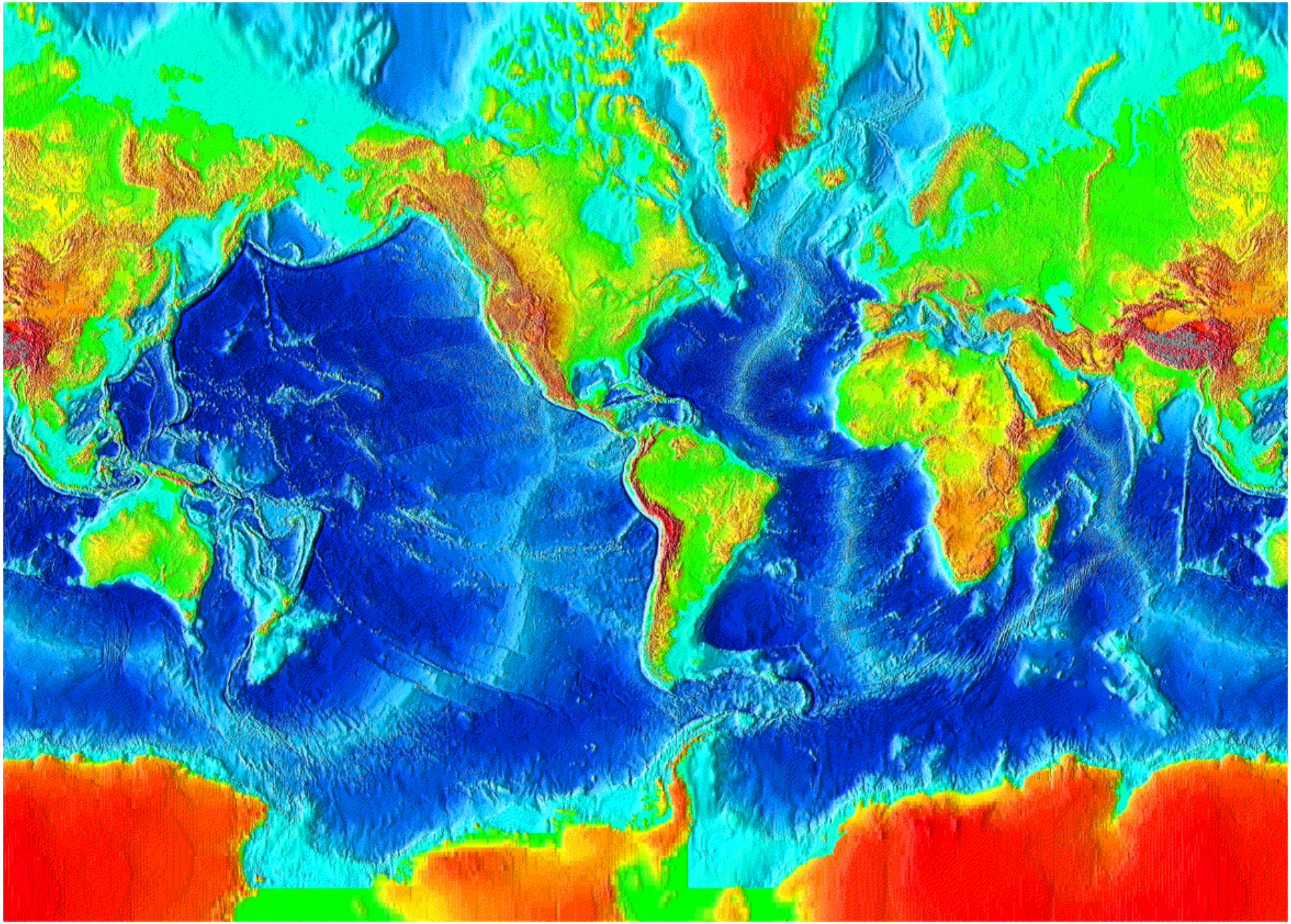
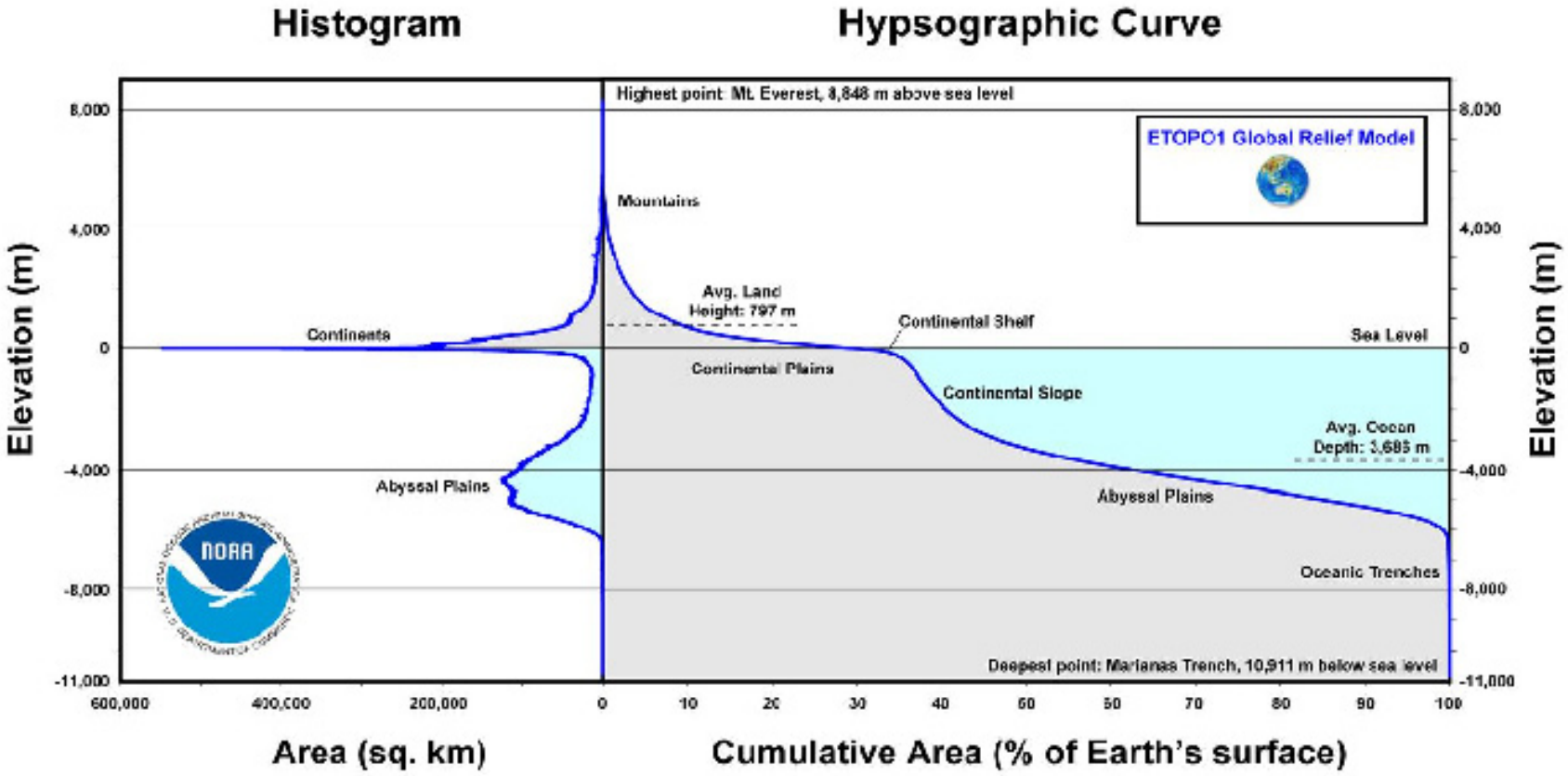
Plate Tectonics

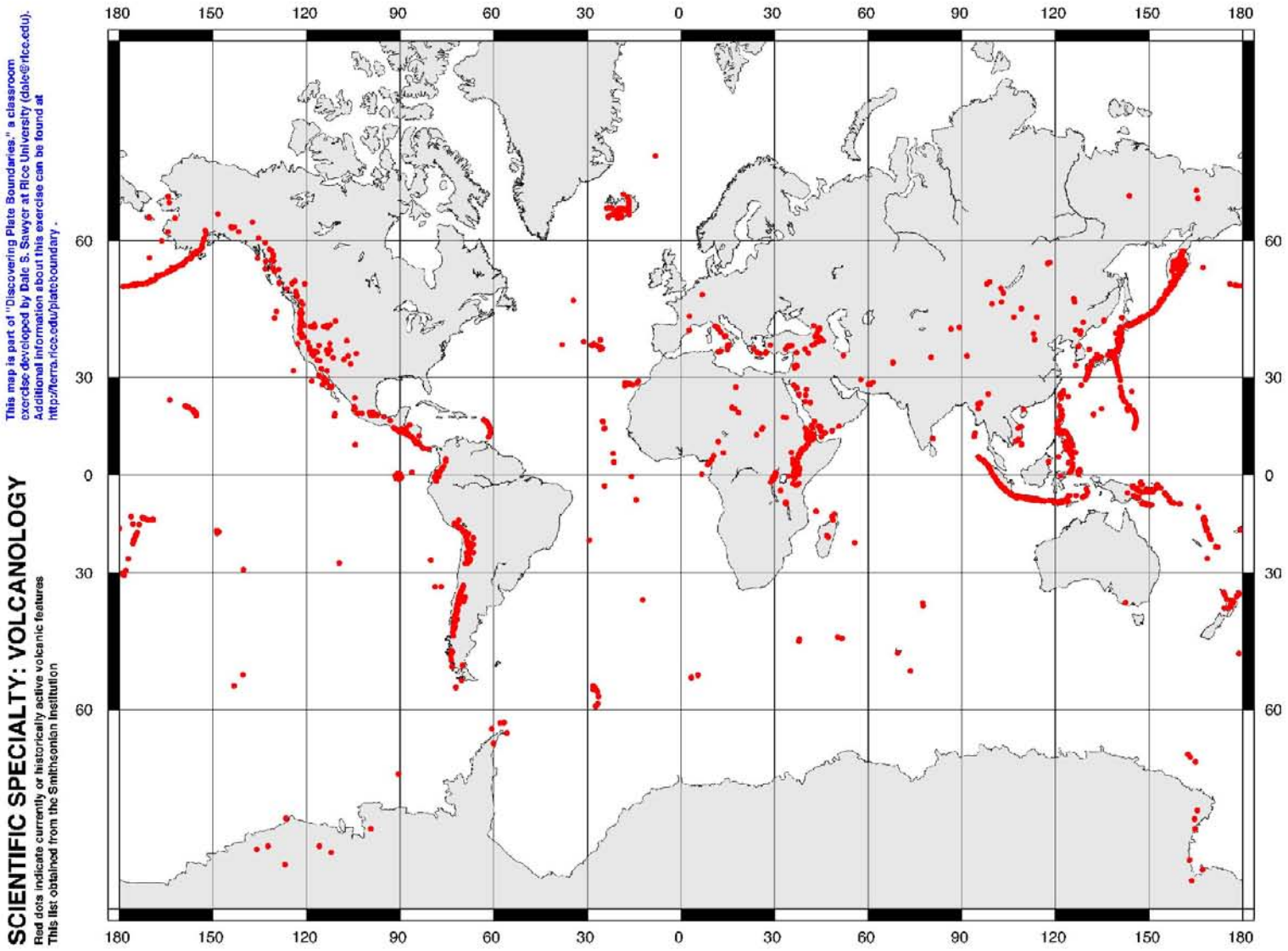
12.001 – 10-15 October 2012



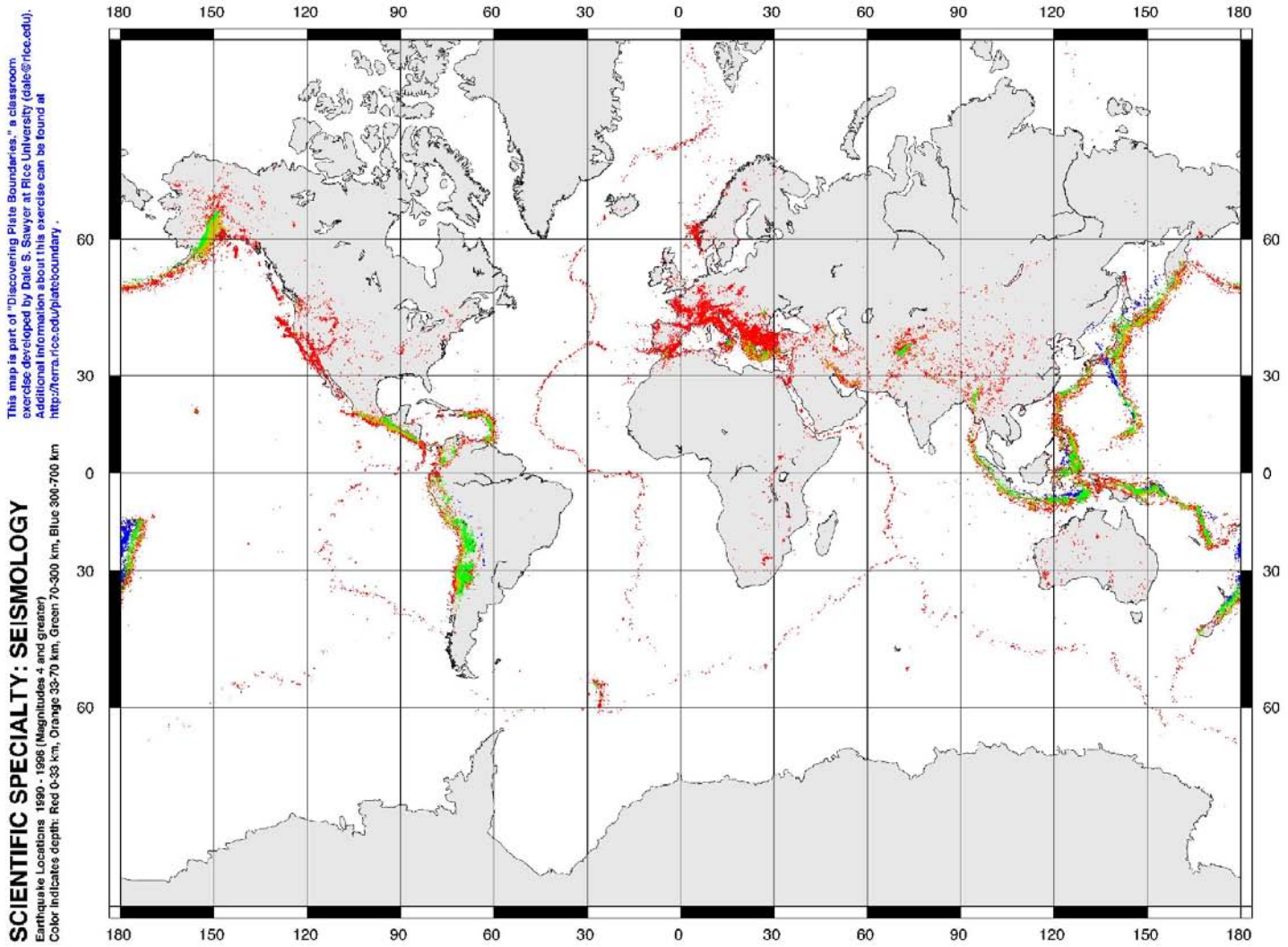
Courtesy of NOAA. Map in the public domain.



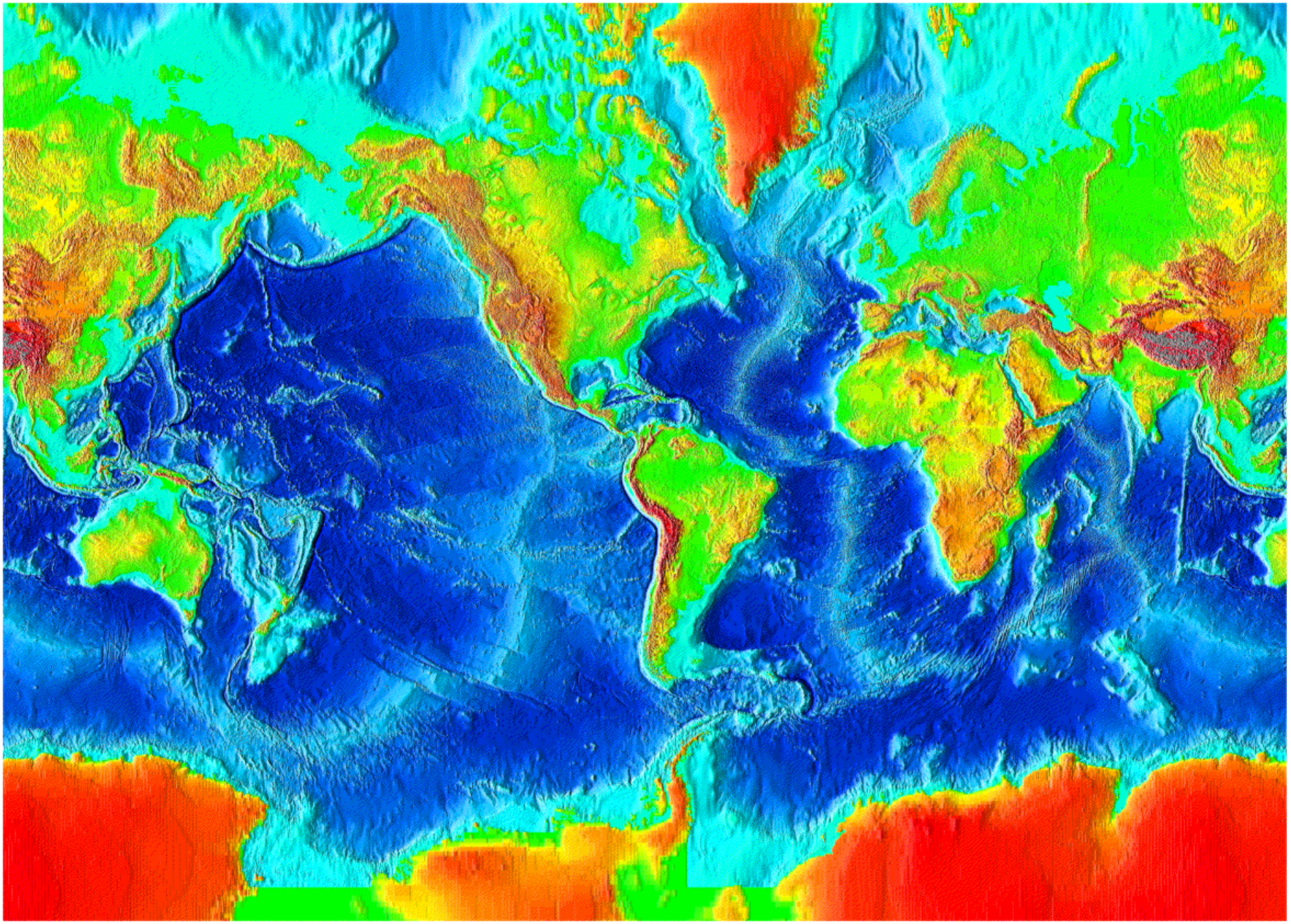
Courtesy of NOAA. Figure in the public domain.



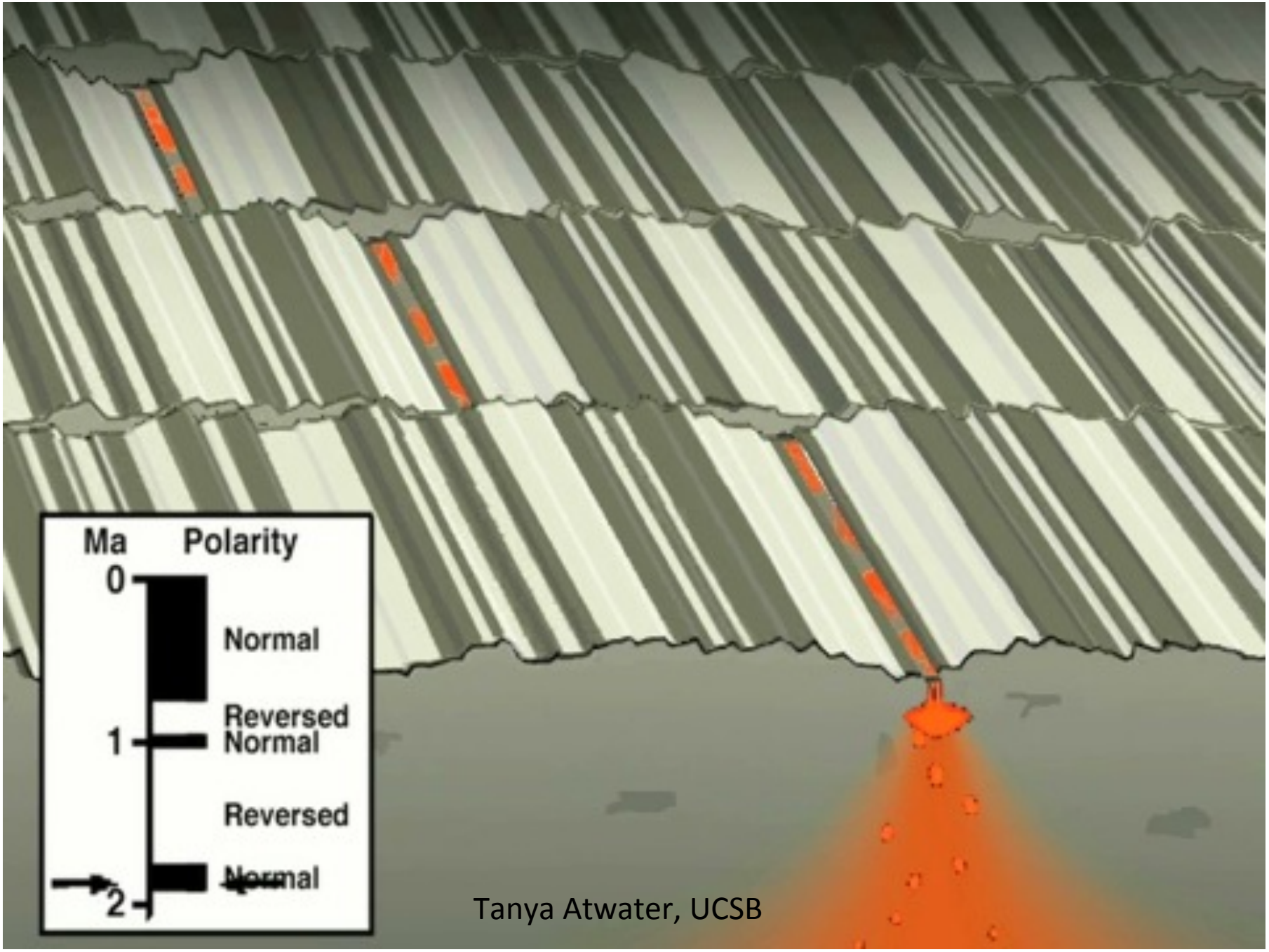
Source: Discovering Plate Boundaries by Dale S. Sawyer.

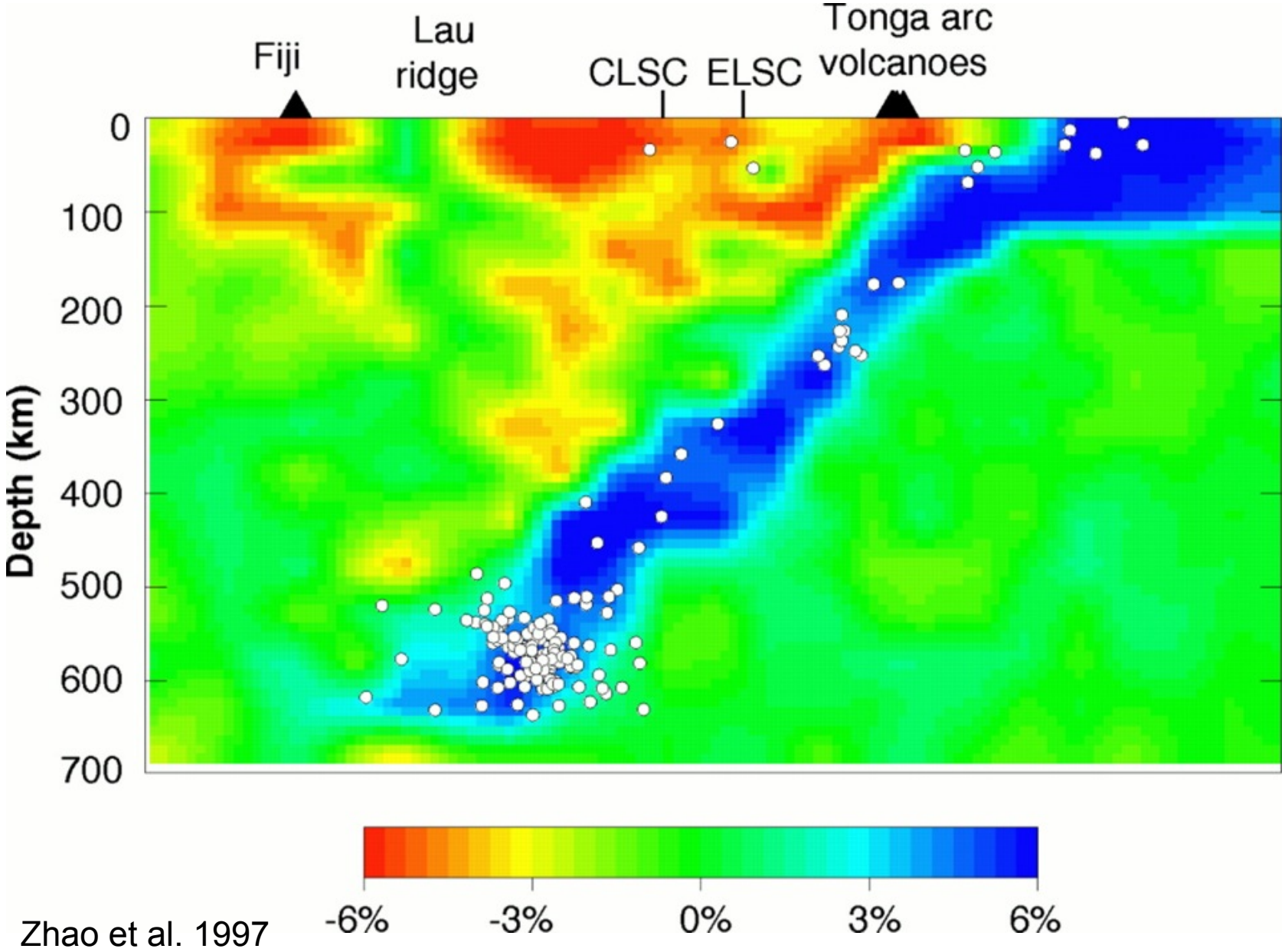


Source: Discovering Plate Boundaries by Dale S. Sawyer.



Courtesy of NOAA. Map in the public domain.

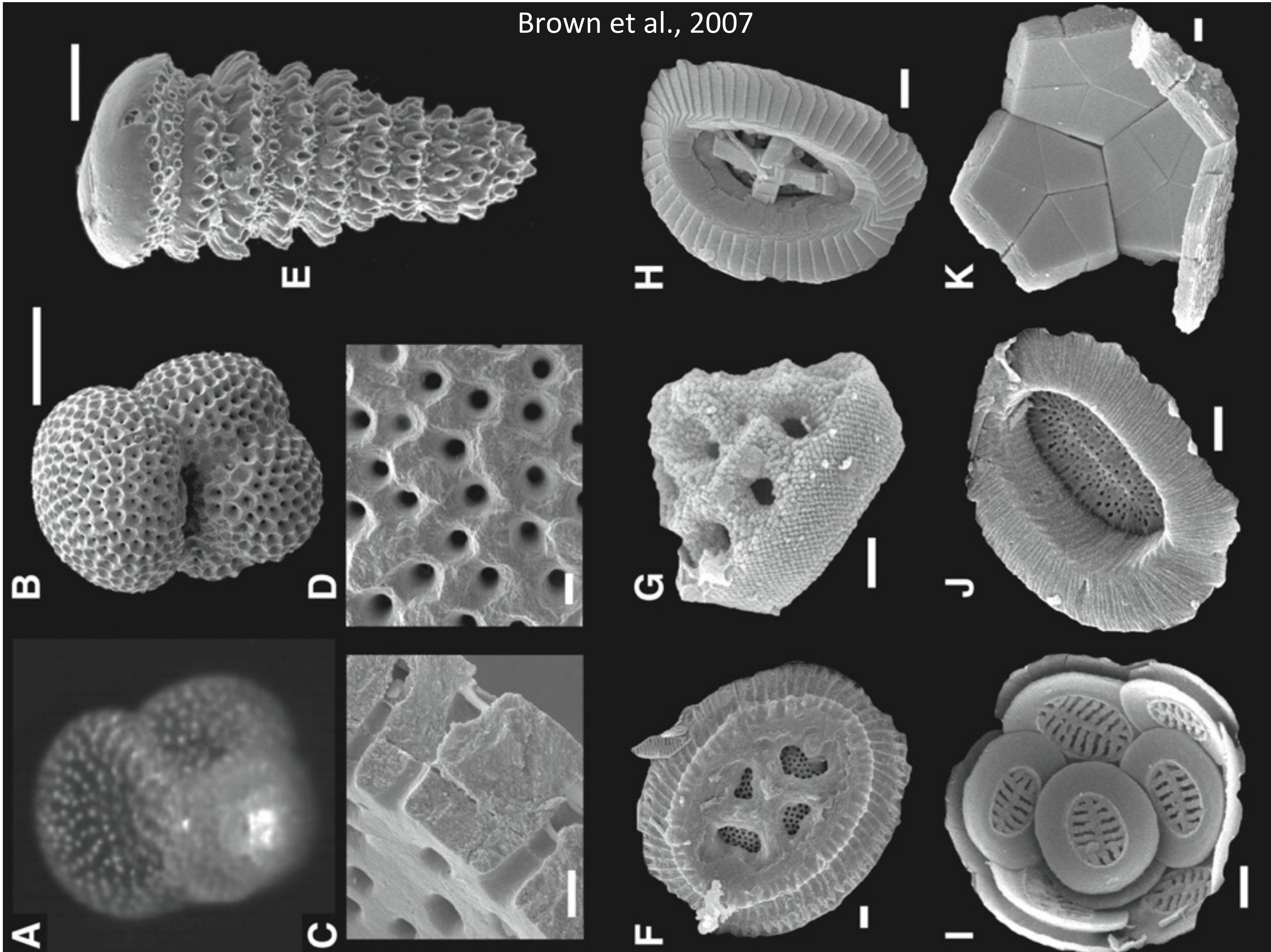


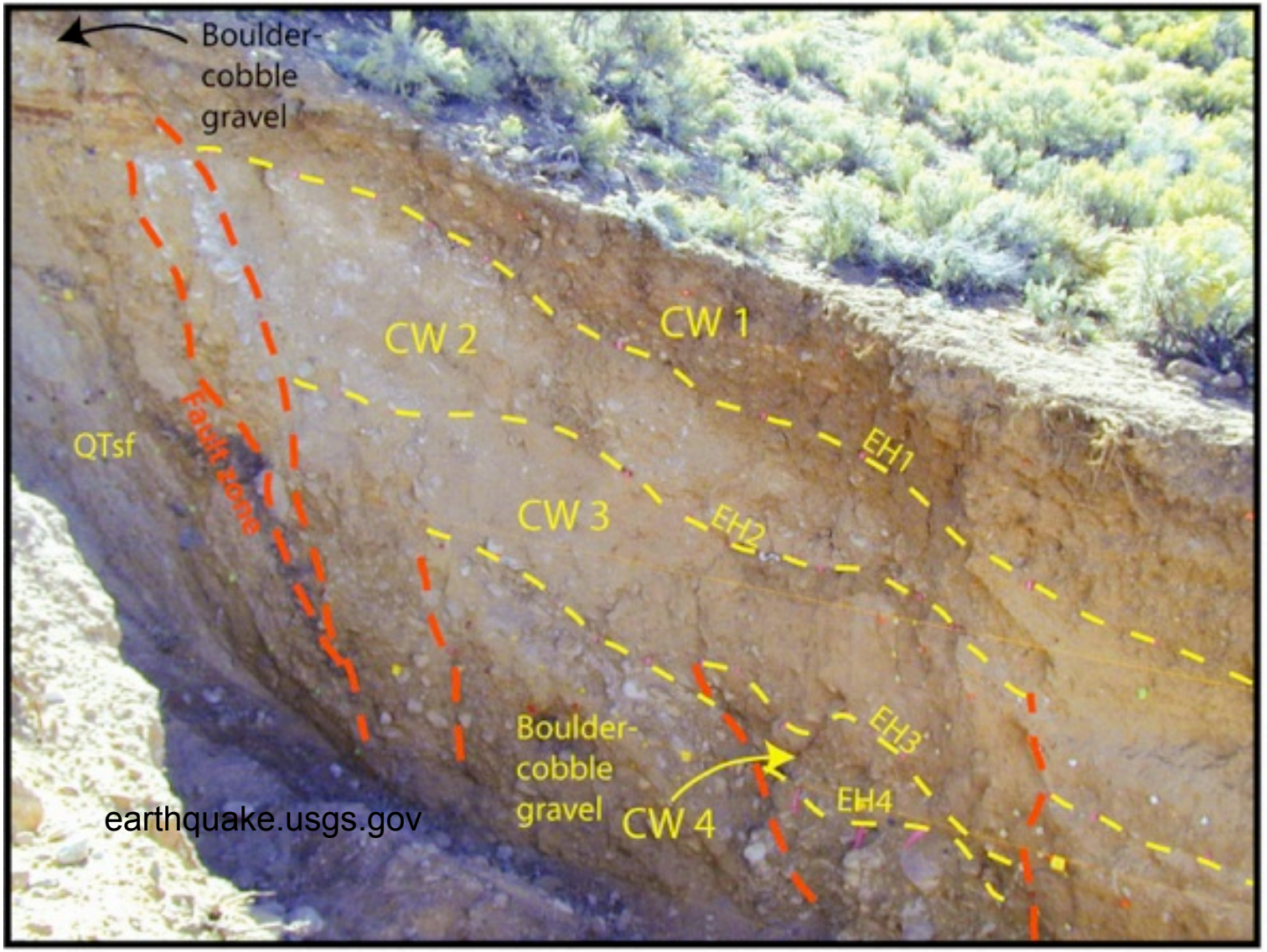


Zhao et al. 1997

Source: Zhao, Dapeng, Yingbiao Xu, et al. "Depth Extent of the Lau Back-arc Spreading Center and its Relation to Subduction Processes." *Science* 278, no. 5336 (1997): 254-7.

Brown et al., 2007



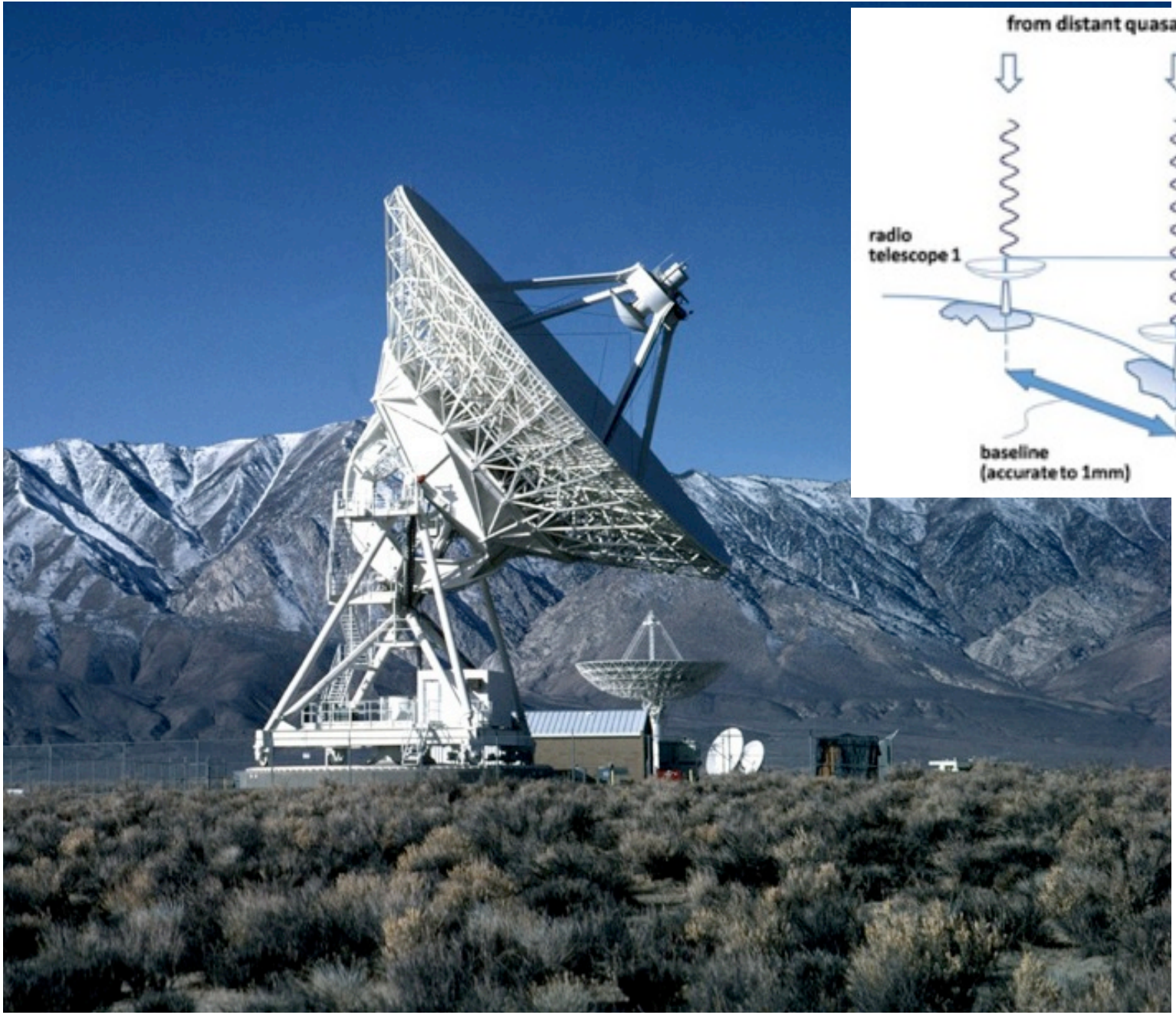


Photograph of trench across large scarp at the Rito Seco site. The trench exposed Santa Fe Formation(QTsf) and overlying fluvial gravel on the upthrown side of the fault and a sequence of three well-defined colluvial wedges (CW 1, CW 2 and CW 3) and remanents of a probable old, fourth wedge (CS 4) on the downdropped side of the fault zone. Event horizons (EH) show the ground surface at the time of each surface-faulting event.

LAGEOS satellite

Goddard Geophysical and Astronomical Observatory

Courtesy of NASA. Photographs in the public domain.

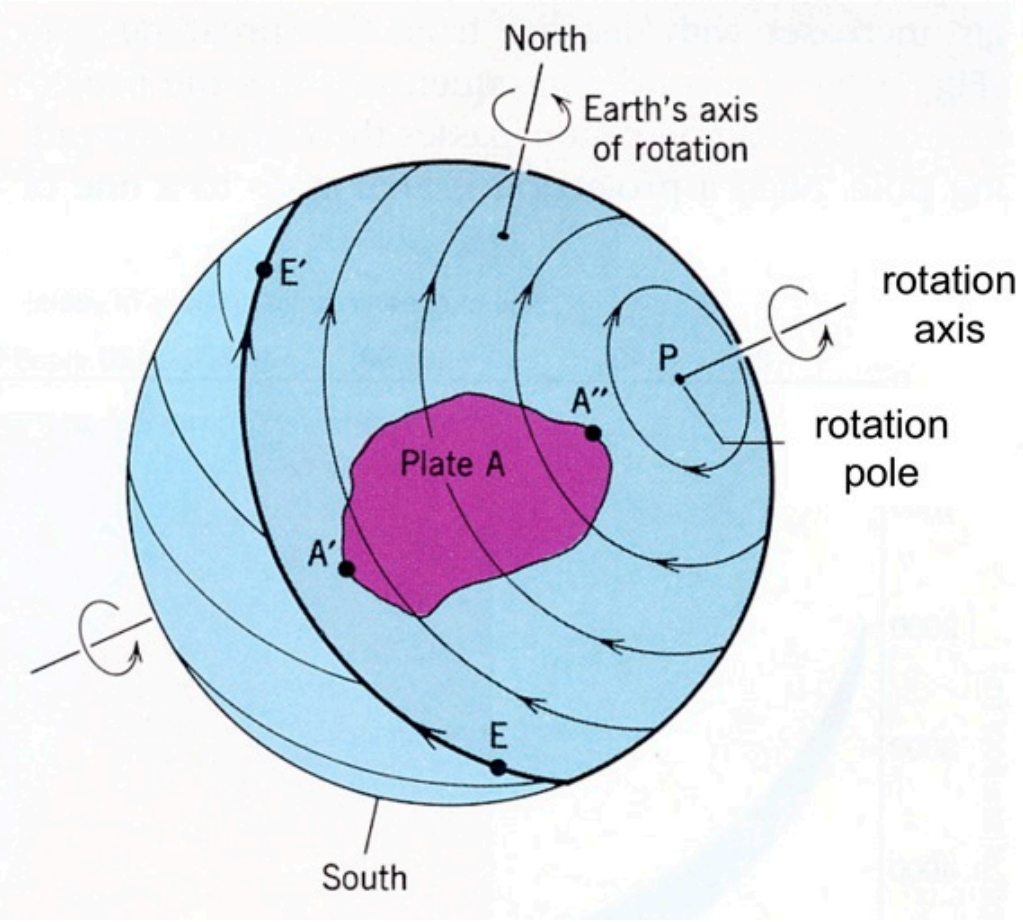


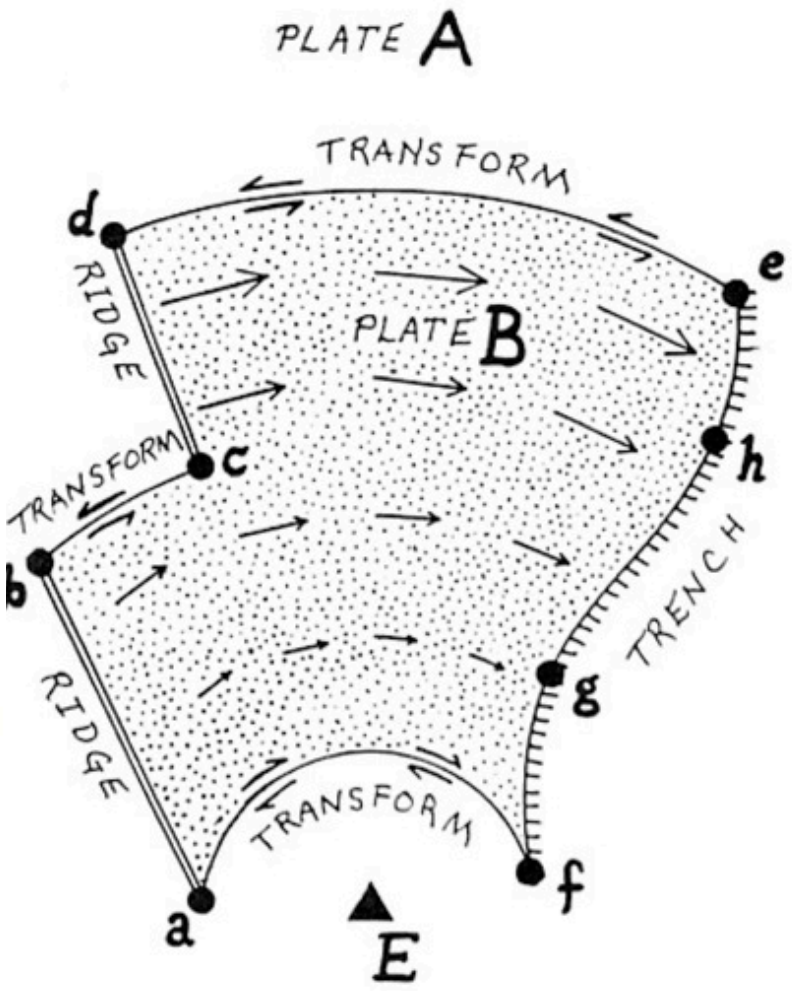
linz.govt.nz

Owens Valley VLBI antenna

Photograph of a scientist at a GPS receiver removed due to copyright restrictions. See the image on the GNS Science website.

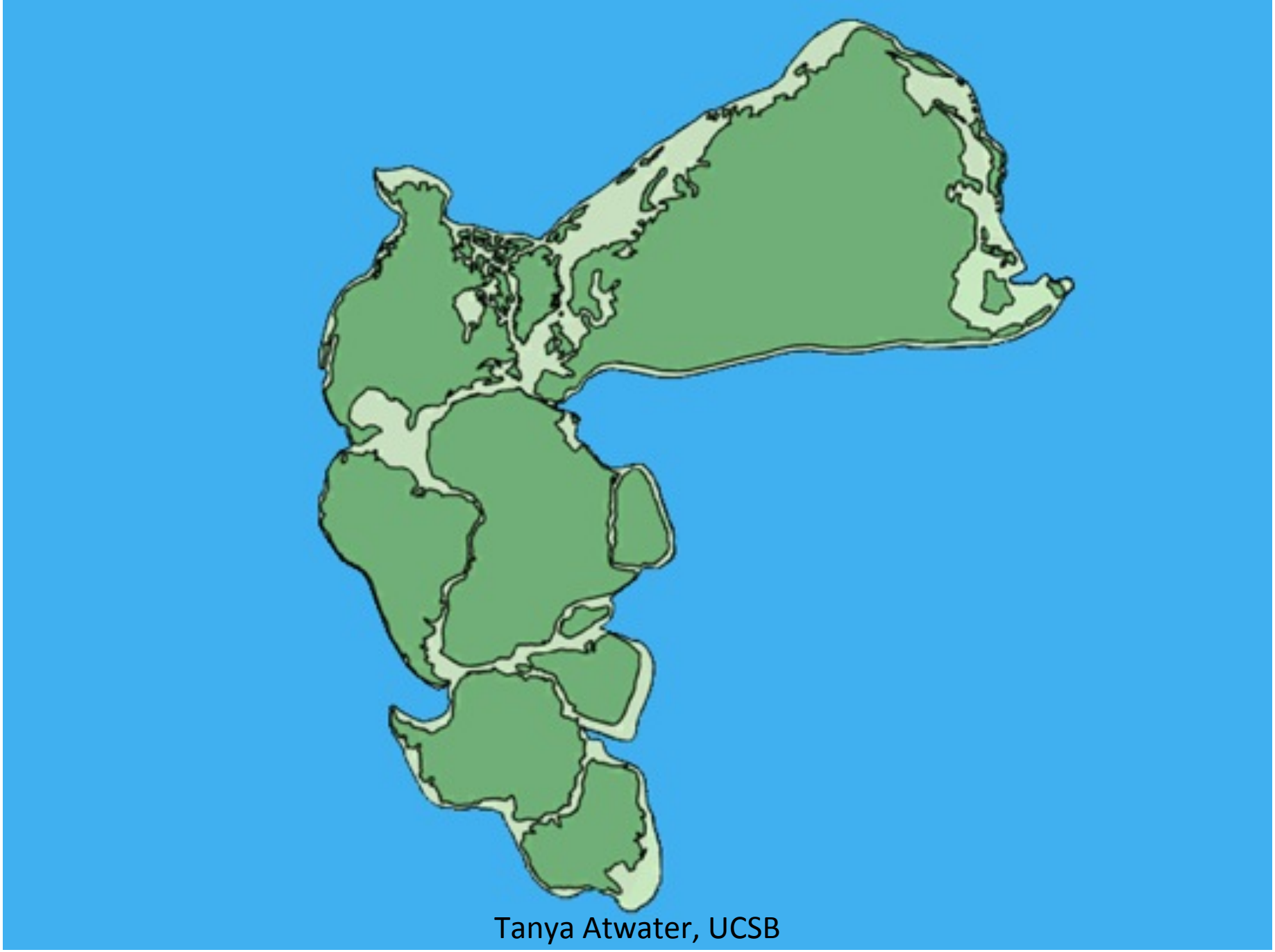
gns.cri.nz





Eric Calais, Purdue

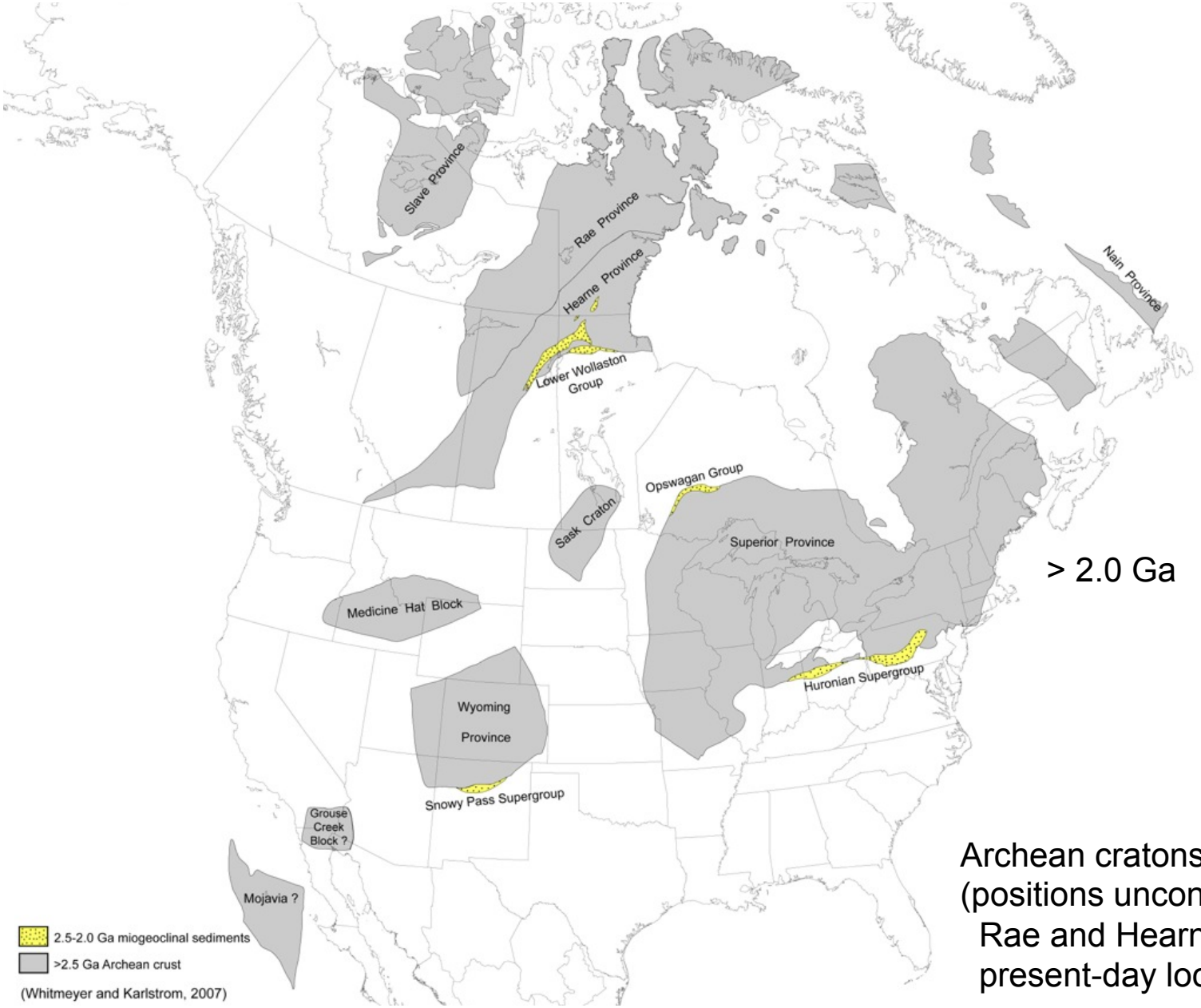
Source: Cox, Allan, and Robert Brian Hart. *Plate Tectonics: How It Works*. John Wiley & Sons, 2009.



PLATES 2004
Atlas of Plate Reconstructions
(750 Ma to Present Day)

By
L.A. Lawver, I.W.D. Dalziel, L.M. Gahagan, R.M. Kygar, and B.D. Herber

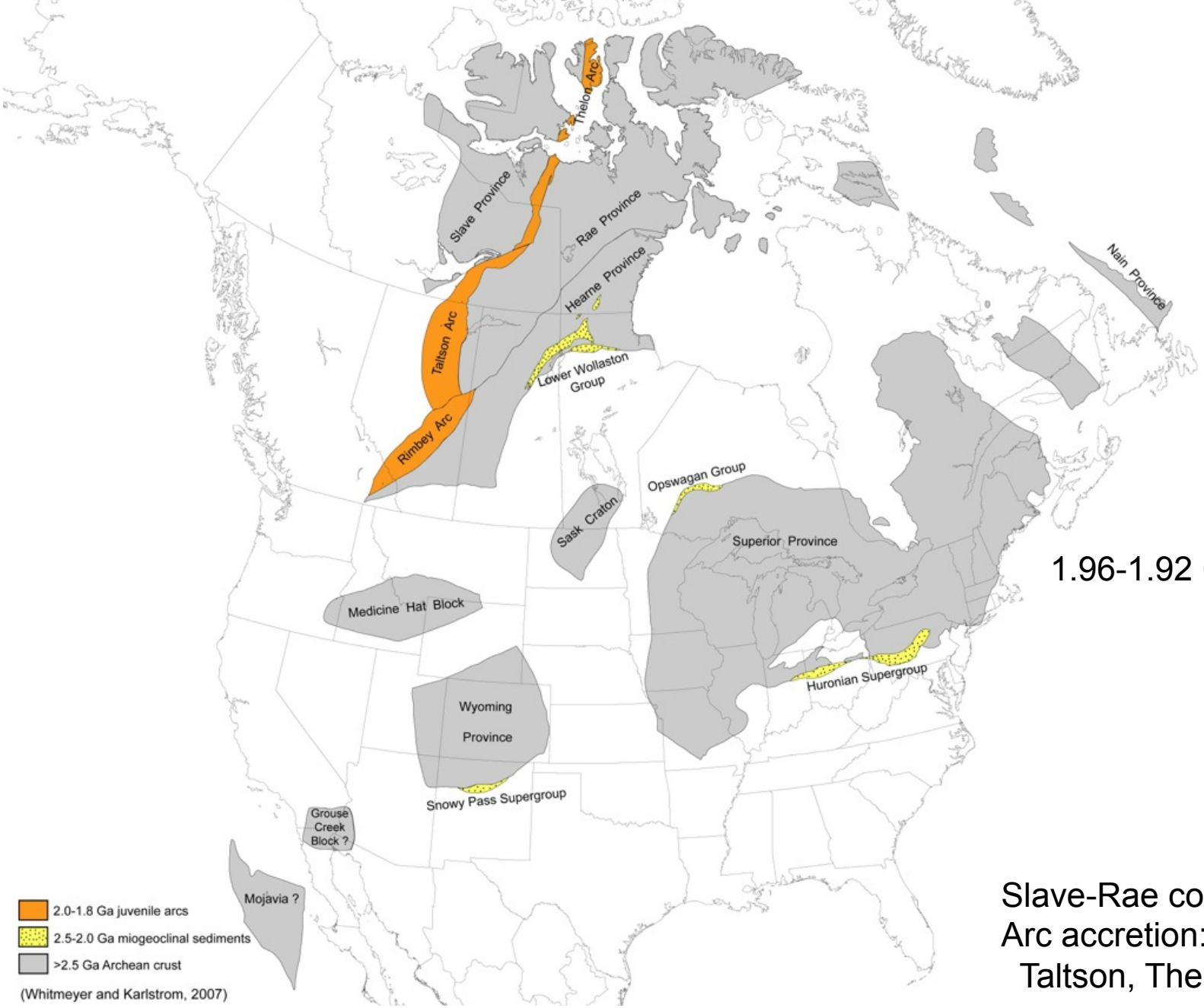
October 15, 2004



> 2.0 Ga

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

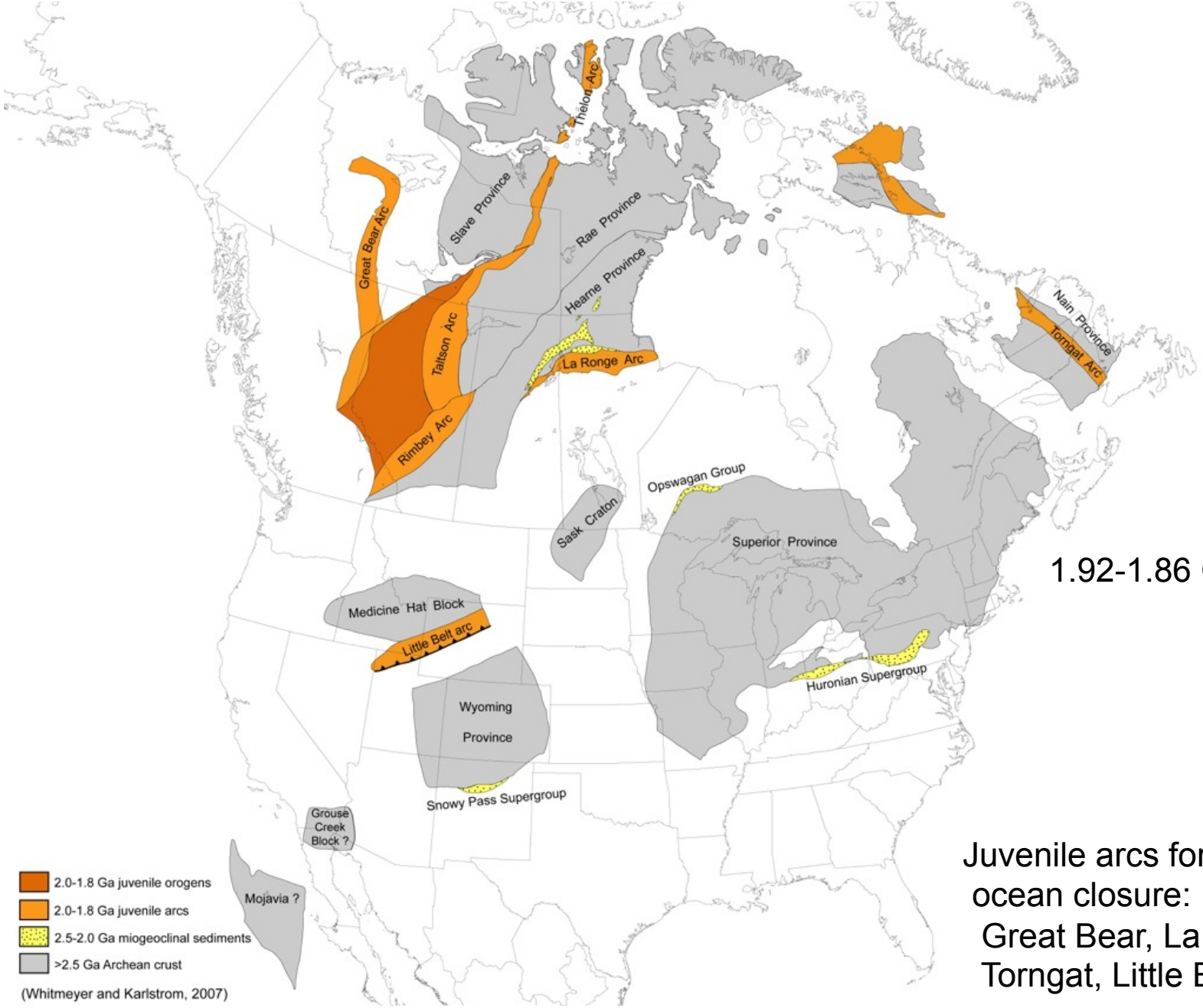
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.96-1.92 Ga

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

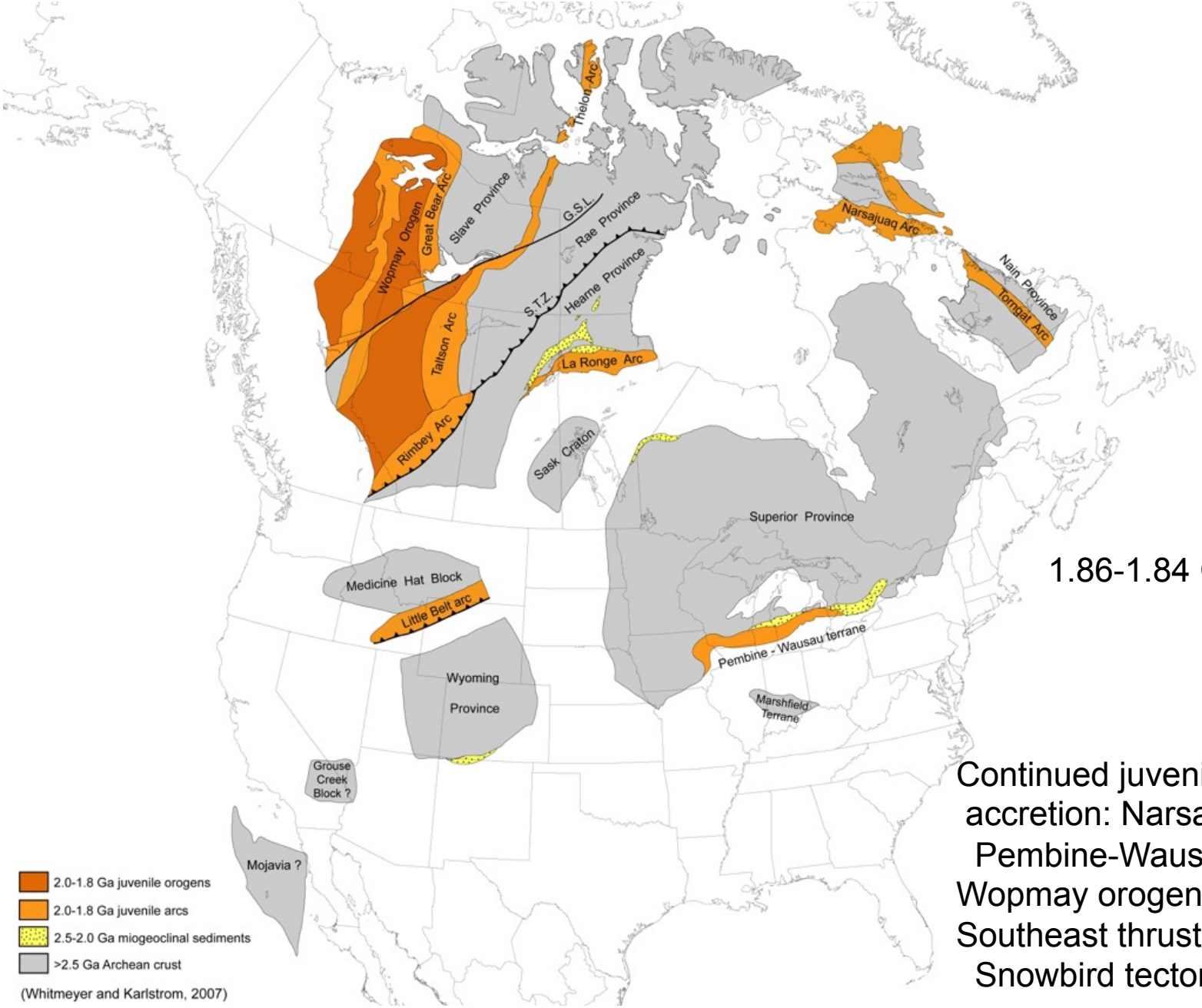
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.92-1.86 Ga

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

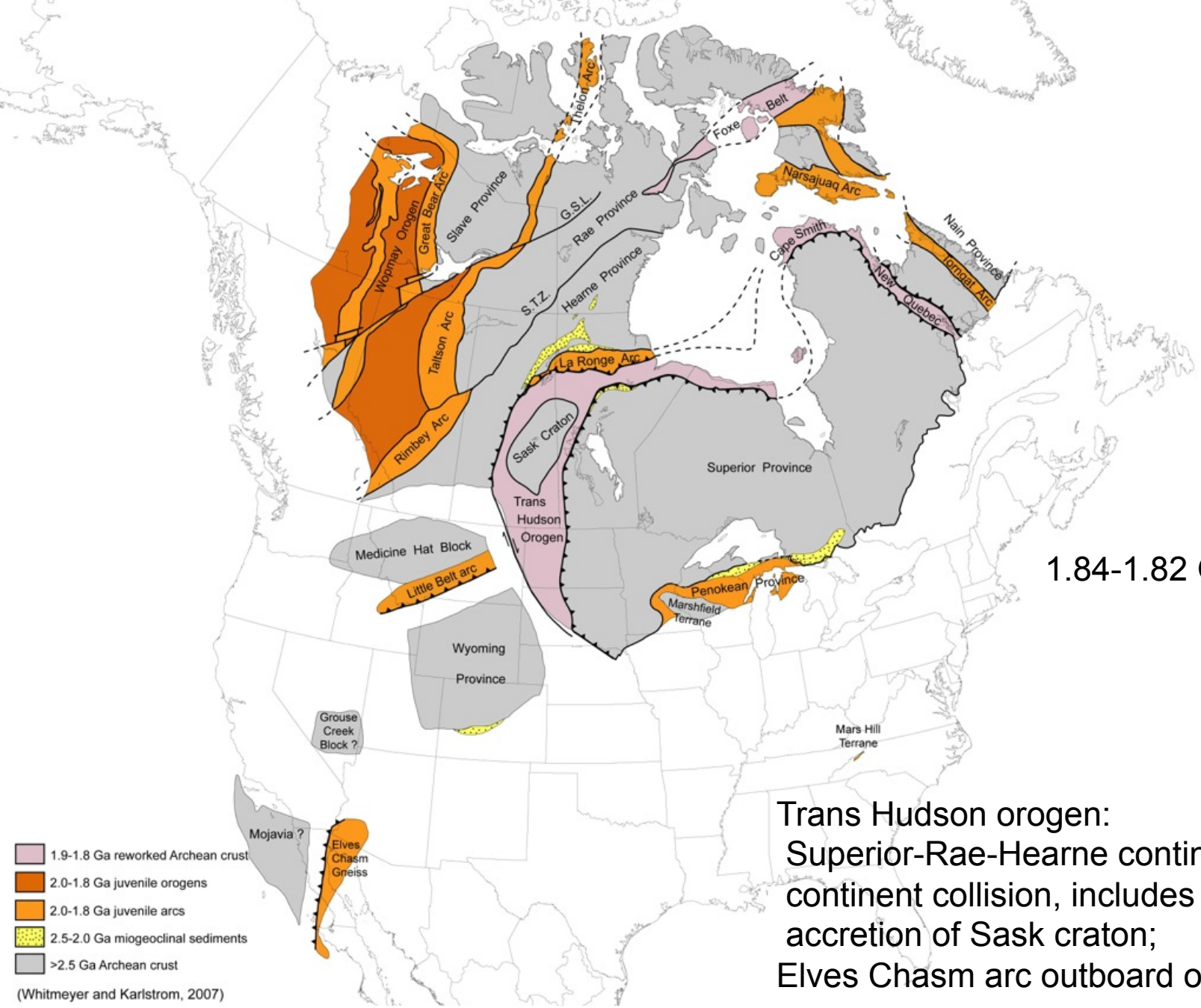
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.86-1.84 Ga

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

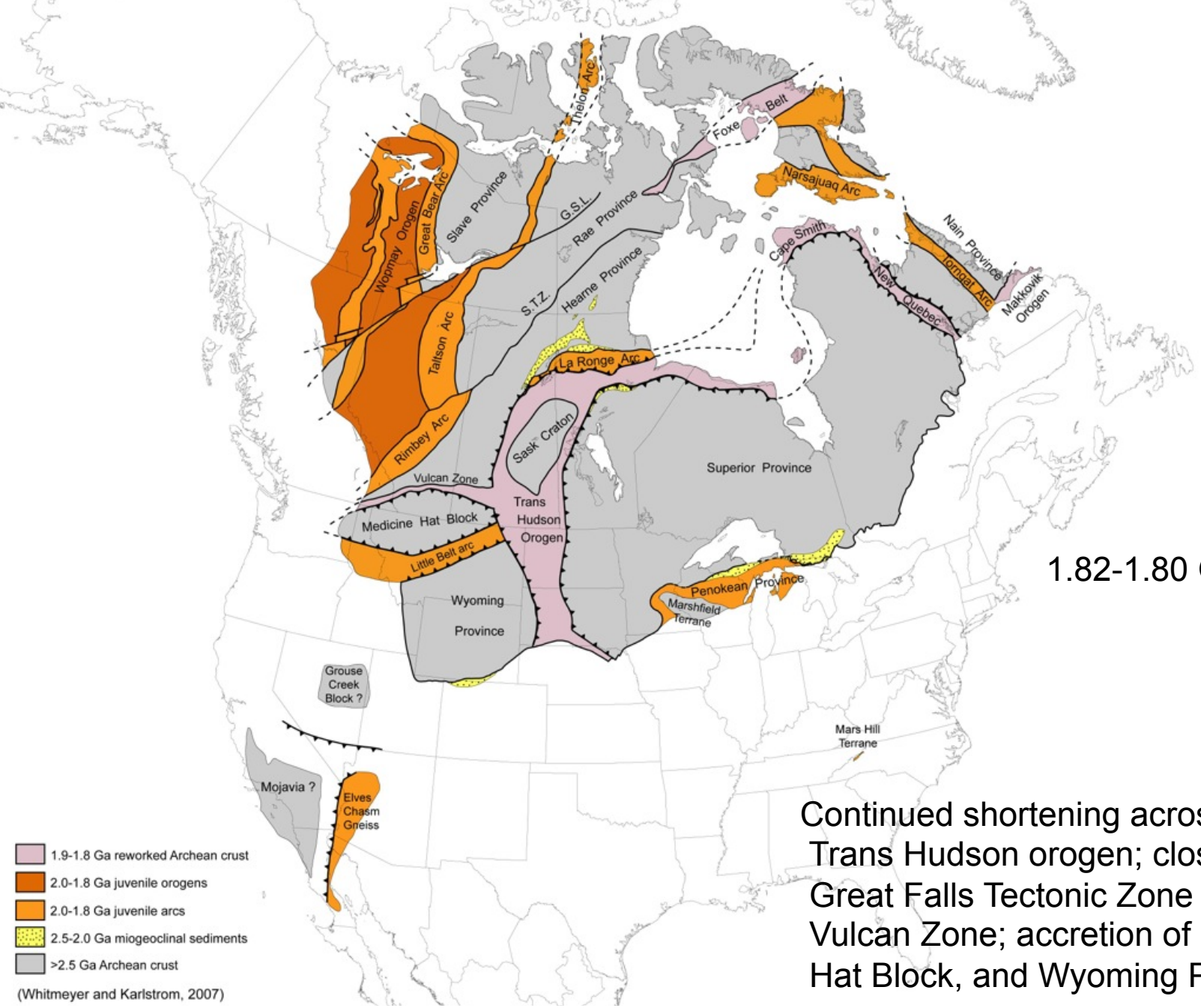
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



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

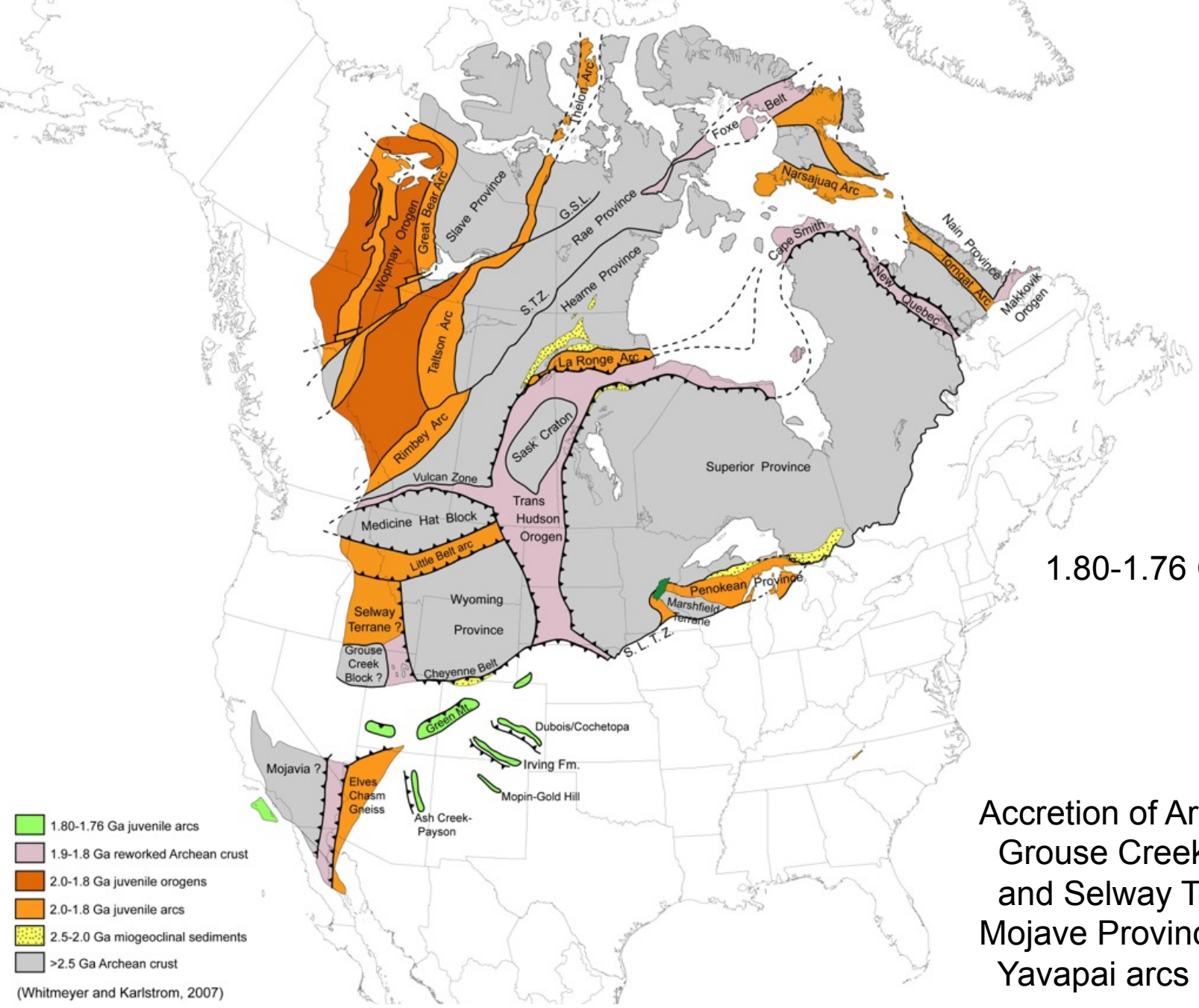
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



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

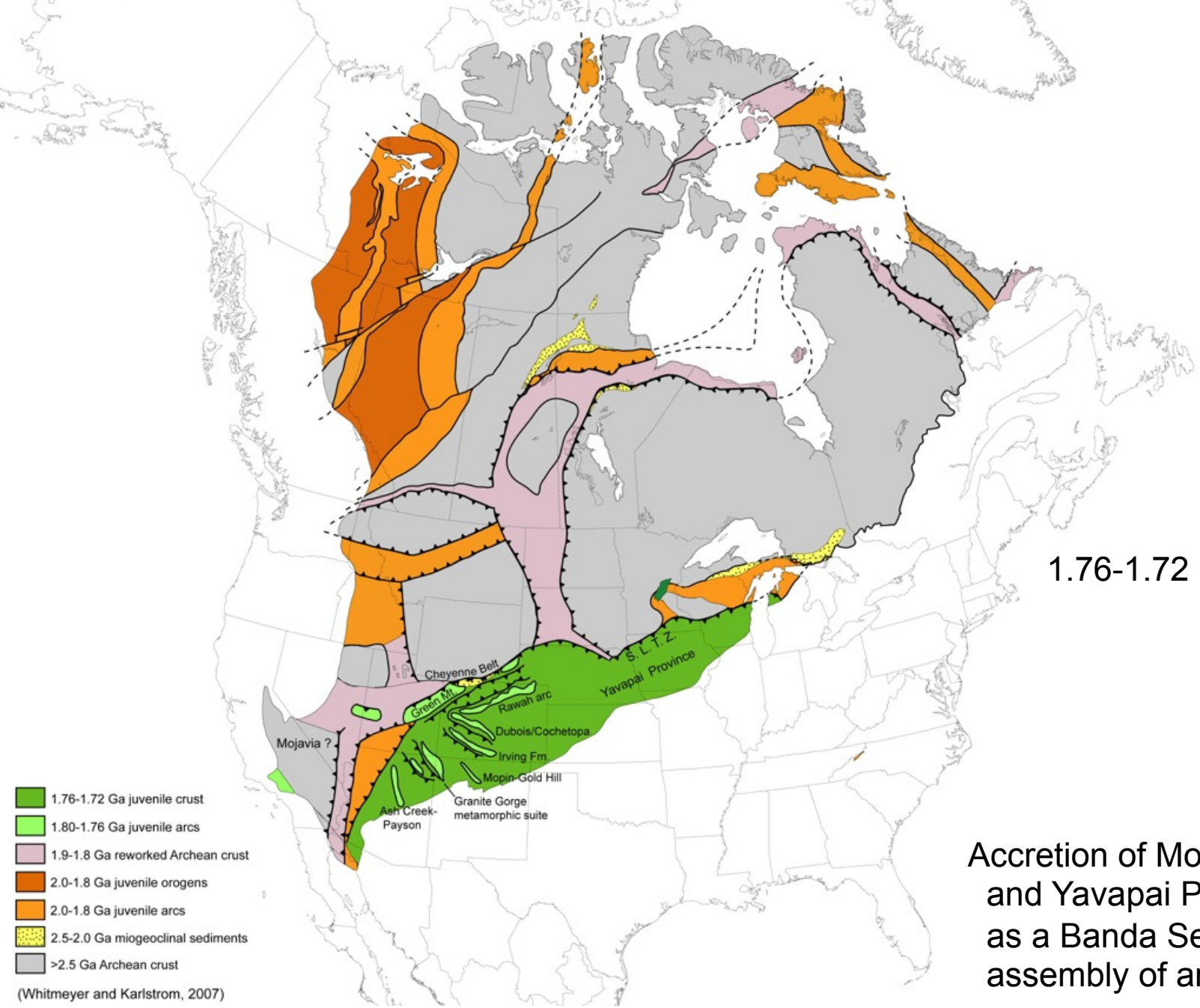
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.80-1.76 Ga

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

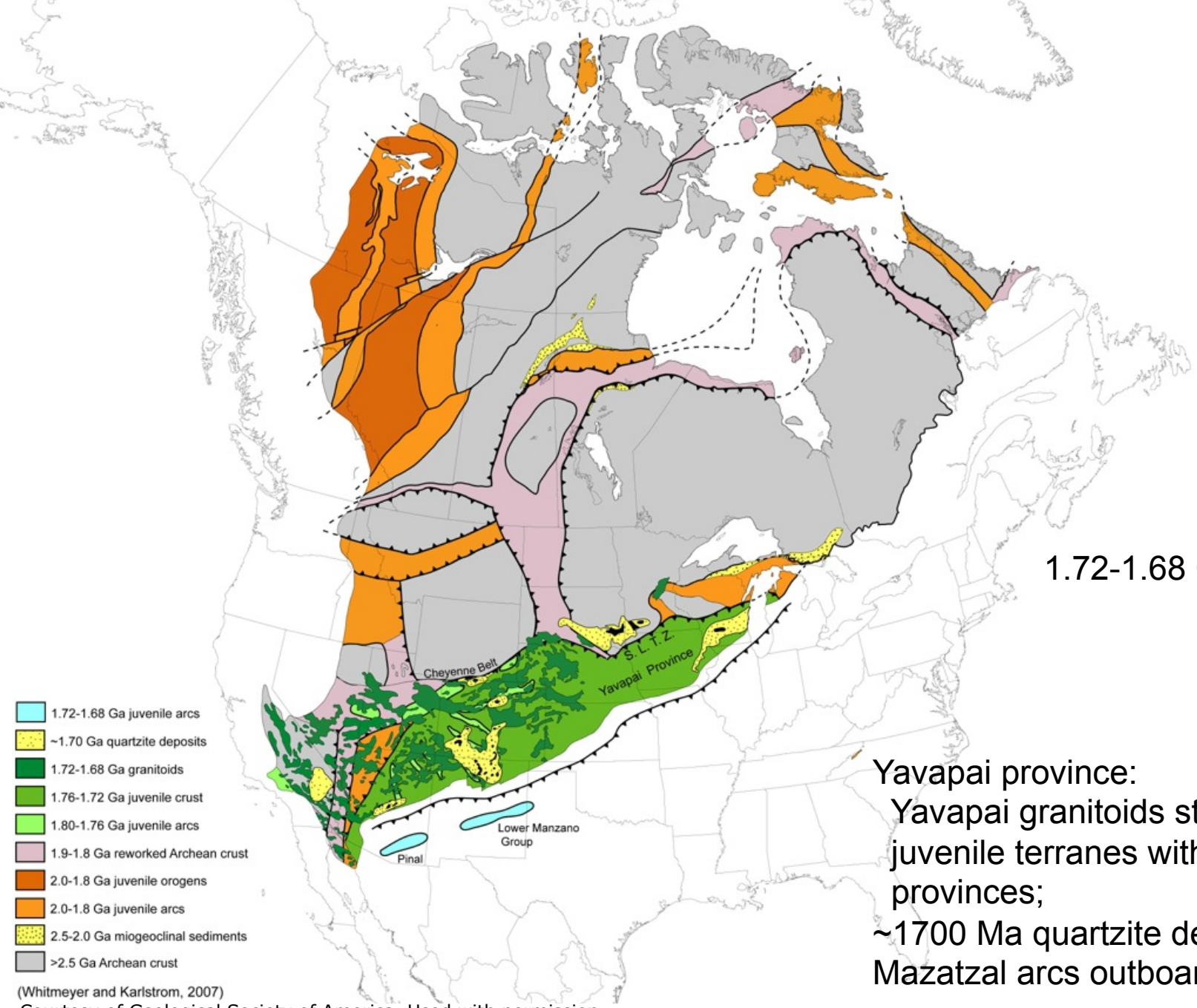
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.76-1.72 Ga

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

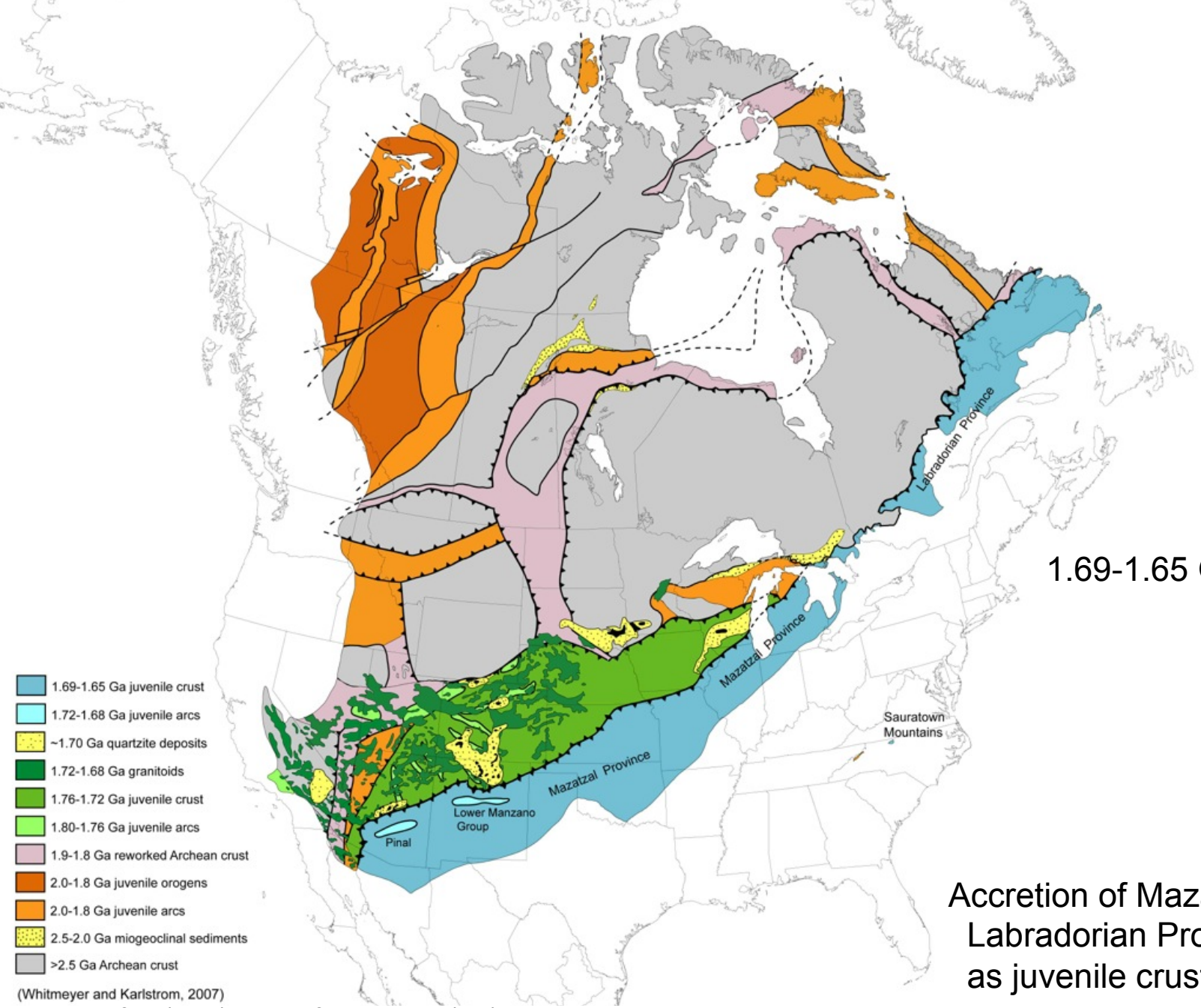
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.72-1.68 Ga

Yavapai province:
Yavapai granitoids stitch juvenile terranes with older provinces;
~1700 Ma quartzite deposition;
Mazatzal arcs outboard

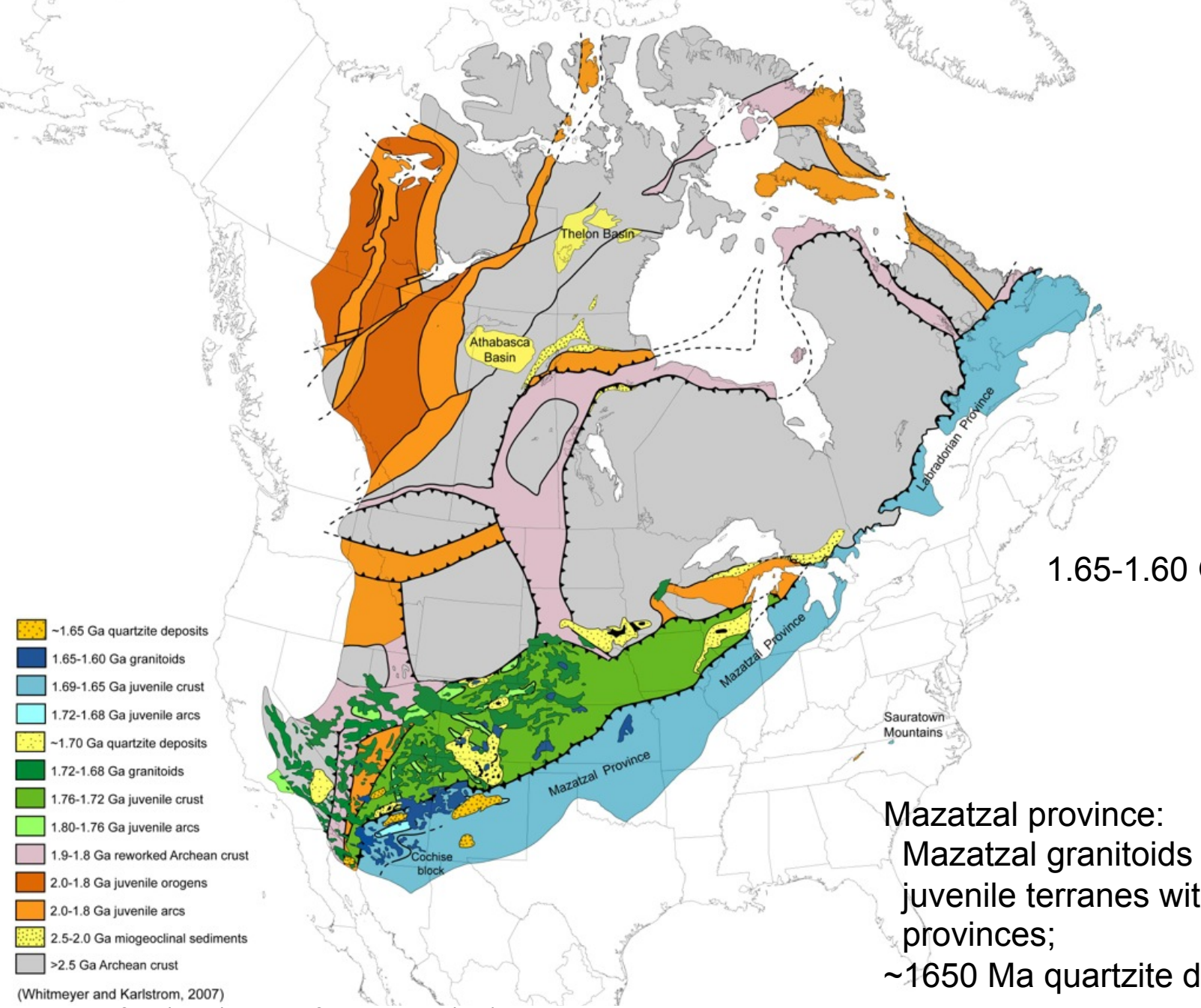
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.69-1.65 Ga

Accretion of Mazatzal and Labradorian Provinces, as juvenile crust

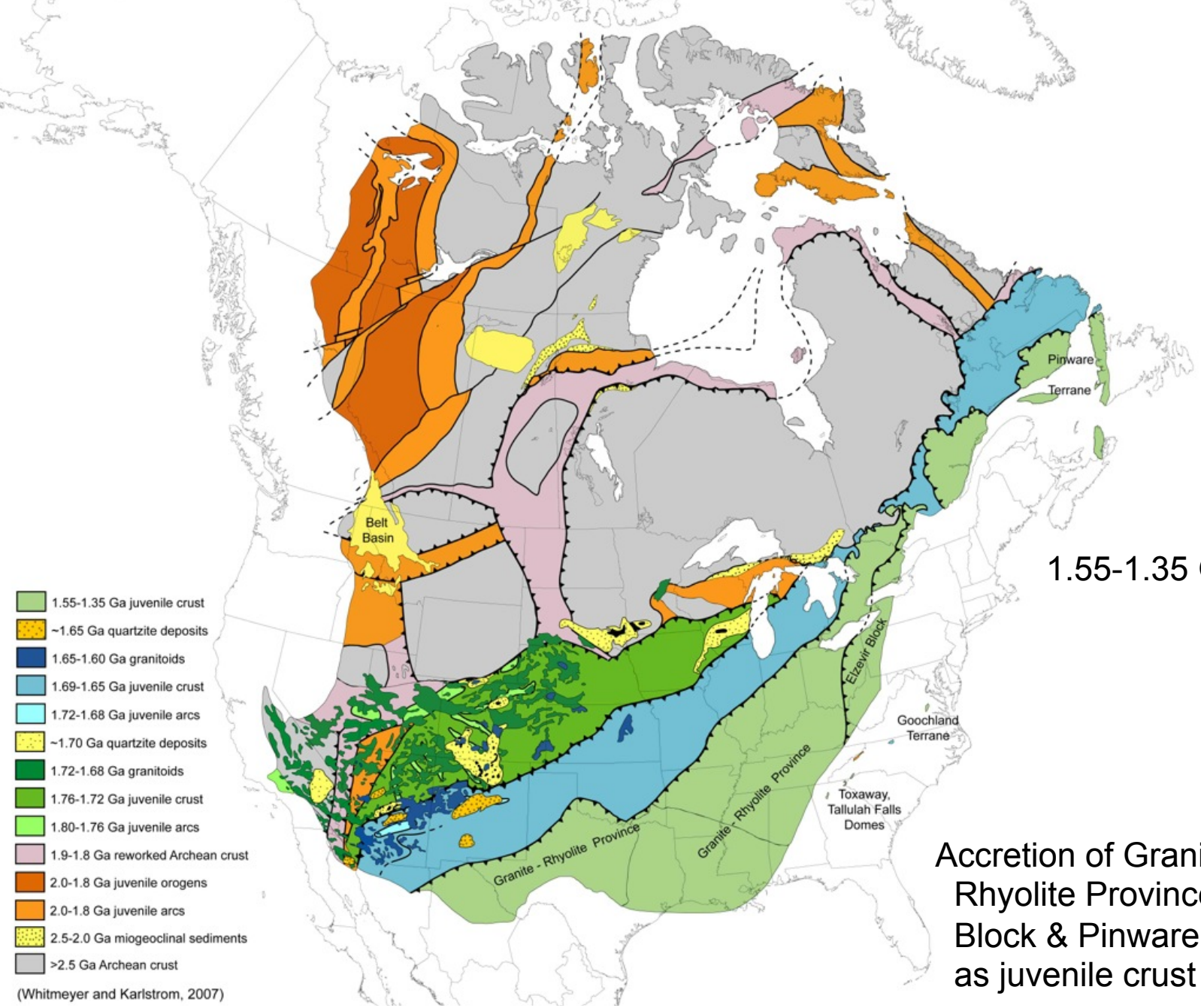
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.65-1.60 Ga

Mazatzal province:
Mazatzal granitoids stitch juvenile terranes with older provinces;
~1650 Ma quartzite deposition

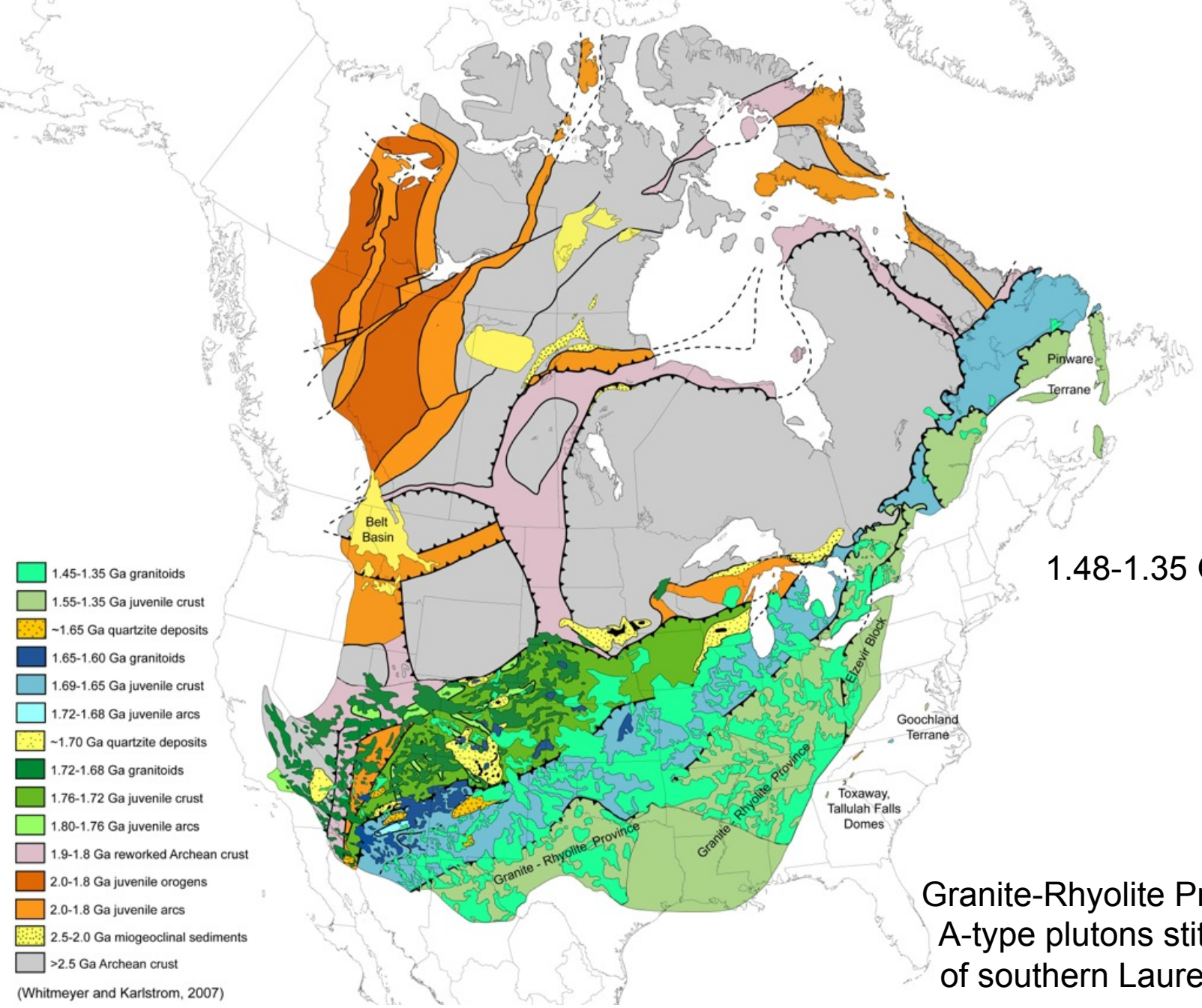
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.55-1.35 Ga

Accretion of Granite-Rhyolite Province, Elzevir Block & Pinware terrane, as juvenile crust

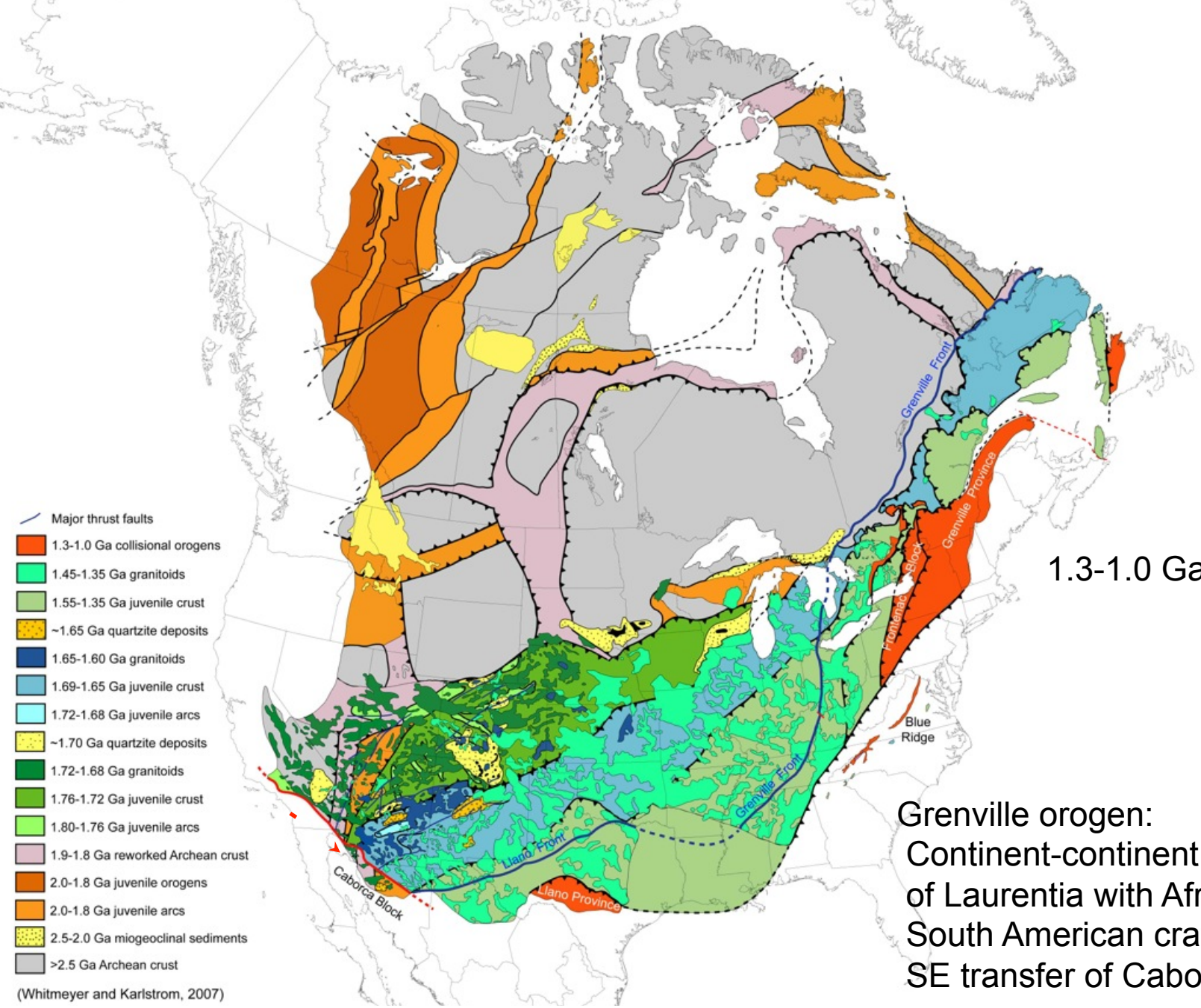
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.48-1.35 Ga

Granite-Rhyolite Province:
A-type plutons stitch much of southern Laurentia

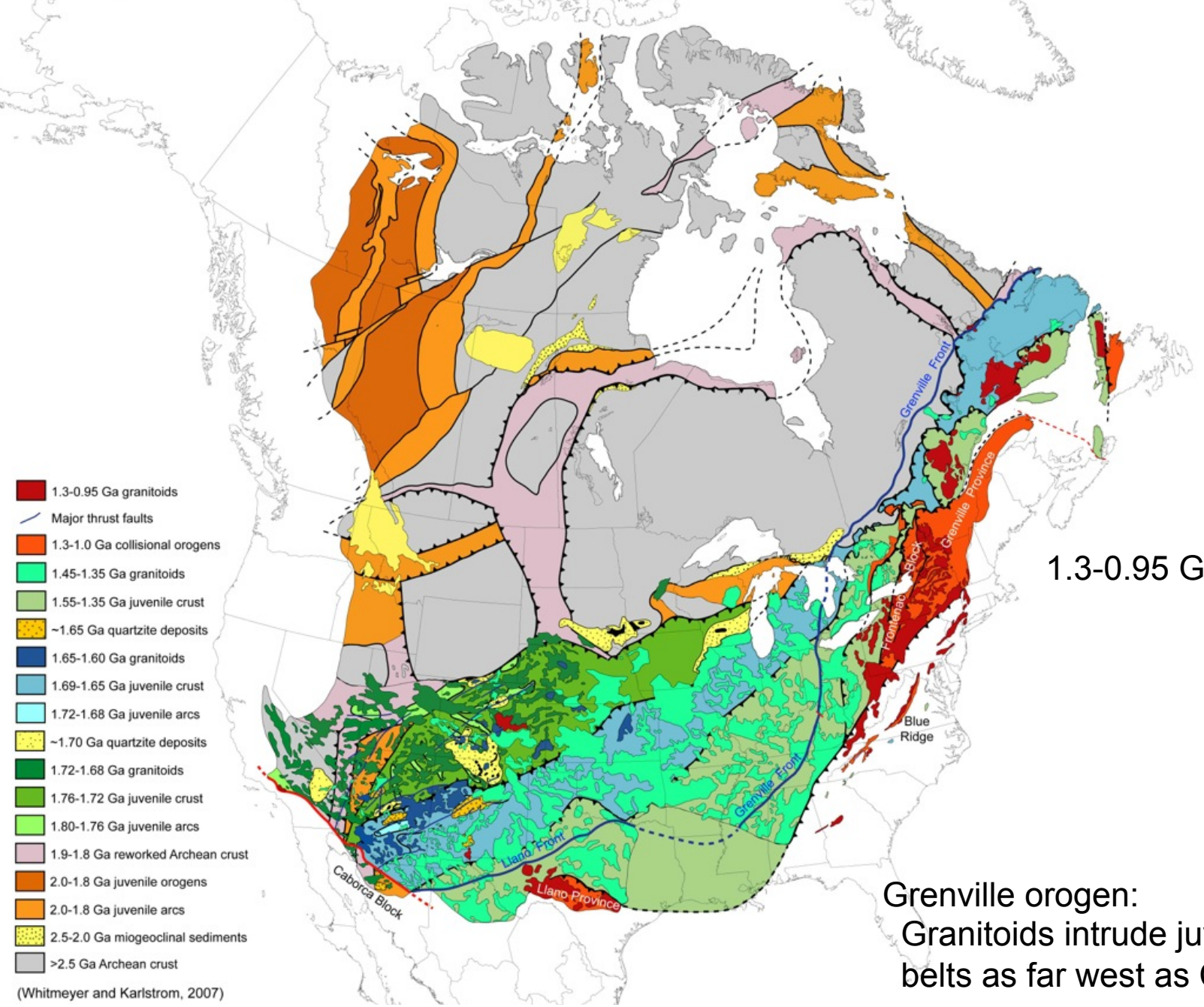
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.3-1.0 Ga

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

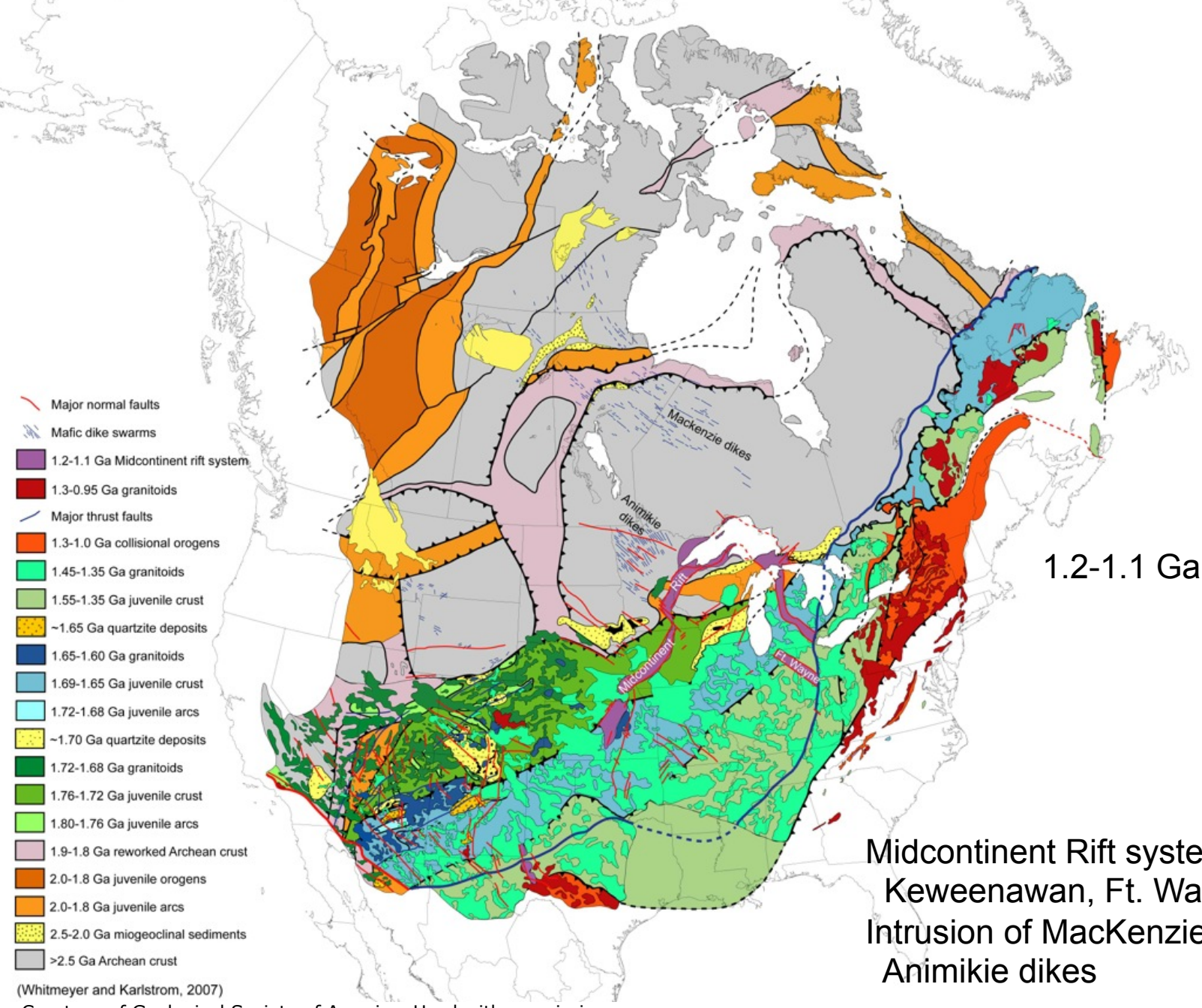
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.3-0.95 Ga

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

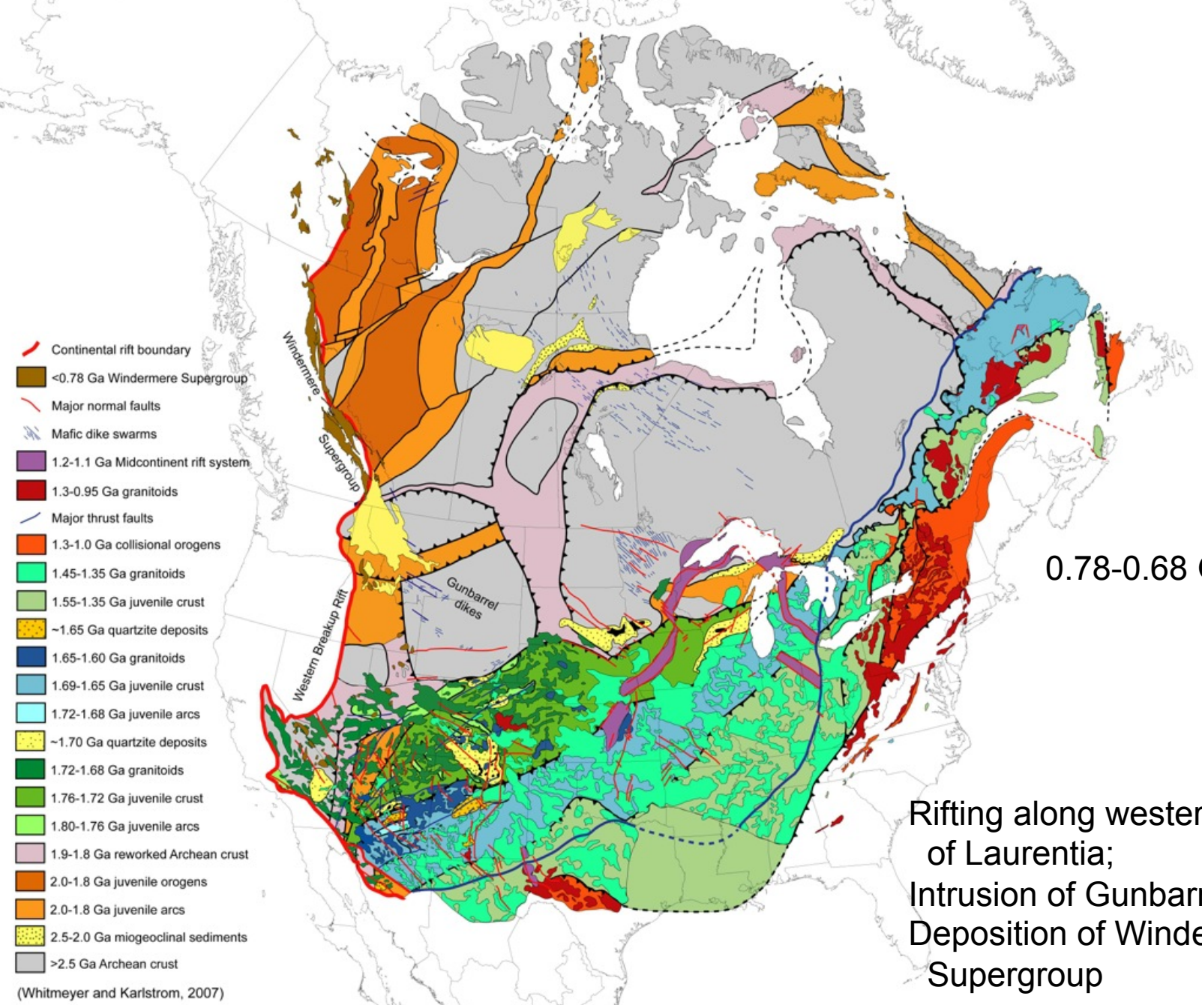
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



1.2-1.1 Ga

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

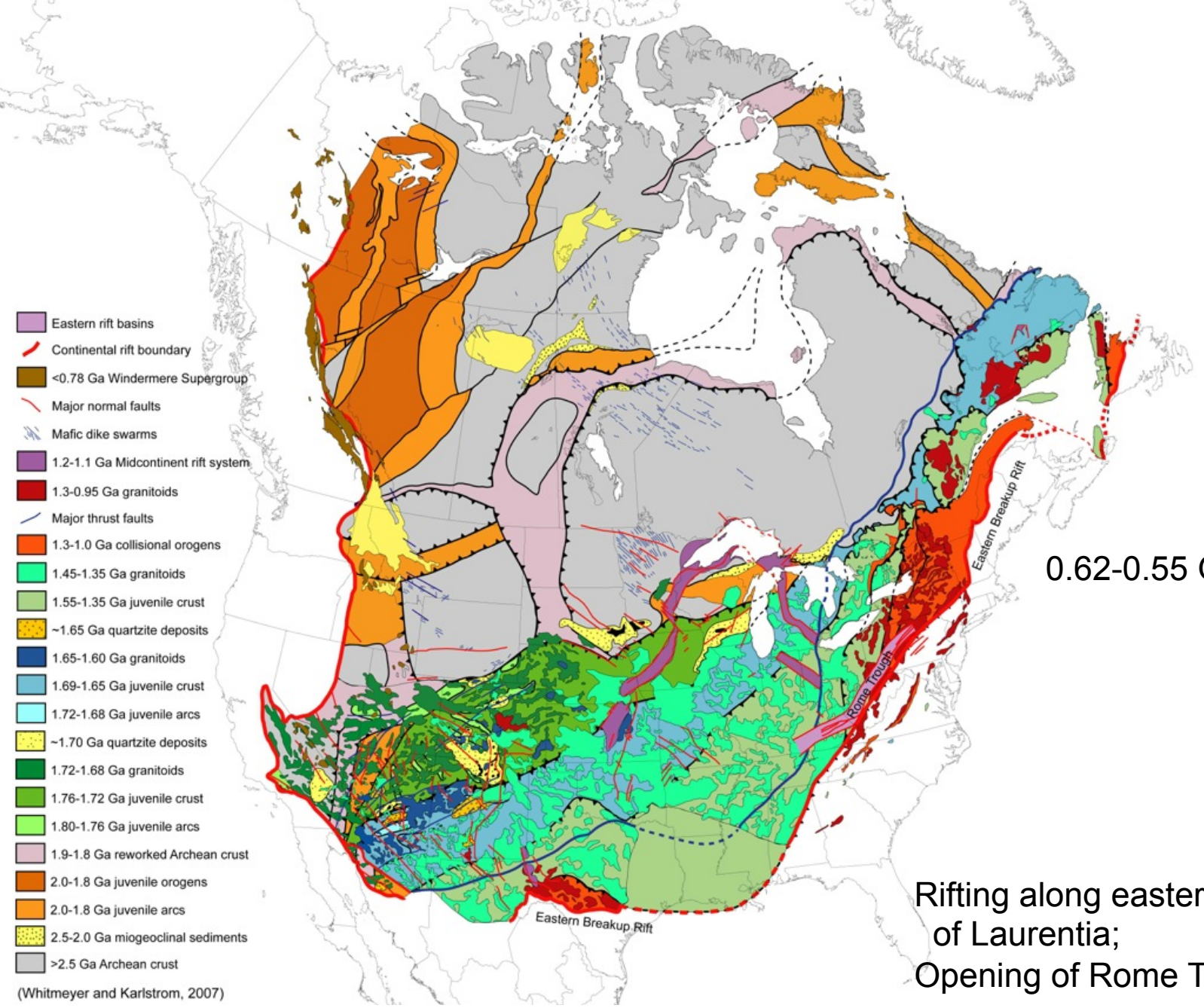
Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



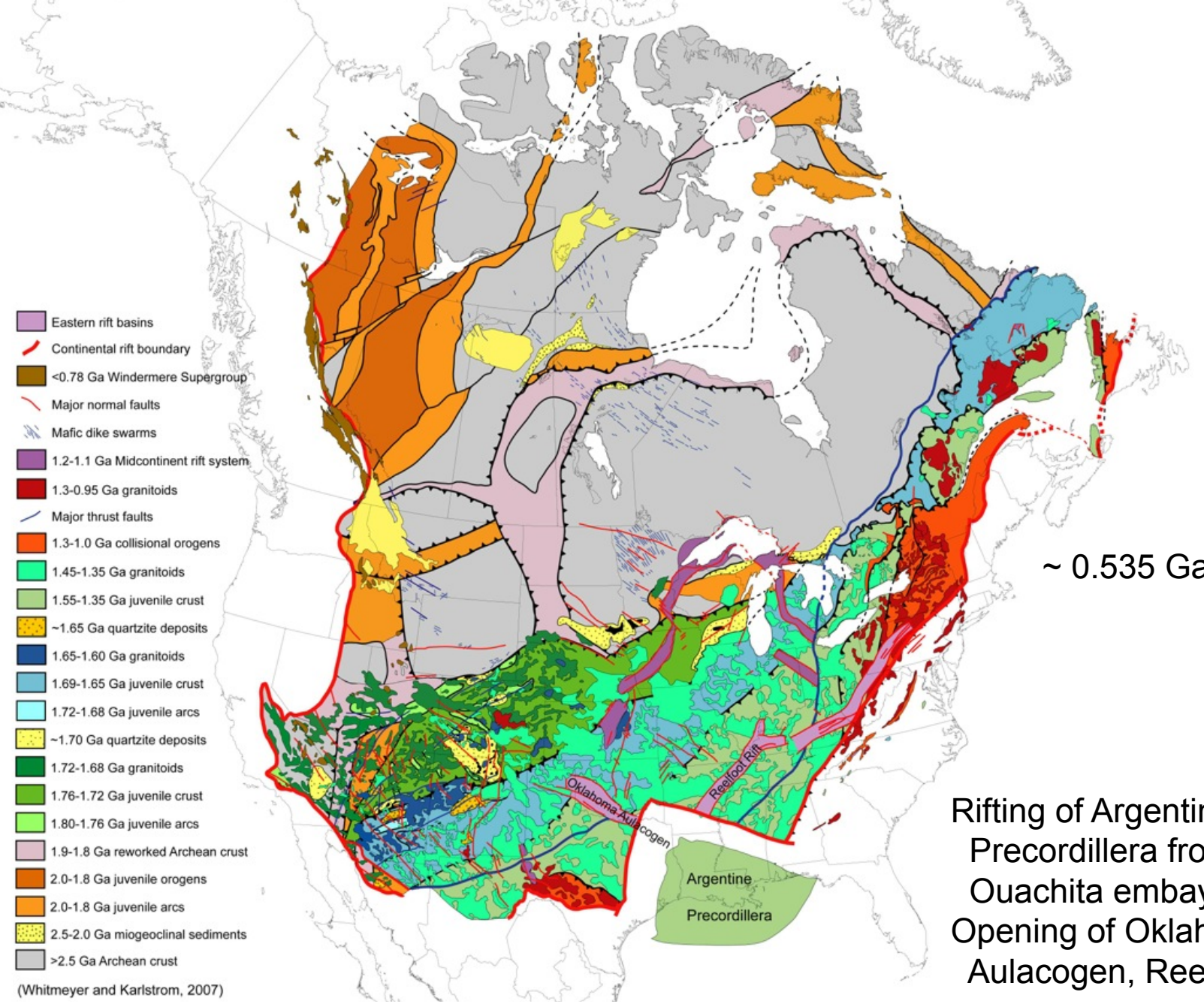
0.78-0.68 Ga

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

Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.



~ 0.535 Ga

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

Source: Whitmeyer, Steven J., and Karl E. Karlstrom. "Tectonic Model for the Proterozoic Growth of North America." *Geosphere* 3, no. 4 (2007): 220-59.

1. Continental rifting (ex: E. Africa)

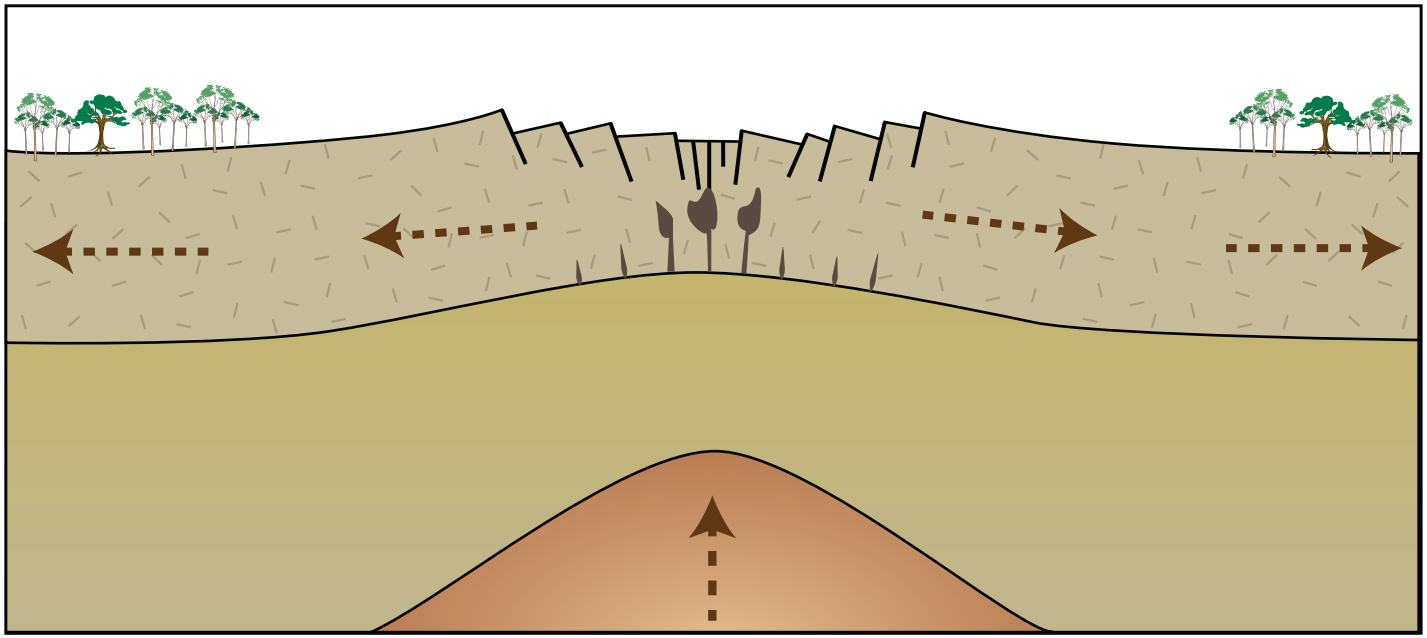


Image by MIT OpenCourseWare.

2. Formation of seafloor spreading center (ex: Red Sea)

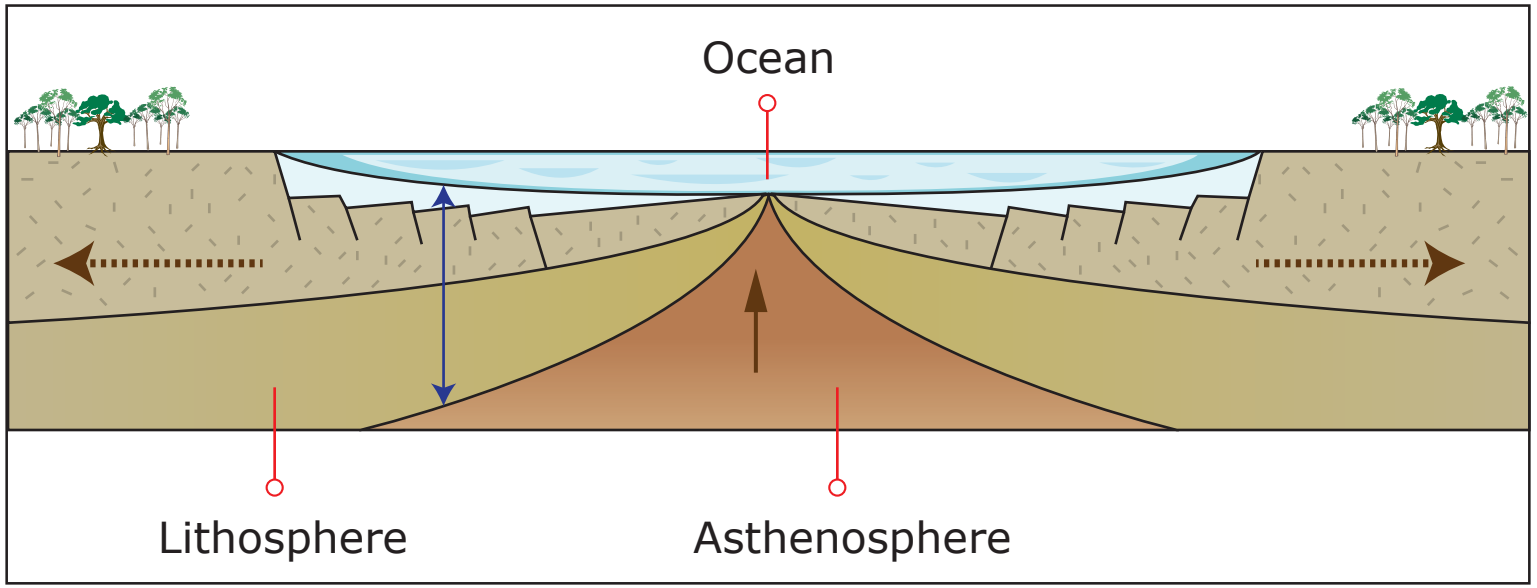


Image by MIT OpenCourseWare.

3. Widening ocean basin (ex: Atlantic)

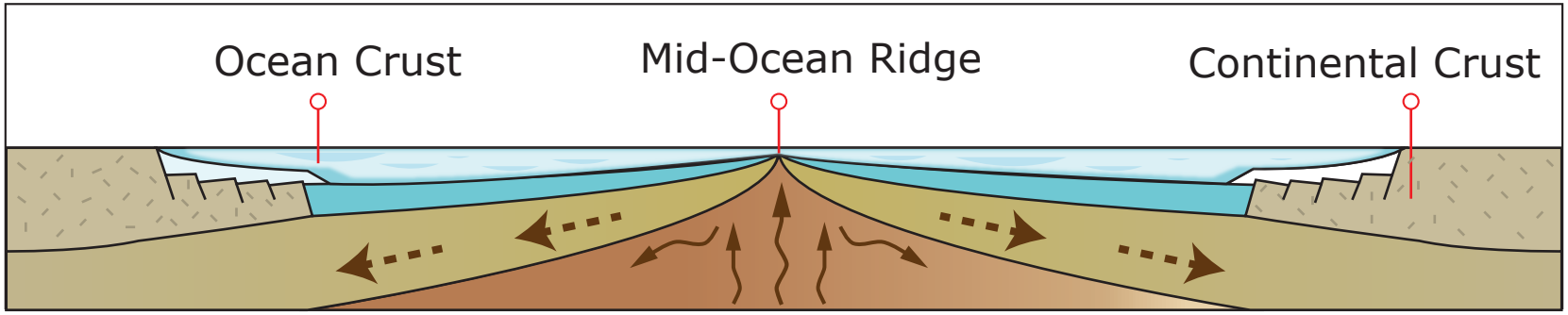


Image by MIT OpenCourseWare.

4. Initiation of subduction (ex: Pacific Rim)

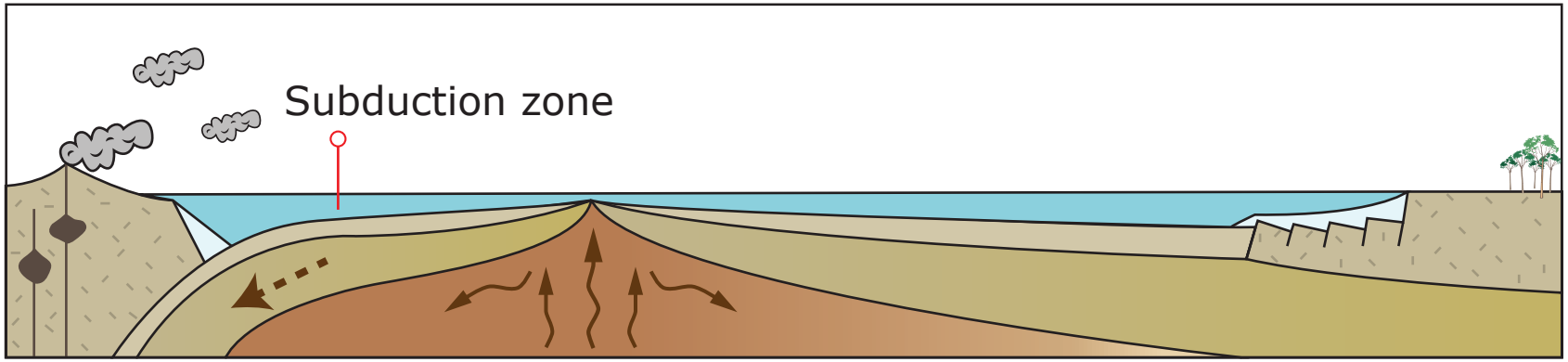


Image by MIT OpenCourseWare.

5. Subduction of spreading center (ex: Juan de Fuca Ridge)

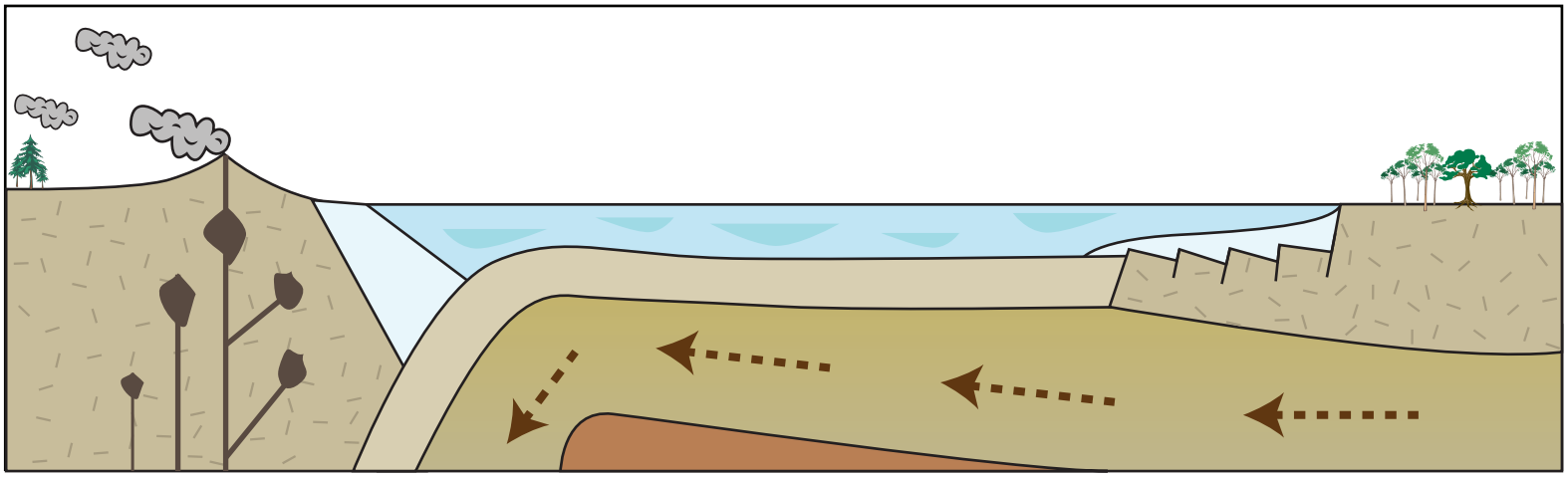


Image by MIT OpenCourseWare.

6. Closing of ocean, formation of collisional orogen (ex: closure of Iapetus Ocean to form the Appalachians)

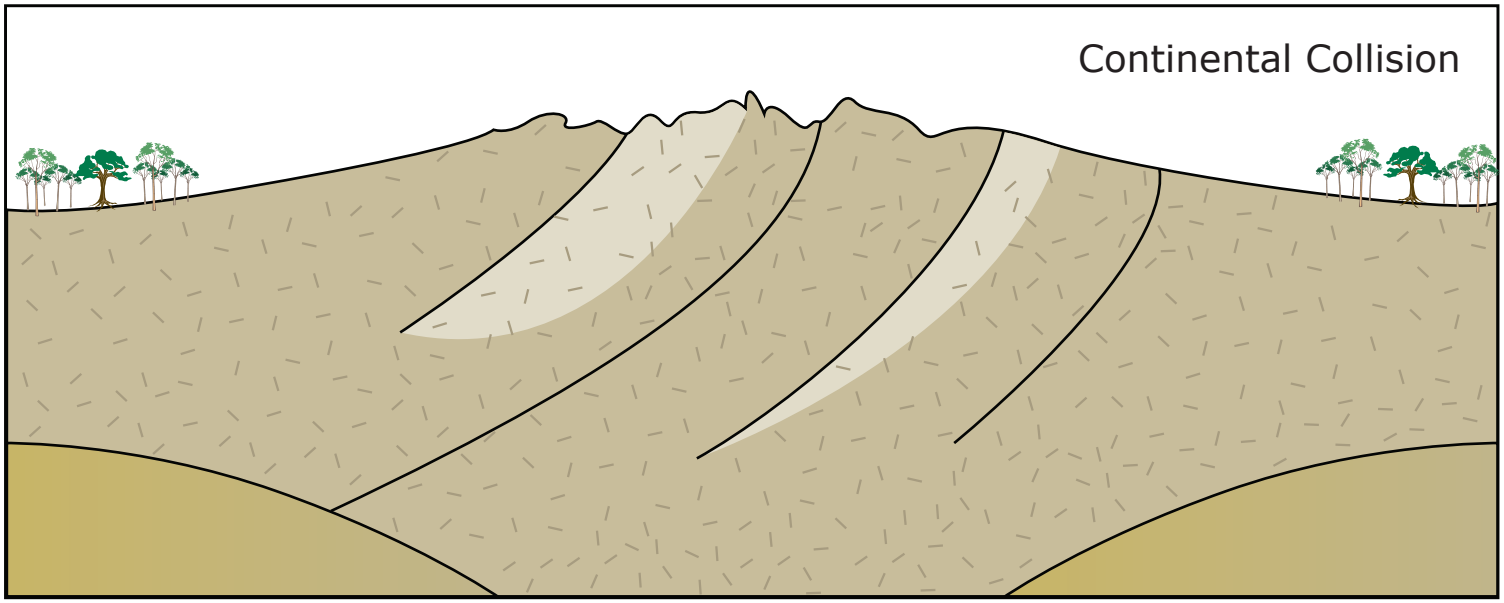
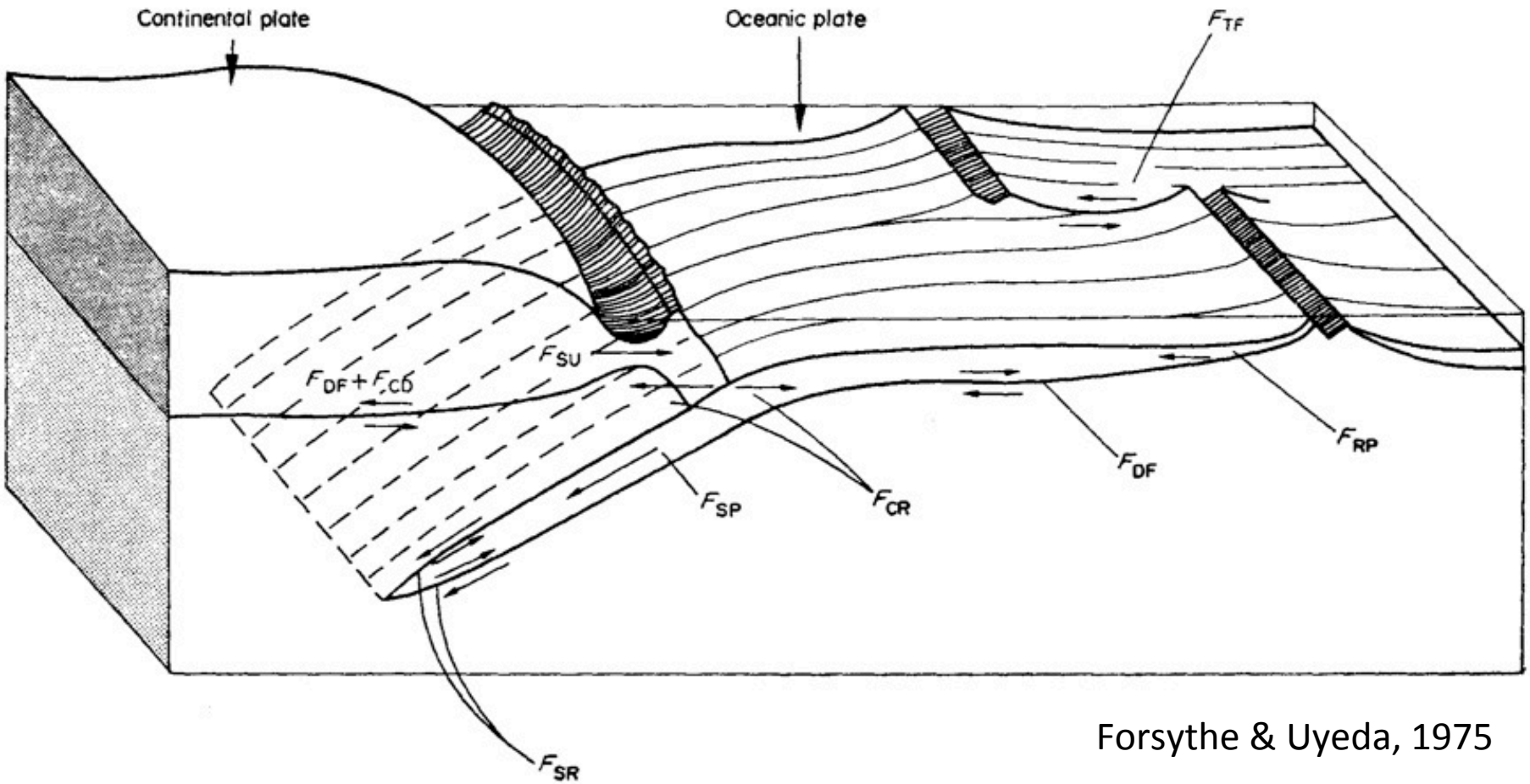
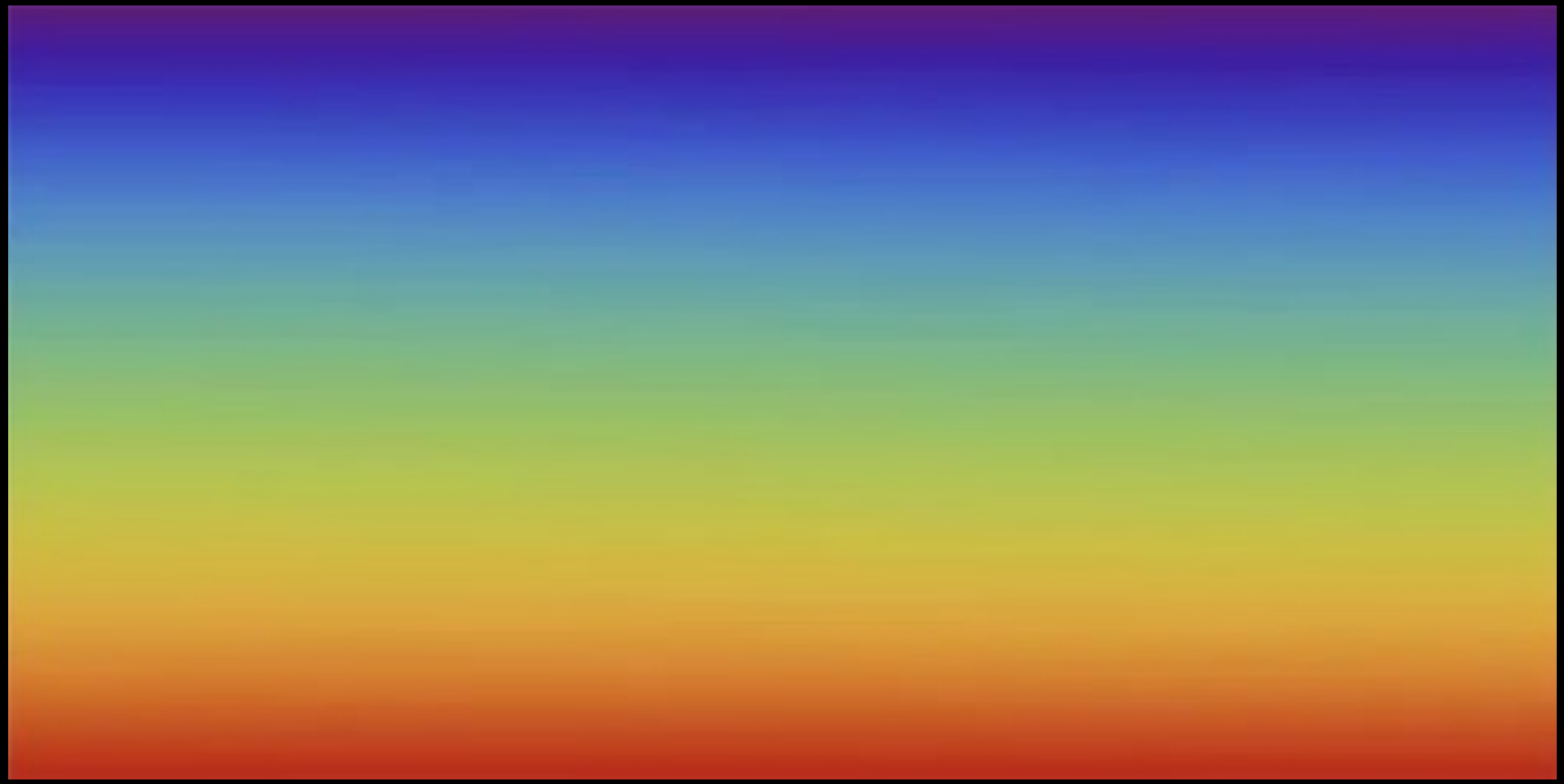


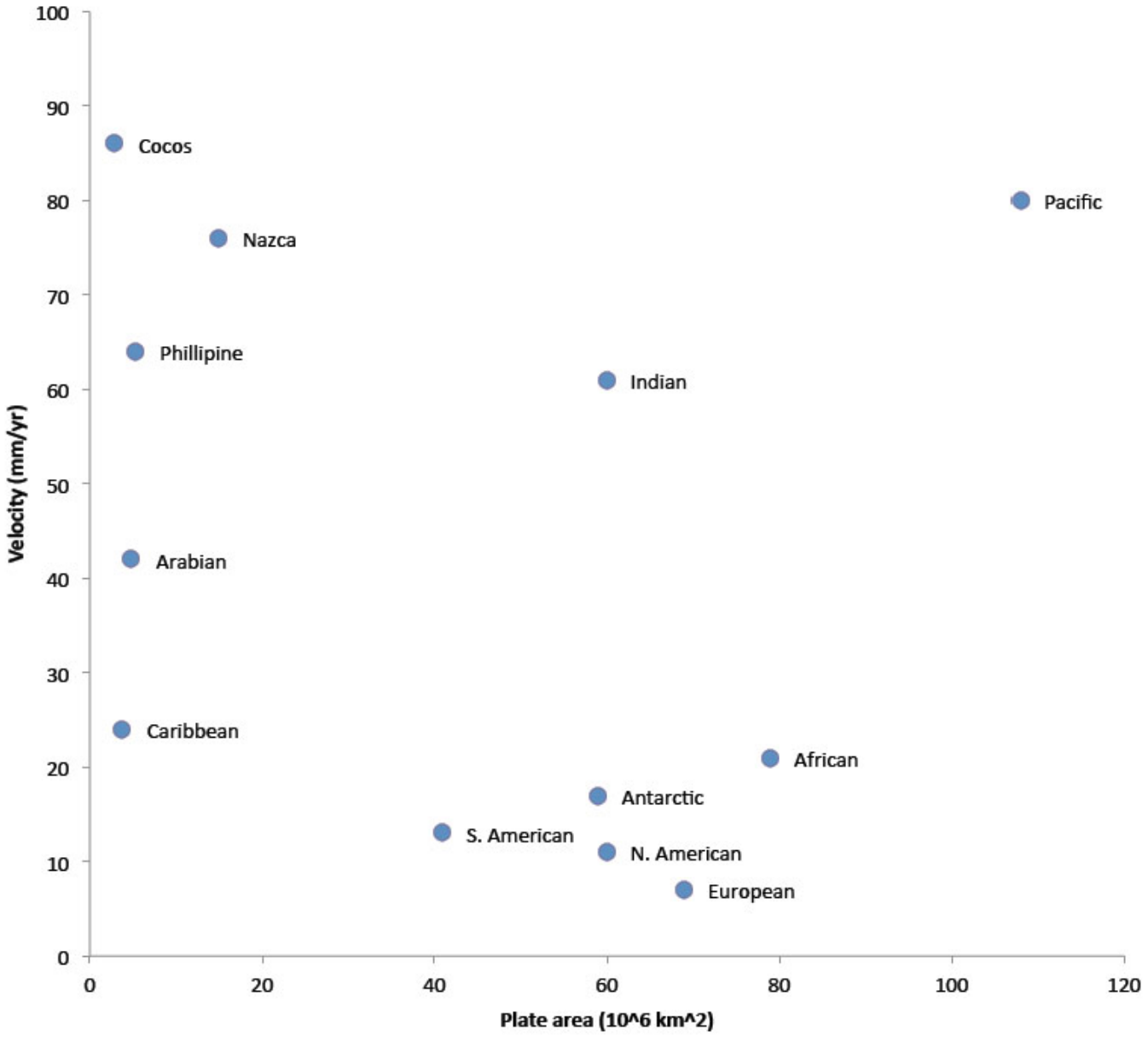
Image by MIT OpenCourseWare.



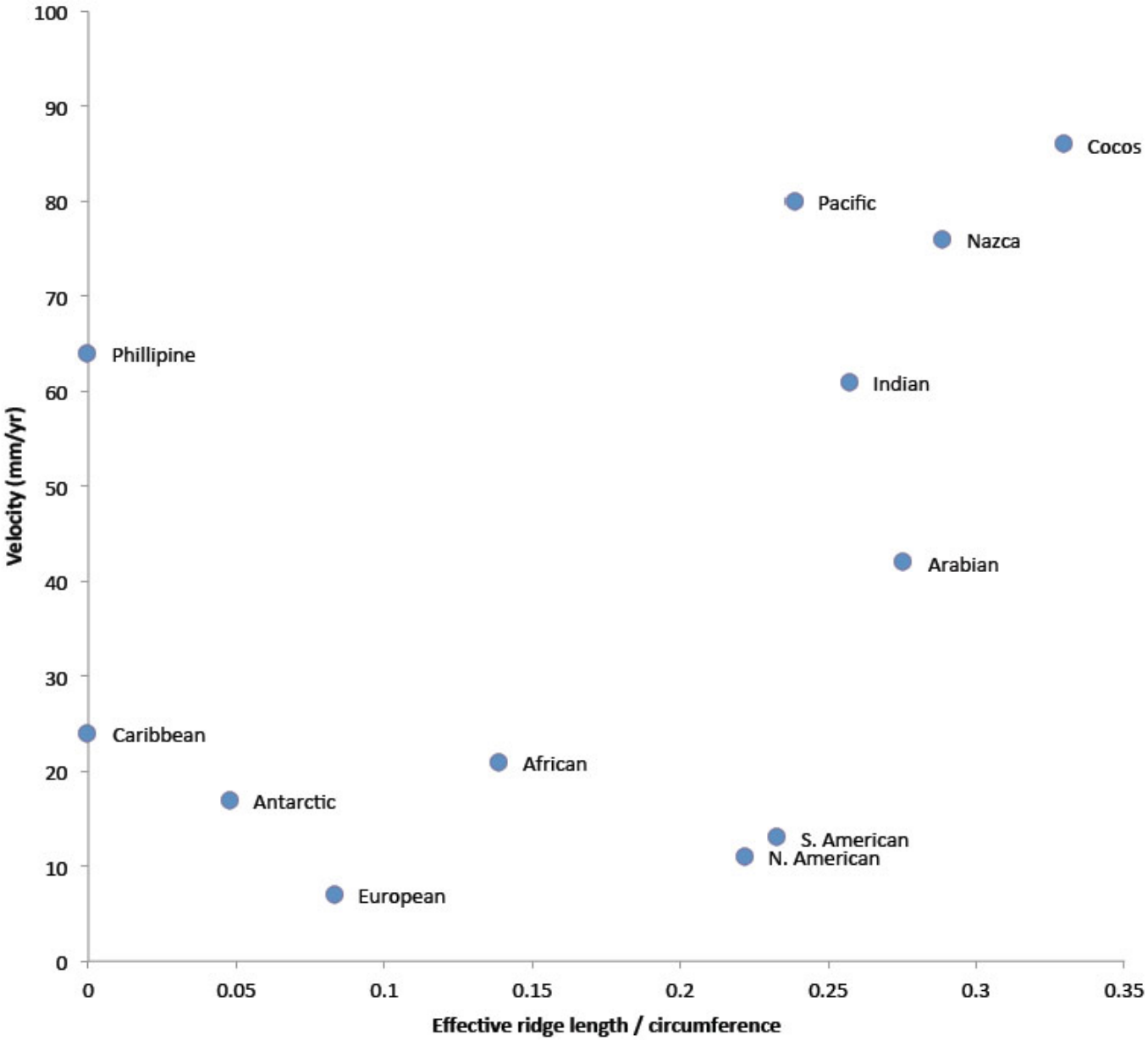
Forsythe & Uyeda, 1975

Source: Uyeda, S., and D. Forsythe. "On the Relative Importance of the Driving Forces of Plate Motion." *Royal Astronomical Society Geophysical Journal* 43 (1975): 163-200.





Data from Forsythe & Uyeda, 1975



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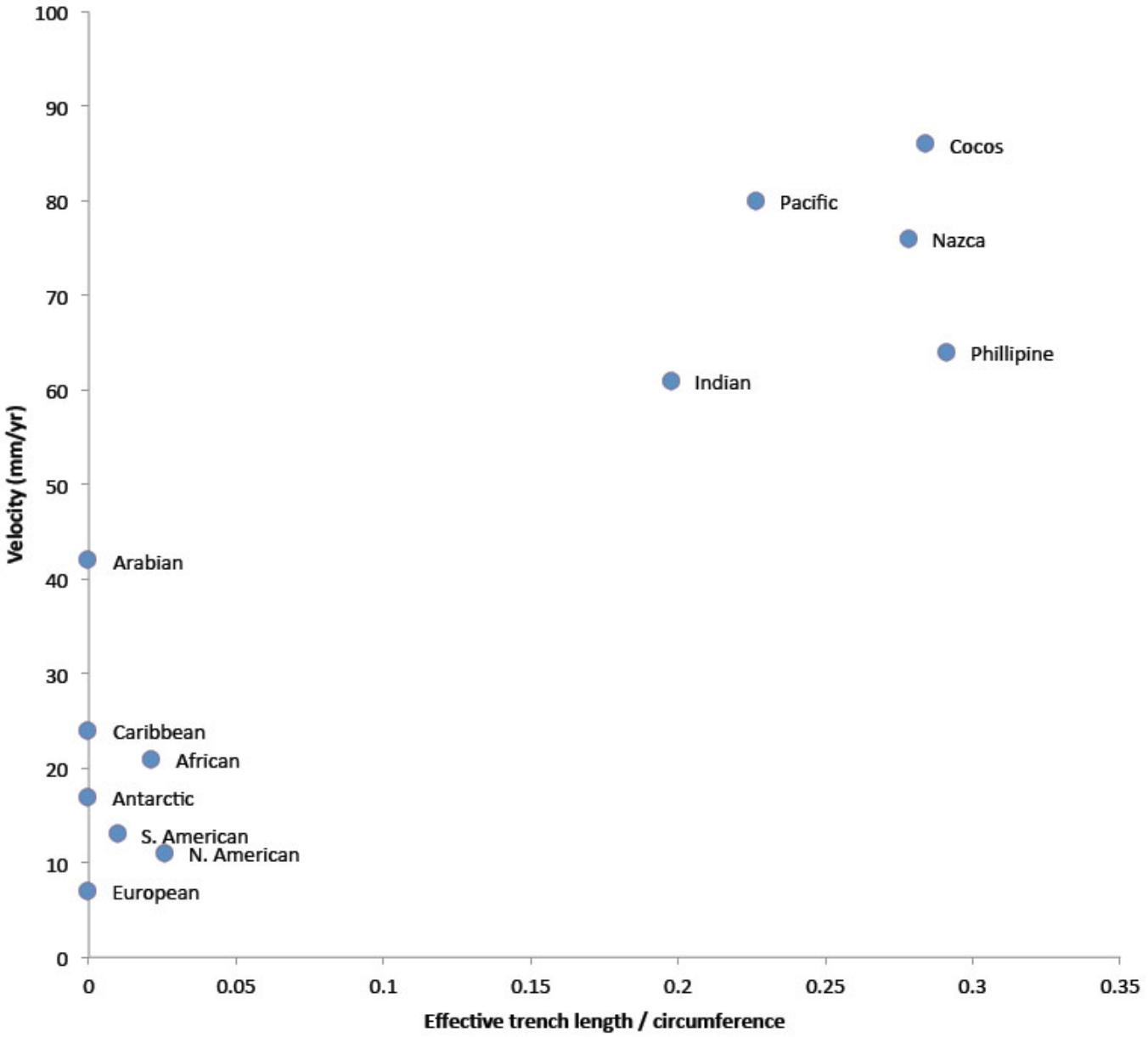
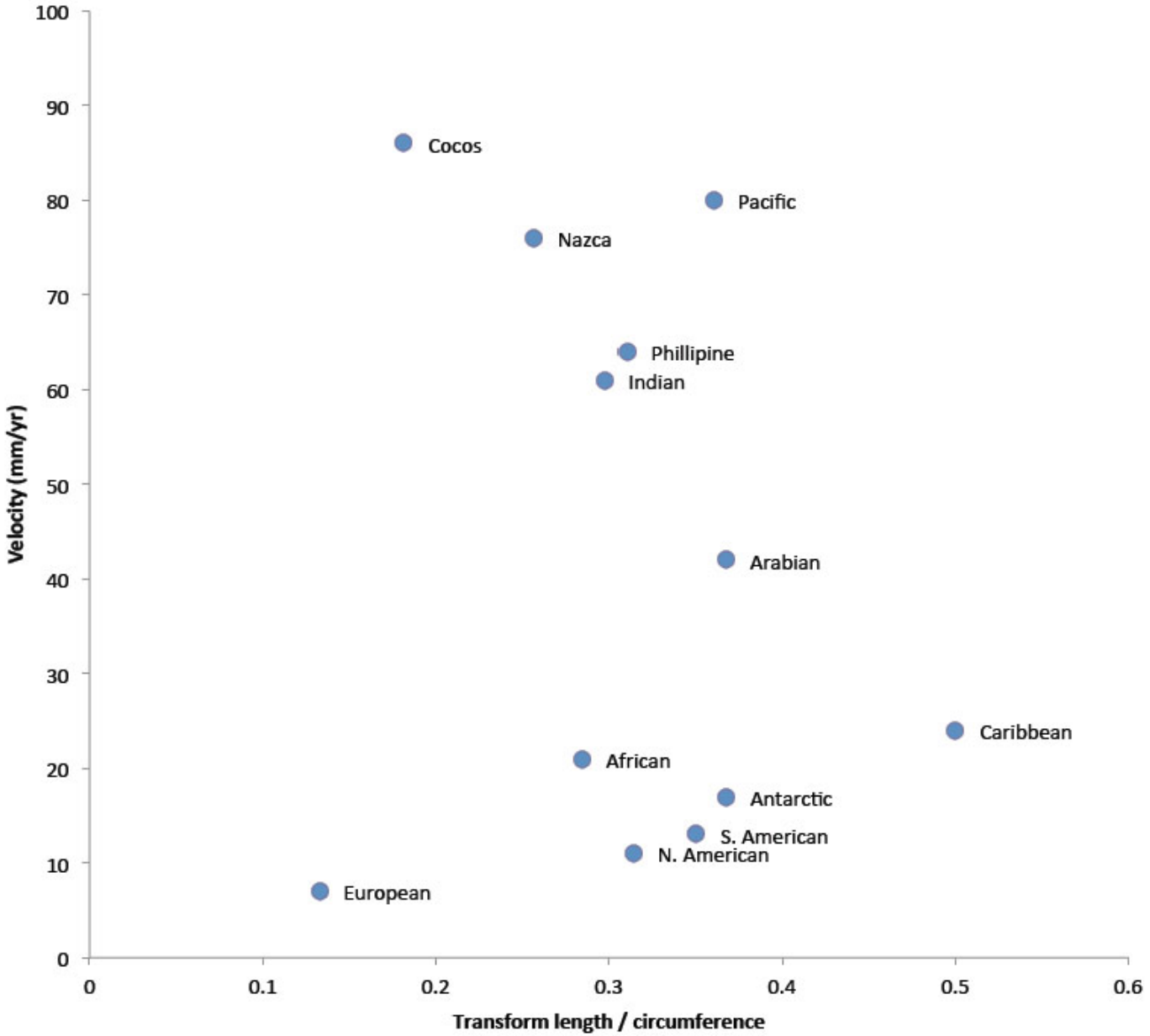
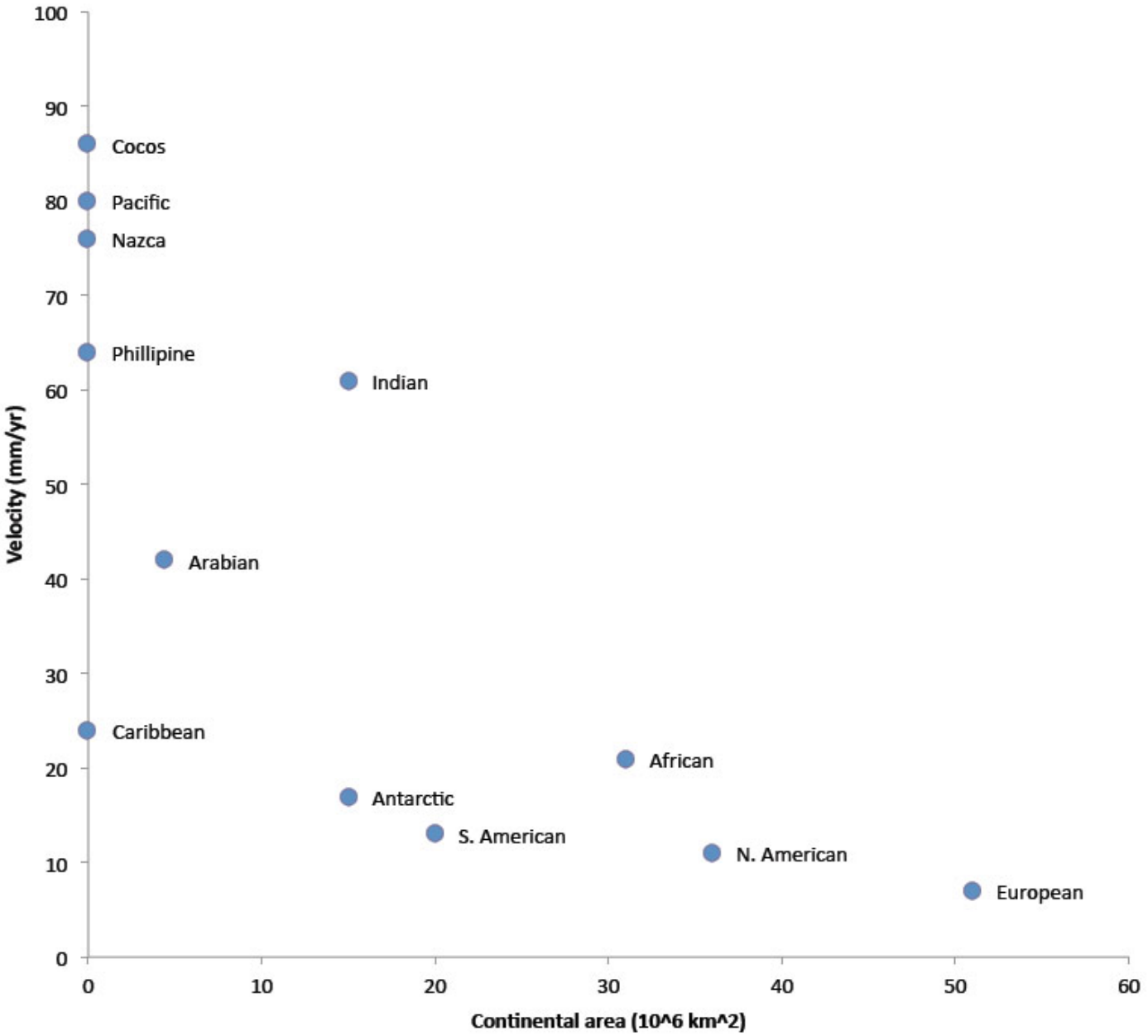


Data from Forsythe & Uyeda, 1975



Data from Forsythe & Uyeda, 1975



Data from Forsythe & Uyeda, 1975

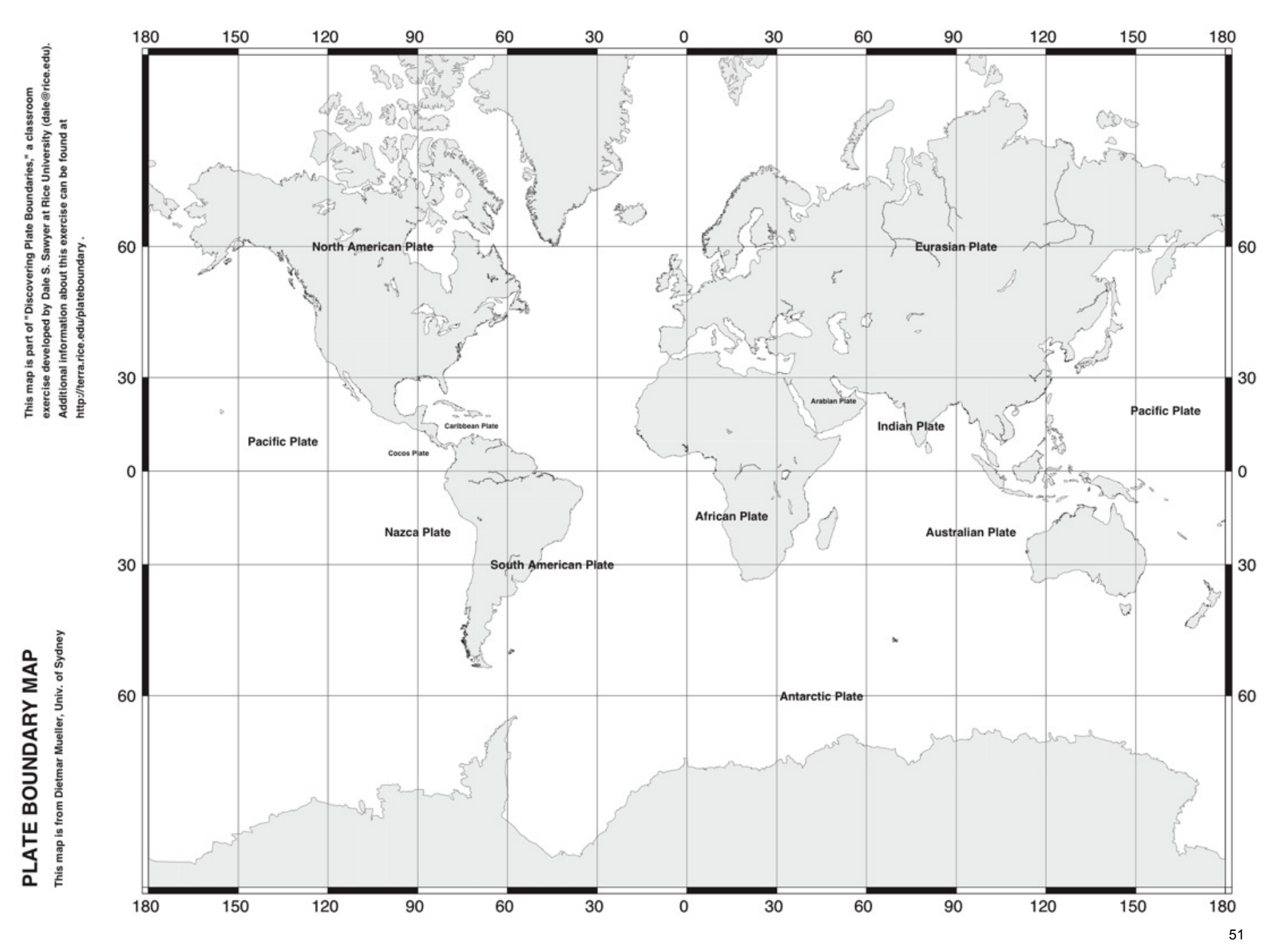
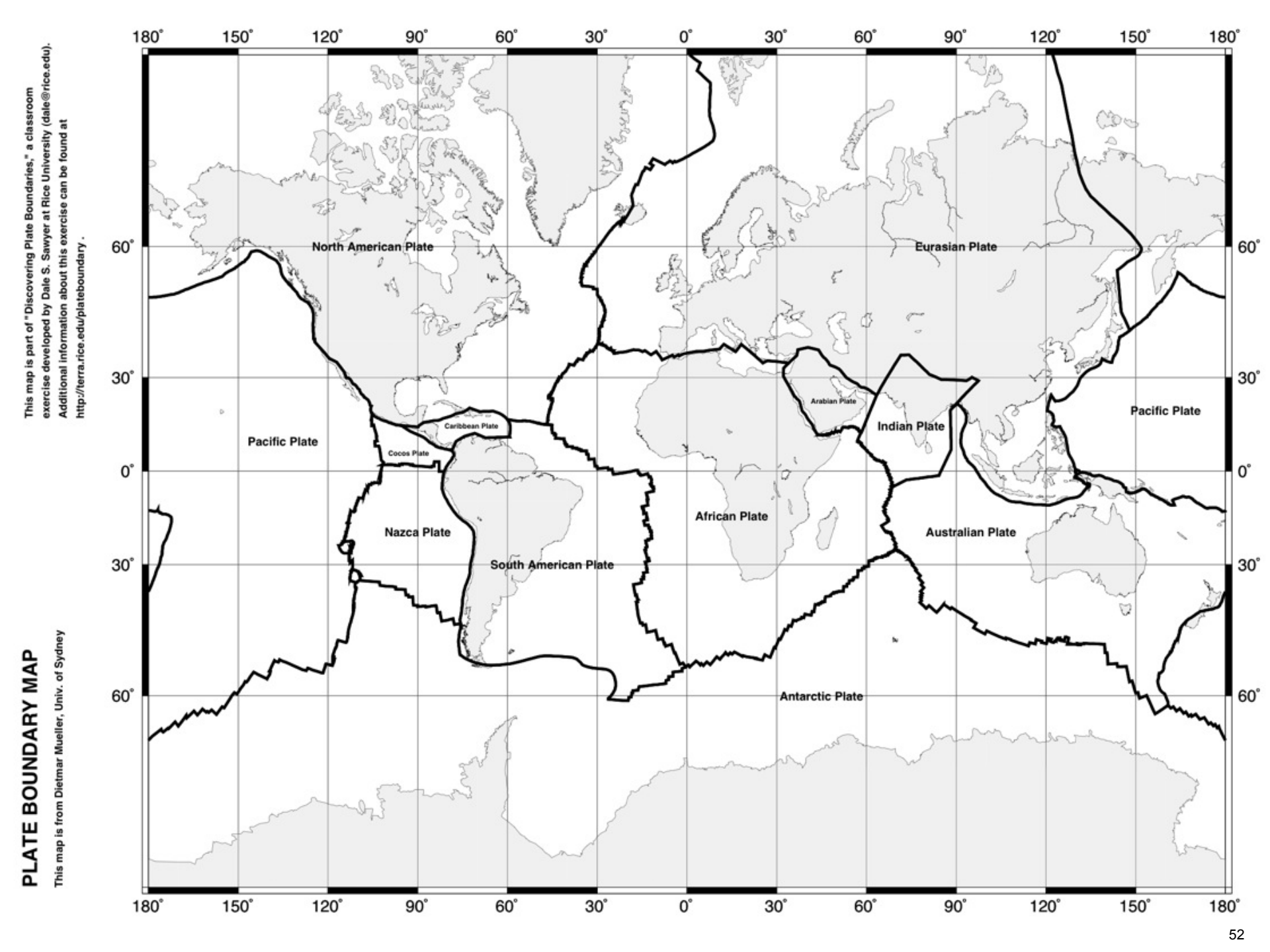


PLATE BOUNDARY MAP
This map is from Dietmar Mueller, Univ. of Sydney
This map is part of "Discovering Plate Boundaries," a classroom exercise developed by Dale S. Sawyer at Rice University (dale@rice.edu). Additional information about this exercise can be found at http://terra.rice.edu/plateboundary .
180 150 120 90 60 30 0 30 60 90 120 150 180
60
30
0
30
60
North American Plate
Eurasian Plate
Pacific Plate
Caribbean Plate
Cocos Plate
Arabian Plate
Indian Plate
Pacific Plate
Nazca Plate
South American Plate
African Plate
Australian Plate
Antarctic Plate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180° 150° 120° 90° 60° 30° 0° 30° 60° 90° 120° 150° 180°
60°
30°
0°
30°
60°
North American Plate
Eurasian Plate
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12.001 Introduction to Geology
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