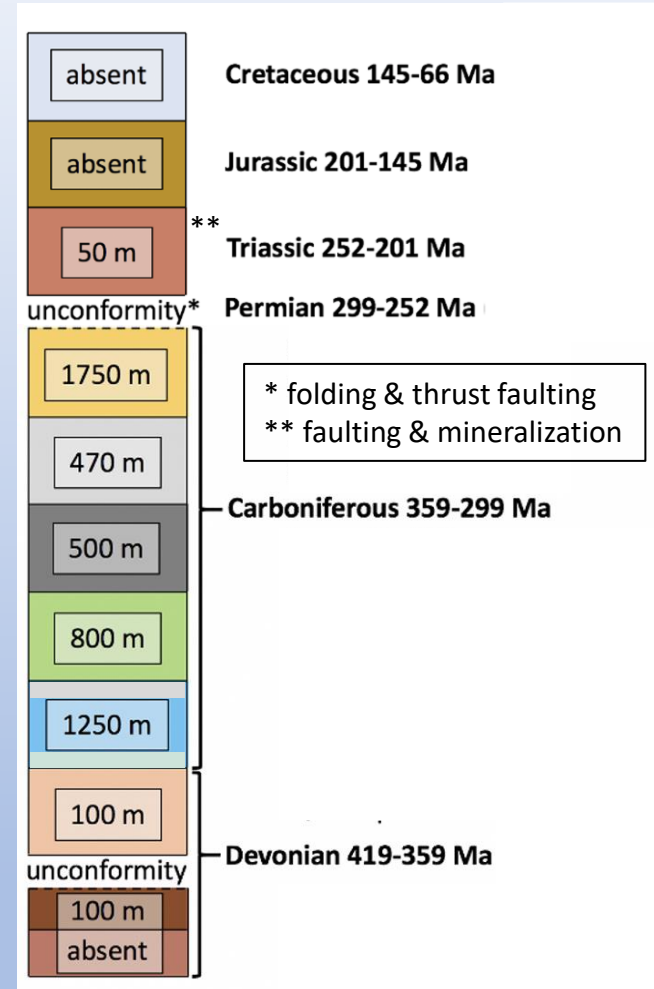
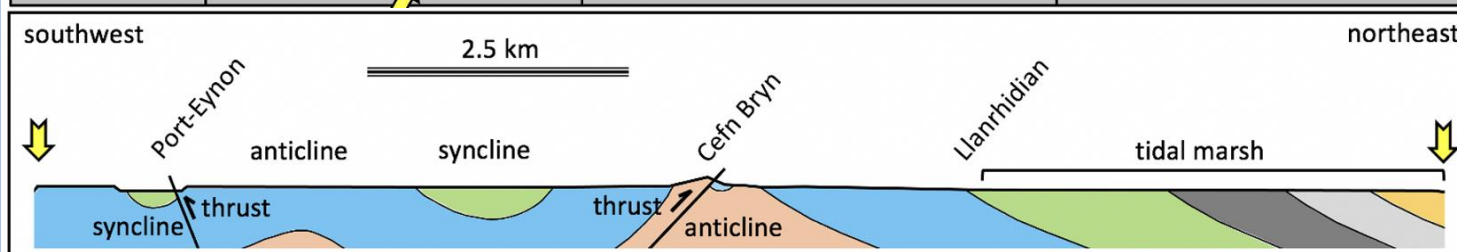
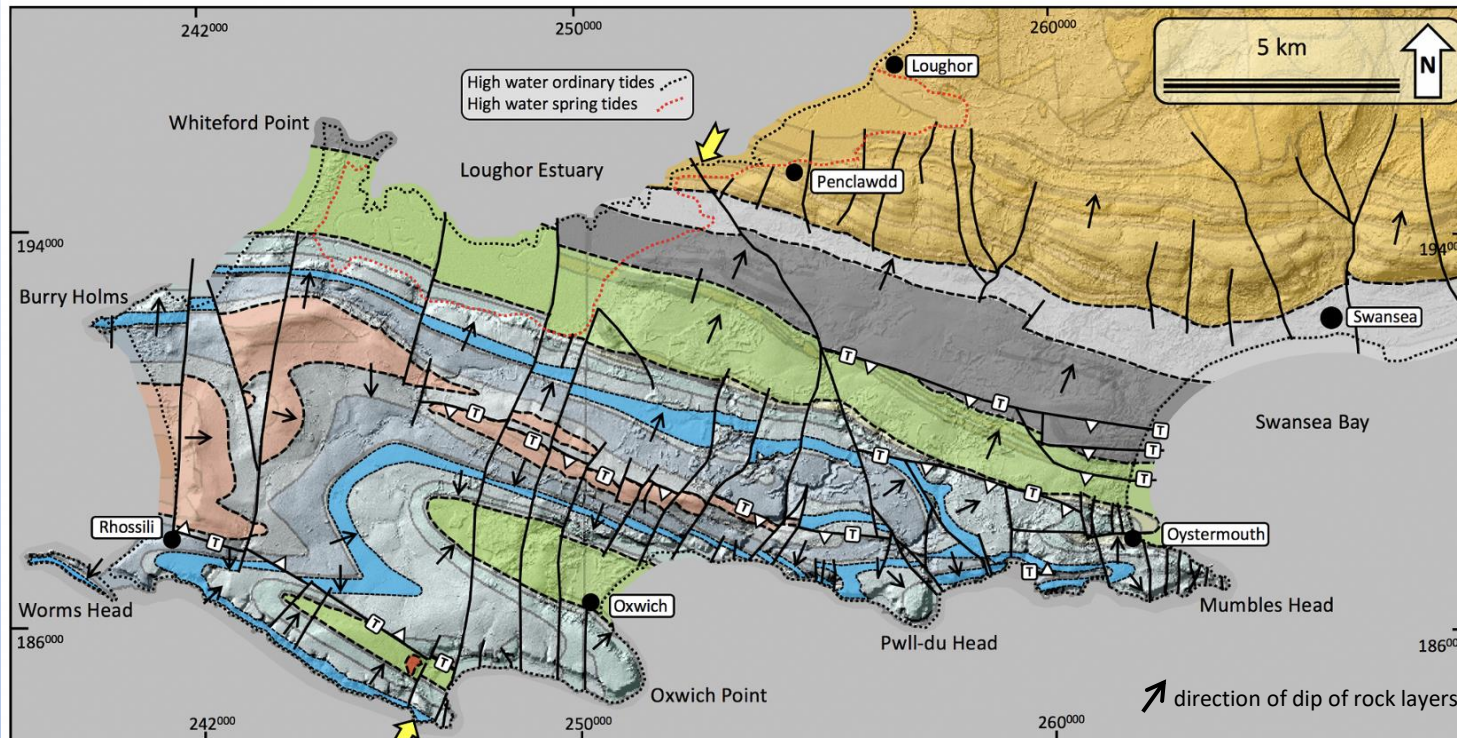


Platform cut by marine abrasion

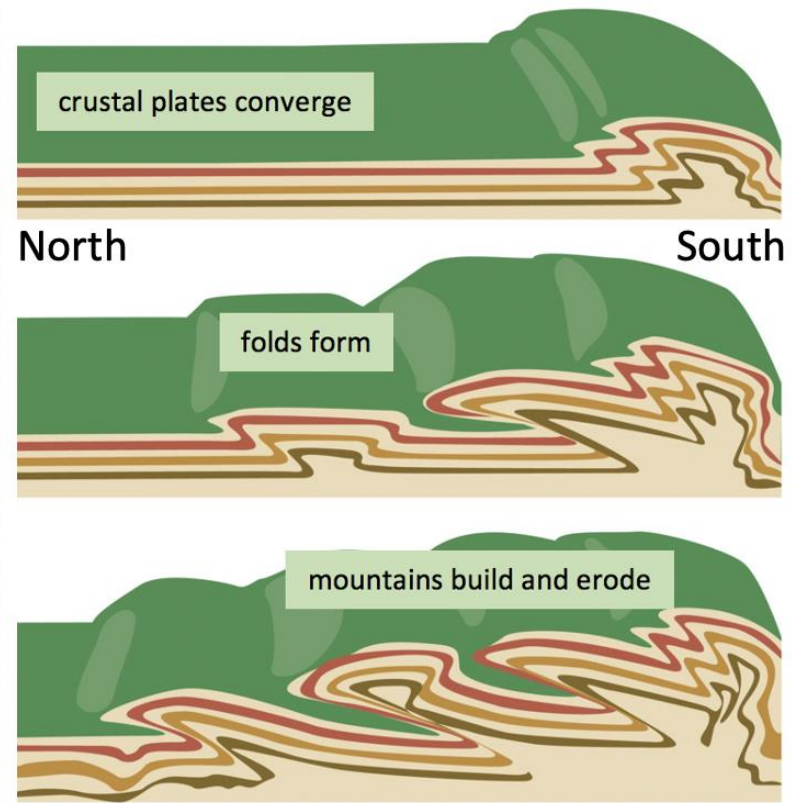
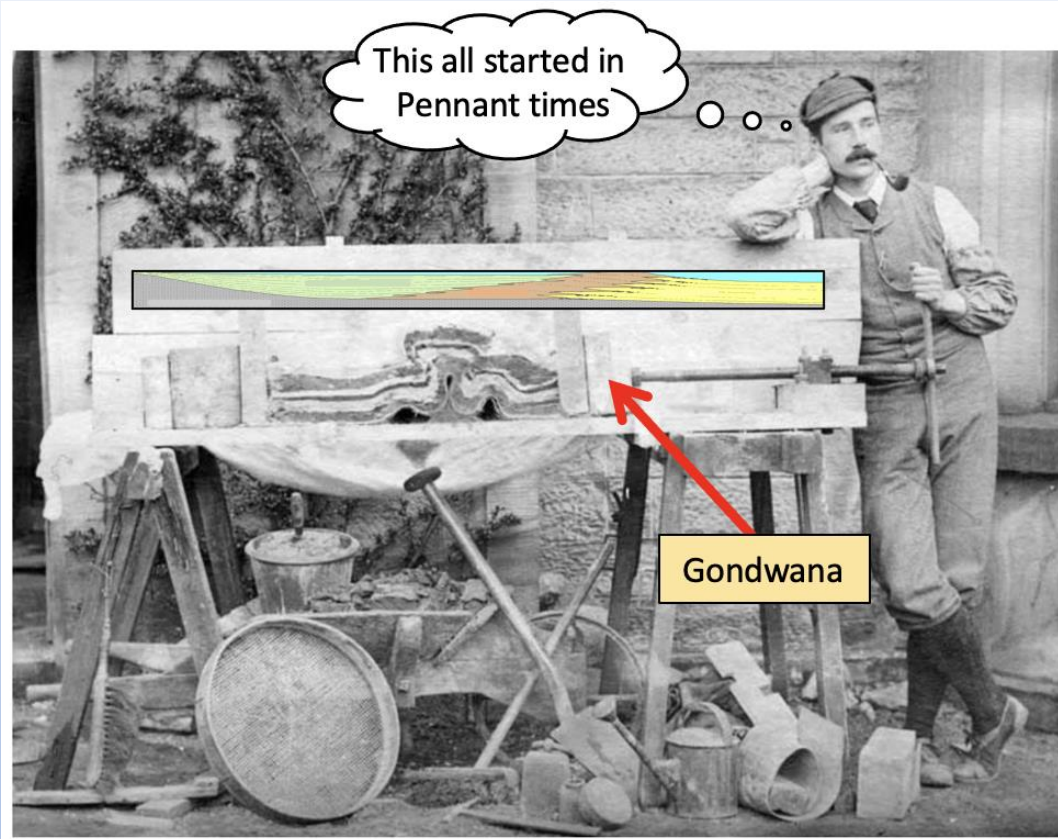


Platform cut by marine dissolving of limestone

A little geology...



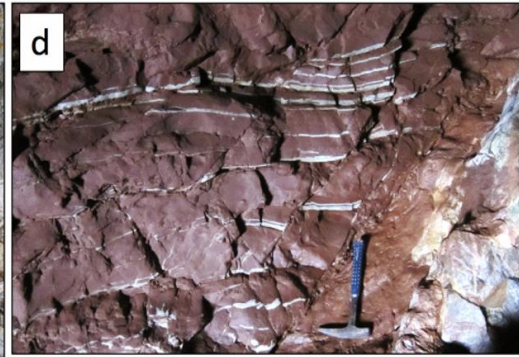
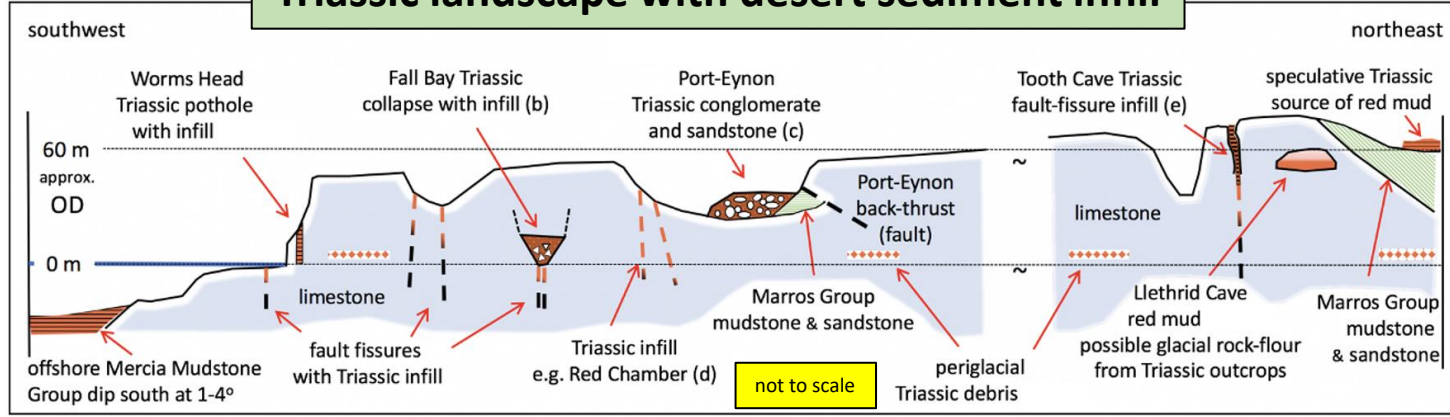
Map simplified from images originally provided to the author by BGS © UKRI and derived in part from NextMap Britain elevation data provided under licence to BGS from Intermap Technologies.



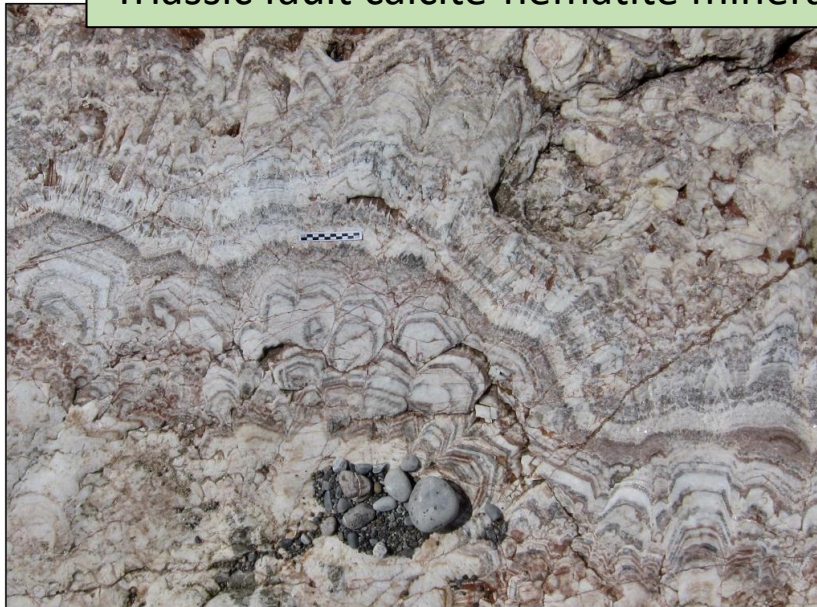
Gower folds formed 300-290 million years ago - Early Permian times

Pennant sandstones record early mountain uplift to the south

Triassic landscape with desert sediment infill



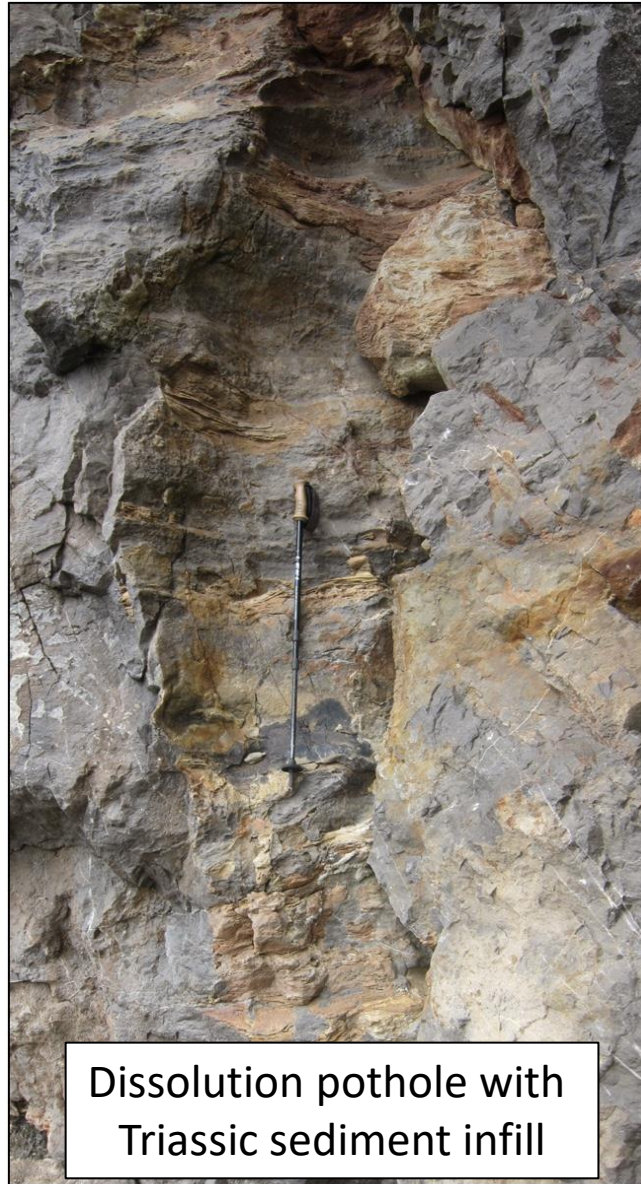
Triassic fault calcite-hematite mineralization - probably beneath hot springs



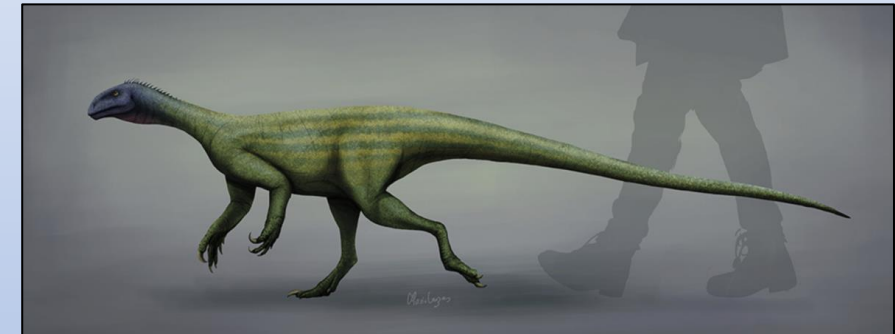
Worms Head Triassic karst



~ 201 million years old!



Dissolution pothole with
Triassic sediment infill



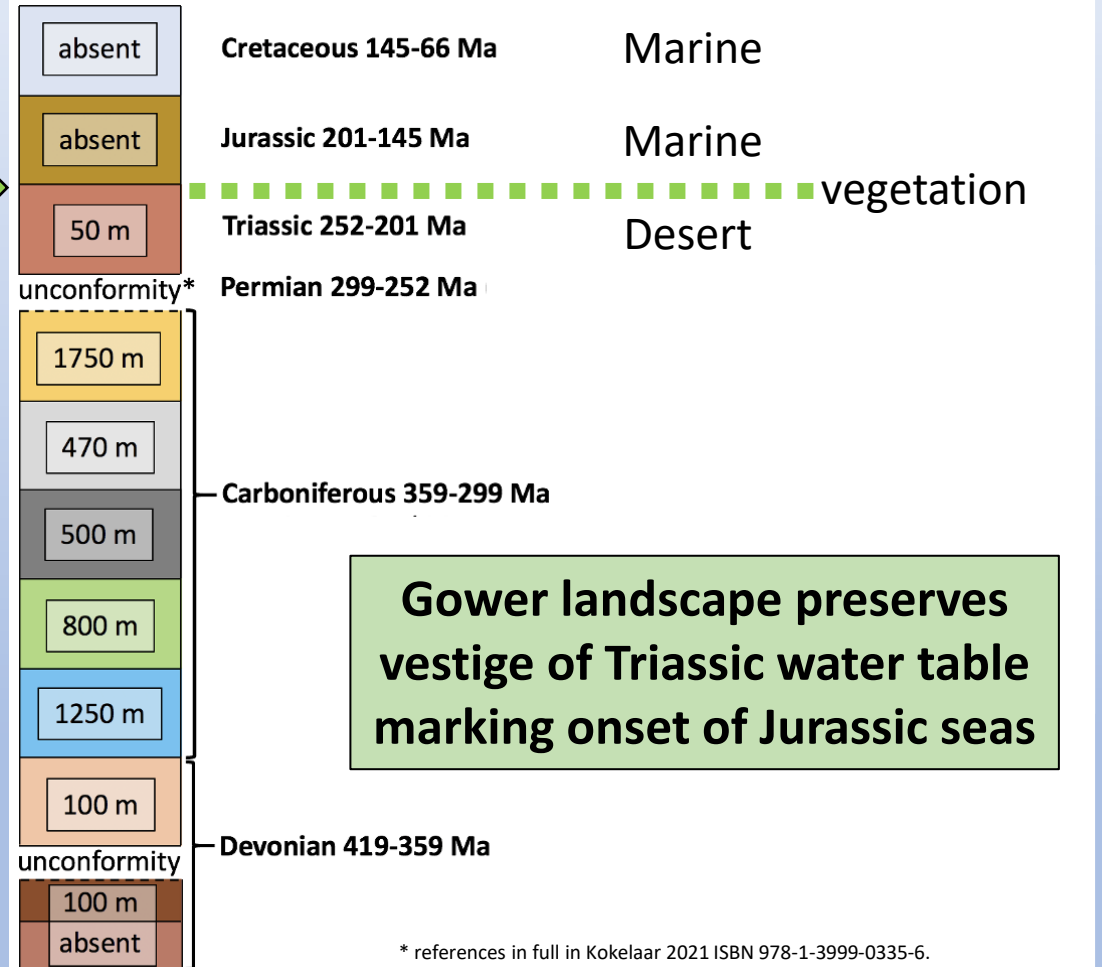
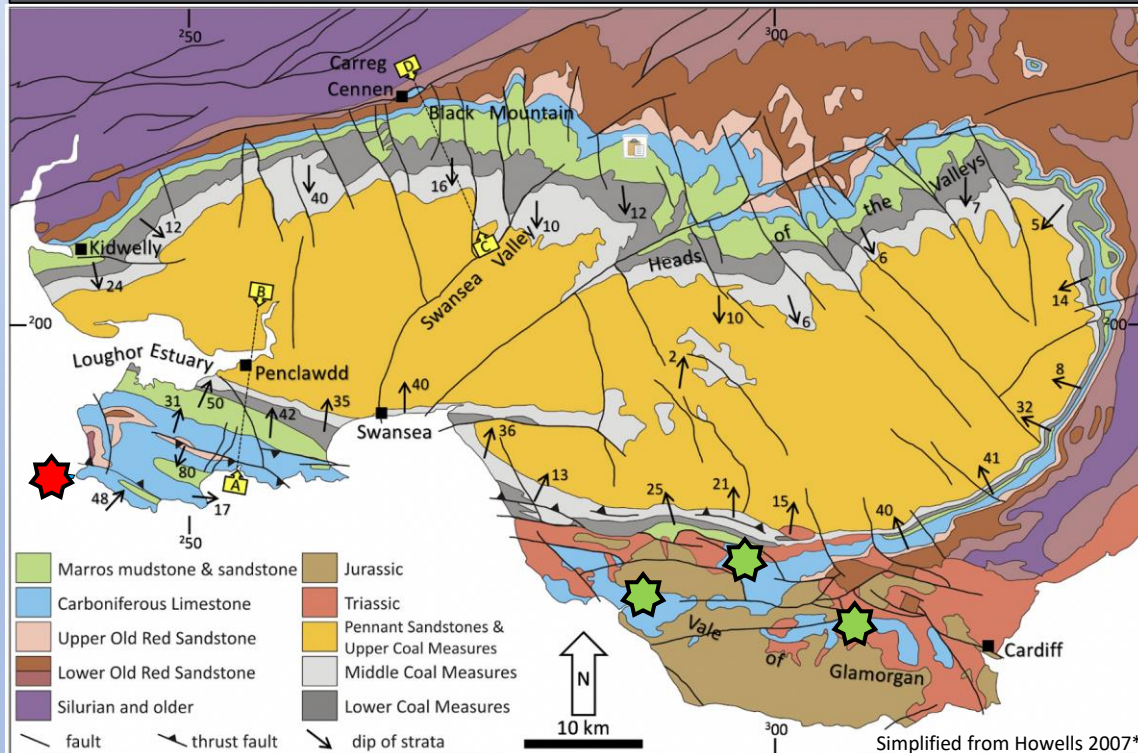
by Mario Lanzas

Contemporary herbivore

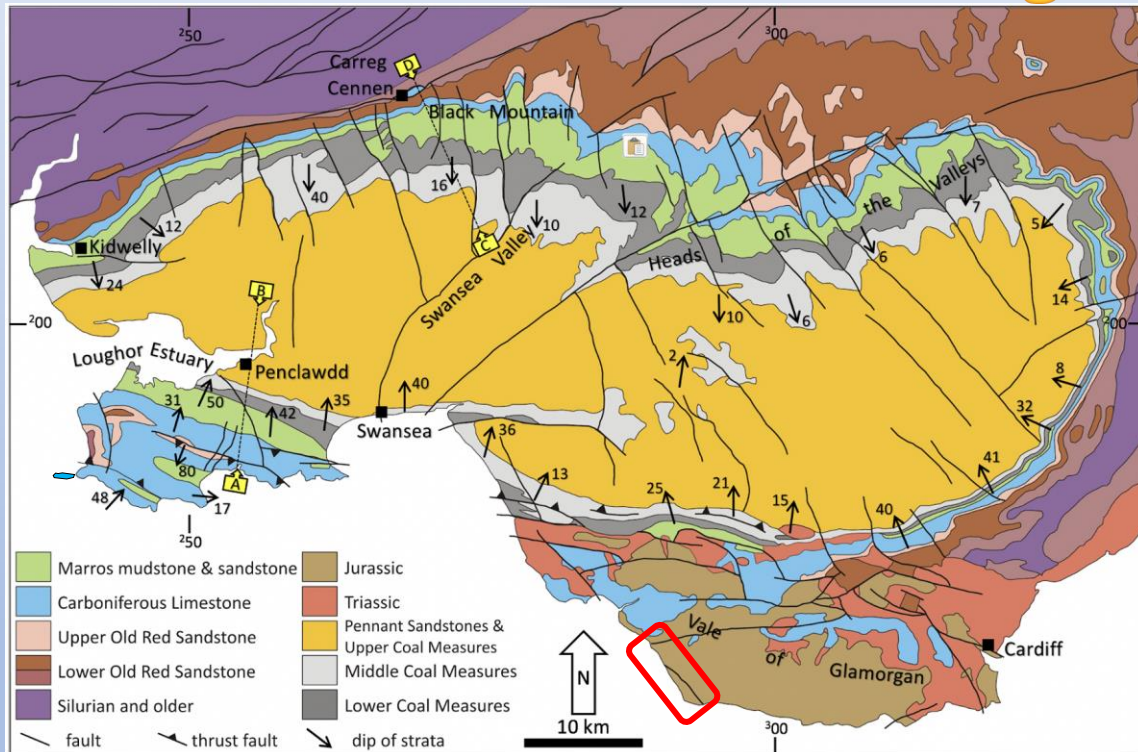
Herbivore Thecodontosaurus



★ = latest Trias in limestone fissures locally with fossils of early plant-eating reptiles



Jurassic marine sediments probably covered Gower peninsula like south Glamorgan... but now are eroded off. Why is that? 🤔

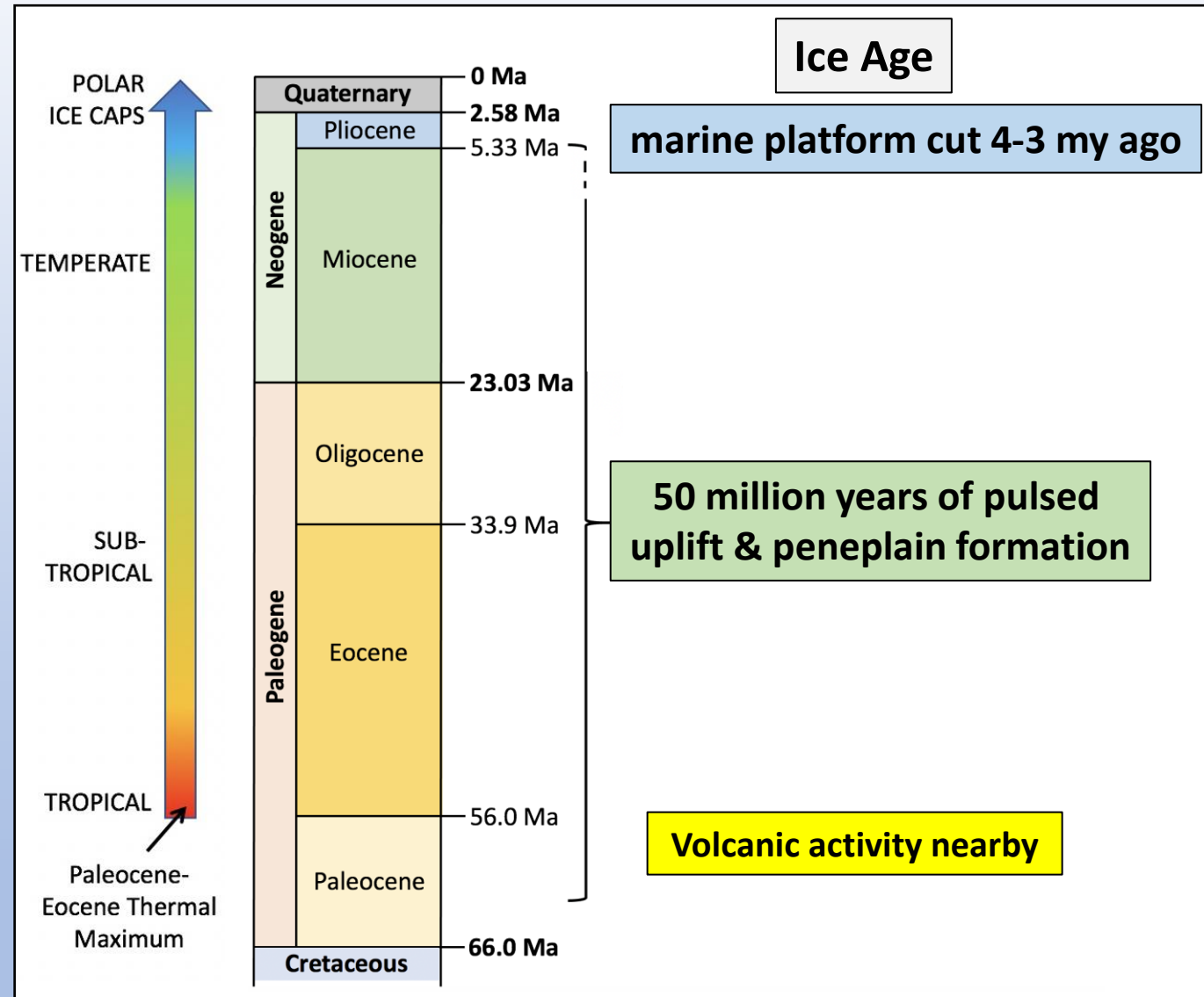


absent	Cretaceous 145-66 Ma	Marine sedimentation? (no evidence on Gower)
absent	Jurassic 201-145 Ma	Marine sedimentation (rocks eroded off Gower)
50 m	Triassic 252-201 Ma	Desert sedimentation
unconformity*	Permian 299-252 Ma (no rocks)	Rock deformation, uplift & erosion

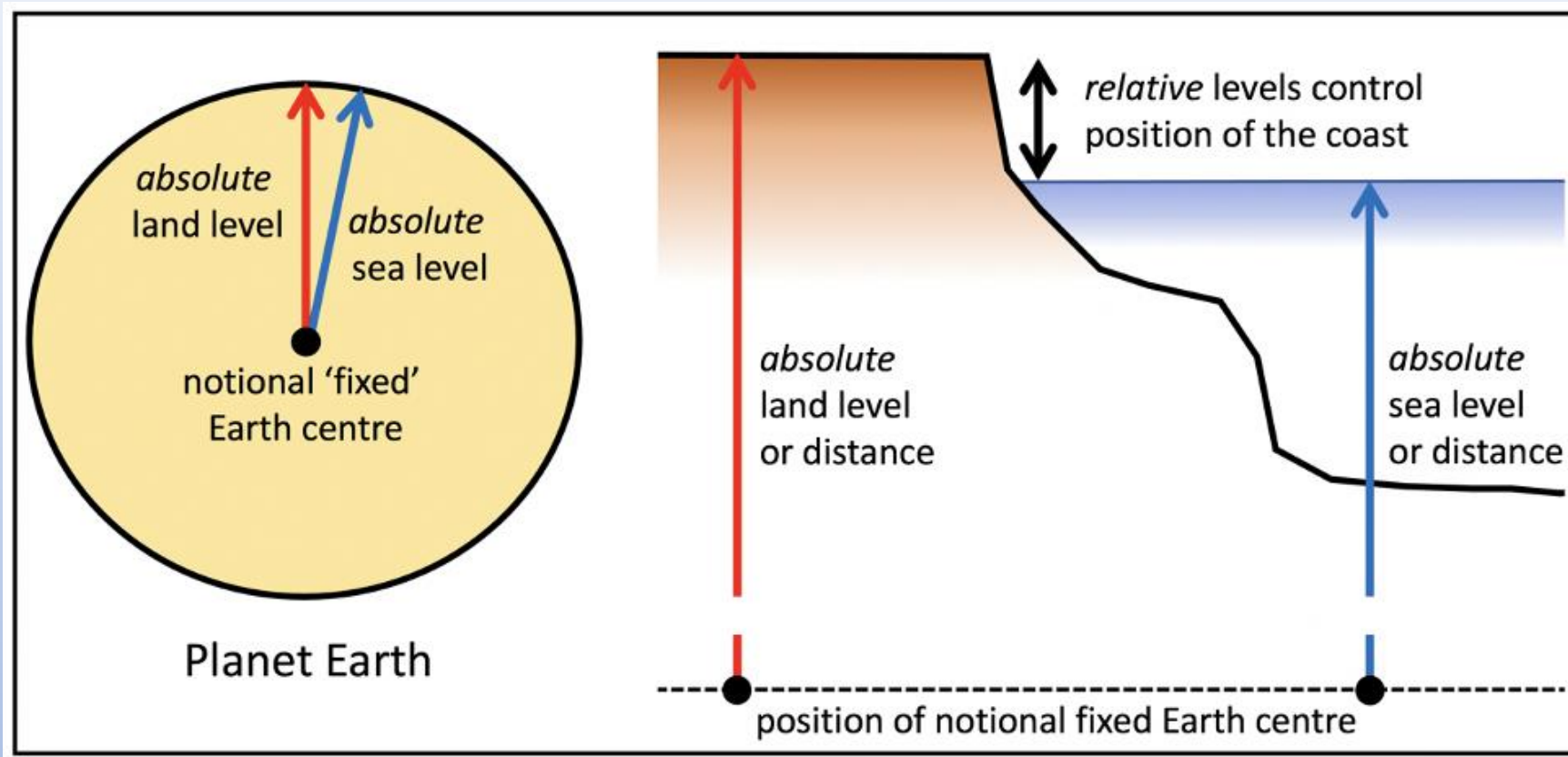


Vast volumes of rock have been eroded away

Conditions affecting southern Wales after Cretaceous times

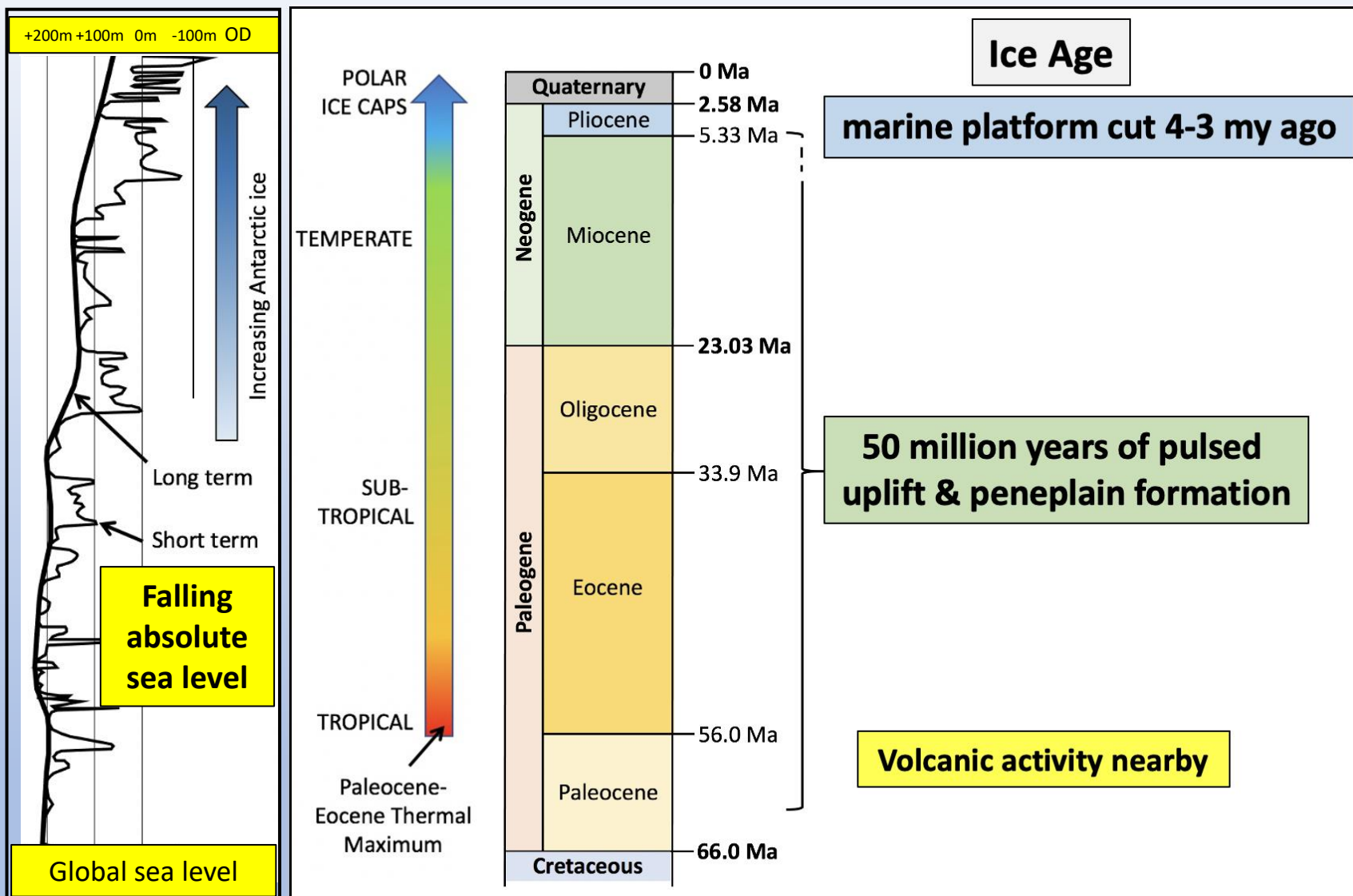


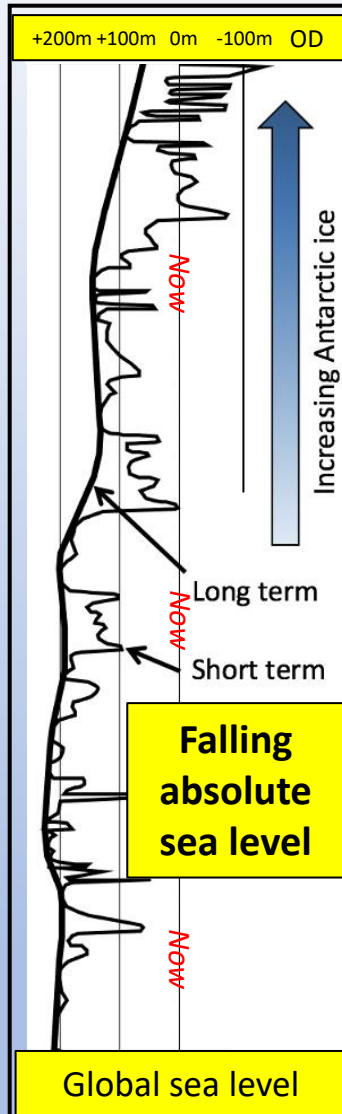
Absolute versus relative levels



To understand the landscape, we must be concerned with changes of **absolute** levels and hence their effect on relative levels



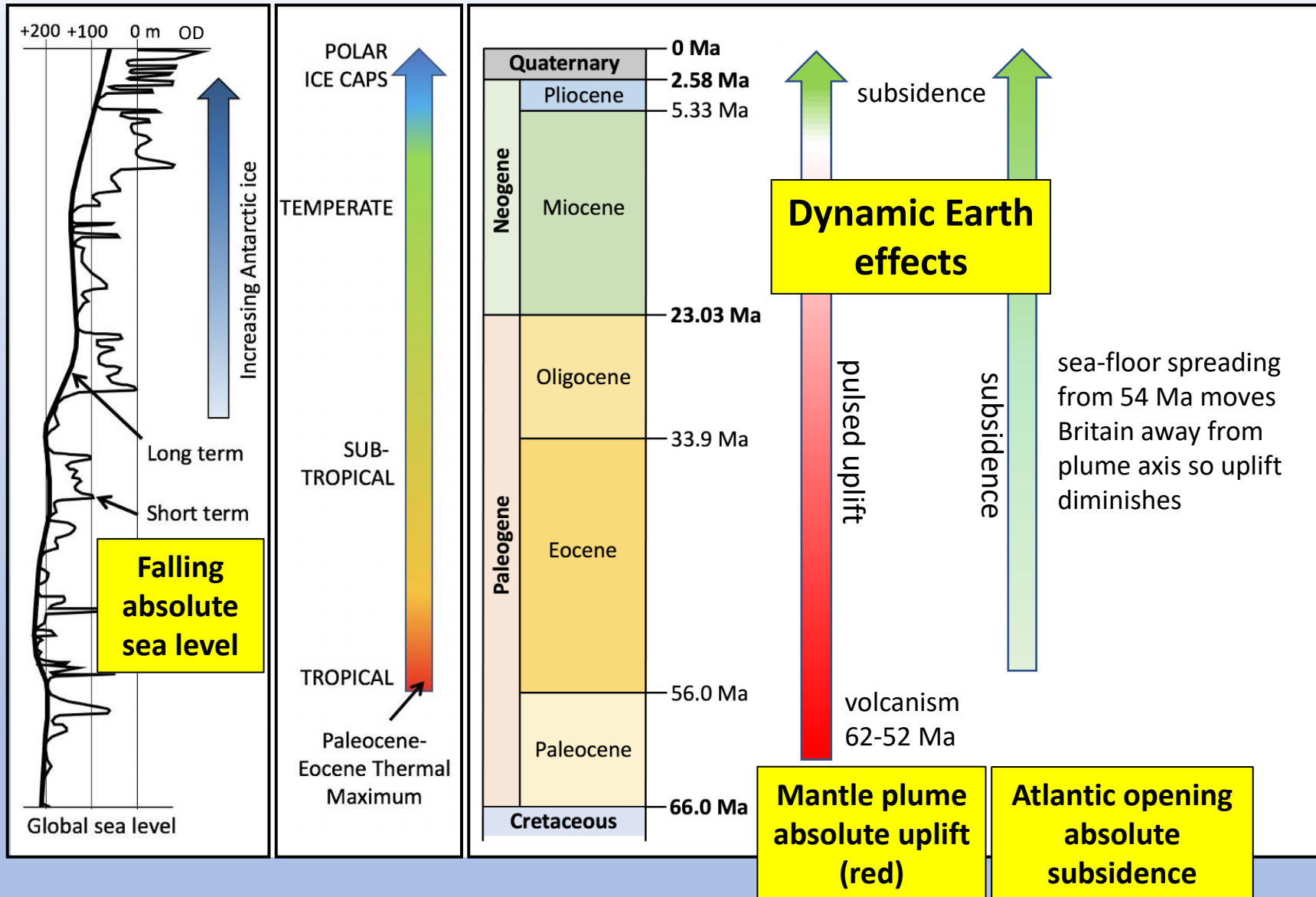


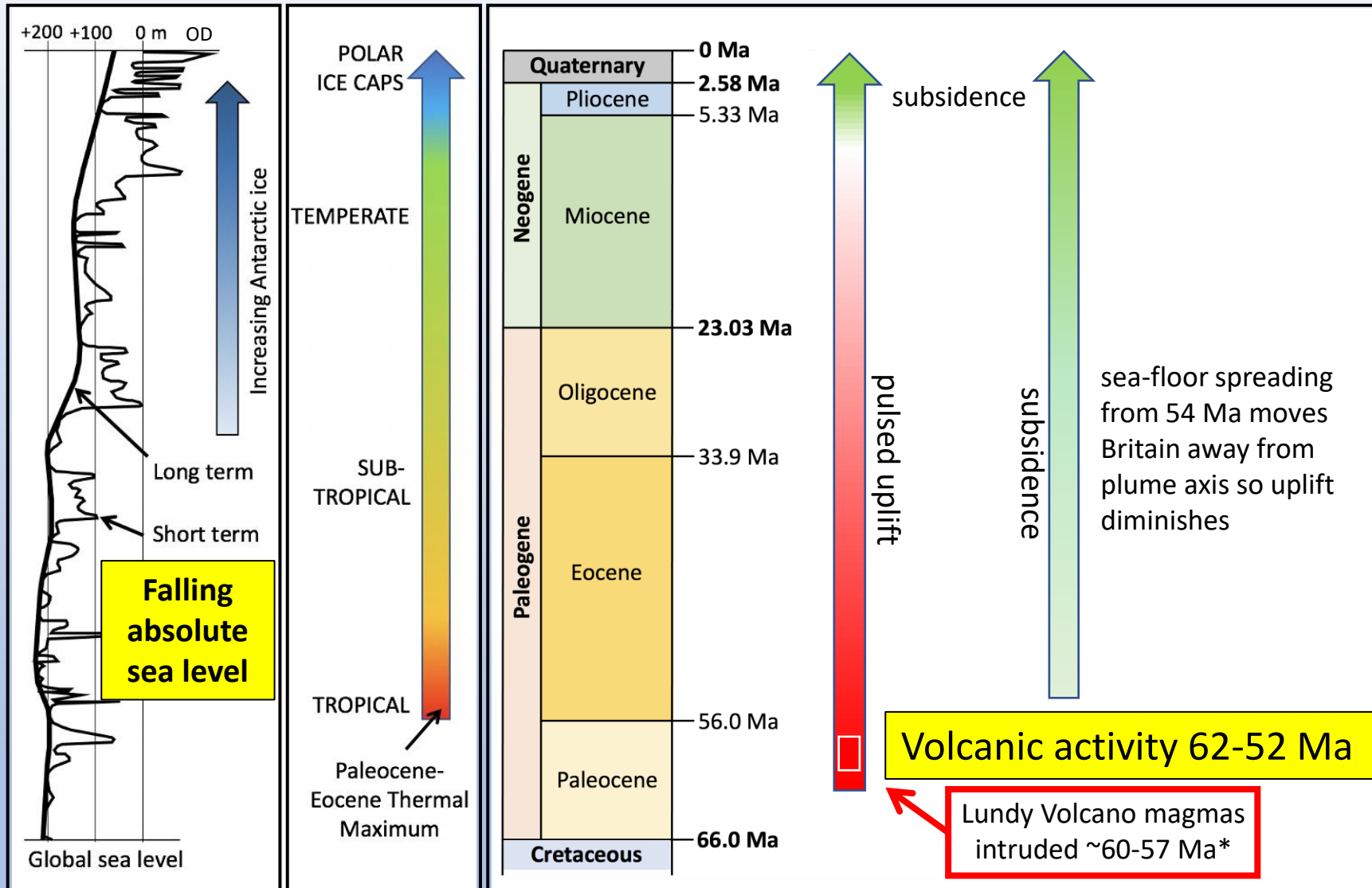


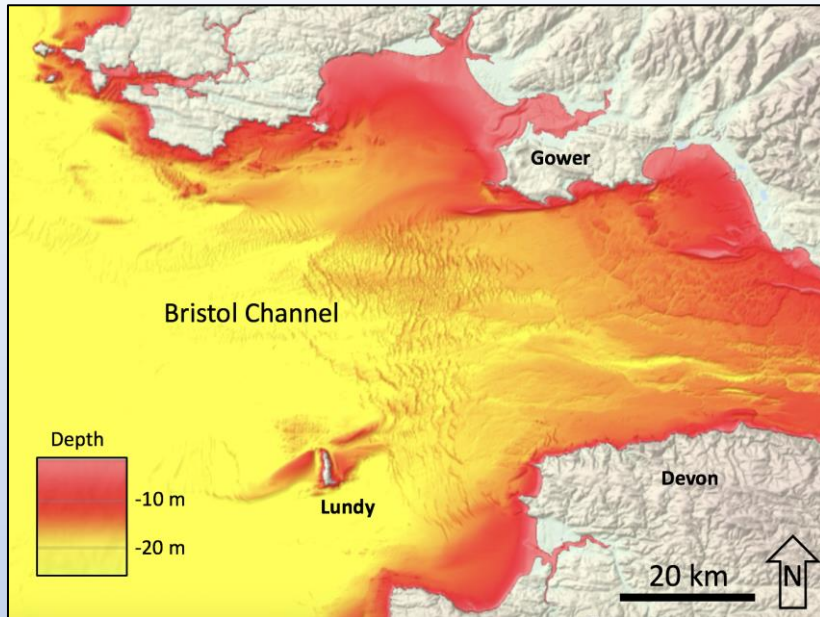
Global (mean) sea level is mainly controlled -

Long term by depth of ocean basins & water temperature / volume

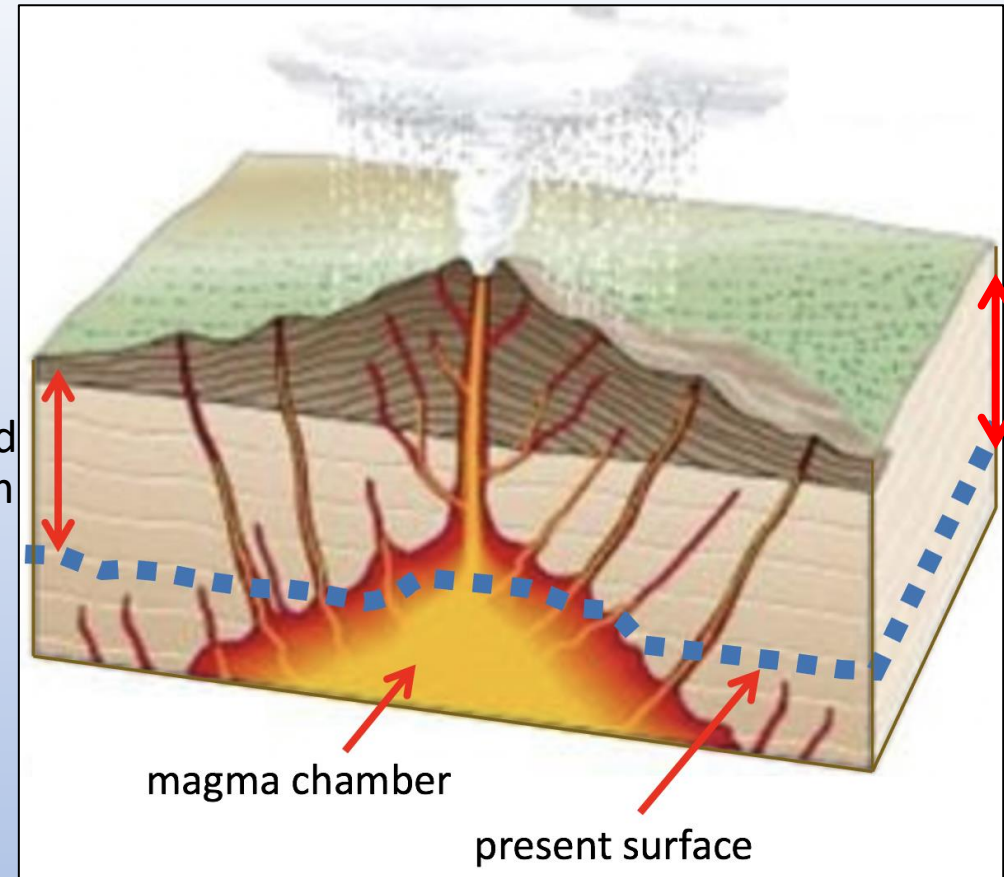
Short term by fluctuating volume of ice grounded on land







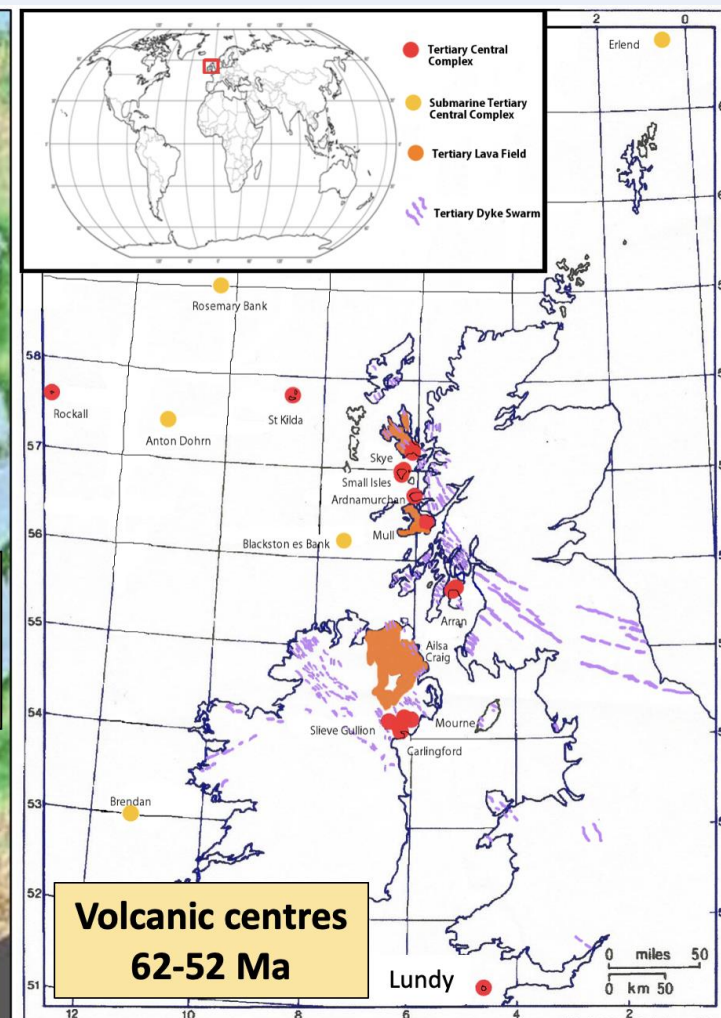
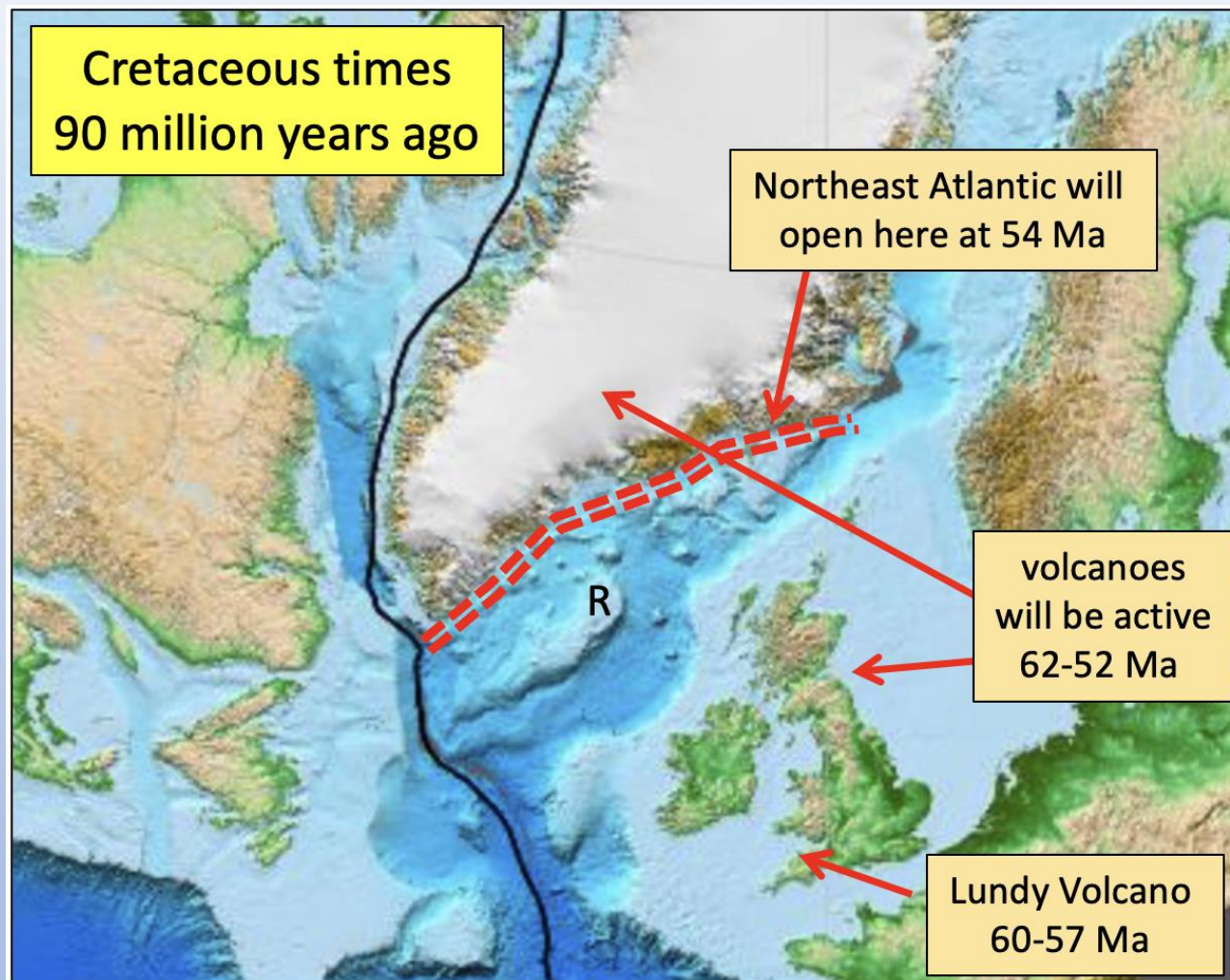
now eroded
away ≥ 1 km



Lundy granite is a remnant of a volcano magma chamber active 60-57 million years ago.

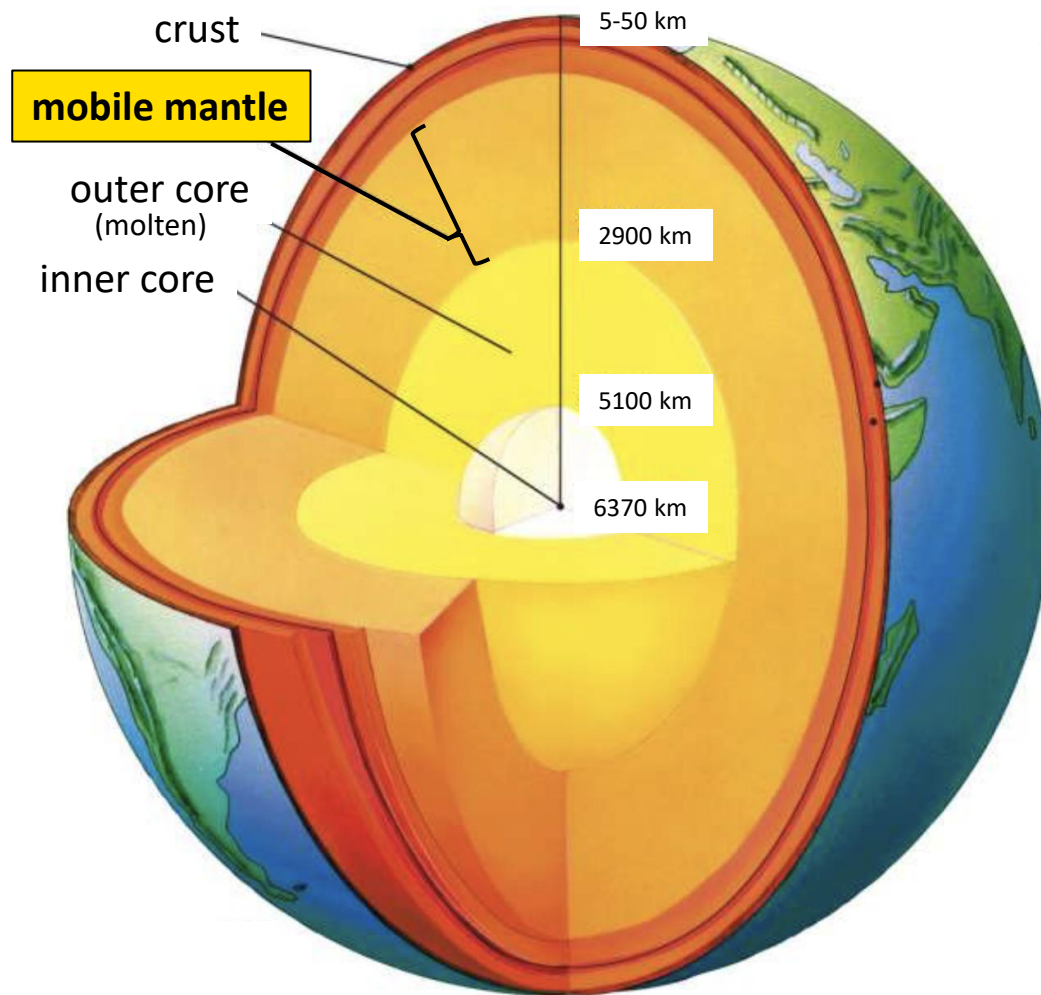
Vast volumes of rock have been eroded away

Snowdon 1,085 m (3,560 ft)!

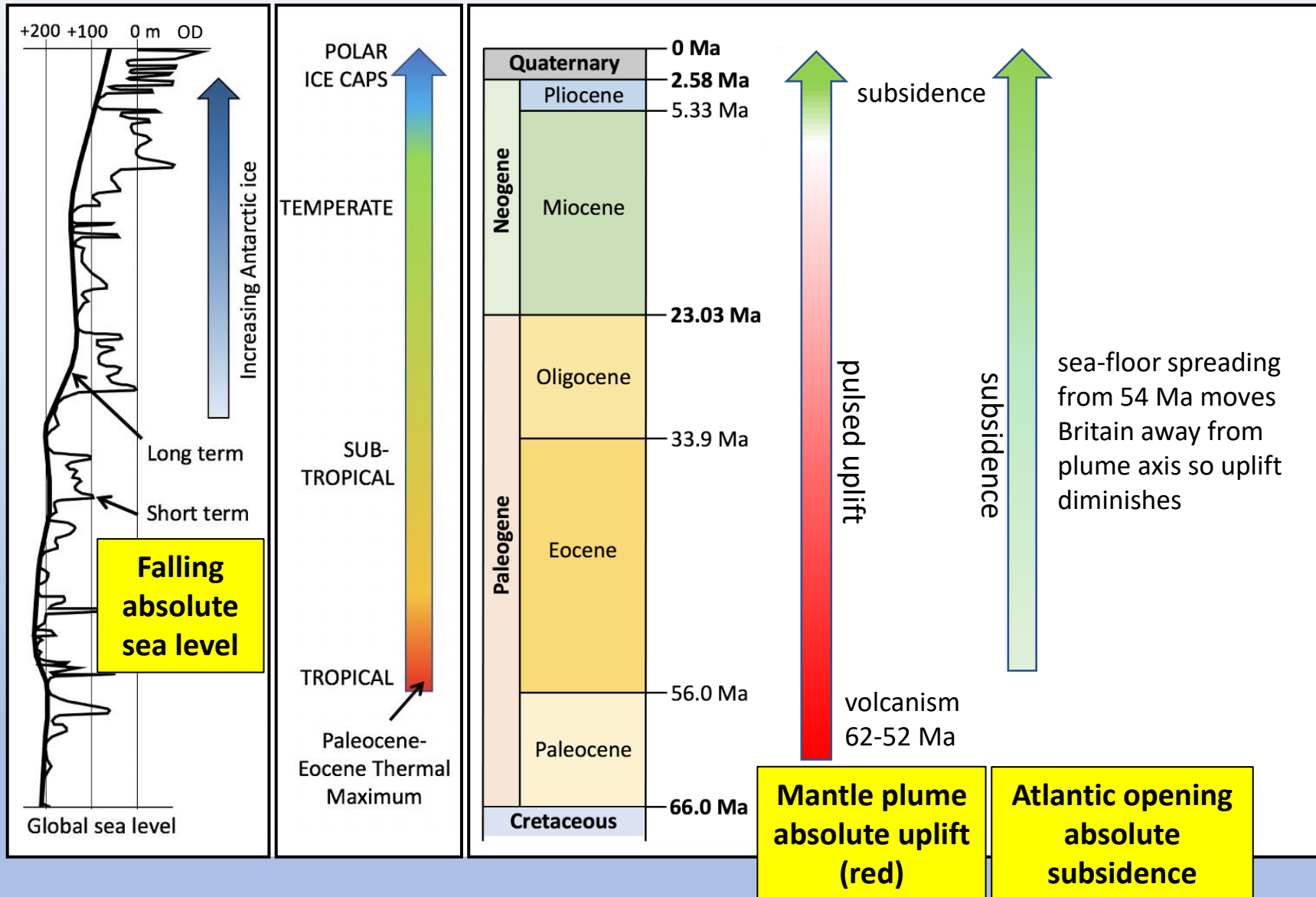


Lundy Volcano is part of a huge volcanic field that included Greenland

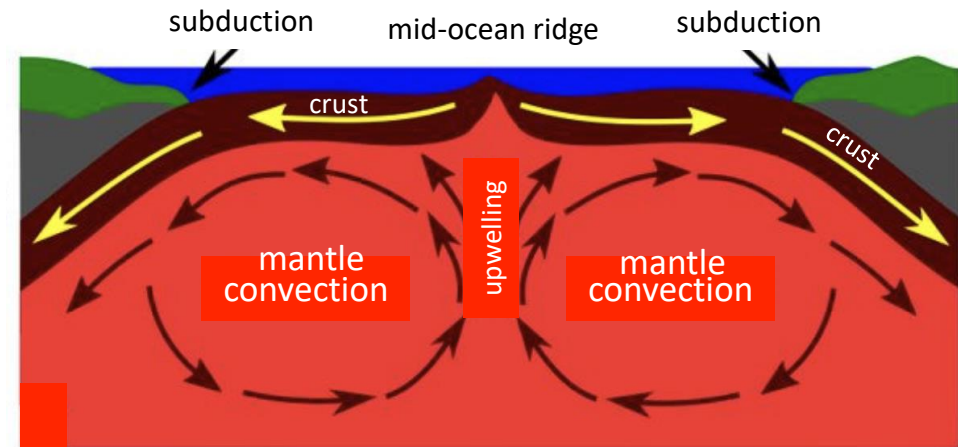
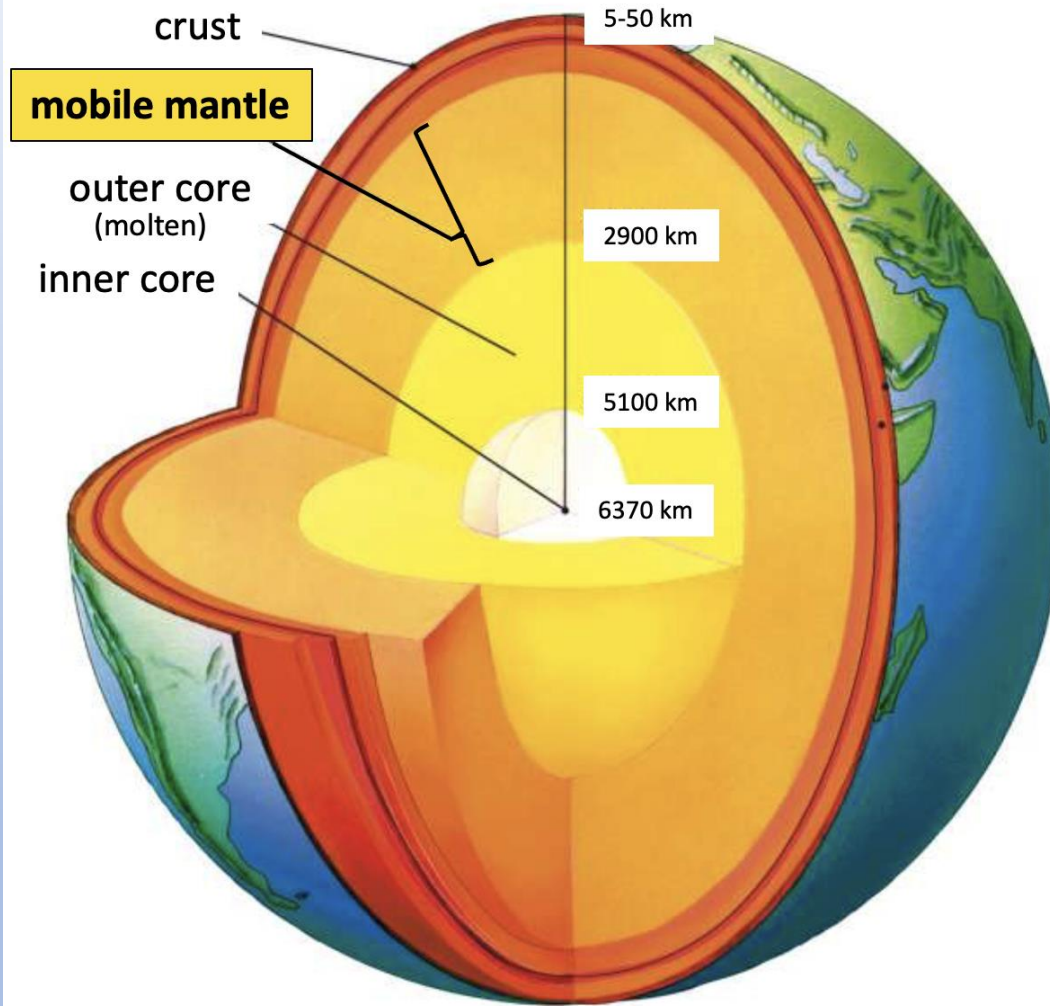
Mantle plumes - briefly...



Mantle plumes rise from above the outer core to cause ***widespread volcanism and uplift*** of Earth's crust

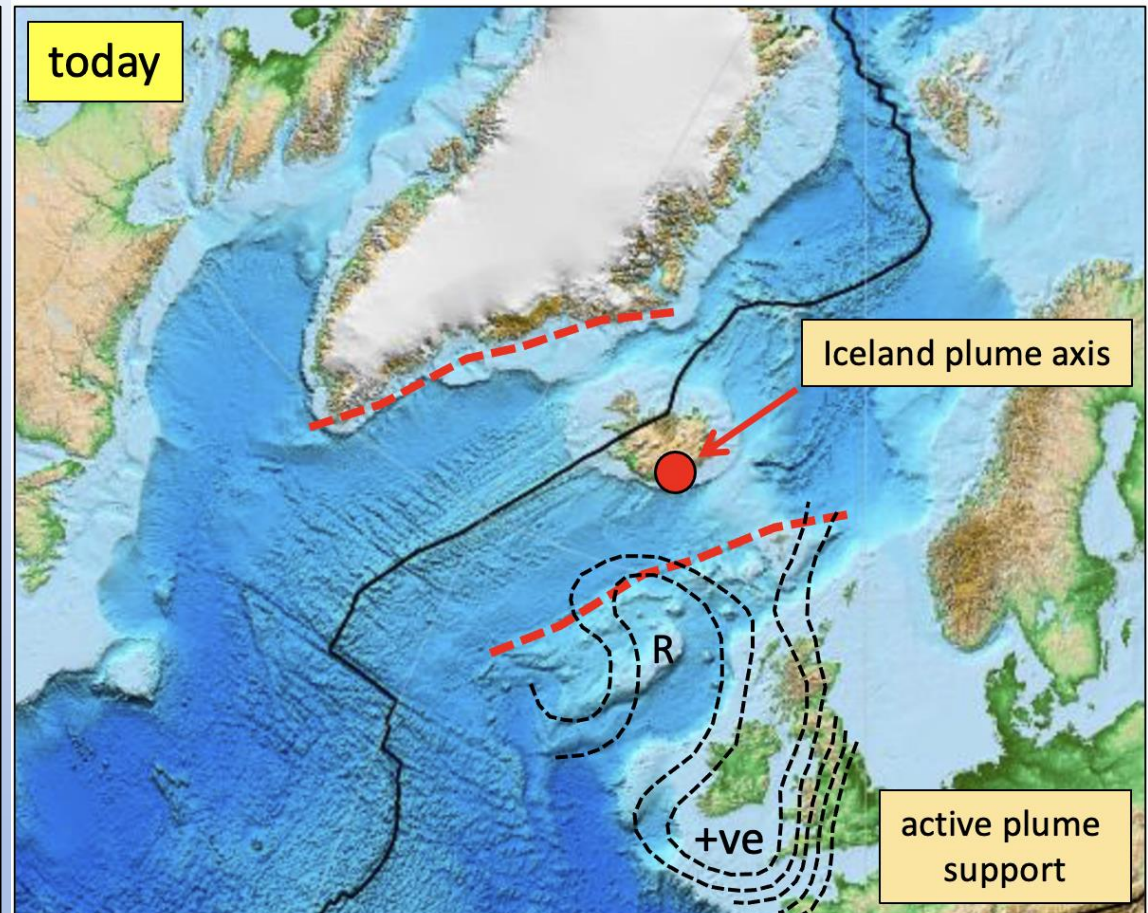
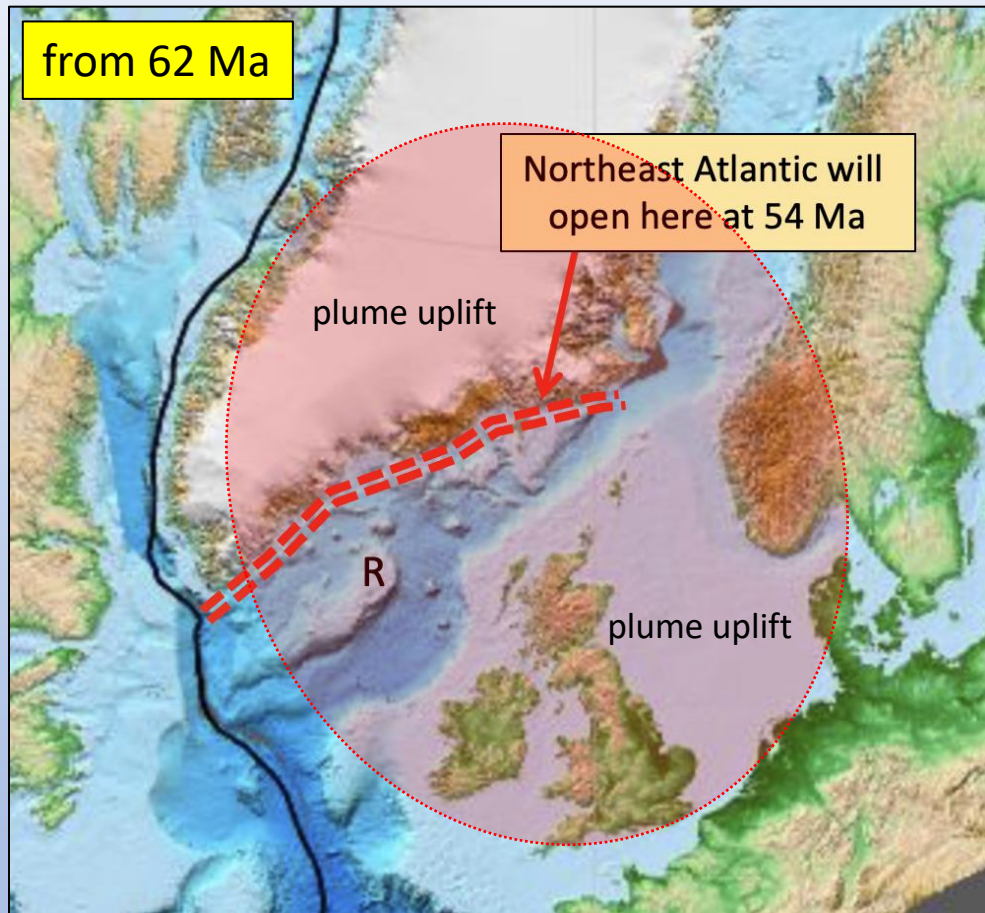


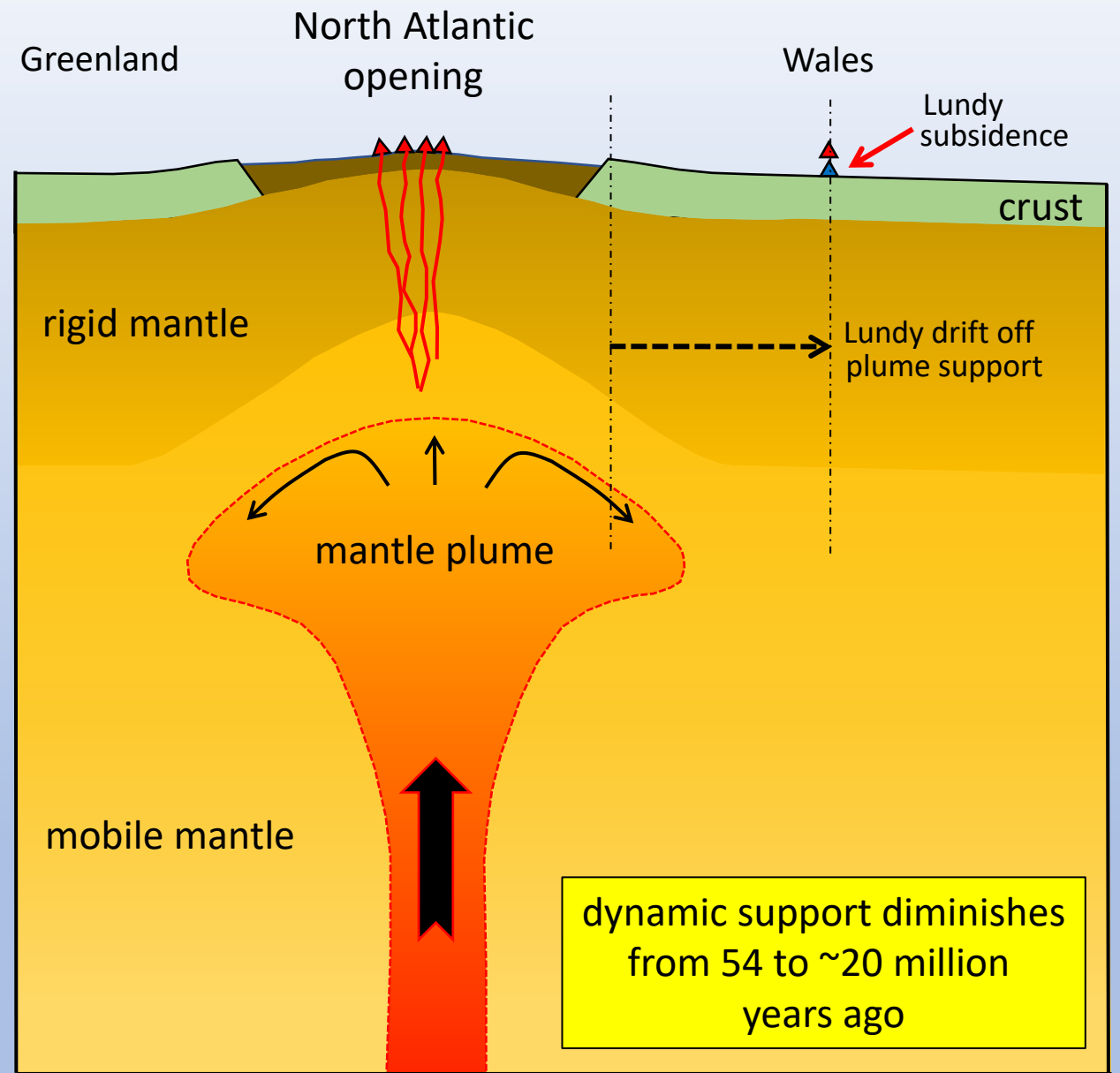
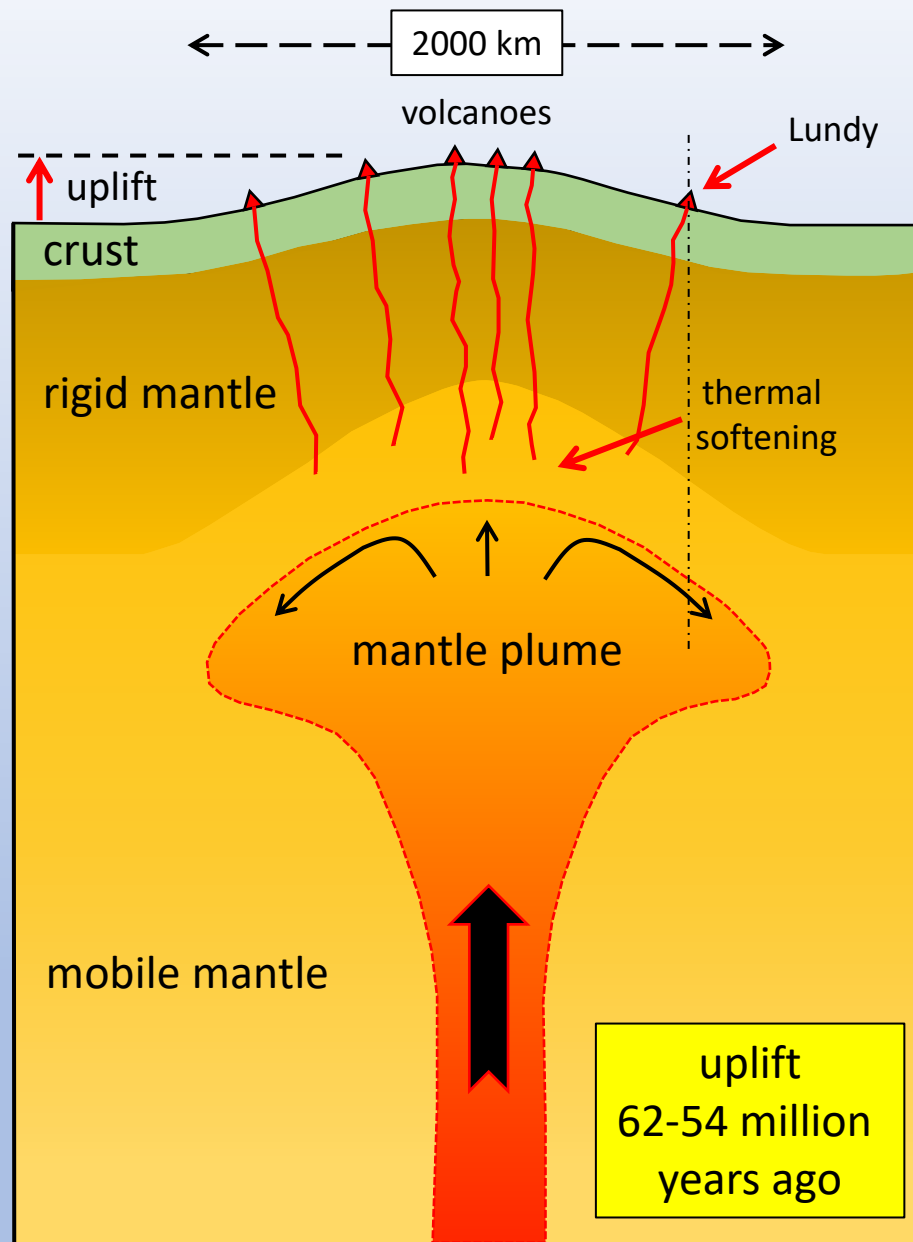
Sea-floor spreading - briefly...



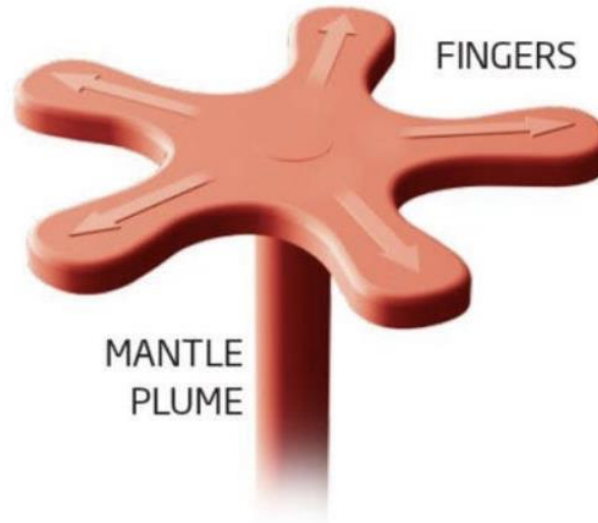
Mantle convection with upwelling
beneath an oceanic spreading centre

Sea-floor crust forms at a mid-ocean
ridge so crustal plates move apart
and ocean basin opens

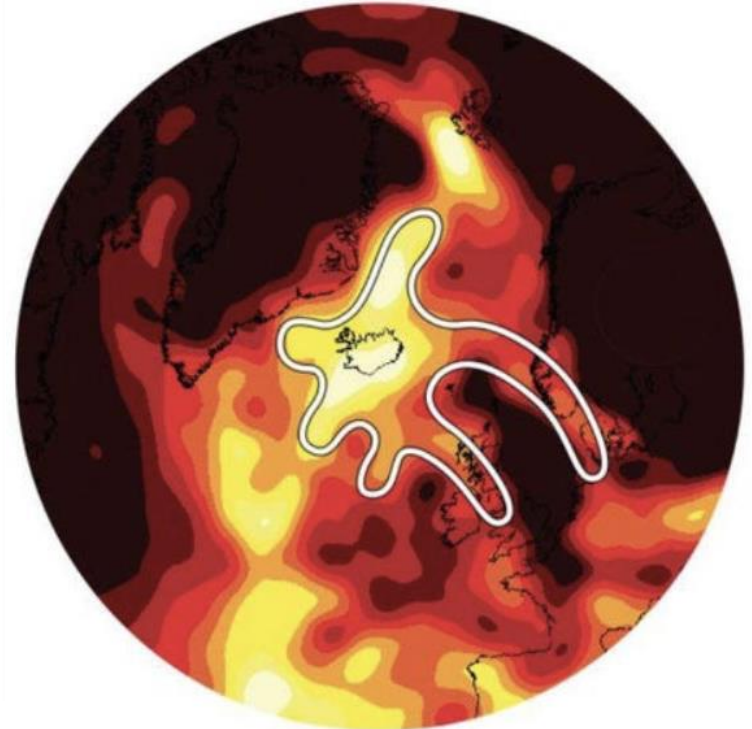




What shape is a mantle-plume head?

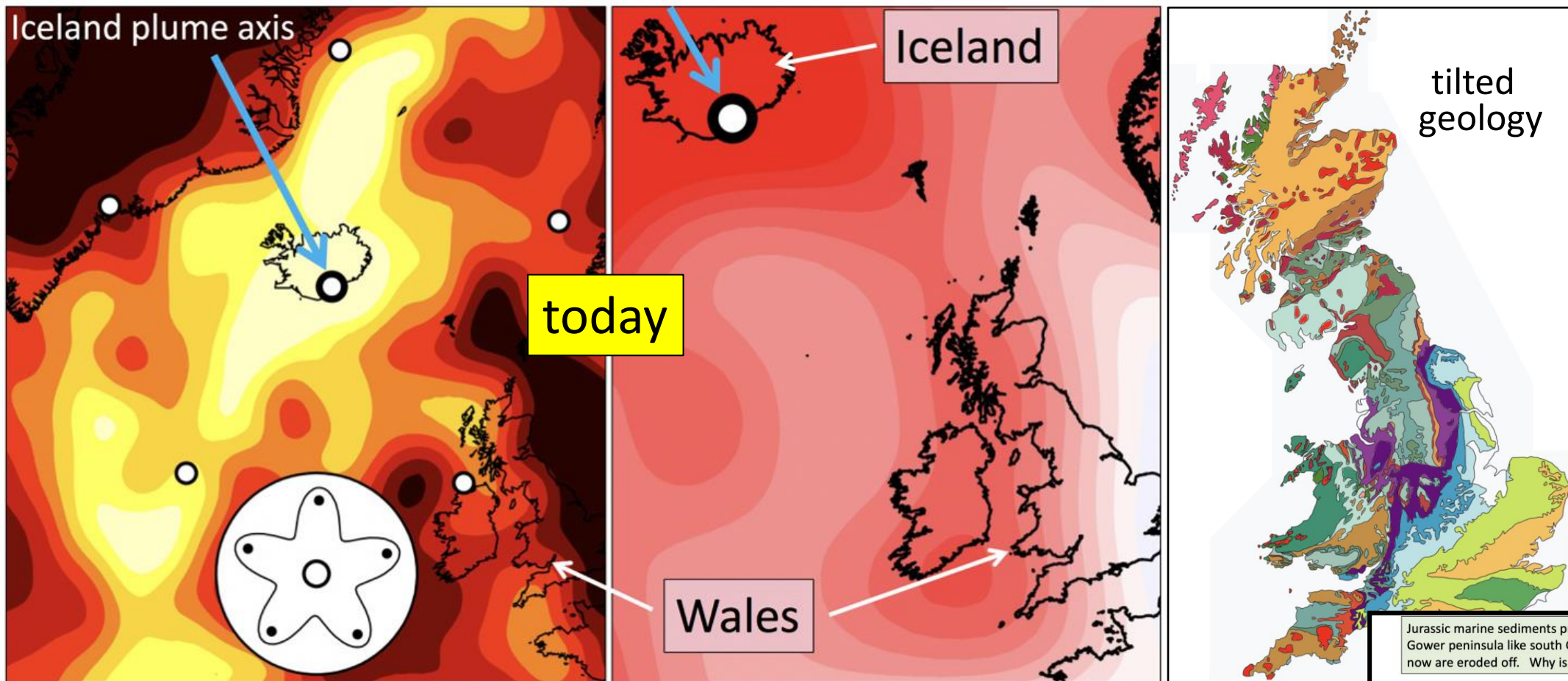


Idealised shape of
radially directed
mantle flow



anomalies of Earth's **gravity**
centred on Iceland

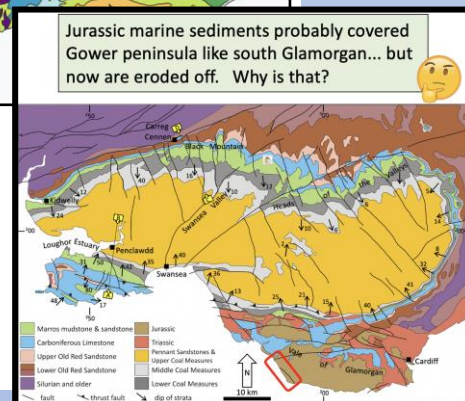
Graphics kindly supplied by Hannah Galbraith-Olive
and Nicky White of Cambridge University.

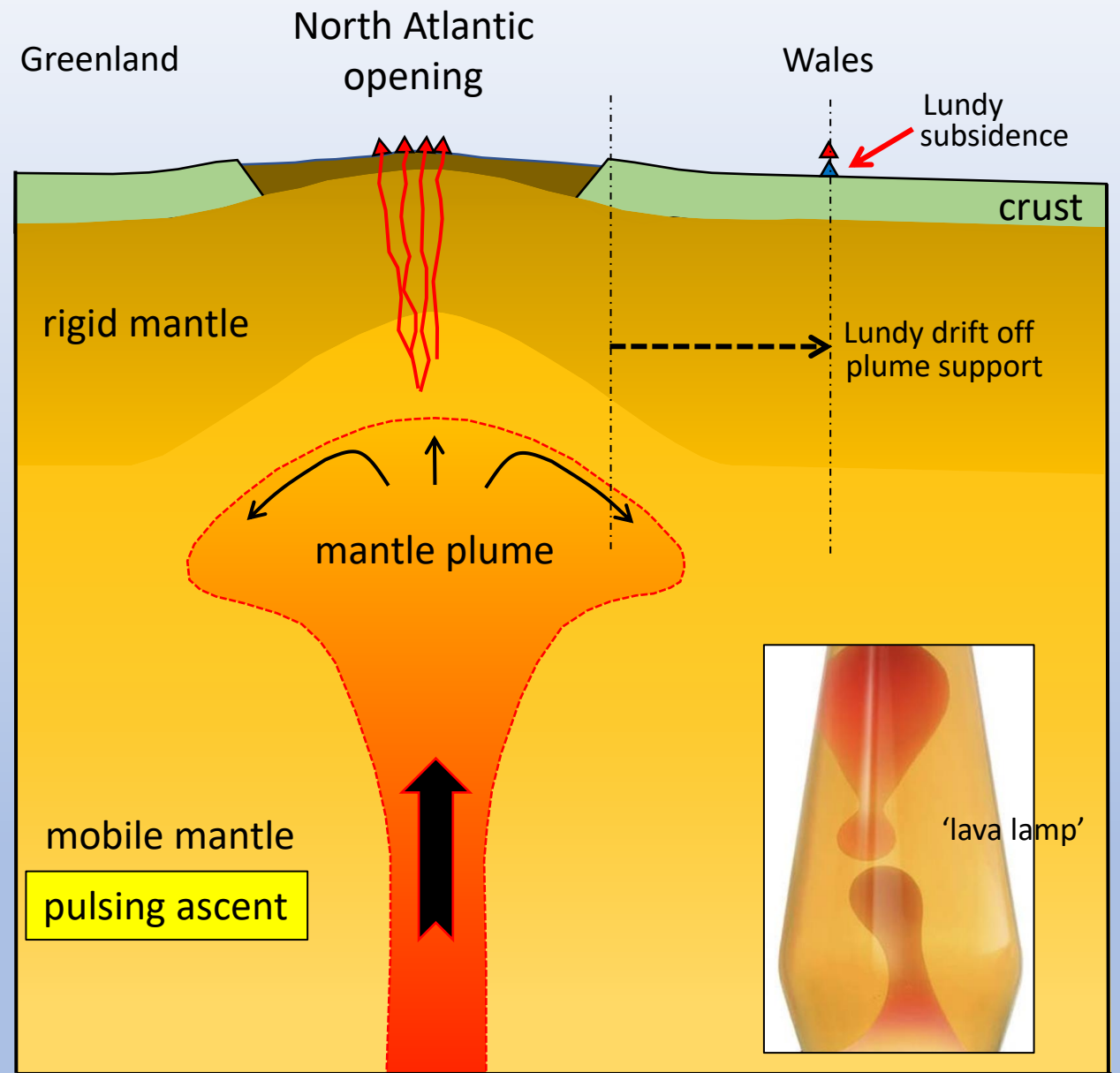
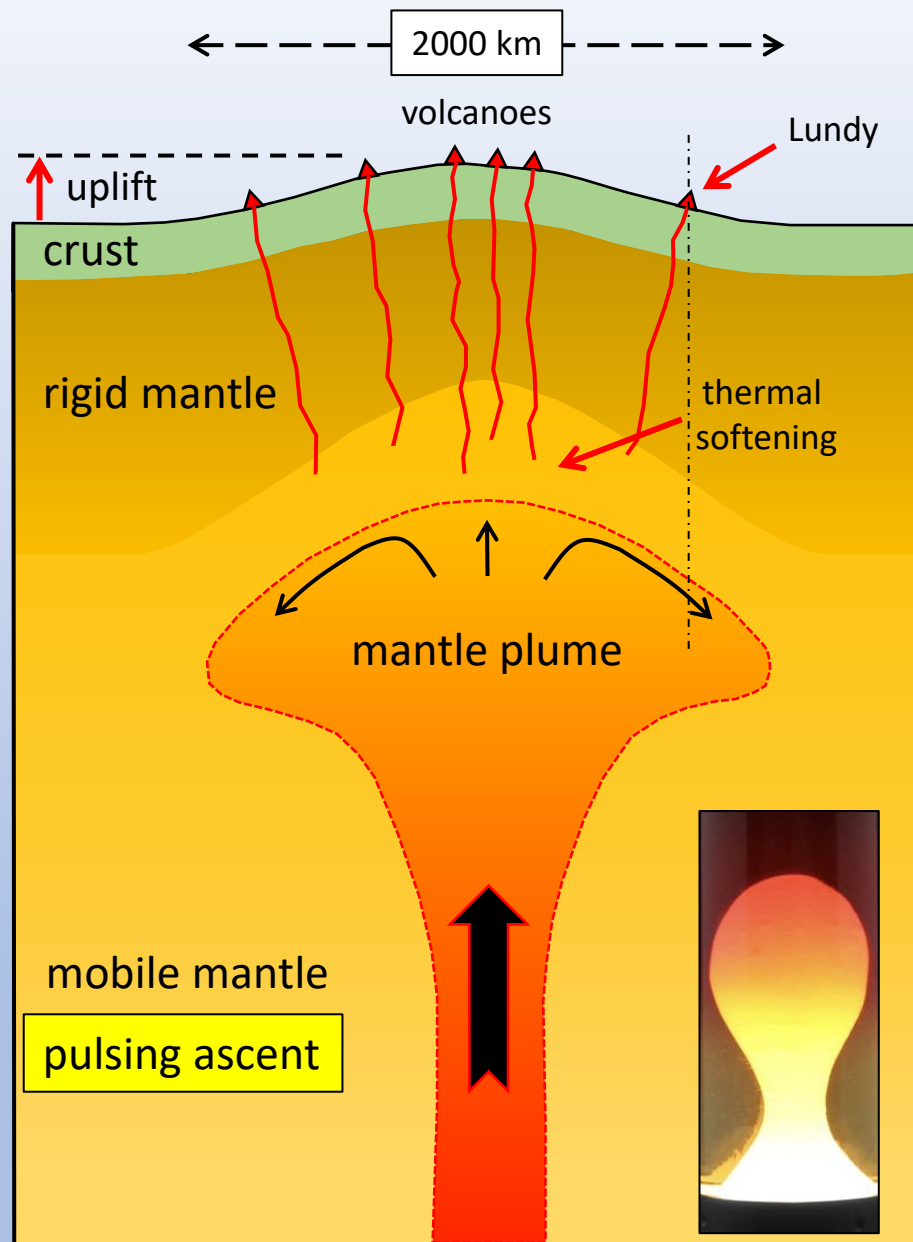


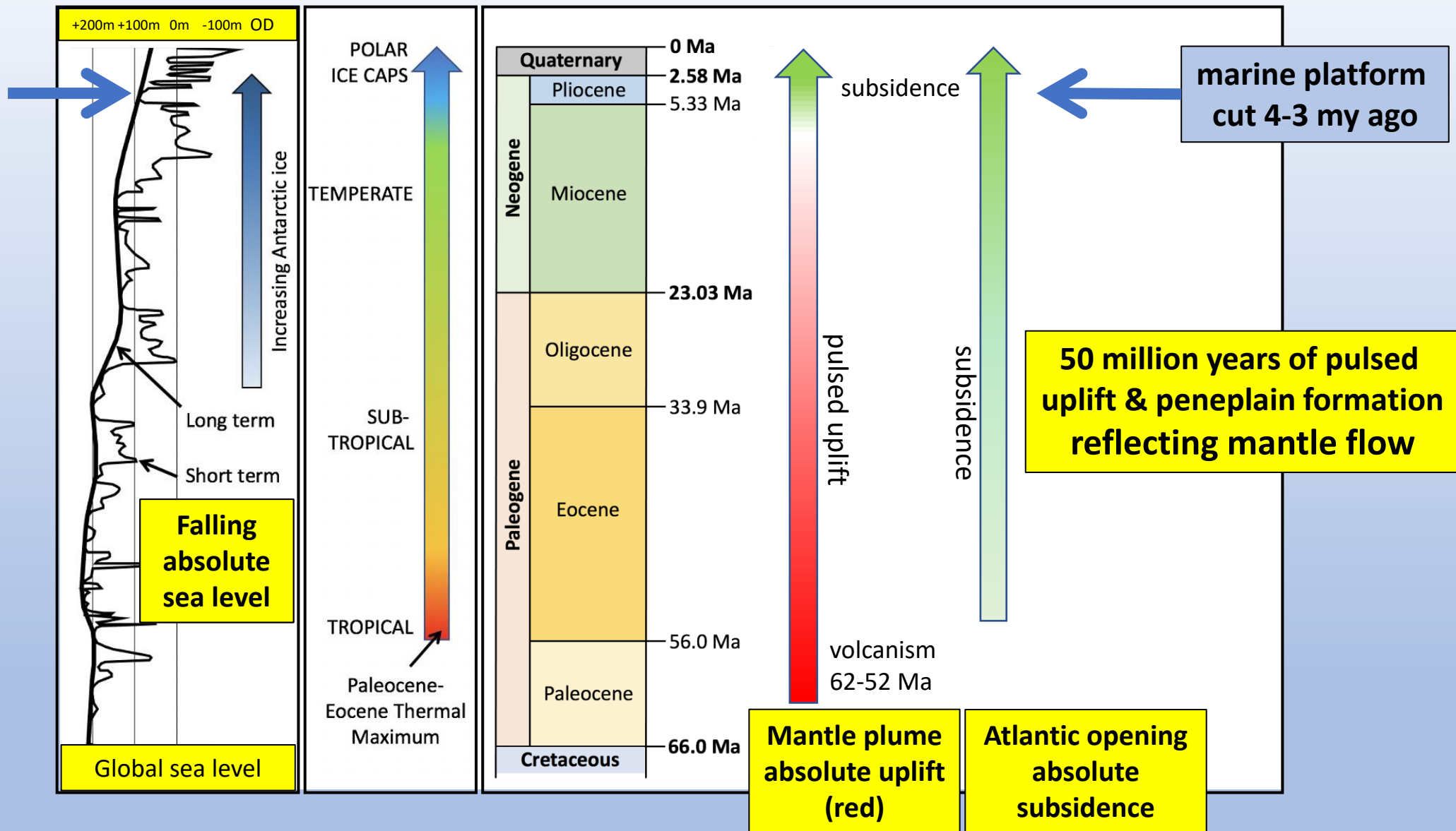
Graphics kindly supplied by Hannah Galbraith-Olive and Nicky White of Cambridge University.

high temperature ➡ low density ➡ high buoyancy ➡ high uplifting support

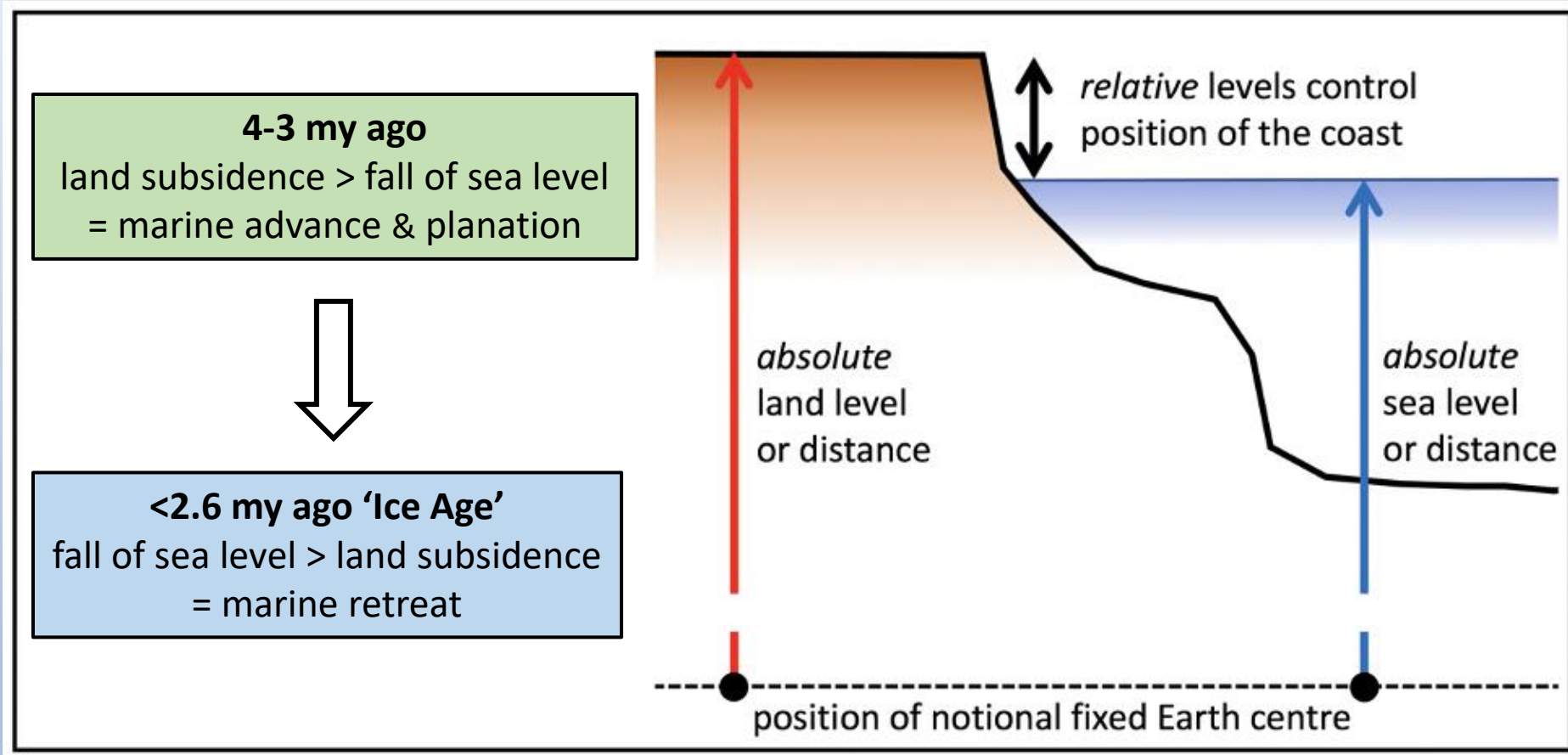
low gravity

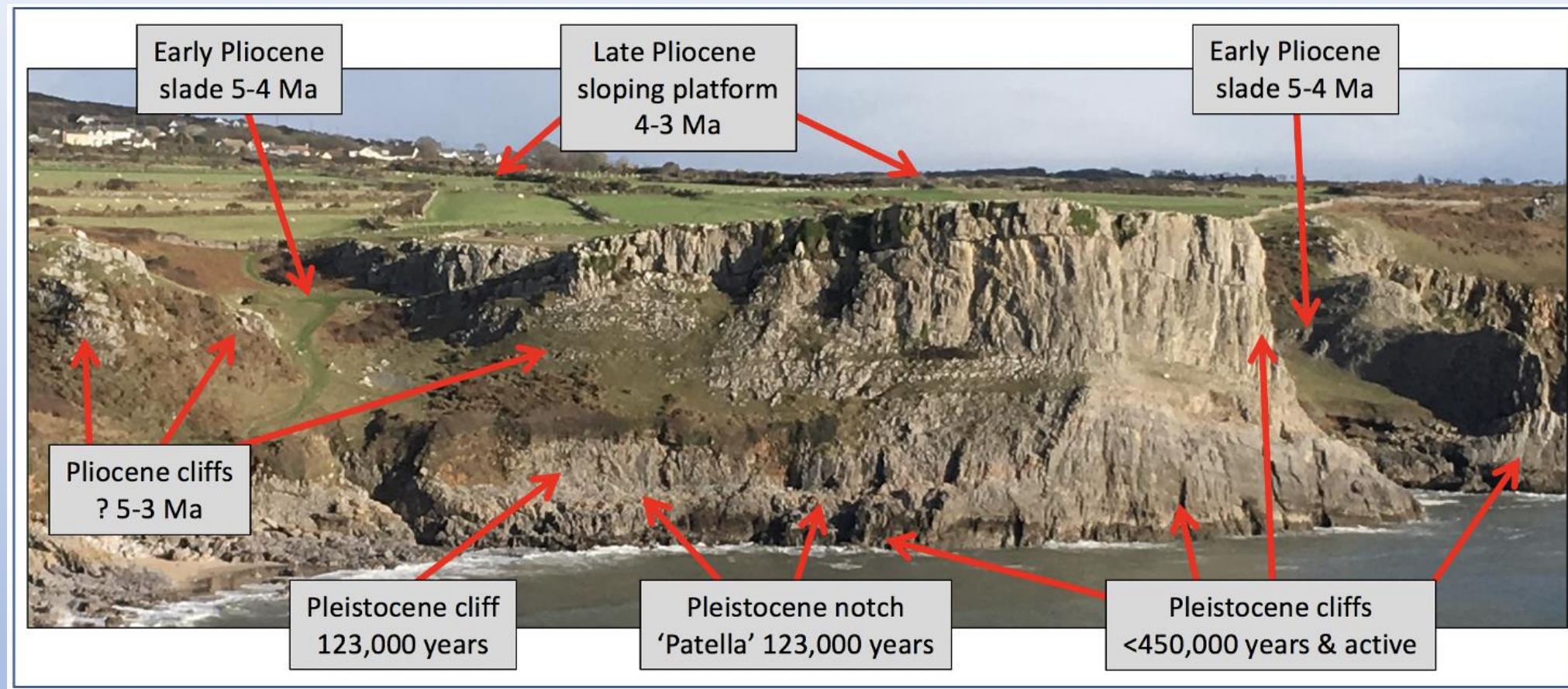


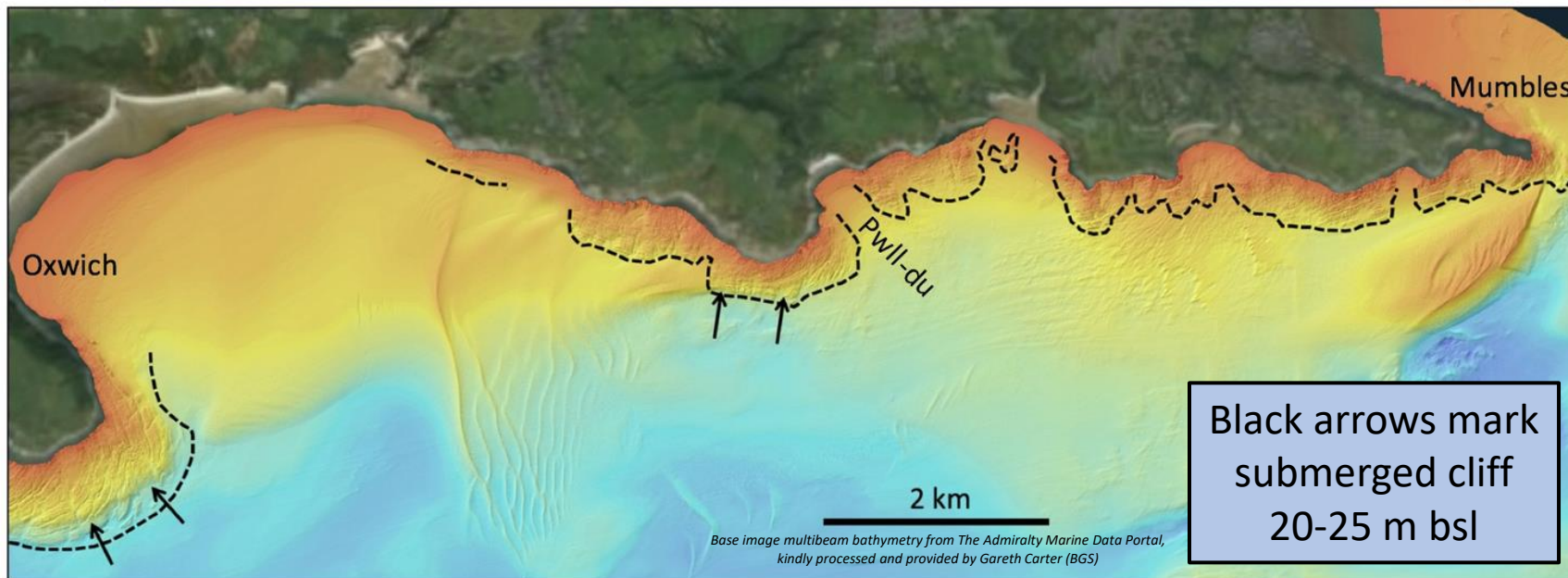
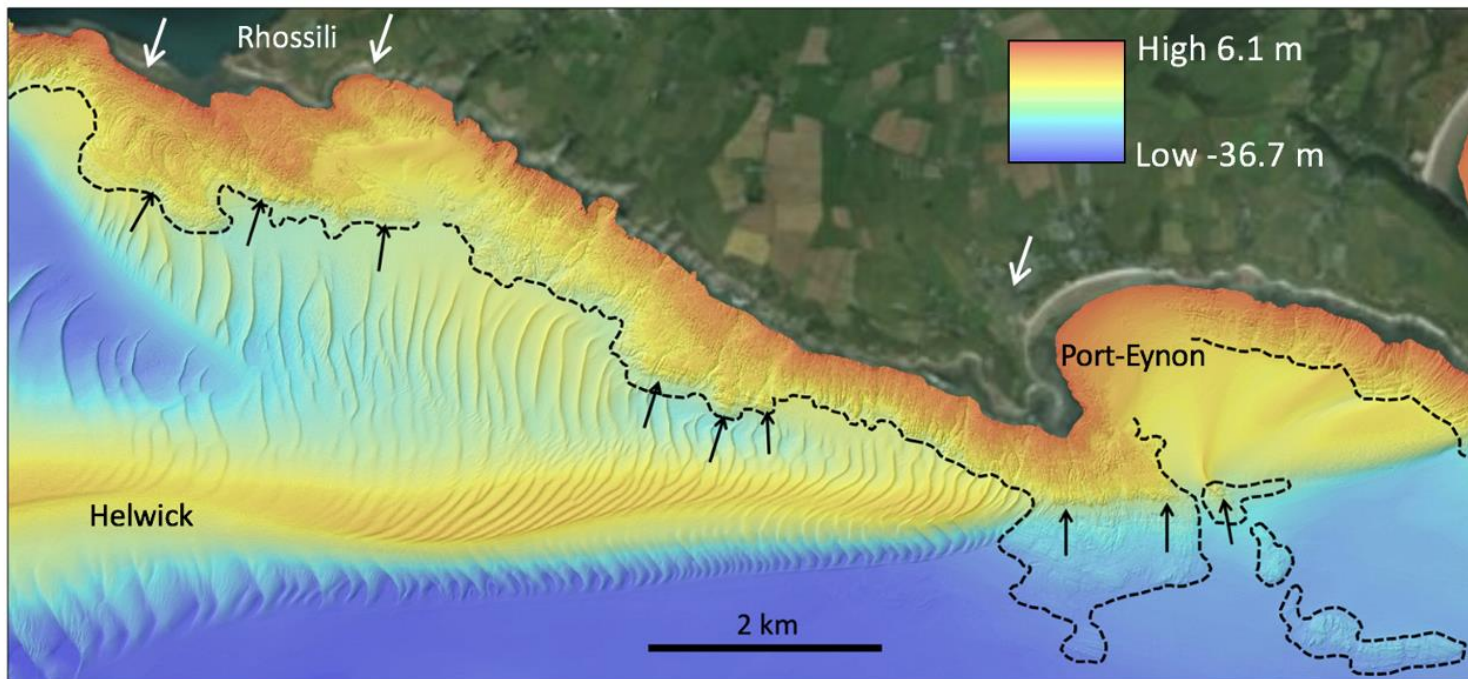




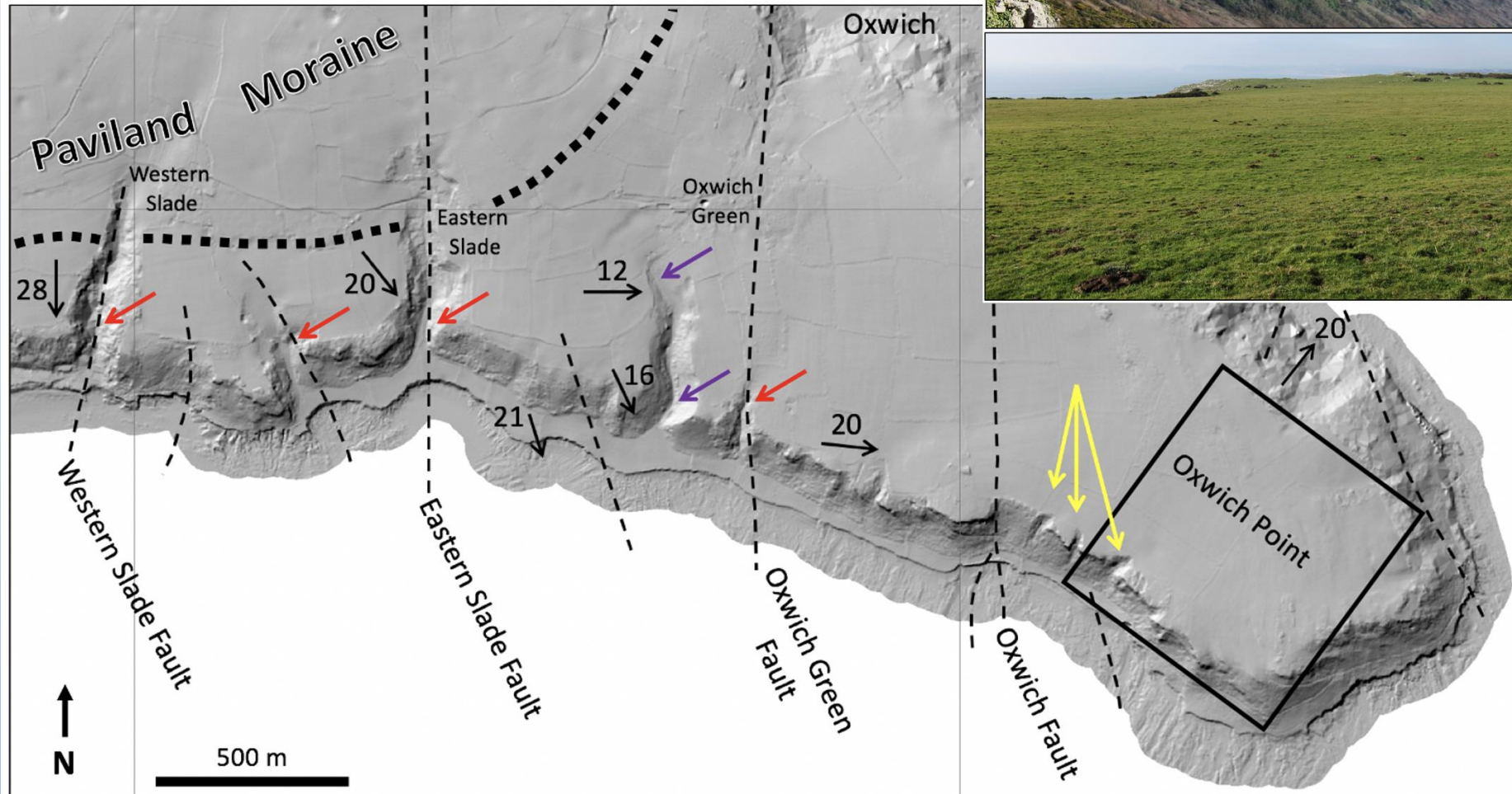
Absolute versus relative levels



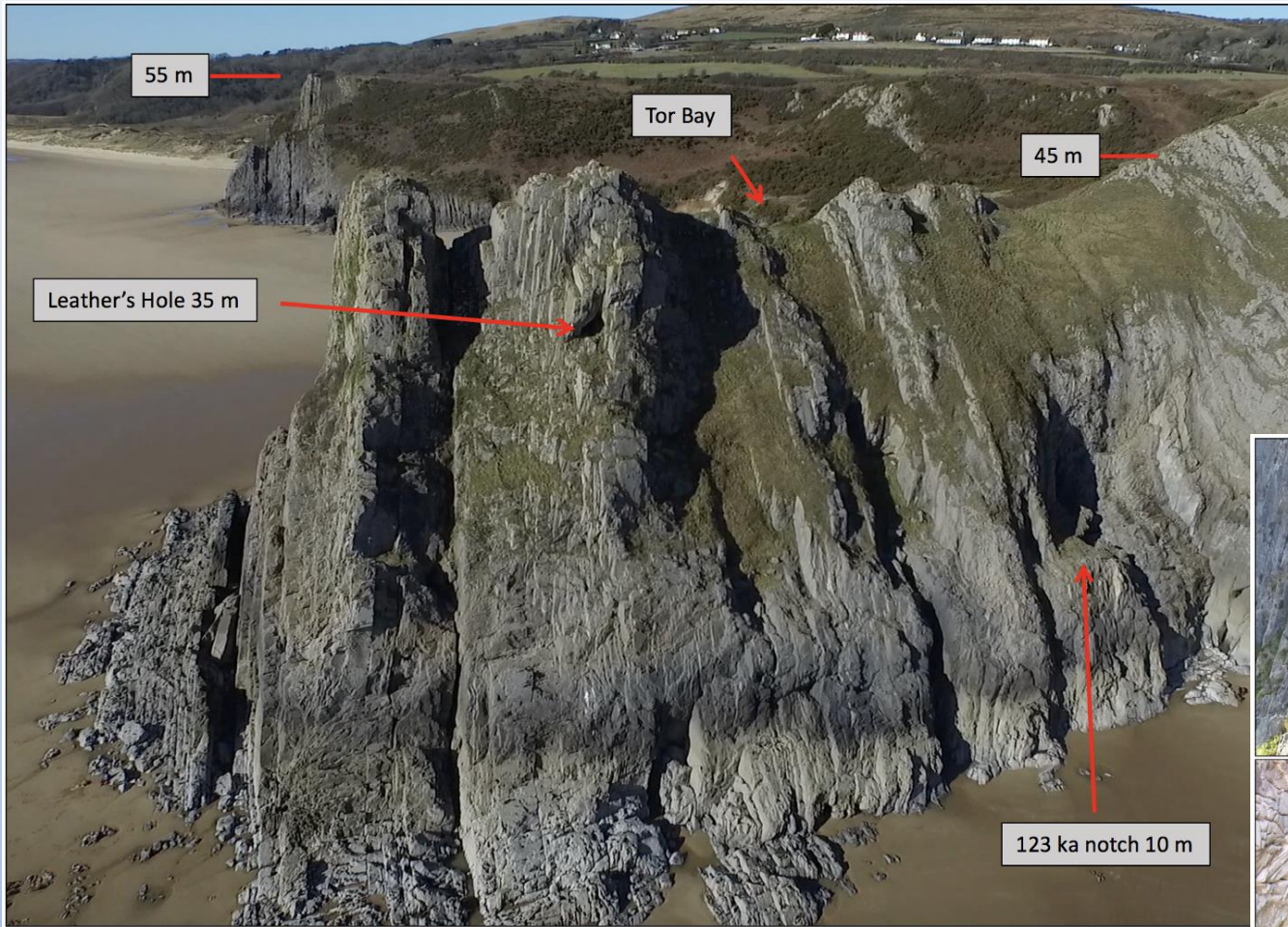




The headless slades problem - identified by TN George 1932



Slades are remnants of valleys beheaded by the marine planation of 3 or 4 million years ago, so the valleys must be at least 4 or 5 million years old

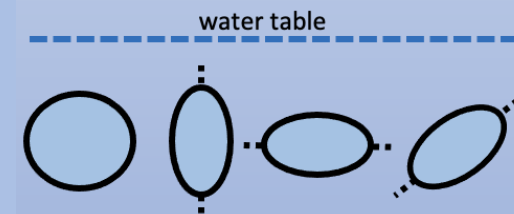


Some Gower caves are very old!

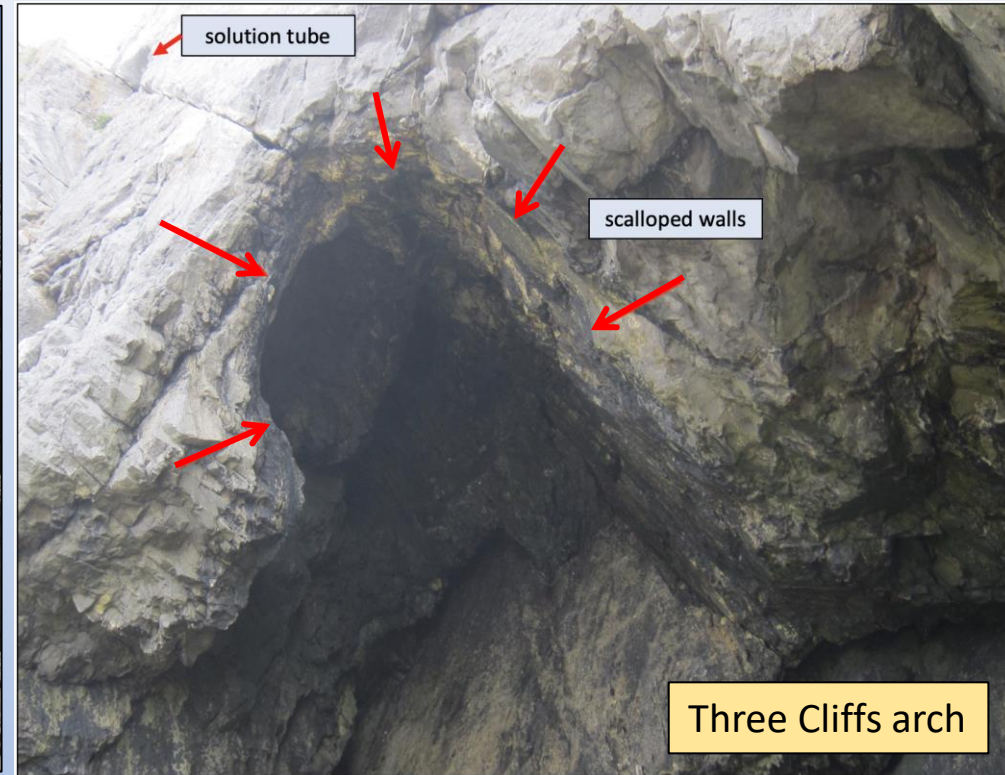
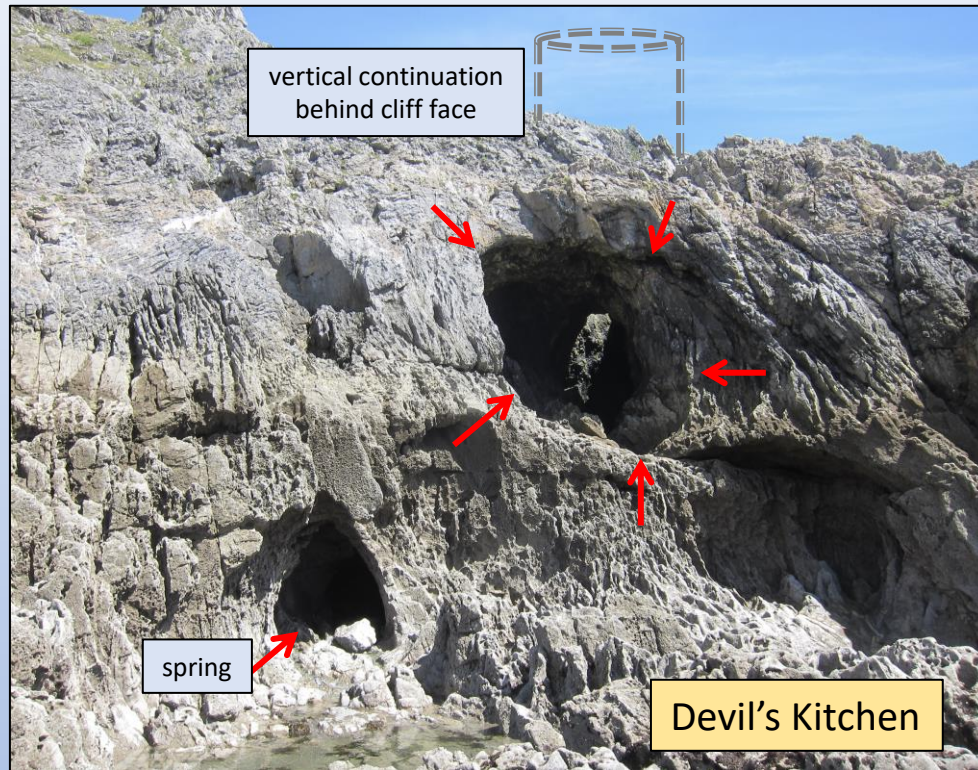
Many caves in Gower limestones must predate the slades and so are much older than 4 or 5 million years, possibly at least 10 million years old



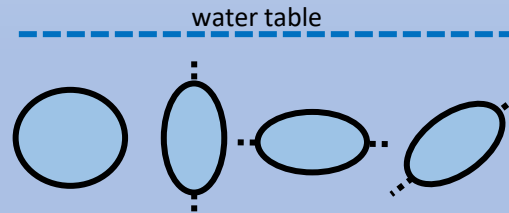
Caves initiate by dissolution beneath the water table



Ancient cave passages isolated by deep erosion

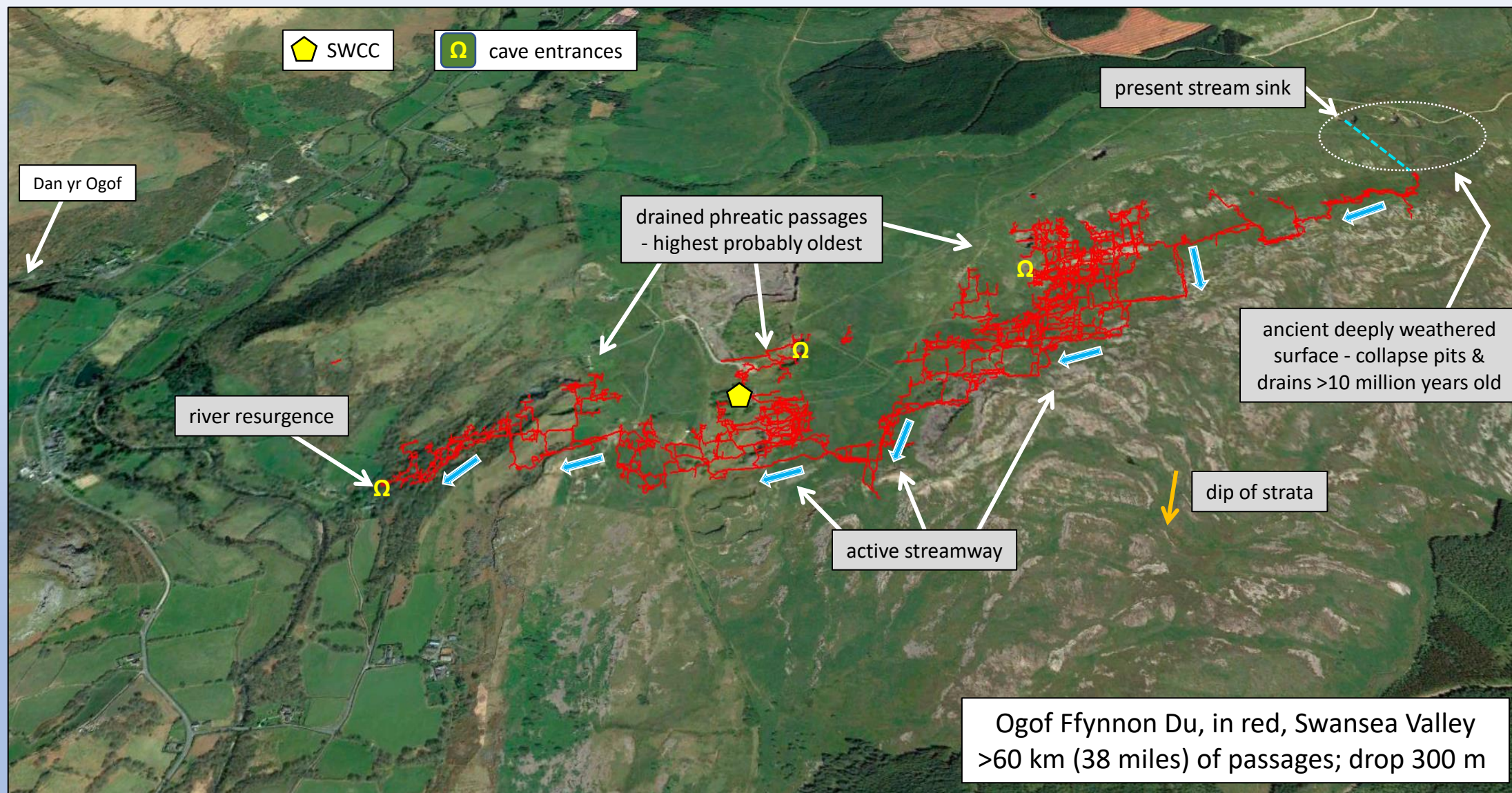


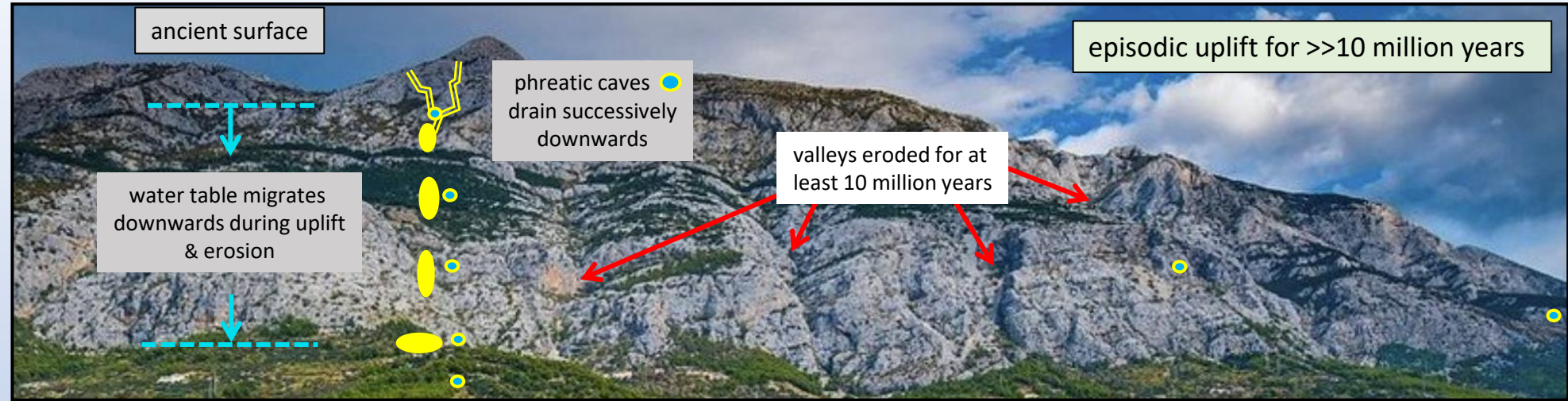
Remnants of phreatic tube passages
- **dissolved** around all contacts



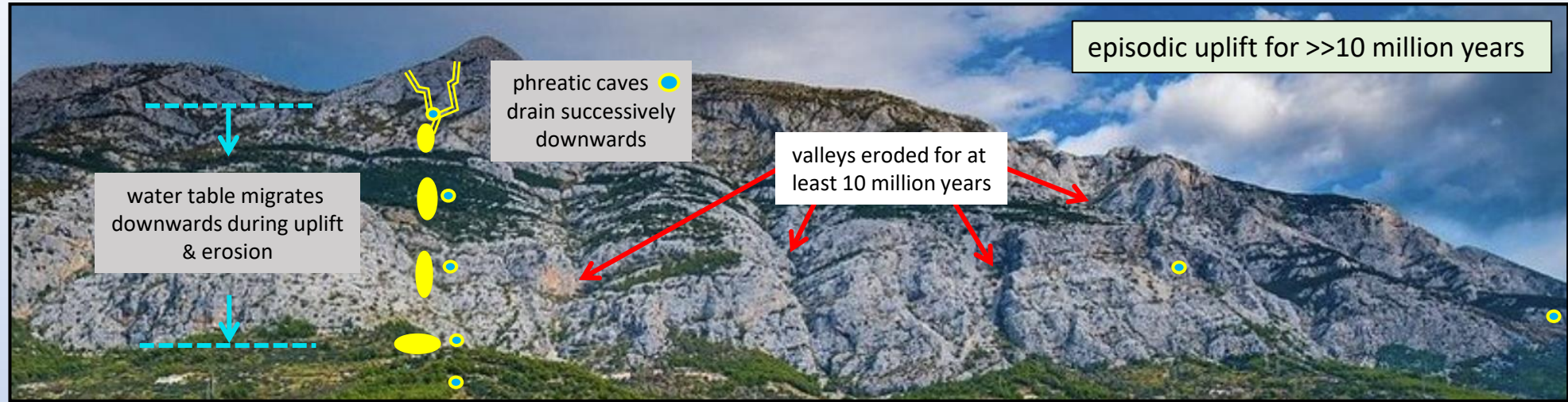
Sea caves - **eroded**
most towards base

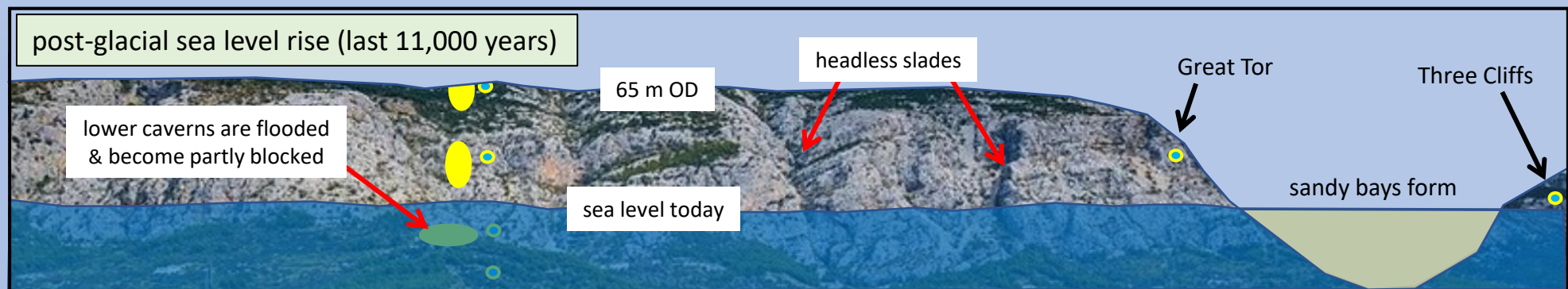
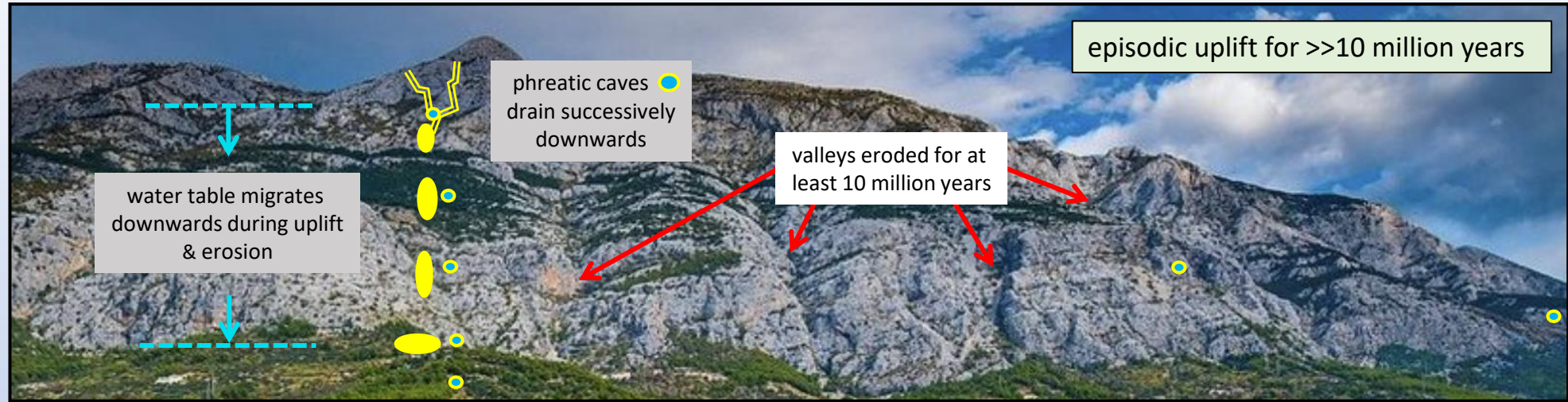


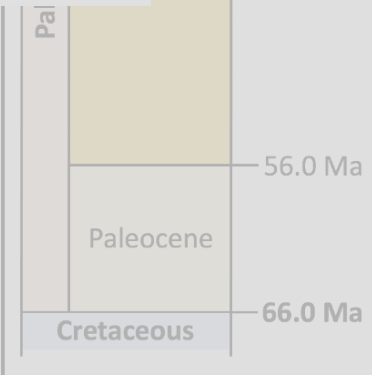
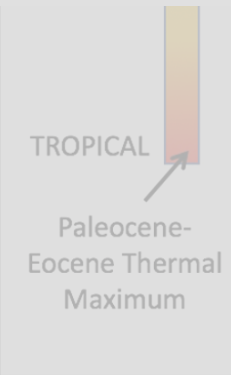
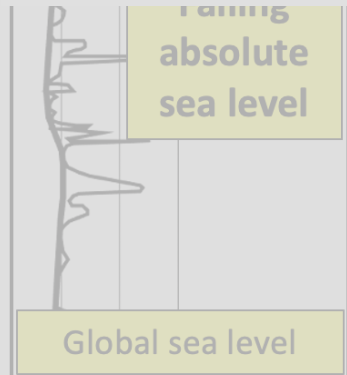




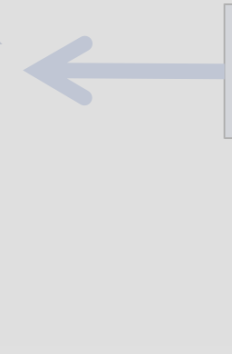
Schematic evolution of south Gower coast
(using Adriatic coastal limestone mountains)





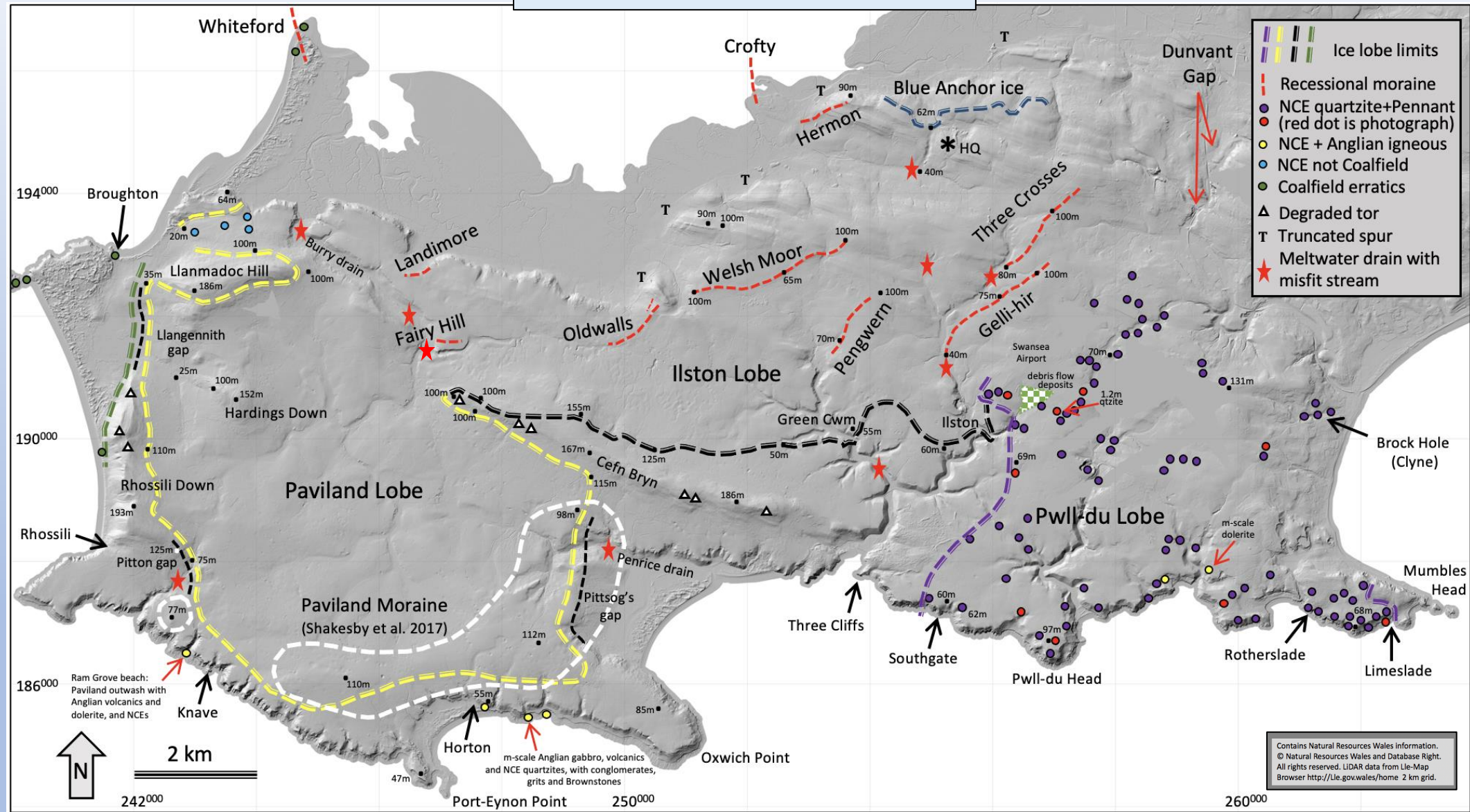


Mantle absolute (red, subsidence)



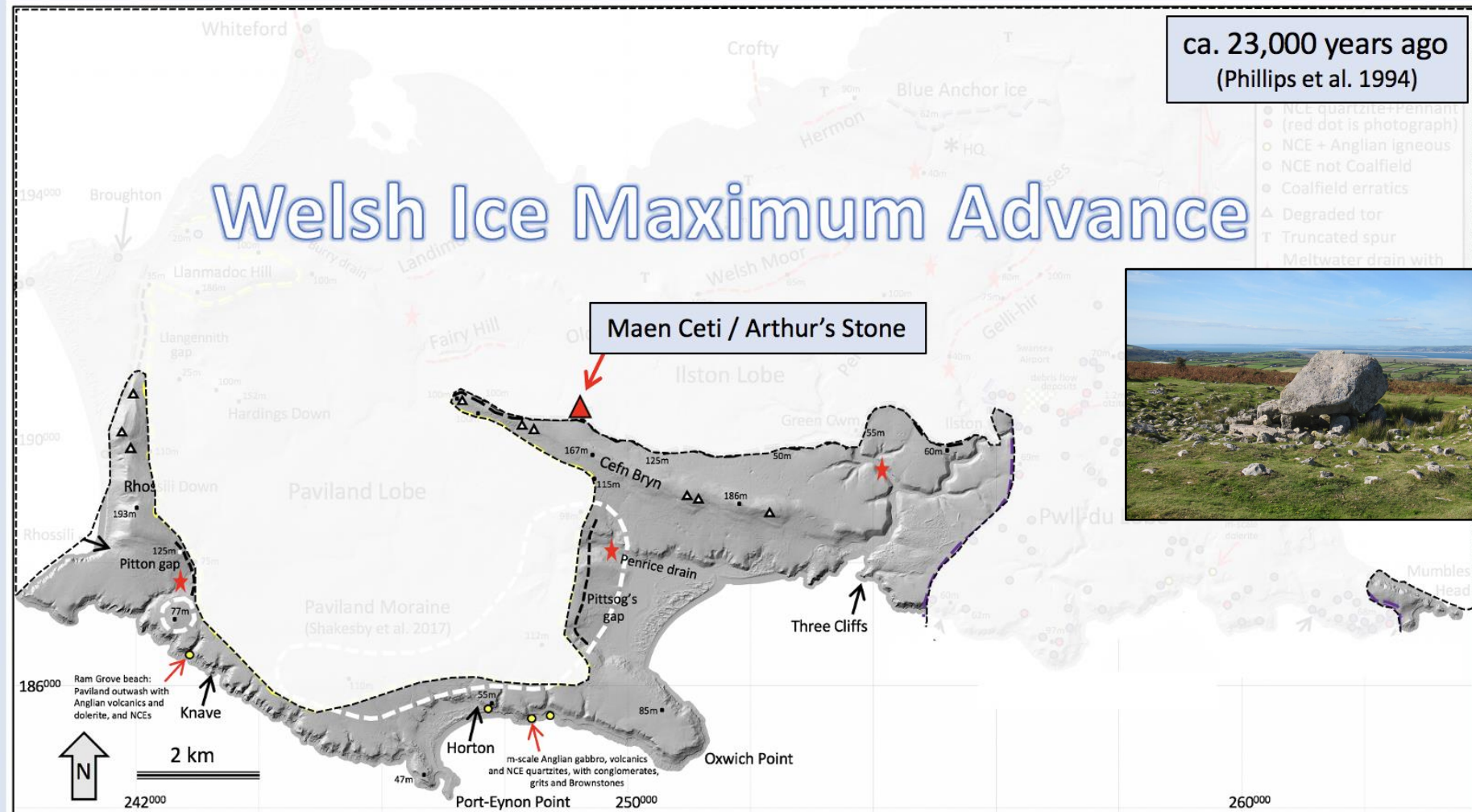
marine platform cut 4-3 my ago

The Last Glaciation of Gower

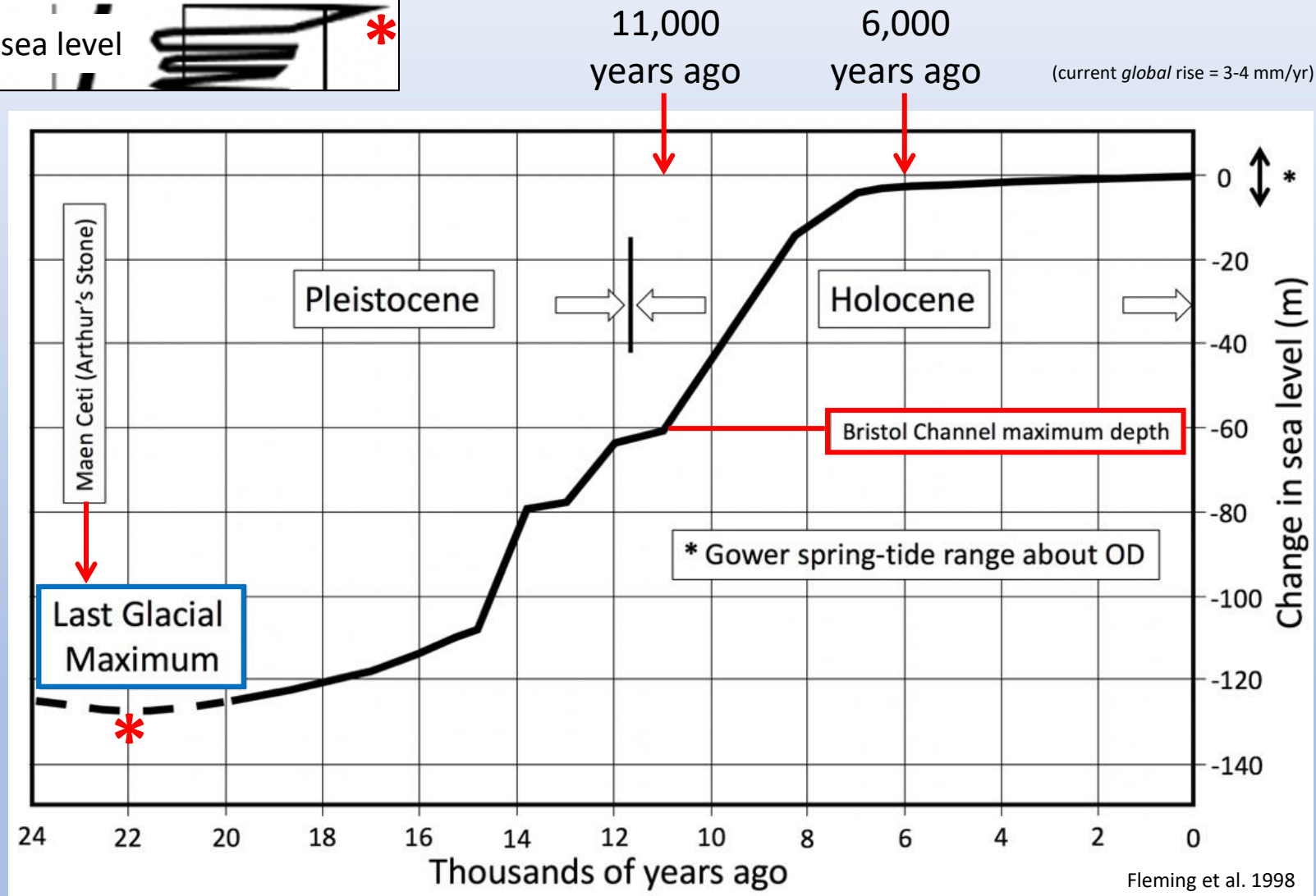
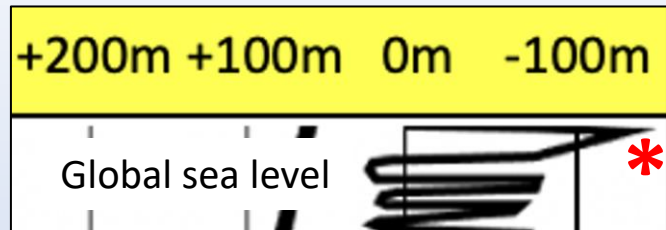


Welsh Ice Maximum Advance

ca. 23,000 years ago
(Phillips et al. 1994)



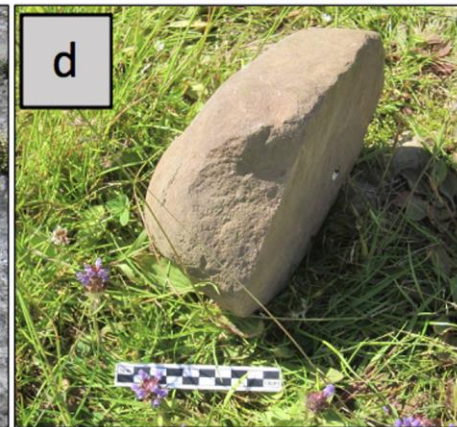
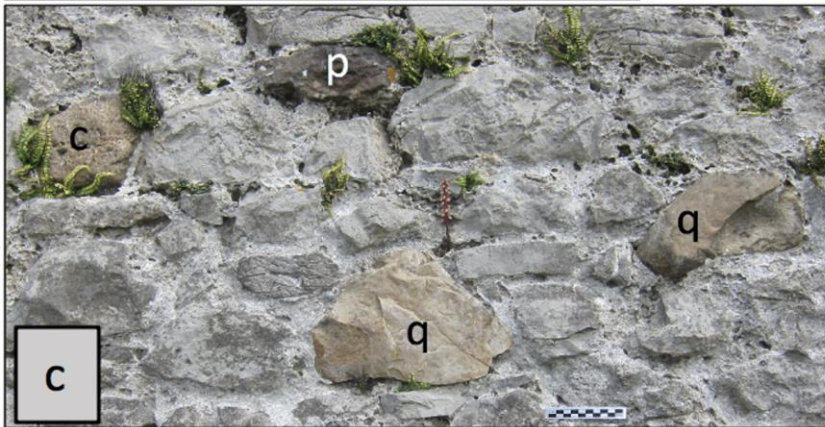
Sea shoreline nowhere near





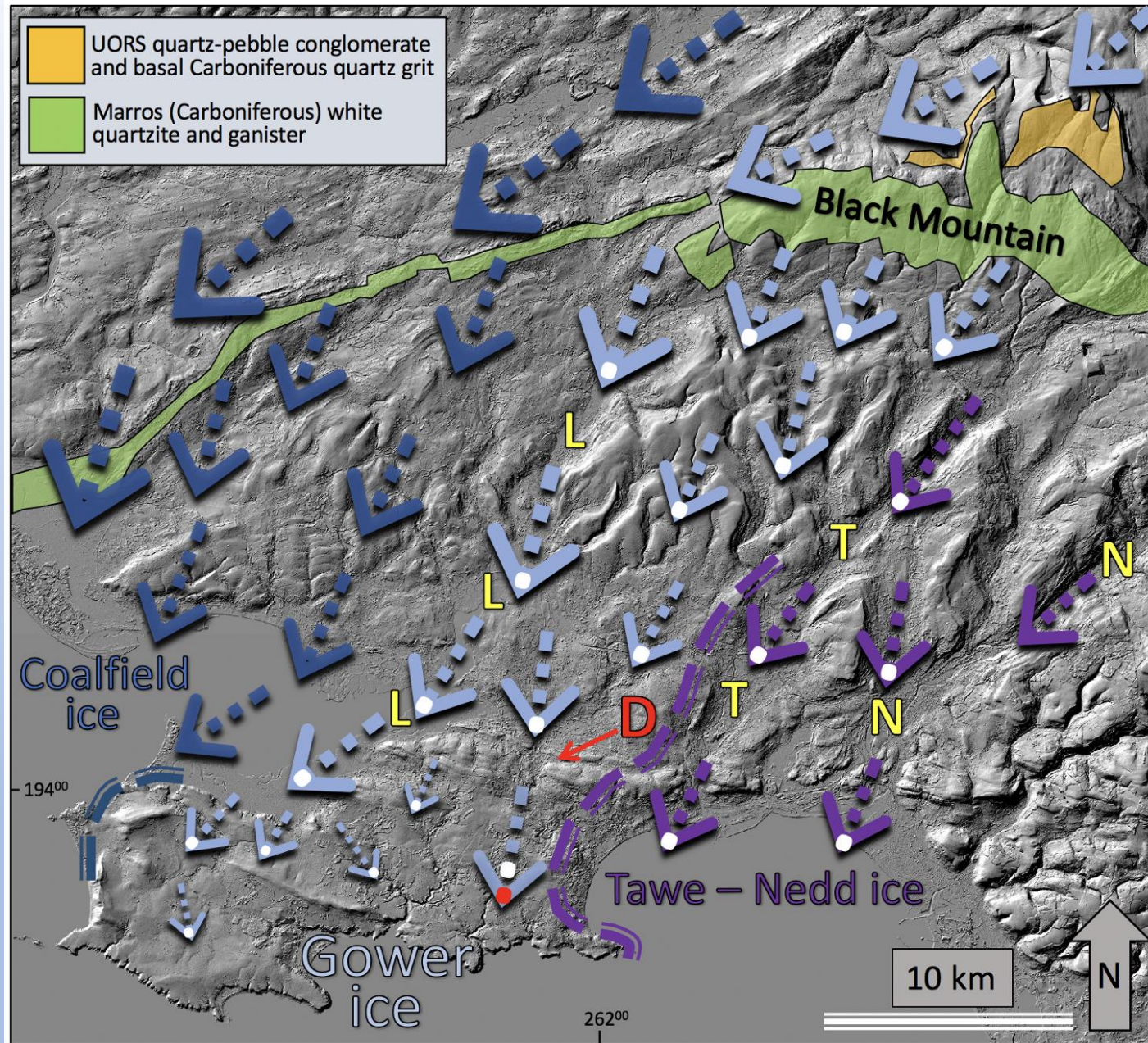
Welsh Ice distinguished by 'north crop' ***erratics***.

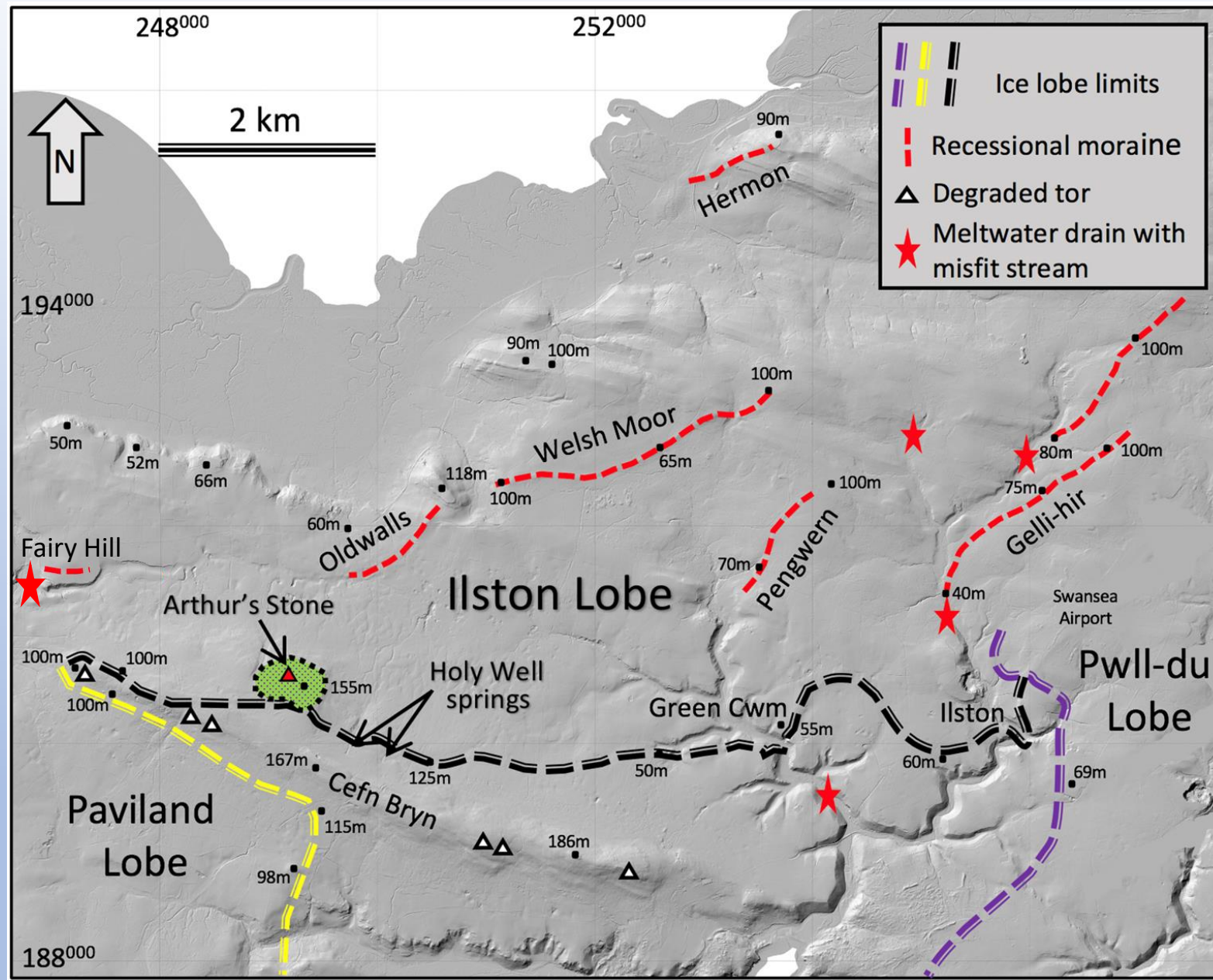
Quartz-rich rocks can only come from Black Mountain area.

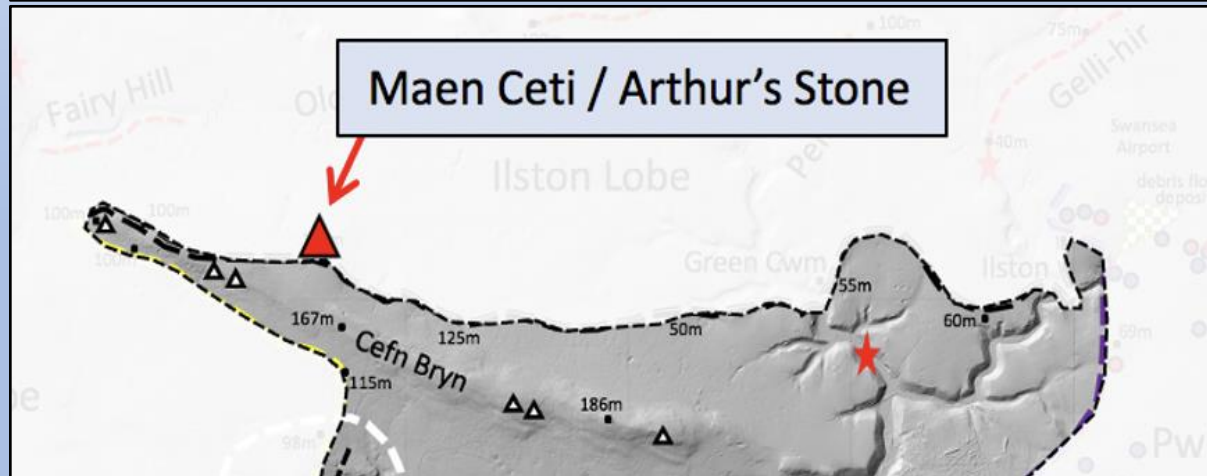


Rounding occurred in rivers ahead of the advancing ice, e.g., in Loughor river valley.

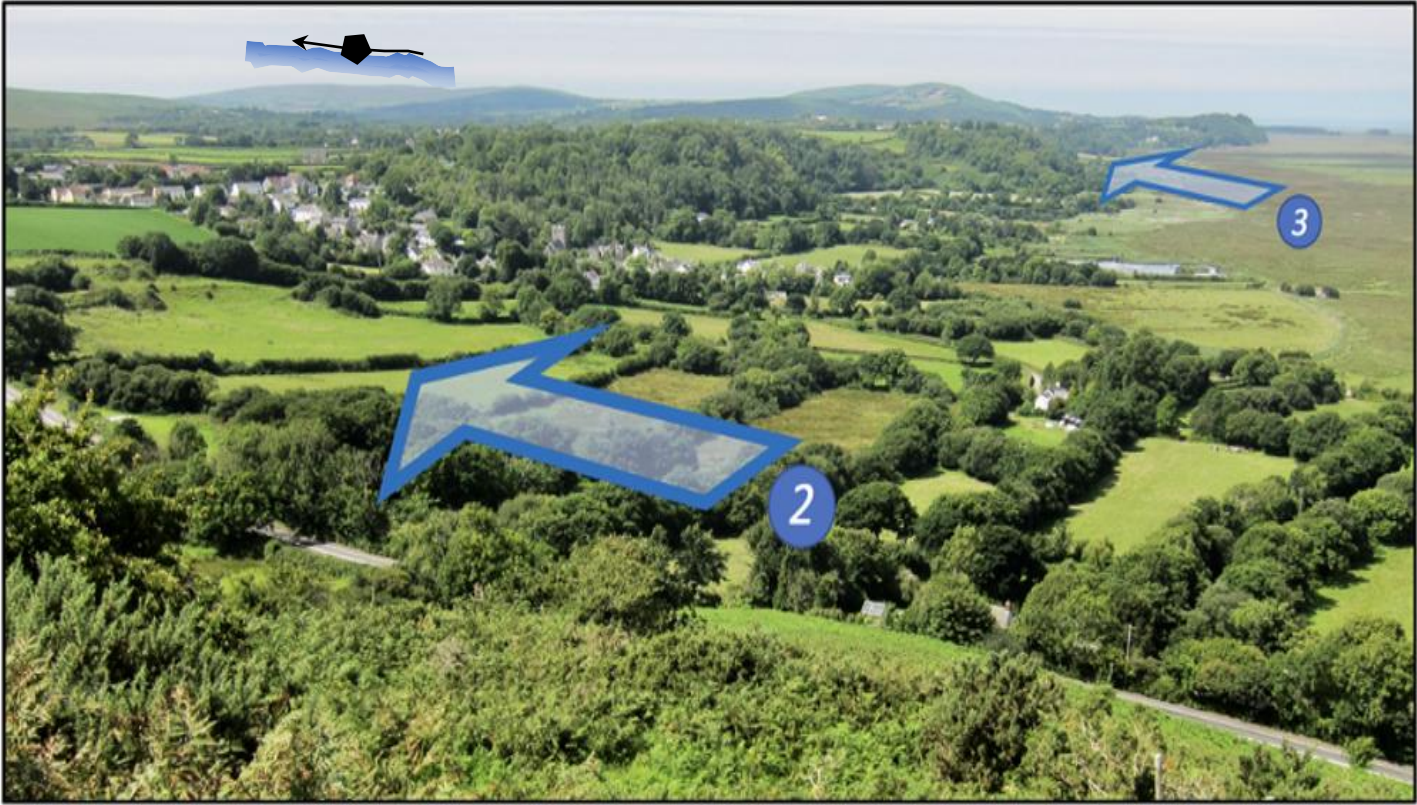
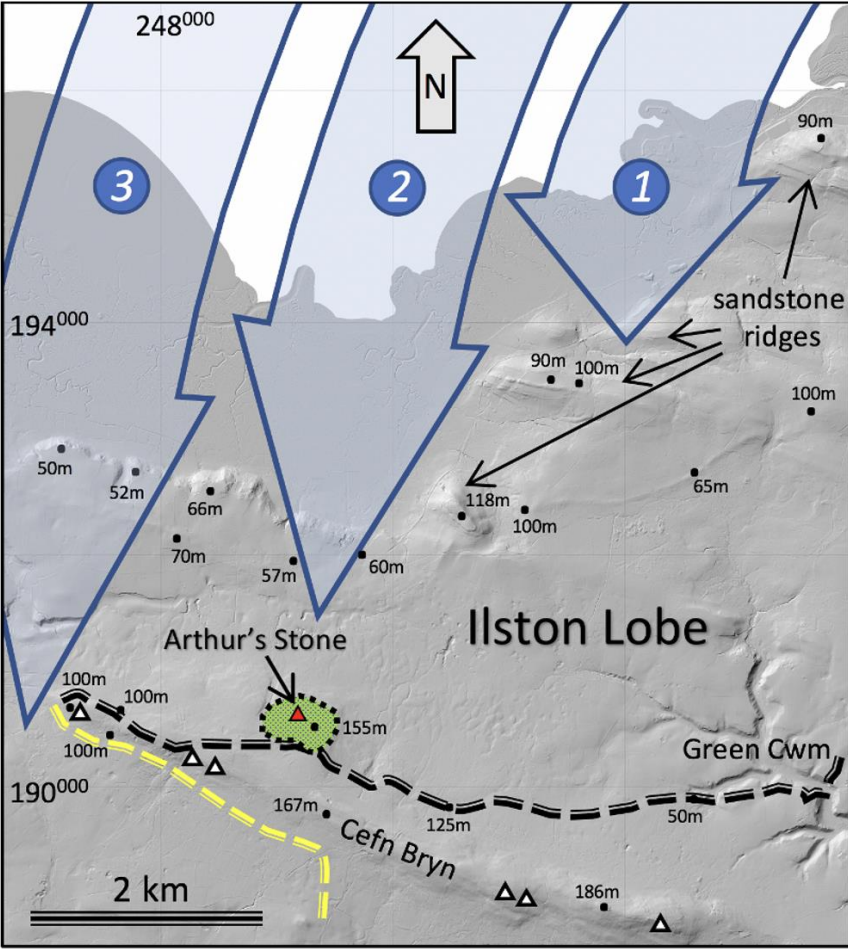




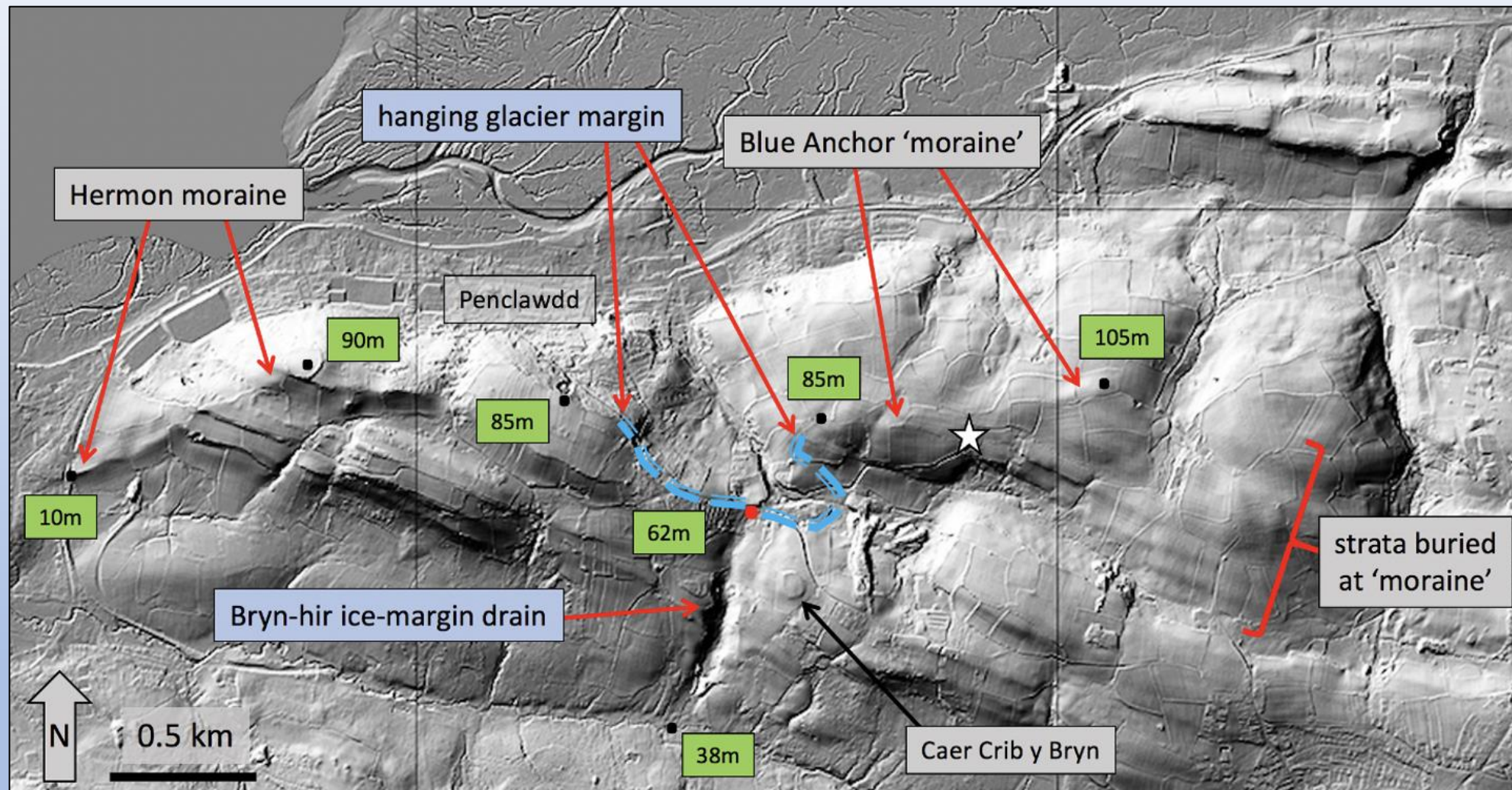


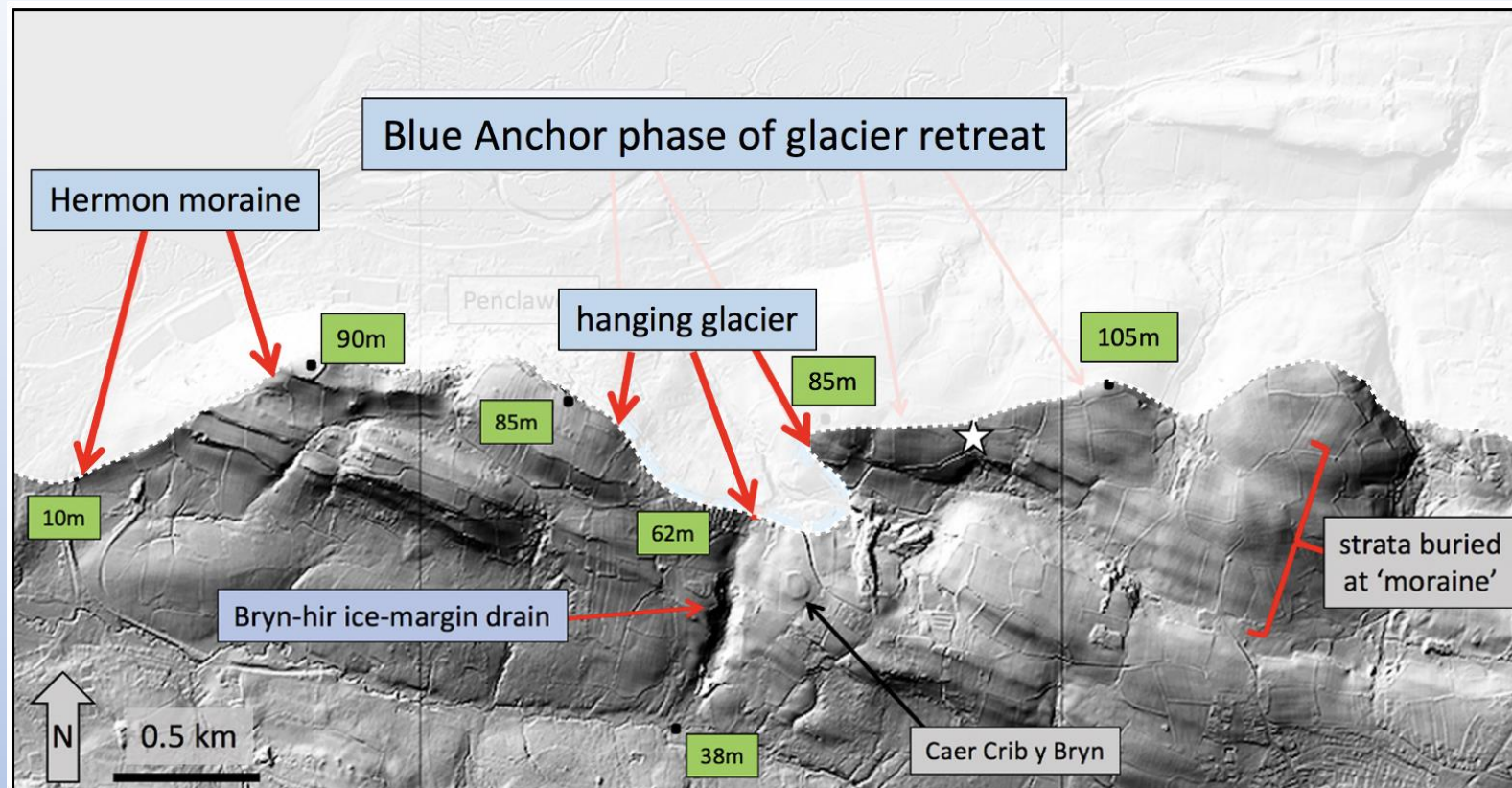


Passage of ice streams within the sheet through low passes.

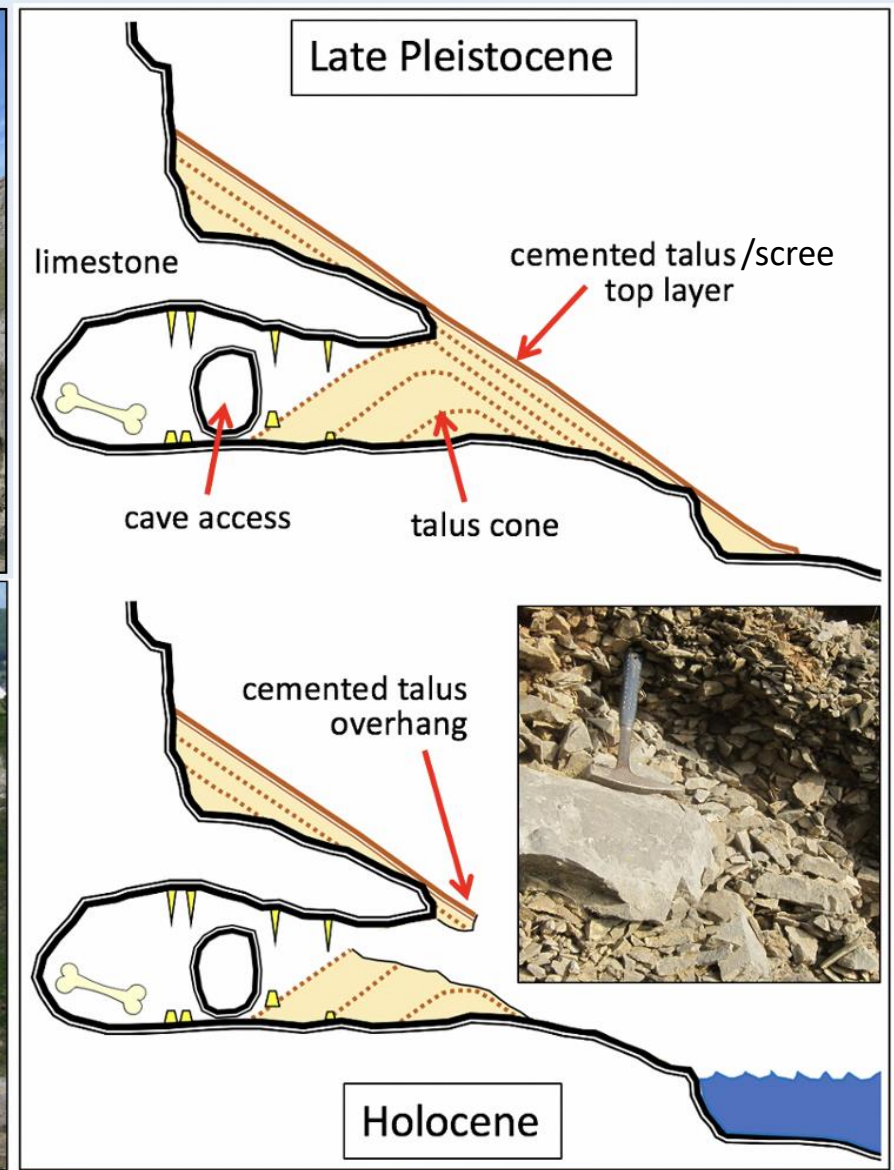
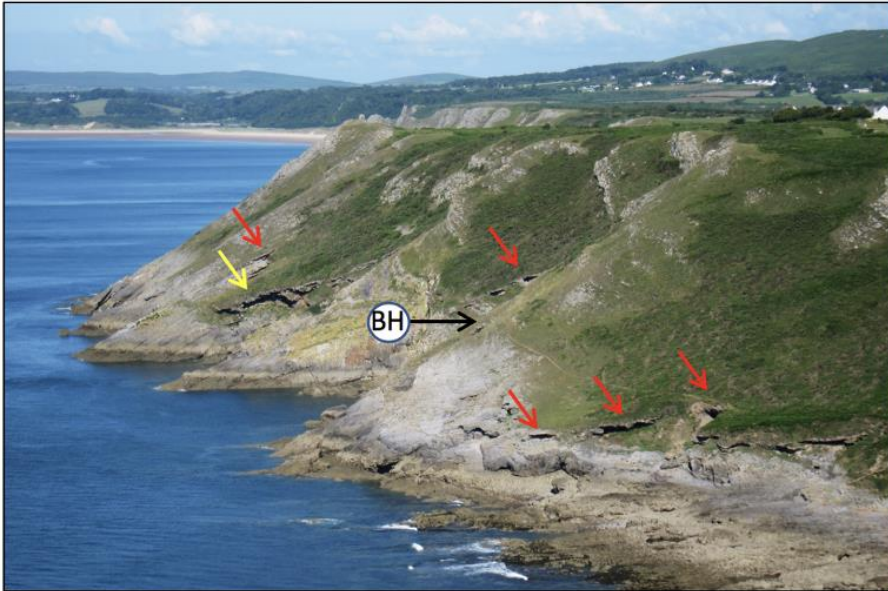


Blue Anchor phase of glacier retreat

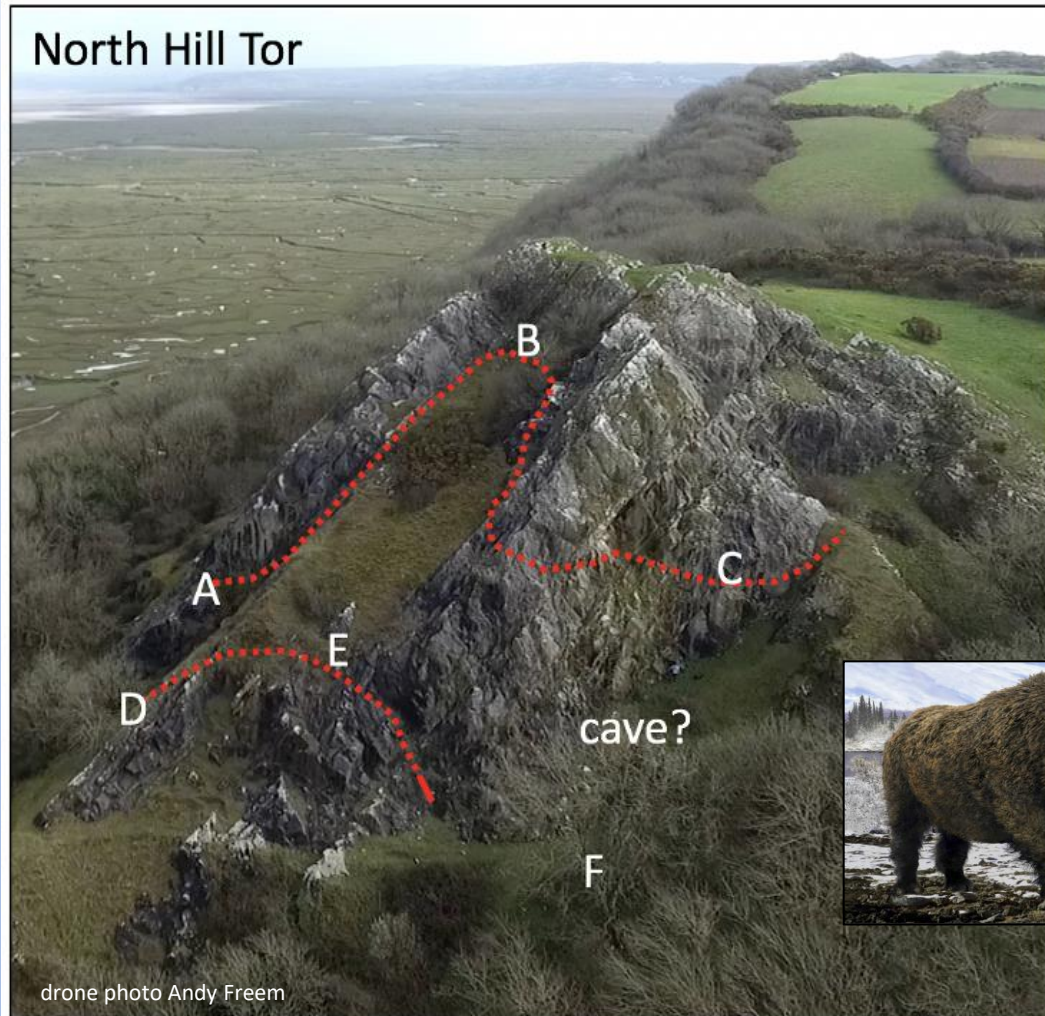




Freezing and
warming



Cave excavated in 1869 by Col. ER Wood who found remains of cave bear, woolly rhinoceros and hyena, with flint tools (Late Stone Age 50,000 to 10,000 years ago). ***"The cave was destroyed by quarrying."***



Landscape highlights

Oldest landscape features are Triassic, 200 million years old

Lundy records **at least 1 km of rocks eroded away**

Stepped peneplains record mantle-plume pulsed uplift

**Marine platform sloping to ~75 m OD records land subsidence
faster than sea level fall 3-4 million years ago**

**'Ice Age' sea level falls faster than land subsidence so coast
retreats; interglacial sea-level rises cut cliffs**

**Welsh Ice drapes landscape in glacial till and gravels ~23,000
years ago**

Freezing conditions form screes that flank cliffs and bury caves

Humans scratch the surface





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