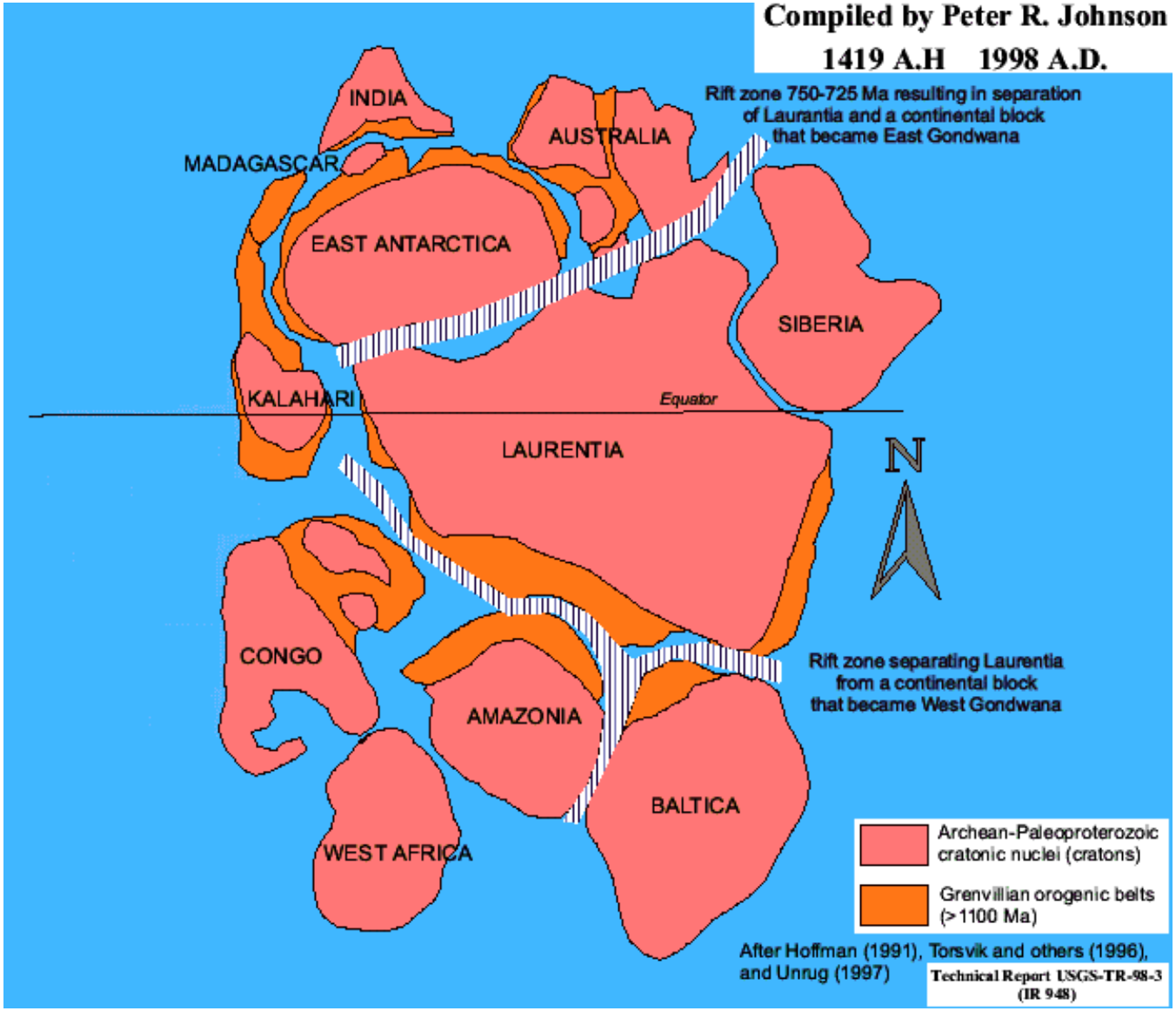
Paleogeografie a tektonické procesy

Paleogeography

Původně jednotný superkontinent **Rodinia** se začal rozpadat již během nejvyššího proterozoika a jeho rozpadání pokračovalo i v nejspodnějším paleozoiku. Na počátku paleozoika můžeme ještě sledovat doznívání **kadomské** (assyntské) orogeneze.
Kolize kontinentů v paleozoiku měla za následek **kaledonskou** (spodní paleozoikum - uzavírání Japetu) a **variskou** (především svrchní paleozoikum - uzavírání Paleotethydy) orogenezi, která byla ukončena opětovným vznikem nového superkontinentu **Pangei**.

Rodinia


Compiled by Peter R. Johnson
1419 A.H 1998 A.D.
INDIA
MADAGASCAR
AUSTRALIA
Rift zone 750-725 Ma resulting in separation of Laurantia and a continental block that became East Gondwana
EAST ANTARCTICA
SIBERIA
KALAHARI
Equator
LAURENTIA
N
CONGO
AMAZONIA
Rift zone separating Laurentia from a continental block that became West Gondwana
BALTICA
WEST AFRICA
Archean-Paleoproterozoic cratonic nuclei (cratons)
Grenvillian orogenic belts (>1100 Ma)
After Hoffman (1991), Torsvik and others (1996), and Unrug (1997)
Technical Report USGS-TR-98-3 (IR 948)

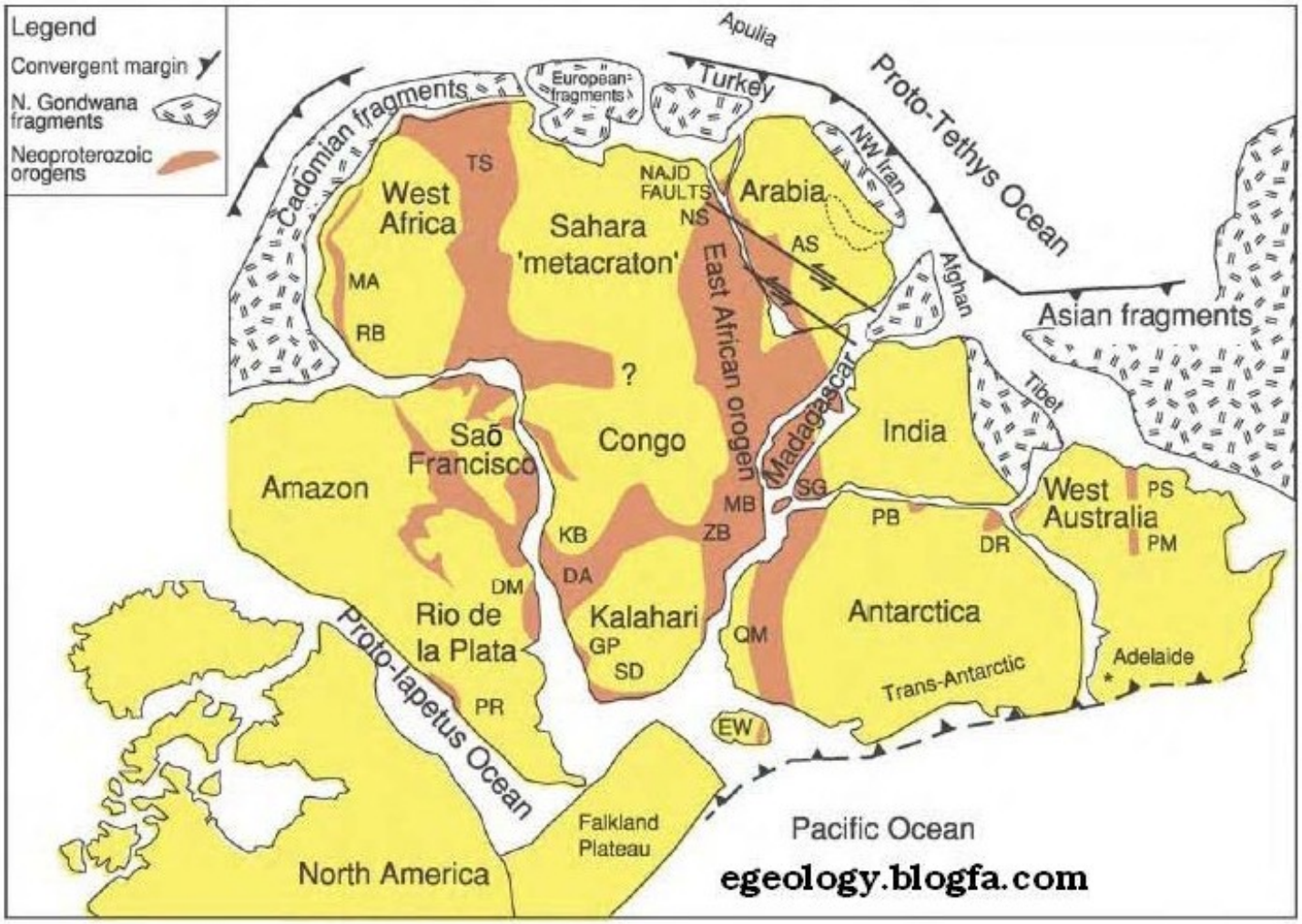


Figure 1 Map of Gondwana at the end of Neoproterozoic time (~540 Ma) showing the general arrangement of Pan African belts. AS, Arabian Shield; BR, Brasiliano; DA, Damara; DM, Dom Feliciano; DR, Denman Darling; EW, Ellsworth Whitmore Mountains; GP, Gariep; KB, Kaoko; MA, Mauretanides; MB, Mozambique Belt; NS, Nubian Shield; PM, Peterman Ranges; PB, Pryolz Bay; PR, Pampean Ranges; PS, Paterson; QM, Queen Maud Land; RB, Rokelides; SD, Saldania; SG, Southern Granulite Terrane; TS, Trans Sahara Belt; WB, West Congo; ZB, Zambezi. (Reproduced with permission from Kusky *et al.*, 2003.)

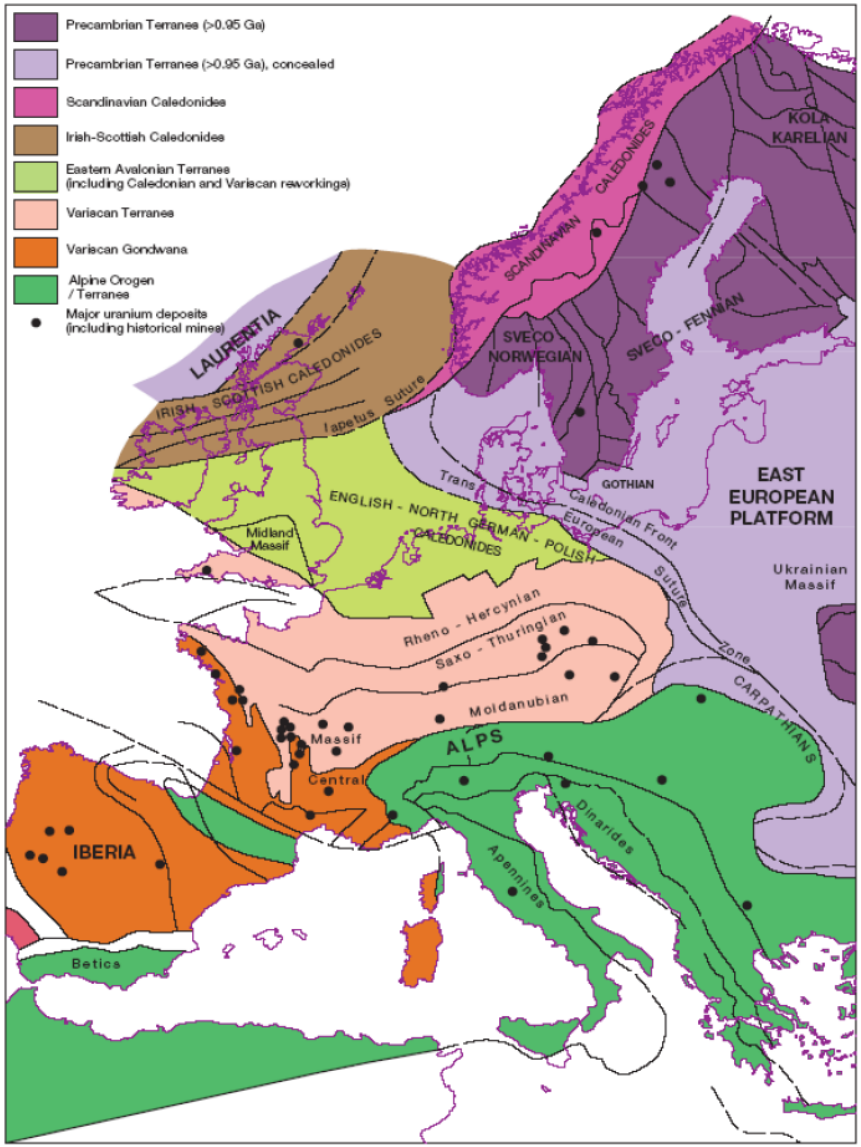
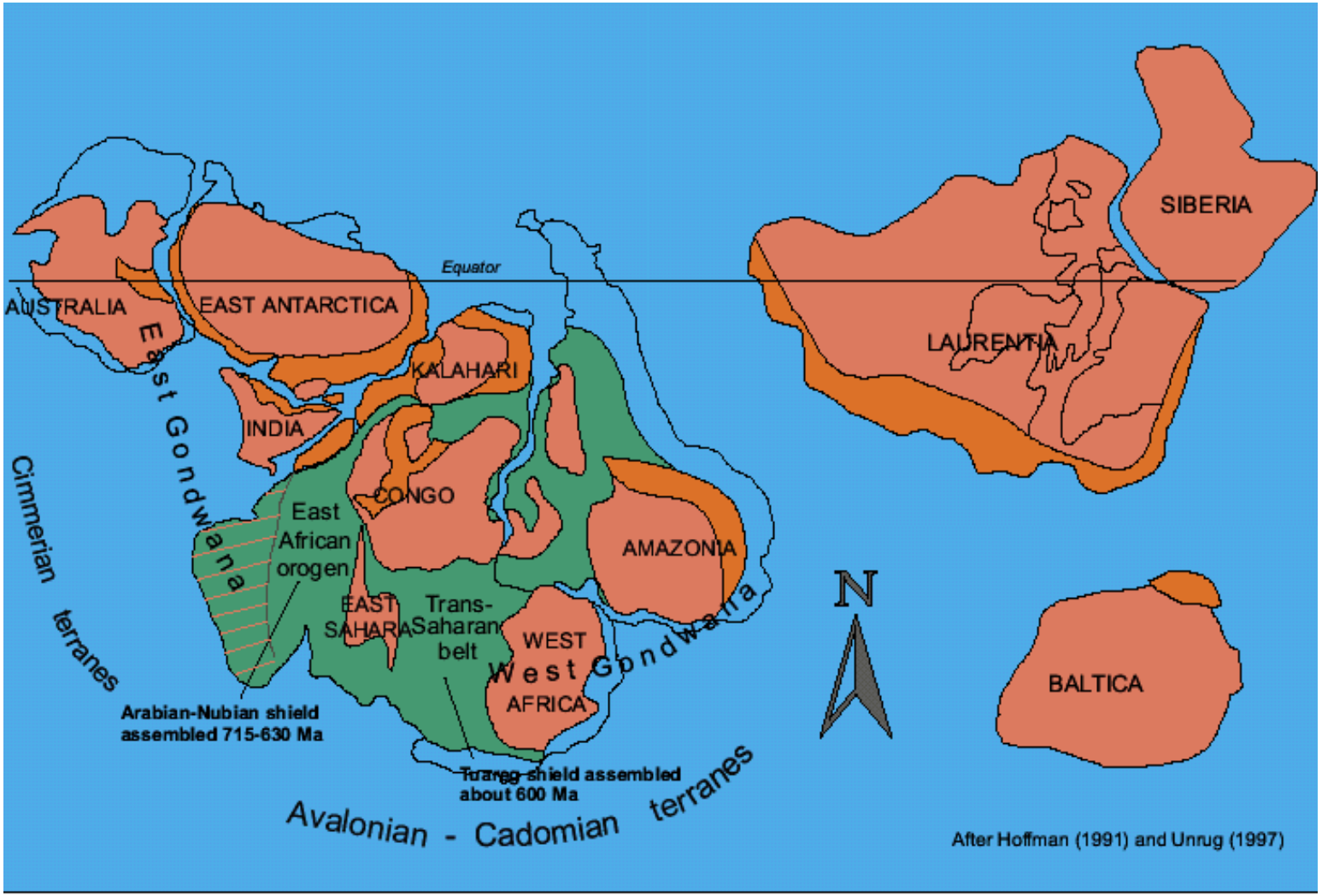
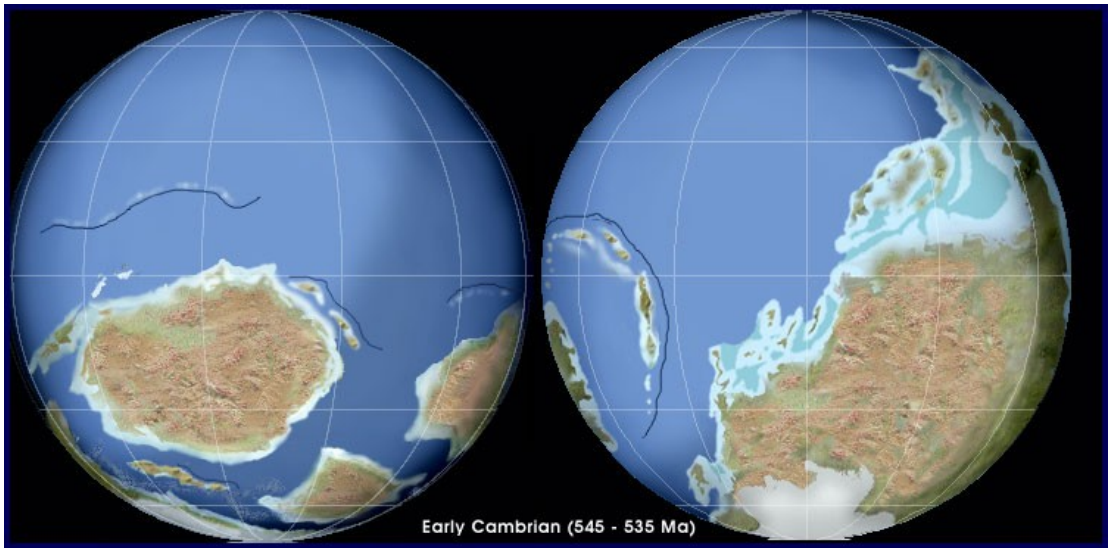


Figure 1. The 'terrane collage' of Precambrian and Phanerozoic Europe, a simplified sketch. Sutures and orogenic fronts are shown as bold lines, internal borders as thin or thin broken lines. Note that the size and shape of the terranes do not change significantly with time (approximate direction of younging is from north to south) (Reproduced with permission from Blundell *et al.* 1992, and Plant *et al.* 2003, Fig. 1, p. B229).

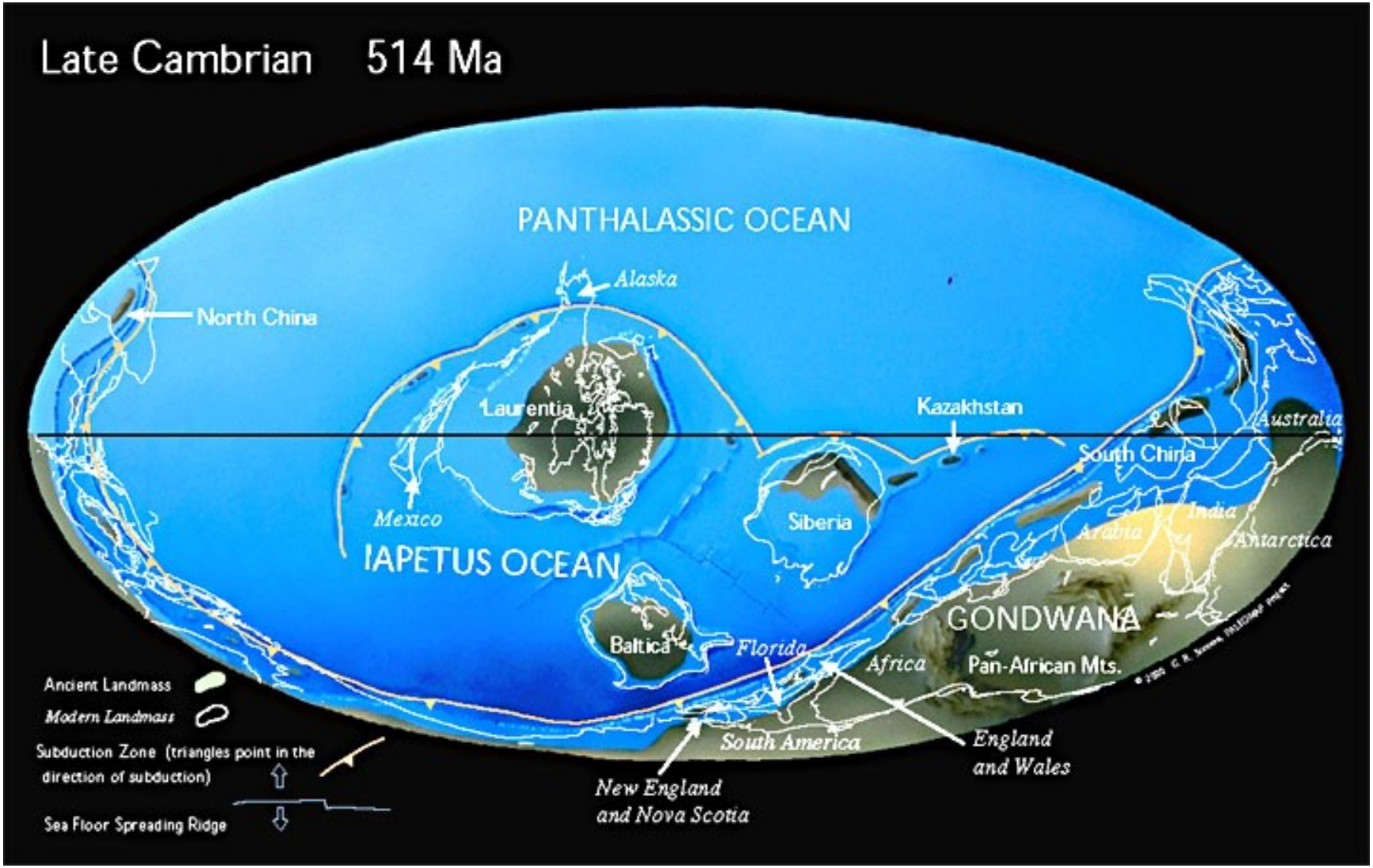


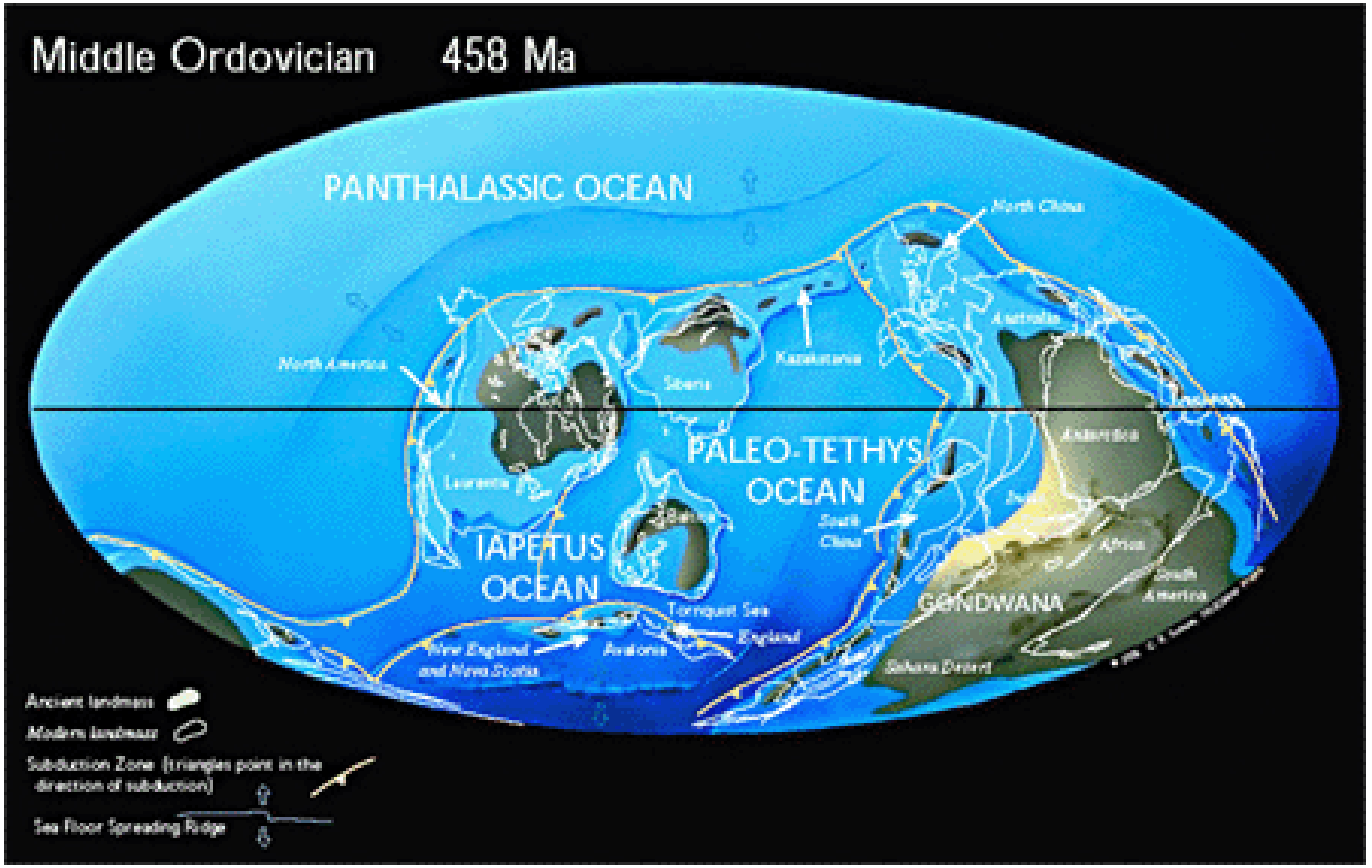
Compiled by Peter R. Johnson 1998

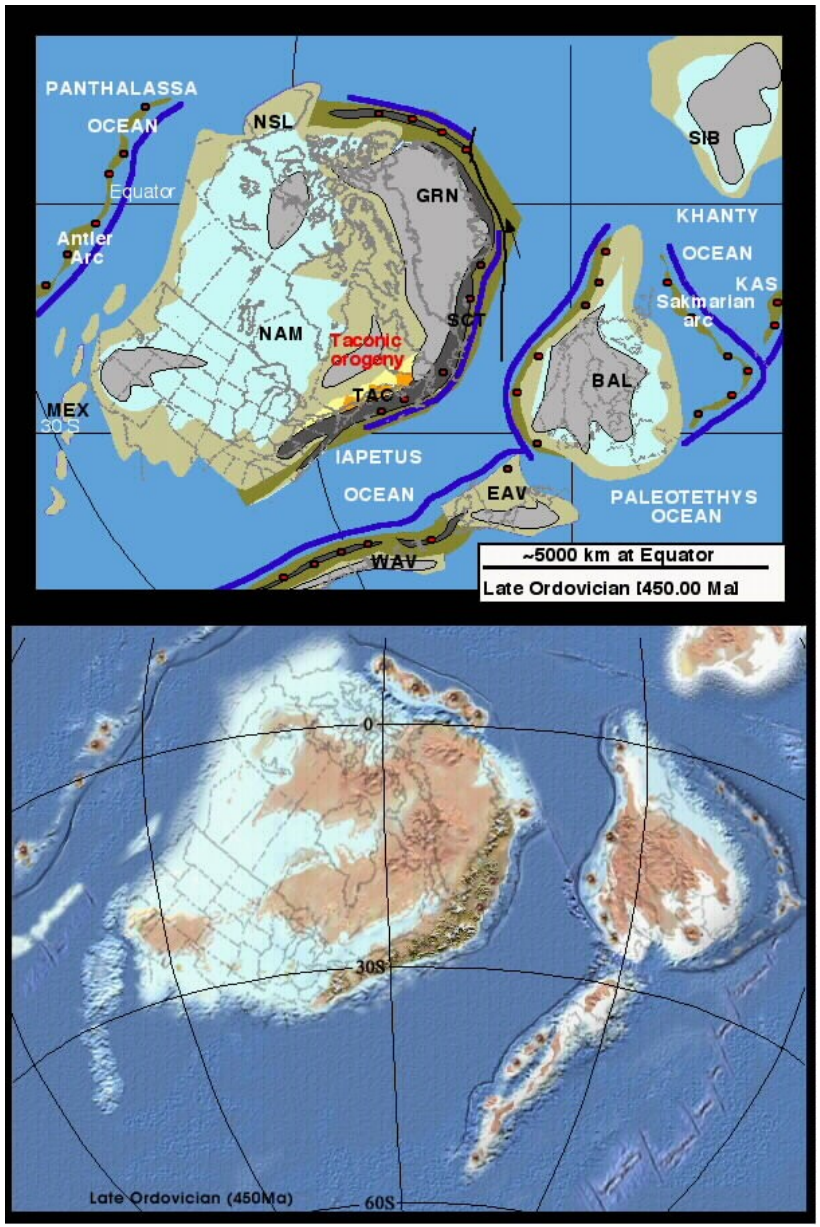
Technical Report USGS-TR-98-3
(IR 948)


Early Cambrian (545 - 535 Ma)


Prototethys Ocean
Mon Arc
Panthalassic Ocean
SIB
NAM
Kaz Arc
Gon
Taconic arc
Bal
Iapetus Ocean
Early Cambrian 550 Ma

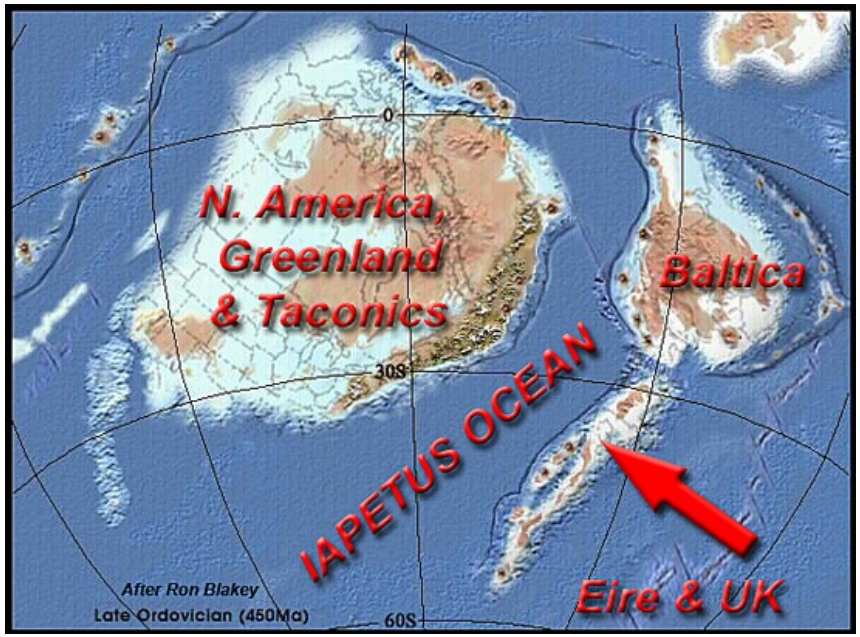

Late Cambrian 514 Ma
PANTHALASSIC OCEAN
Alaska
North China
Laurentia
Kazakhstan
Australia
South China
Mexico
IAPETUS OCEAN
Siberia
India
Arabia
Antarctica
GONDWANA
Baltica
Florida
Africa
Pan-African Mts.
South America
England and Wales
New England and Nova Scotia
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Middle Ordovician 458 Ma
PANTHALASSIC OCEAN
North China
Australia
North America
Siberia
Kazakstania
Laurentia
PALEO-TETHYS OCEAN
Avalonia
South China
IAPETUS OCEAN
Africa
South America
GONDWANA
Torrquet Sea
New England and Nova Scotia
Avalonia
England
Sahara Desert
Ancient landmass
Modern landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge

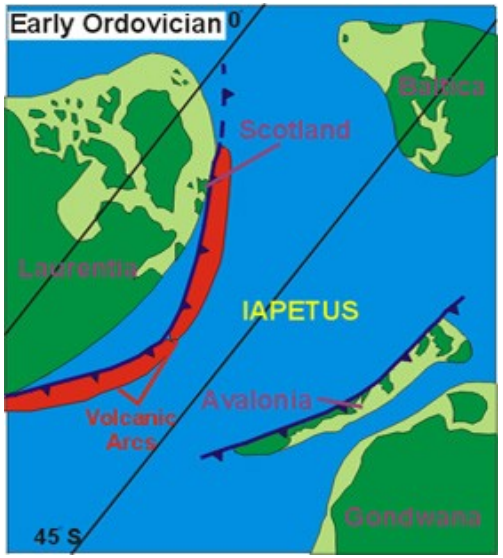


Caledonian orogeny

Taconic phase


0
30S
60S
N. America,
Greenland
& Taconics
Baltica
IAPETUS OCEAN
Eire & UK
After Ron Blakey
Late Ordovician (450Ma)

Caledonian orogeny



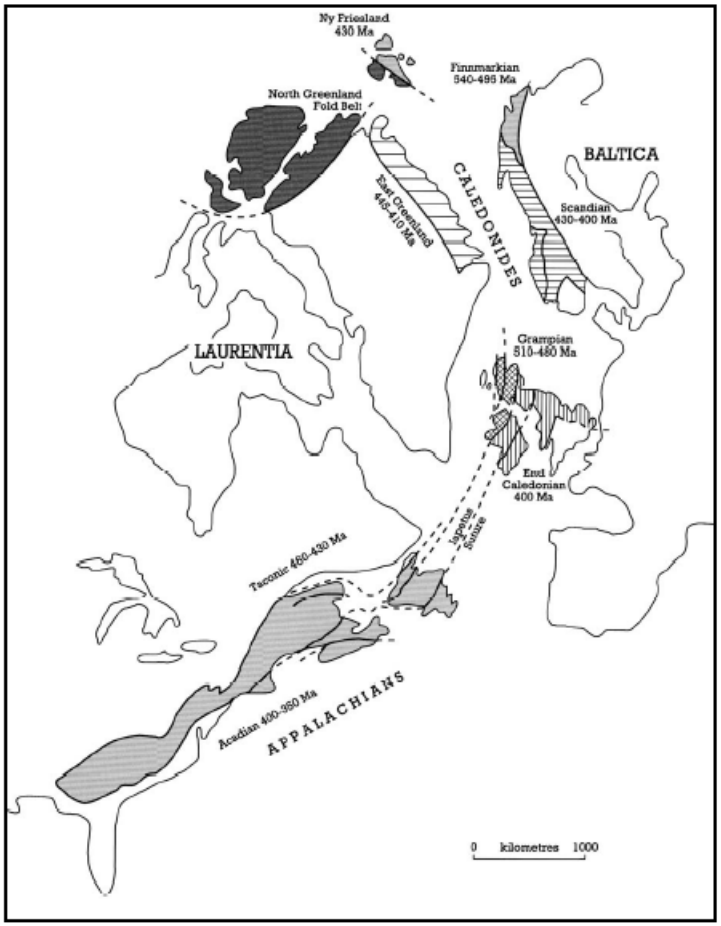


Figure 1.1 Regions of the Caledonian–Appalachian Oregen in their pre-Mesozoic drift configurations, showing ages of principal deformation events (after Baker and Gayner, 1985).

Ordovician glaciation

dropstone

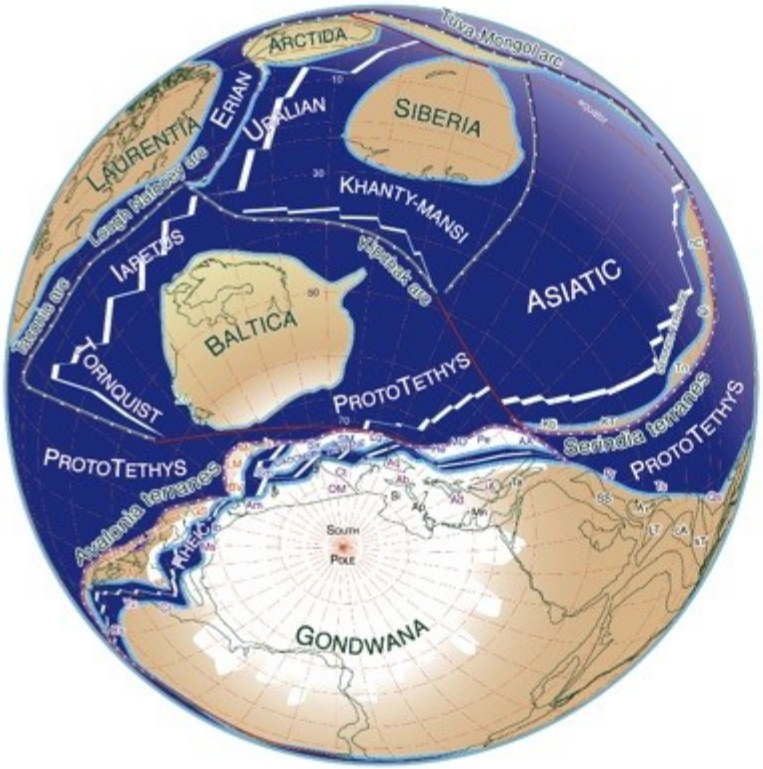
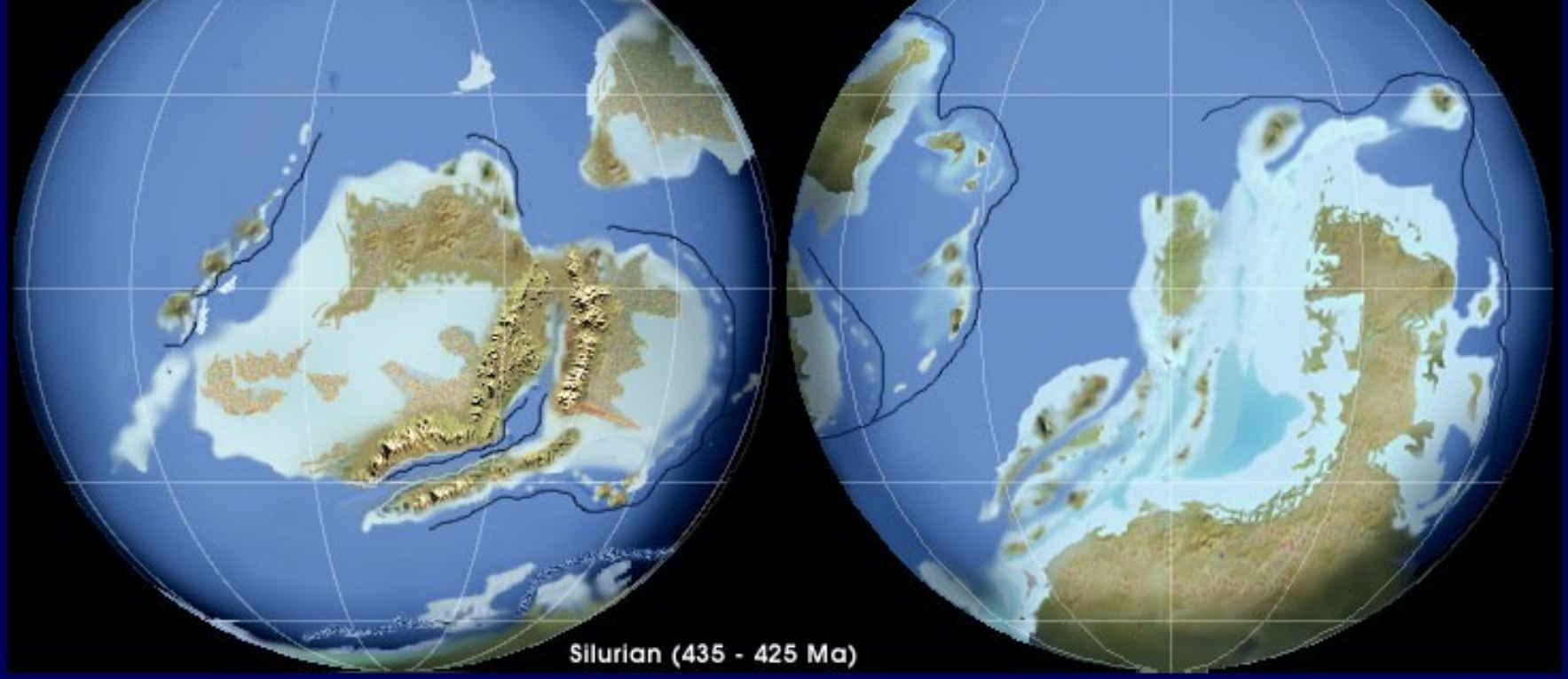
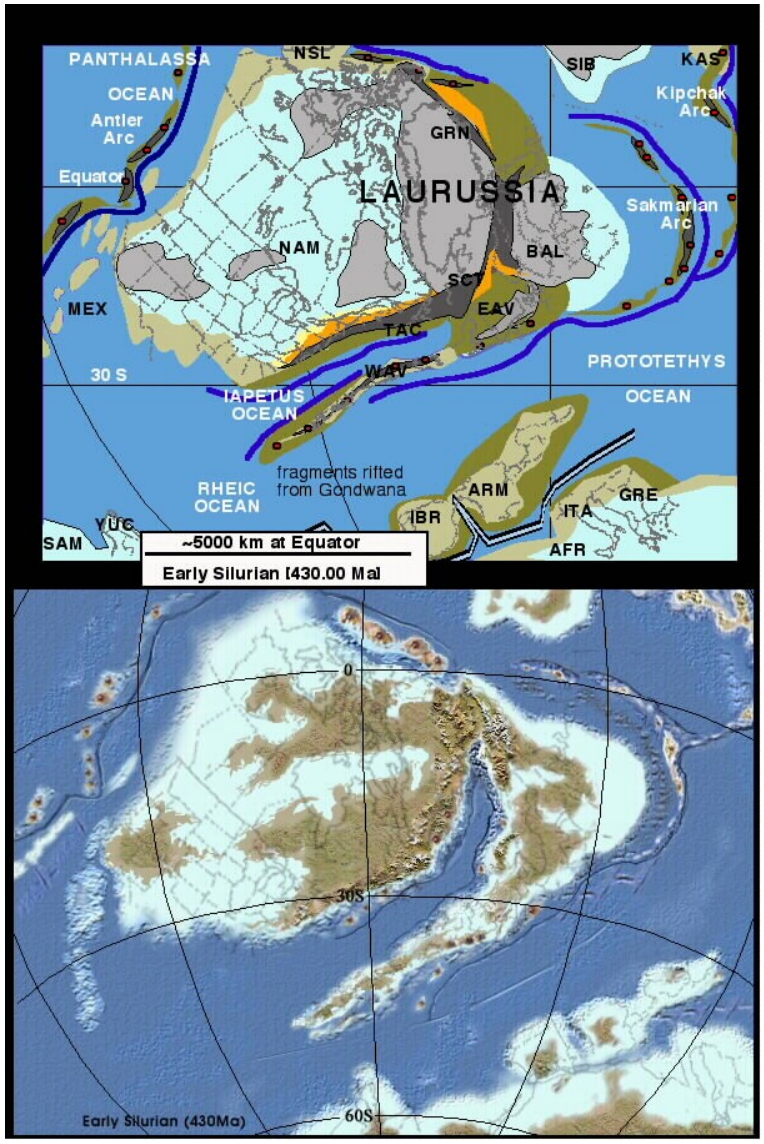


Plate Reconstructions from Stampfli & Borel (2002)


Silurian (435 - 425 Ma)


SIB
Caledonian O
Kaz
Arc
Antler
Arc
NAM
closing of
Iapetus
Bal
Paleo-
tethys
Ocean
Rheic Ocean
S Eur
Gon



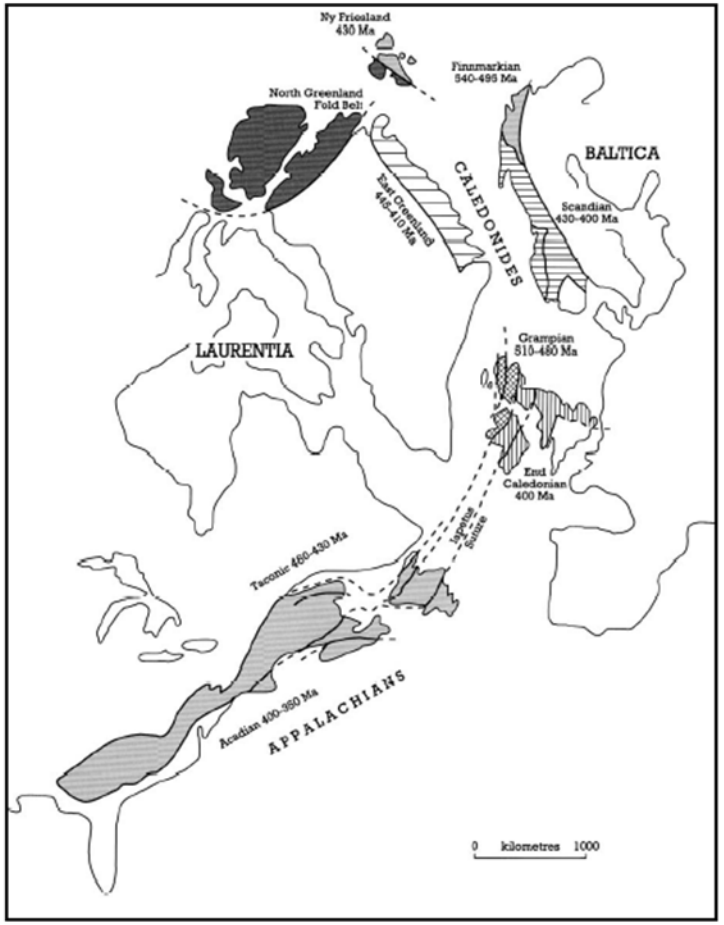
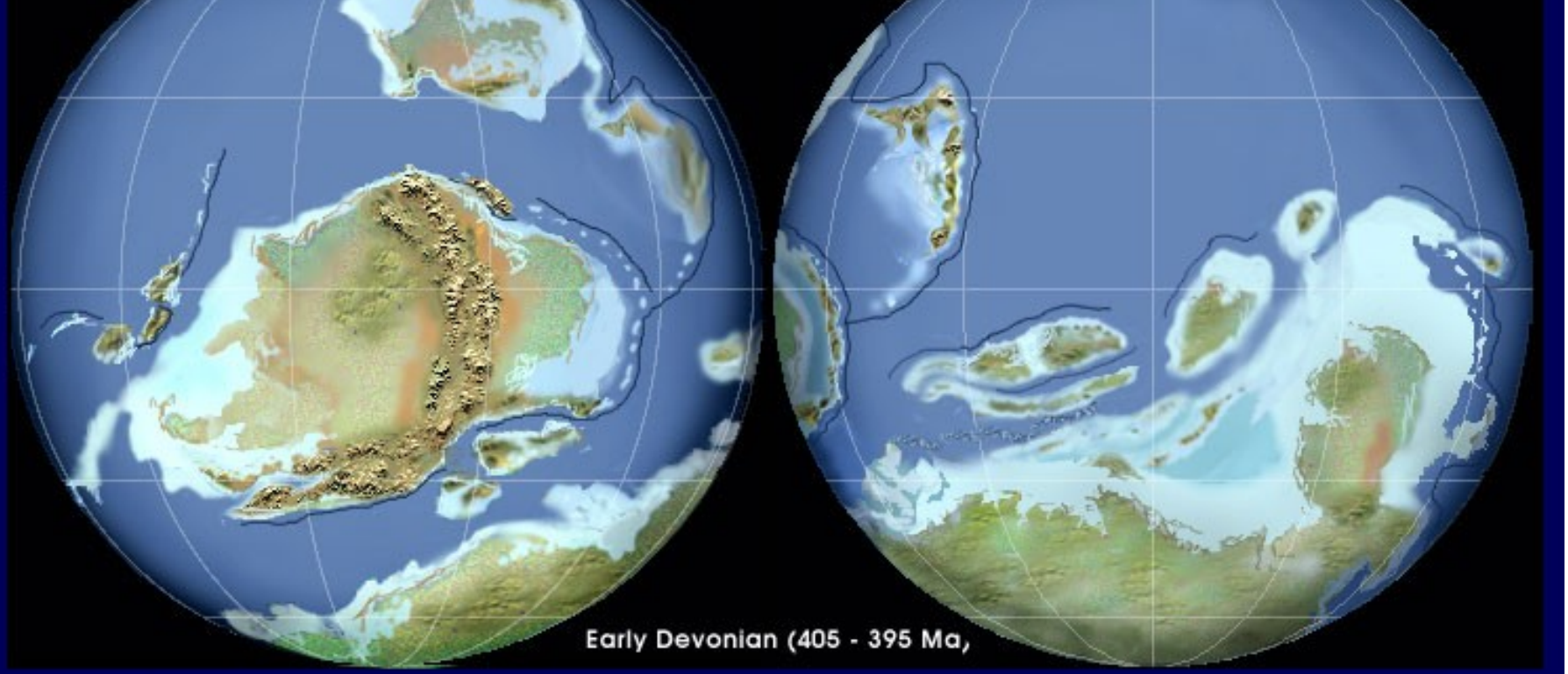
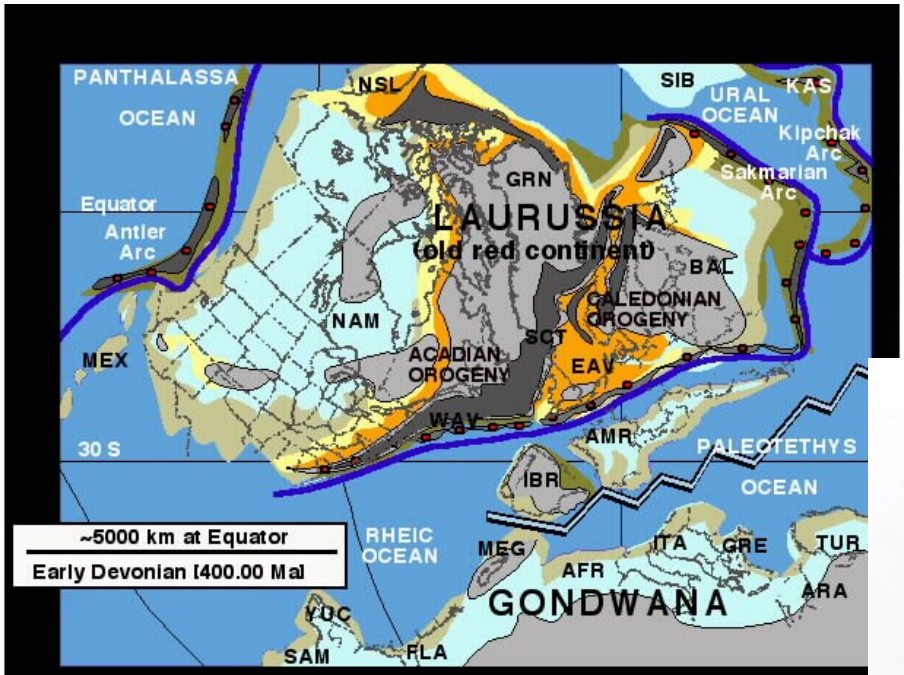
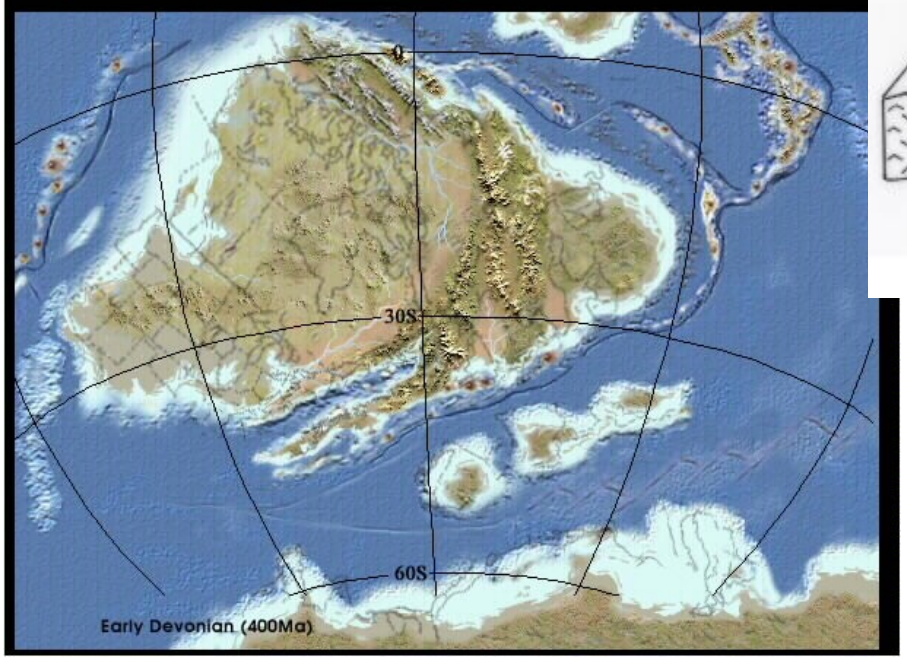


Figure 1.1 Regions of the Caledonian–Appalachian Orogen in their pre-Mesozoic drift configurations, showing ages of principal deformation events (after Baker and Gayner, 1985).

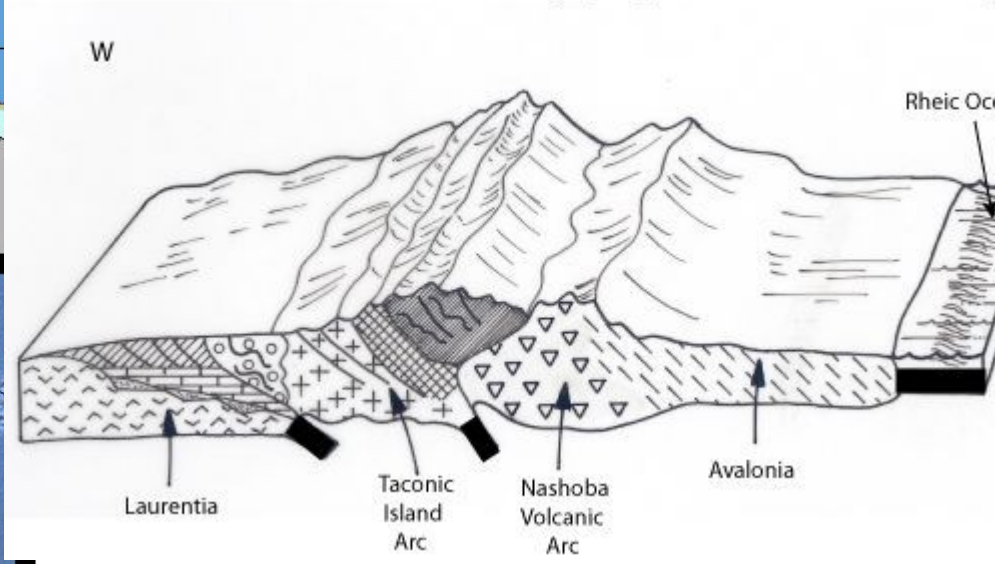

Early Devonian (405 - 395 Ma,


Mon
Arc
"Old Red"
Continent
Kaz
Arc
Antler
Arc
Ellsmerian O
China
blocks
Caledonian O
Acadian O
Gon





ACADIAN OROGENY ~ 400 - 350 Mya (Early Devonian - Middle Devonian)



Greenland Caledonides– only Caledonian orogeny

Appalachaians– **terrane structure, Caledonian (Tacon, Acadian) as well as Variscan (Alleghan) phases**

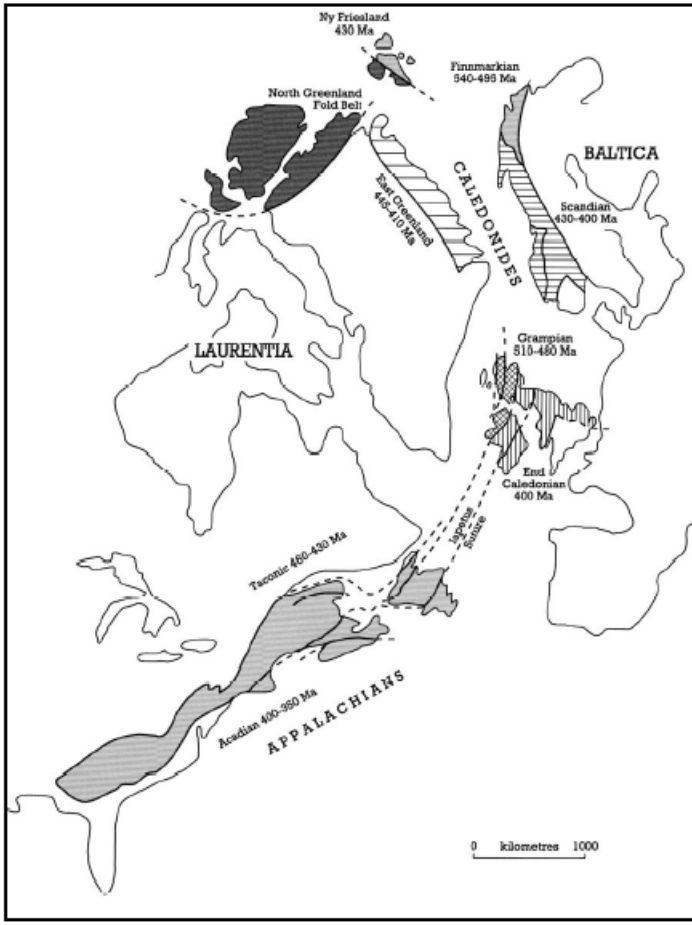


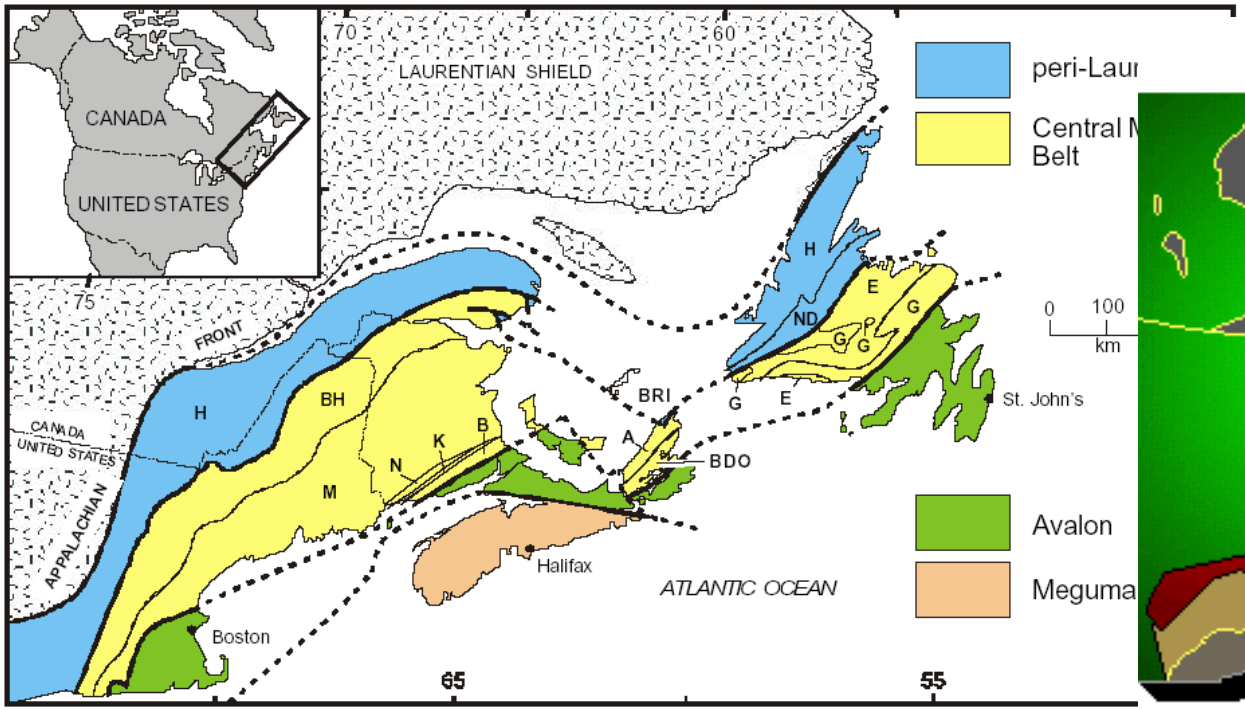
Figure 1.1 Regions of the Caledonian–Appalachian Oregen in their pre-Mesozoic drift configurations, show ages of principal deformation events (after Baker and Gayner, 1985).

Quatchita-Marathon Belt – Alleghan(Variscan) phase, collisions with South American Gondwana in Carboniferous

Laurentia – **Humber, Valley and Ridge, Blue-Ridge teranes**

Centrální zóna – **hlavně vulkanické oblouky (Notre Dam, Dunnage, Exploit, Piedmony aj.) a akreční melanž Iapetu**

Gondwanské terány – **Avalonia, Meguma, Gondwana**



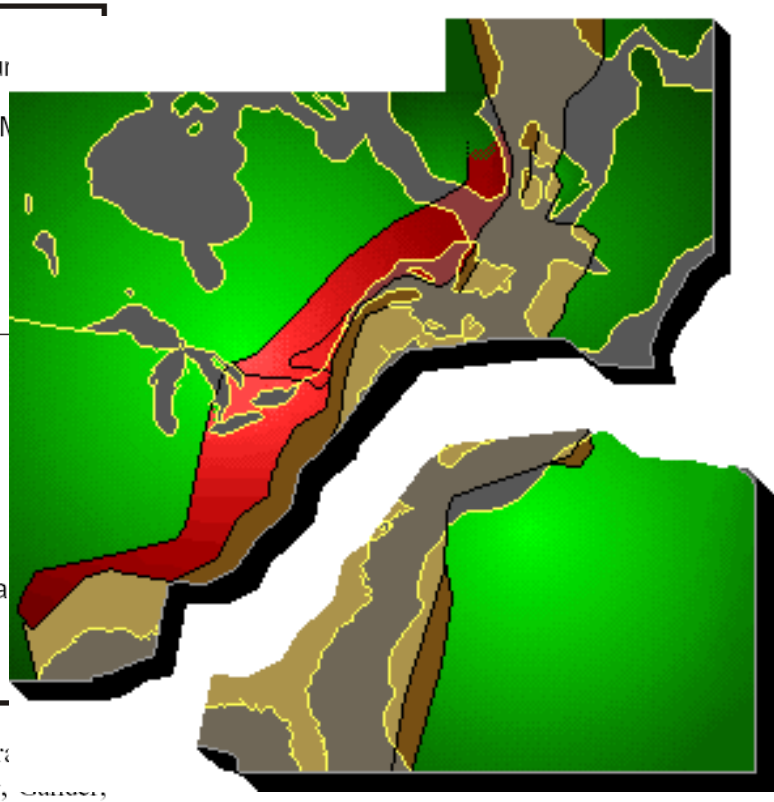


Figure 1. Simplified map of the northern Appalachian orogen showing crustal blocks and terra
Aspy; B, Brookville; BDO, Bras d'Or; BH, Bronson Hill; BRI, Blair River inlier; E, Exploits; G,
H, Humber; K, Kingston; M, Miramichi; N, New River; ND, Notre Dame;

Skandinávské kaledonidy

1) Finnmarkská fáze – ordovik, kolize ostrovního oblouku

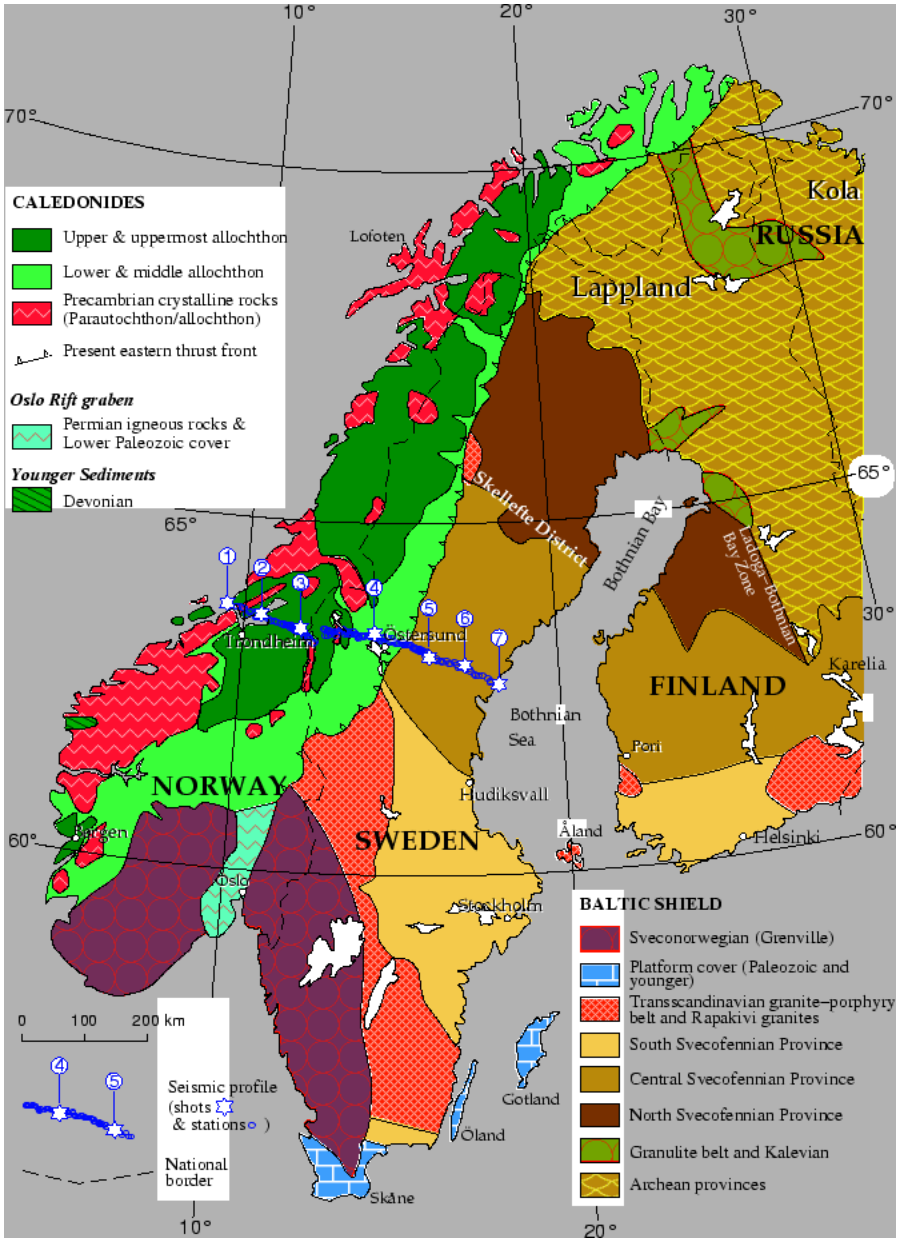
2) Kolize Baltiky a Laurentie – svrch silur-spodní devon, kůra Baltiky subdukovala pod Laurentii

Hlavní zóny od východu k západu jsou:

Svrchní nebo nejsvrchnější alochton – fragmenty kontinentů a ostrovní oblouky

Spodní a střední alochton – tektonicky zkrácený okraj Baltiky a fragmenty Lurentie

Nespodnější alochton (paraautochton) – vysoce metamorfovaná západní rulová zóna


CALEDONIDES
Upper & uppermost allochthon
Lower & middle allochthon
Precambrian crystalline rocks (Parautochthon/allochthon)
Present eastern thrust front
Oslo Rift graben
Permian igneous rocks & Lower Paleozoic cover
Younger Sediments
Devonian
BALTIC SHIELD
Sveconorwegian (Grenville)
Platform cover (Paleozoic and younger)
Transscandinavian granite–porphyry belt and Rapakivi granites
South Svecofennian Province
Central Svecofennian Province
North Svecofennian Province
Granulite belt and Kalevian
Archean provinces
Seismic profile (shots & stations)
National border
0 100 200 km
NORWAY
SWEDEN
FINLAND
RUSSIA
Kola
Lappland
Lofoten
Trondheim
Östersund
Skellefte District
Bothnian Bay
Bothnian Sea
Karelia
Pori
Hudiksvall
Åland
Helsinki
Bergen
Oslo
Stockholm
Gotland
Öland
Skåne
10°
20°
30°
70°
65°
60°

Britské kaledonidy

1) Grampianská fáze – kolize severní částí britských ostrovů s ostrovním obloukem v ordoviku

2) Mladokaledonská fáze – kolize Avalonii, silur/devon

Hlavní zóny od severu k jihu

Erijská platforma, od grampianské zóny oddělená moinským nasunutím

Grampianská zóna – aktivní okraj erijské platformy, horniny Laurentie a přilehlého Iapetu

Riftová zóna Midland Valley – ostrovní oblouky a akreční prisma

Southern Uplands – ostrovní oblouky a akreční prisma

Keltská zóna – nemetamorfované kaledonidy, sedimenty se ukládaly pří okraji Avalonie

Laurentie

Gondwana

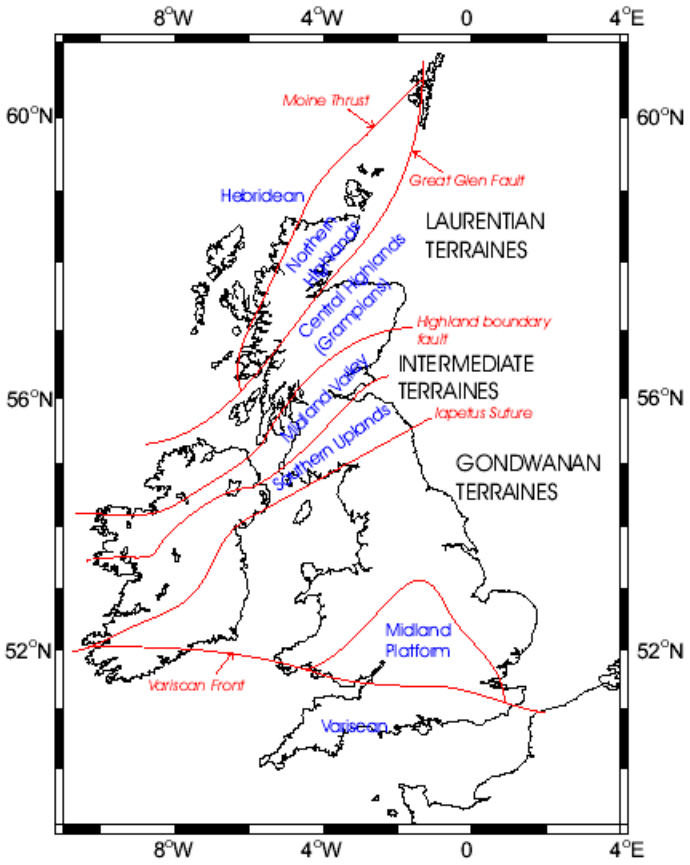


Figure 1.4: Simplified Palaeozoic terrane map of Britain and Ireland (adapted from Woodcock and Strachan (2000)).

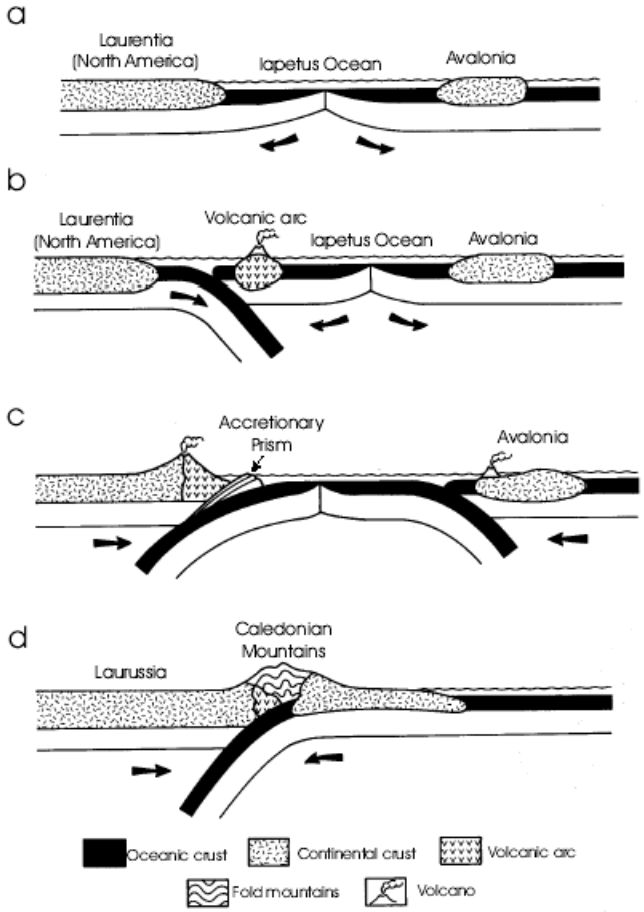
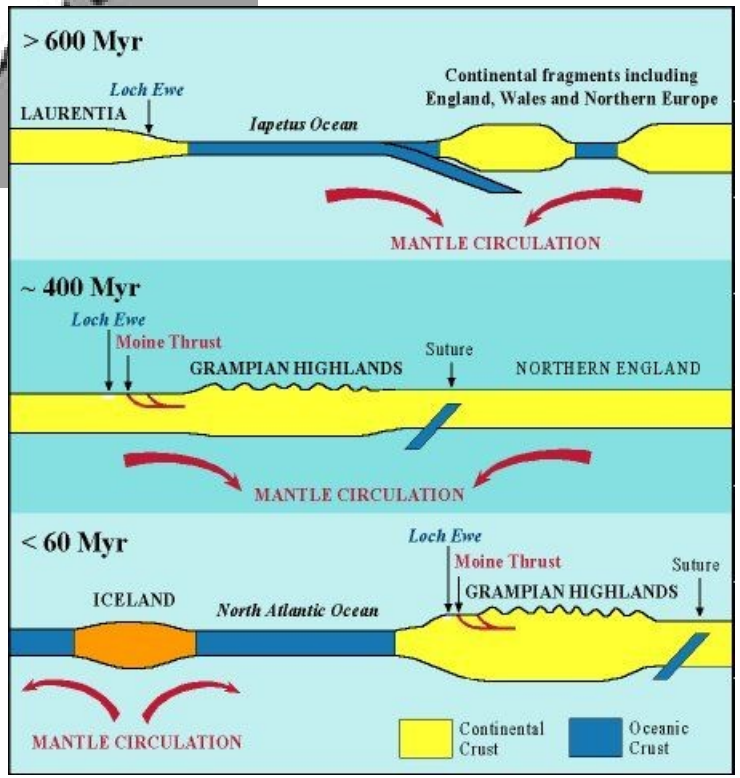


Figure 1.5: Schematic figure showing cross-sections through the Caledonian Orogeny at four different stages. (a) Prior to the Ordovician (> 510Ma), (b) Earliest Orodovician (510 Ma), (c) Early Ordovician (490 Ma), (d) Late Silurian - Main Caledonian Orogeny (410 Ma). (Adapted from Doyle et al. (1994)).


Greenland
Canada
Scotland +
N Ireland
IAPETUS OCEAN
England, Wales
+ S Ireland
NW Newfoundland
Nova Scotia
E Newfoundland
E New England


> 600 Myr
Loch Ewe
LAURENTIA
Iapetus Ocean
Continental fragments including
England, Wales and Northern Europe
MANTLE CIRCULATION
~ 400 Myr
Loch Ewe
Moine Thrust
GRAMPIAN HIGHLANDS
Suture
NORTHERN ENGLAND
MANTLE CIRCULATION
< 60 Myr
Loch Ewe
Moine Thrust
Suture
GRAMPIAN HIGHLANDS
ICELAND
North Atlantic Ocean
MANTLE CIRCULATION
Continental
Crust
Oceanic
Crust

Středoevropské kaledonidy

Jediné dobře dochované doklady pro kaledonskou orogenezi máme ve Svatokřížských horách v Polsku, na silurském flyši zde spočívá devon s úhlovou diskordancí. Kaledonské struktury v Německu překryty mladšími sedimenty.

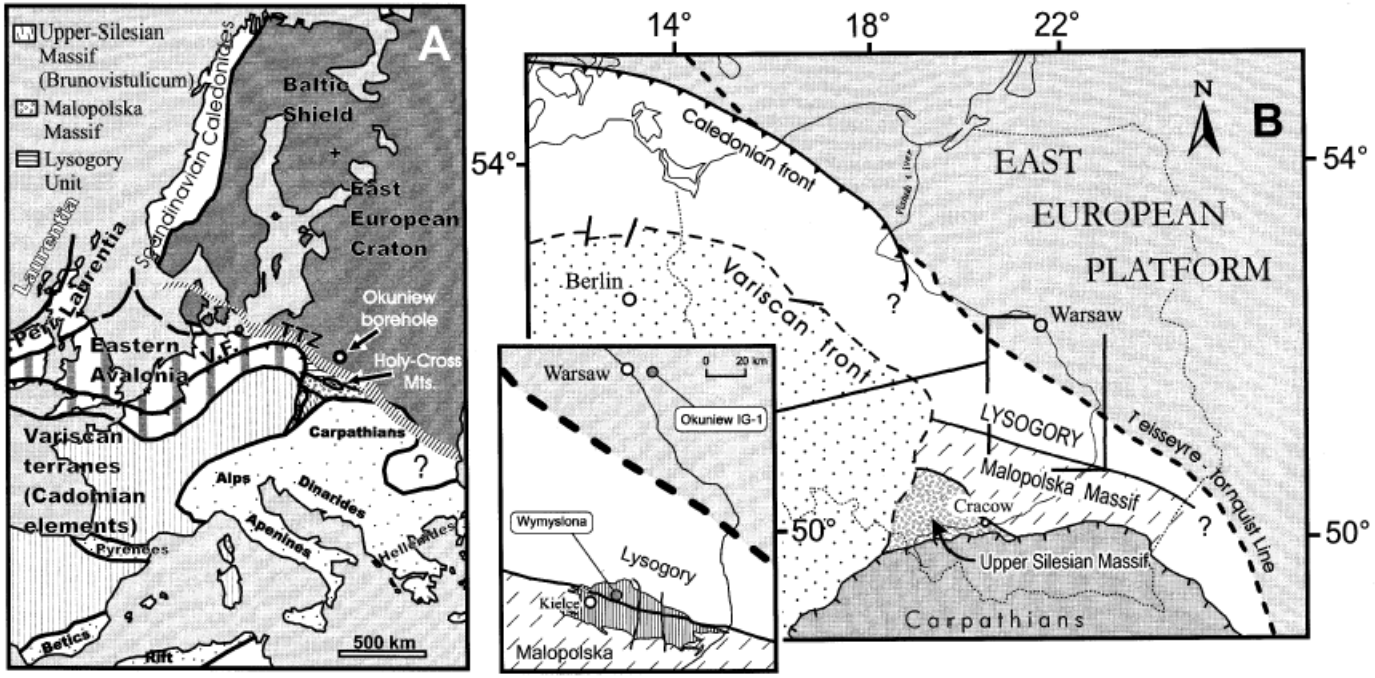


Fig. 1. A: Simplified map of the Paleozoic terranes of Western Europe, alpine areas excluded, showing the location of the terranes along the Trans-European Suture Zone (modified after [5,6]). Pattern: area with anomalous geophysical signatures along the margin of Baltica–East European Craton; TTZ: Teyssere–Tornquist Zone; V.F.: Variscan front. B: Suspected Paleozoic terranes in central Poland. Inset map: sample location; striped area, Holy Cross Mountains.

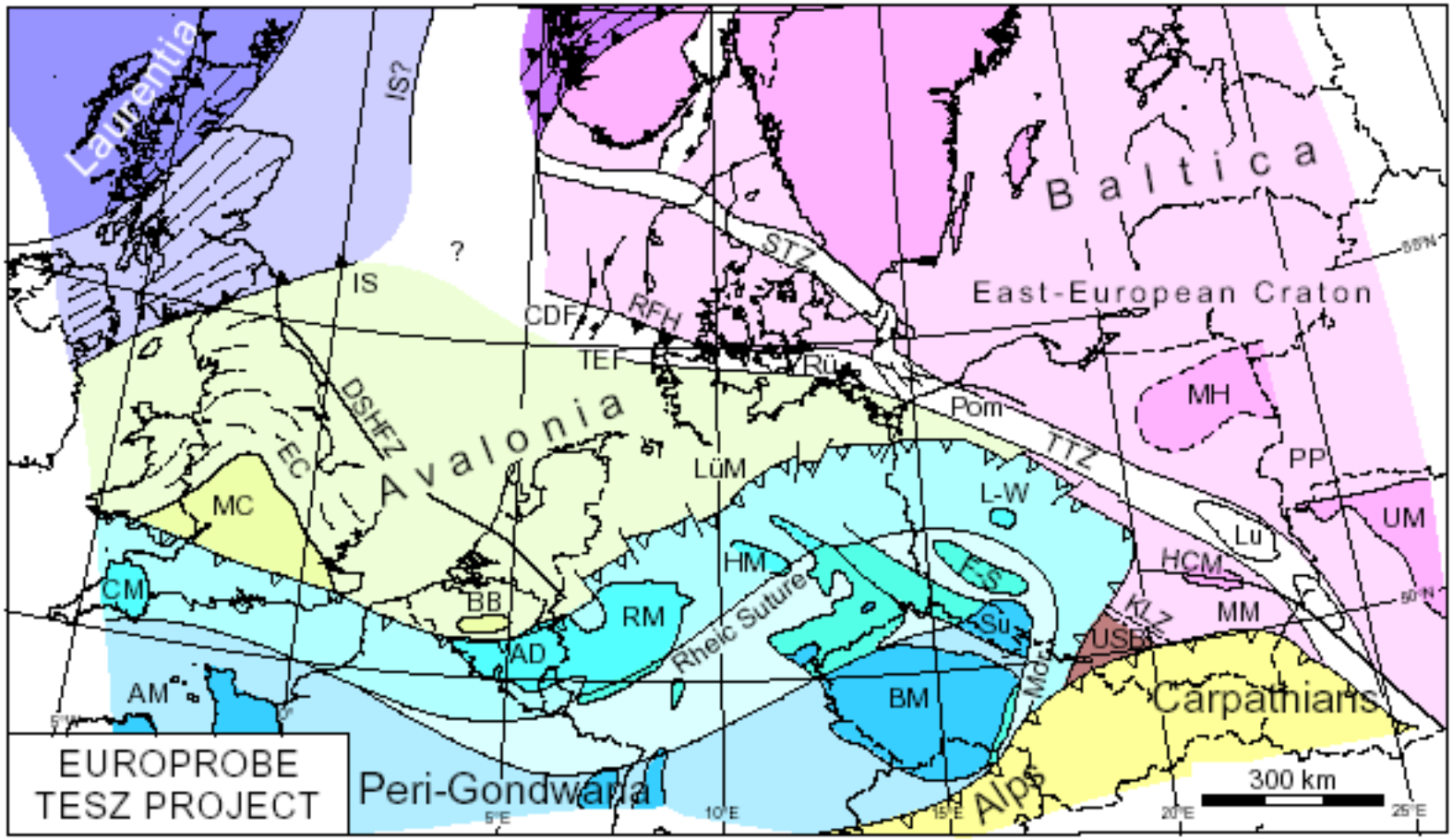


Figure 4.1: Basement tectonic sketch map of the TESZ and adjacent areas, slightly modified from Berthelsen (1994), in EUROPROBE Newsletter 5. The Central Polish Trough is located at the position of the letters TTZ on this map. Key: AD, Ardennes; AM, Armorican Massif; BB, Brabant Massif; BM, Bohemian Massif; C, Cadomia; CDF, Caledonian Deformation Front; CM, Cornubian Massif; DSHFZ, Dowsing-South Hewett Fault Zone; EC, Eastern English Caledonides; EEC, East-European Craton; F-S, Fore-Sudetic Block; HM, Harz Mountains; HCM, Holy Cross Mountains; IS, Iapetus Suture (Avalonia-Laurentia); IS?, uncertain location of Laurentia-Baltica Suture; KLZ, Kraków-Lubliniec Zone; Lu, Lublin Trough; LüM, Lüneberg Massif; L-W, Leszno-Wolsztyn Basement High; MC, Midlands microcraton; MH, Mazurska High; MM, Małopolska Massif; Mor, Moravia; Pom, Pomerania; PP, Pripyat Trough; RFH, Ringkøbing-Fyn High; RM, Rhenish Massif; Rü, Rügen Island; STZ, Sorgenfrei-Tornquist Zone; Su, Sudetes Mountains; TEF, Trans-European Fault Zone; TTZ, Teisseyre-Tornquist Zone; UM, Ukrainian Massif; USB, Upper Silesian Coal Basin.

Antler orogeny

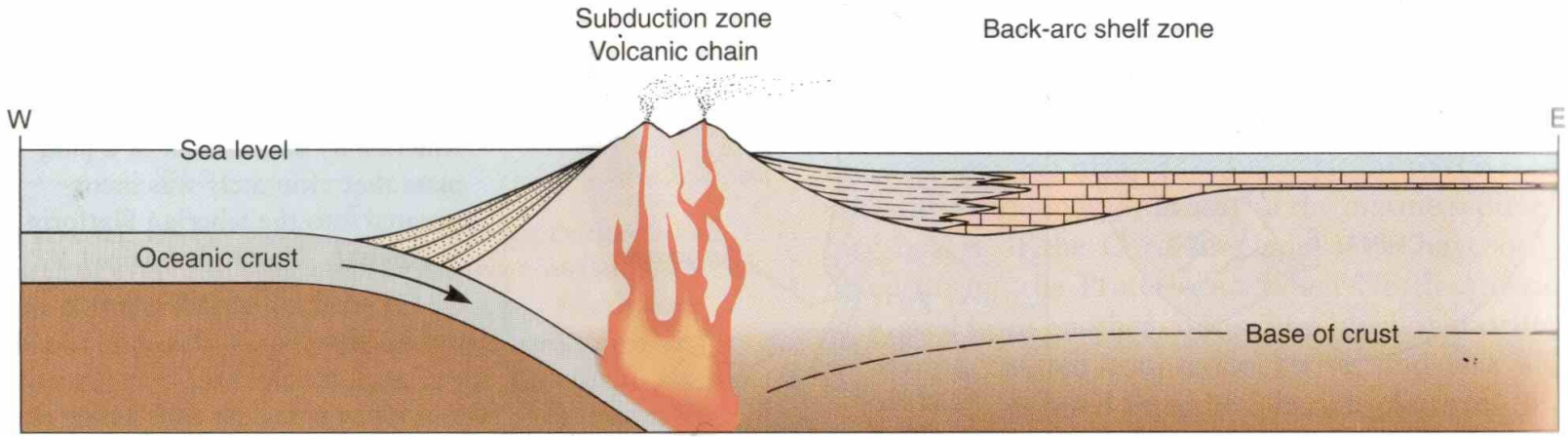
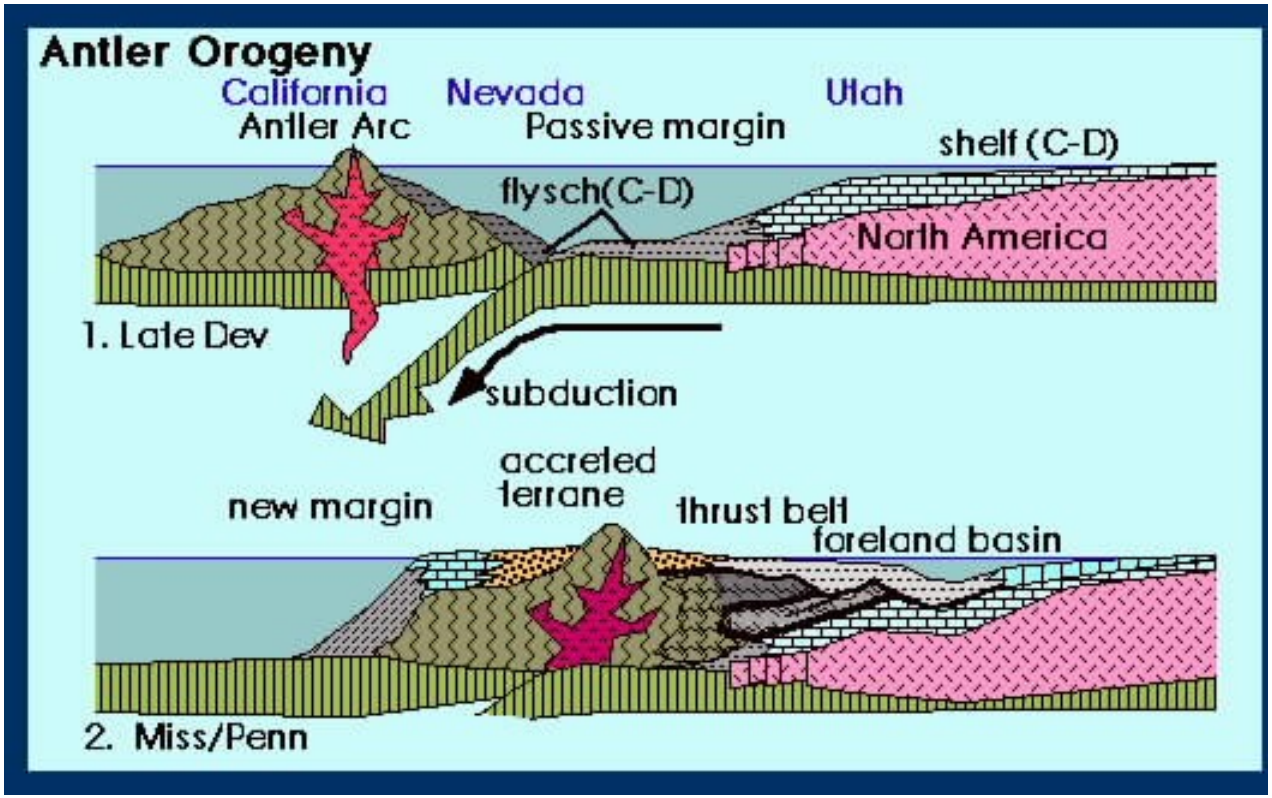
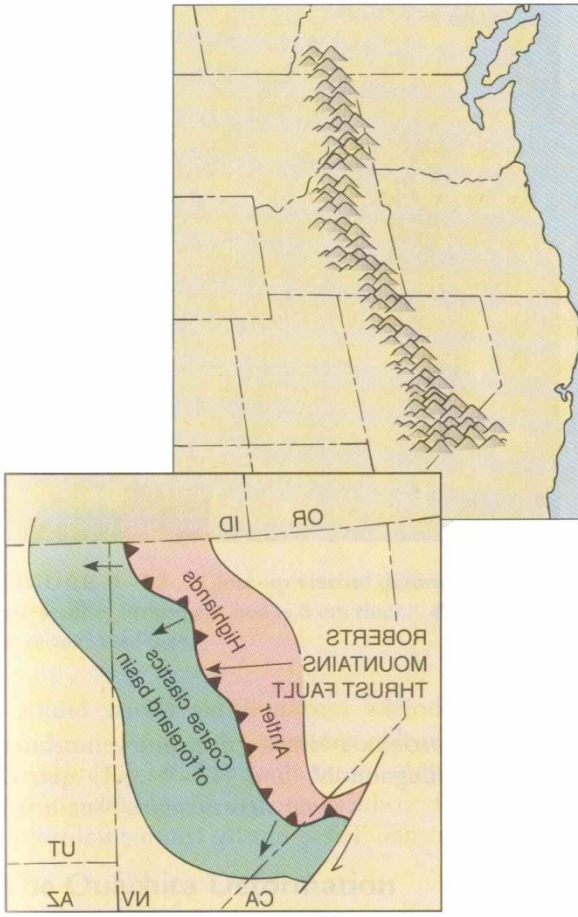


FIGURE 8–20 Interpretive cross-section of conditions across the Cordilleran region during early Paleozoic time.





GURE 9–35 Extent of highland areas associated
th the Antler orogeny, and location of the Roberts
ountains Thrust Fault.

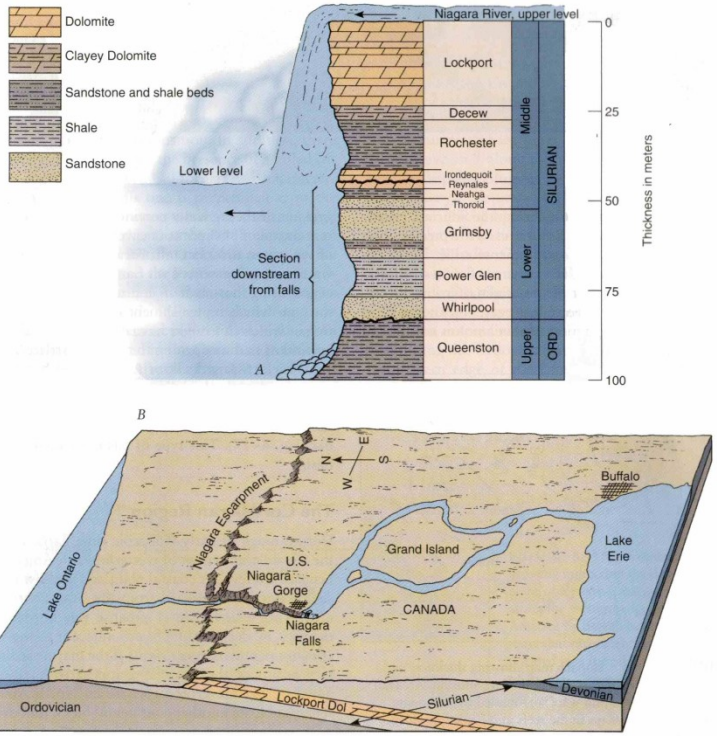
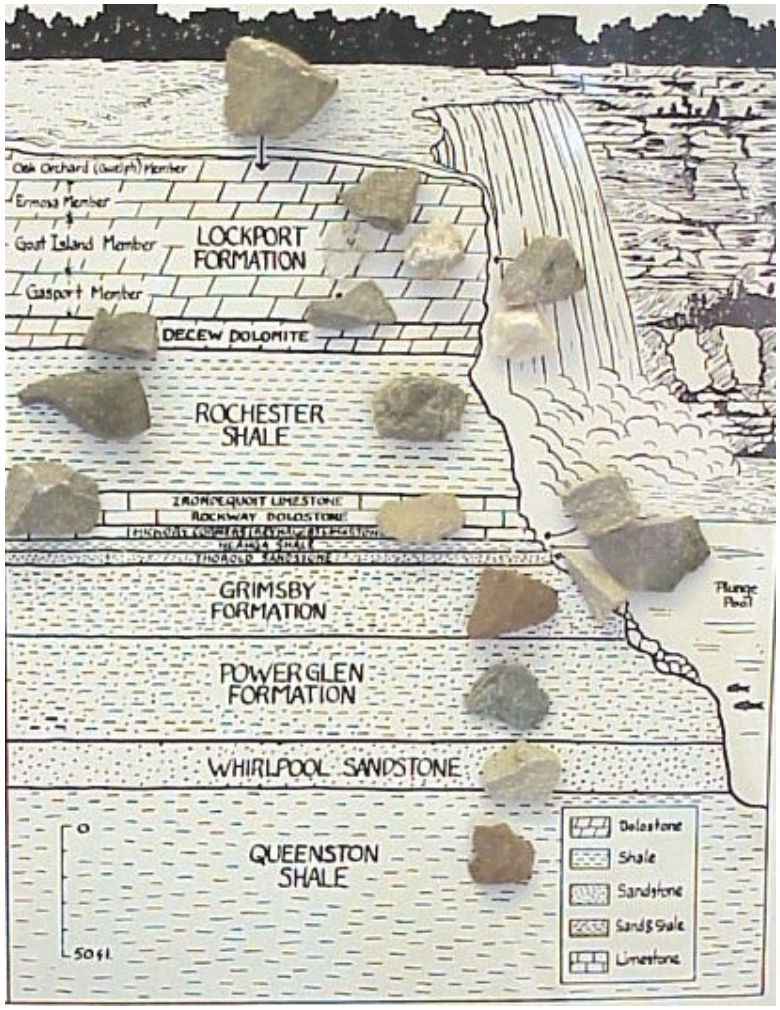


FIGURE 8–14 Stratigraphic section (A) and block diagram (B) of Niagara Falls. The Lockport Dolomite forms the resistant lip of the falls. The rocks dip gently to the south in this area, and where harder dolomite layers such as the Lockport Dolomite intersect the surface, they form a line of bluffs known as the Niagaran Escarpment. *(Map after E. T. Raisz.)*

FIGURE 8–15 Niagara Falls, formed where the Niagara River flows from Lake Erie into Lake Ontario. The classic section of the American Silurian System is exposed along the walls of the gorge below the falls. *(Guido Alberto Rossi/The Image Bank.)*

EARLY PALEOZOIC EVENTS

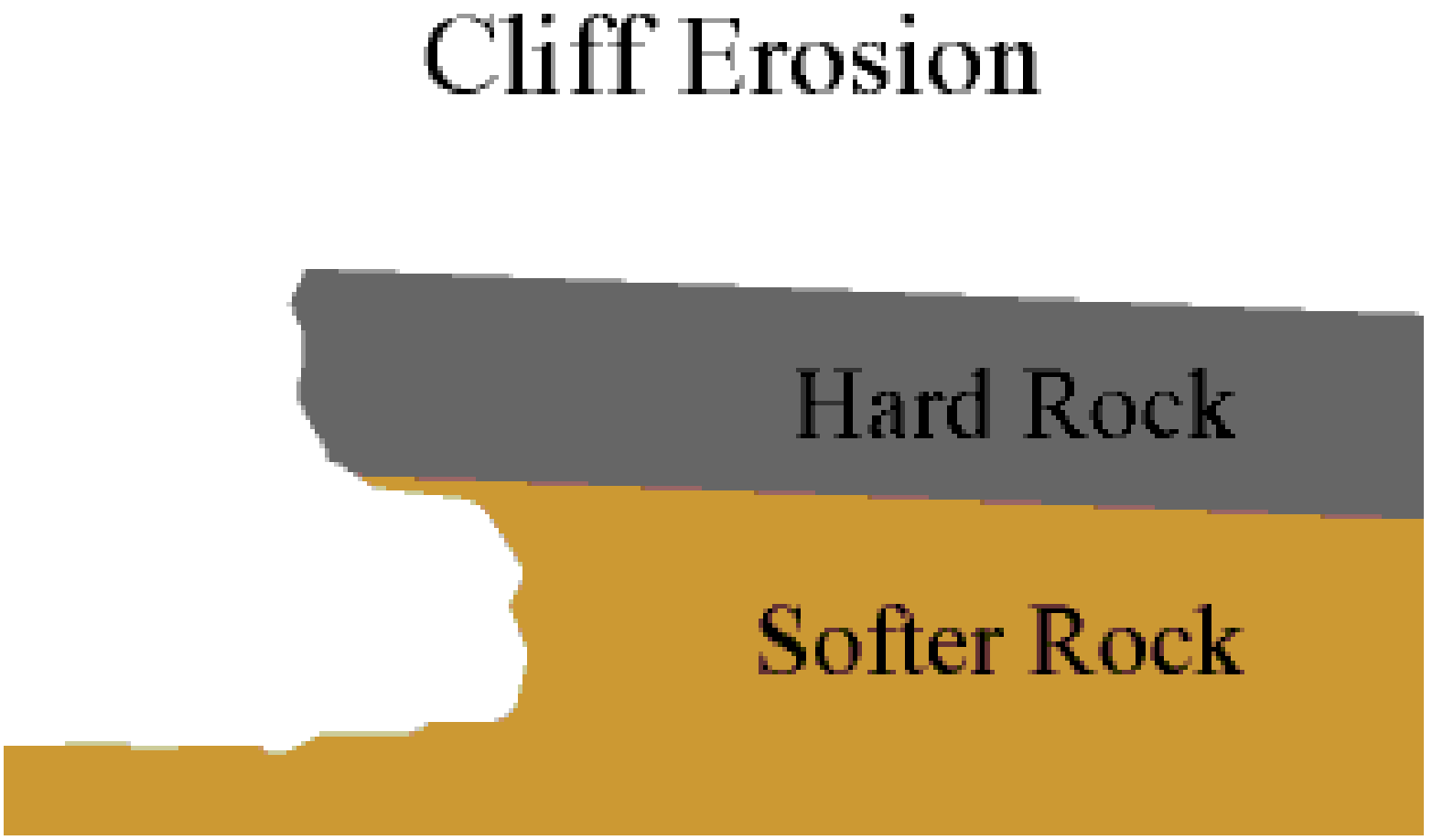
SILURIAN PALEOGEOGRAPHY



Resistant Lockport Dolomite
Niagara Falls
Part of Tippecanoe Sequence

EARLY PALEOZOIC EVENTS

SILURIAN PALEOGEOGRAPHY



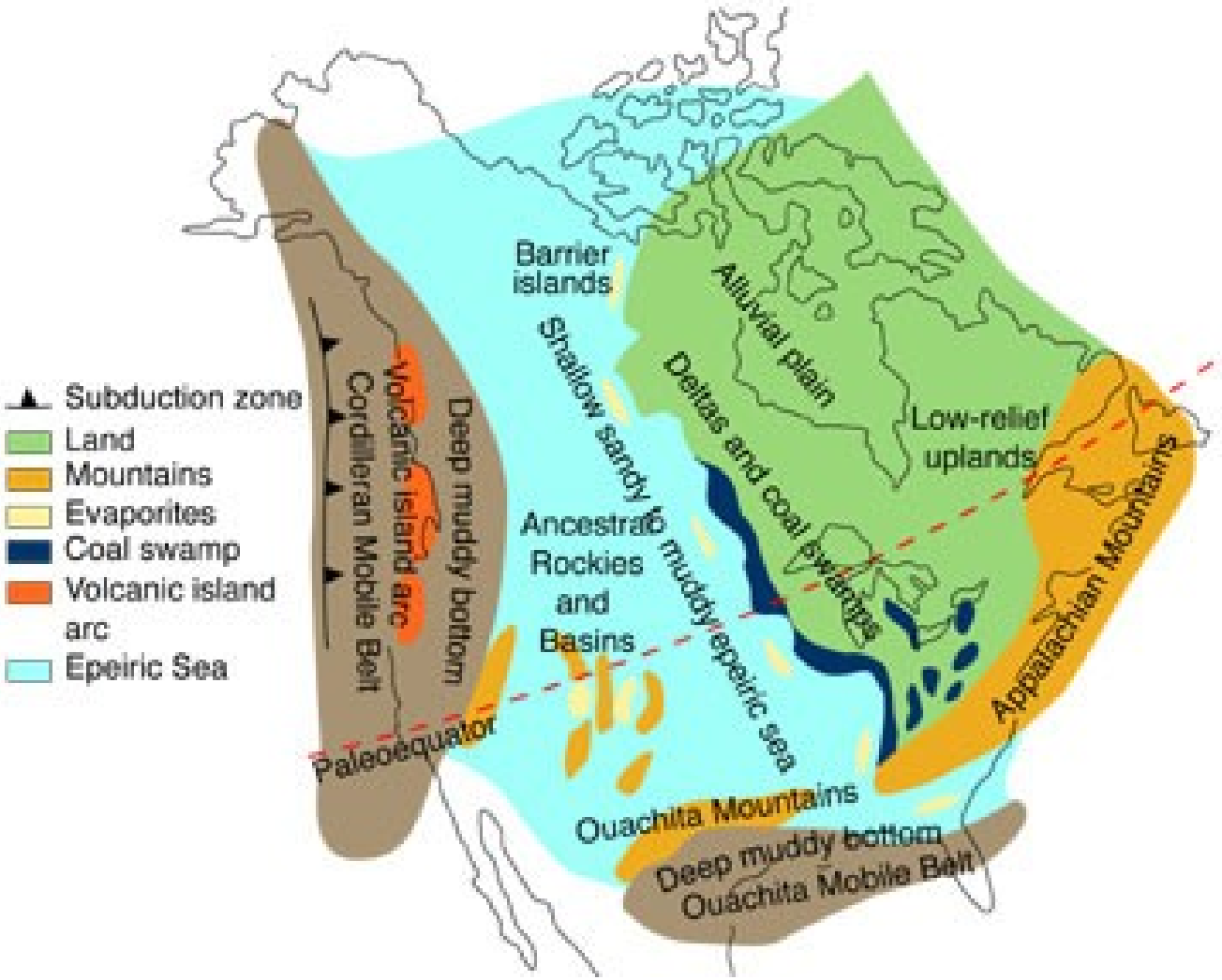
Phanerozoic mobile zones of North America

Caledonian Appalachian mobile zone

Cordilleran mobile zone

Franklin-Inuit mobile Zone

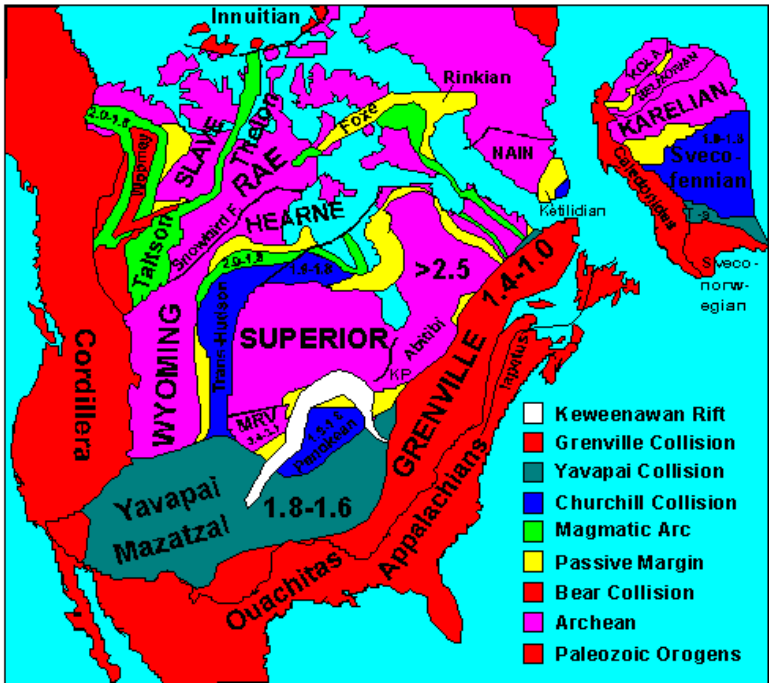

Greenland
North American Craton
CONTINENTAL CRUST THAT HAS REMAINED RELATIVELY STABLE FOR THE PAST 600 MILLION YEARS
Deformed Craton
ACCRETIONARY BELT-welded to the North American continental margin within the last 600 million years
Coastal plain


Subduction zone
Land
Mountains
Evaporites
Coal swamp
Volcanic island arc
Epeiric Sea
Deep muddy bottom
Cordilleran Mobile Belt
Volcanic island arc
Barrier islands
Shallow sandy to muddy epeiric sea
Ancestral Rockies and Basins
Alluvial plain
Deltas and coal swamps
Low-relief uplands
Appalachian Mountains
Paleoequator
Ouachita Mountains
Deep muddy bottom
Ouachita Mobile Belt

Franklinsko – inuitská orogeneze

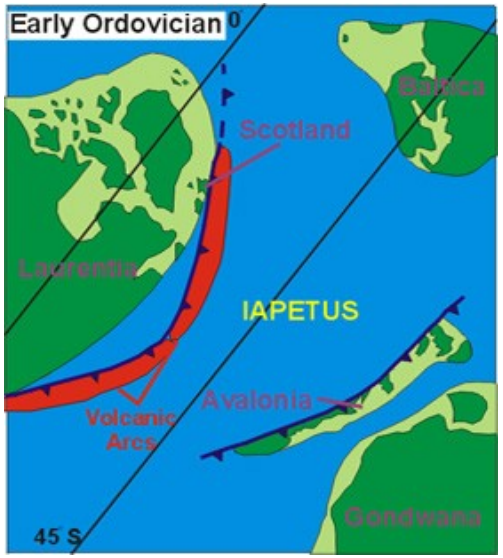
The **Franklinian orogeny**, in the northwestern Canada (Plafker & Berg, 1994), could be a result of collision of the Verkhoyanskian part of **Siberia** with the North Slope-Chukotkan part of Laurentia. According to Okulitch (1998), the suturing in the Canadian Islands occurred during **Ordovician-Silurian** time.

The **Innuitian Orogeny** started in the earliest Middle Devonian and may be linked to plate movements that also emplaced an exotic terrane, Pearya, on the northern edge of the region.



Na gondwanský původ kontinentálních bloků se donedávna usuzovalo kromě paleobiogeografických údajů především na základě přítomnosti hornin kadomského (panafrického) stáří hornin.

V poslední době byly objeveny horniny kadomského stáří i v oblasti Uralu, což vede k přehodnocování původu některých kontinentálních bloků.



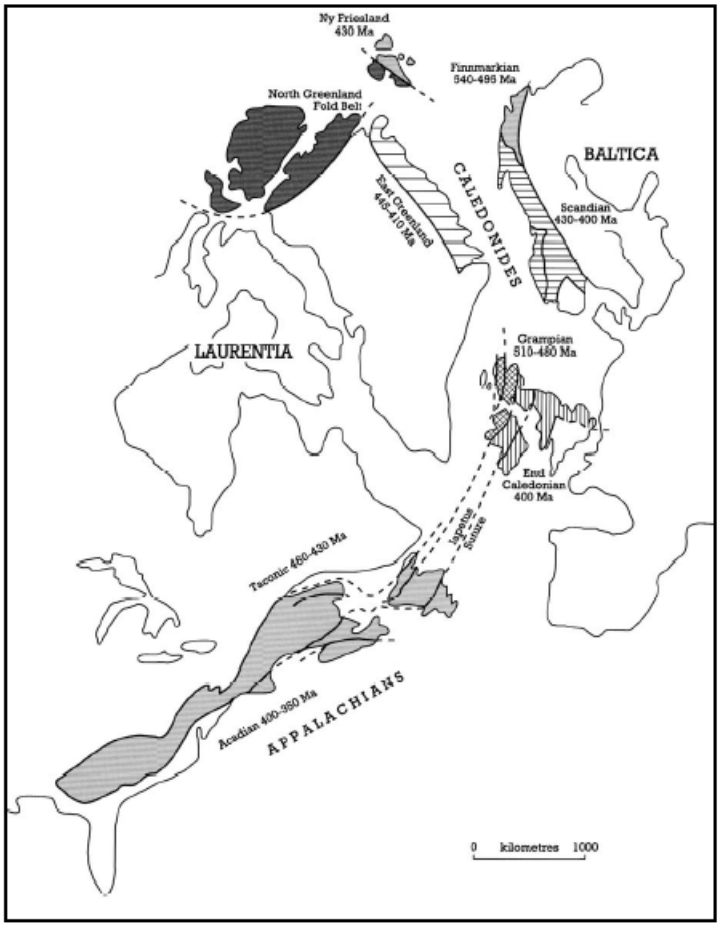
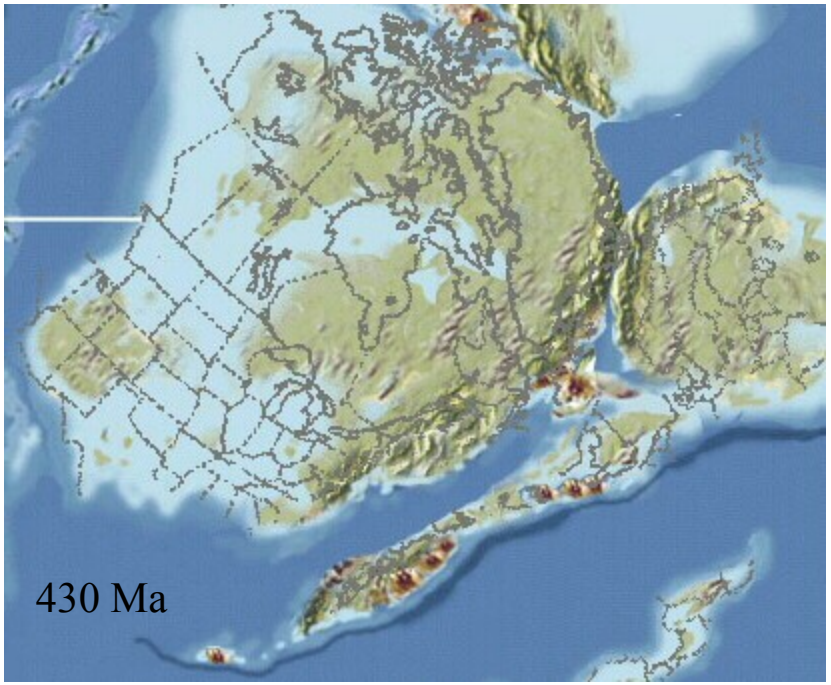
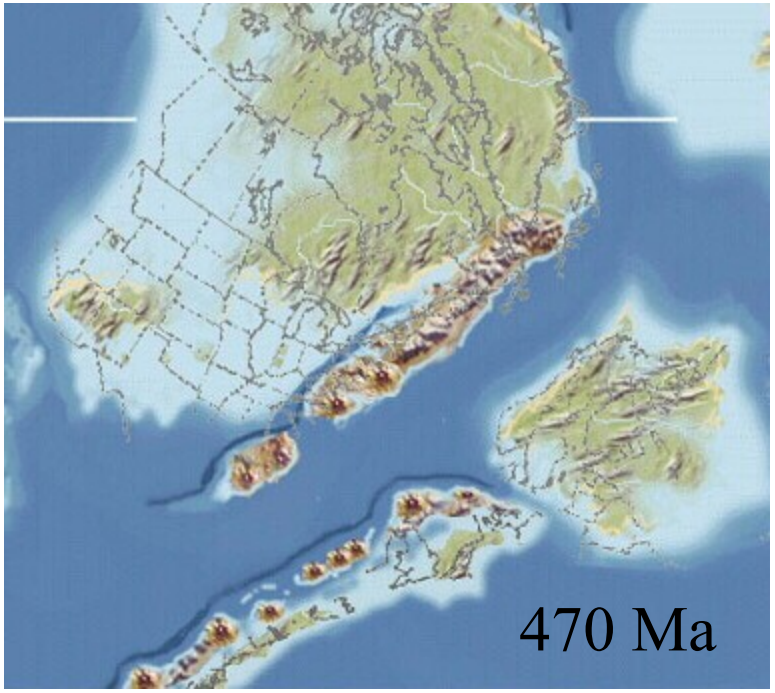


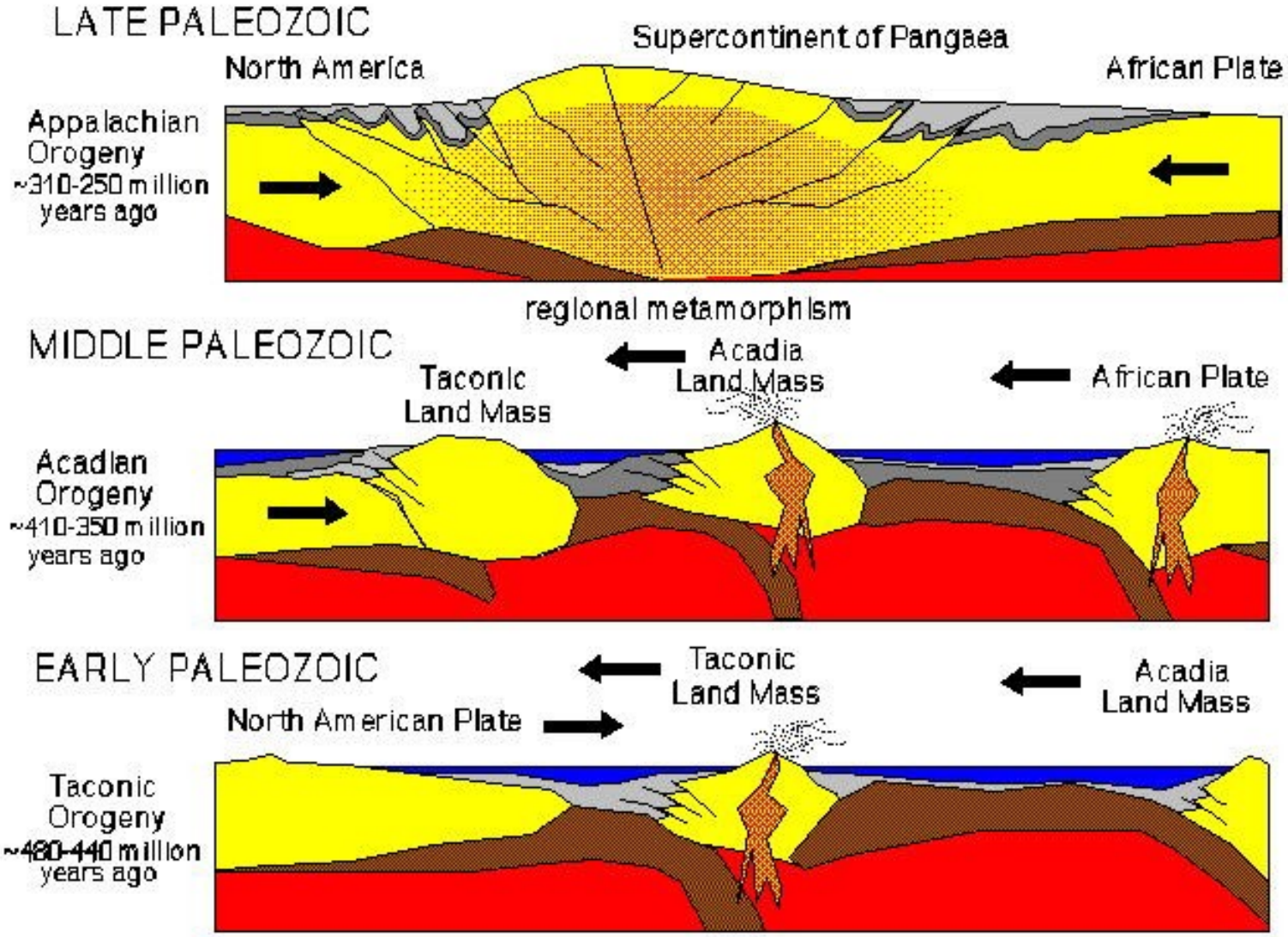
Figure 1.1 Regions of the Caledonian–Appalachian Oregen in their pre-Mesozoic drift configurations, showing ages of principal deformation events (after Baker and Gayner, 1985).


510 Ma


430 Ma


470 Ma


400 Ma


LATE PALEOZOIC
Supercontinent of Pangaea
North America
African Plate
Appalachian Orogeny ~310-250 million years ago
regional metamorphism
MIDDLE PALEOZOIC
Taconic Land Mass
Acadia Land Mass
African Plate
Acadian Orogeny ~410-350 million years ago
EARLY PALEOZOIC
Taconic Land Mass
Acadia Land Mass
North American Plate
Taconic Orogeny ~480-440 million years ago

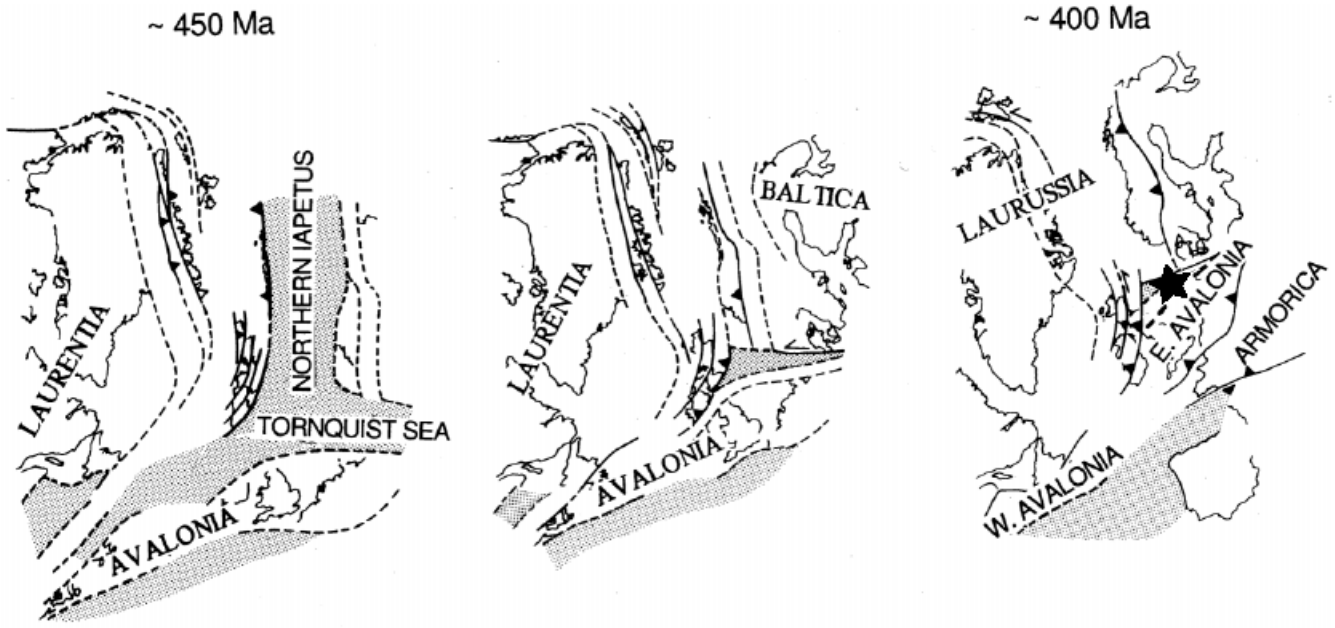
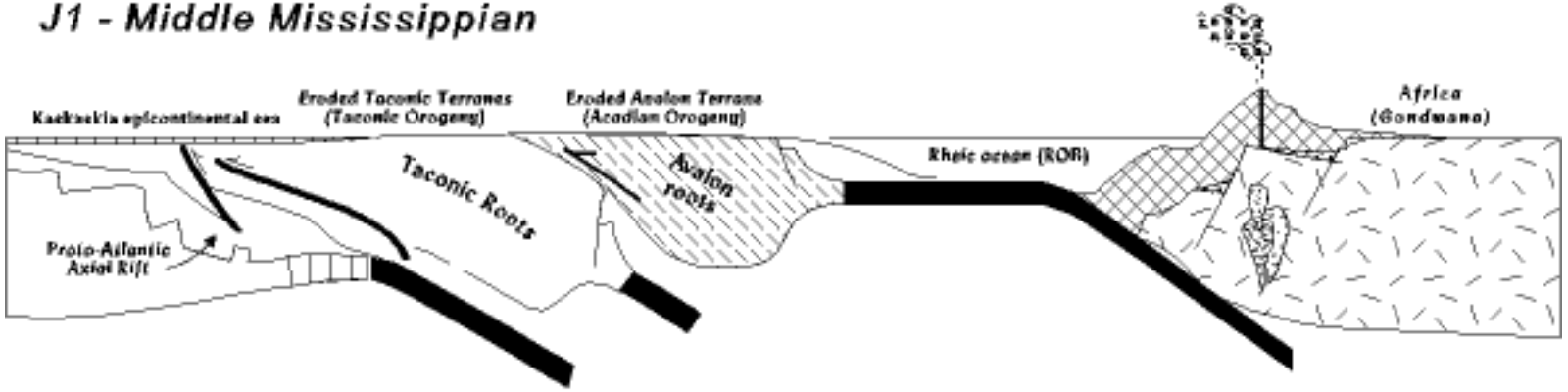
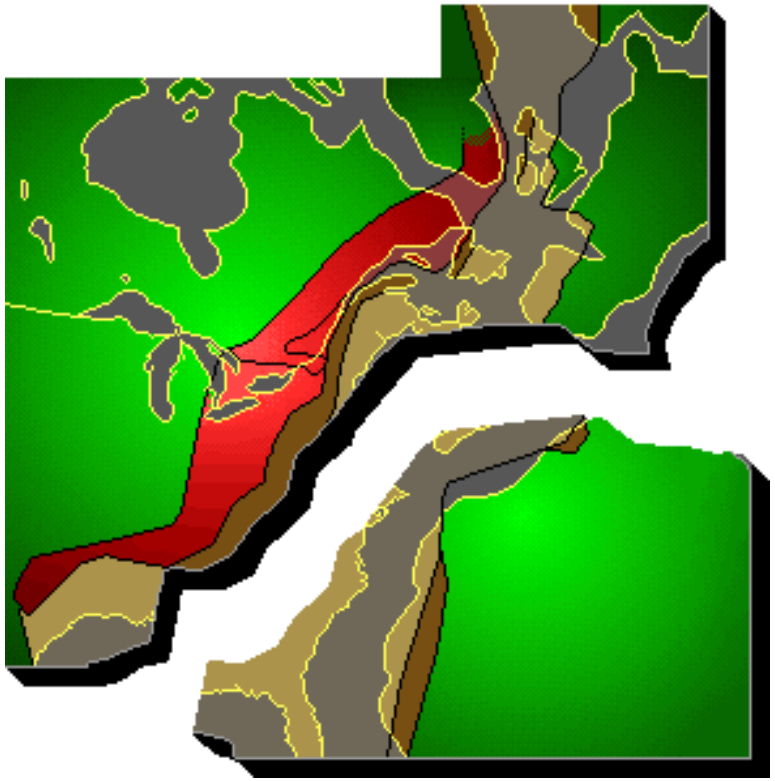


Fig. 4. Closure of the Northern Iapetus Ocean and Tornquist Sea according to the three-plate collision model (Baltica, Laurentia and Avalonia) giving rise to formation of the Caledonides and associated suture zones along plate margins. (After Soper et al. (1992); Meissner et al. (1994).)

J1 - Middle Mississippian





Caledonian Orogeny

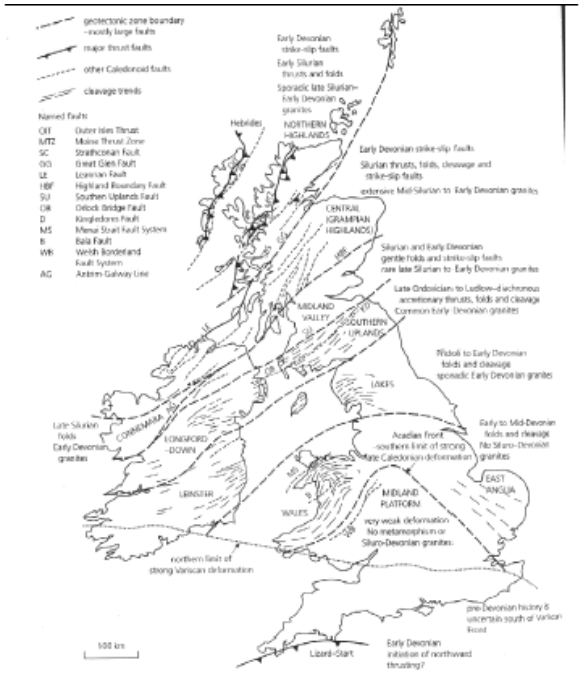


Fig. 12.1 Map of Britain and Ireland showing the extent and general character of Caledonian deformation, metamorphism and igneous activity (faults and cleavage traces from Soper 1986.)

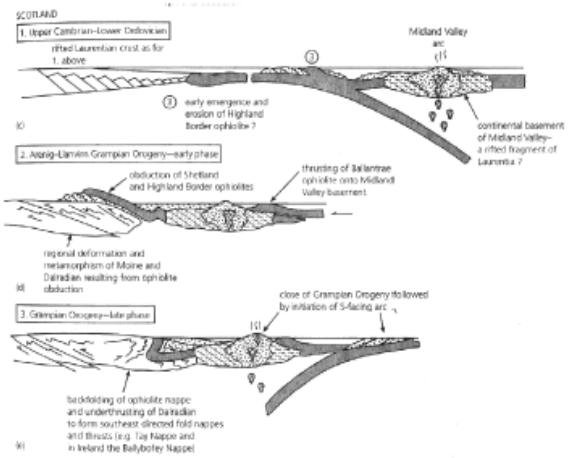


Fig. 6.11 A possible model for the Grampian Orogeny in Ireland (a,b) (modified from Ryan & Dewey 1991) and Scotland (c–e). See text for explanation.

Caledonian Granites - Mechanisms for emplacement

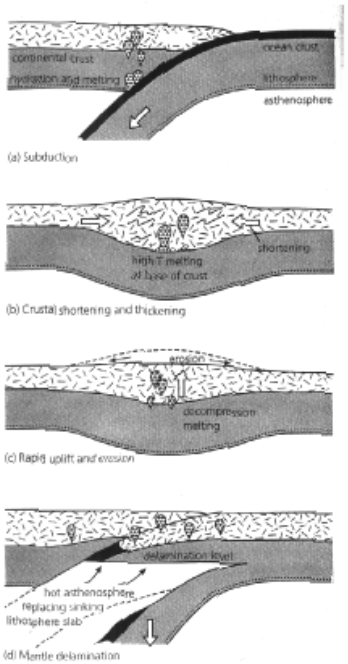
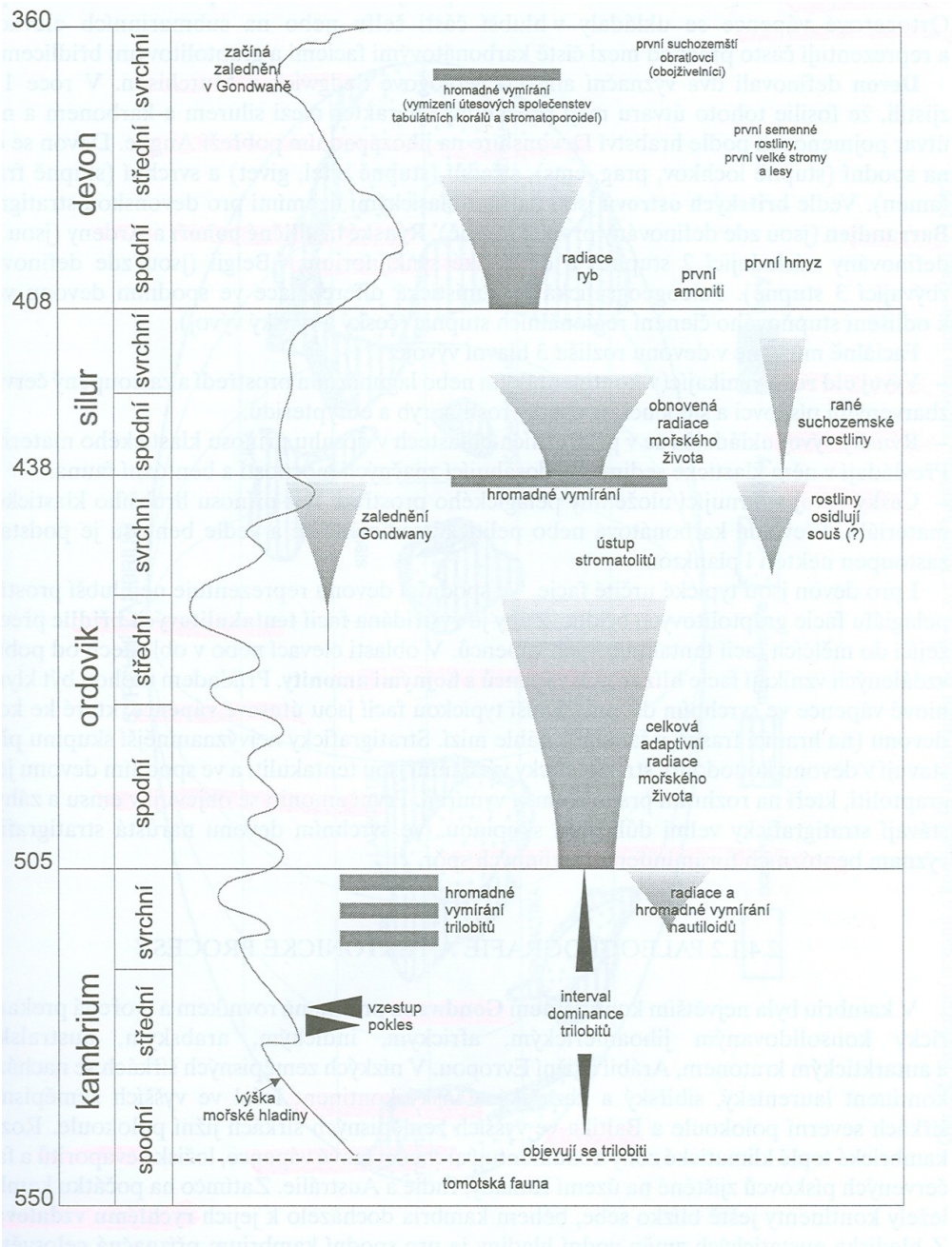


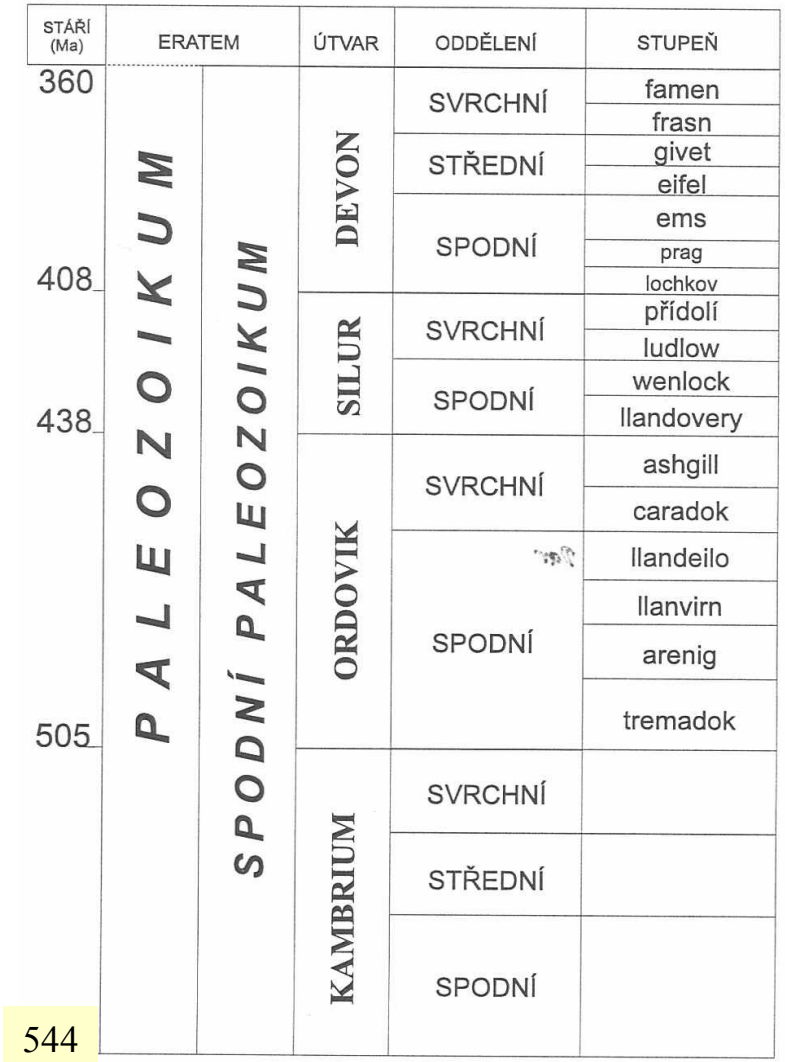
Fig. 12.11 Alternative origins for the Caledonian granites. See text for discussion.

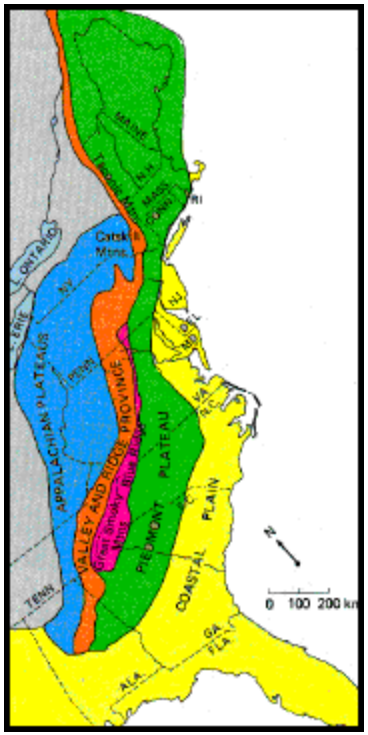


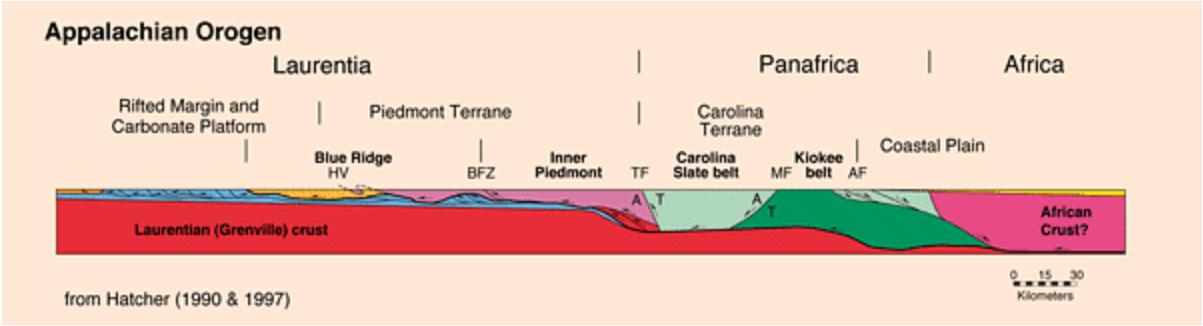
Silurian – typical facies of graptolite shales, **Orthoceras** limestones

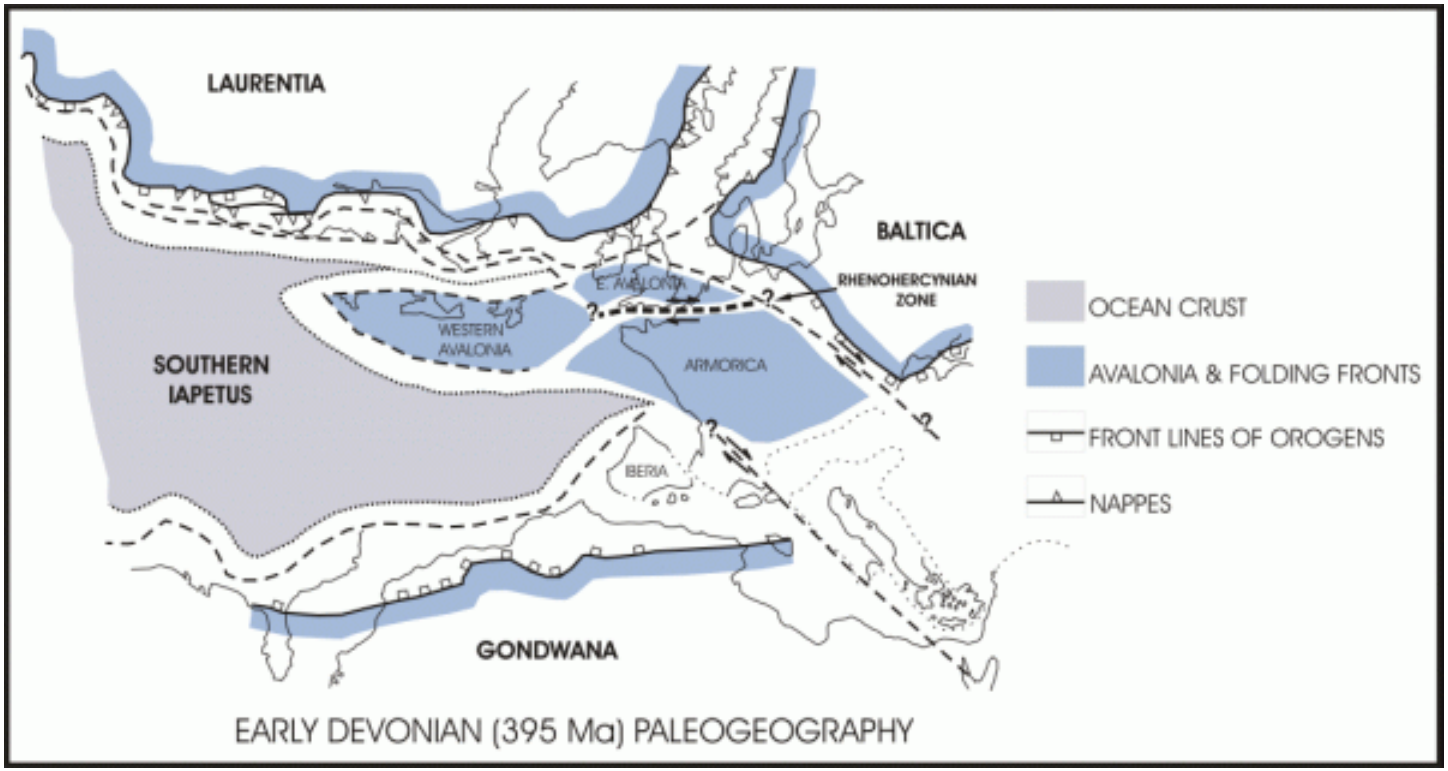
Devonian – typical facies of tentaculite shales, nodular limestones with ammonites, Reef limestones

).


STÁŘÍ (Ma)
ERATEM
ÚTVAR
ODDĚLENÍ
STUPEŇ
360
408
438
505
544
PALEOZOIKUM
SPODNÍ PALEOZOIKUM
DEVON
SILUR
ORDOVIK
KAMBRIUM
SVRCHNÍ
STŘEDNÍ
SPODNÍ
famen
frasn
givet
eifel
ems
prag
lochkov
přídolí
ludlow
wenlock
llandovery
ashgill
caradok
llandeilo
llanvirn
arenig
tremadok


MAINE
VT.
N.H.
MASS.
CONN.
R.I.
N.Y.
Catskill Mts.
ONTARIO
ERIE
PENN.
N.J.
MD.
VA.
W.VA.
N.C.
APPALACHIAN PLATEAUS
VALLEY AND RIDGE PROVINCE
Great Smoky Mts.
Blue Ridge
PIEDMONT PLATEAU
COASTAL PLAIN
TENN.
S.C.
GA.
ALA.
FLA.
N
0 100 200 km


Appalachian Orogen
Laurentia
Panafrica
Africa
Rifted Margin and Carbonate Platform
Piedmont Terrane
Carolina Terrane
Coastal Plain
Blue Ridge
HV
BFZ
Inner Piedmont
TF
Carolina Slate belt
MF
Kiokee belt
AF
A
T
A
T
Laurentian (Grenville) crust
African Crust?
0 15 30
Kilometers
from Hatcher (1990 & 1997)



EARLY DEVONIAN (395 Ma) PALEOGEOGRAPHY

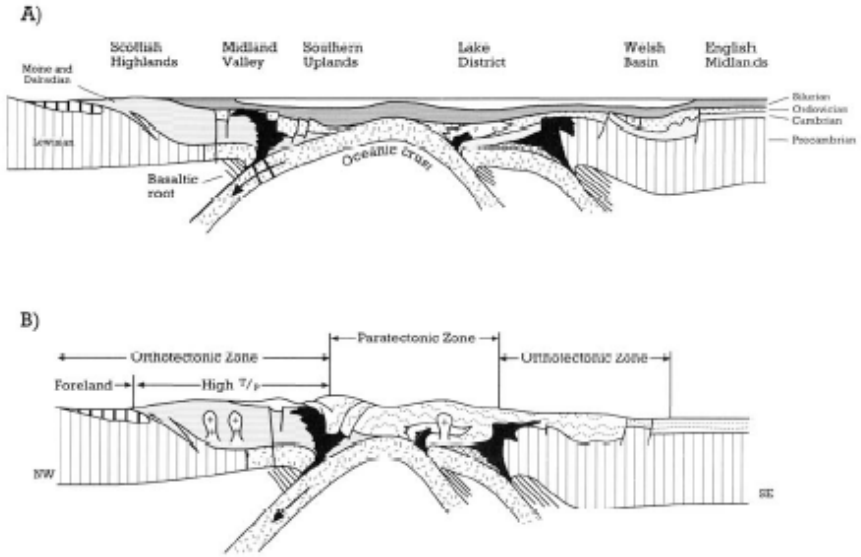


Figure 1.2 Schematic cross-sections of the Caledonides, after Dewey (1969, figs 2E, F). (A) represents Iapetus during the Silurian. (B) shows the situation after the collision in the early Devonian, with ornament indicating fold style in Lower Palaeozoic rocks. Black areas represent volcanics and intrusions of the Ballantrae Complex (NW) and Gwna Group of Anglesey (SE). Vs represent Upper Ordovician volcanics of the Lake District and Wales.

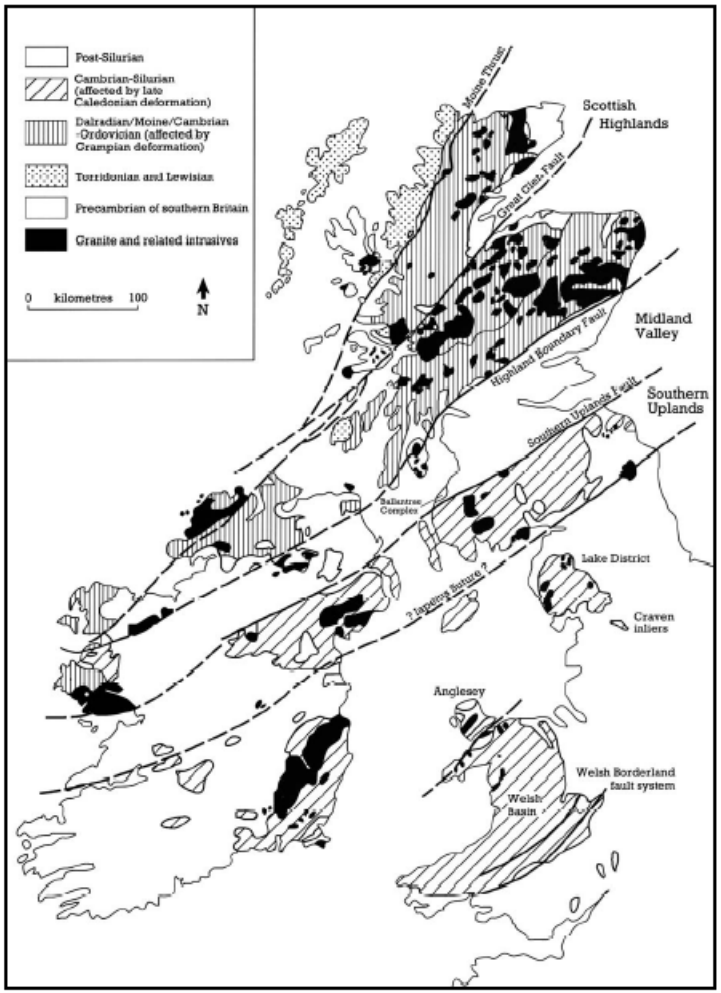
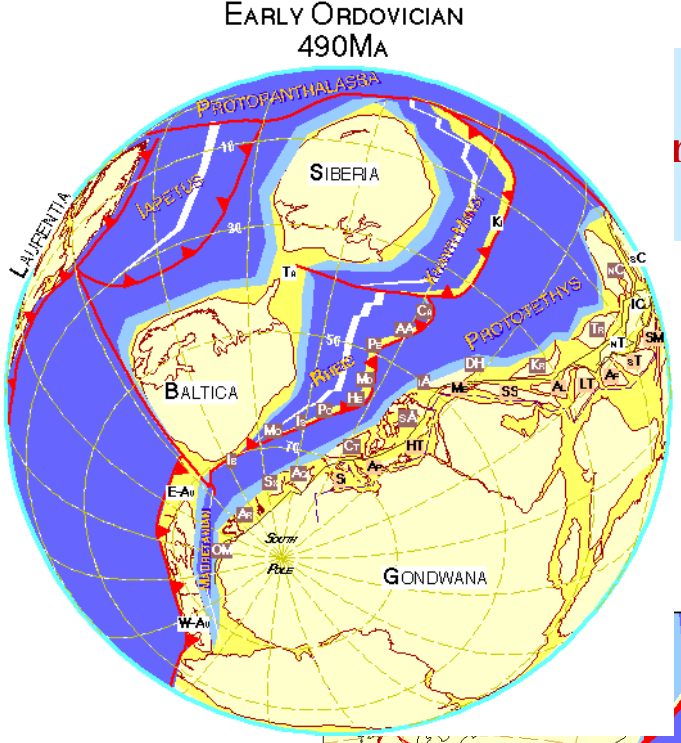
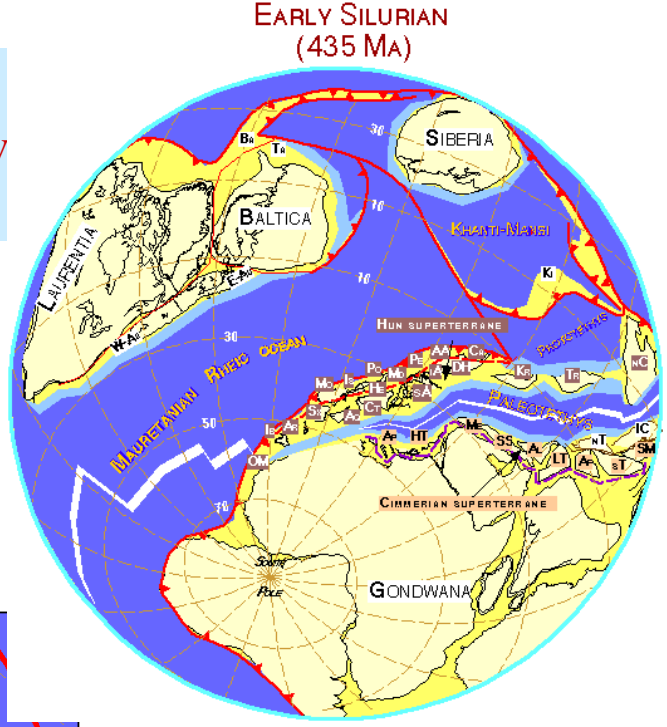


Figure 1.3 Simplified map of the British Caledonides modified from Leake *et al.* (1983).

Geologický vývoj rigondwanských teránů v spodním paleozoiku





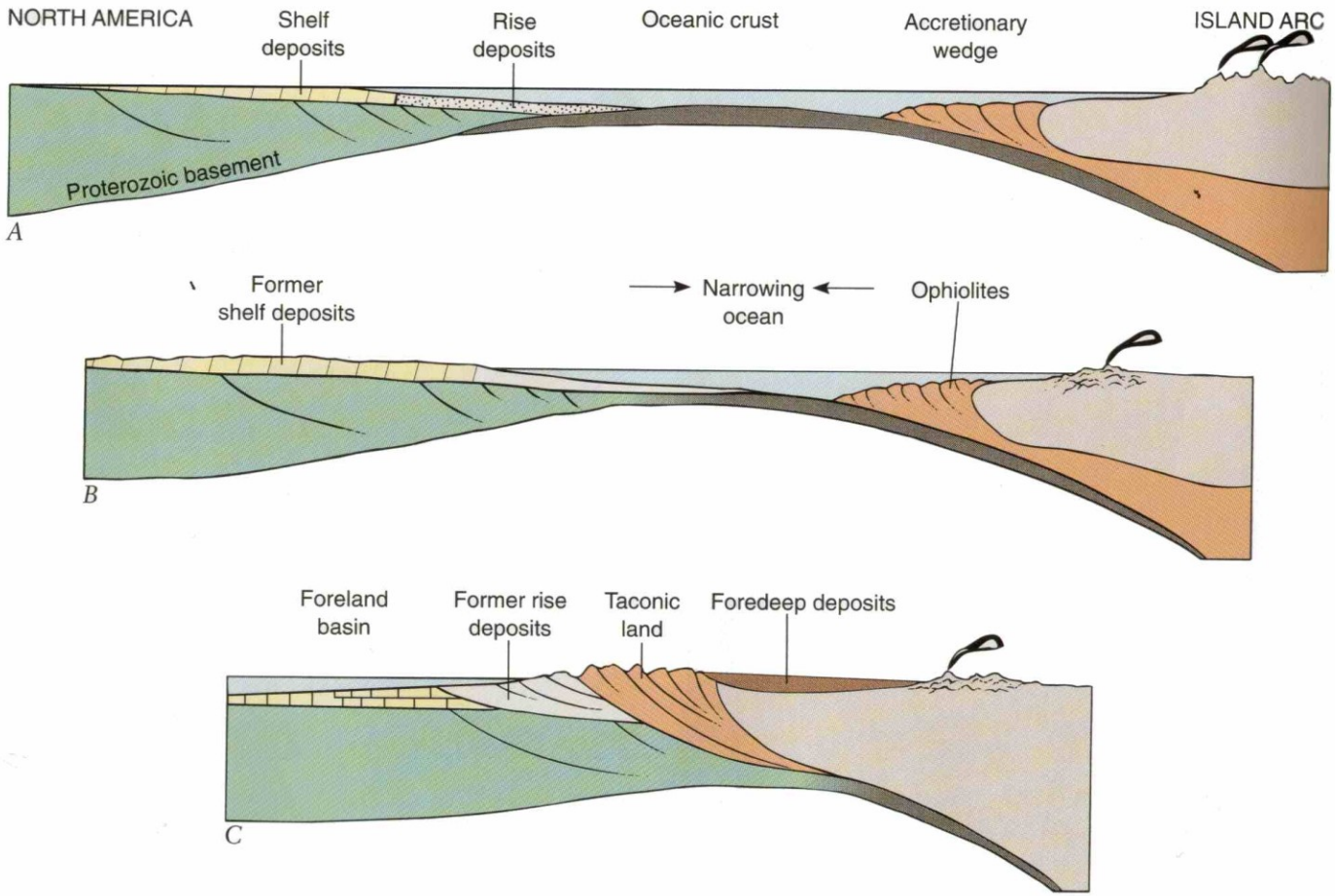


FIGURE 8–23 Plate tectonic forces that resulted in the Taconic orogeny. Following the Neoproterozoic break-up of Rodinia, a passive margin characterized the eastern border of North America (A). Subsequently, a large island arc converged on the passive margin and converted it to an orogenic belt with growing mountain ranges (B and C). *(Adapted from Rowley, D. B., and Kidd, S. F. 1981.* J. Geol. *89:199–218.)*