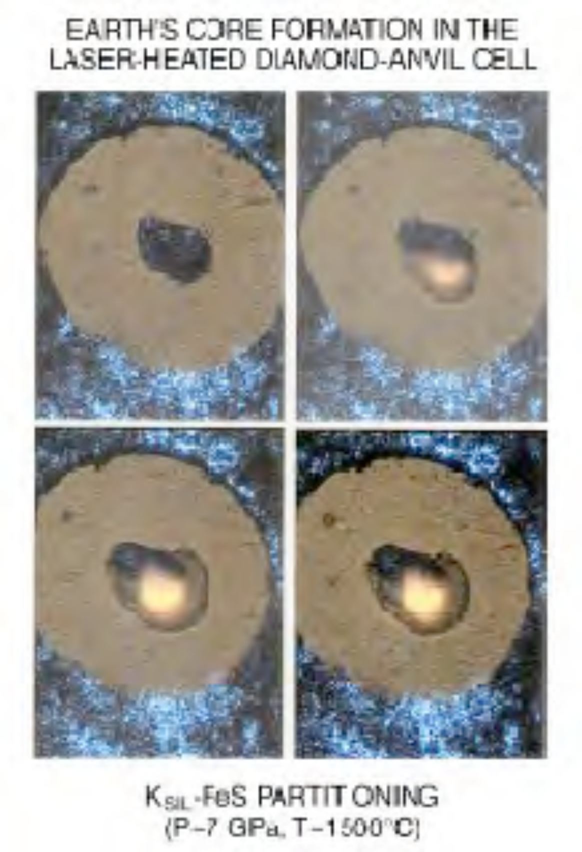
A Selective Geological History of North America

Hadean: 4500-3800 MY



http://www.earth.ox.ac.uk/research/groups/ultra_high_pressure/research/high-pressure_mineralogy

Late Bombardment: could life survive?

Mesophiles 20-50°C

Thermophiles 50-80°C

Hyperthermophiles 80-110°C

Microbial habitability of the Hadean Earth during the late heavy bombardment Oleg Abramov & Stephen J. Mojzsis*Nature* **459**, 419-422(21 May 2009)doi:10.1038/nature08015

http://www.nature.com/nature/journal/v459/n7245/extref/nature08015-s3.mov

Thermal evolution of the Earth's lithosphere during the Late Heavy Bombardment in our baseline scenario. Only impactors larger than 10 km in diameter are included in this animation. The upper surface shows temperatures at a depth of 4 km. Dark areas denote crater imprints.

Late Bombardment: could life survive?

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http://www.nature.com/nature/journal/v459/n7245/extref/nature08015-s4.mov

Thermal evolution of the Earth's lithosphere during the Late Heavy Bombardment in the extreme scenario: surface temperature of 50−C, geothermal gradient of 48−C km^{-1}, and 100X mass delivered. Only impactors larger than 10 km in diameter are included. The upper surface shows temperatures at a depth of 4 km.

Archean: 3800-2500 MY

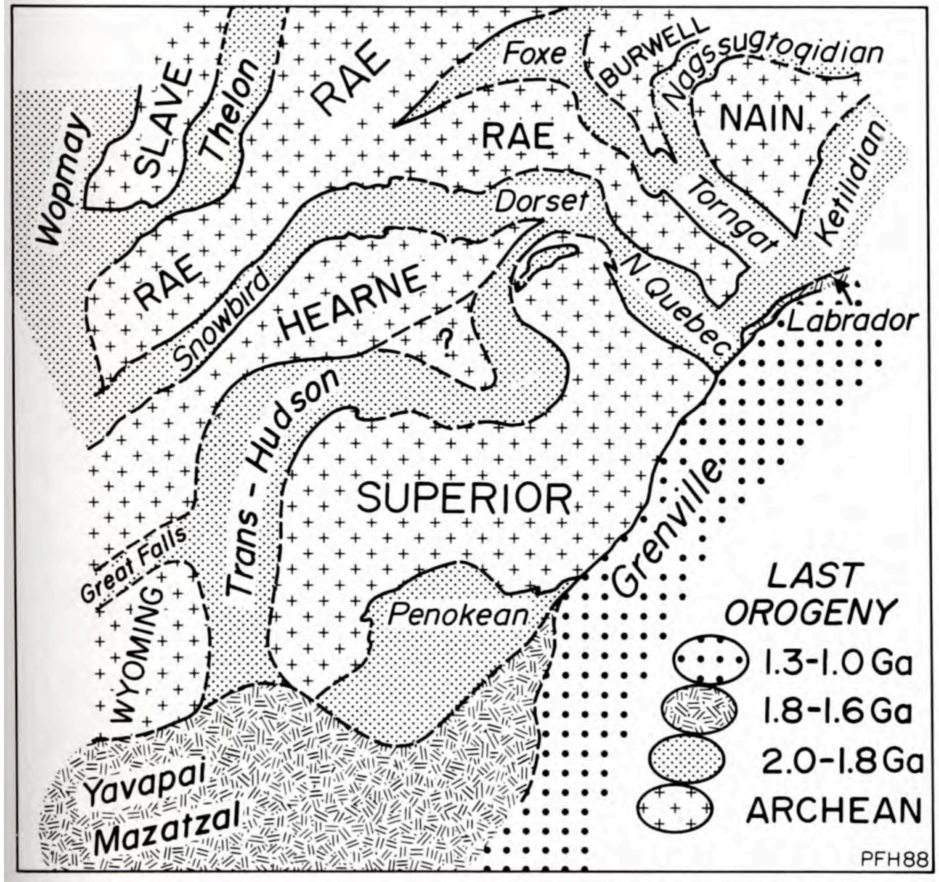
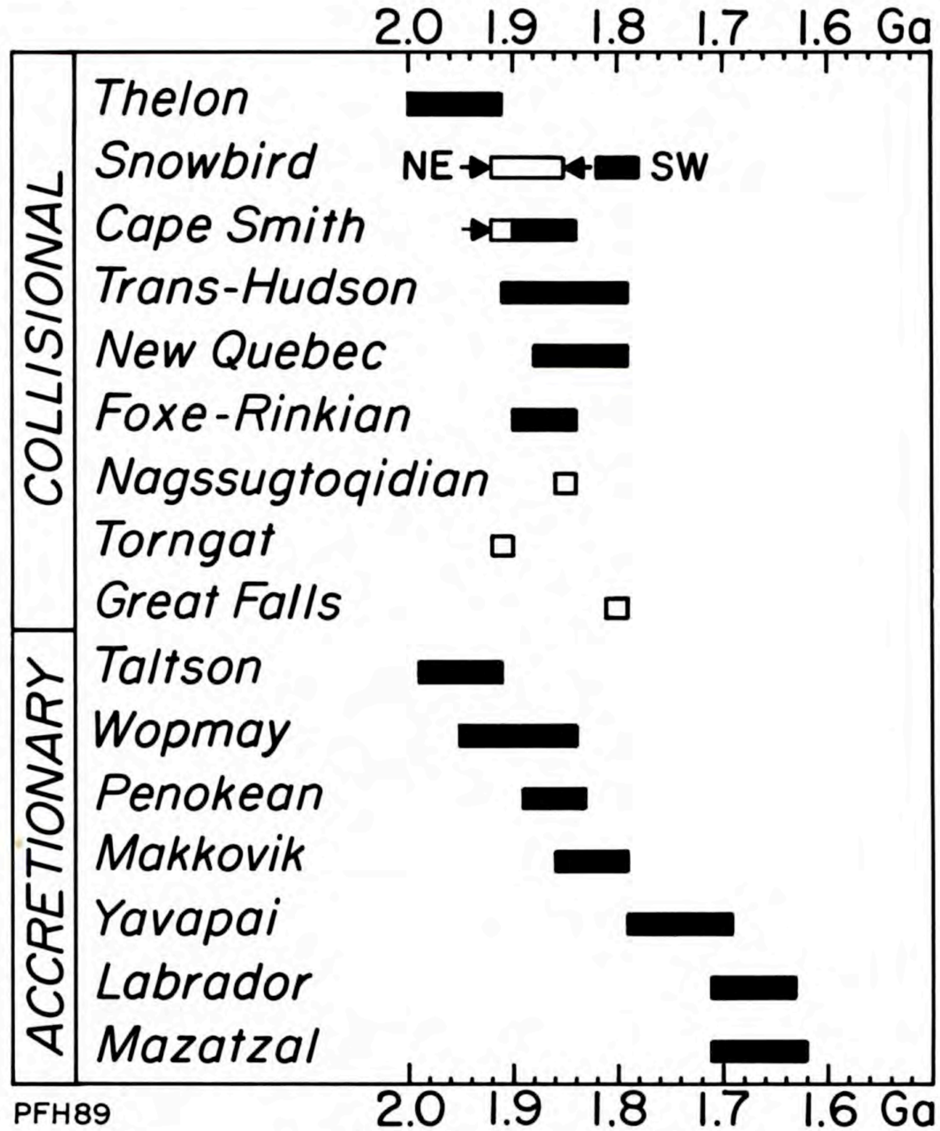


Figure 3. Exploded craton showing inferred Archean microcontinents (upper case names) and bounding Proterozoic orogens (italic lower case names). Separation of Archean provinces is arbitrary and not meant to imply a particular paleogeography.



Archean: Nuuk Greenland

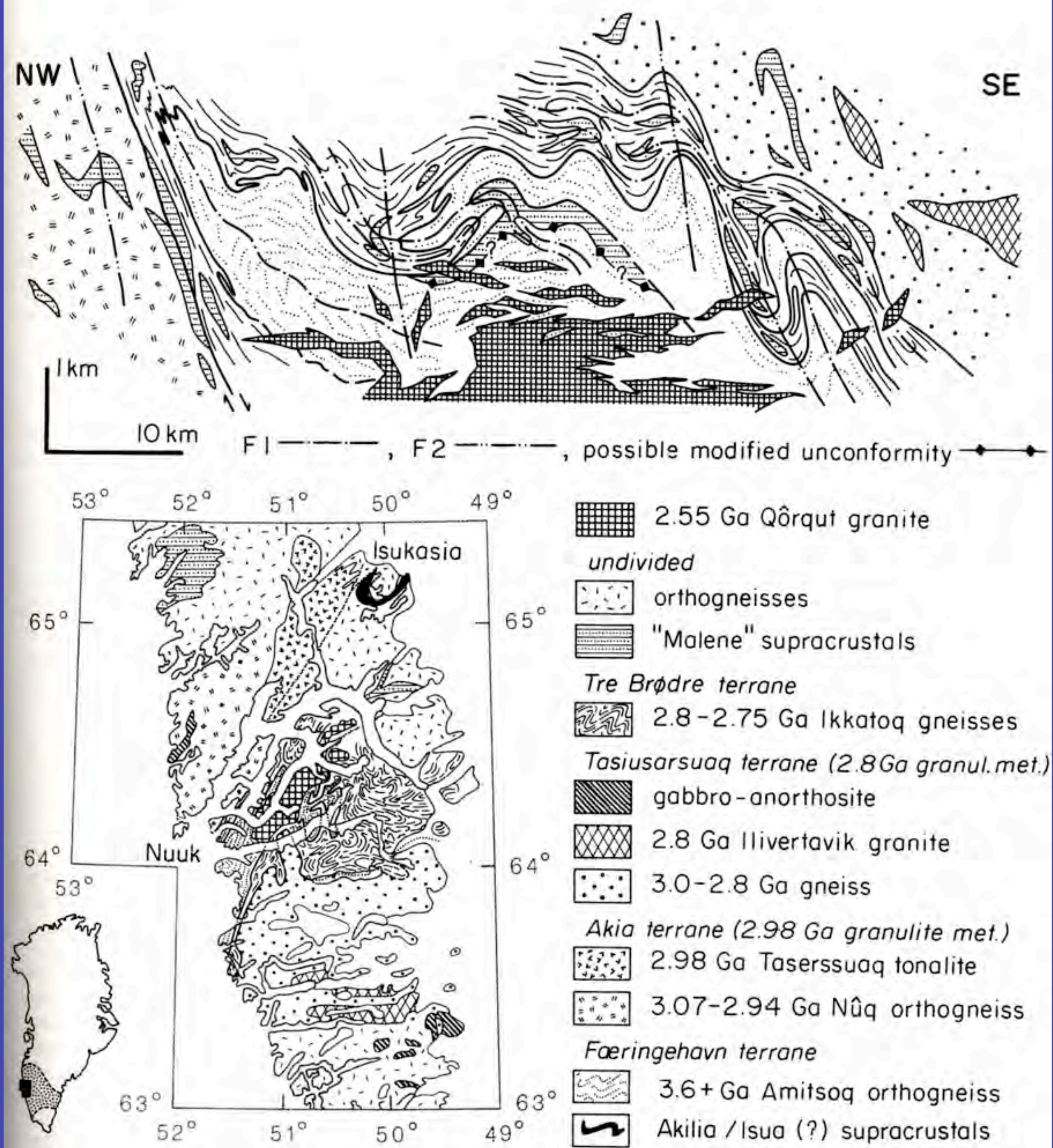
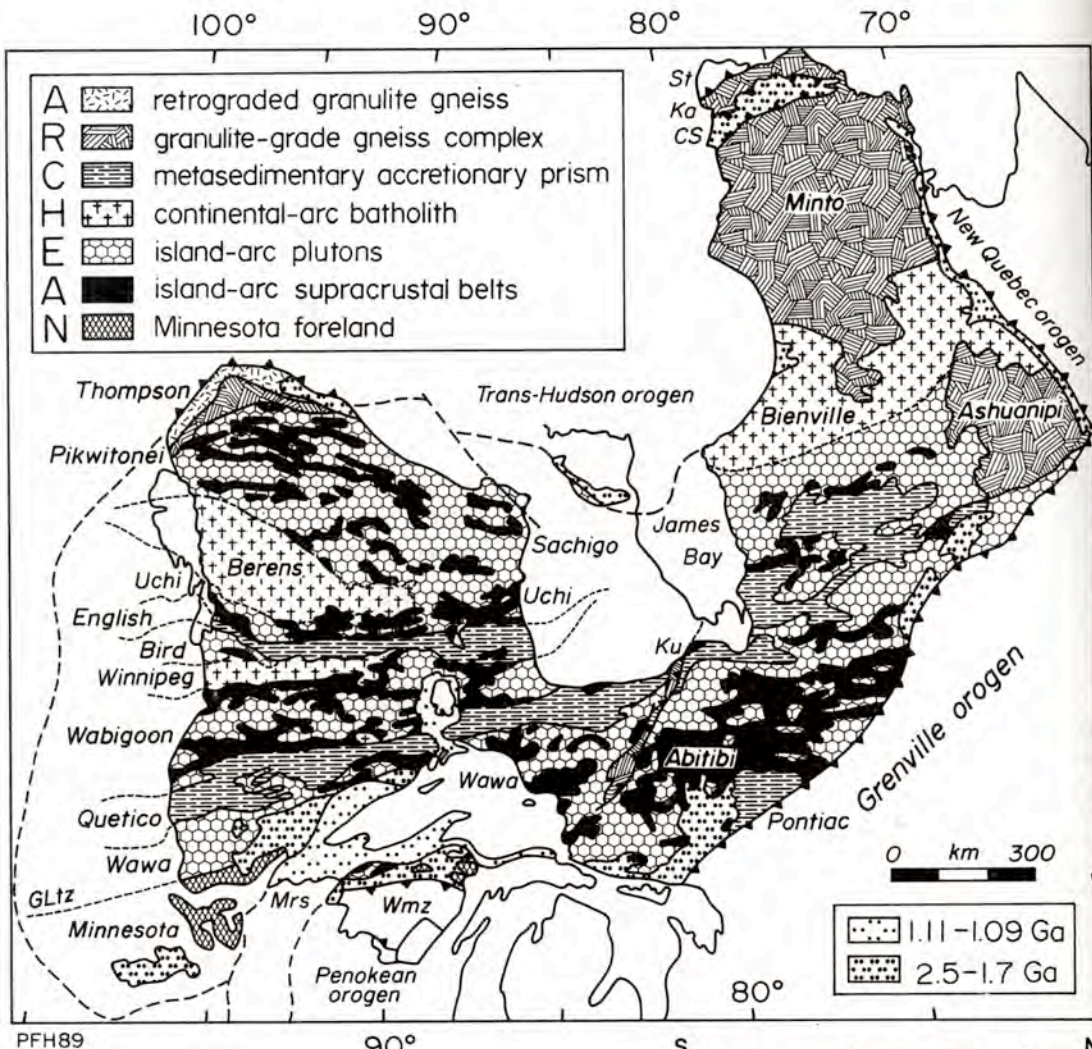


Figure 7. Geology and generalized cross-section of Archean terranes near Nuuk, southwest Greenland (central Nain province), modified after *Nutman and others (1989).*

Fault between 3.8 B Amitsoq gneiss (left side) and 3.8+ B Isua belt

Archean:
Hudson Bay
To
Lake Superior



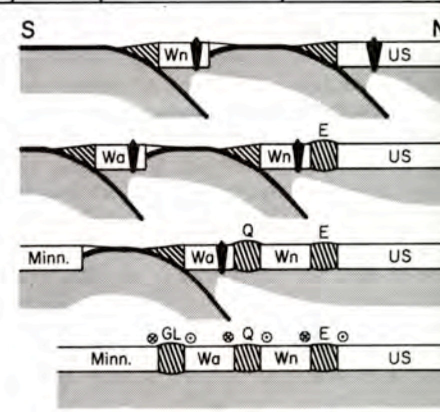


Figure 5. Geology of the Superior province showing subsurface extensions (dashed) of terrane boundaries. Map modified after *Card (1989)*. Cs, Cape Smith belt; GLtz, Great Lakes tectonic zone; Ka, Kovik antiform; Ku, Kapuskasing uplift; Mrs, Midcontinent rift system; St, Sugluk terrane; Wmz, Wisconsin magmatic zones of Penokean orogen. Cross-sections in lower left show plate tectonic evolution, modified after *Langford and Morin (1976)*, involving southward accretion of island arcs and terminal collision with the Minnesota foreland. E, English River accretionary prism; GL, Great Lakes tectonic zone; Q, Quetico accretionary prism; US, Uchi-Sachigo composite island-arc terrane; Wa, Wawa island-arc terrane; Wn, Wabigoon island-arc terrane.

Paleoproterozoic: 2500-1600 MY

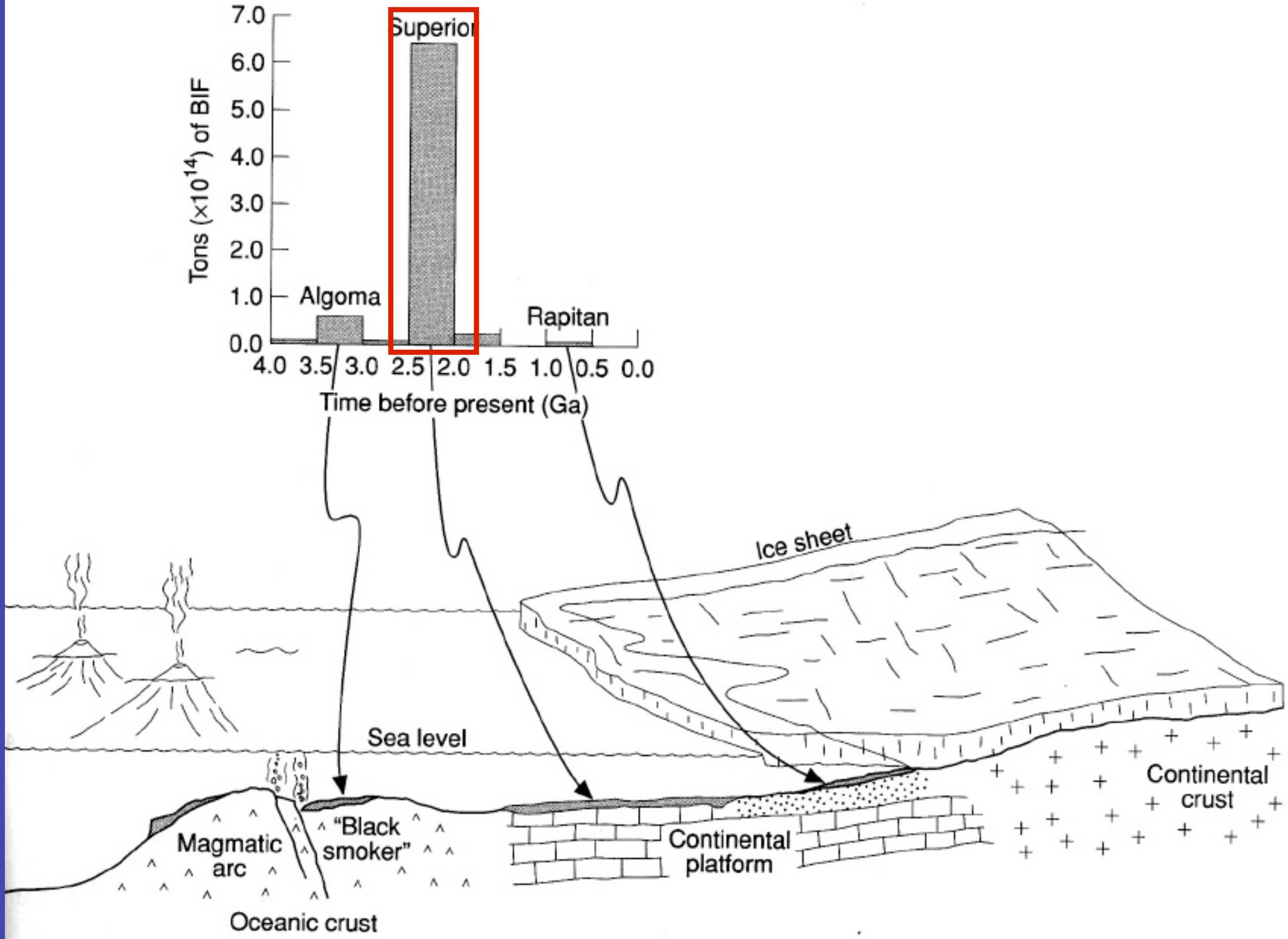


Figure 5.16 Tectonic and environmental model showing the depositional settings for Algoma, Superior, and Rapitan type BIFs (after Clemmey, 1985; Maynard, 1991). The inset histogram illustrates the approximate tonnages of BIF resource for each of the three major types as a function of time (after Holland, 1984).

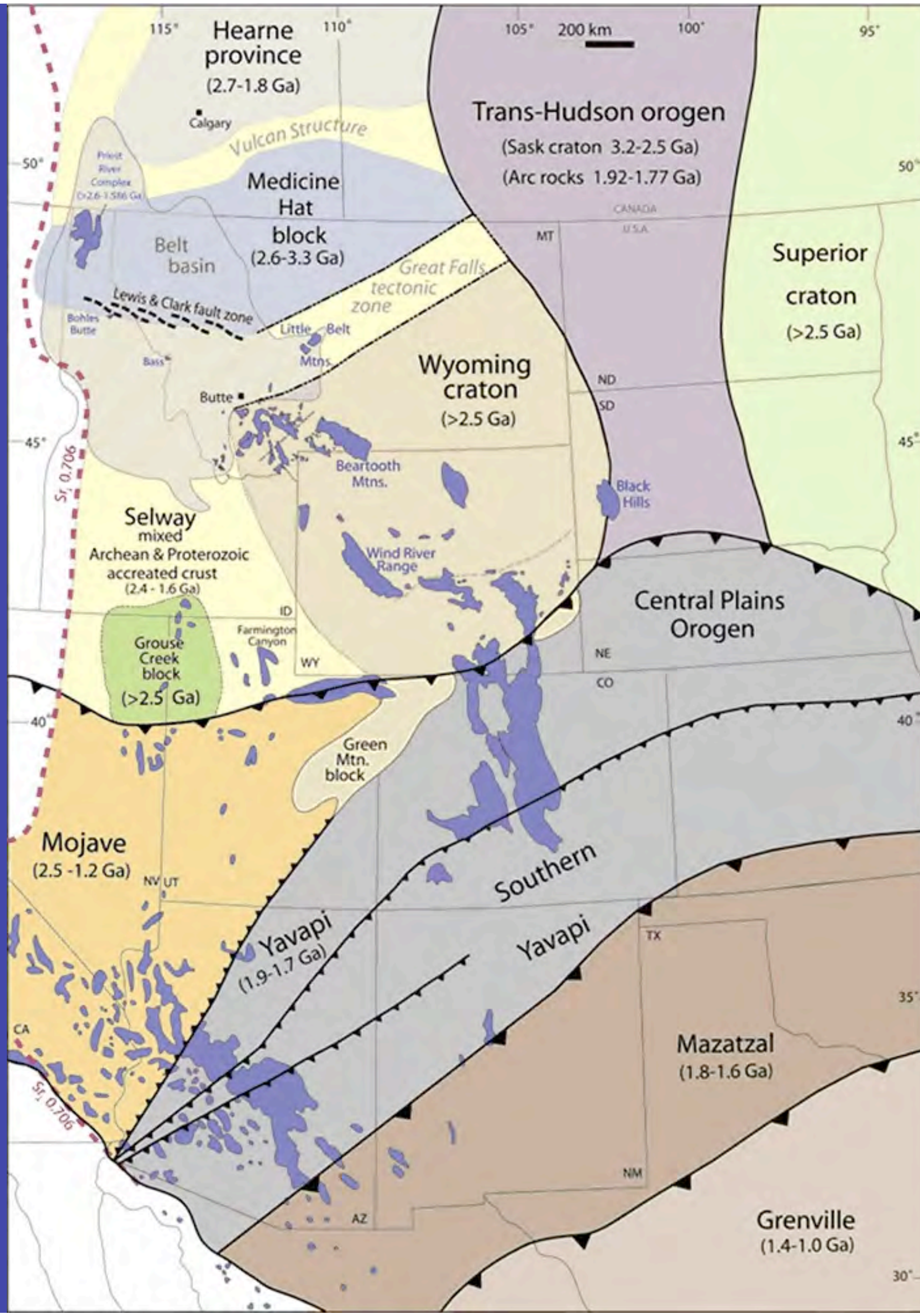
Banded Iron Formations

Middle Proterozoic Mesabi Range, MN Iron ore outcrop

Abandoned iron mine pits, Virginia, MN

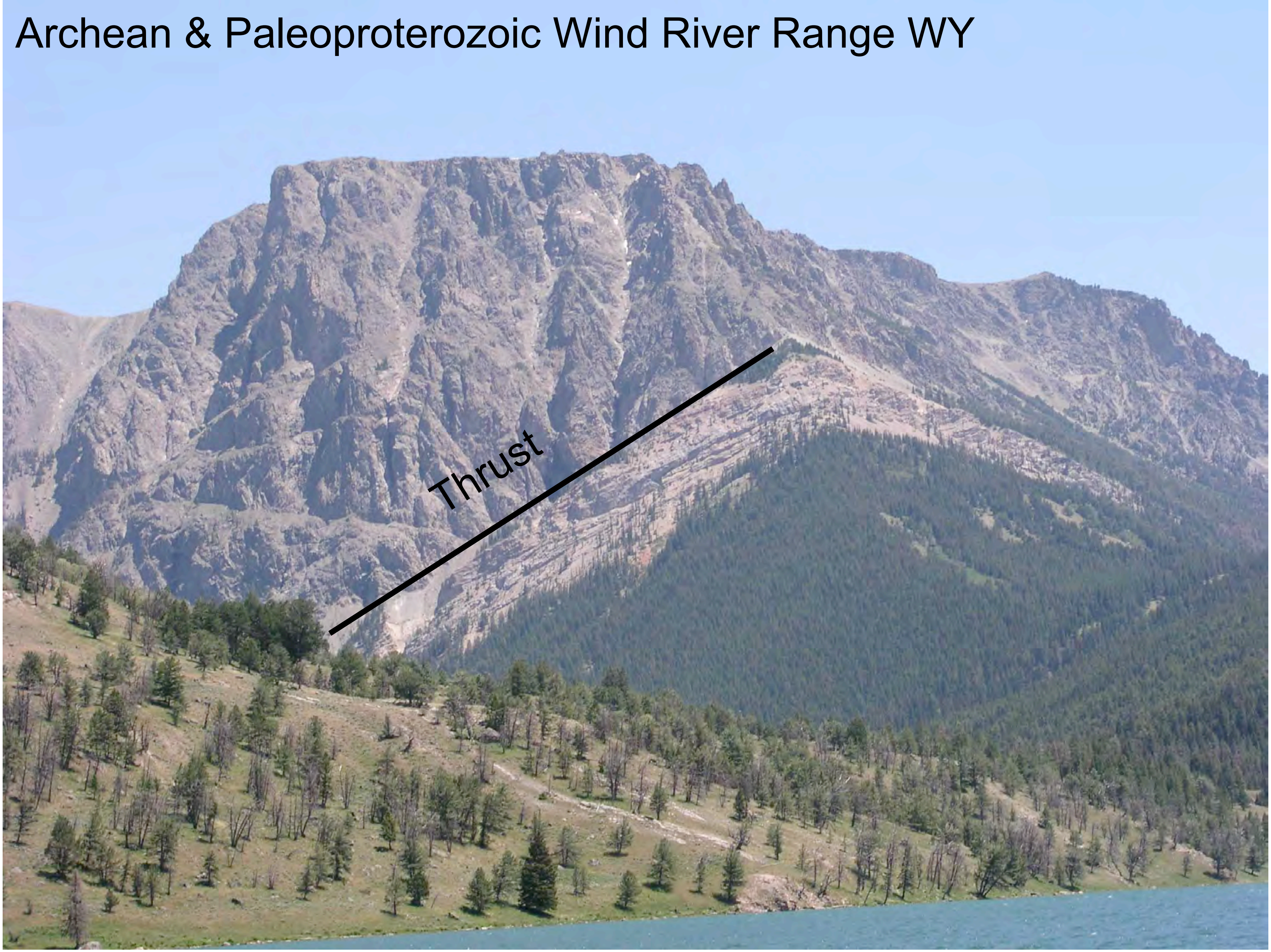
Iron-bearing chert outcrop

Hull Rust Iron Mine (world's largest)


Hearne province
(2.7-1.8 Ga)
Calgary
Vulcan Structure
Medicine Hat block
(2.6-3.3 Ga)
Belt basin
Lewis & Clark fault zone
Great Falls tectonic zone
Little Belt Mtns
Trans-Hudson orogen
(Sask craton 3.2-2.5 Ga)
(Arc rocks 1.92-1.77 Ga)
CANADA
U.S.A.
MT
Superior craton
(>2.5 Ga)
Wyoming craton
(>2.5 Ga)
Butte
Beartooth Mtns.
Black Hills
ND
SD
Selway
mixed
Archean & Proterozoic
accreted crust
(2.4 - 1.6 Ga)
Wind River Range
Central Plains Orogen
ID
WY
NE
CO
Grouse Creek block
(>2.5 Ga)
Farmington Canyon
Green Mtn. block
Mojave
(2.5 -1.2 Ga)
NV
UT
Southern
Yavapi
Yavapi
(1.9-1.7 Ga)
TX
CA
Mazatzal
(1.8-1.6 Ga)
NM
AZ
Grenville
(1.4-1.0 Ga)
200 km
115°
110°
105°
100°
95°
50°
45°
40°
35°
30°
Sr 0.706

Paleoproterozoic Belt Group, St Marys Lake, Glacier NP, Montana

Archean & Paleoproterozoic Wind River Range WY



Grand Canyon AZ: The Great Unconformity


Paleoproterozoic Superstition Mountains, Arizona

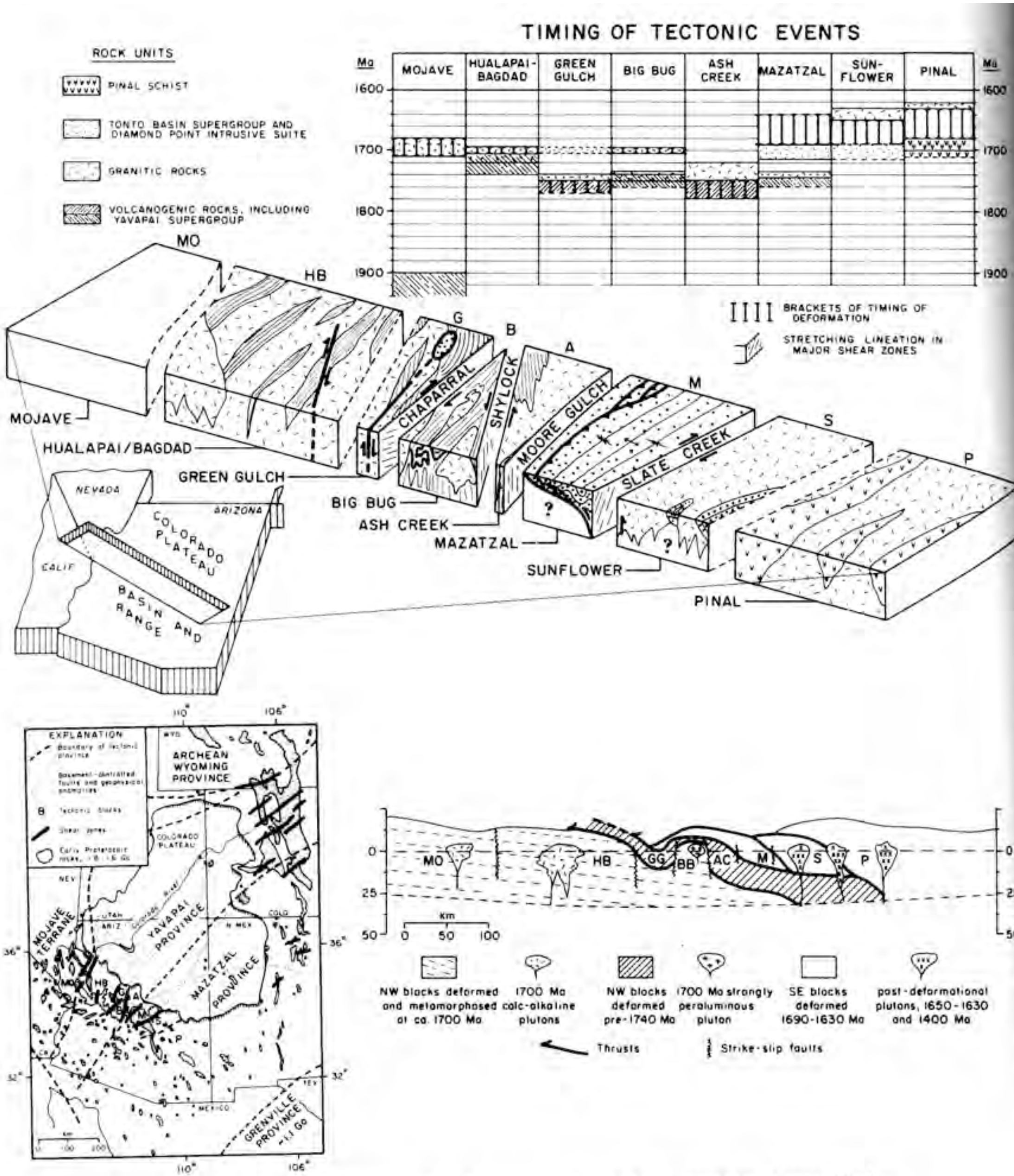
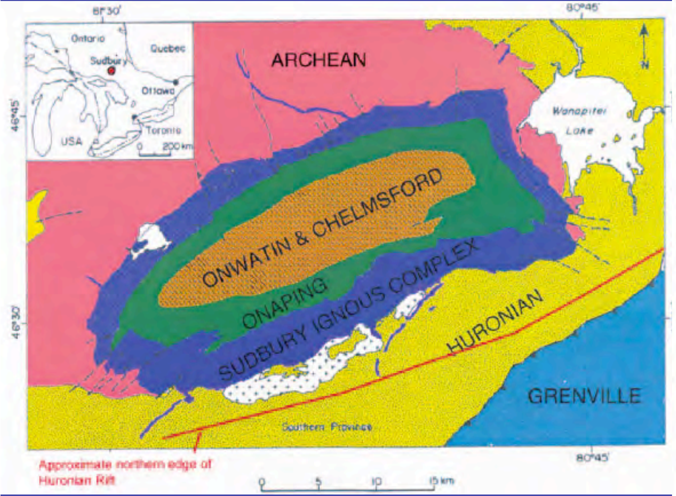


Figure 30. (Lower left) Exposures of Early Proterozoic rocks and inferred boundaries of tectonic blocks, according to *Karlstrom and Bowring, 1989.* (Above) Block diagram showing tectonostratigraphic blocks in Arizona and adjacent regions proposed by *Karlstrom and Bowring, 1988.* Moore Gulch fault separated composite northwestern region (5 blocks) from composite southeastern region (3 blocks). Timing of tectonic events based on U-Pb geochronology. (Lower right) Schematic NW-SE cross-section through central Arizona, from *Karlstrom and Bowring (1988),* showing minimum complexity of assembled blocks. At least three major terranes seem to be required by data on timing of deformation.

1.85 B Sudbury



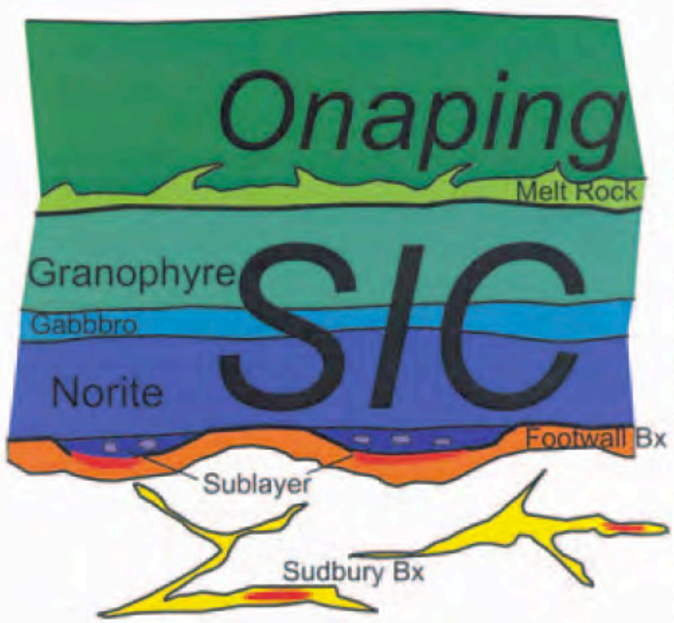


Figure 3. Schematic diagram showing main units resulting from the Sudbury "event." SIC—Sudbury Igneous Complex.

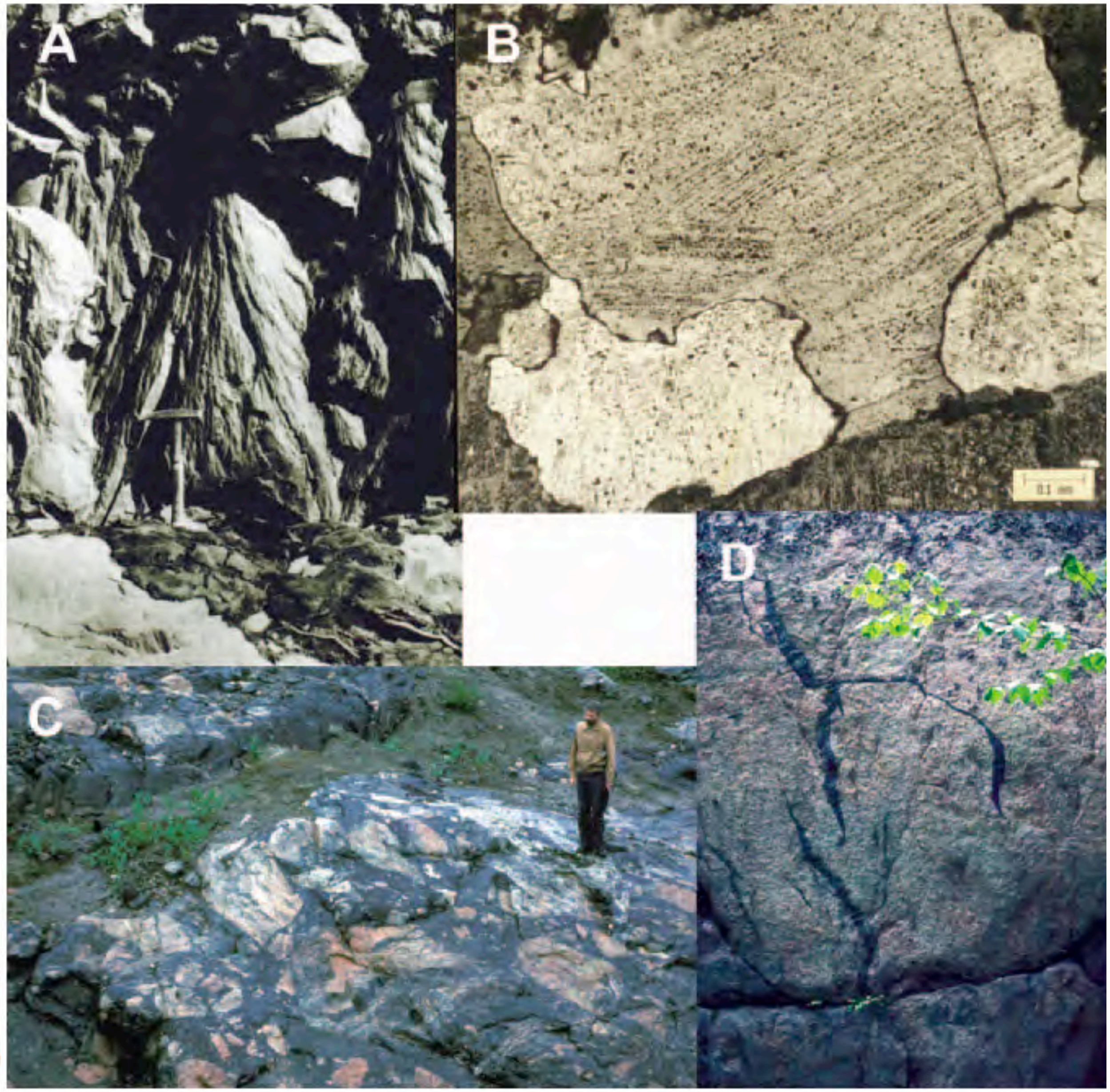


Figure 4. A: A shatter cone from the site south of Kelly Lake, Sudbury, where Bob Dietz first identified them (from Dietz, 1964). **B:** Shocked quartz showing at least two orientations of original lamellae of thetamorphic glass (photo thanks to Bevan French). **C:** Large area of Sudbury Breccia (photo thanks to Burkhardt Dressler). **D:** Thin veinlets of Sudbury Breccia cutting Archean granite (photo thanks to Burkhardt Dressler).

Mesoproterozic: 1600-900 MY

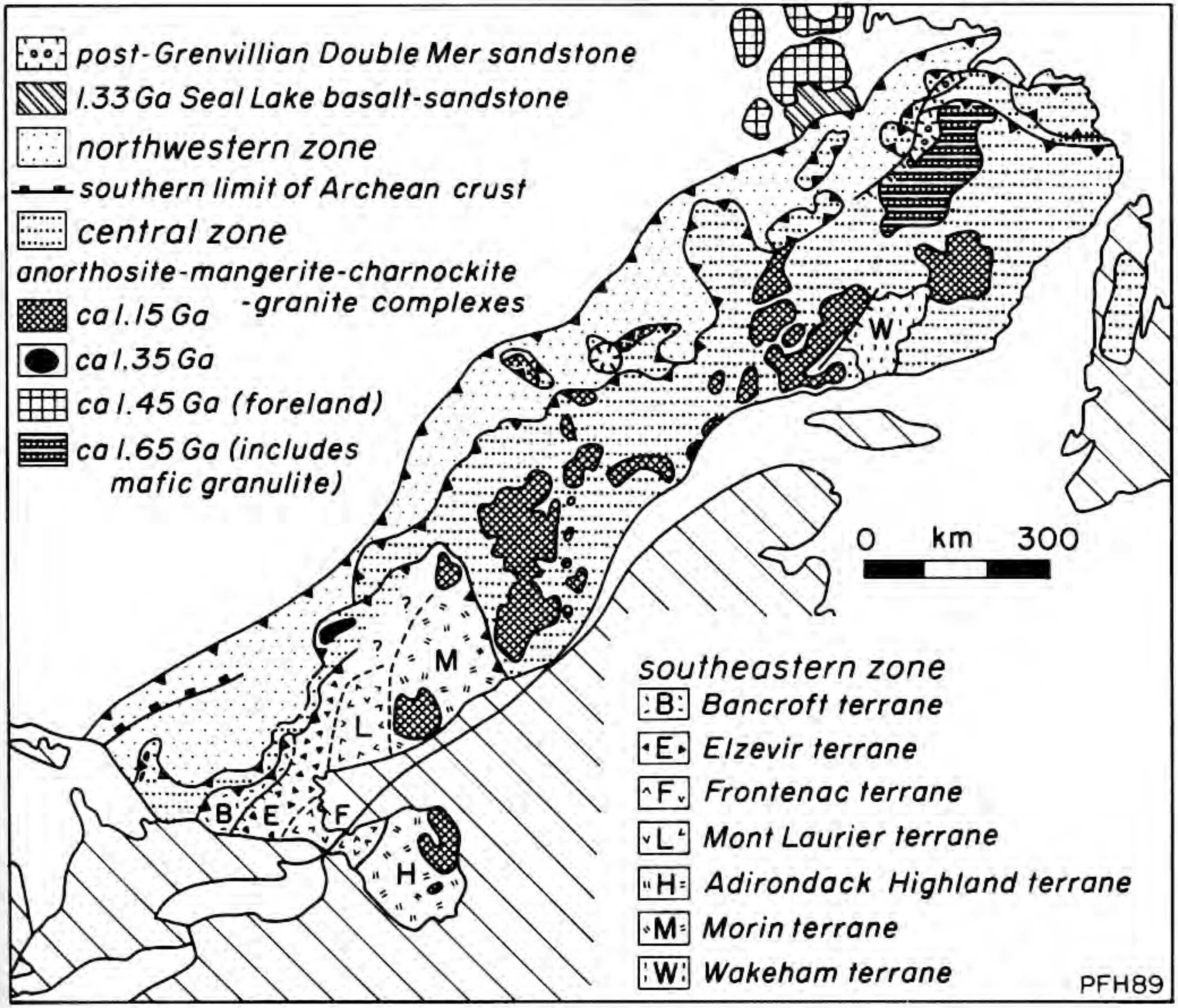
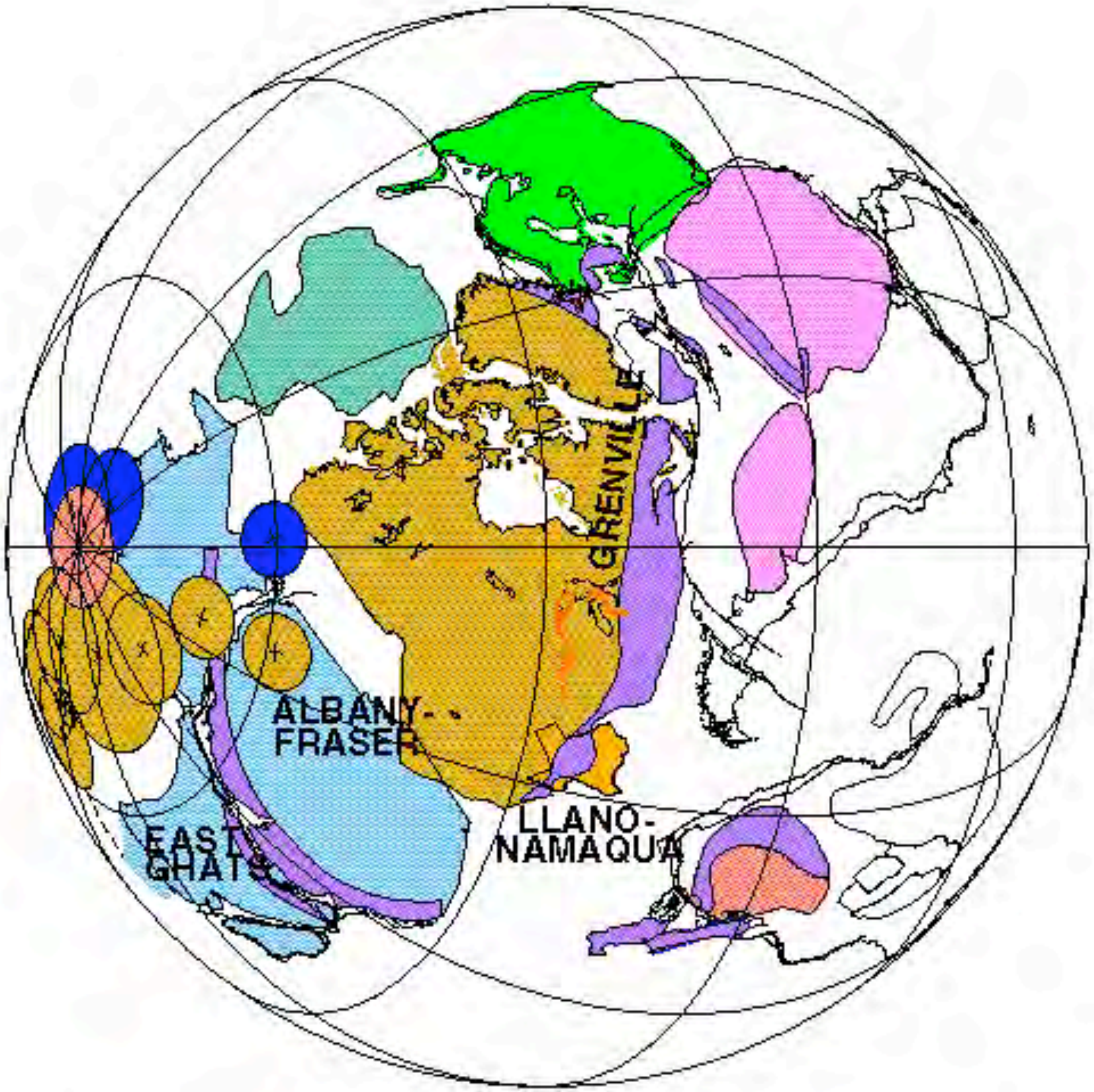


Figure 40. Geology of Grenville orogen in southeastern Canadian shield.



RODINIA
~1000-750 Ma

Dalziel, Mosher, & Gahagan
99-06-04

Neoproterozoic: 900-543 MY

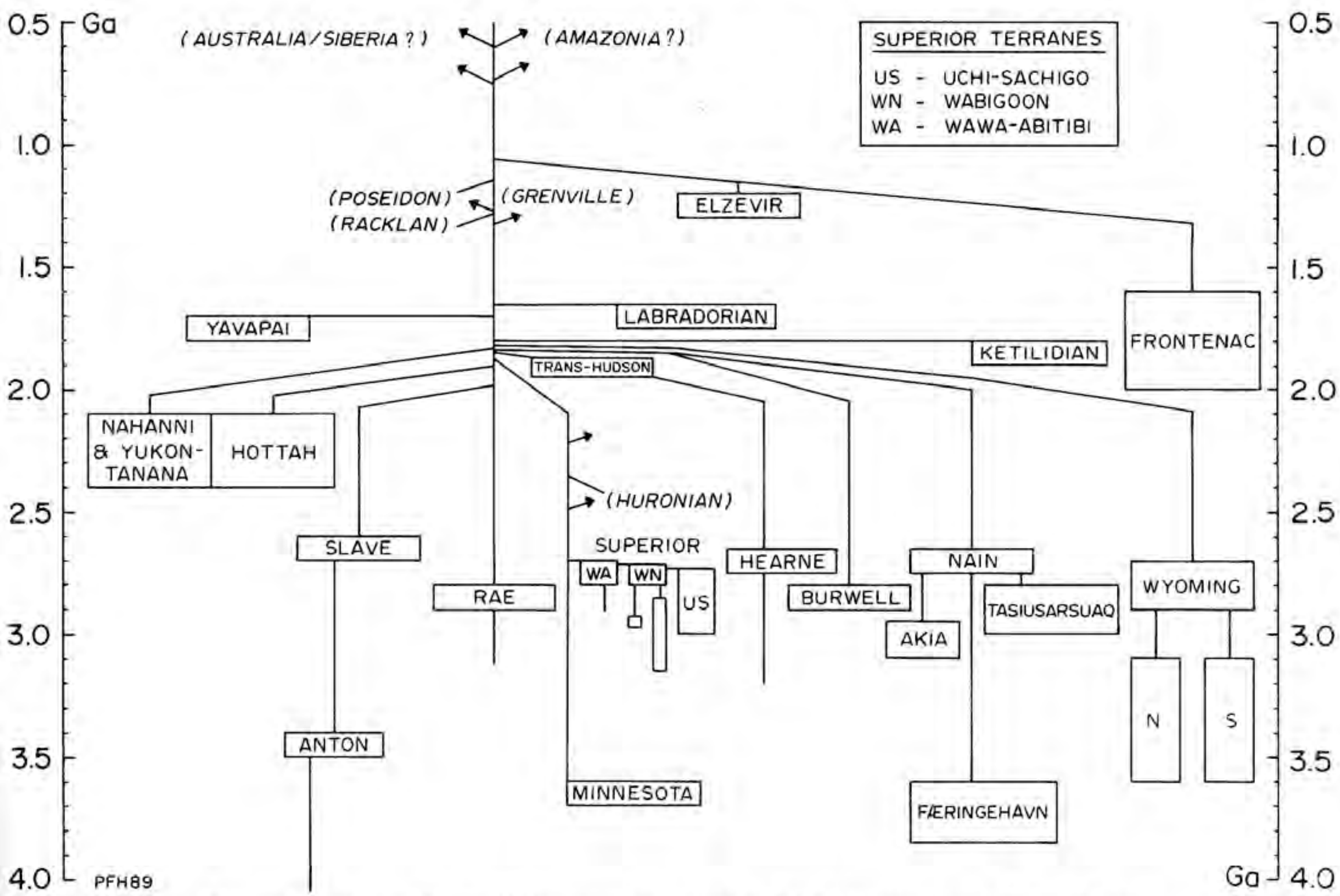


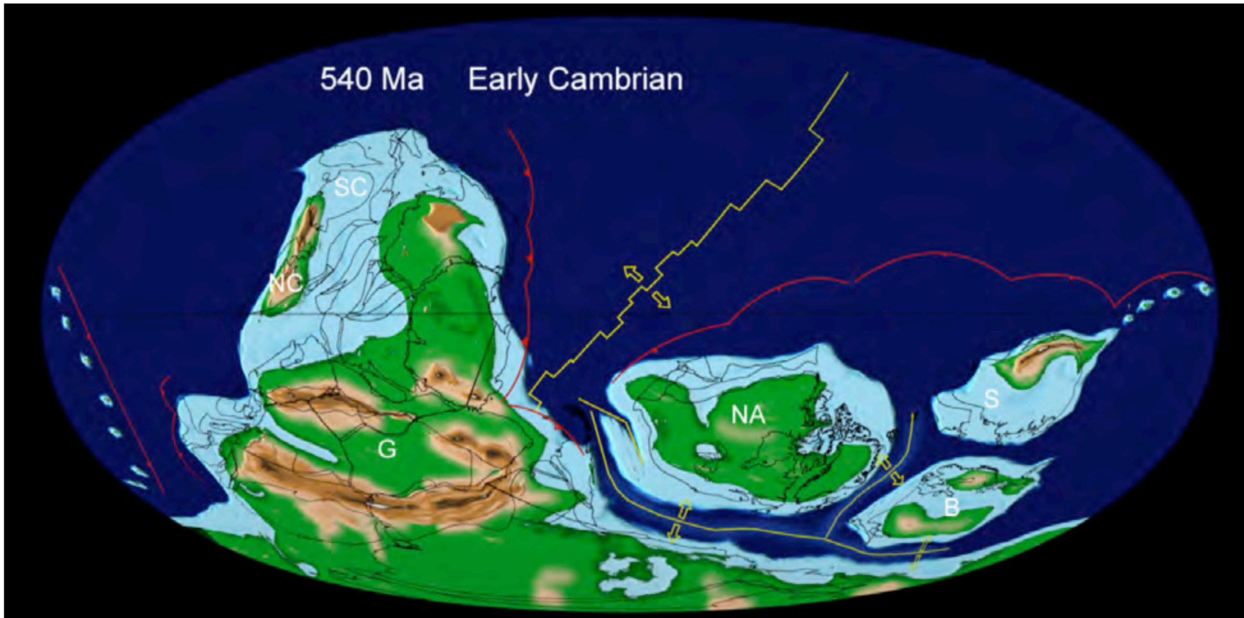
Figure 49. Cladogram (*Young, 1986*) summarizing accretion of North American craton. Boxes indicate times of crust formation of specific terranes. Merging of lines gives age of collision of respective terranes. Splitting of lines gives age of separation of terranes (bracketed names locate sites of separation; bracketed names with question marks identify terranes postulated to have separated). Note major episode of crust formation at 2.9 to 2.7 Ga, important confluence of Archean terranes at 2.0 to 1.8 Ga, accretion of juvenile crust at 1.9 to 1.7 Ga, and lack of convergent tectonism during 1.6 to 1.2 Ga period of anorogenic magmatism.

Paleozoic: 543-248 MY

Animation of Assembly and Breakup of Rodinia

http://geosphere.gsapubs.org/content/suppl/2009/02/13/3.6.511.DC1/i1553-040X-3-6-511-m03.mov

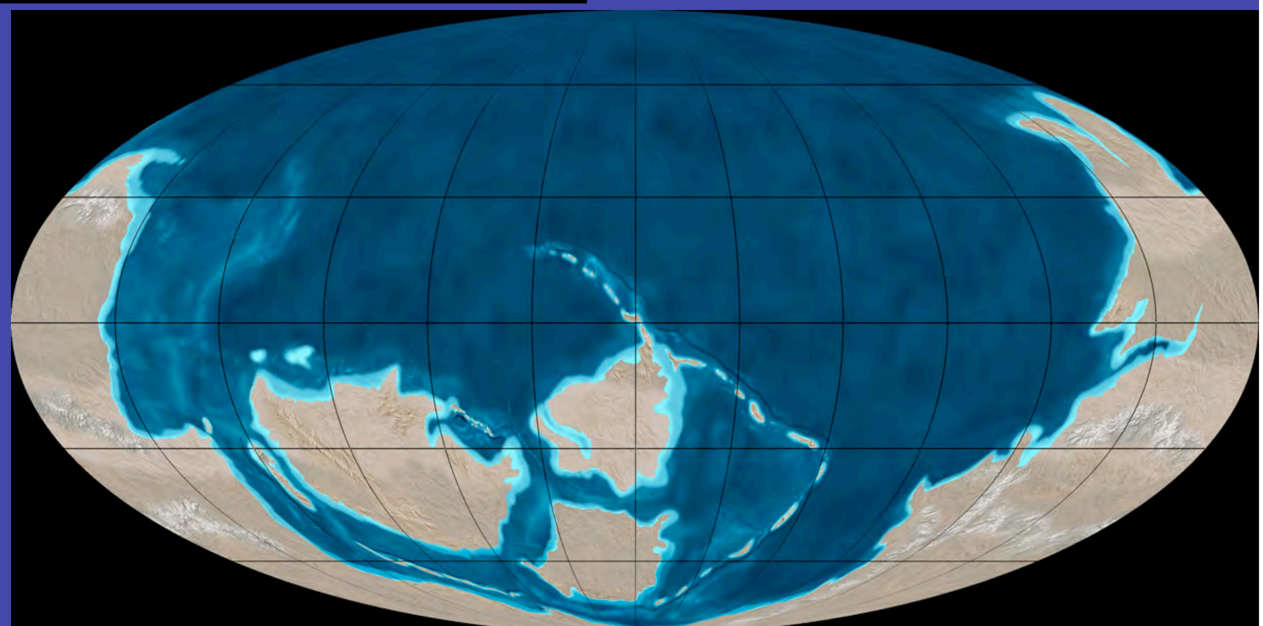
Whitmeyer et al 2007



Chris Scotese Interpretation

http://www.searchanddiscovery.net/documents/2008/08029scotese/images/09.htm

Ron Blakey Interpretation



http://jan.ucc.nau.edu/~rcb7/540moll.jpg

Early Cambrian Paleogeographies: Two Views

Animation of 1966 Wilson Cycle Concept

http://geosphere.gsapubs.org/content/suppl/2009/02/13/3.6.511.DC1/i1553-040X-3-6-511-m01.mov

Whitmeyer et al 2007

Animation
Assembly of Pangea
Neoproterozoic to Permian

http://geosphere.gsapubs.org/content/suppl/2009/02/13/3.6.511.DC1/i1553-040X-3-6-511-m02.mov

Whitmeyer et al 2007

An animated tectonic reconstruction of southwestern North America since 36 Ma

Nadine McQuarrie and Brian P. Wernicke

Geosphere; December 2005; v. 1; no. 3; p. 147-172; DOI: 10.1130/GES00016.1

http://geosphere.geoscienceworld.org/content/vol1/issue3/images/data/147/DC1/10.1130_GES00016.1.s1.mov

October 23, 1981