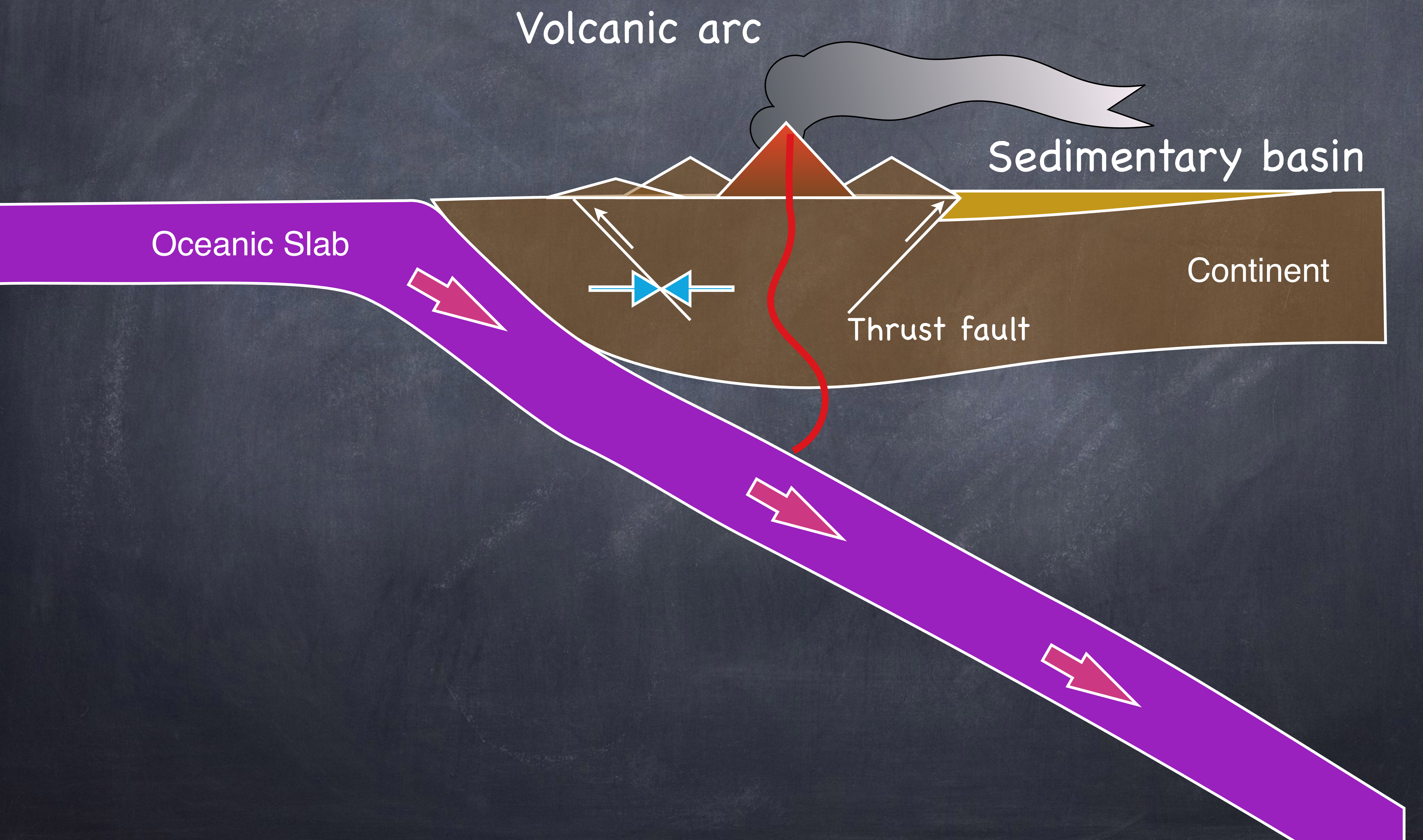
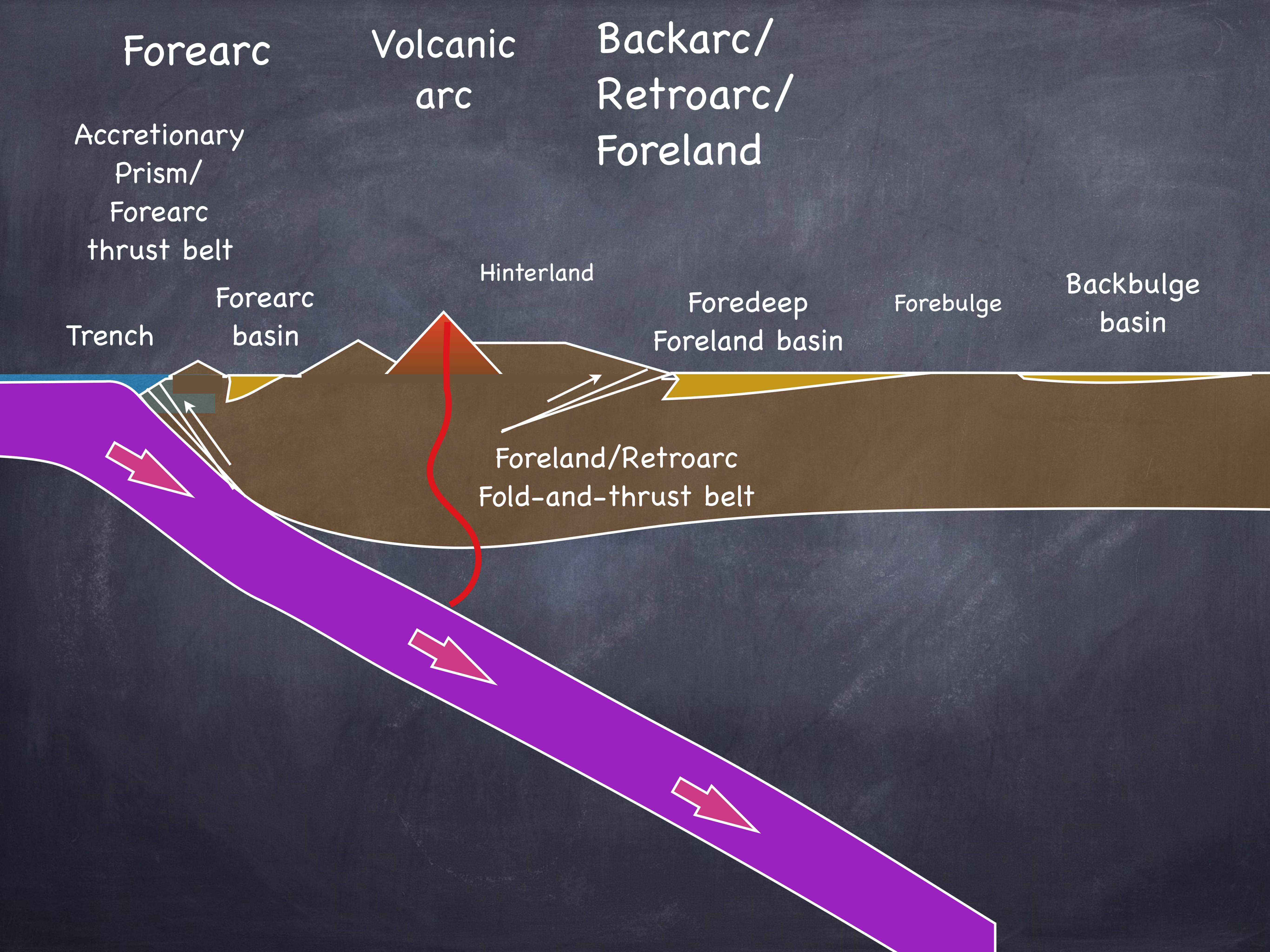
Typical subduction



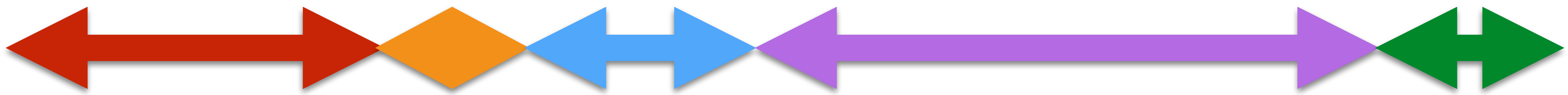

Forearc
Volcanic arc
Backarc/ Retroarc/ Foreland
Accretionary Prism/ Forearc thrust belt
Hinterland
Trench
Forearc basin
Foredeep Foreland basin
Forebulge
Backbulge basin
Foreland/Retroarc Fold-and-thrust belt

Old words we still sometimes use

Miogeocline	Usually as an adjective, this refers to a thick wedge-shaped sequence of sedimentary rock with few or no volcanics. Basically, a passive margin sequence.
Eugeocline	Usually as an adjective, this refers to a sequence of deep-water sediments (cherts, pelagic limestones) and volcanics (dominantly pillow basalts). Basically, ocean floor material.
Tertiary	The Cenozoic minus the Quaternary. (Left over from when the Paleozoic was the Primary and the Mesozoic the Secondary. The Quaternary continues, but as a Period within the Cenozoic).

A broad overview

Precambrian (Proterozoic) | Paleozoic | Mesozoic | Cenozoic



Accretion of island arcs

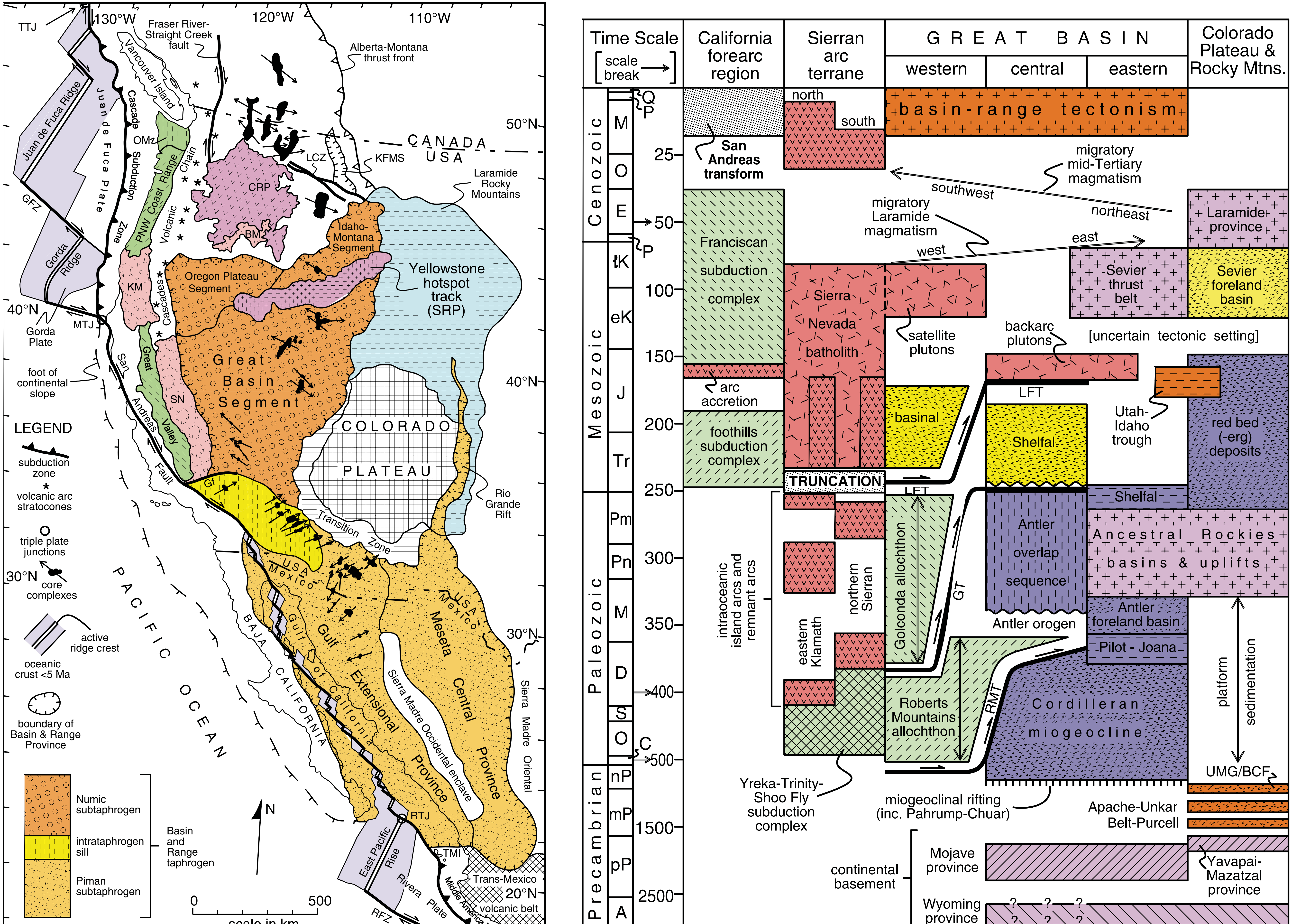
Magmatic episodes

Rifting

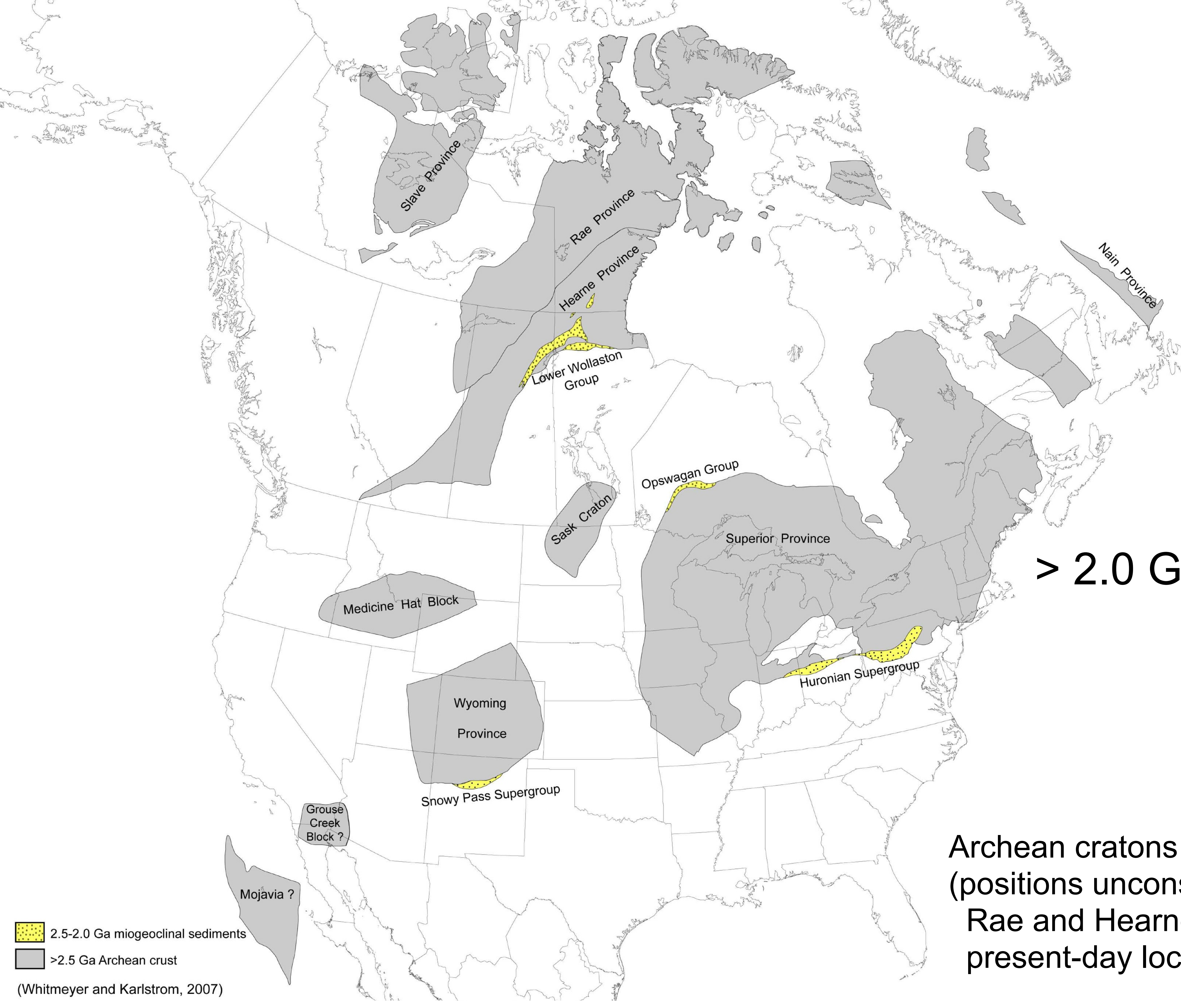
Passive margin (except for exotic terranes to the west)

Contractional tectonics (arcs, fold-and-thrust belts, accretion)

Transition to strike-slip (transform) tectonics, extensional tectonics

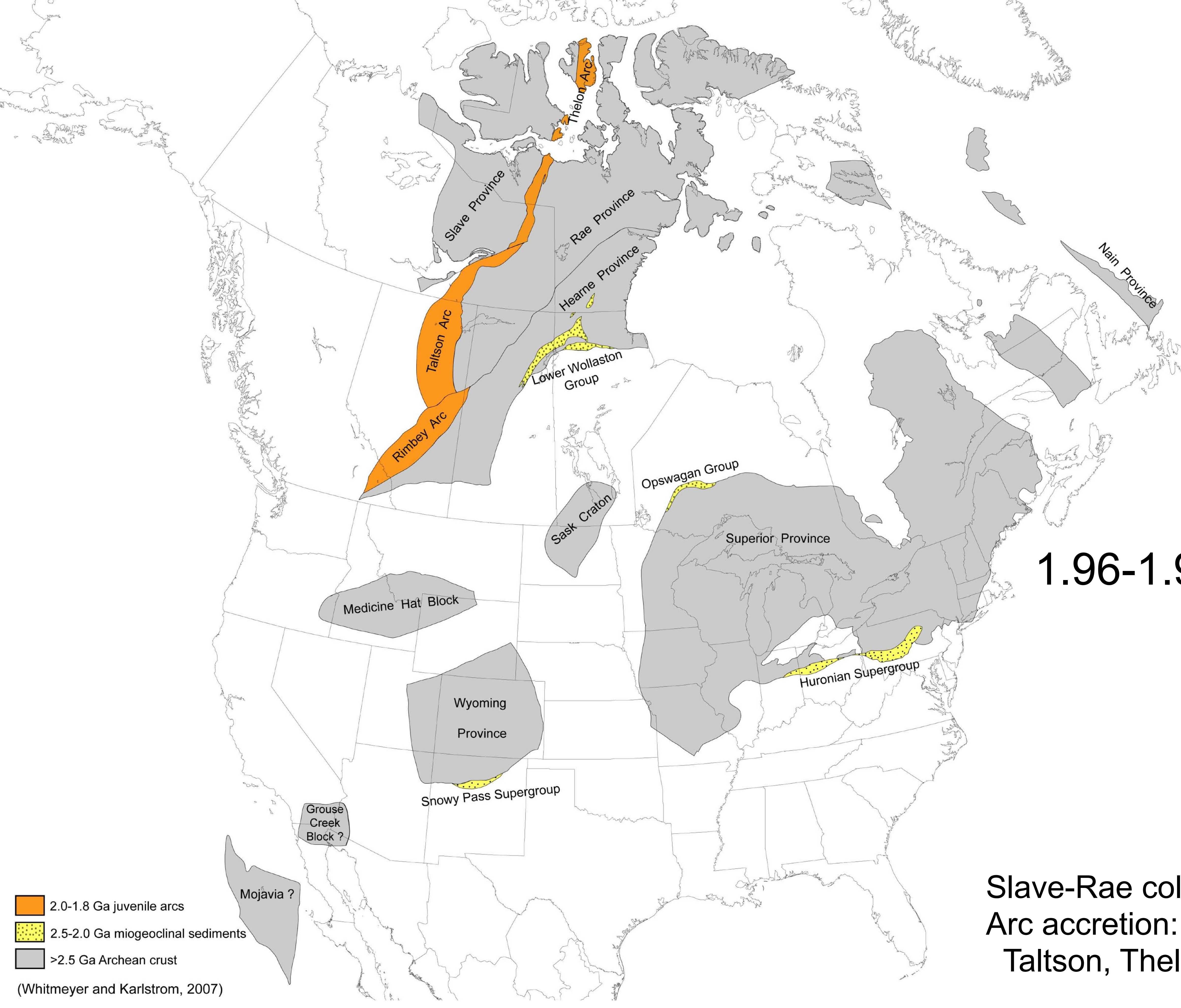


Dickinson, Geosphere, 2006



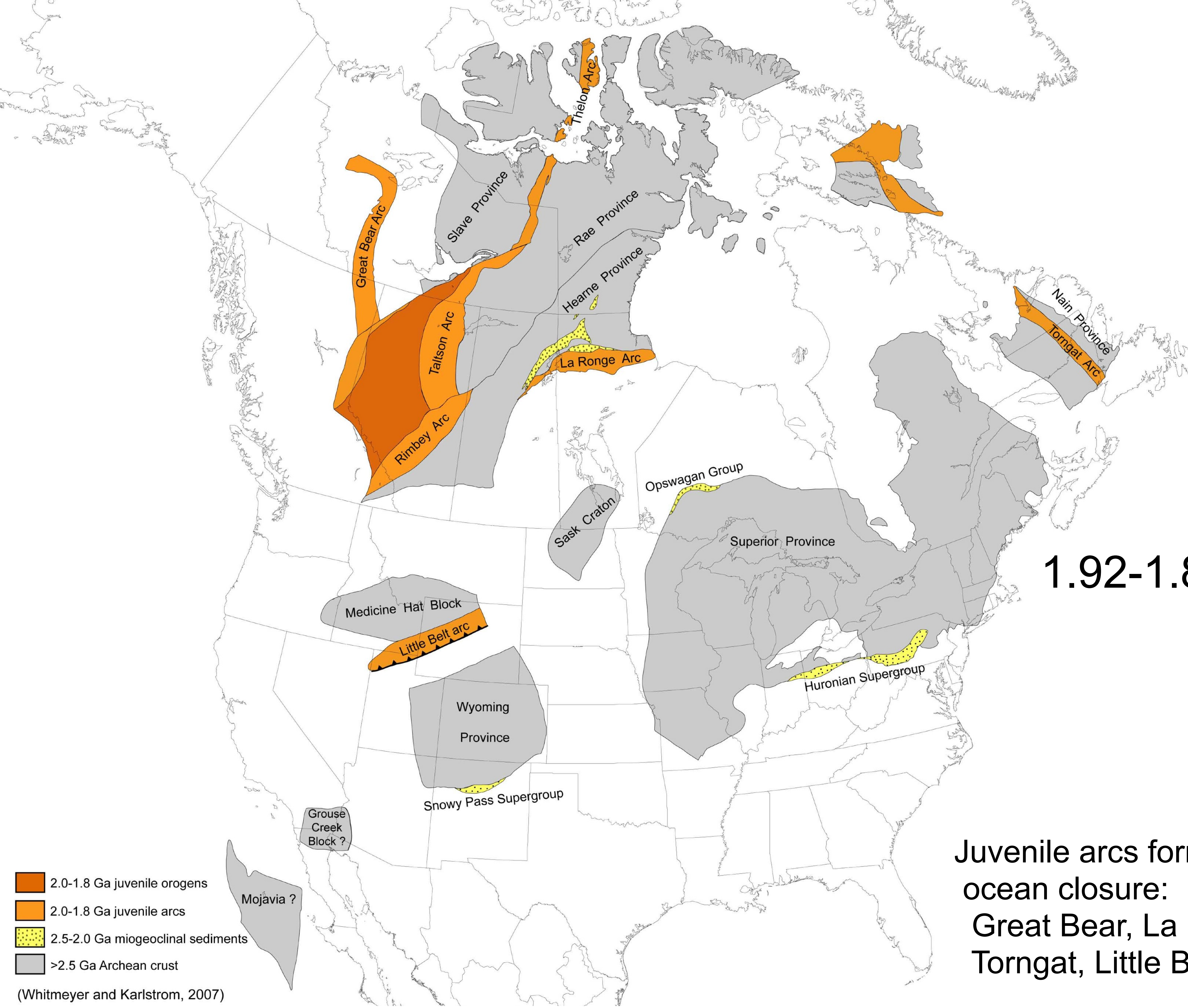
> 2.0 Ga

Archean cratons (positions unconstrained; Rae and Hearne in present-day locations)



1.96-1.92 Ga

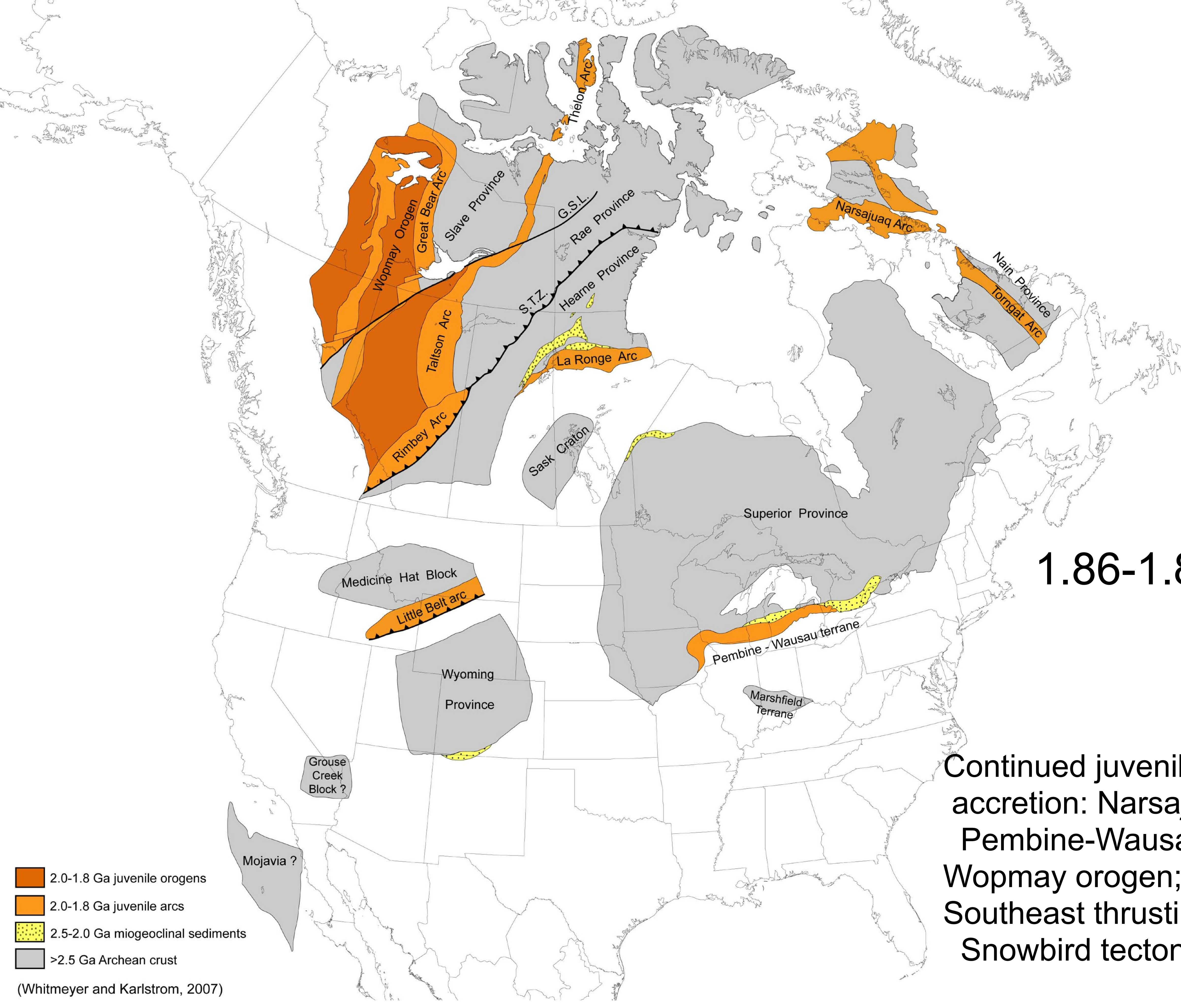
Slave-Rae collision,
Arc accretion: Rimbey,
Taltson, Thelon arcs



(Whitmeyer and Karlstrom, 2007)

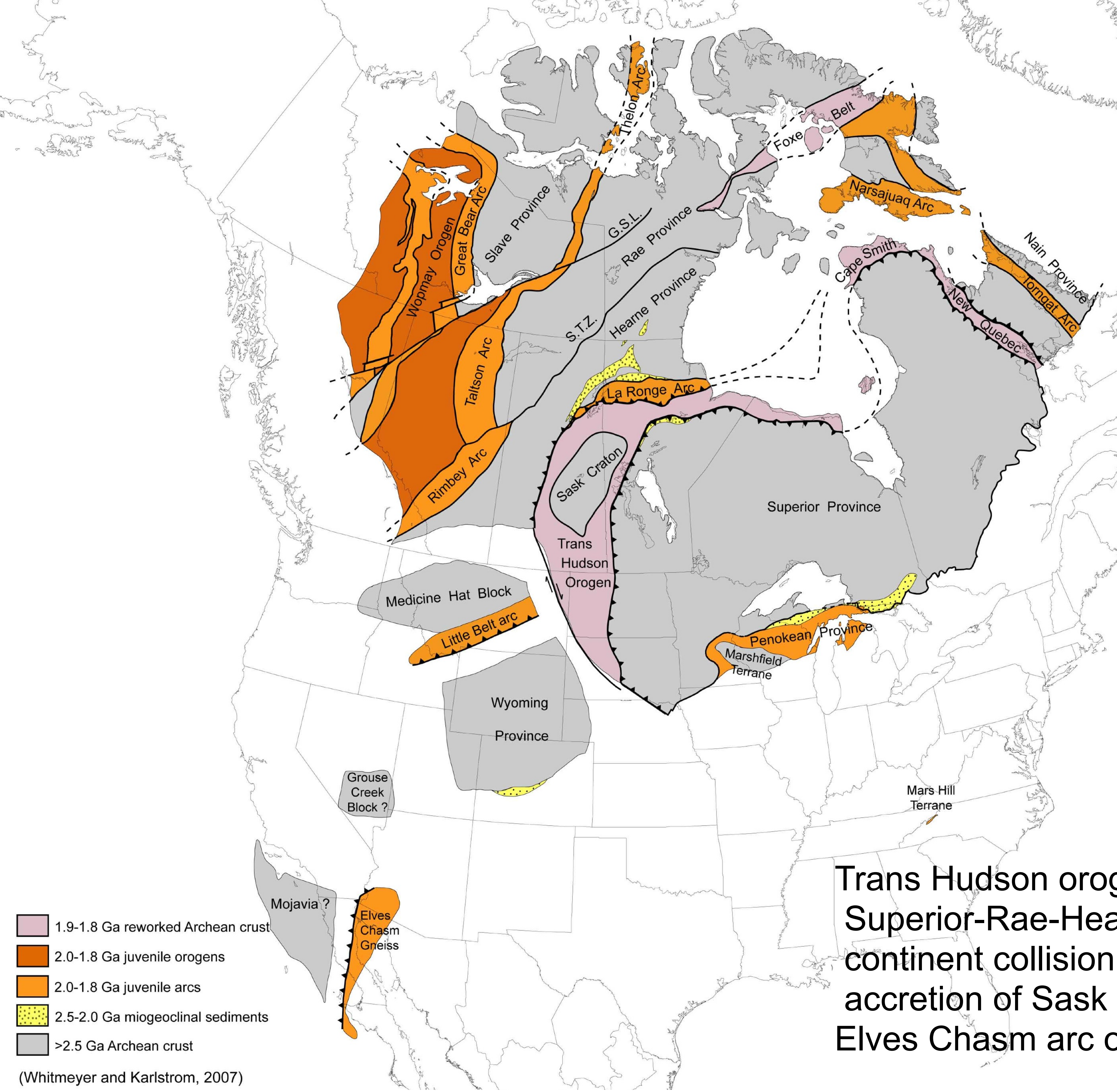
1.92-1.86 Ga

Juvenile arcs form during
ocean closure:
Great Bear, La Ronge,
Torngat, Little Belt arcs



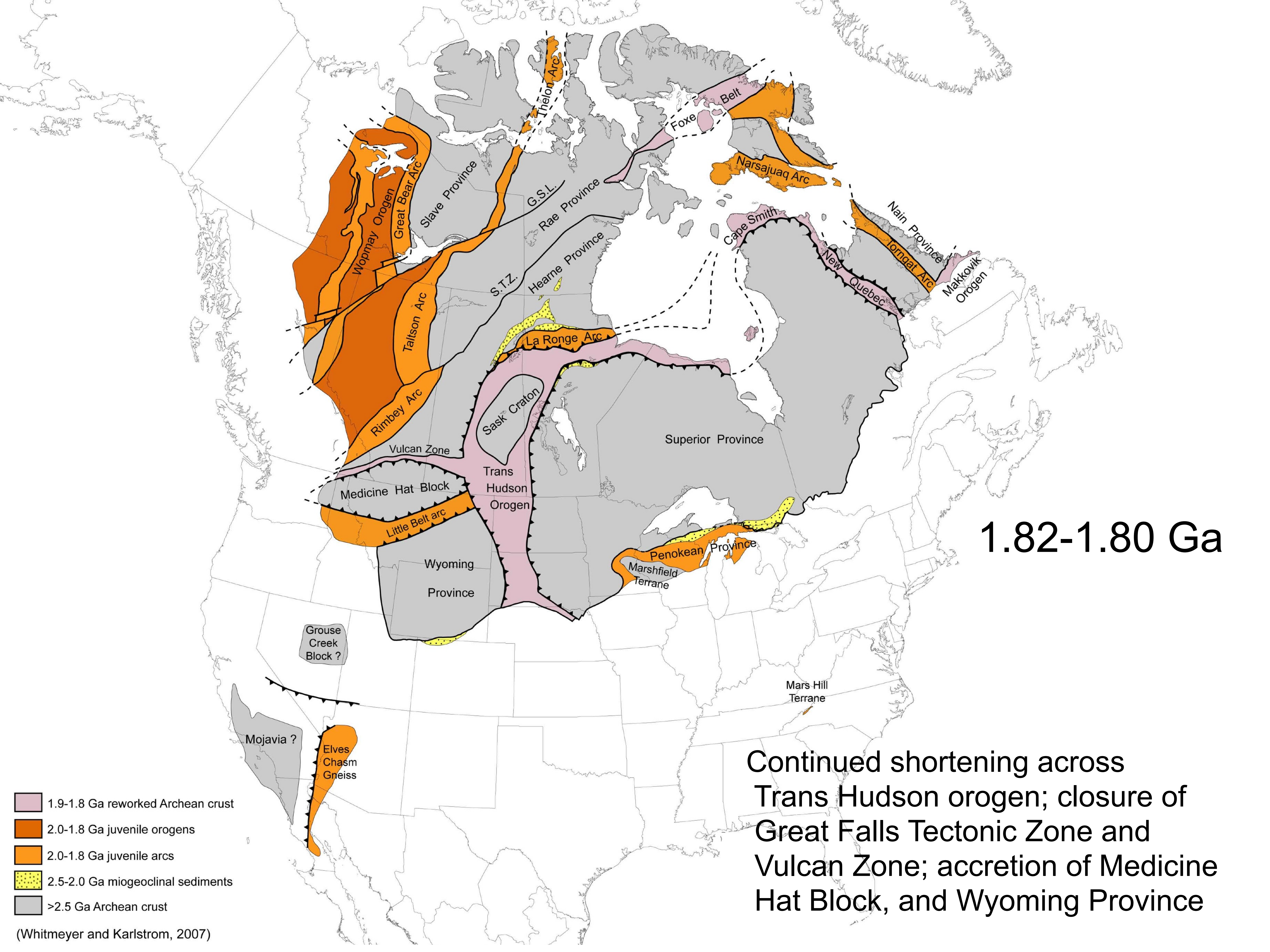
1.86-1.84 Ga

Continued juvenile arc accretion: Narsajuaq, Pembine-Wausau; Wopmay orogen; Southeast thrusting along Snowbird tectonic zone



1.84-1.82 Ga

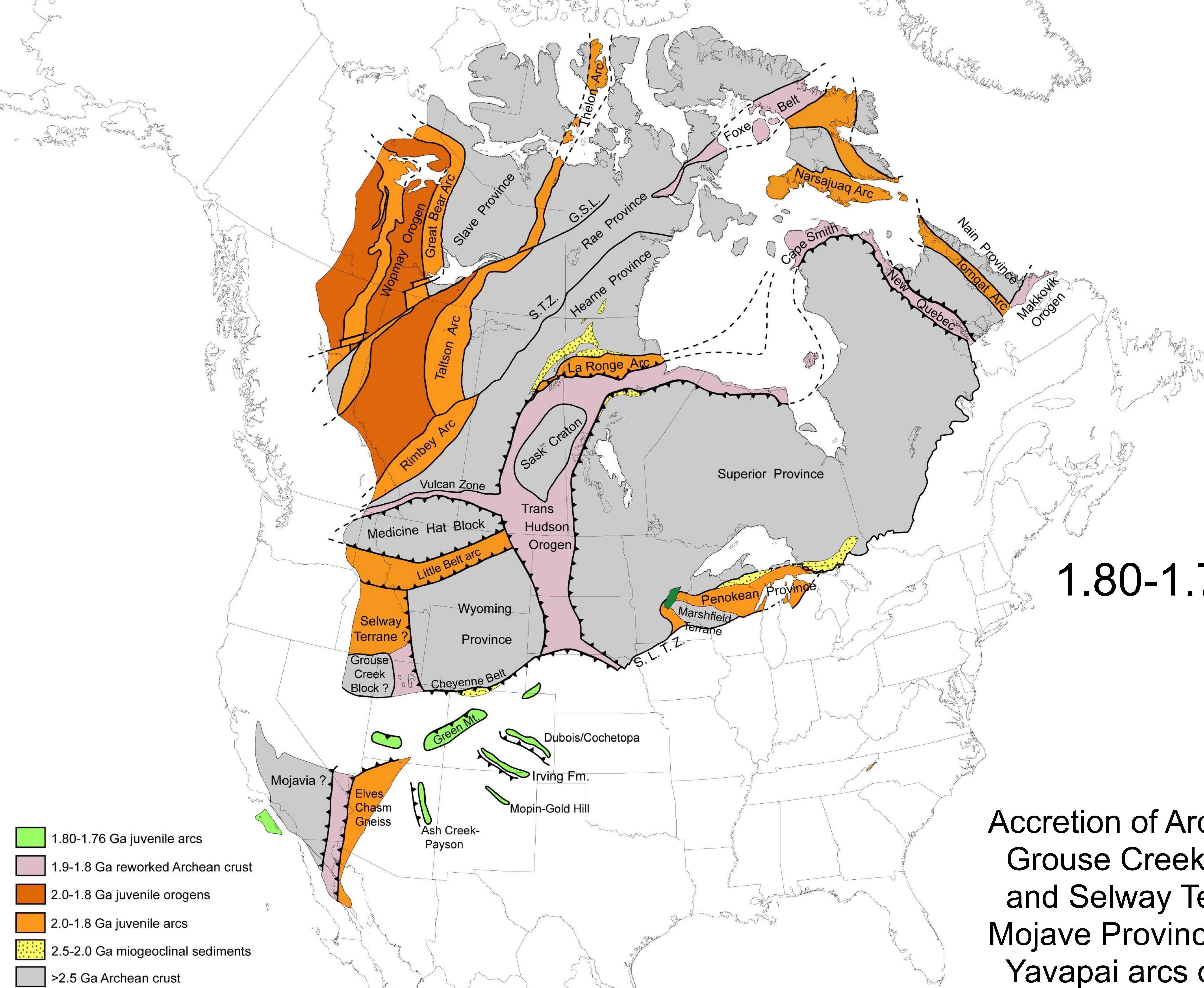
Trans Hudson orogen:
Superior-Rae-Hearne continent-continent collision, includes accretion of Sask craton;
Elves Chasm arc outboard of Mojavia



1.82-1.80 Ga

Continued shortening across Trans Hudson orogen; closure of Great Falls Tectonic Zone and Vulcan Zone; accretion of Medicine Hat Block, and Wyoming Province

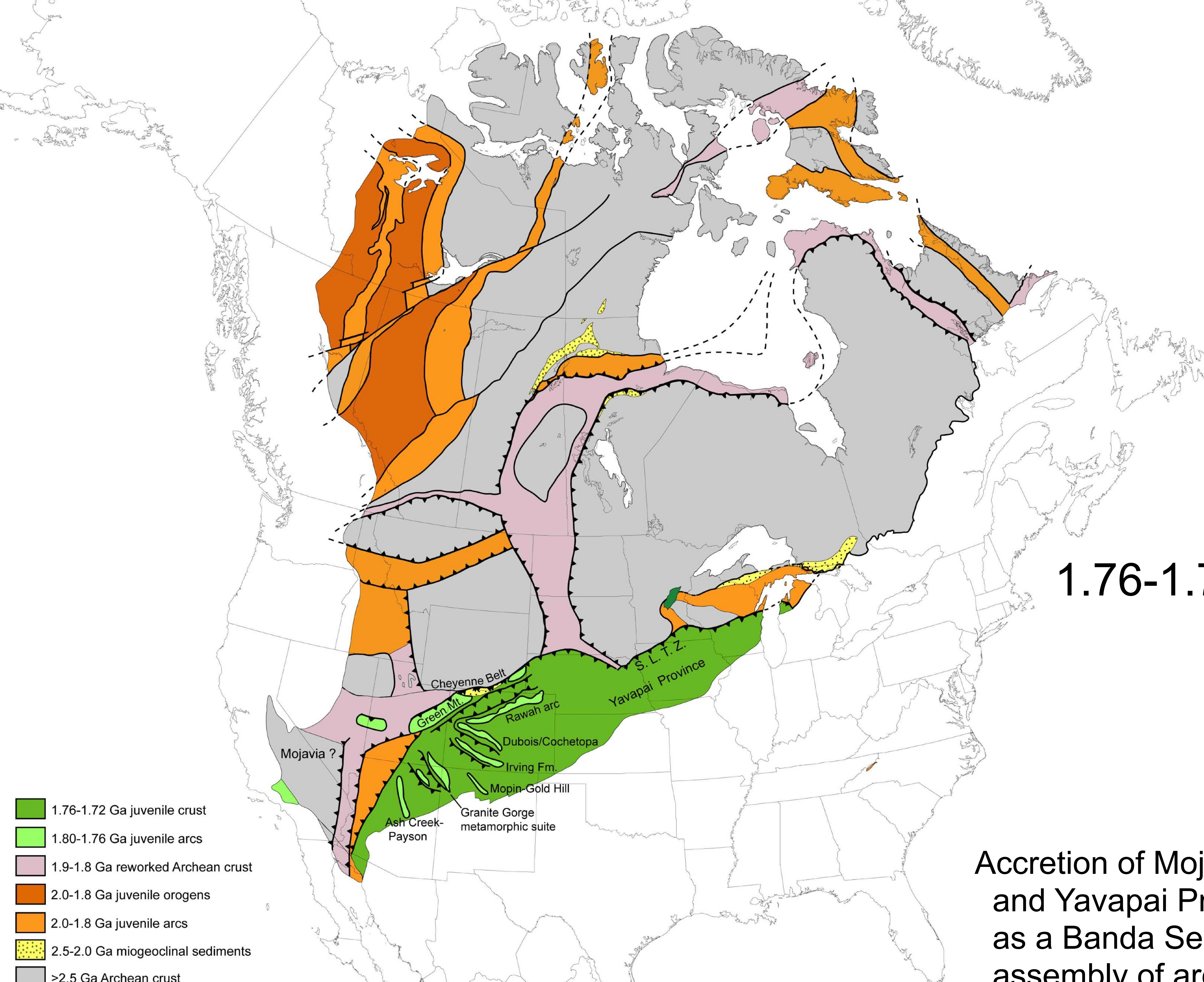
1.80-1.76 Ga



(Whitmeyer and Karlstrom, 2007)

Accretion of Archean(?) Grouse Creek Block and Selway Terrane; Mojave Province and Yavapai arcs outboard

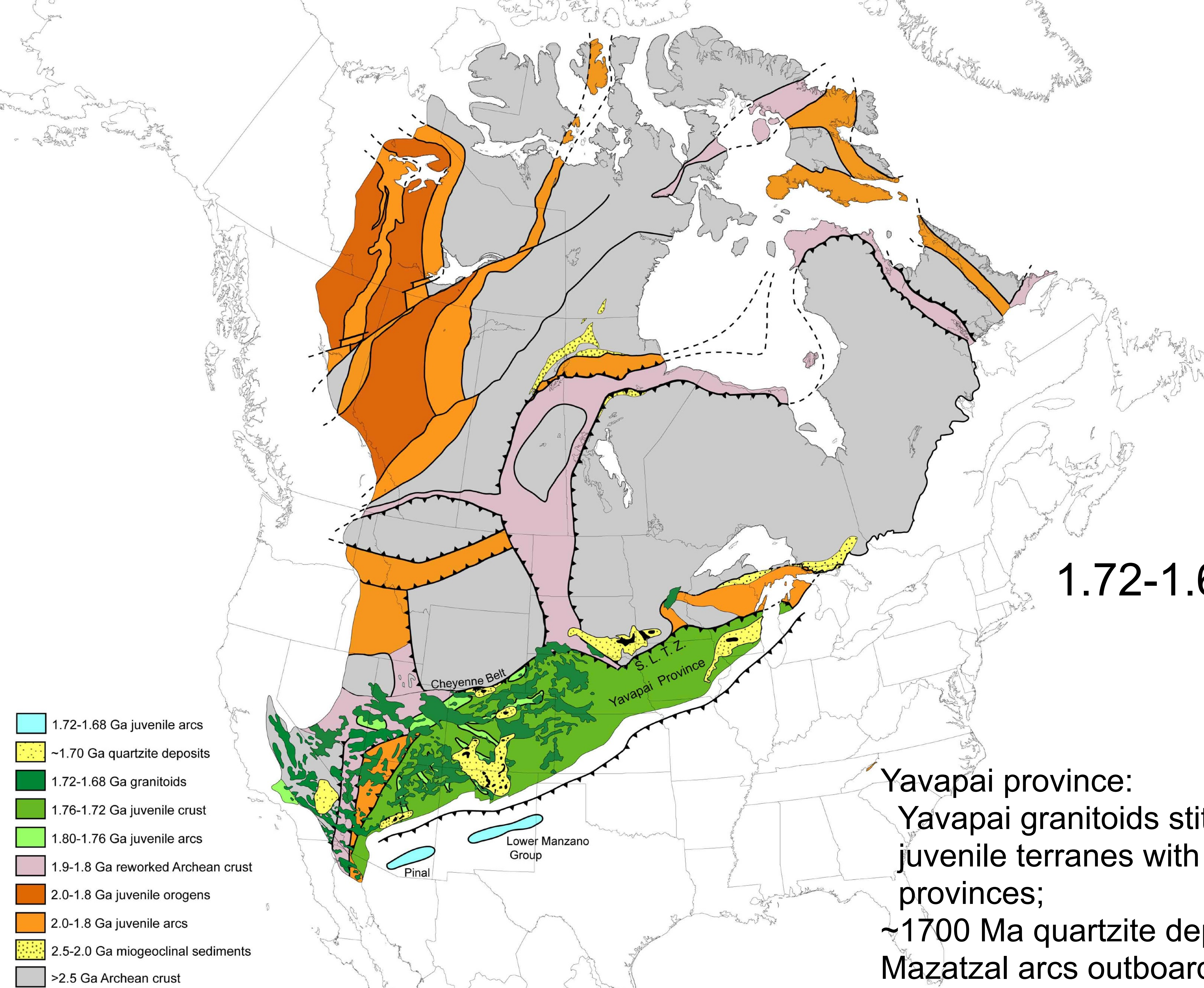
1.76-1.72 Ga



(Whitmeyer and Karlstrom, 2007)

Accretion of Mojavia(?) and Yavapai Province, as a Banda Sea style assembly of arcs

1.72-1.68 Ga

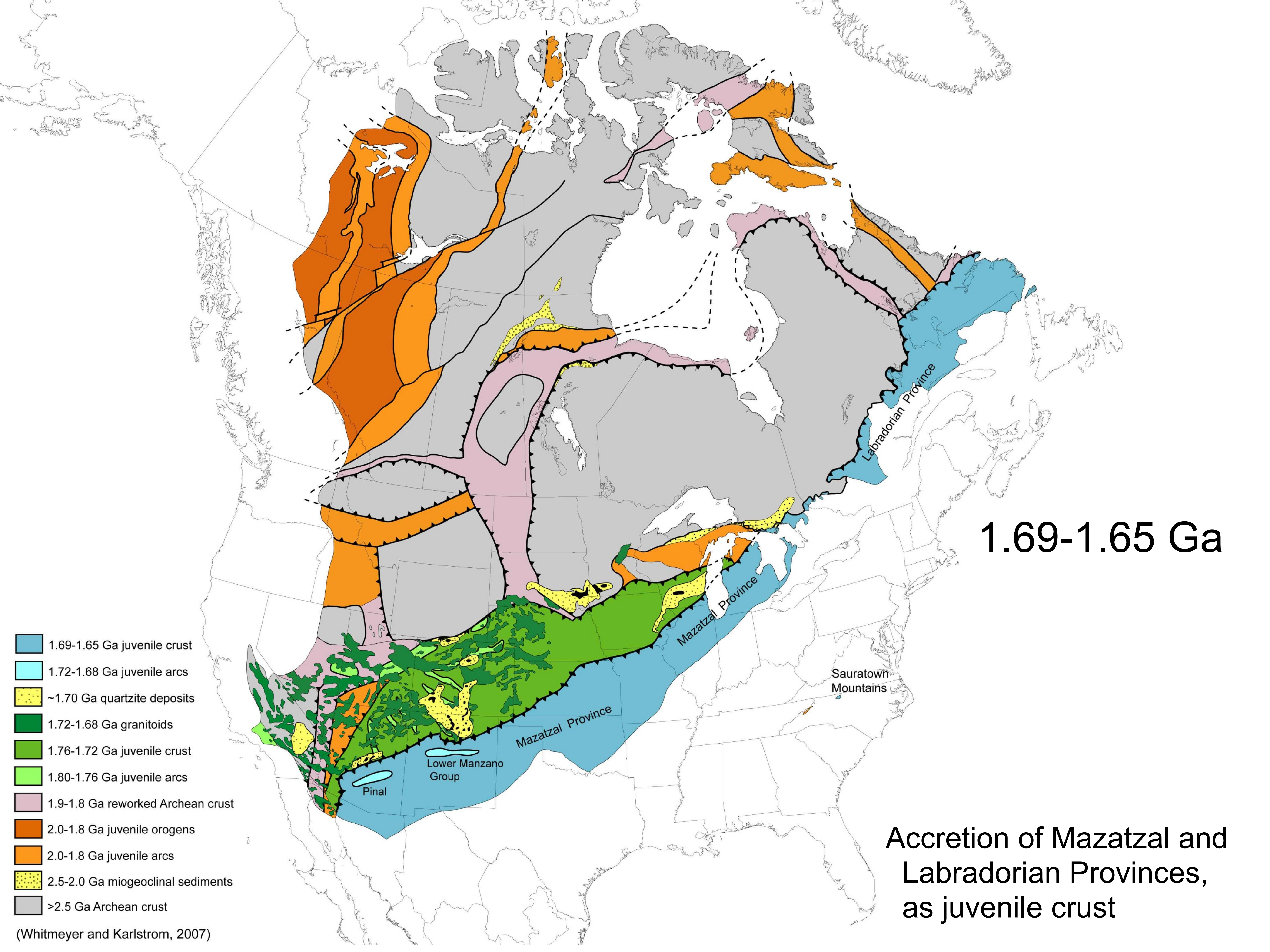


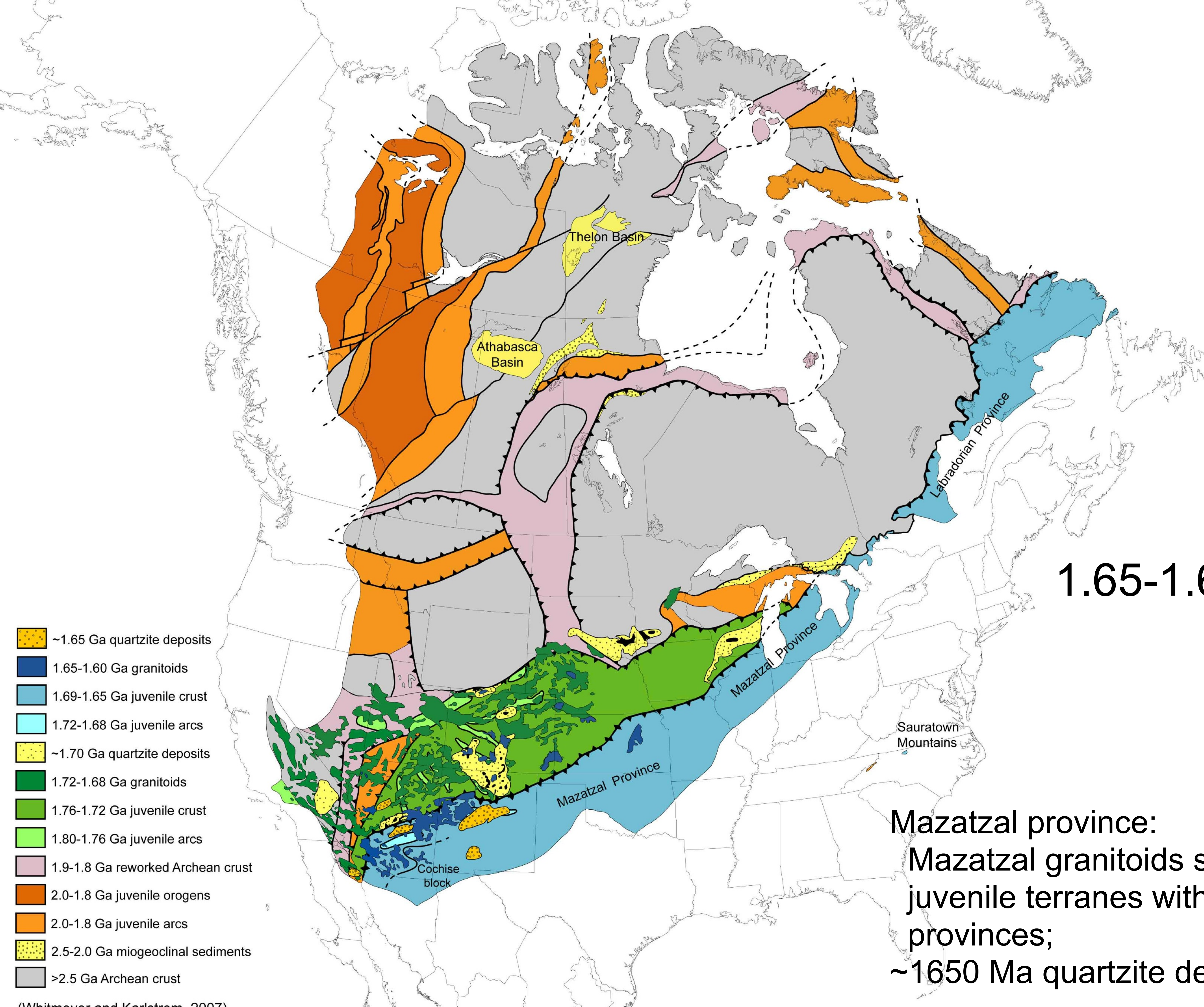
(Whitmeyer and Karlstrom, 2007)

Yavapai province:
- Yavapai granitoids stitch juvenile terranes with older provinces;

~1700 Ma quartzite deposition;

Mazatzal arcs outboard


1.69-1.65 Ga
Labradorian Province
Mazatzal Province
Mazatzal Province
Lower Manzano Group
Pinal
Sauratown Mountains
1.69-1.65 Ga juvenile crust
1.72-1.68 Ga juvenile arcs
~1.70 Ga quartzite deposits
1.72-1.68 Ga granitoids
1.76-1.72 Ga juvenile crust
1.80-1.76 Ga juvenile arcs
1.9-1.8 Ga reworked Archean crust
2.0-1.8 Ga juvenile orogens
2.0-1.8 Ga juvenile arcs
2.5-2.0 Ga miogeoclinal sediments
>2.5 Ga Archean crust
(Whitmeyer and Karlstrom, 2007)
Accretion of Mazatzal and Labradorian Provinces, as juvenile crust

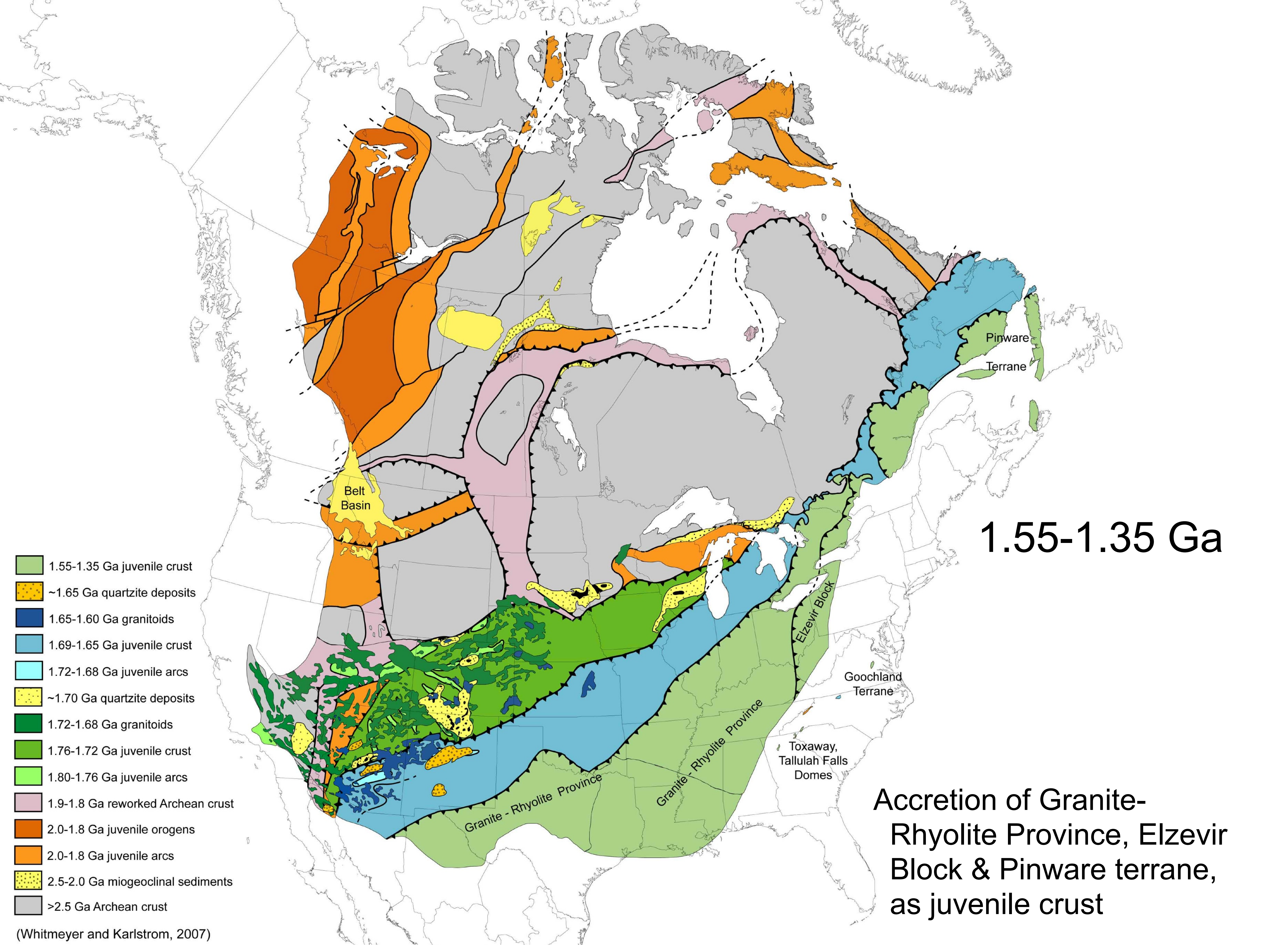


(Whitmeyer and Karlstrom, 2007)

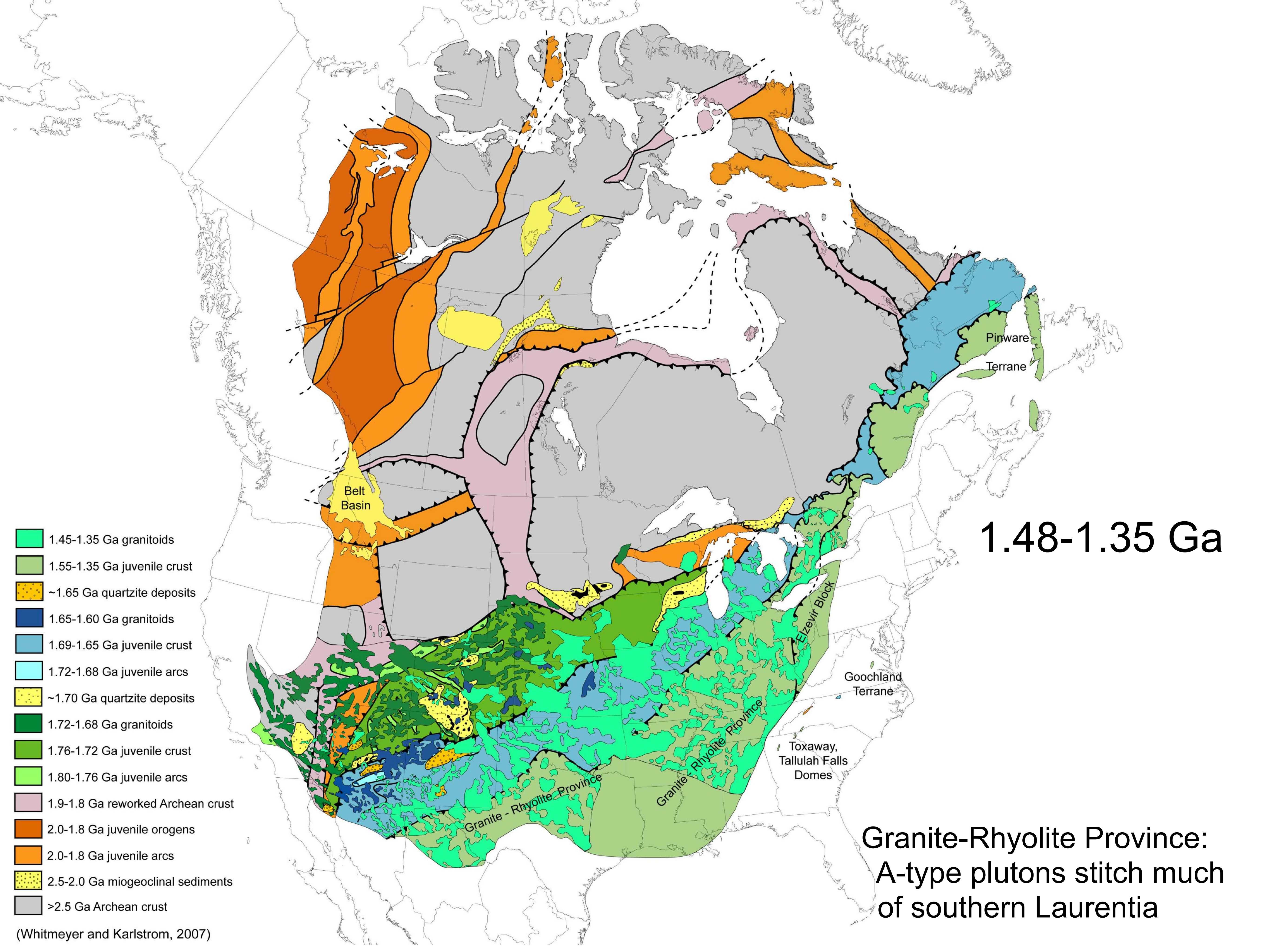
1.65-1.60 Ga

Mazatzal province:
- Mazatzal granitoids stitch juvenile terranes with older provinces;

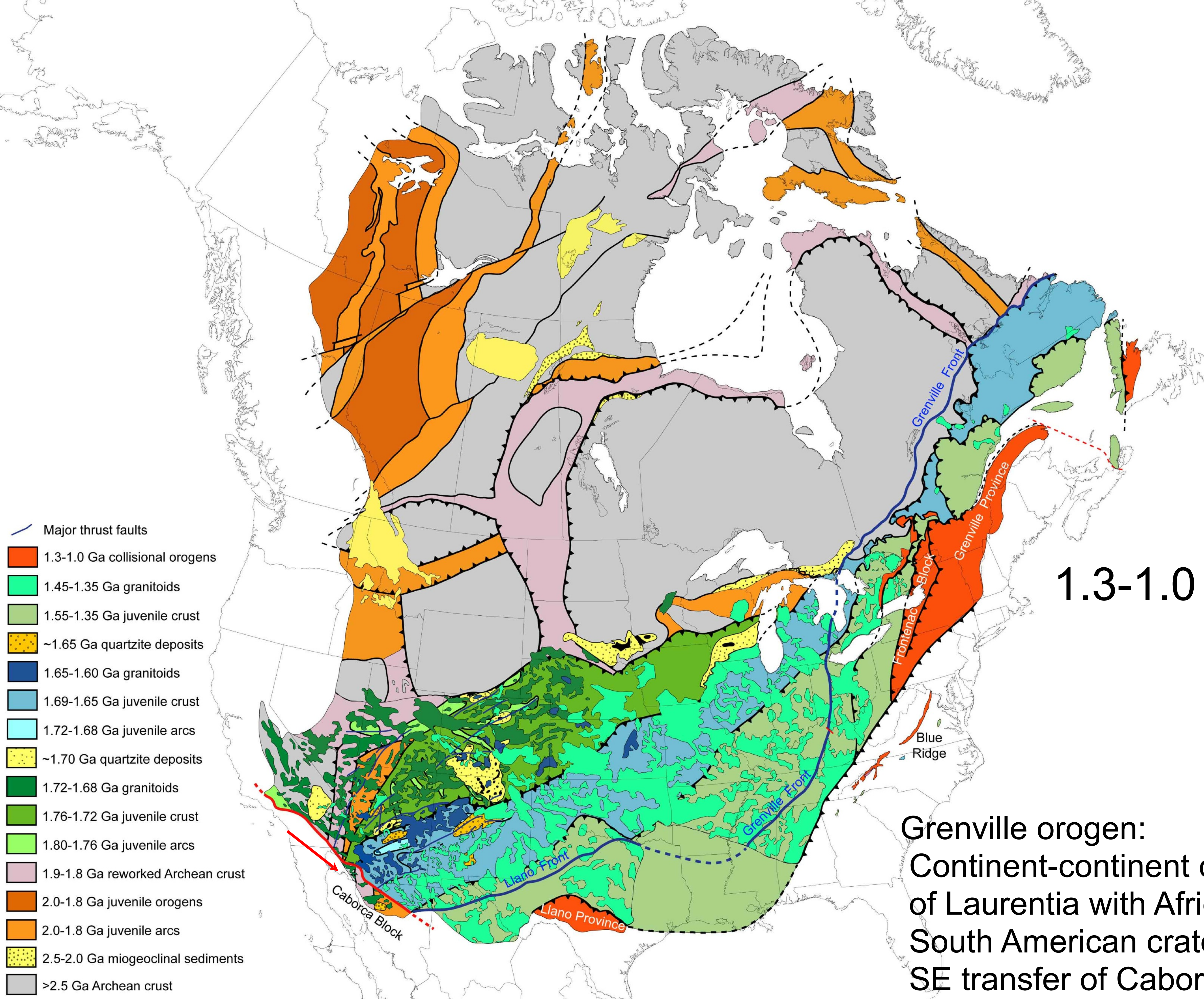
~1650 Ma quartzite deposition



1.55-1.35 Ga
Accretion of Granite-Rhyolite Province, Elzevir Block & Pinware terrane, as juvenile crust
Belt Basin
Pinware Terrane
Elzevir Block
Goochland Terrane
Granite - Rhyolite Province
Granite - Rhyolite Province
Toxaway, Tallulah Falls Domes
1.55-1.35 Ga juvenile crust
~1.65 Ga quartzite deposits
1.65-1.60 Ga granitoids
1.69-1.65 Ga juvenile crust
1.72-1.68 Ga juvenile arcs
~1.70 Ga quartzite deposits
1.72-1.68 Ga granitoids
1.76-1.72 Ga juvenile crust
1.80-1.76 Ga juvenile arcs
1.9-1.8 Ga reworked Archean crust
2.0-1.8 Ga juvenile orogens
2.0-1.8 Ga juvenile arcs
2.5-2.0 Ga miogeoclinal sediments
>2.5 Ga Archean crust
(Whitmeyer and Karlstrom, 2007)


1.48-1.35 Ga
Granite-Rhyolite Province:
A-type plutons stitch much
of southern Laurentia
1.45-1.35 Ga granitoids
1.55-1.35 Ga juvenile crust
~1.65 Ga quartzite deposits
1.65-1.60 Ga granitoids
1.69-1.65 Ga juvenile crust
1.72-1.68 Ga juvenile arcs
~1.70 Ga quartzite deposits
1.72-1.68 Ga granitoids
1.76-1.72 Ga juvenile crust
1.80-1.76 Ga juvenile arcs
1.9-1.8 Ga reworked Archean crust
2.0-1.8 Ga juvenile orogens
2.0-1.8 Ga juvenile arcs
2.5-2.0 Ga miogeoclinal sediments
>2.5 Ga Archean crust
(Whitmeyer and Karlstrom, 2007)
Belt
Basin
Pinware
Terrane
Elzevir Block
Goochland
Terrane
Toxaway,
Tallulah Falls
Domes
Granite - Rhyolite Province
Granite - Rhyolite Province

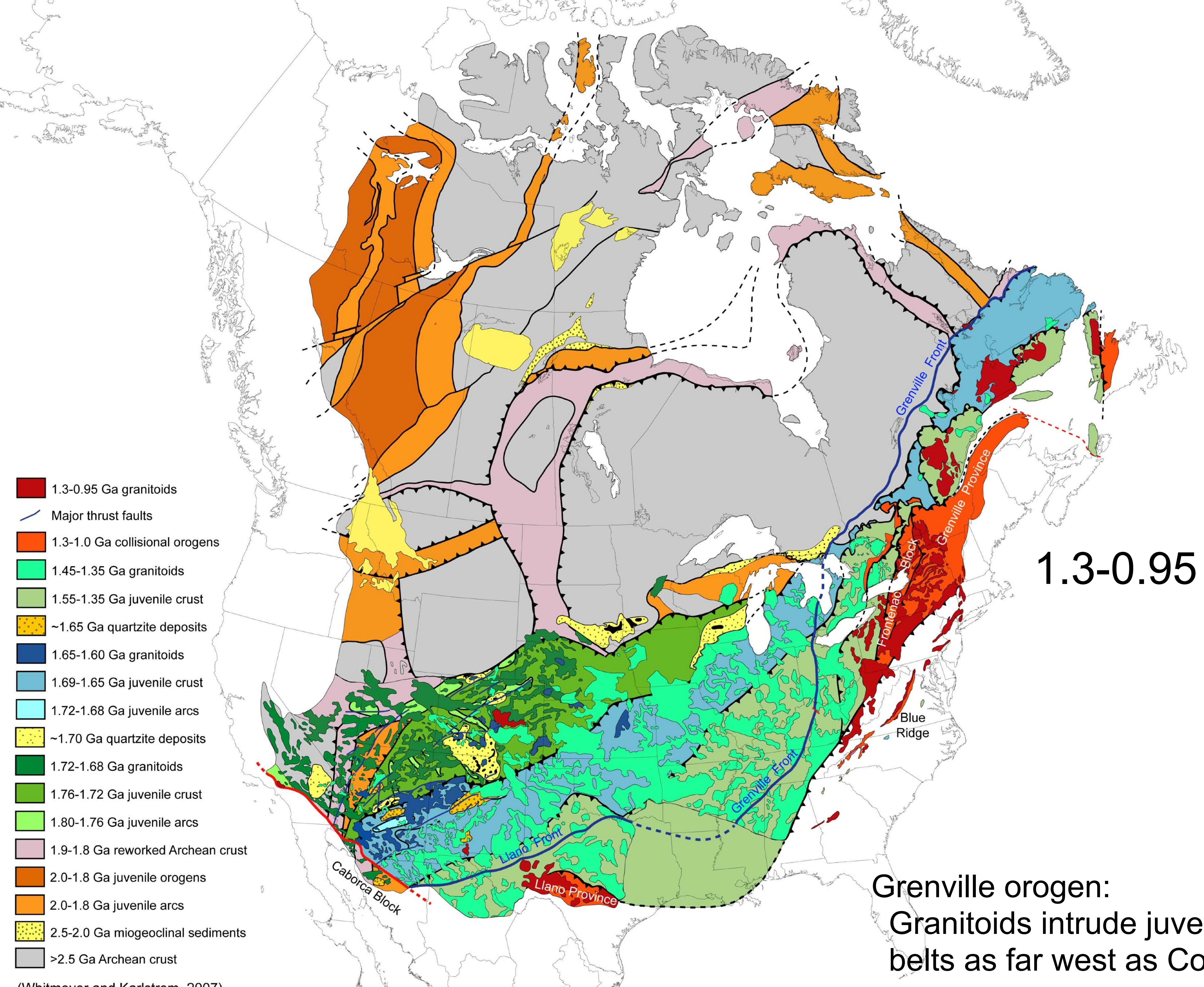
1.3-1.0 Ga



(Whitmeyer and Karlstrom, 2007)

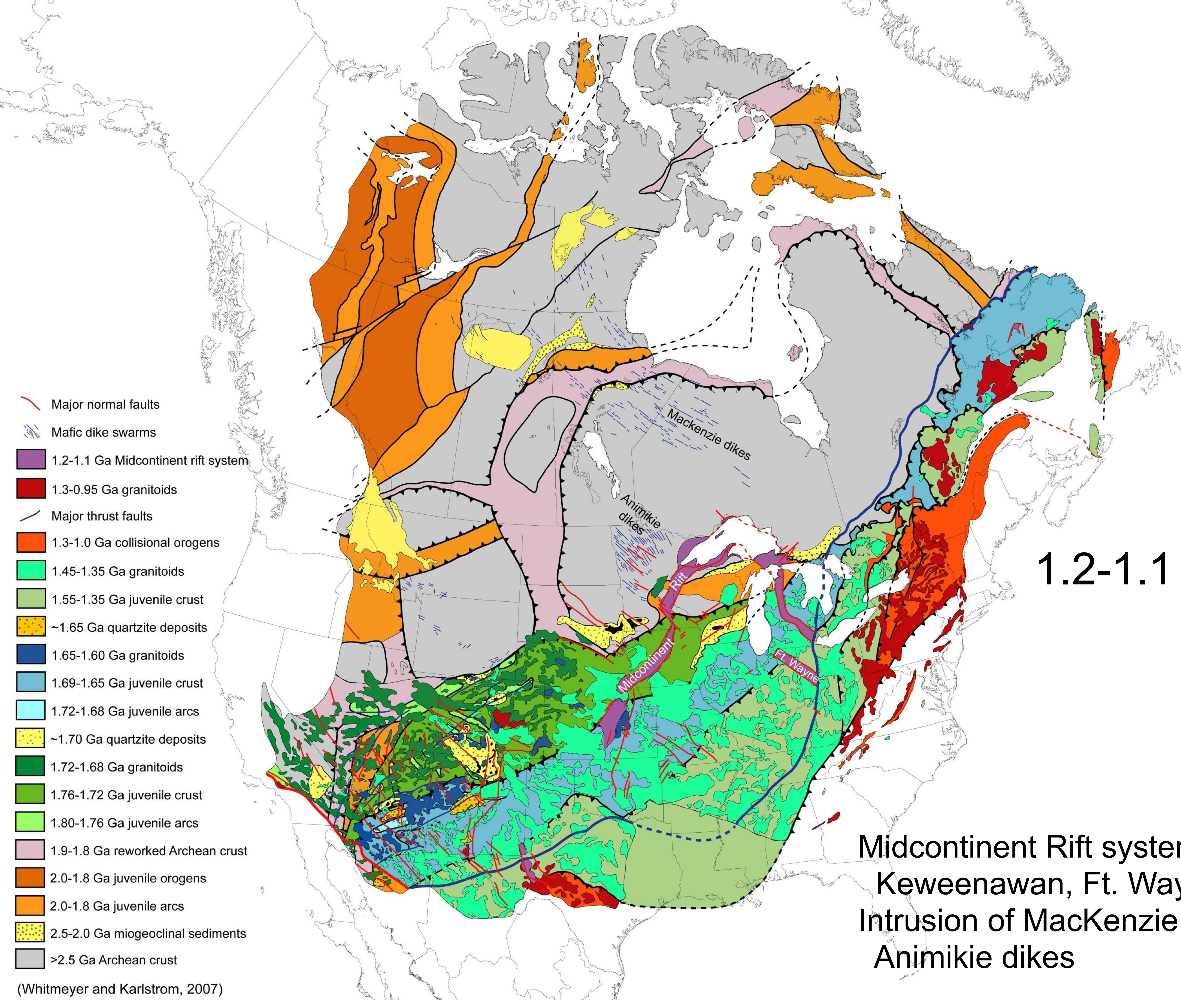
Grenville orogen:
Continent-continent collision of Laurentia with African and South American cratons;
SE transfer of Caborca block

1.3-0.95 Ga



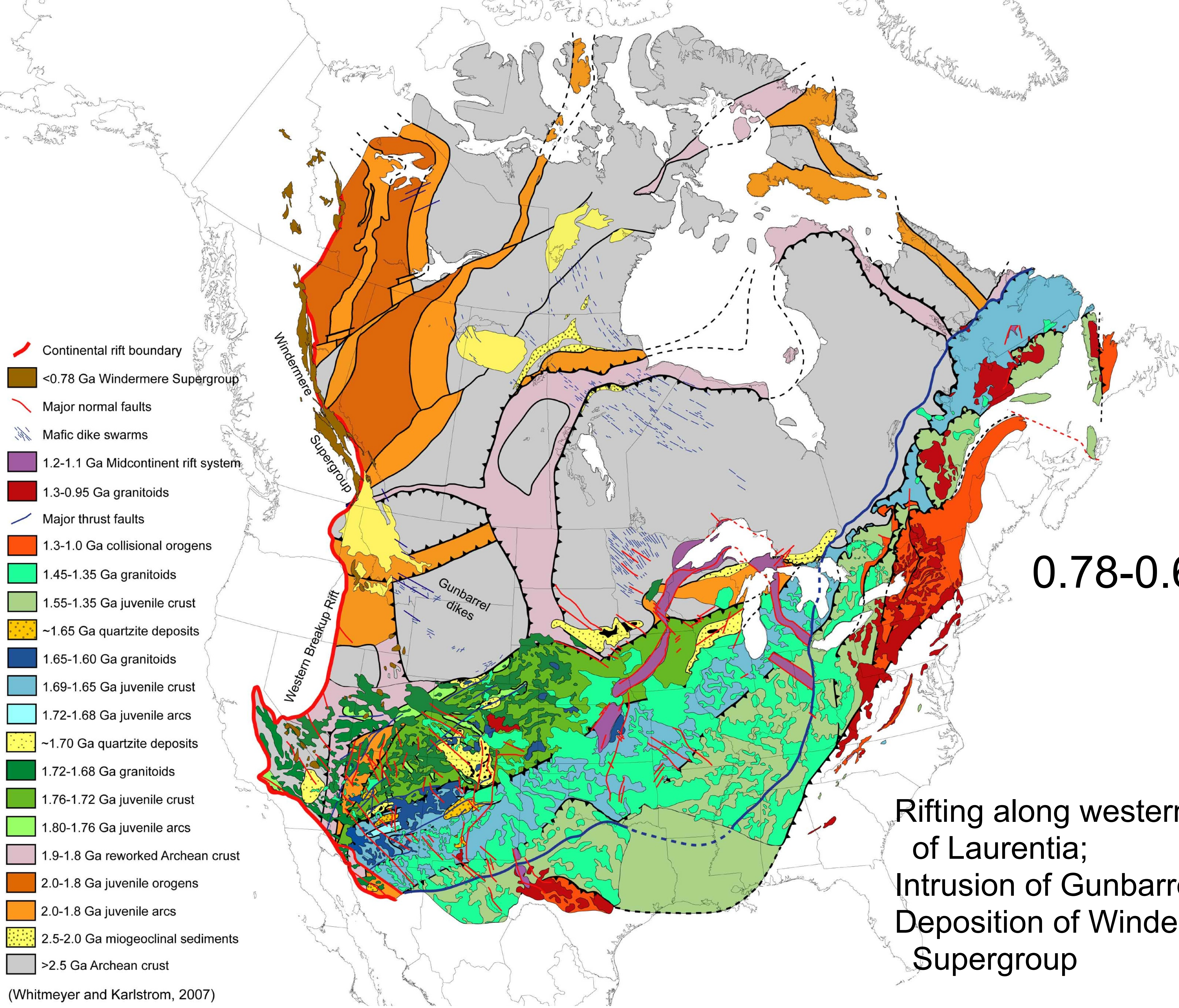
(Whitmeyer and Karlstrom, 2007)

Grenville orogen:
Granitoids intrude juvenile belts as far west as Colorado



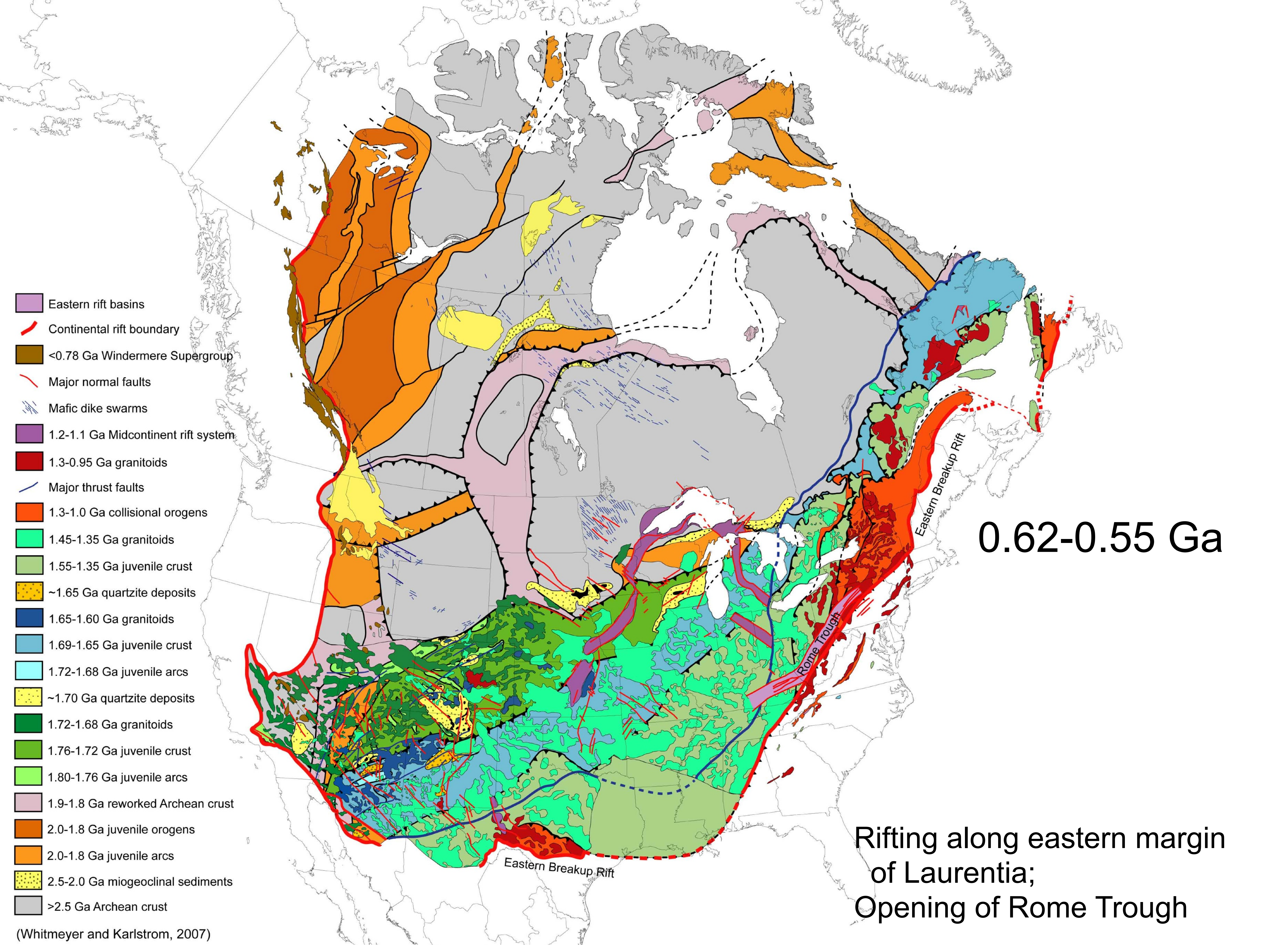
1.2-1.1 Ga

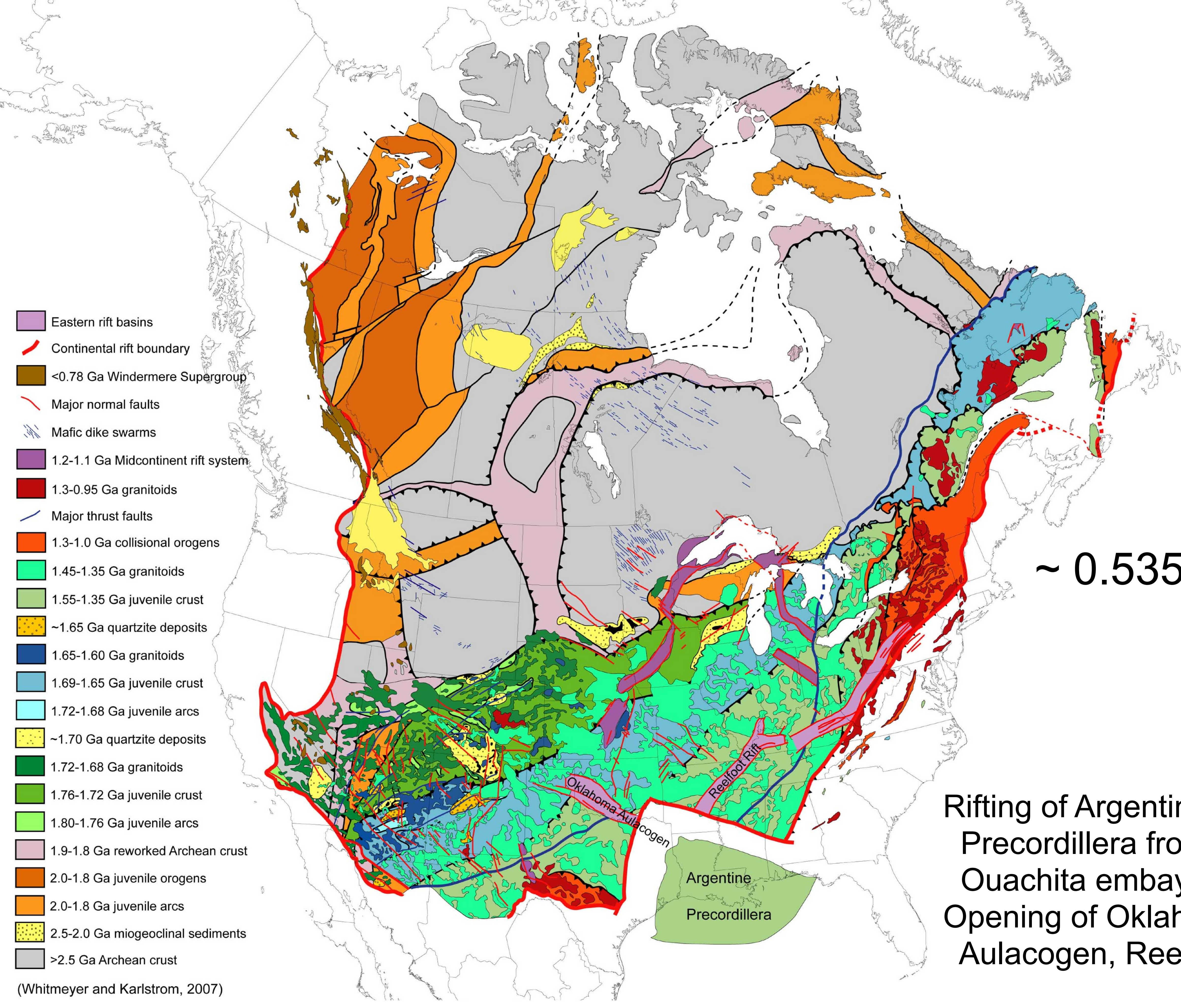
Midcontinent Rift system:
Keweenawan, Ft. Wayne rifts;
Intrusion of MacKenzie and
Animikie dikes



0.78-0.68 Ga

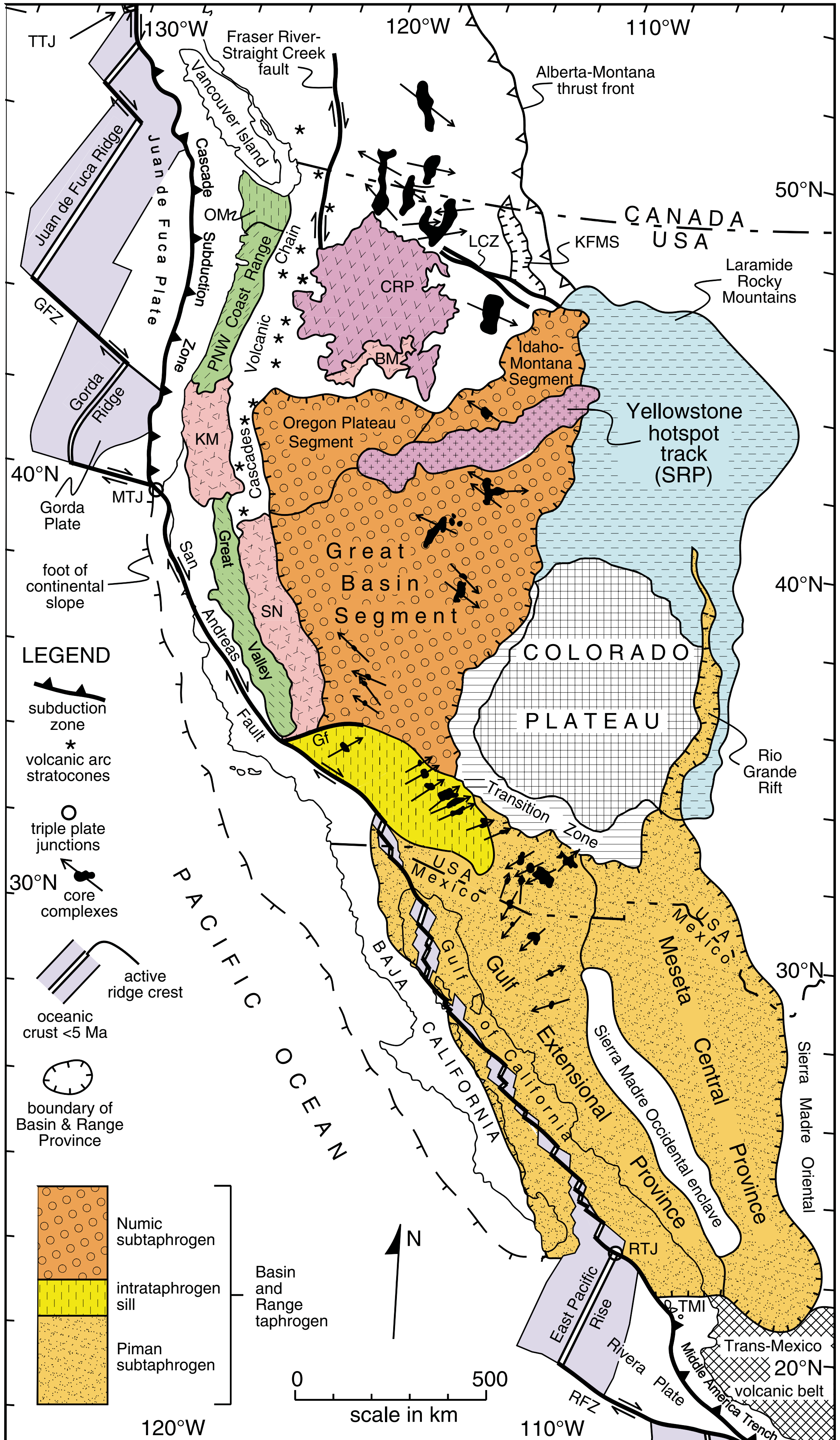
Rifting along western margin of Laurentia;
Intrusion of Gunbarrel dikes,
Deposition of Windermere Supergroup

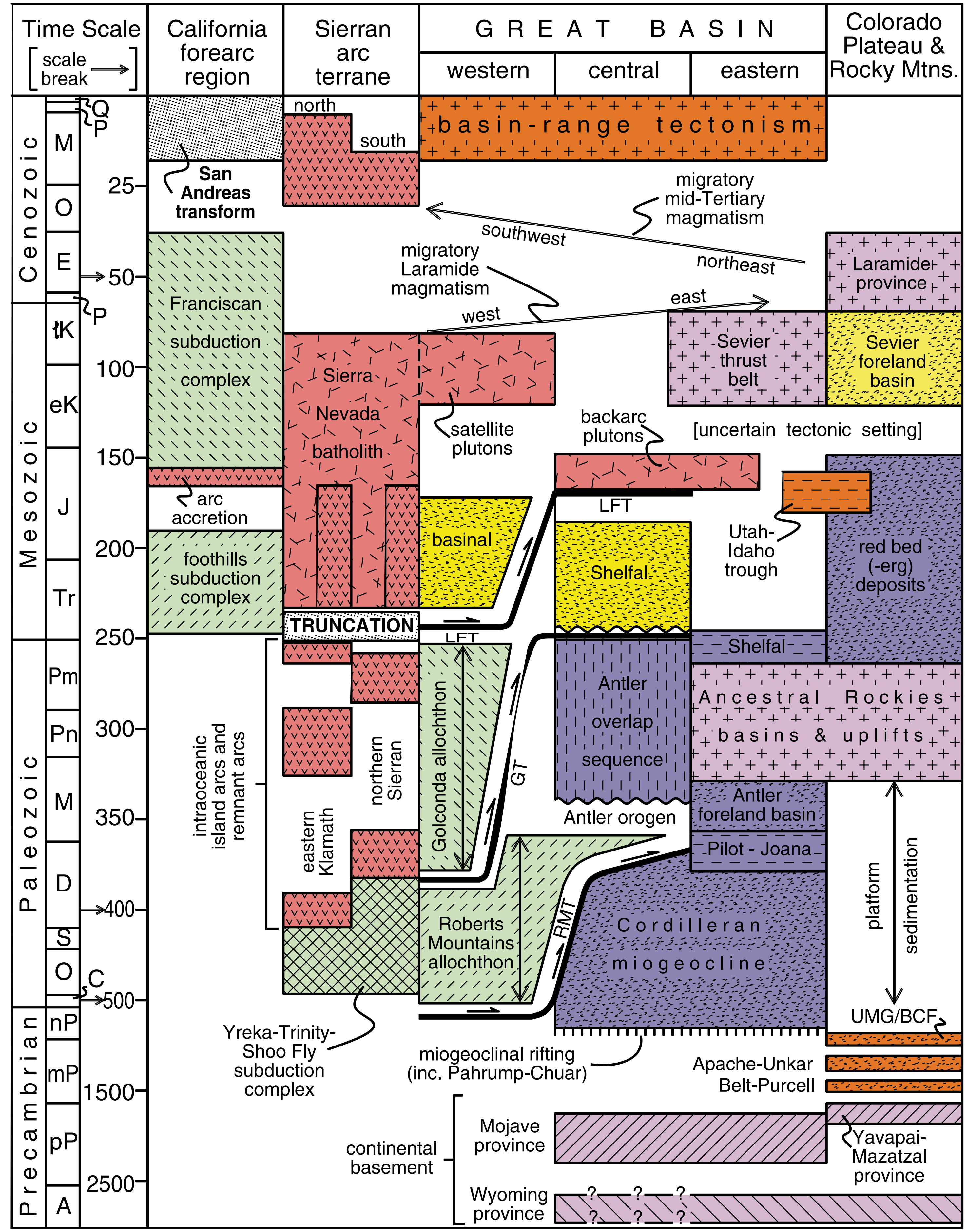

Eastern rift basins
Continental rift boundary
<0.78 Ga Windermere Supergroup
Major normal faults
Mafic dike swarms
1.2-1.1 Ga Midcontinent rift system
1.3-0.95 Ga granitoids
Major thrust faults
1.3-1.0 Ga collisional orogens
1.45-1.35 Ga granitoids
1.55-1.35 Ga juvenile crust
~1.65 Ga quartzite deposits
1.65-1.60 Ga granitoids
1.69-1.65 Ga juvenile crust
1.72-1.68 Ga juvenile arcs
~1.70 Ga quartzite deposits
1.72-1.68 Ga granitoids
1.76-1.72 Ga juvenile crust
1.80-1.76 Ga juvenile arcs
1.9-1.8 Ga reworked Archean crust
2.0-1.8 Ga juvenile orogens
2.0-1.8 Ga juvenile arcs
2.5-2.0 Ga miogeoclinal sediments
>2.5 Ga Archean crust
(Whitmeyer and Karlstrom, 2007)
Eastern Breakup Rift
Rome Trough
Eastern Breakup Rift
0.62-0.55 Ga
Rifting along eastern margin of Laurentia;
Opening of Rome Trough



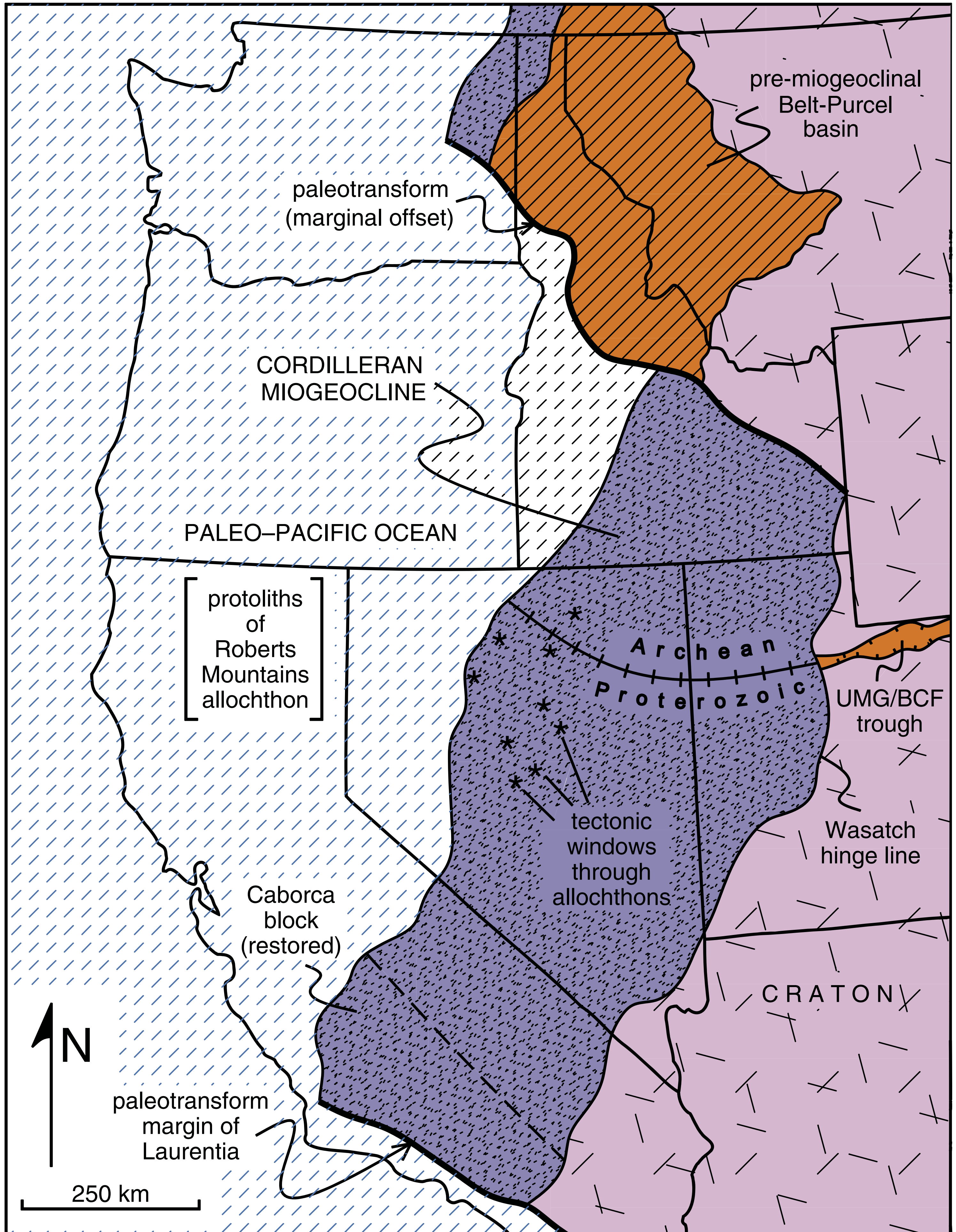
~ 0.535 Ga

Rifting of Argentine Precordillera from Ouachita embayment; Opening of Oklahoma Aulacogen, Reelfoot Rift





Dickinson, Geosphere, 2006


pre-miogeoclinal
Belt-Purcel
basin
paleotransform
(marginal offset)
CORDILLERAN
MIOGEOCLINE
PALEO–PACIFIC OCEAN
protoliths
of
Roberts
Mountains
allochthon
Archean
Proterozoic
UMG/BCF
trough
Wasatch
hinge line
tectonic
windows
through
allochthons
Caborca
block
(restored)
CRATON
N
paleotransform
margin of
Laurentia
250 km

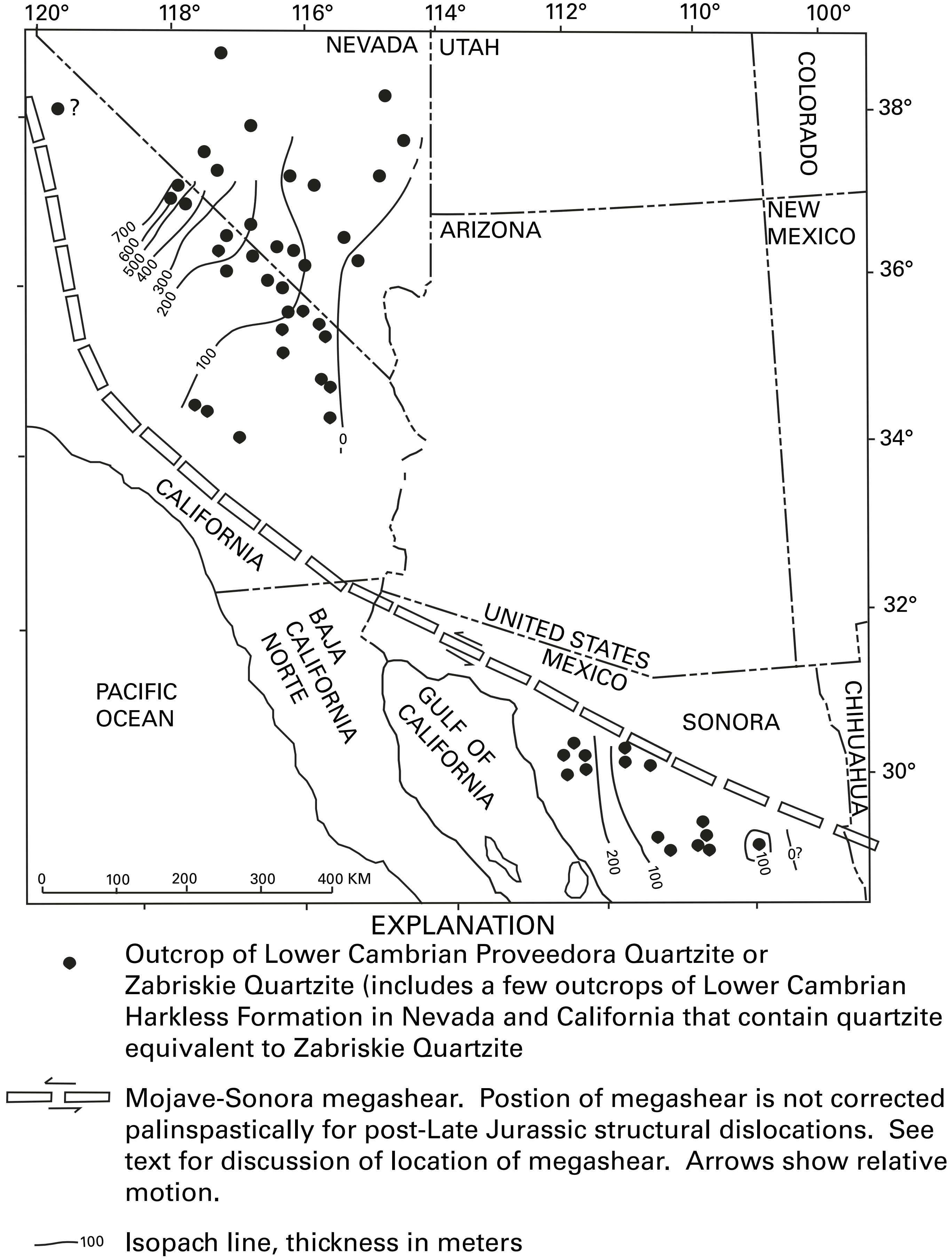


Figure 4. Distribution and thickness of Lower Cambrian Zabriskie Quartzite in California and Nevada and of the correlative Proveedora Quartzite in Sonora. Based on Stewart (1970) and Stewart et al. (1984).

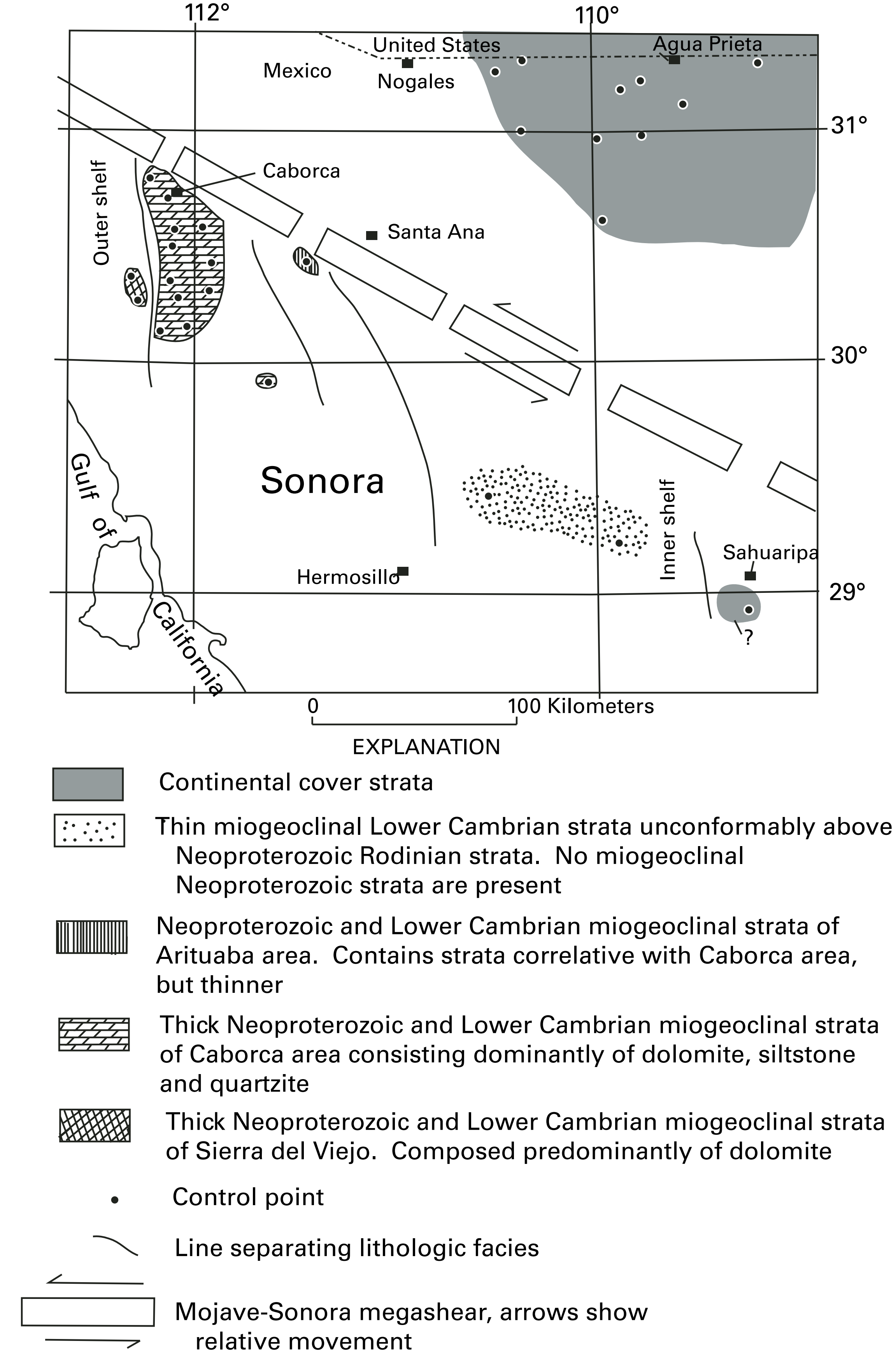
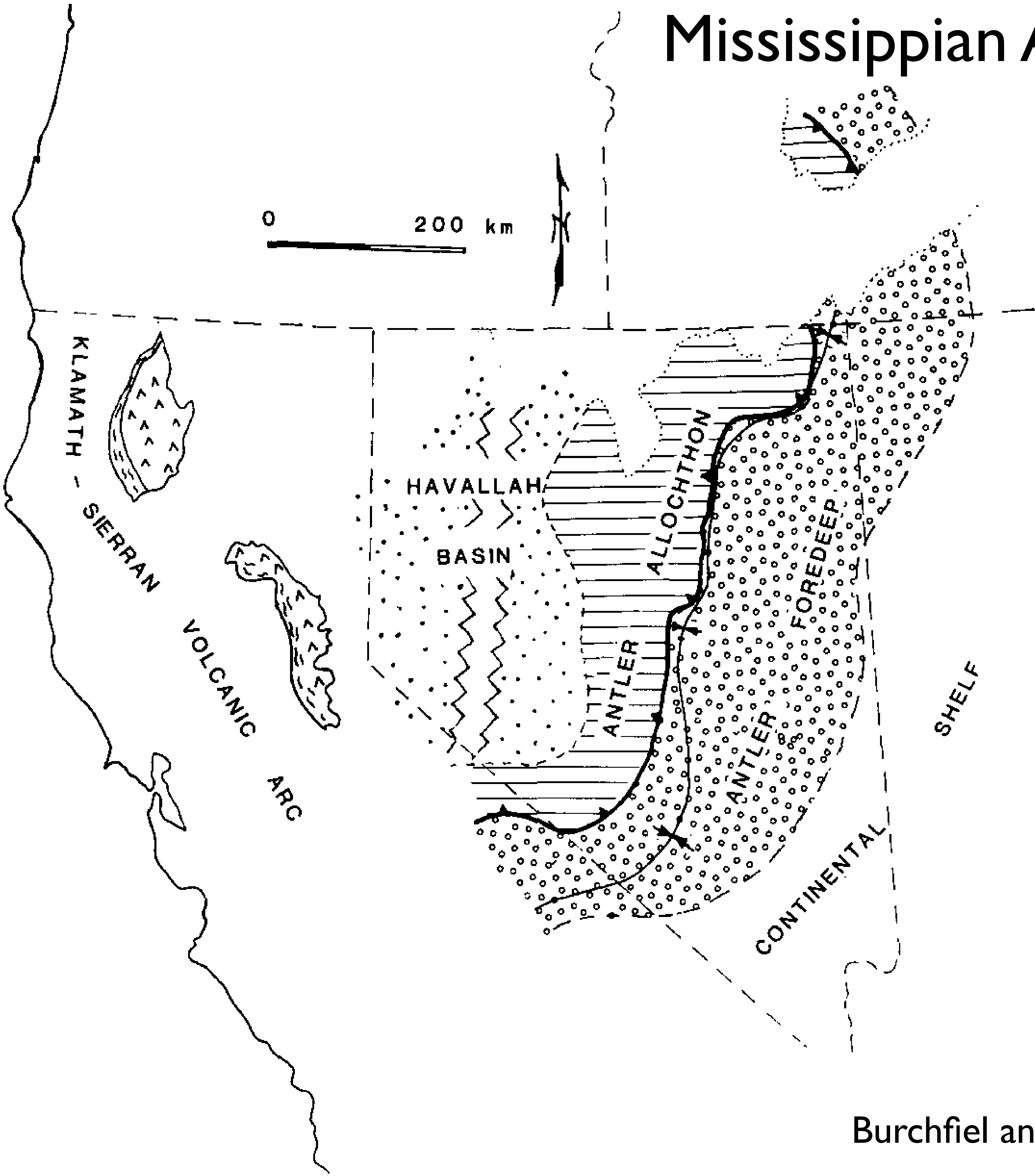


Figure 5. Facies trends of Neoproterozoic and Lower Cambrian strata in Sonora. Based on data in Stewart et al. (2002).

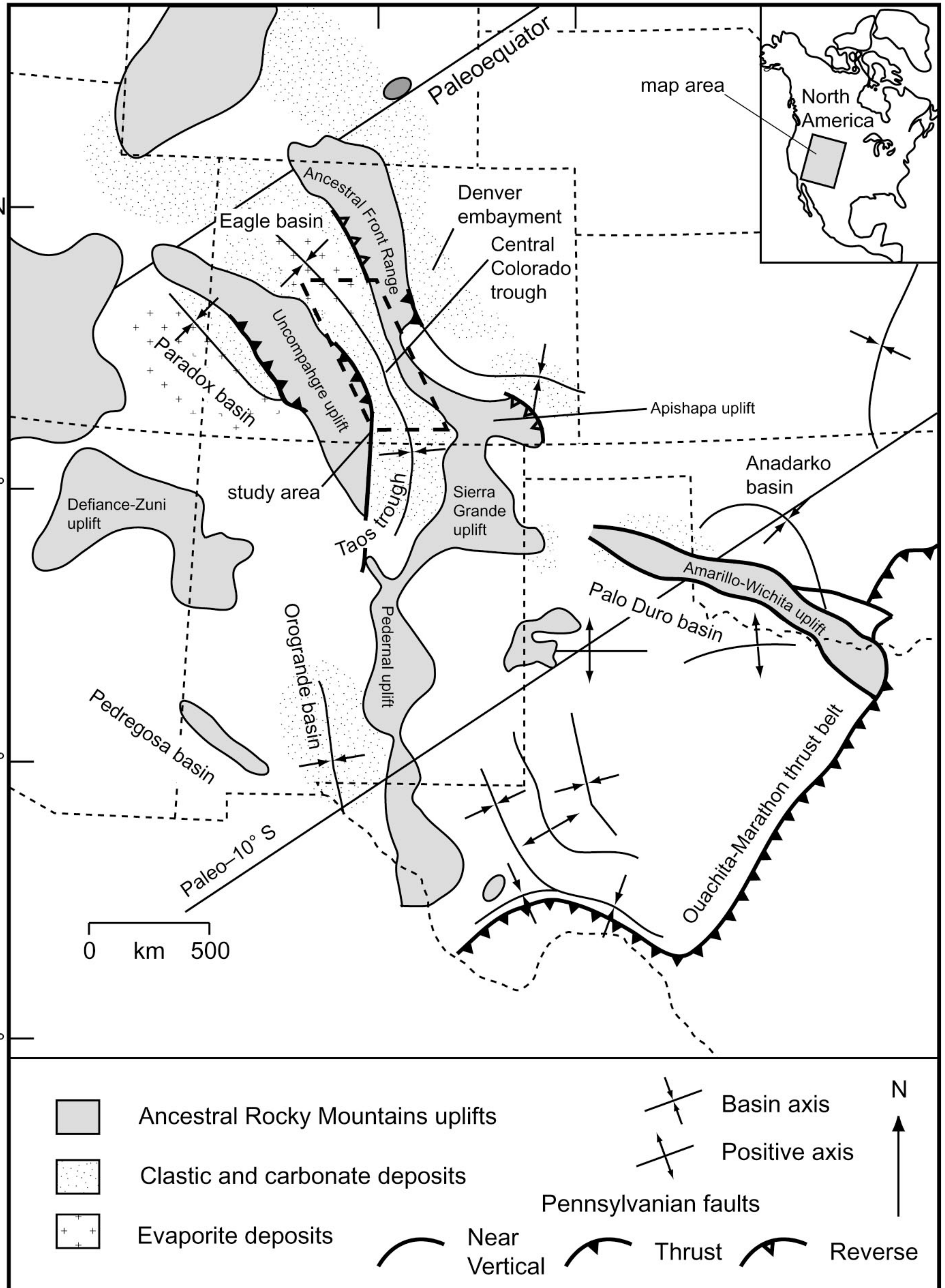
Stewart, GSA SP 393, 2005

Mississippian Antler orogeny



Burchfiel and Royden, Geology, 1991

Pennsylvanian



Hoy and Ridgway 2002

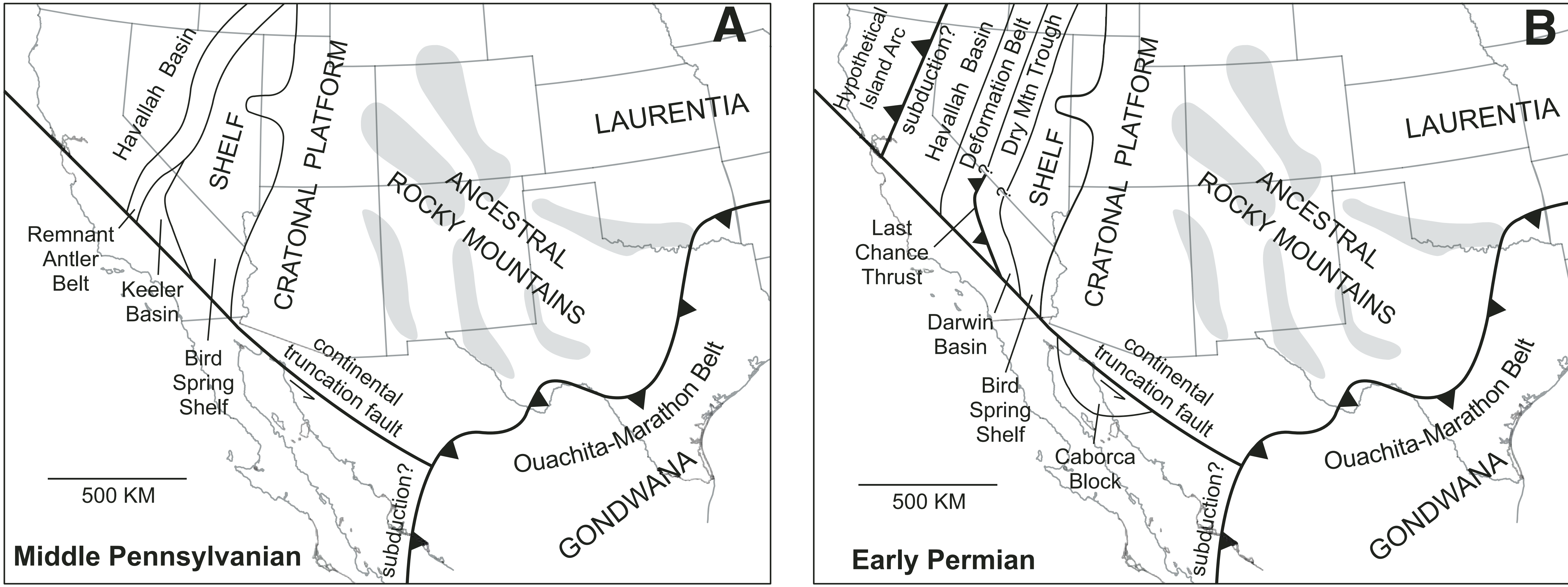
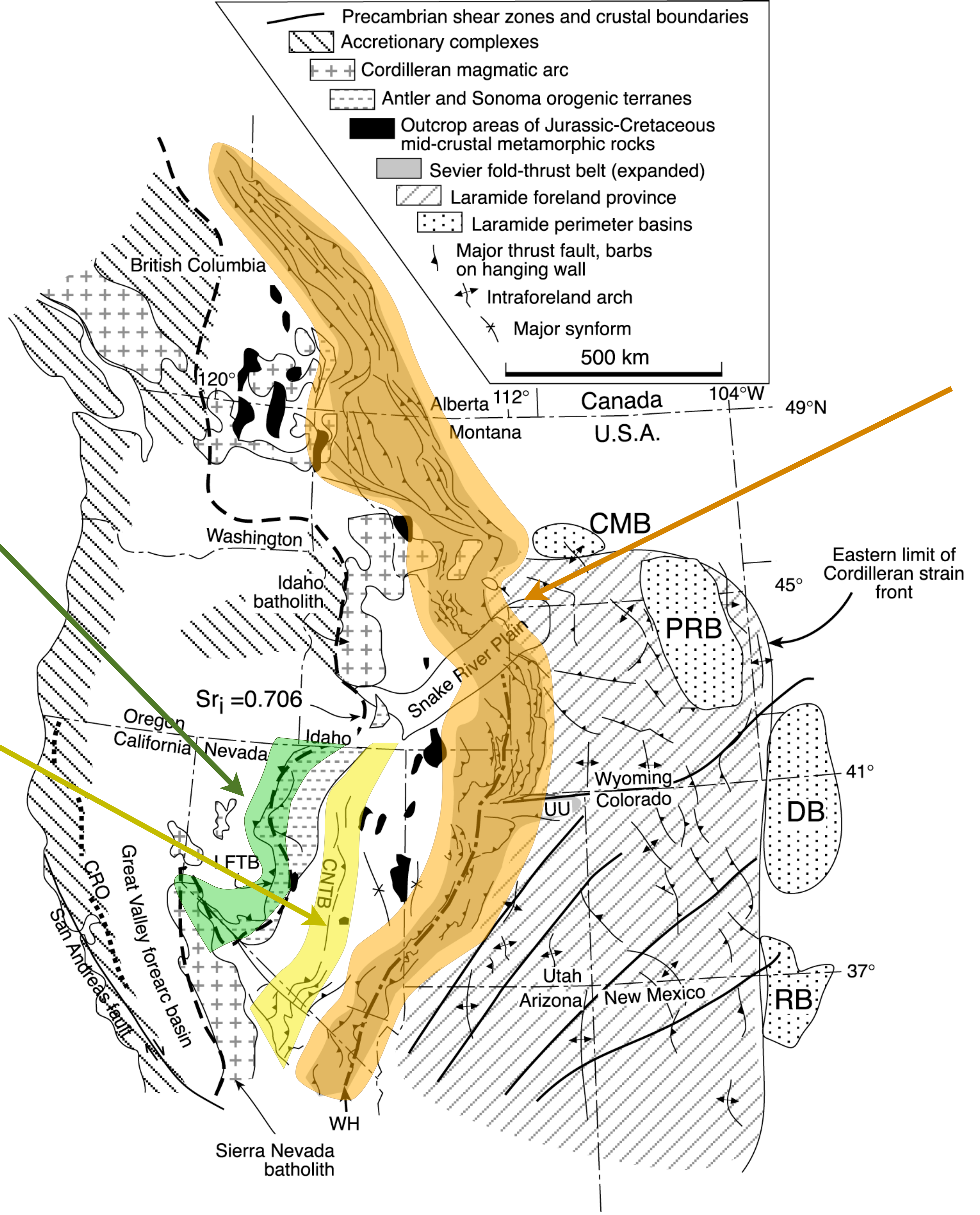


Figure 13. Maps showing major paleotectonic features related to the Bird Spring Shelf. (A) Middle Pennsylvanian. (B) Early Permian. Modified from Stevens et al. (1993), Dickinson (2000) and Trexler et al. (2004). Shaded areas are uplifts of the ancestral Rocky Mountains.

Stevens and Stone,
GSA SP 429, 2007

Luning-Fencemaker
thrust belt
mid or late J to K

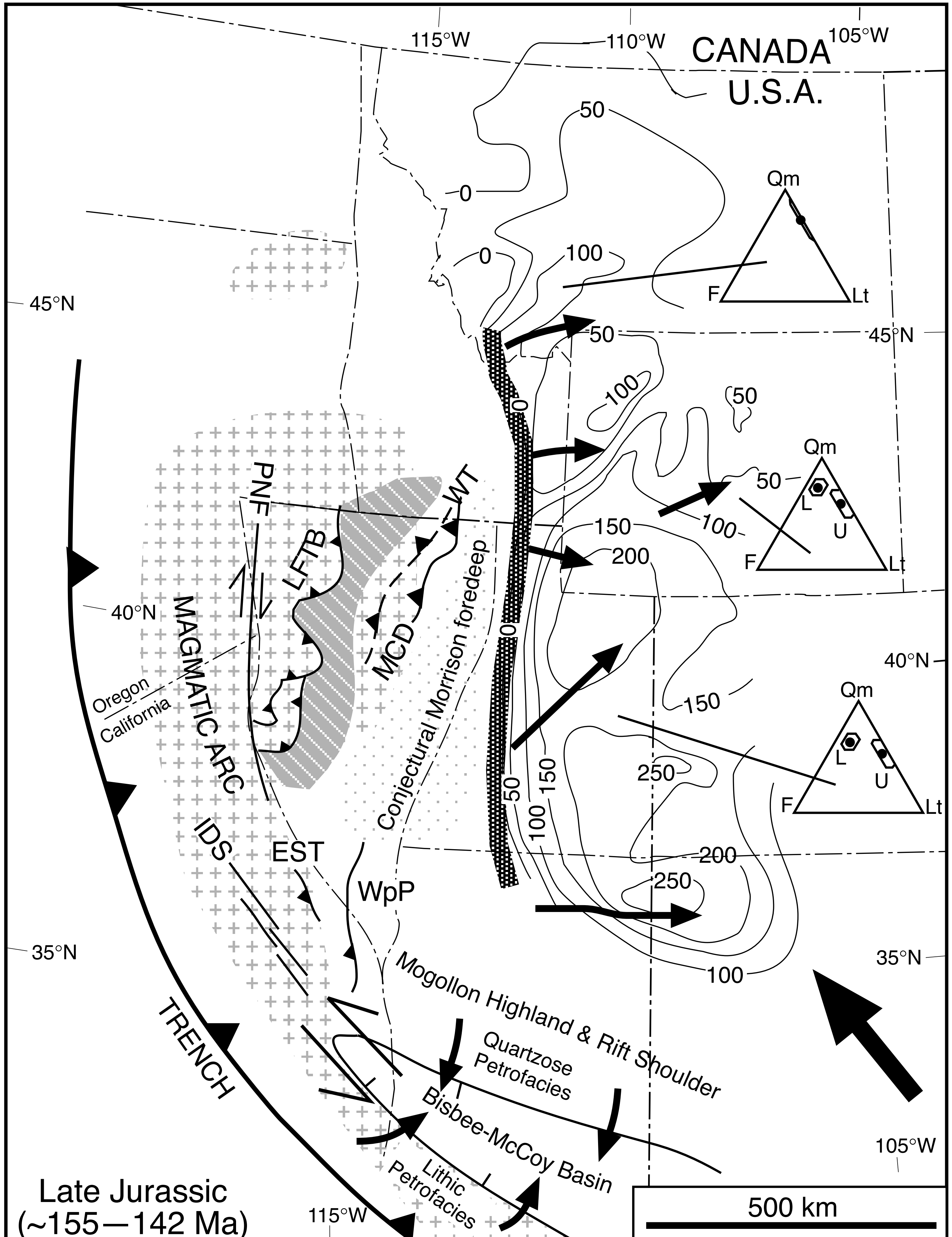
Central Nevada thrust
belt (Ely belt)
mid-J to Cretaceous



Sevier thrust belt
late J to early T

Fig. 2. Tectonic map of the western United States, showing the major components of the Cordilleran orogenic belt. The initial Sr ratio line is taken to represent the approximate western edge of North American cratonic basement (Armstrong and others, 1977; Kistler and Peterman, 1978). Abbreviations as follows: CRO, Coast Range ophiolite; LFTB, Luning-Fencemaker thrust belt; CNTB, Central Nevada thrust belt; WH, Wasatch hinge line; UU, Uinta Mountains uplift; CMB, Crazy Mountains basin; PRB, Powder River basin; DB, Denver basin; RB, Raton basin. Precambrian shear zones after Karlstrom and Williams (1998).

DeCelles, *Am J Sci*, 2004



DeCelles, *Am J Sci*, 2004

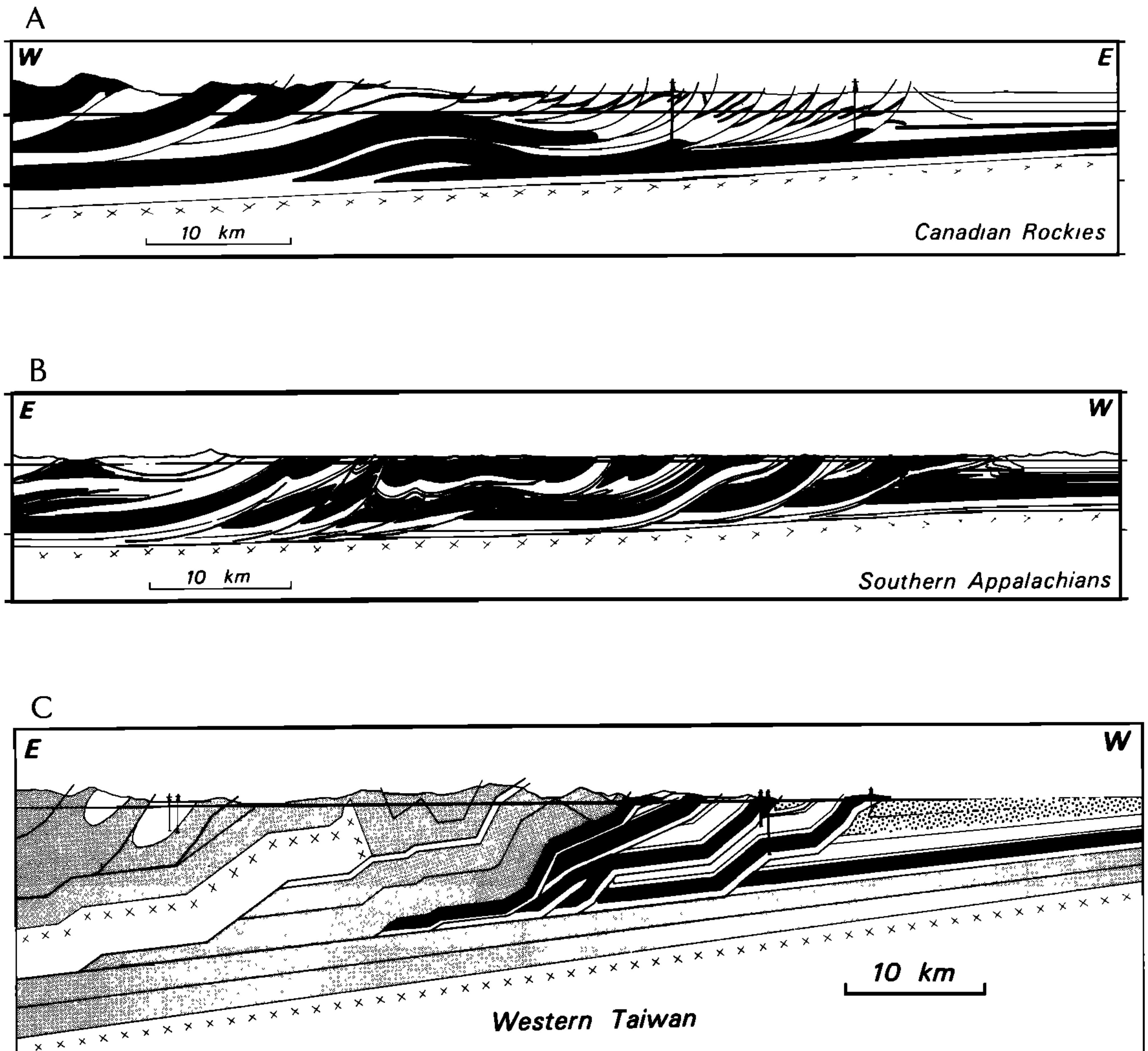
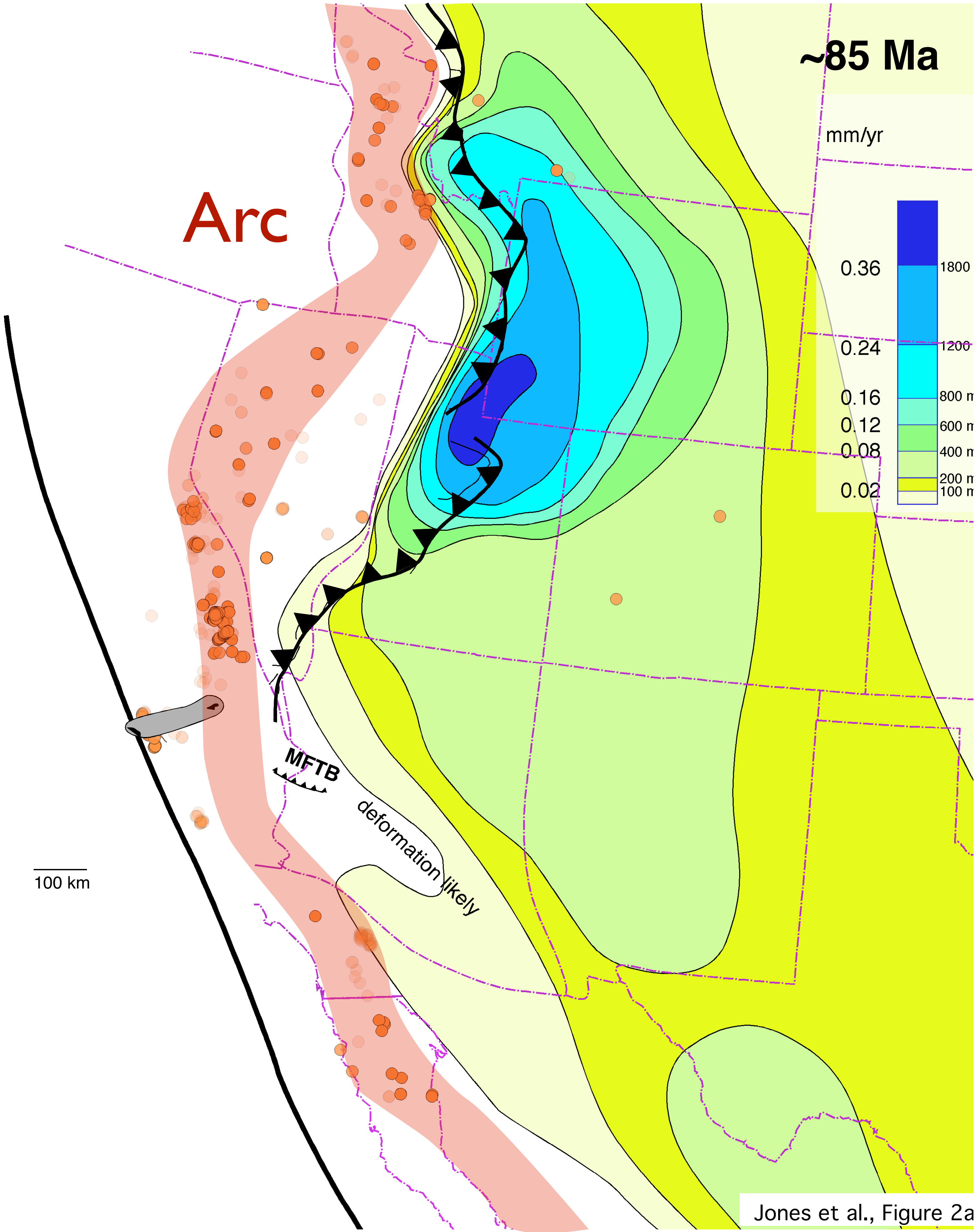


Fig. 1. Cross sections of several foreland fold-and-thrust belts: (*a*) Canadian Rockies [after *Bally et al.*, 1966], (*b*) southern Appalachians [after *Roeder et al.*, 1978], and (*c*) western Taiwan [after *Suppe*, 1980*a*].

Davis et al., JGR, 1984

Sevier orogeny

Classic "Andean margin"
- -arc
- -fold-and-thrust
- -foredeep



Jones et al., Subm. Geosphere 2009

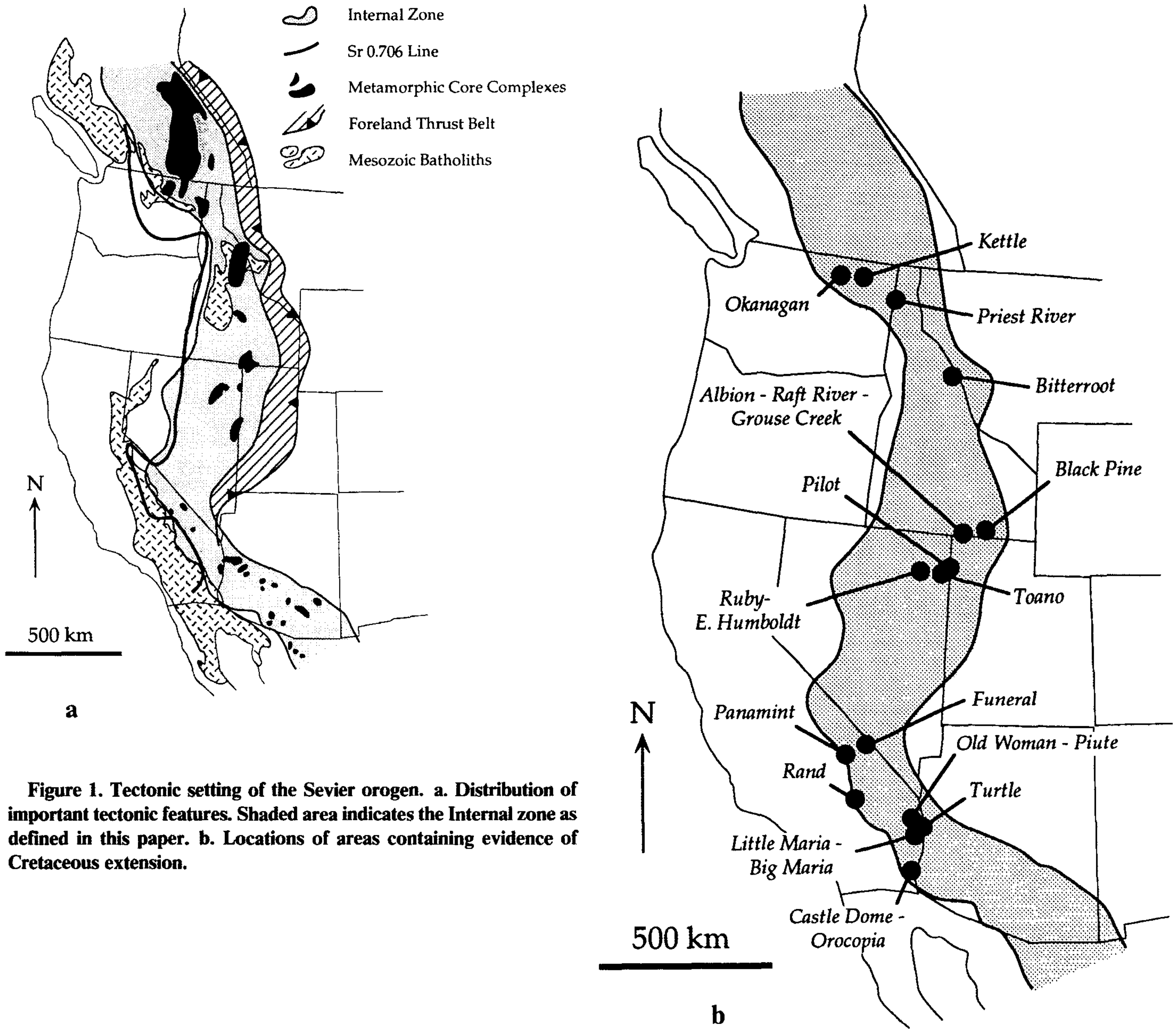
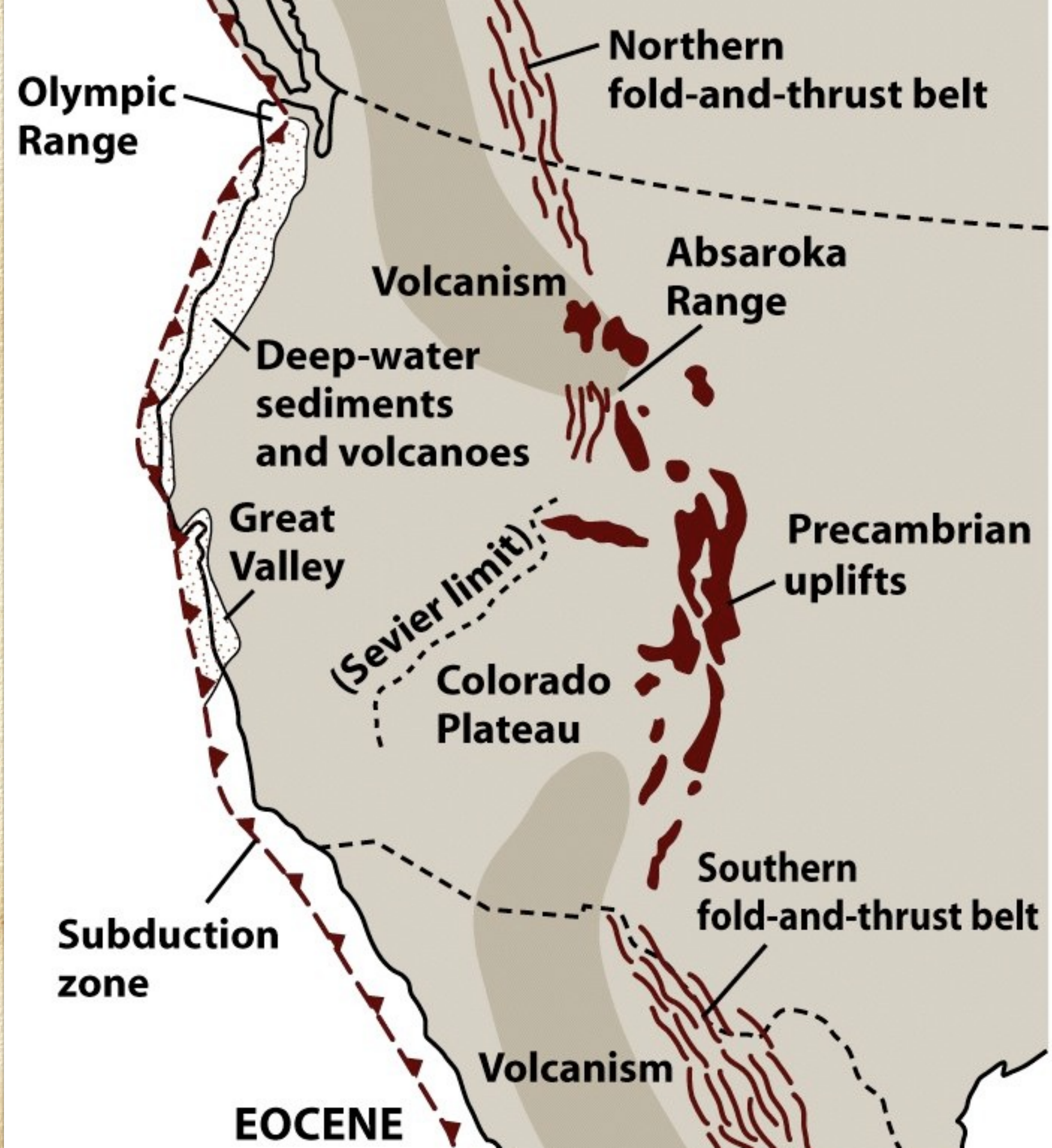


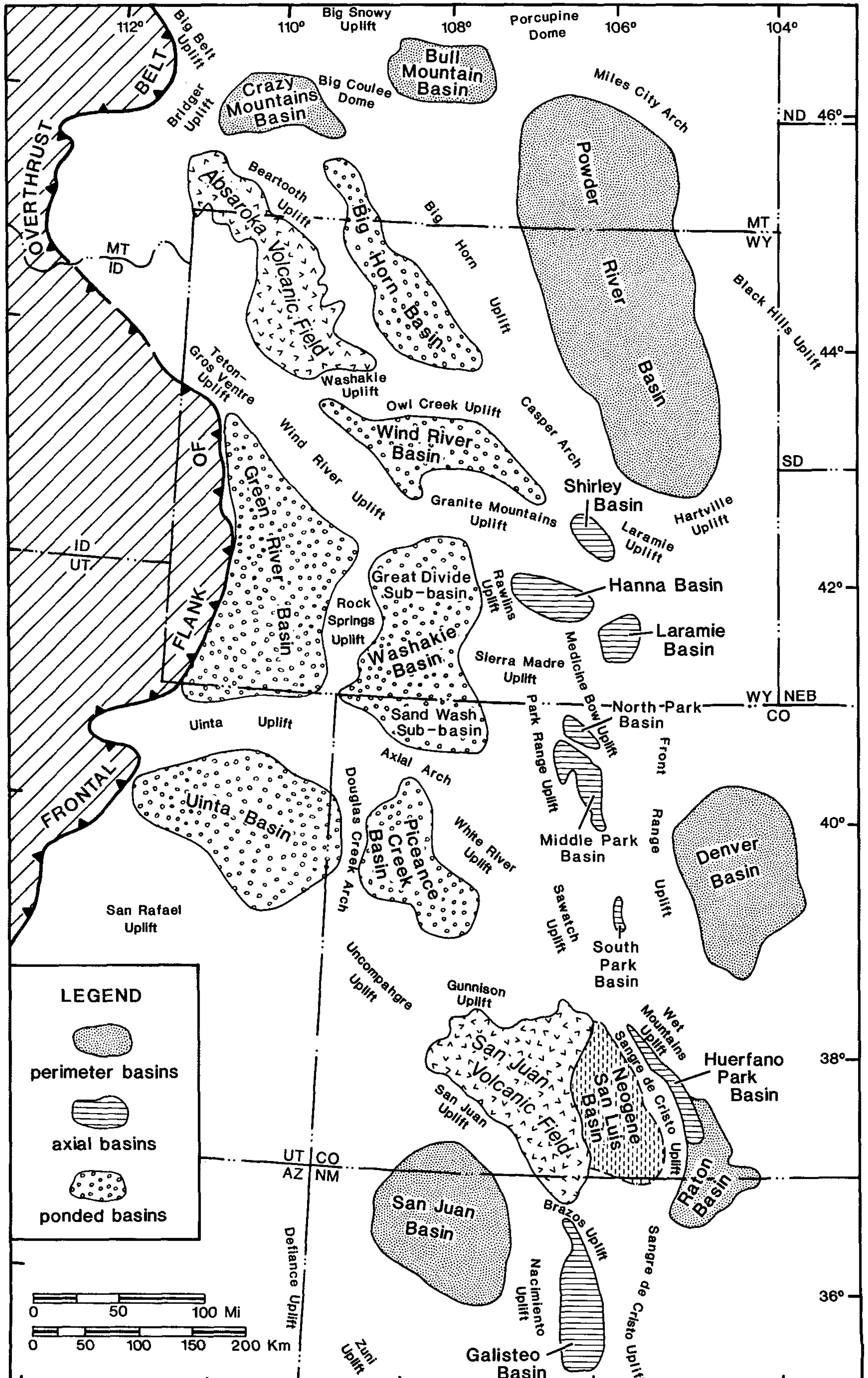
Figure 1. Tectonic setting of the Sevier orogen. a. Distribution of important tectonic features. Shaded area indicates the Internal zone as defined in this paper. b. Locations of areas containing evidence of Cretaceous extension.

Hodges & Walker, GSA Bull., 1992

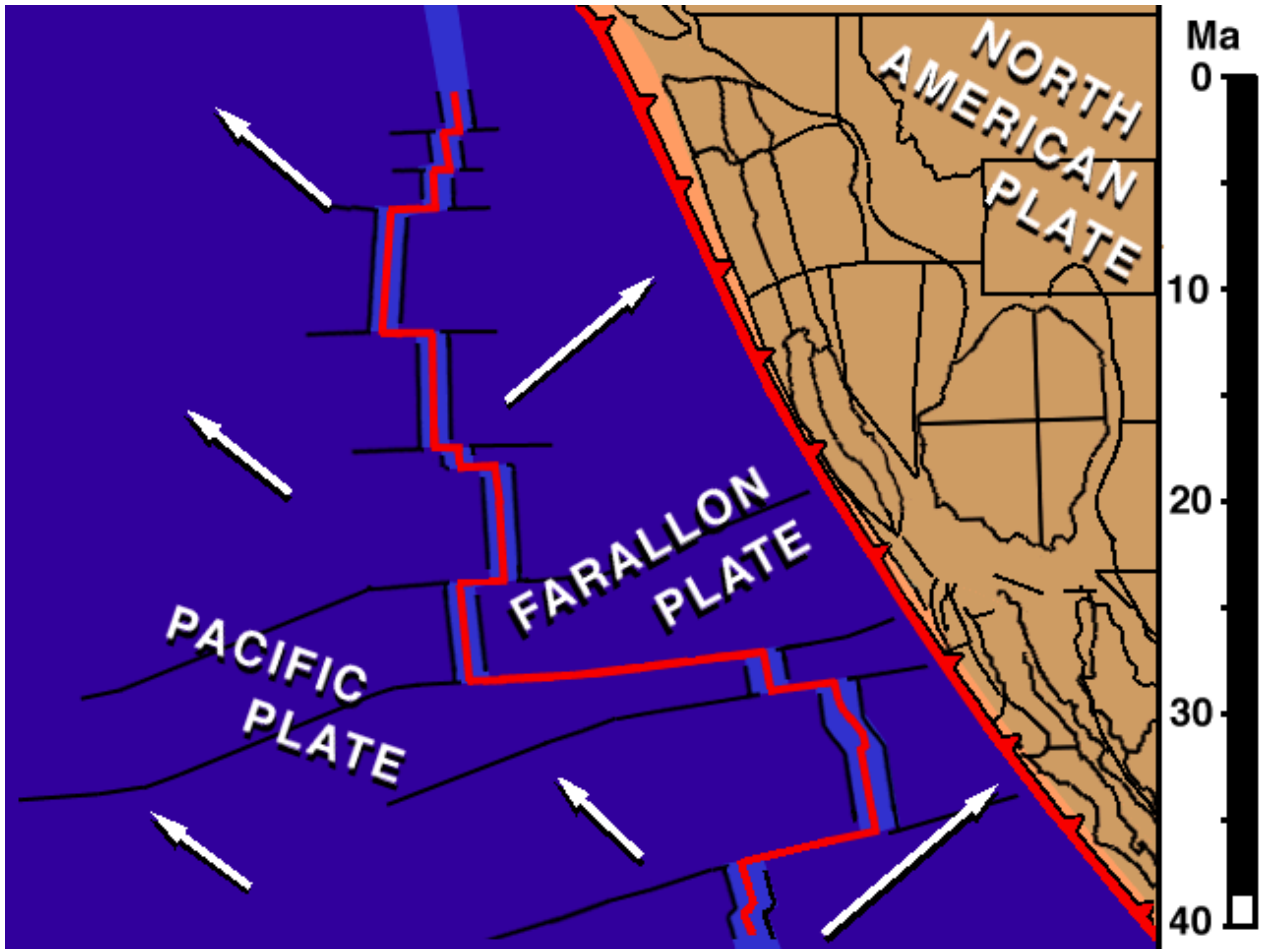


Northern
fold-and-thrust belt
Olympic
Range
Absaroka
Range
Volcanism
Deep-water
sediments
and volcanoes
Great
Valley
(Sevier limit)
Precambrian
uplifts
Colorado
Plateau
Southern
fold-and-thrust belt
Subduction
zone
Volcanism
EOCENE

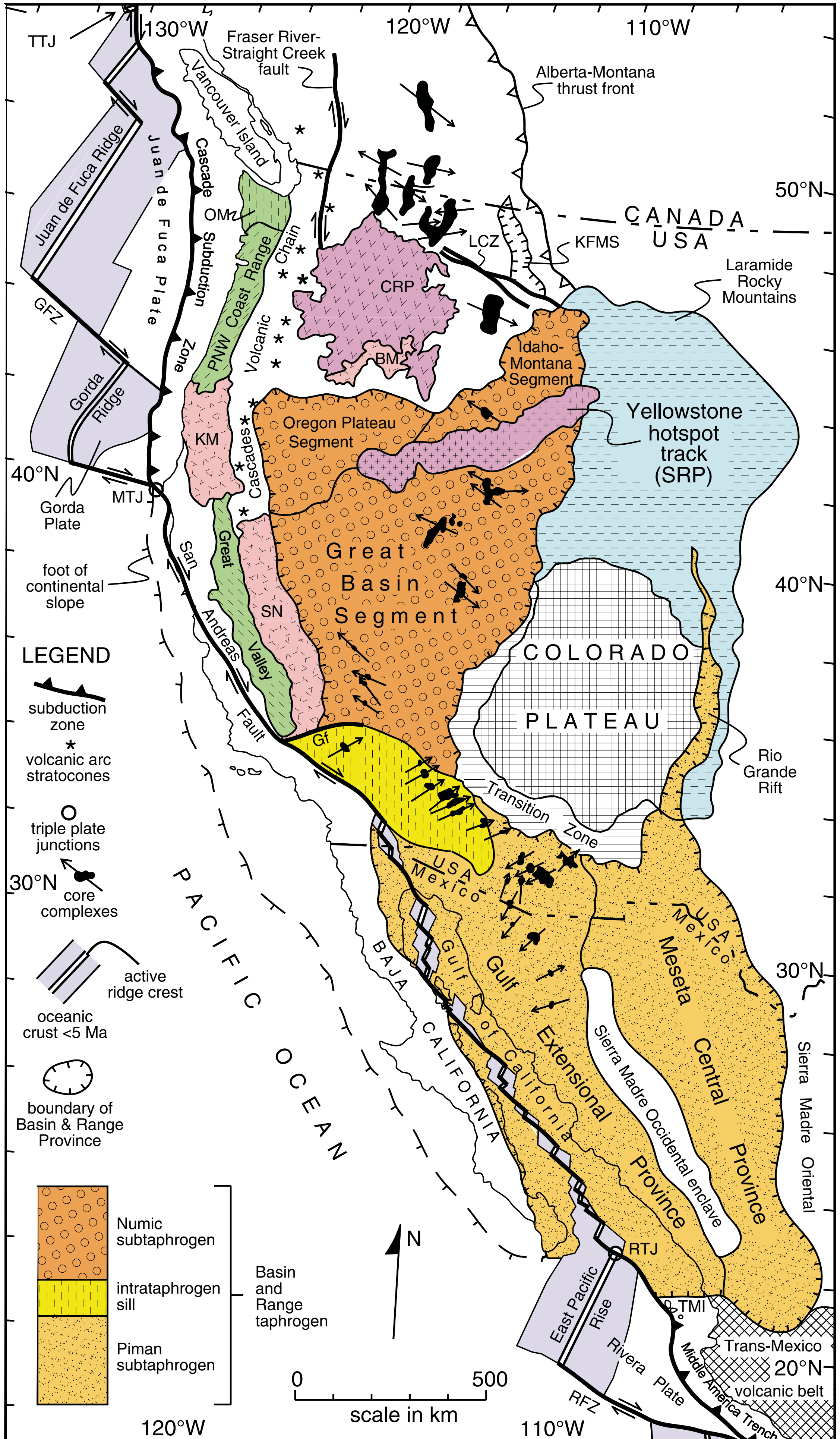
Figure 2. Distribution of key Laramide sedimentary basins and intervening uplifts in the Rocky Mountain region between central Montana and central New Mexico. Eocene Absaroka and Oligocene San Juan volcanic fields mask Laramide relations locally.

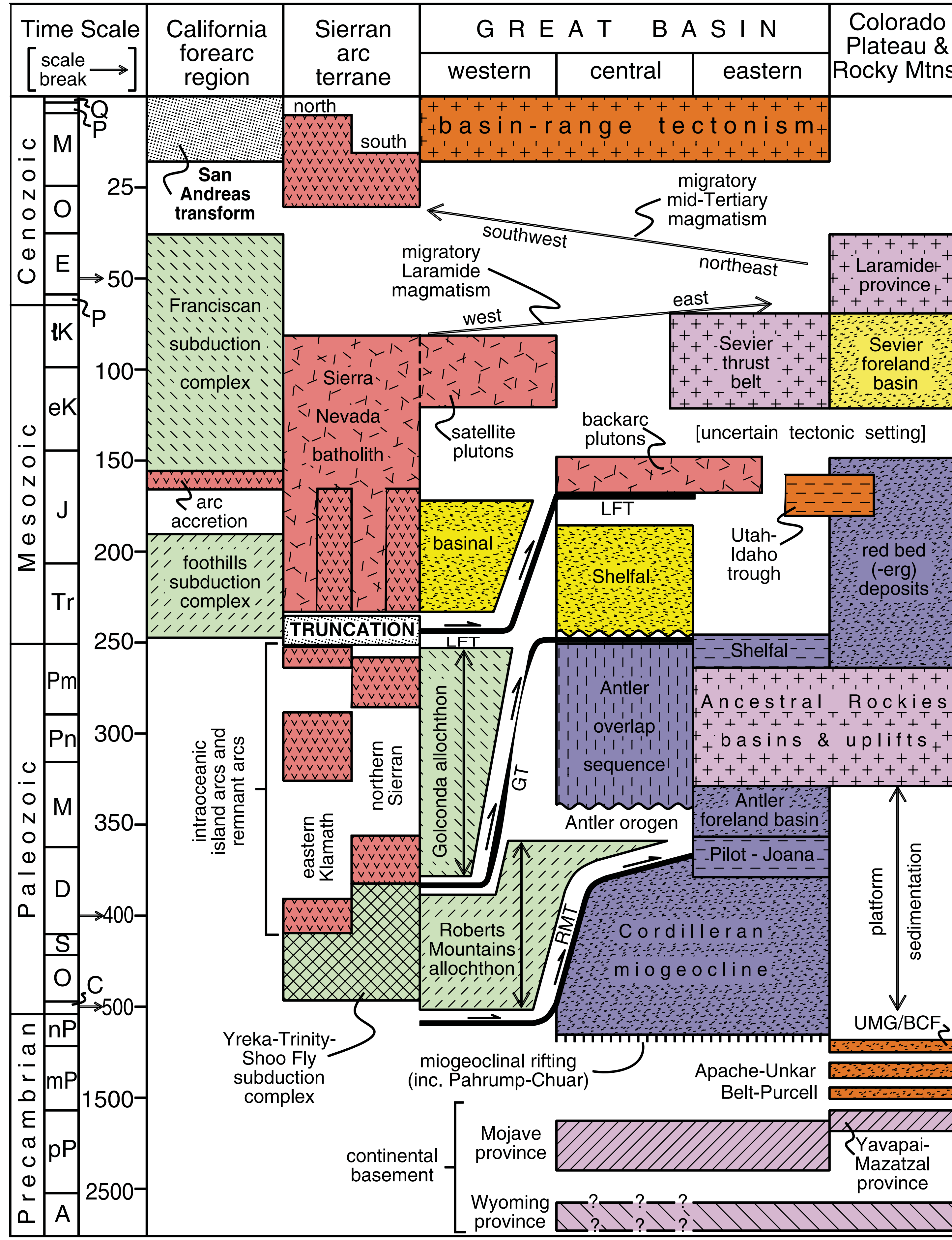


Dickinson et al., GSA Bull 1988

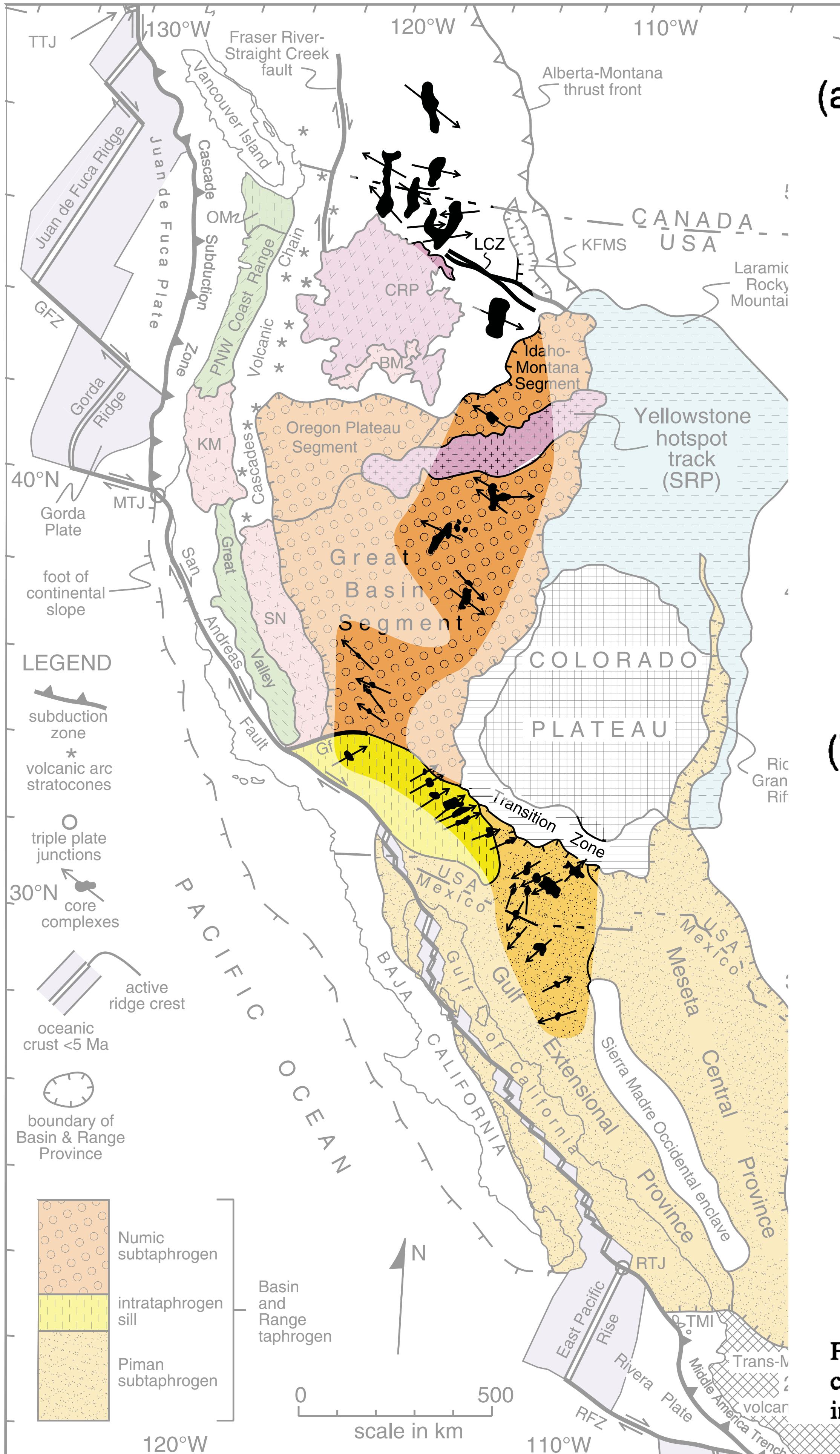


T. Atwater animation





Dickinson, Geosphere, 2006



Dickinson, Geosphere, 2006

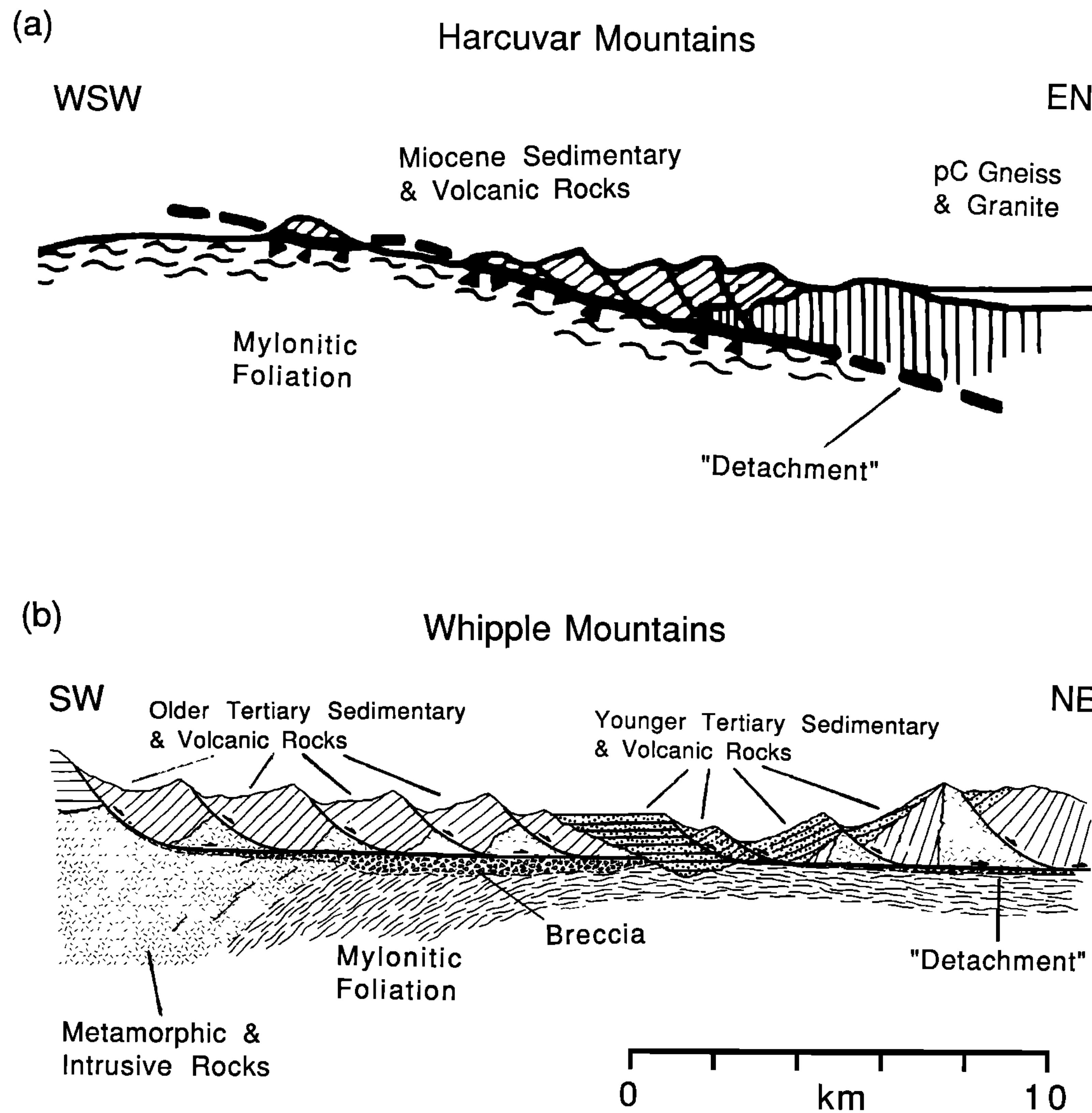
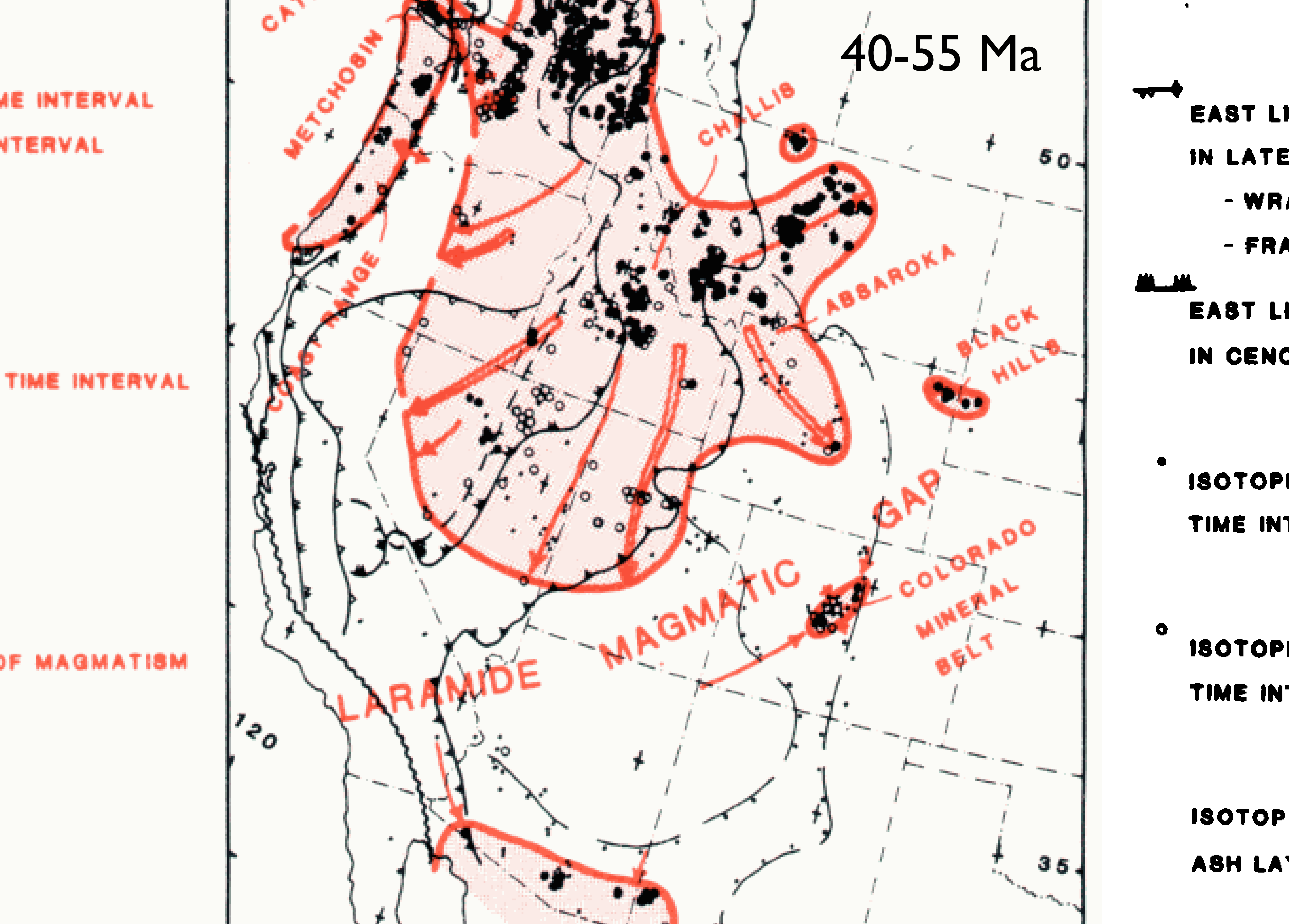


Fig. 1. Interpretative cross sections of two metamorphic core complexes showing features common to many core complexes: (a) the Harcuvar Mountains in Arizona [after Rehrig and Reynolds, 1980] and (b) the Whipple Mountains in California with inferred doming removed [after Davis, 1980].

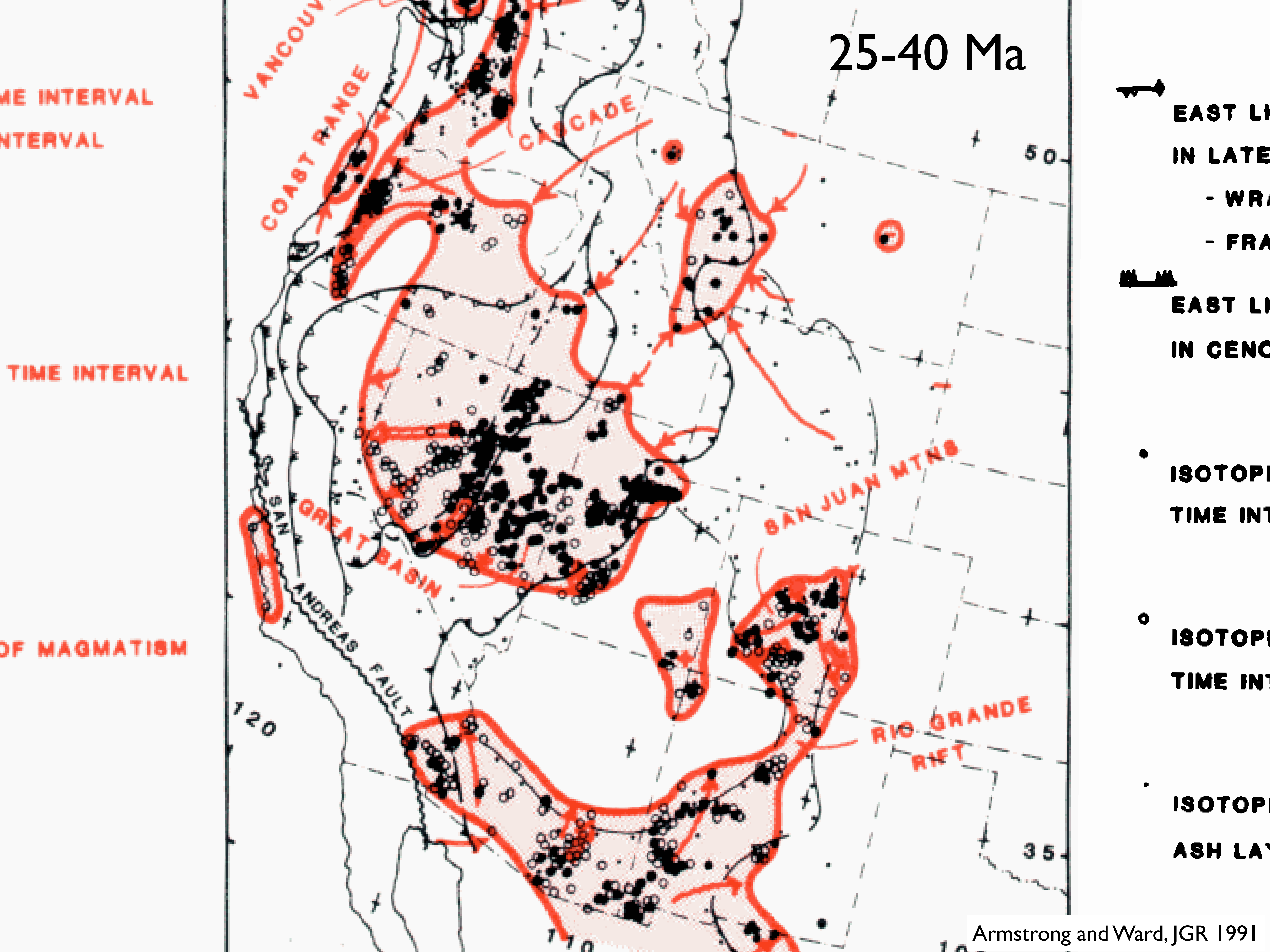
Buck, Tectonics, 1988

40-55 Ma



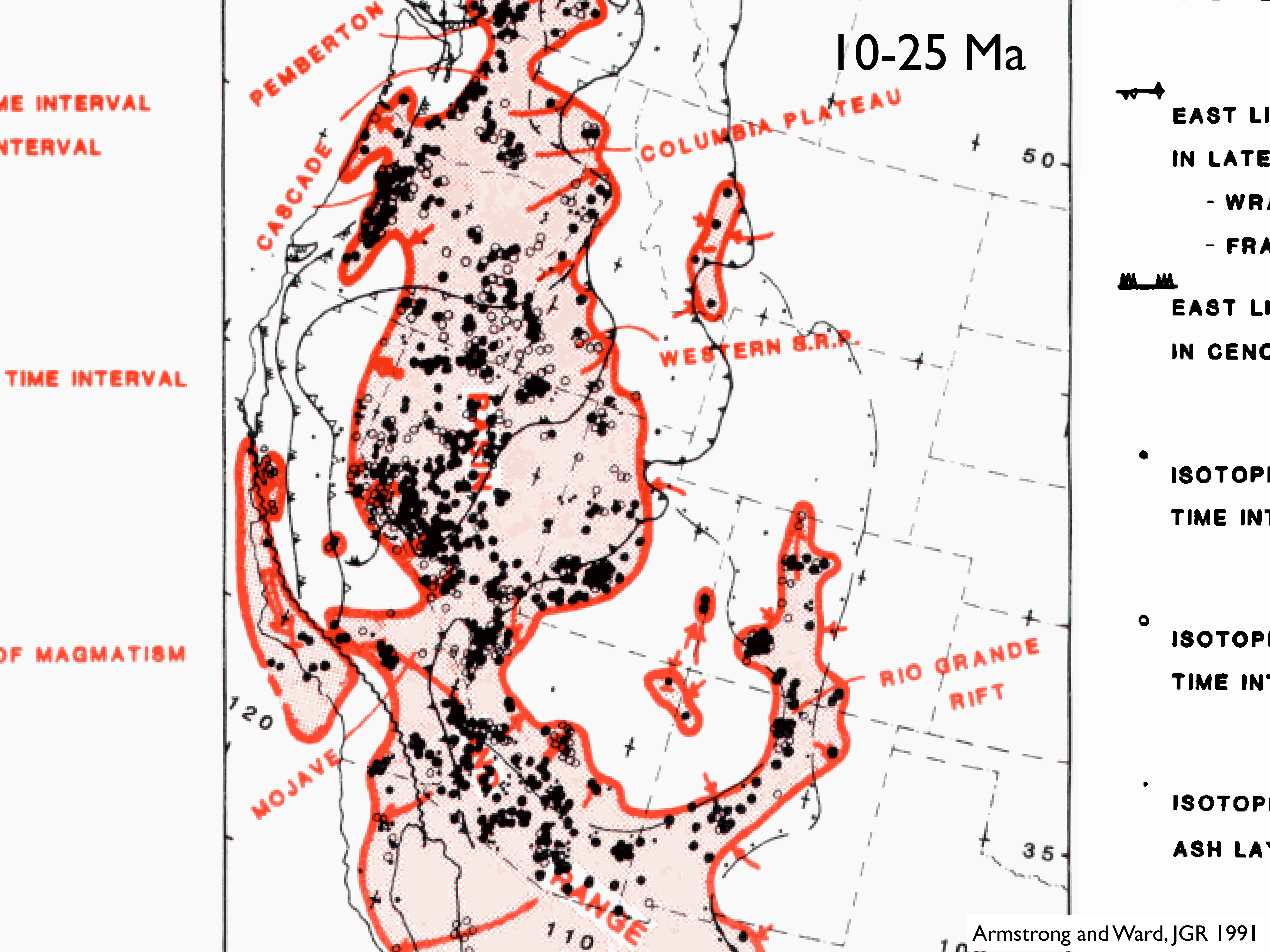
Armstrong and Ward, JGR 1991

25-40 Ma



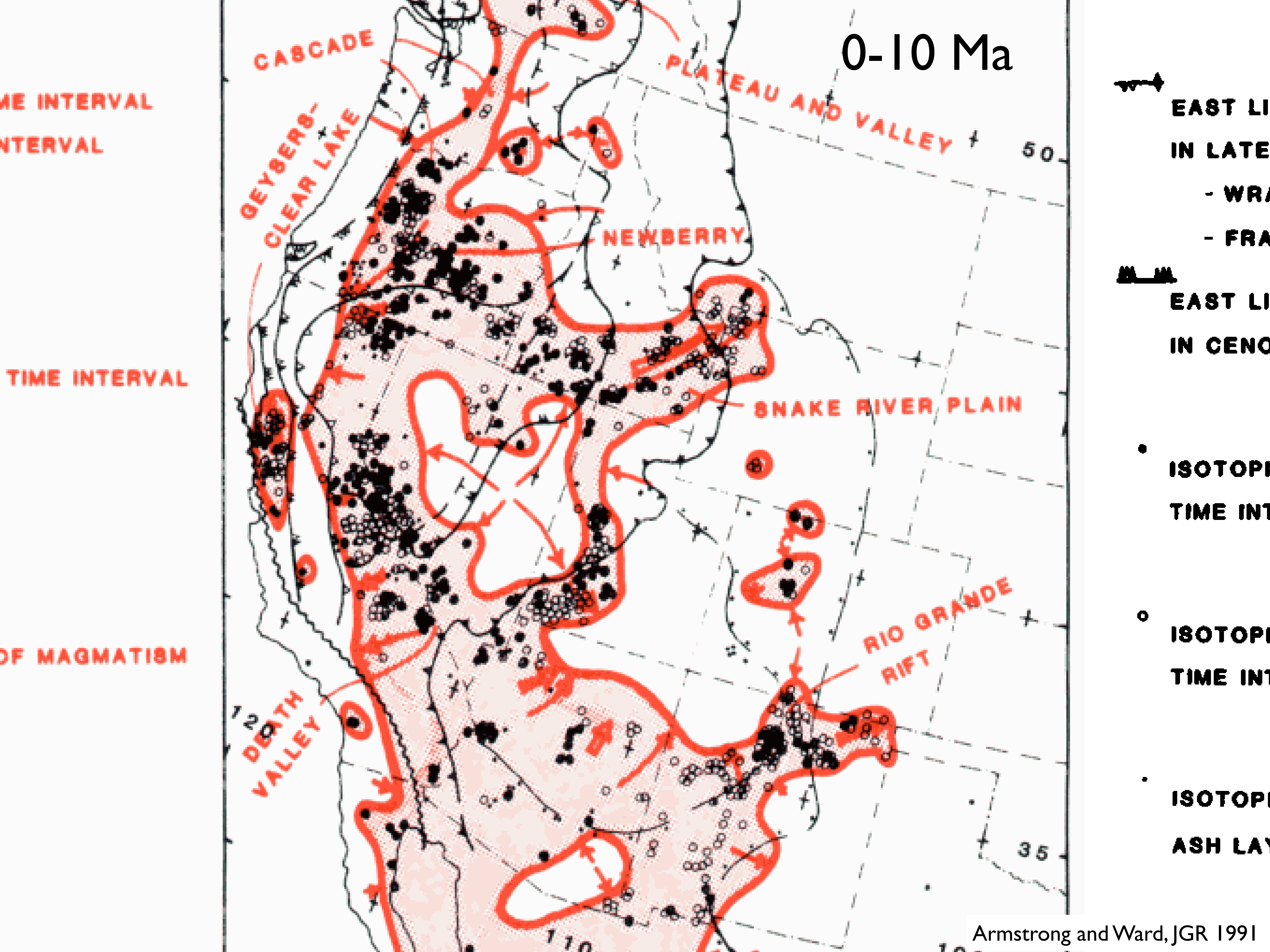
Armstrong and Ward, JGR 1991

10-25 Ma

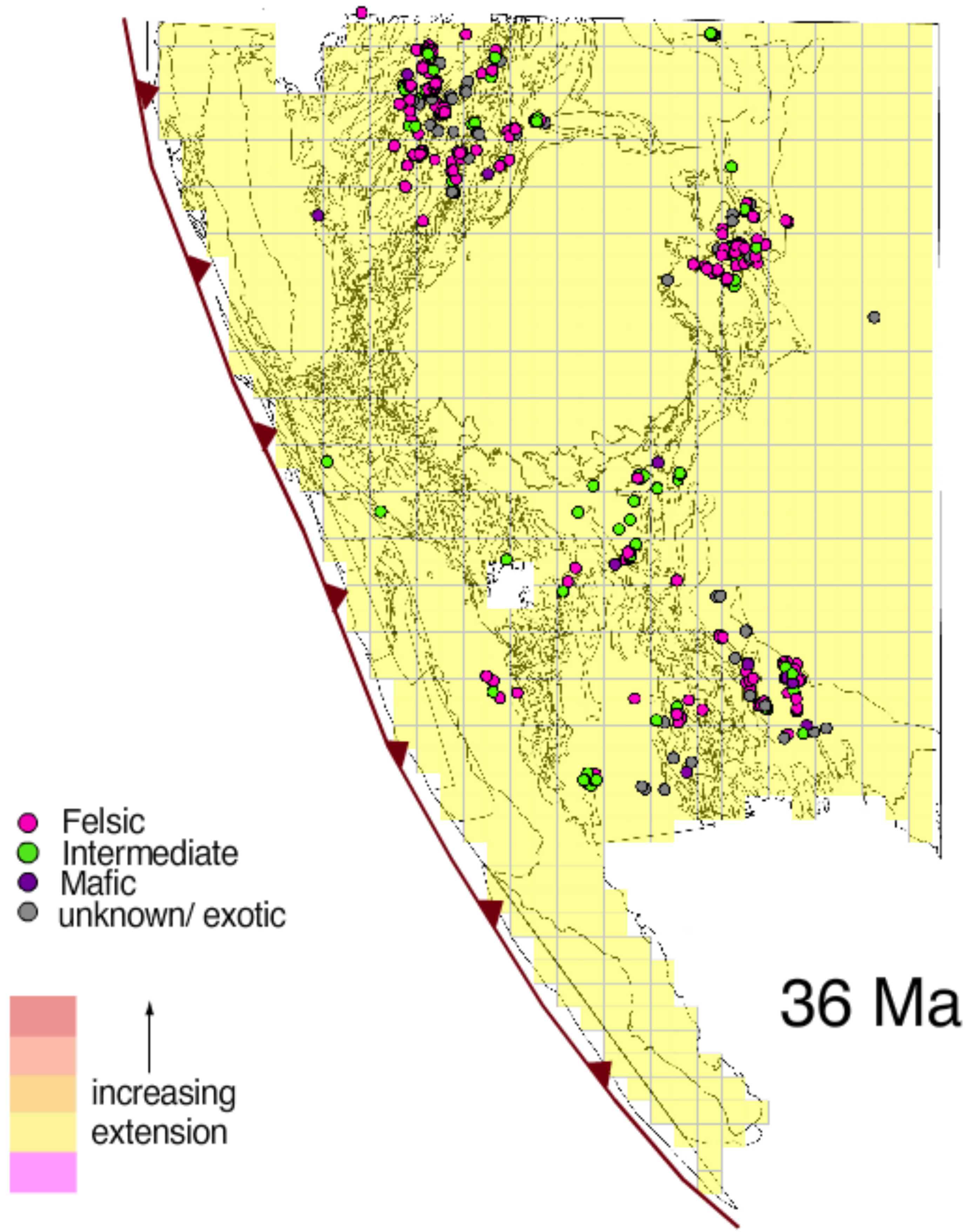


Armstrong and Ward, JGR 1991

0-10 Ma



Armstrong and Ward, JGR 1991



McQuarrie and Oskin, JGR, 2010

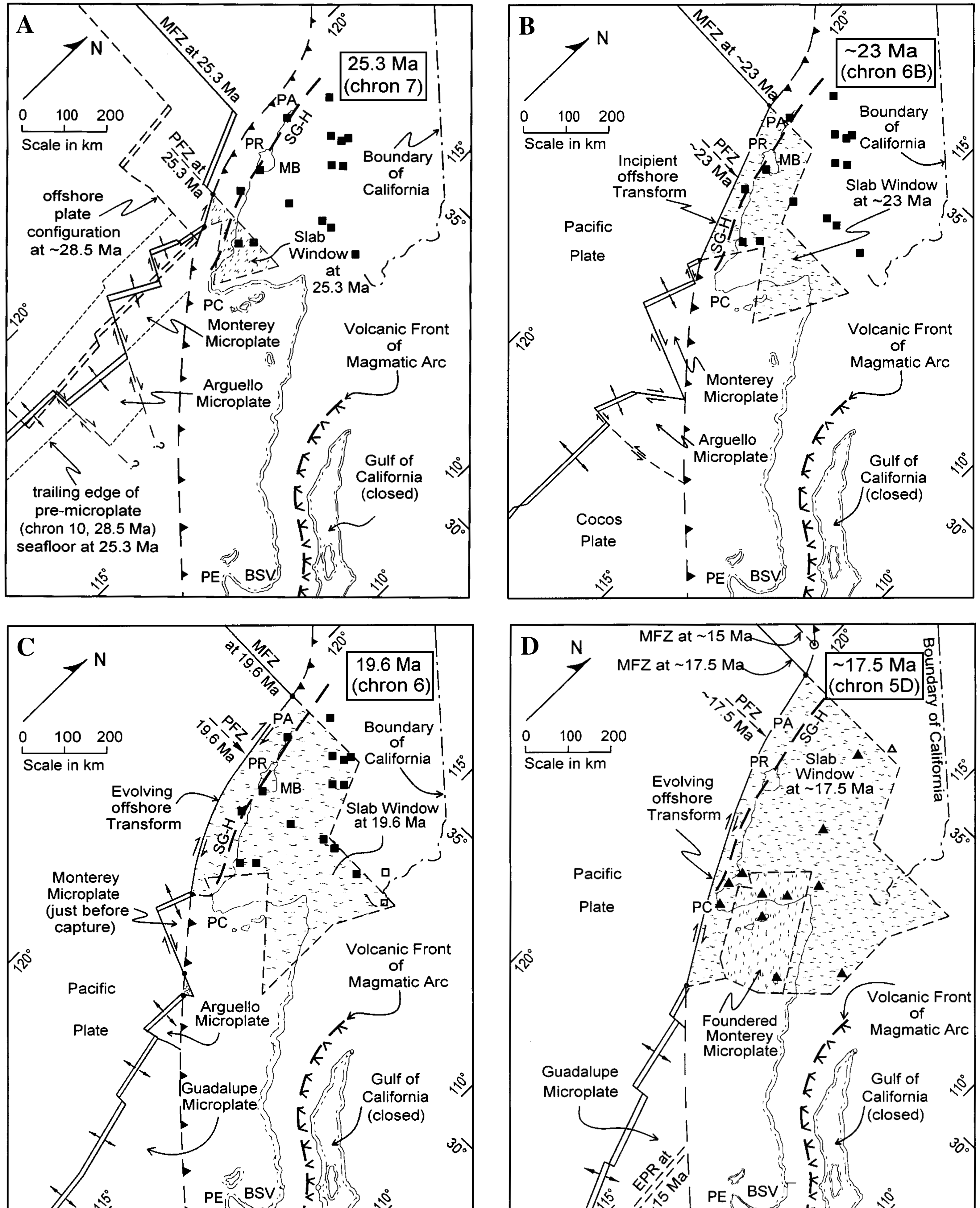
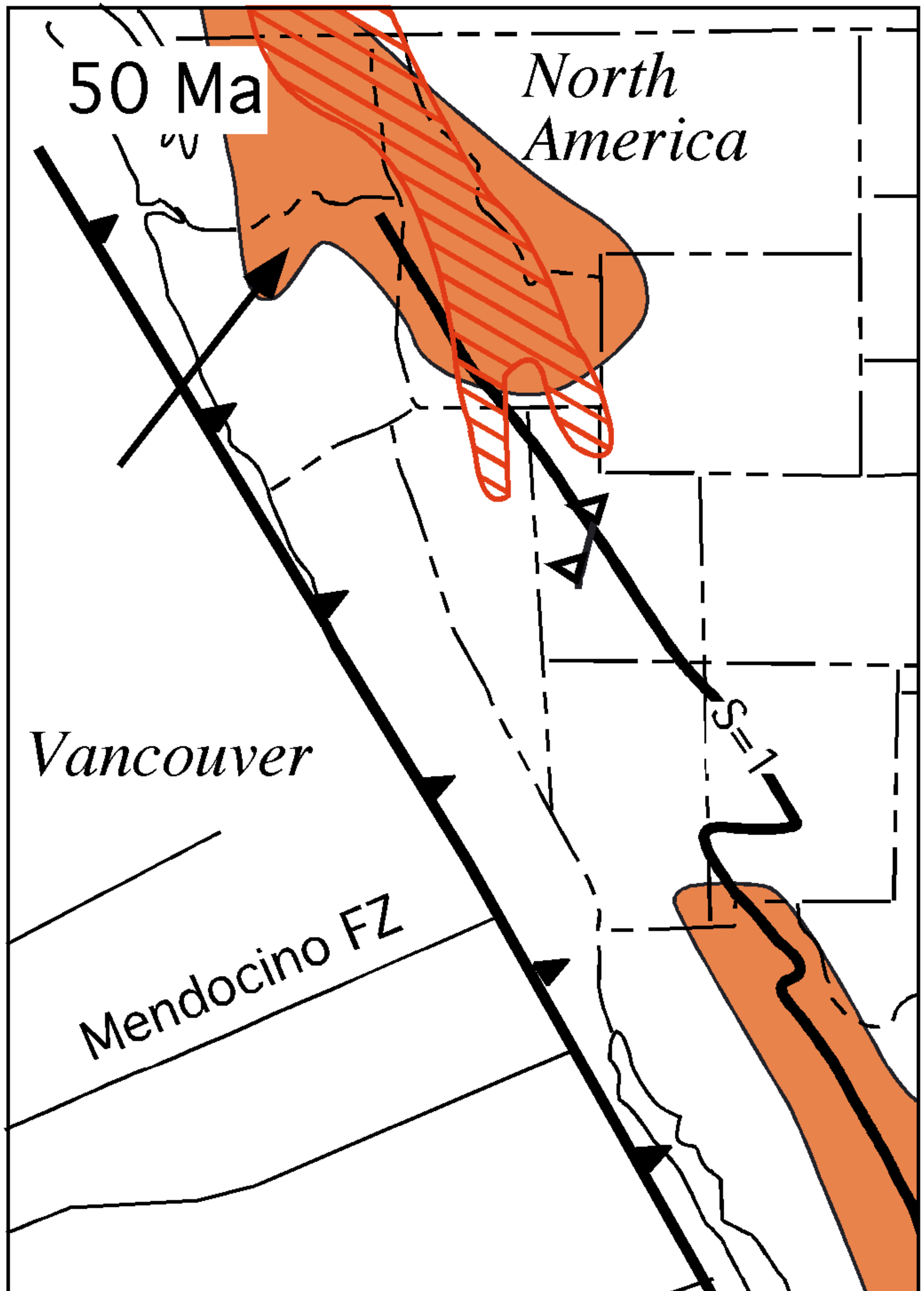
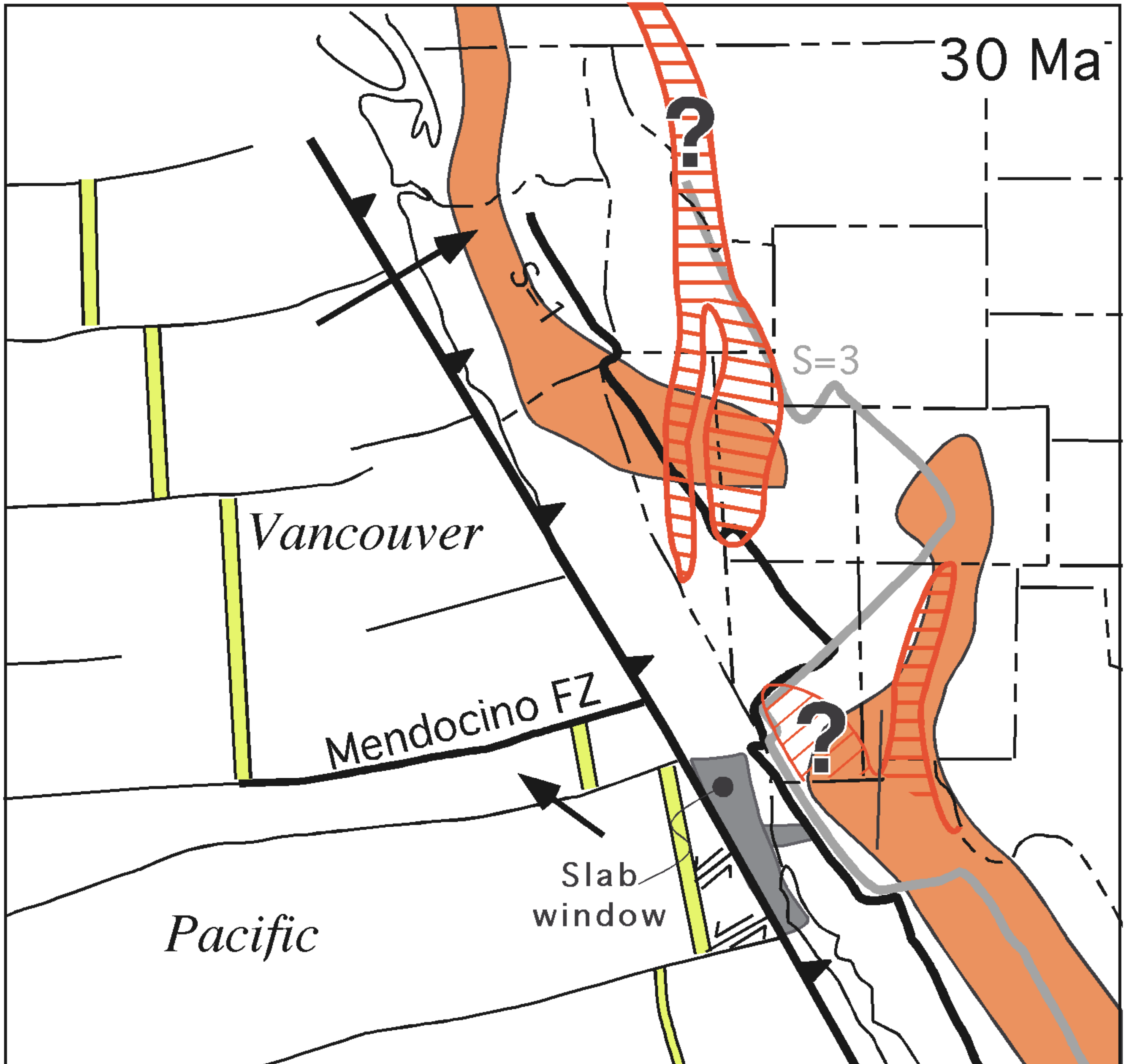


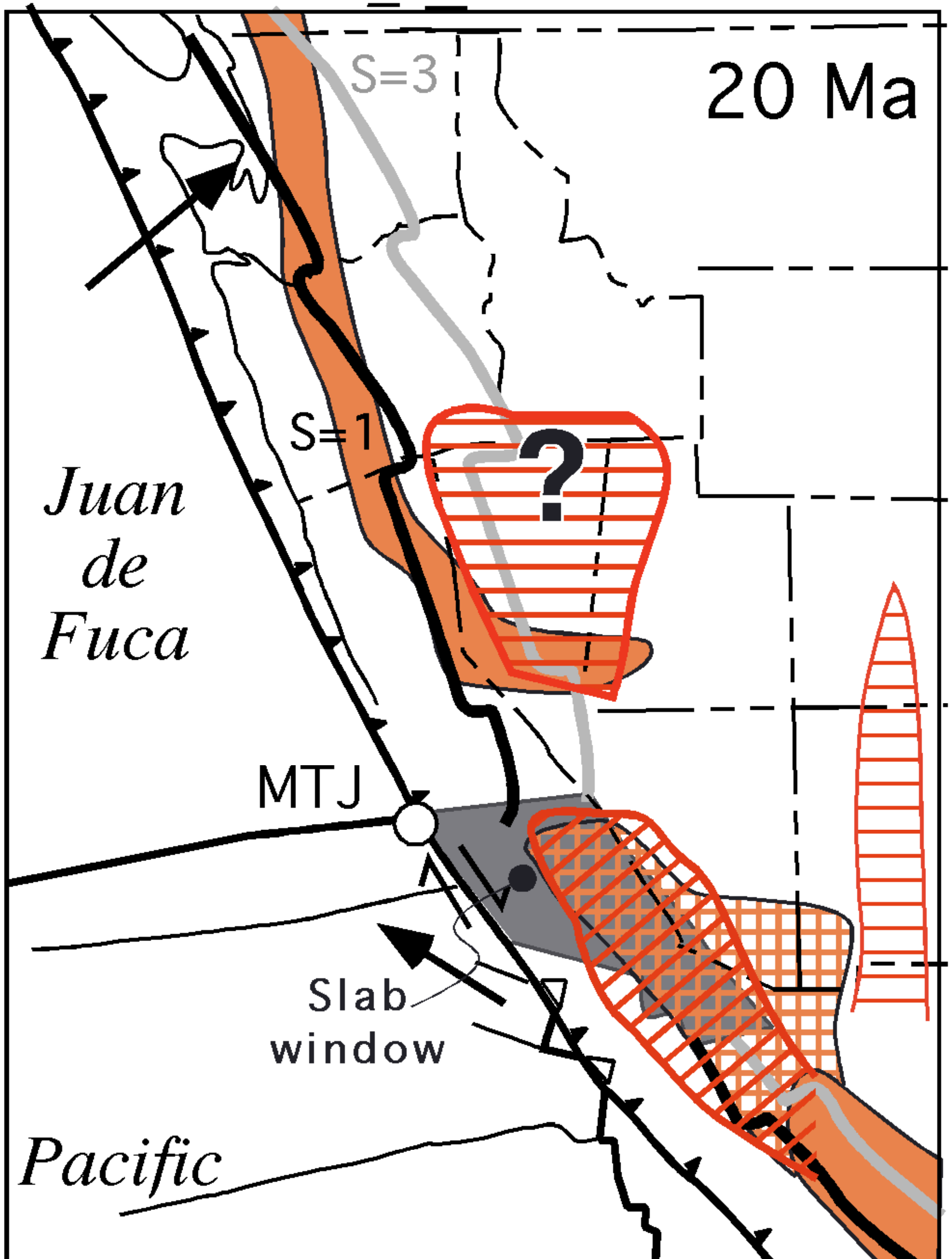
Figure 5.

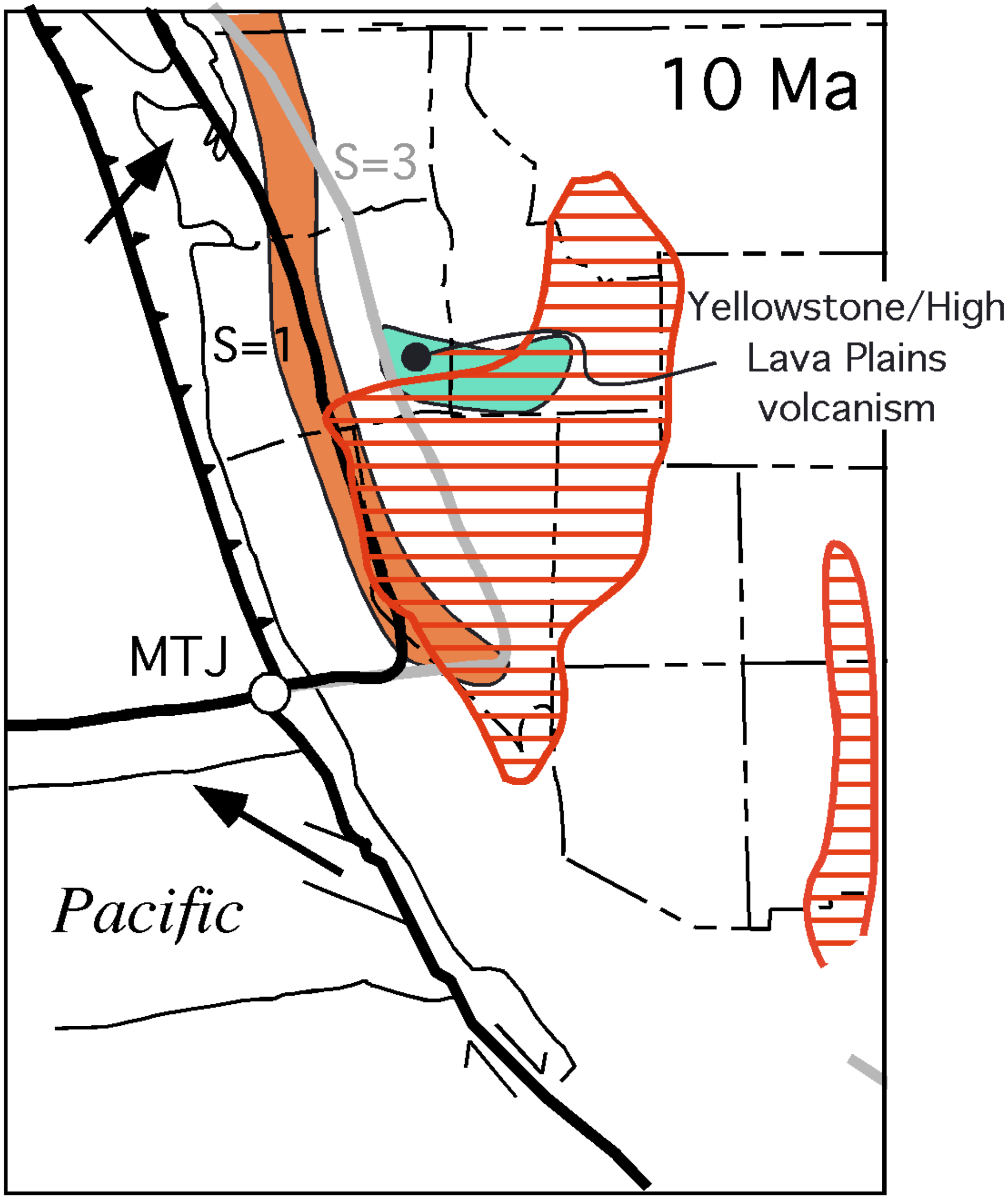
Dickinson, GSA Bull 1997

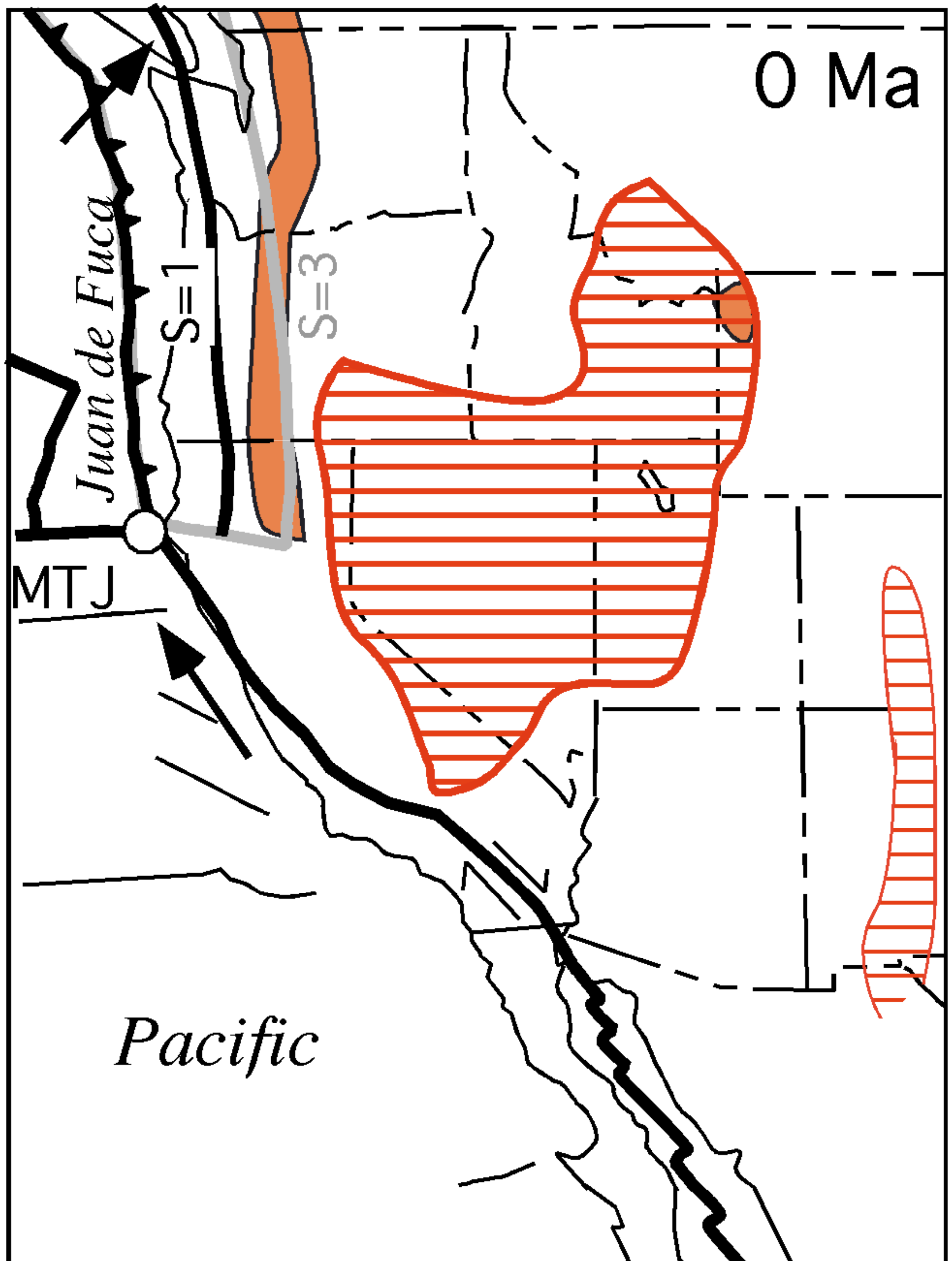


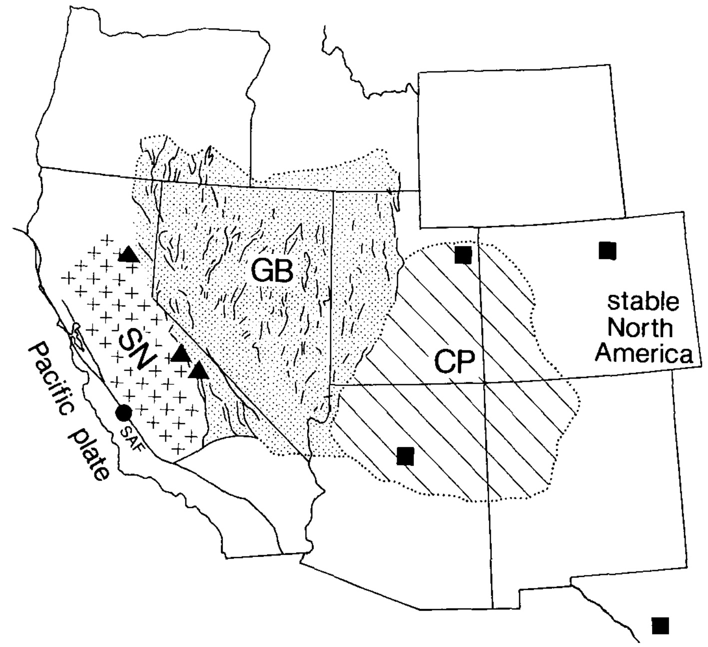
50 Ma
North America
Vancouver
Mendocino FZ
S=1


30 Ma
S=1
S=3
Vancouver
Mendocino FZ
Slab
window
Pacific


20 Ma
S=3
S=1
?
Juan de Fuca
MTJ
Slab window
Pacific


10 Ma
S=3
S=1
Yellowstone/High
Lava Plains
volcanism
MTJ
Pacific


0 Ma
Juan de Fuca
S=1
S=3
MTJ
Pacific



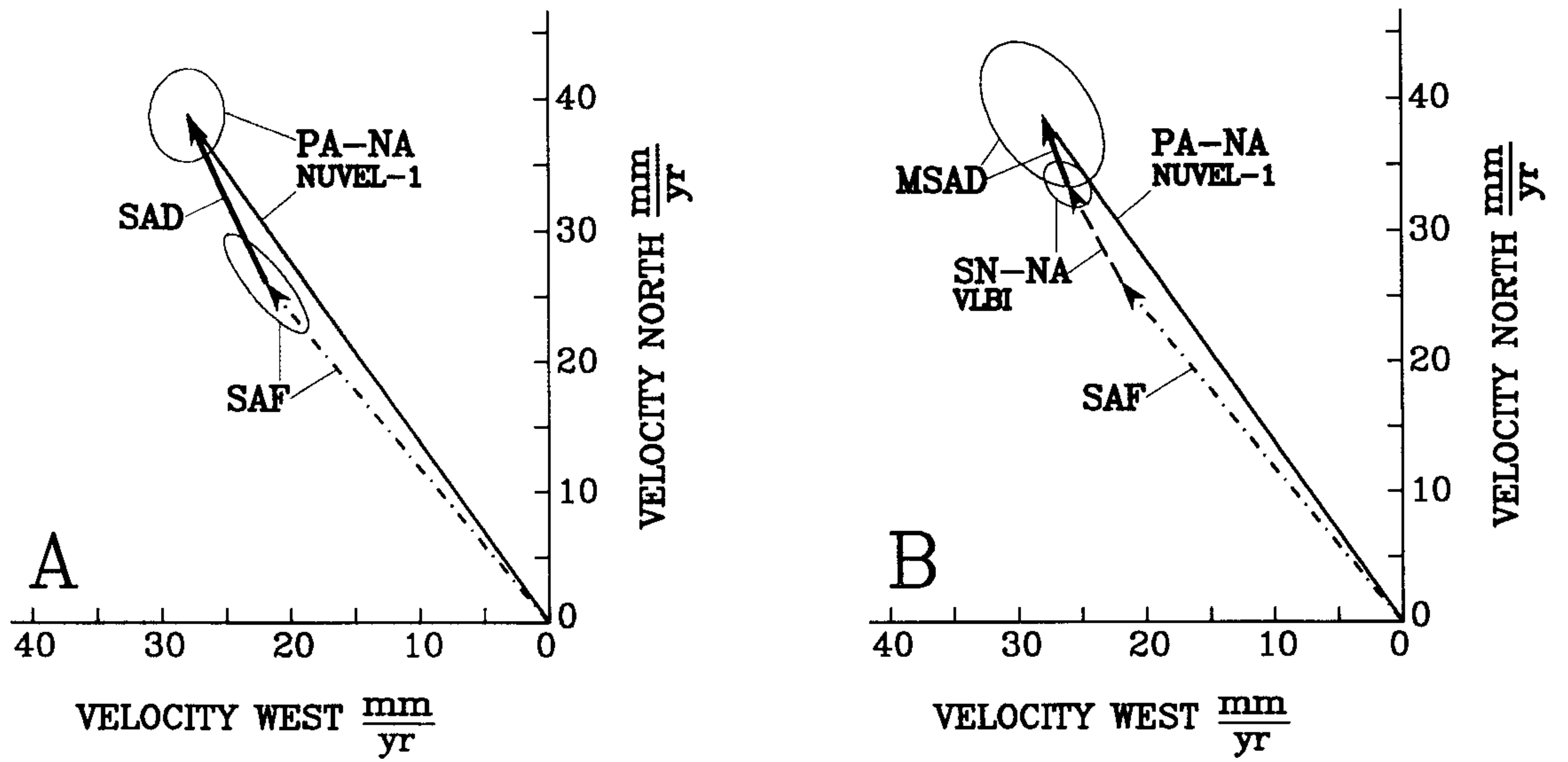
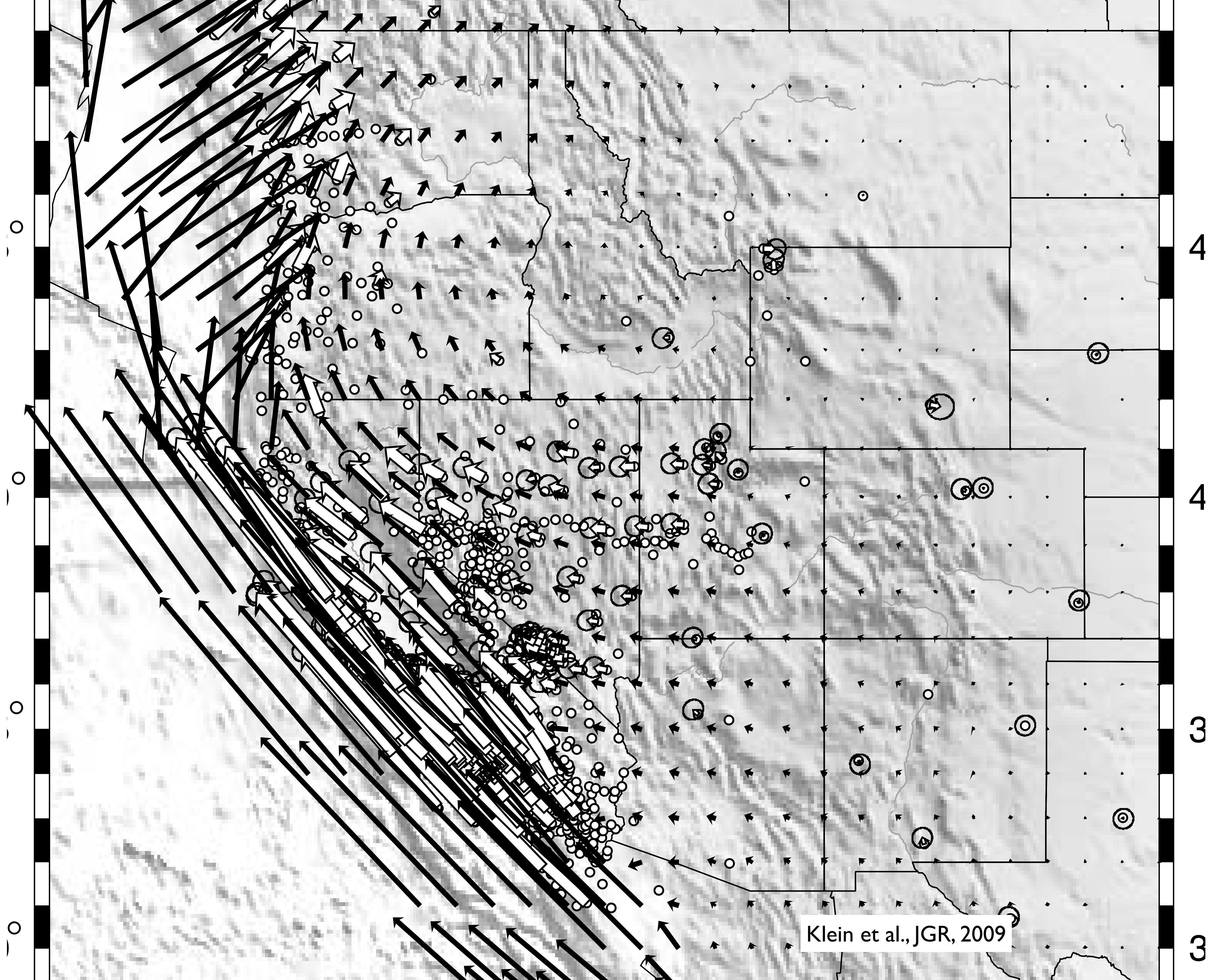
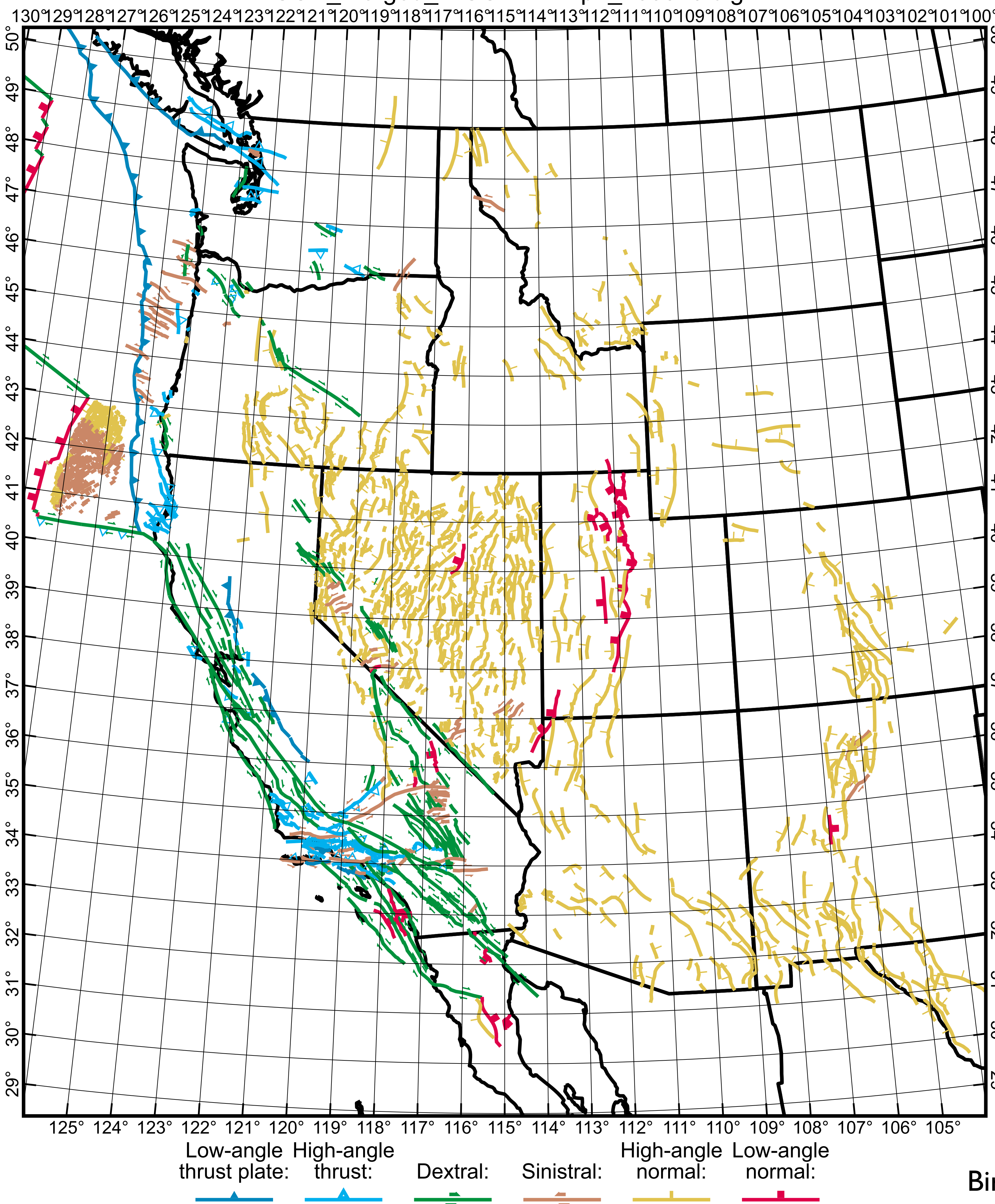


Figure 2. Linear velocity vectors along San Andreas fault at lat 36°N. A: Slip along San Andreas fault (SAF; alternating dash-dot vector) takes up only part of Pacific–North America motion predicted by global-plate-motion model NUVEL-1 (thin solid vector). Vector difference between the two, termed San Andreas discrepancy (SAD; thick solid vector), equals 14 ±2 mm/yr toward N26° ±6°W. Circle and ellipse indicate 95% confidence limits for San Andreas fault slip and for Pacific–North America (PA-NA) motion. B: Vector sum of strike slip along San Andreas fault and Sierra Nevada–North America motion (SN-NA; dashed vector; VLBI = very long baseline interferometry) differs little from Pacific– North America motion. Modified San Andreas discrepancy (MSAD), which equals difference between these two quantities, is 6 ±2 mm/yr toward N20° ±17°W. Ellipses indicate 95% confidence limits for Sierra Nevada–North America motion and for modified San Andreas discrepancy.

Argus and Gordon, Geology, 1991


Klein et al., JGR, 2009

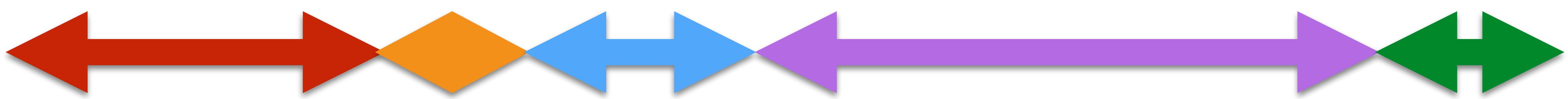
fGCN_merged_WGCEPFM2p2_200810.dig



Bird, JGR, 2009

A broad overview

Precambrian (Proterozoic) | Paleozoic | Mesozoic | Cenozoic



Accretion of island arcs

Magmatic episodes

Rifting

Passive margin (except for exotic terranes to the west)

Contractional tectonics (arcs, fold-and-thrust belts, accretion)

Transition to strike-slip (transform) tectonics, extensional tectonics