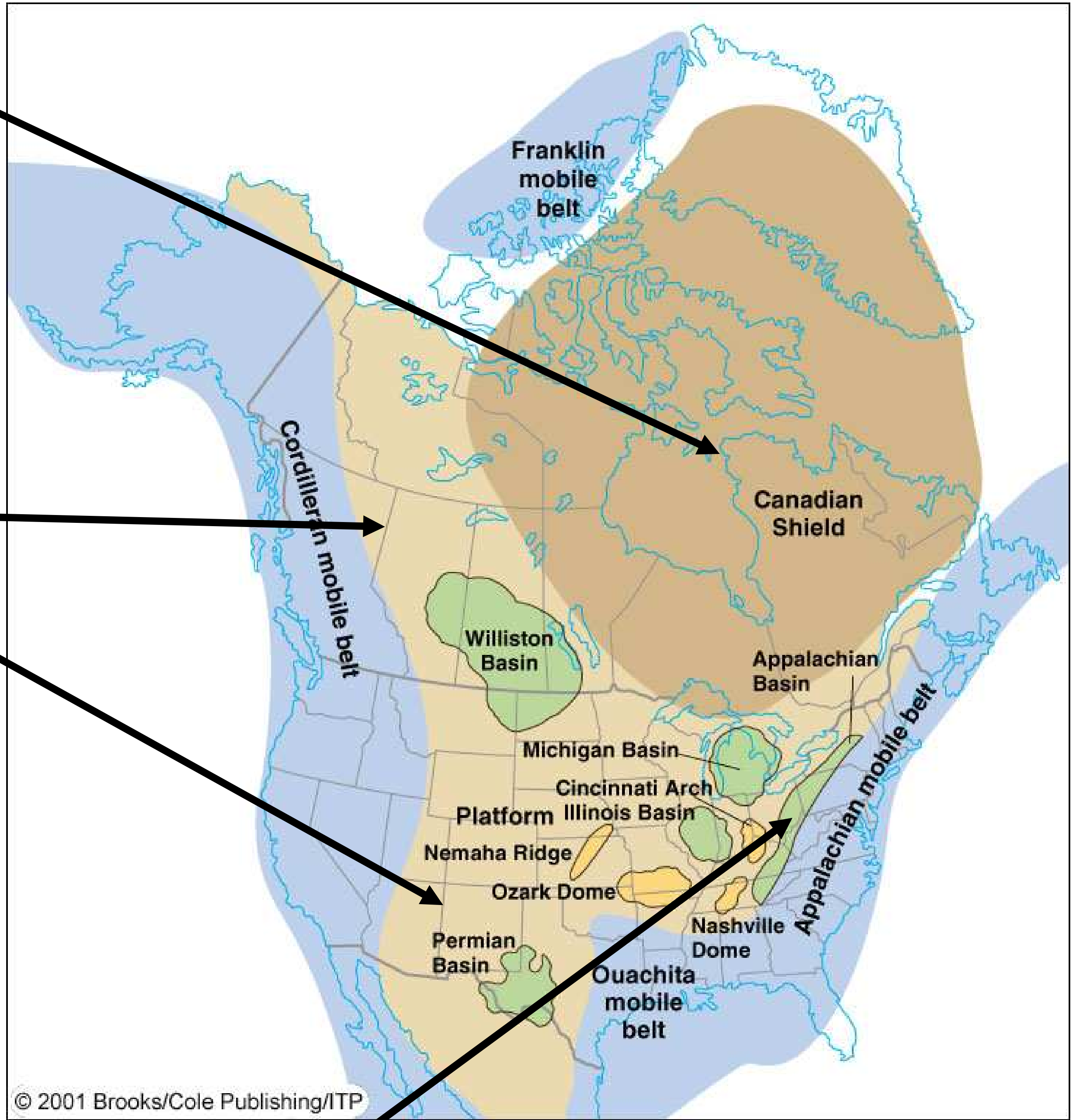
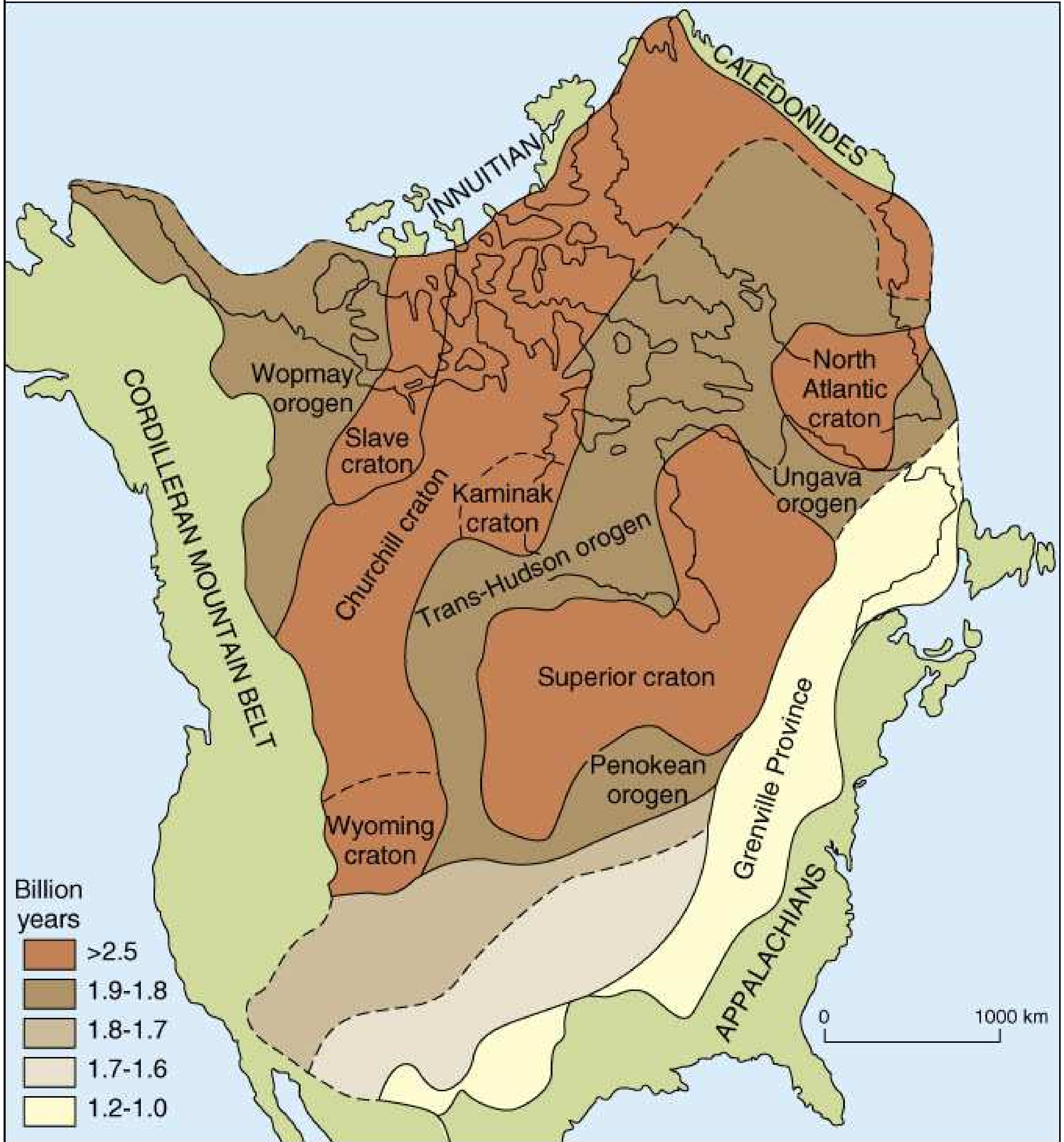
4

Canadian shield – not covered during Paleozoic, re-mainder of craton (light brown) was periodically cover-ed by *epeiric* (shallow, inland) *seas*. Green (basins) & yellow (domes) = local areas of gentle warpage of platform sedimentary rocks.

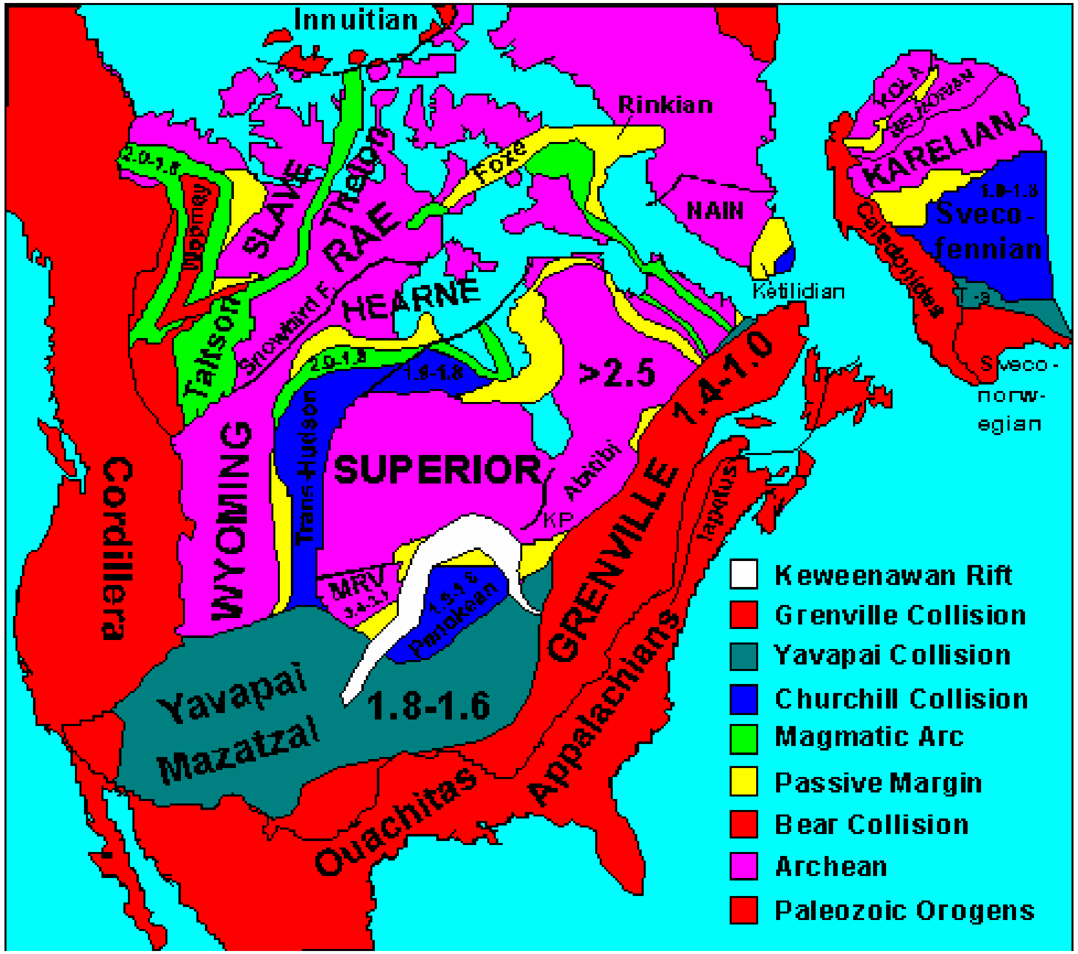


Appalachian Basin


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



Hlavní část **laurentského štítu** byla vytvořena při **transhudsonské** orogenezi (1,8-1,9 Ga), menší části byly přičleněny při **mazatzalské** a **penocké** orogenezi (1,5-1,8). Nejmladší proterozoickou orogenezi je **grenvilská**, která skončila před 1,0 Ga.



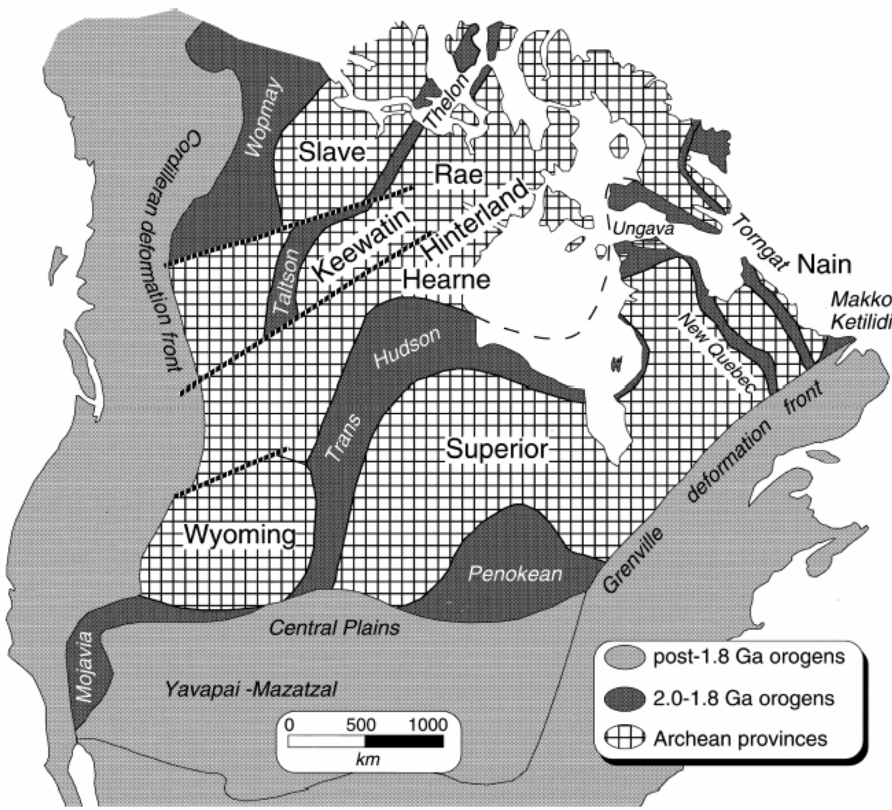


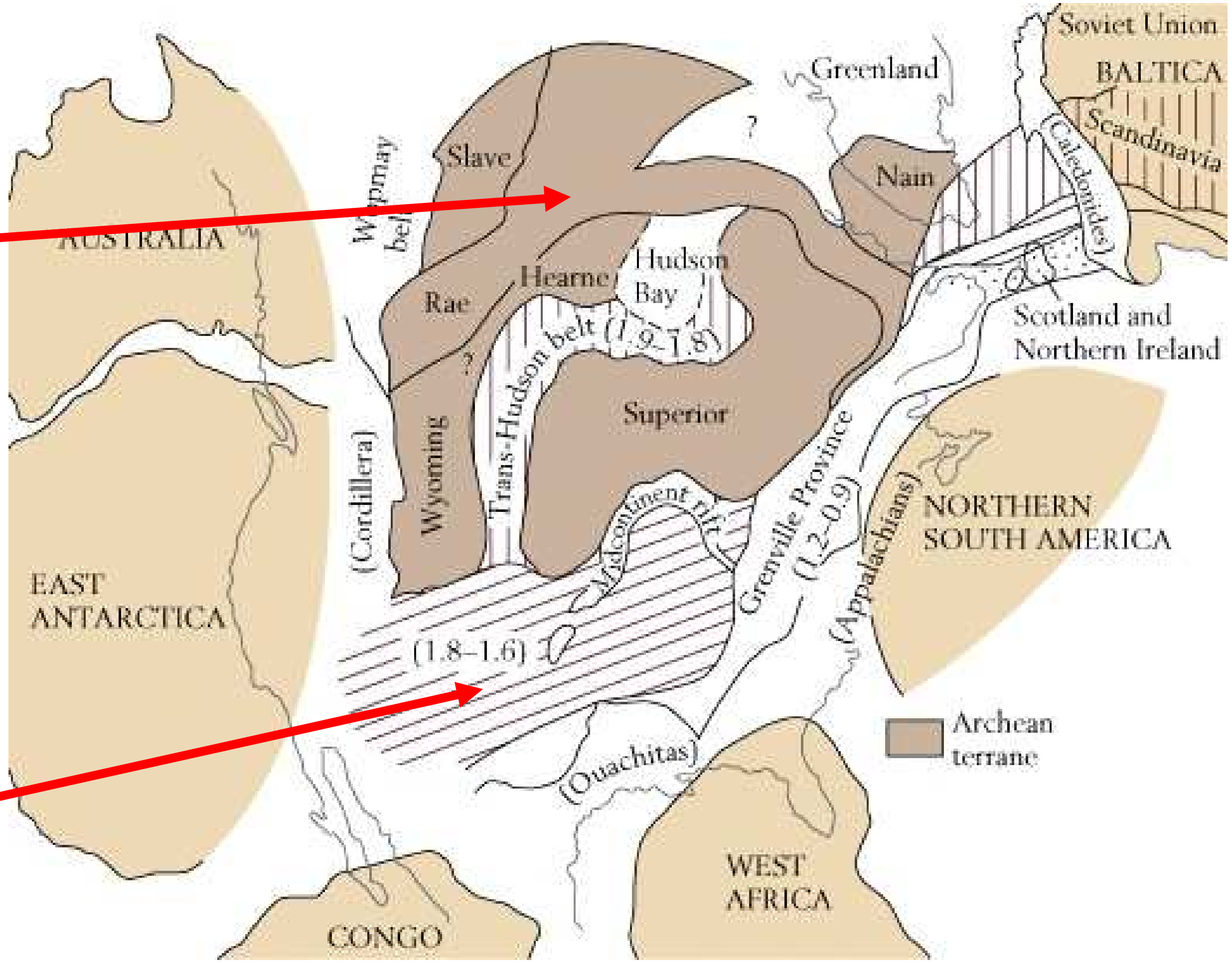
Fig. 1. Archean provinces and surrounding orogens in North America. For simplicity, ca. 2.5–2.1 Ga cover rocks have been omitted. Modified after Hoffman (1988, 1989a).

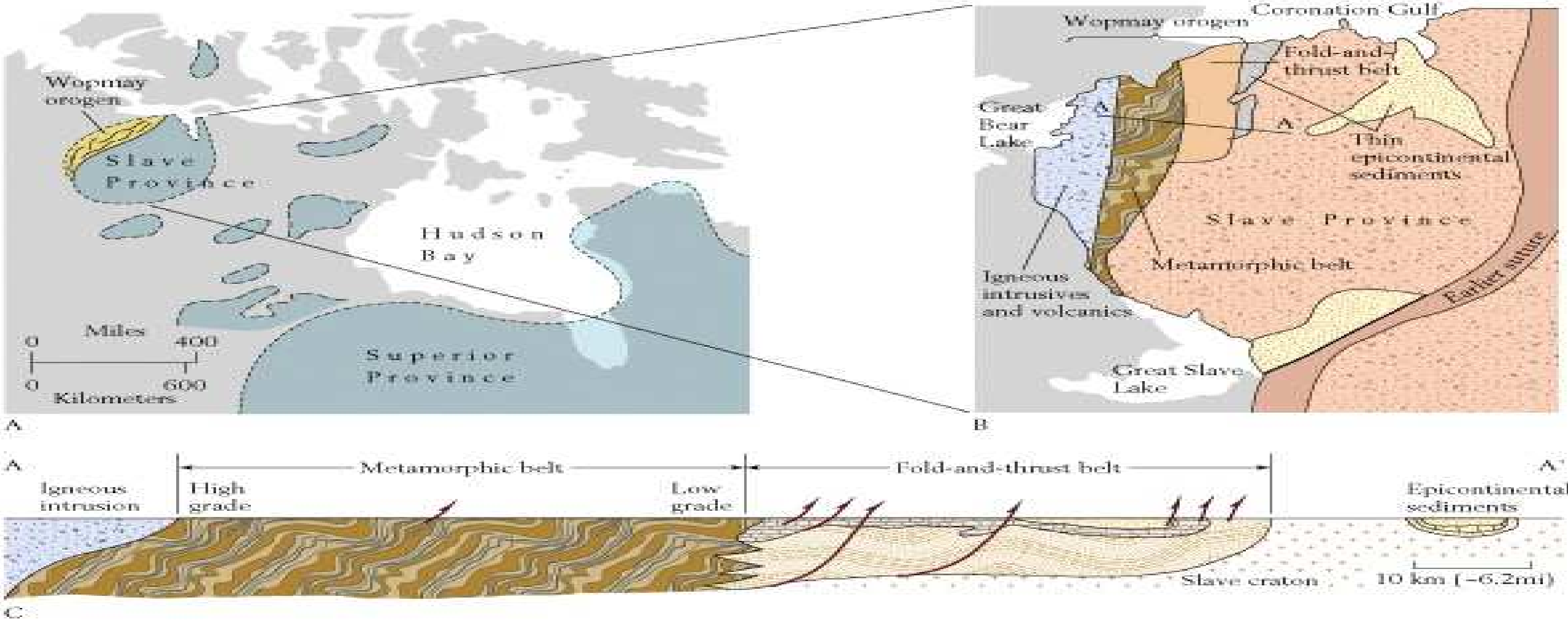
Continental Accretion

- During Proterozoic, Laurentia was growing by accretion

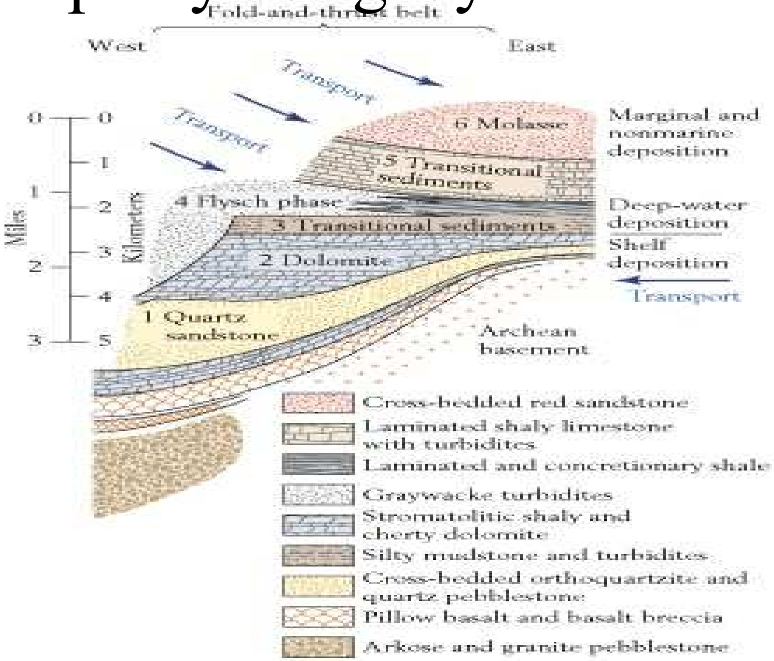
Phase 1:
1.95-1.85 bya
Suturing of ~six microcontinents

Phase 2:
1.8-1.6 bya
Suturing of island arc to south

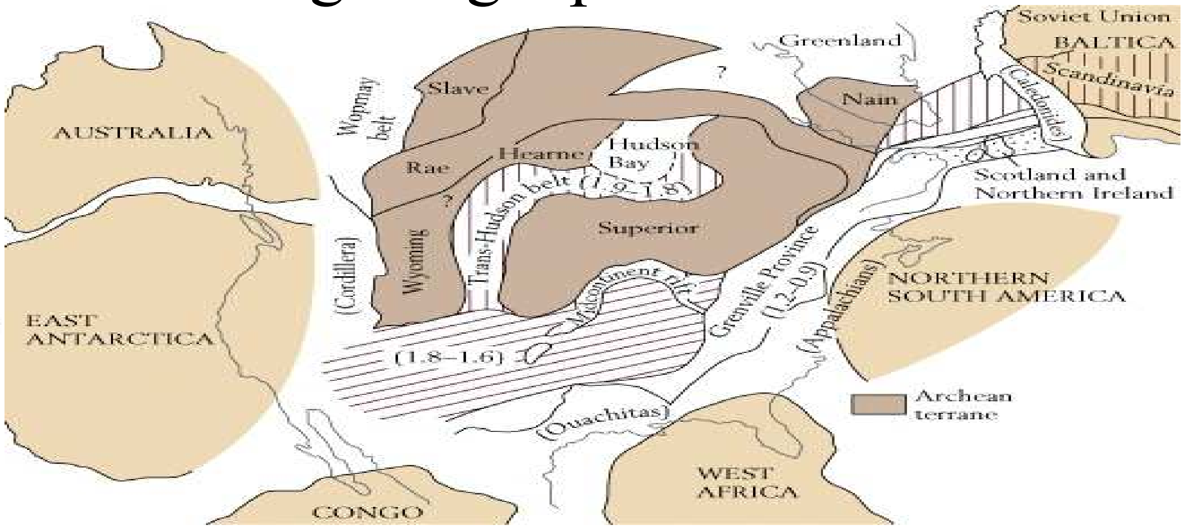




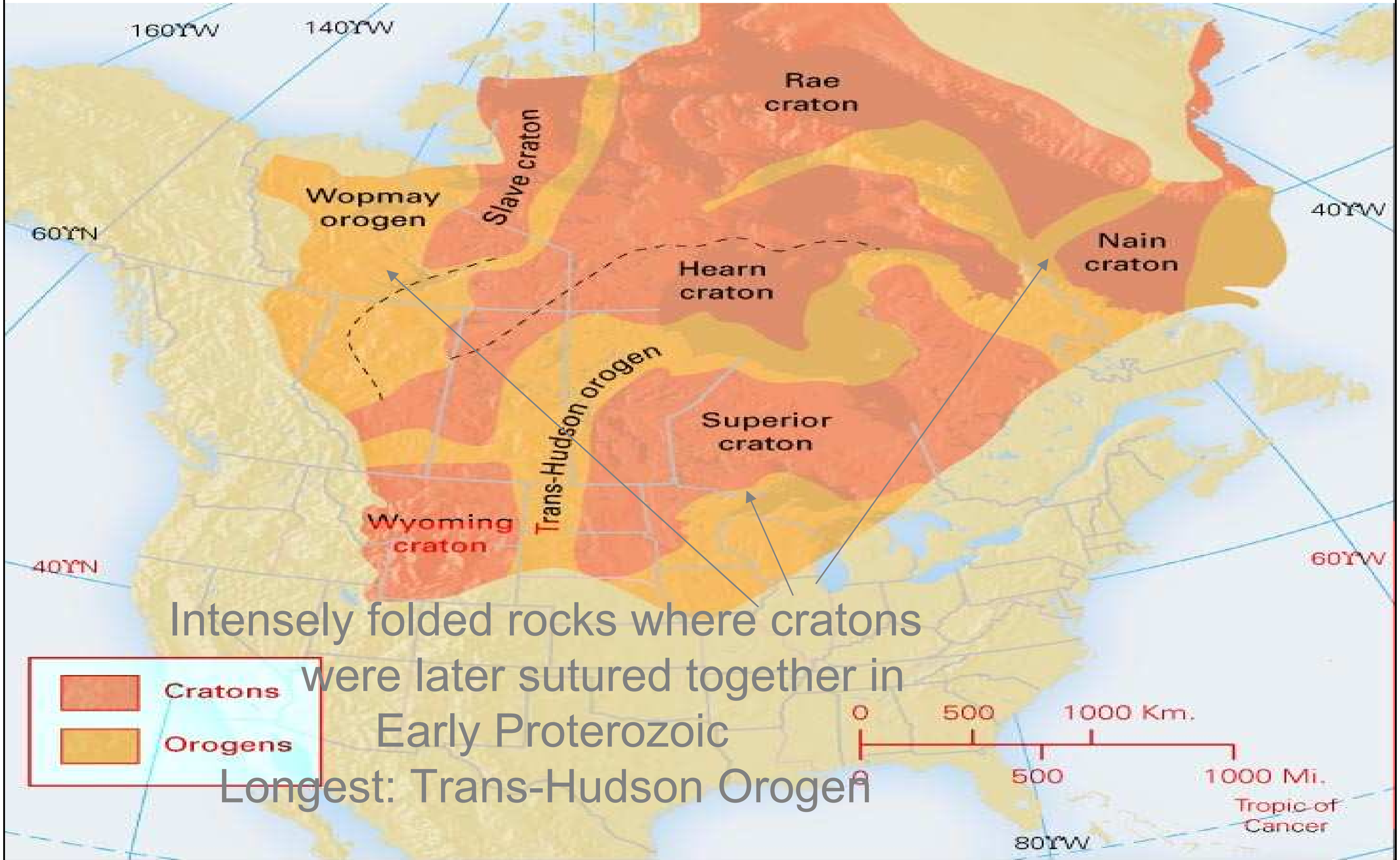
Wopmay Orogeny



NA geologic provinces



Archean Crustal Provinces once separated Canadian Shield assembled from small cratons



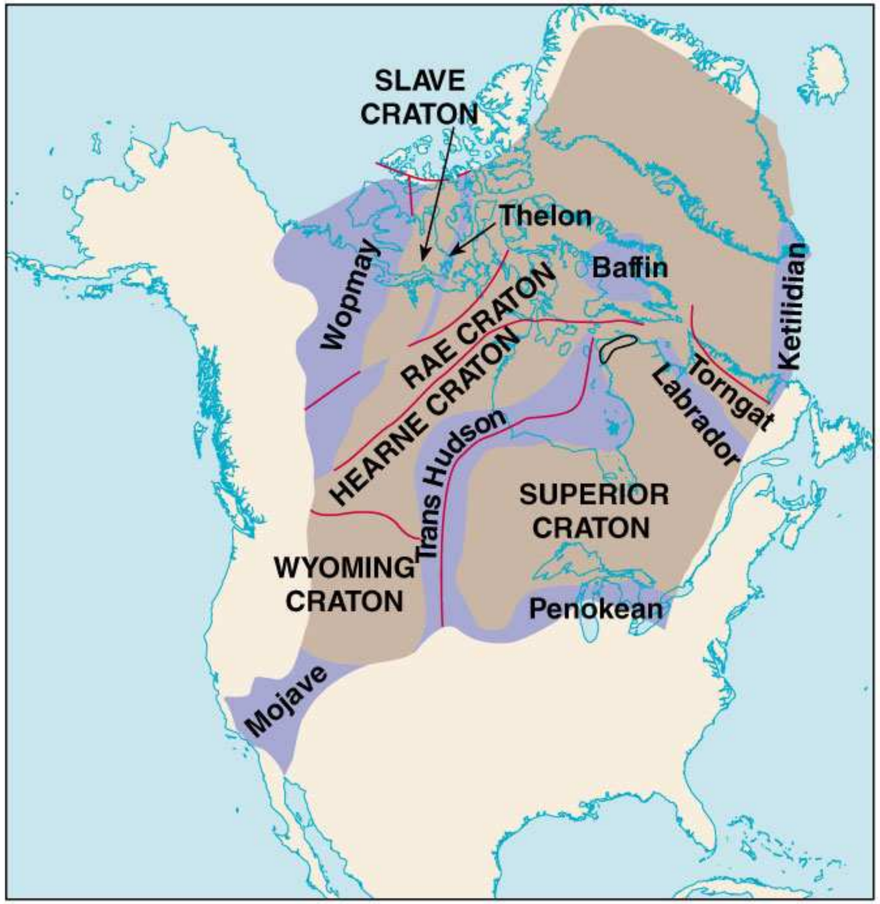
Intensely folded rocks where cratons were later sutured together in Early Proterozoic

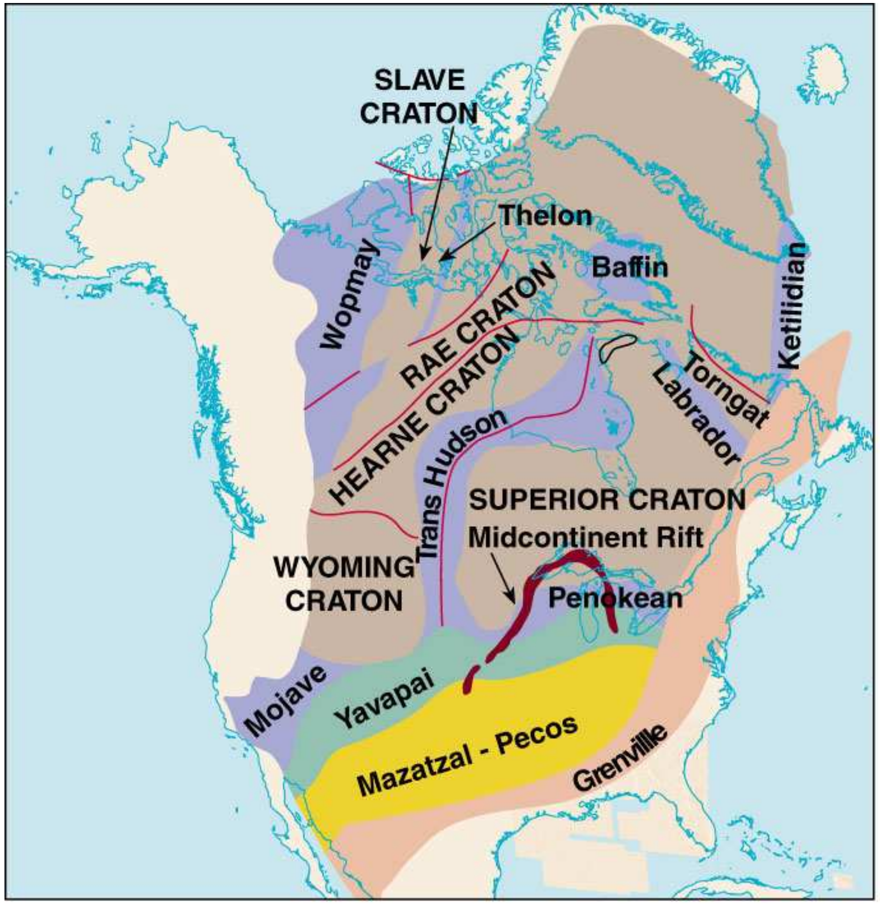
Longest: Trans-Hudson Orogen

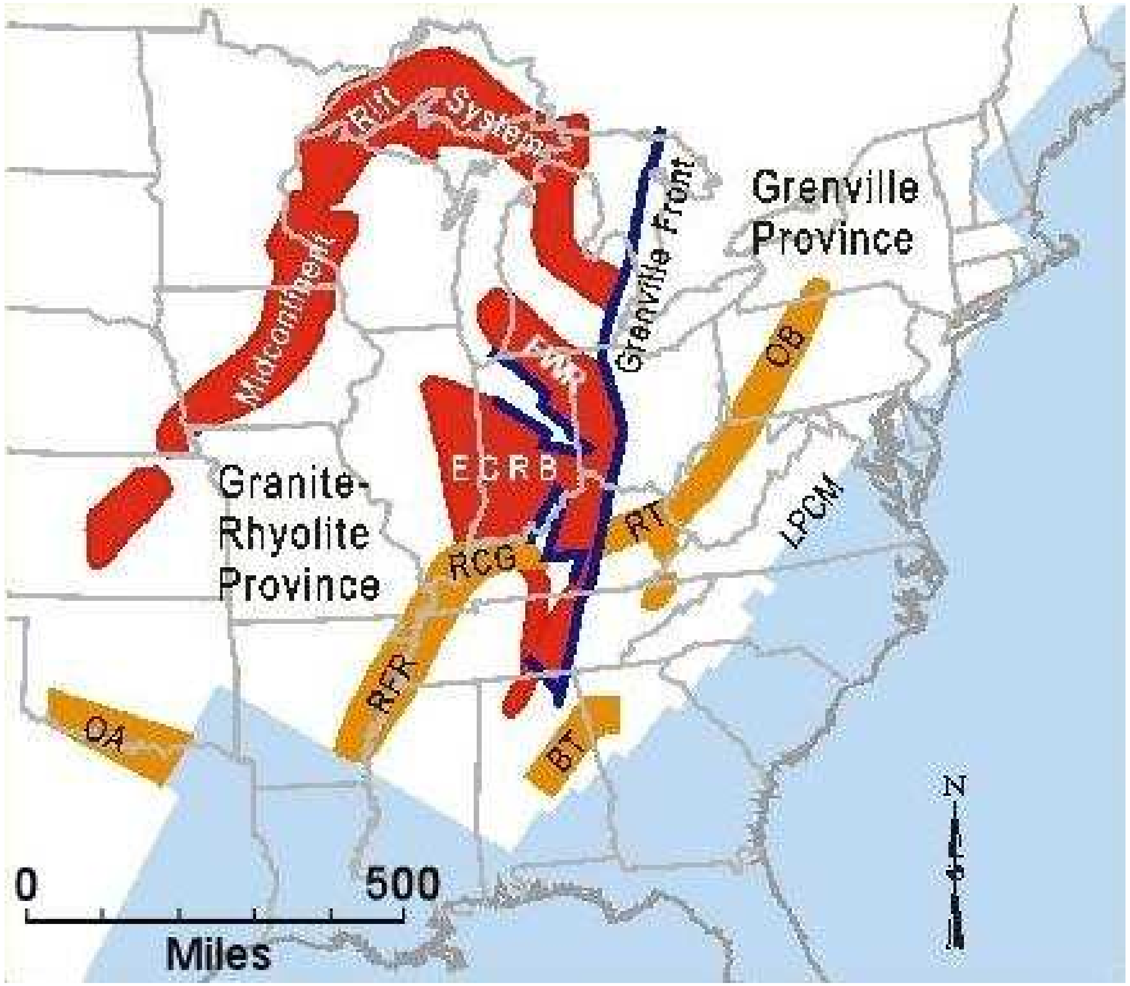
4

- 900 million - 1.2 billion
- 1.6 billion- 1.75 billion
- 1.75 billion- 1.8 billion
- 1.8 billion - 2.0 billion
- 2.5 billion - 3.0 billion

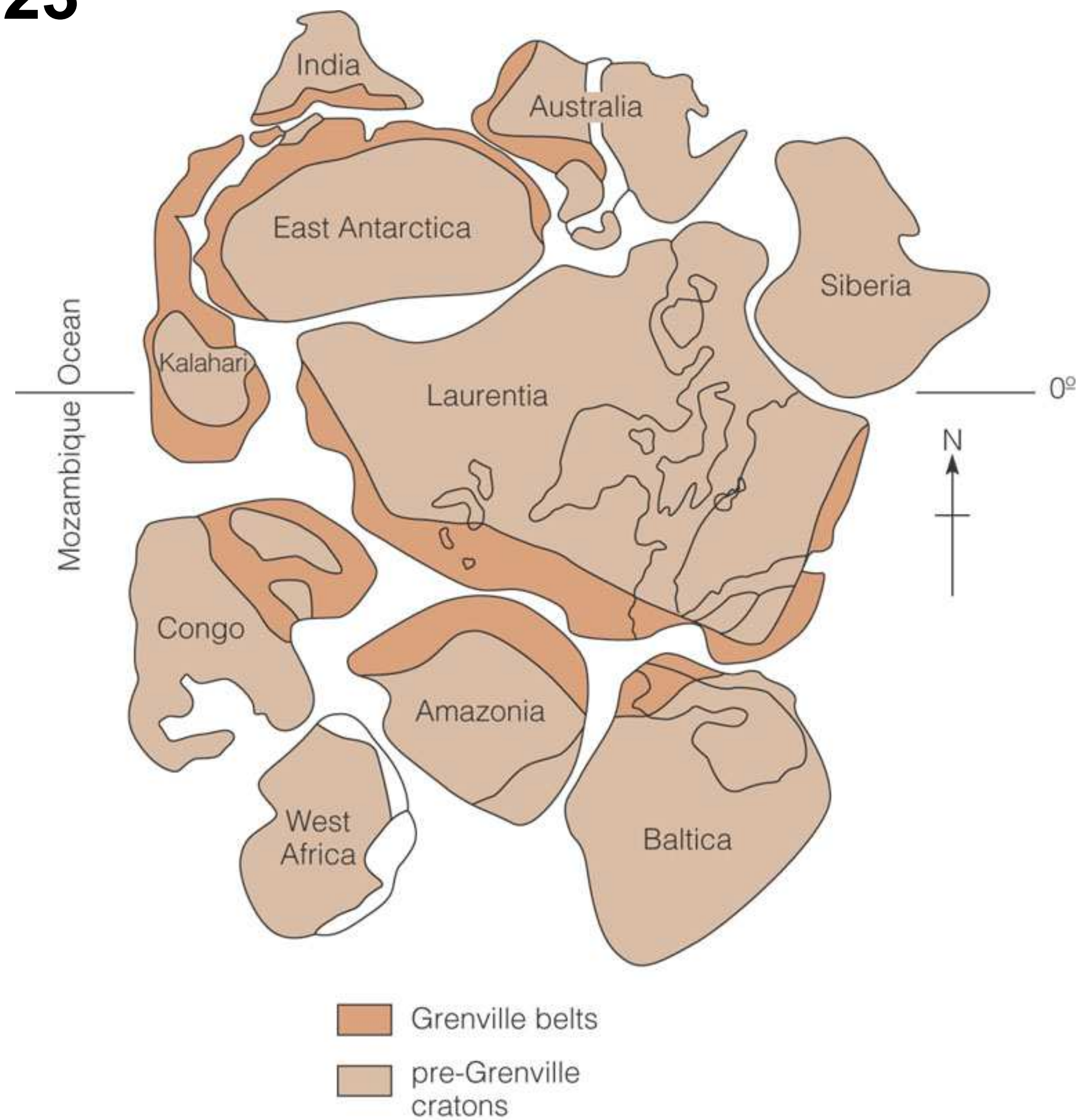
During Proterozoic, Laurentia grew to southeast by accretion of other cratons. Collision zones = orogenic belts. Brown masses – Archean age.

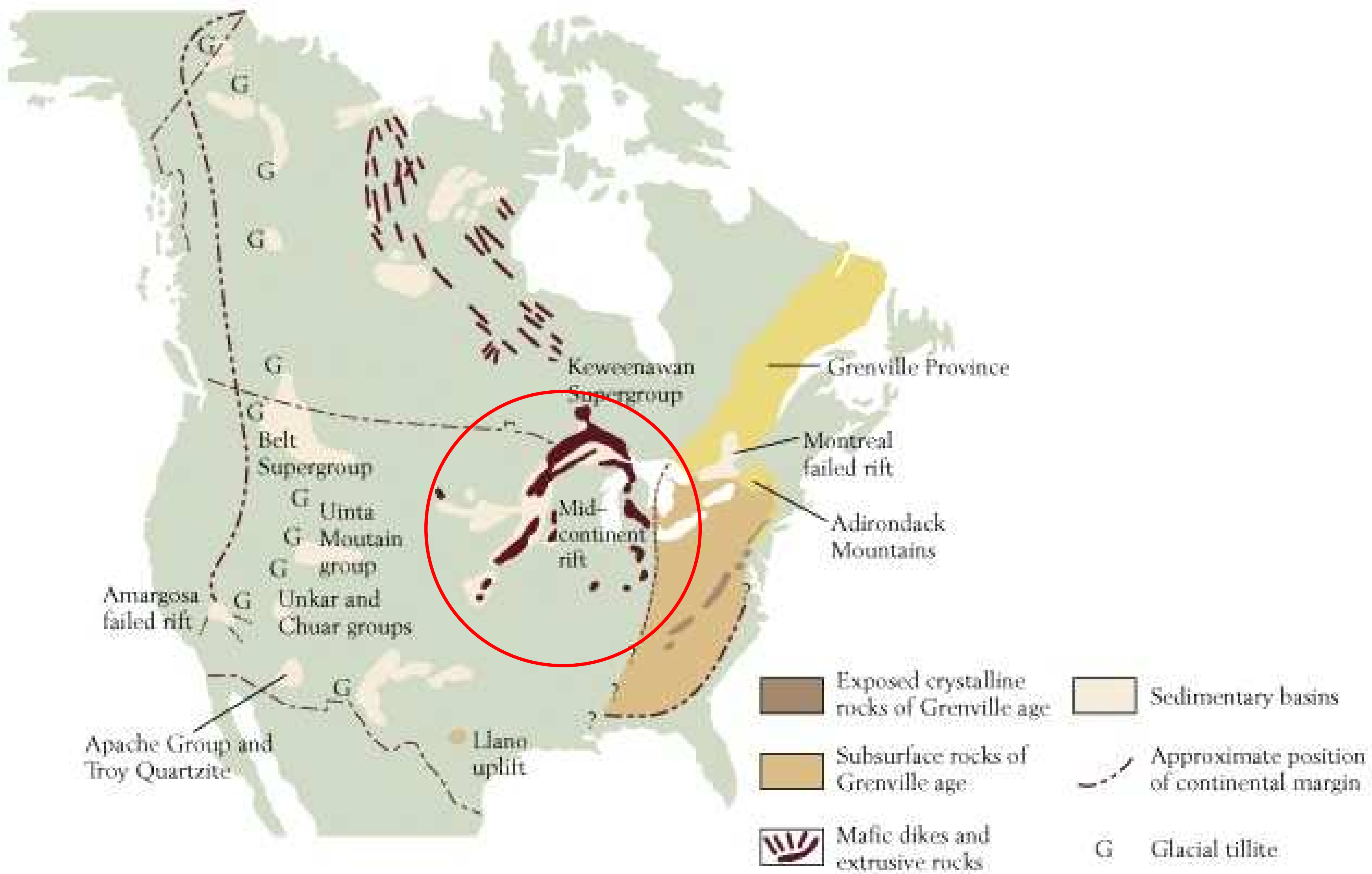





Rift System
Midcontinent
Grenville Front
Grenville Province
MR
ECRB
Granite-Rhyolite Province
OB
RT
LPCM
RCG
RFR
OA
BT
0
500
Miles
N

Rodinia – final "assembly" during Grenville Orogeny (1.3 to 1.0 b.y. ago), then fragmentation began 750 m.y. ago.




Keweenawan Supergroup
Grenville Province
Montreal failed rift
Adirondack Mountains
Belt Supergroup
Uinta Moutain group
Mid-continent rift
Amargosa failed rift
Unkar and Chuar groups
Apache Group and Troy Quartzite
Llano uplift
Exposed crystalline rocks of Grenville age
Sedimentary basins
Subsurface rocks of Grenville age
Approximate position of continental margin
Mafic dikes and extrusive rocks
G Glacial tillite

Fanerozoické mobilní zóny

Kaledonsko – apalačská mobilní zóna

Kordilerská mobilní zóna

Franklinsko-inuitská mobilní zóna

KALEDONSKO-VARISKÁ OROGENEZE

Grónské kaledonidy

Apalače – **teránní stavba, kaledonské (takonská, akadská) i variské (alleghanská) fáze**

Pásmo Quatchita-Marathon – **alleghanská fáze, kolize s jihoamerickou části Gondwany**

APALAČE

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

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

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

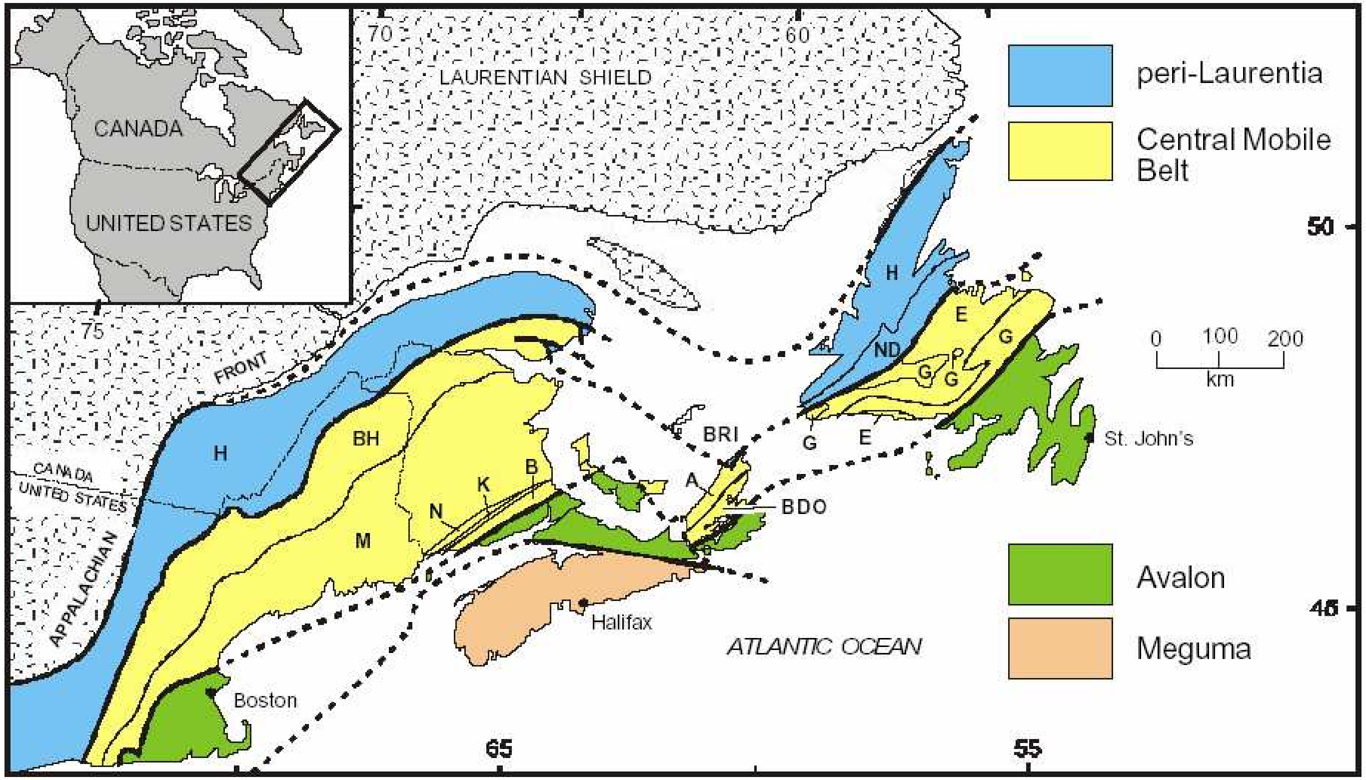
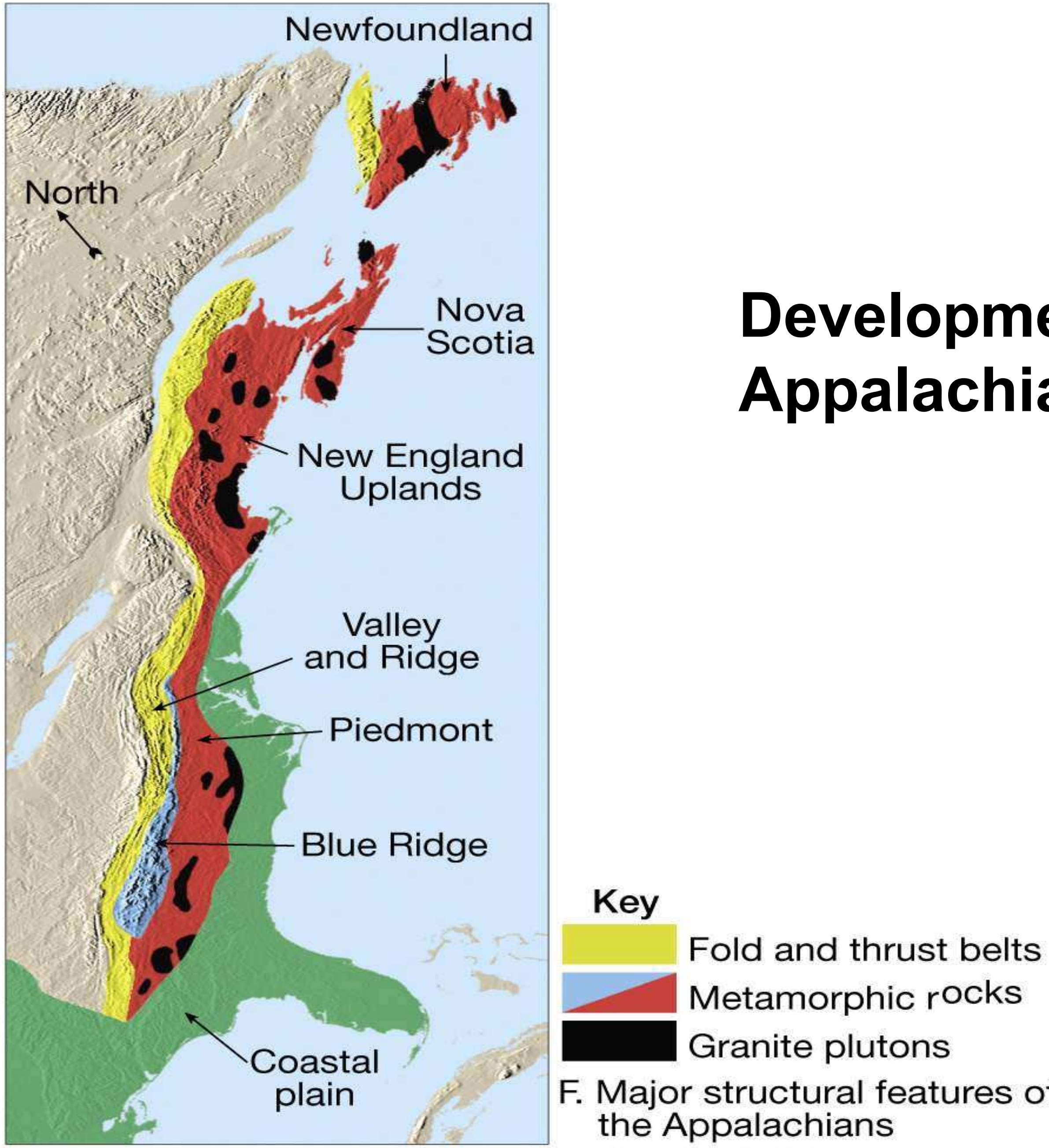


Figure 1. Simplified map of the northern Appalachian orogen showing crustal blocks and terranes (A, Aspy; B, Brookville; BDO, Bras d'Or; BH, Bronson Hill; BRI, Blair River inlier; E, Exploits; G, Gander; H, Humber; K, Kingston; M, Miramichi; N, New River; ND, Notre Dame;

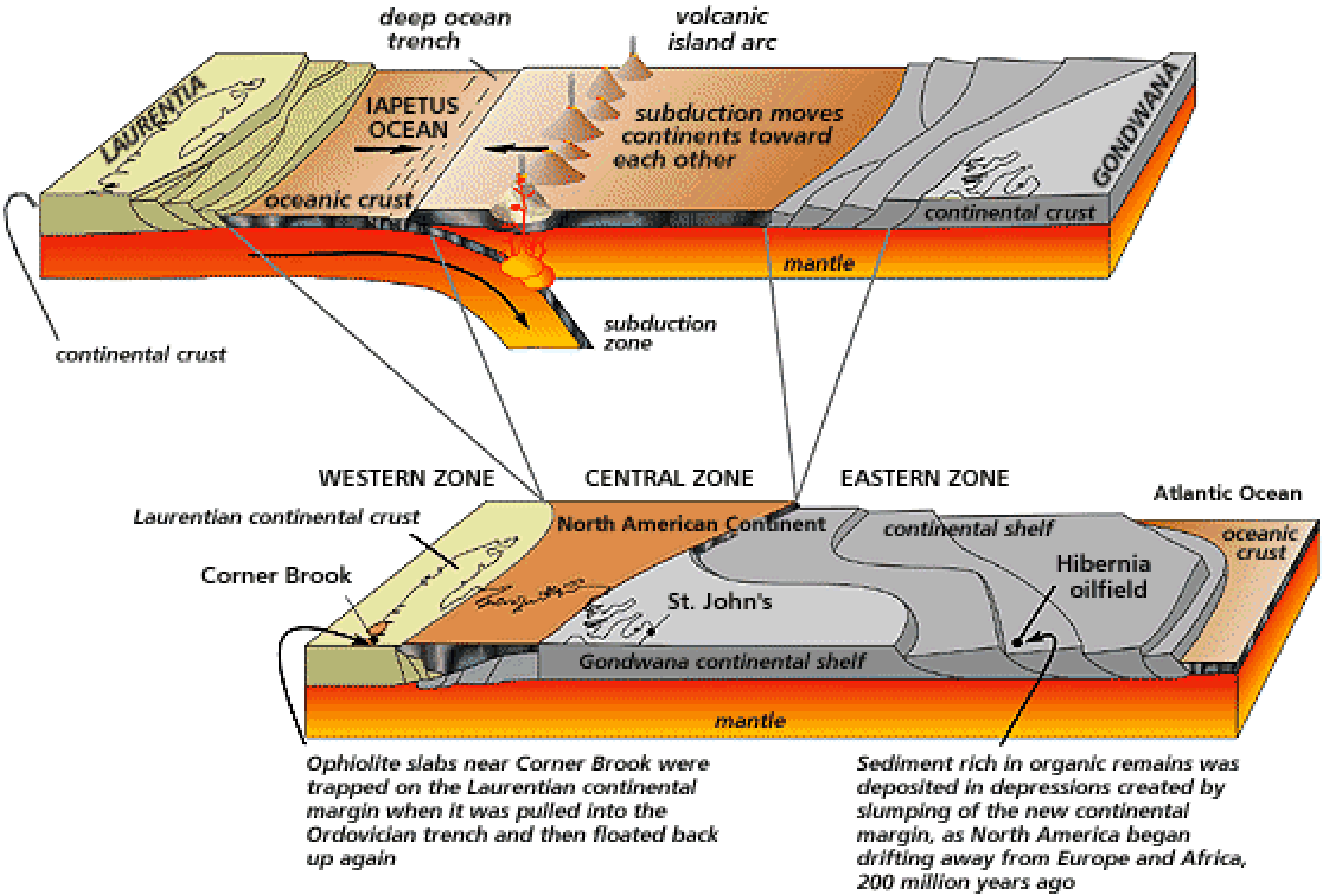
Development of the Appalachian Mountains

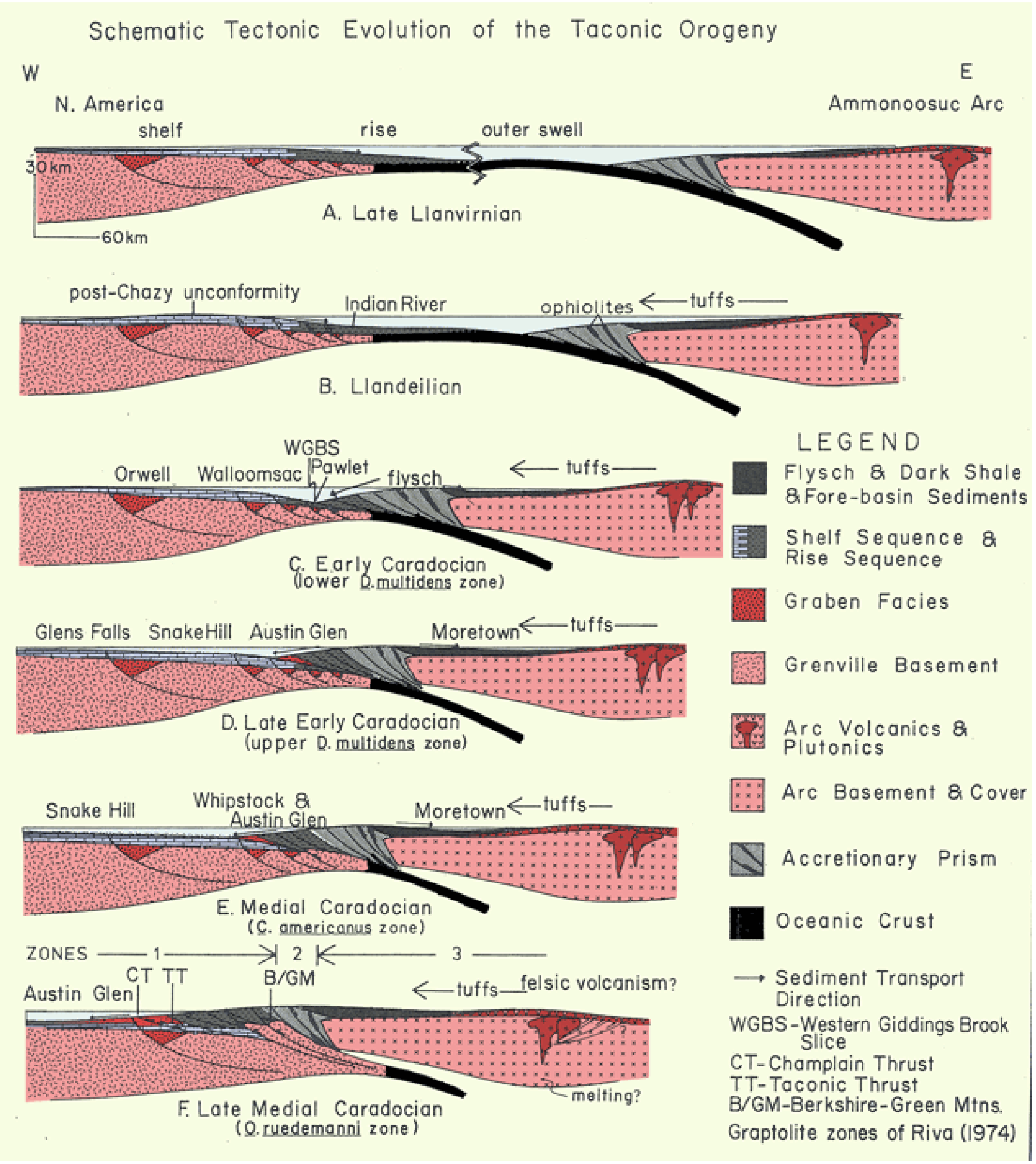


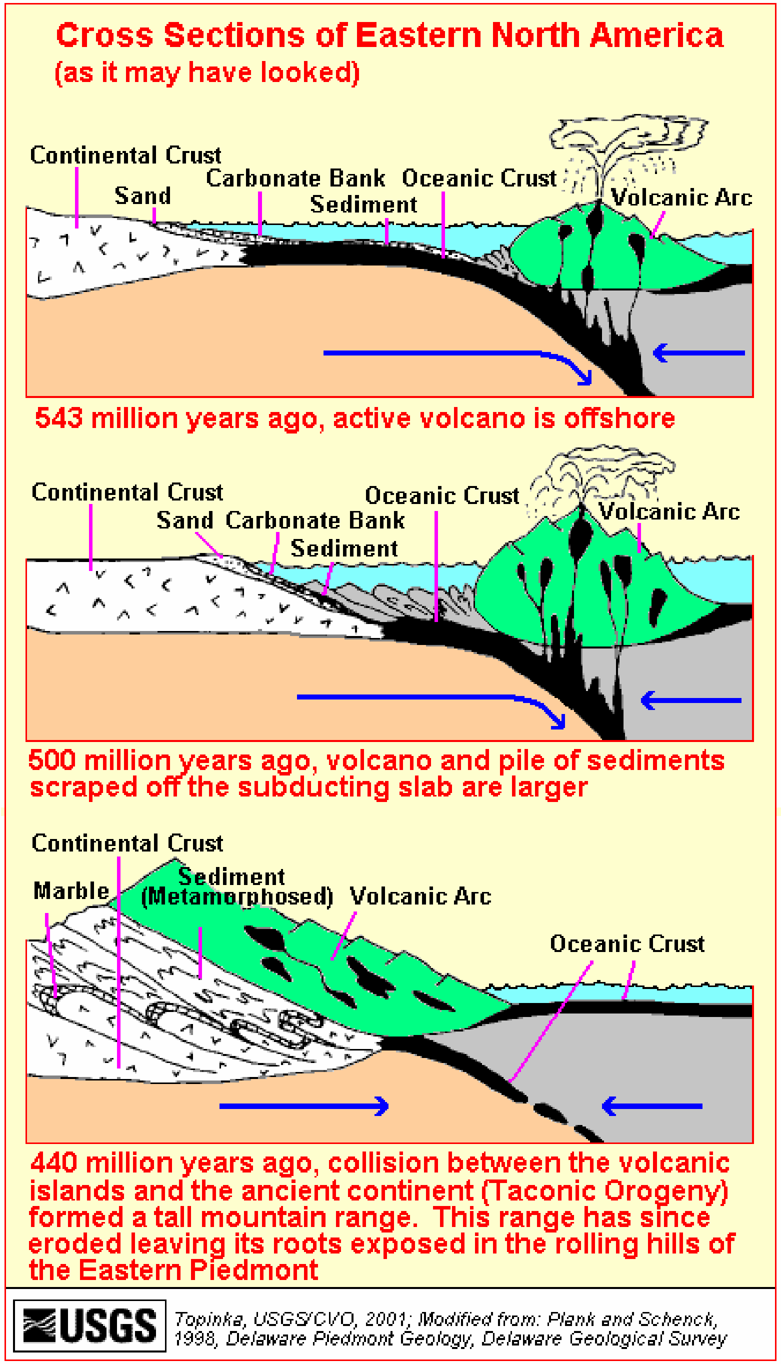
F. Major structural features of the Appalachians

EARLY PALEOZOIC EVENTS

ORDOVICIAN PALEOGEOGRAPHY




Schematic Tectonic Evolution of the Taconic Orogeny
W
E
N. America
Ammonoosuc Arc
shelf
rise
outer swell
30km
60km
A. Late Llanvirnian
post-Chazy unconformity
Indian River
ophiolites
tuffs
B. Llandeilian
WGBS
Orwell
Walloomsac
Pawlet
flysch
tuffs
C. Early Caradocian
(lower D. multidens zone)
Glens Falls
Snake Hill
Austin Glen
Moretown
tuffs
D. Late Early Caradocian
(upper D. multidens zone)
Snake Hill
Whipstock &
Austin Glen
Moretown
tuffs
E. Medial Caradocian
(C. americanus zone)
ZONES 1 2 3
Austin Glen
CT TT
B/GM
tuffs
felsic volcanism?
melting?
F. Late Medial Caradocian
(O. ruedemanni zone)
LEGEND
Flysch & Dark Shale & Fore-basin Sediments
Shelf Sequence & Rise Sequence
Graben Facies
Grenville Basement
Arc Volcanics & Plutonics
Arc Basement & Cover
Accretionary Prism
Oceanic Crust
Sediment Transport Direction
WGBS-Western Giddings Brook Slice
CT-Champlain Thrust
TT-Taconic Thrust
B/GM-Berkshire-Green Mtns.
Graptolite zones of Riva (1974)


Cross Sections of Eastern North America
(as it may have looked)
Continental Crust
Sand
Carbonate Bank
Sediment
Oceanic Crust
Volcanic Arc
543 million years ago, active volcano is offshore
Continental Crust
Sand
Carbonate Bank
Sediment
Oceanic Crust
Volcanic Arc
500 million years ago, volcano and pile of sediments scraped off the subducting slab are larger
Continental Crust
Marble
Sediment (Metamorphosed)
Volcanic Arc
Oceanic Crust
440 million years ago, collision between the volcanic islands and the ancient continent (Taconic Orogeny) formed a tall mountain range. This range has since eroded leaving its roots exposed in the rolling hills of the Eastern Piedmont
USGS
Topinka, USGS/CVO, 2001; Modified from: Plank and Schenck, 1998, Delaware Piedmont Geology, Delaware Geological Survey

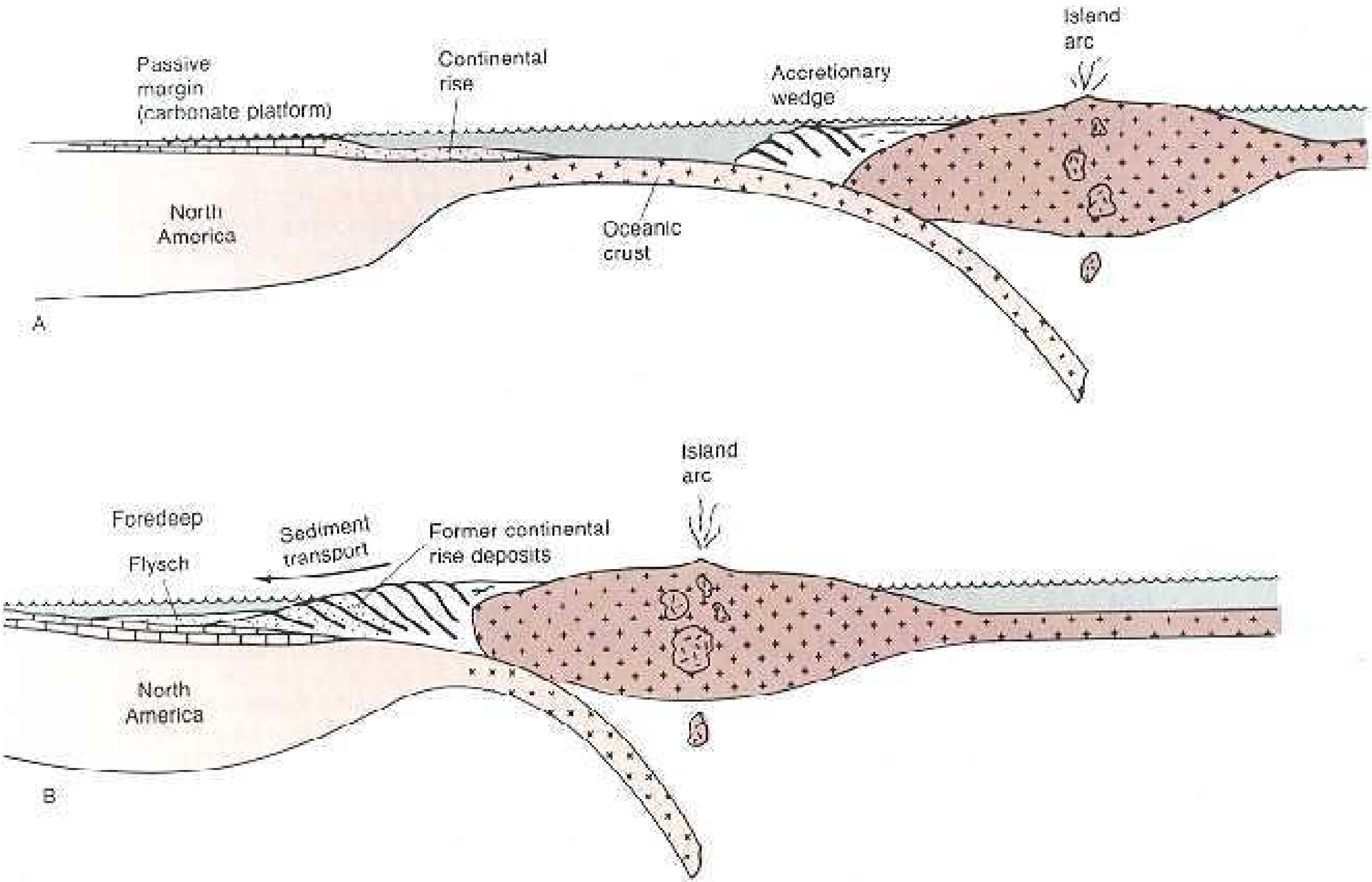
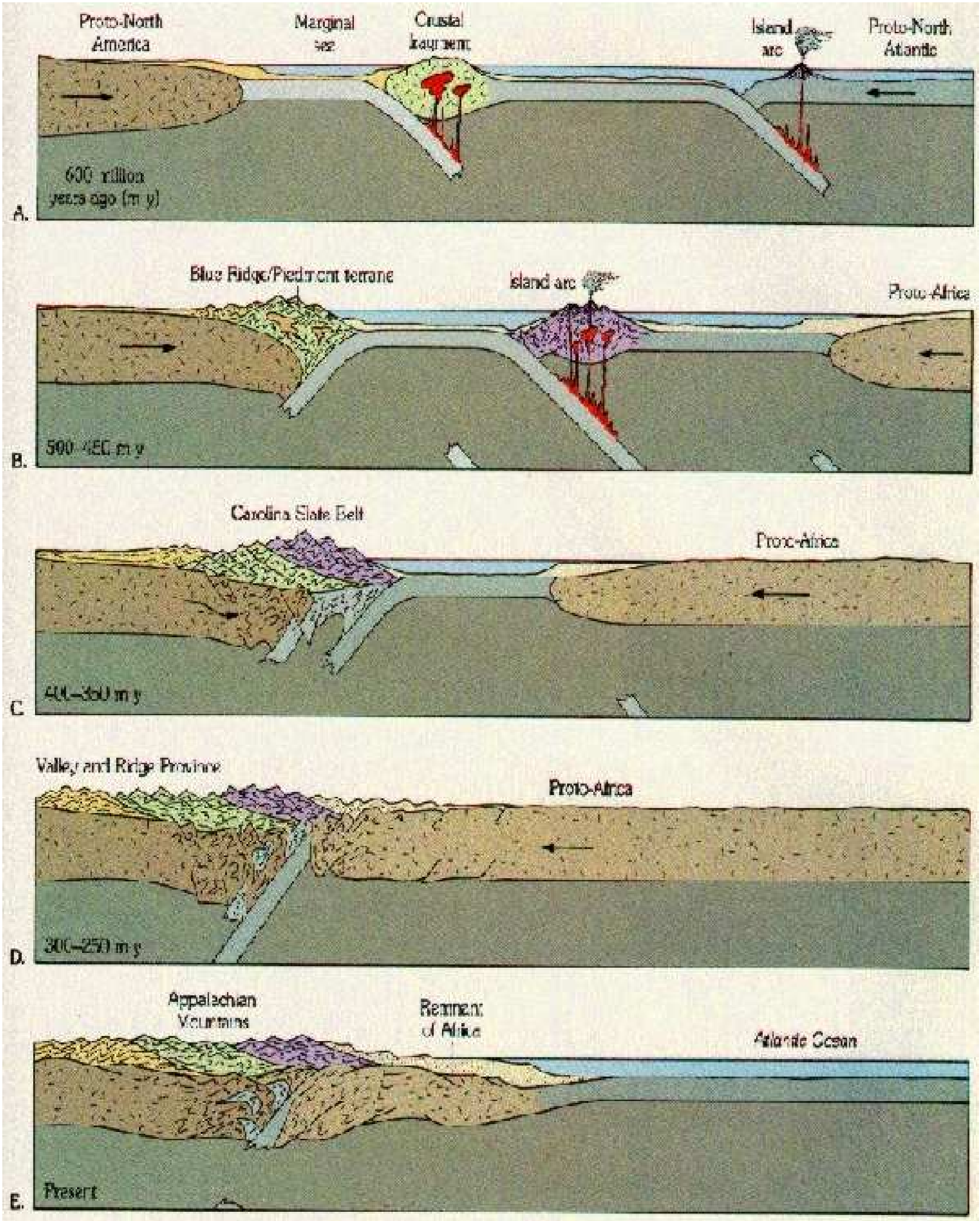
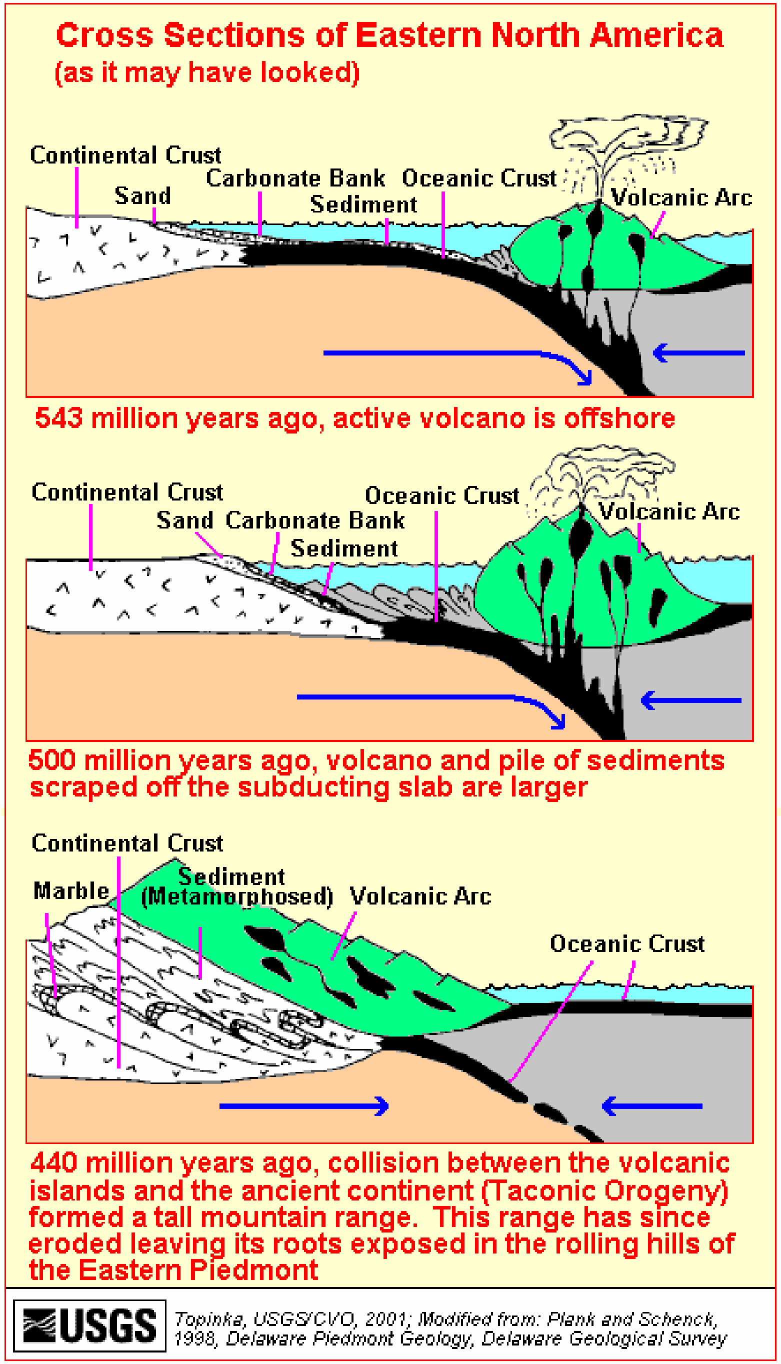
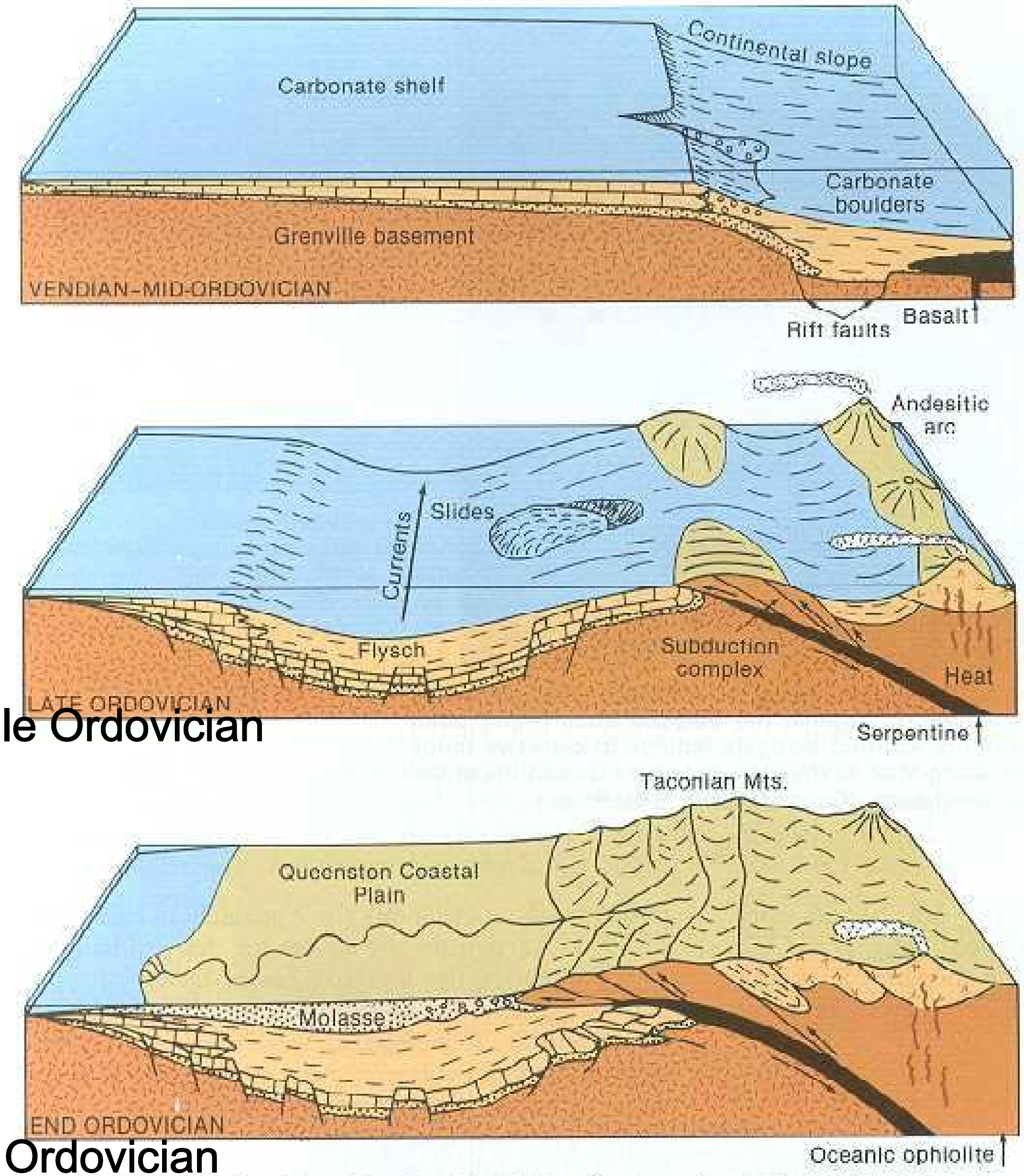


FIGURE 8-29 Diagrammatic illustration of the plate movements that in mid-Ordovician time transformed the passive margin of northeastern North America *(A)* into a foredeep *(B)*. This happened when the passive margin, which supported a carbonate bank, encountered an island arc. The accretionary wedge bordering the island arc was thrust over the continental margin, as were deep-water deposits that had accumulated along the continental rise of North America, in front of the carbonate bank. The island arc thus joined North America as an exotic terrane.


Proto-North America
Marginal sea
Crustal fragment
Island arc
Proto-North Atlantic
600 million years ago (m.y.)
A.
Blue Ridge/Piedmont terrane
Island arc
Proto-Africa
500–450 m.y.
B.
Carolina Slate Belt
Proto-Africa
400–350 m.y.
C.
Valley and Ridge Province
Proto-Africa
300–250 m.y.
D.
Appalachian Mountains
Remnant of Africa
Atlantic Ocean
Present
E.


Cross Sections of Eastern North America
(as it may have looked)
Continental Crust
Sand
Carbonate Bank
Sediment
Oceanic Crust
Volcanic Arc
543 million years ago, active volcano is offshore
Continental Crust
Sand
Carbonate Bank
Sediment
Oceanic Crust
Volcanic Arc
500 million years ago, volcano and pile of sediments scraped off the subducting slab are larger
Continental Crust
Marble
Sediment (Metamorphosed)
Volcanic Arc
Oceanic Crust
440 million years ago, collision between the volcanic islands and the ancient continent (Taconic Orogeny) formed a tall mountain range. This range has since eroded leaving its roots exposed in the rolling hills of the Eastern Piedmont
USGS
Topinka, USGS/CVO, 2001; Modified from: Plank and Schenck, 1998, Delaware Piedmont Geology, Delaware Geological Survey

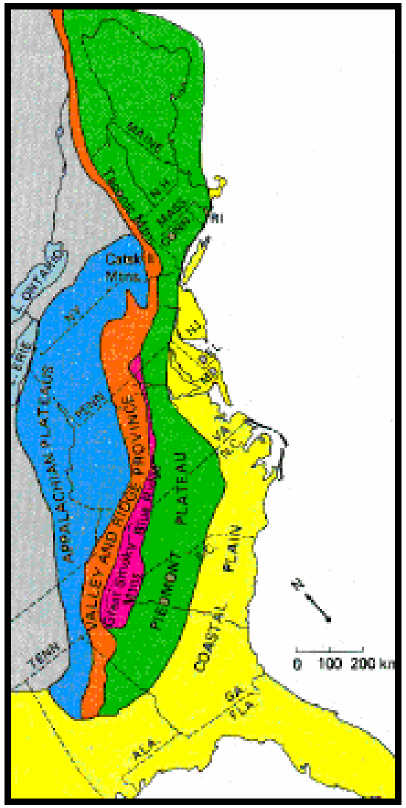


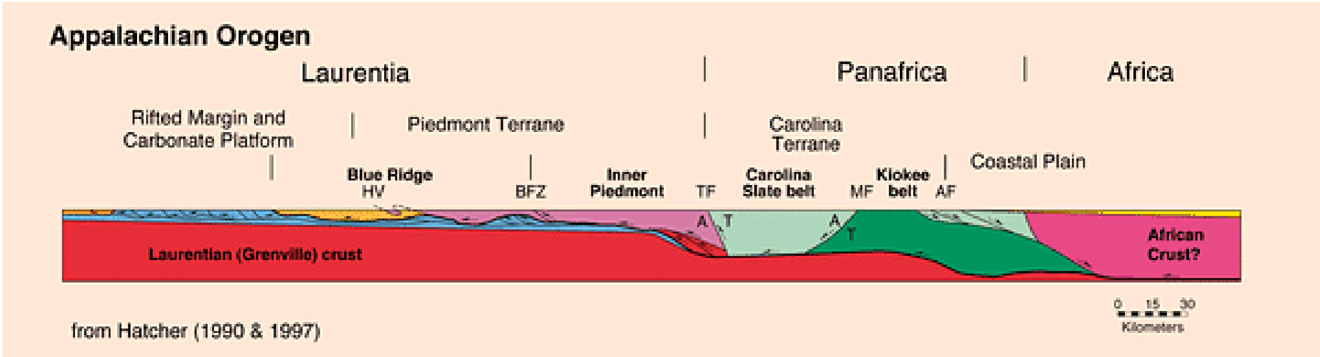
Middle Ordovician

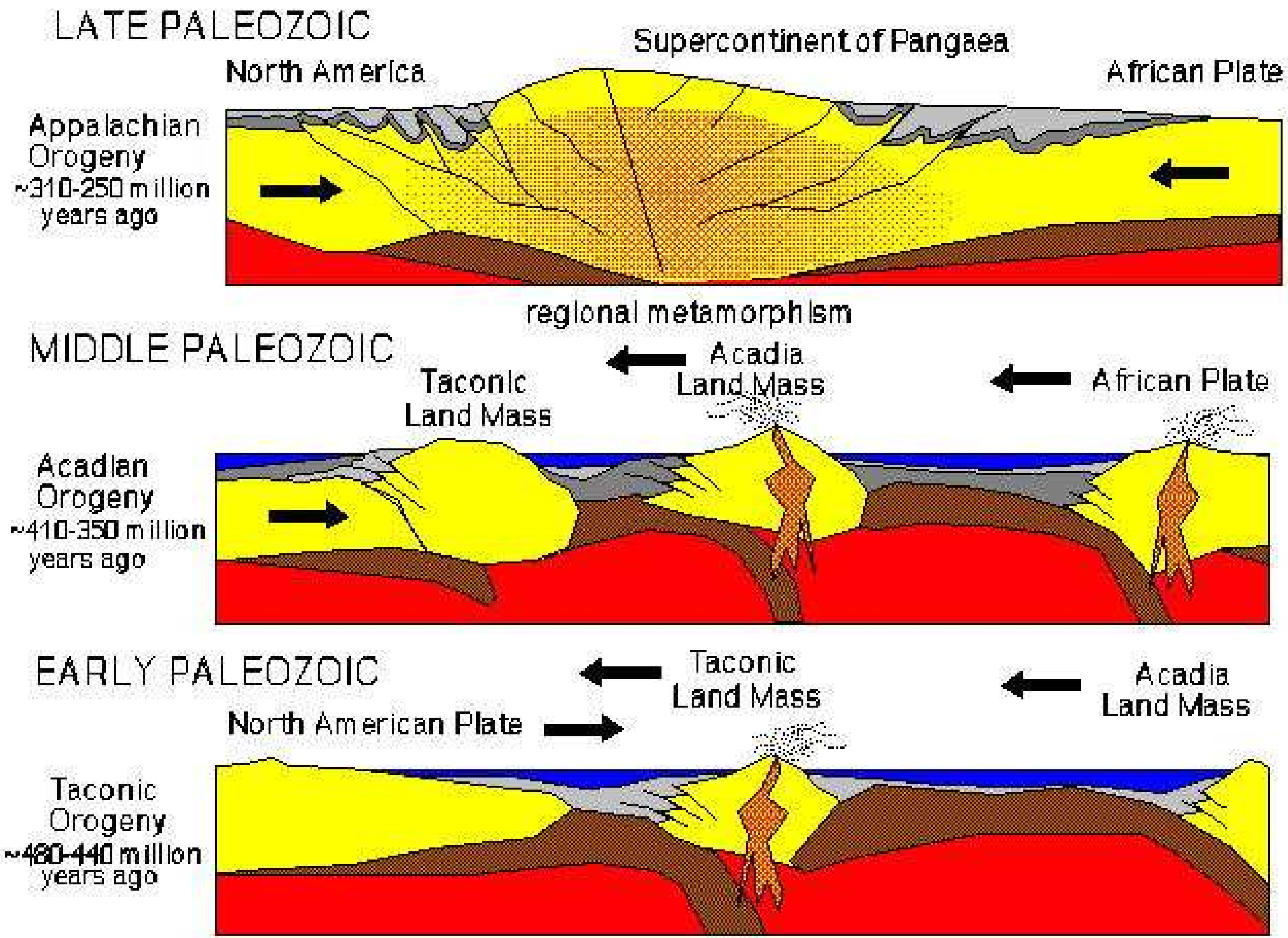
Late Ordovician

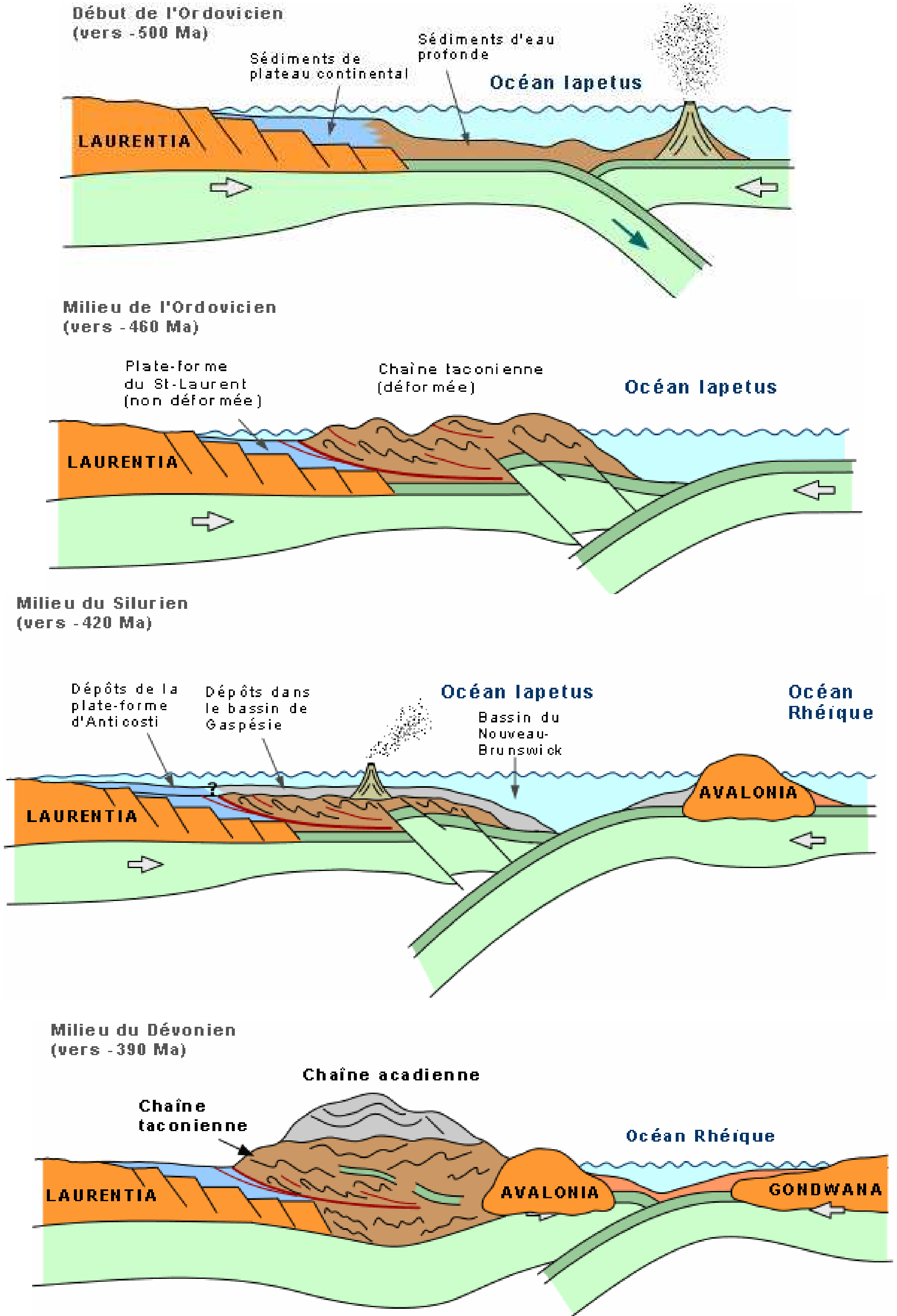
FIGURE 11.33 Restoration of eastern North America showing evolution from a passive to an active continental margin culminating in arc collision, which caused the Taconian orogeny. As the continental margin was downwarped in Late Ordovician time, carbonate sedimentation gave way to deeper-water *flysch* deposition. Finally, Taconian upheaval resulted in westward spreading of nonmarine molasse. (*Adapted from J. F. Dewey and J. M. Bird, 1970, Bulletin of the Geological Society of America, v. 81, pp. 1031–1061; and D. B. Rowley and W. F. Kidd, 1981, Journal of Geology, v. 89, pp. 199–218.*)

The Taconic Orogeny changed eastern North America from a passive margin to a foreland basin setting. Ancient slope and rise and abyssal plain sediment was thrust up onto the continent east of the Hudson River, NY going south to Harrisburg, PA. This rock is called the Taconic allochthon. The line between the allochthon and the autochthon (rock that was not moved) is called Logan's Line. Parts of the island arc that collided with North America can be seen in the Berkshire Mnts., MA. Ophiolite successions can be seen in New Foundland.

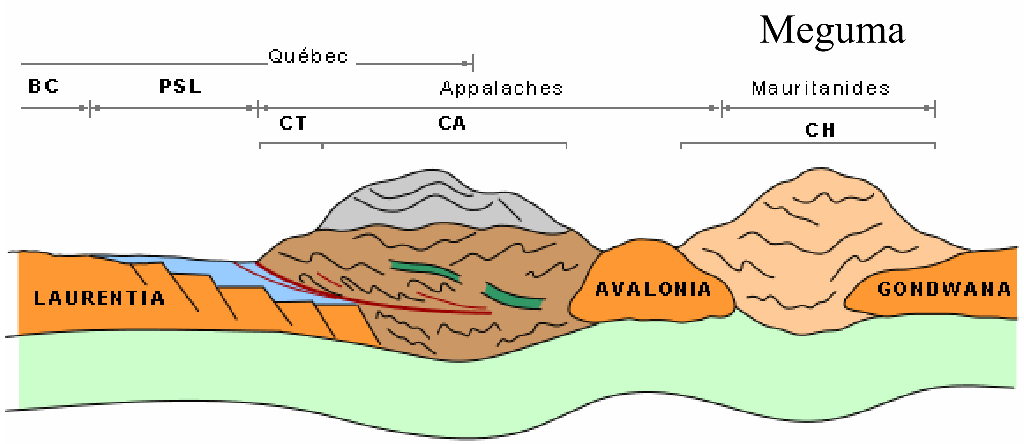

ONTARIO
ERIE
MAINE
N.H.
MASS.
CONN.
RI
N.Y.
Catskill Mtns.
N.J.
PENN.
APPALACHIAN PLATEAUS
VALLEY AND RIDGE PROVINCE
PIEDMONT
PLATEAU
COASTAL PLAIN
TENN.
GA
FLA
ALA.
N
0 100 200 km


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
Laurentian (Grenville) crust
African Crust?
0 15 30
Kilometers
from Hatcher (1990 & 1997)


LATE PALEOZOIC
Supercontinent of Pangaea
North America
African Plate
Appalachian Orogeny ~310-250 million years ago
regional metamorphism
MIDDLE PALEOZOIC
Acadia Land Mass
Taconic 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


Début de l'Ordovicien
(vers -500 Ma)
Sédiments de plateau continental
Sédiments d'eau profonde
Océan Iapetus
LAURENTIA
Milieu de l'Ordovicien
(vers -460 Ma)
Plate-forme du St-Laurent (non déformée)
Chaîne taconienne (déformée)
Océan Iapetus
LAURENTIA
Milieu du Silurien
(vers -420 Ma)
Dépôts de la plate-forme d'Anticosti
Dépôts dans le bassin de Gaspésie
Océan Iapetus
Bassin du Nouveau-Brunswick
Océan Rhéique
?
LAURENTIA
AVALONIA
Milieu du Dévonien
(vers -390 Ma)
Chaîne acadienne
Chaîne taconienne
Océan Rhéique
LAURENTIA
AVALONIA
GONDWANA

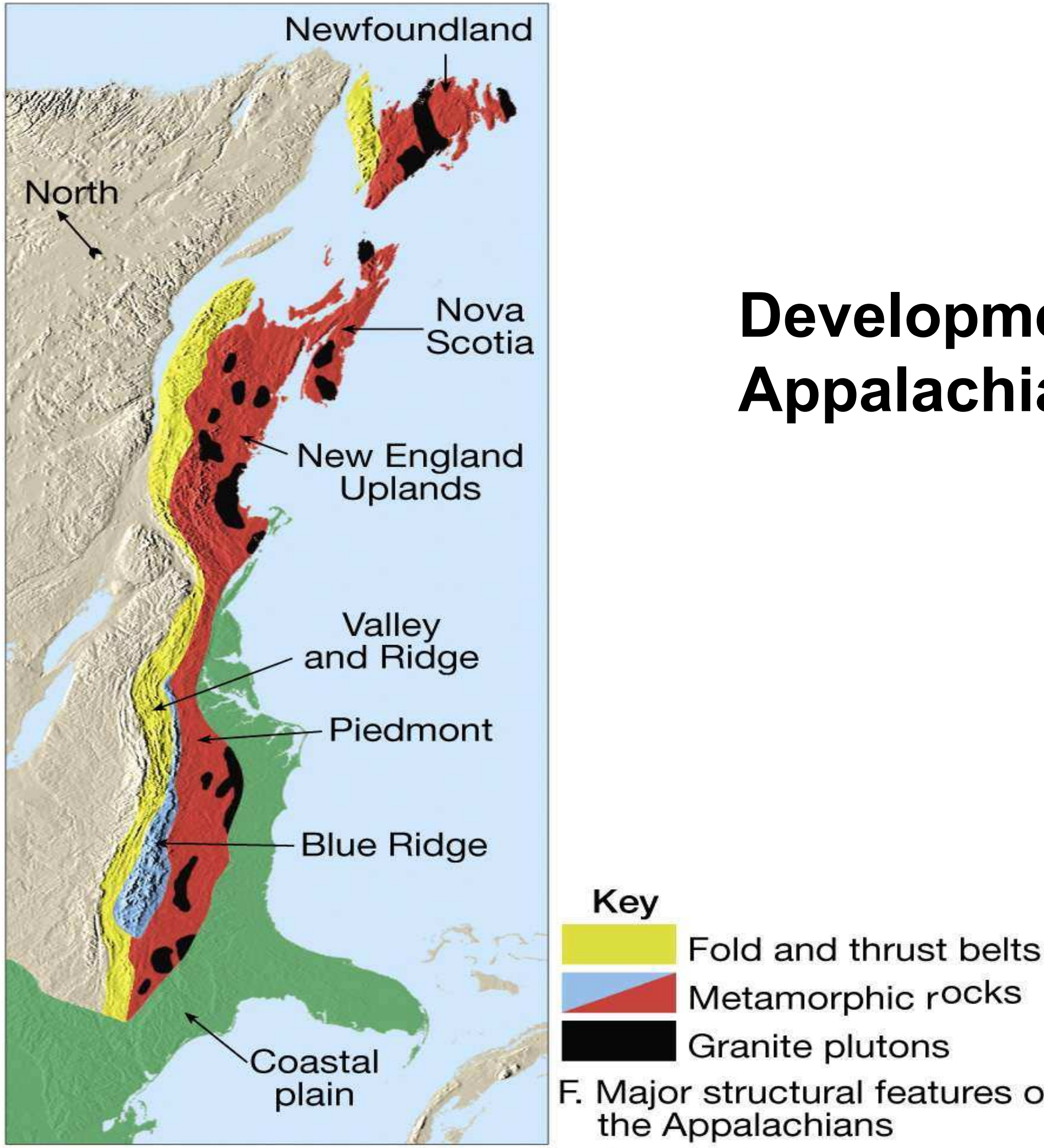
Fin du Carbonifère
(vers -310 Ma)



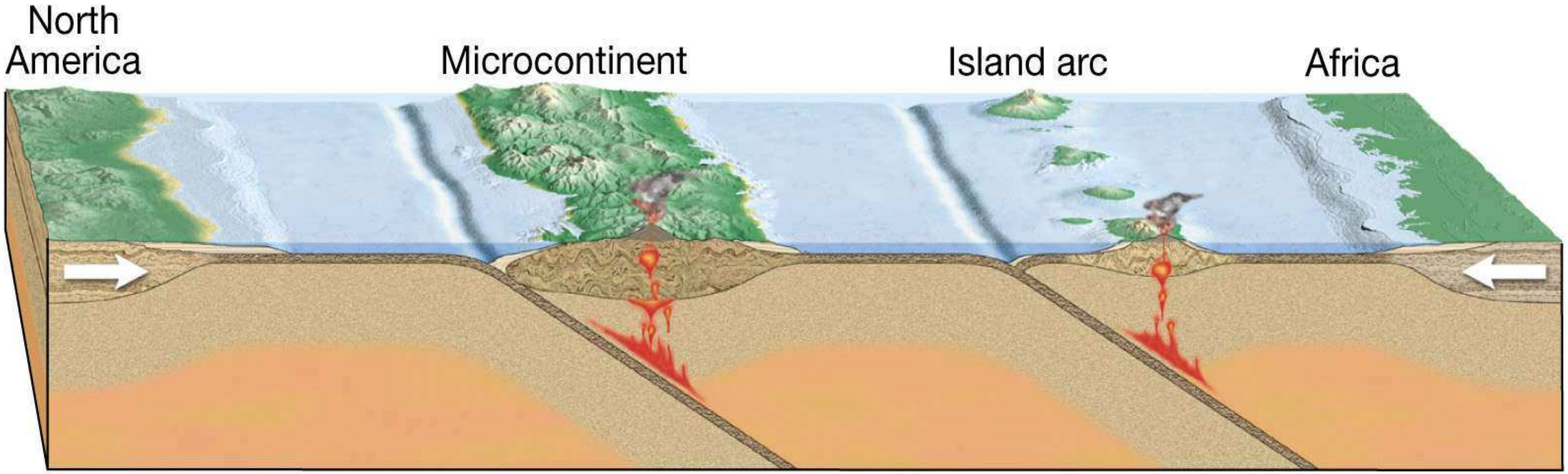
BC Bouclier canadien
CT Chaîne taconienne

Jurassique
(vers -160 Ma)

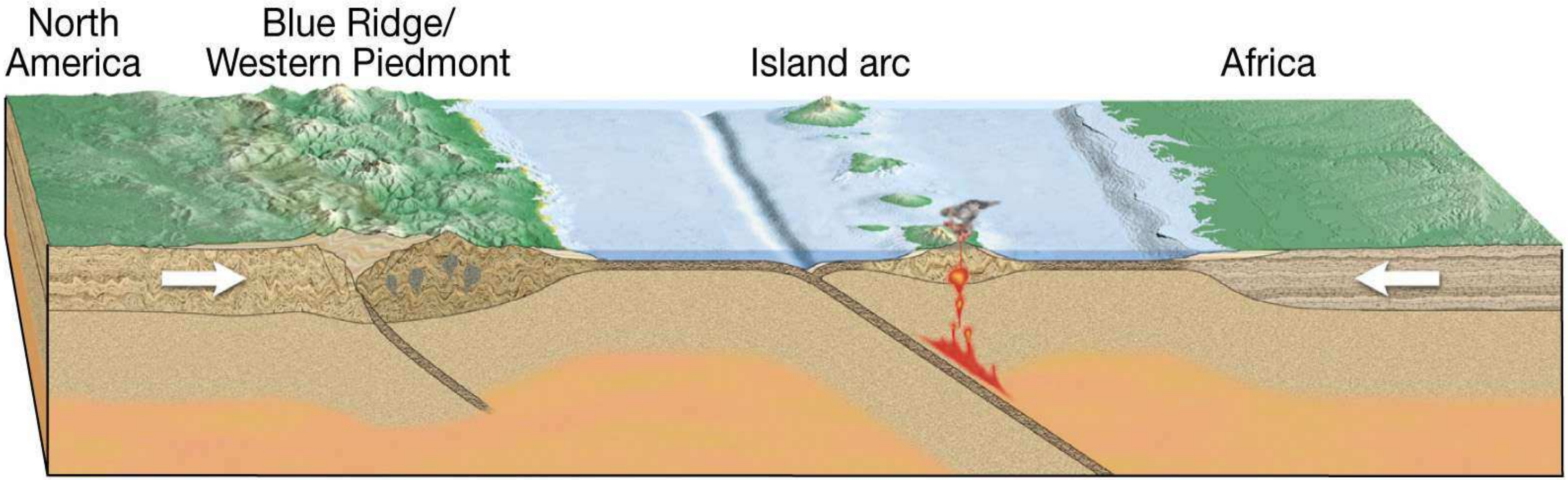
Development of the Appalachian Mountains



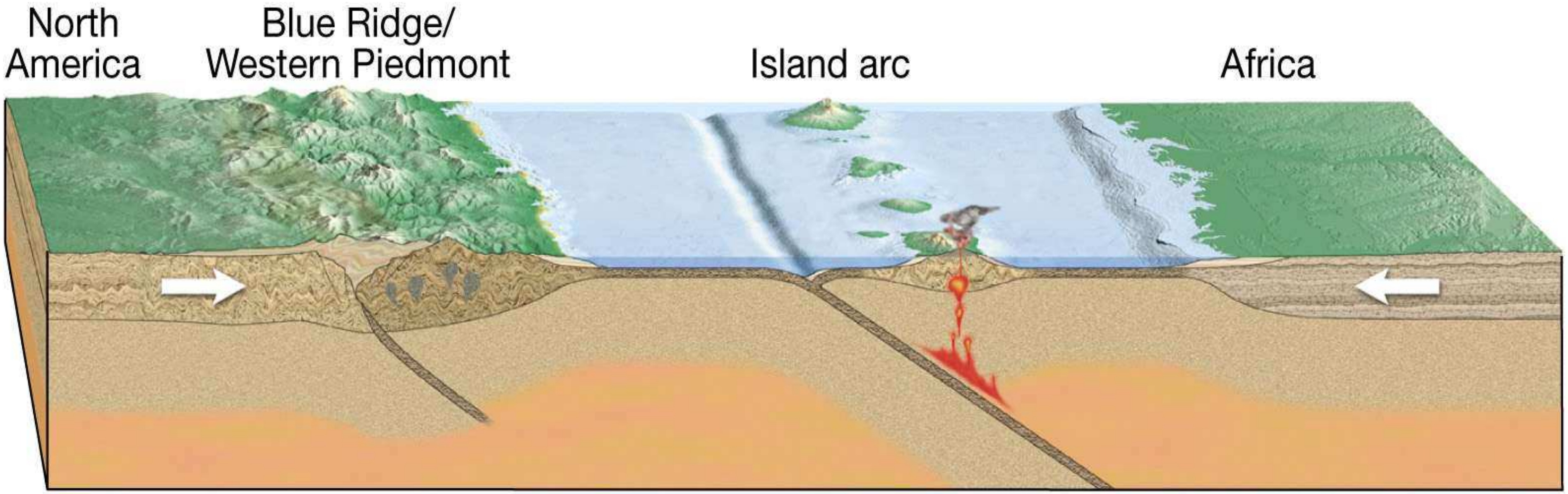
F. Major structural features of the Appalachians



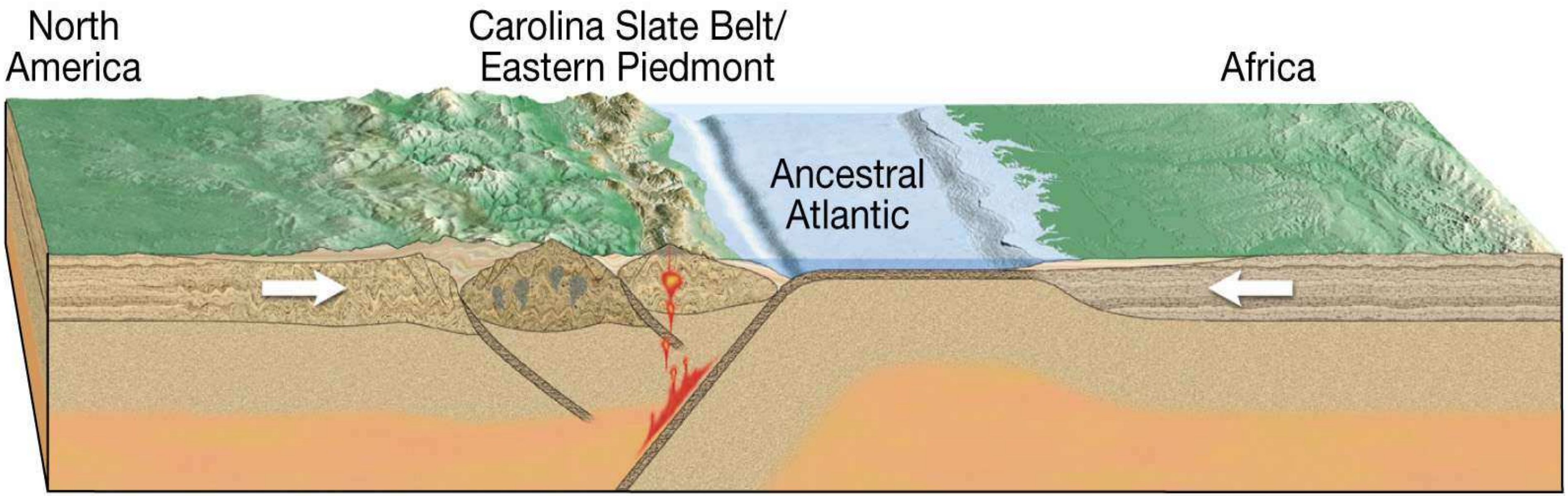
A. 600 million years ago



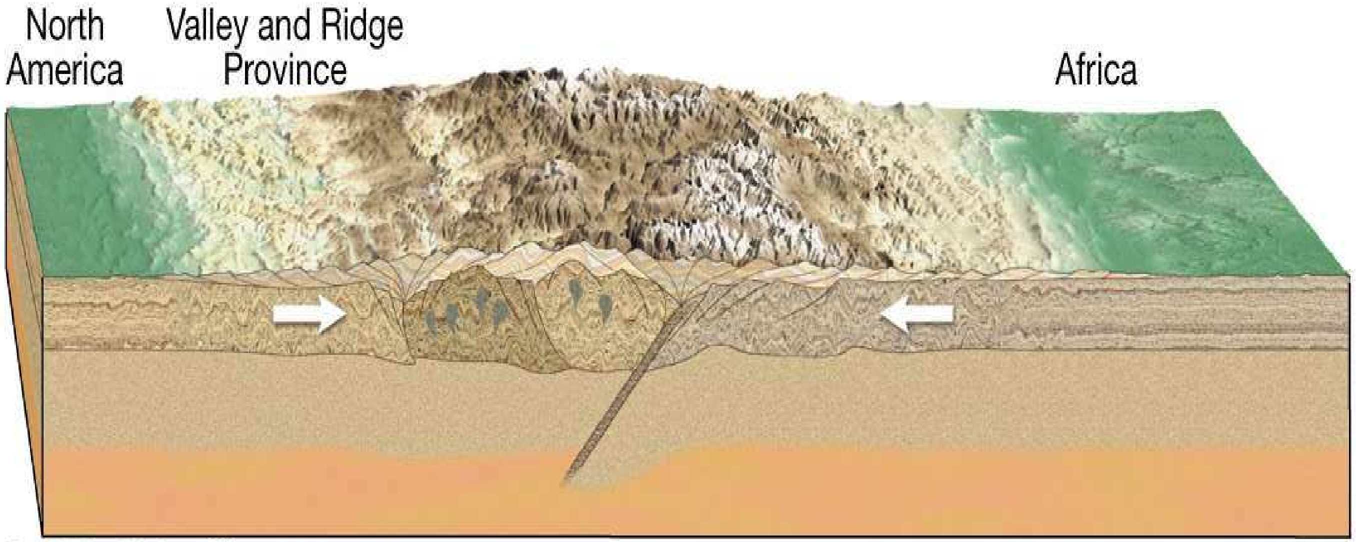
B. 450–500 million years ago



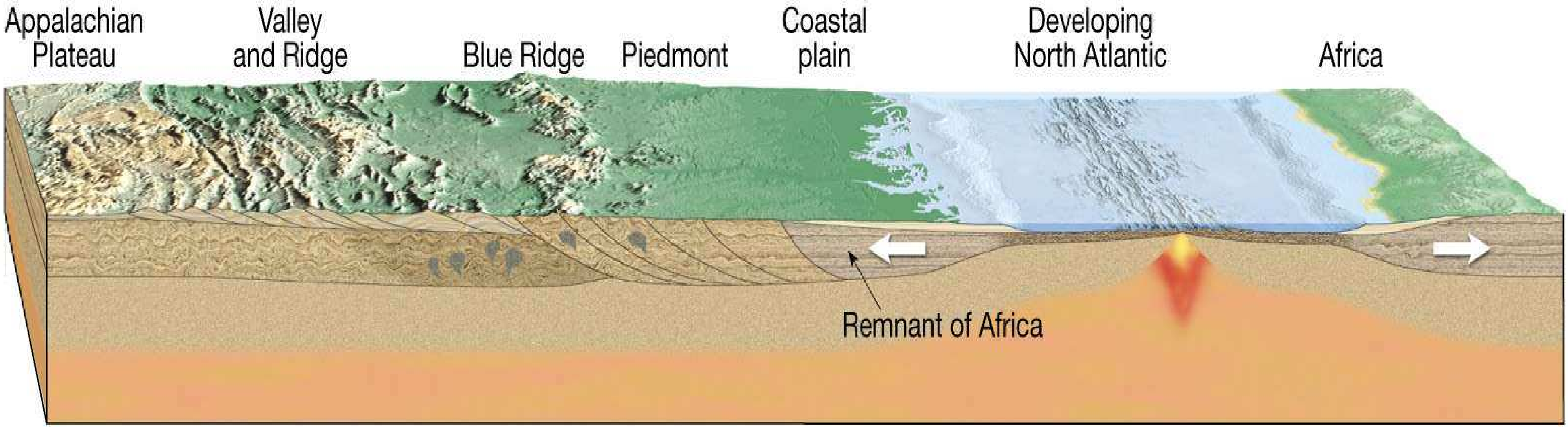
B. 450–500 million years ago



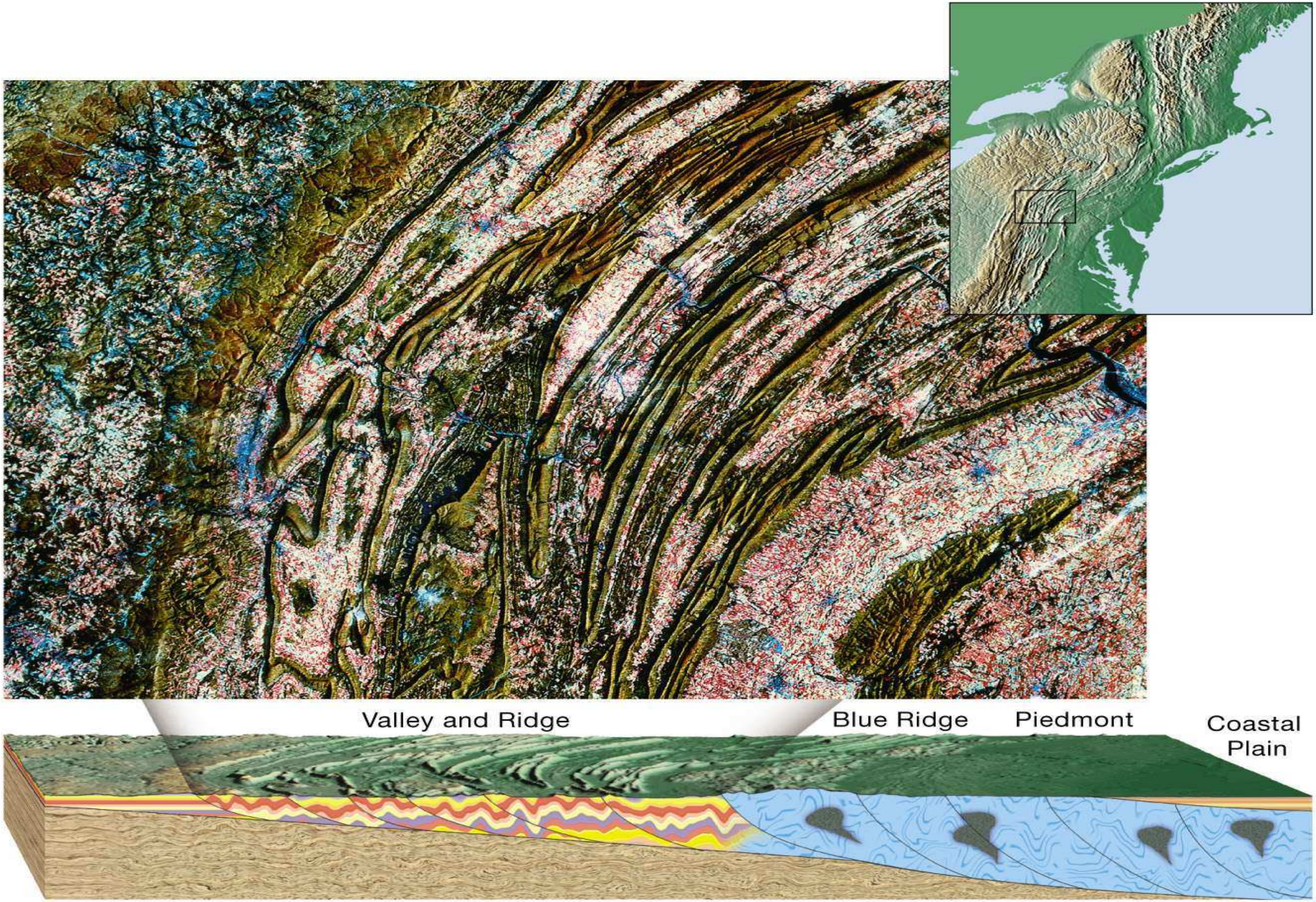
C. 400 million years ago



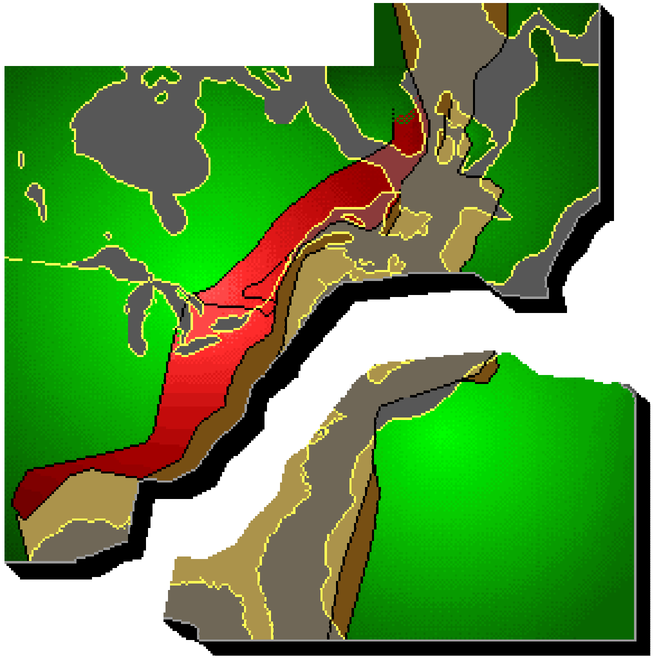
D. 250–300 million years ago

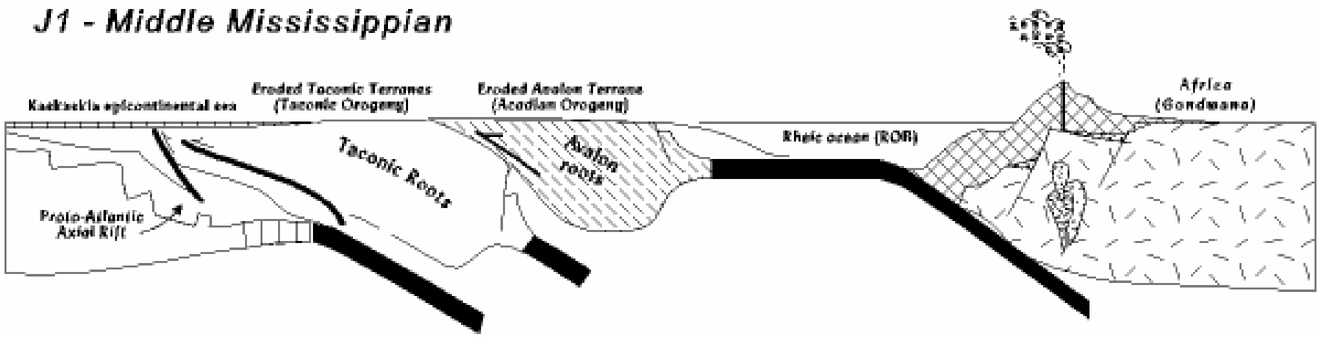


E. Begin 200 million years ago North Atlantic begin to open

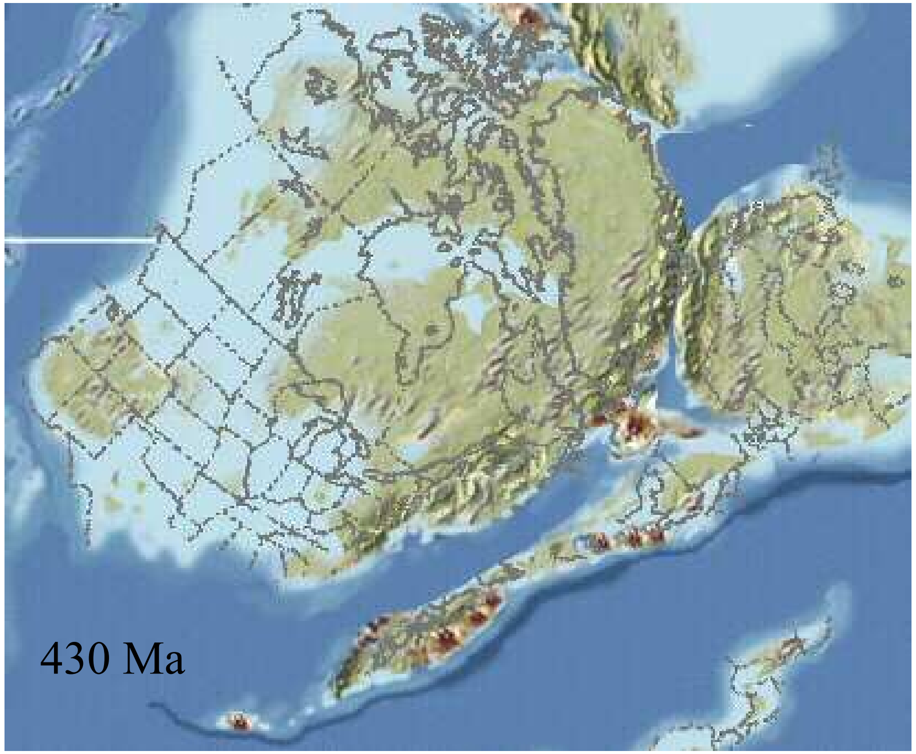


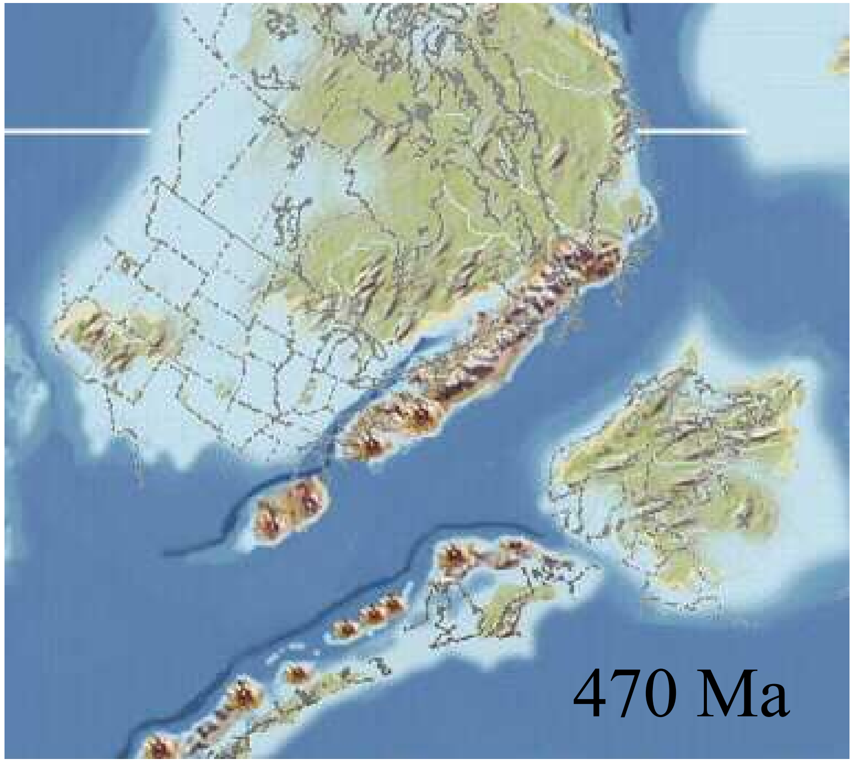
Folded mountains in the Valley and Ridge Province

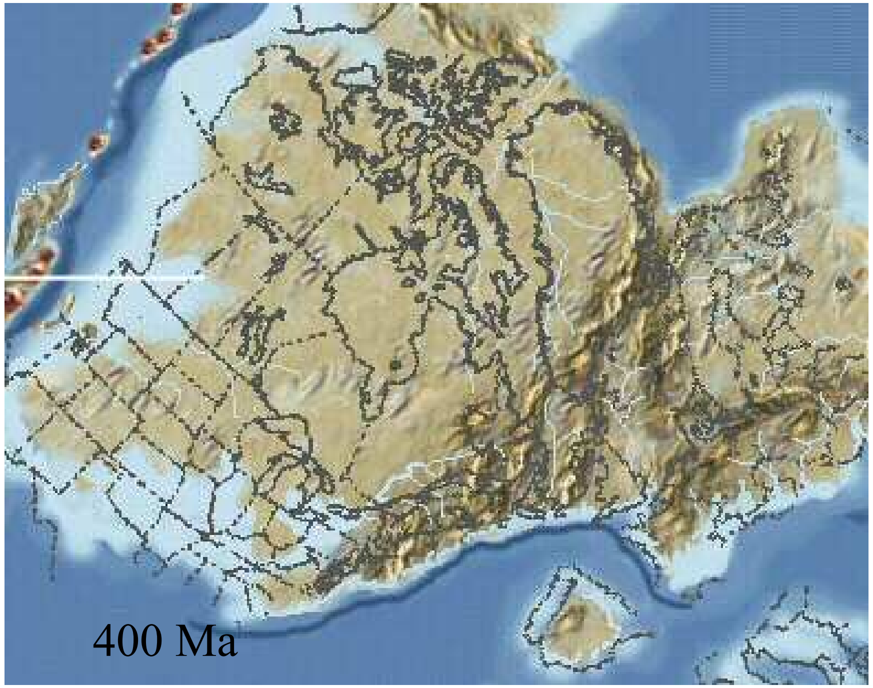


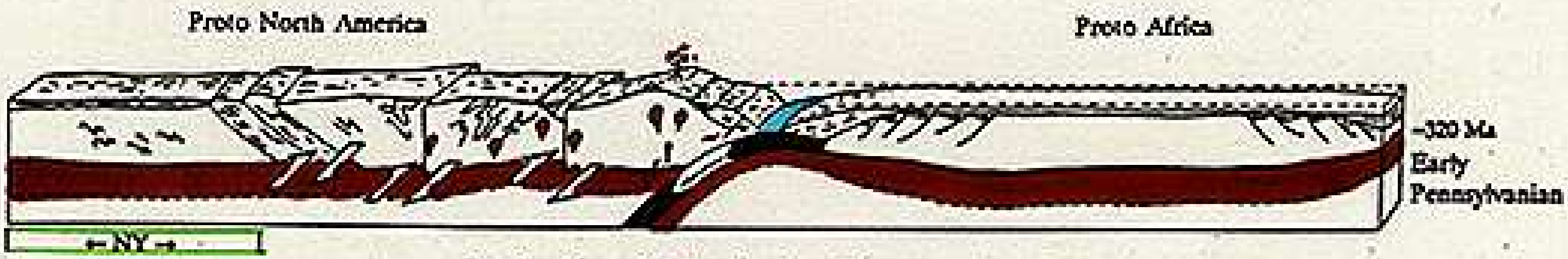

J1 - Middle Mississippian
Kaskaskia epicontinental sea
Eroded Taconic Terranes
(Taconic Orogeny)
Eroded Avalon Terrane
(Acadian Orogeny)
Taconic Roots
Avalon roots
Proto-Atlantic Axial Rift
Rheic ocean (ROR)
Africa
(Gondwana)


510 Ma

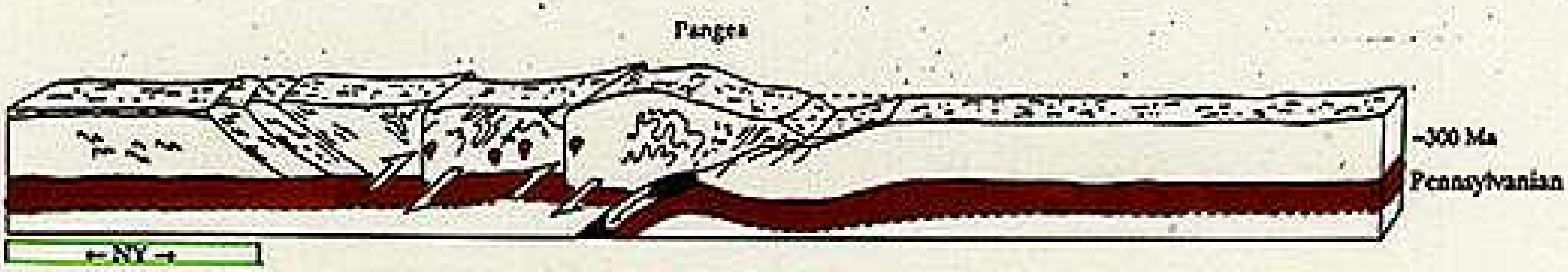

430 Ma


470 Ma

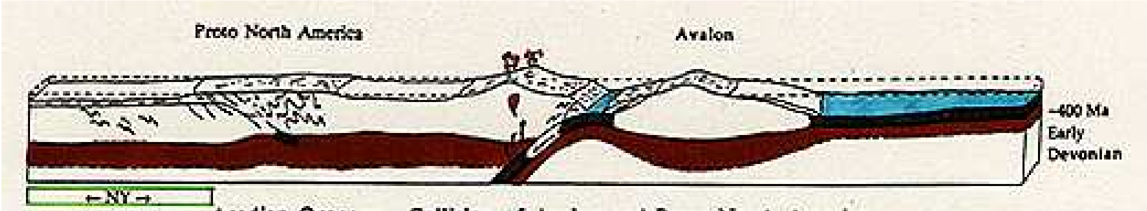

400 Ma



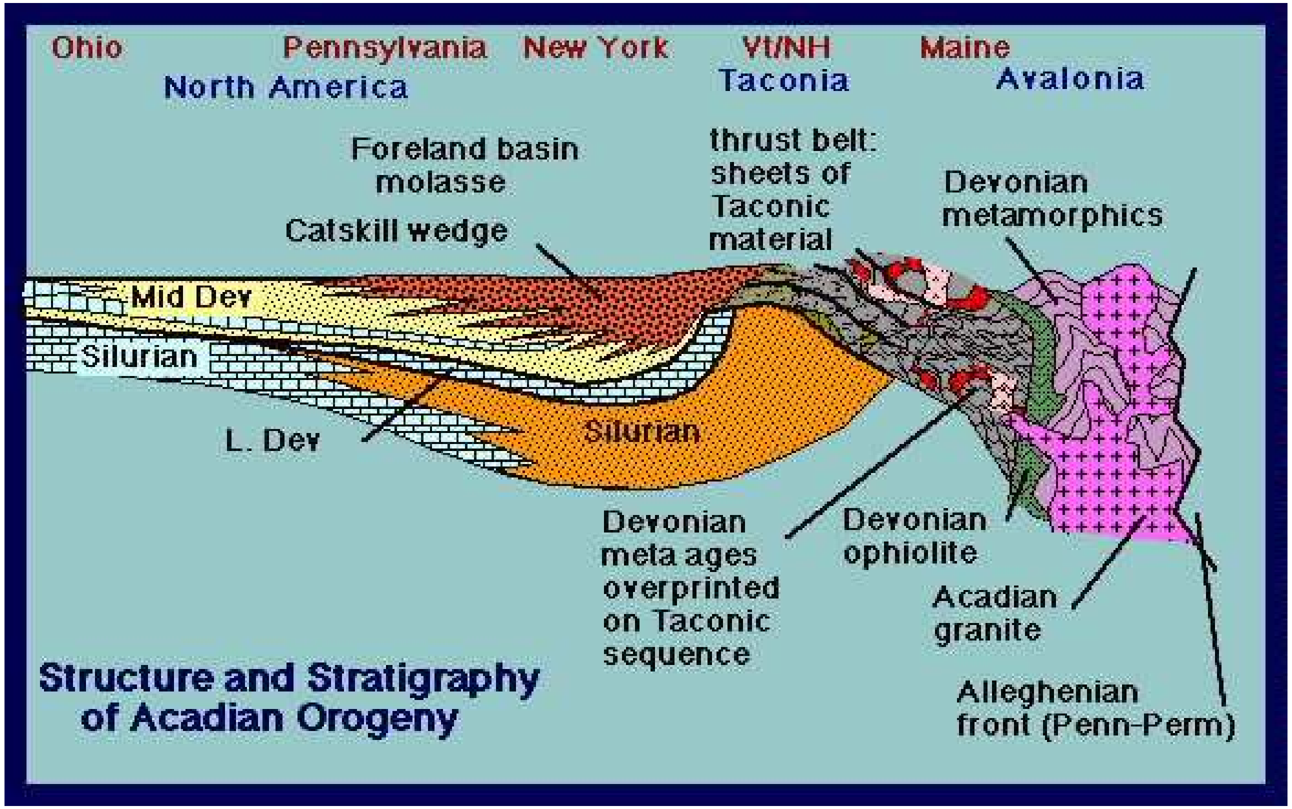
Beginning of Alleghanian Orogeny



Continued Alleghanian Orogeny - Formation of Supercontinent Pangea



Acadian Orogeny - Collision of Avalon and Proto North America



Apalače **představují složený orogen, jehož tvorba probíhala jak během kaledonských fází tak během variských fází . V jejich rámci můžeme rozlišit několik teránů.**
Údaje seismiky ukazují, že celá jižní část Apalačí je pravděpodobně podstýlána velkou zónou odlepení a celý horský hřeben je alochtonní. Podobné struktury se dají pozorovat v seismických řezech i v severních Apalačích. Pro geologickou stavbu jsou významné alochtonní terány.

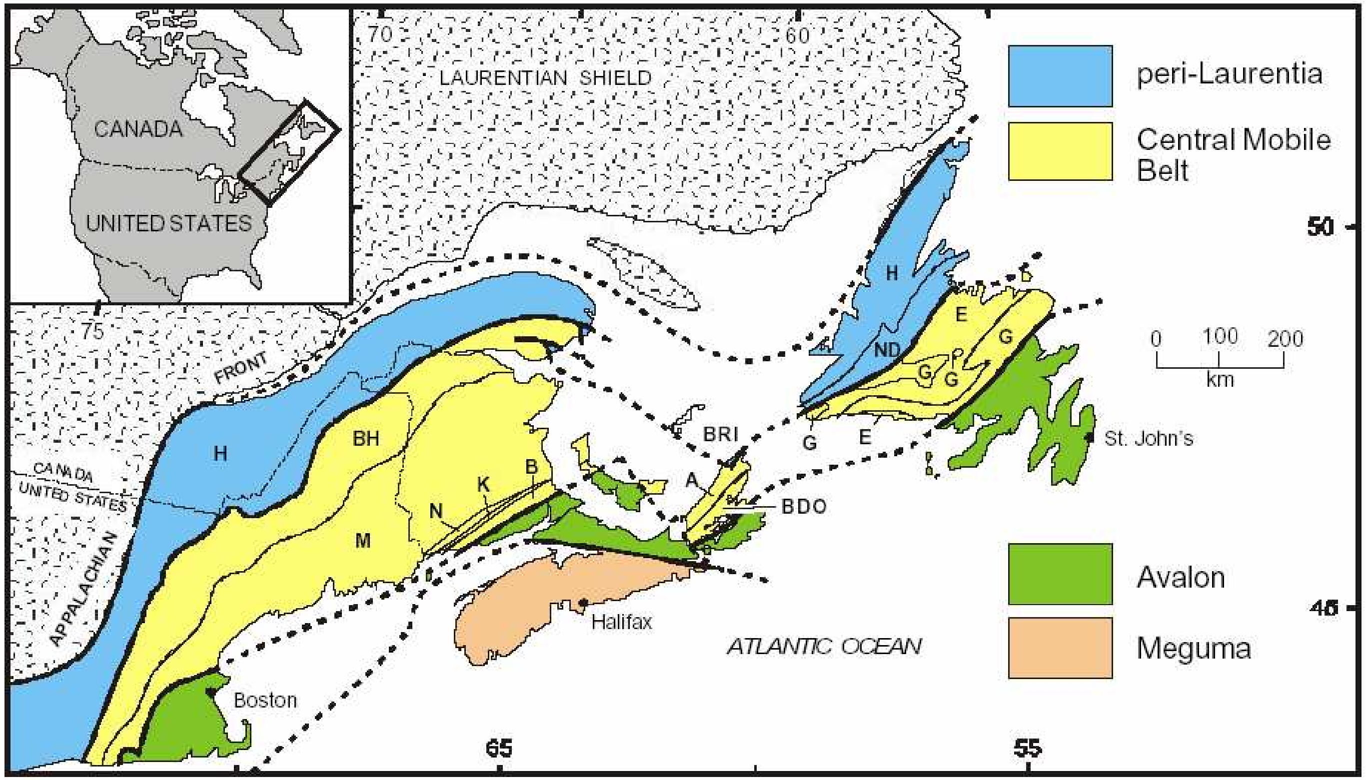
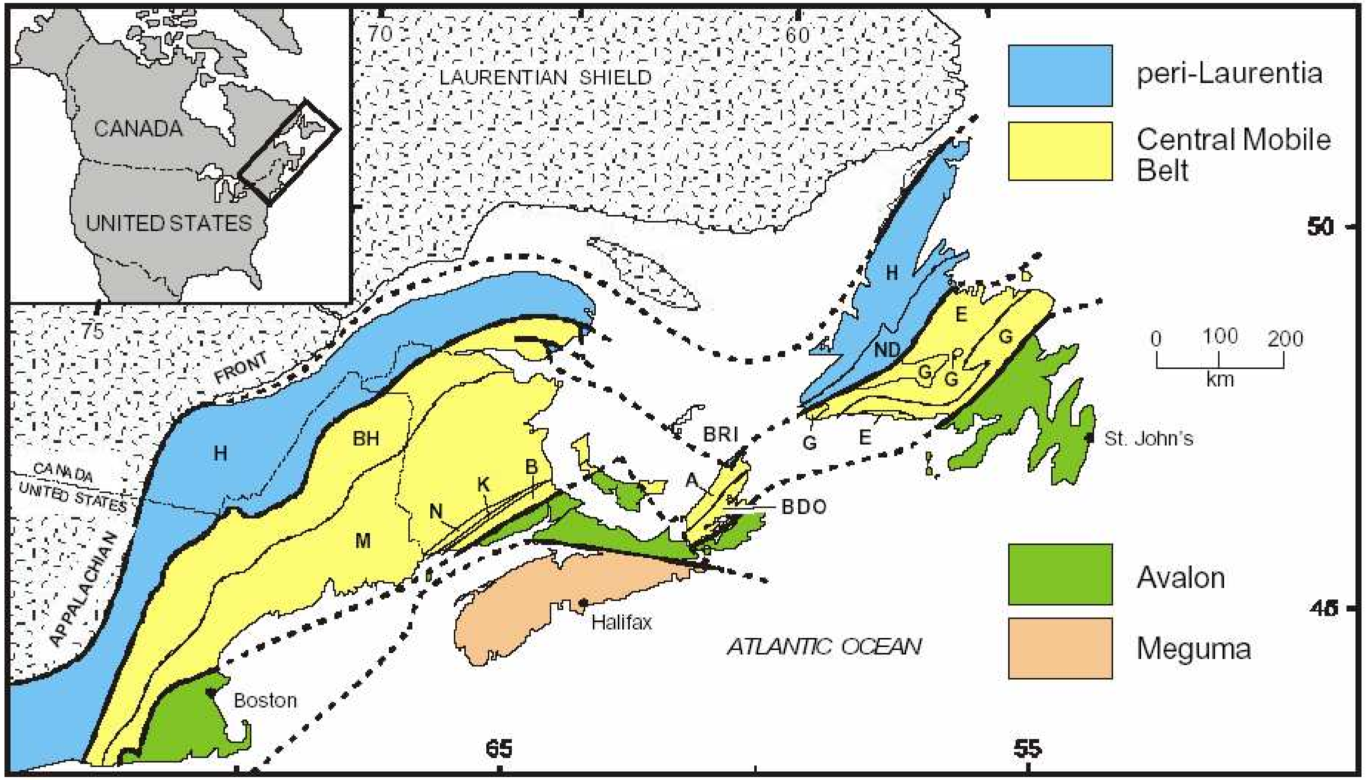


Figure 1. Simplified map of the northern Appalachian orogen showing crustal blocks and terranes (A, Aspy; B, Brookville; BDO, Bras d'Or; BH, Bronson Hill; BRI, Blair River inlier; E, Exploits; G, Gander; H, Humber; K, Kingston; M, Miramichi; N, New River; ND, Notre Dame;

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

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

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



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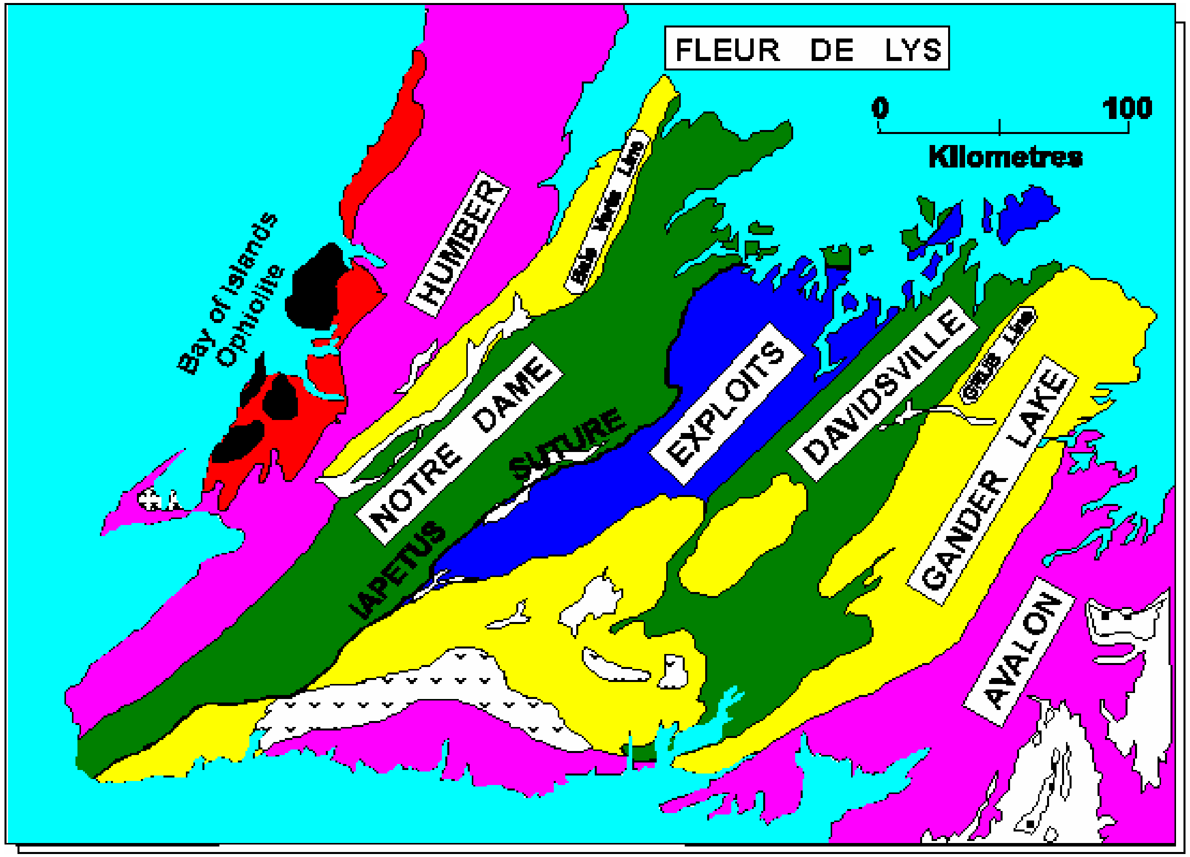
Terány skupiny I je tvořen sedimenty nejvyššího proterozoika a spodního paleozoika a svrchnoproterozoickým krystalinikem. Reprezentuje **fragmenty Laurentie** nebo **mikrokontinenty** původně situované blízko jejího kontinentálního okraje.

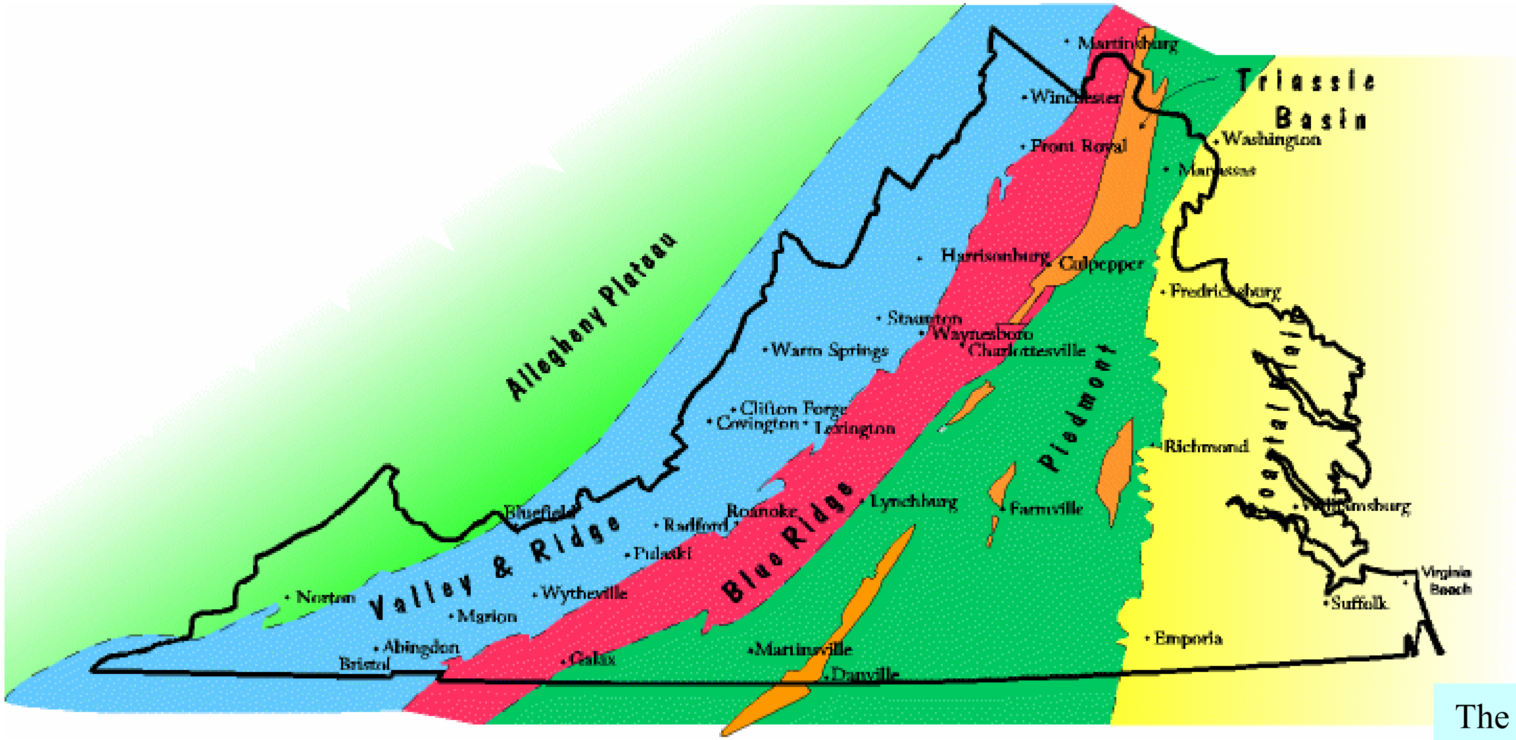
Terán Humber

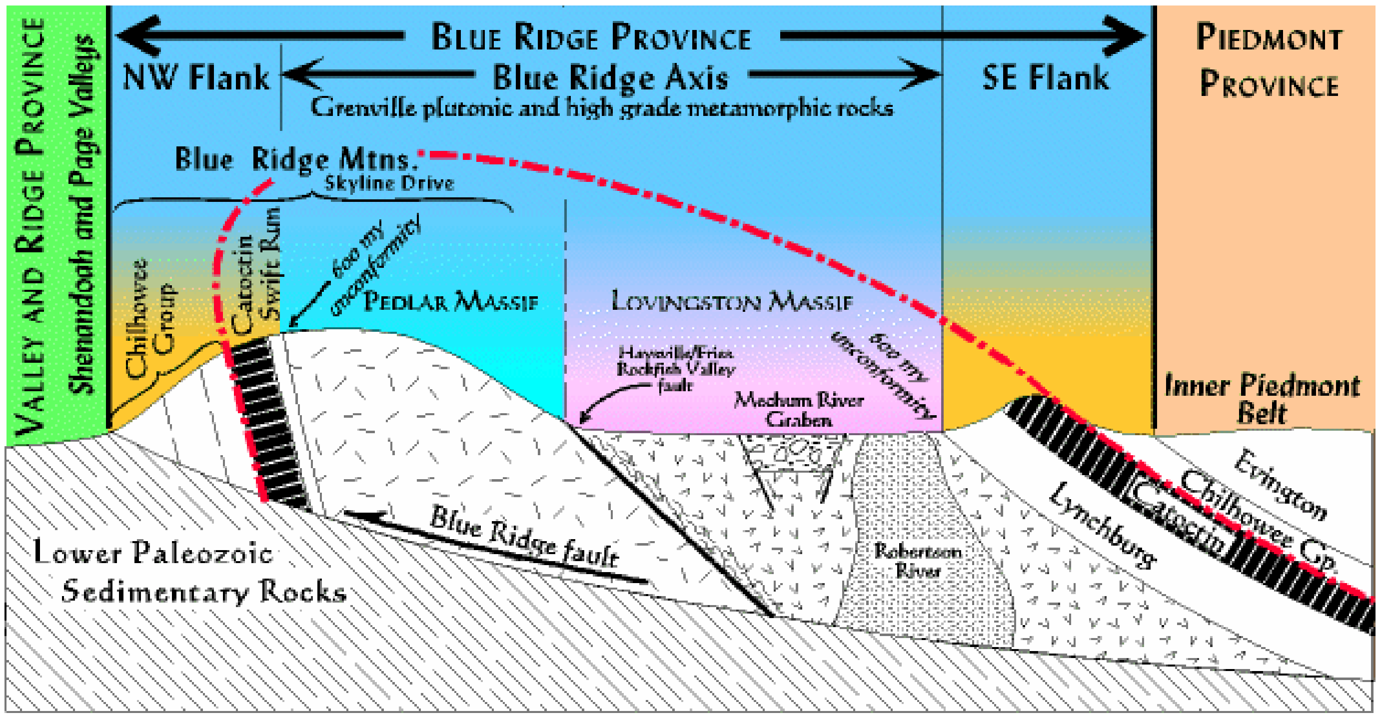
Tento terán zahrnuje miogeosynklinálu situovanou na laurentinském pasivním kontinentálním okraji a takonské alochtony. Táhne se od SZ Newfoundlandu do zóny **Valley and Ridge a Blue Ridge na jihu**. Basement se skládá z **grenvilských** rul (1,0Ma) na kterých spočívají klastické a karbonátové riftové **sedimenty** kambria až spodního ordoviku

Na kontinentální okraj jsou obdukovány **dva typy teránů** – **Fleur de Lys Supergroup** (metapelity a meetapsamity interpretované jako sedimenty kontinentálního svahu na jv od karbonátové lavice) a **velké alochtony** obsahující **ofiolity** jako jsou **Bay of Island Complex**, který byl obdukován v llanvirnu.

První výskyt **flyšových** úlomků v slepencích karbonátového okraje datuje přičlenění prvních teránů k americkému kontinentálnímu okraji v nejvyšším **arenigu-llanvirnu**.

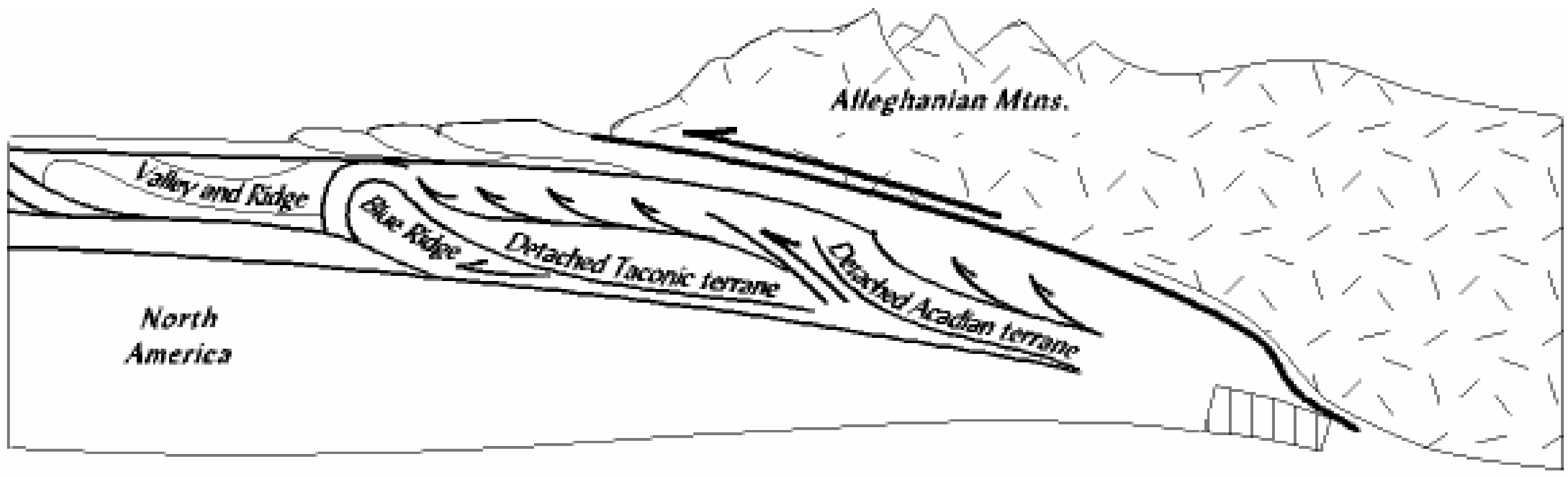






The modern Blue Ridge is an overturned anticline. That is, the rocks have been arched up into a fold, and then shoved over toward the west (left) so that the rocks on the western flank are now no longer right side up (follow the red dashed line).

Notice the Blue Ridge thrust fault at the base; the Blue Ridge province has been moved westward from its site of origin, perhaps as far east as Richmond. Below the Blue Ridge fault Cambrian and Ordovician sediments ("Lower Paleozoic Sedimentary Rocks") of the Valley and Ridge extend eastward under the Blue Ridge and piedmont provinces (cross section).


Alleghanian Mtns.
Valley and Ridge
Blue Ridge
Detached Taconic terrane
Detached Acadian terrane
North
America

Terány II a III reprezentuje **ostrovní oblouky**, jedná se o **ofiolity** a přidruženou **akreční melánž**, Zahrnuje **takonskou** sekvenci v USA a Kanadě (Notre Dame) a terány **Dunnage a Exploit a Gander** v Kanadě a terán **Piedmont** v jižních Apalačích.. Seismické údaje ukazují, že terány Dunnage a Gander jsou alochtonní nad spodní kontinentální kůrou a že seveoamerický okraj pokračuje 70 km pod terán Tyto terány představují jenom velmi hrubé rozdělení, protože **každý z nich se skládá ze značného počtu fragmentů** (nebo dílčích teránů?) různého původu. Obsahují mnoho ofiolitů a oblouků odvozených z Iapetu a deformovaných během kolize kontinentálních okrajů Laurentie a Avalonie.

Terán Piedmont (nebo Vnitřní Piedmont) je složený z několika různých **teránů a fragmentů**. Jedná se o nakupení na západ sunutých příkrovů obsahujících krystalické břidlice, ruly, amfibolity a mafické-ultramafické tělesa , které mohou reprezentovat zbytky ofiolitů.. Reflexní profily ukazují, že piedmontský terán a přilehlé pásy **břidlic Blue Ridge, Charlotte a Carolina** náléžejí 6-15 km mocnému příkrovu nad autochtonním basementem. Zdá se, že byl transportován přinejmenším **260km přes** kontinetální okraj Laurentie během alleghanské orogeneze produkované kolizí Severní Ameriky a Afriky.

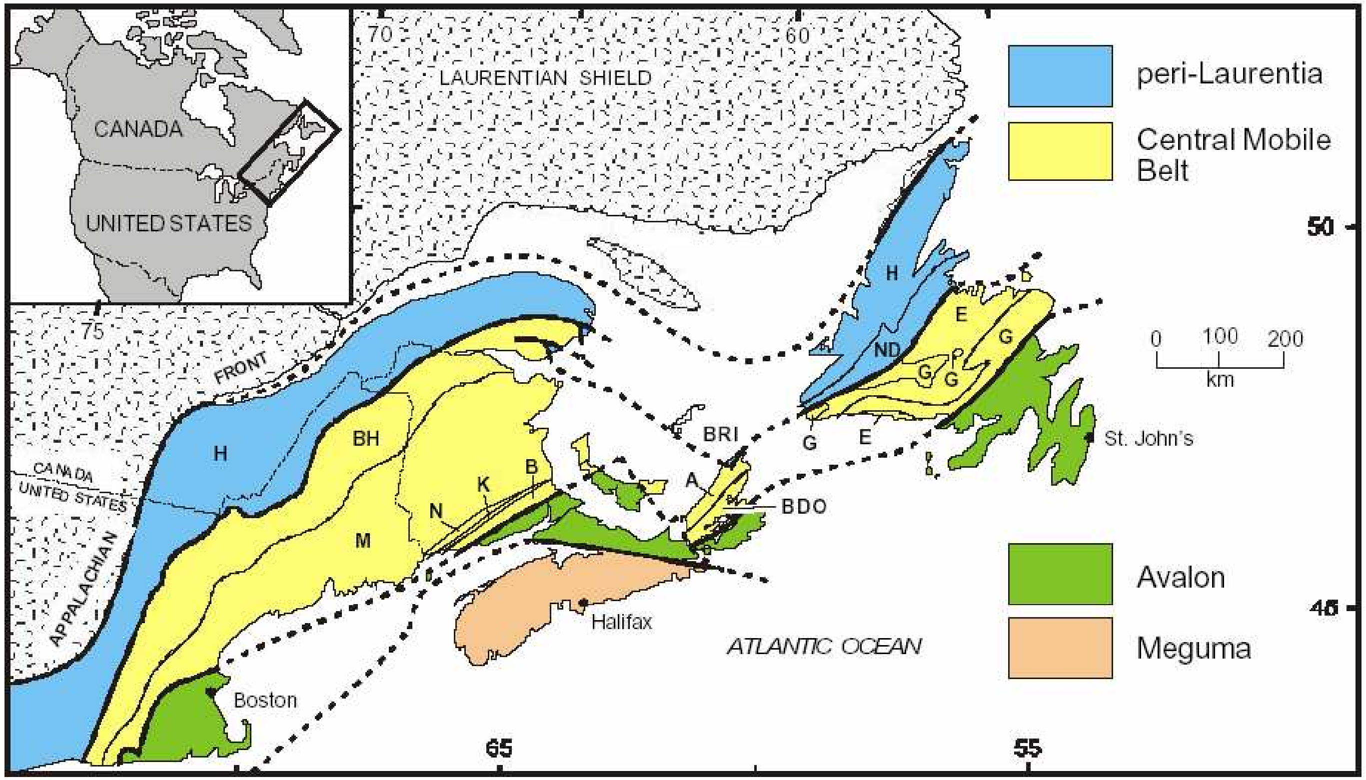


Figure 1. Simplified map of the northern Appalachian orogen showing crustal blocks and terranes (A, Aspy; B, Brookville; BDO, Bras d'Or; BH, Bronson Hill; BRI, Blair River inlier; E, Exploits; G, Gander; H, Humber; K, Kingston; M, Miramichi; N, New River; ND, Notre Dame;

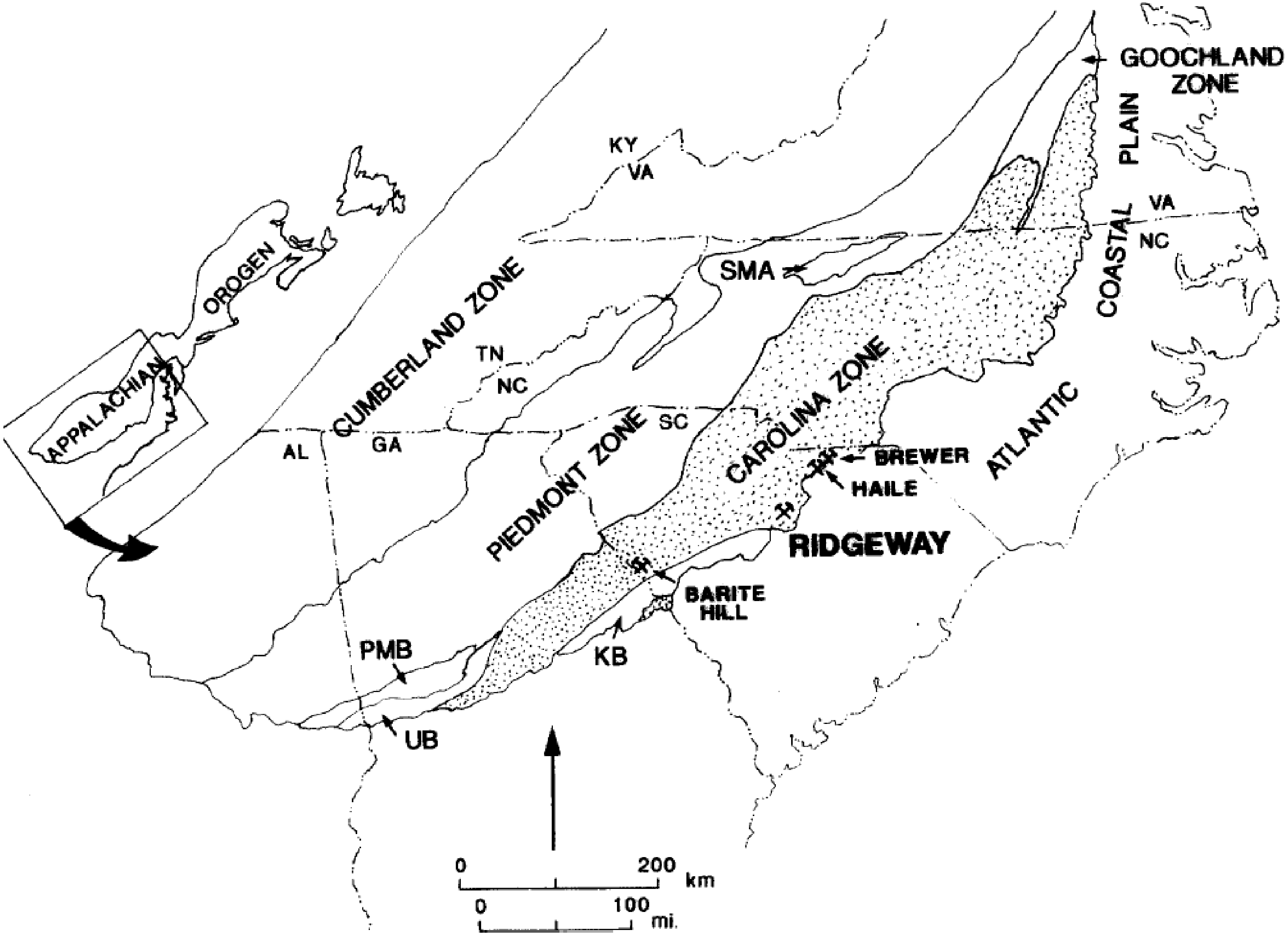
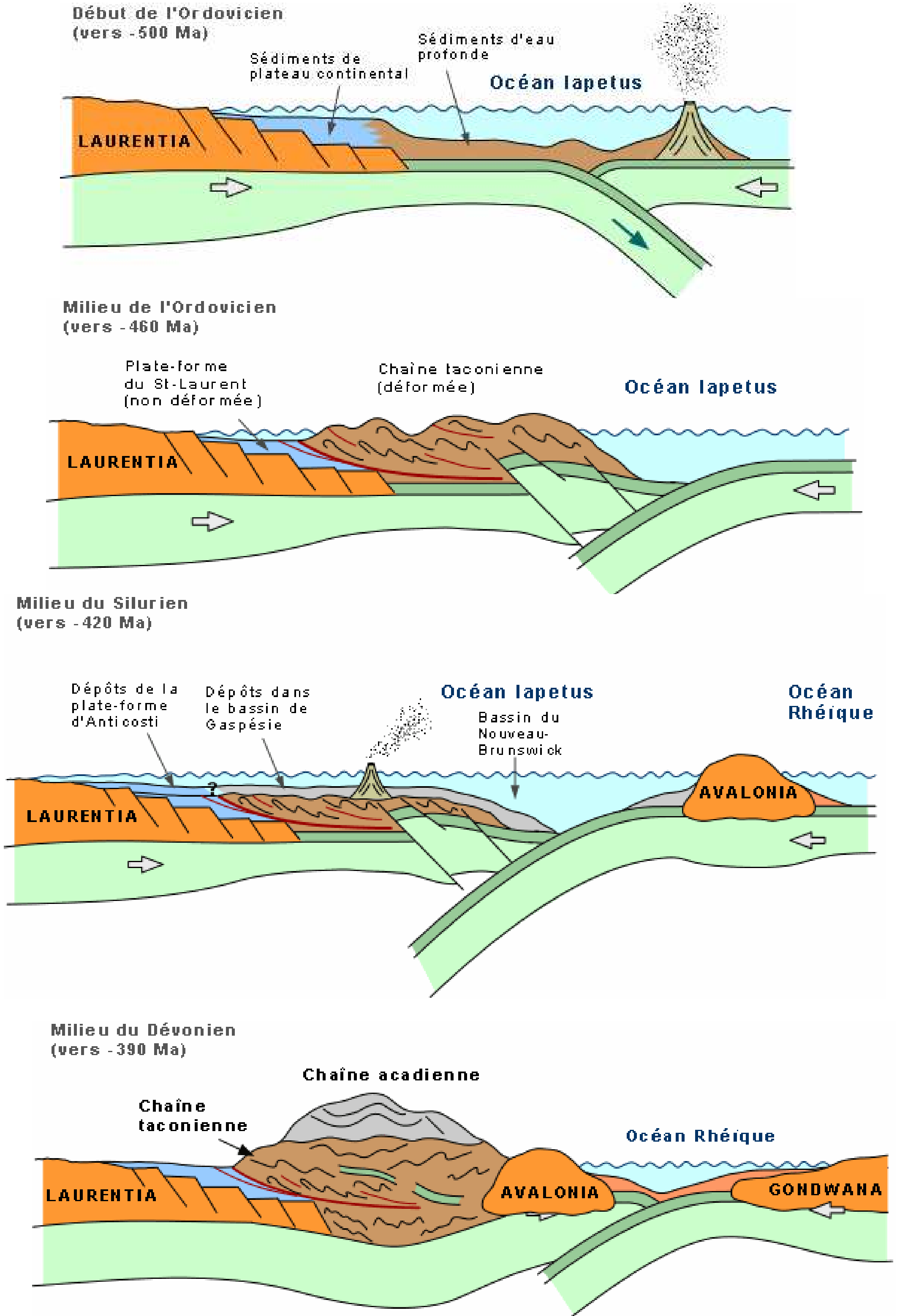


Figure 1. Tectonostratigraphic zonal map of the Southern Appalachian orogen (after Hibbard and Samson, 1995). Locations of the four gold mines active in South Carolina during the late twentieth century are posted on the map. The mines are located within he Carolina zone, whose largest subunit is the Carolina terrane subduction volcanic arc.

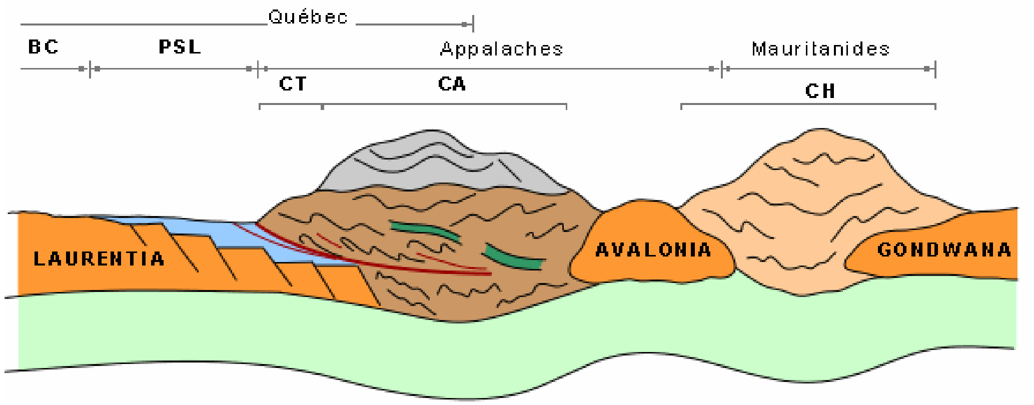
Terány skupiny IV. Zahrnuje v jižní části Apalačí **karolinské břidličné pásmo** a **avalonský** sled v severních Apalačích. **Avalonský terán** obsahuje menší **dílčí fragmenty** je označován jako avalonský **složený terán nebo jako avalonský superterán**. Obsahuje **ruly**, **vulkanické** a **sedimentární horniny** pozdně prekambrického až spodnopaleozoického stáří, které jsou již dlouho považovány za africko-gondwanské.
Avalonský terán má jinou přesilurskou historii než terán Gander a západnější terány, obzvláště **odlišnou kambrickou trilobitovou faunu**.

Terán V. Jedná se o sekvenci kambrických-ordovických drob a břidlic usazenou poblíž okraje kontinentu. V Apalačich se označuje jako terán **Meguma** a podobné horniny jsou známy i ze severozápadní Afriky z **mauritanid**.
Terán Meguma obsahuje kambro-ordovický **flyš**.

Few of the sedimentary rocks of the Carolina Slate Belt in South Carolina contain fossils of Cambrian age (about 500 million years old). They are referred to as "Gondwanan" because they resemble Cambrian fossils found in the southern continents rather than those in North America. These fossils and those in other blocks along the eastern edge of North America show that a series of terranes (known as "Avalonian") were close to the western margin of South America 500 million years ago and moved to collide ("dock") with eastern North America at a later time.

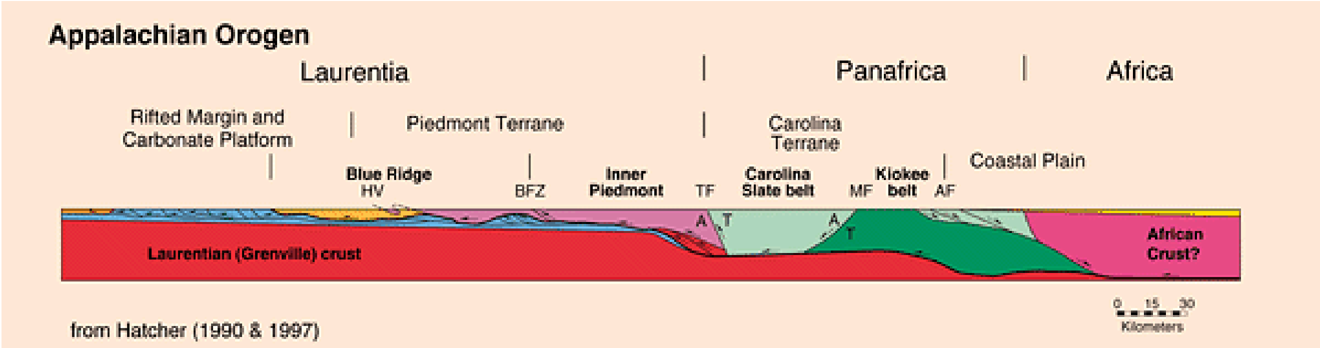

Début de l'Ordovicien
(vers -500 Ma)
Sédiments de plateau continental
Sédiments d'eau profonde
Océan Iapetus
LAURENTIA
Milieu de l'Ordovicien
(vers -460 Ma)
Plate-forme du St-Laurent (non déformée)
Chaîne taconienne (déformée)
Océan Iapetus
LAURENTIA
Milieu du Silurien
(vers -420 Ma)
Dépôts de la plate-forme d'Anticosti
Dépôts dans le bassin de Gaspésie
Océan Iapetus
Bassin du Nouveau-Brunswick
Océan Rhéique
?
LAURENTIA
AVALONIA
Milieu du Dévonien
(vers -390 Ma)
Chaîne acadienne
Chaîne taconienne
Océan Rhéique
LAURENTIA
AVALONIA
GONDWANA

Fin du Carbonifère
(vers -310 Ma)



BC Bouclier canadien **CT** Chaîne taconienne

Jurassique
(vers -160 Ma)



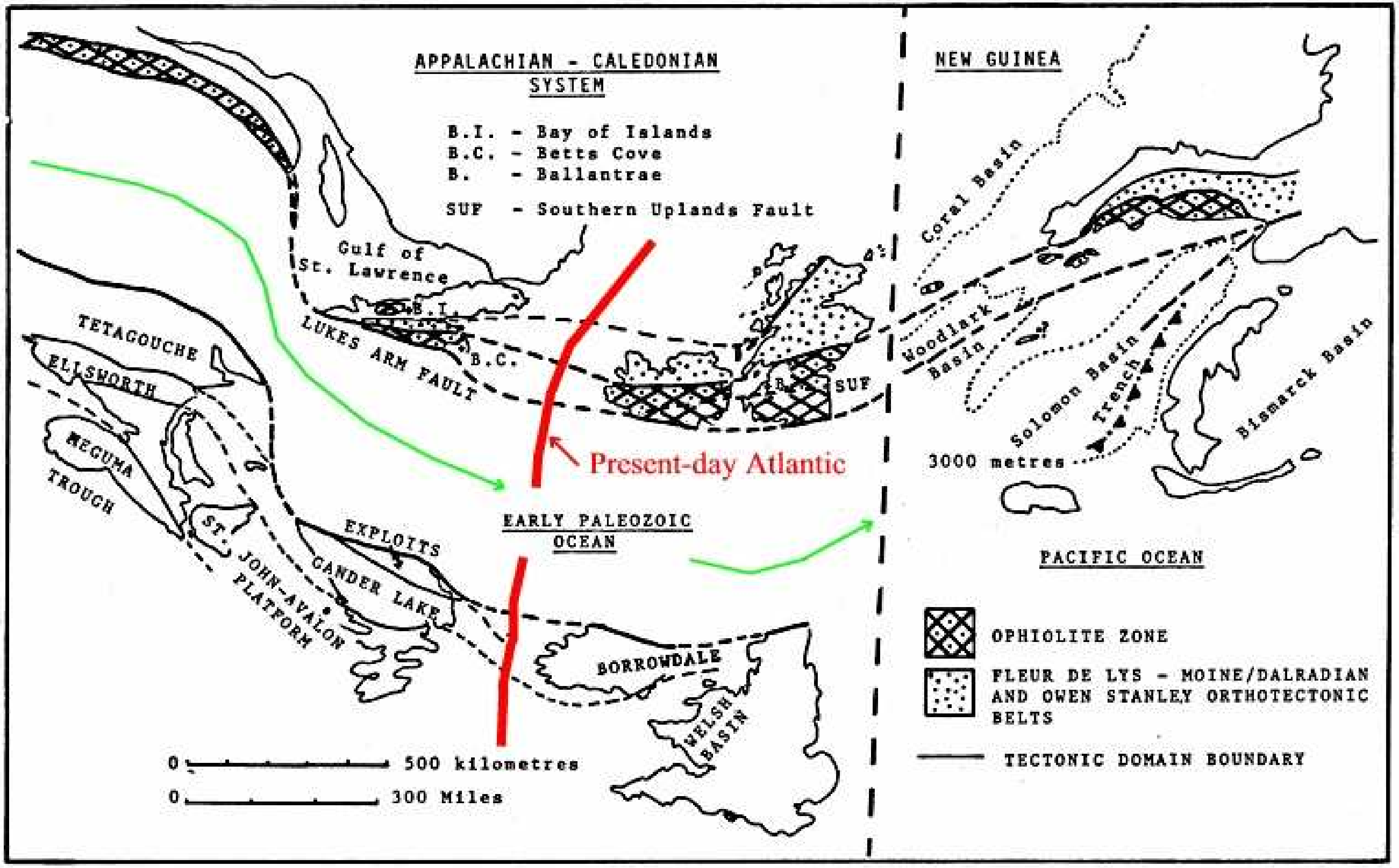
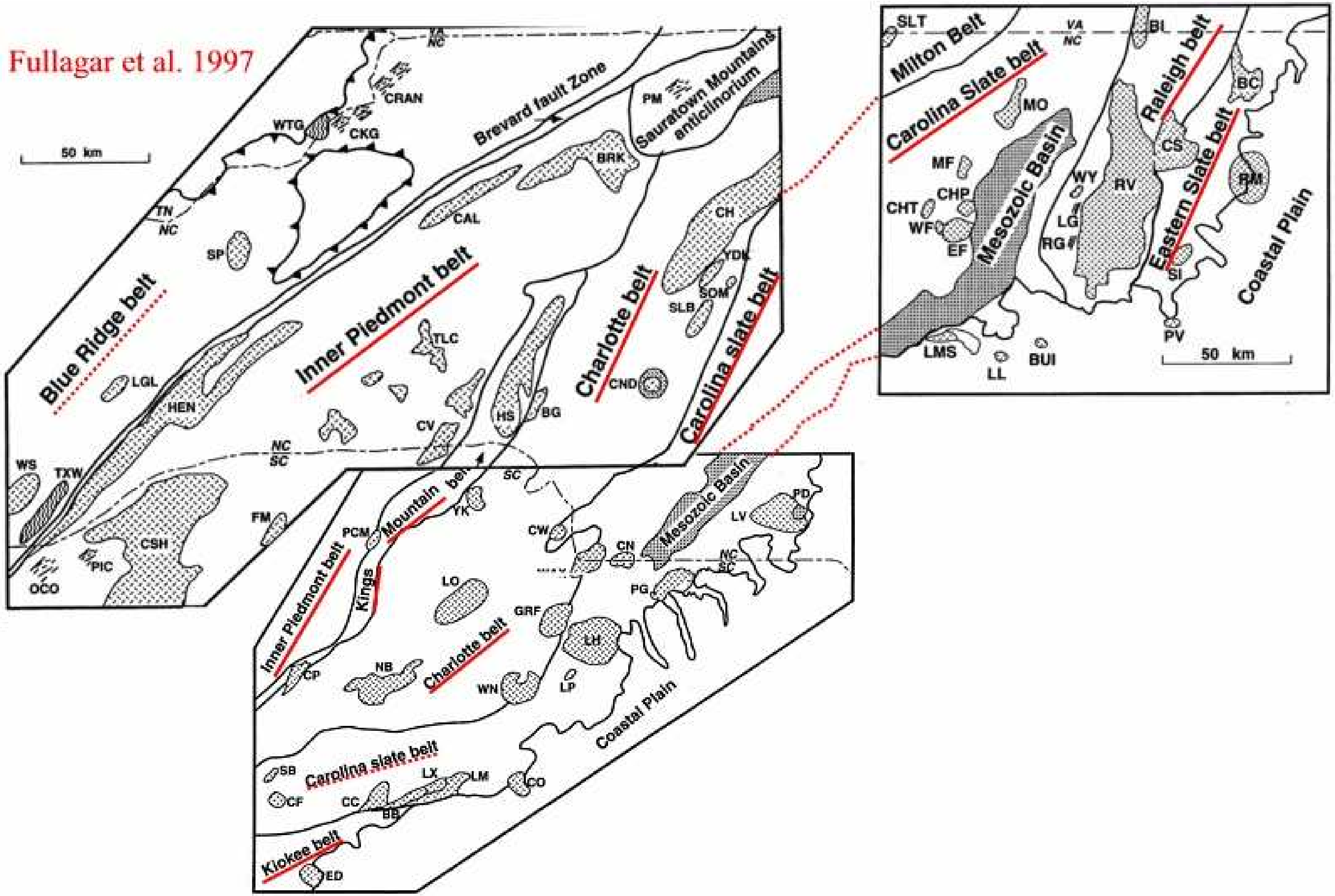
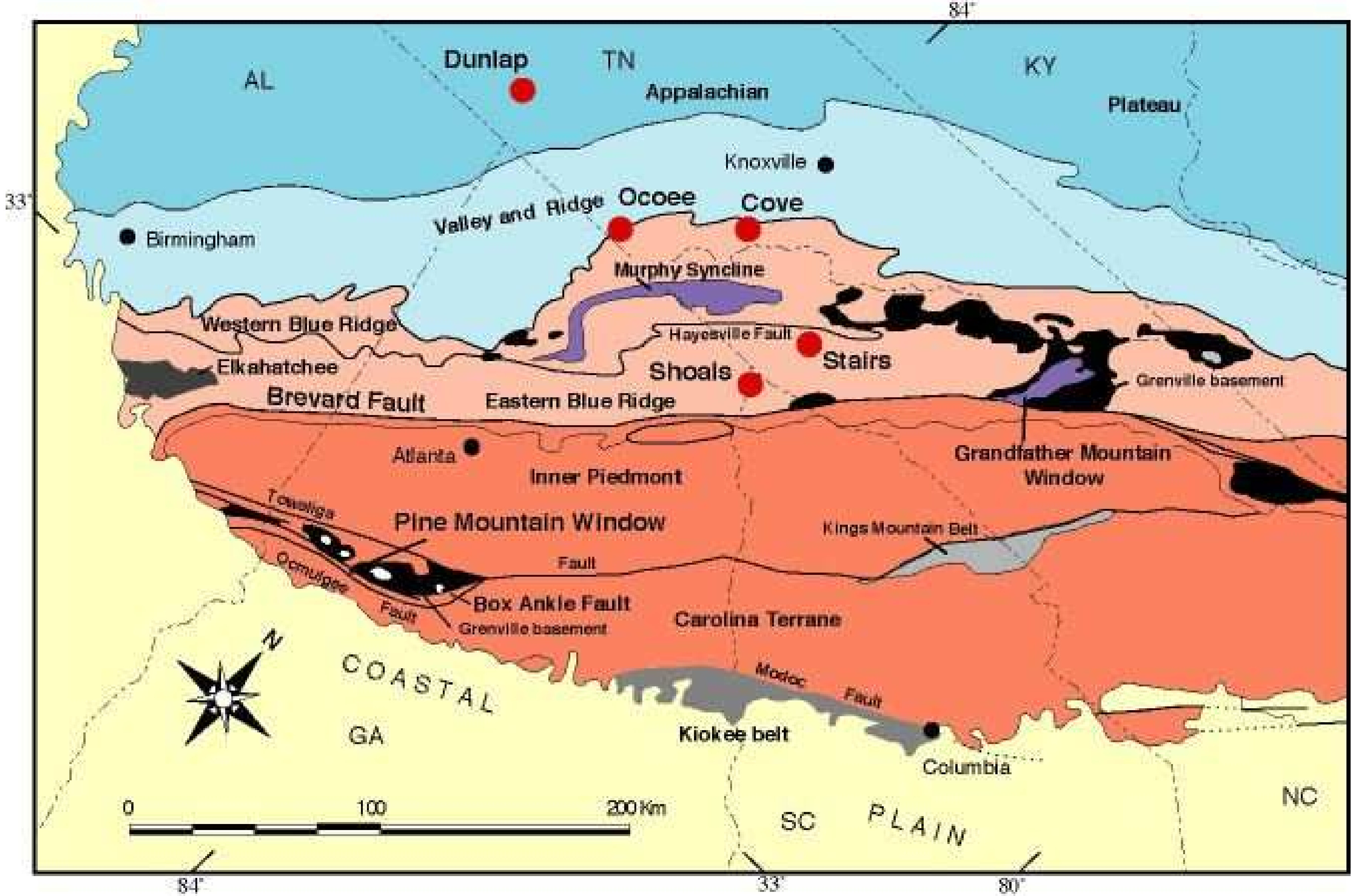


Figure 3. Map illustrating the distribution of the ophiolite and orthotectonic metamorphic belts of New Guinea and the Appalachian-Caledonian system.

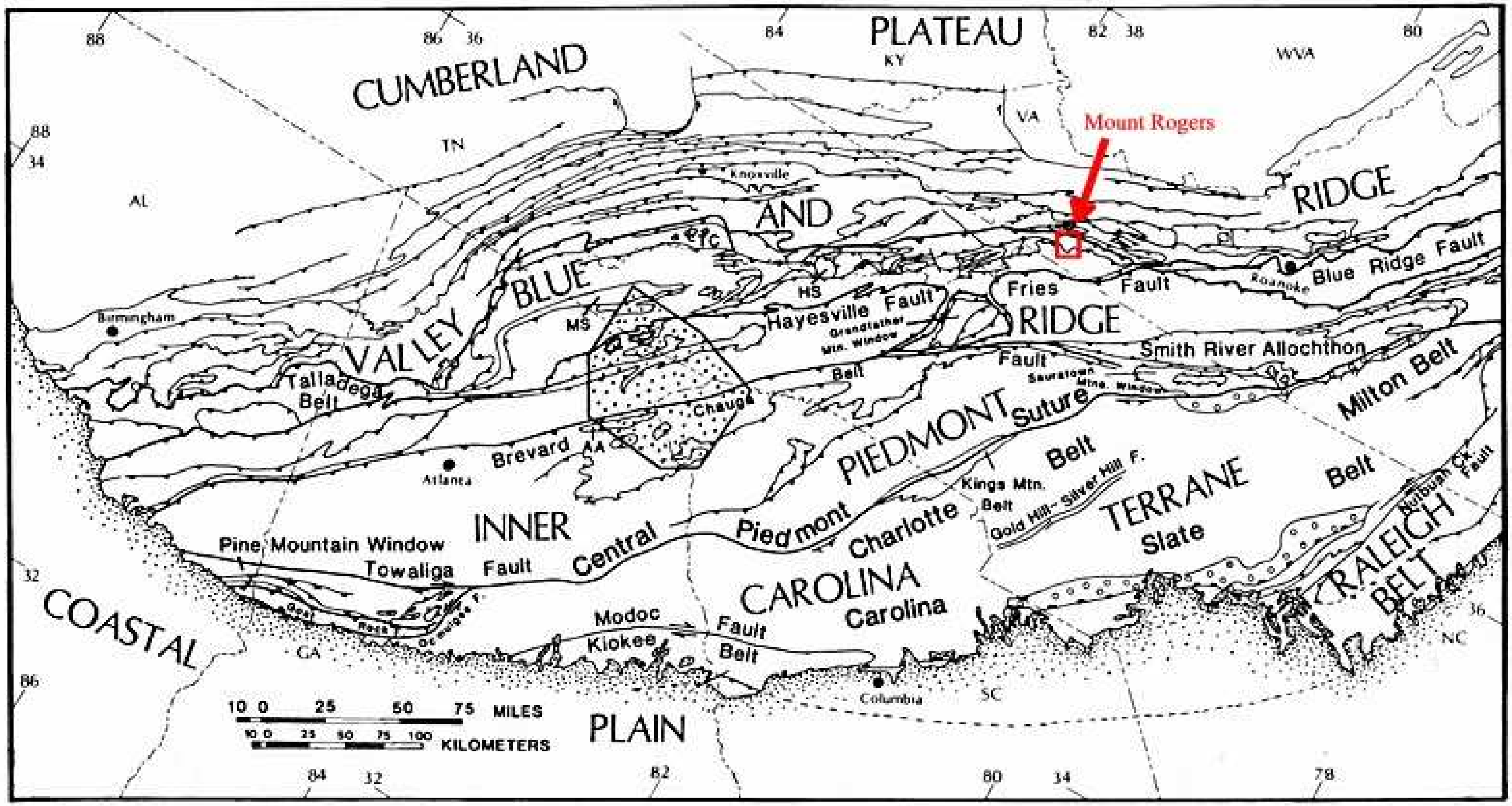
Fullagar et al. 1997





84°
Dunlap
TN
AL
KY
Appalachian
Plateau
Knoxville
33°
Birmingham
Valley and Ridge
Ocoee
Cove
Murphy Syncline
Western Blue Ridge
Hayesville Fault
Stairs
Elkahatchee
Shoals
Grenville basement
Brevard Fault
Eastern Blue Ridge
Atlanta
Inner Piedmont
Grandfather Mountain
Window
Towaliga
Pine Mountain Window
Kings Mountain Belt
Fault
Ocmulgee
Fault
Box Ankle Fault
Grenville basement
Carolina Terrane
N
COASTAL
Modoc
Fault
GA
Kiokee belt
Columbia
0
100
200 Km
SC
PLAIN
NC
84°
33°
80°

Newfoundland	S. Appalachians
No correlative	Valley and Ridge Tectonic Province
Western Newfoundland foreland	Jefferson terrane
Fleur de Lys	Potomac terrane
Notre Dame Bay ophiolite/arc terrain	Bel Air/Chopawamsic ophiolitic arc terranes
Burlington Granodiorite	Occoquan pluton
IAPETUS SUTURE	
Exploits	Inner Piedmont terrane
Davidsville/GRUB line	Juliette terrane
Gander Lake	Uchee or Charlotte terranes
Avalonia	Carolina terrane
RHEIC SUTURE	
No correlative	Suwannee



Hopson et al., 1989

Figure 1. Lithotectonic map of the southern Appalachians. The stippled area is the region shown in Figure 2. The Hayesville fault separates the Blue Ridge into eastern and western seg ments. MS, Murphy Syncline; AA, Alto allochthon; TC, Tuckaleechee Cove window; HS, Hot Springs Window.

Figure 3c.

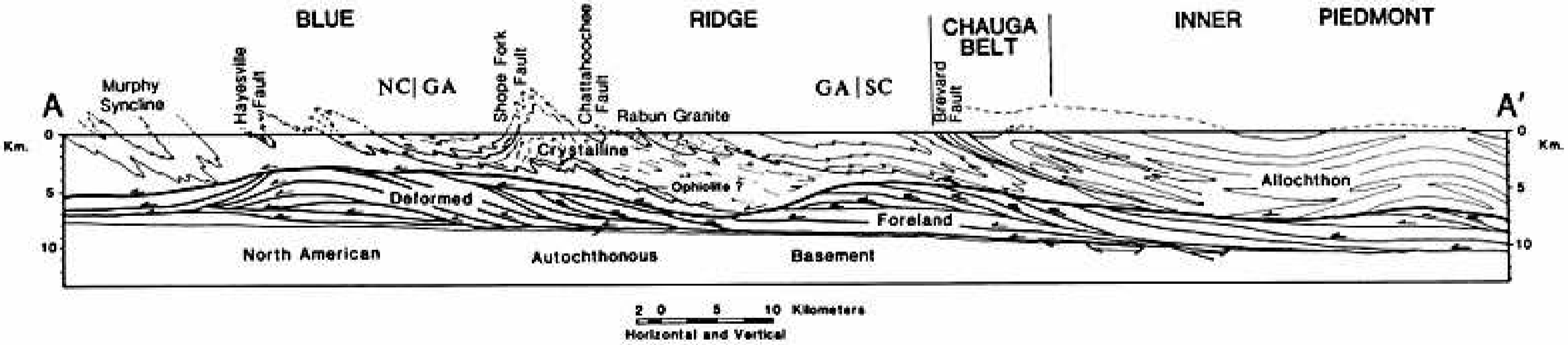
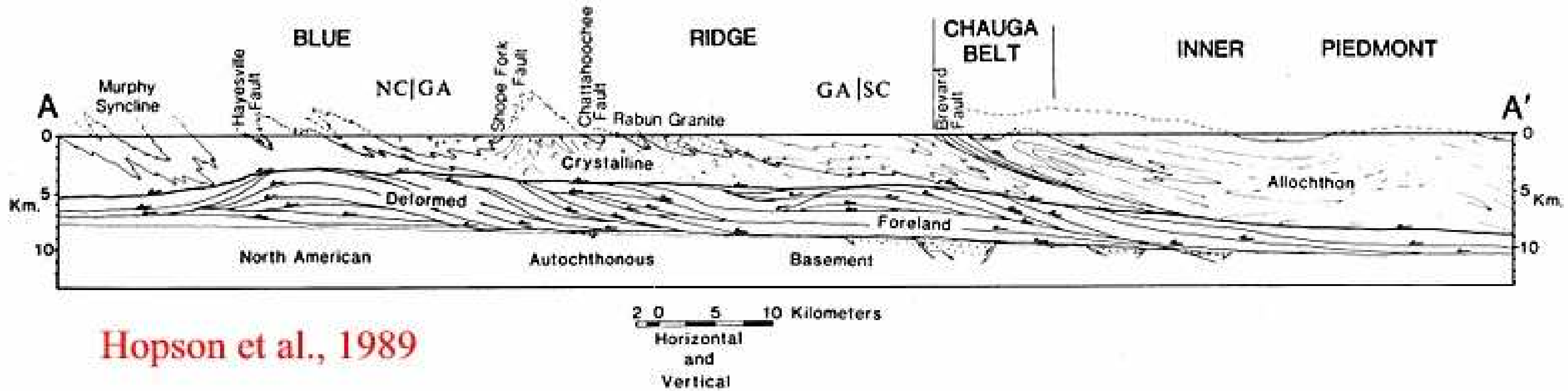
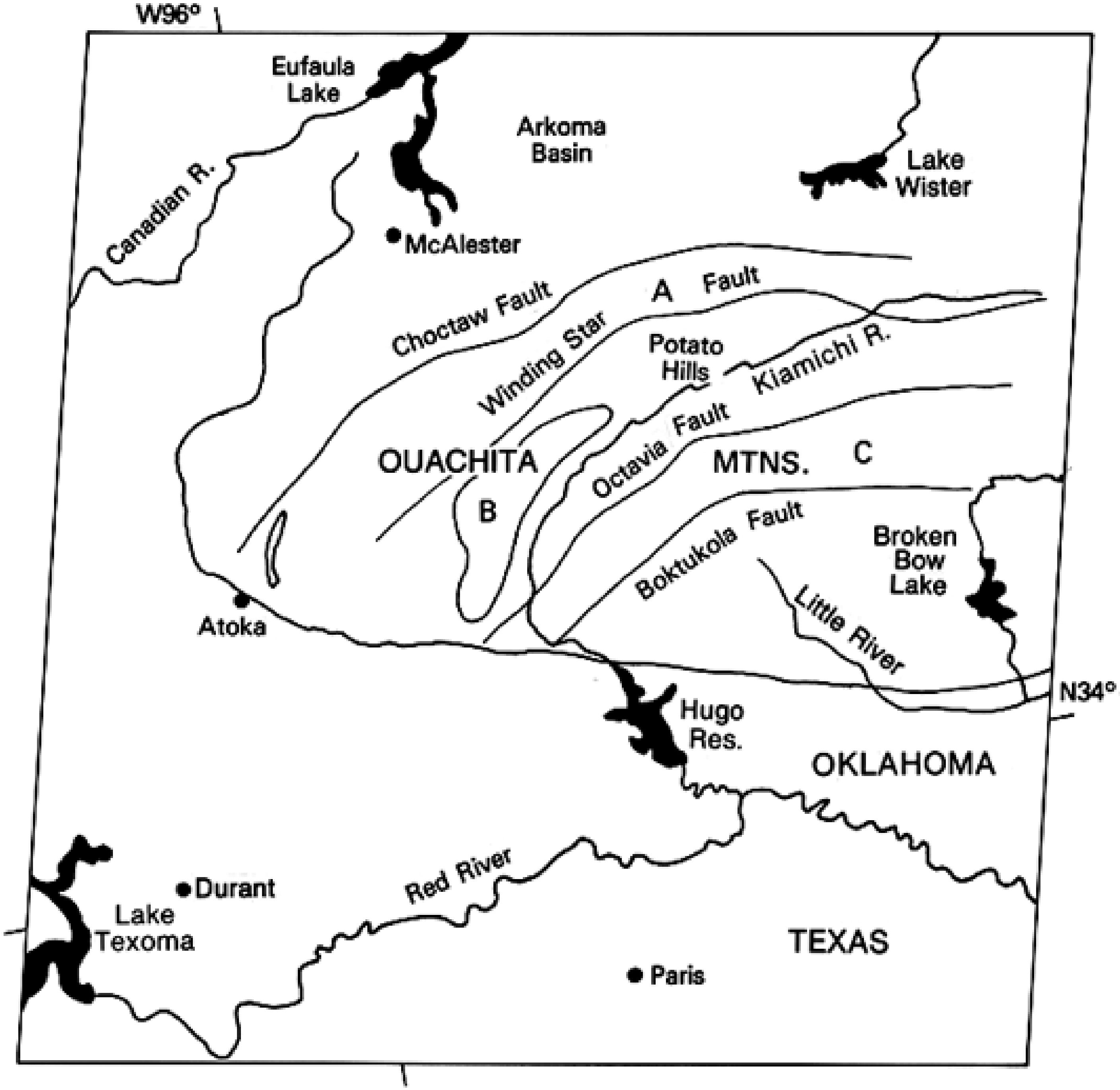


Figure 3d.

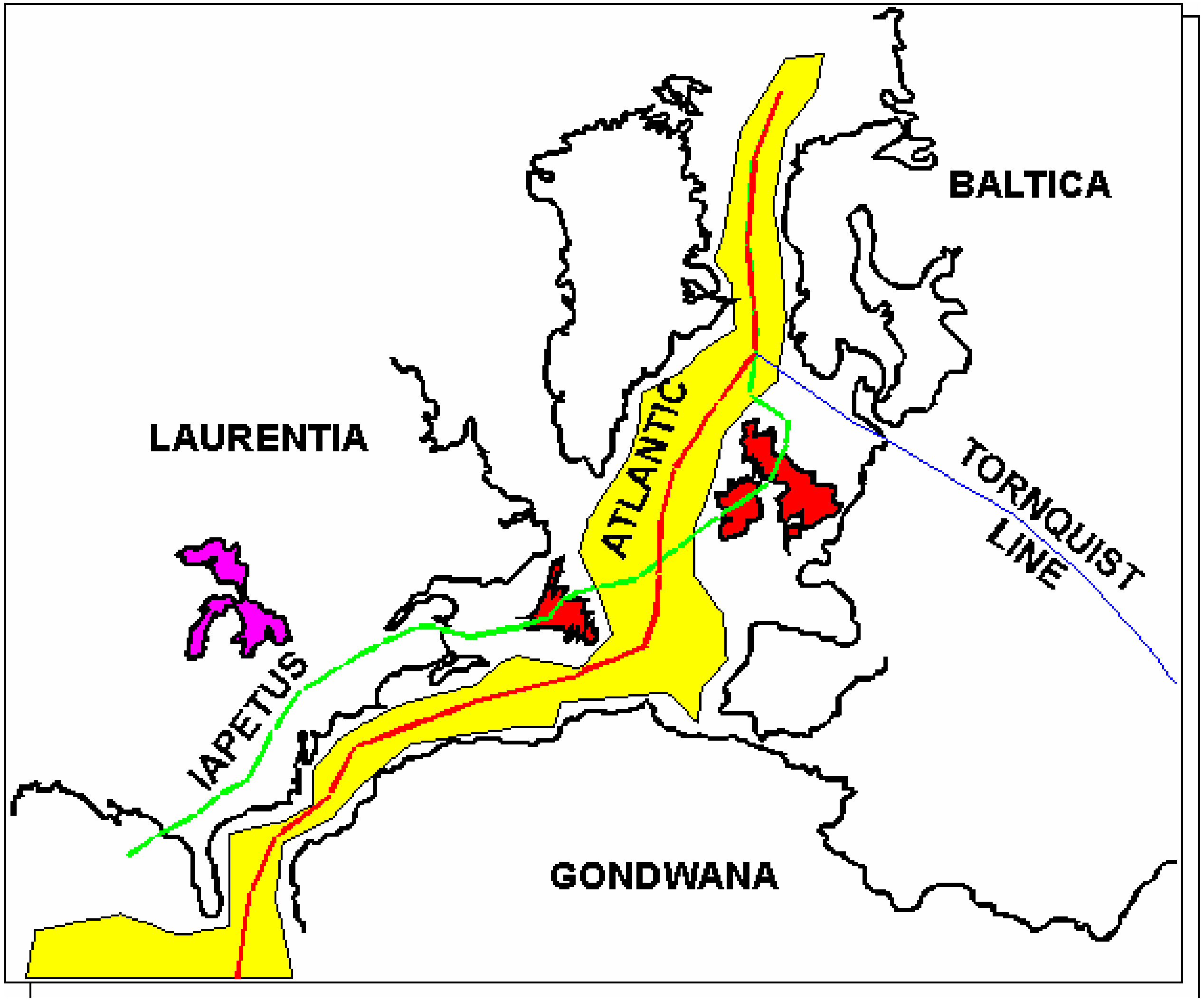


Hopson et al., 1989

Pásmo Quatchita-Marathon – **alleghanská fáze, kolize s jihoamerickou části Gondwany**



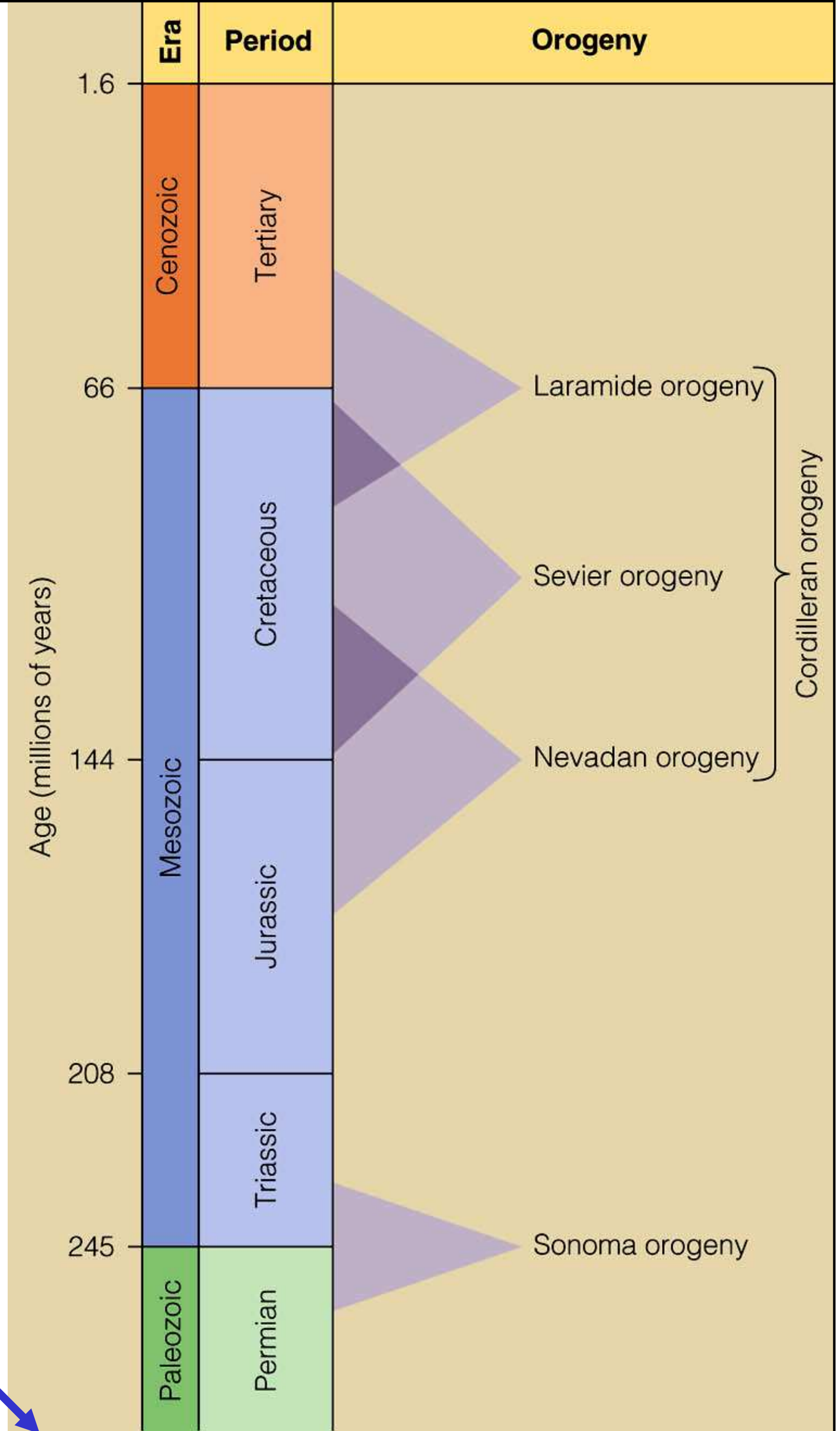
W96°
Eufaula Lake
Arkoma Basin
Lake Wister
Canadian R.
McAlester
Choctaw Fault
A
Fault
Winding Star
Potato Hills
Kiamichi R.
Octavia Fault
OUACHITA
MTNS.
C
B
Boktukola Fault
Broken Bow Lake
Little River
Atoka
N34°
Hugo Res.
OKLAHOMA
Red River
Durant
Lake Texoma
TEXAS
Paris


BALTICA
LAURENTIA
ATLANTIC
TORNQUIST
LINE
IAPETUS
GONDWANA

KORDILERY

K
O
R
D
I
L
E

Antler Orogeny in Devonian

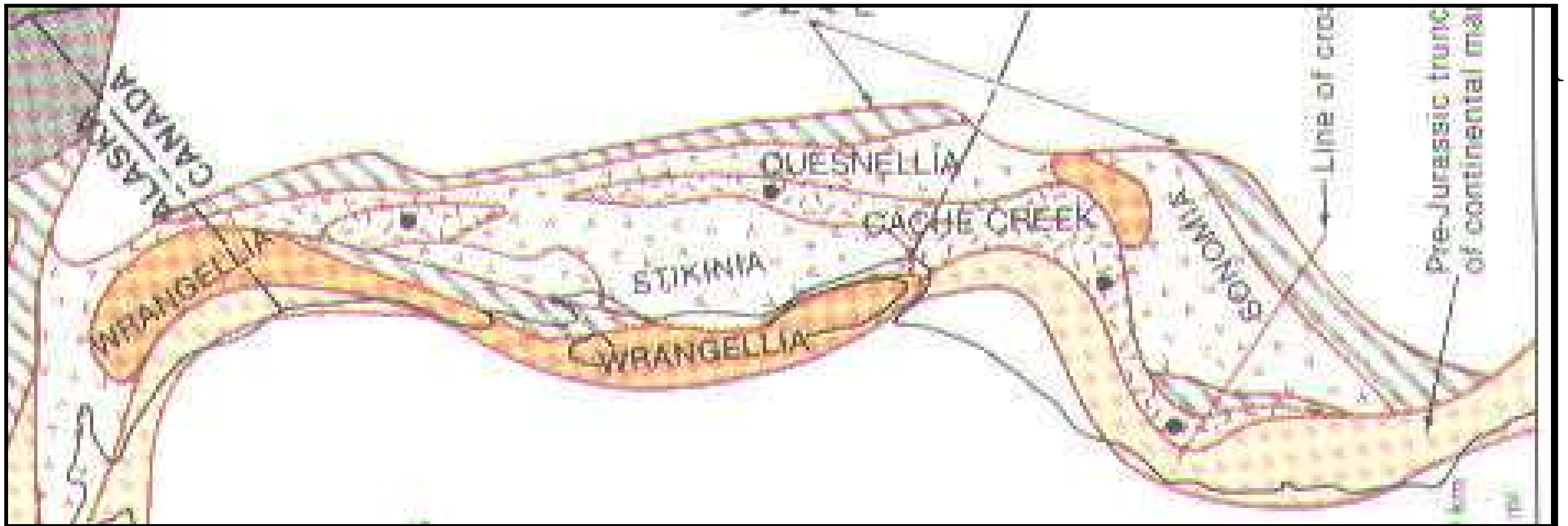



Alaska
1.2
1.5
3.7
3
5
1.5
NORTH
CORDILLERAN
AMERICAN
1.
1.4
9
1.1
1.3
2.0
2.5
1.2
5.5
PACIFIC
OCEAN
MOBILE
Belt
Basin
Canada
U.S.
CRATON
1.4
BELT
5
7
Uinta
Basin
1.2
2.1
Apache
Basin
0.6

The Western Collage

- Cordillera an collage of microplates and arcs
  - accreted during the Paleozoic and Mesozoic
  - terrains have different rock types and fossil assemblages that cannot be correlated
  - suspect terrains--fault-bounded regions that be correlated

s



Paleozoic Passive Margin

• Existed in Late Precambrian and Early Paleozoic

• Craton and cratonic basin deposits

• Miogeocline continental shelf deposits

• An arc formed in the Ordovician

Antler Orogeny

(300 (300-375 Ma) 375 Ma)

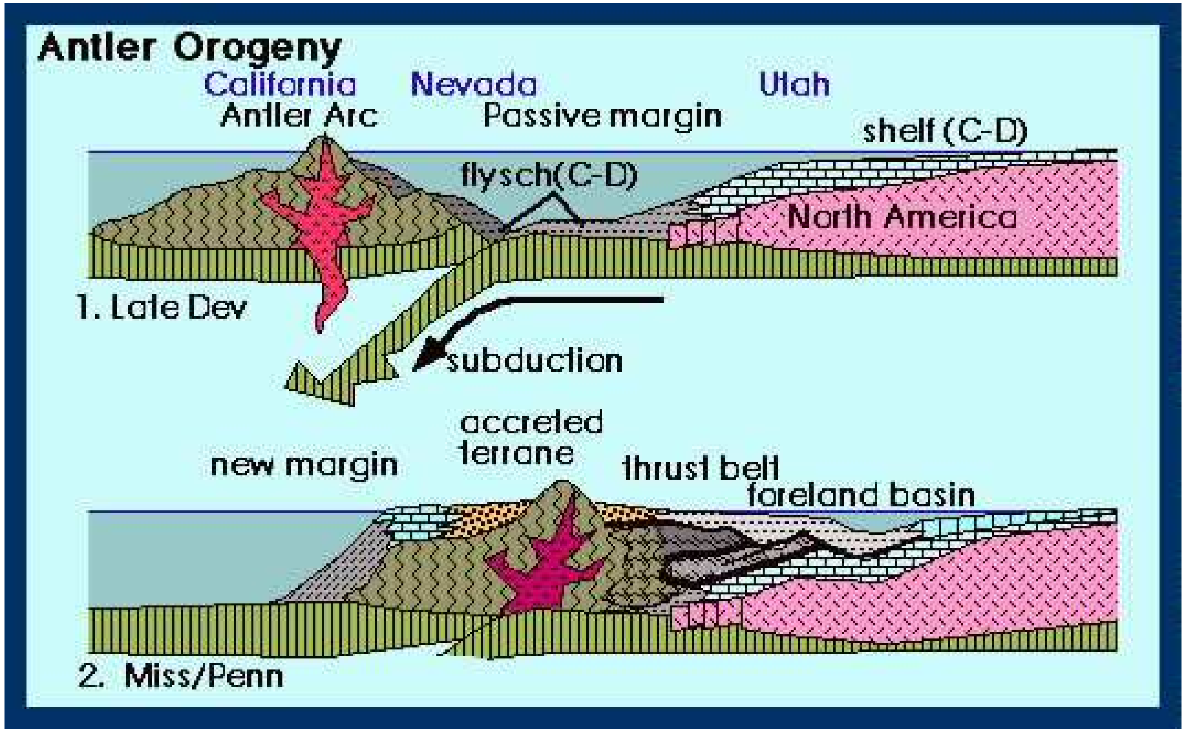
• Late Devonian - Early Mississippian

• Collision of the arc with a passive margin

• Roberts Mountain Allochton thrust over the passive margin

• A series of foreland basins formed in eastern Nevada

Orogeneze: antlerská, kolize klamathského ostrovního oblouku v devonu a spodním karbonu

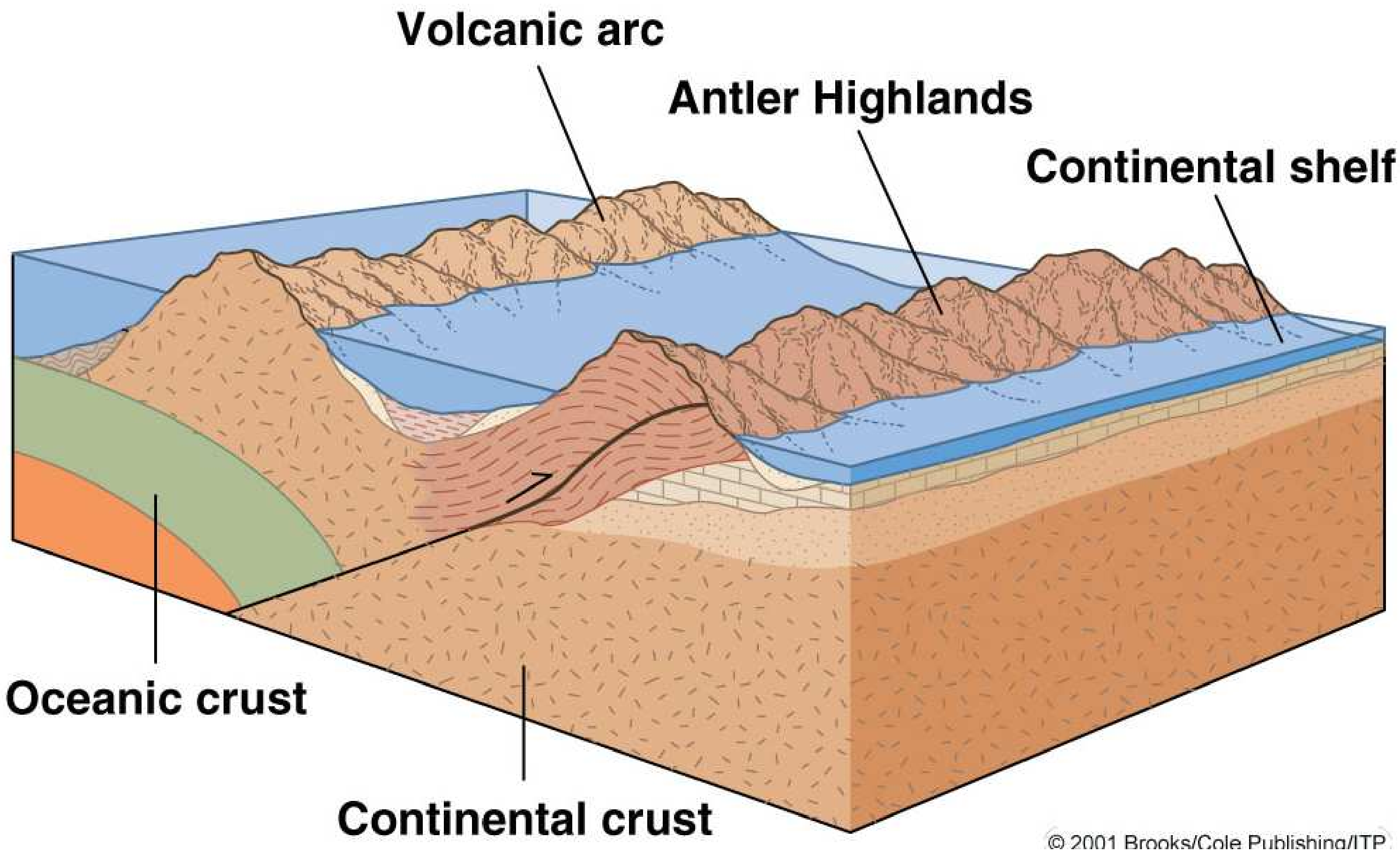


20

Western craton (Cordilleran) was a passive margin Late Proterozoic to Early Paleozoic.

Beginning in the Middle Paleozoic - an island arc formed off the western margin of the craton.

Antler Orogeny – collision of island arc with craton – Late Devonian/Early Mississippian.



From the Antler Orogeny, the western margin remains an active margin.

Sonoma Orogeny (200-280 Ma)

• Permo -Triassic

• Collision of Arc With a Passive Margin

• Island Arc Terrains Were Accreted

• Golconda Allochthon

– Thrust Partly Over Roberts Mountain Allochthon

Nevadan Orogeny ((140-150 Ma)

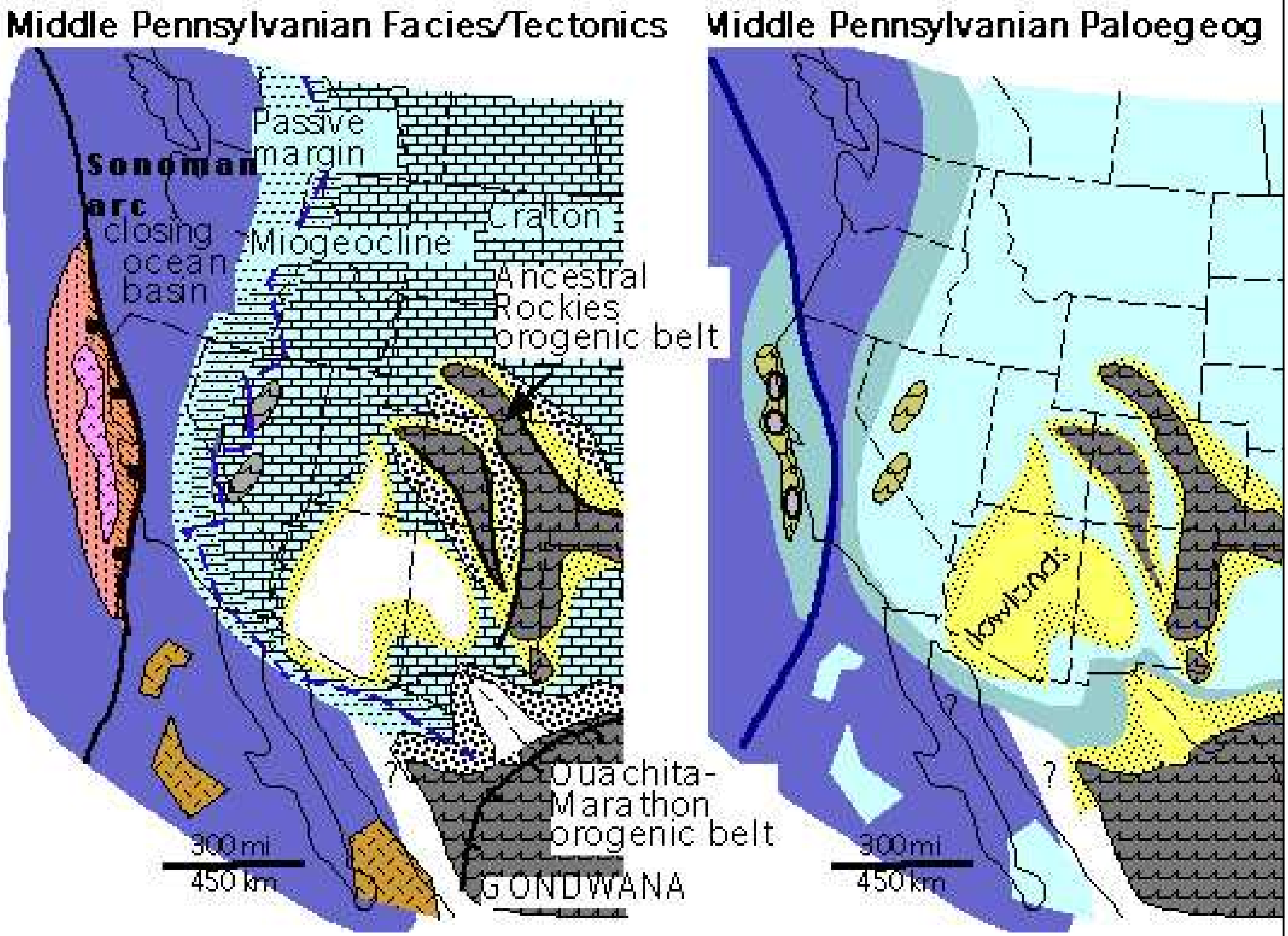
• Several Upper Jurassic Arcs Collided

• Cretaceous Franciscan Fm in the accretionary prism

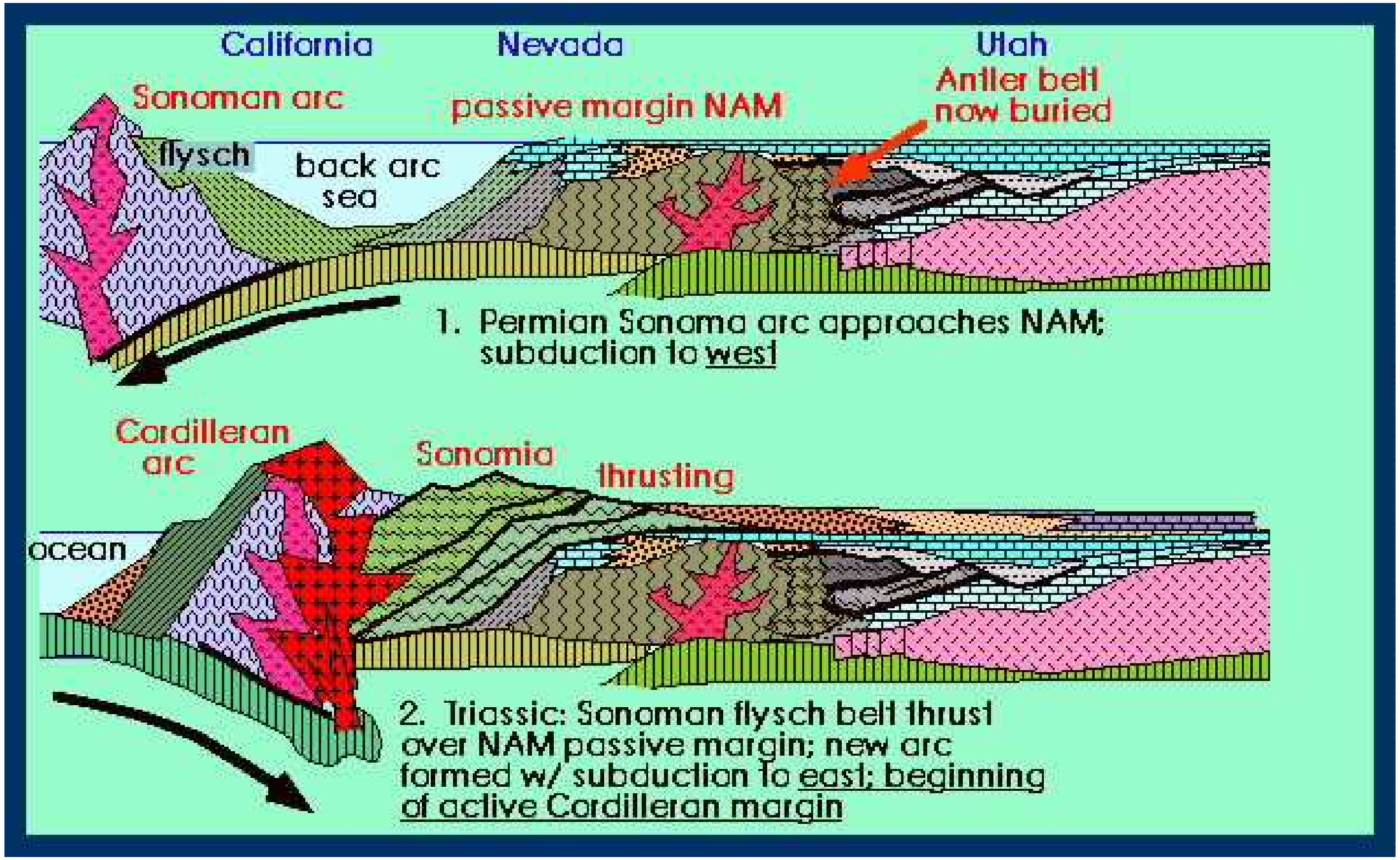
• Great Valley Sequence filled an elongated forearc basin

• Sierra Nevada was the root zone of the arc

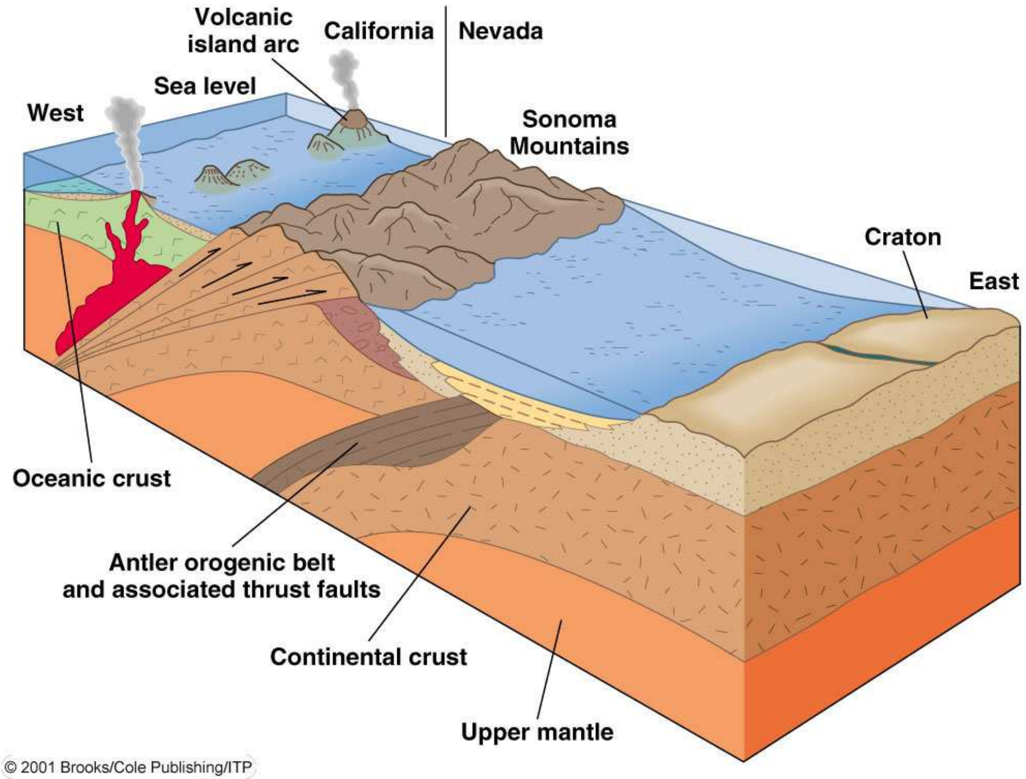
Western U.S., Mid Penn

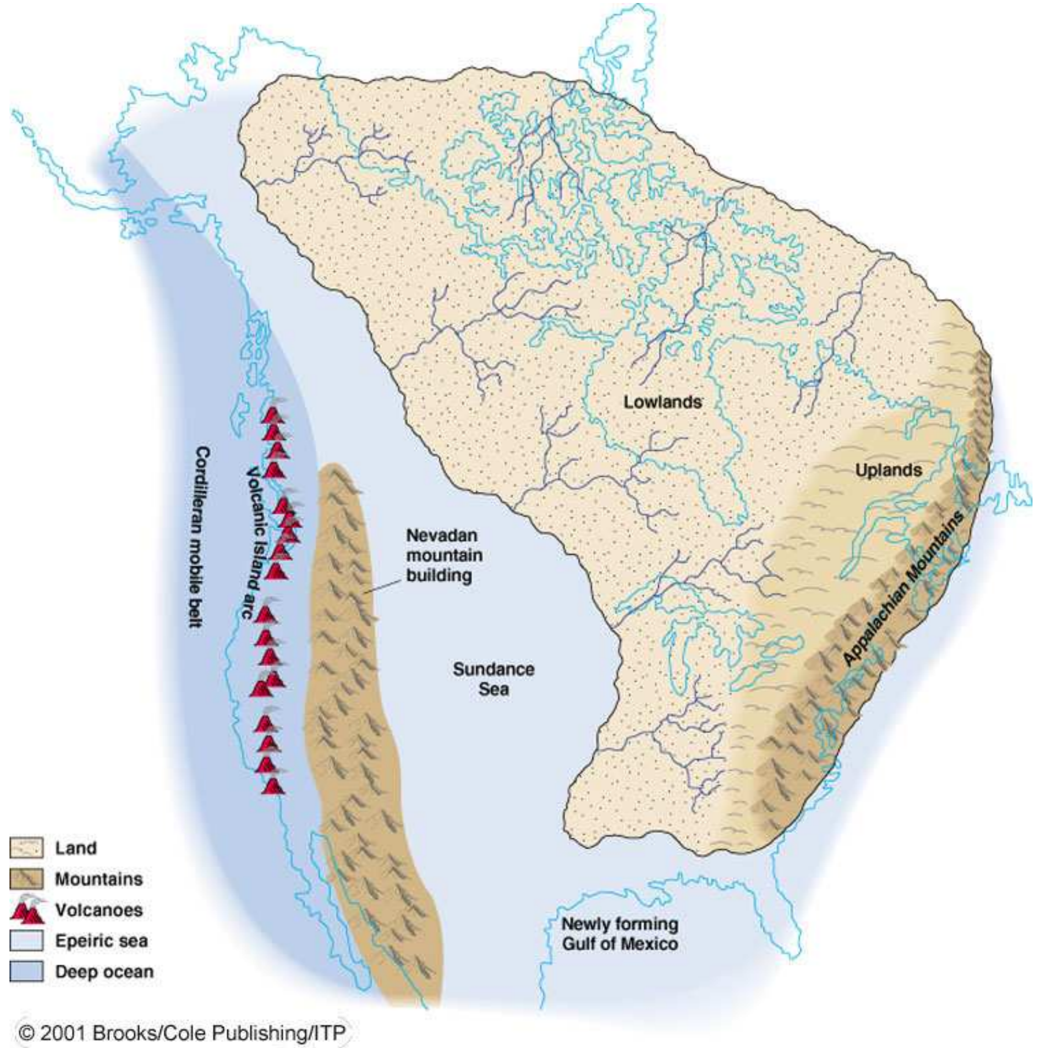


sonomská, kolize dalšího ostrovníhp oblouku na konci paleozoika



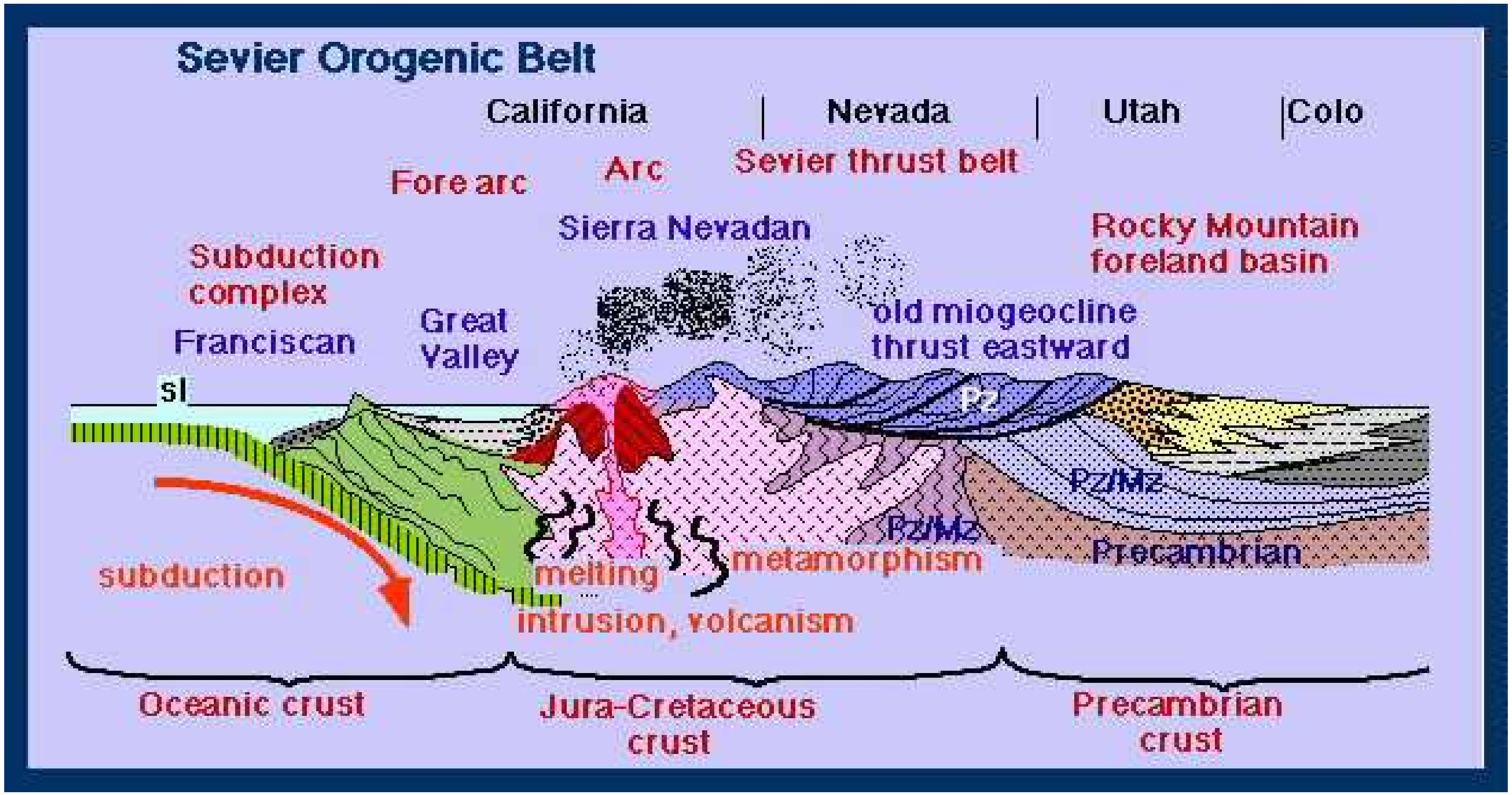
Jurassic Period – after collision between island arc & continent, Cordilleran margin became a continental arc.





Sevier Orogen (80 Sevier Orogen (80-130 Ma) 130 Ma)

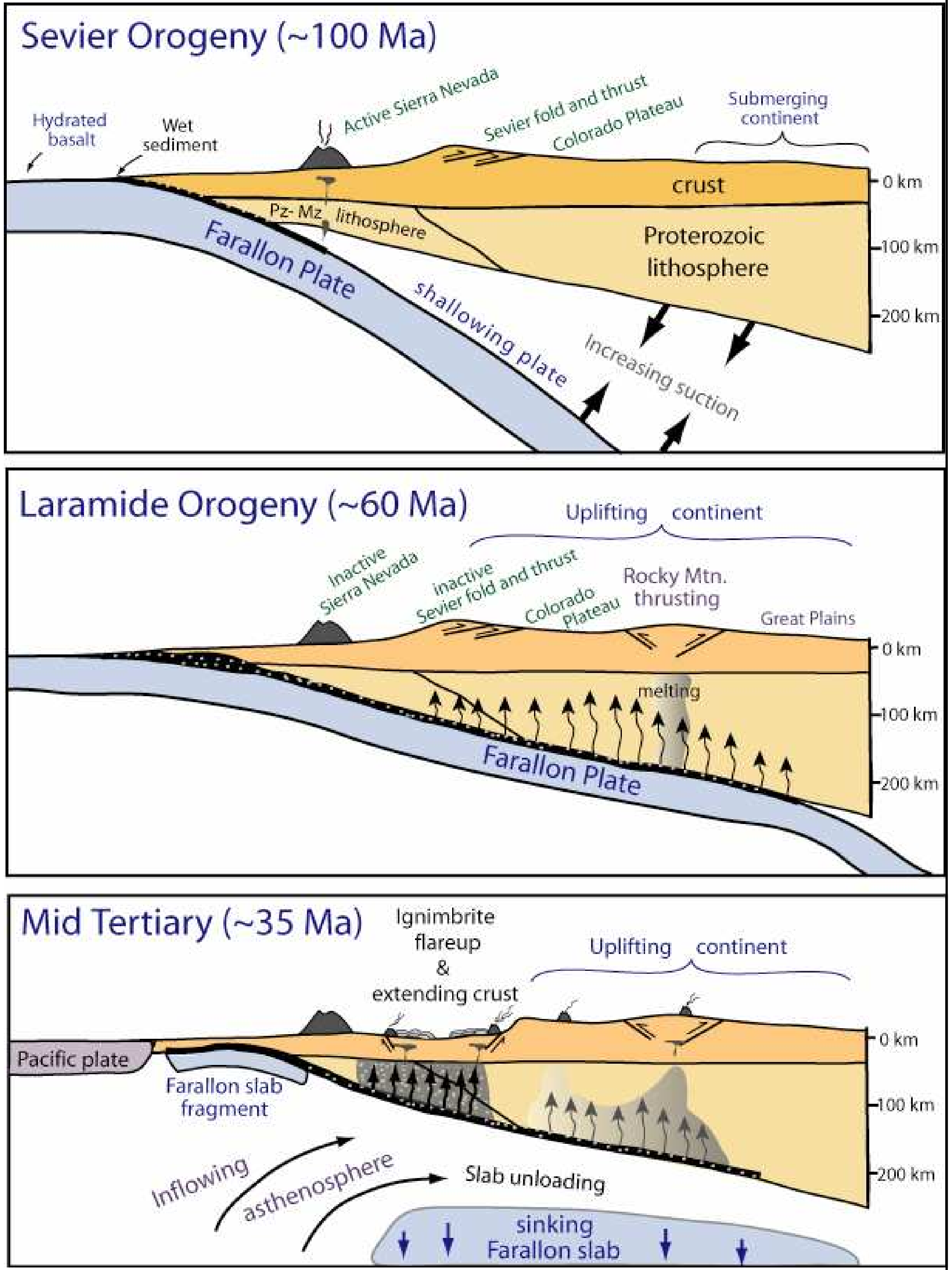
- Fold-thrust belt behind the arc
- Eastward directed thrusts
- Prominent retro arc basins to the East
- Late Jurassic to Late Cretaceous
- Batholithic intrusions
- Great Valley Sequence
- Franciscan Formation



Laramide Orogeny **(50- 80 Ma)**

- Late Cretaceous - Early Eocene
- Deformation shifted eastward following magmatism
- Westward directed thrusts
- Formation of major mineral belts

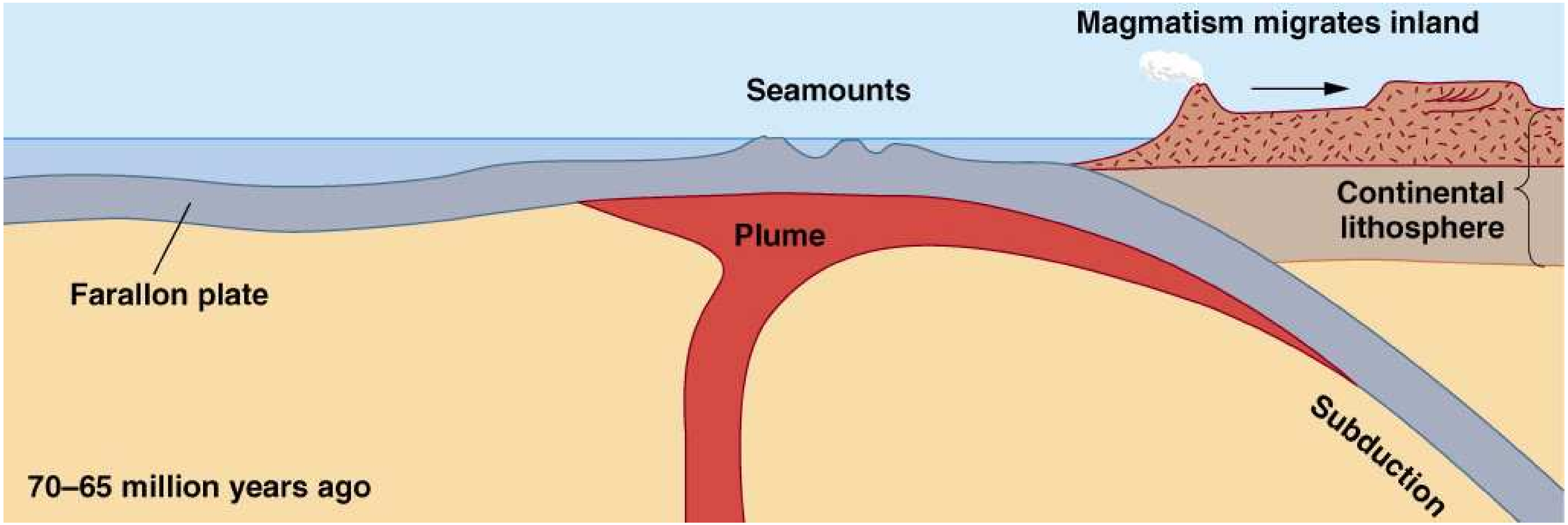
Asthospheric upwelling at 54-50 Ma
(older than in the south)



Humphreys et al., 2003

Laramide orogeny

– took place as the Farallon plate, buoyed up by a mantle plume subducted beneath North America at a decreasing angleand igneous activity shifted inland

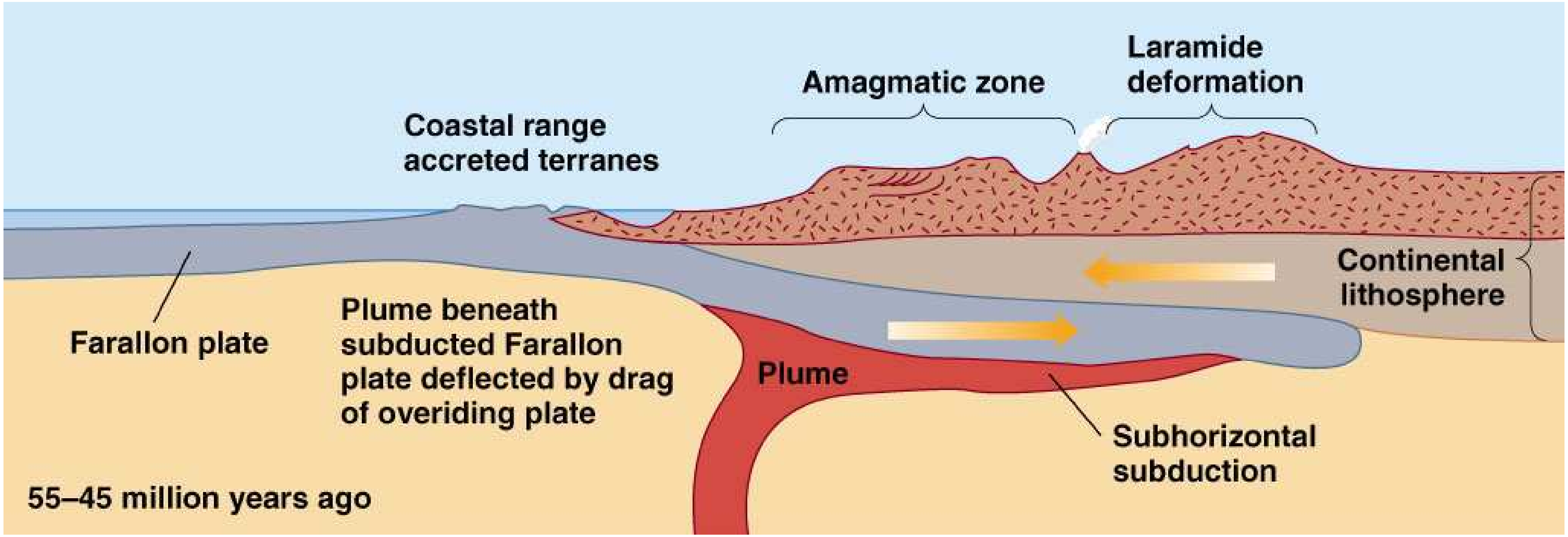


Change to Shallow Subduction

- By Early Tertiary time,
  - the westward-moving North American plate
  - had overridden the part of the Farallon plate,
  - above the head of the mantle plume
- The lithosphere
  - immediately above this plume
  - was buoyed up,
  - accounting for a change
  - from steep to shallow subduction

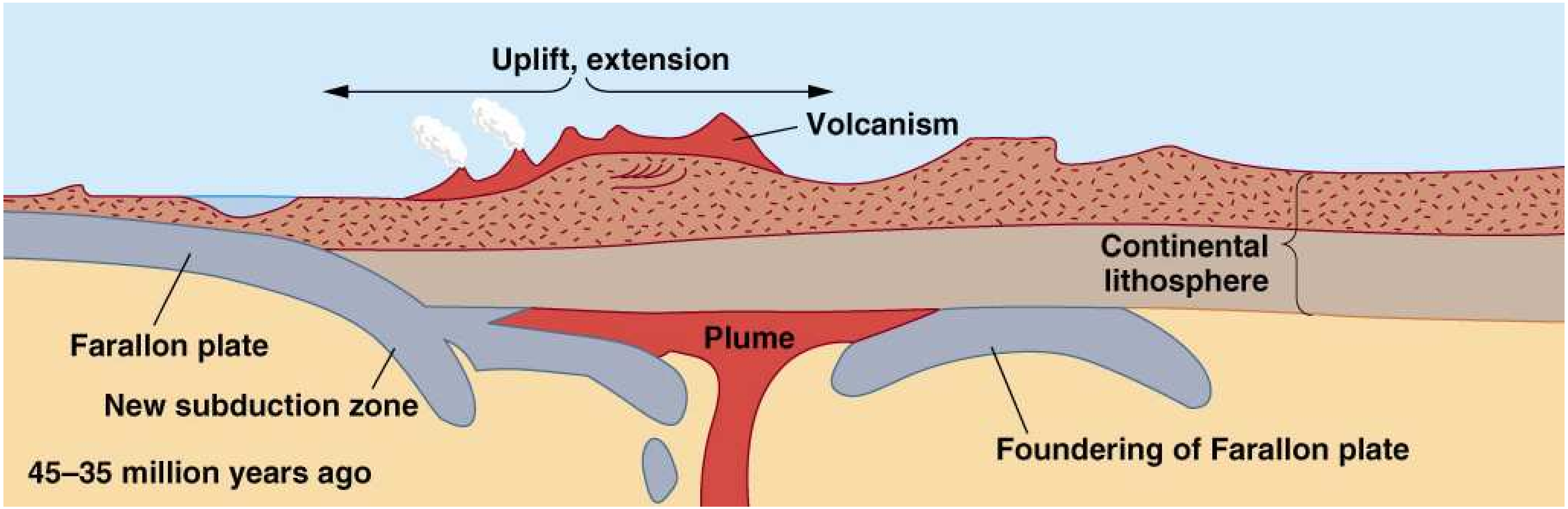
Igneous Activity Ceased

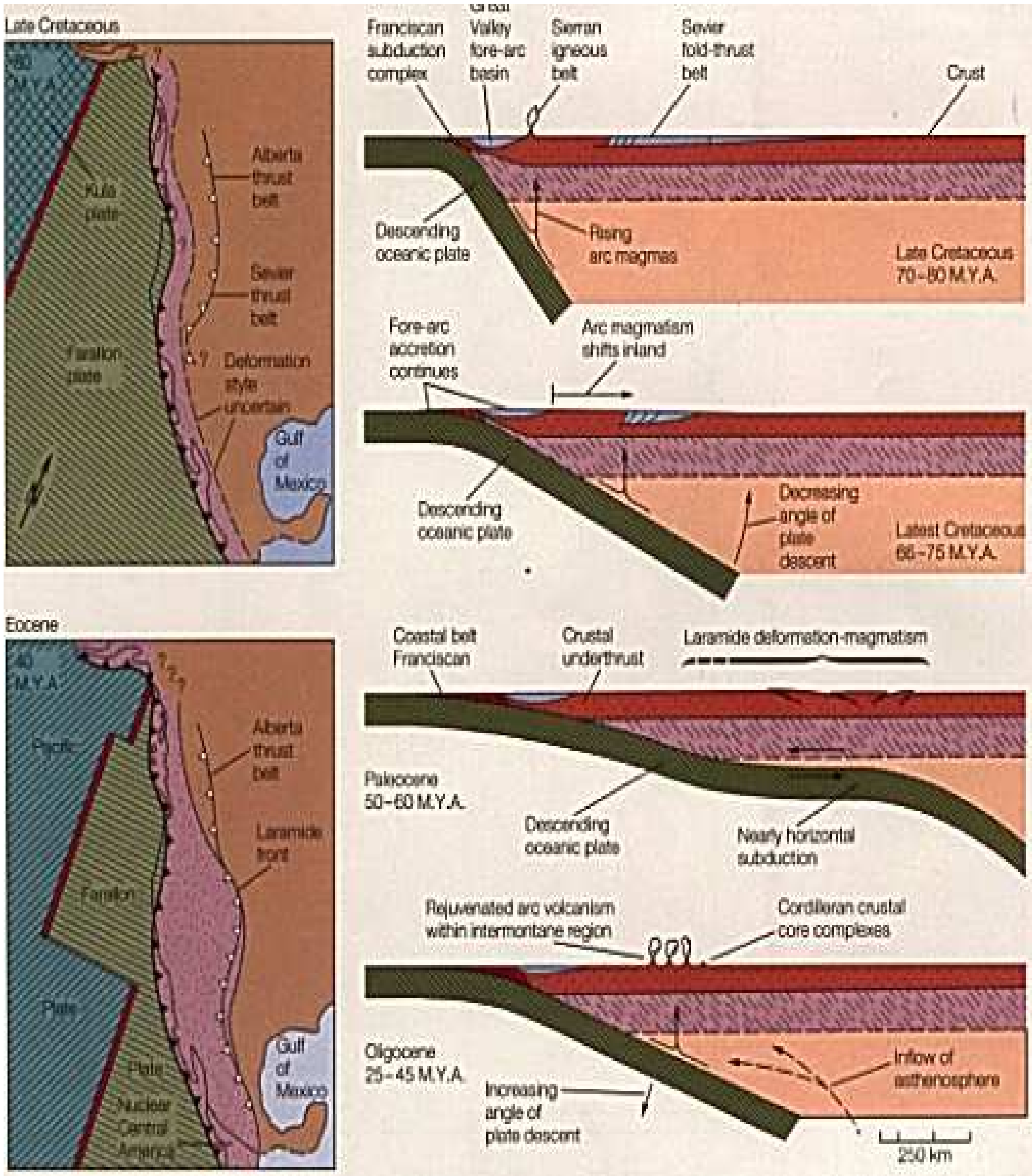
- With nearly horizontal subduction,igneous activity ceased and the continental crust was deformed mostly by vertical uplift



Renewed Igneous Activity

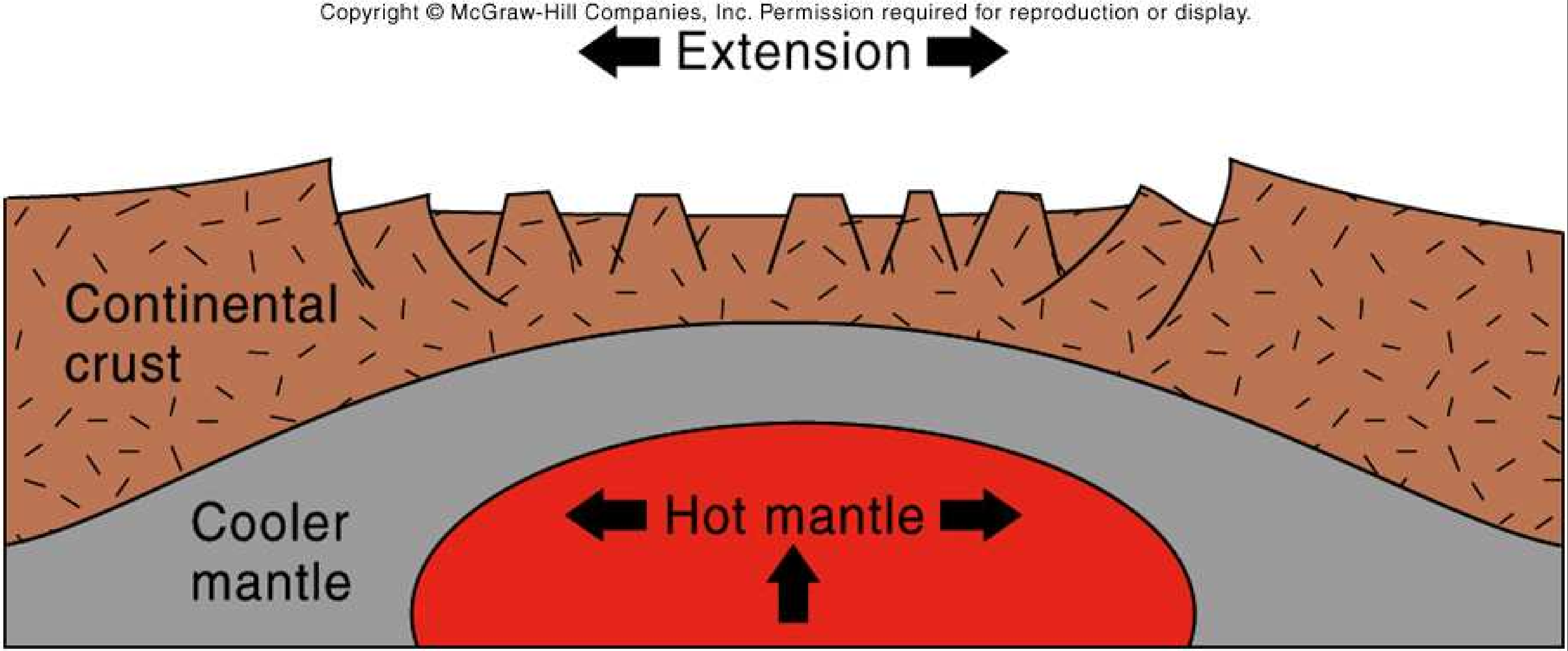
- Disruption of the oceanic plate by the mantle plumemarked the onset of renewed igneous activity





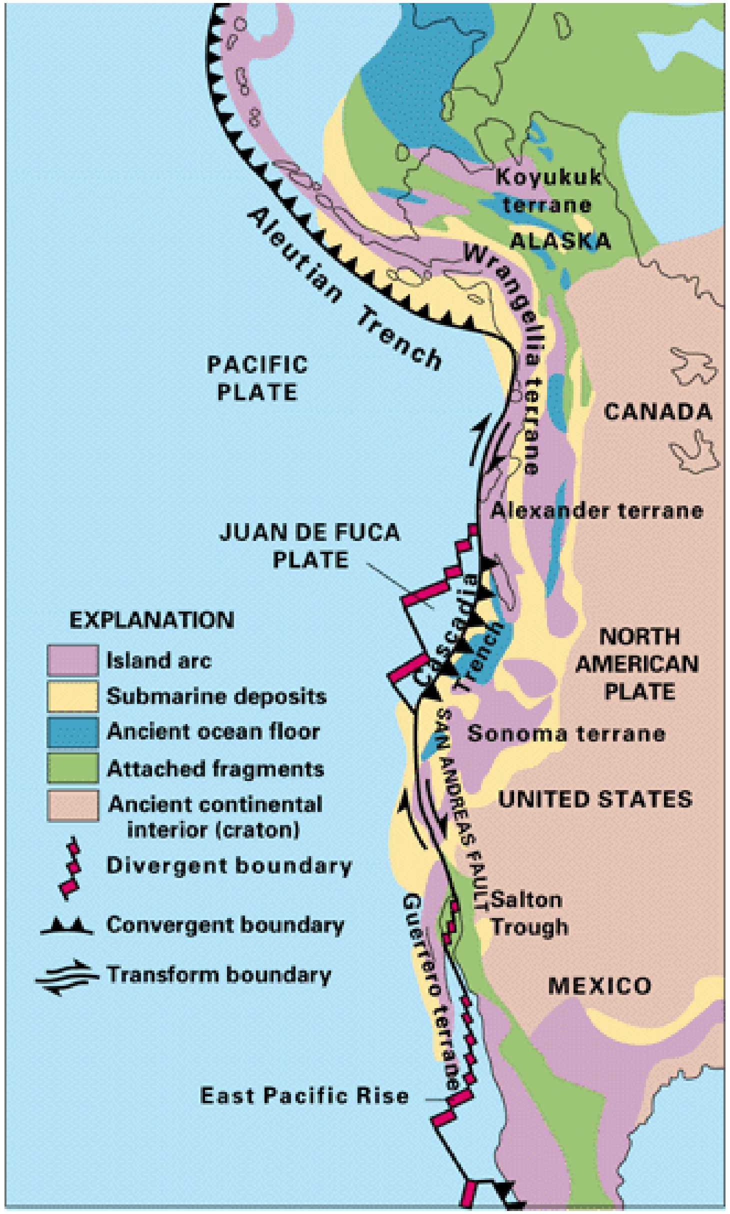
Late Cretaceous
80 M.Y.A.
Kula plate
Farallon plate
Alberta thrust belt
Sevier thrust belt
Deformation style uncertain
Gulf of Mexico
Franciscan subduction complex
Great Valley fore-arc basin
Sierran igneous belt
Sevier fold-thrust belt
Crust
Descending oceanic plate
Rising arc magmas
Late Cretaceous 70–80 M.Y.A.
Fore-arc accretion continues
Arc magmatism shifts inland
Descending oceanic plate
Decreasing angle of plate descent
Latest Cretaceous 66–75 M.Y.A.
Eocene
40 M.Y.A.
Pacific
Plate
Farallon
Plate
Nuclear Central America
Alberta thrust belt
Laramide front
Gulf of Mexico
Coastal belt Franciscan
Crustal underthrust
Laramide deformation-magmatism
Paleocene 50–60 M.Y.A.
Descending oceanic plate
Nearly horizontal subduction
Rejuvenated arc volcanism within intermontane region
Cordilleran crustal core complexes
Oligocene 25–45 M.Y.A.
Increasing angle of plate descent
Inflow of asthenosphere
250 km

The mechanism responsible for formation of the North American Basin and Range province



The Tetons (a range), as seen looking west across Jackson Hole, WY (a basin)

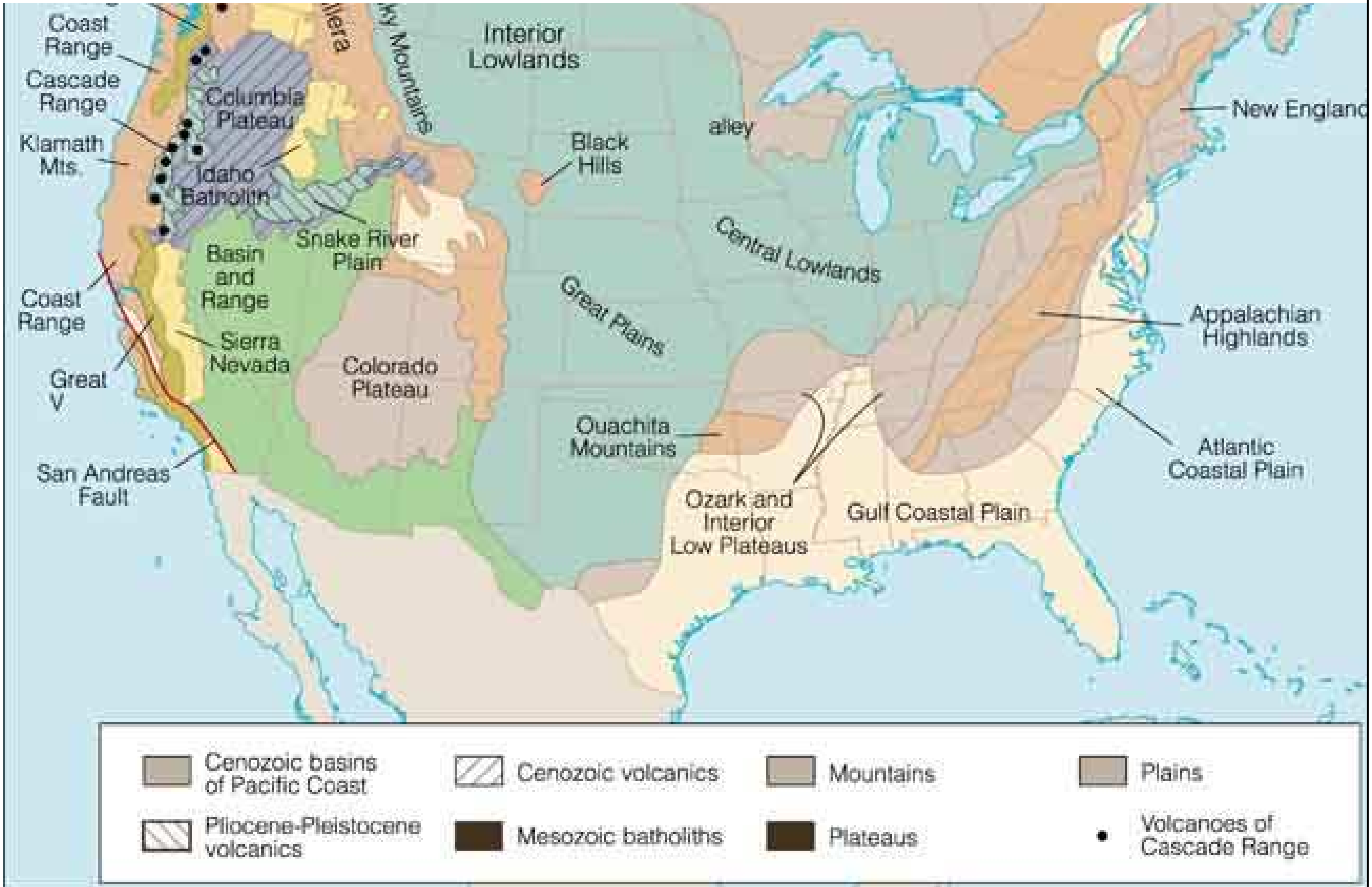
Photo by C. C. Plummer



Post Laramide Events

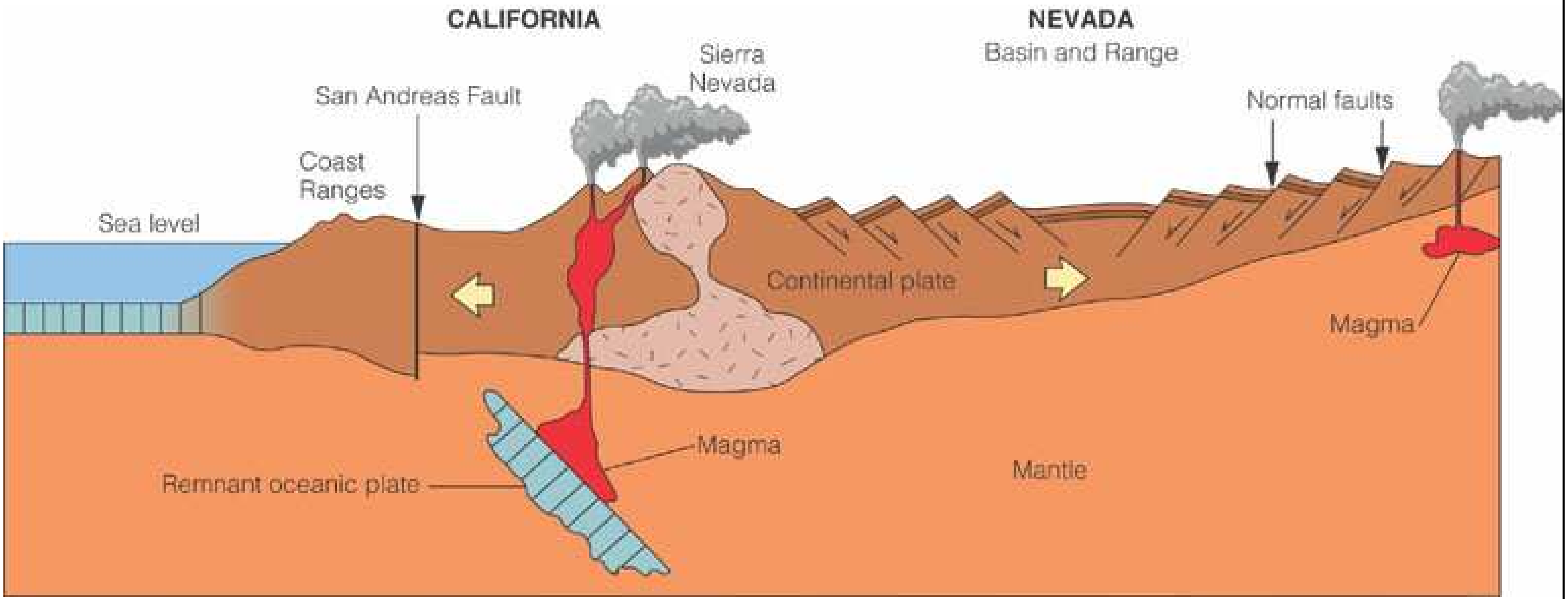
- Cenozoic extension
- Basin and Range formation
- Cenozoic magmatism
- Widespread volcanism

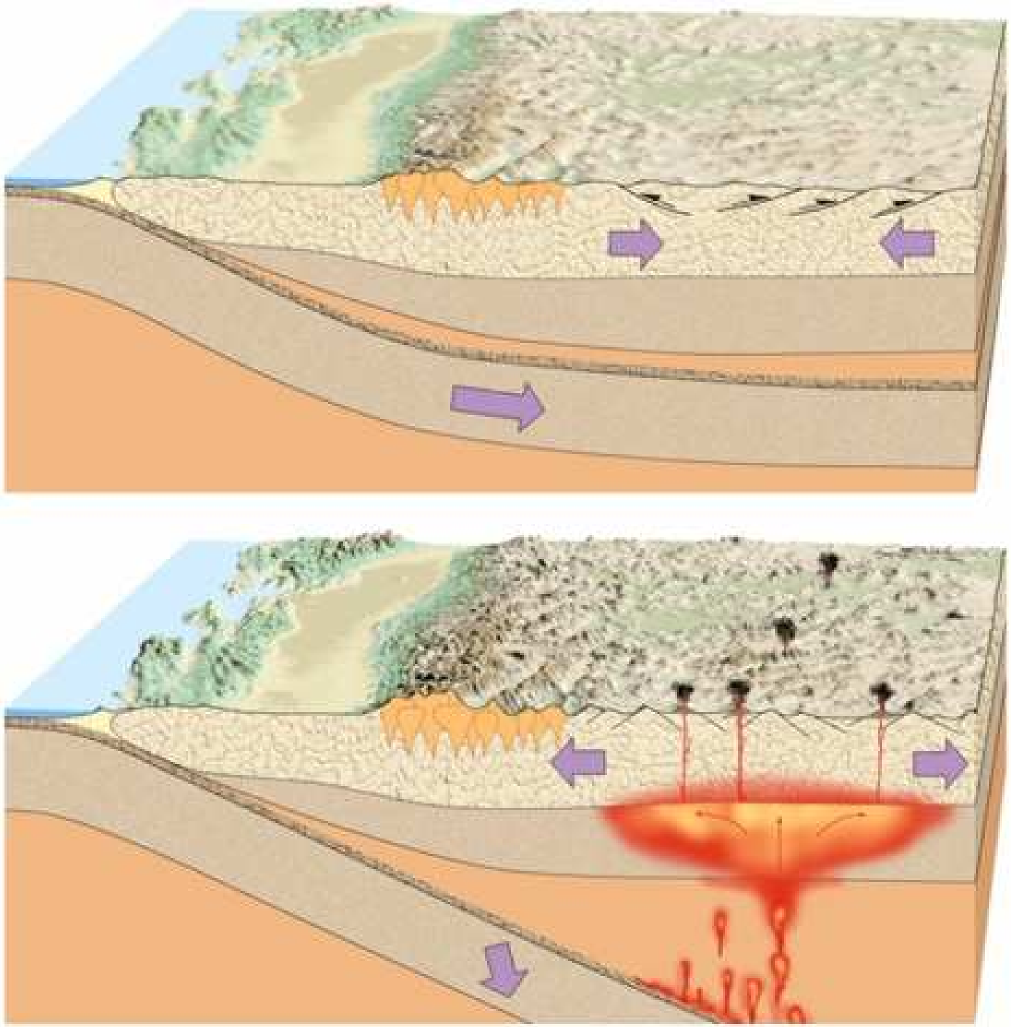
Colorado Plateau



Basin and Range Province

- Generalized cross section of the Basin and Range Province
  - ranges are bounded by faults

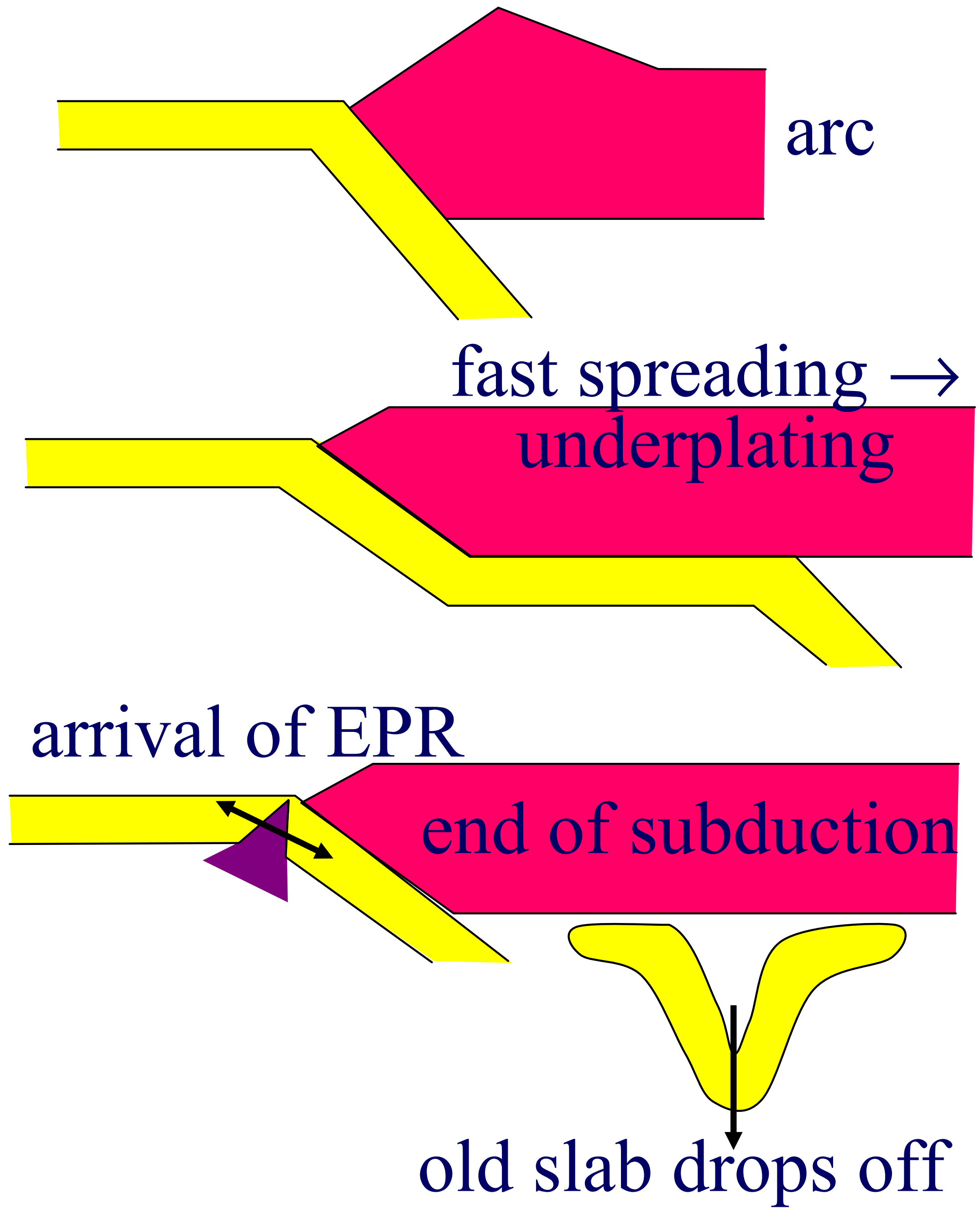




Bottom: Sinking of this oceanic slab allowed for the upwelling of hot material from the asthenosphere. The buoyancy of the warm material caused upwarping and tensional fracturing in the crust above. This event was associated with volcanism and east-west extension of the crust by nearly 150 kilometers.

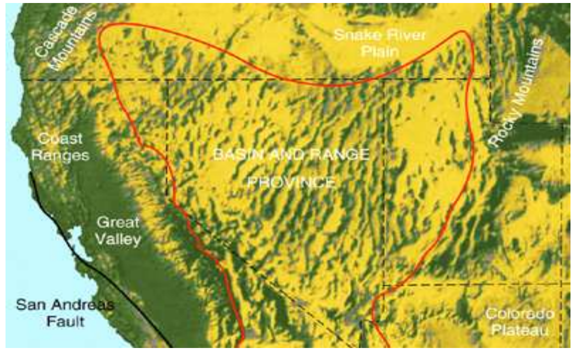
Basin and Range

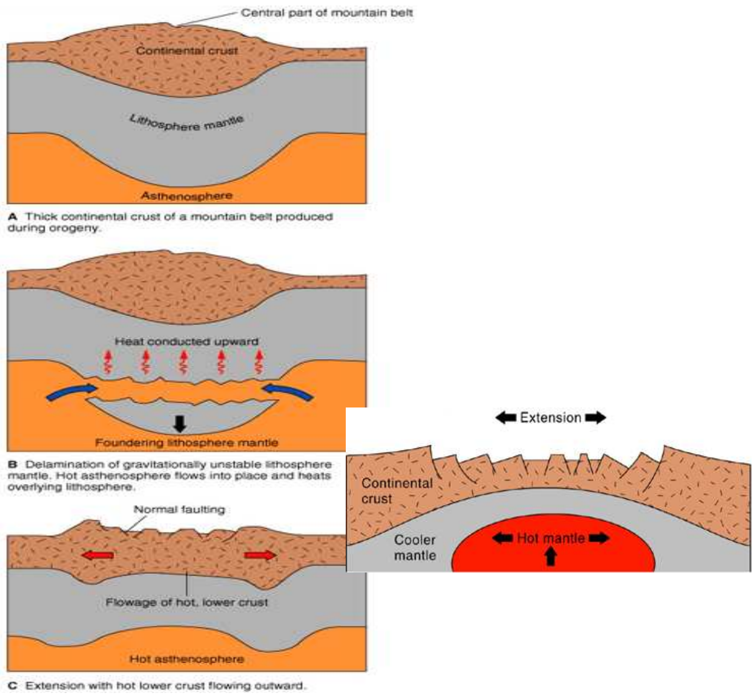
- why is there extension in the Basin and Range in the first place?
- extension started about 25 Ma - same time as the beginning of subduction of the East Pacific Rise
- when slab drops off, mantle oozes around it → huge positive gravity anomaly
- fast uplift of Colorado Plateau (since 5 Ma) as a result of thermal expansion



Evolution of Mountain Belts

- Basin-and-Range province of western North America may be the result of *delamination*
  - Overthickened mantle lithosphere beneath old orogenic mountain belt may break off and sink (*founder*) into asthenosphere
  - Resulting inflow of hot *asthenosphere* can stretch and thin overlying crust, producing normal faults under tension



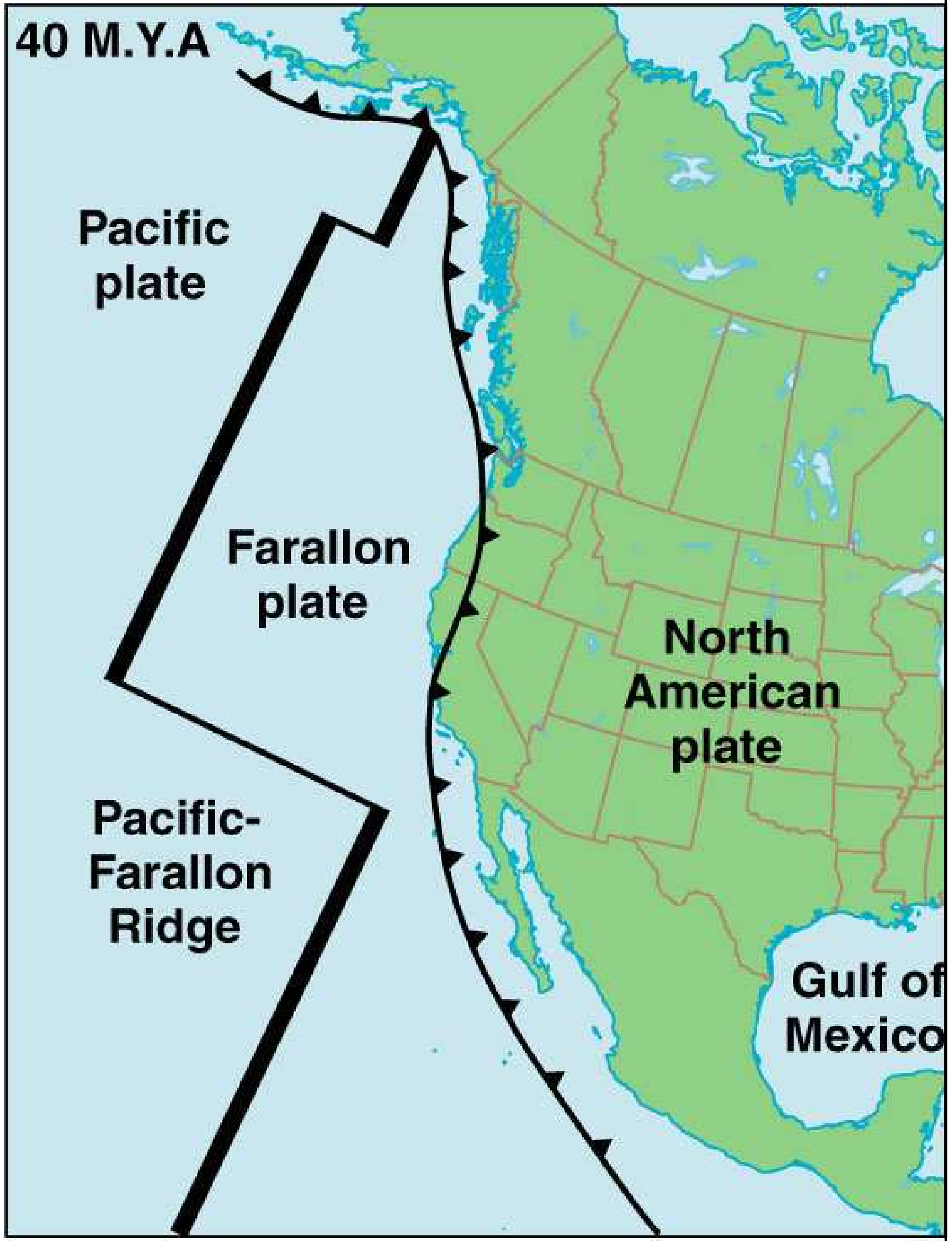


Cordillera Evolved

- After Laramide deformation, Cordillera continued to evolve with large-scale block-faulting, extensive volcanism and vertical uplift and deep erosion
  - **Basin and Range**
- During about the first half of the Cenozoic Era, a subduction zone was present along the entire western margin of the Cordillera, but now most of it is a transform plate boundary

Pacific Coast

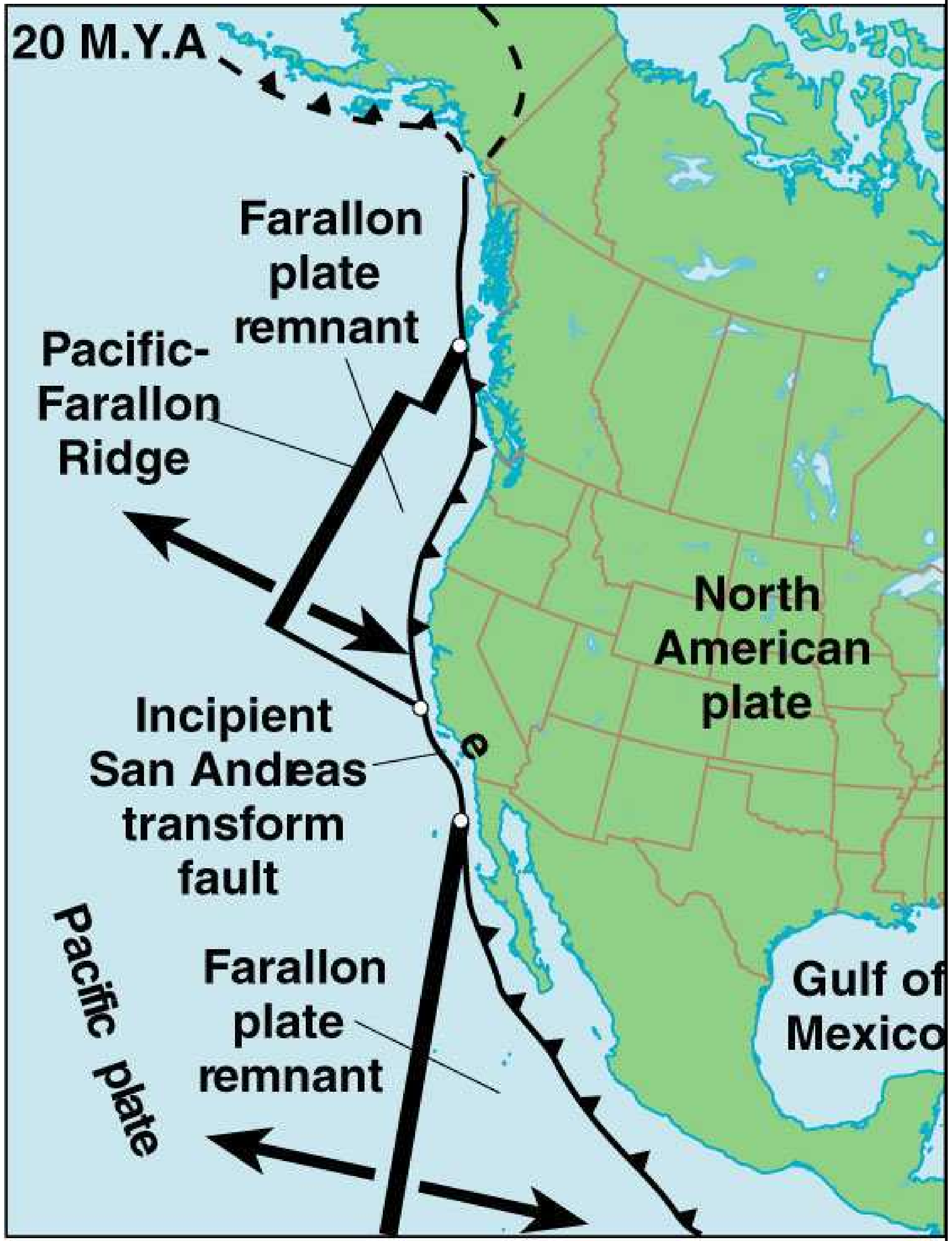
- Before the Eocene,
  - the entire Pacific Coast was a convergent plate boundary
  - Farallon plate was consumed at a subduction zone
  - stretched from Mexico to Alaska



(a)

Change from Subduction

- As the North American Plate overrode the Pacific–Farallon Ridge, its margin became transform faults
    - the San Andreas
    - and the Queen Charlotte
  - alternating with subduction zones



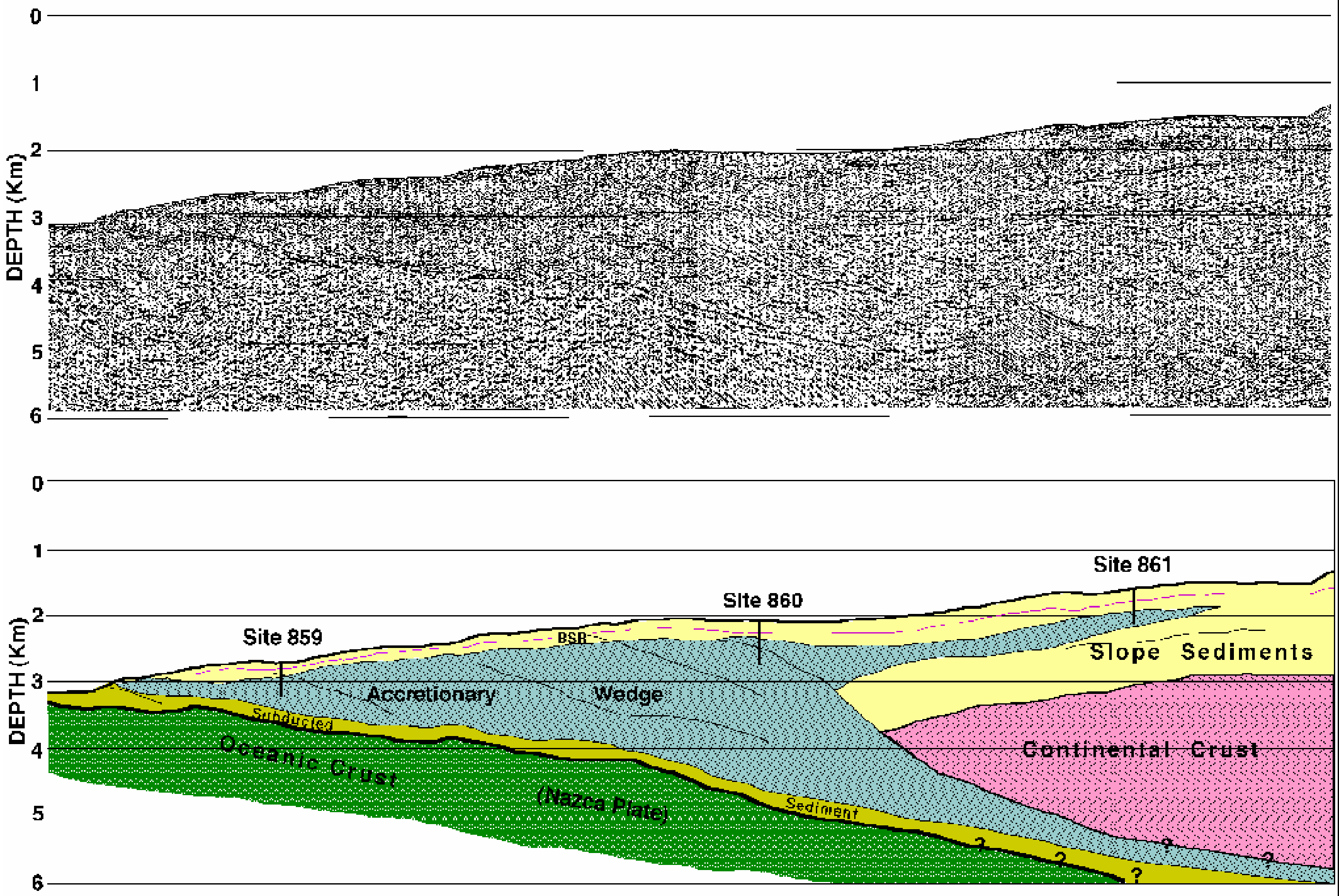
(b)

Extending the San Andreas Fault

- Further overriding of the ridge extended the San Andreas Fault and diminished the size of the Farallon–Plate remnants
- Now only two small remnants of the Farallon plate exist
  - the Juan de Fuca and Cocos plates

(c)

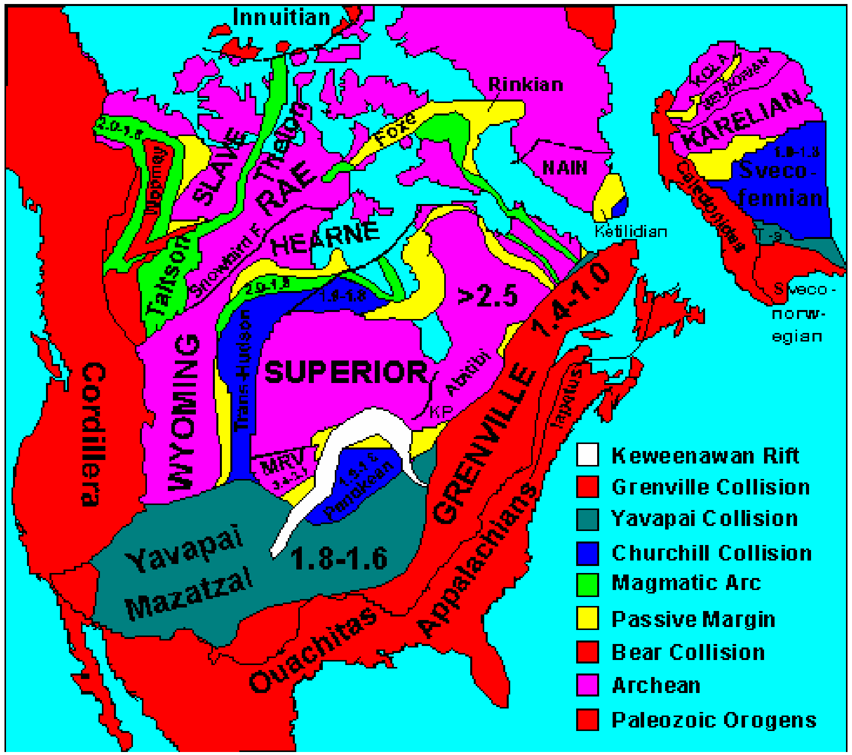
Line 745


DEPTH (Km)
0
1
2
3
4
5
6
DEPTH (Km)
Site 859
Site 860
Site 861
BSR
Slope Sediments
Accretionary Wedge
Subducted
Oceanic Crust
(Nazca Plate)
Sediment
Continental Crust
?

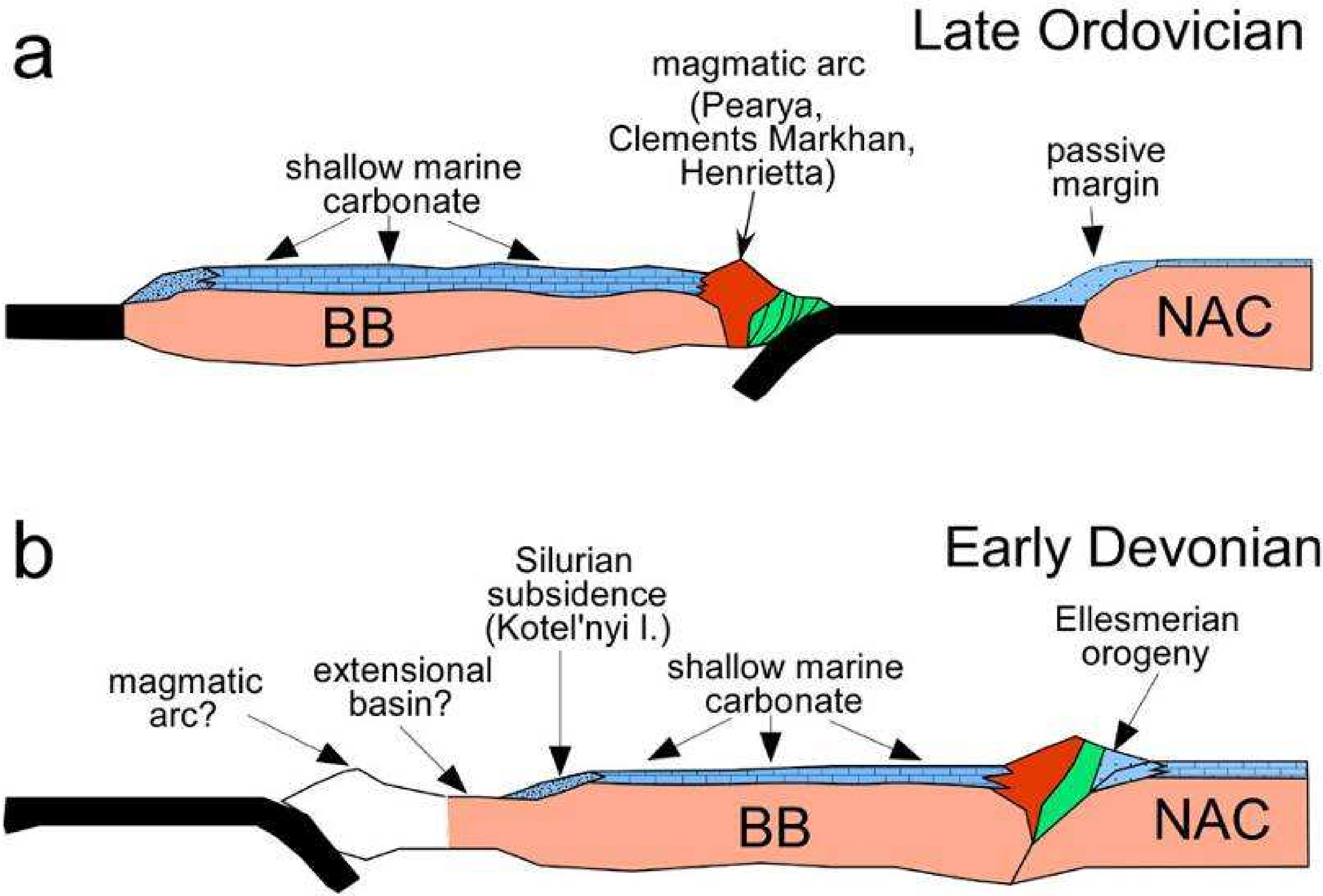
Franklinsko – inuitská orogeneze

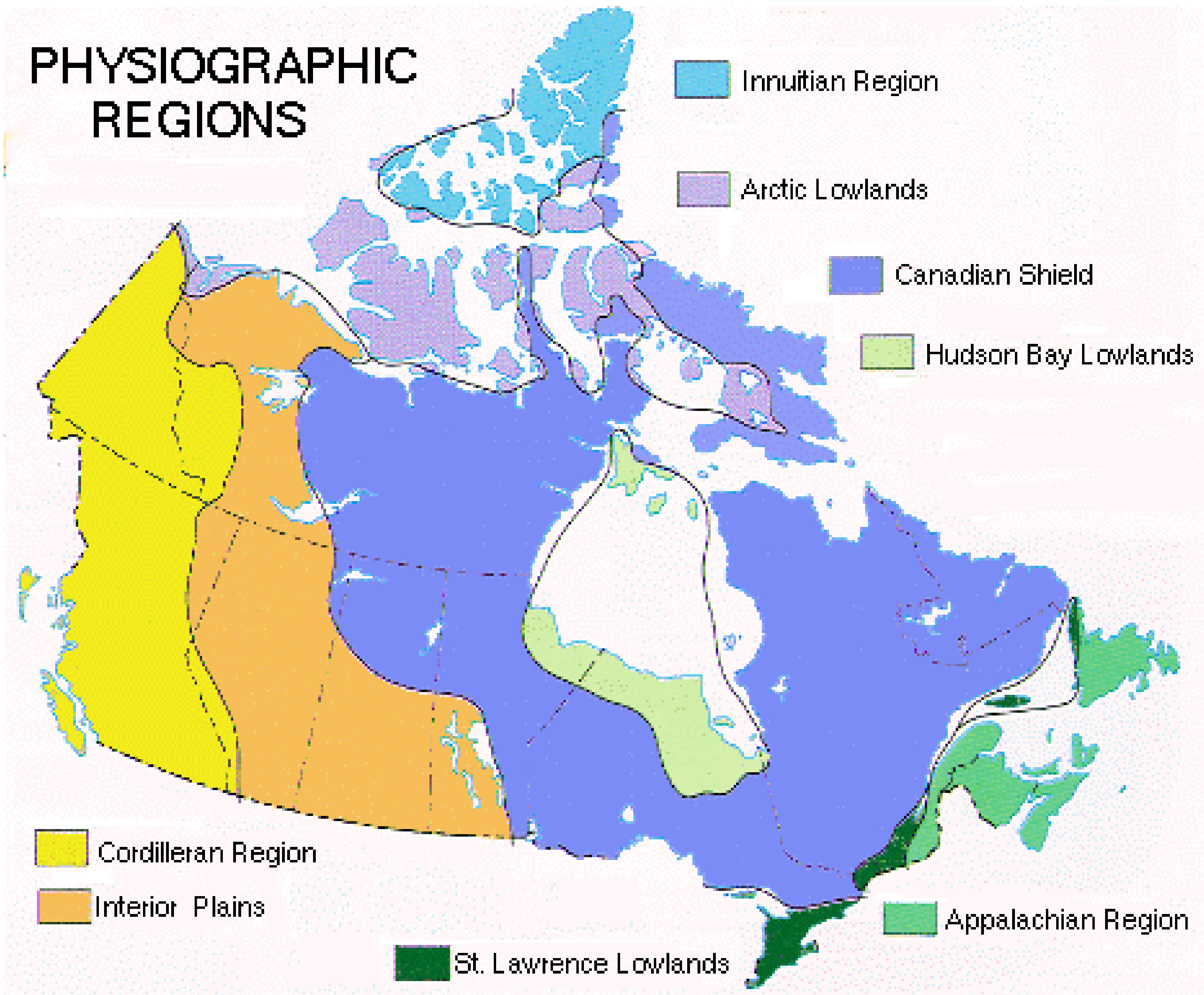
The **Franklinian orogeny**, in the northwestern Canada (Plafker & Berg, 1994), could be a result of collision of the Verkhoyanskian part of Siberia with the North Slope-Chukotkan part of Laurentia. According to Okulitch (1998), the suturing in the Canadian Islands occurred during Ordovician-Silurian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

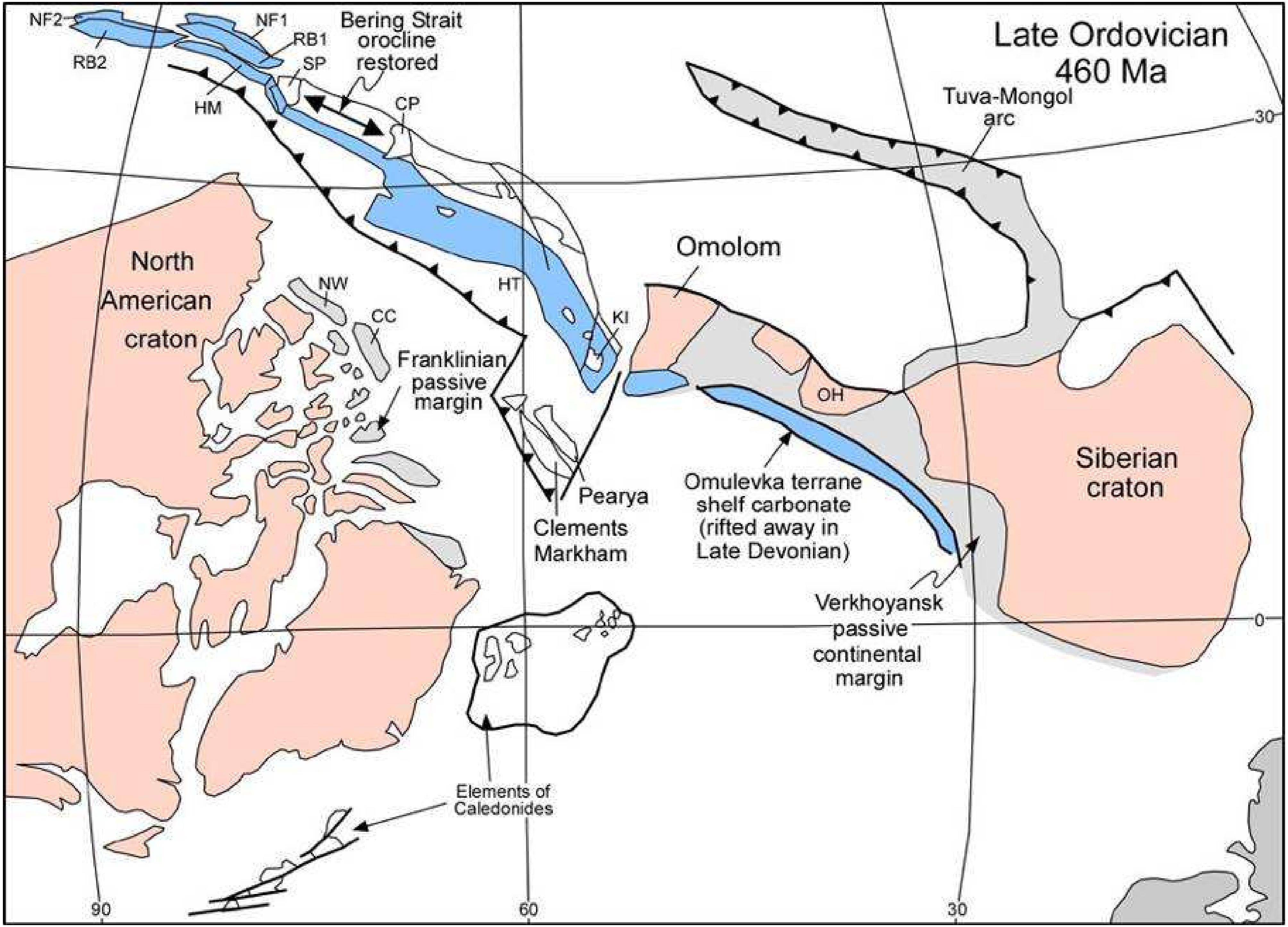


The late Silurian-early Devonian collision of the Bennett-Barrovia block

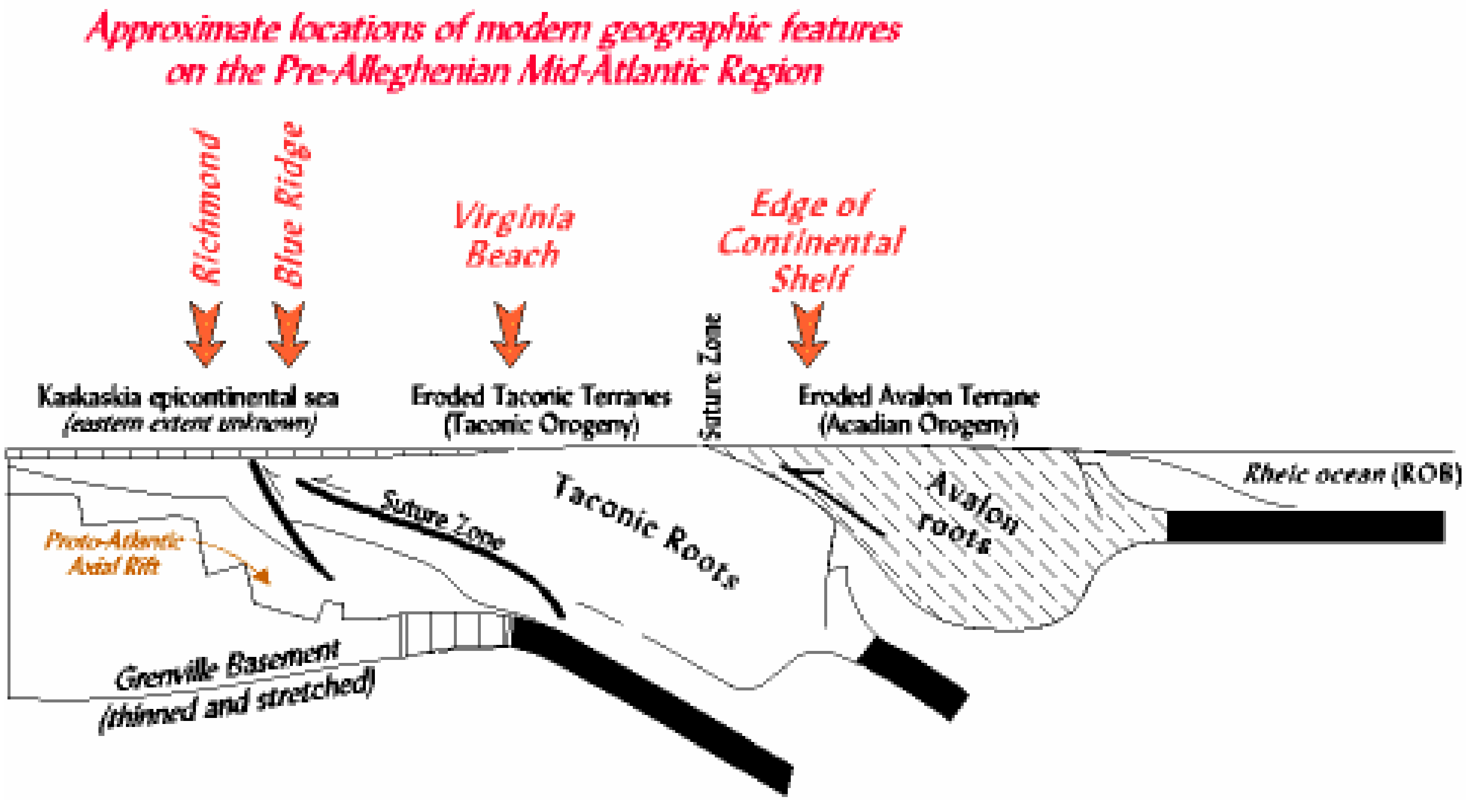




PHYSIOGRAPHIC REGIONS
Innuitian Region
Arctic Lowlands
Canadian Shield
Hudson Bay Lowlands
Cordilleran Region
Interior Plains
St. Lawrence Lowlands
Appalachian Region



Late Ordovician
460 Ma
NF2
NF1
RB1
RB2
SP
HM
Bering Strait
orocline
restored
CP
Tuva-Mongol
arc
30
North
American
craton
NW
CC
HT
KI
Omolom
Franklinian
passive
margin
Pearya
Clements
Markham
OH
Omulevka terrane
shelf carbonate
(rifted away in
Late Devonian)
Siberian
craton
Verkhoyansk
passive
continental
margin
0
Elements of
Caledonides
90
60
30


Approximate locations of modern geographic features
on the Pre-Alleghenian Mid-Atlantic Region
Richmond
Blue Ridge
Virginia Beach
Edge of Continental Shelf
Kaskaskia epicontinental sea
(eastern extent unknown)
Eroded Taconic Terranes
(Taconic Orogeny)
Suture Zone
Eroded Avalon Terrane
(Acadian Orogeny)
Rheic ocean (ROB)
Proto-Atlantic Axial Rift
Suture Zone
Taconic Roots
Avalon roots
Grenville Basement
(thinned and stretched)

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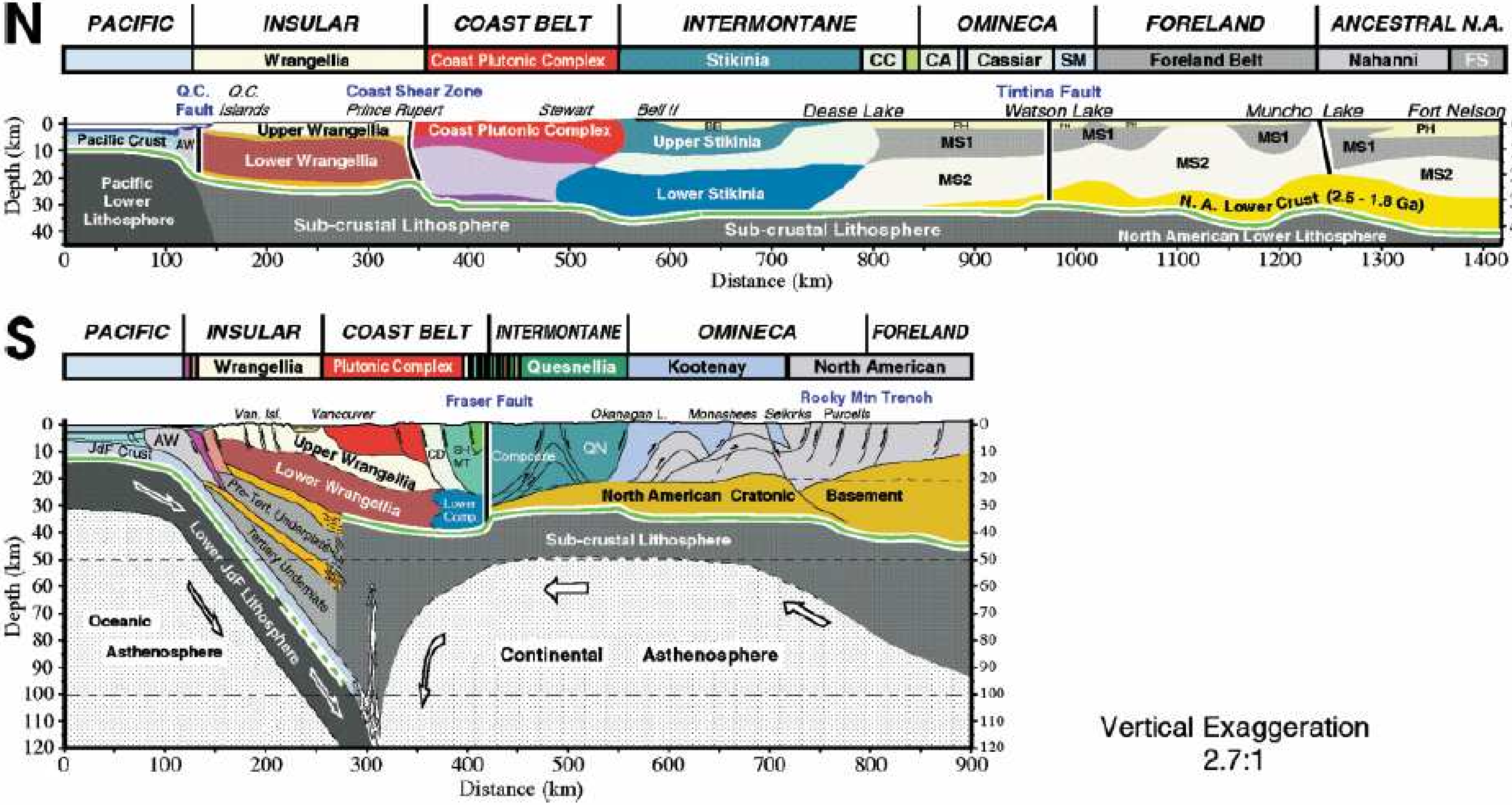

Figure 2. Comparison of interpreted simplified lithospheric structures along the northern (N) and southern (S) Cordilleran Lithoprobe transects, whose locations are shown by the red lines in Figure 1. In both profiles, the heavy green line is the crust-mantle boundary (Moho). AW accreted wedge; AX Alexander terrane; BB Bowser Basin; CA Cassiar terrane; CC Cache Creek terrane; CD Cadwallader terrane; FS, Fort Simpson (a Precambrian terrane in the craton); KO Kootenay terrane; MS1 undivided Precambrian (1200-800 Ma) metasedimentary rocks; MS2 undivided Precambrian (1800-1200 Ma) metasedimentary rocks; MT-SH undivided Methow and Shuksan terranes; QN Quesnel terrane; SM Slide Mountain terrane; ST Stikine terrane; WR Wrangellia. Most terrane descriptions are in Table 2. Figure modified by P.T.S. Hammer from Clowes and Hammer, 2000.

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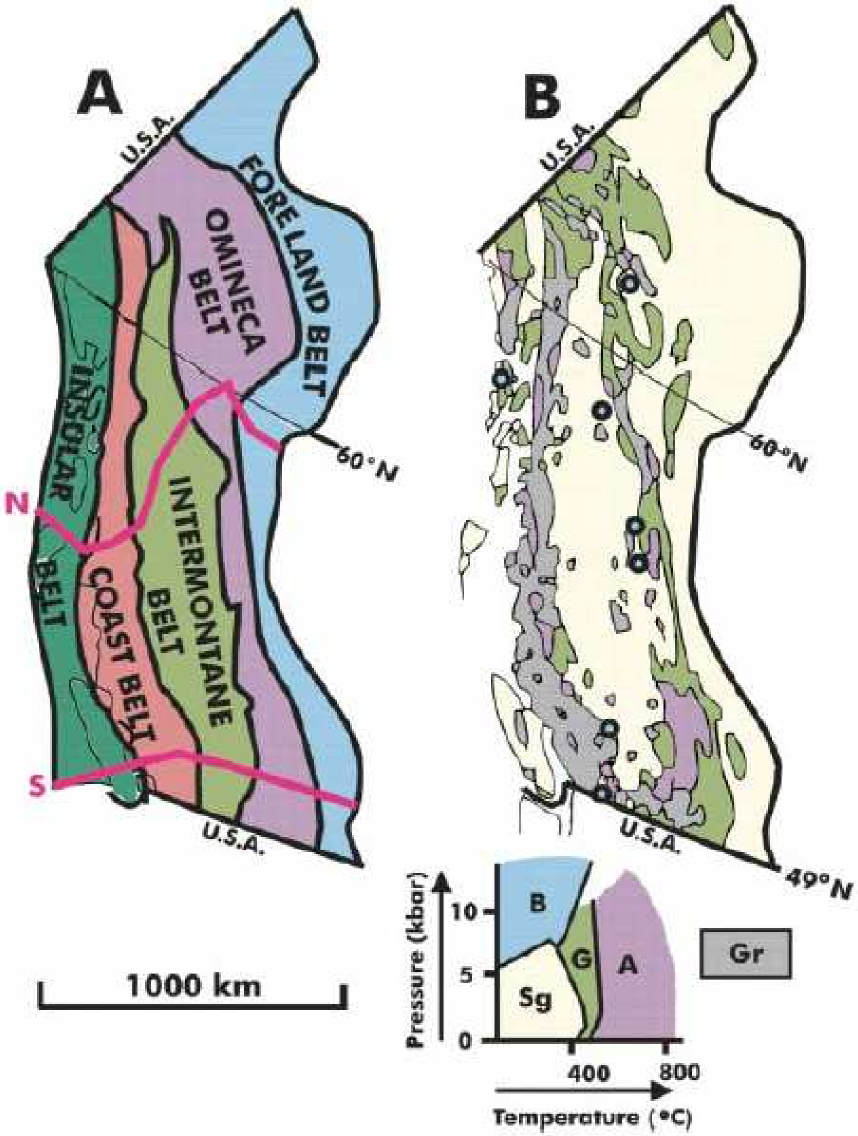

Figure 1. The Canadian Cordillera and adjoining parts of southeastern Alaska showing:
A *Location of the five morphogeological belts (details in Table 1); red lines show approximate positions of the northern (N) and southern (S) Canadian Cordilleran Lithoprobe transects, details of which are in Figure 2.*
B *Simplified metamorphic map of the Canadian Cordillera, showing the close correspondence between the distribution of higher grade metamorphic rock facies and granitic rocks and Omineca and Coast belts. The map legend below is a pressure-temperature diagram whose colours correspond with those on the map; metamorphic facies are: Sg subgreenschist; G greenschist; A amphibolite, and B blueschist (blue dots on map); box labelled Gr denotes granitic rock.*

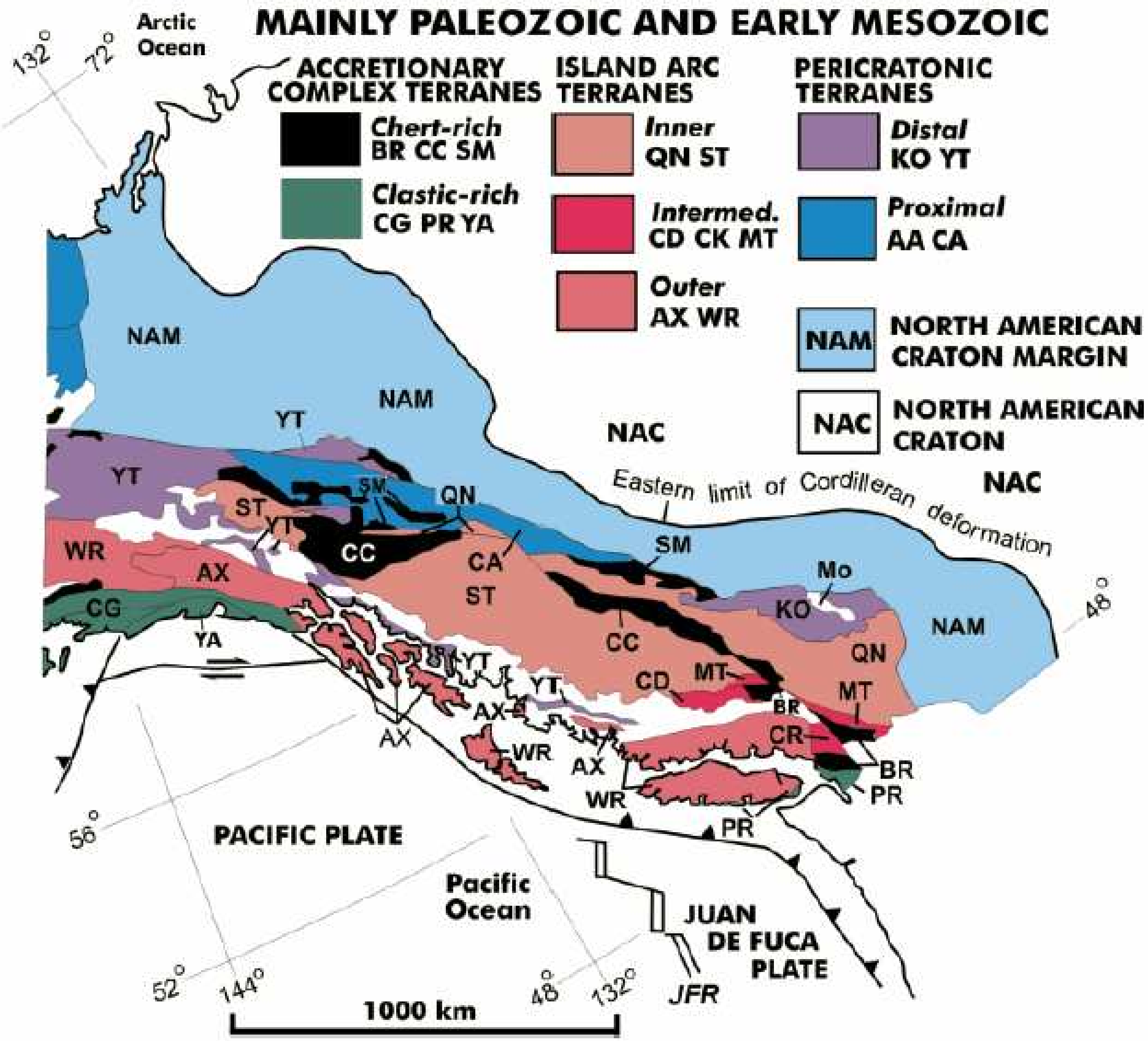

Figure 3. Terrane map of the Canadian Cordillera and adjacent parts of Alaska; most rocks shown are of Paleozoic and early Mesozoic ages. Map shows locations of: (1) rocks (NAM) that were deposited on the ancient continental margin; Mo is part of the craton exposed in a structural window; (2) proximal (CA) and distal (KO, YT) pericratonic terranes that formed along the margin but in uncertain paleogeographic relationship to it; (3) accreted terranes of (3a) (mainly) island arc affinity; "inner terranes" (QN, ST) accreted in the Jurassic; "outer terranes" (AX, WR) accreted in the Cretaceous; (3b) accretionary complexes; "chert-rich" (BR (part), CC, SM) are pre-Middle Jurassic; "clastic-rich" (BR (part), CG, PR) include Late Jurassic to Recent rocks. The terranes are named and their nature summarized in Table 2. White areas, mainly in the Coast Belt, feature voluminous Middle Jurassic and younger granitic rocks; JFR is the Juan de Fuca Ridge (modified from Monger and Nokleberg, 1996 and Nokleberg et al., 2000).

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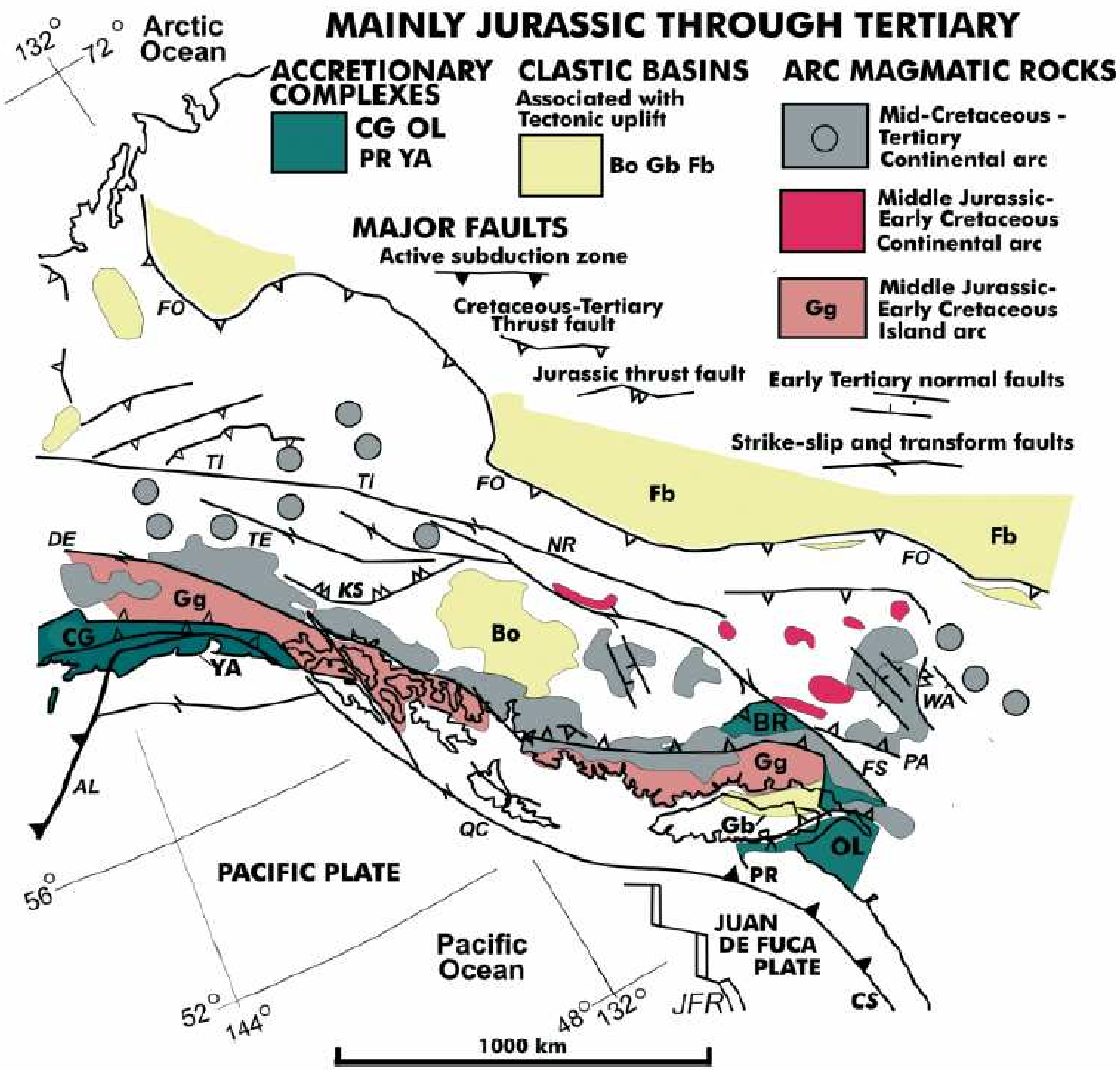

Figure 4. Locations of features of the Canadian Cordillera and adjacent parts of Alaska that formed during the period of terrane accretion and mountain building, mainly from Middle Jurassic through early Tertiary time (~180-40 Ma). (1) Middle Jurassic to Early Cretaceous continental arcs that are emplaced across CC, QN, KO; (2) Middle Jurassic through Early Cretaceous Gravina-Gambier (Gg) island arc, emplaced across WR, AX; (3) Mid-Cretaceous through early Tertiary continental arcs emplaced across all terranes, with exception of the accompanying accretionary complexes; filled circles denote plutons too small to show on the map; (4) clastic sedimentary basins (Bo Bowser Basin; Fb Foreland Basin, Gb Georgia Basin; not shown are basins on the continental shelf filled with material eroded from adjoining, uplifted fold and thrust belts. (5) Major faults include (5a) active subduction zones (AL Aleutian; CS Cascade); (5b) active transform fault (QS Queen Charlotte); (5c) major thrust fault systems of (a) Jurassic age (KS King Salmon; WA Waneta) and (b) mid-Cretaceous and early Tertiary ages (FO Foreland; PA Pasayten); (5d) major strike-slip faults of mainly Late Cretaceous and Tertiary ages (DE Denali; NR Northern Rocky Mountain Trench; TE Teslin; TI Tintina); (5e) early Tertiary normal faults.

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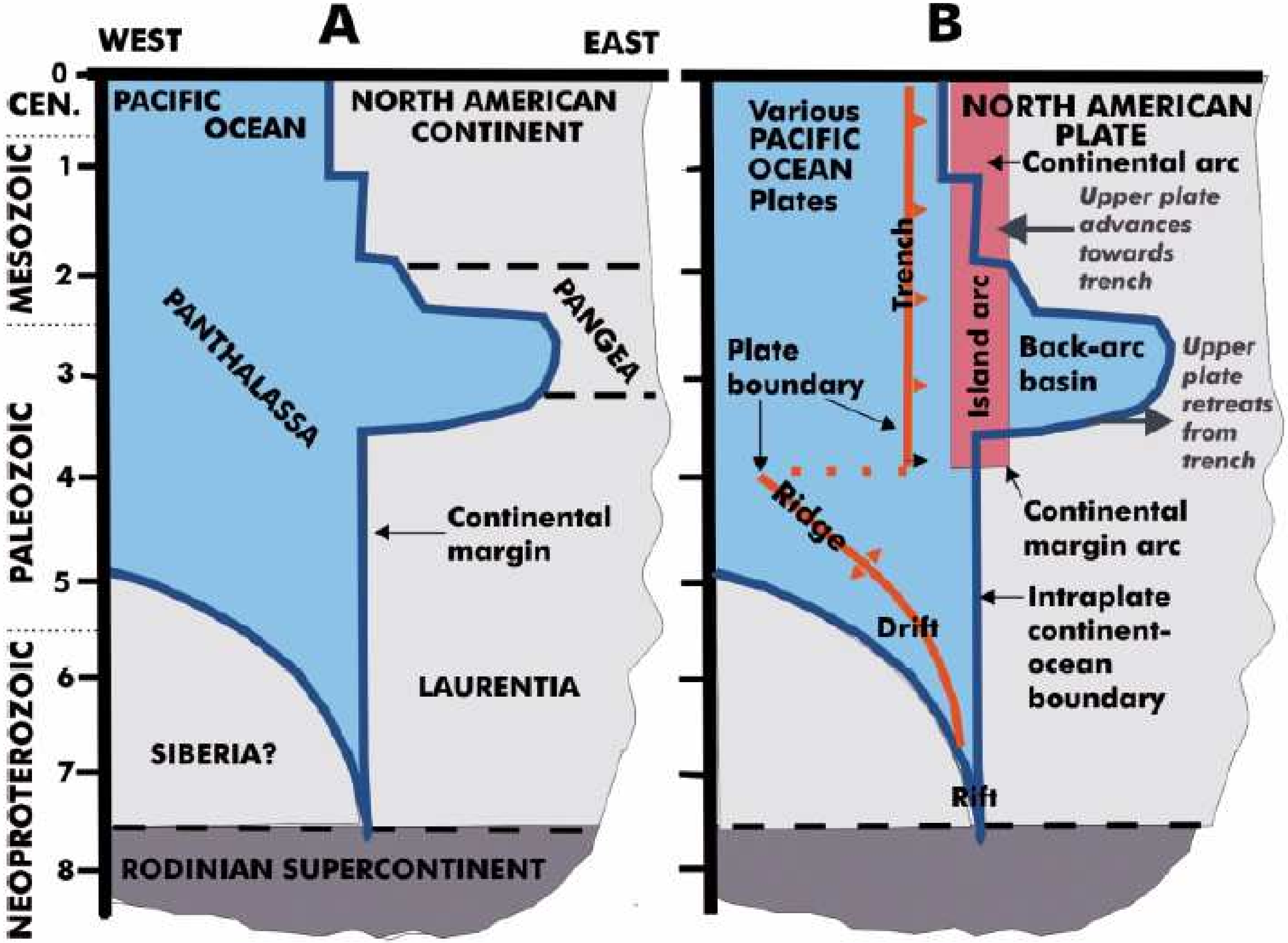

Figure 5: Evolution of the Canadian Cordillera cartooned on space-time diagrams. Horizontal coordinate: west to east (in present geographic coordinates); geographic position (after Early Devonian time) is fixed relative to the trench; vertical coordinate: numbers show age in hundreds of millions of years before present. A gives names of continents and ocean at different times and the names applied to each at those times. B shows features related to the plate tectonic activity at different times.

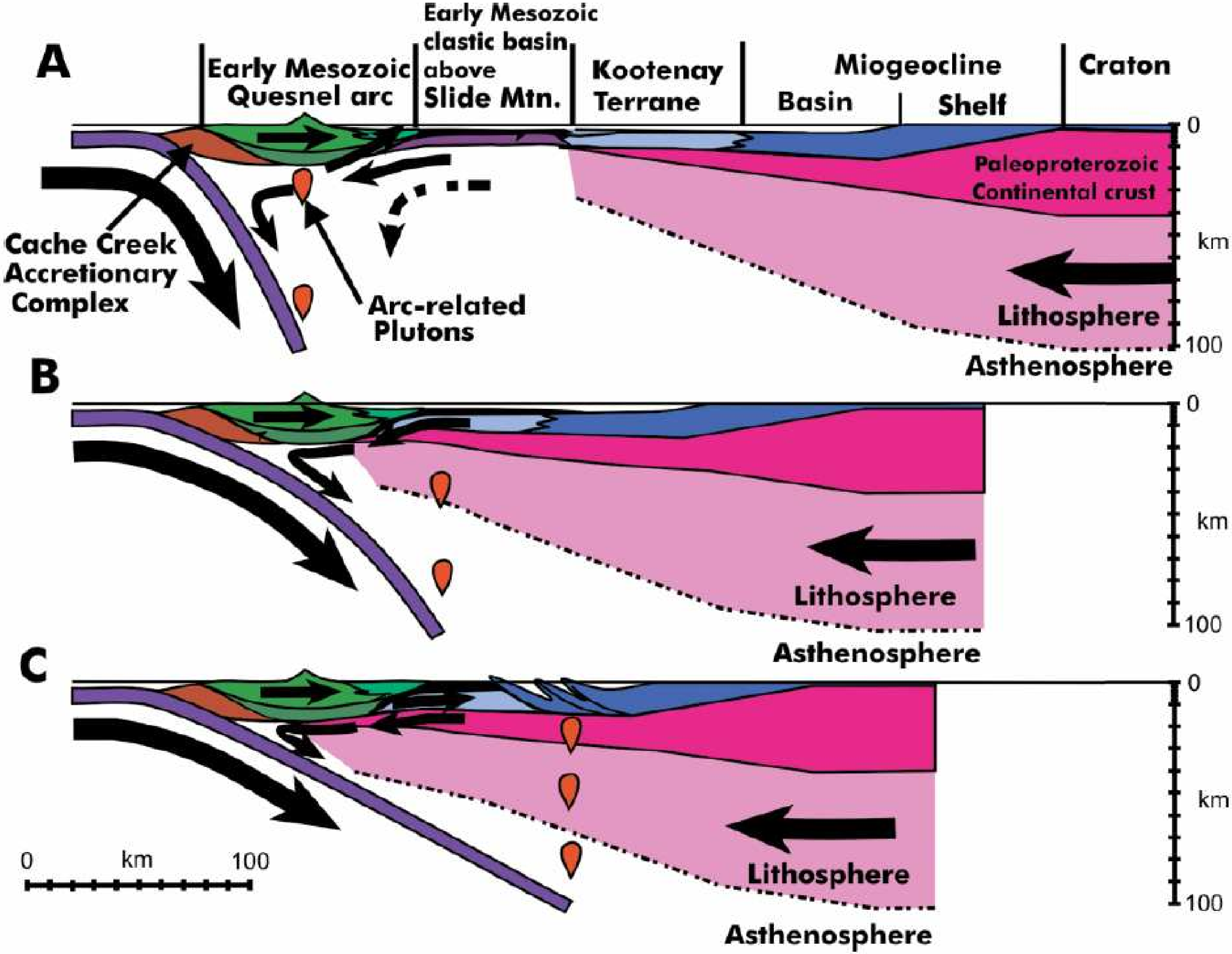

Figure 6: Tectonic wedging and crustal thickening in southeastern British Columbia.
A: Early Jurassic (~185 Ma) island arc (of QN, Figure 3) and its early Mesozoic back-arc basin, (mainly) on top of Slide Mountain terrane; onset of convergence of North America with trench to west and collapse of back-arc basin. B: Late Early Jurassic (~180 Ma) collapsed basin thrust over old continental margin; flattening of subduction zone and initiation of continental margin arc. C: Early Middle Jurassic (~170 Ma) southwest verging deformation occurred as Kootenay terrane was detached from North America and wedged under the old continental margin deposits; North American lithosphere wedged under Quesnel terrane; entrained and consumed in the subduction zone; subduction zone flattened and magmatic arc migrated eastward into the zone of southwest verging deformation.