

From Rodinia to Laurentia: Quite a Journey!



Simplified terrane map of Scotland

The oldest part of Britain. Maximum age 2800 million years. Nothing much has happened here for 1000 million years.



Hebridean Terrane
(the Lewisian)

The Moine

The Grampian Highlands

The Midland Valley

The Southern Uplands

Ancient rocks altered by heat and pressure. Age range 1800-1000 million years.

Slightly less-ancient rocks, also altered by heat and pressure, between 1400-600 million years old.

A terrane made up of rocks older than 1500 million years, but completely covered with younger rocks.

Foundations entirely hidden beneath thick layers of rock laid down 500-400 million years ago.

Northern Britain was separated from Southern Britain until about 400 million years ago, when they joined up along this line.

A string of volcanic islands and

The first 3 billion years!

The Hebridean Terrane has travelled a long way from its cratonic origins, from supercontinent to supercontinent...

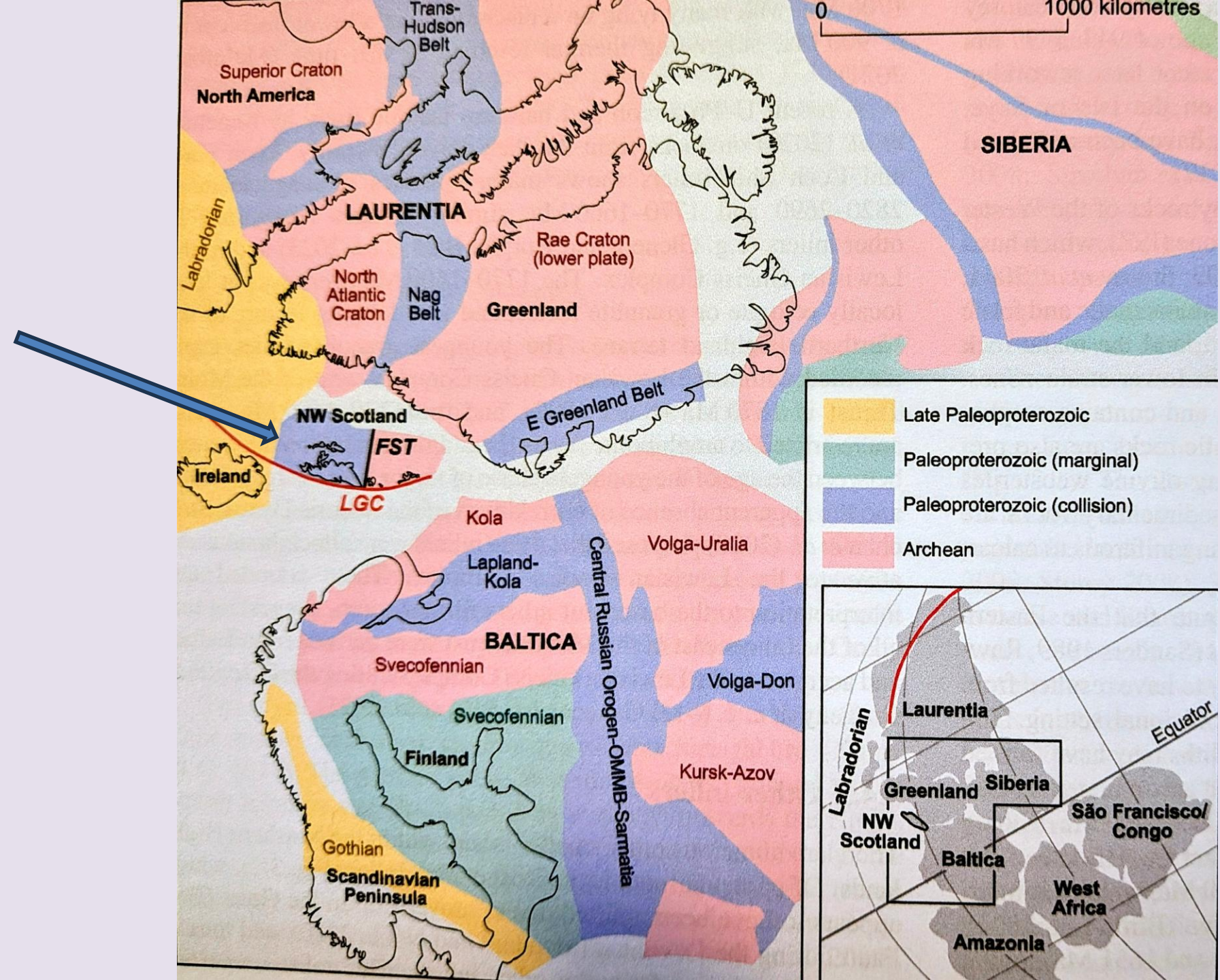
Vaalbara? 3.6 – 2.8 Ga

→ Ur 3.0 – 2.8 Ga

→ Kenorland 2.7 – 2.1 Ga

→ Nena & Columbia 2.0 – 1.2 Ga

Welcome to Columbia!



2.0-1.8 Ga - Nuna and Columbia

Nuna: a minor supercontinent

(Northern Europe – North America)

Columbia: a vast supercontinent

- Nuna (NW Scotland on its edge) collides with Columbia, and becomes part of Columbia.
- The later continent of Laurentia was part of Columbia, and the Hebridean Terrane was part of Laurentia...
- **BUT** already Columbia is breaking up elsewhere, and the future belongs to **Rodinia** – for a while!
- Laurentia, taking the Hebridean Terrane with it, is going to be part of Rodinia.
- Rodinia: still lifeless – barren. Ultraviolet radiation still too high for terrestrial life.

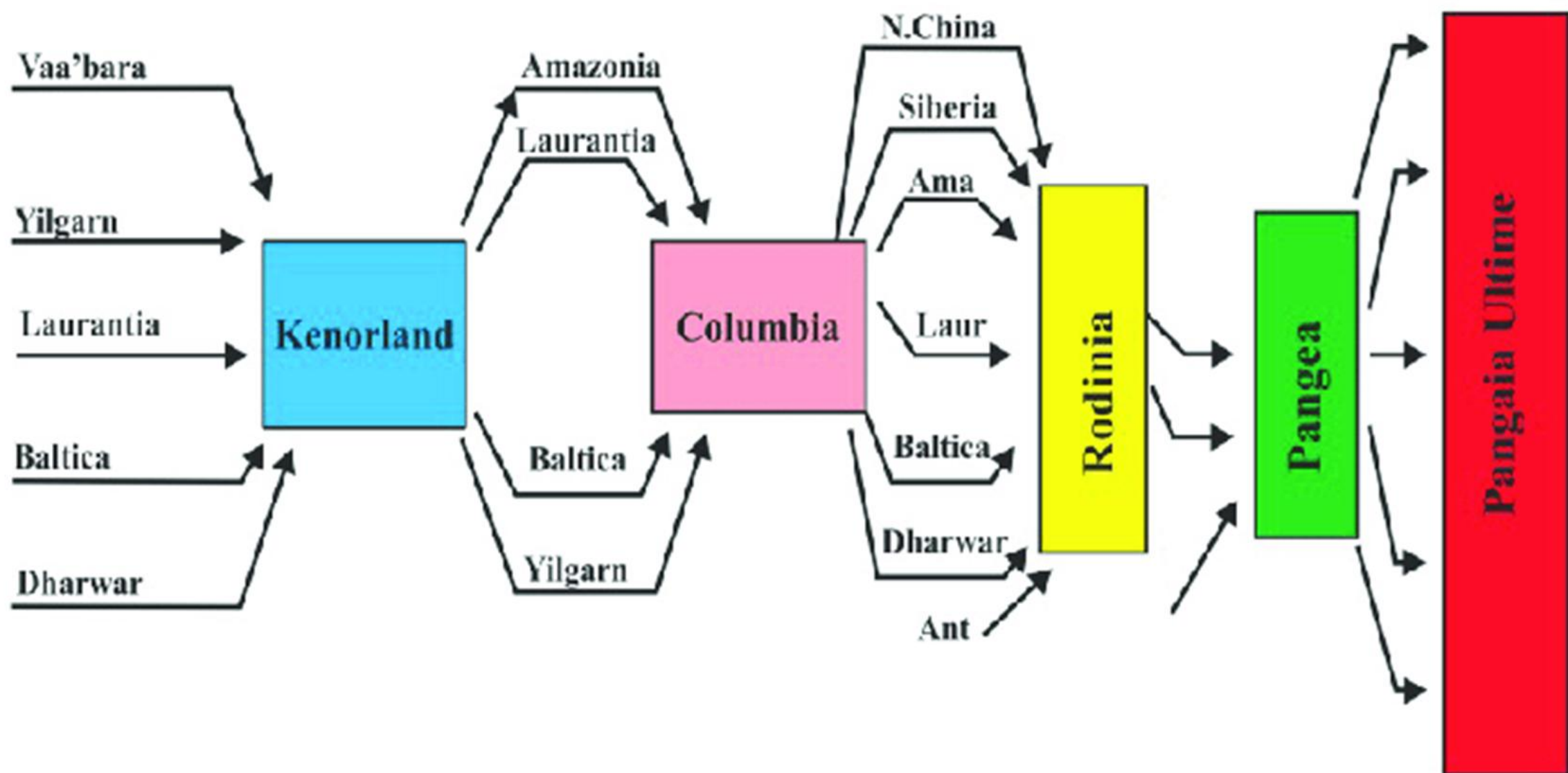
Time (Ga)

3

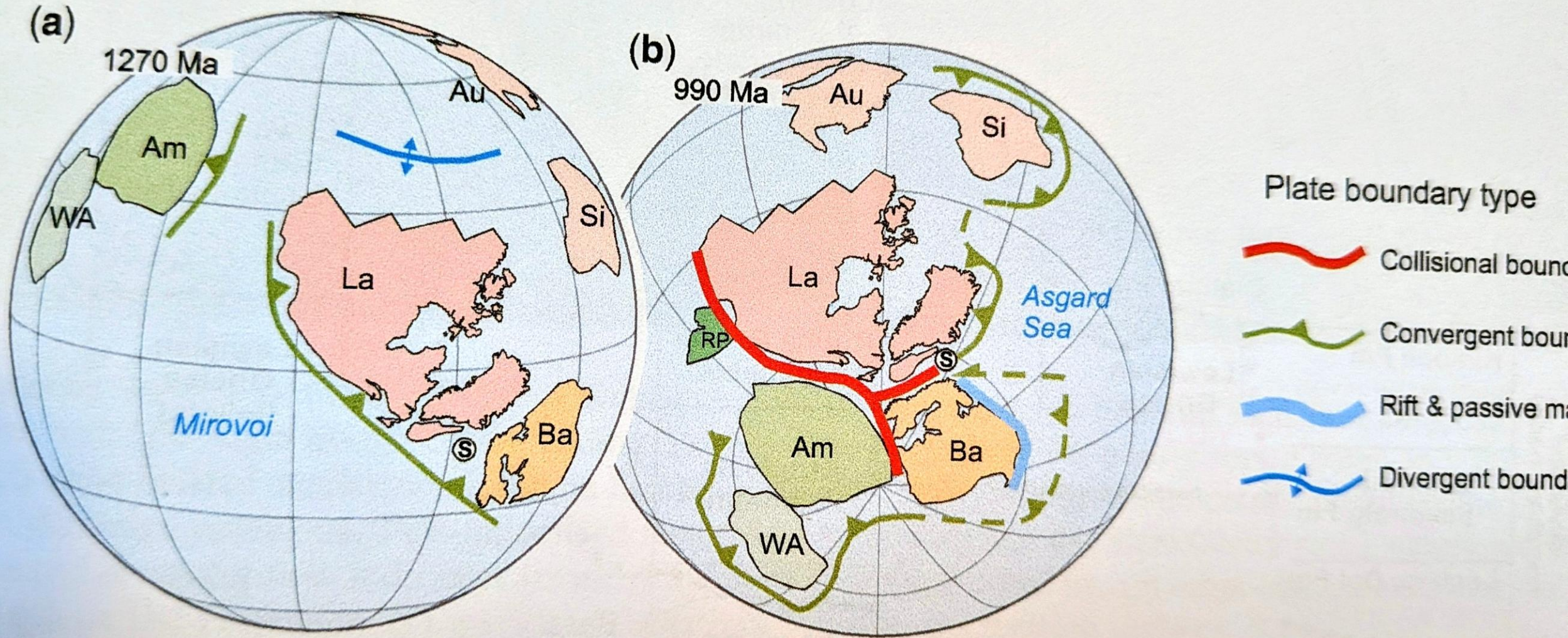
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1

0



Formation of Rodinia



Rodinia 1.1 - 0.75 Ga

Grenvillian orogenic belt

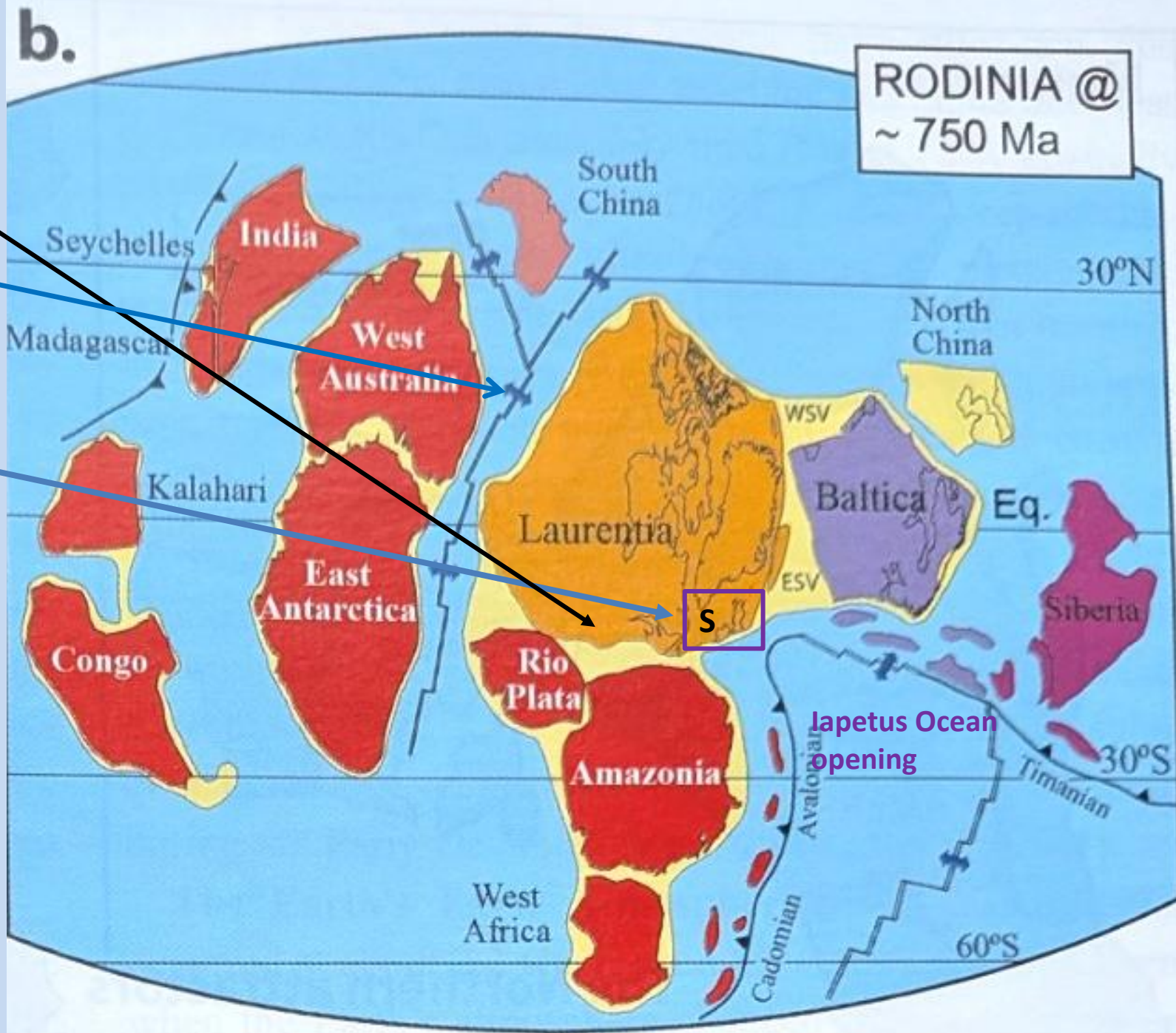
Rifting caused the 'top' of Rodinia to break away to form the **Adamastor Ocean**.

Further south, rift valleys (*grabens*) opened across Laurentia. Erosion and transport filled these with vast quantities of sediment.

Palaeoclimate, deduced from comparison of these sediments with modern analogues:

- Latitude 10°-30° south
- Long hot dry summers
- Cool wet winters, up to 1m rainfall

This produced the oldest sedimentary rock sequence in Scotland, essentially unmetamorphosed, the **Torrionian**.



Let us focus on just one of the grabens, near the southern edge of Rodinia...

... between the Minch Fault and the Moine Thrust

... 80 km across, at least 200 km long
... fed by sediments from the northwest, carried by rivers from eroding mountains

... creating the 'Torridonian'

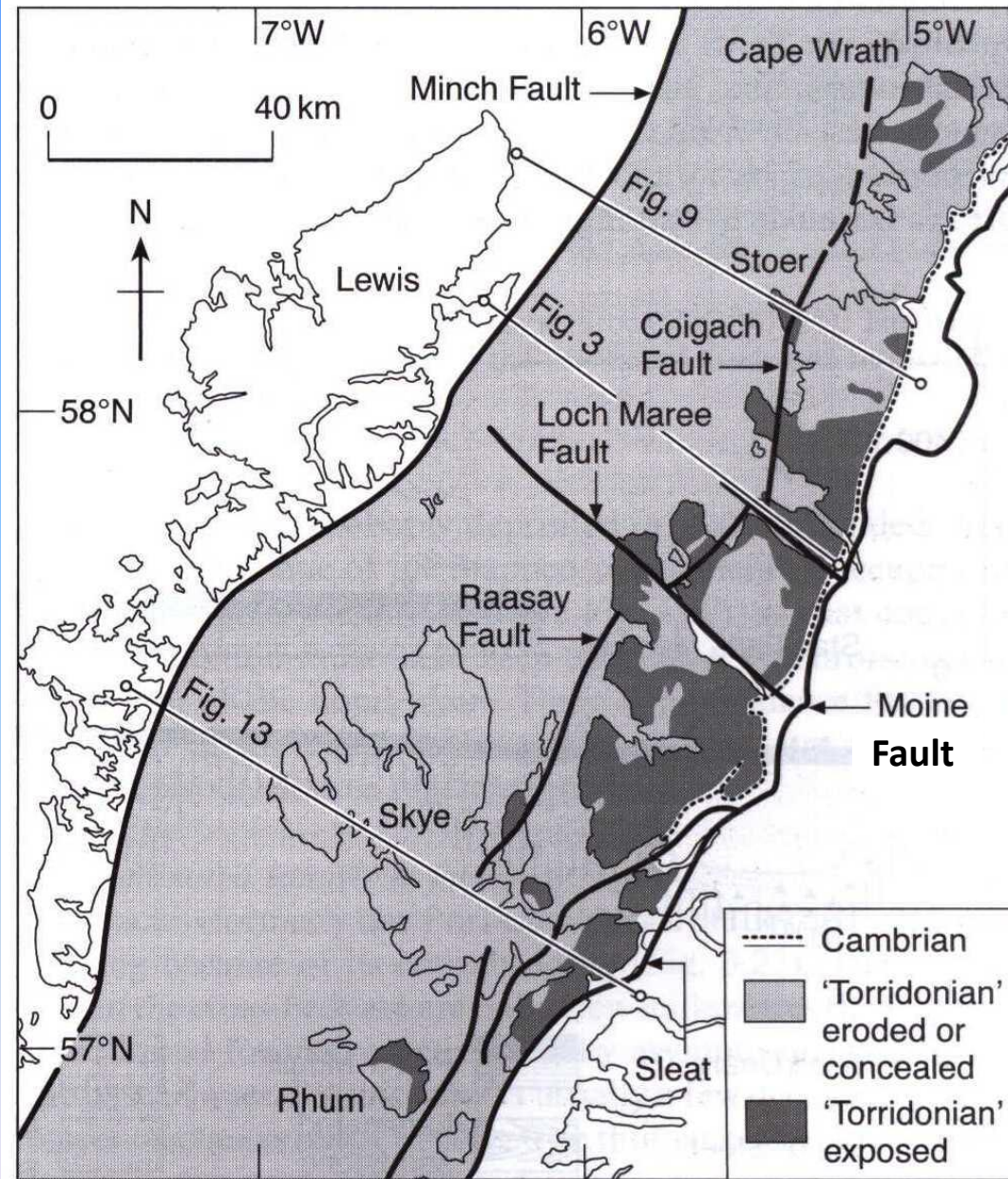


Fig. 3.17. Sketch map of northwest Scotland showing the present and former extent of the 'Torridonian', together with some major faults.

The Stoer Canyonlands, 1.2 Ga BP, as interpreted by Sir Archibald Geikie

**Reminder of the Torridonian
sequence that filled this graben:**

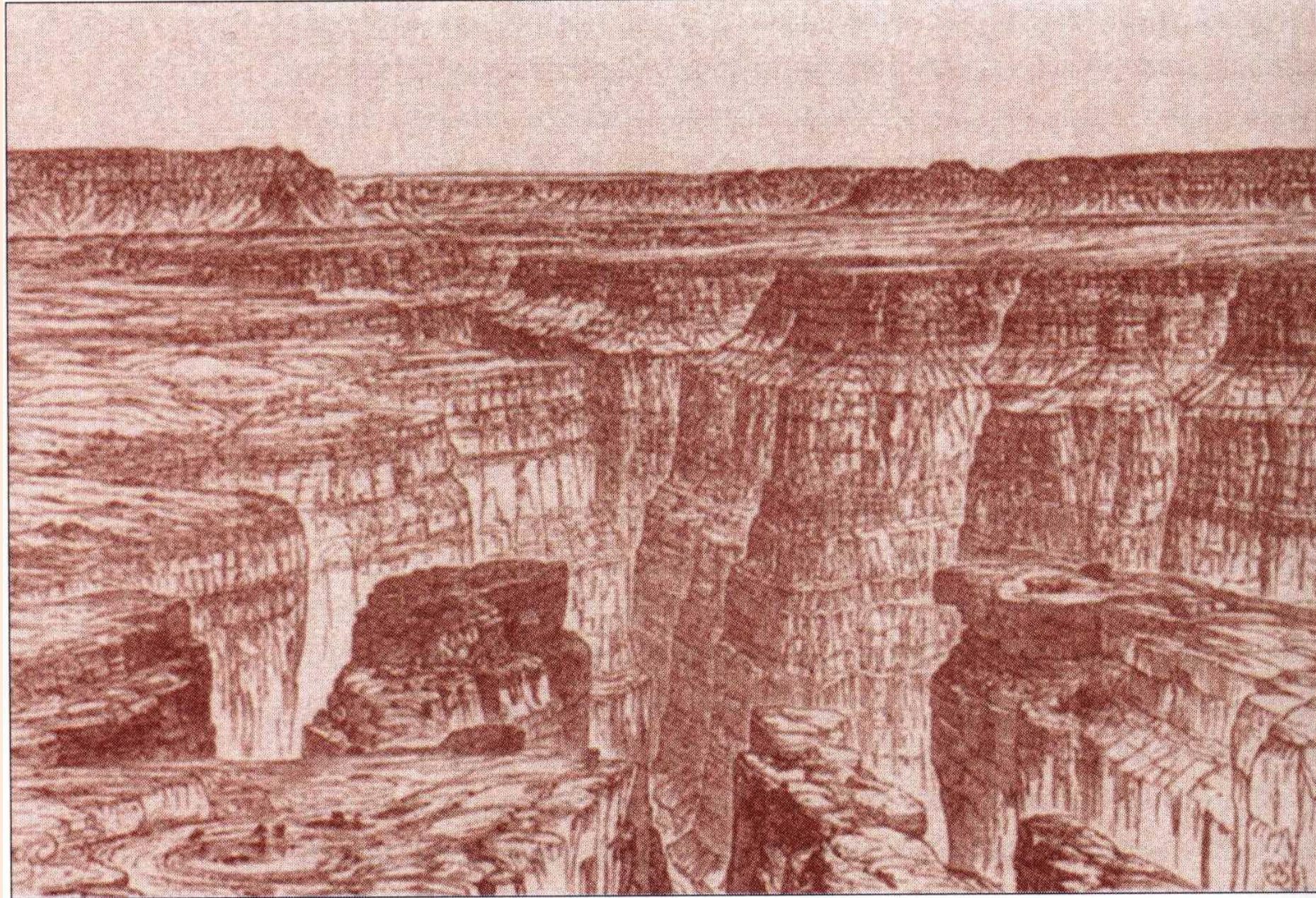
Torridon group

on top of both these groups

Sleat group

which is separate from the older

Stoer group



Stoer group forming the Stoer peninsula, north of Lochinver – 1.2 – 1.05 Ga, comprising:

(begin at the bottom, the oldest)

Meall Dearg Formation: more braided river deposits

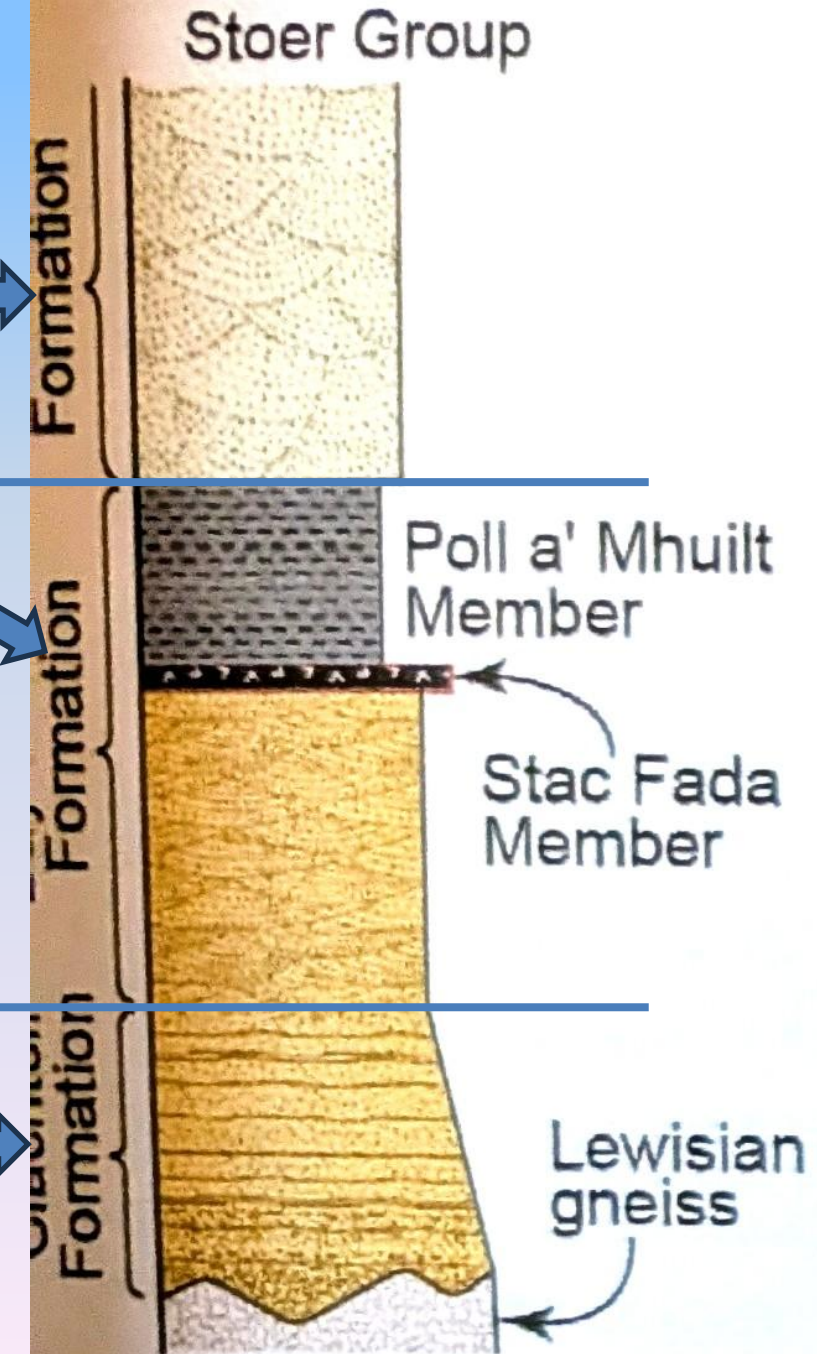
Bay of Stoer Formation: red pebbly sandstones, braided river deposits, grading upward into less pebbly, finer-grains material. In the upper regions two distinctively different members:

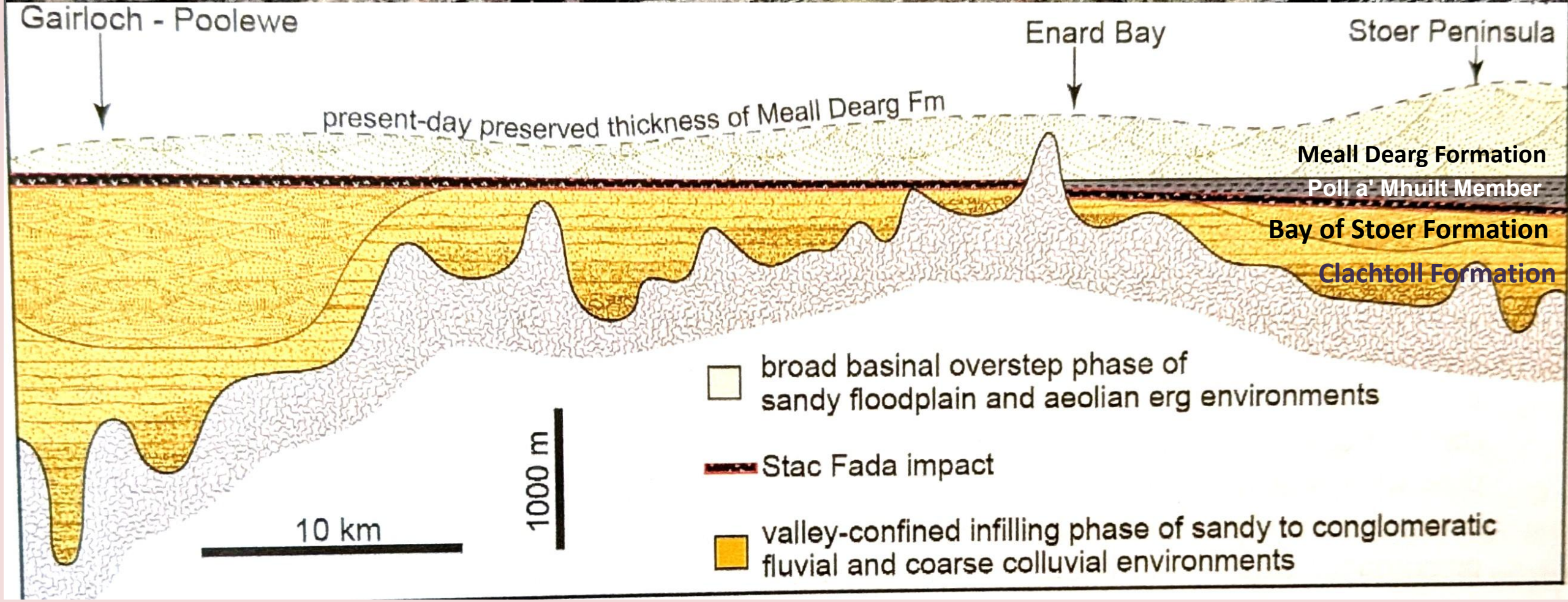
Stac Fada Member: muddy sandstones with abundant glassy fragments, 10 m thick, and large rafts of gneiss and sandstone.

Poll a' Mhuilt Member: sequence of siltstones and fine sandstones alternating with muddy sandstones, suggesting deposition in a lacustrine environment.

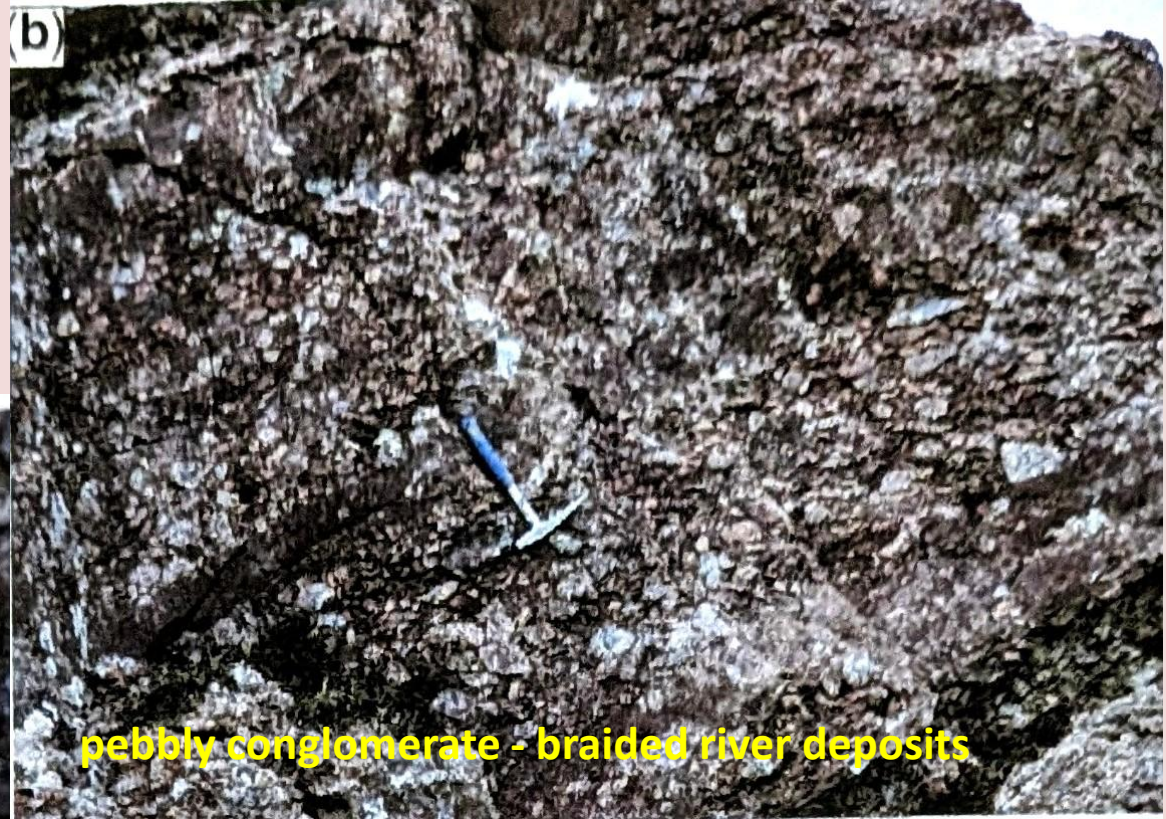
Clachtoll Formation: basal breccia, Lewisian clasts, lying unconformably on Lewisian gneiss.

all infilling the canyons!





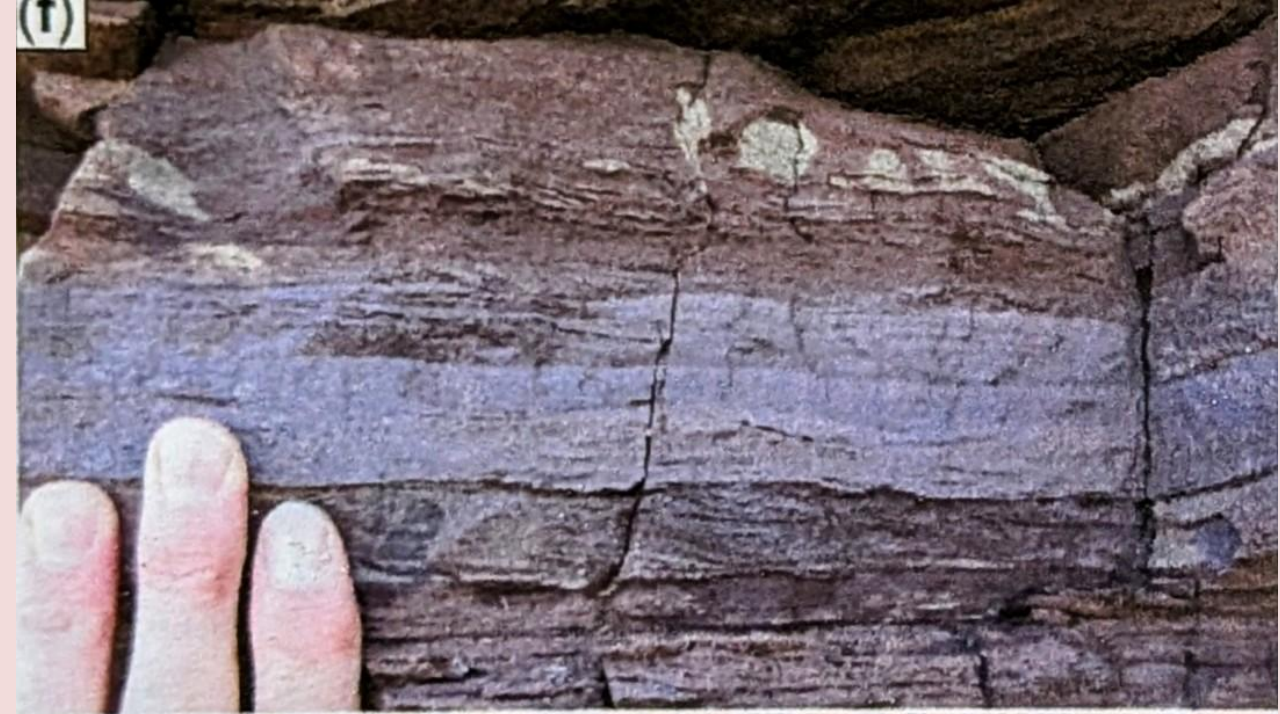
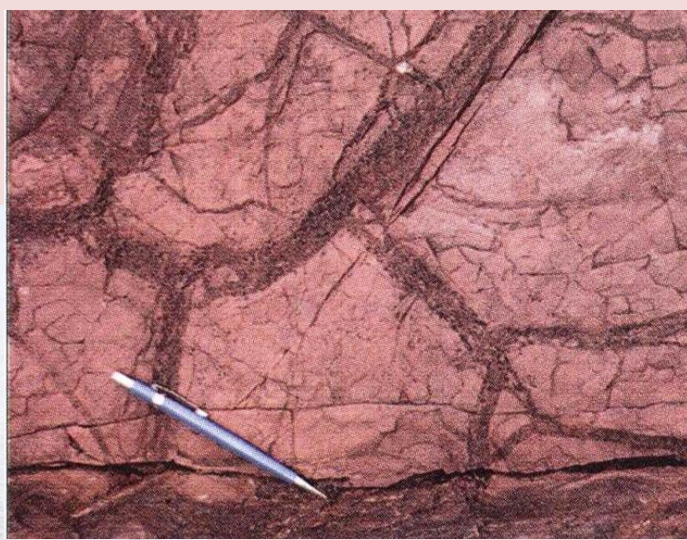
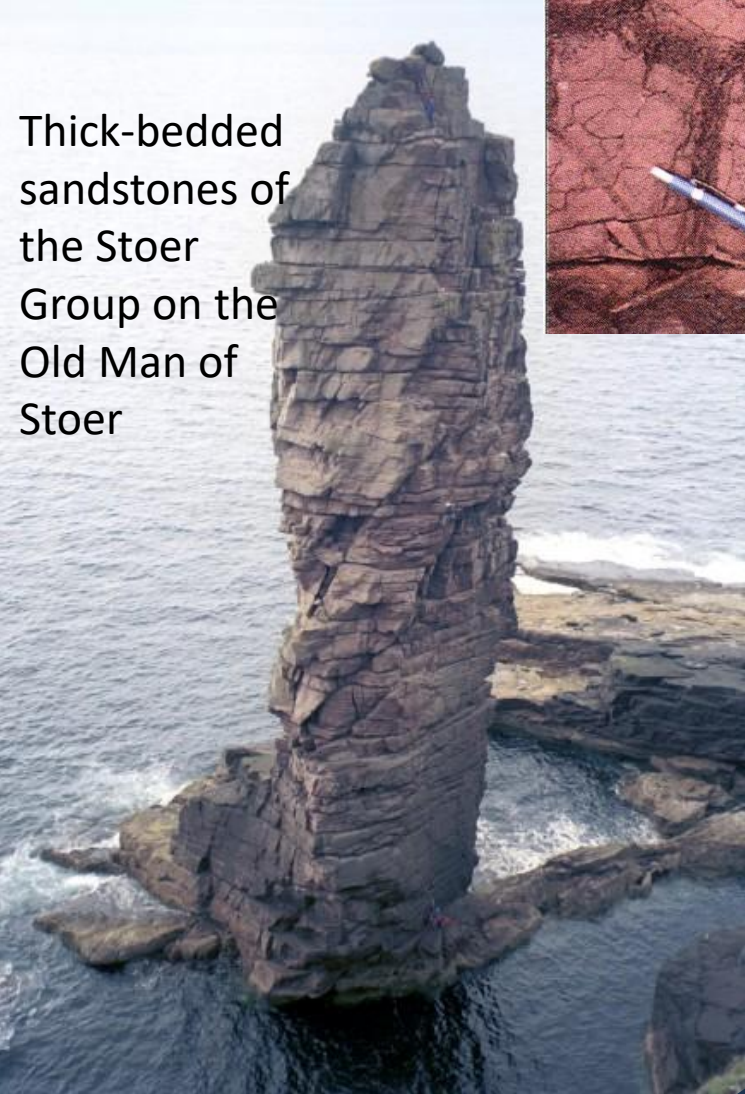
Clachtoll Formation



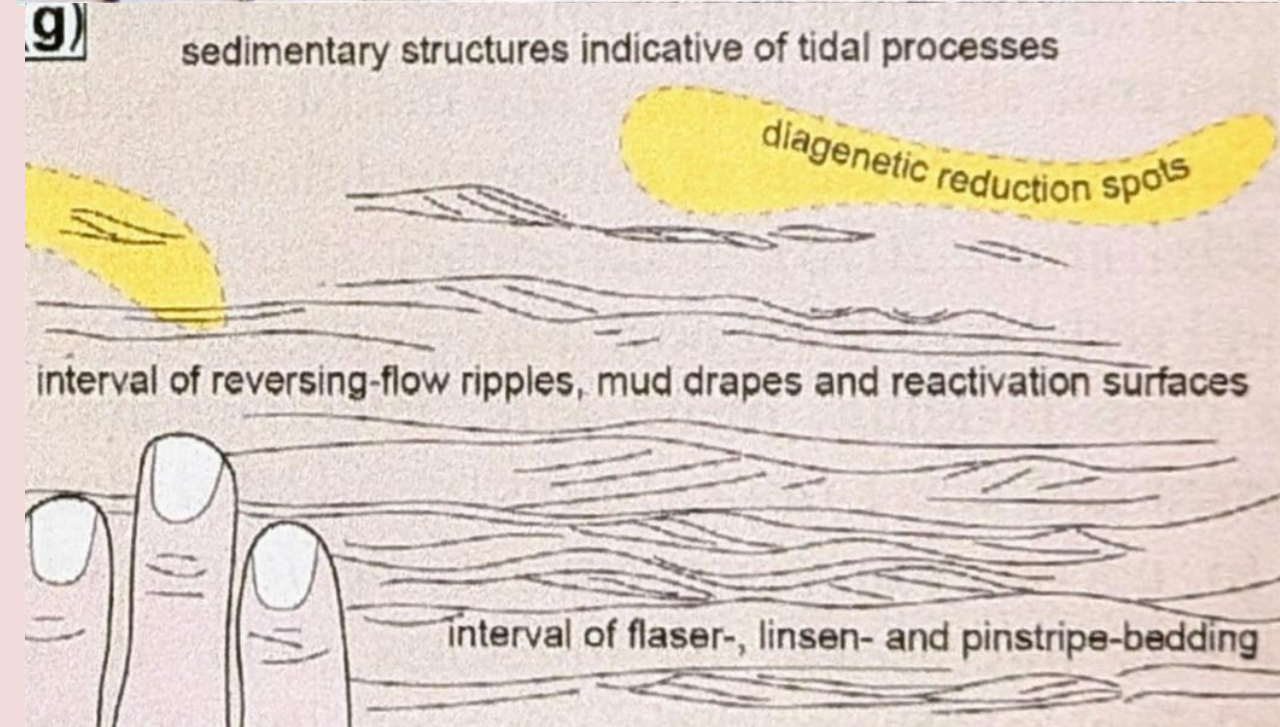
Exclusively Lewisian clasts in all Clachtoll Fm deposits

Bay of Stoer Fm

Thick-bedded sandstones of the Stoer Group on the Old Man of Stoer



Poll a' Mhuilt Member:
c.90 m thick, tidal mudflats with reversing flow ripples as the tide went in and out, so the area has changed from terrestrial mountains eroding into valleys and now includes coastal floodplain by the end of Bay of Stoer times.

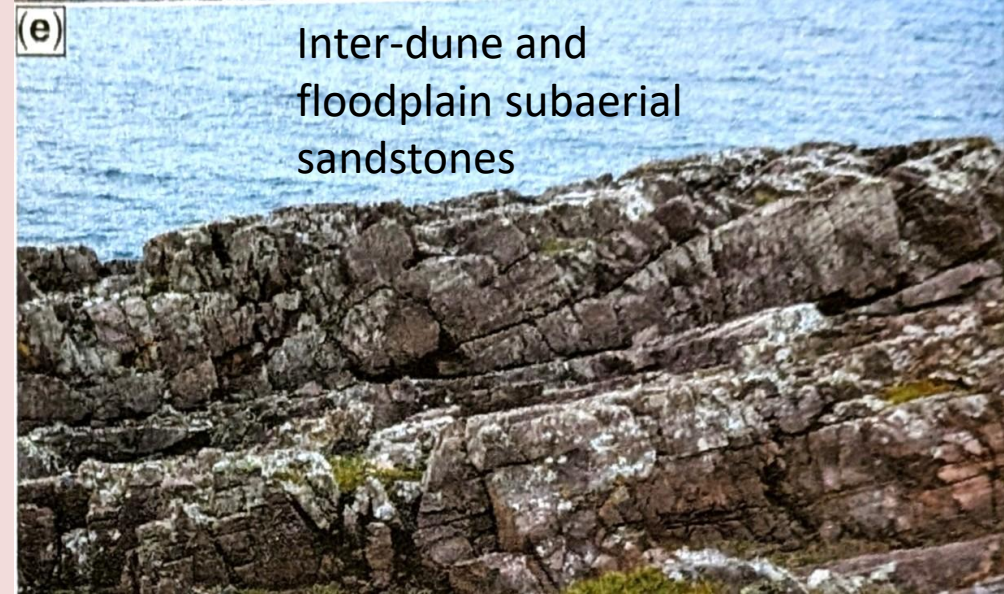


So the sea must be coming in – a marine transgression

Meall Dearg Formation



Fluvial mudstones with sand-filled desiccation cracks and symmetrical ripples




Inter-dune and floodplain subaerial sandstones

Enigmatic limestone deposit 1m thick draping and encrusting across uneven basement of gneiss blocks.



But what about the **Stac Fada Member**?

- Muddy sandstones with **abundant glassy fragments**
- Averaging 10 m thick but very variable 5-30 m, from Stoer peninsula to Enard Bay
- Clasts of once-melted material – accretionary lapilli 
- Numerous fragments of green devitrified glass embedded in the muddy sandstones
- Large rafts of gneiss and sandstone in a matrix of melt rocks



<https://www.youtube.com/watch?v=HmOf6TODAL0>

What on Earth was going on?

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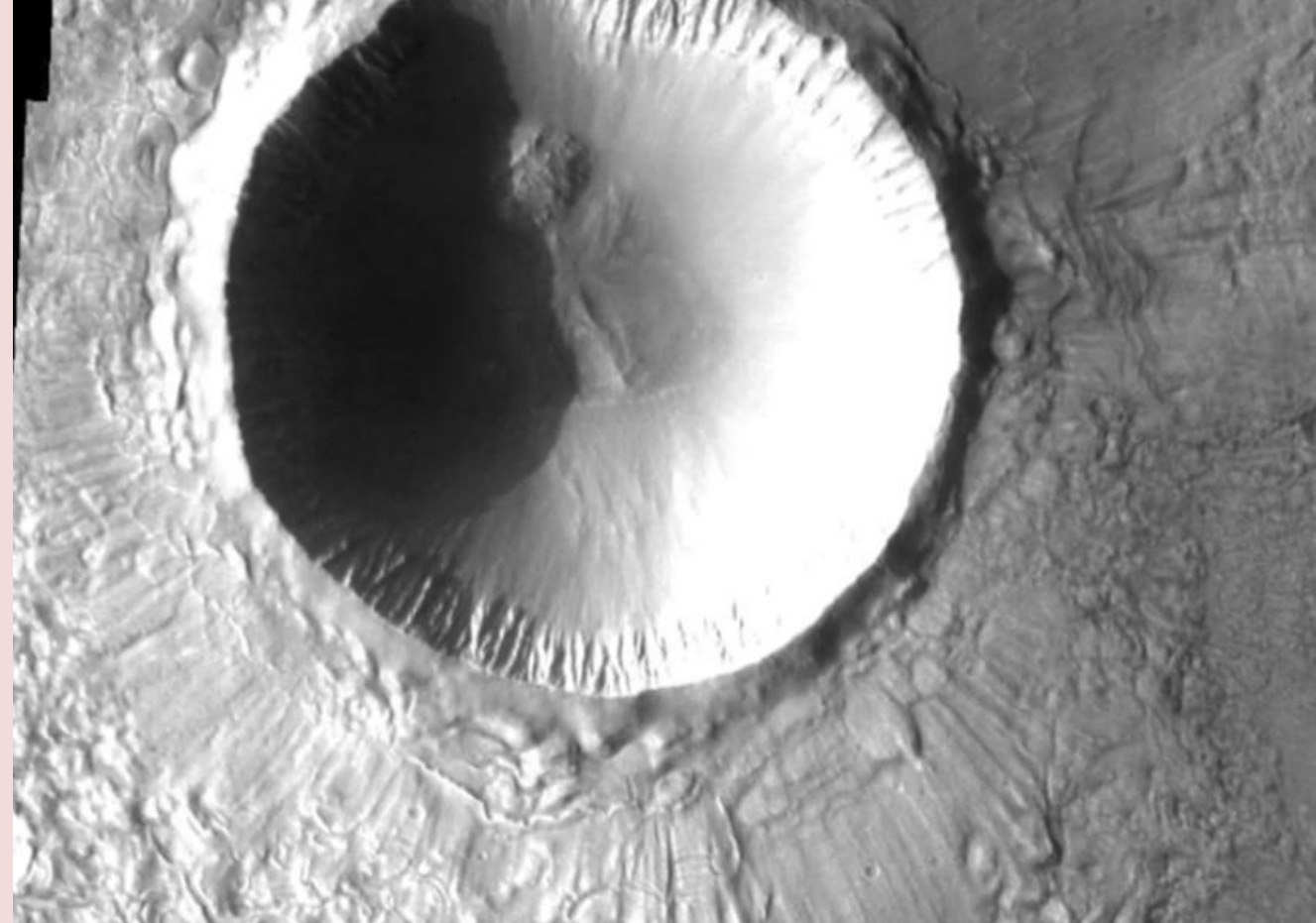
What on Earth was going on?

Options

- BGS initially interpreted as a conglomerate containing clasts from a mafic dyke eruption, with pyroclastic flows and tuffs.
- Very characteristic of a tephra deposit from a volcanic eruption.
- Alternatively the (unlikely) possibility of a meteorite impact, leaving an ejecta blanket surrounding the impact crater but no impact crater visible!
- Further research needed!



Weird!



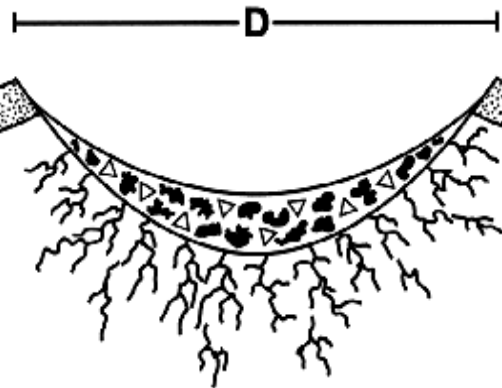
2024: research have progressed, North West Highlands Geopark held a one-day symposium to draw all the research conclusions together. You can view the talks and the evidence they presented on YouTube.

Go to <https://nwhgeopark.com/stac-fada-symposium/>

But the firm conclusion is that there was a meteorite impact in Torridonian times. Crater not yet found!

Craters on Mars

Simple Crater



△ Breccia

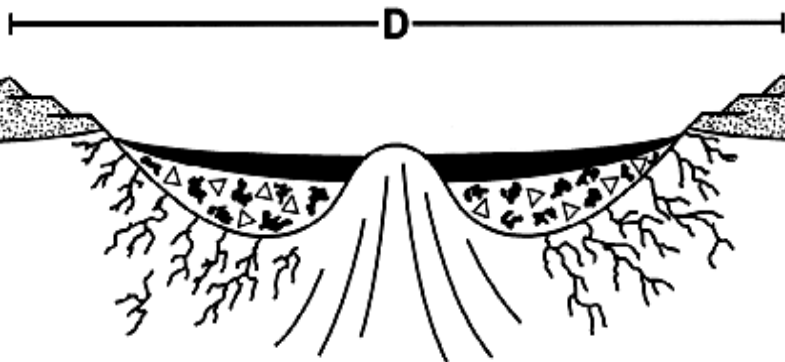
■ Impact melt

▨ Impact ejecta

Fractured bedrock

Central peak uplift

Complex Crater



Research revealed (2008-2024):

- presence of shocked quartz
- enhanced levels of platinum group metals
- a non-terrestrial chromium isotope present
- the mineral reidite in zircon grains –
evidence of very high pressures

All convincing evidence of a meteorite impact, not a volcanic event. **Recently dated 990 Ma.**

But where is the crater?

Two possibilities:

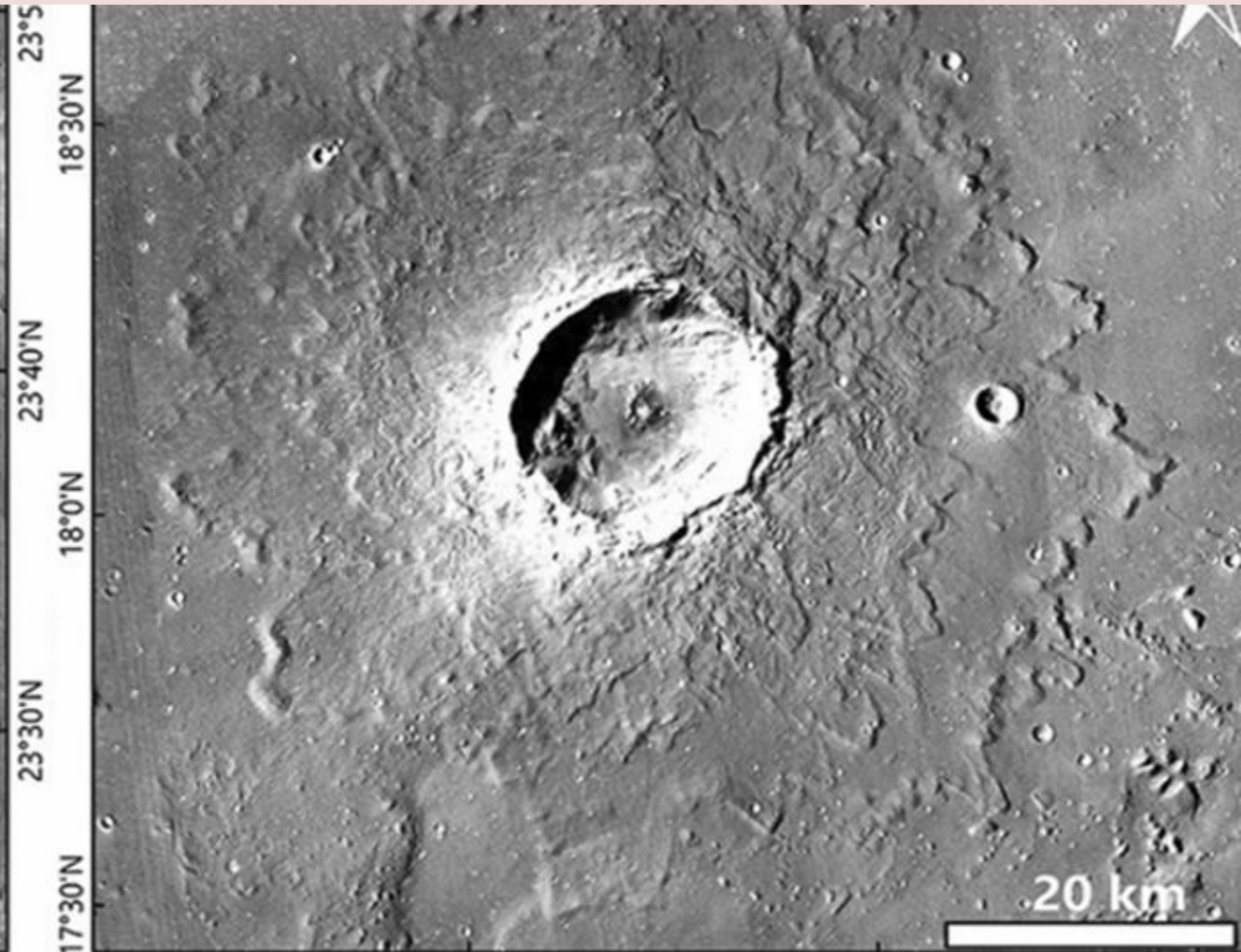
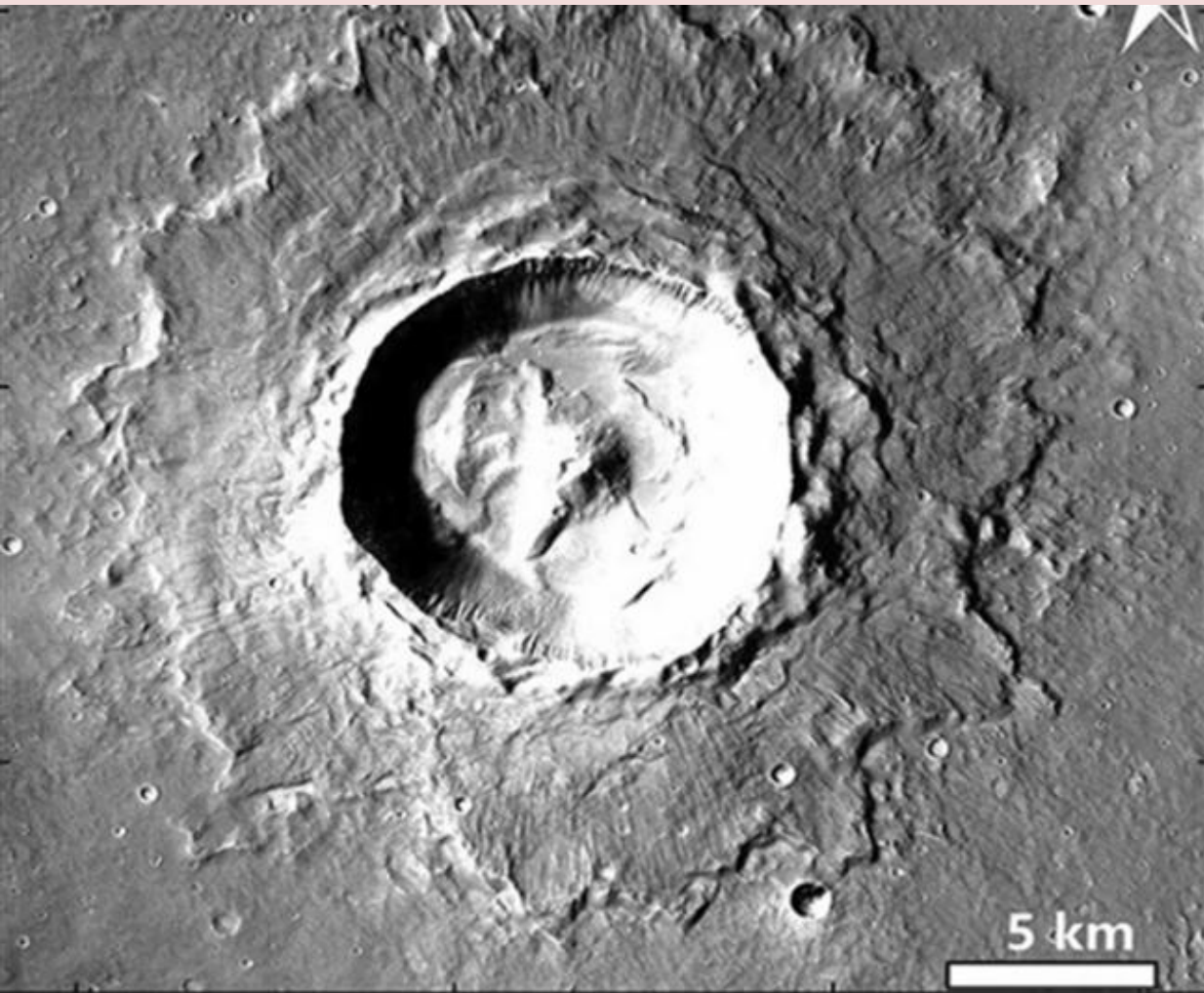
- out in the Minch, buried under later sediments
- near Lairg, where a gravity low lies beneath the Northern Highland terrane – again buried under later rocks.

Such an impact would have created a crater about 13-14 km across, a blast equivalent to 145 000 megatonnes.

Further research on associated thrust faults, folds and striae, also magnetic susceptibility in the rock fabric indicates **the Minch off the coast of Stoer** as more likely – sorry Lairg.

Pingualuit crater in Nunavik, northern Quebec,





<https://www.youtube.com/watch?v=HmOf6TODAL0>

Life around Rodinia

The land surface of Rodinia probably remained barren, though there are claims that bacteria may have colonised favourable niches.

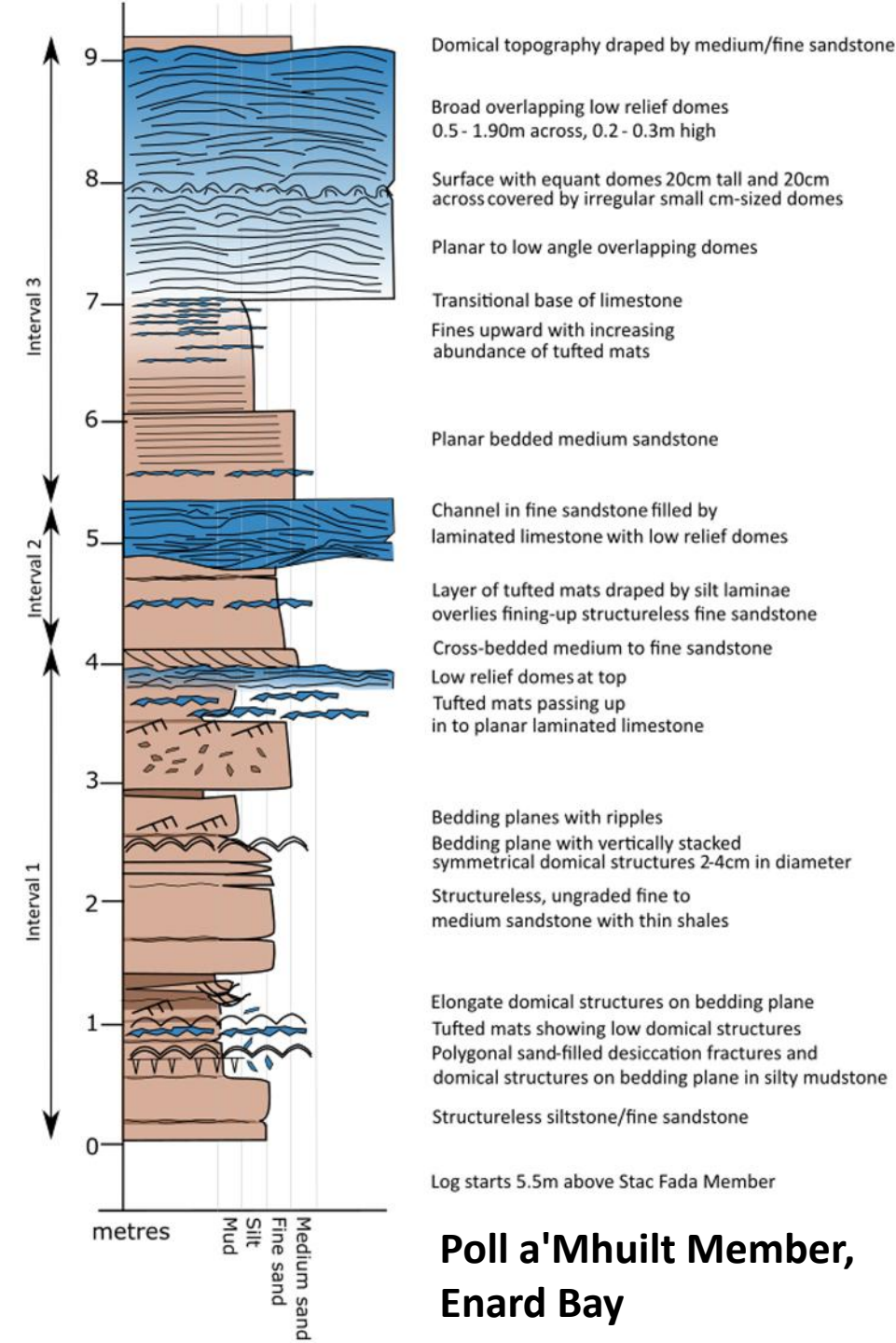
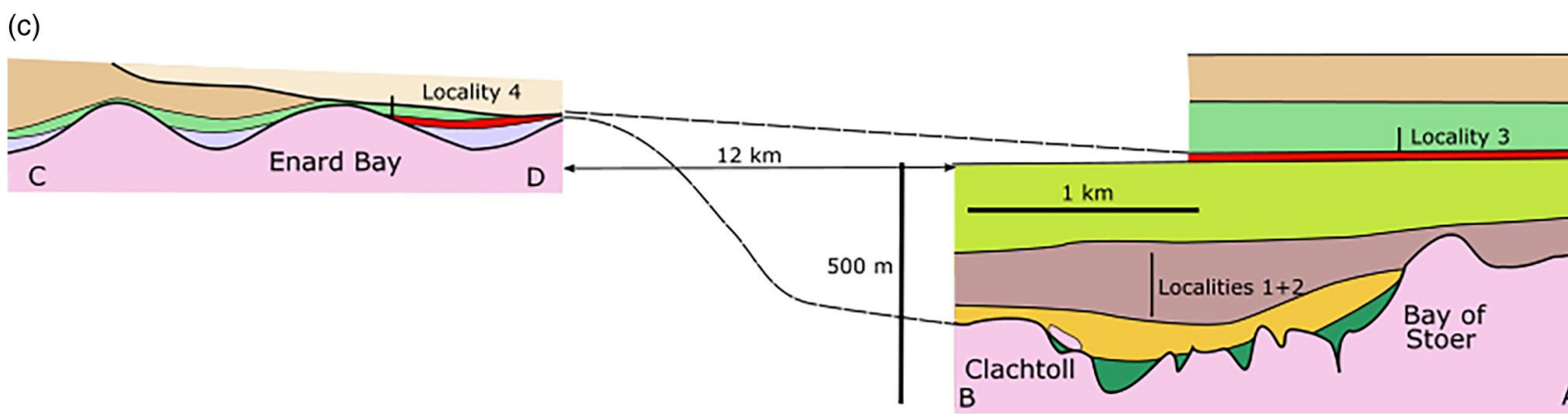
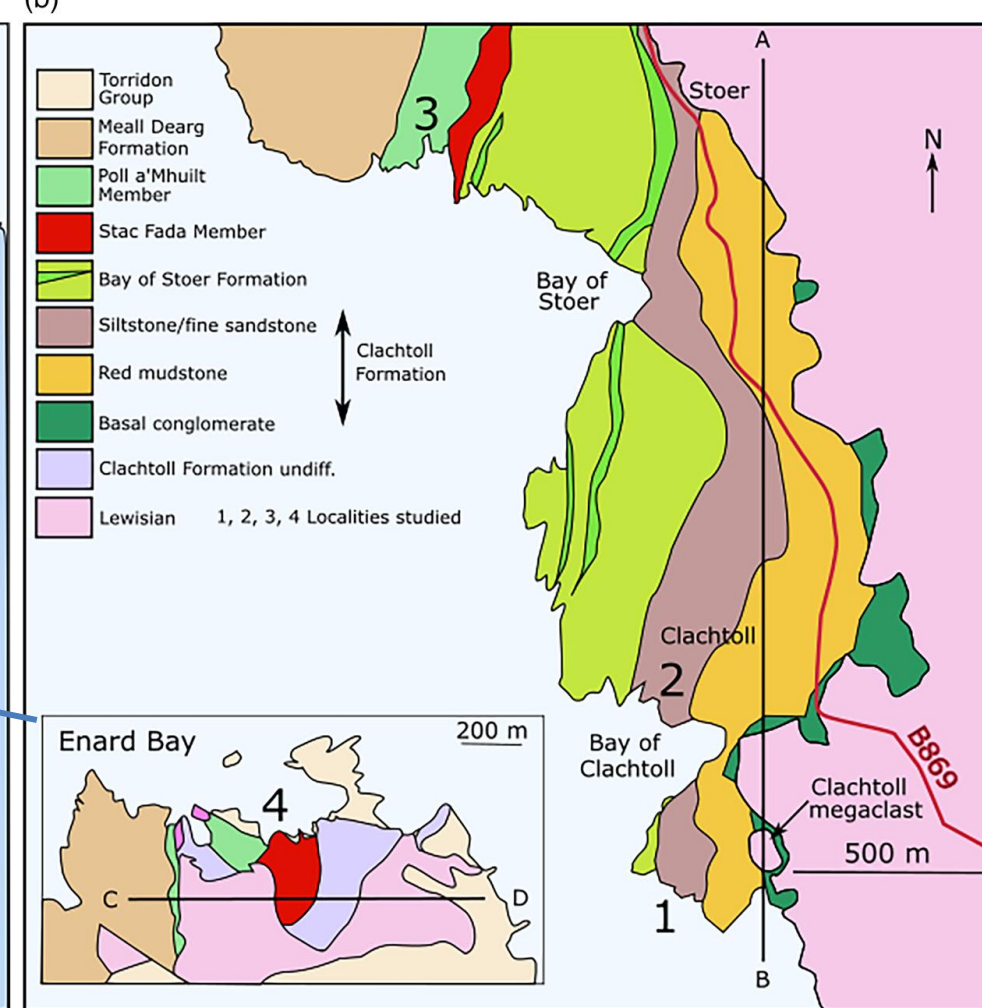
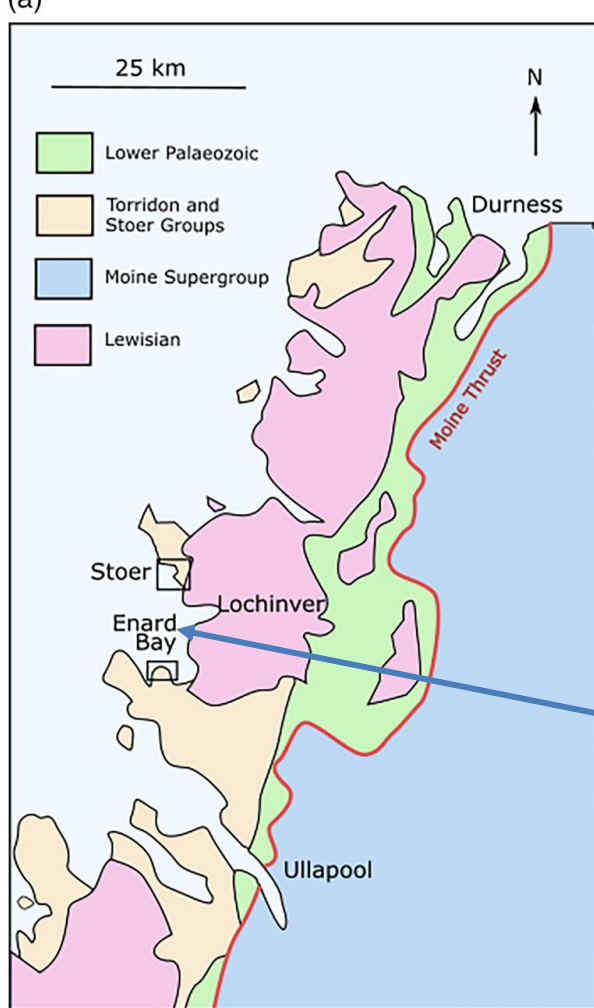
Otherwise life remained aquatic - but where?



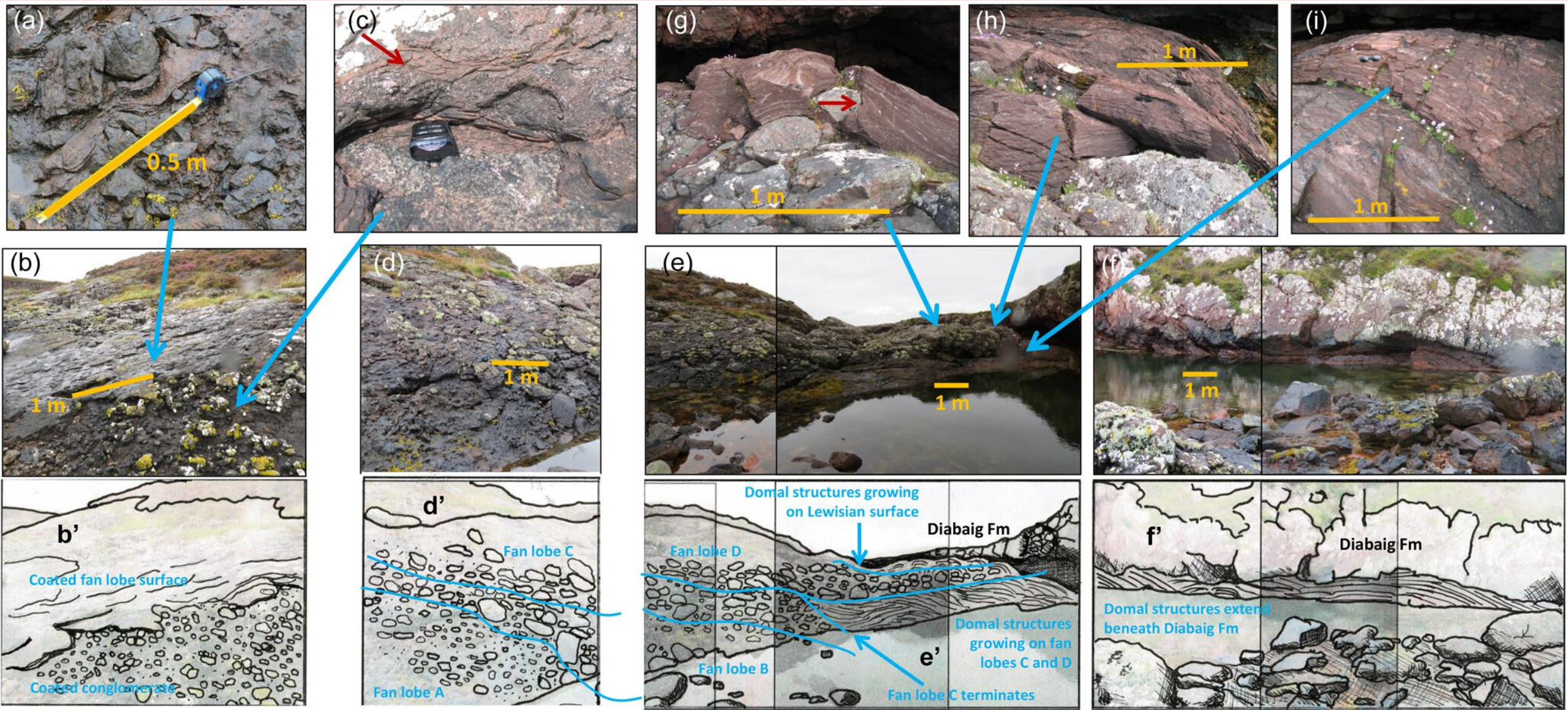
Red stained algal limestone draped over Lewisian gneiss (in the foreground), overlain by red mudstone (**Poll a' Mhuilt Member**) largely eroded by wave action, overlain by boulder conglomerate (Diabaig Formation).

Microbially mediated carbonates in the Mesoproterozoic Stoer Group of NW Scotland; earliest evidence of life in Britain?

Peter Gutteridge, Department of Earth and Environmental Sciences, The University of Manchester; Journal of the Geological Society 2025

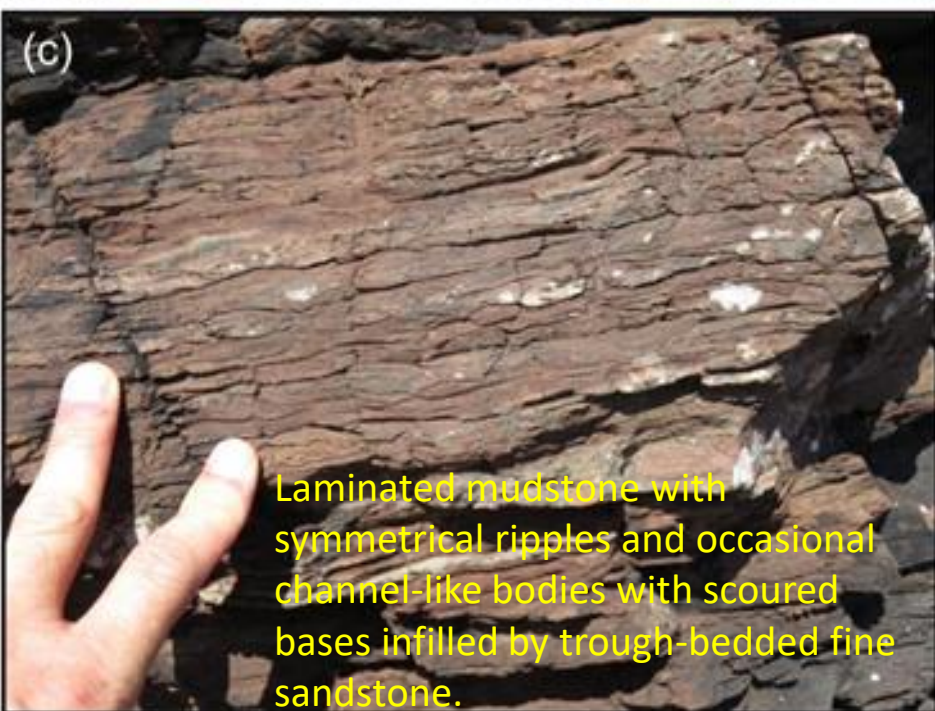
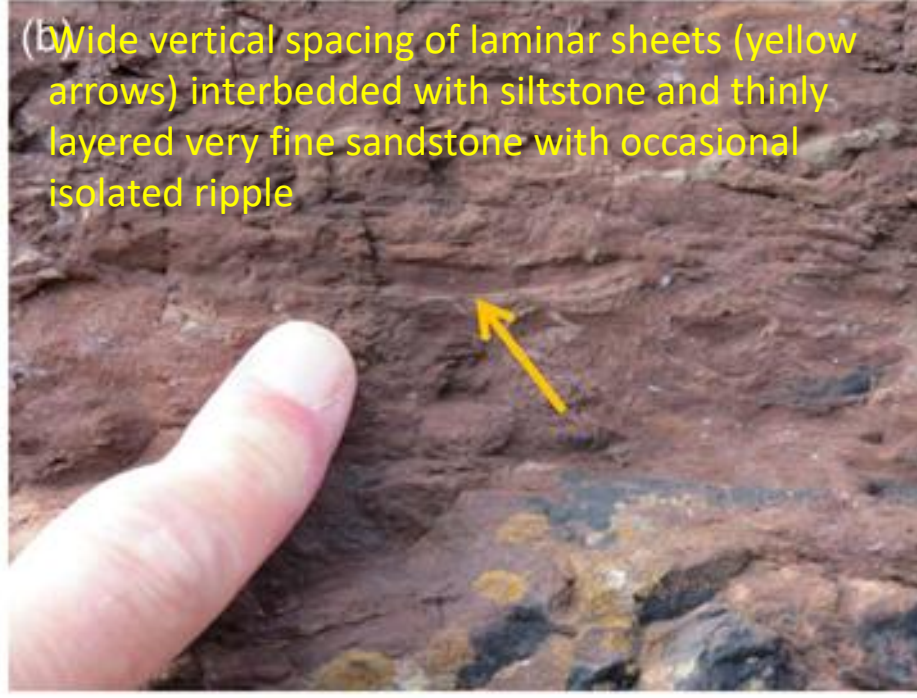


Poll a'Mhuil Member, Enard Bay

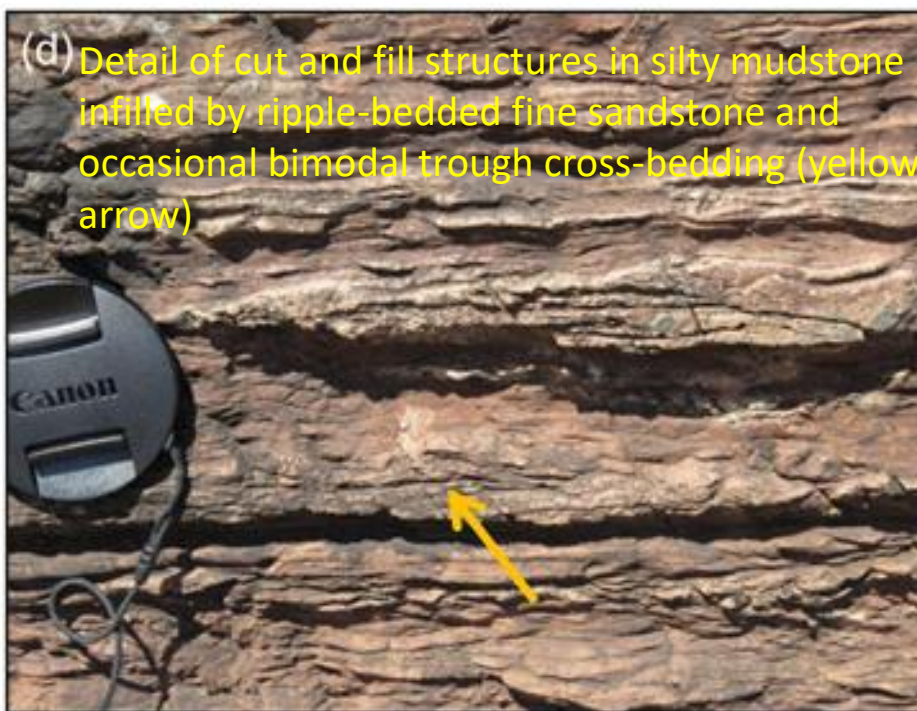


Termination of breccio-conglomeratic body at oblique surface with accretion of laminated calcareous red mudstone with offlapping domical structures that is then overlain by layer of cobble conglomerate encrusted by smaller domes

Laminated calcareous red mudstone with offlapping domical structures truncated by sub-Diabaig Formation unconformity.



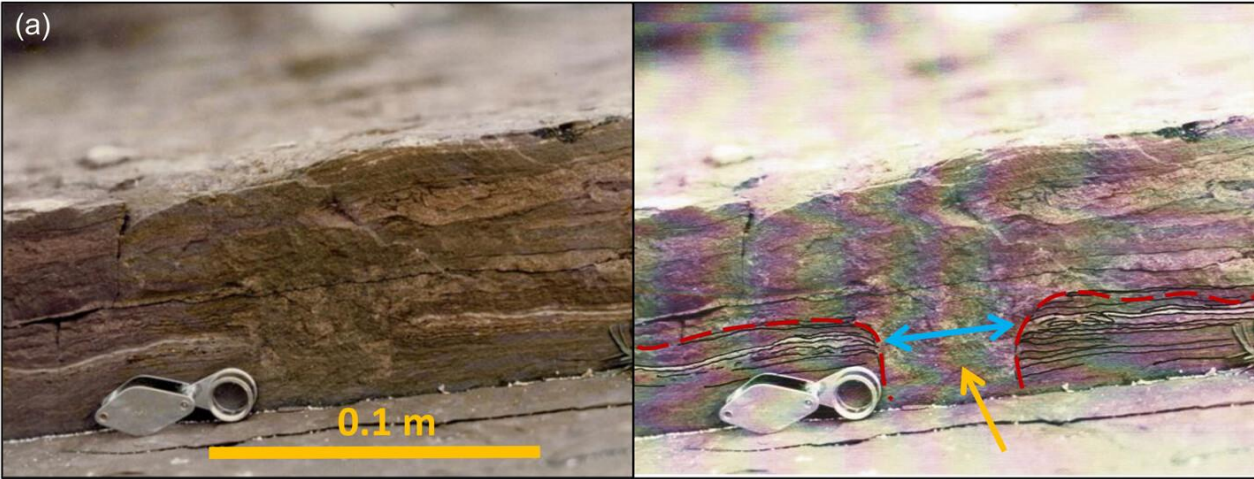
Laminated mudstone with symmetrical ripples and occasional channel-like bodies with scoured bases infilled by trough-bedded fine sandstone.



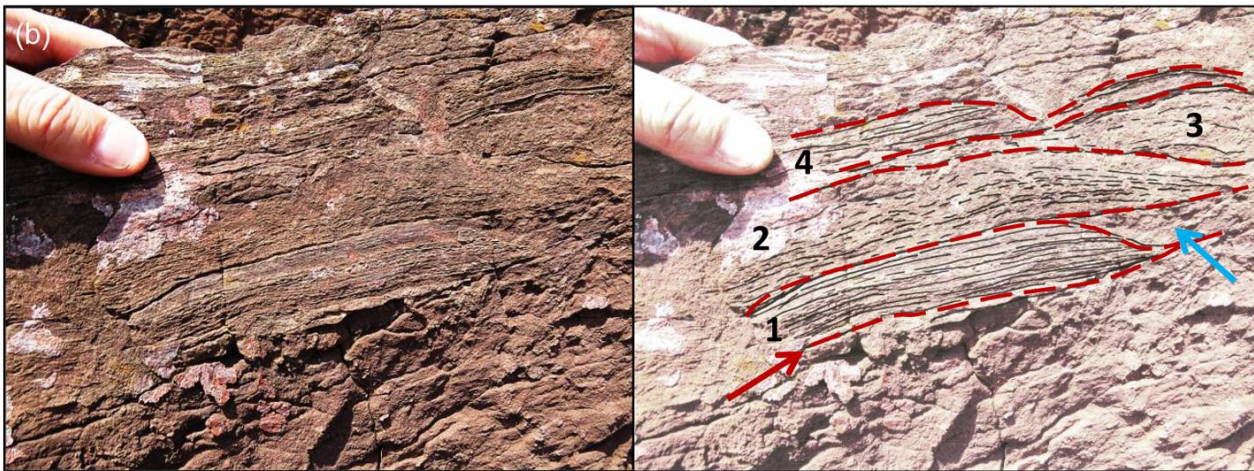
Detail of cut and fill structures in silty mudstone infilled by ripple-bedded fine sandstone and occasional bimodal trough cross-bedding (yellow arrow)



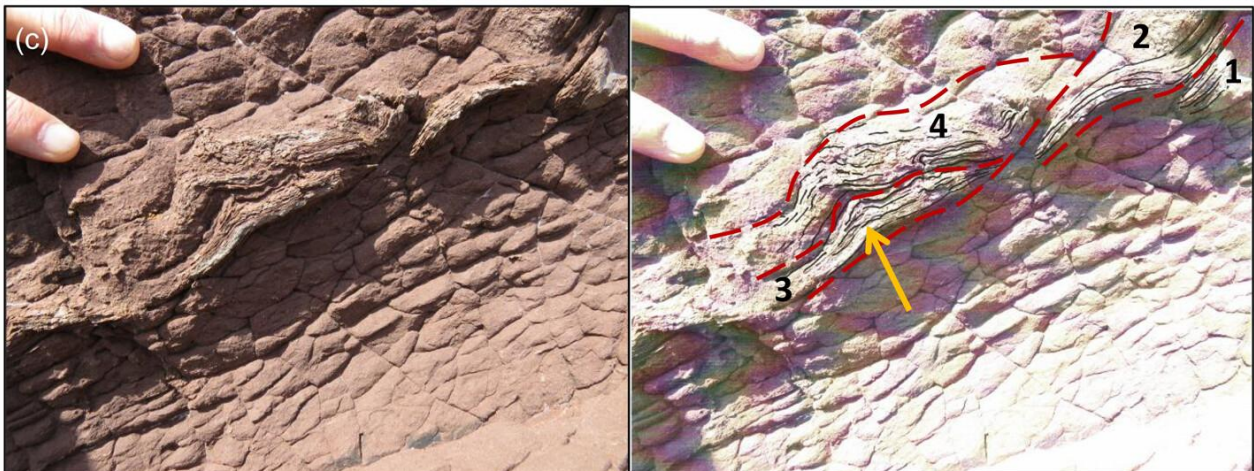
Bedding plane in mudstone showing low-relief domes (outlined) with stringers of darker reddish brown very fine sand and silt preserved between the domes (yellow arrows).



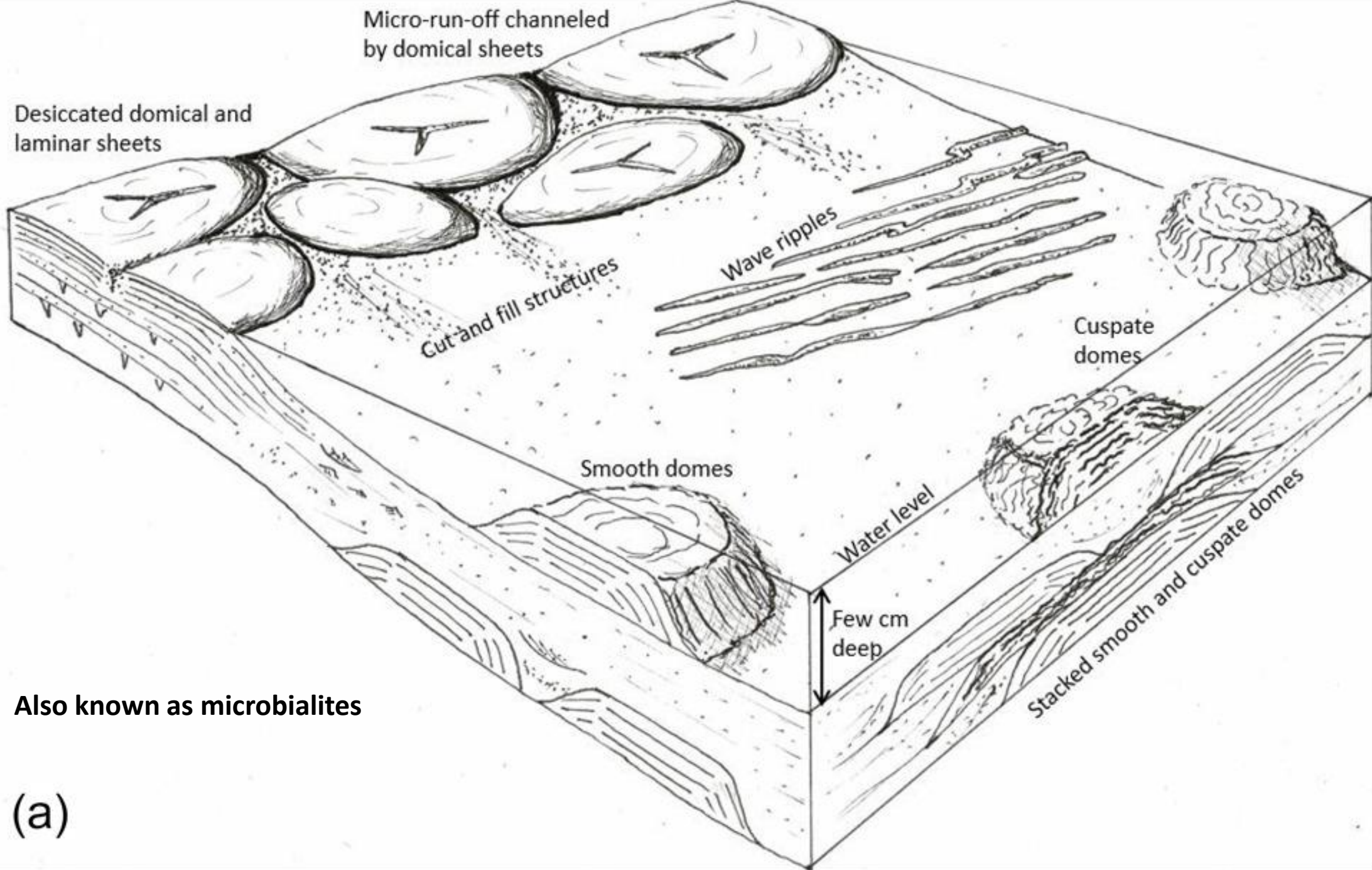
(a) Adjacent isolated smooth domes with vertical margins separated by fine sandstone and siltstone (yellow arrow). Each dome comprises alternating planar uniform carbonate and siltstone layers with the development of discontinuous carbonate layers at the same level in each dome (blue arrow).



(b) Smooth dome (1) with planar base overlying fine sandstone (red arrow). Internal microspar laminae are sub-parallel and dip towards the margins of the dome. The right-hand margin of Dome 1 is overlapped by lens-shaped package of fine silty sandstone (blue arrow). Dome 1 plus the lens of siltstone is then overgrown by Dome 2, which has a crinkly internal fabric. Dome 2 is then further overgrown by smaller offlapping isolated domes 3 and 4.

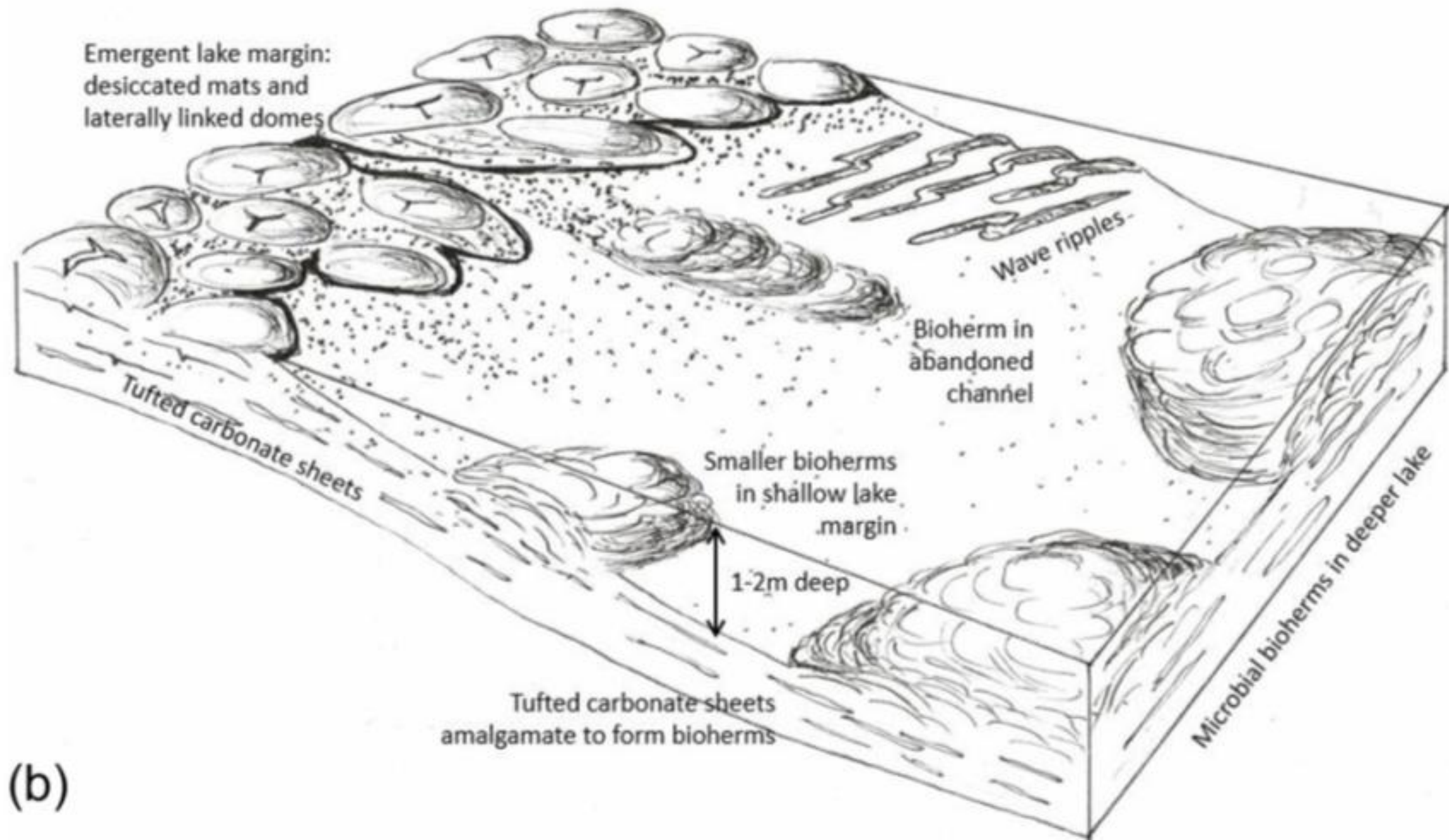


(c) Cuspate dome with crinkly internal carbonate fabric that consists of small domes with planar to undulatory bases showing offlapping growth (domes 1 and 2). Dome 3 shows upward development of sharply 'folded' cusp (yellow arrow). Final form of dome (4) shows further development of upward projecting cusp

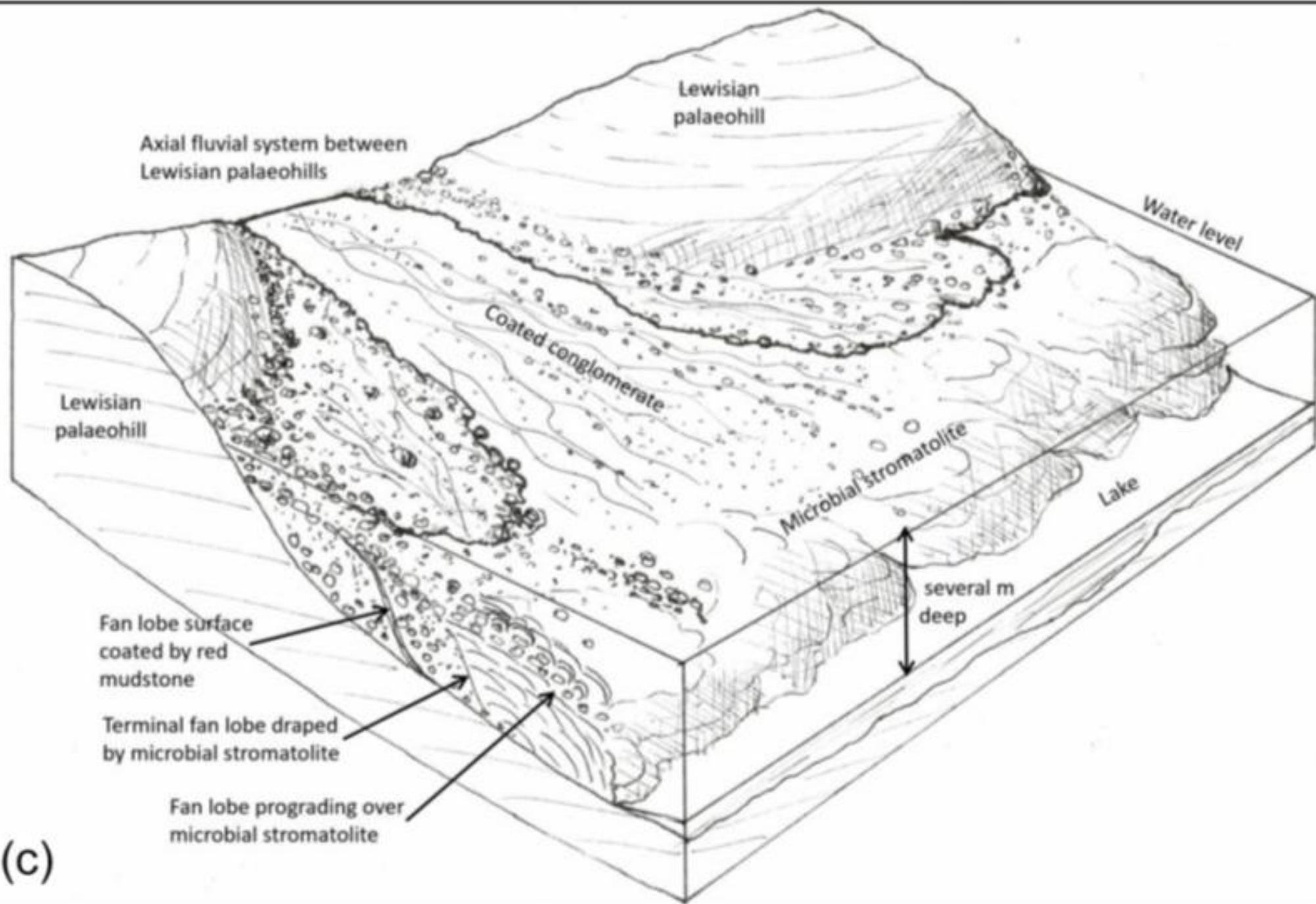


Also known as microbialites

(a)



(b)



(c)



After all the excitement of the Stoer Group 1.2-1.1 Ga...

...there follows nearly 200 million years of nothing much!

But then at about 1.0 Ga...



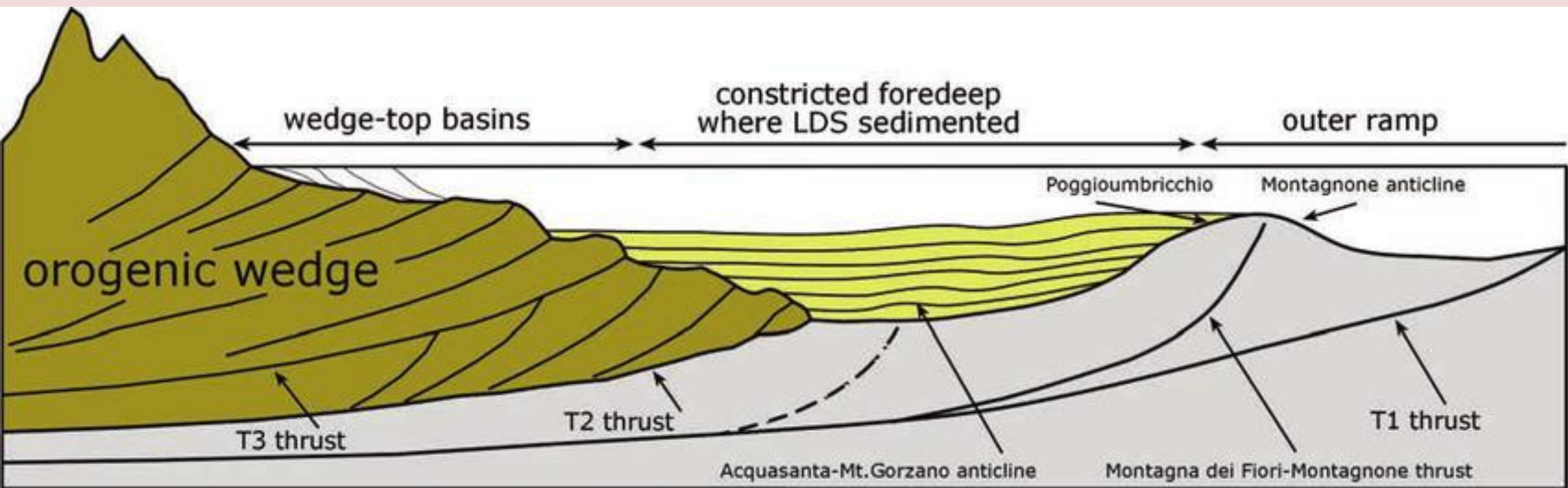
Torrion mountains in the Applecross and Aultbea formations

Note the lack of significant dip or folding – no evidence of metamorphism either.



Applecross Formation

- 2 – 3 Km thick
- Coarse red sandstones, with pebbles
- Finer sandstones towards the top
- Much soft-sediment deformation
- Fossil remains of a microscopic lake flora in thin grey shales in between the finer sandstones (but still no evidence of life on land).
- Sediment sourced from the west, possibly from Grenvillian Mountains – conflicting interpretations of the evidence – into a foreland basin (plate collision) or a rift basin (ocean opening) as a molasse deposit.



The activity of Mt. Sibillini thrust (T3) occurred during the deposition of Laga 1 and Laga 2 units, and also during Laga 3 deposition.

T2 thrust (Gran Sasso thrust) was active during deposition of Laga 1 and Laga 2 units. Movements continued also during the sedimentation of Laga 3 unit.

Acquasanta - Mt. Gorzano anticline began to develop after the deposition of Laga 1 unit.

T1 thrust is the main structure of the basin. Its activity started during Laga 2 deposition and controlled the depocenter migration from Laga 2 to Laga 3. It was still active during Early Pliocene.

Aultbea Formation

- 1 – 2 km thick
- Finer red sandstones, without pebbles
- Even more soft-sediment deformation
- Interpreted as braided river sand deposits – sand bars in very shallow rivers, with channels 1 - 3 m deep
- Semi-arid environment, but without vegetation, so rapid run-off in flood events
- Recently interpreted as a broad braid-plain apron deposited by rivers several hundred kilometres long, bearing sediments from the erosion of the Grenvillian Orogeny.
- But through the Torridon stage, no evidence of a marine environment

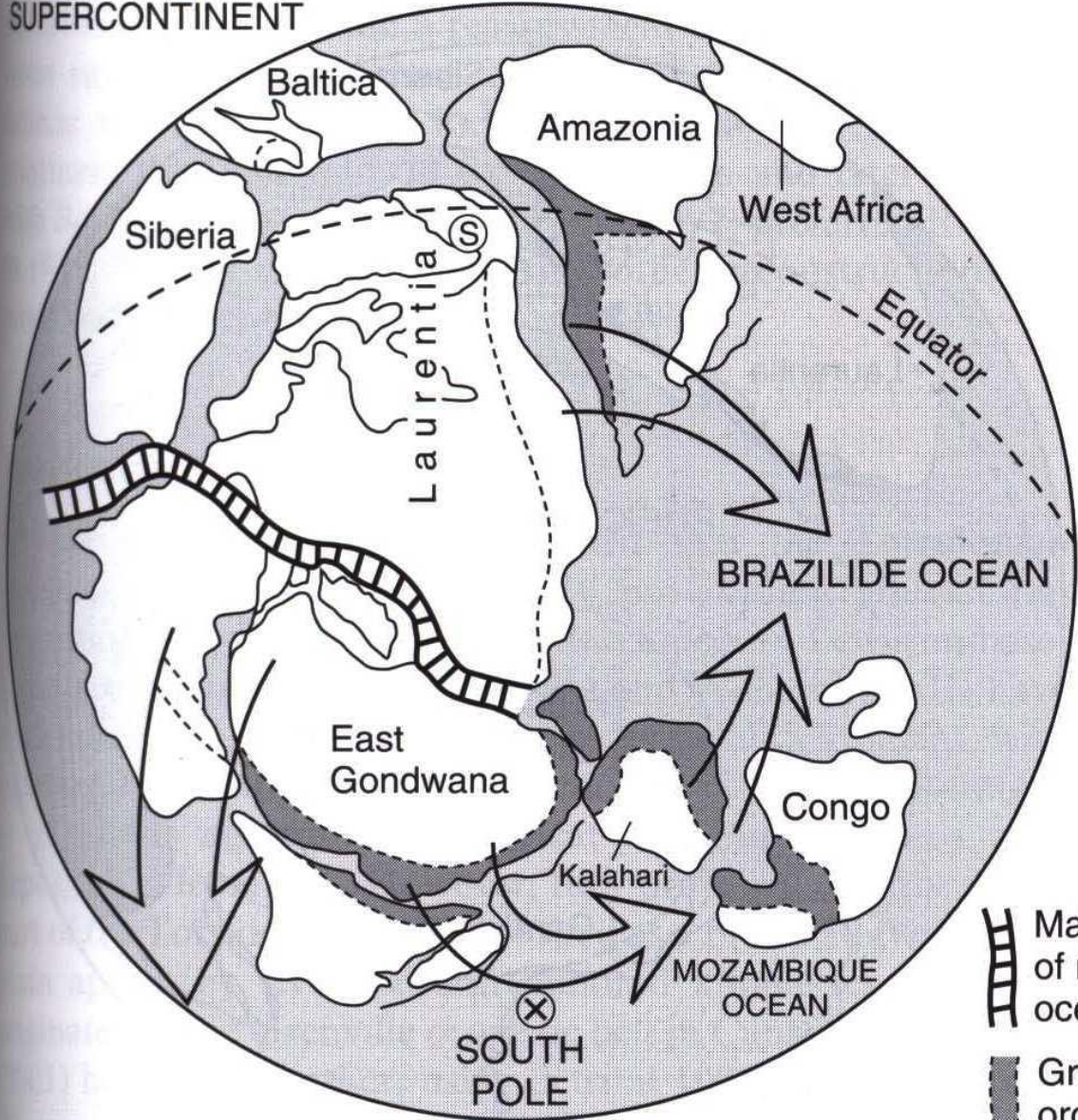
The End of the Torridonian Era

- By about 770 Ma BP, rifting in the Torridonian graben has ended
- The Hebridean Terrane is now around the Equator
- The Torridonian rocks remain relatively unaffected except by weathering and erosion until the present day
- With the massive Archaean gneiss basement below, the Torridonian is 'protected' from deformation and igneous intrusion.
- No metamorphism, just a gentle tilt!
- Oh, and by the way, the oxygen content of the atmosphere has risen fast, possibly now over 10% - **you have to wonder why!**

Scourie Bay at sunset – peace while you have tea or coffee!

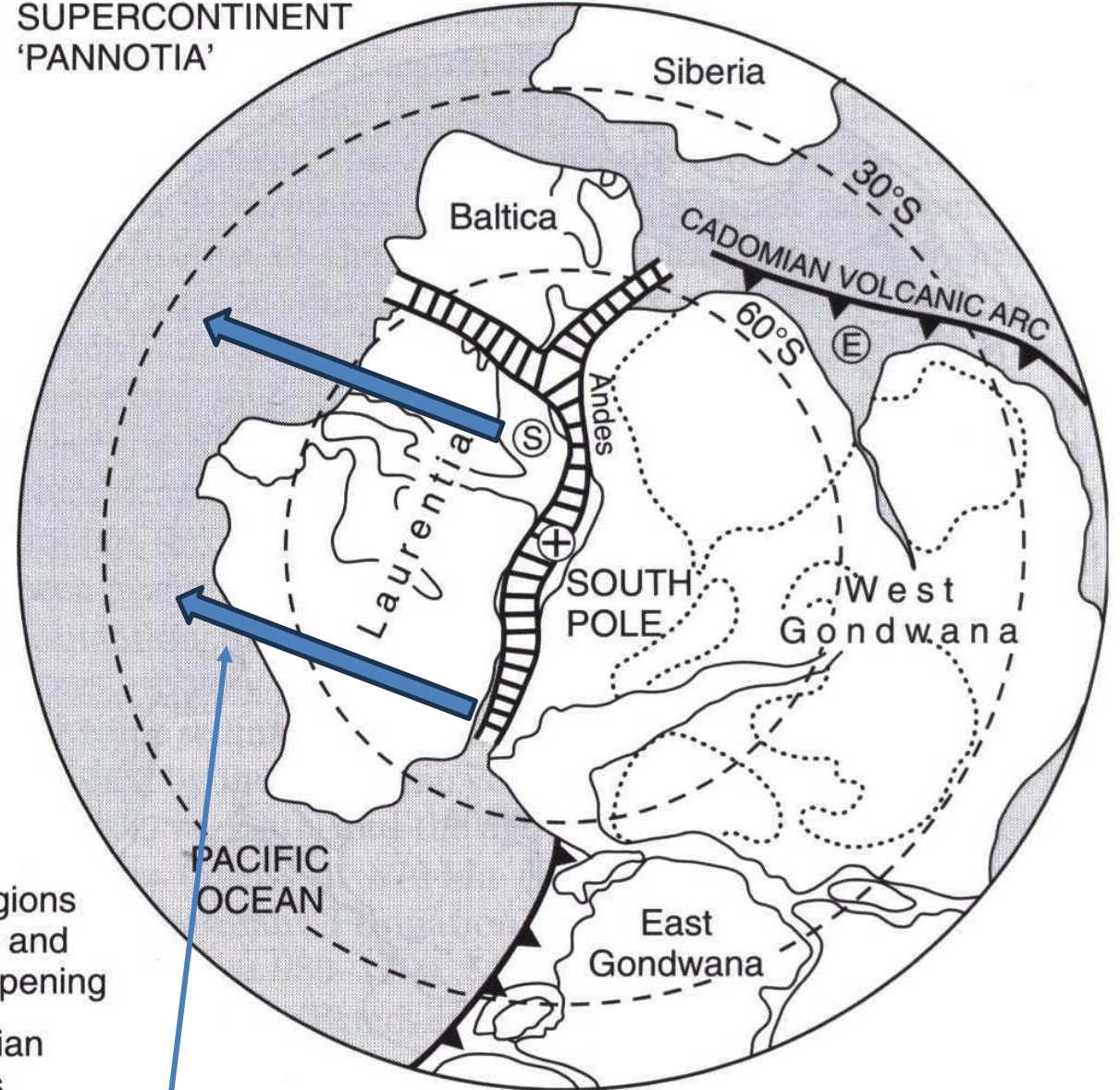


c. 750 Ma
 RODINIA
 SUPERCONTINENT



(a) Rodinia prior to break up and formation of Pannotia

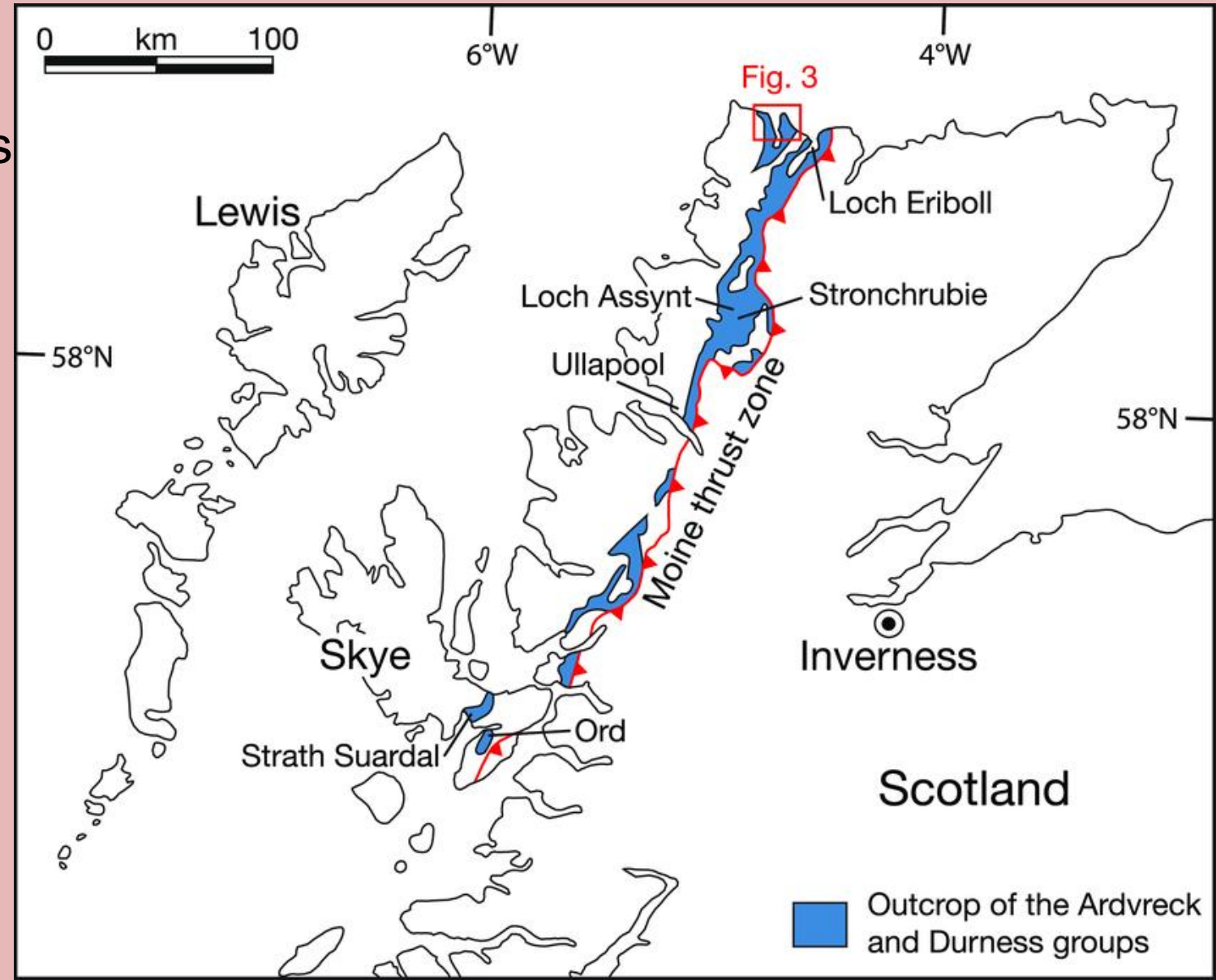
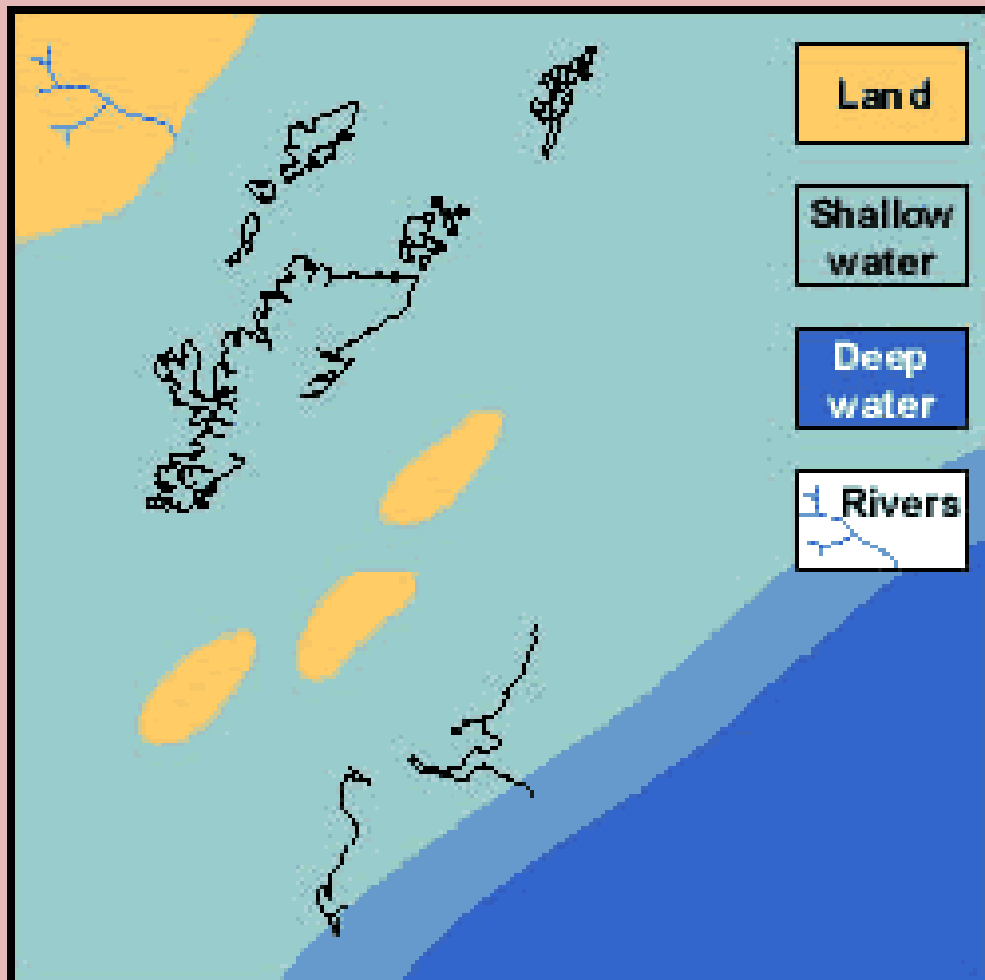
c. 580 Ma
 'VENDINIAN'
 SUPERCONTINENT
 'PANNOTIA'



(b) Laurentia starts to drift away

The End of the Torridonian Era - the Cambrian period has begun!

530 Ma, the surface of the Torridon Group rocks is submerged beneath the sea, a highly eroded surface is ready to be buried by new sediments





The eroded remnants of the Torridonian and exposed Lewisian basement provide a shallow and remarkably level sea floor for the Cambrian age sediments to settle on. Are those going to be islands in the distance?



Oh dear no! The basal Cambrian quartzite deposits sit happily on top of the Torridon Mountains

A horizontal unconformity – both Torridon and Cambrian lie horizontally, one on top of the other.

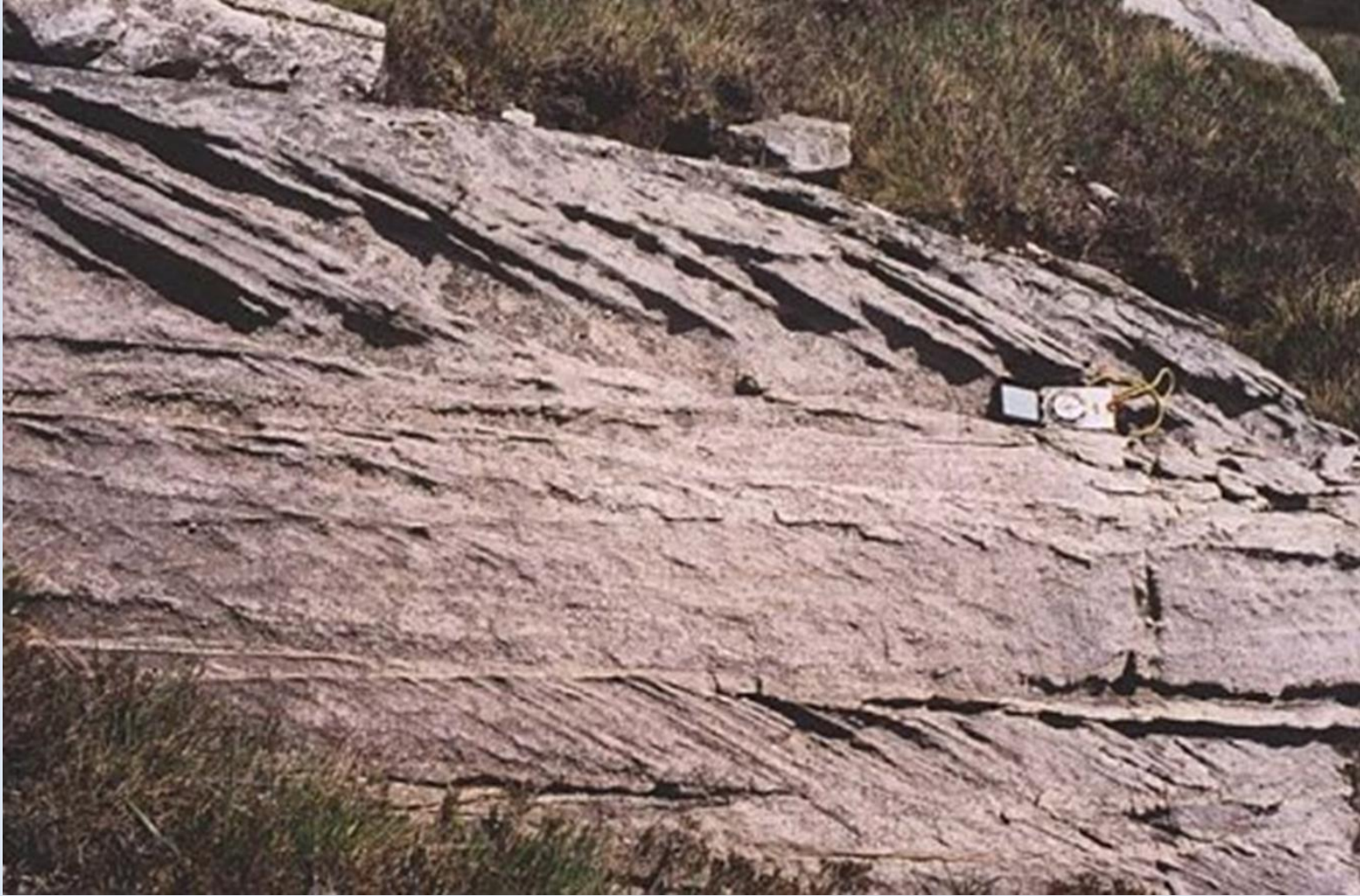
So a lot of erosion has happened since Cambrian times



Arkle, NW Sutherland: Cambrian deposits lying directly on uneven Lewisian basement



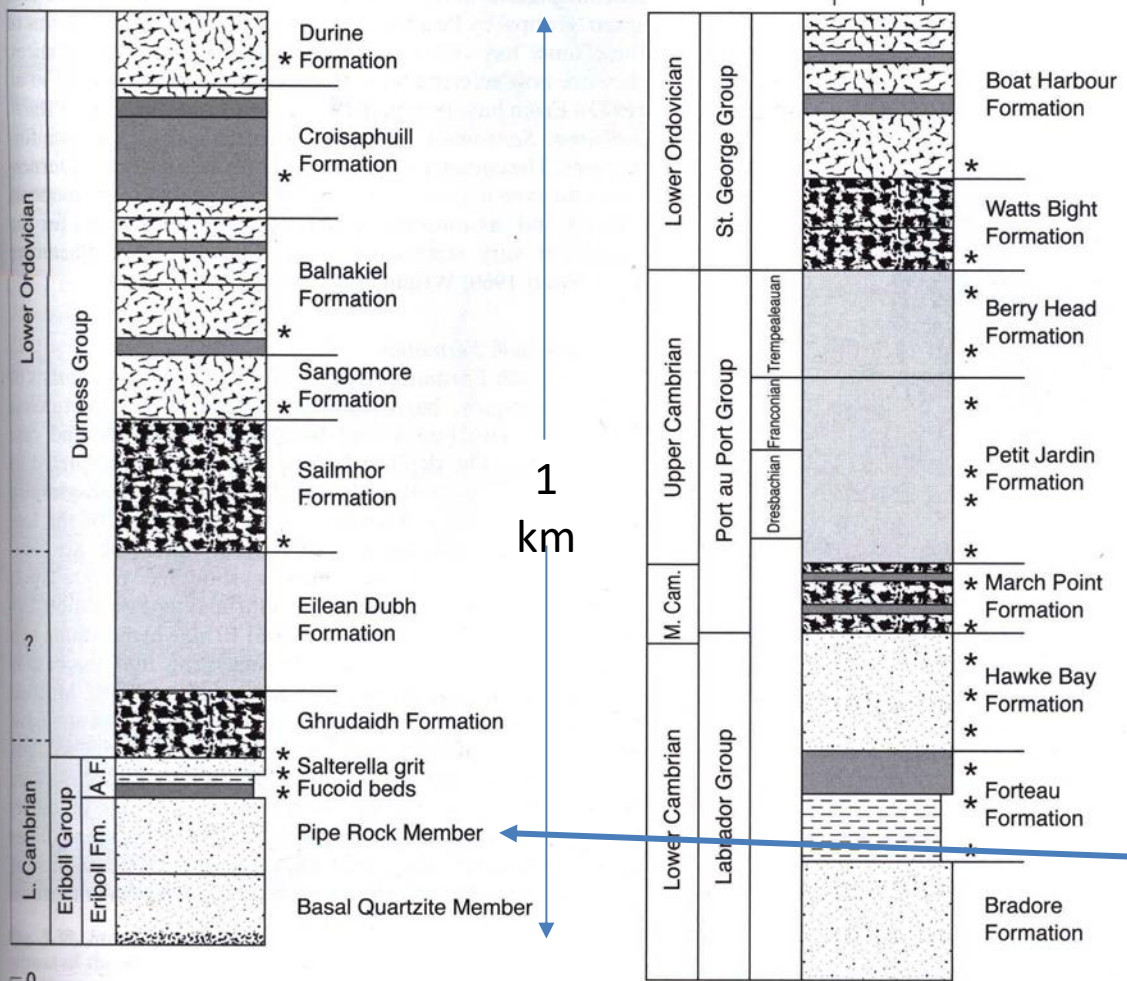
The Cambrian – a New Beginning?

- Another long time gap, 770 to 530 Ma
 - Plenty of time for subaerial erosion to denude the Torridonian landscape
 - No deposition that may have occurred remaining to be seen.
 - But no doubt plenty of eroded sediments on the surface, just waiting for their time to be moved.
 - Sediments from erosion of the Laurentian continent are carried offshore by tidal currents.
- 
- Onto the level floor is deposited first a layer of rounded pebbles of quartz, feldspar and felsite, which are later cemented by a cream-coloured fine matrix.
 - White quartzite sands are washed by the tidal currents over the pebbly base, forming layer upon layer with conspicuous cross-bedding.
 - Up to 100 m of these quartzites forms the basal quartzite member of the Eriboll Formation.

HEBRIDEAN TERRANE

(a) Scotland

(b) Newfoundland



Limestone	Dol. siltstone	Pale dolostone	Calc. shales	M. Cam. = Middle Cambrian
Dolostone	Quartzite + basal conglomerate	Mottled dolostone	* Age diagnostic fauna	A.F. = An-t-Sron Formation

Deposition now continues for about 70 Ma, producing a total thickness of sedimentary rock approaching 1 km.

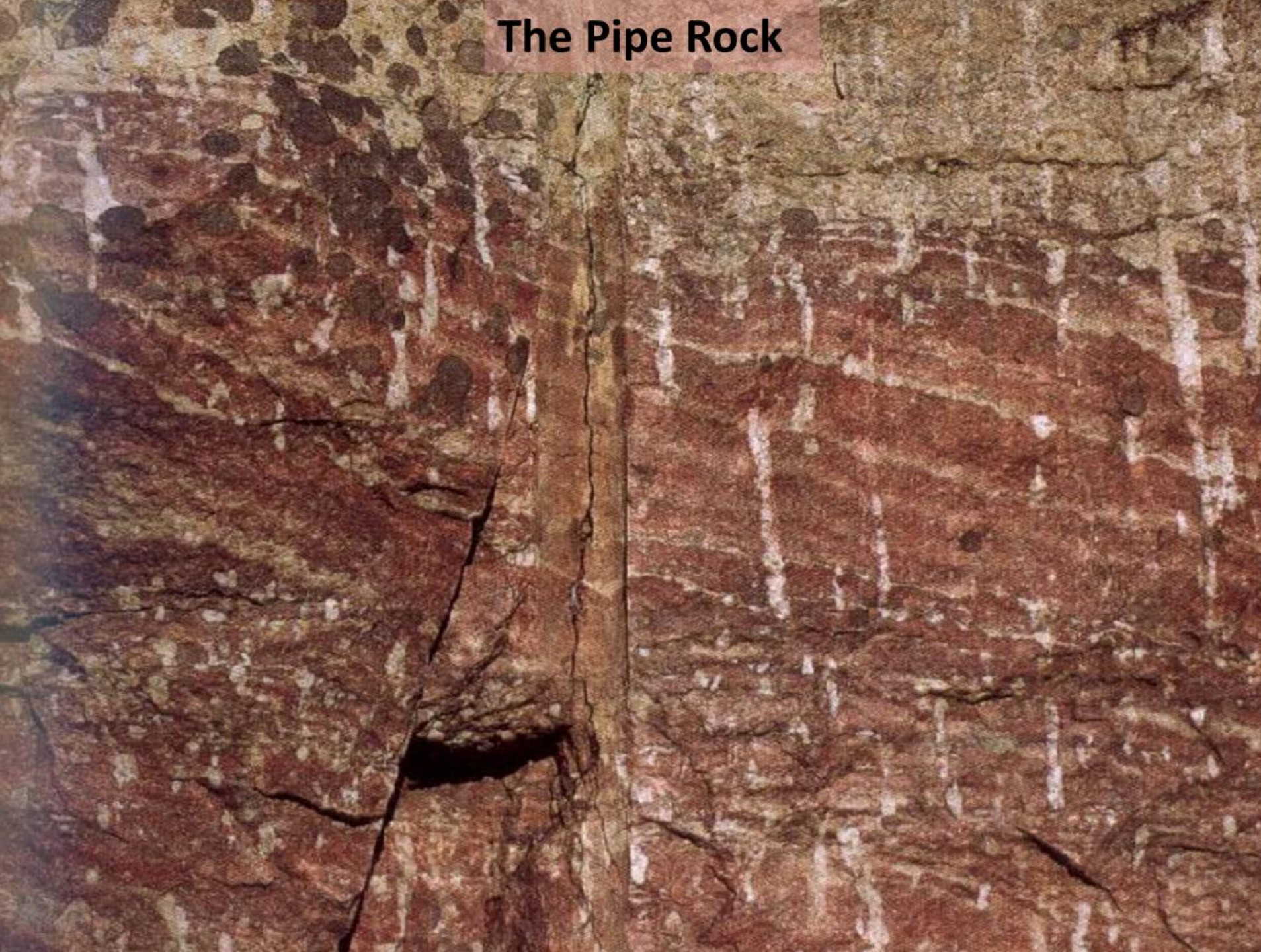
Note the similarities with the contemporary deposits found in Newfoundland.

And a new major player in sedimentary rocks emerges – **fossils** of multi-cellular organisms.

Introducing the **Pipe Rock**, 75-100 m thick, a thinly bedded quartzite...

Fig. 3.35. Simplified stratigraphy of the Cambro-Ordovician of (a) Northwest Scotland and (b) western Newfoundland. Note similarity of lithofacies successions between biostratigraphic benchmarks of Lower Cambrian and Lower Ordovician strata.

The Pipe Rock



Abundant thin white vertical columns, some with a trumpet-shaped top - TRACE fossils – but produced by what?

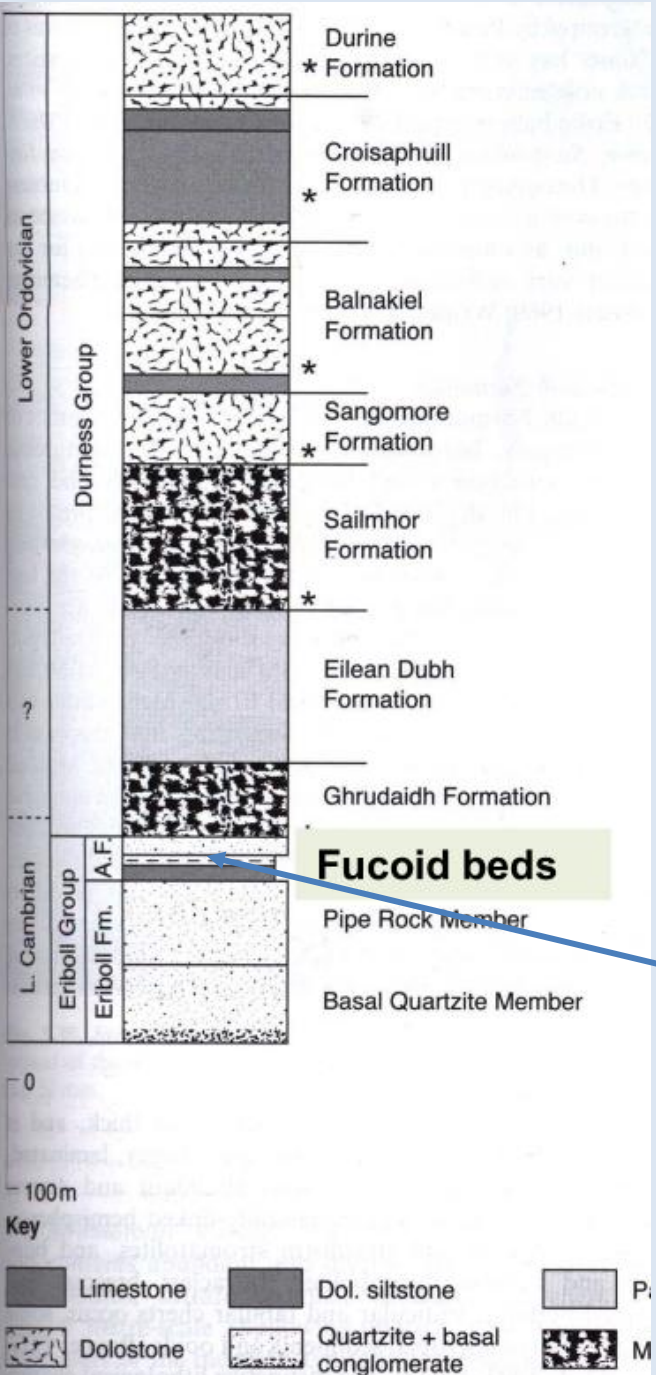
Clearly a thriving and abundant organism with lots of food available.

But these are burrows, up to 2 m long!

Trumpet tops = escape structures?

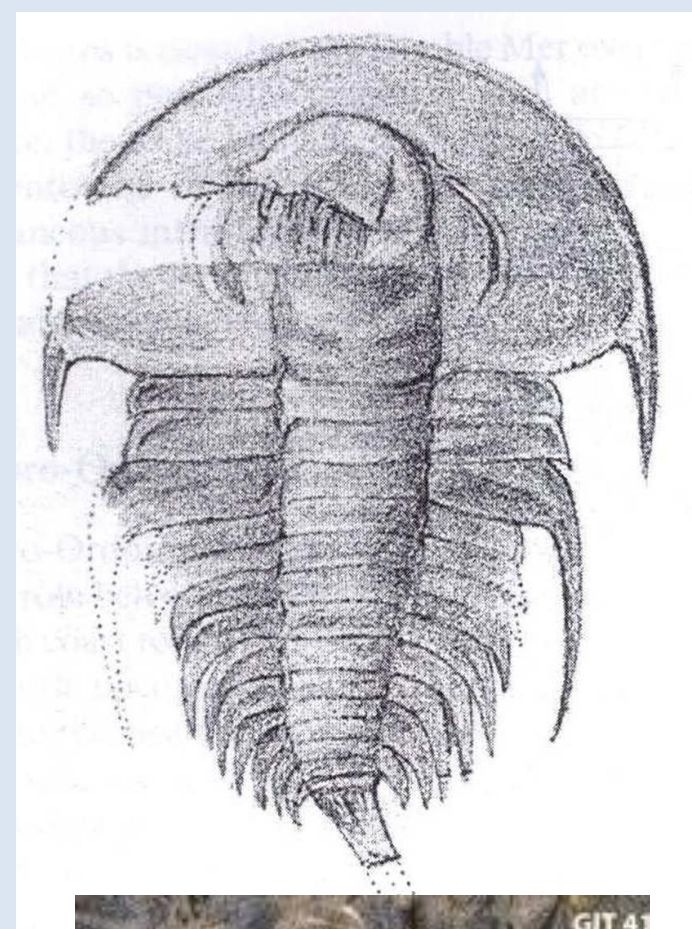
The animals have heavily bioturbated the sediments, obscuring most sedimentary structures

Occasional survivals of such structures indicate tidal zones, prone to storms, probably in a tidal flat and protective barrier island setting.



The Fucoid Beds

- 12-27 m thick
- Brown siltstones – dolomitic (Ca/Mg carbonates), ferruginous.
- Plentiful sand-filled burrows *parallel* to bedding
- Rare trilobite fossils – the earliest index fossils in this sequence
- Also some brachiopods, molluscs and echinoderms
- Storm-dominated tidal environment (hence often fragmentary fossils)



The Salterella Grit (below the Fucoid beds)

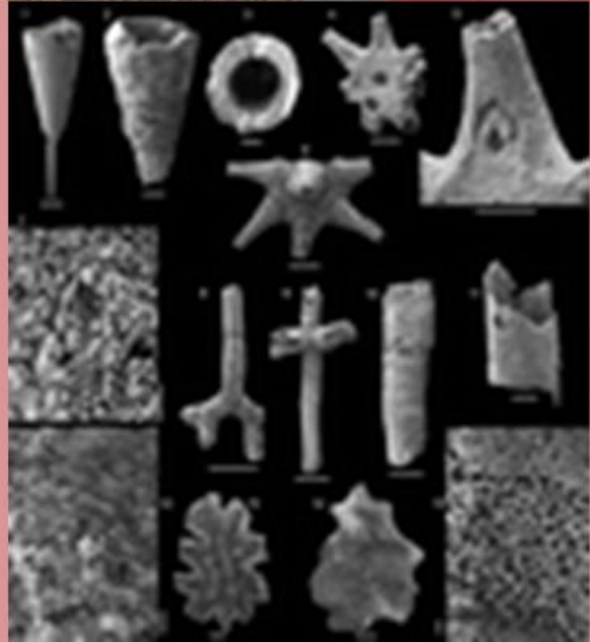
Thin, white coarse quartzite, so sandy sediments again, retreating sea

Becoming dolomitic as sea advanced again

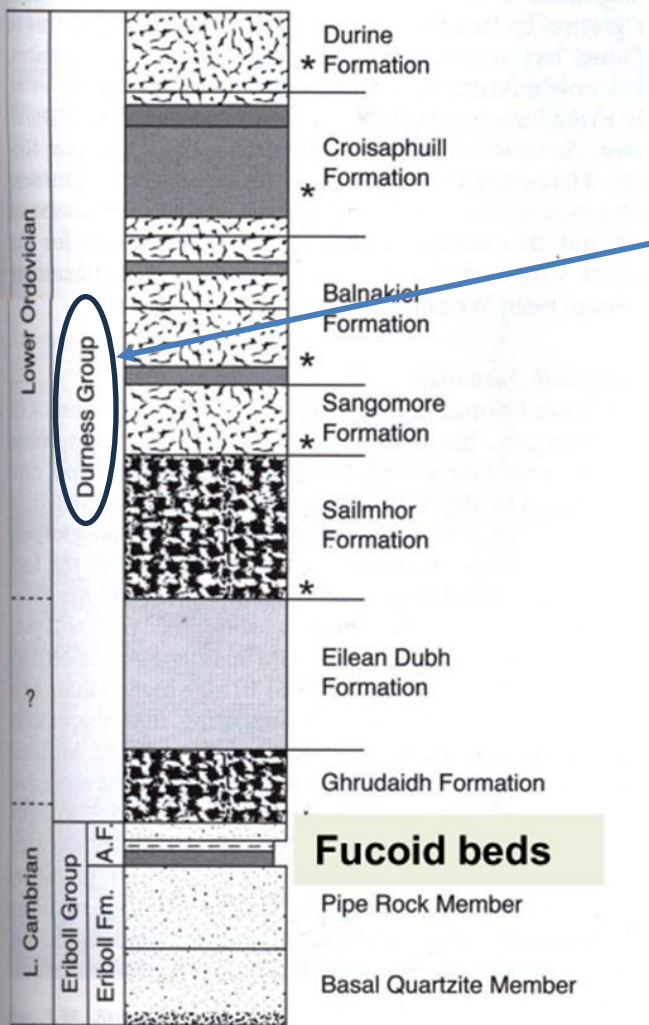
More fossils! Characteristic conical shells of *Salterella maccullochi*, phylum *Agnata*



Fig. 3.35. Simplified stratigraphy of the Cambro-Ordovician of (s)



The Durness Group



- Dominated by carbonates – so-called Durness limestone (as at Smoo Caves) – mainly dolostones, intervals of limestone and chert
- Dolostones are carbonate deposits (mainly calcium carbonate) that have been later dolomitised by magnesium-rich solutions percolating through – very complex processes
- Seven formations totalling ~800m thick
- Colour varies from pale grey to dark grey, with rare intervals of other colours – monotonous!
- Abundant evidence of life – bioturbation and burrows, but also **microbialites**
- Microbialites - microbial colonies with secretion of calcium carbonate
- Microbialites can take many forms – best known are stromatolites and thrombolites, which can both exist in varied shapes.
- Microbes that build microbialites include both bacteria and archaea, the former often including cyanobacteria. Both bacteria and archaea include sulphate reducing microbes that form microbialites.

Fig. 3.35. Simplified stratigraphy of the Cambro-Ordovician of (a) successions between biostratigraphic benchmarks of Lower Cam

Smoo Cave

A typical feature of a limestone landscape

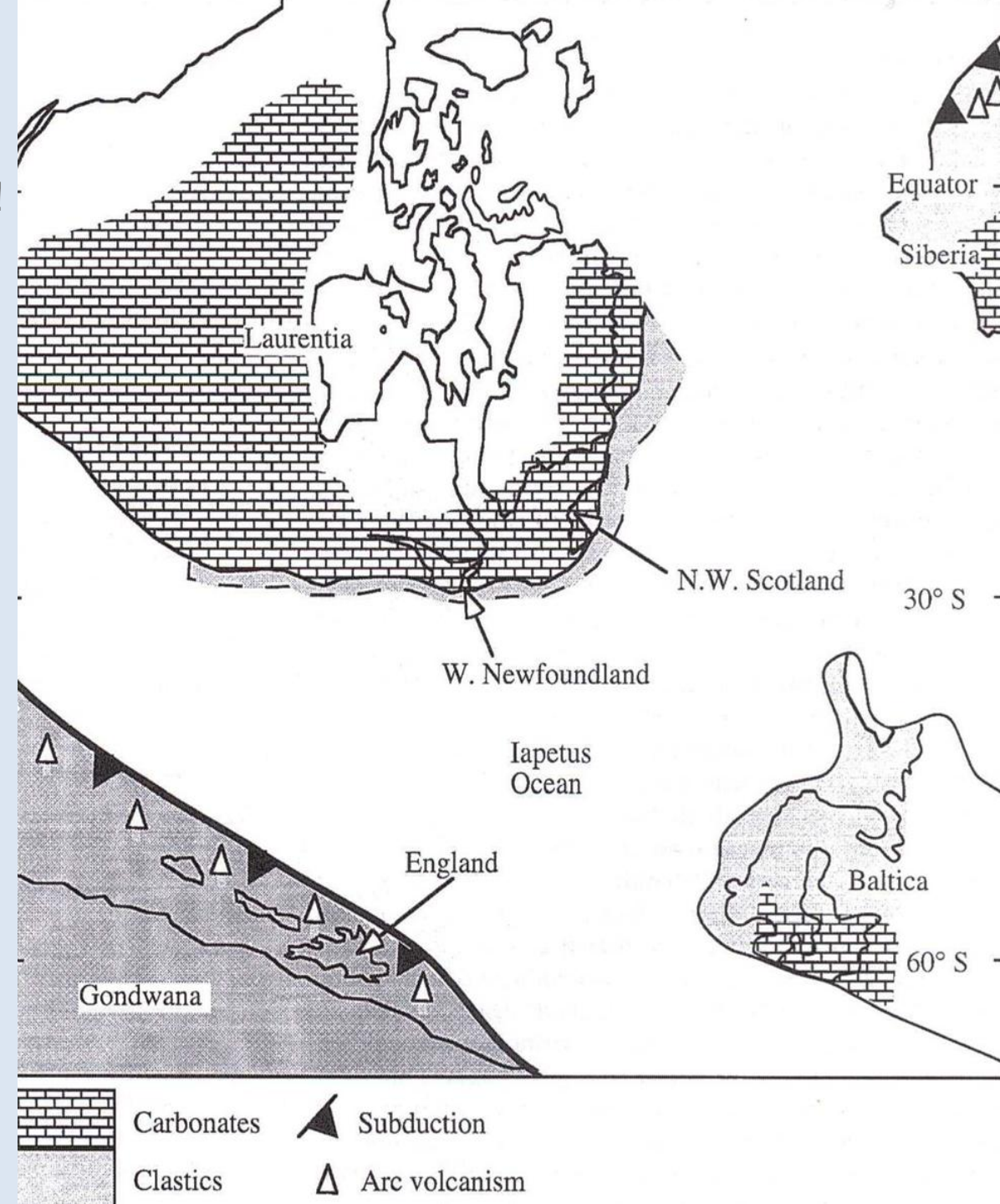




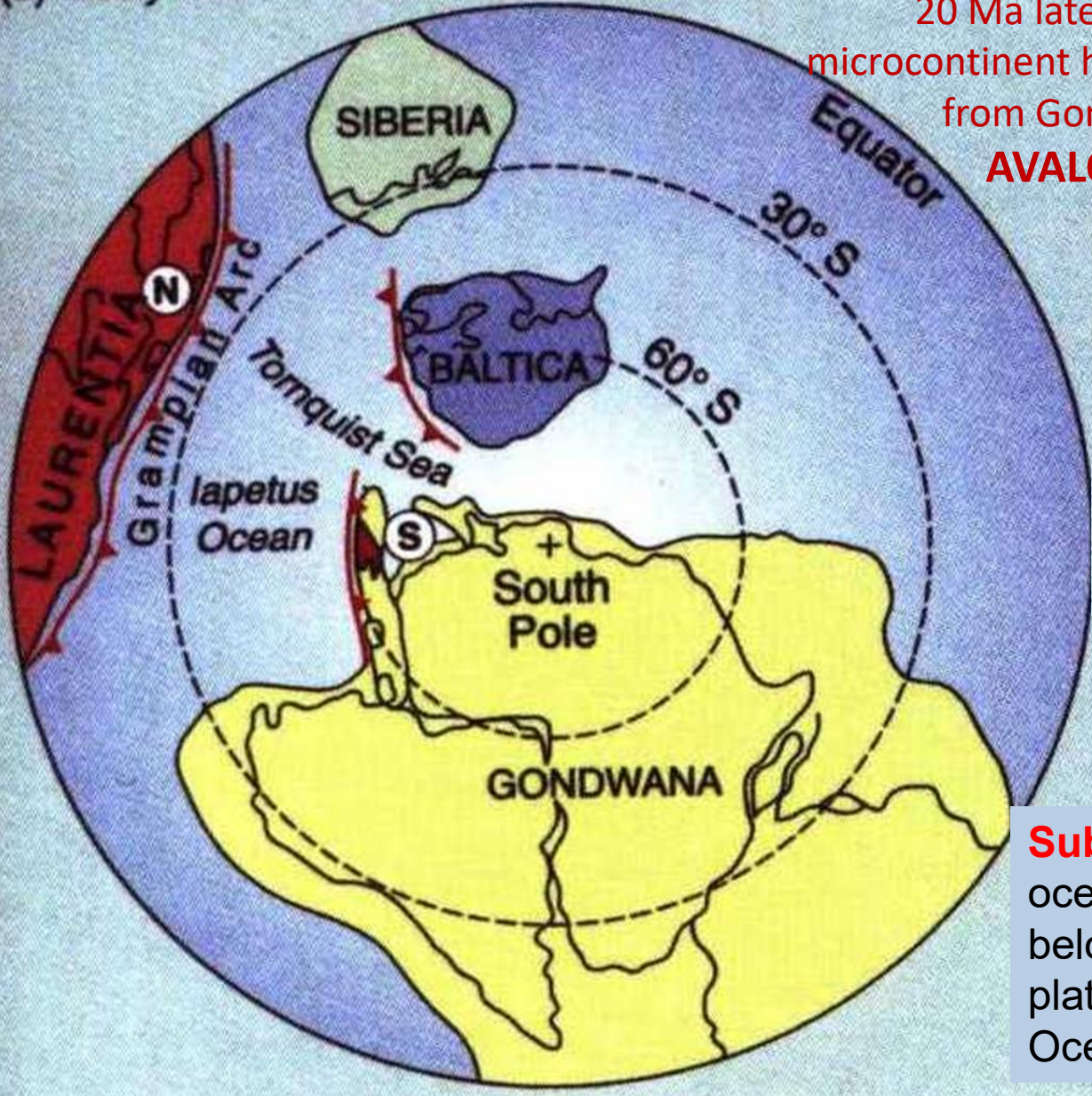
Fig. 3.39. Weathered upper surface of digitate stromatolite bioherm from the Stromatolite Member of the Eilean Dubh Formation at Balnakiel Bay, showing characteristic pitted, meandrine outlines of cross-sections of digitate columns. Blank areas represent sand, silt and

So where has NW Scotland drifted to by now?

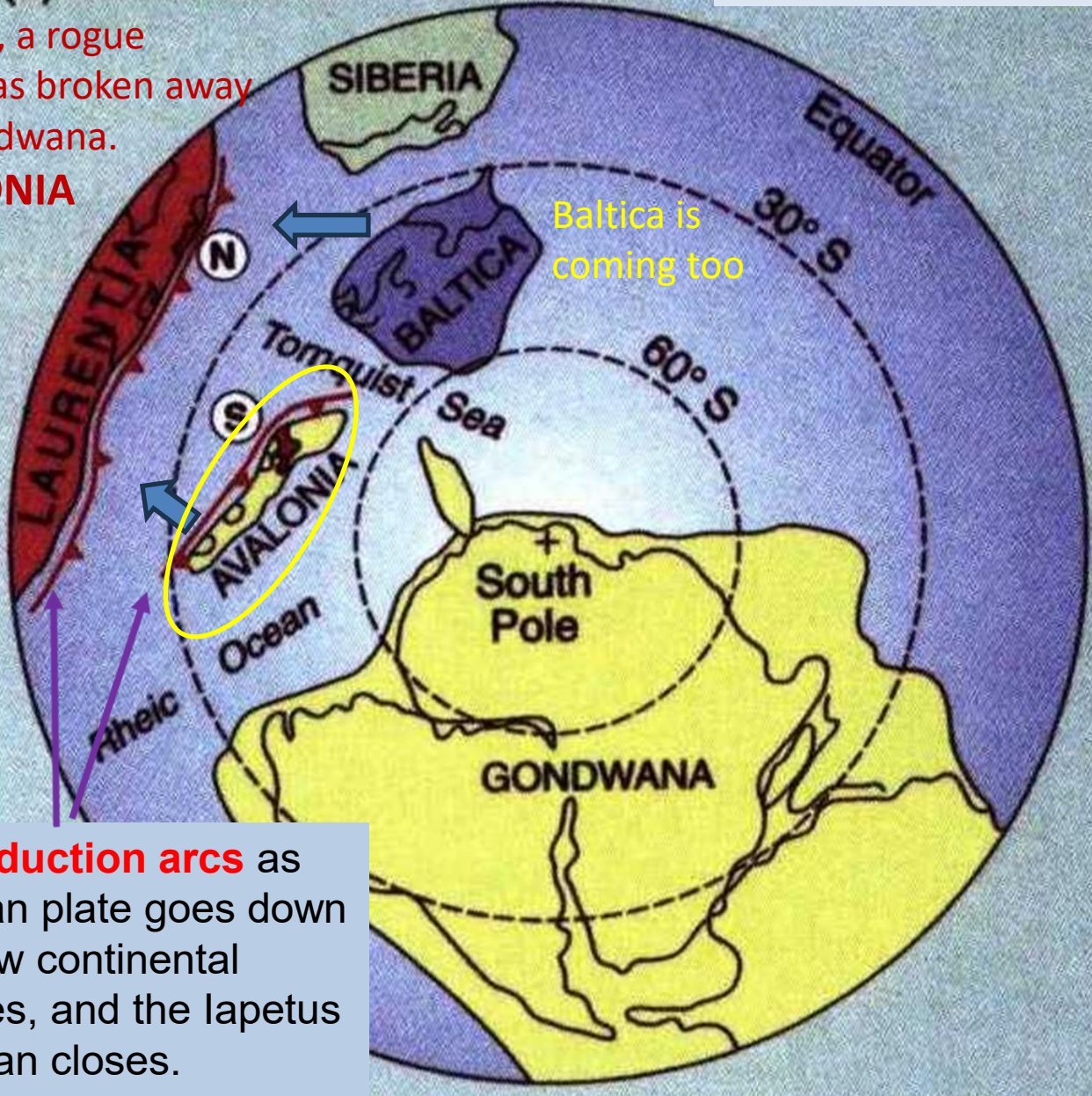
- Still on the edge of Laurentia, W Newfoundland not far away!
- Thriving marine life, even if multicellular organisms seem to appear, go away and come back.
- Extensive carbonate deposits
- All adds up to warm, shallow seas at the continental edge
- So at 480 Ma BP lets have a look at the palaeo-map...
- Scotland heading north towards the Equator, on the edge of the vast carbonate platform forming the continental shelf of Laurentia.
- But where are the other terranes of Scotland?



(c) Early Ordovician c. 490 Ma



(d) Mid-Ordovician c. 470 Ma



20 Ma later, a rogue microcontinent has broken away from Gondwana.

AVALONIA

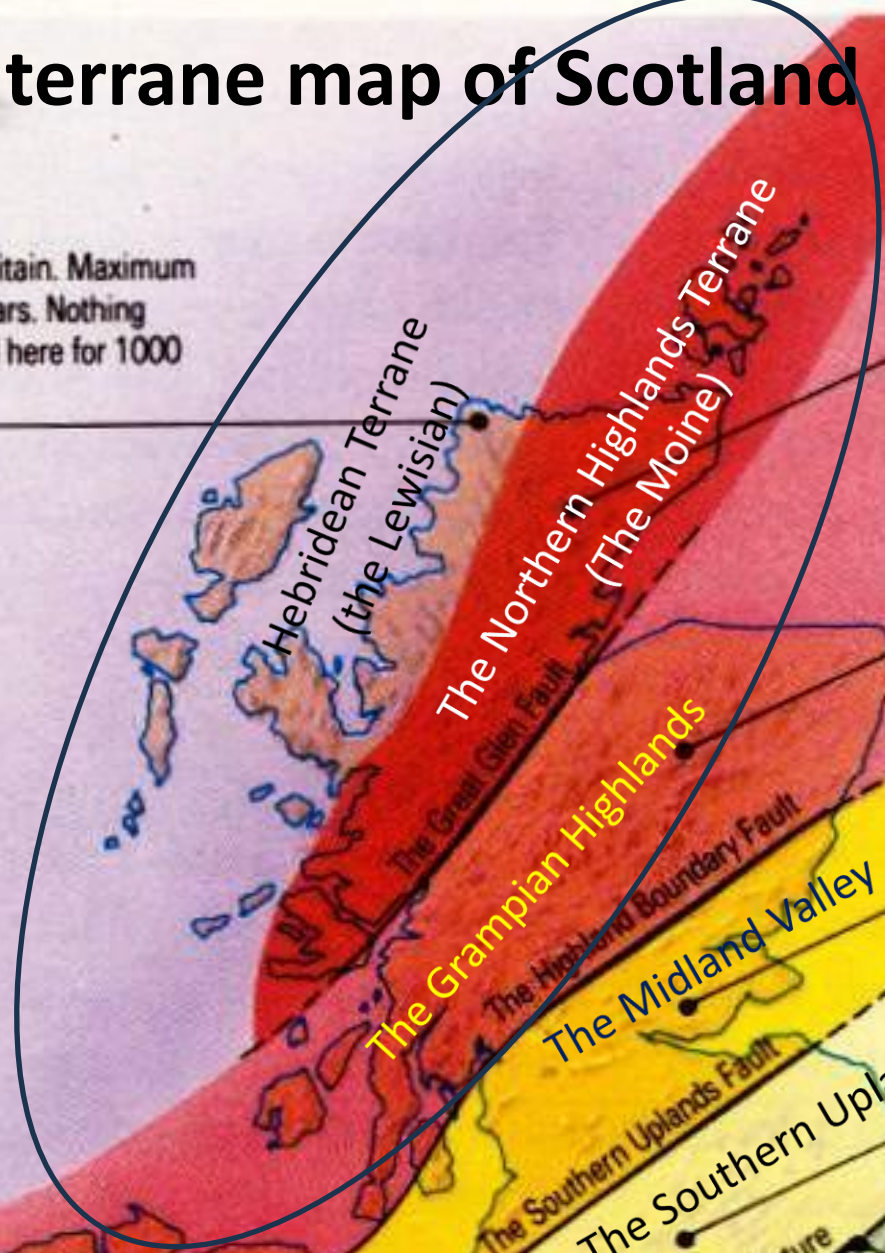
Baltica is coming too

Subduction arcs as ocean plate goes down below continental plates, and the Iapetus Ocean closes.

The Iapetus Ocean at 490 Ma is about the same width as the present N Atlantic, but closing after this.

Simplified terrane map of Scotland

The oldest part of Britain. Maximum age 2800 million years. Nothing much has happened here for 1000 million years.



Hebridean Terrane
(the Lewisian)

The Northern Highlands Terrane
(The Moine)

The Grampian Highlands

The Midland Valley

The Southern Uplands

Ancient rocks altered by heat and pressure. Age range 1800-1000 million years.

Slightly less-ancient rocks, also altered by heat and pressure, between 1400-600 million years old.

A terrane made up of rocks older than 1500 million years, but completely covered with younger rocks.

Foundations entirely hidden beneath thick layers of rock laid down 500-400 million years ago.

Northern Britain was separated from Southern Britain until about 400 million years ago, when they joined up along this line.

A string of volcanic islands and

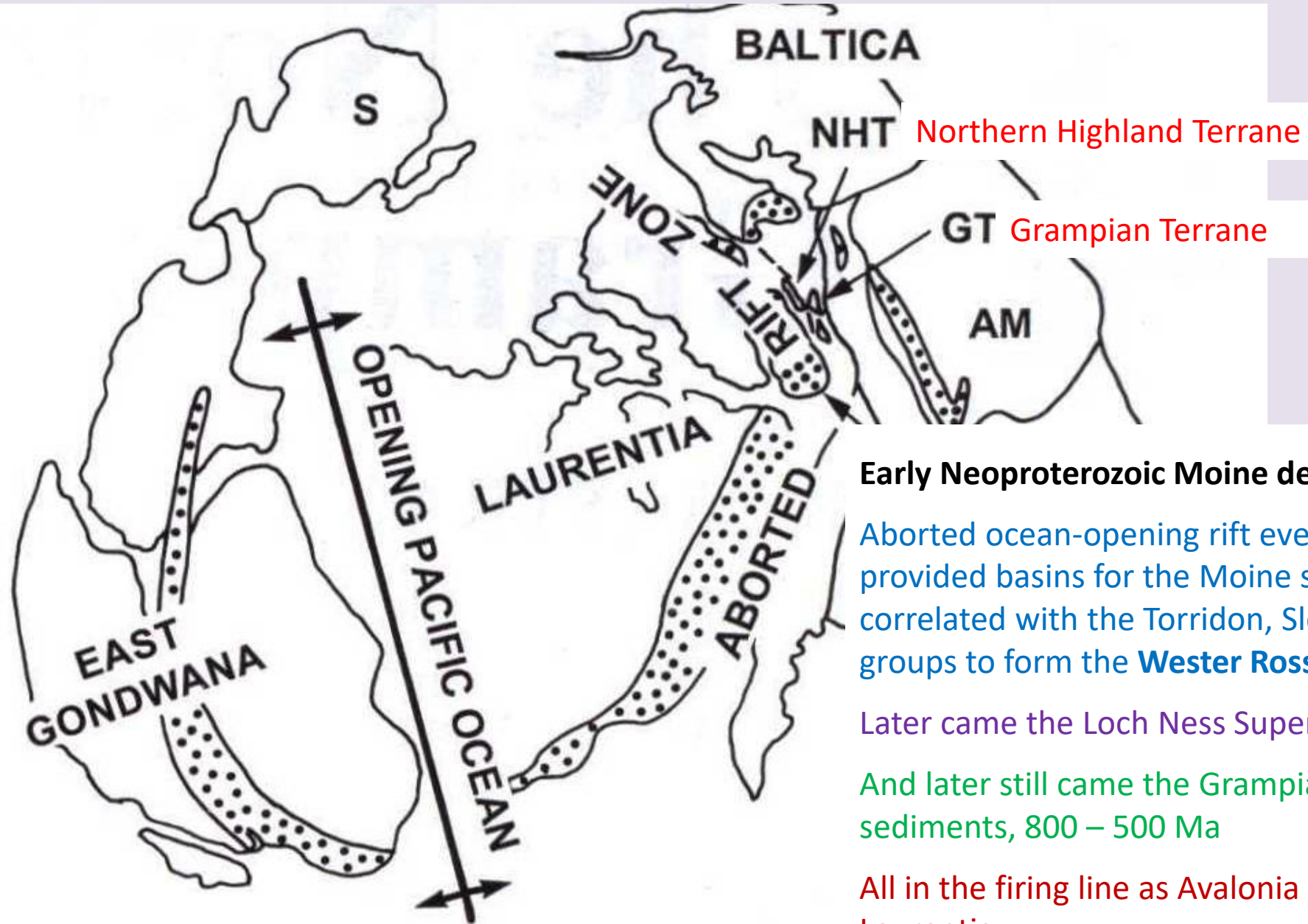
In the centre of this collision between Avalonia and Laurentia lay the three north-westerly terranes of Scotland, as well as Newfoundland.

The remaining terranes of Scotland are the result of the collision, as we will see later.

So what is the story of the Northern Highlands Terrane (The Moine) – where did it come from?

- What is the Archaean basement for the Moine Supergroup?
- There are Archaean gneiss inliers in the Moine Terrane – but are they Lewisian?
- No, say some geologists. Ages do not match! Geochemistry does not match!
- Yes, say other geologists, who find evidence for linkage to the Grenvillian orogeny!
- Let us say that both Hebridean and Northern Highlands terranes derive from Laurentia, and close enough together to have become closely related terranes as Rodinia broke up. We will find a clearer story later on.
- So let's have a first look at the Northern Highlands Terrane

But where were these depositional basins for the Moine sediments?



Early Neoproterozoic Moine deposition:

Aborted ocean-opening rift event along east side of Laurentia provided basins for the Moine sediment deposition, now correlated with the Torridon, Sleaf, Morar, Iona and Shetland groups to form the **Wester Ross Supergroup**, 1000-950 Ma.

Later came the Loch Ness Supergroup, 900-870 Ma.

And later still came the Grampian Terrane with the Dalradian sediments, 800 – 500 Ma

All in the firing line as Avalonia took aim at the coast of Laurentia

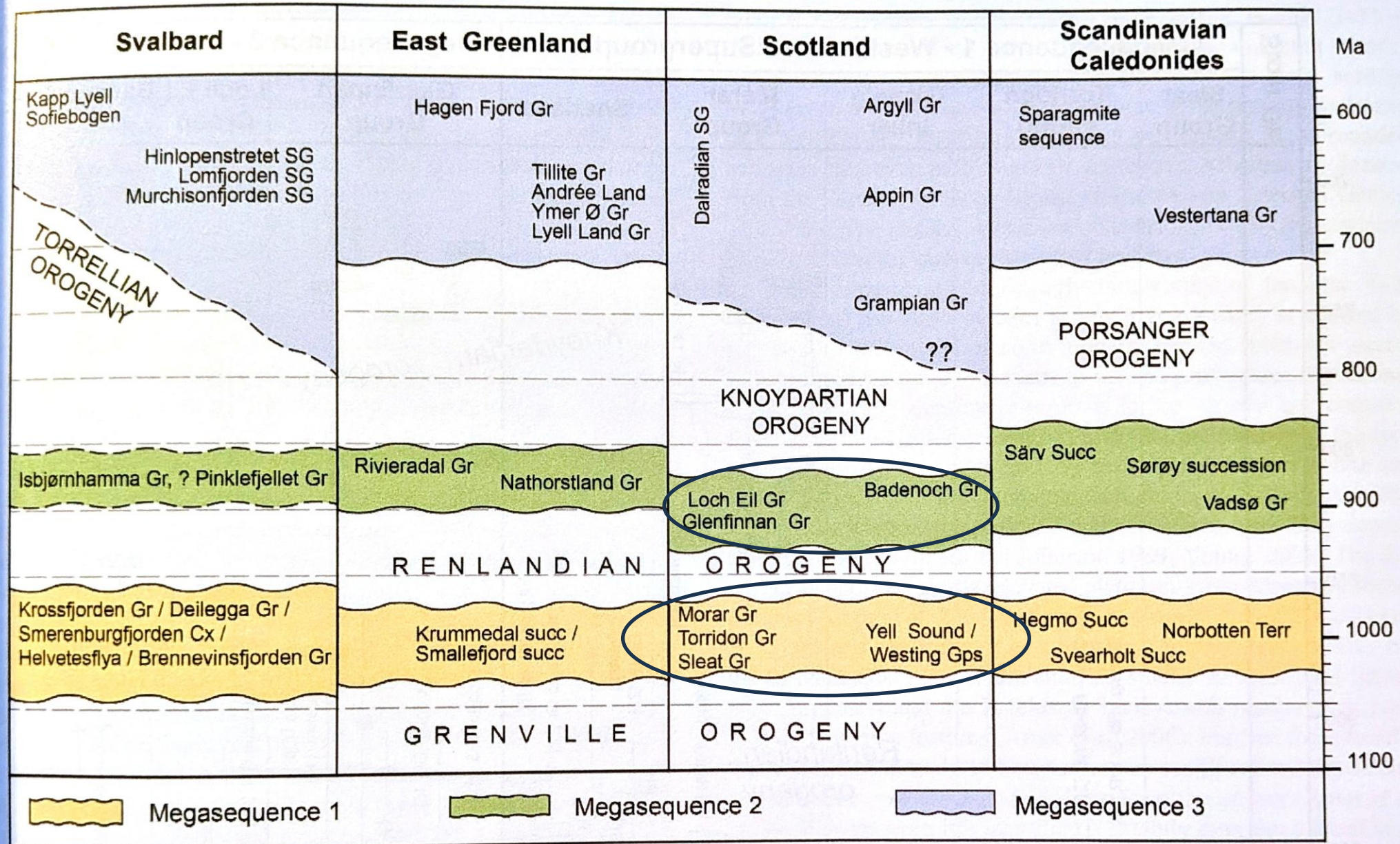
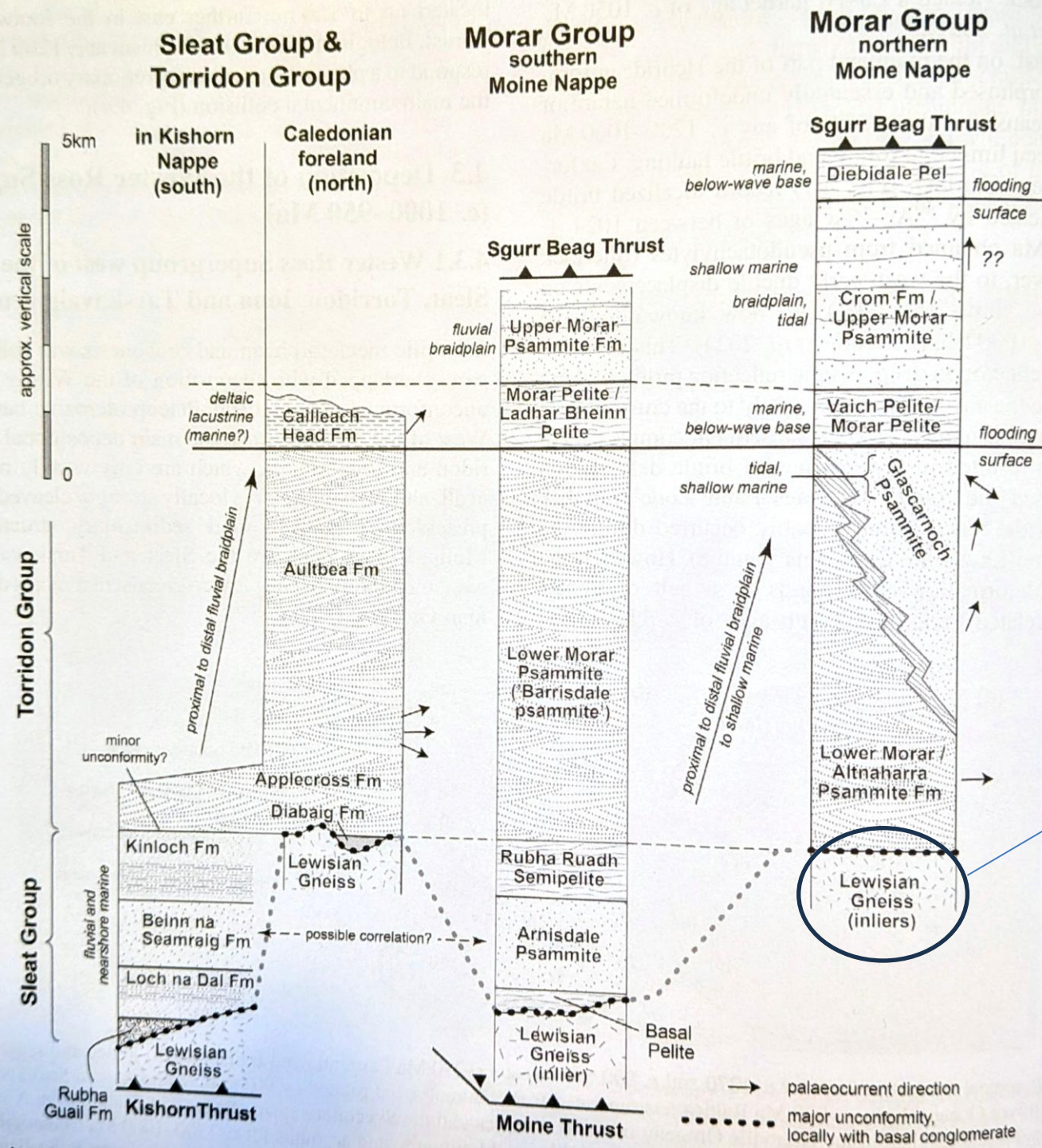


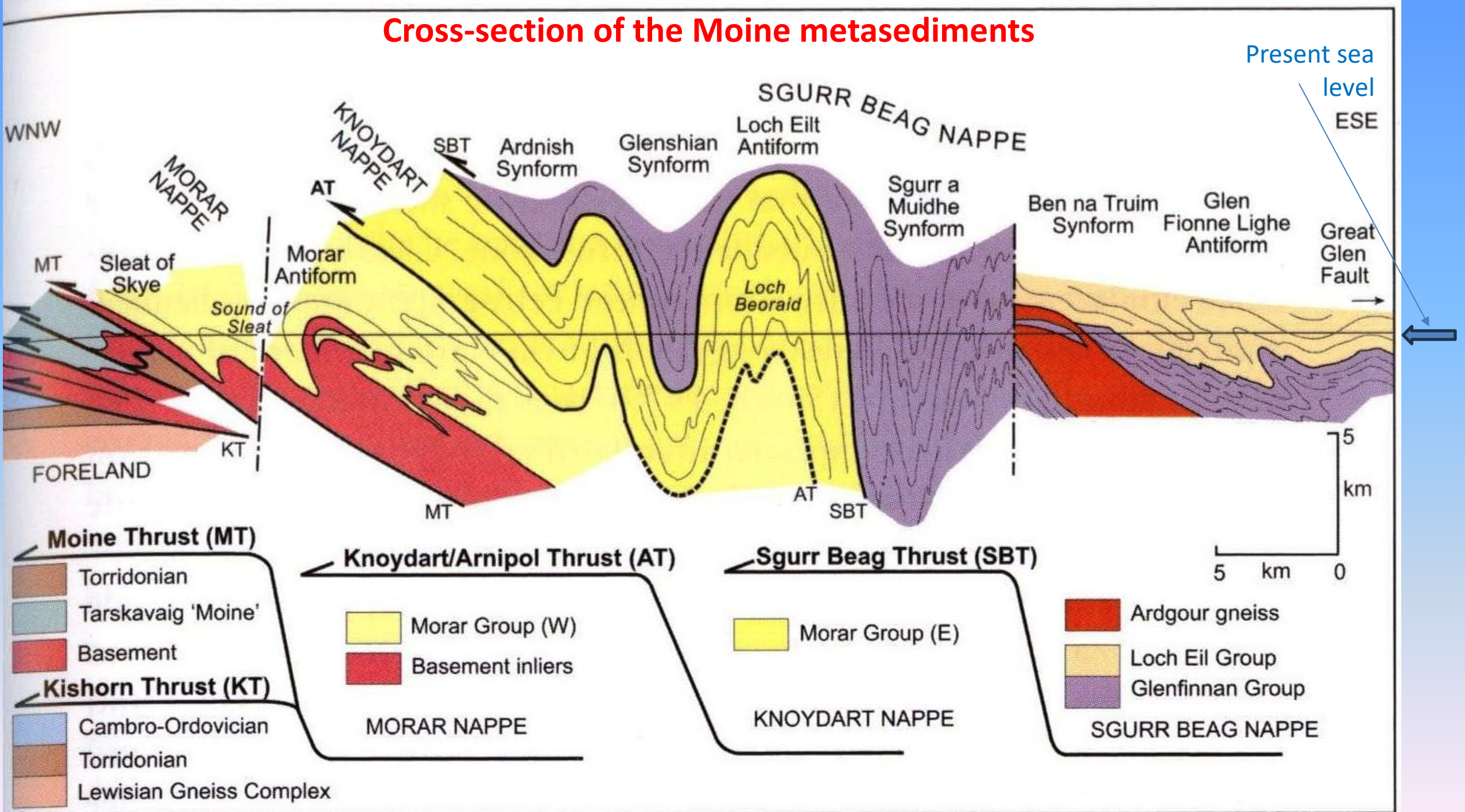
Fig. 4.2. Overview of Mesoproterozoic and Neoproterozoic megasequences in the North Atlantic region. Within each column, the horizontal placings of stratigraphic units reflect differing geographical or tectonic settings. Source: compiled from Olierook *et al.* (2020), Krabbendam *et al.* (2022) and Wala *et al.* (2021).

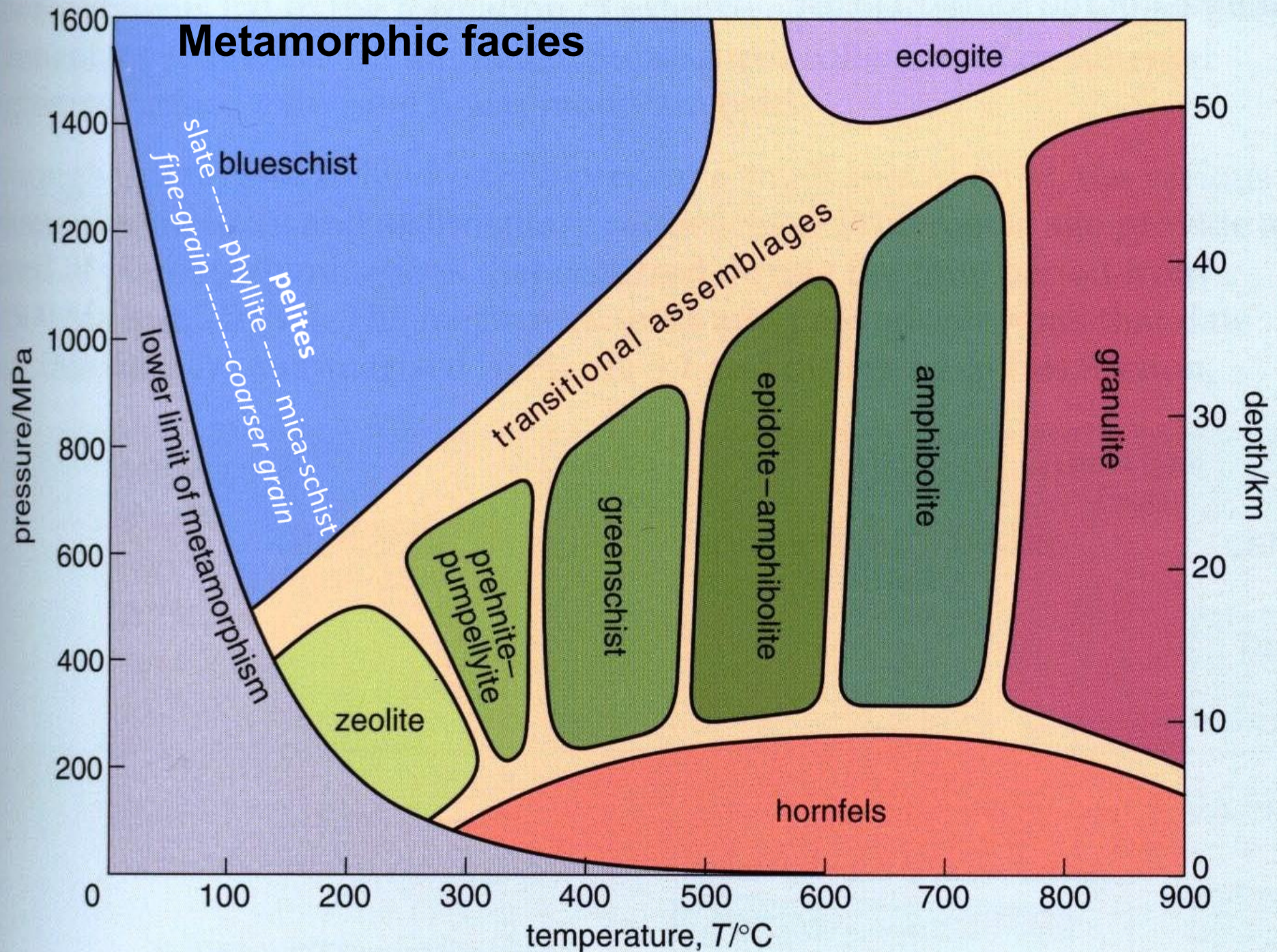


Lewisian Gneiss Inliers

But with a different history to the Hebridean Lewisian

Cross-section of the Moine metasediments





The Meeting of the Terranes



Northern Highland Terrane

So how did the Hebridean and Northern Highland Terranes Get Together?

Hebridean Terrane

Between a Rock and a Hard Place!

- The Hebridean Terrane: part of a huge craton once forming the core of Laurentia
- Stable for over 2.5 billion years
- A basement of almost structureless gneiss, with few lineaments to provide lines of weakness
- Perhaps 50 km thick!
- Only a thin 'icing' of Cambrian-Ordovician sediments on top.

The Hard Place!

- The Hebridean Terrane: part of a huge craton once forming the core of Laurentia
- Stable for over 2.5 billion years
- A basement of almost structureless gneiss, with few lineaments to provide lines of weakness
- Perhaps 50 km thick!
- Only a thin 'icing' of Cambrian-Ordovician sediments on top.
- *But it did break apart when the Atlantic Ocean opened – hmm....*

The Rock – The Northern Highland Terrane

- signs of a slice of stable Lewisian basement craton below (but a different history to Hebridean gneiss)
- a thick cover of Moine rocks
- Moine rocks began as marine sediments, but were seriously mangled by a previous orogeny

The Rock – The Northern Highland Terrane

- Less strong, much weaker than gneiss, so more liable to respond to forces resulting from plate collision
- Major lines of weakness already existed – the Moine Fault between the two terranes, and another possible suture line now represented by the Sgurr Beag thrust.
- The result is that the Moine schists are crushed – another metamorphosis – to form **mylonites** at the terrane boundary

The Clash of the Titans?

Prepare for Action!

The Hard Place

Lewisian

The Rock

Moine

And may the forces be with you!



Avalonia has arrived

Knockan Crag

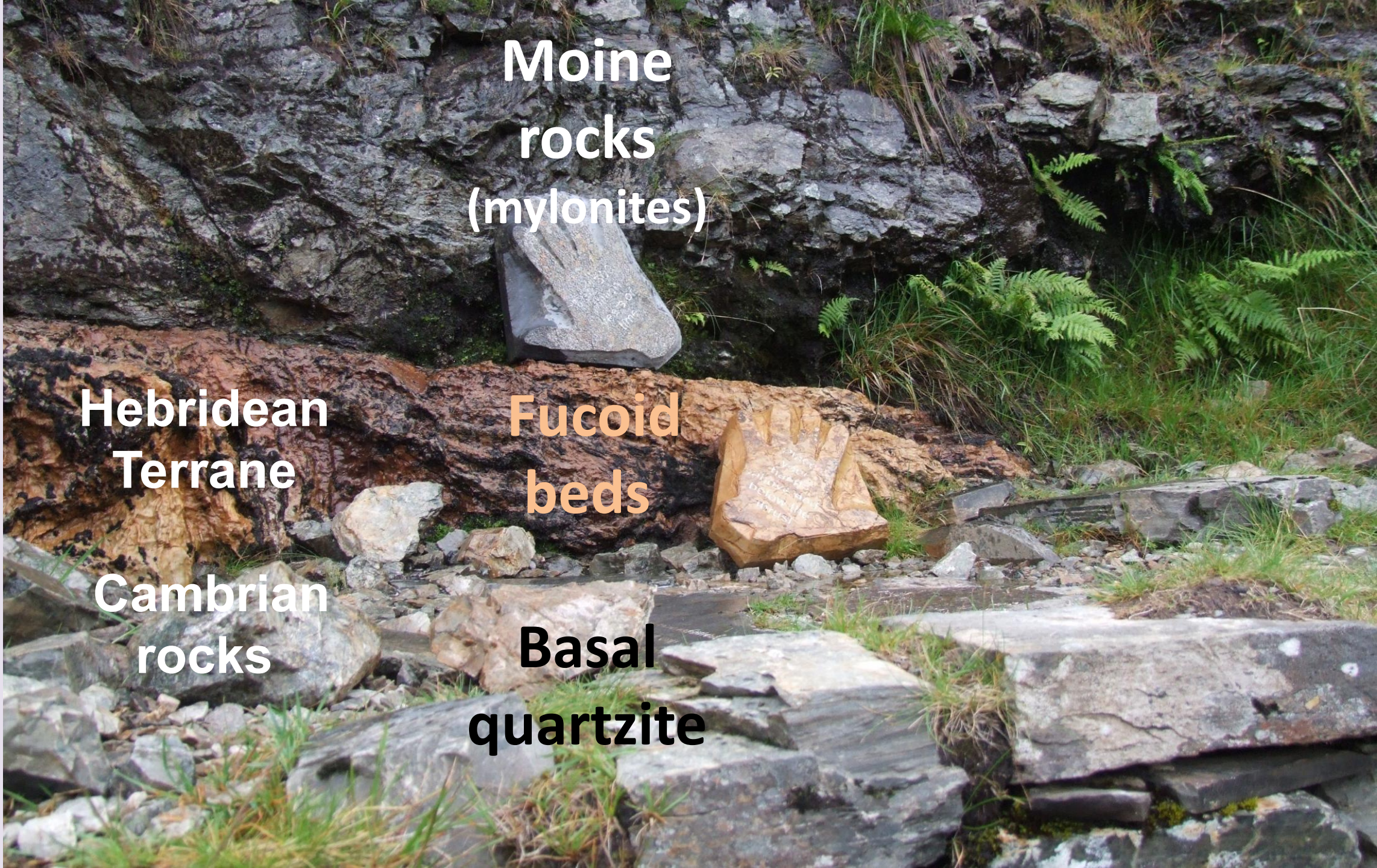
**Moine
rocks
(mylonites)**

**Hebridean
Terrane**

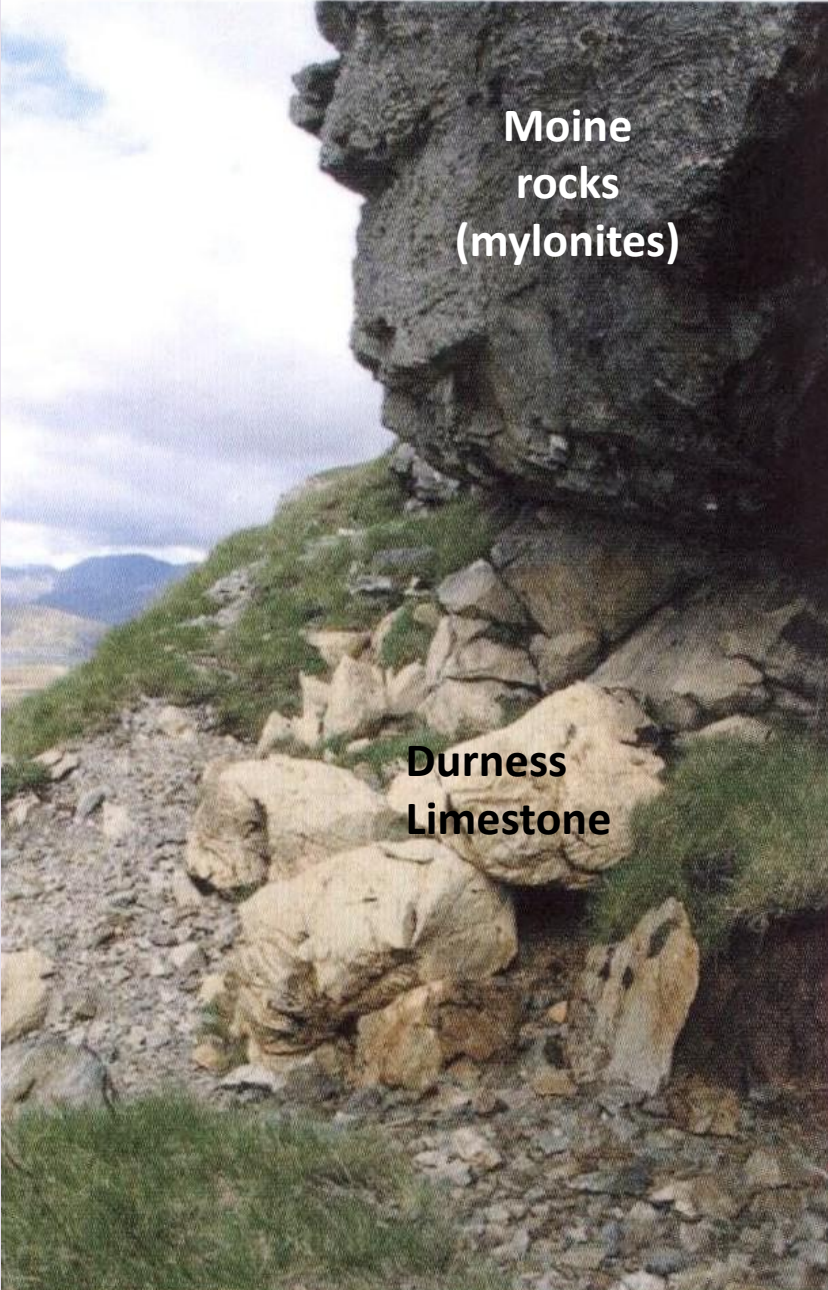
**Fucoid
beds**

**Cambrian
rocks**

**Basal
quartzite**



Dark Moine Rocks on top of creamy Durness Limestone, separated by the Moine Thrust

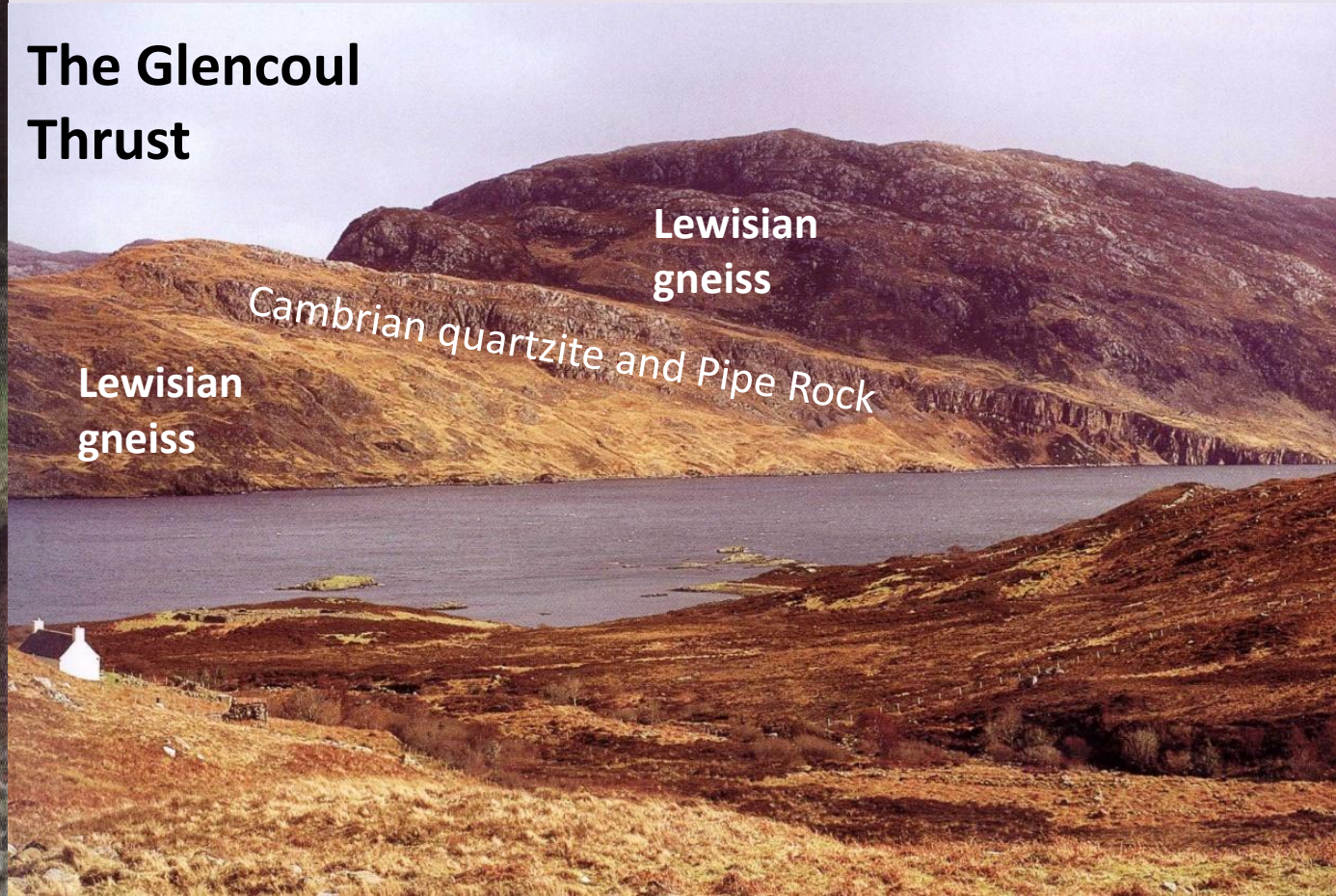


**Moine
rocks
(mylonites)**

**Durness
Limestone**

What you see.

The Glencoul Thrust

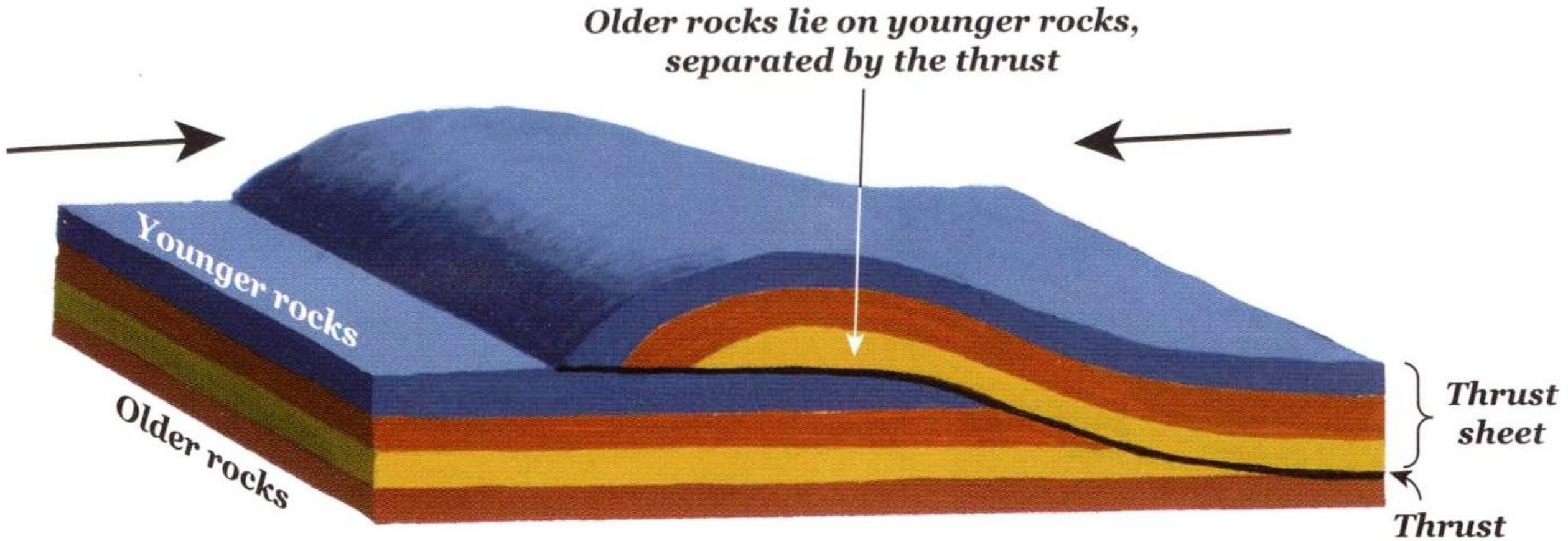


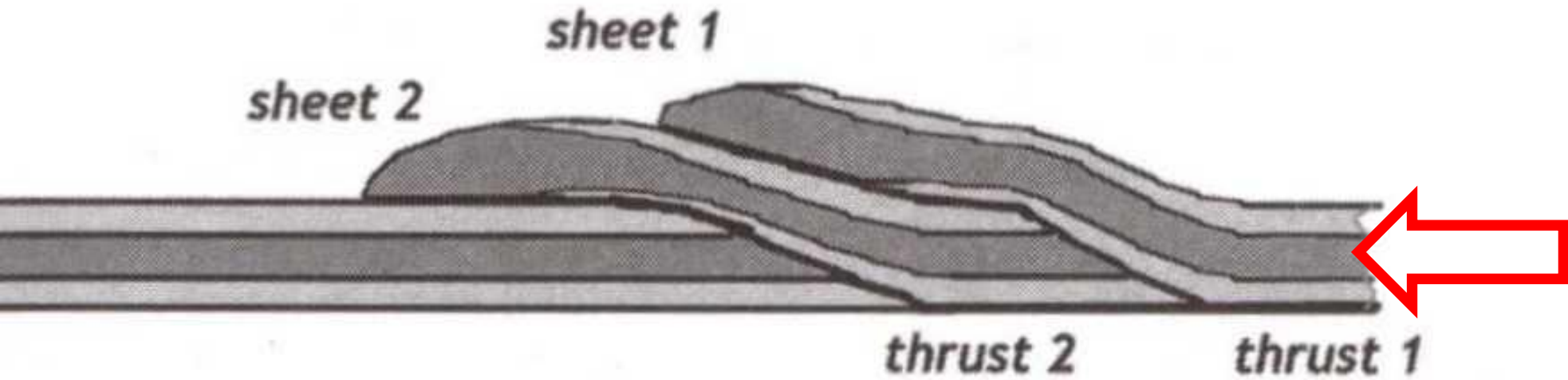
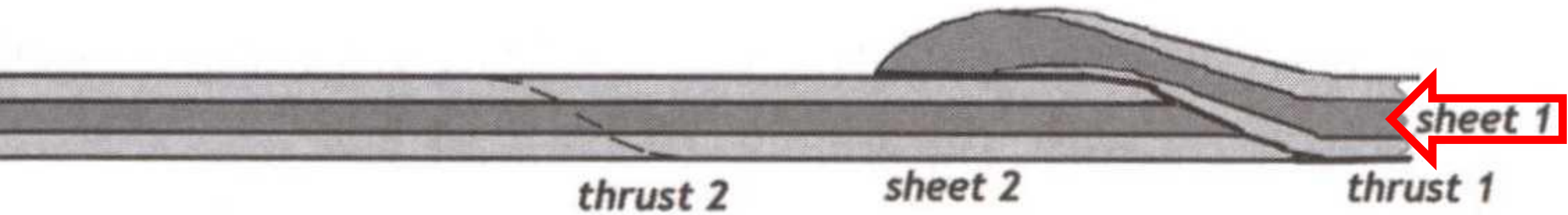
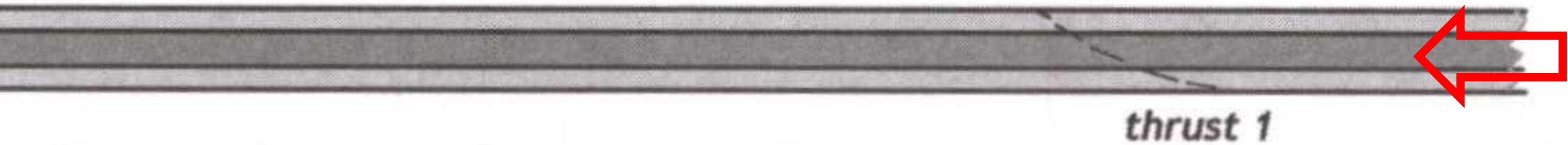
**Lewisian
gneiss**

Cambrian quartzite and Pipe Rock

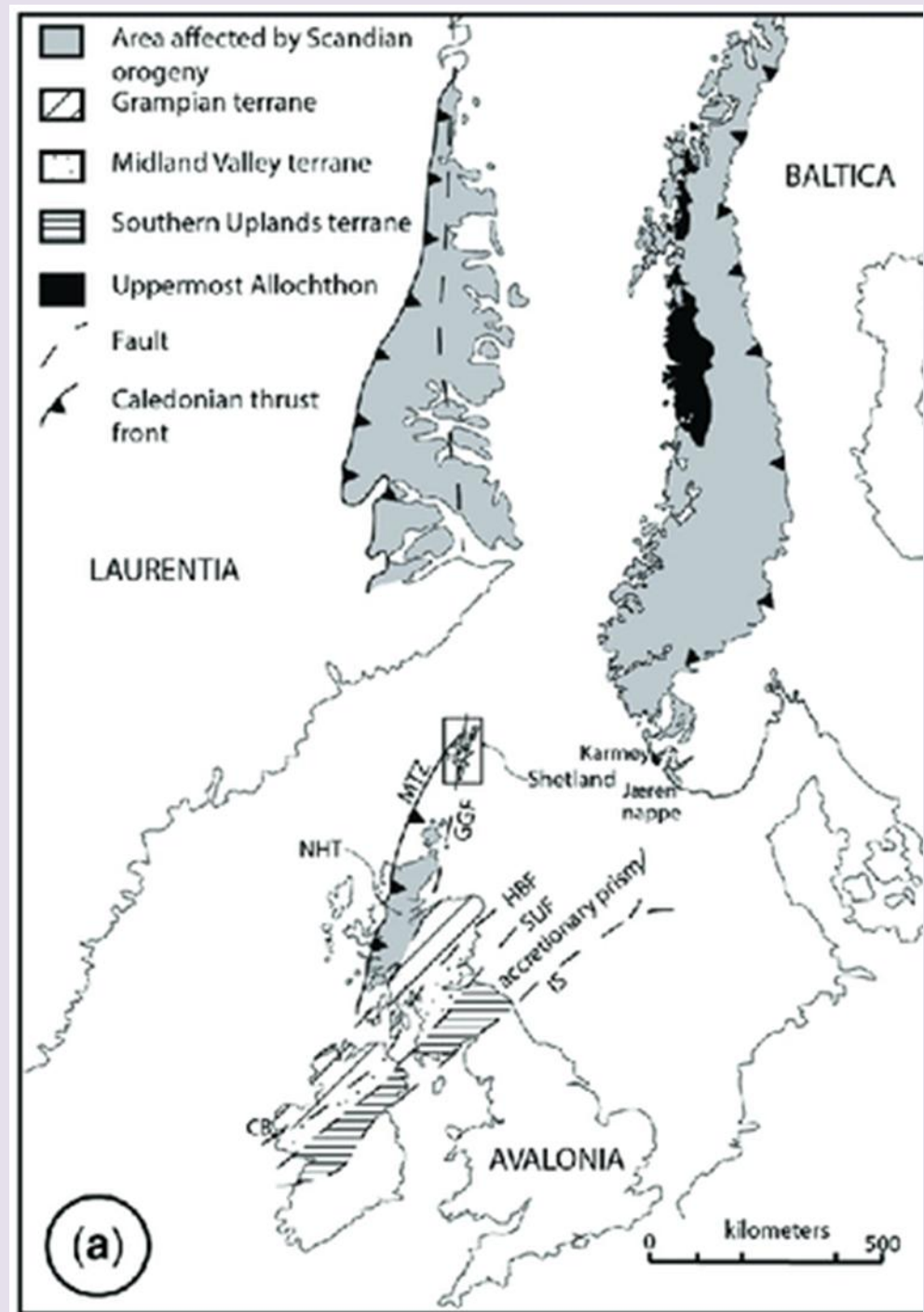
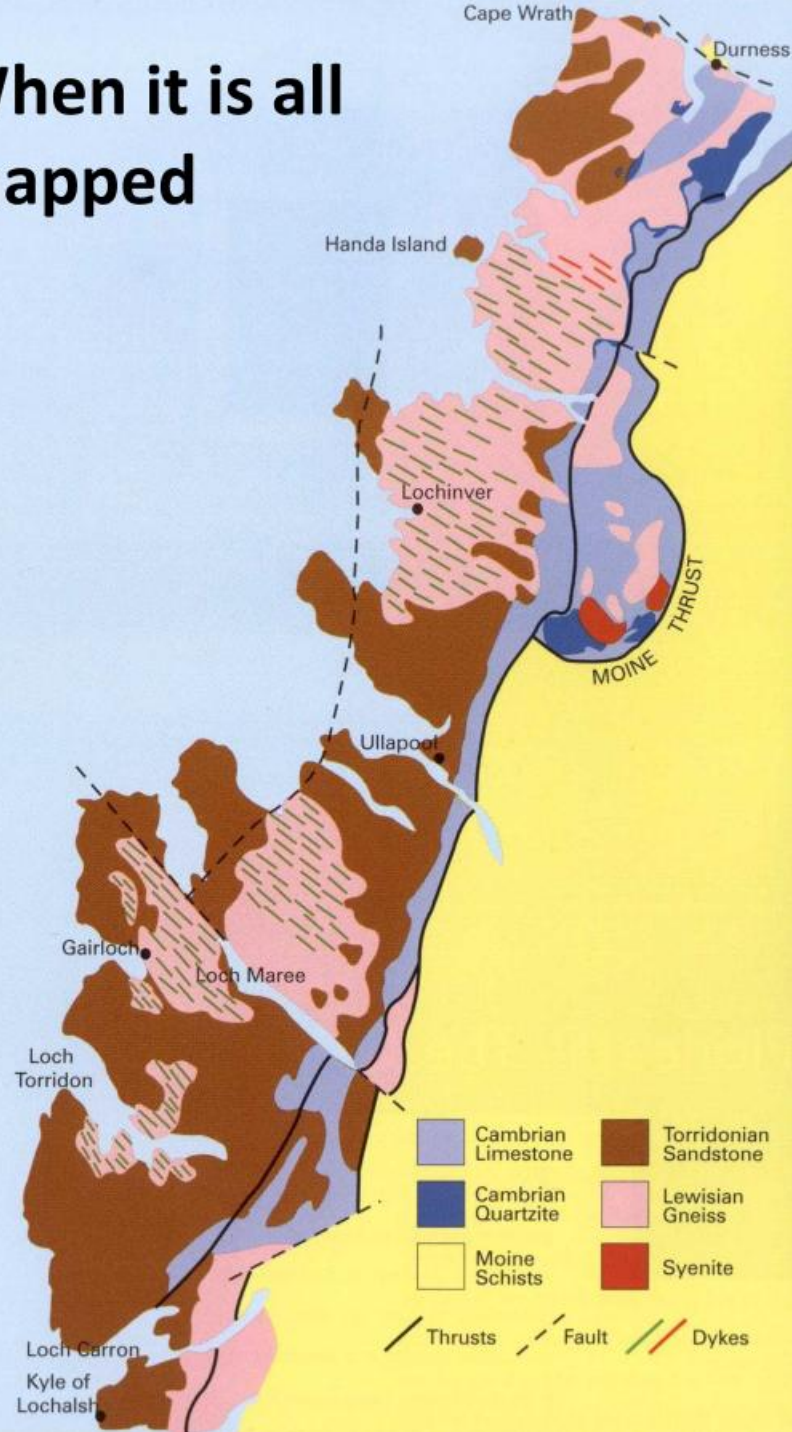
**Lewisian
gneiss**

Thrust Tectonics

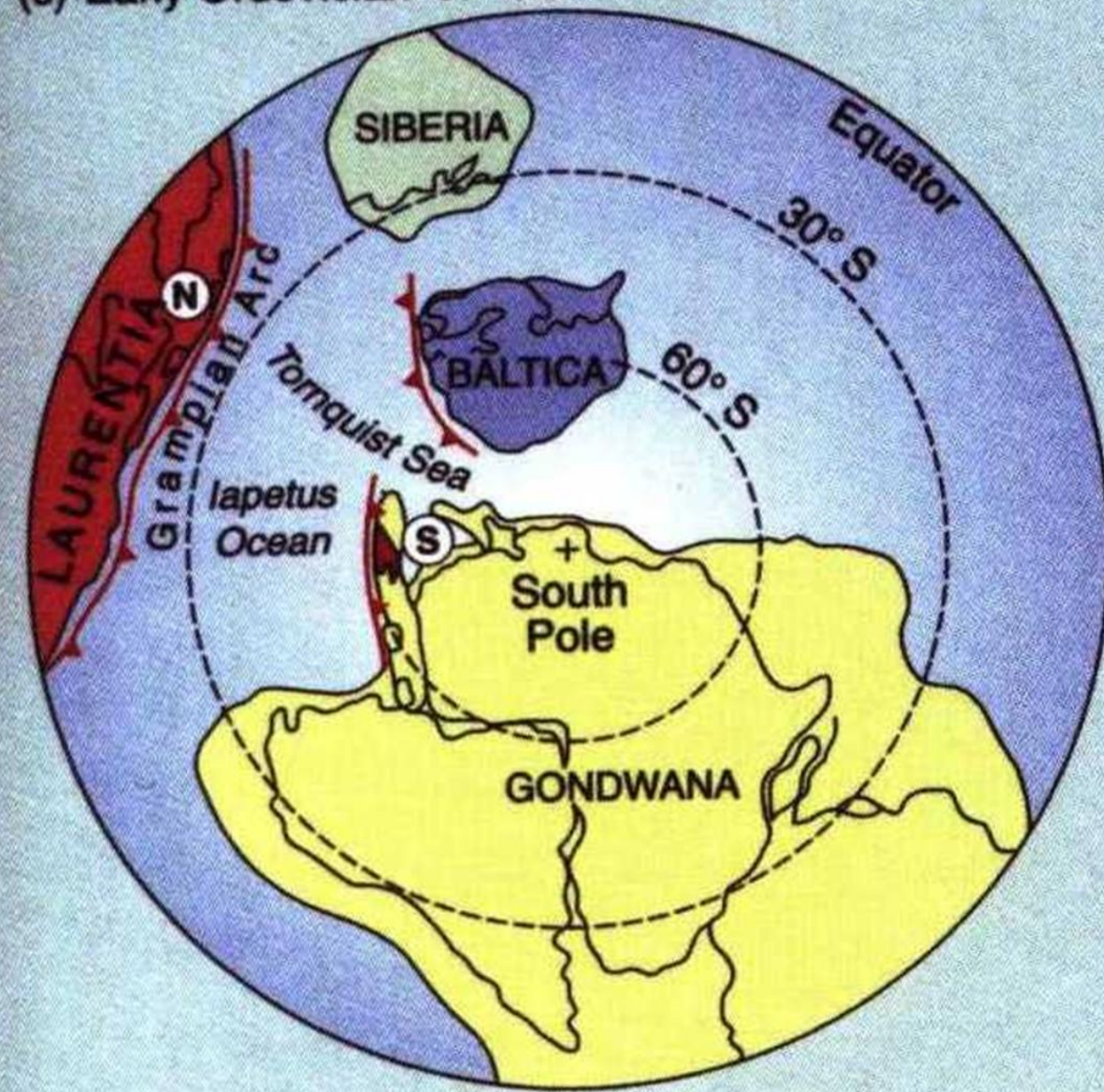




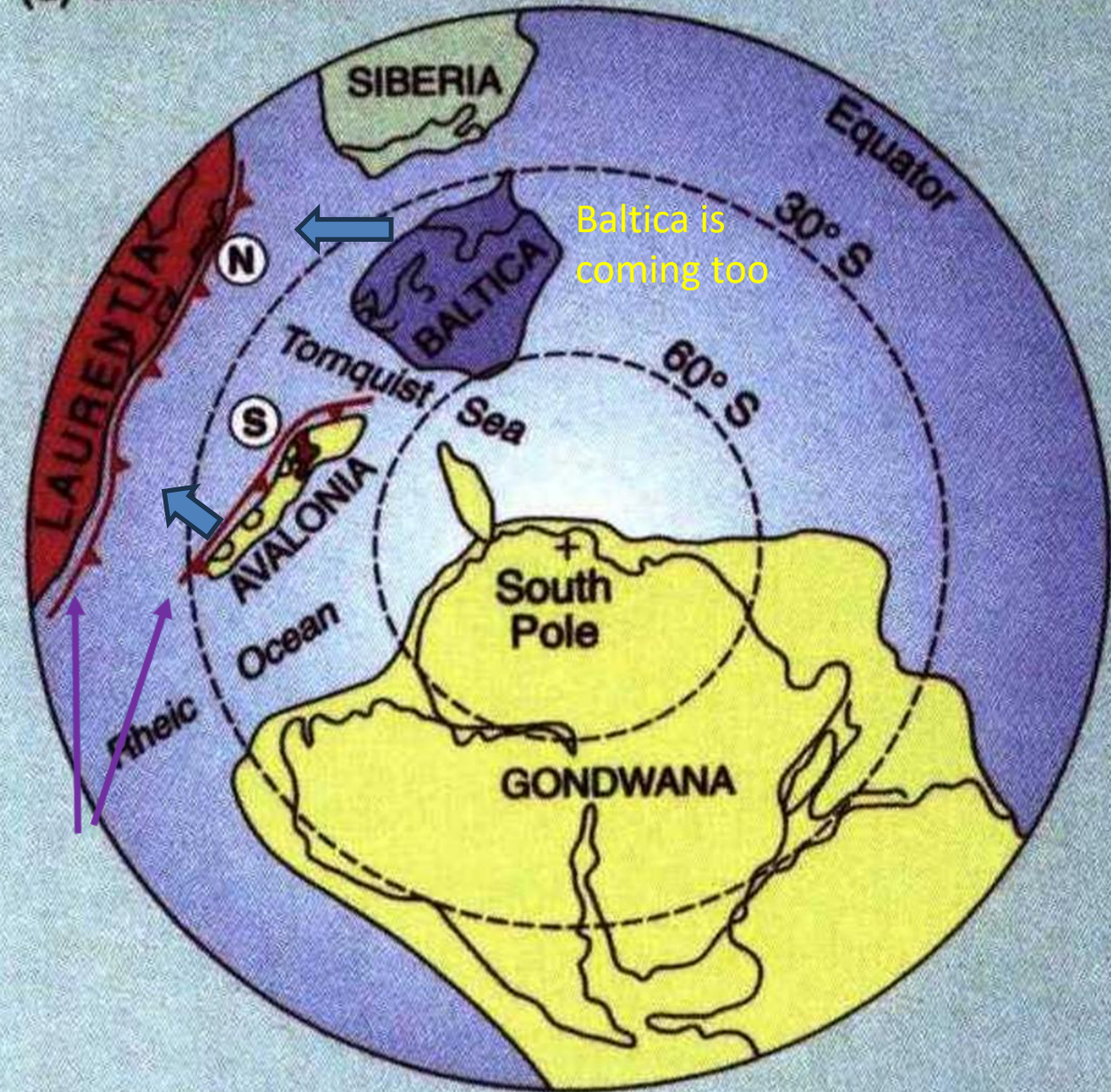
When it is all mapped



(c) Early Ordovician c. 490 Ma

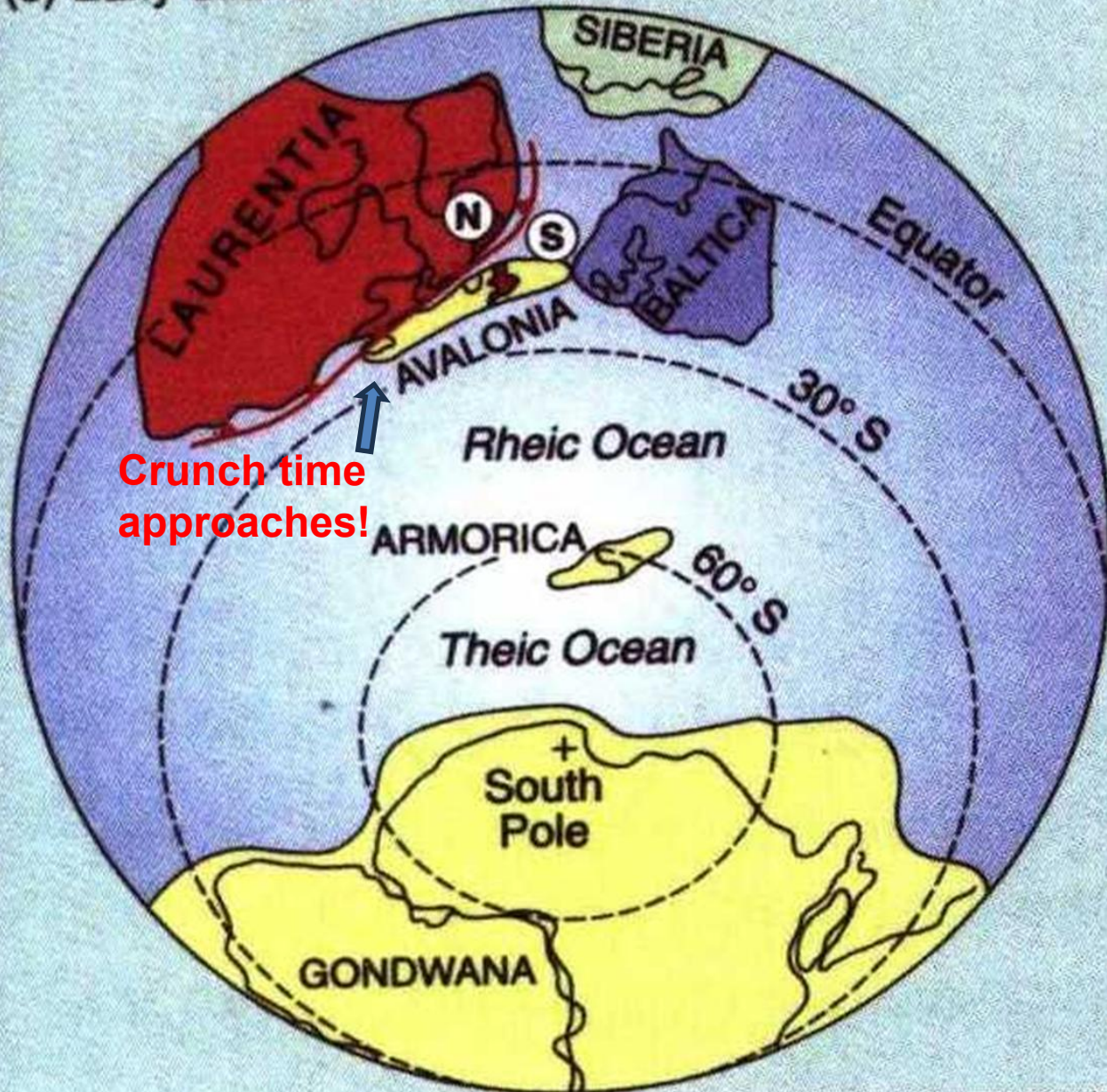


(d) Mid-Ordovician c. 470 Ma

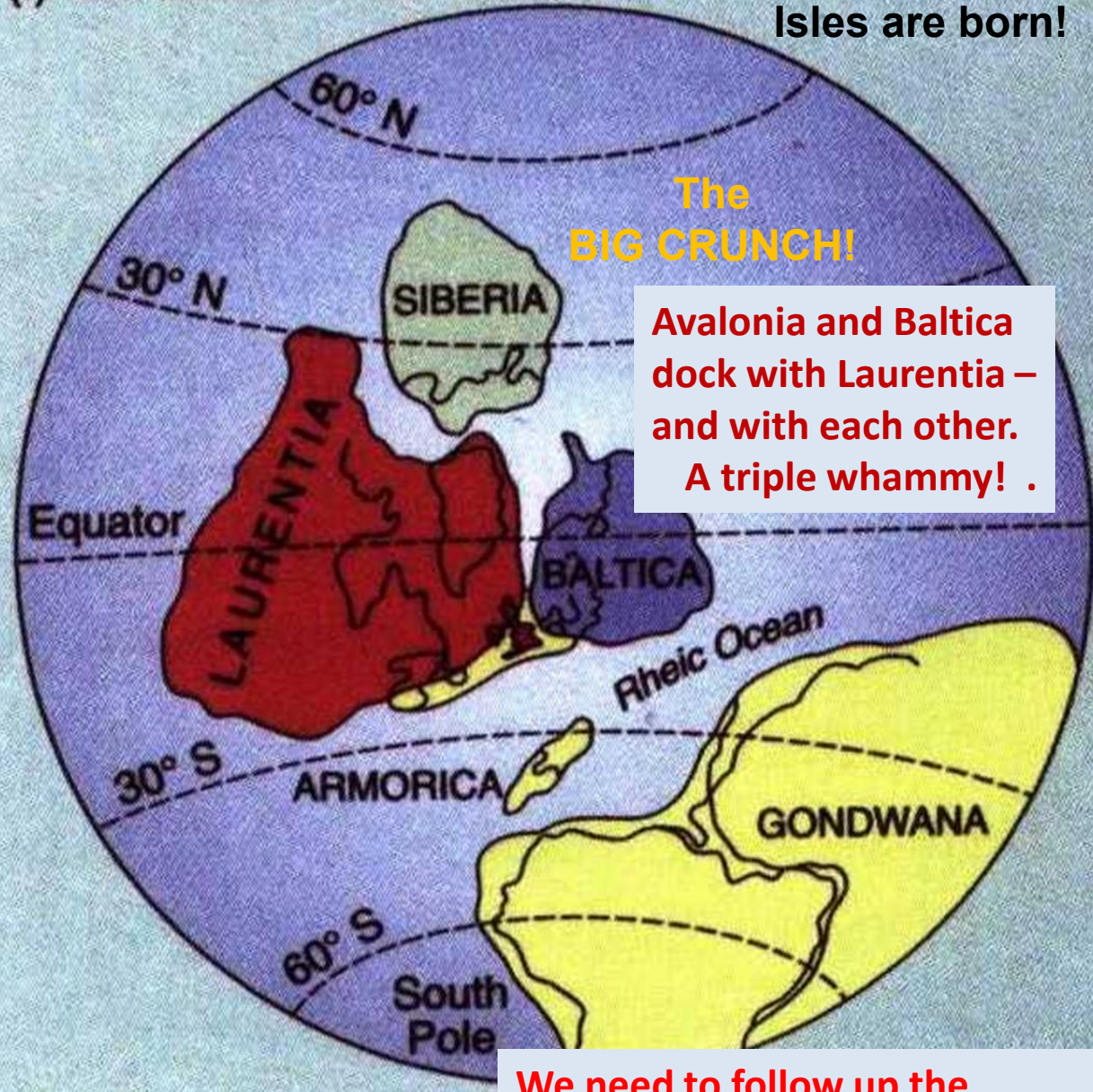


The Iapetus Ocean at 490 Ma is about the same width as the present N Atlantic, but closing after this.

(e) Early Silurian c. 440 Ma



(f) Mid-Silurian c. 425 Ma



The British Isles are born!

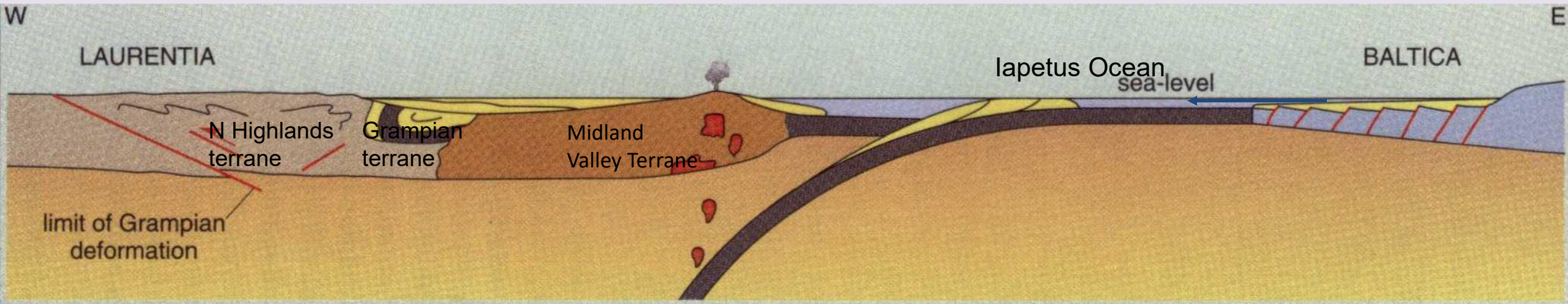
The BIG CRUNCH!

Avalonia and Baltica dock with Laurentia – and with each other. A triple whammy! .

We need to follow up the consequences for the Hebridean Terrane

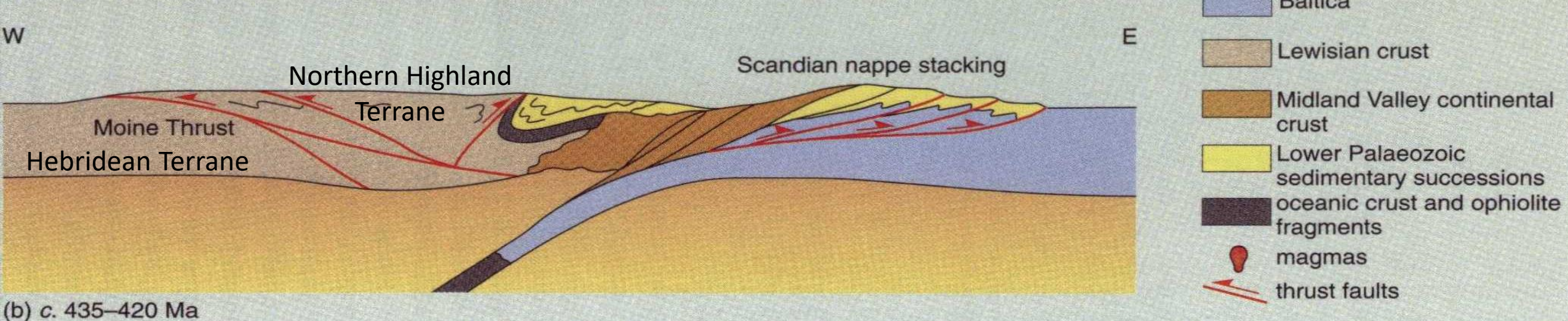
Avalonia has sped north to catch up with lumbering Laurentia! Baltica comes in from the side. The Iapetus Ocean closure has been matched by the Rheic Ocean opening behind Avalonia.

The Cause of the damage: the Caledonian Orogeny – 1. the Scandian Phase



(a) c. 460–435 Ma

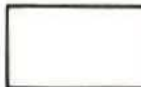




Northern arm of Iapetus Ocean subducts below Laurentia – magmatism in Midland Valley Terrane

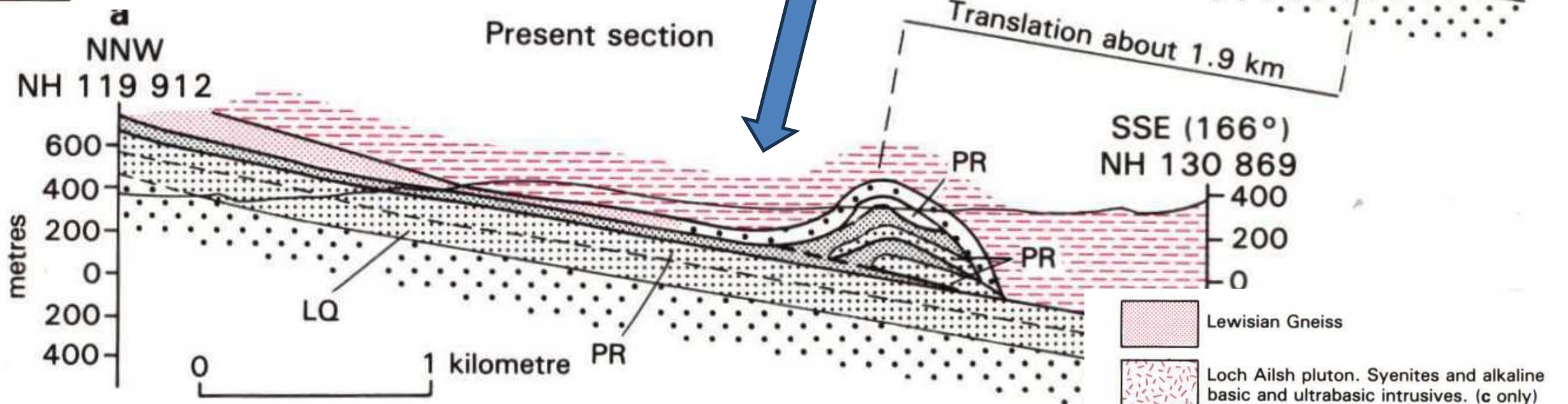
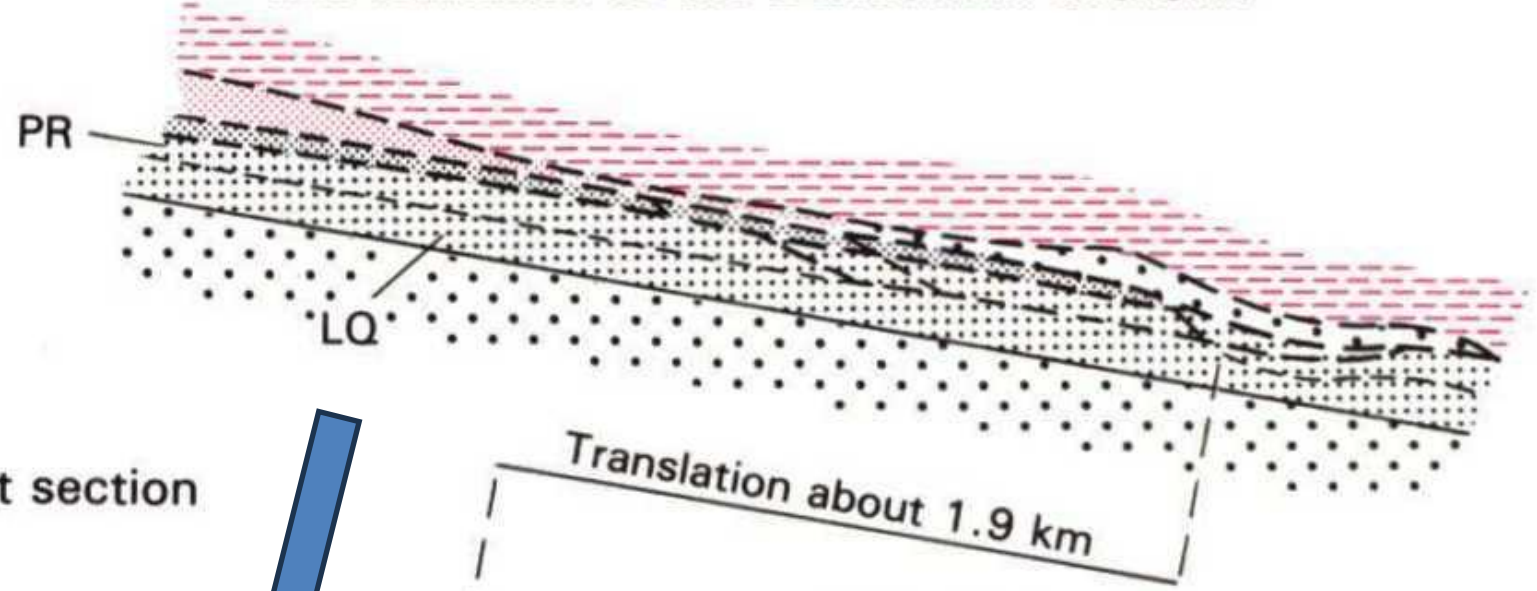


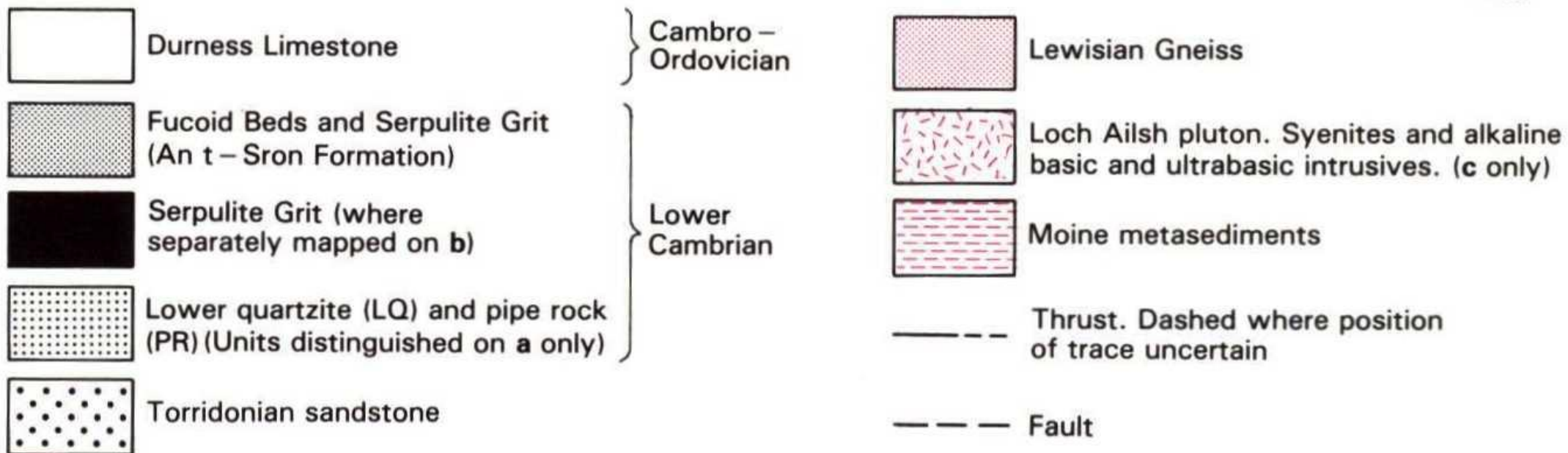
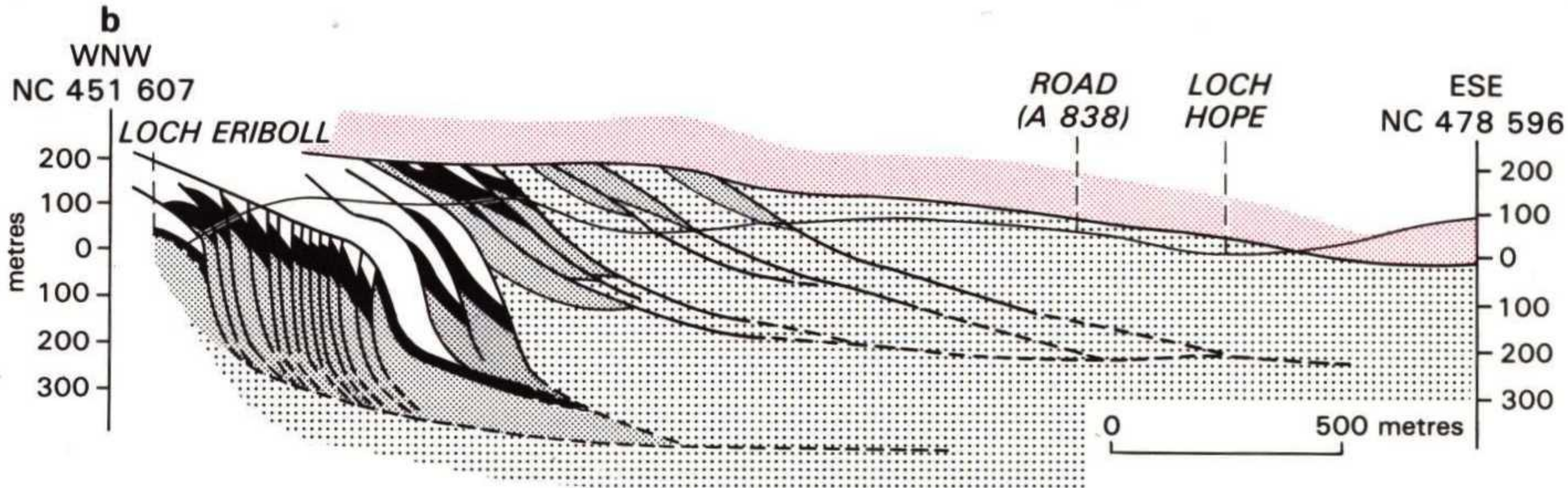
(b) c. 435–420 Ma

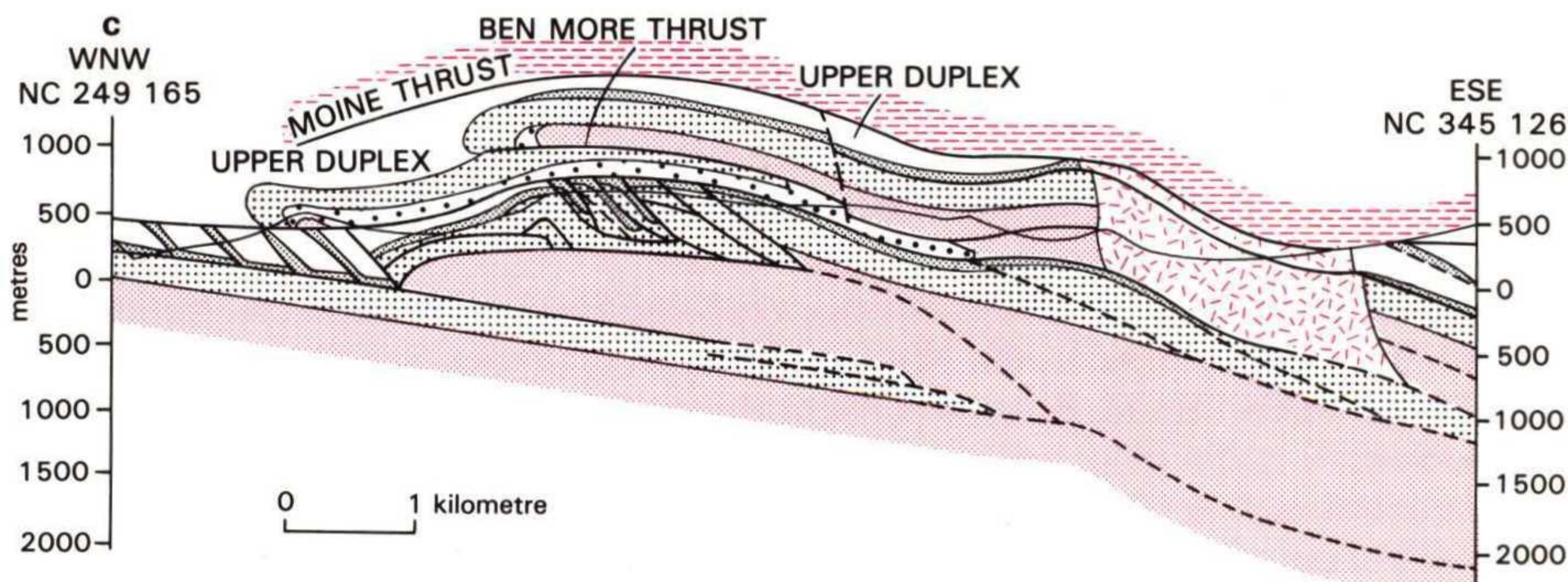
Baltica thrusts under Laurentia – Moine Thrust develops, and N Highlands Terrane is thrust westwards along Great Glen Fault


Probable structure prior to late thrusting and formation of the Dundonnell antiform


-  Durness Limestone } Cambro-Ordovician
-  Fucoïd Beds and Serpulite Grit (An t-Sron Formation) } Lower Cambrian
-  Serpulite Grit (where separately mapped on b) }
-  Lower quartzite (LQ) and pipe rock (PR) (Units distinguished on a only) }
-  Torridonian sandstone

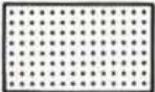






 Furoid Beds and Serpulite Grit (An t-Sron Formation)


 Serpulite Grit (where separately mapped on b)


 Lower quartzite (LQ) and pipe rock (PR) (Units distinguished on a only)

 Torridonian sandstone

} Lower Cambrian

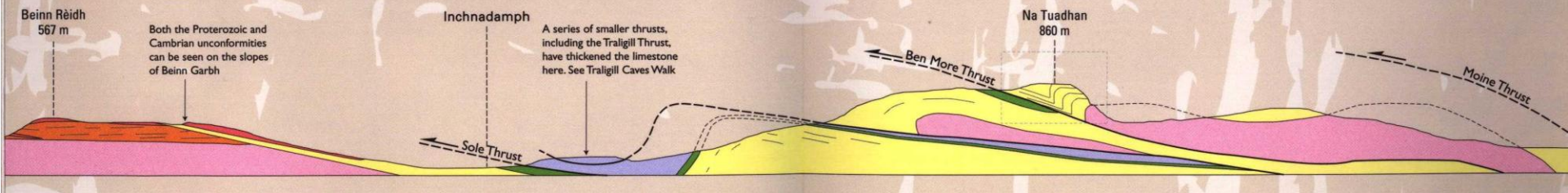
 Loch Ailsh pluton. Syenites and alkaline basic and ultrabasic intrusives. (c only)

 Moine metasediments

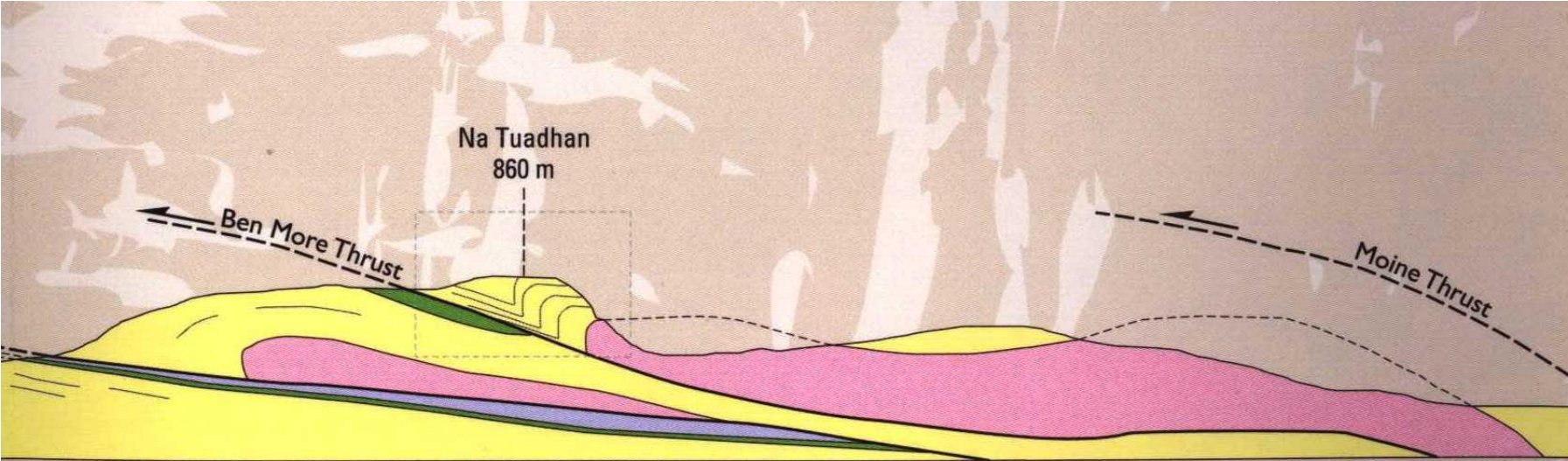
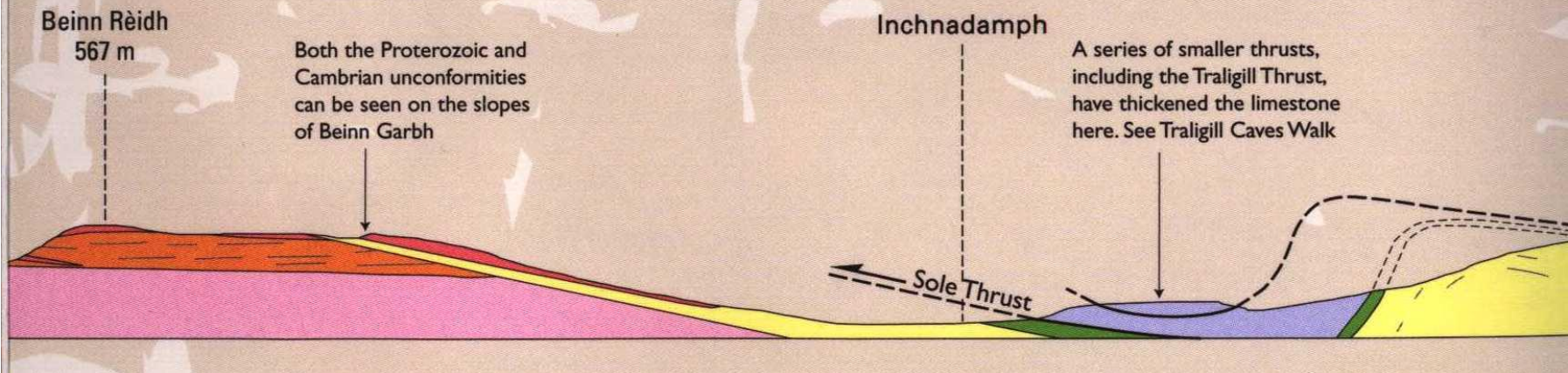
 Thrust. Dashed where position of trace uncertain

 Fault

vertical scale 1:50 000



vertical scale 1:50 000



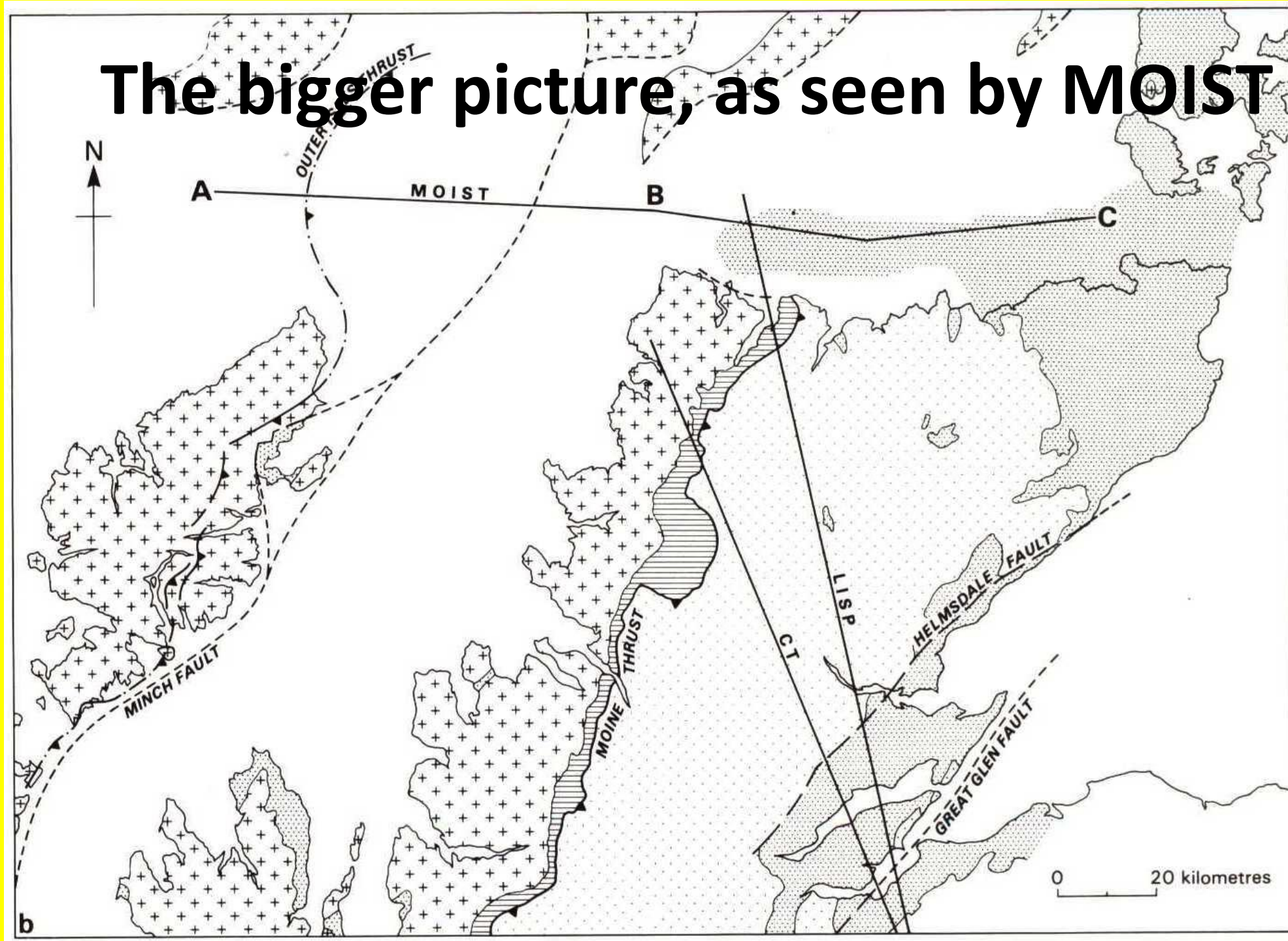
Moine Thrust Zone

The MTZ stretches from Shetland to Sound of Iona and onwards to Ireland

The MTZ represents an overthrust of the Moine rocks of the Northern Highland Terrane onto the Hebridean Terrane for a distance of

c.100 km!

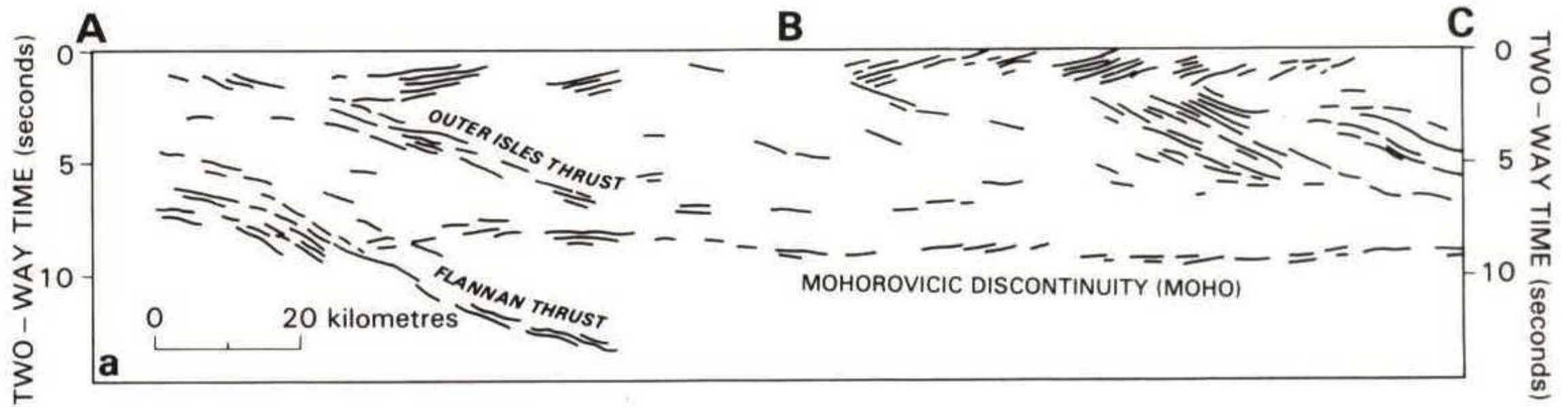
The bigger picture, as seen by MOIST

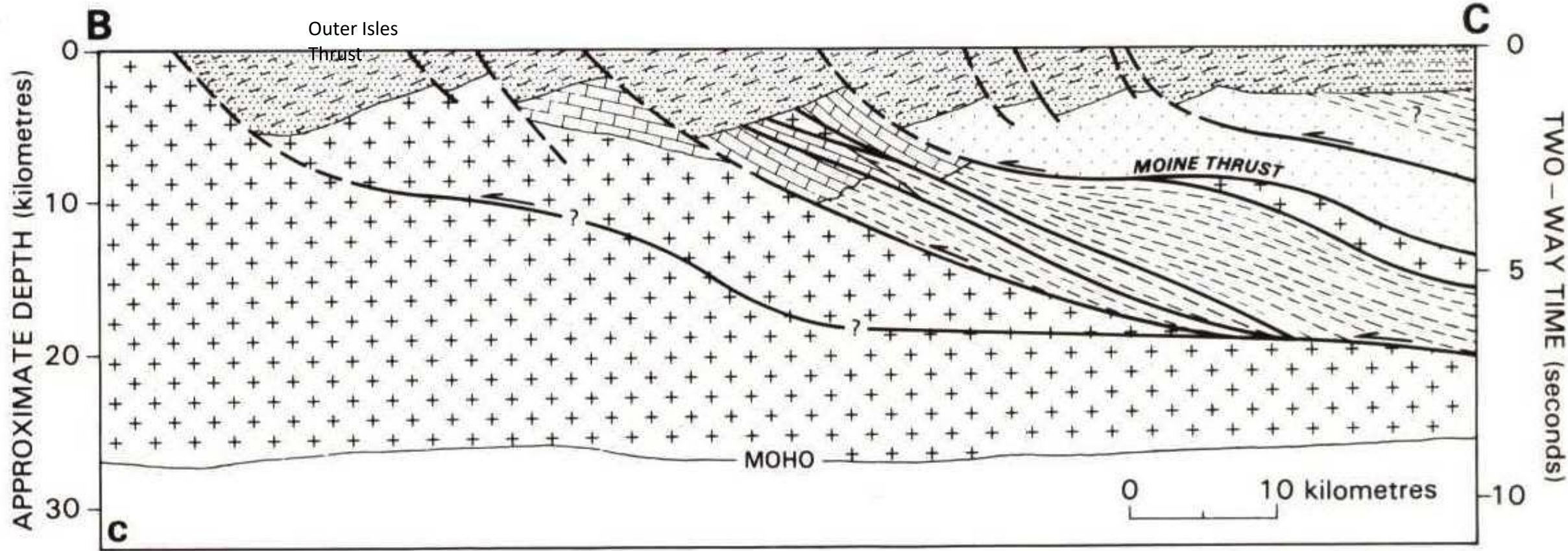



Moine and Outer Isles Seismic Traverse

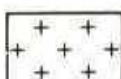
The bigger picture, as seen by MOIST


Moine and Outer Isles thrust zones







 Devonian and later sediments

 Foreland, mainly Lewisian Gneiss with Torridonian and Cambro-Ordovician shelf sediments


 Line of MOIST deep seismic reflection profile (ABC)


 Fault, onshore

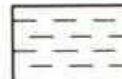
 Moine Thrust Zone


 Moine Series with Caledonised Lewisian Gneiss. Intruded by granitoids and minor basics

 Line of LISP explosion seismic refraction profile

 Thrust, onshore

 Cambro-Ordovician shelf sediments of foreland

 Off-shelf sediments of Late Precambrian to Cambro-Ordovician age

 Line of conductivity traverse


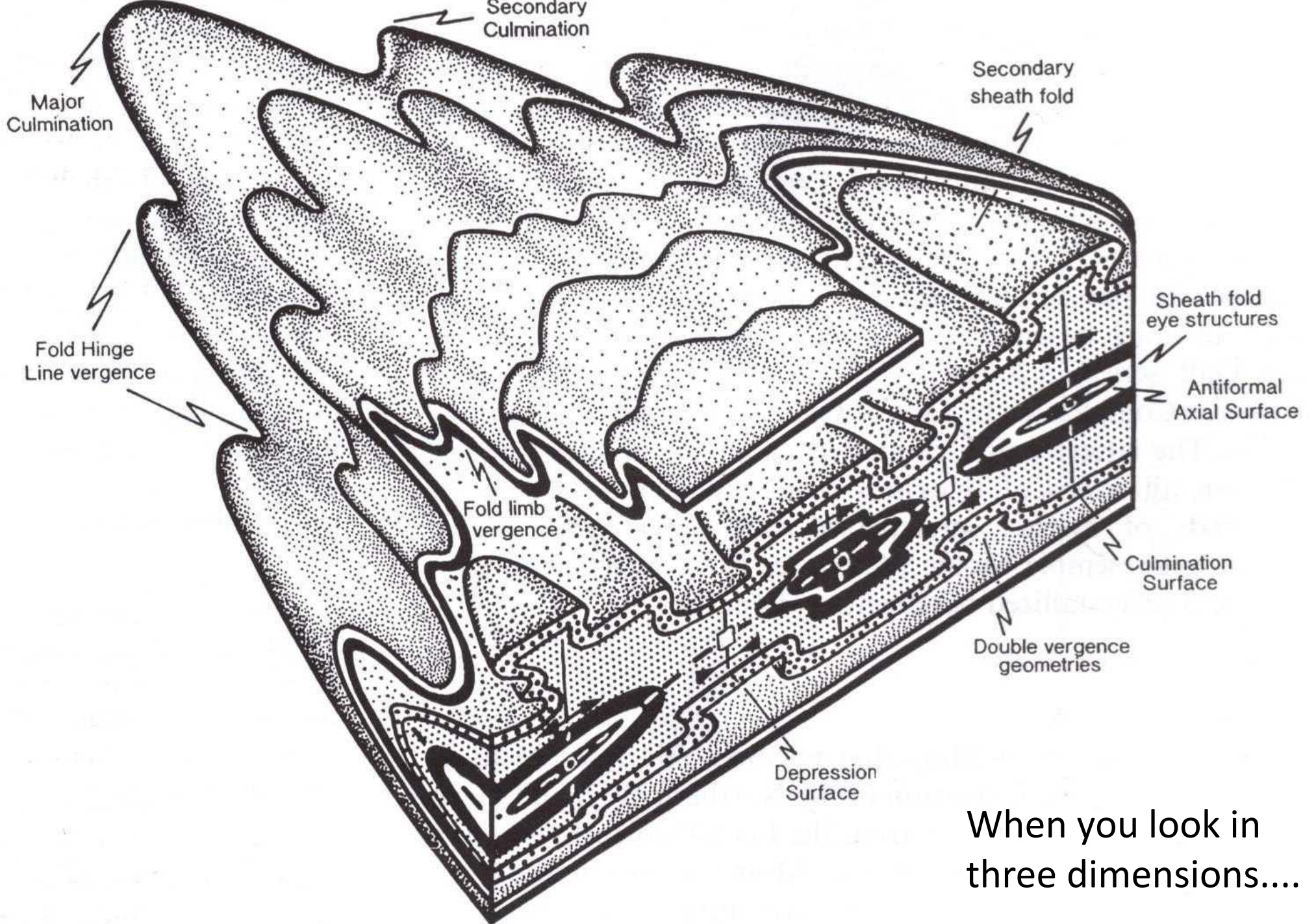
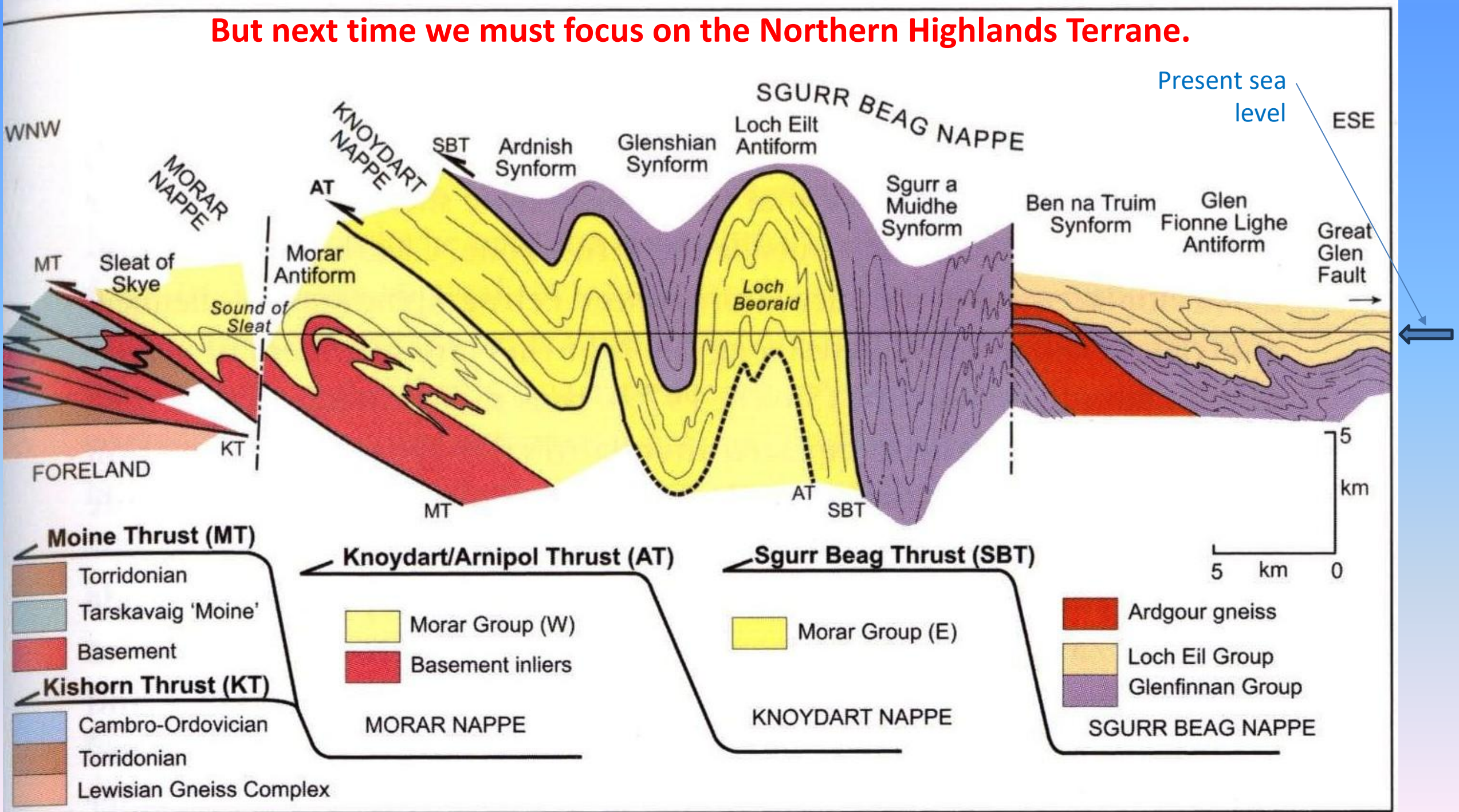
 Prominent seismic reflectors (Fig. 13a only)

Fig. 13c only

The end of an unfinished chapter



But next time we must focus on the Northern Highlands Terrane.



Possible dates in April

14th April: Life Story, From Cretaceous to Palaeogene – a big change for life

21st April: Geology of Scotland, Northern Highlands Terrane – The Moine