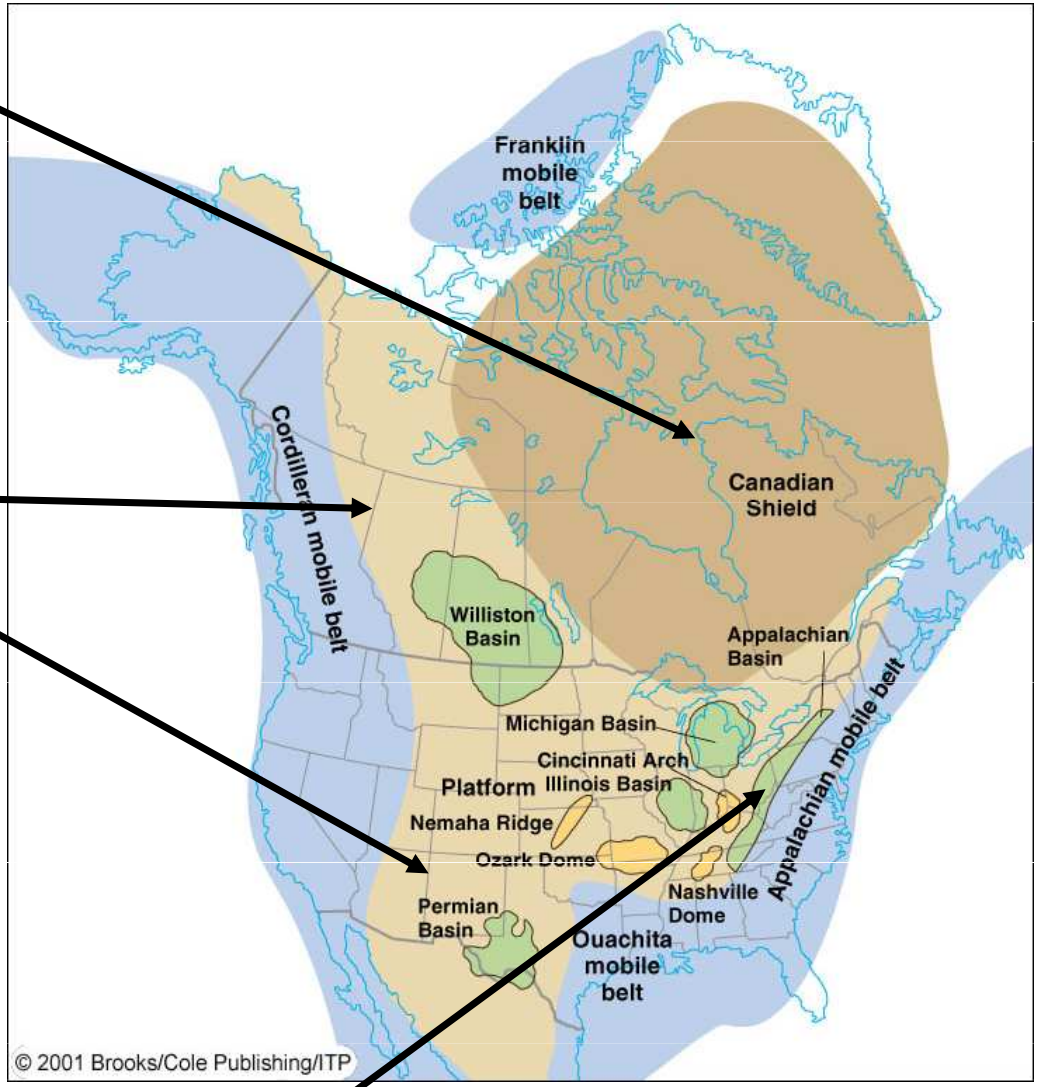
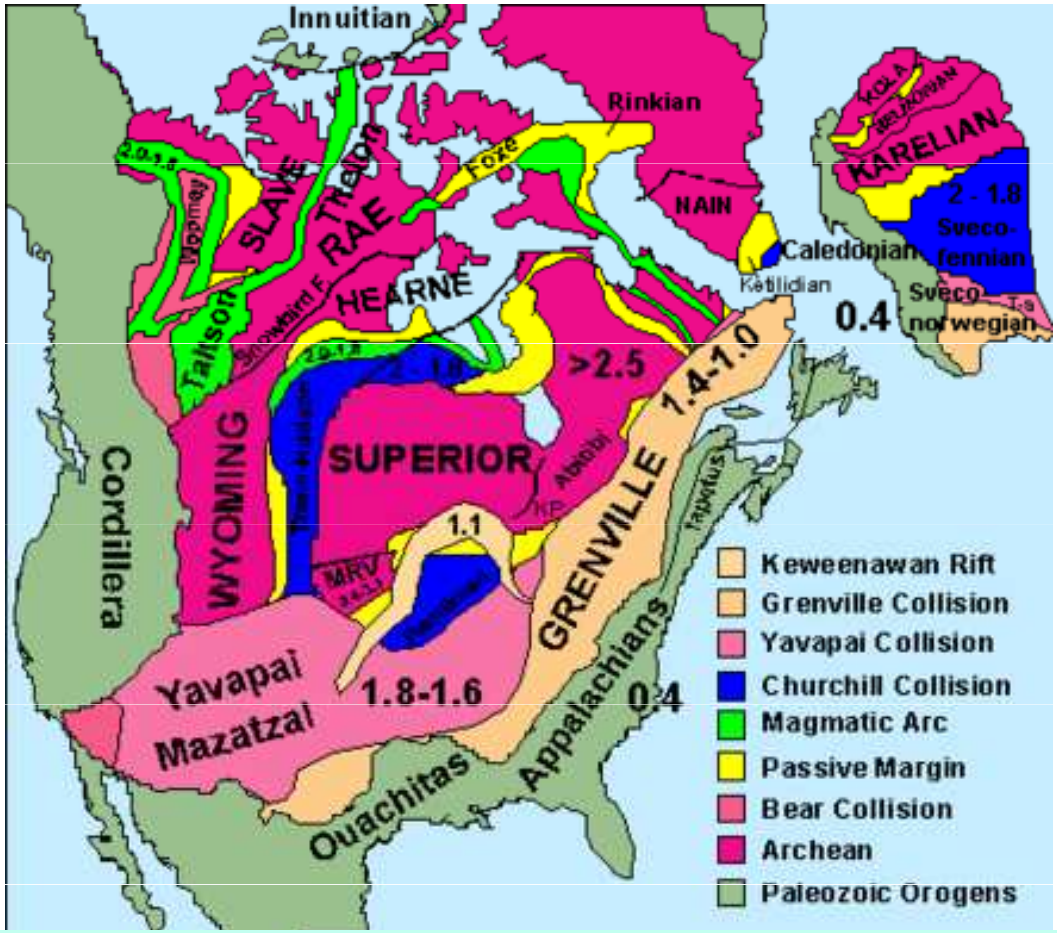
Severoamerický kraton

4

Canadian (Laurent) 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.



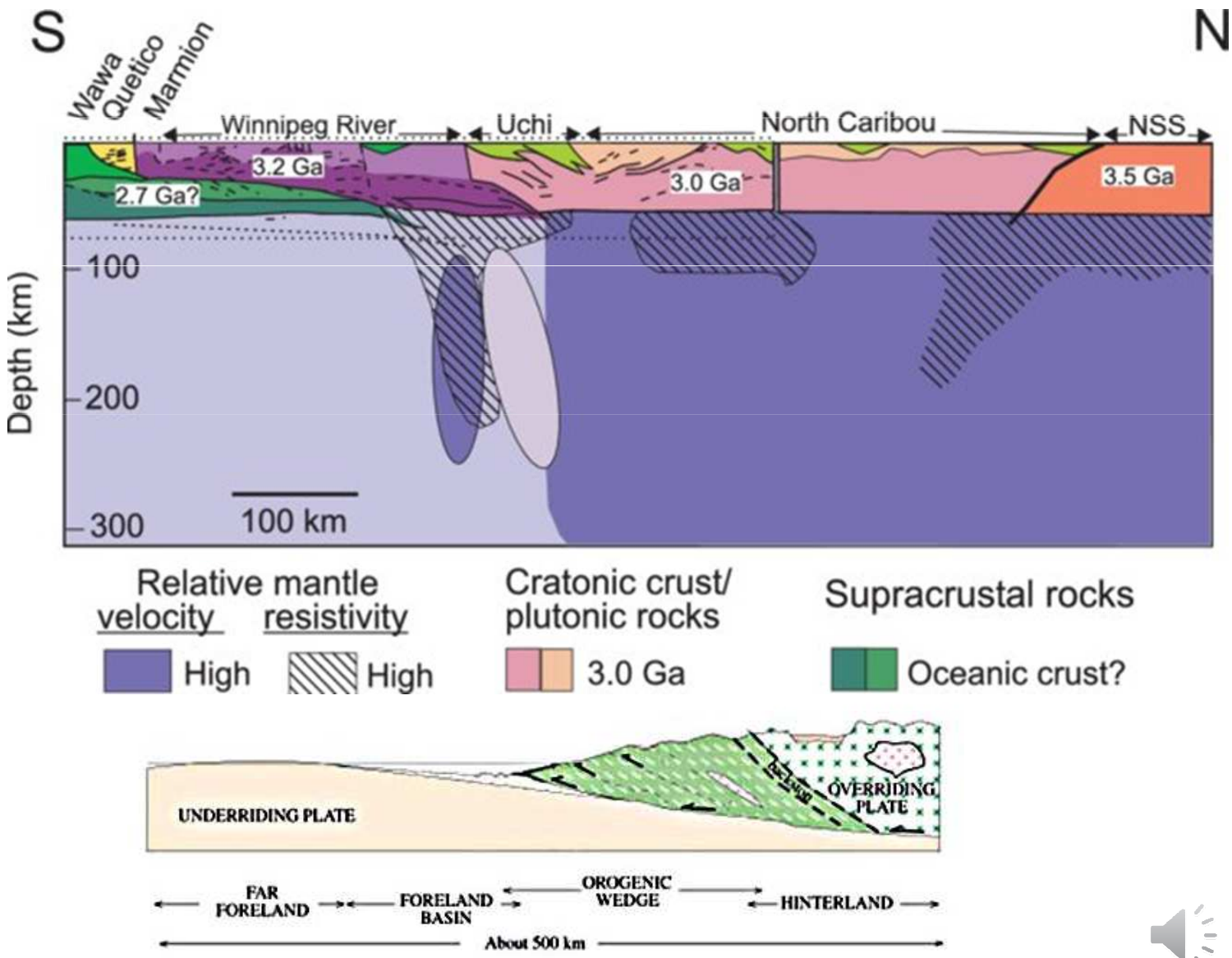
Appalachian Basin



První významnou orogenezí byla na konci archaika **orogeneze algomská** (kenoranská), která vytvořila kraton **Superior**. V paleoproterozoiku **Taltson – Thelon** orogeneze přičlenila ke kratonu Rae kraton Slave. Hlavní část laurentského štítu byla vytvořena při **transhudsonské orogenezi** (1,8-1,9 Ga), menší části byly přičleněny při **woopmayské. yavapaiské, mazatzalské a penocké orogenezi** (1,5-1,8). Nejmladší proterozoickou orogenezi je **grenvilská**, která skončila před 1,0 Ga.

Algoman (kenoran) orogeny

The Algoman orogeny, known as the Kenoran orogeny in Canada, was an episode of mountain-building (orogeny) during the Late Archean Eon that involved repeated episodes of continental collisions, compressions and subductions. Five discrete accretionary events assembled fragments of continental and oceanic crust into a coherent Superior craton by 2.60 Ga. The final accretionary event involved addition of the Minnesota River Valley terrane (MRVT) from the south. Blocks were added to the Superior province along a 1,200 km (750 mi) boundary that stretches from present-day eastern South Dakota into the Lake Huron area; The current boundary between these terranes is known as the Great Lakes tectonic zone (GLTZ)



The Minnesota River Valley subprovince collided with and overrode the Superior province.

Taltson – Thelon orogeny

The Taltson magmatic and Thelon tectonic zones have historically been considered parts of a single orogen recording collision between the Slave craton and Buffalo Head terrane to the Rae craton between2.0 and 1.9 Ga.

We have provided two alternative models for the Talston orogeny. In the first, the Taltson orogen and the combined Thelon tectonic zone and Ksituan domain represent two separate orogenic belts. They record the accretion of the Slave craton and a superterrane that includes the Kiskatinaw-Chinchaga-Buffalo Head aeromagnetic domains and this amalgam was subsequently accreted to the southwest mar-gin of the Rae craton. In the second, where the Slave craton was already attached to the western Rae craton before the Taltson orogeny, the superterrane including the Kiskatinaw-Chinchaga-Buffalo Head aeromagnetic domains was accreted to the southwestmargin of Rae.

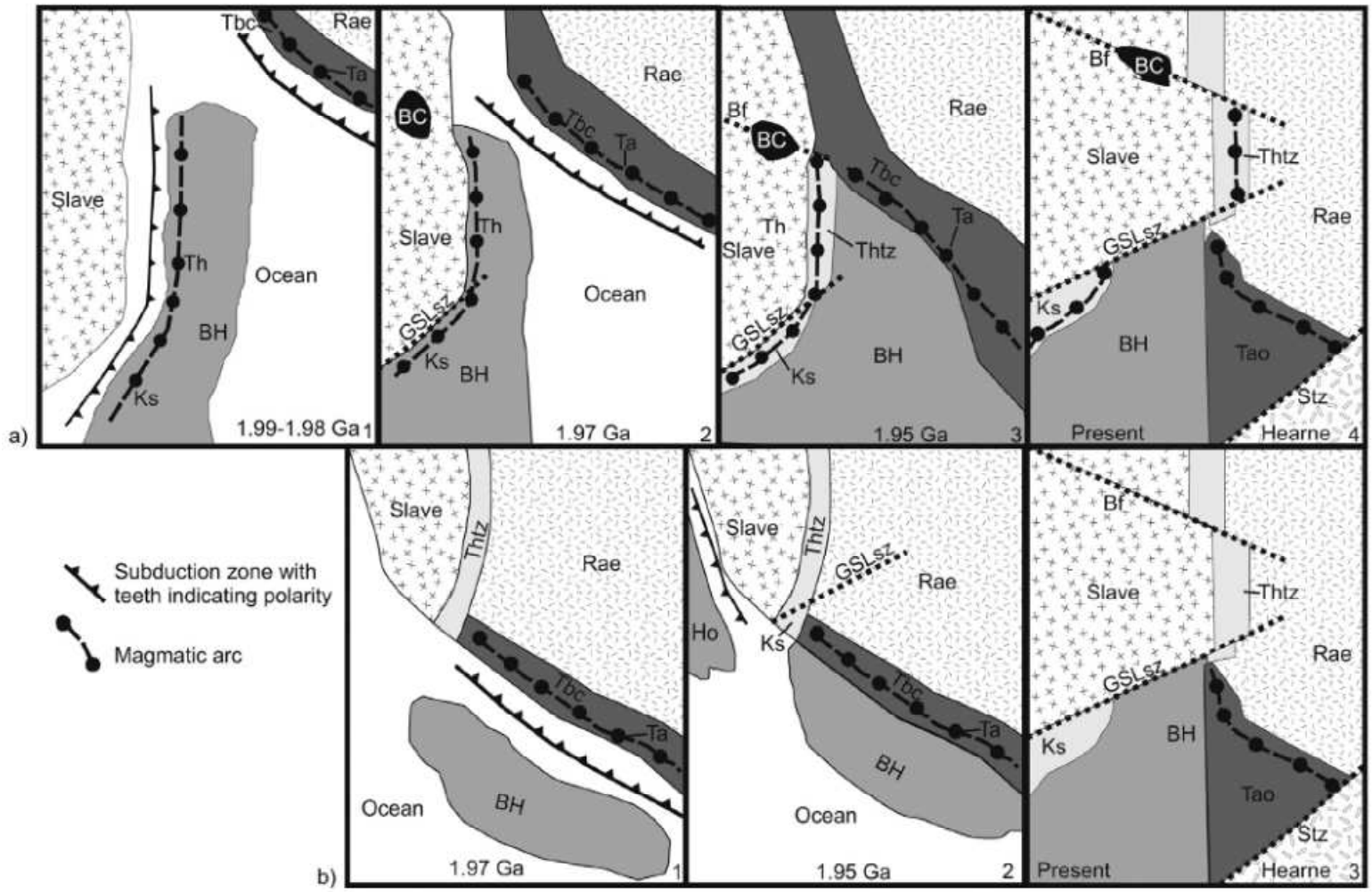


Fig. 11. Tectonic reconstruction cartoons hypothesizing the potential timelines of the Taltson orogeny. (a) Model 1. The Slave craton is an active part of separate Taltson and Thelon orogenies. (b) Model 2. The Slave craton was accreted to the Rae margin in advance of the Taltson orogeny. See text for discussion. Abbreviations: BC = Bear Creekforedeep; Bf = Bathurst fault; BH = Buffalo Head; Kiskatinaw and Chinchaga terranes; GSLsz = Great Slave Lake shear zone; Ho = Hottah terrane; Ks = Ksituan arc; Stz = Snowbirdtectonic zone; Ta = Taltson arc; Tao = Taltson orogen; Tbc = Taltson basement complex; Th = Thelon arc; Thtz = Thelon tectonic zone.

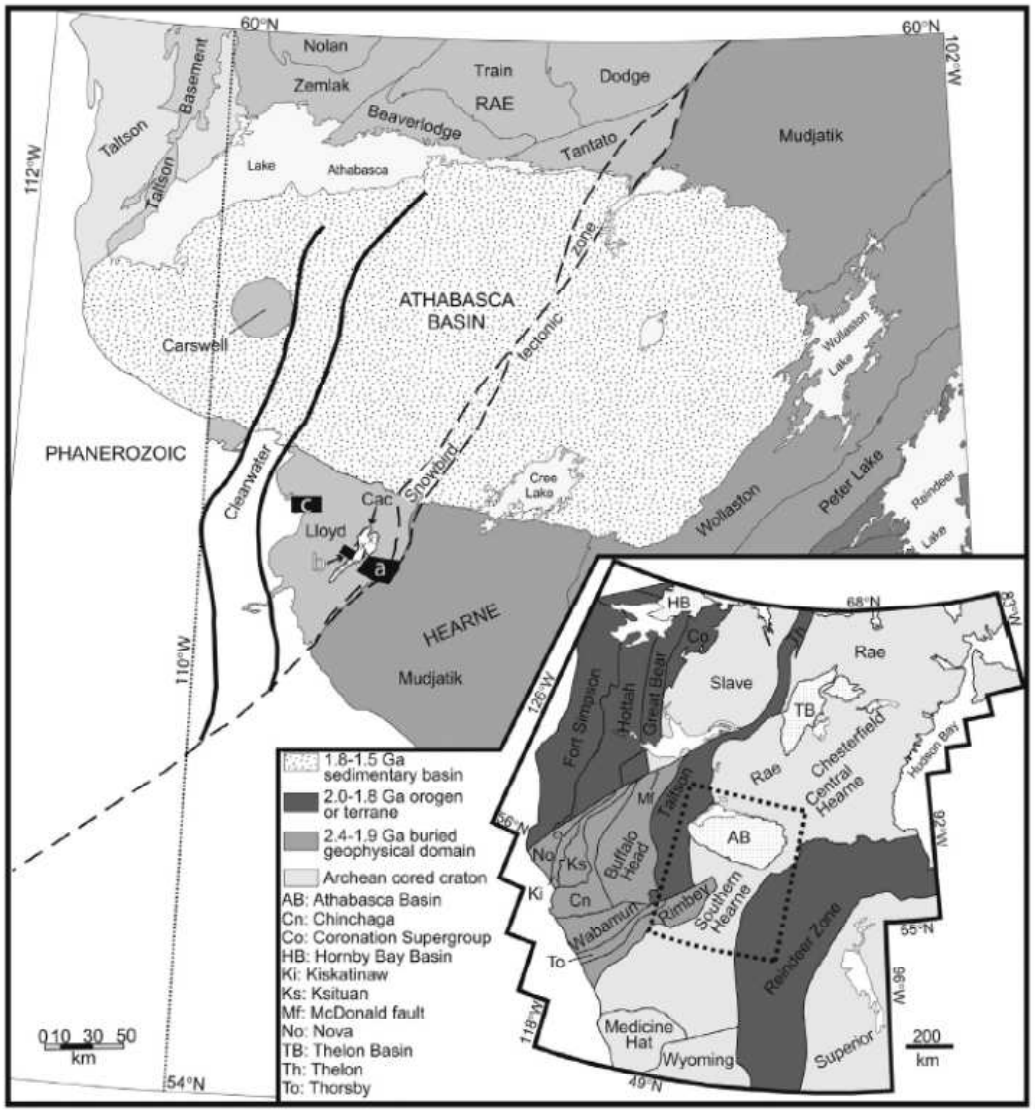
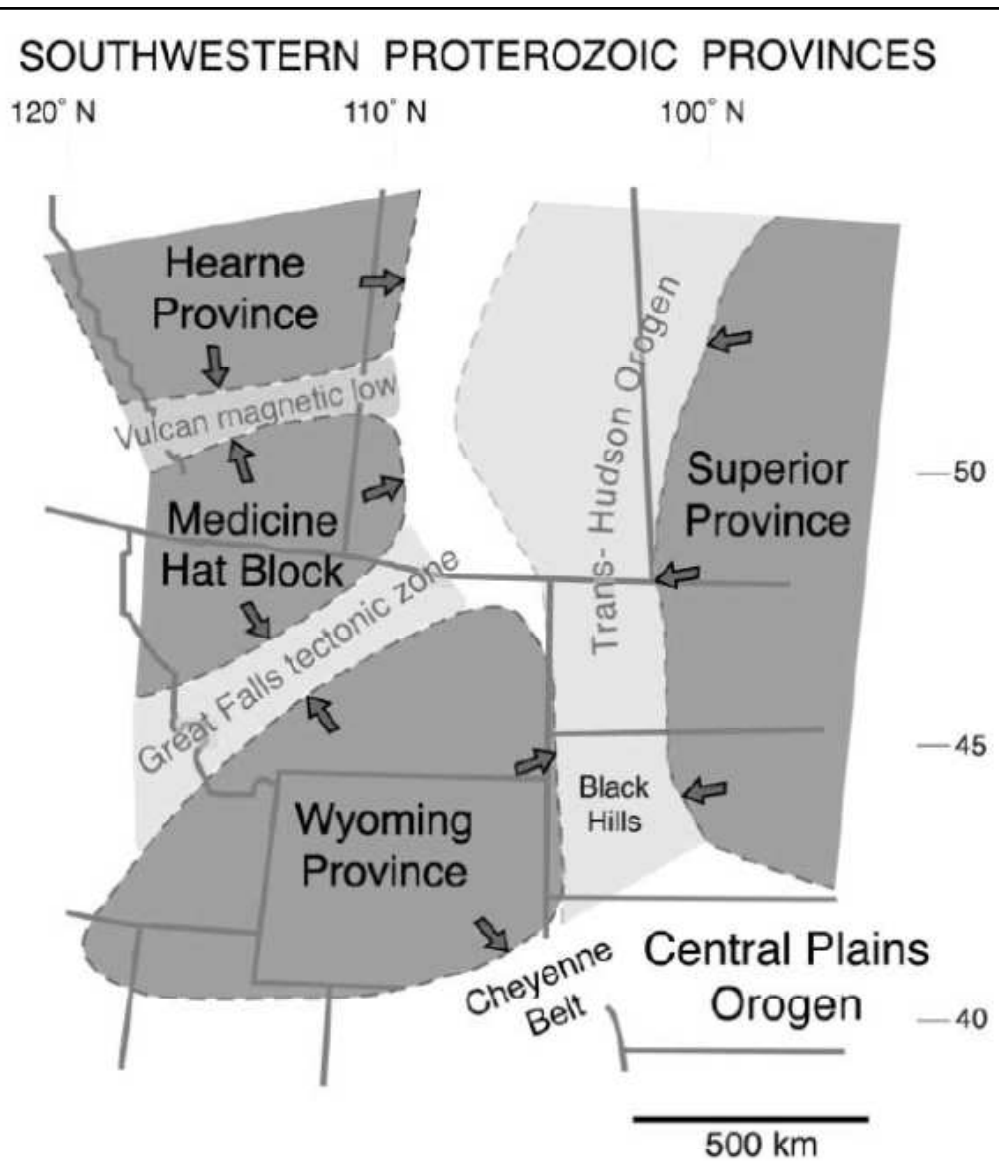


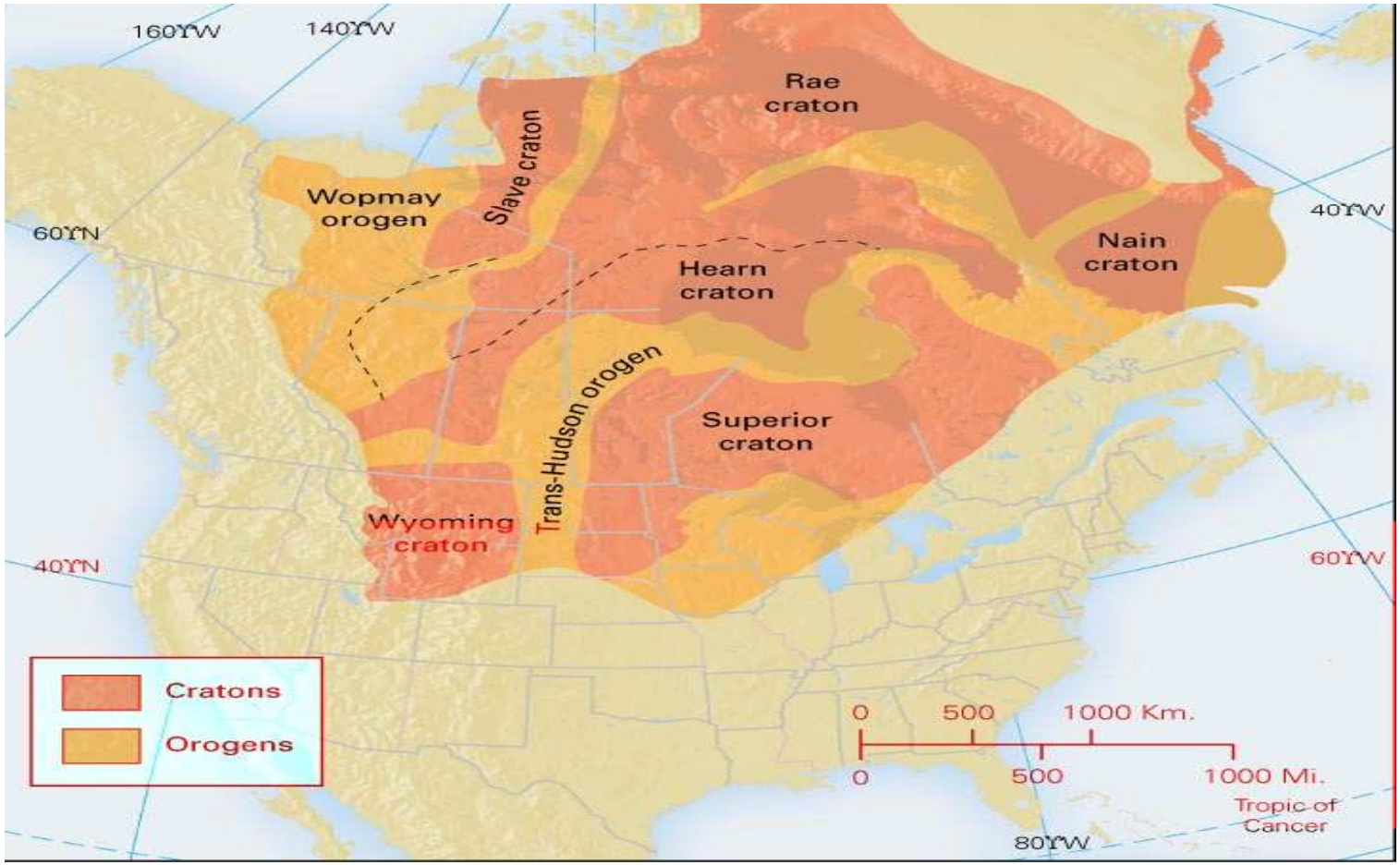
Fig. 1. Cratonic map of western Laurentia (after Hoffman, 1988; Ross et al., 1991). Precambrian lithostructural domains of northern Saskatchewan and northeastern Alberta
(dashed box, inset). Black polygons are regions mapped during this study: a = Careen Lake; b = Fournier Lake; c = Lloyd Lake. Hatched polygon in the Lloyd domain labelled
Cac indicates the extent of the Clearwater anorthosite complex.

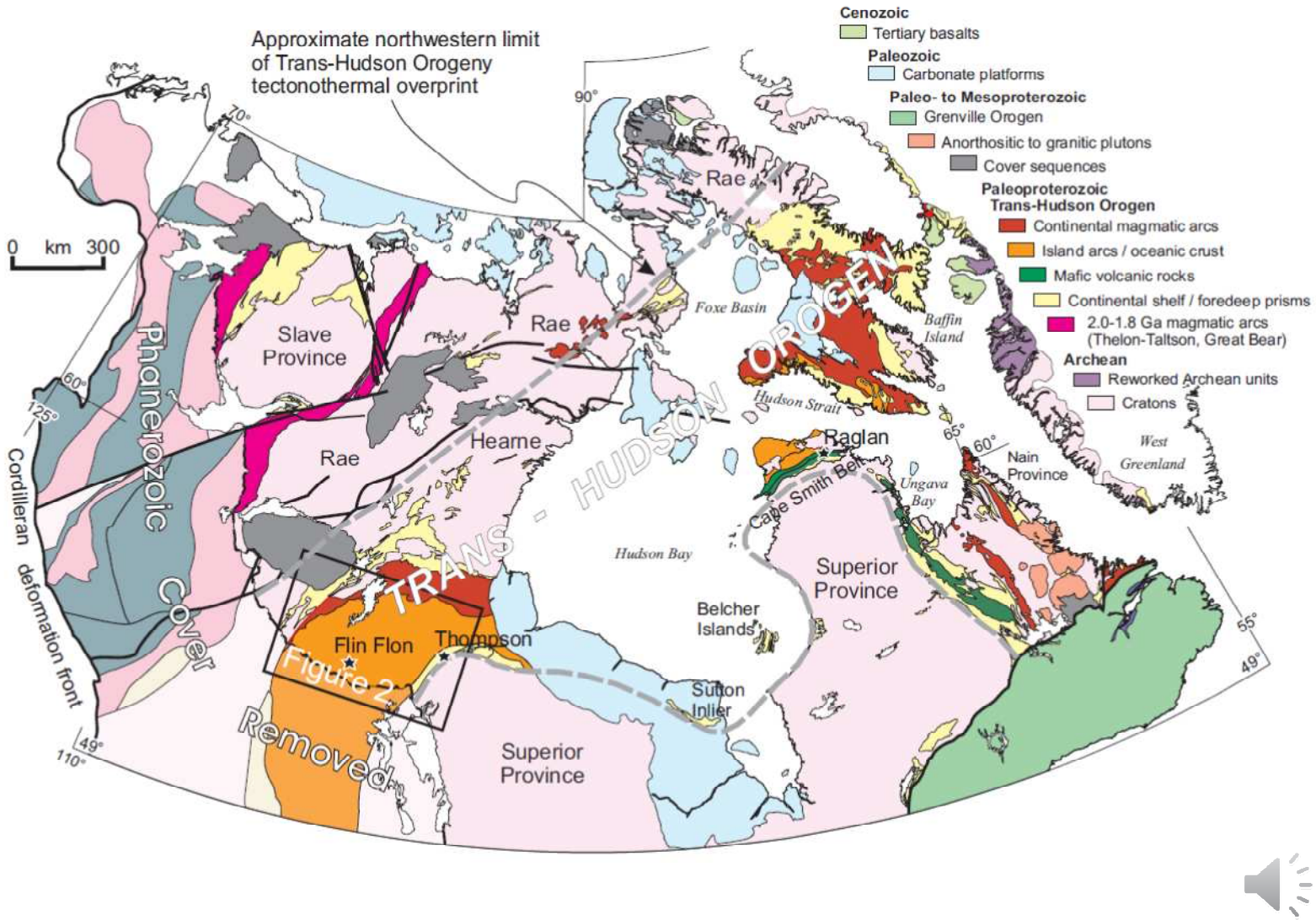
Trans-Hudson orogen

The Trans-Hudson Orogen (THO) of North America is one of the earliest orogens in Earth's history that evolved through a complete **Wilson Cycle**. **The trans-Hudson Orogen sensu stricto** represents ca. 150 Ma of opening of the **Manikewan Ocean**, from c. 2.07-1.92 Ga, before it started to close in the interval 1.92-1.80 Ga. The Manikewan Ocean (Stauffer 1984) is the oceanic plate that once existed between the **Superior** Craton and the **Hearne** Craton (Fig. 2a), stretching from South Dakota to the Ungava Peninsula in northern Que´bec. **Snowbird orogeny** at ca. 1.90 Ga. during which the Rae craton was thrust over the Hearne is regarded as trans- Hudson orogen sensu lato.

The Trans-Hudson orogen **sutured together the Hearne-Rae, Superior, and Wyoming cratons** to form the cratonic core of North America in a network of Paleoproterozoic orogenic belts. The orogenic belts include at least three large continental fragments or **micro-continents** identified in the Manikewan Ocean 'realm' and identified as the **Sask, Sugluk and Meta Incognita–Core** Zone blocks and several oceanic and pericratonic arc and back-ar complexes (Figure 2a). There are two interpretation of Wyoming craton 1) together with Hearne forming one continental block 2) involved in a separate, younger collisional event at ~1.77 Ga with Hearne


SOUTHWESTERN PROTEROZOIC PROVINCES
120° N
110° N
100° N
Hearne Province
Vulcan magnetic low
Medicine Hat Block
Great Falls tectonic zone
Trans- Hudson Orogen
Superior Province
Wyoming Province
Black Hills
Cheyenne Belt
Central Plains Orogen
50
45
40
500 km


160°W
140°W
60°N
40°N
40°W
60°W
80°W
Rae craton
Slave craton
Wopmay orogen
Hearn craton
Nain craton
Trans-Hudson orogen
Superior craton
Wyoming craton
Cratons
Orogens
0
500
1000 Km.
0
500
1000 Mi.
Tropic of Cancer


Approximate northwestern limit
of Trans-Hudson Orogeny
tectonothermal overprint
0 km 300
Cenozoic
Tertiary basalts
Paleozoic
Carbonate platforms
Paleo- to Mesoproterozoic
Grenville Orogen
Anorthositic to granitic plutons
Cover sequences
Paleoproterozoic
Trans-Hudson Orogen
Continental magmatic arcs
Island arcs / oceanic crust
Mafic volcanic rocks
Continental shelf / foredeep prisms
2.0-1.8 Ga magmatic arcs
(Thelon-Taltson, Great Bear)
Archean
Reworked Archean units
Cratons
Phanerozoic Cover
Cordilleran deformation front
Slave Province
Rae
Hearne
Rae
Rae
TRANS - HUDSON OROGEN
Foxe Basin
Baffin Island
Hudson Strait
Raglan
Cape Smith Belt
Nain Province
Ungava Bay
West Greenland
Hudson Bay
Superior Province
Belcher Islands
Sutton Inlier
Flin Flon
Thompson
Figure 2
Removed
Superior Province
90°
70°
60°
125°
110°
49°
65°
60°
55°
49°

Snowbird orogeny

Snowbird orogeny at ca. 1.90 Ga. The Rae craton was thrust over the Hearne at this time and that uplift continued during dextral – oblique, strike-slip displacement during the early parts of the Trans-Hudson orogeny

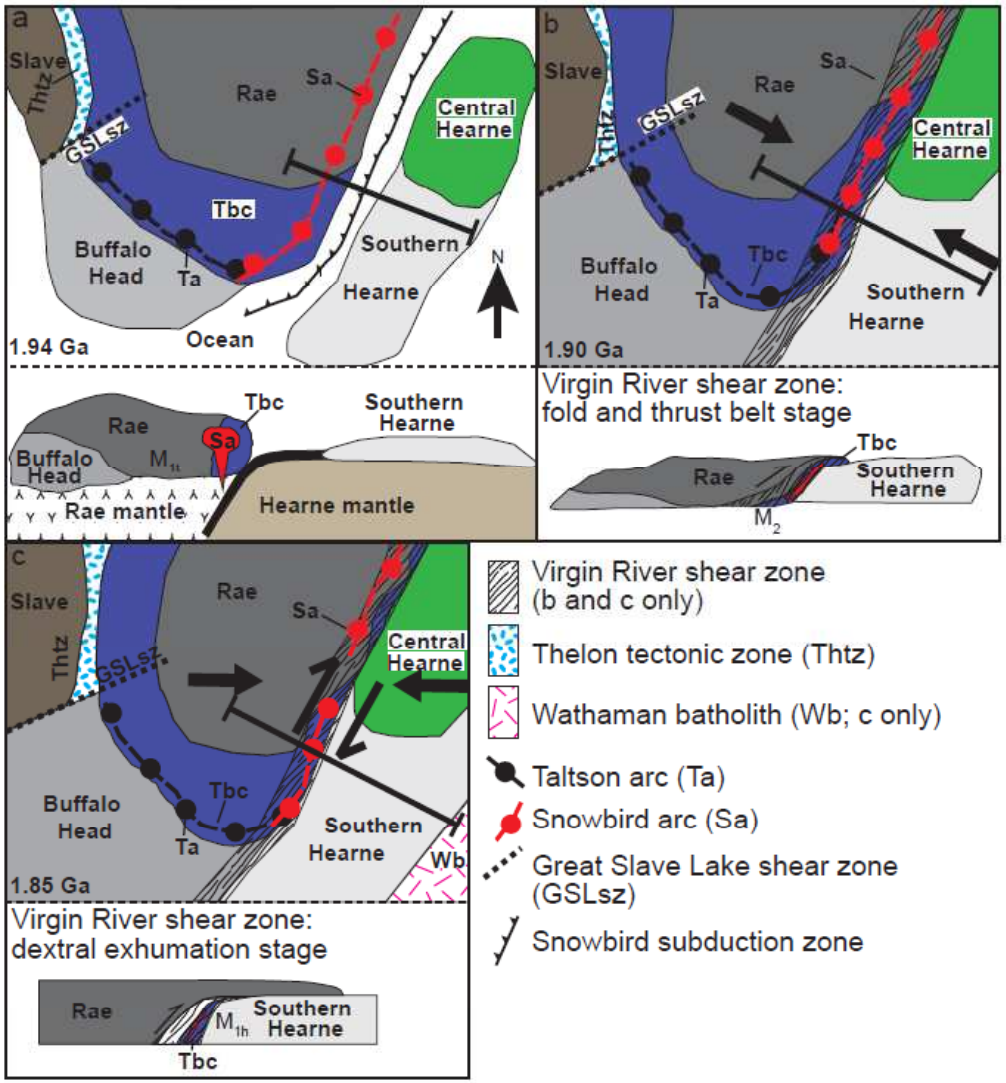
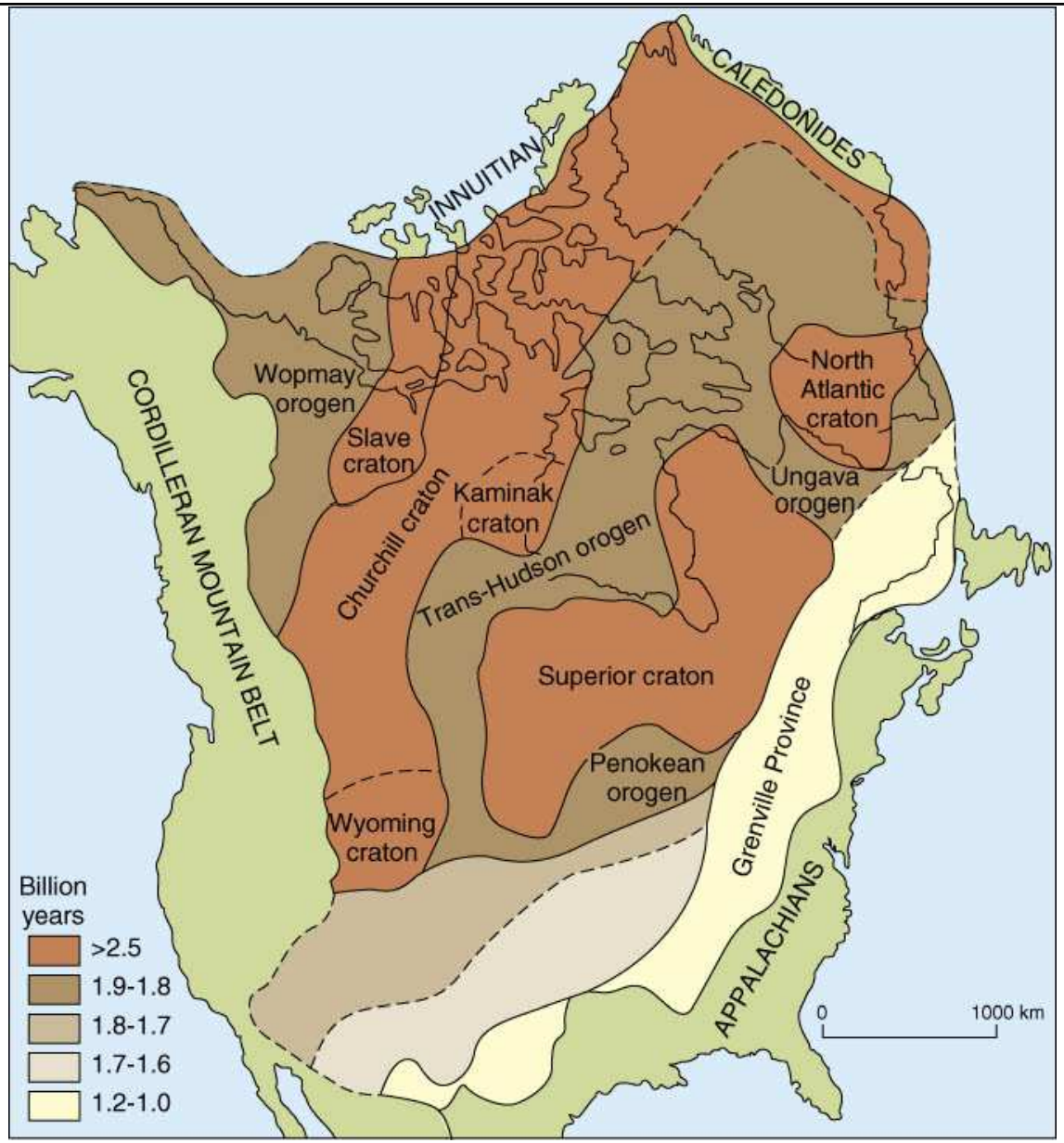
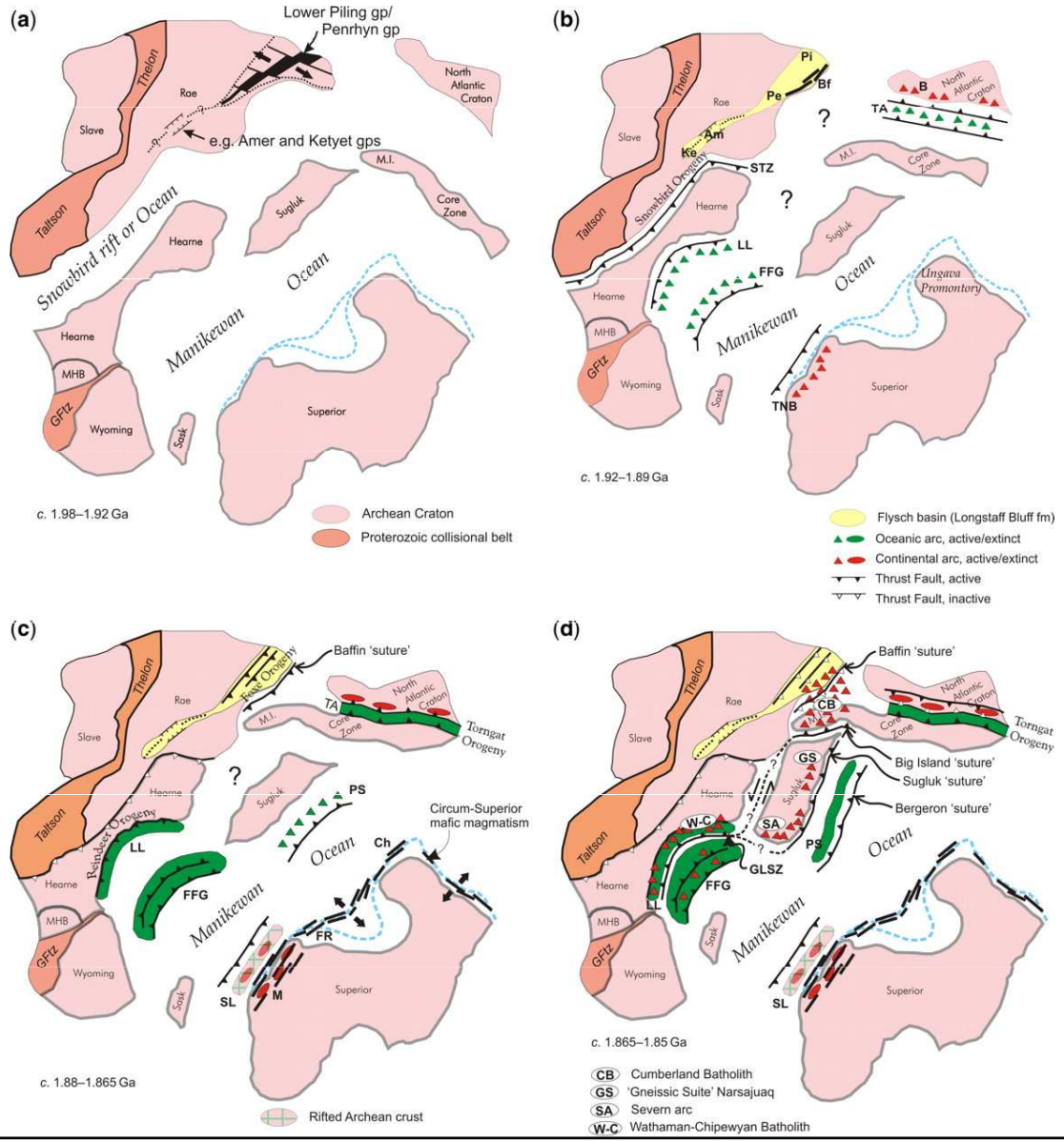


Figure 4.9. Cartoon depicting the evolution of the Virgin River shear zone at three different times. (a) The proposed position of the various cratonic blocks at ca. 1.94 Ga, the culmination of the of the Taltson orogeny (M1r). A new subduction zone is nucleating southeast of the Rae craton bringing the Hearne craton and causing emplacement of the Snowbird arc. The north arrow pertains to the present-day position of the various cratonic elements. A cross section of this scenario is below. (b) The compressional stage of the **Snowbird orogeny a**t ca. 1.90 Ga. The Taltson basement complex is folded around the core of the Rae craton after the Hearne craton docks. The cross section shows the fold and thrust belt of the Virgin River shear zone with slices of the Taltson basement complex and Rae craton thrust over the Hearne craton. (c) The Virgin River shear zone has converted to a dextral-oblique, strike-slip structure by 1.85 Ga but exhumation of the Rae block continues, loading the Hearne craton and leading to M3h metamorphism in the latter. The Taltson basement complex is dismembered along the Snowbird tectonic zone during this stage. See text for discussion. Original in colour.

Transhudson orogeny sensu stricto


CALEDONIDES
INNUITIAN
Wopmay orogen
Slave craton
Churchill craton
Kaminak craton
Trans-Hudson orogen
North Atlantic craton
Ungava orogen
Superior craton
Penokean orogen
Wyoming craton
CORDILLERAN MOUNTAIN BELT
Grenville Province
APPALACHIANS
Billion years
>2.5
1.9-1.8
1.8-1.7
1.7-1.6
1.2-1.0
0
1000 km


(a)
Lower Piling gp/
Penrhyn gp
Thelon
Rae
Slave
North Atlantic Craton
e.g. Amer and Ketyet gps
M.I.
Core Zone
Sugluk
Taltson
Snowbird rift or Ocean
Hearne
Manikewan
Ocean
Hearne
MHB
GFtz
Wyoming
Sask
Superior
c. 1.98–1.92 Ga
Archean Craton
Proterozoic collisional belt
(b)
Pi
Pe
Bf
B
North Atlantic Craton
TA
?
Am
Ke
STZ
Snowbird Orogeny
M.I.
Core Zone
Hearne
?
Sugluk
LL
FFG
Ocean
Ungava Promontory
Manikewan
MHB
GFtz
Wyoming
Sask
TNB
Superior
c. 1.92–1.89 Ga
Flysch basin (Longstaff Bluff fm)
Oceanic arc, active/extinct
Continental arc, active/extinct
Thrust Fault, active
Thrust Fault, inactive
(c)
Baffin 'suture'
Foxe Orogeny
Thelon
Rae
Slave
TA
North Atlantic Craton
M.I.
Core Zone
Torngat Orogeny
?
Hearne
Sugluk
PS
Circum-Superior mafic magmatism
Taltson
Reindeer Orogeny
LL
Ocean
Ch
Hearne
FFG
Manikewan
MHB
FR
GFtz
Wyoming
SL
M
Sask
Superior
c. 1.88–1.865 Ga
Rifted Archean crust
(d)
Baffin 'suture'
Thelon
Rae
Slave
CB
North Atlantic Craton
M.I.
Core Zone
Torngat Orogeny
GS
Big Island 'suture'
Sugluk 'suture'
Hearne
Sugluk
Bergeron 'suture'
W-C
SA
Taltson
PS
Ocean
GLSZ
Hearne
FFG
LL
MHB
Sask
Manikewan
GFtz
Wyoming
SL
Superior
c. 1.865–1.85 Ga
CB Cumberland Batholith
GS 'Gneissic Suite' Narsajuaq
SA Severn arc
W-C Wathaman-Chipewyan Batholith

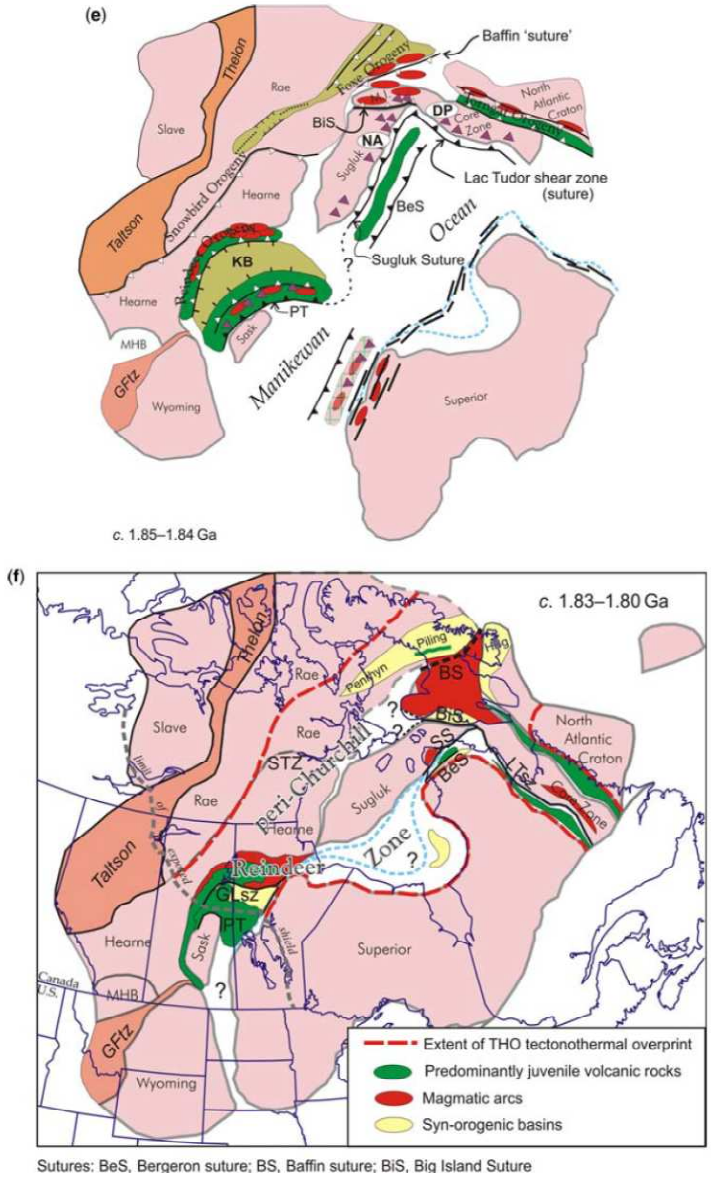
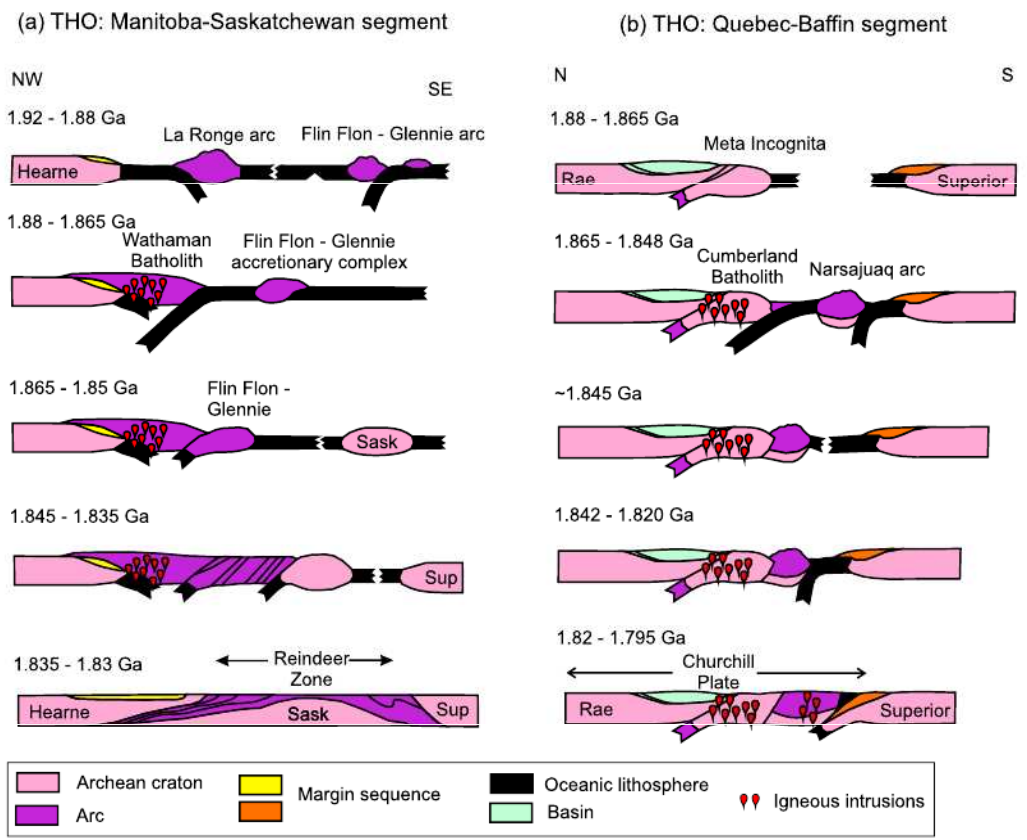


Fig. 2. Series of cartoons illustrating a map view of the geological evolution of the THO, with the main tectonic elements shown: (a) main lithotectonic elements during the interval 1.98–1.92 Ga, prior to the onset of convergence; (b) the interval 1.92–1.89 Ga; (c) the interval 1.88–1.865 Ga; (d) the interval 1.865–1.85 Ga; (e) the interval 1.85–1.83 Ga; and (f) the interval 1.83–1.80 Ga. The blue coloured hashed lines represent possible extensions of the Superior Craton at Moho. Although not discussed in text, evolution of North Atlantic Craton (shown here to include Archaean basement rocks and their cover on Hall and Cumberland peninsulas on Baffin Island (e.g. Scott 1999; Jackson & Berman 2000) and tectonostratigraphic elements of the New Quebec and Torngat orogens are after Wardle et al. (2002). Abbreviations: Am, Amer group; B, Burwell arc; BeS, Bergeron suture; BS, Baffin suture; BiS, Big Island suture; Bf, Bravo formation; Ch, Chukotat; FFG, Flin Flon–Glennie Complex; FR, Fox River belt; GFtz, Great Falls tectonic zone; GLsz, Granville Lake structural zone; Hoare Bay group; KB, Kisseynew Basin; Ke, Ketyet group; LL, La Ronge–Lynn Lake belts; LTSz, Lac Tudor shear zone; M, Molson dykes; MHB, Medicine Hat block; M.I., Meta Incognita micro-continent; Pe, Penrhyn group; Pi, Piling group; PS, Parent arc and Spartan forearc; PT, Pelican thrust; SL, Snow Lake belt; SS, Sugluk suture; STZ, Snowbird Tectonic Zone; TA, Tasiuyak domain; TNB, Thompson Nickel Belt


(a) THO: Manitoba-Saskatchewan segment
NW
SE
1.92 - 1.88 Ga
La Ronge arc
Flin Flon - Glennie arc
Hearne
1.88 - 1.865 Ga
Wathaman Batholith
Flin Flon - Glennie accretionary complex
1.865 - 1.85 Ga
Flin Flon - Glennie
Sask
1.845 - 1.835 Ga
Sup
1.835 - 1.83 Ga
Reindeer Zone
Hearne
Sask
Sup
(b) THO: Quebec-Baffin segment
N
S
1.88 - 1.865 Ga
Meta Incognita
Rae
Superior
1.865 - 1.848 Ga
Cumberland Batholith
Narsajuaq arc
~1.845 Ga
1.842 - 1.820 Ga
1.82 - 1.795 Ga
Churchill Plate
Rae
Superior
Archean craton
Arc
Margin sequence
Oceanic lithosphere
Basin
Igneous intrusions

Columbia

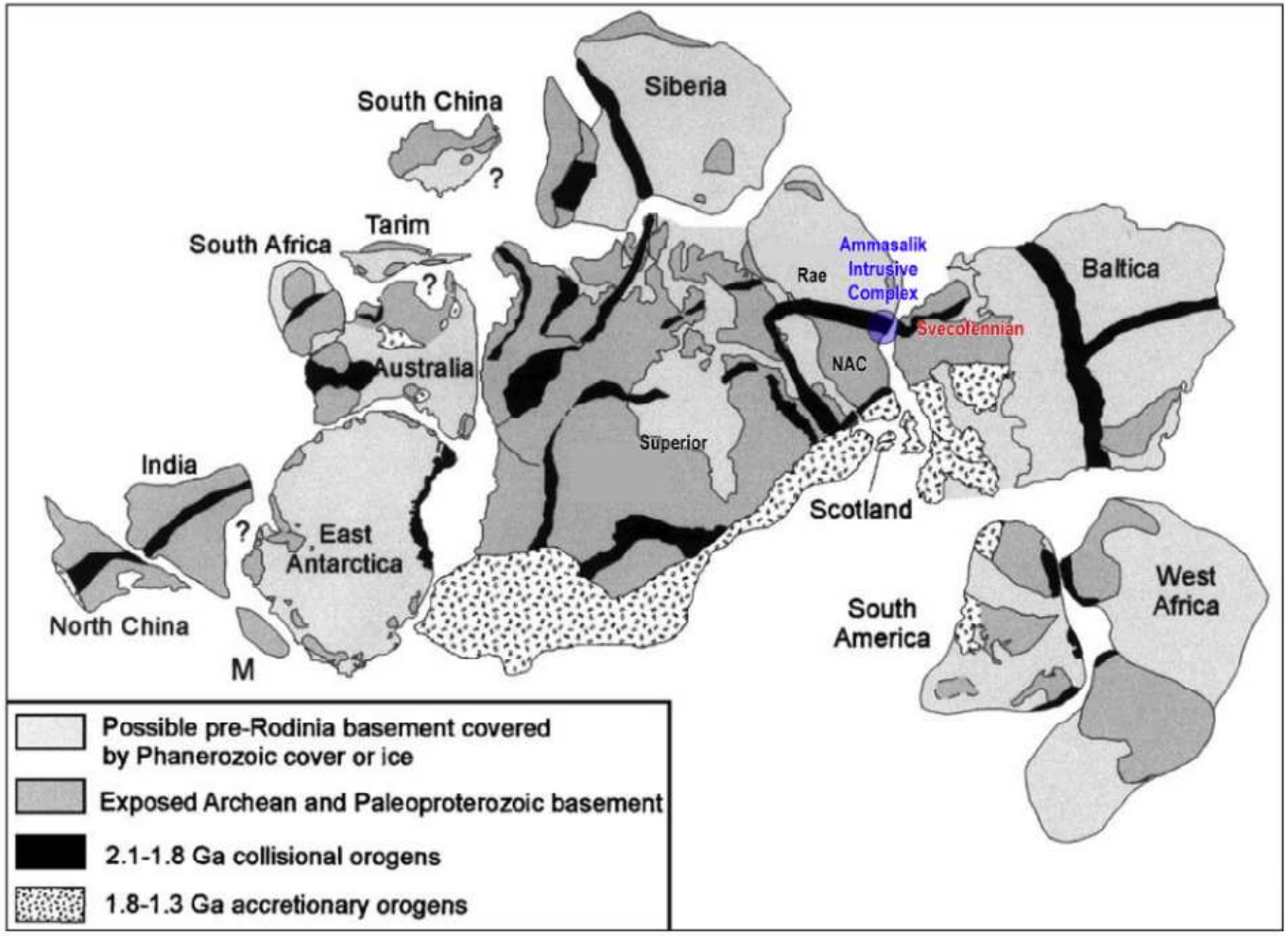
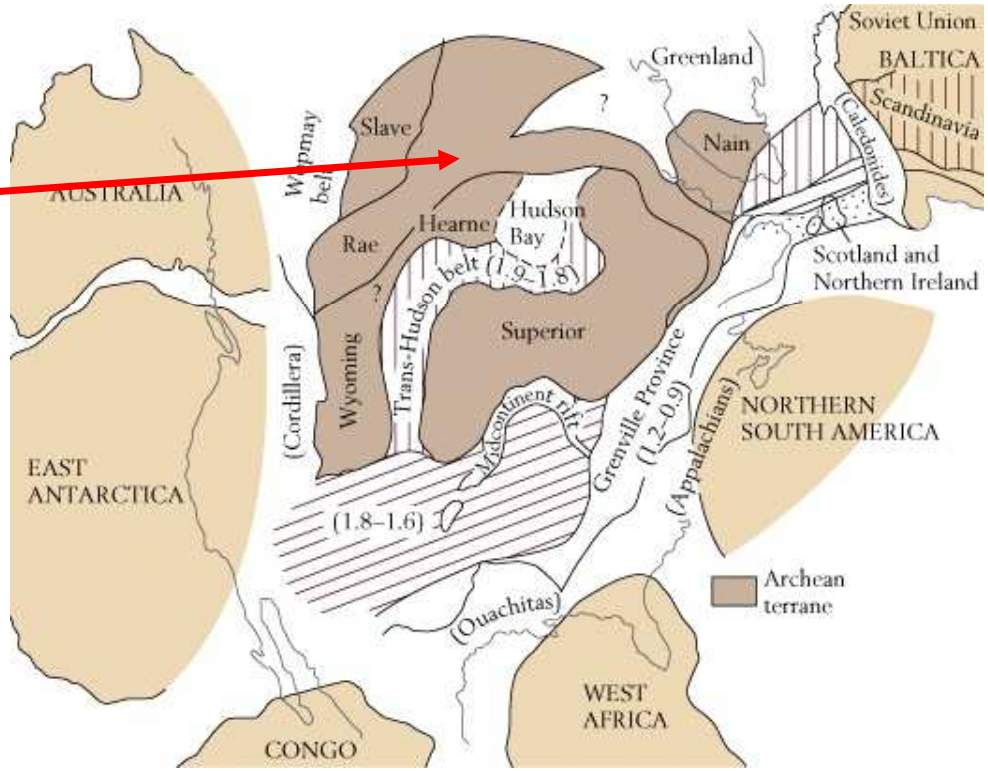


Fig. 16. Reconstruction of the Columbia supercontinent showing the paleo-continuity between the Svecofennian Province and the Tasiilaq region of south-east Greenland. Modified from Zhao et al. (2004).

Continental Accretion

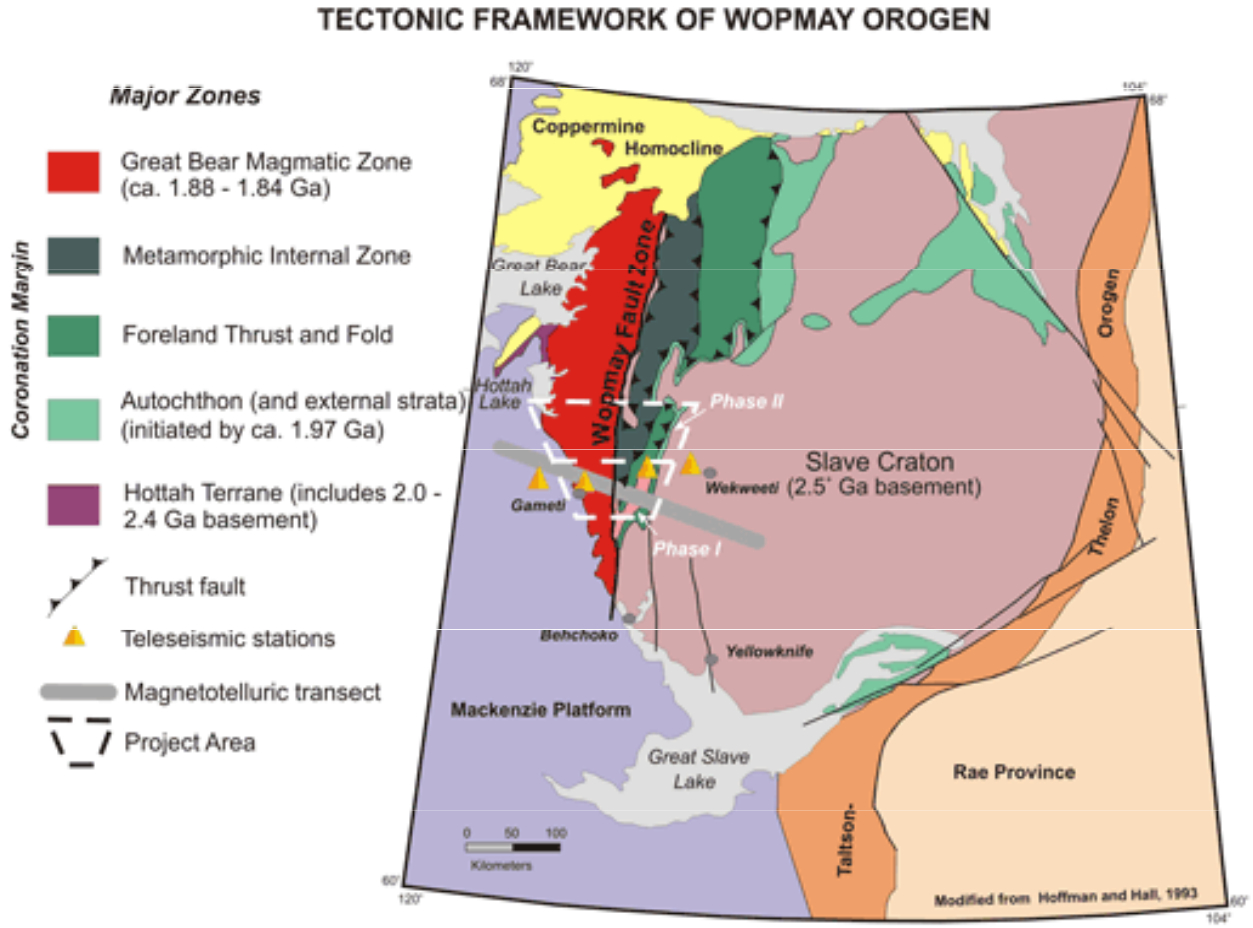
- During Proterozoic, Laurentia was growing by accretion

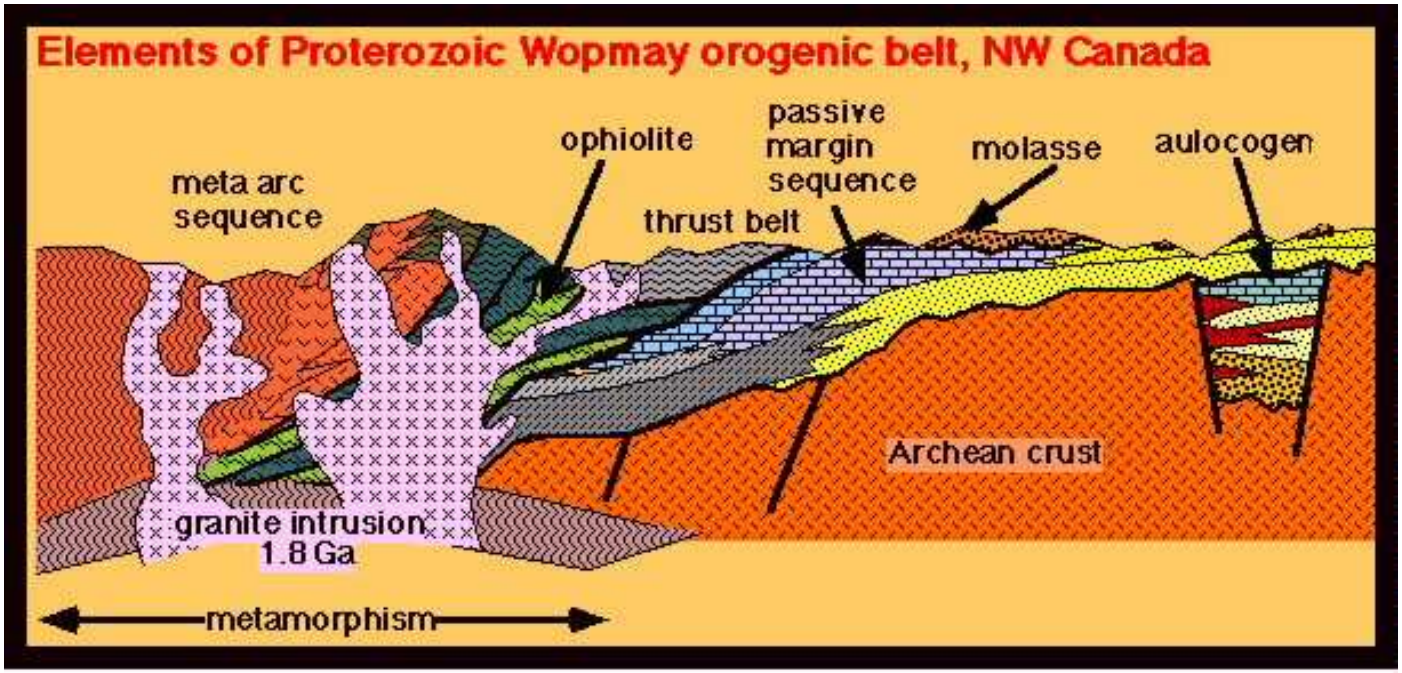
Tranhudson orogeny:
1.95-1.85 bya
Suturing of ~six microcontinents



Woopmay orogeny

The Wopmay orogen is a Paleoproterozoic orogenic belt formed by the obduction of **Hottah terrane**, an arc-bearing microcontinent, onto the western margin of the Archean Slave craton at about 1.88 Ga.





The Wopmay orogen can be subdivided into (east to west): **a passive continental margin, the Wopmay fault zone, the Great Bear magmatic zone, and the Hottah terrane**. The passive margin developed around 1970–1890 Ma on-top of the Slave Craton. The Wopmay fault zone is probably a suture between the Slave craton and the Hottah terrane.

Slave craton

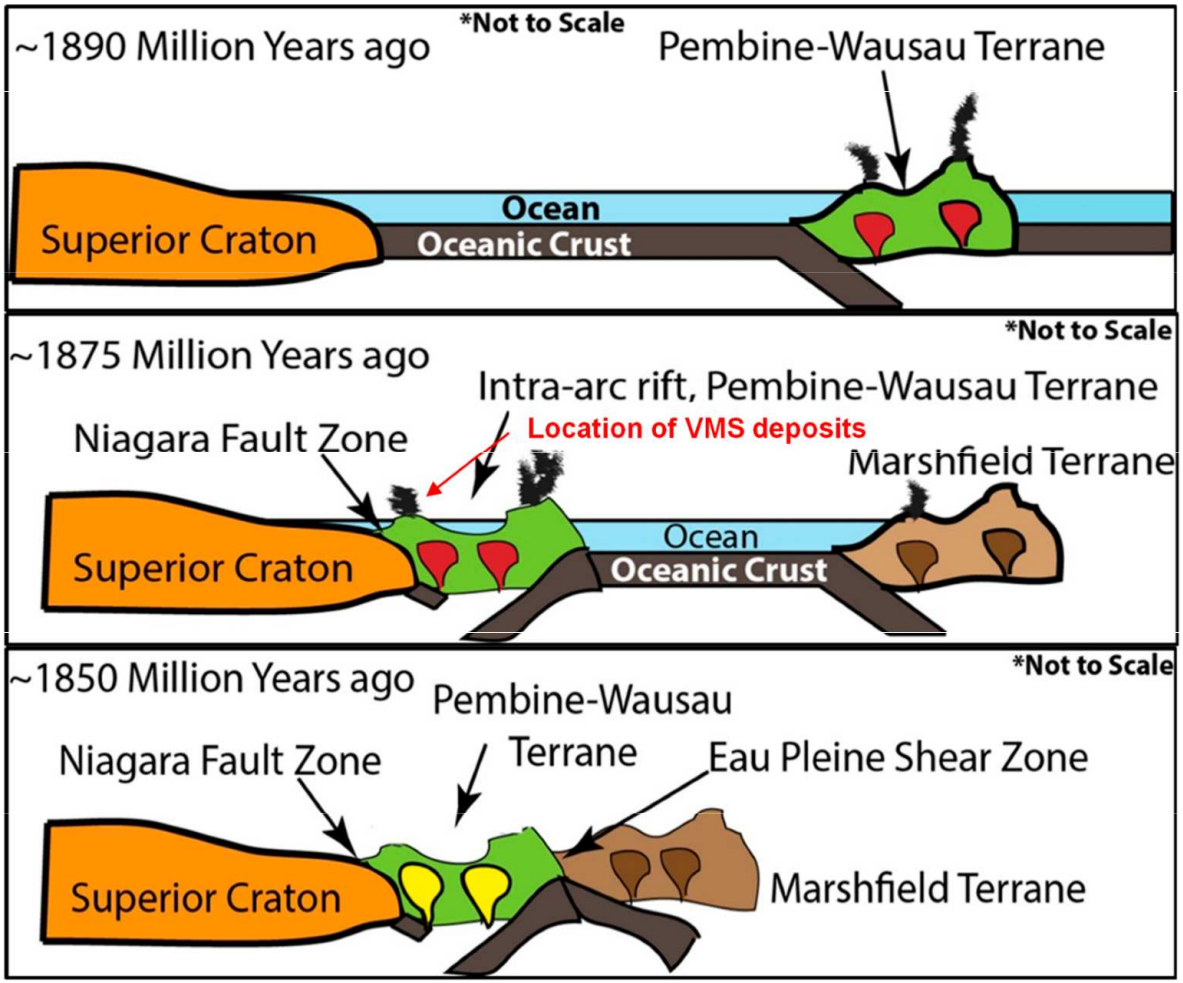
Penokean orogeny

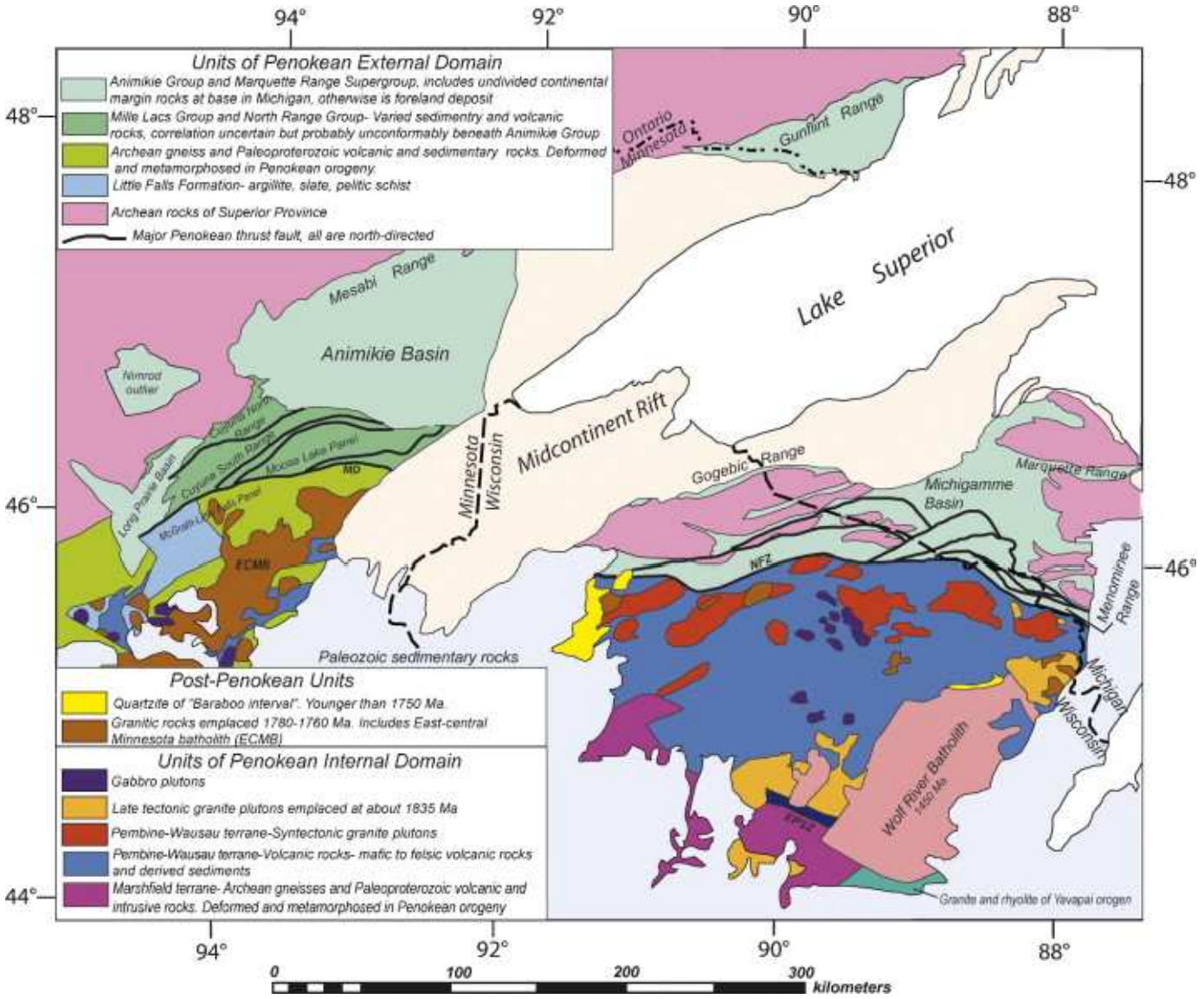
The Penokean orogeny began at about 1880 Ma when an **oceanic arc**, now the **Pembine–Wausau terrane**, collided with the southern margin of the Archean Superior craton marking the end of a period of south-directed subduction. The docking of the buoyant craton to the arc resulted in a **subduction jump to the south and development of back-arc extension** both in the initial arc and adjacent craton margin to the north. The newly established subduction zone caused continued arc volcanism until about **1850 Ma** when a **fragment of Archean crust**, now the basement of the **Marshfield terrane**, arrived at the subduction zone. The convergence of Archean blocks of the Superior and Marshfield cratons resulted in the major contractional phase of the Penokean orogeny.

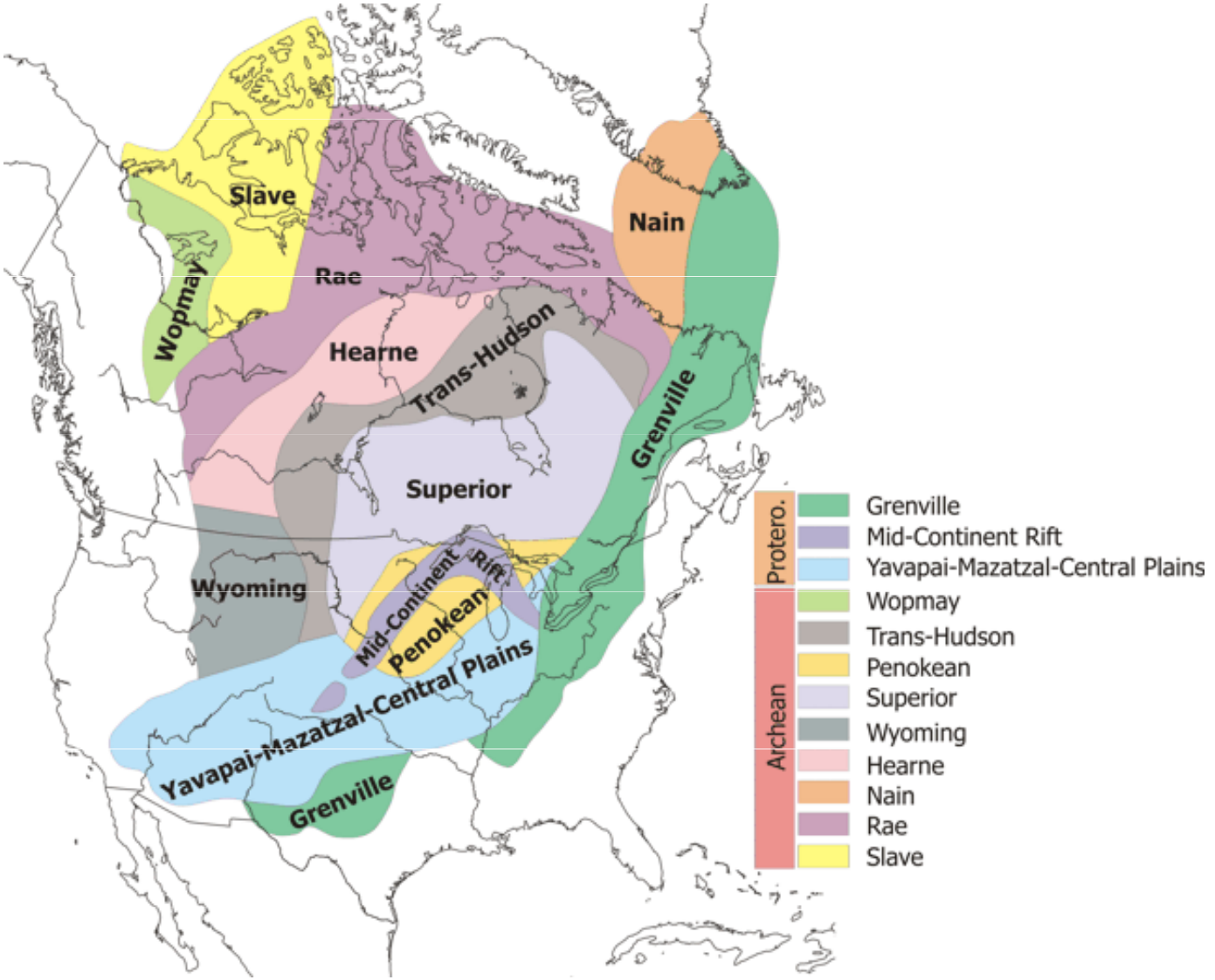
Evidence of the Penokean orogen is now largely confined to the **Lake Superior region**. Comparisons with more recent orogens formed by similar plate tectonic processes implies that significant parts of a once more extensive Penokean orogen have been removed or overprinted by younger tectonic events.

Penokeam orogeny

The Penokean orogeny was a mountain-building episode that occurred in the early Proterozoic about 1.86 to 1.83 billion years ago, in the area of Lake Superior, North America




94°
92°
90°
88°
48°
46°
44°
Units of Penokean External Domain
Animikie Group and Marquette Range Supergroup, includes undivided continental margin rocks at base in Michigan, otherwise is foreland deposit
Mille Lacs Group and North Range Group- Varied sedimentry and volcanic rocks, correlation uncertain but probably unconformably beneath Animikie Group
Archean gneiss and Paleoproterozoic volcanic and sedimentary rocks. Deformed and metamorphosed in Penokean orogeny.
Little Falls Formation- argillite, slate, pelitic schist
Archean rocks of Superior Province
Major Penokean thrust fault, all are north-directed
Ontario
Minnesota
Gunflint Range
Mesabi Range
Animikie Basin
Nimrod outlier
Lake Superior
Midcontinent Rift
Minnesota
Wisconsin
Gogebic Range
Marquette Range
Michigamme Basin
Menominee Range
Michigan
Wisconsin
NFZ
Paleozoic sedimentary rocks
Post-Penokean Units
Quartzite of "Baraboo interval". Younger than 1750 Ma.
Granitic rocks emplaced 1780-1760 Ma. Includes East-central Minnesota batholith (ECMB)
Units of Penokean Internal Domain
Gabbro plutons
Late tectonic granite plutons emplaced at about 1835 Ma
Pembine-Wausau terrane-Syntectonic granite plutons
Pembine-Wausau terrane-Volcanic rocks- mafic to felsic volcanic rocks and derived sediments
Marshfield terrane- Archean gneisses and Paleoproterozoic volcanic and intrusive rocks. Deformed and metamorphosed in Penokean orogeny
Wolf River Batholith
1460 Ma
Granite and rhyolite of Yavapai orogen
0
100
200
300
kilometers


Slave
Wopmay
Rae
Hearne
Trans-Hudson
Nain
Grenville
Superior
Wyoming
Mid-Continent Rift
Penokean
Yavapai-Mazatzal-Central Plains
Grenville
Protero.
Archean
Grenville
Mid-Continent Rift
Yavapai-Mazatzal-Central Plains
Wopmay
Trans-Hudson
Penokean
Superior
Wyoming
Hearne
Nain
Rae
Slave

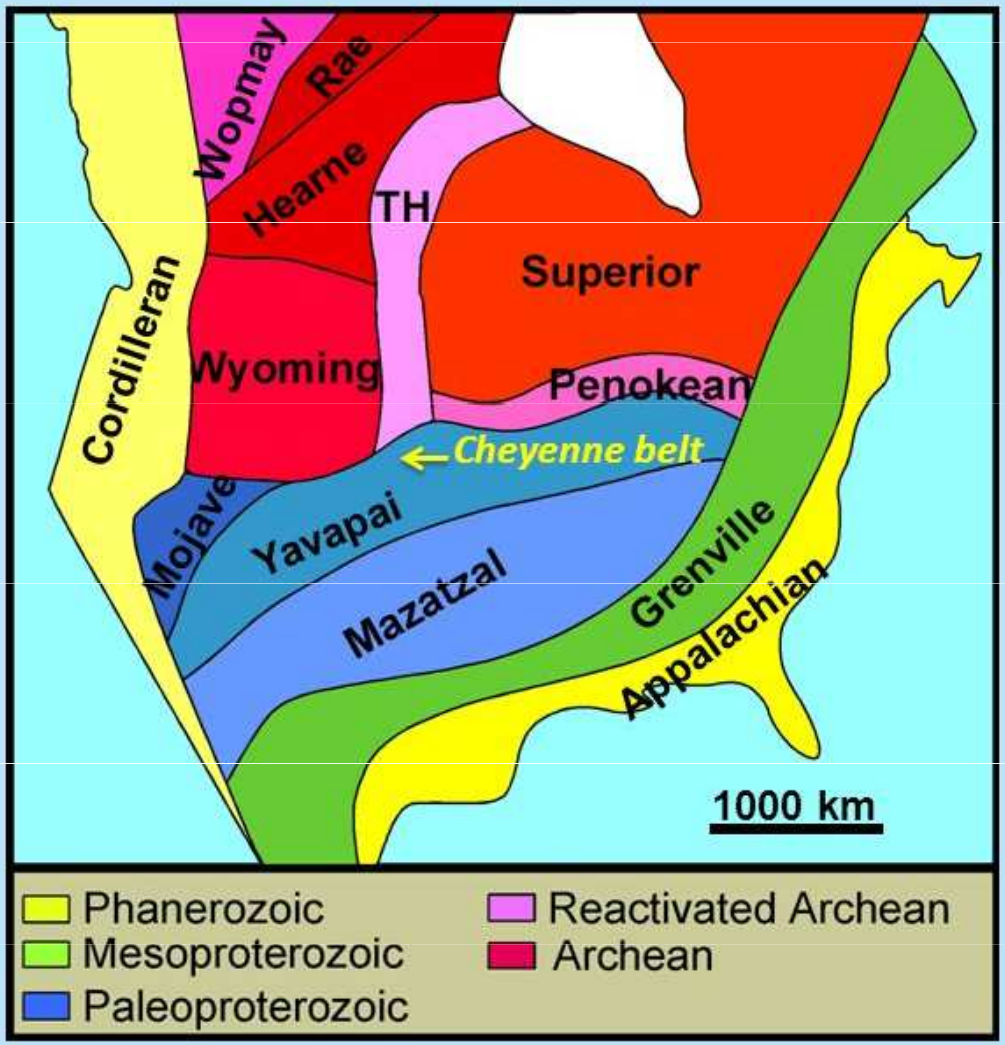
Accretionary tectonics

Accretionary provinces are composed of numerous 10 to 100 km scale terranes or blocks, separated by shear zones, some of which had compound histories as terrane sutures and later crustal assembly structures. Some accreted terranes contain older continental crustal material [Archean(?) Mojavia]. Major northeast-trending accretionary provinces are the Yavapai province (1.80– 1.70 Ga), welded to North America during the 1.71–1.68 Ga **Yavapai orogeny**; the Mazatzal province (1.70–1.65 Ga), added during the 1.65–1.60 Ga **Mazatzal orogeny**.

The **Yavapai orogeny** was an orogenic event in what is now the Southwestern United States from 1710 to 1680 Mya[1] in the Statherian Period of the Paleoproterozoic. Preserved in the rocks of New Mexico and Arizona, it is interpreted as the collision of the 1800-1700 Mya age[1] **Yavapai island arc terrane** with the proto-North American continent.

The **Mazatzal orogeny** was an orogenic event in what is now the Southwestern United States from 1650 to 1600 Mya[1] in the Statherian Period of the Paleoproterozoic. Preserved in the rocks of New Mexico and Arizona, it is interpreted as the collision of the 1700-1600 Mya age[1] **Mazatzal island arc terrane** with the proto-North American continent.

Crustal Provinces and Orogens



Granite-Rhyolite Province

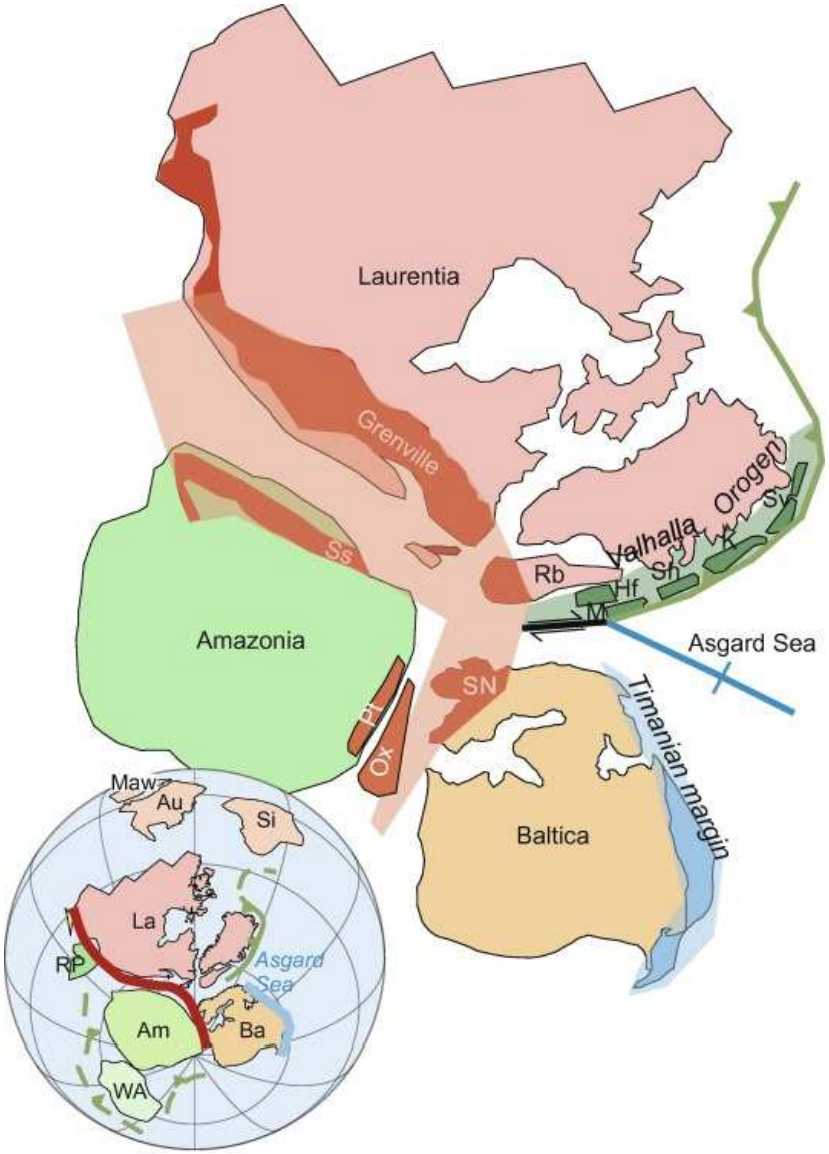
Accretion continued in southwest Laurentia with the docking of 1550–1400 Ma juvenile crust Subduction was accompanied by continental `extension' or `rifting, and widespread 1480–1350 Ma **A-type magmatism** that defines the Granite-Rhyolite Province in southeastern Laurentia (Van Schmus et al., 1996; Whitmeyer and Karlstrom, 2007; Bickford et al., 2015) and also extends into the inboard Paleoproterozoic basement terranes of southwest Laurentia


Laurentia
Yavapai province
Mazatzal province
Granite-Rhyolite province
1.78-1.72 Ga crust

Grenville Orogeny

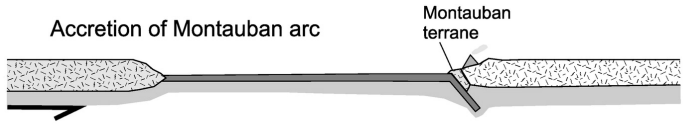
Late Mesoproterozoic Grenville Orogeny **records convergence, arc accretion, and continent continent collision between ca. 1350 and 1000 Ma.** Within the Grenville Province of south-eastern Canada, which is the most thoroughly studied portion of this composite orogen, this period of orogenesis included (1) **an early accretionary stage** at 1.3–1.2 Ga, (2) an **interval of widespread magmatism** at 1.18–1.08 Ga, (3) and a **period of continent–continent collision** at 1.08–0.98 Ga that was rapidly followed by uplift and exhumation of the orogenic core.

The Grenville orogeny was a long-lived Mesoproterozoic mountain-building event **associated with the assembly of the supercontinent Rodinia**. Its record is a prominent orogenic belt which spans a significant portion of the North American continent, from Labrador to Mexico, as well as to Scotland. It is assumed that two separate continental blocks **collided with Laurentia - Baltica and Amazoni**

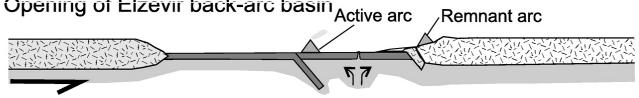

Laurentia
Grenville
SS
Amazonia
Rb
Valhalla
Oroge
Sh
Hf
M
Asgard Sea
SN
Pi
Ox
Timanian margin
Baltica
Maw
Au
Si
La
RP
Asgard Sea
Am
Ba
WA

Ca. 1450 Ma Formation of continental-margin arc on SE Laurentia

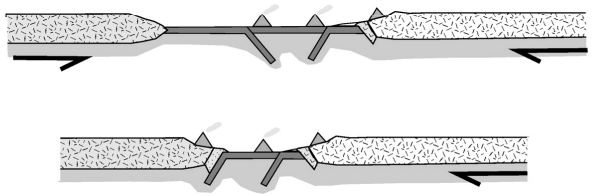
Ca. 1370 Ma Accretion of Montauban arc



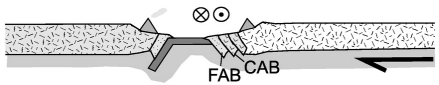
Ca. 1310 Ma Opening of Elzevir back-arc basin



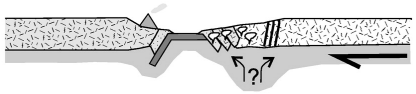
Ca. 1250–1220 Ma Closure of Elzevir marginal basin, initiation of SE-directed subduction



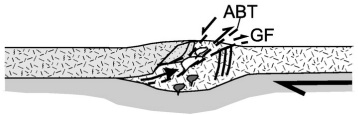
Ca. 1220–1180 Ma Accretion of Elzevir and Frontenac terranes (remnants of back-arc basins)



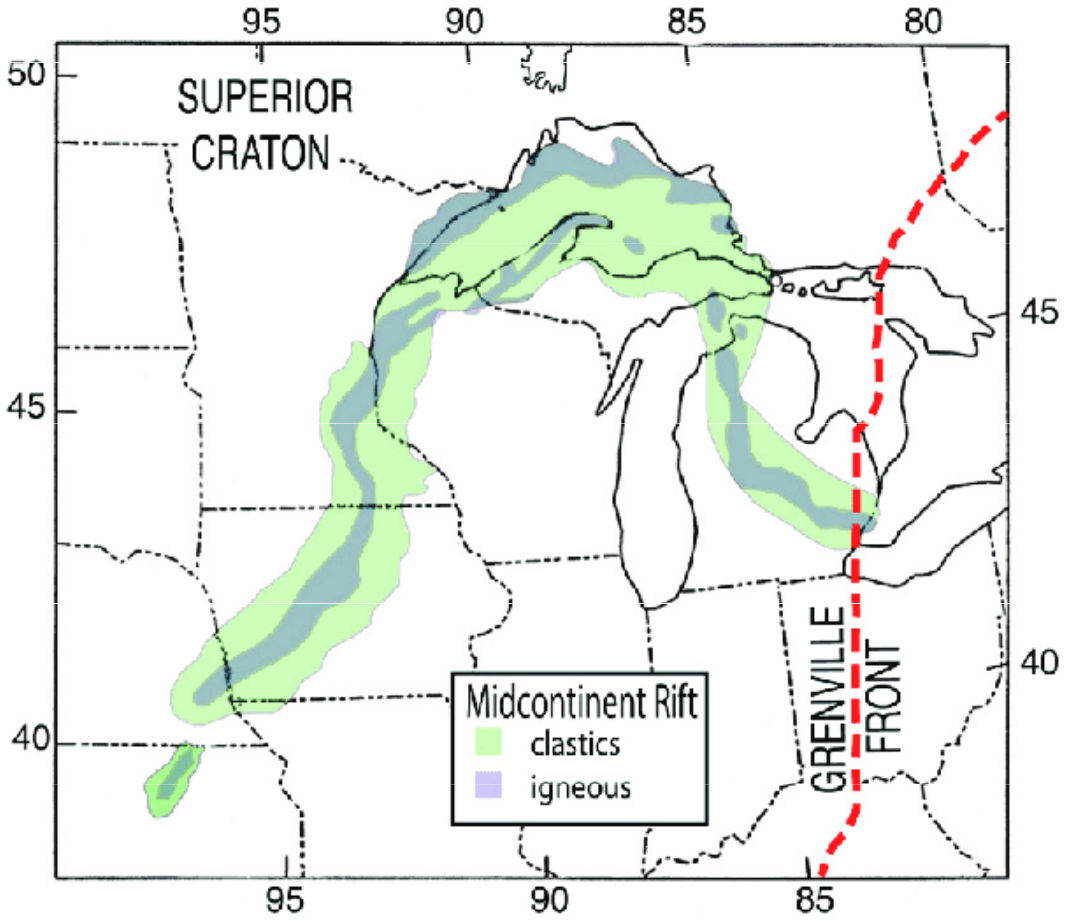
Ca. 1180–1120 Ma Widespread crustal- and mantle-derived magmatism on Laurentian margin, limited extension



Ca. 1090–980 Grenvillian Orogeny: formation of ABT at ca. 1090 Ma, ABT reworked in extension at ca. 1020 Ma, formation of GF at ca. 1000 Ma



Midcontinent rift



The rift system may have been the result of extensional forces behind the continental collision of the Grenville Orogeny to the east which in part overlaps the timing of the rift development. Another model suggests the role of mantle plume. Later compressive forces from the Grenville Orogeny likely played a major role in the rift's failure and closure.