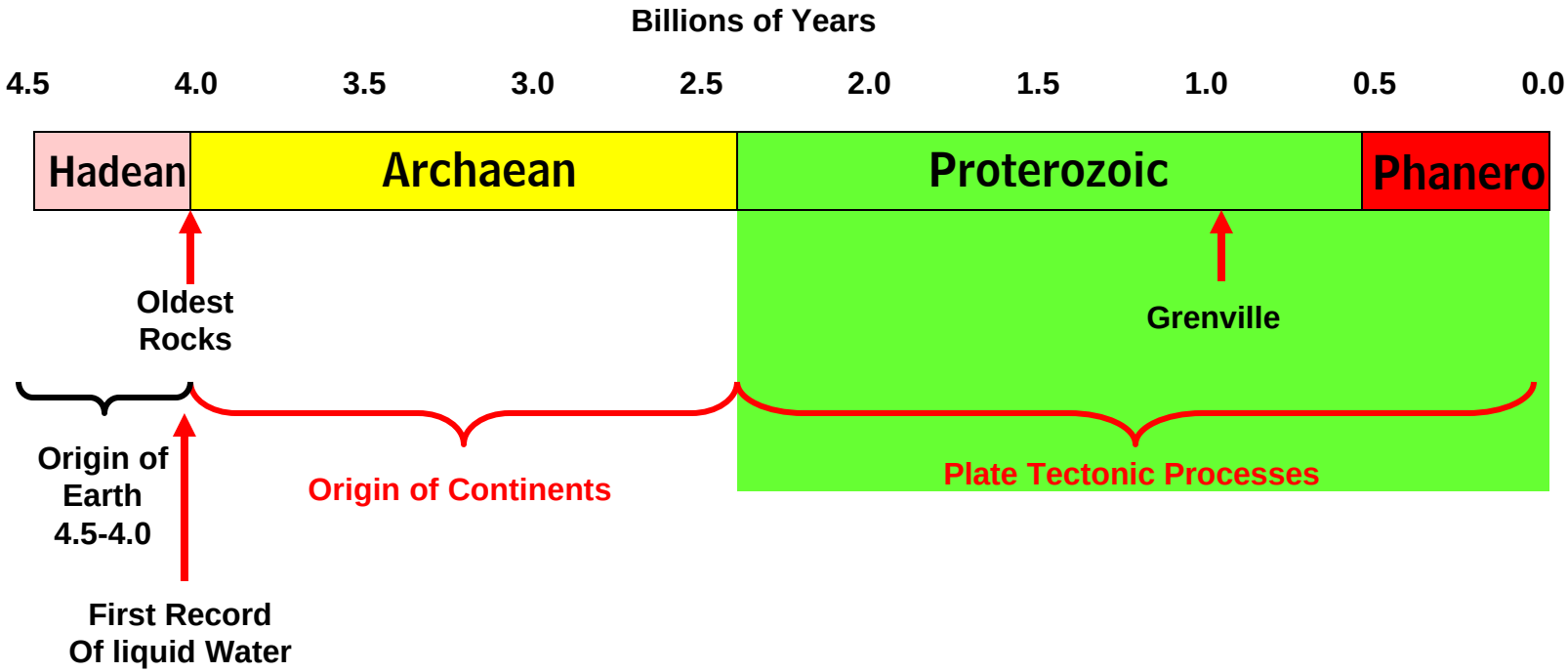
Proterozoic Evolution of North America

Just How Long is Earth History ?
And When Did the Important Things Happen ?

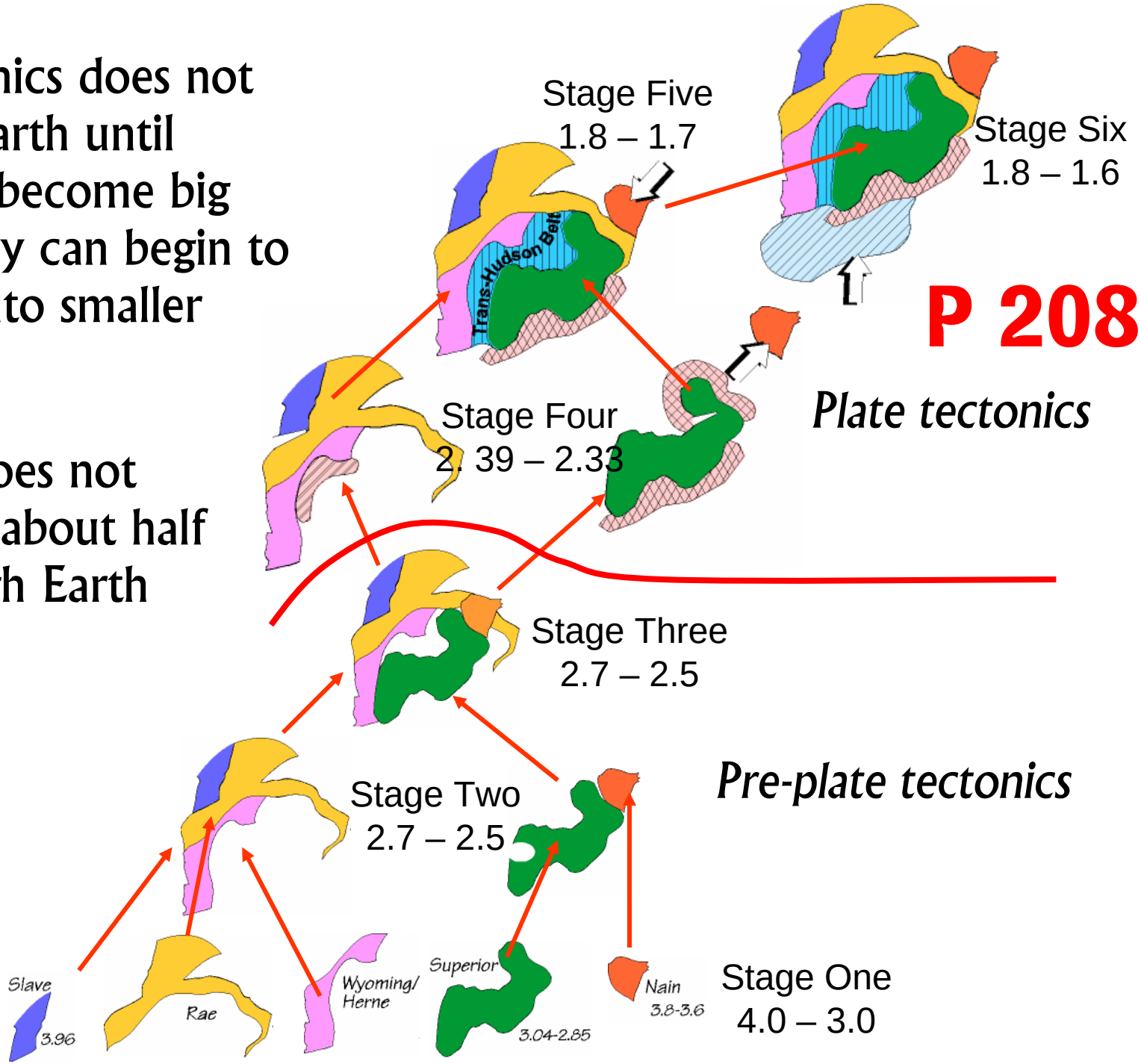


Archaean tectonic evolution of the Earth involved volcanic arcs, evolving into proto-continents, evolving into micro-continents.

Proterozoic evolution involved the building of the continents, and establishment of supercontinent cycles through plate tectonic mechanisms.

Plate tectonics does not begin on Earth until continents become big enough they can begin to rift apart into smaller continents.

And this does not begin until about half way through Earth history.

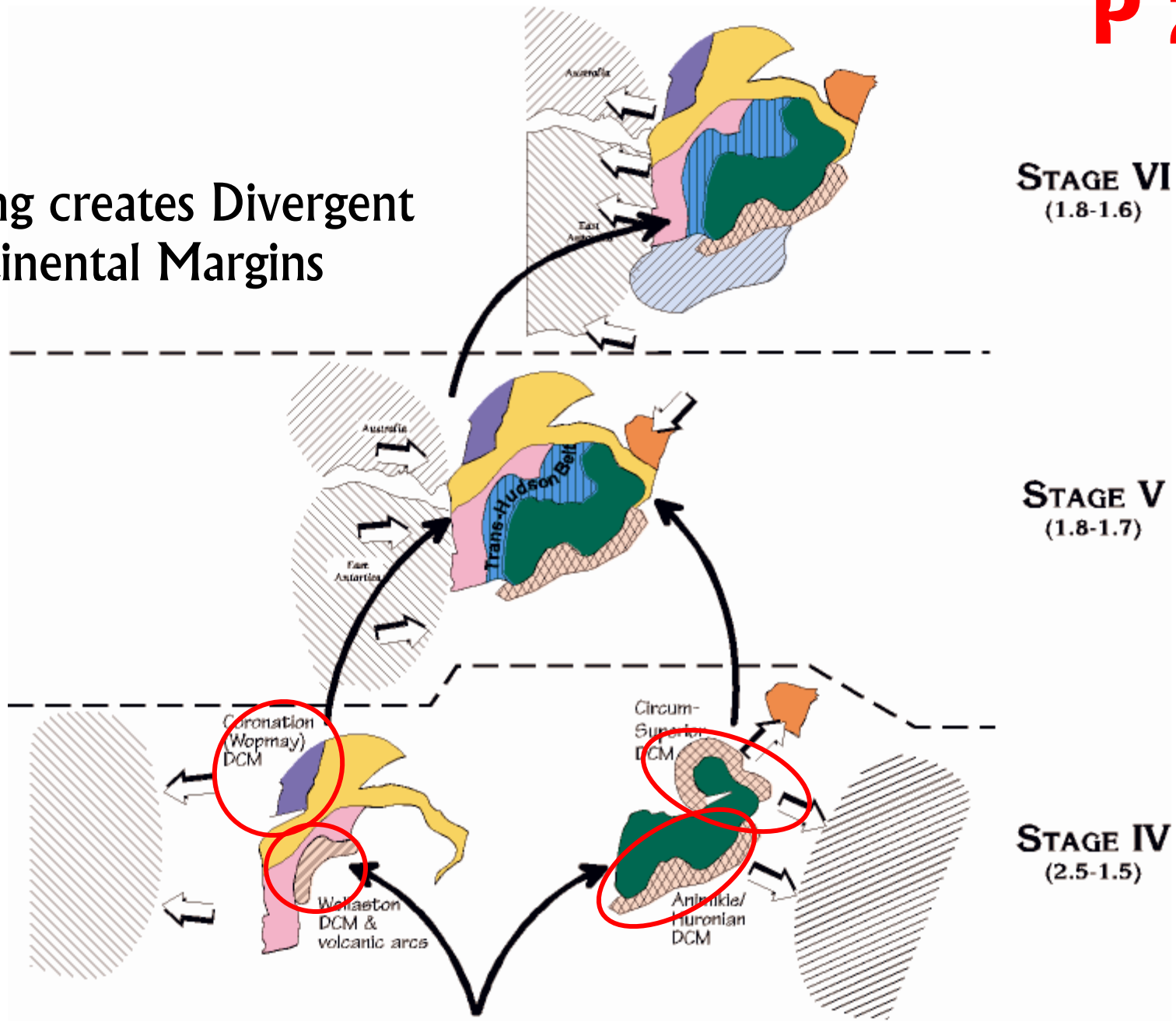


P 208

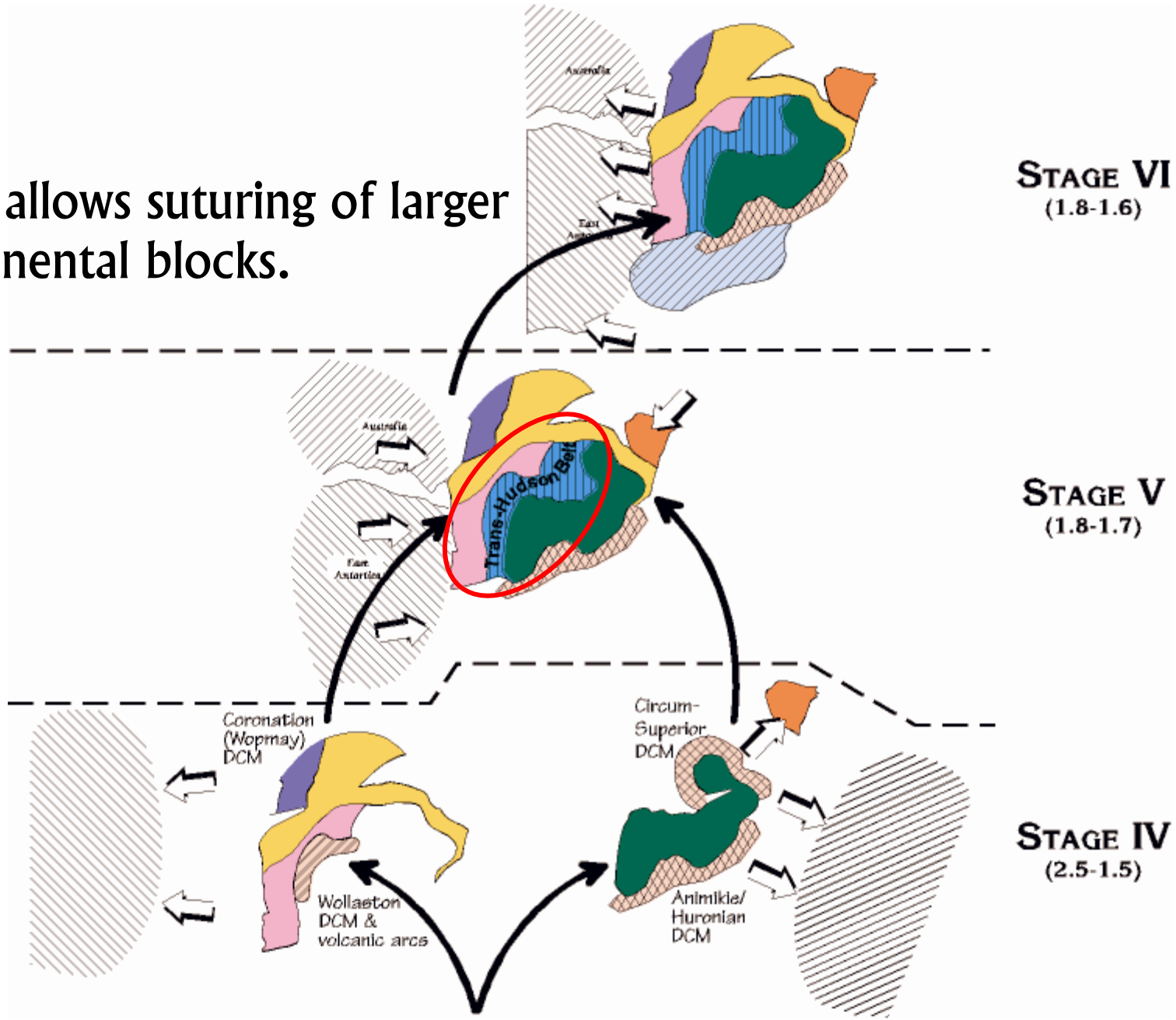
Plate tectonics

Pre-plate tectonics

Rifting creates Divergent Continental Margins



And allows suturing of larger continental blocks.



The history of the Earth embodies two organizing principles.

1. **It is fractal . . .**

   There are patterns, within patterns, within patterns, and cycles, within cycles, within cycles. . . ad infinitum – at all scales of observation.

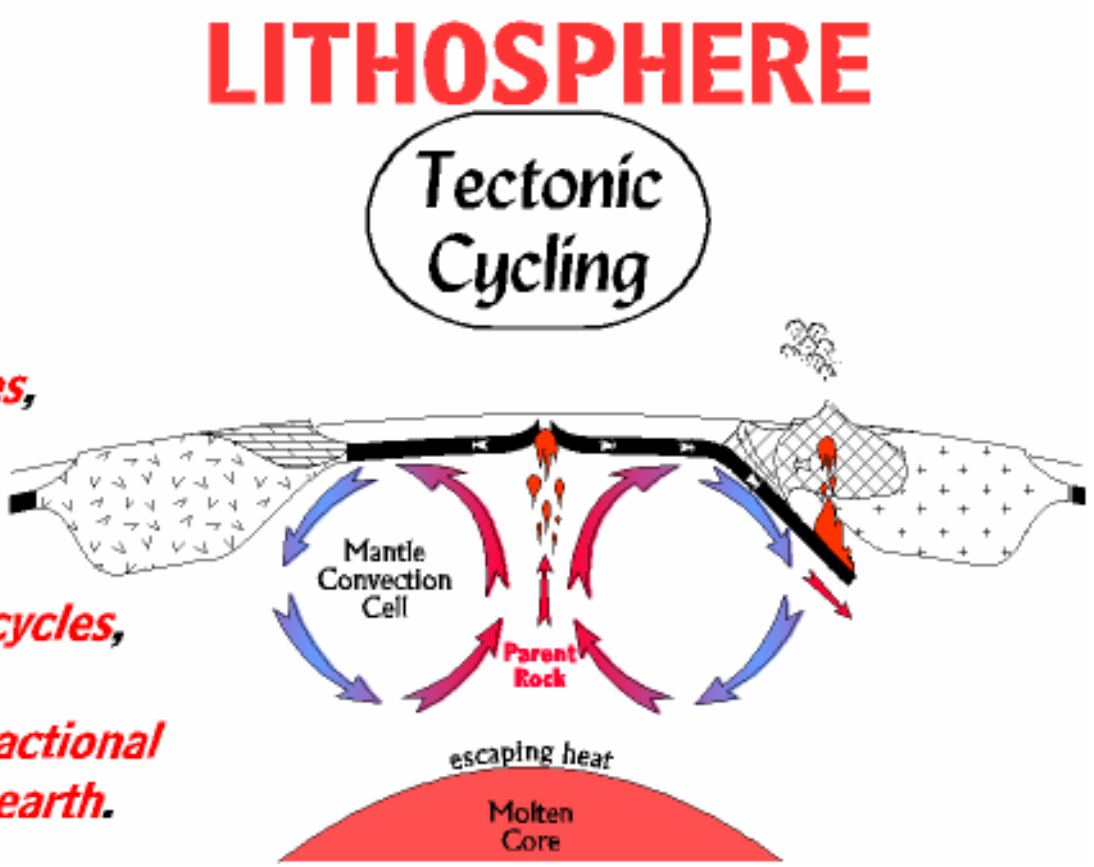
2. **It is evolutionary . . .**

   As energy continuously passes through the various Earth systems they undergo continuous change, . . .
   . . .generally becoming more complex with time through elaboration, fractionation, and self organization.

Cycles Within Cycles

The fractal nature of the Earth

Rock cycles,
within . . .
Convection cycles,
within . . .
Wilson cycles,
within . . .
Supercontinent cycles,
within . . .
The long term fractional evolution of the earth.

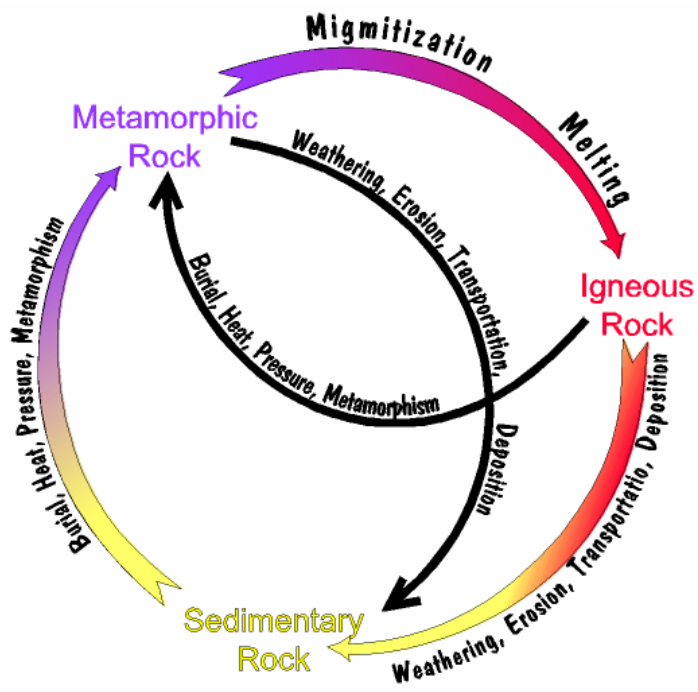


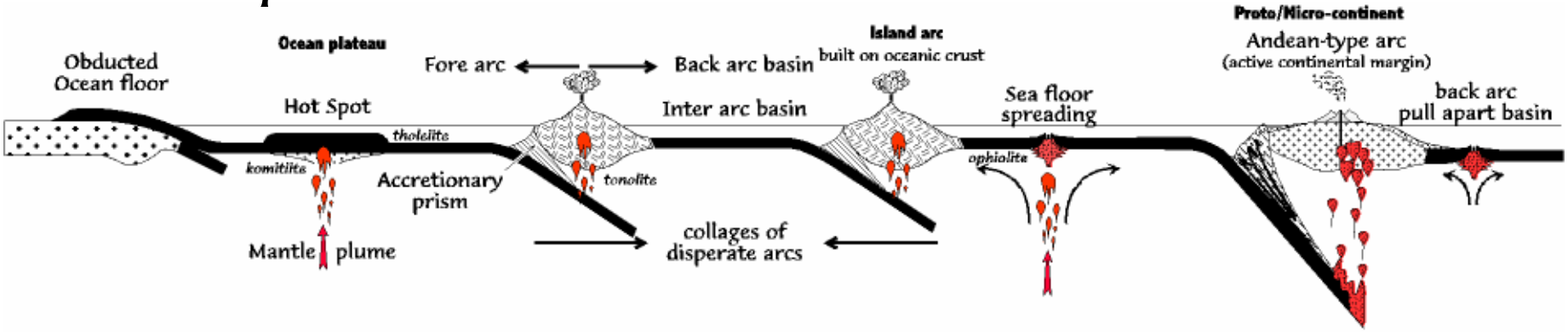
Cycles Within Cycles

ROCK CYCLES . . .

All rocks can be transformed Into other rocks

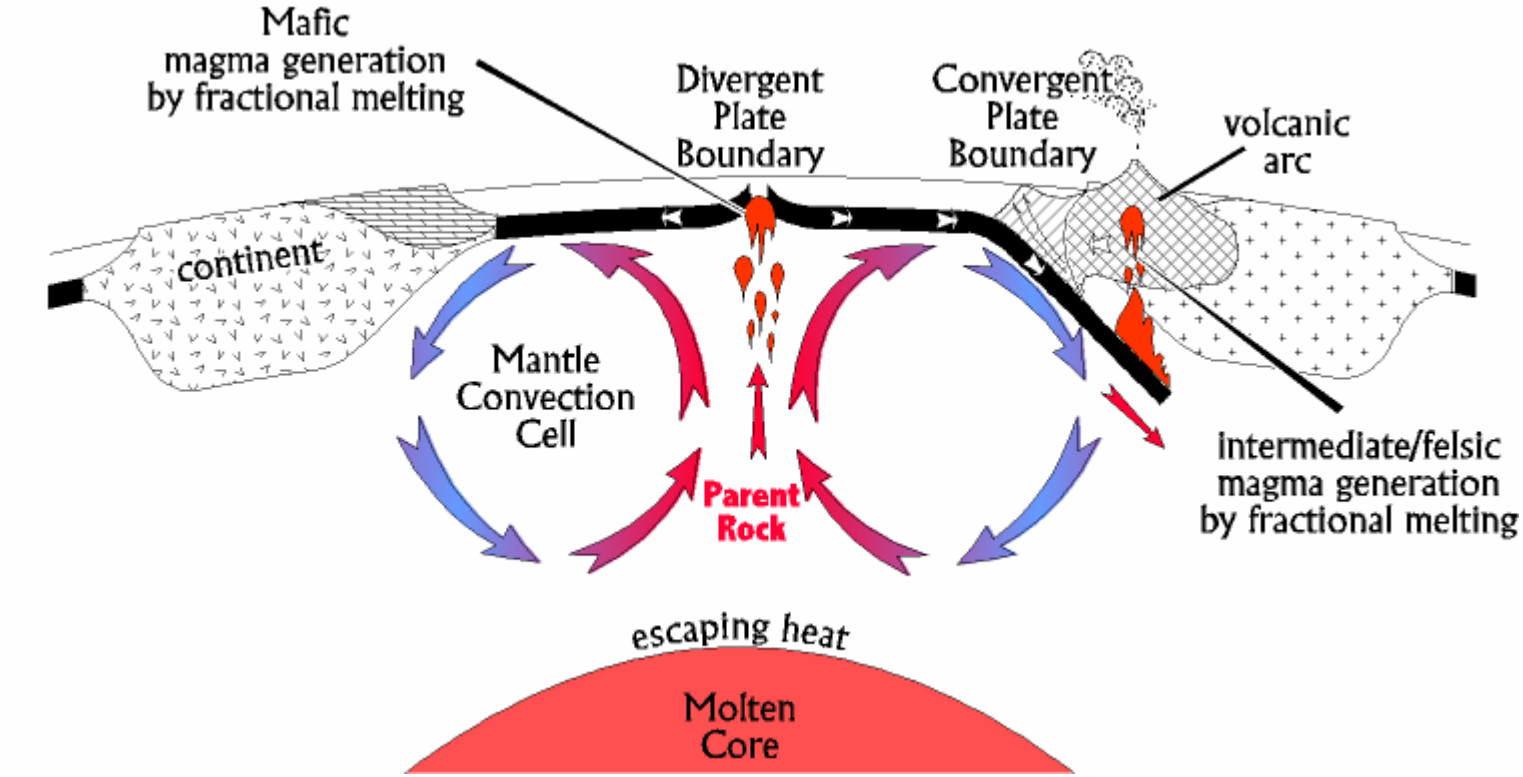
And with every cycle of subduction the igneous rocks that are generated, weather into sedimentary rocks, some of which become metamorphosed.





Cycles Within Cycles

WITHIN CONVECTION CELL CYCLES . . .



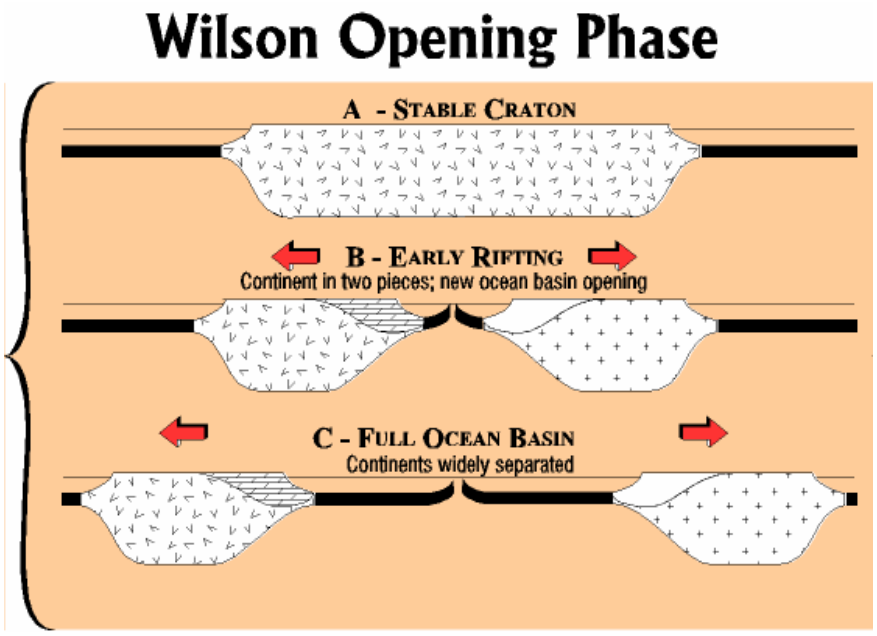
The rock cycle is driven by tectonic energy from the molten cores escaping inexorably to space.

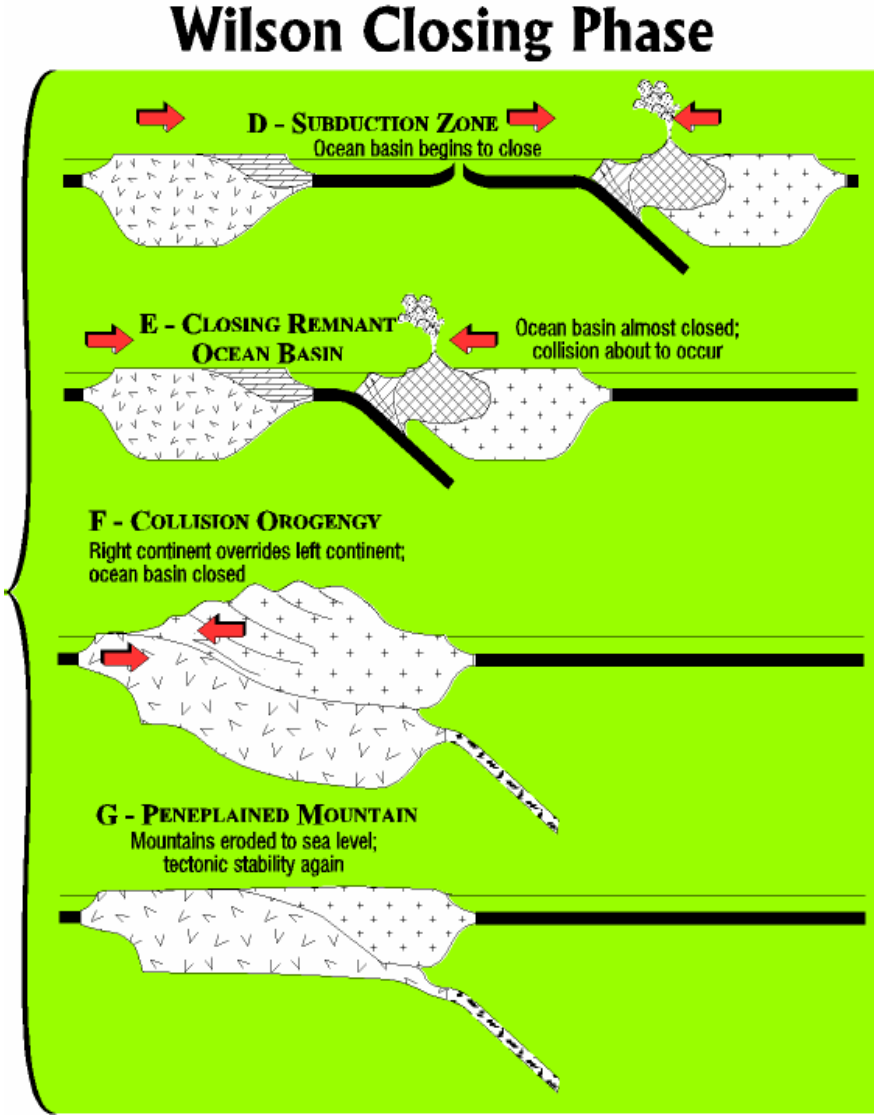
Cycles Within Cycles

P 203

WITHIN WILSON CYCLES . . .

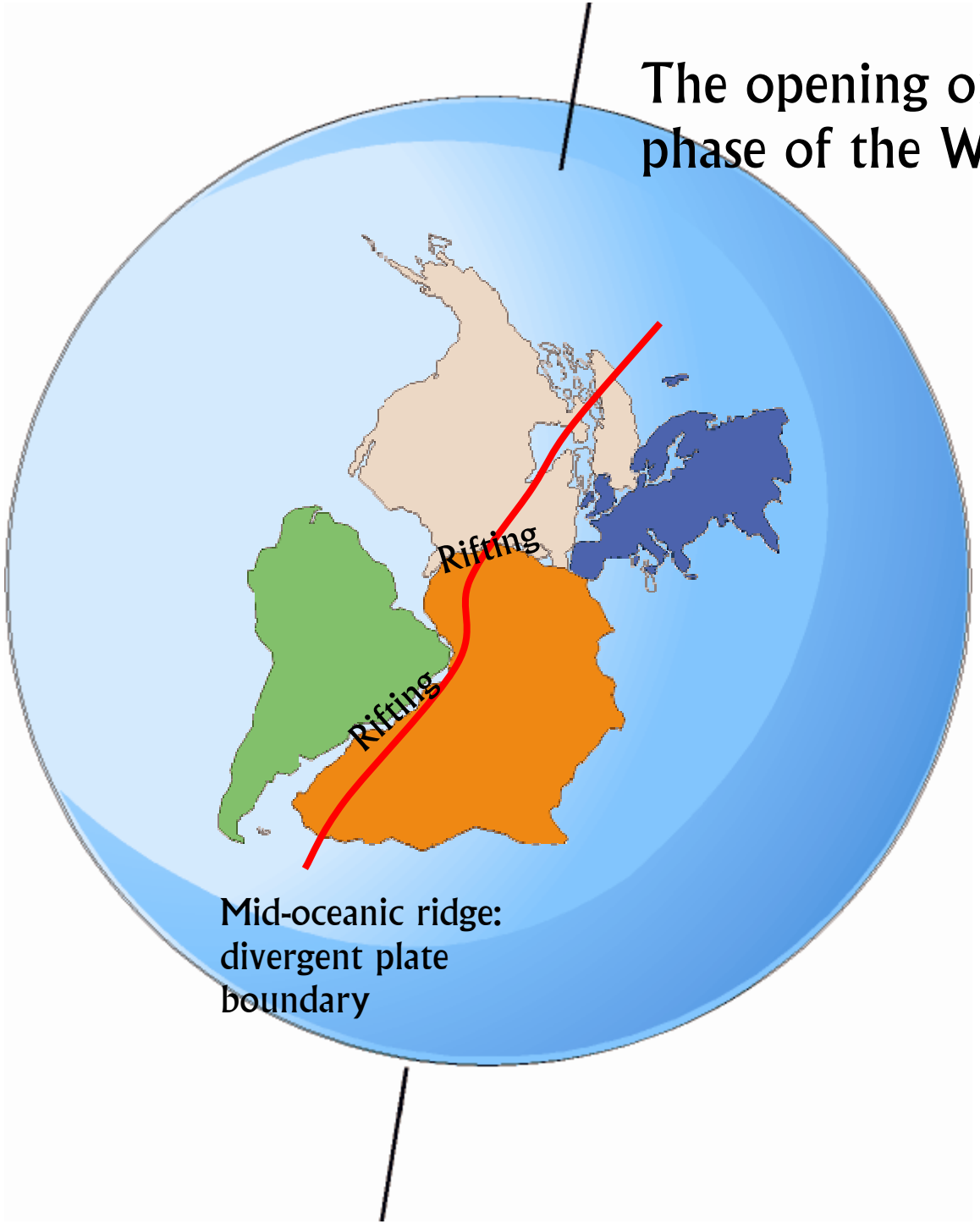
The opening and closing of an ocean basin



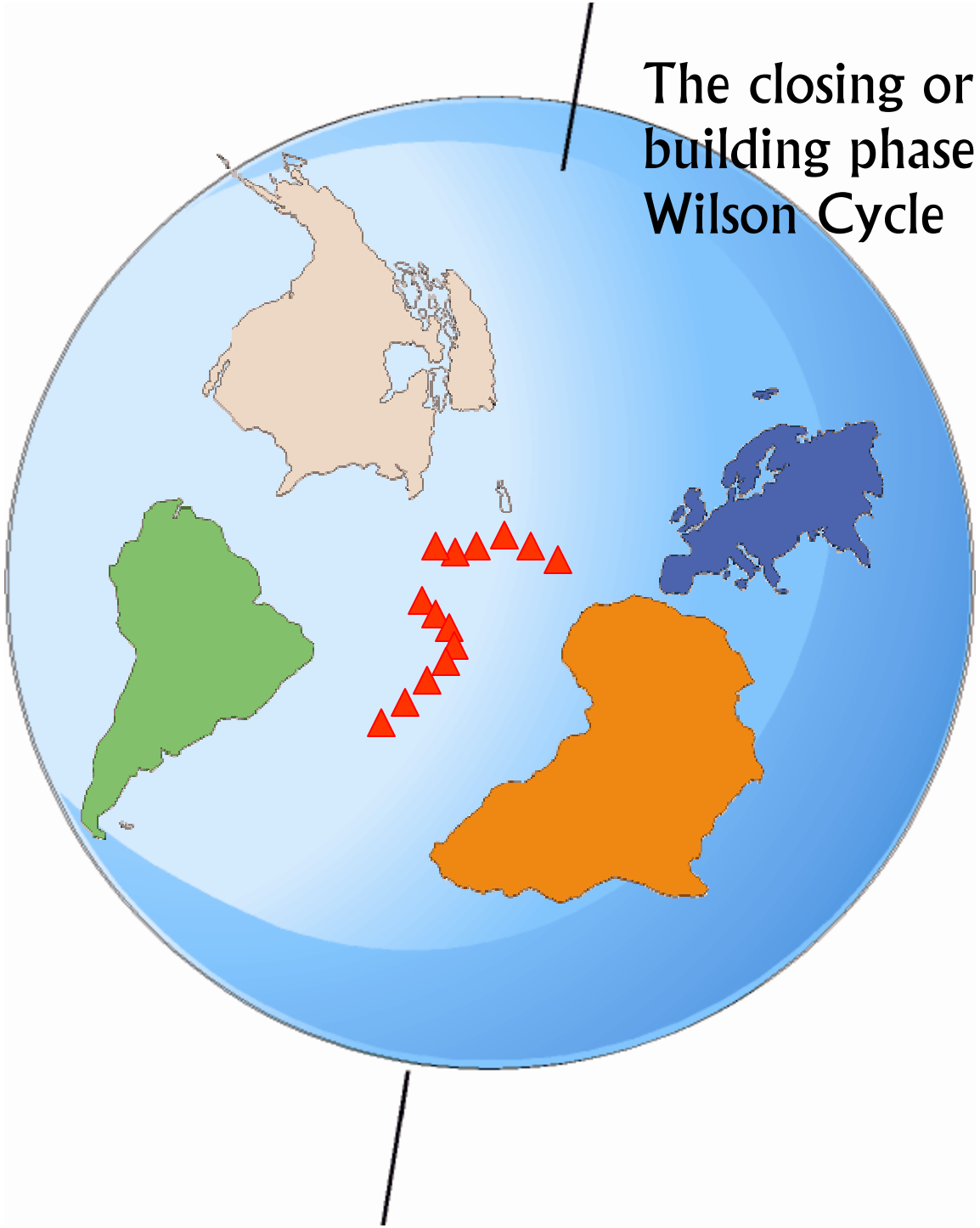


Leading to . . .

The opening or rifting phase of the Wilson Cycle



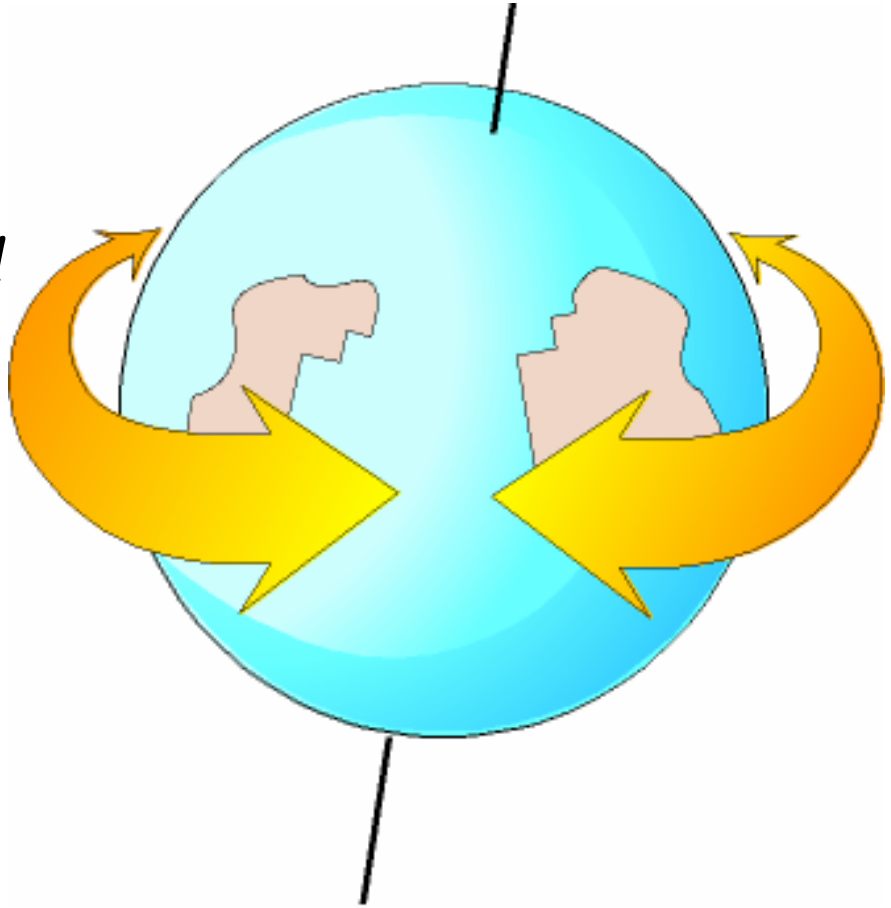
The closing or mountain building phase of the Wilson Cycle



Cycles Within Cycles

WITHIN SUPERCONTINENT CYCLES . . .

In a supercontinent model continents sweep back and forth across the globe. Simplistically the result would be two Wilson cycles, each half out of phase with each other. When a super-continent breaks apart on one side of the globe, initiating an opening phase, it also begins a closing half of the other cycle on the other side of the globe.

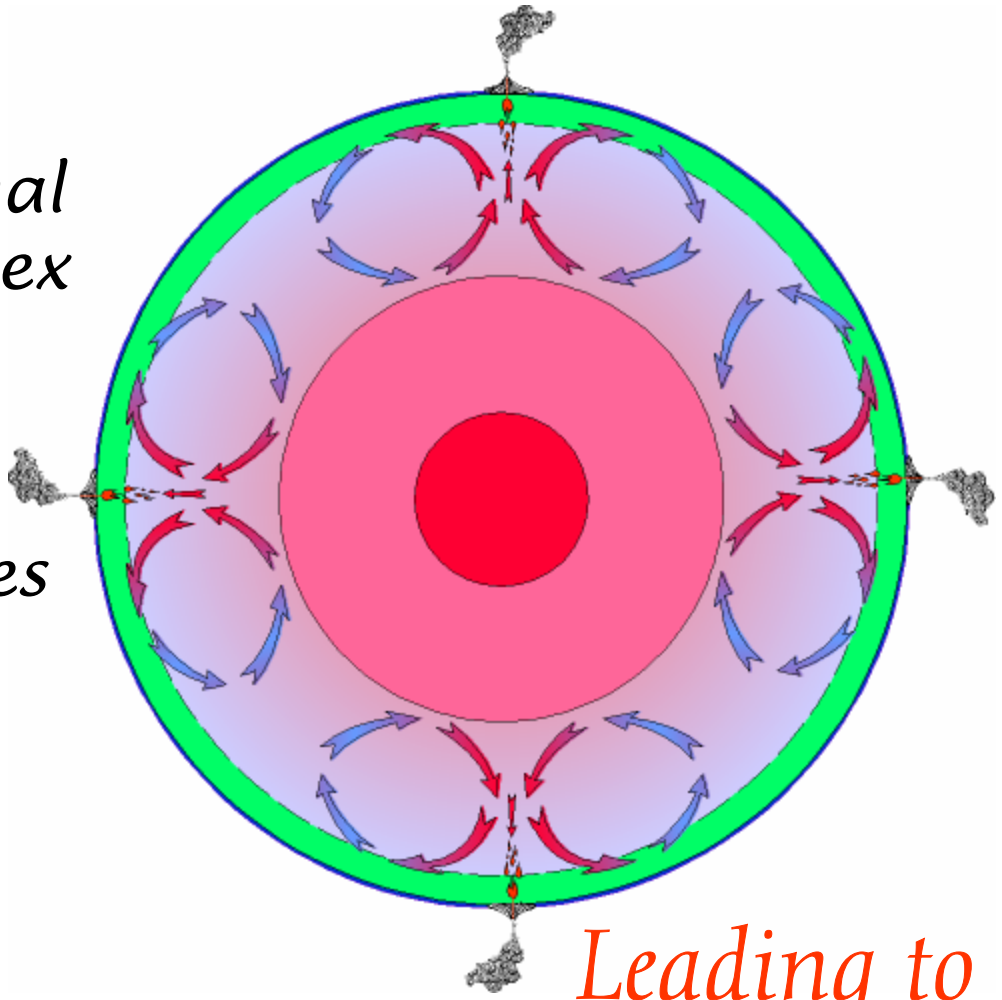


But, more realistic

Cycles Within Cycles

A Complex of Convection Cells

But, the Earth is three dimensional and has a complex system of convection cells making the possible outcomes more complex than simple.



Leading to . . .

Cycles Within Cycles

Scattering Supercontinent Cycles

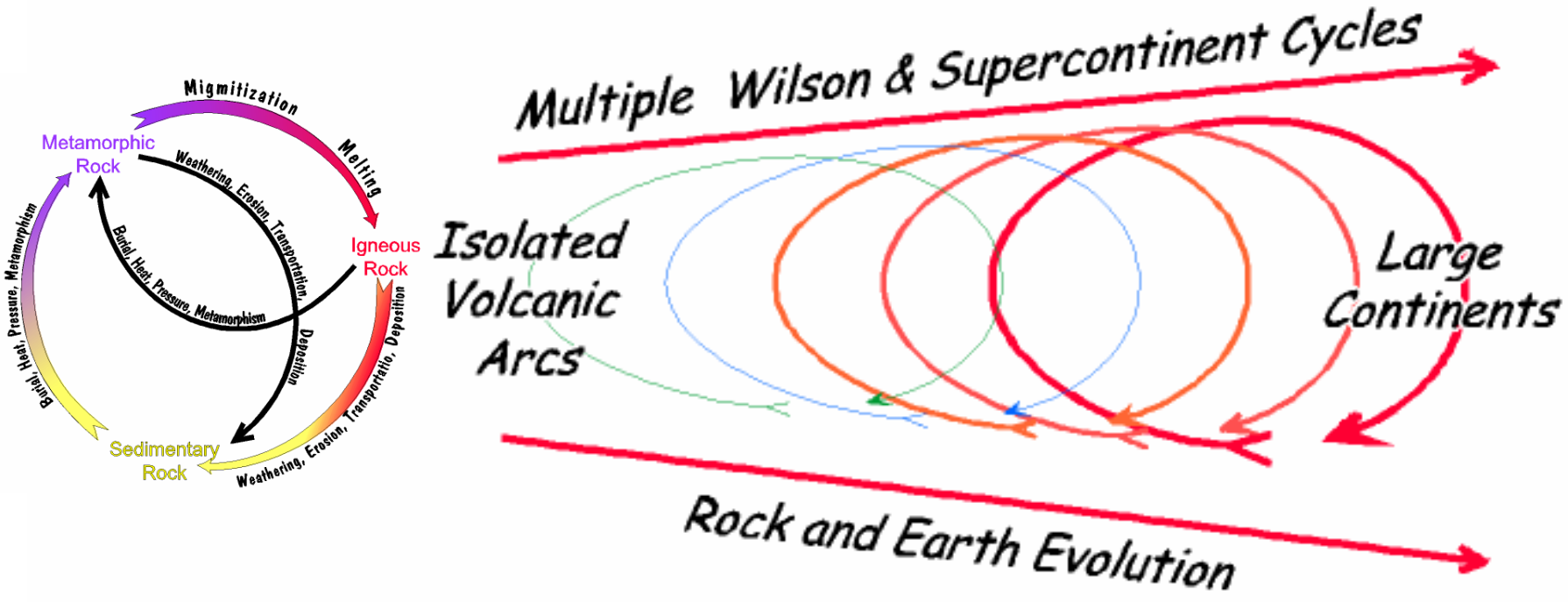
A more realistic movement of continents around the Globe is that they scatter like a shotgun blast in all directions.

. . . Leading to . . .

Cycles Within Cycles

Evolutionary Rock Cycles

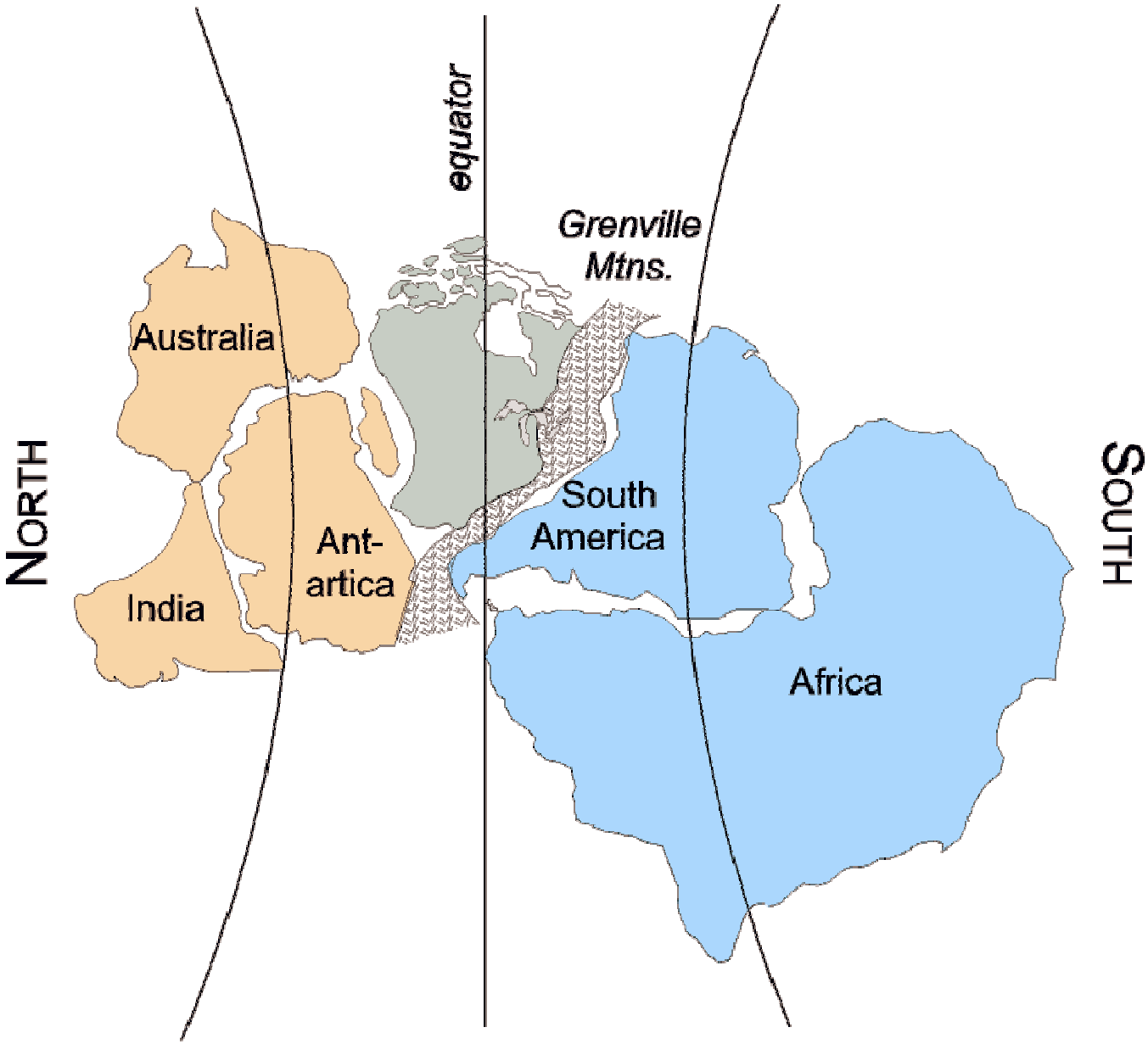
And as a result of every cycle the continents get bigger, and more igneous, sedimentary, and metamorphic rocks are generated by fractionation.



Supercontinent Cycles

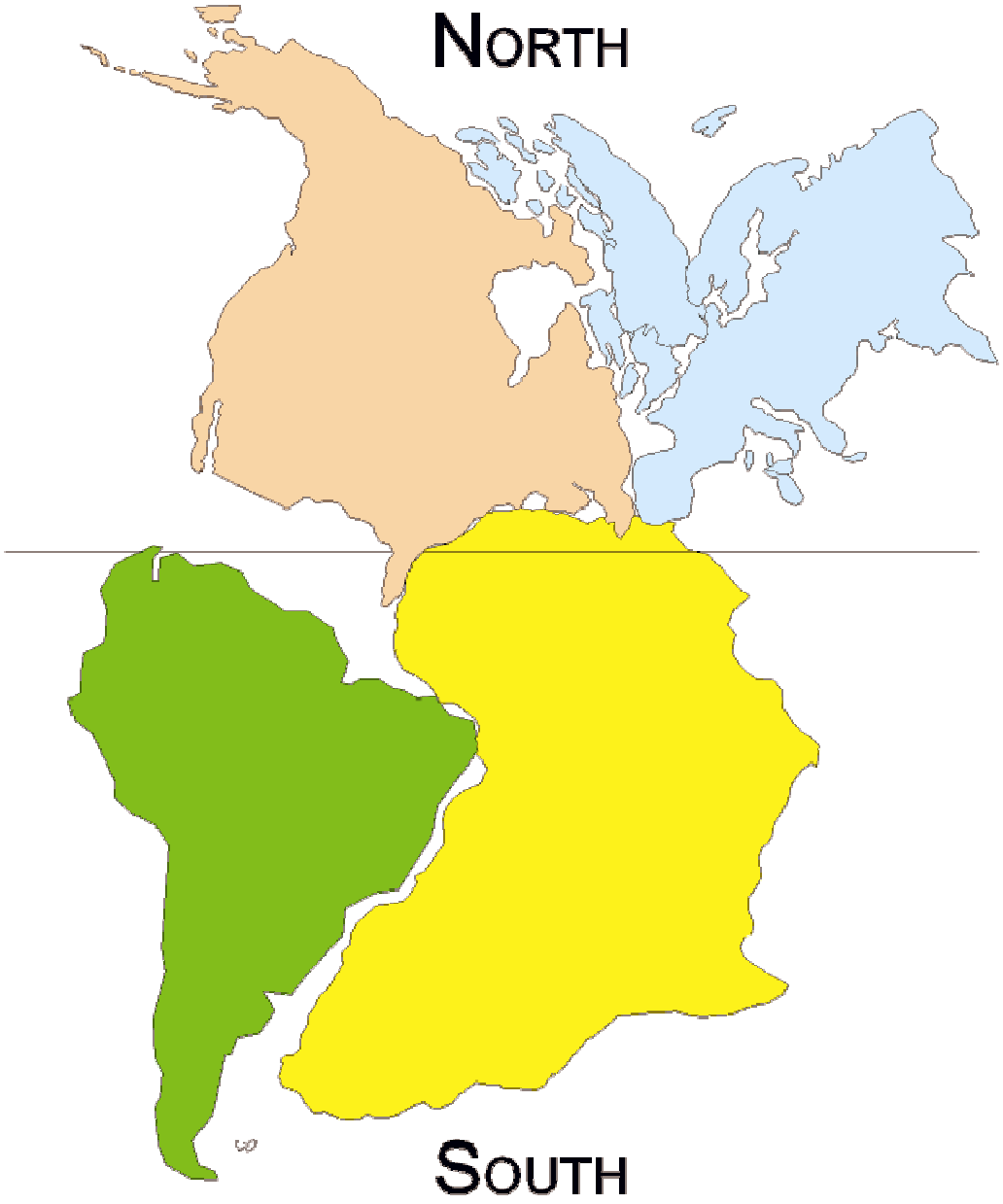
Rodinia Supercontinent

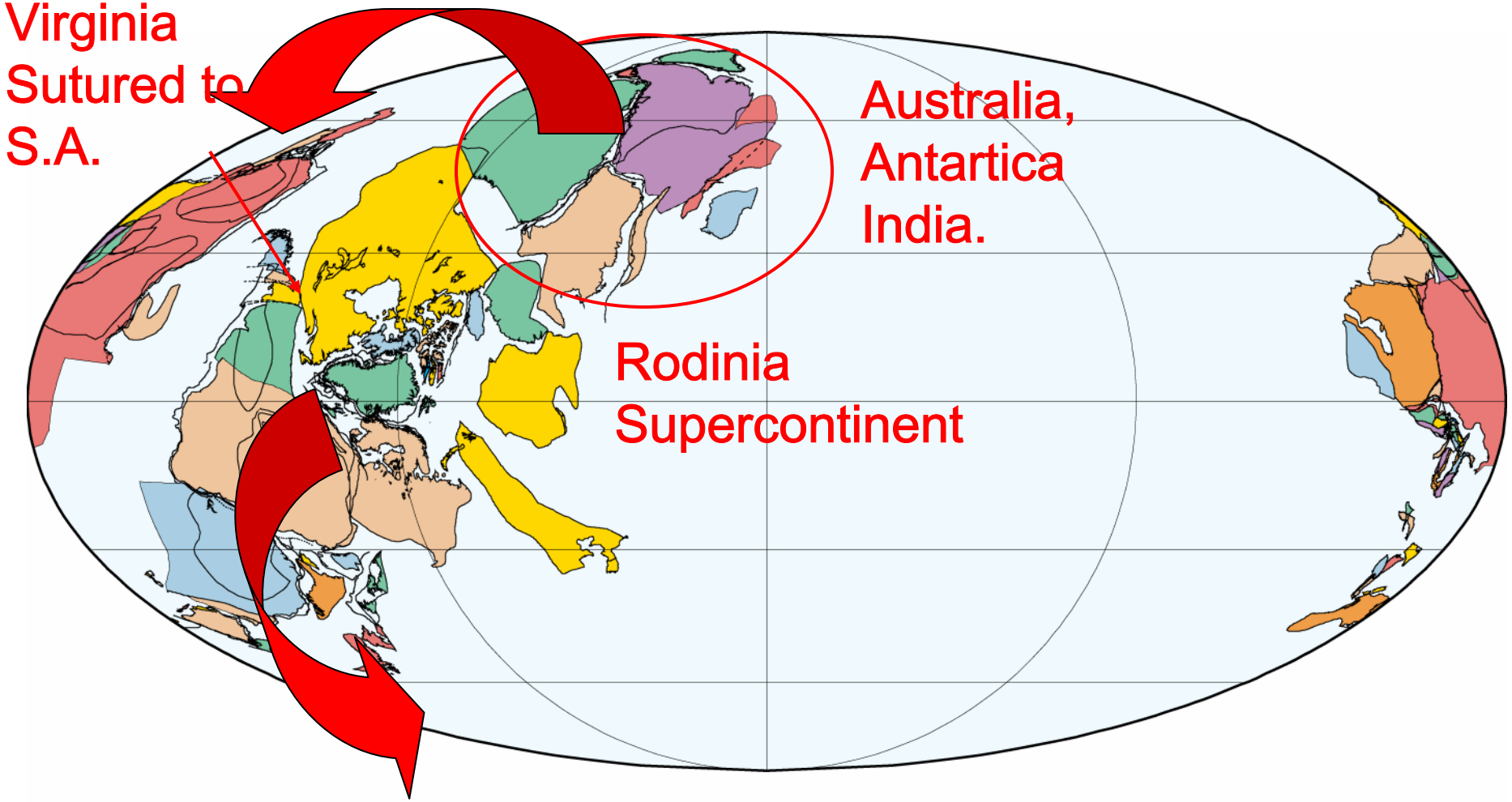
750 - 550

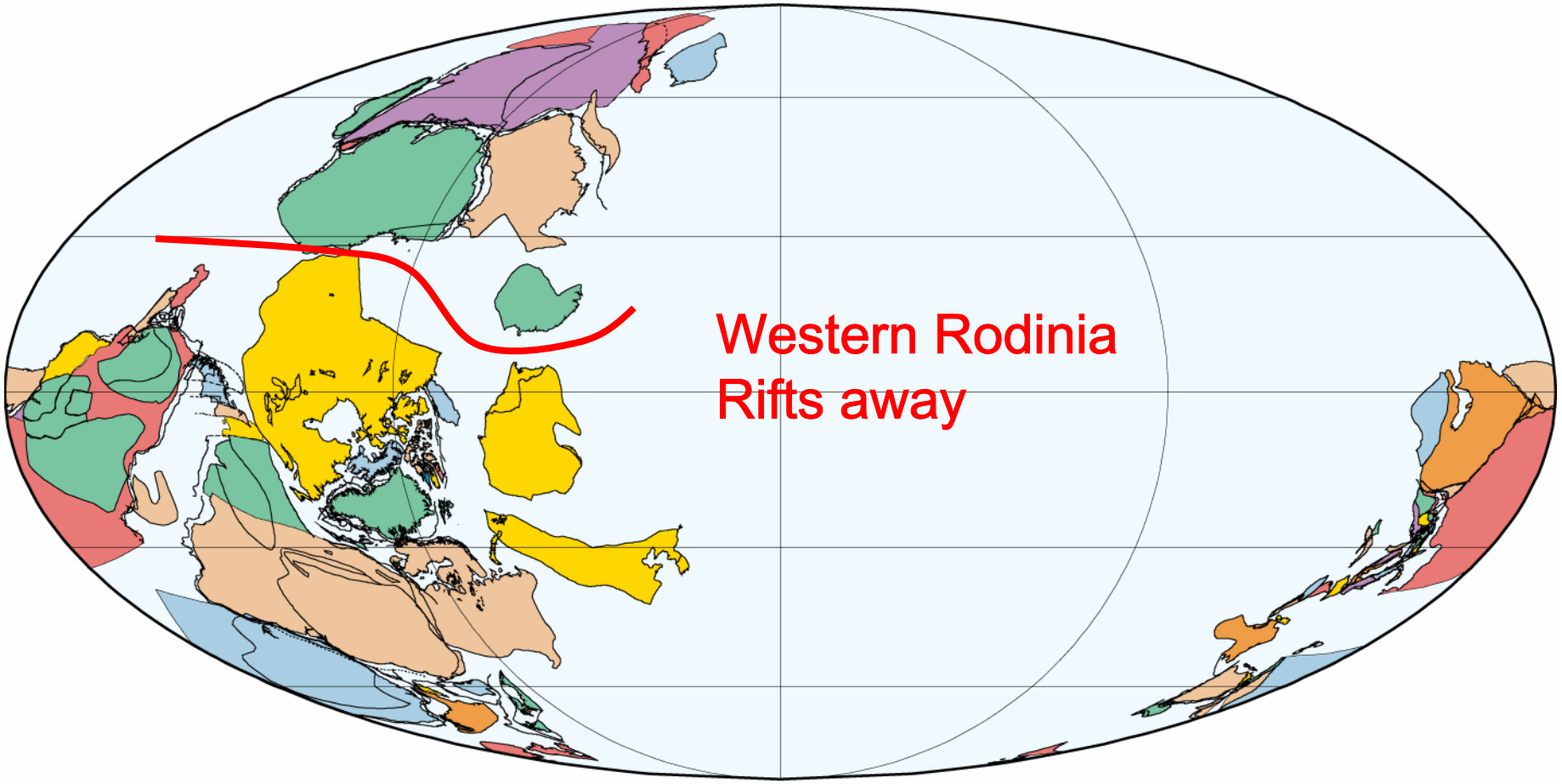


Pangaea Supercontinent

428 - 320

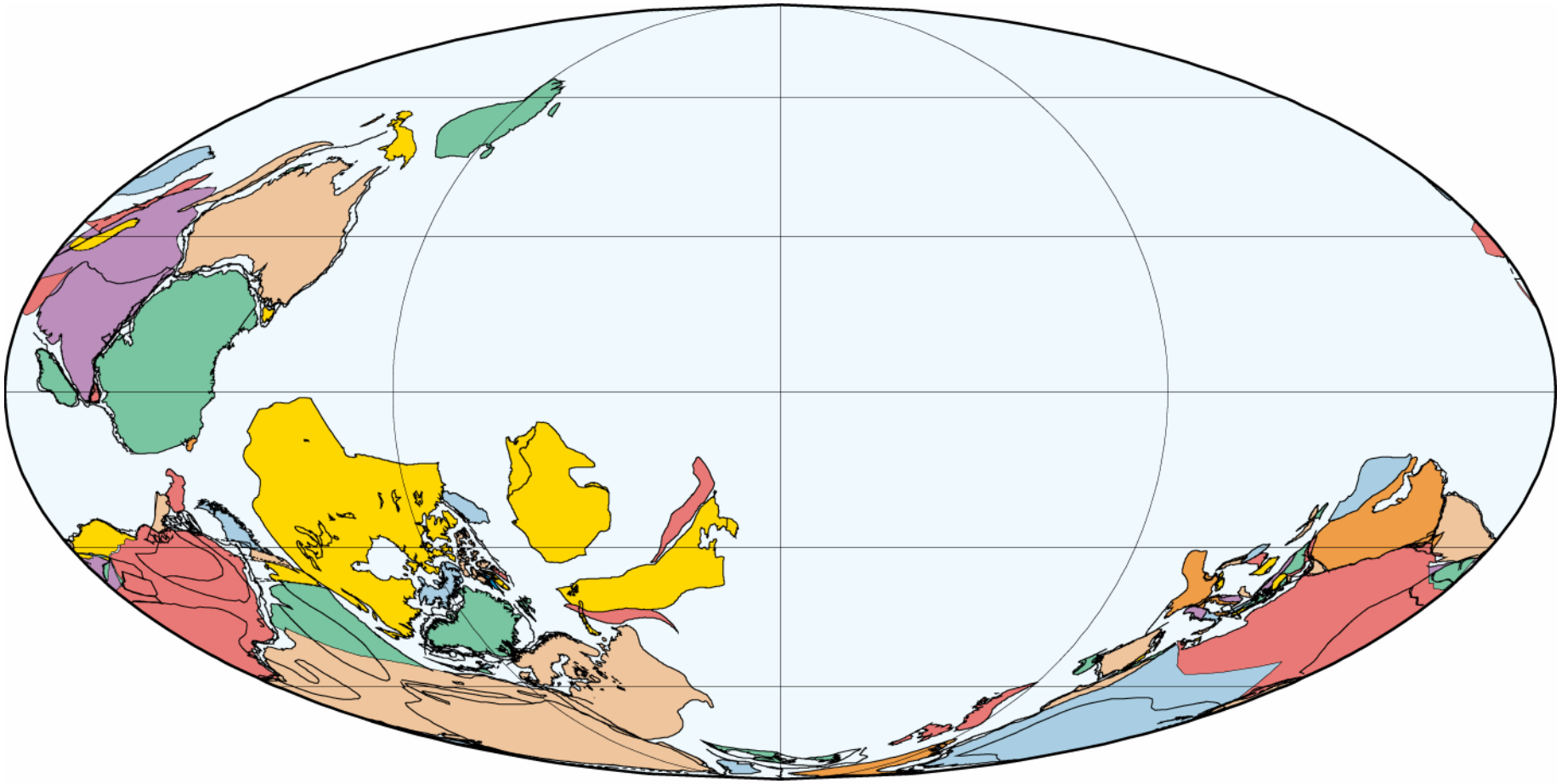



Virginia
Sutured to
S.A.
Australia,
Antartica
India.
Rodinia
Supercontinent
750 Ma
Late Proterozoic
PLATES/UTIG
August 2002



700 Ma
Late Proterozoic

PLATES/UTIG
August 2002

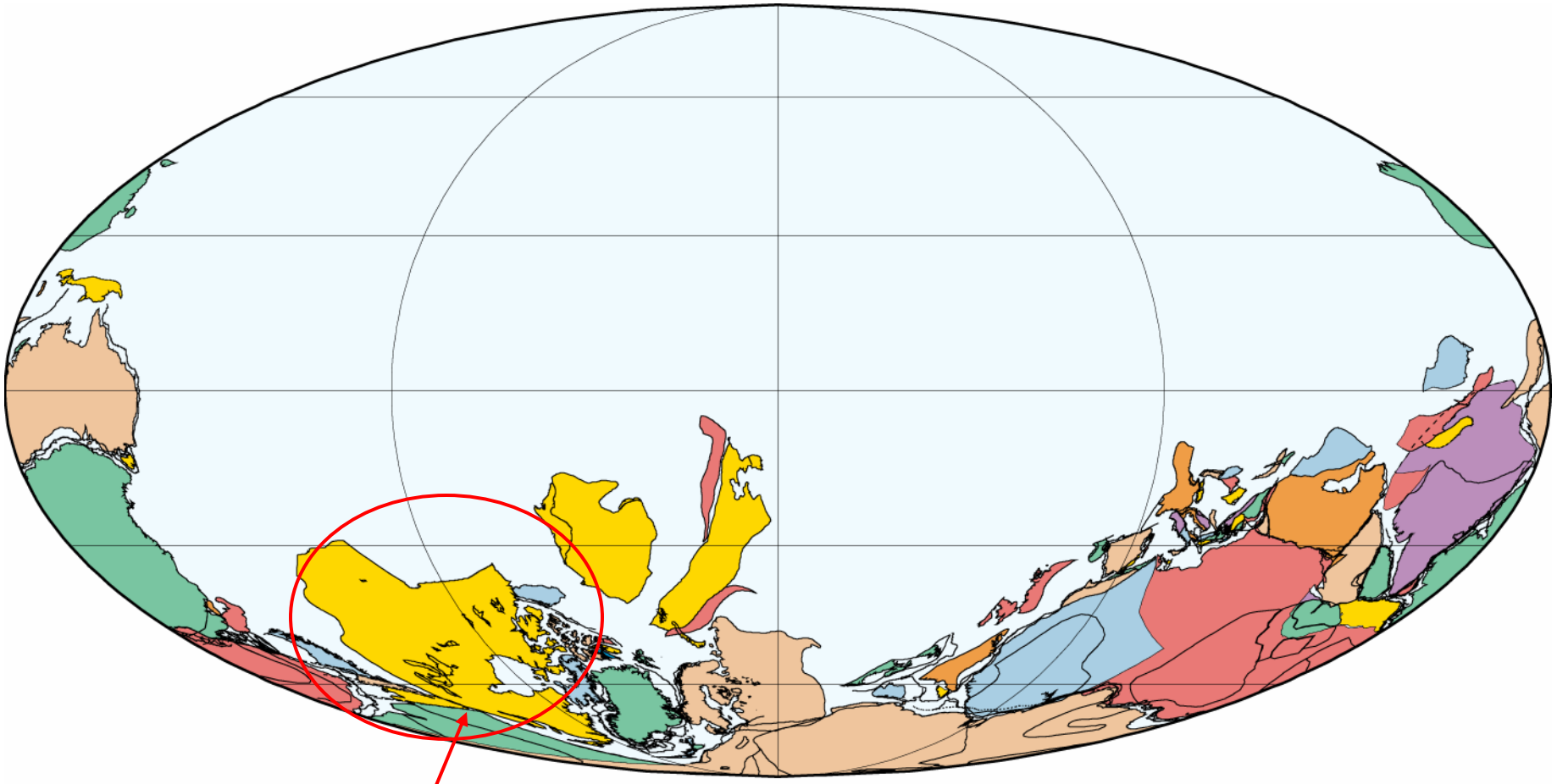


650 Ma

Late Proterozoic

PLATES/UTIG

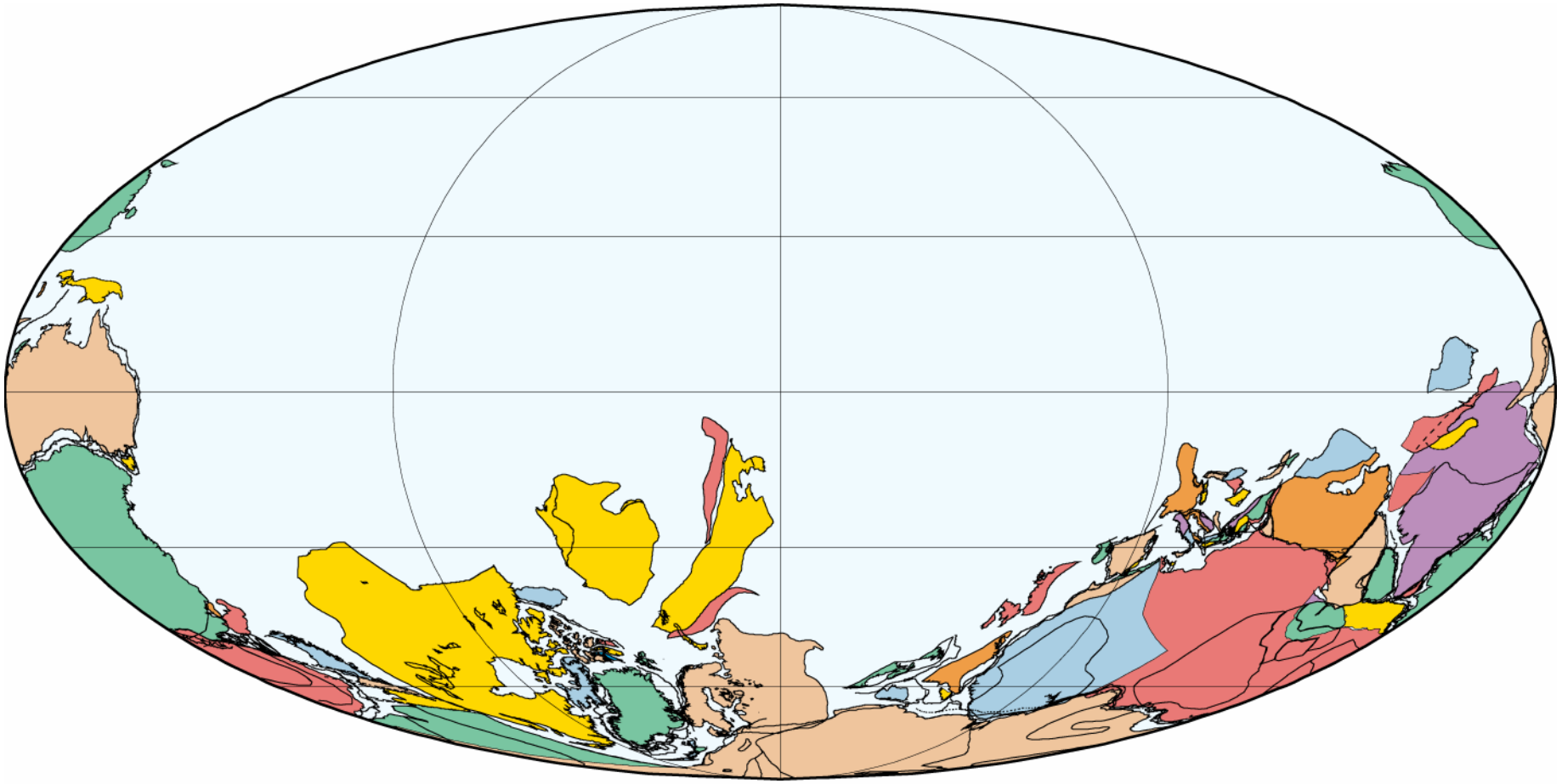
August 2002



600 Ma
Late Proterozoic

Eastern Rodinia rifts away; Virginia disconnects from South America

PLATES/UTIG
August 2002

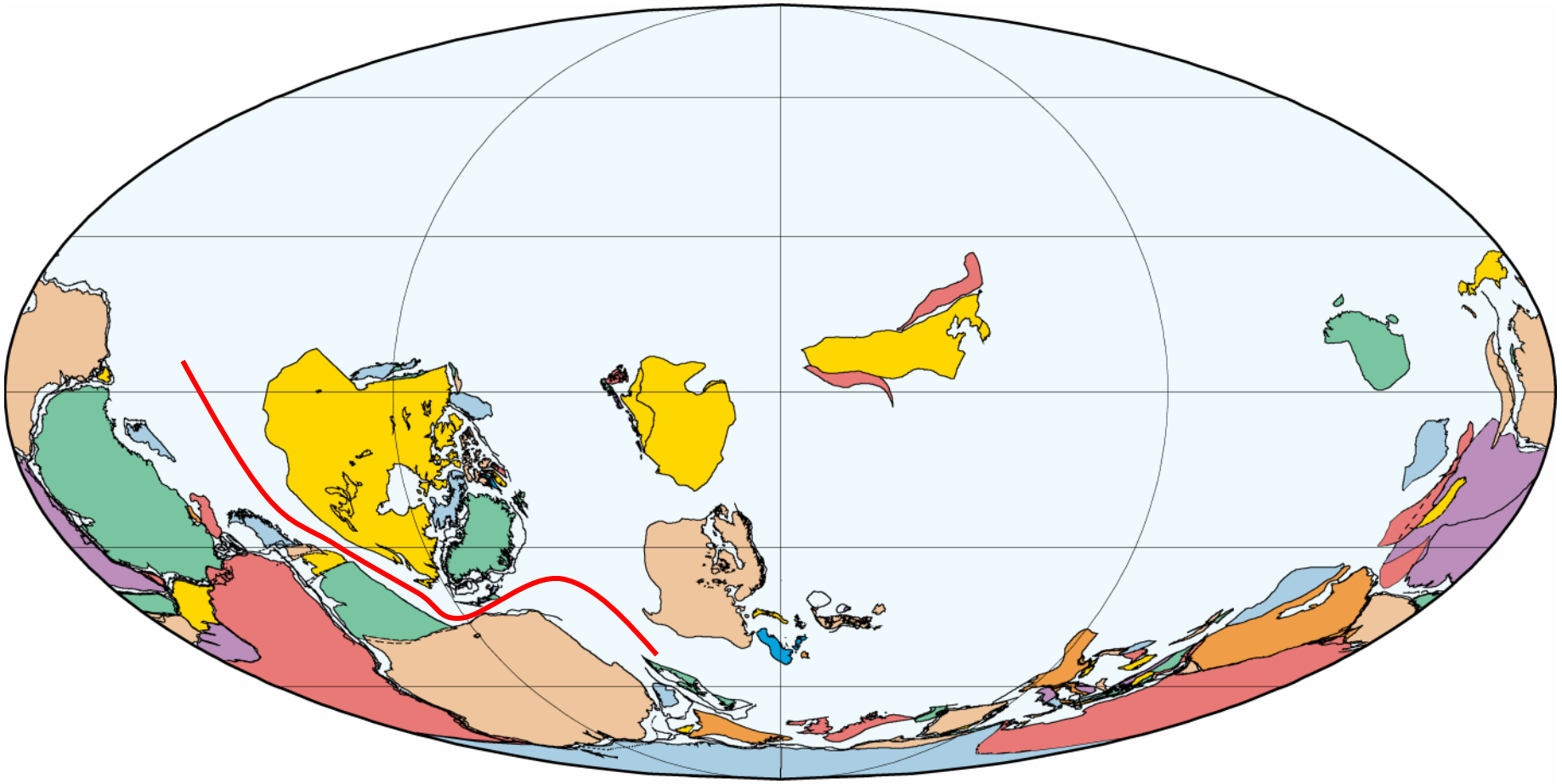


600 Ma

Late Proterozoic

PLATES/UTIG

August 2002

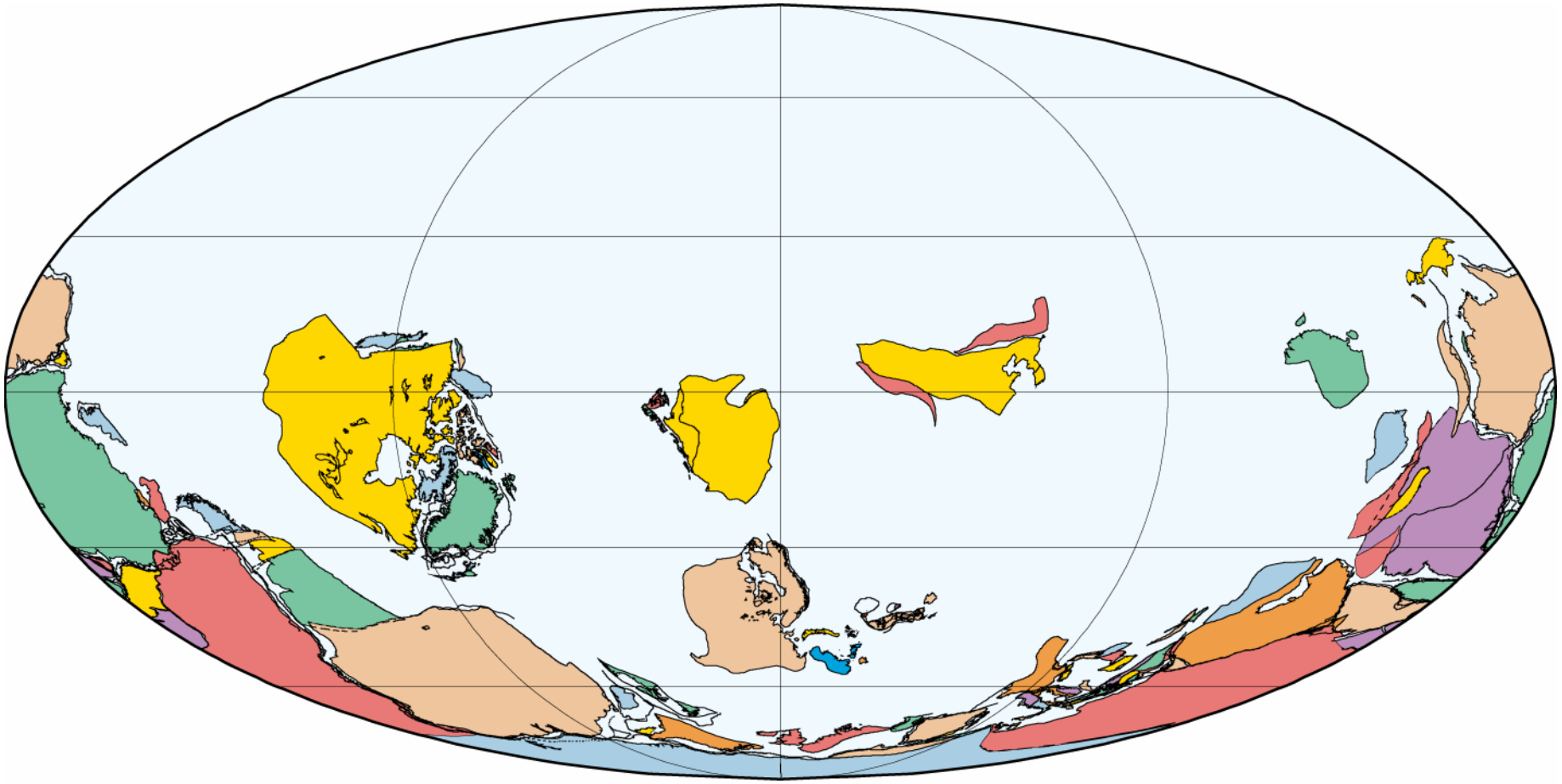


540 Ma

Nemakitian-Daldynian (Early Cambrian)

PLATES/UTIG

August 2002

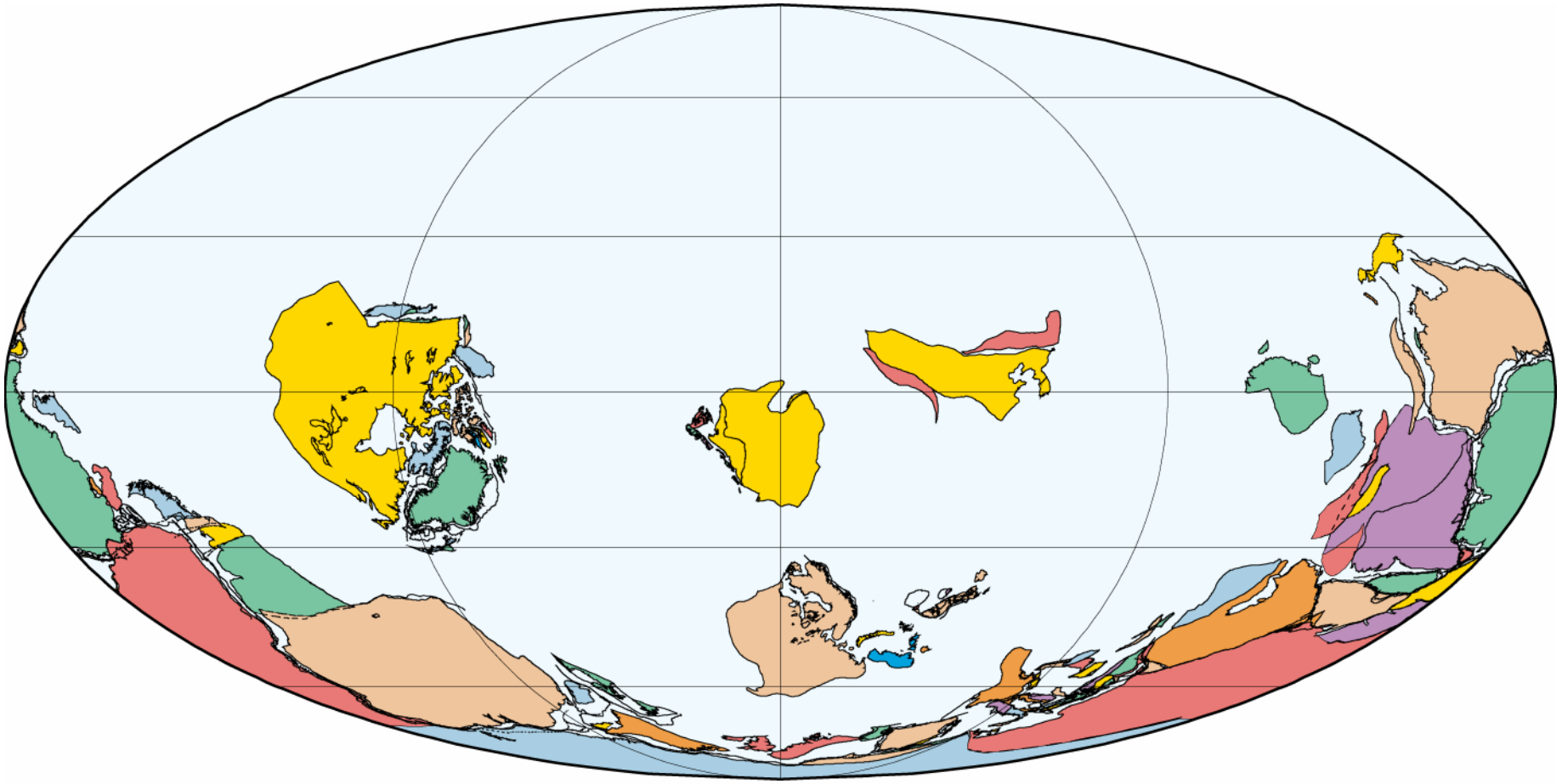


530 Ma

Late Tommotian/Early Atdabanian (Early Cambrian)

PLATES/UTIG

August 2002

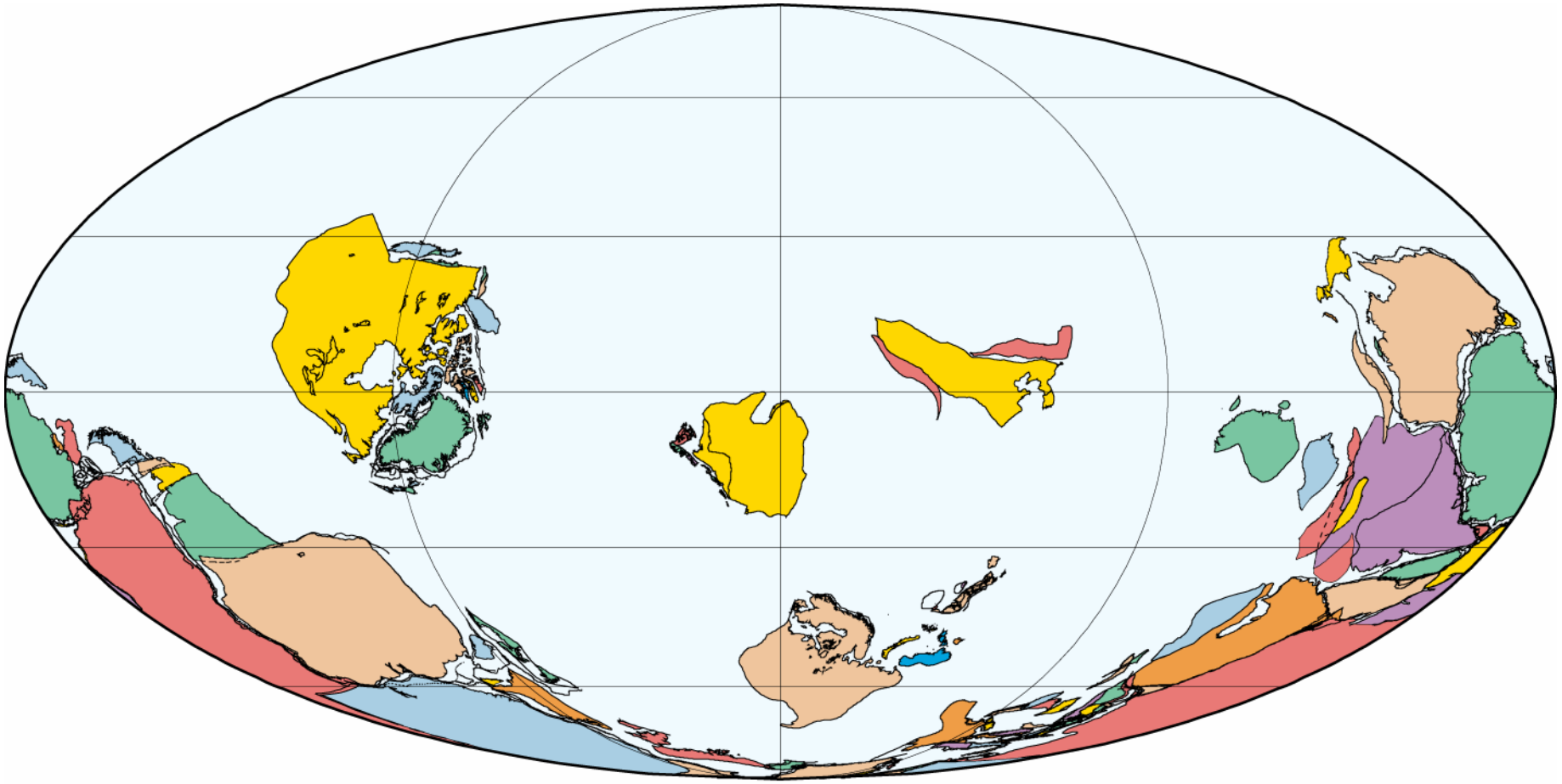


520 Ma

Lenian (Early Cambrian)

PLATES/UTIG

August 2002

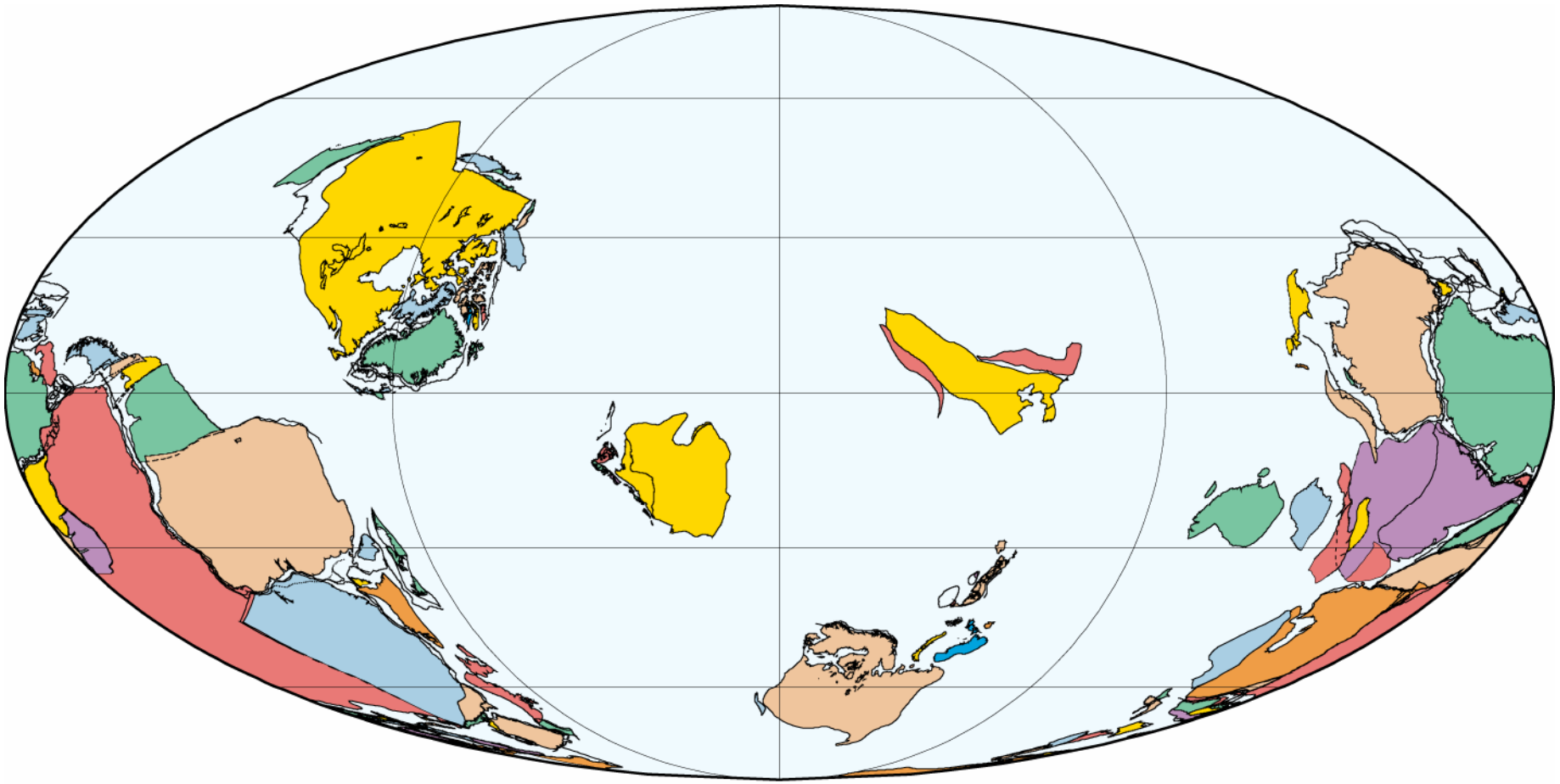


510 Ma

Middle Cambrian

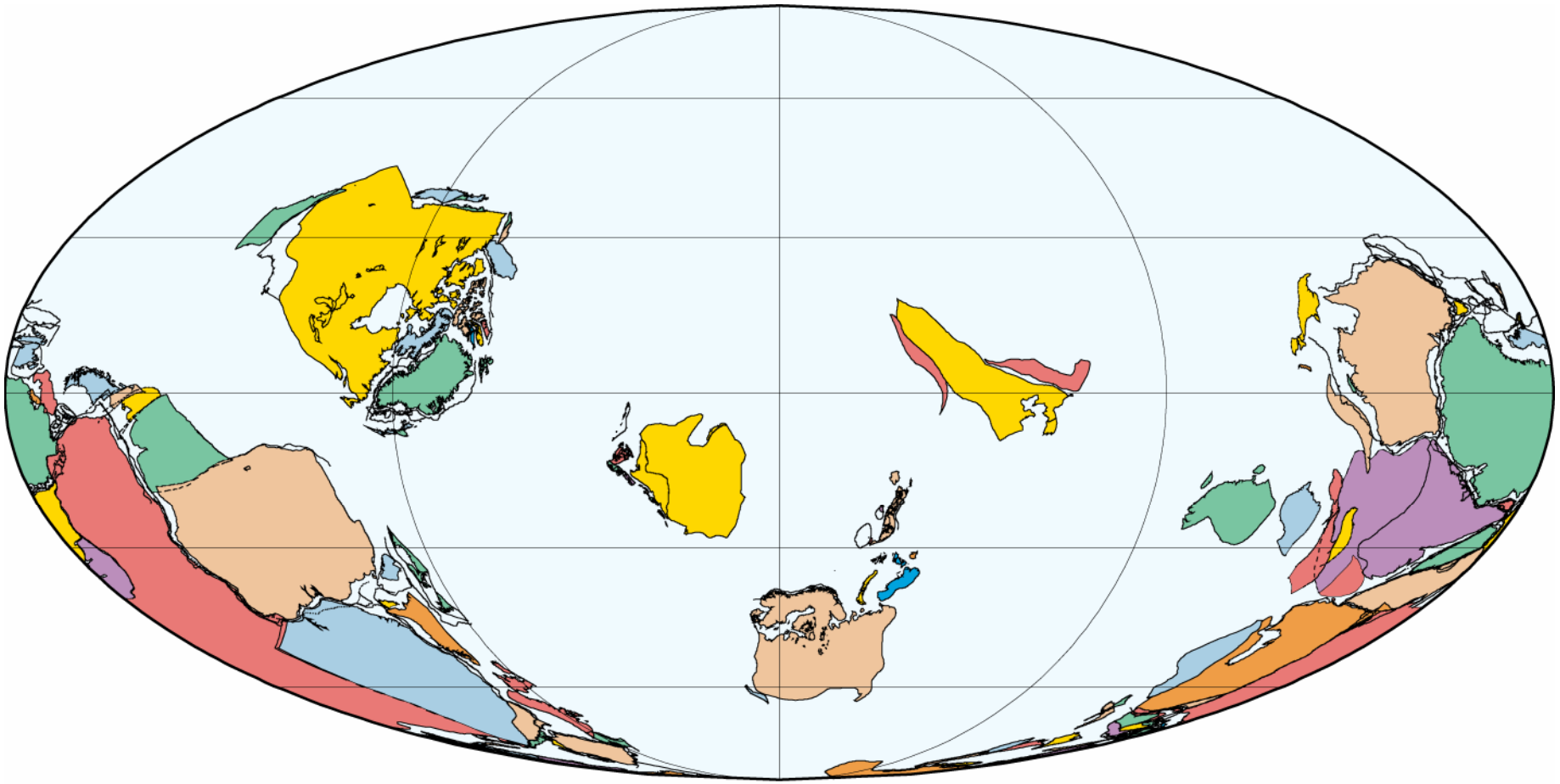
PLATES/UTIG

August 2002



500 Ma
Late Cambrian

PLATES/UTIG
August 2002

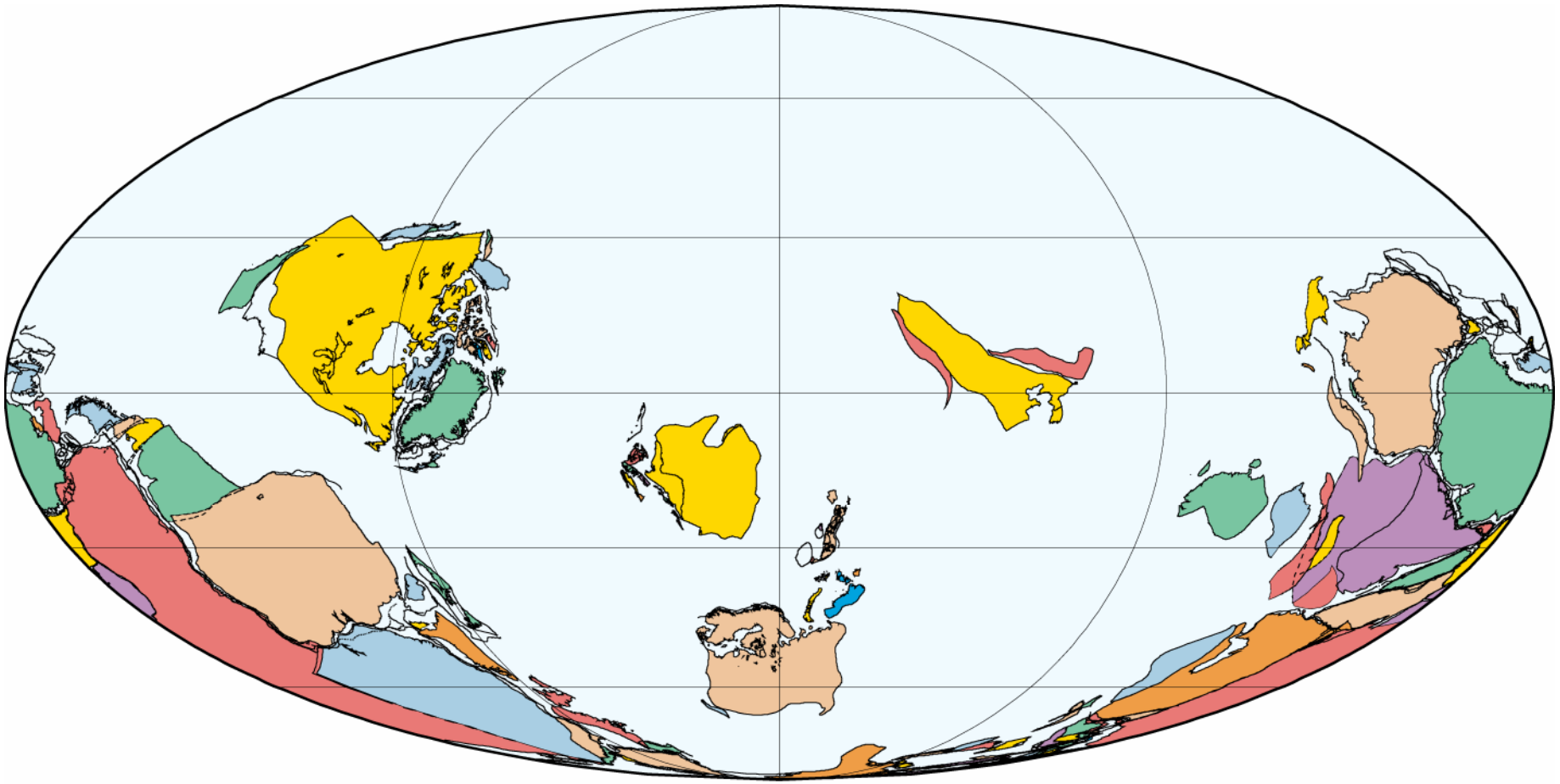


490 Ma

Tremadocian (Early Ordovician)

PLATES/UTIG

August 2002

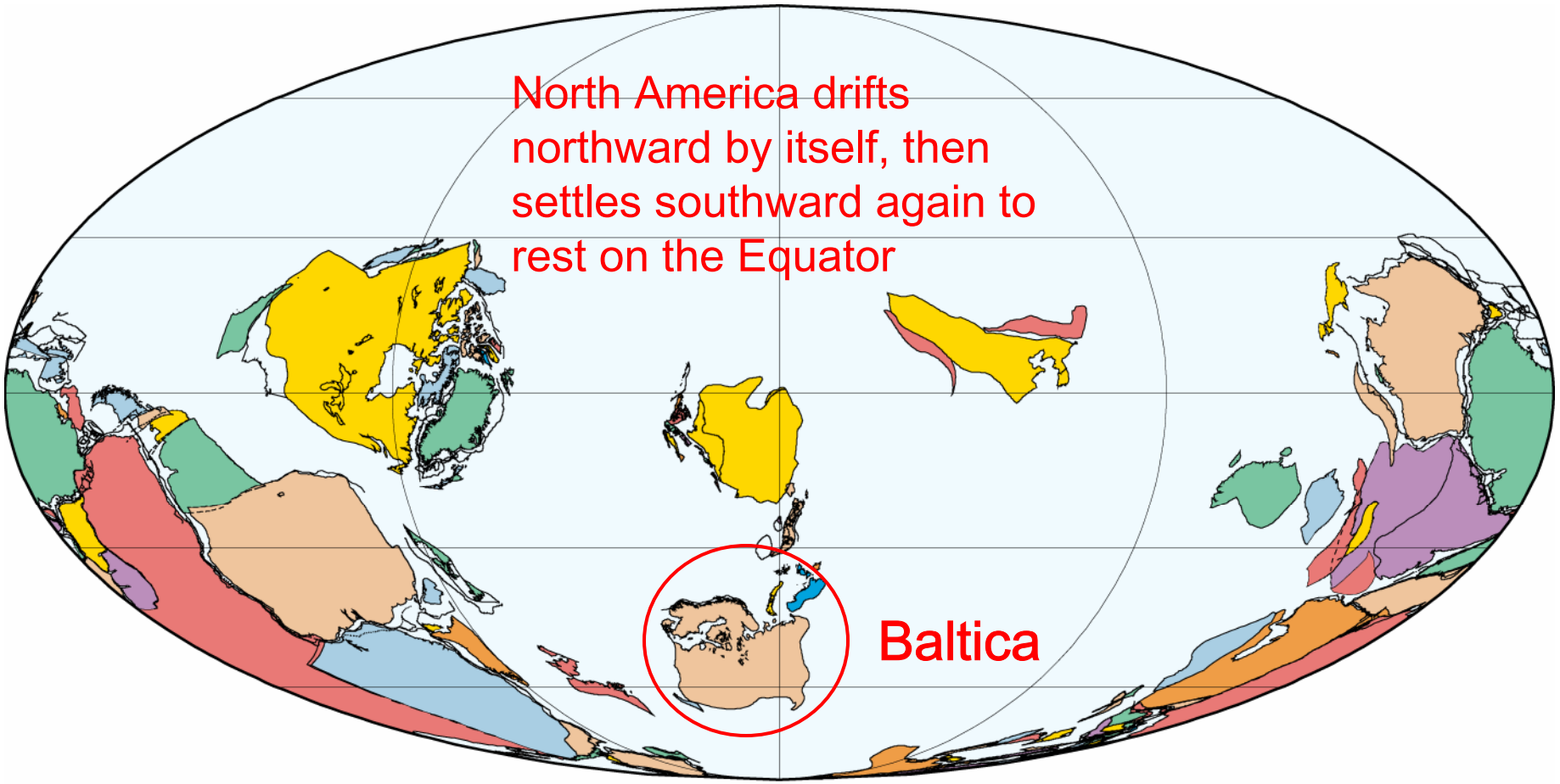


480 Ma

Arenigian (Early Ordovician)

PLATES/UTIG

August 2002

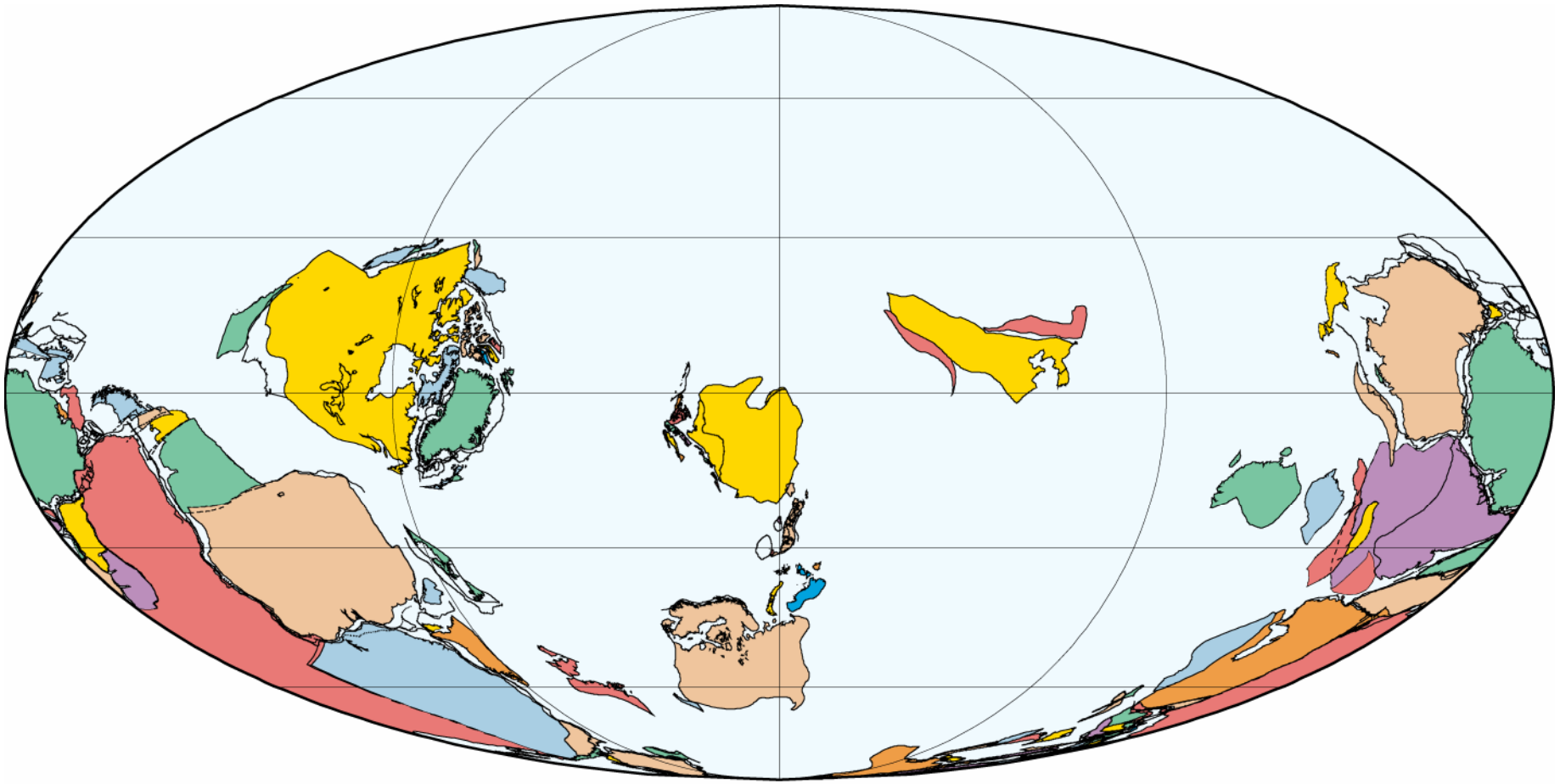


470 Ma

Late Arenigian/Early Llanvirnian (Early/Middle Ordovician)

PLATES/UTIG

August 2002

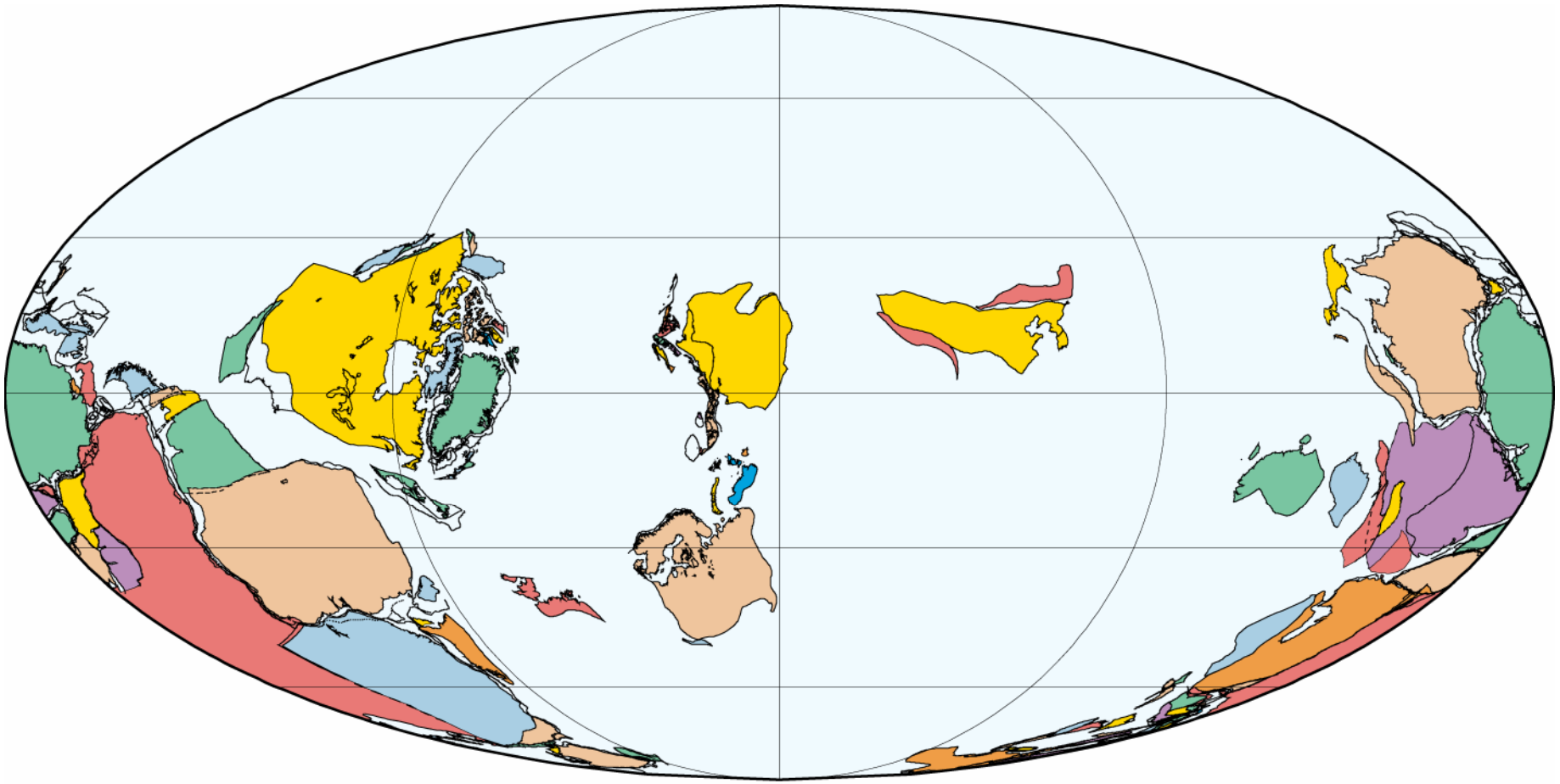


470 Ma

Late Arenigian/Early Llanvirnian (Early/Middle Ordovician)

PLATES/UTIG

August 2002

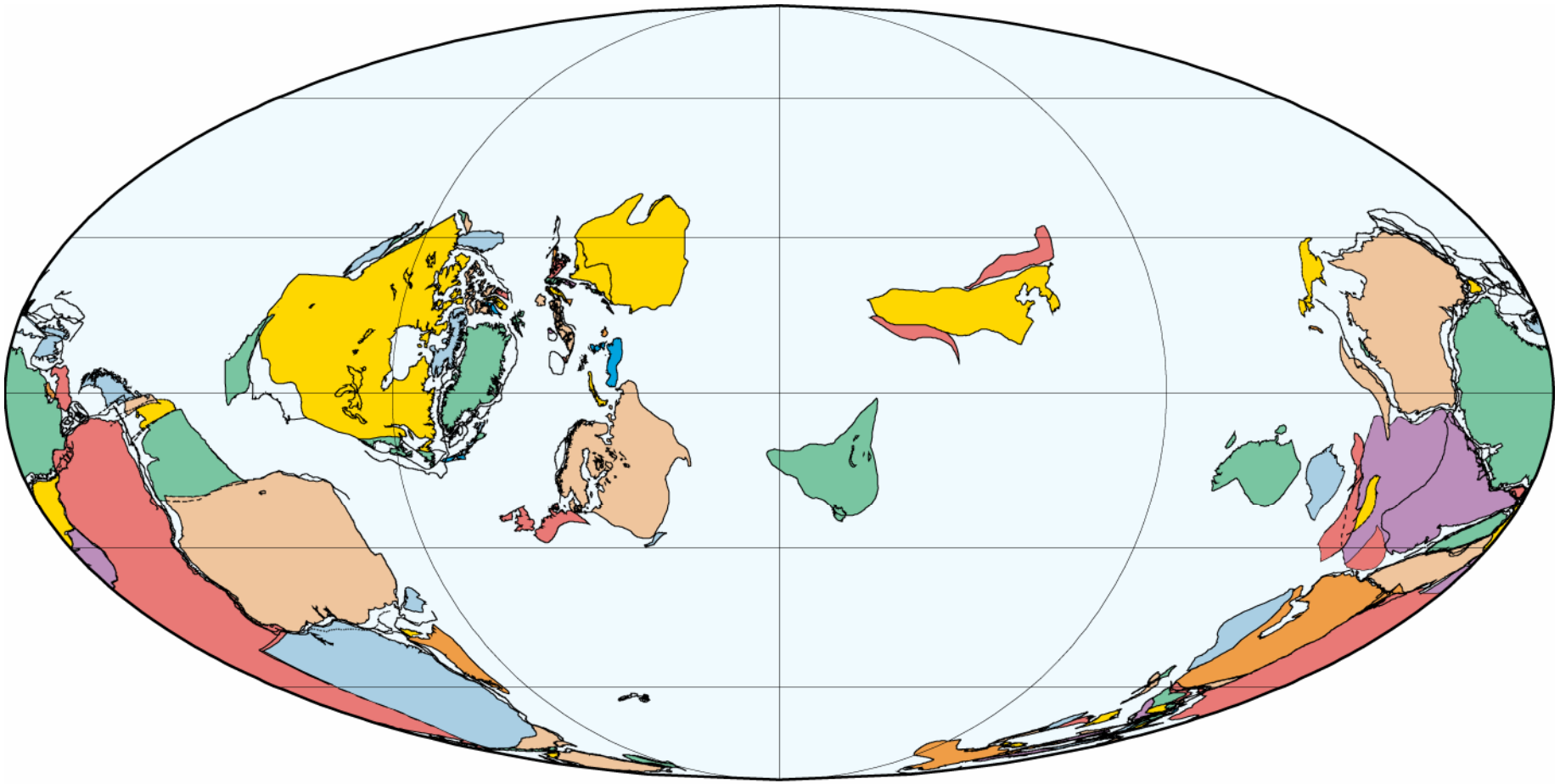


460 Ma

Llandeilan (Middle Ordovician)

PLATES/UTIG

August 2002

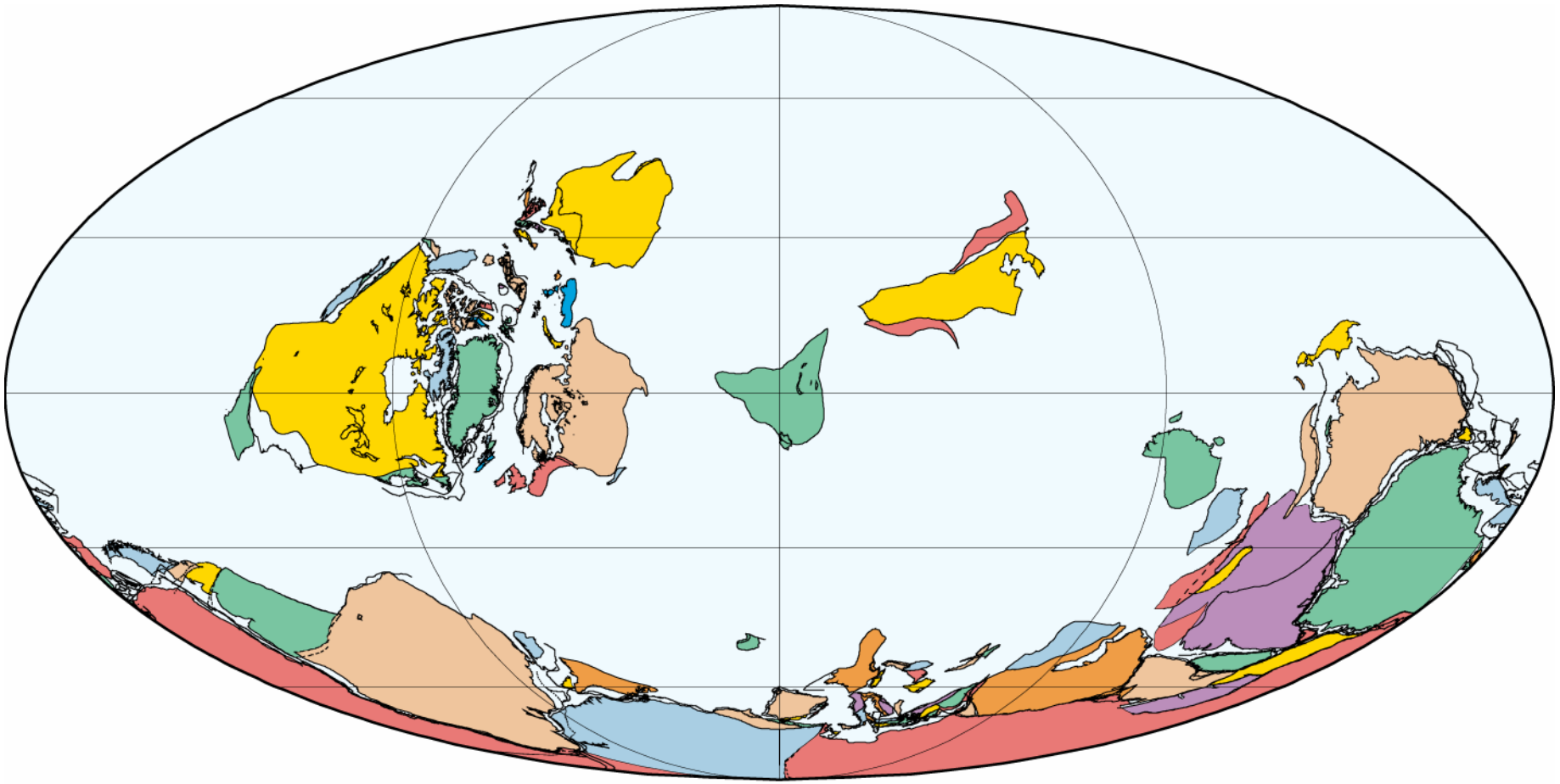


450 Ma

Caradocian (Late Ordovician)

PLATES/UTIG

August 2002

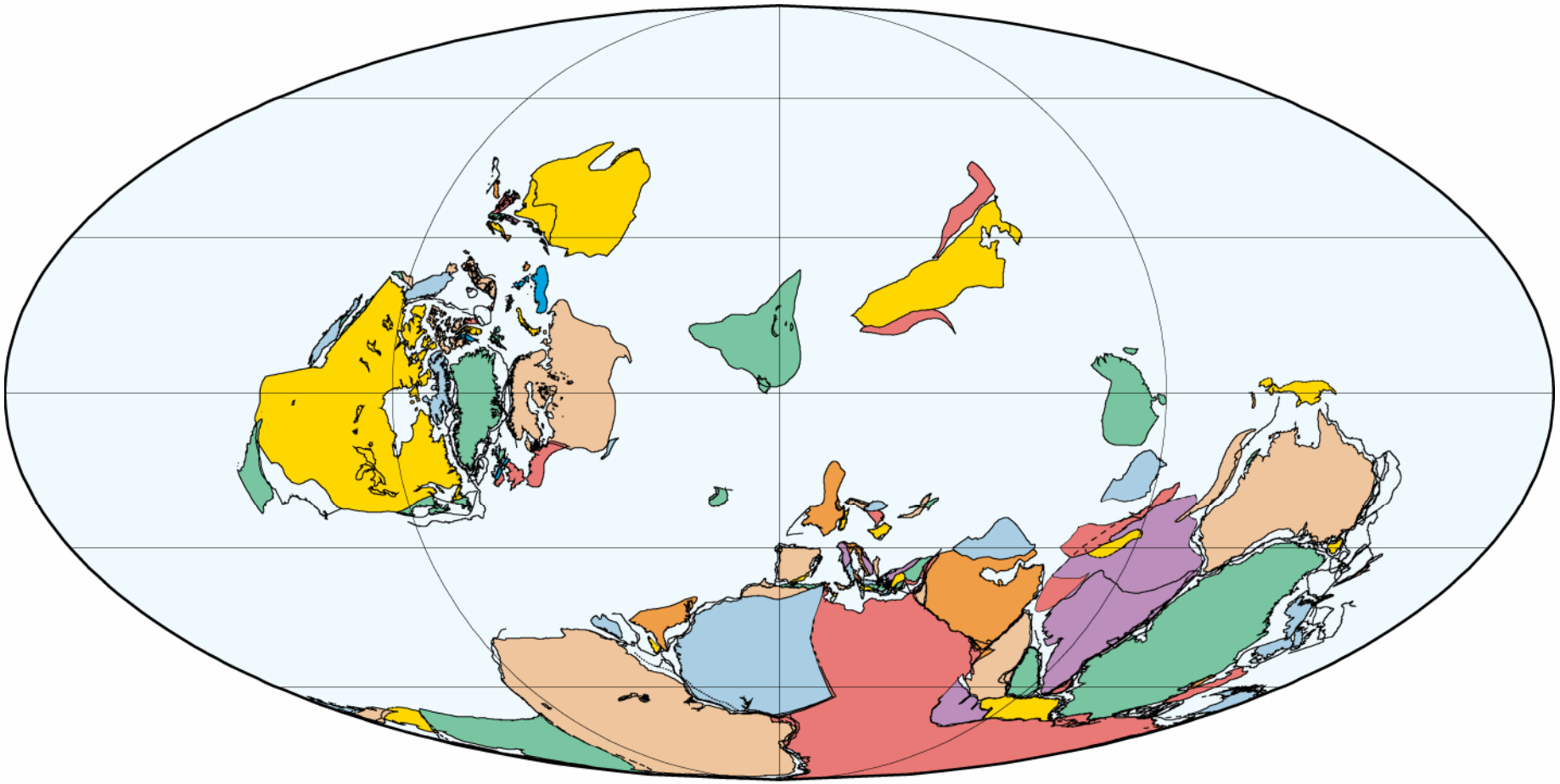


440 Ma

Early Llandoverian (Early Silurian)

PLATES/UTIG

August 2002

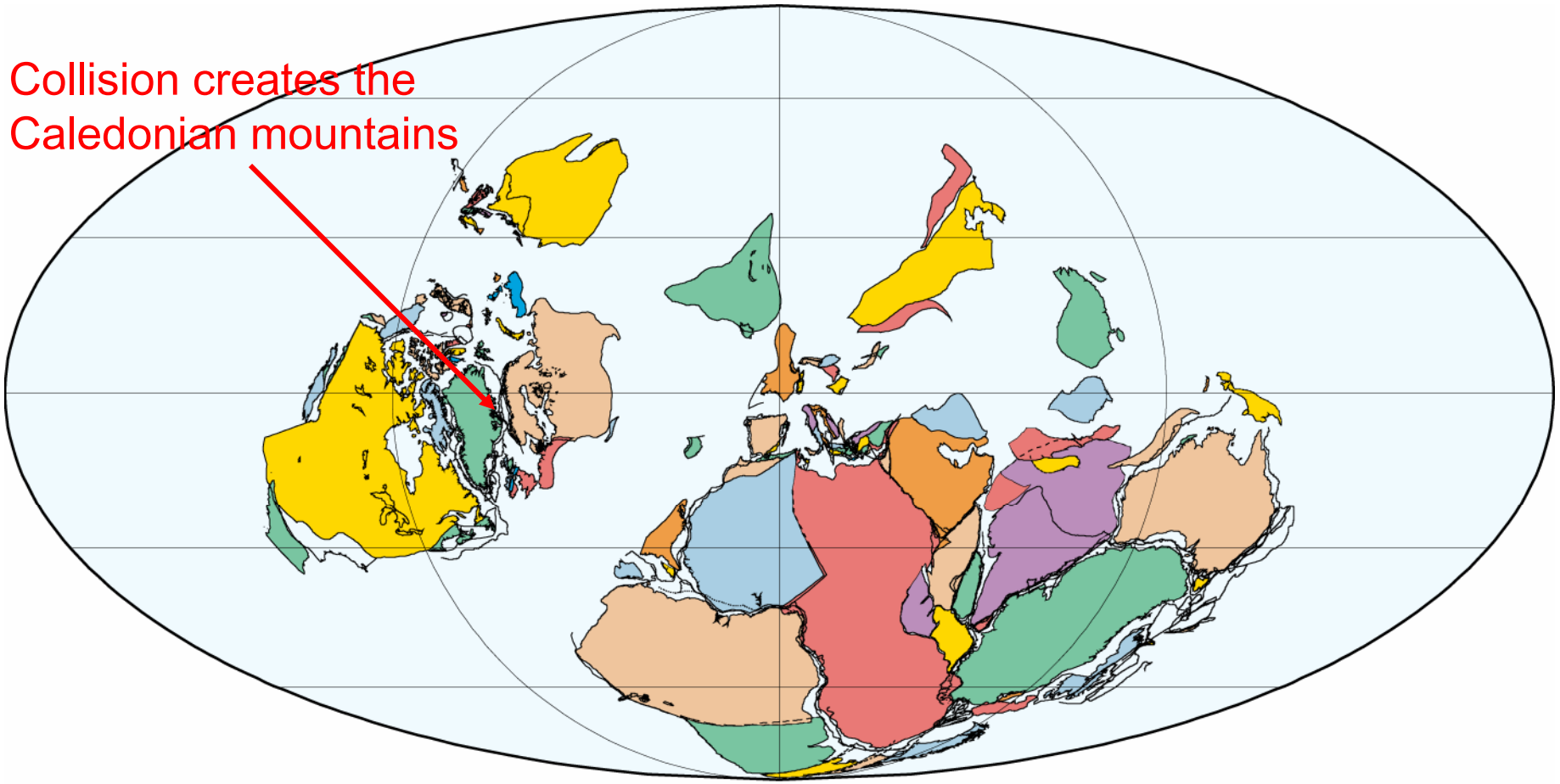


430 Ma

Late Llandoverian (Early Silurian)

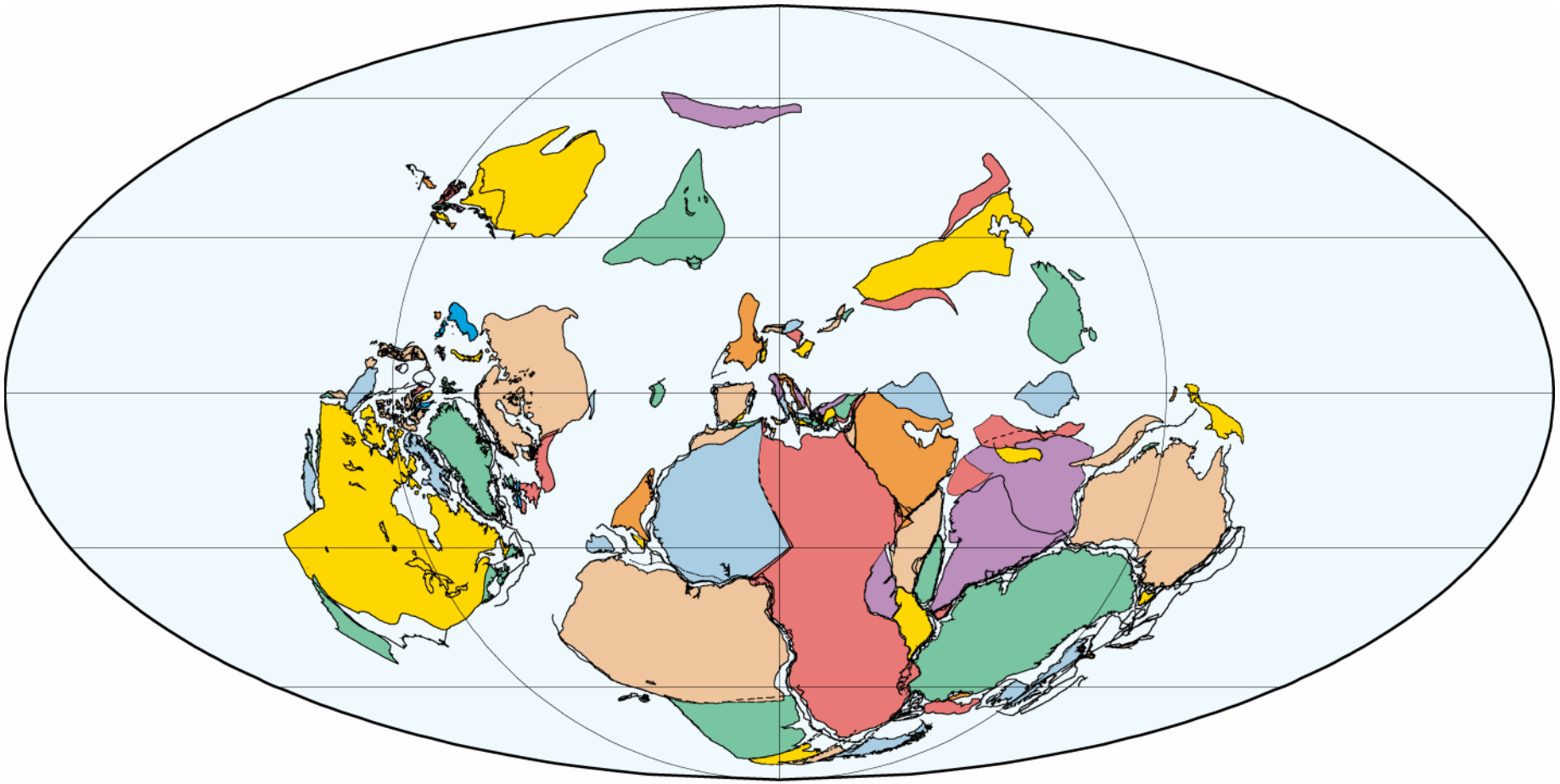
PLATES/UTIG

August 2002



420 Ma
Ludlovian (Late Silurian)

PLATES/UTIG
August 2002

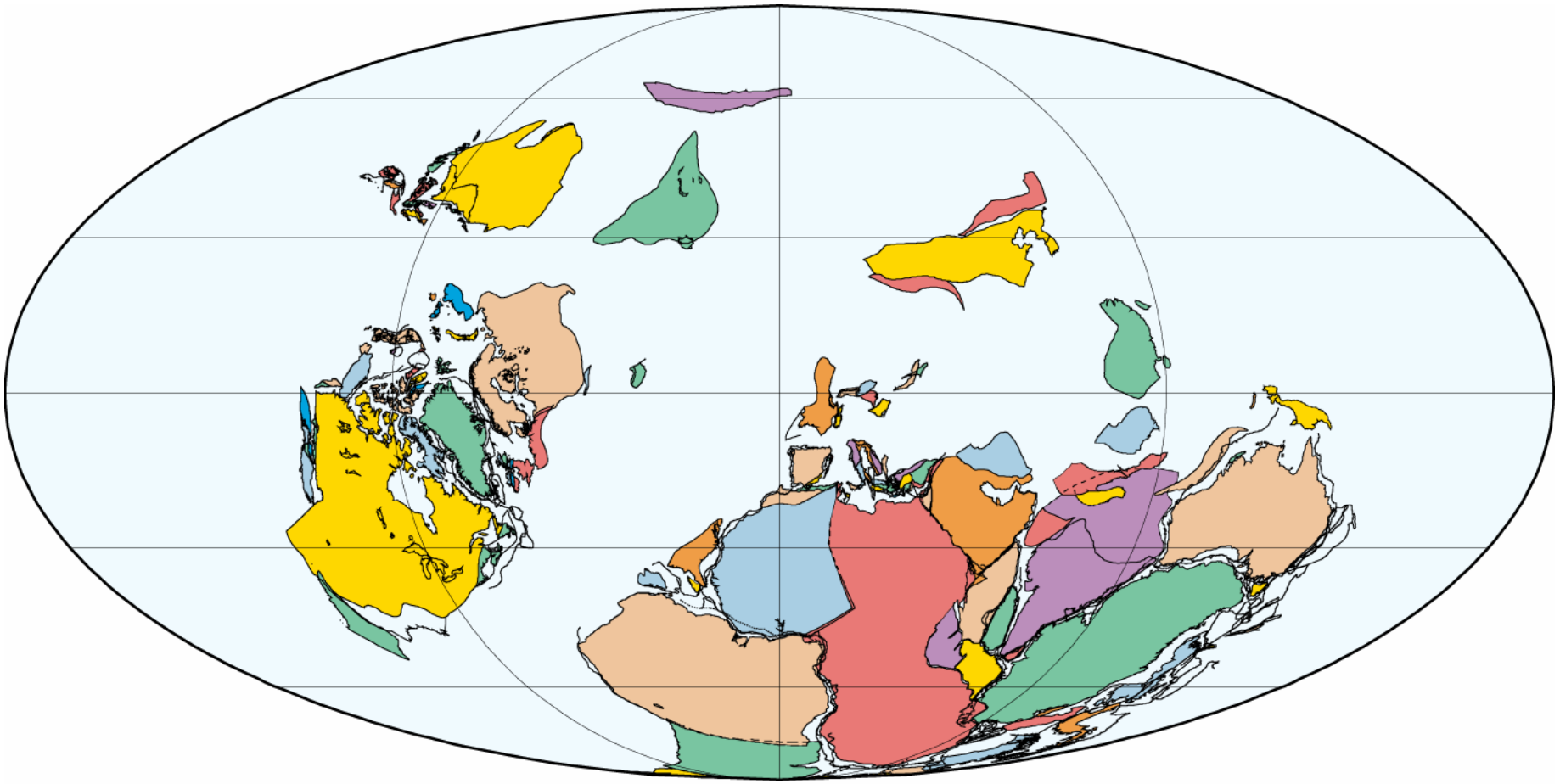


410 Ma

Early Praghian (Early Devonian)

PLATES/UTIG

August 2002

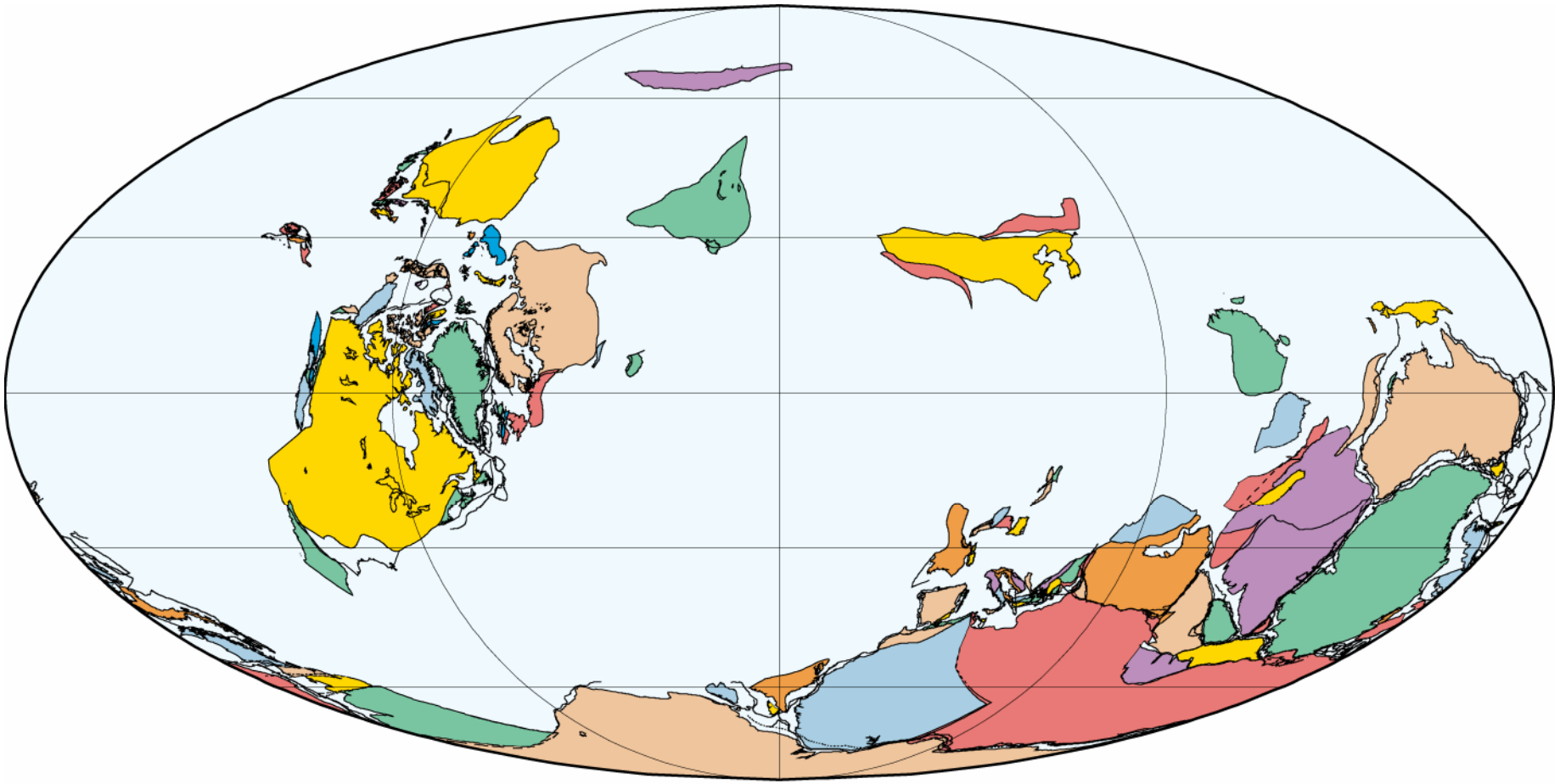


400 Ma

Late Praghian/Early Emsian (Early Devonian)

PLATES/UTIG

August 2002

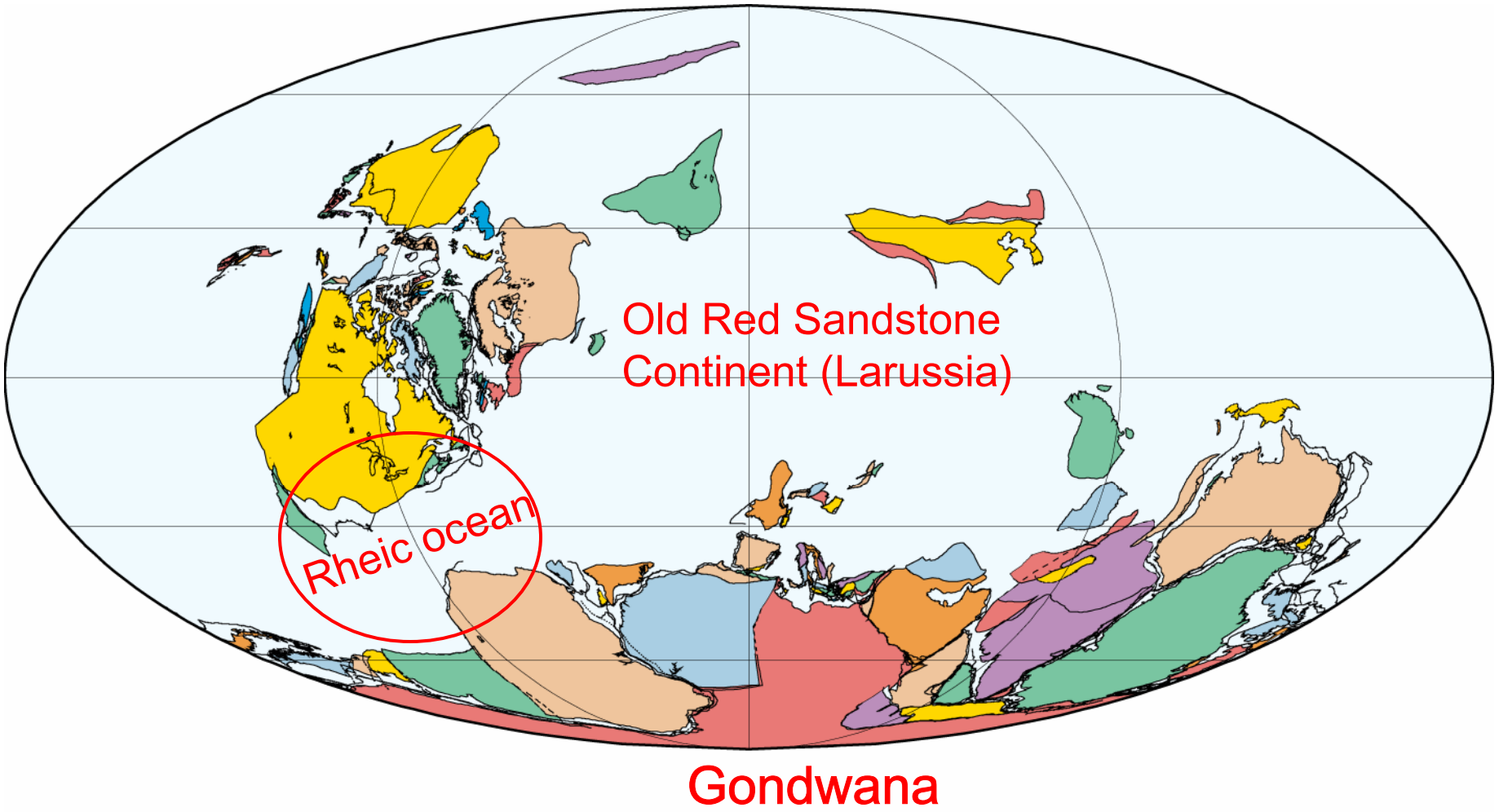


390 Ma

Early Eifelian (Early Devonian)

PLATES/UTIG

August 2002

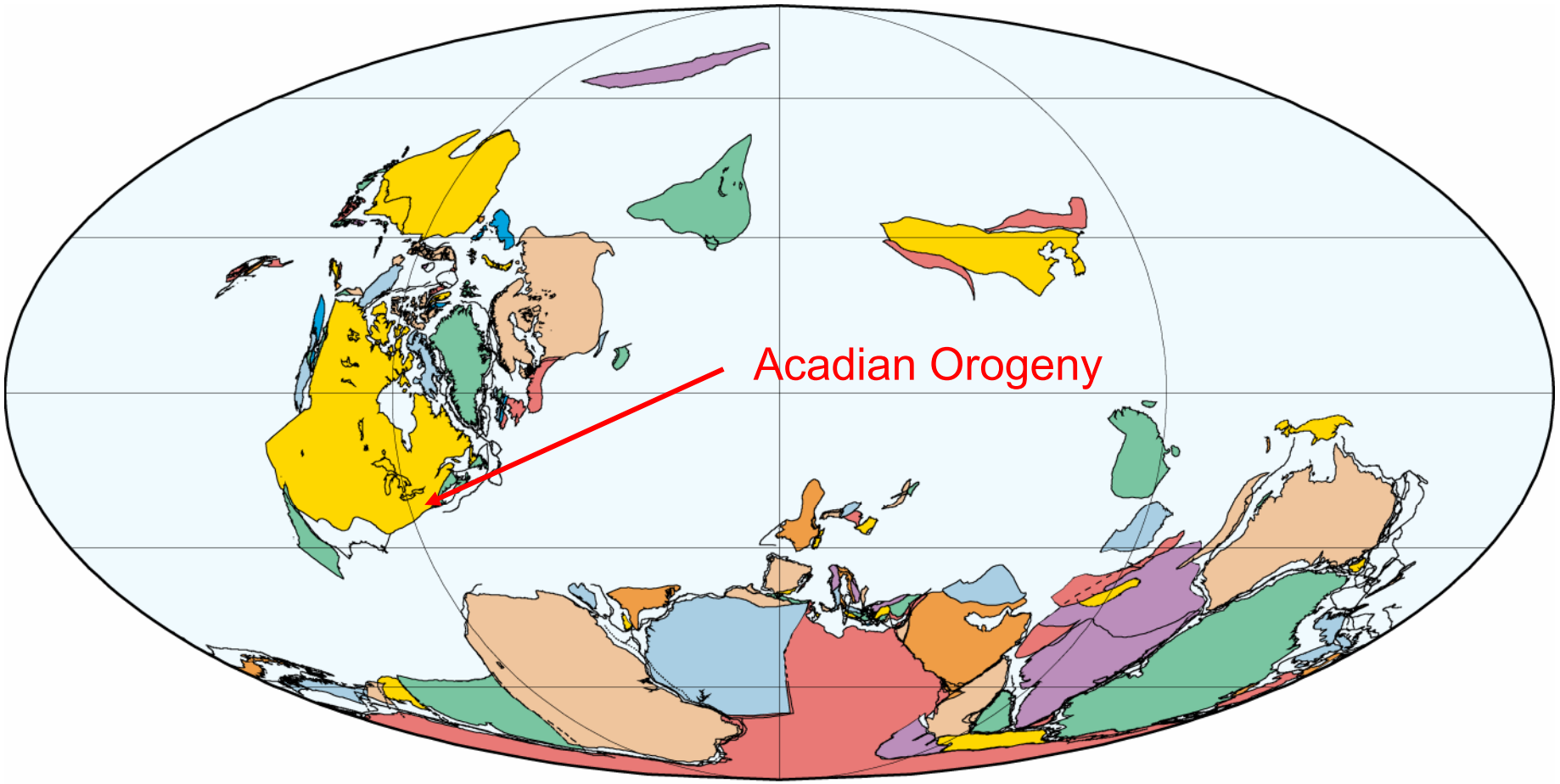


380 Ma

Late Eifelian/Early Givetian (Middle Devonian)

PLATES/UTIG

August 2002

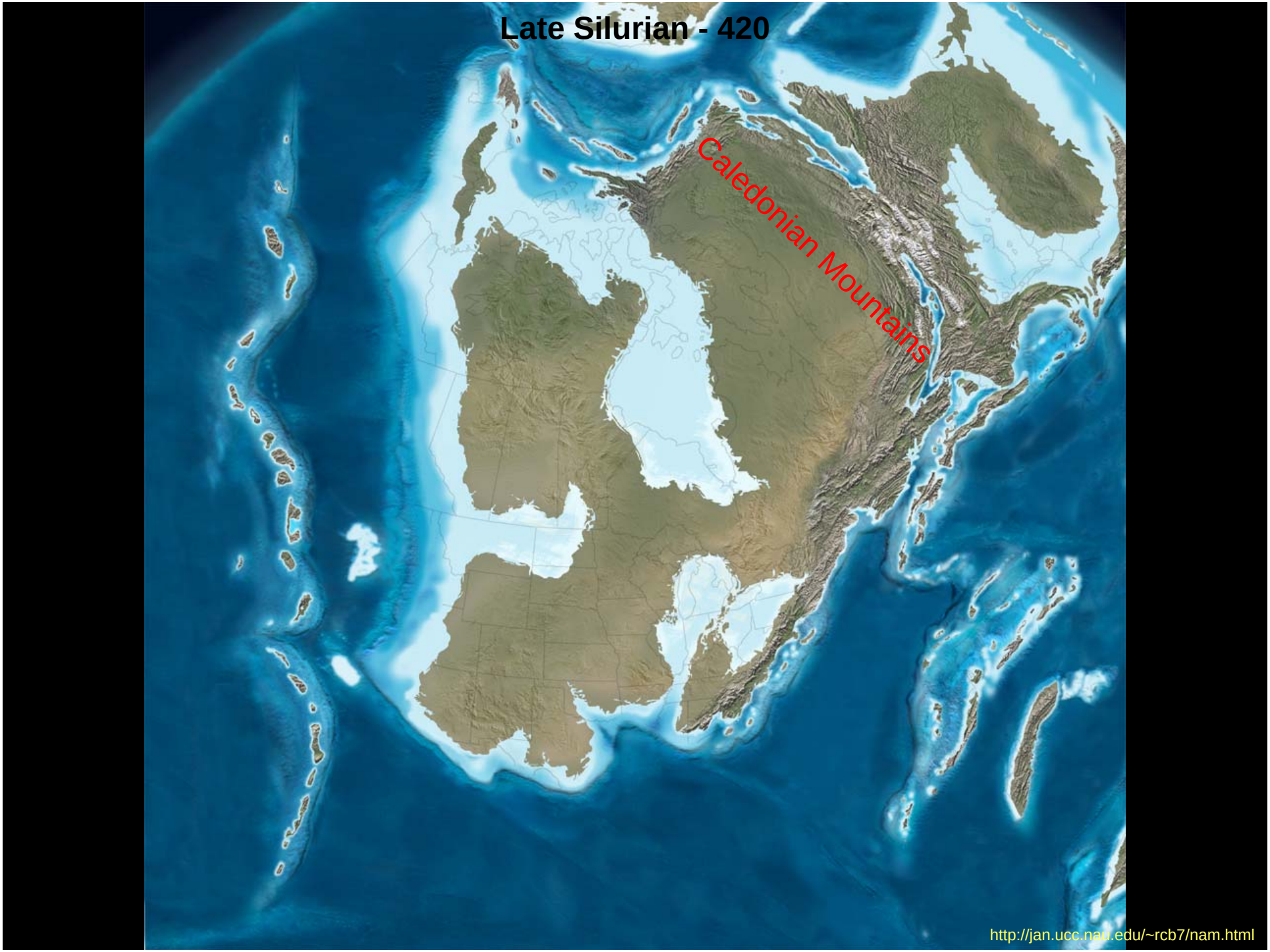


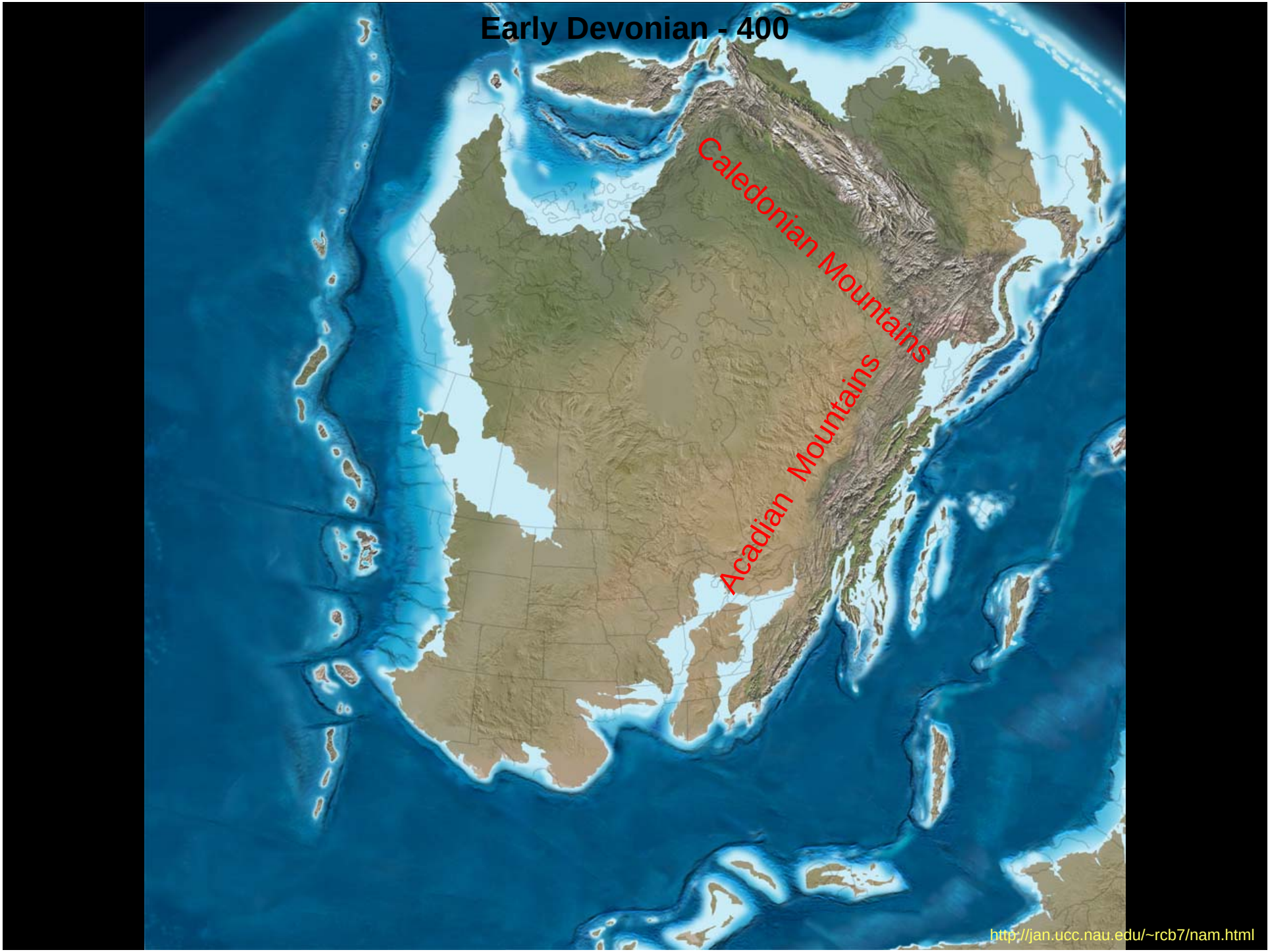
380 Ma

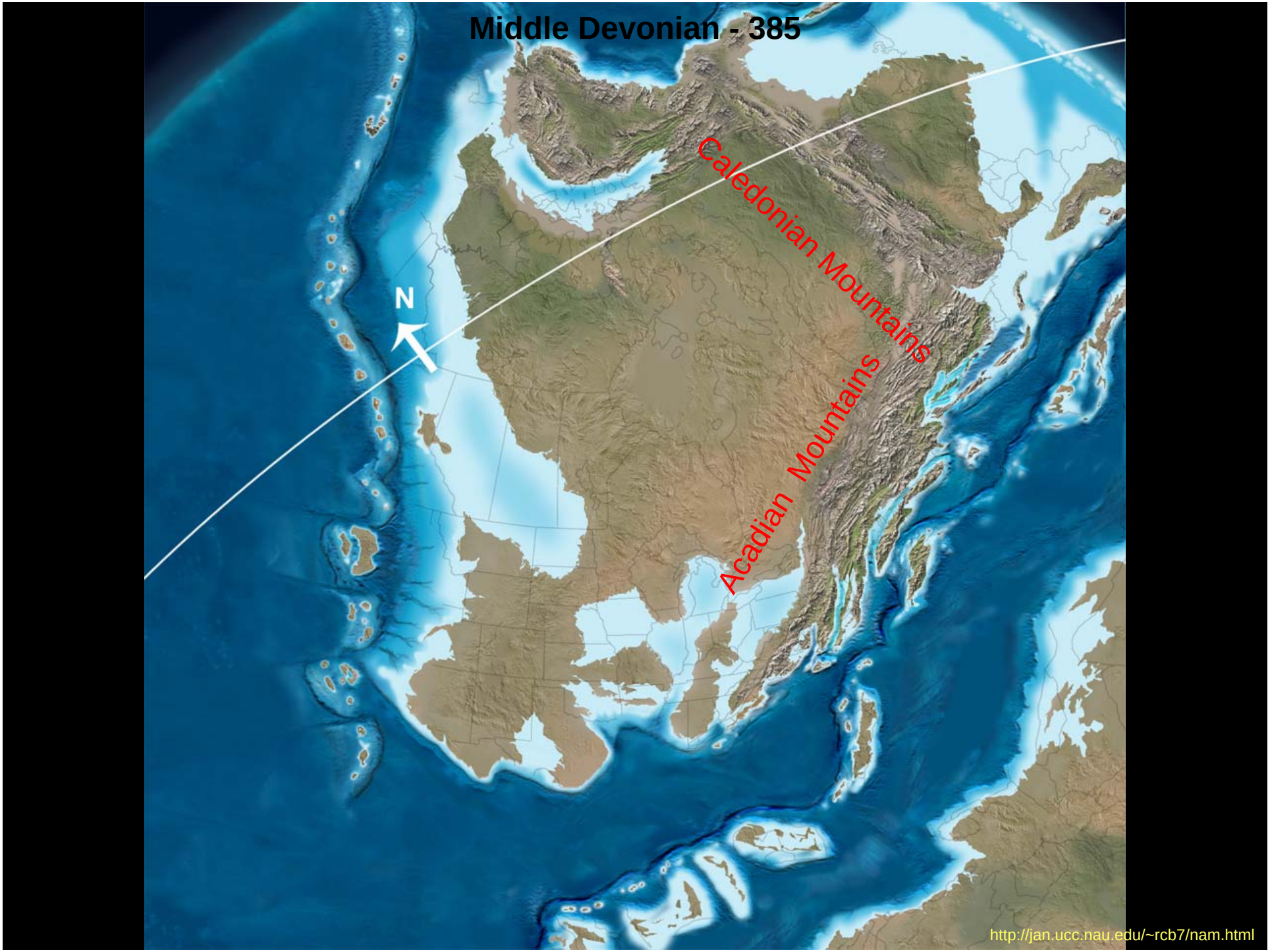
Late Eifelian/Early Givetian (Middle Devonian)

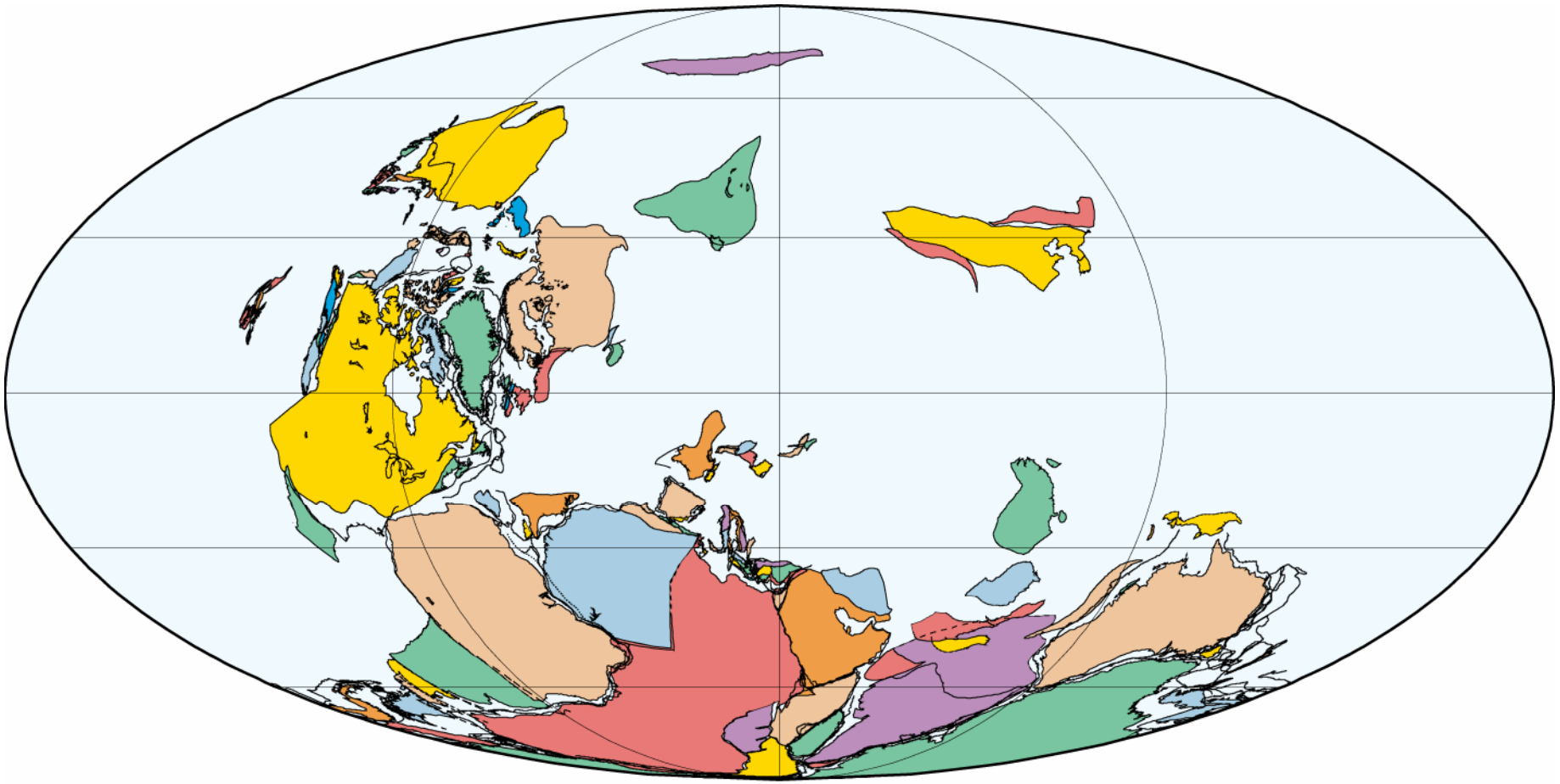
PLATES/UTIG

August 2002


Late Silurian - 420
Caledonian Mountains
http://jan.ucc.nau.edu/~rcb7/nam.html


Early Devonian - 400
Caledonian Mountains
Acadian Mountains
http://jan.ucc.nau.edu/~rcb7/nam.html


Middle Devonian - 385
Caledonian Mountains
Acadian Mountains
N
http://jan.ucc.nau.edu/~rcb7/nam.html

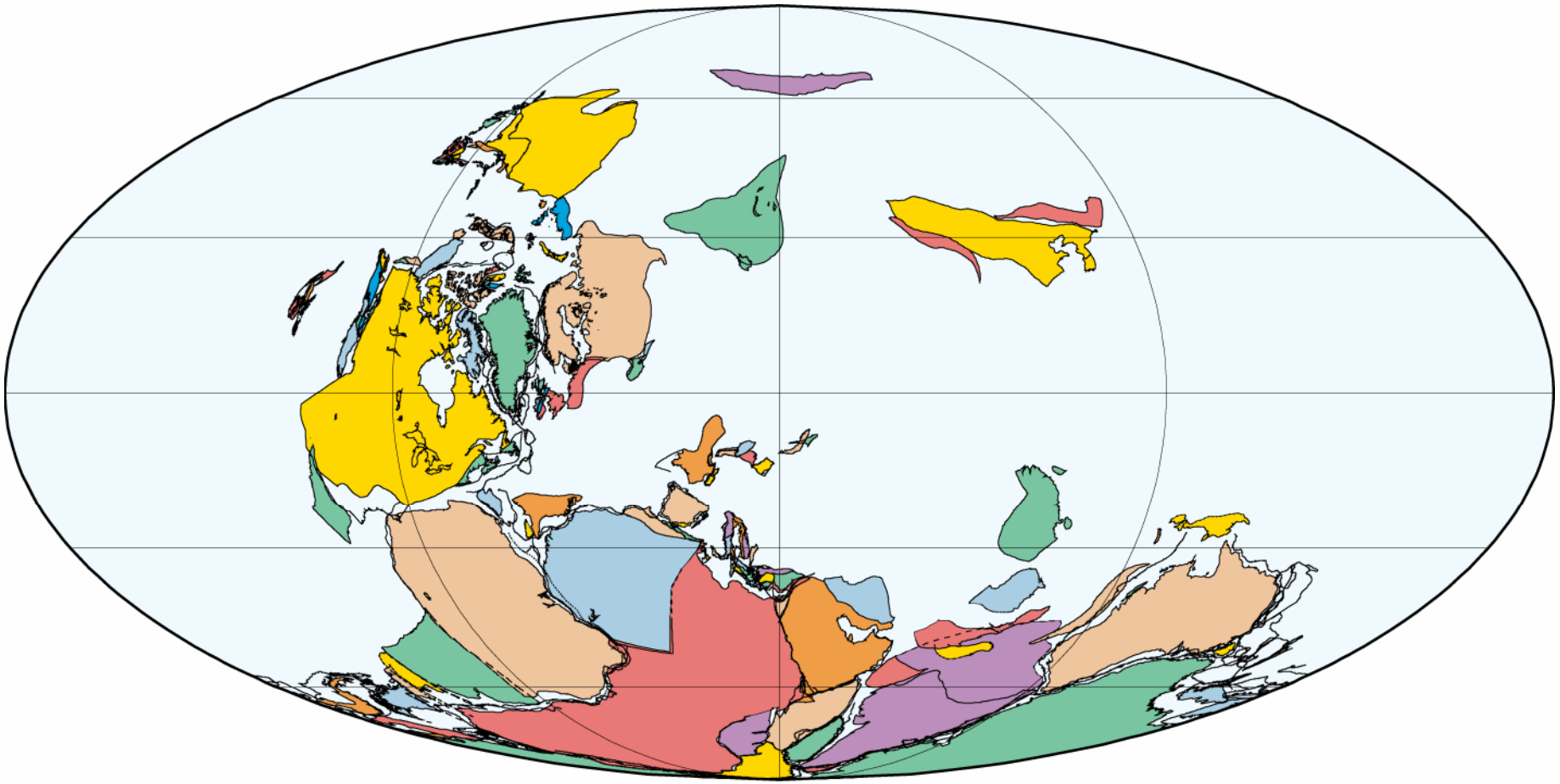


370 Ma

Late Givetian/Early Frasnian (Late Devonian)

PLATES/UTIG

August 2002

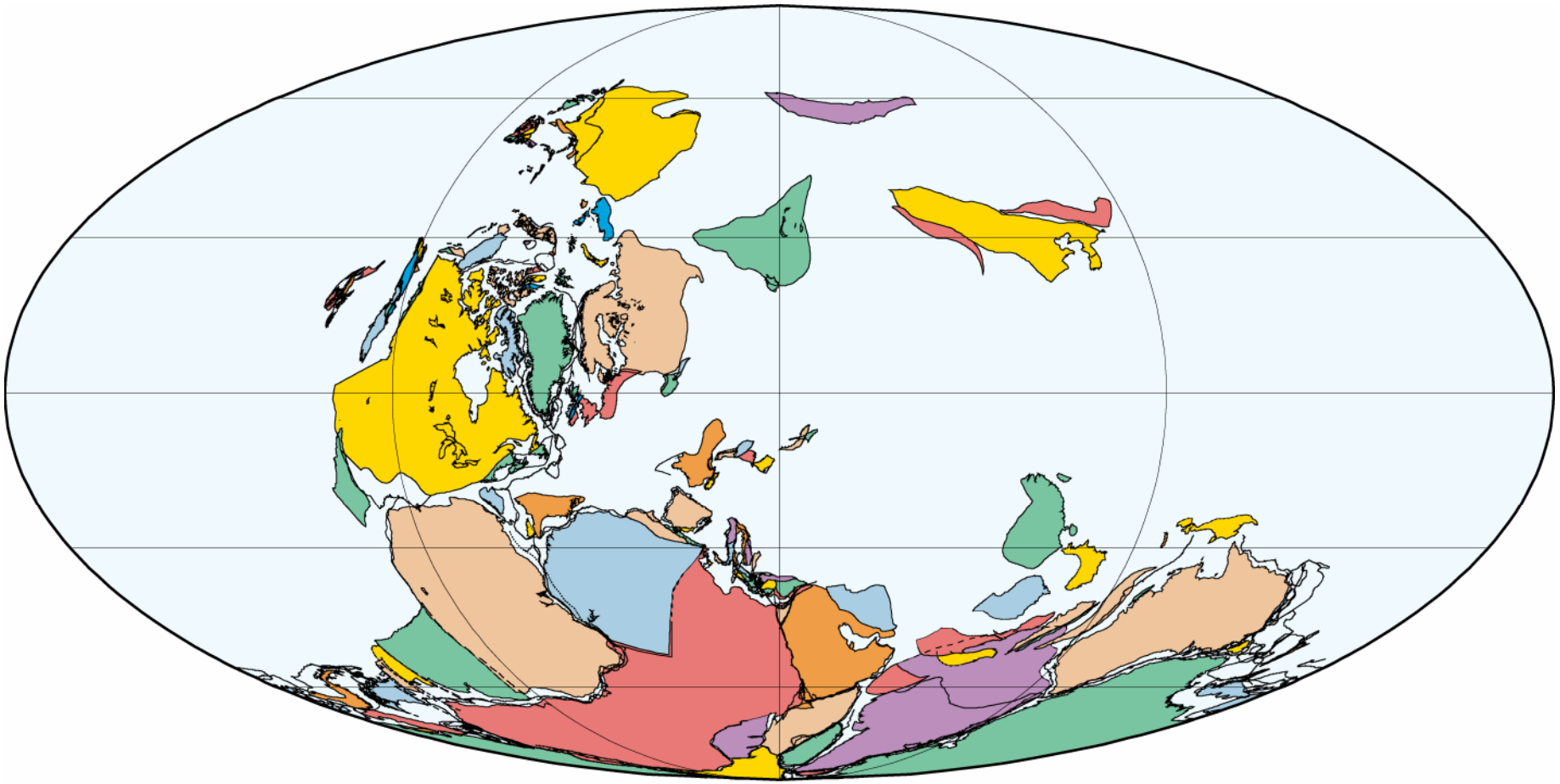


360 Ma

Famennian (Late Devonian)

PLATES/UTIG

August 2002

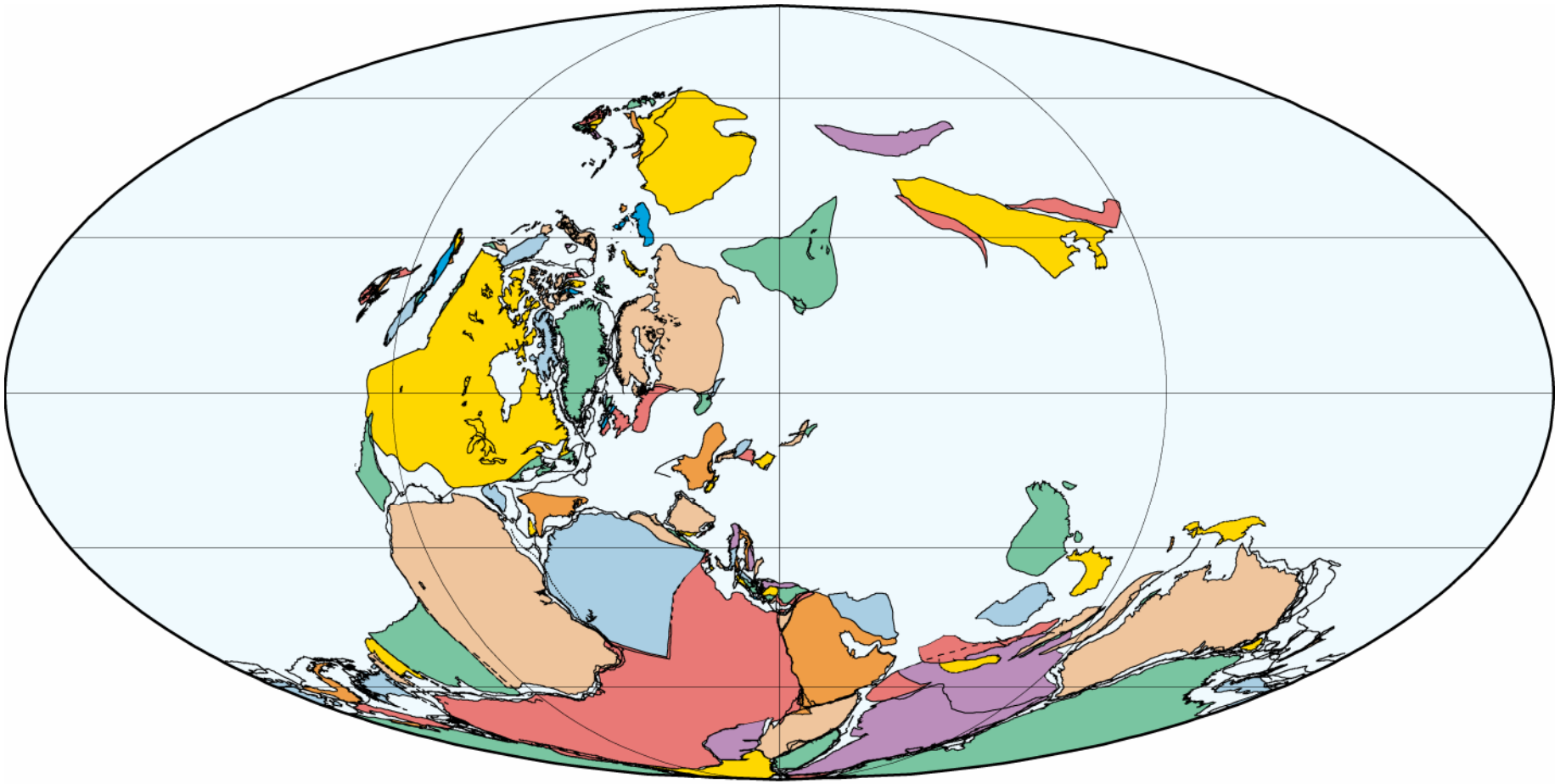


350 Ma

Tournaisian (Mississippian)

PLATES/UTIG

August 2002

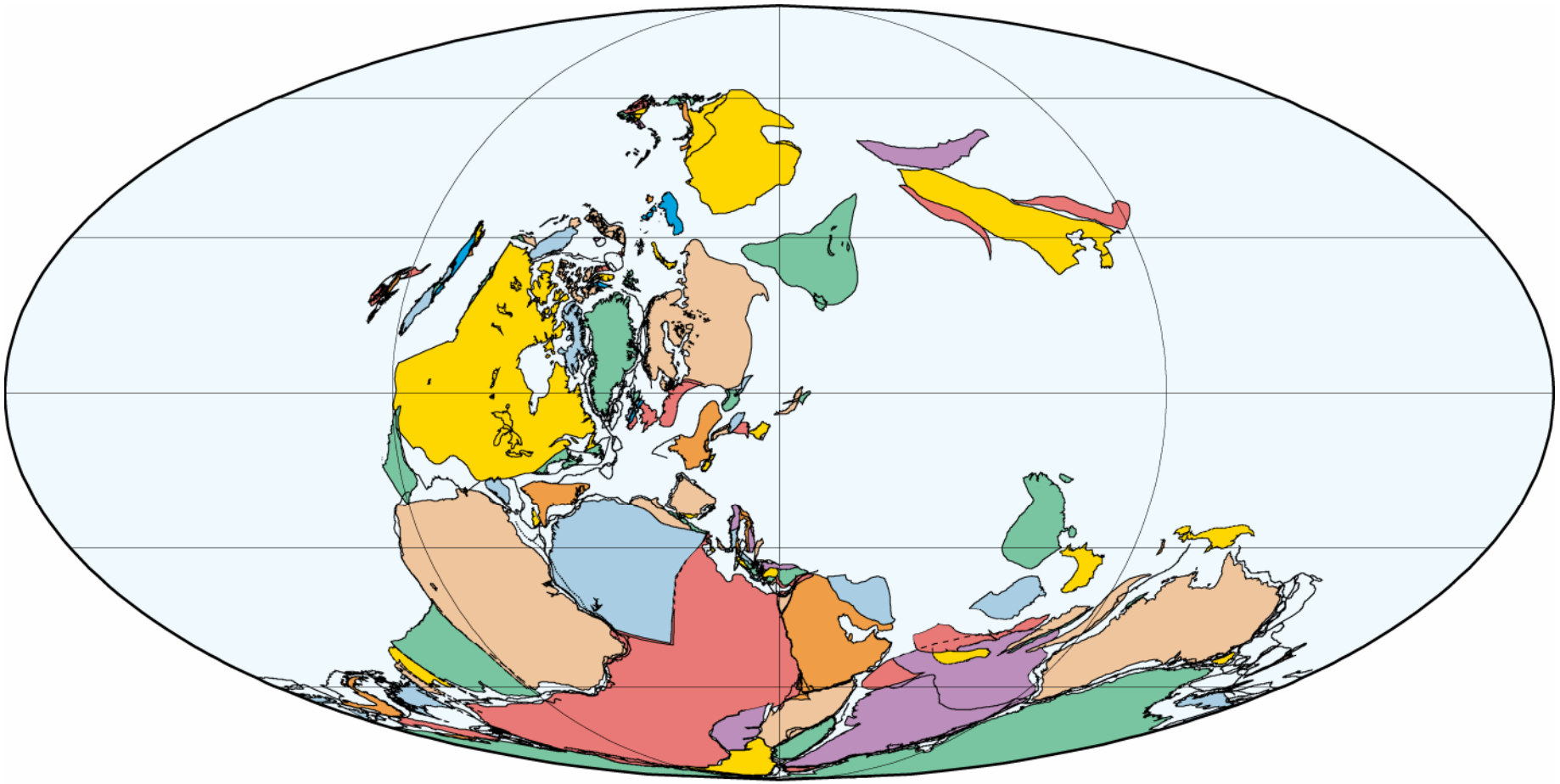


340 Ma

Early Visean (Mississippian)

PLATES/UTIG

August 2002

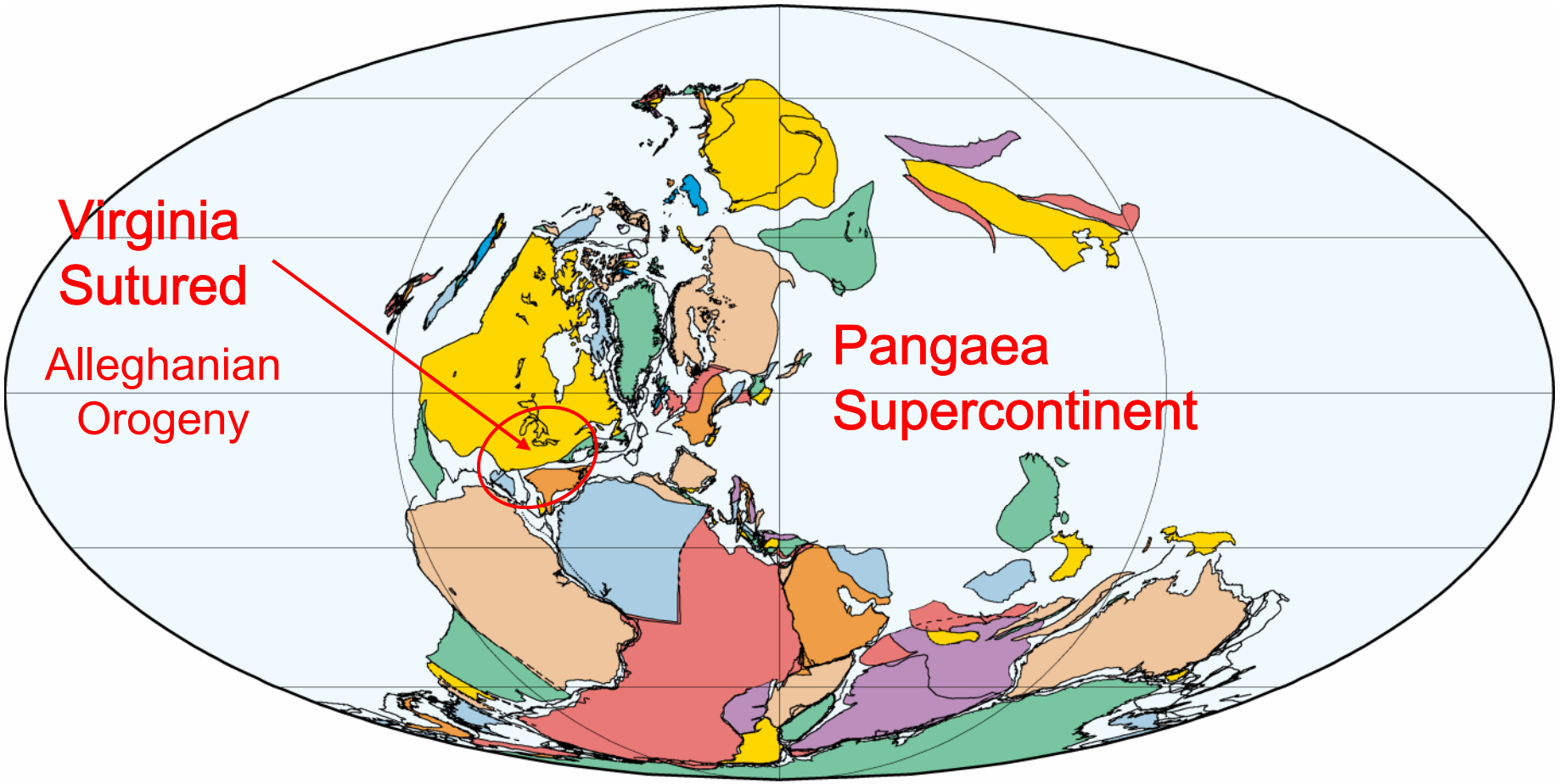


330 Ma

Late Visean (Mississippian)

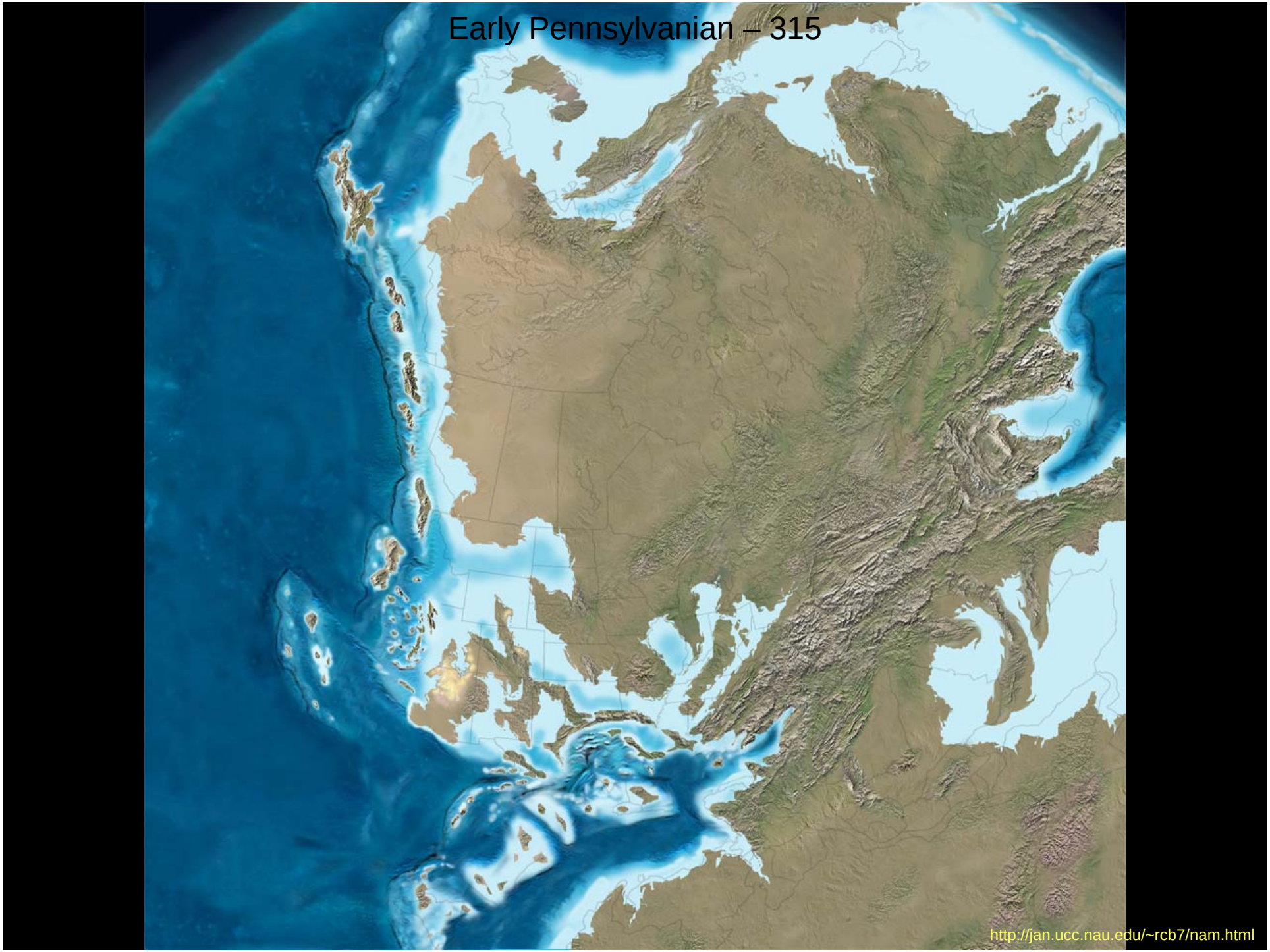
PLATES/UTIG

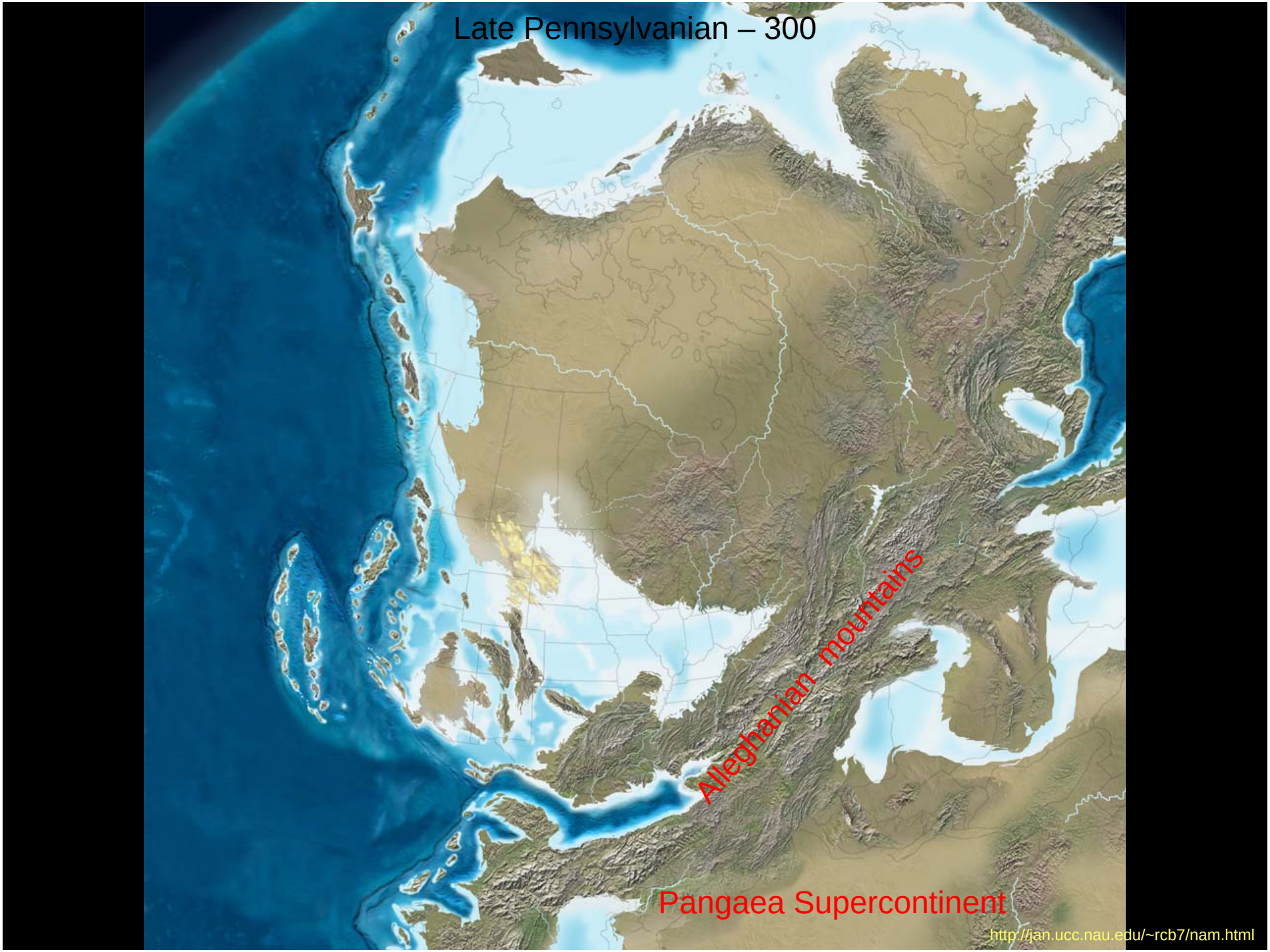
August 2002

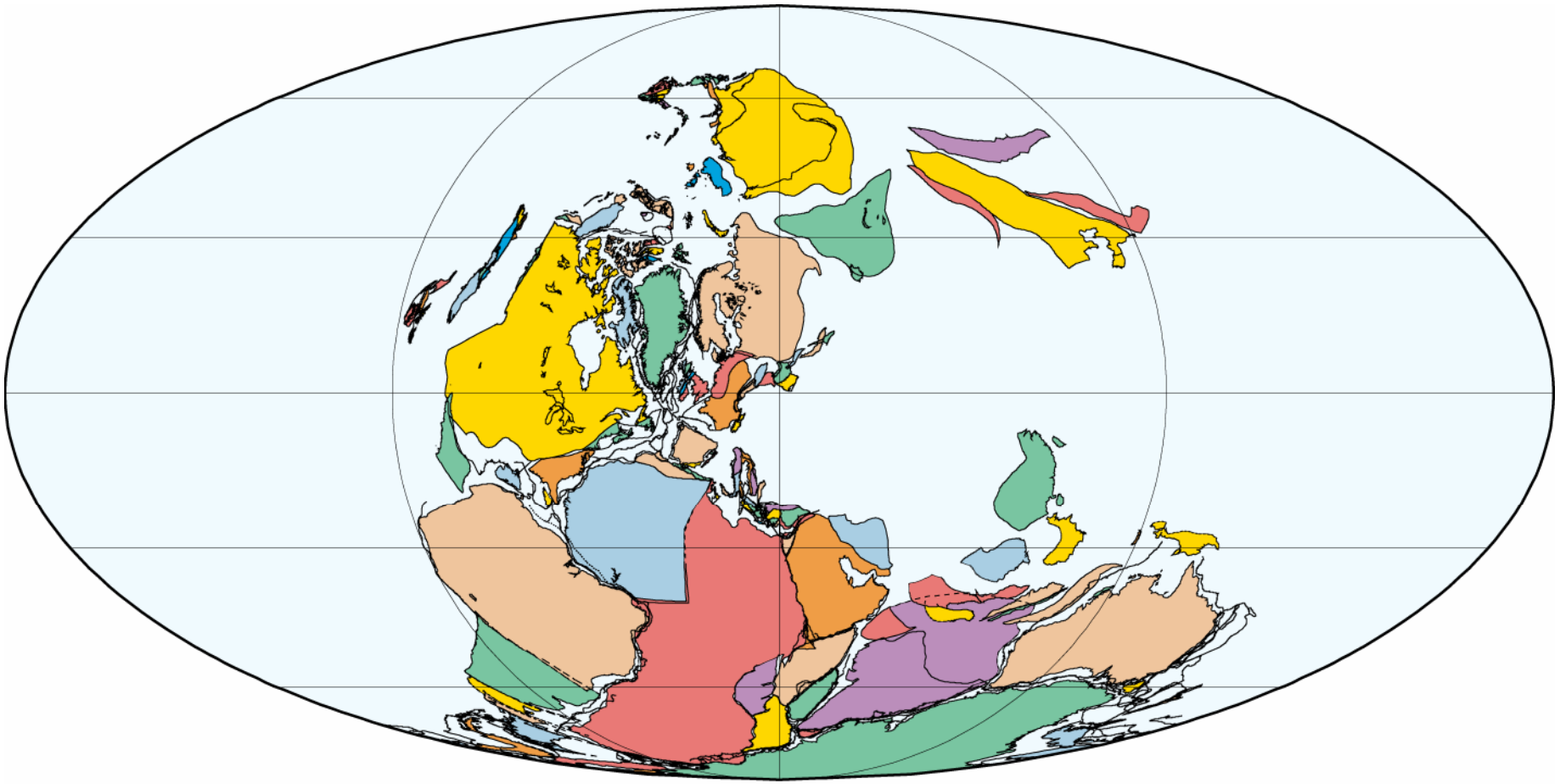


320 Ma
Bashkirian (Pennsylvanian)

PLATES/UTIG
August 2002


Early Pennsylvanian – 315
http://jan.ucc.nau.edu/~rcb7/nam.html


Late Pennsylvanian – 300
Alleghanian mountains
Pangaea Supercontinent
http://jan.ucc.nau.edu/~rcb7/nam.html

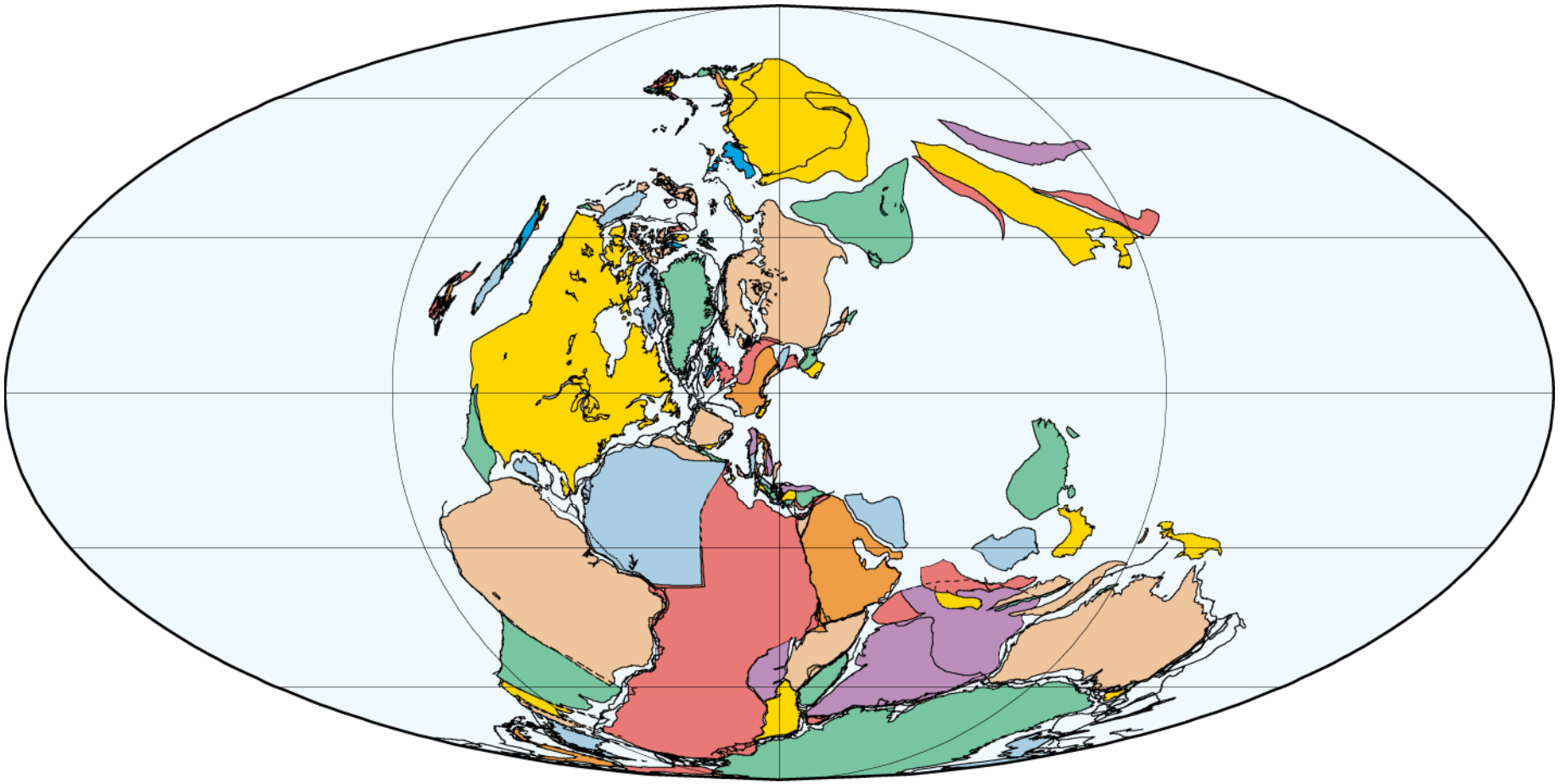


310 Ma

Moscovian (Pennsylvanian)

PLATES/UTIG

August 2002

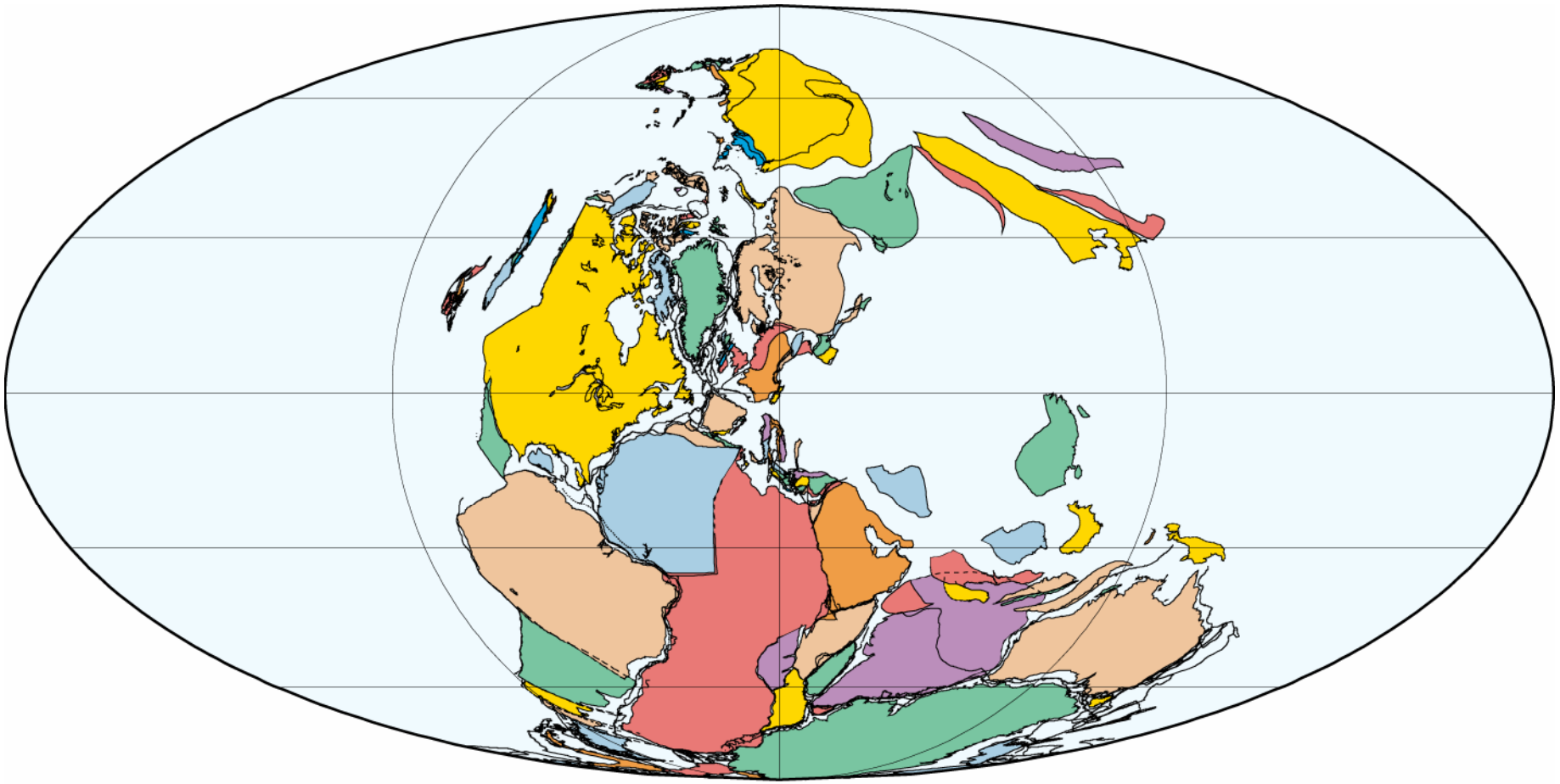


300 Ma

Kasimovian (Pennsylvanian)

PLATES/UTIG

August 2002

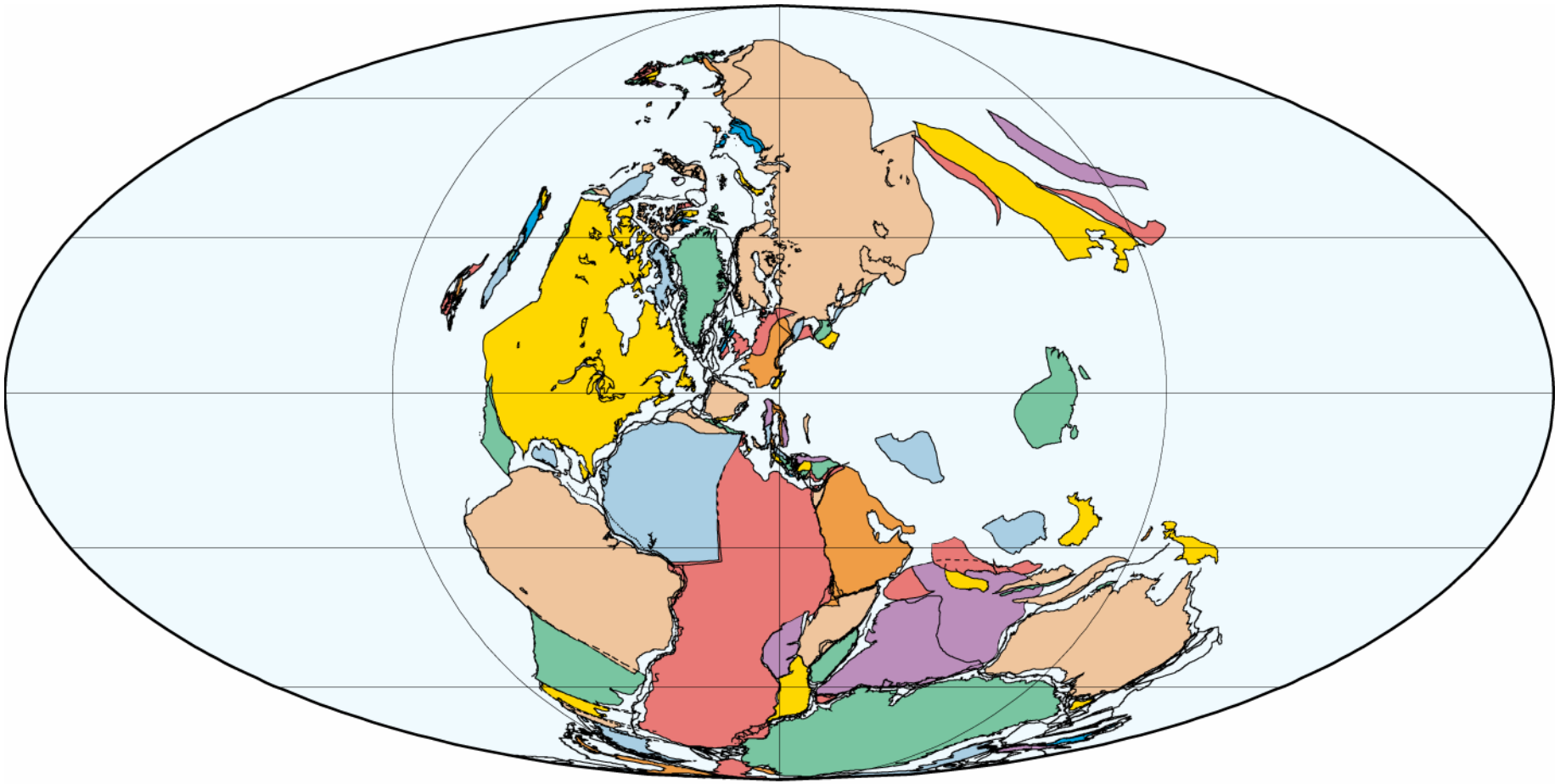


290 Ma

Late Gzelian/Early Asselian (Pennsylvanian/Permian)

PLATES/UTIG

August 2002

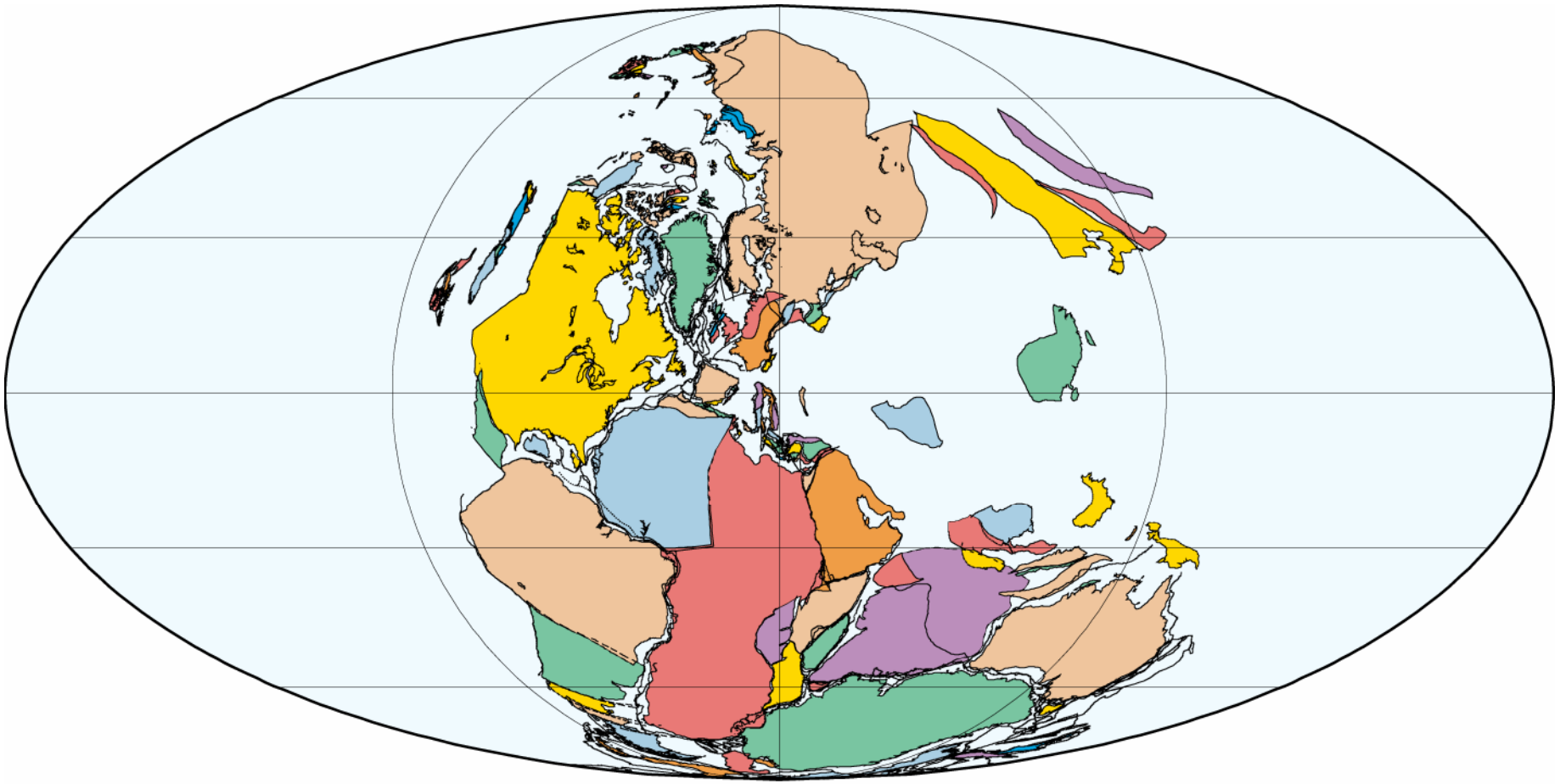


280 Ma

Early Sakmarian (Early Permian)

PLATES/UTIG

August 2002

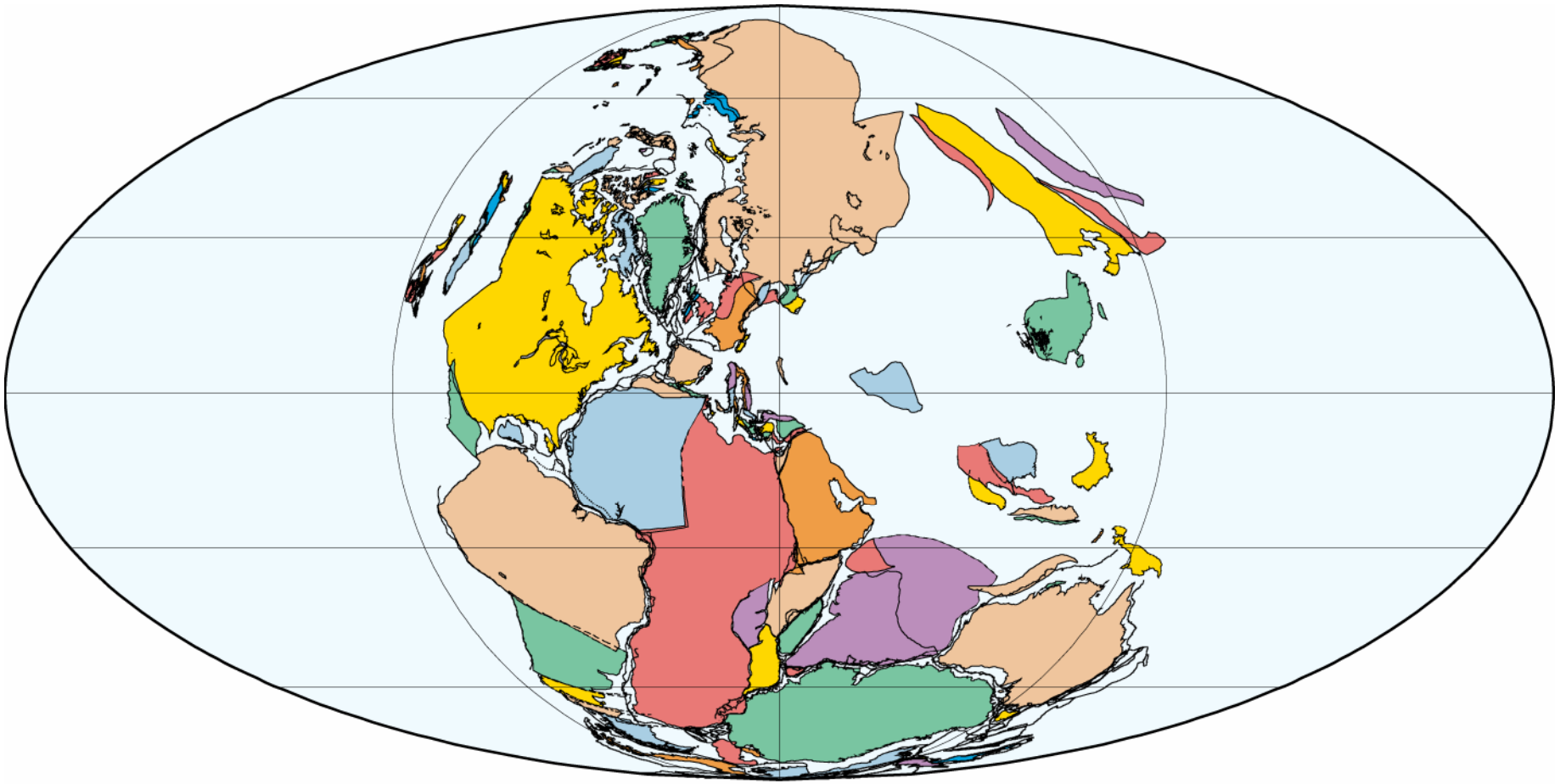


270 Ma

Late Sakmarian (Early Permian)

PLATES/UTIG

August 2002

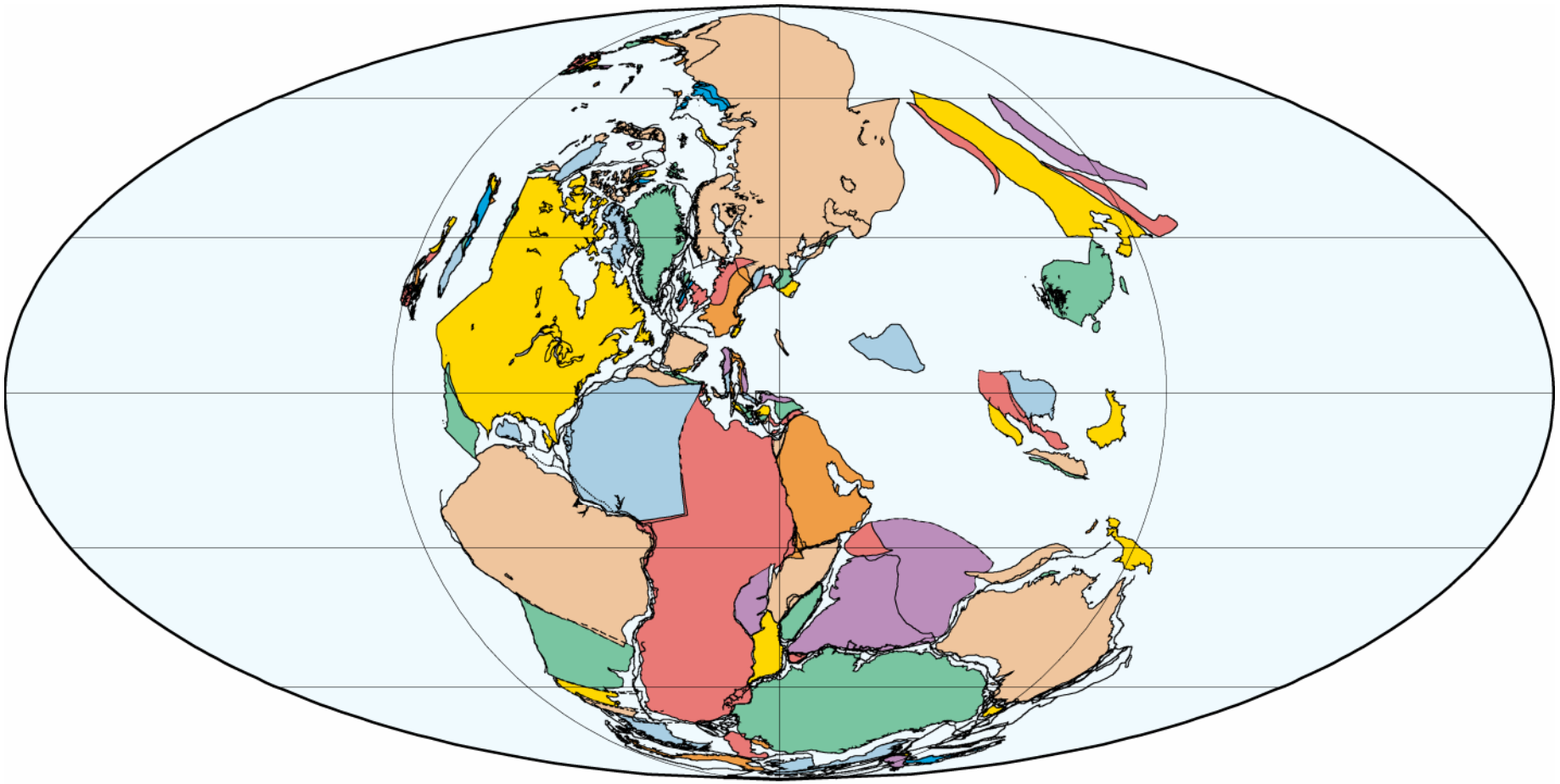


260 Ma

Late Artinskian/Early Kungurian (Early Permian)

PLATES/UTIG

August 2002

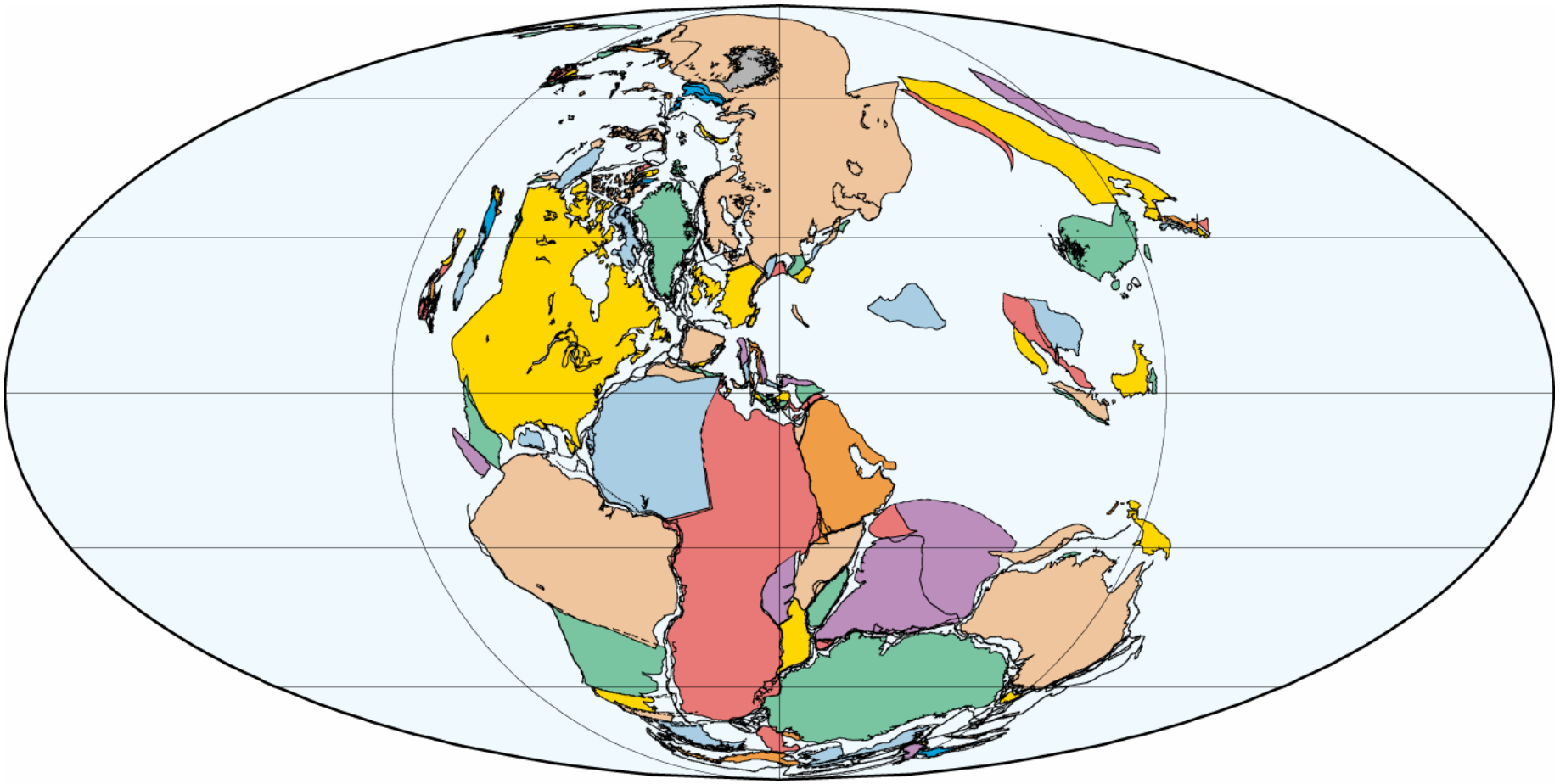


250 Ma

Tatarian (Late Permian)

PLATES/UTIG

August 2002

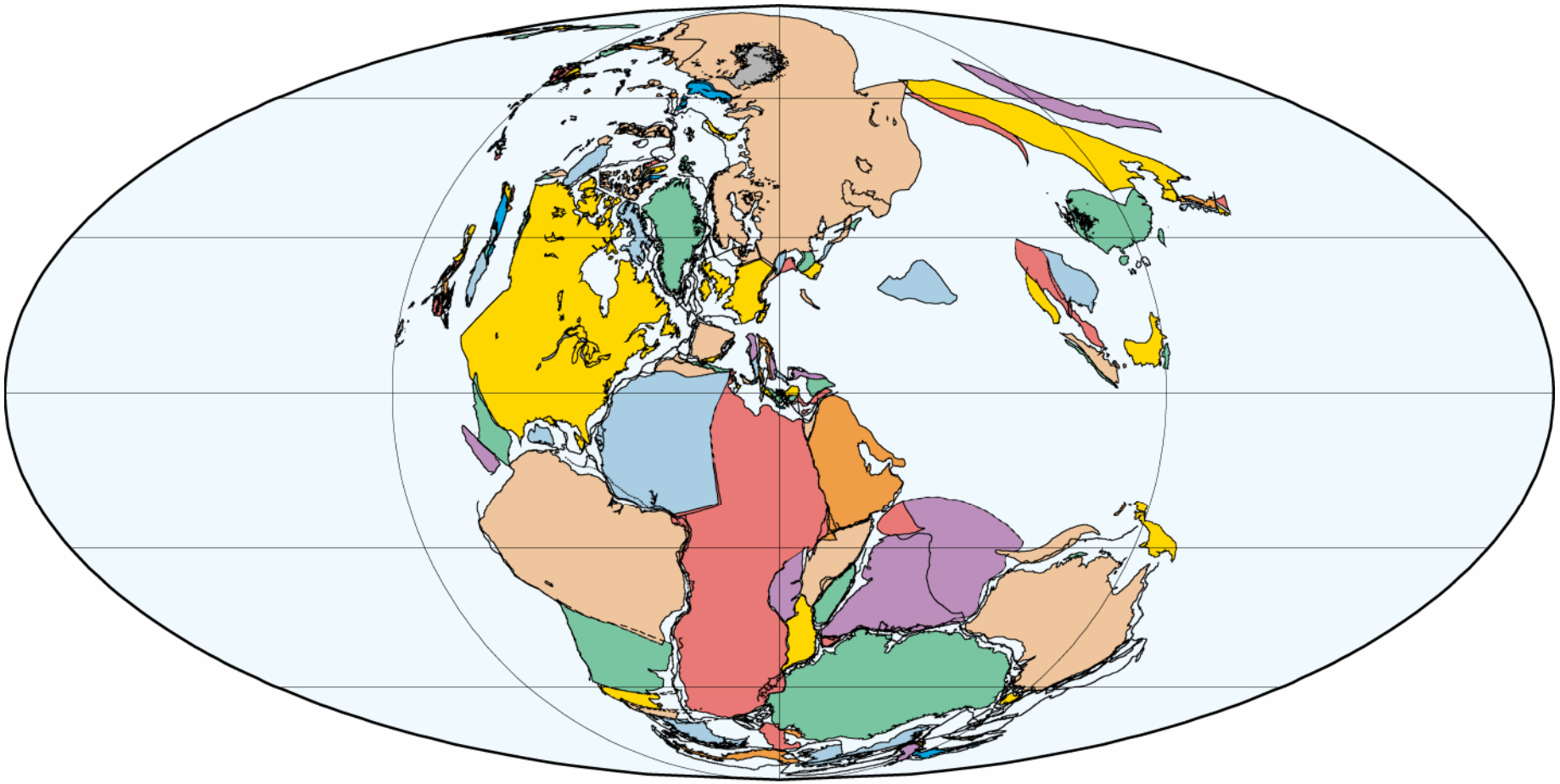


240 Ma

Anisian (Middle Triassic)

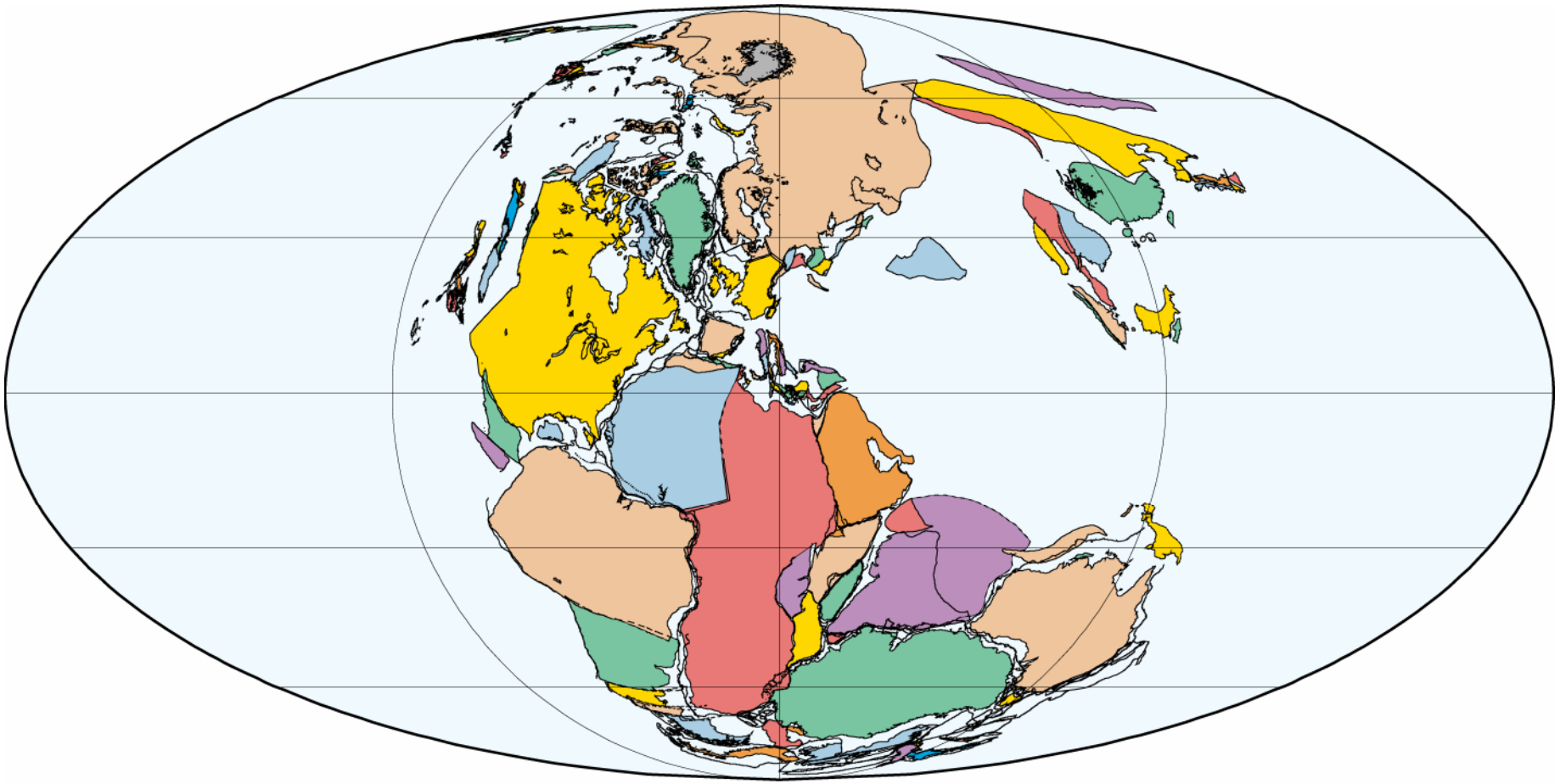
PLATES/UTIG

August 2002



230 Ma
Ladinian (Middle Triassic)

PLATES/UTIG
August 2002

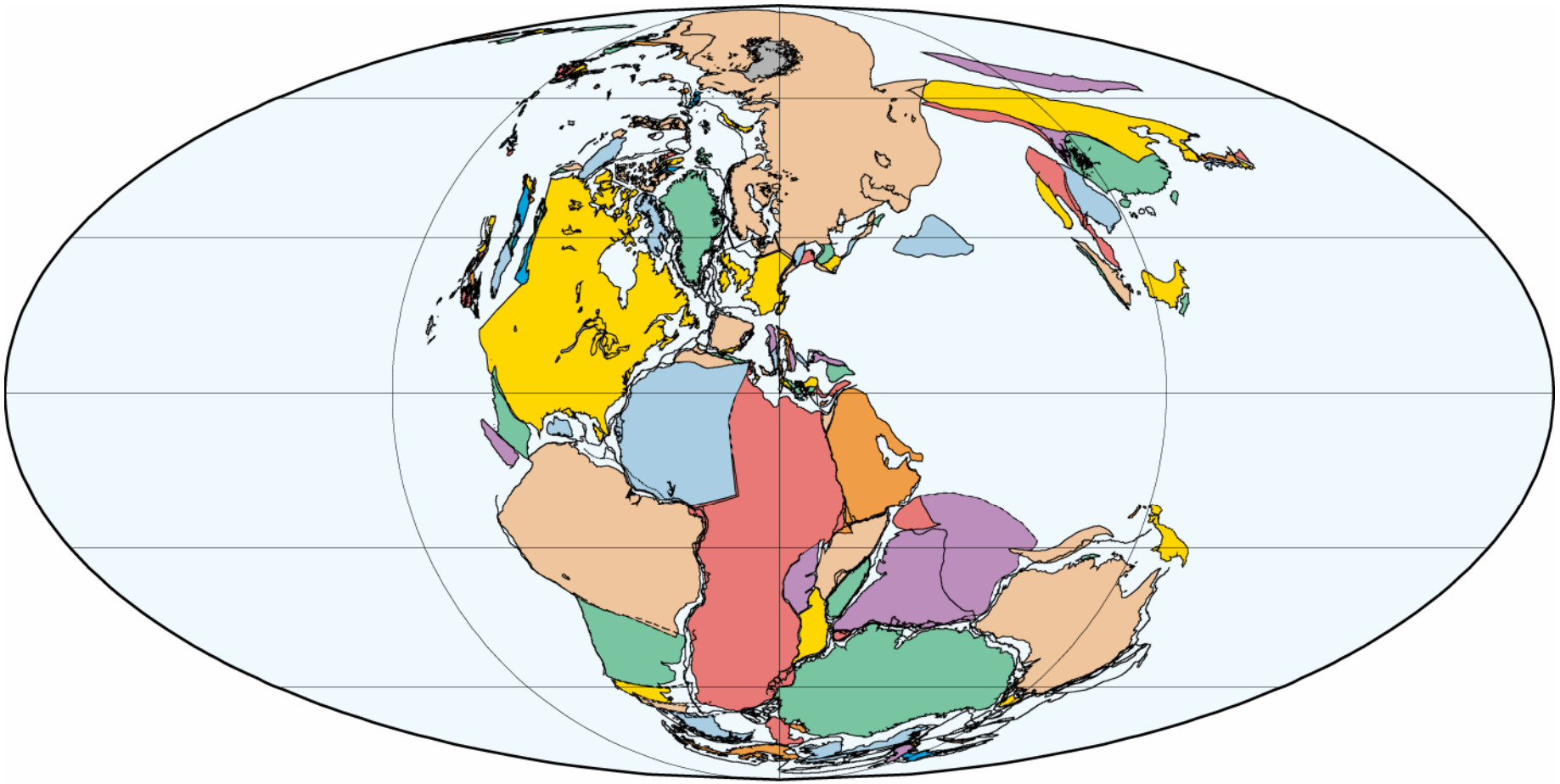


220 Ma

Early Norian (Late Triassic)

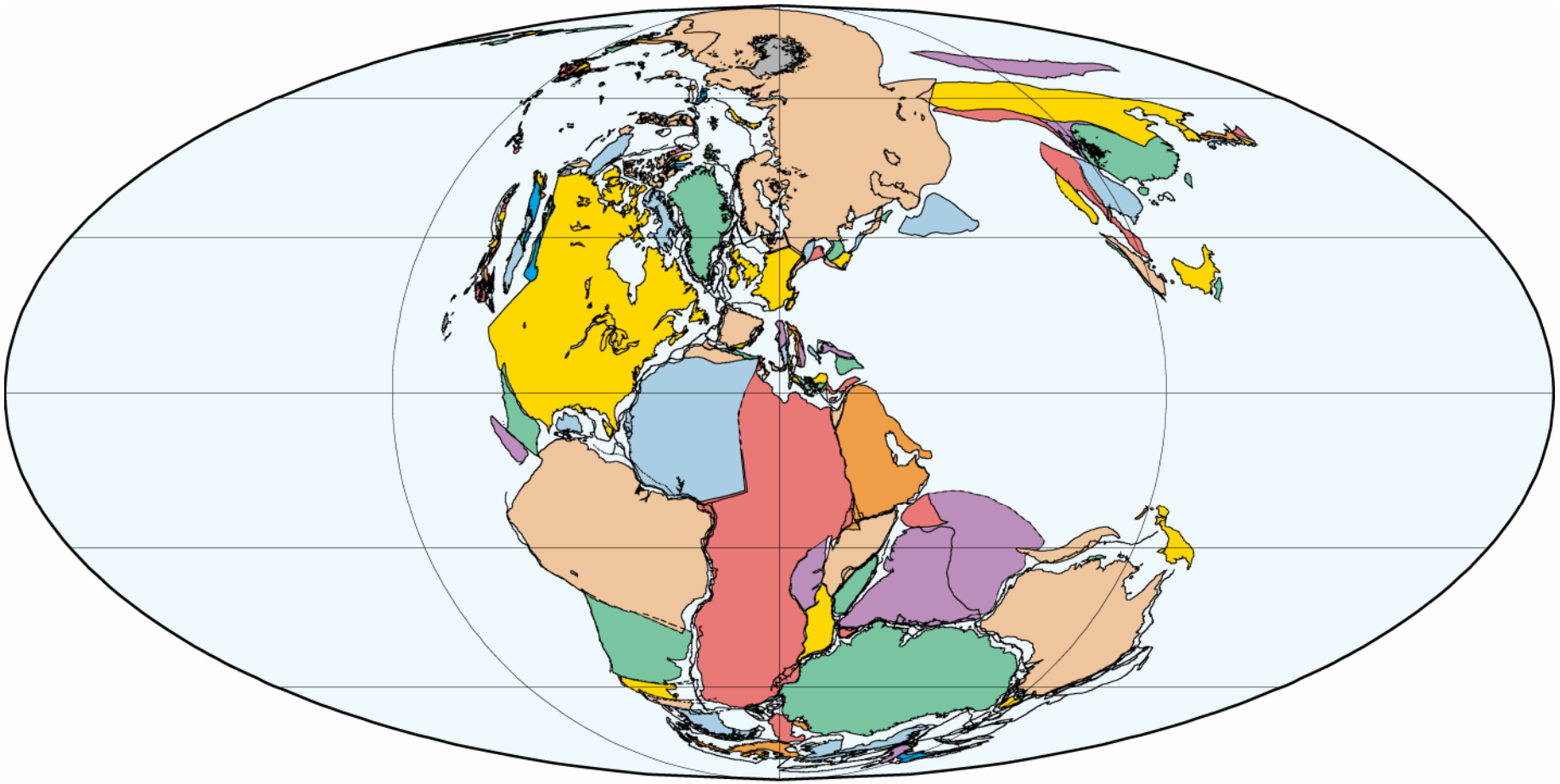
PLATES/UTIG

August 2002



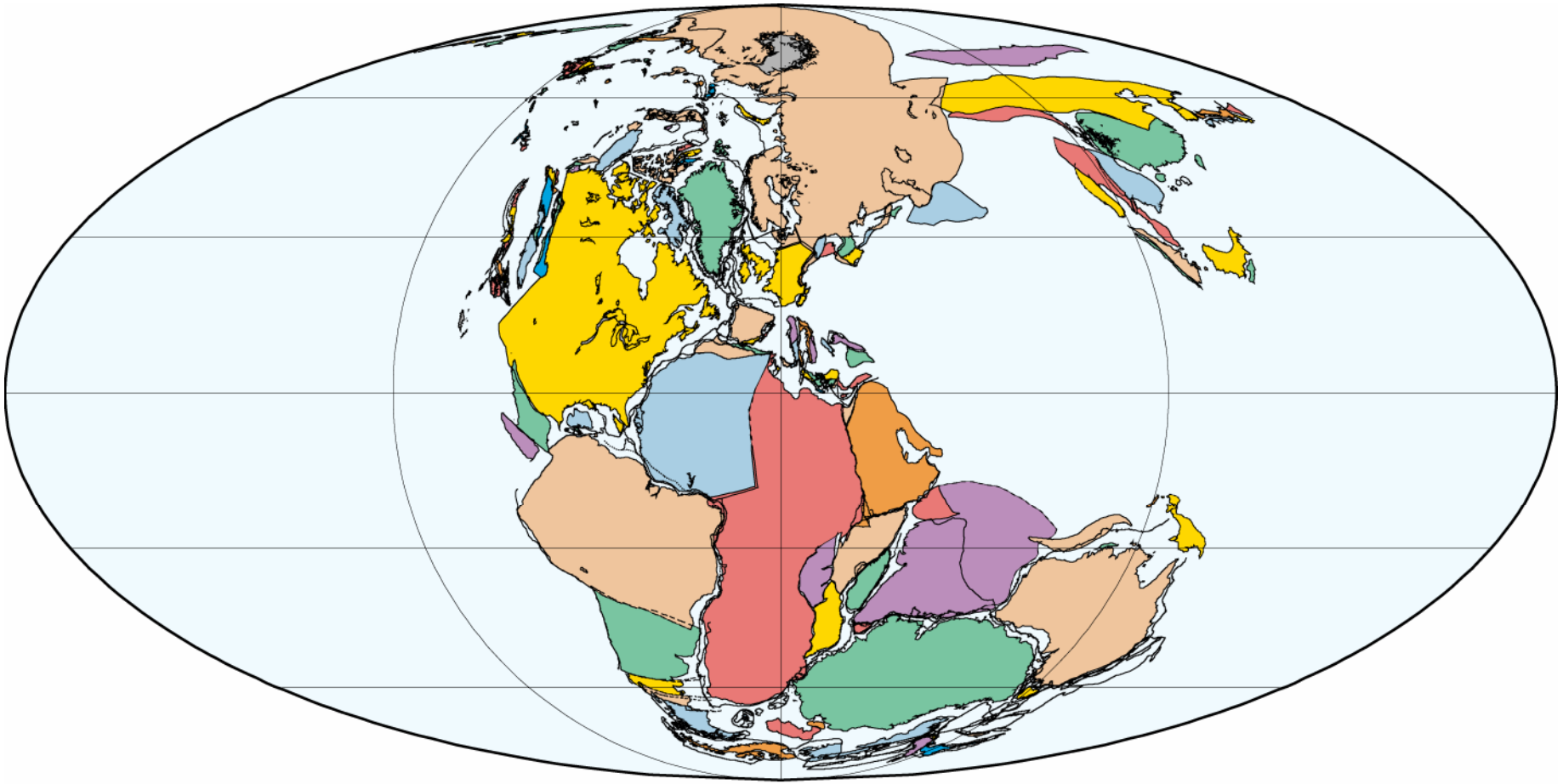
210 Ma
Late Norian (Late Triassic)

PLATES/UTIG
August 2002



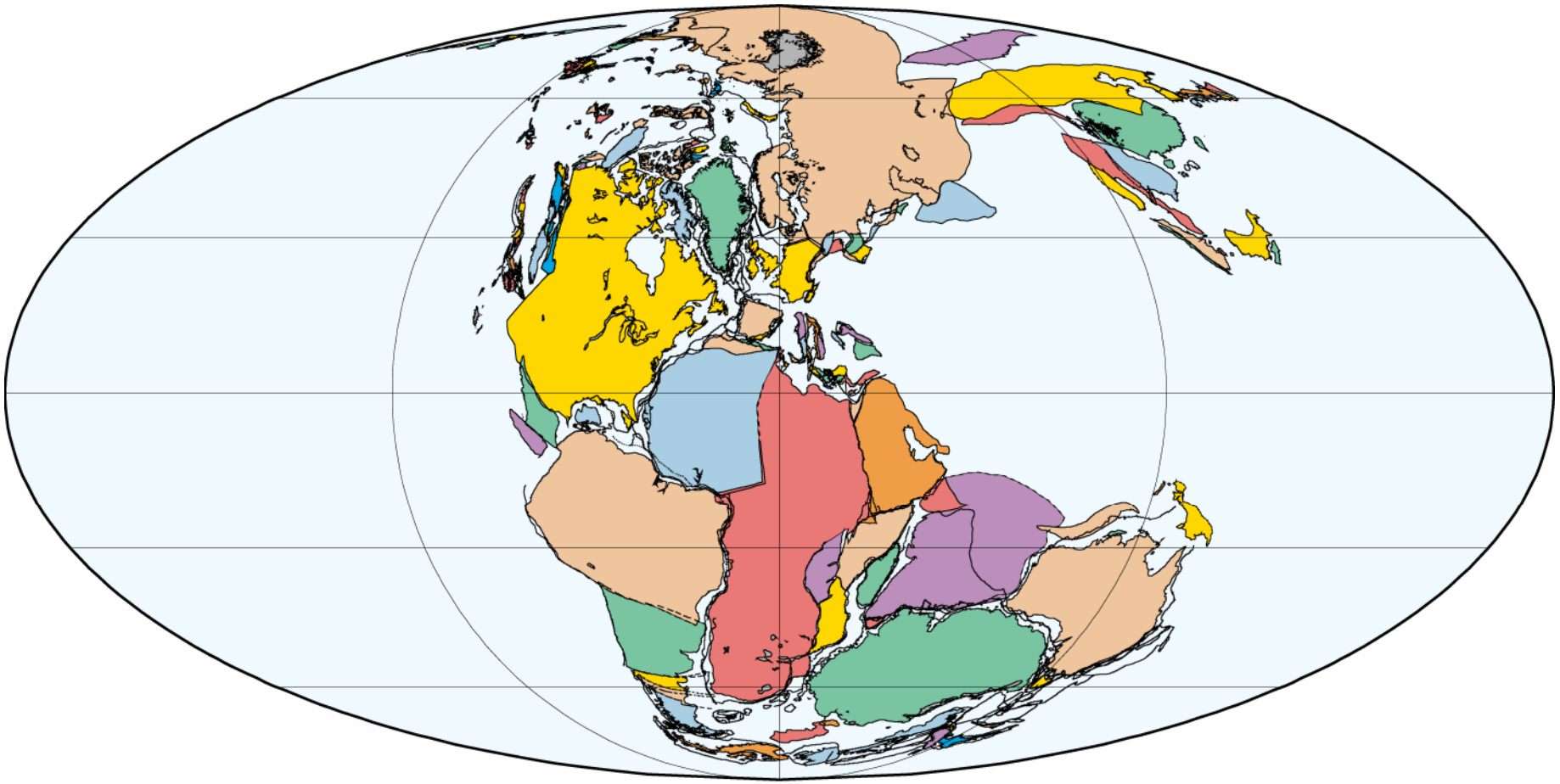
200 Ma
Sinemurian (Early Jurassic)

PLATES/UTIG
August 2002



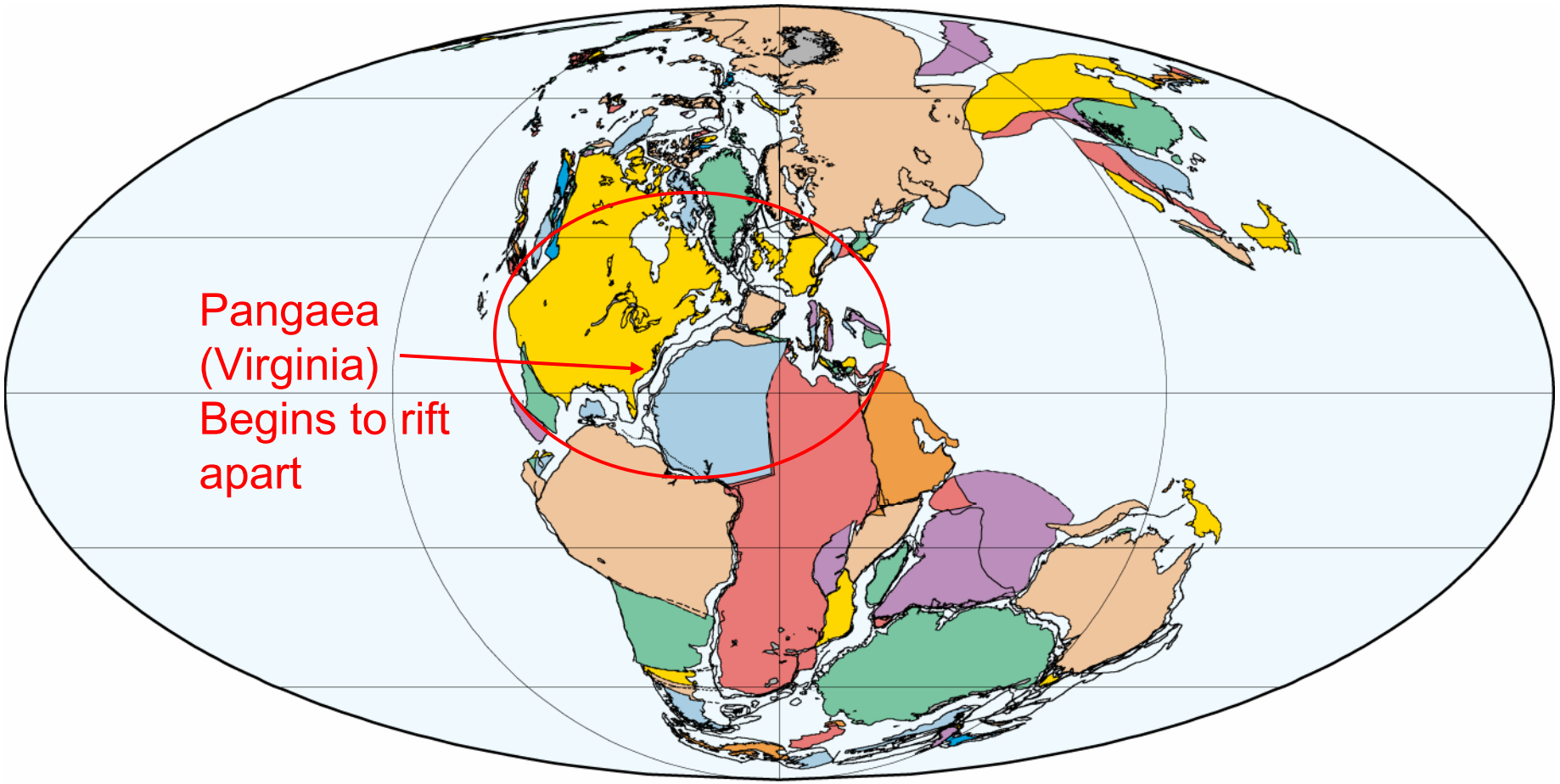
190 Ma
Pliensbachian (Early Jurassic)

PLATES/UTIG
August 2002



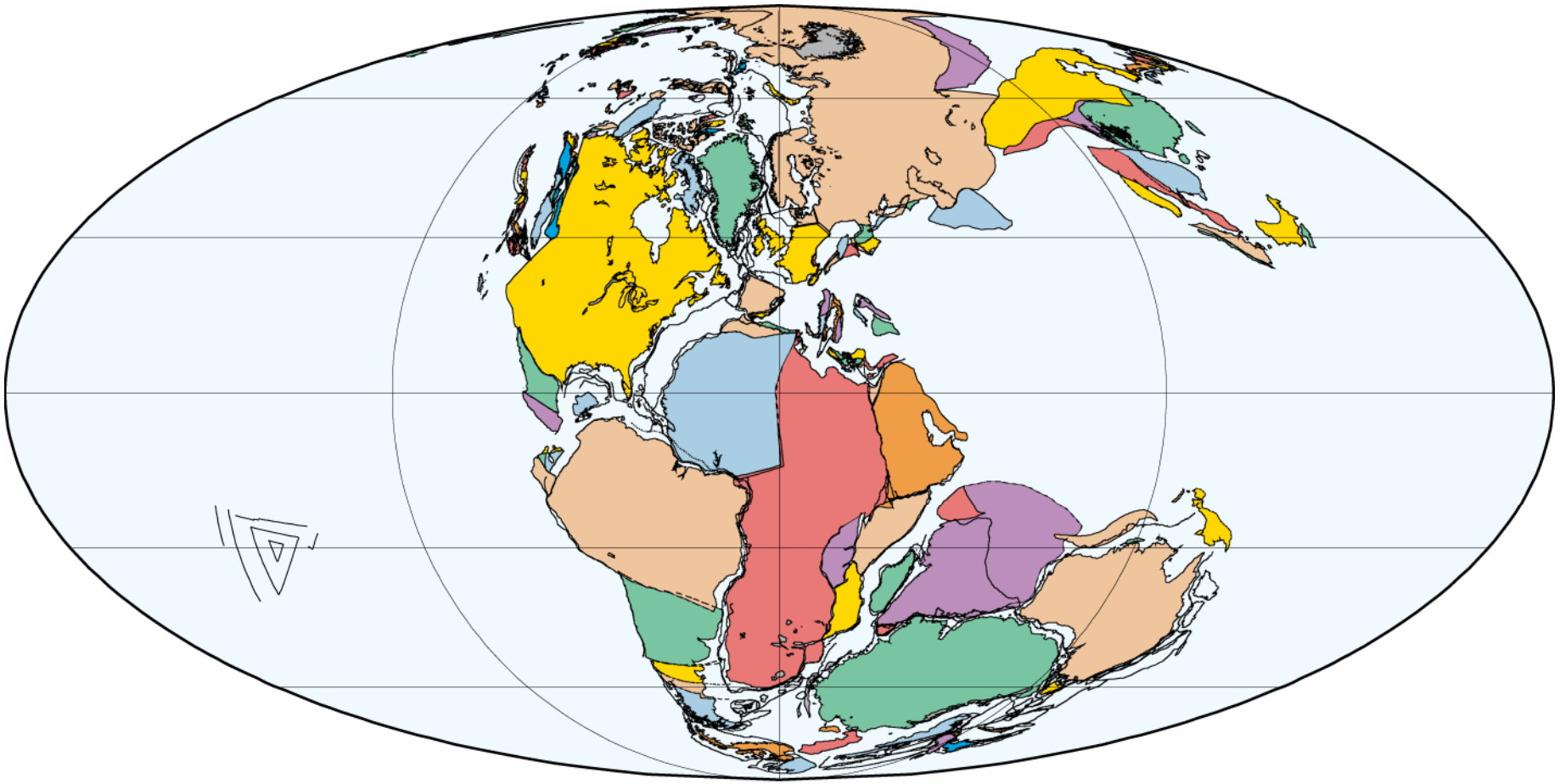
180 Ma
Aalenian (Middle Jurassic)

PLATES/UTIG
August 2002



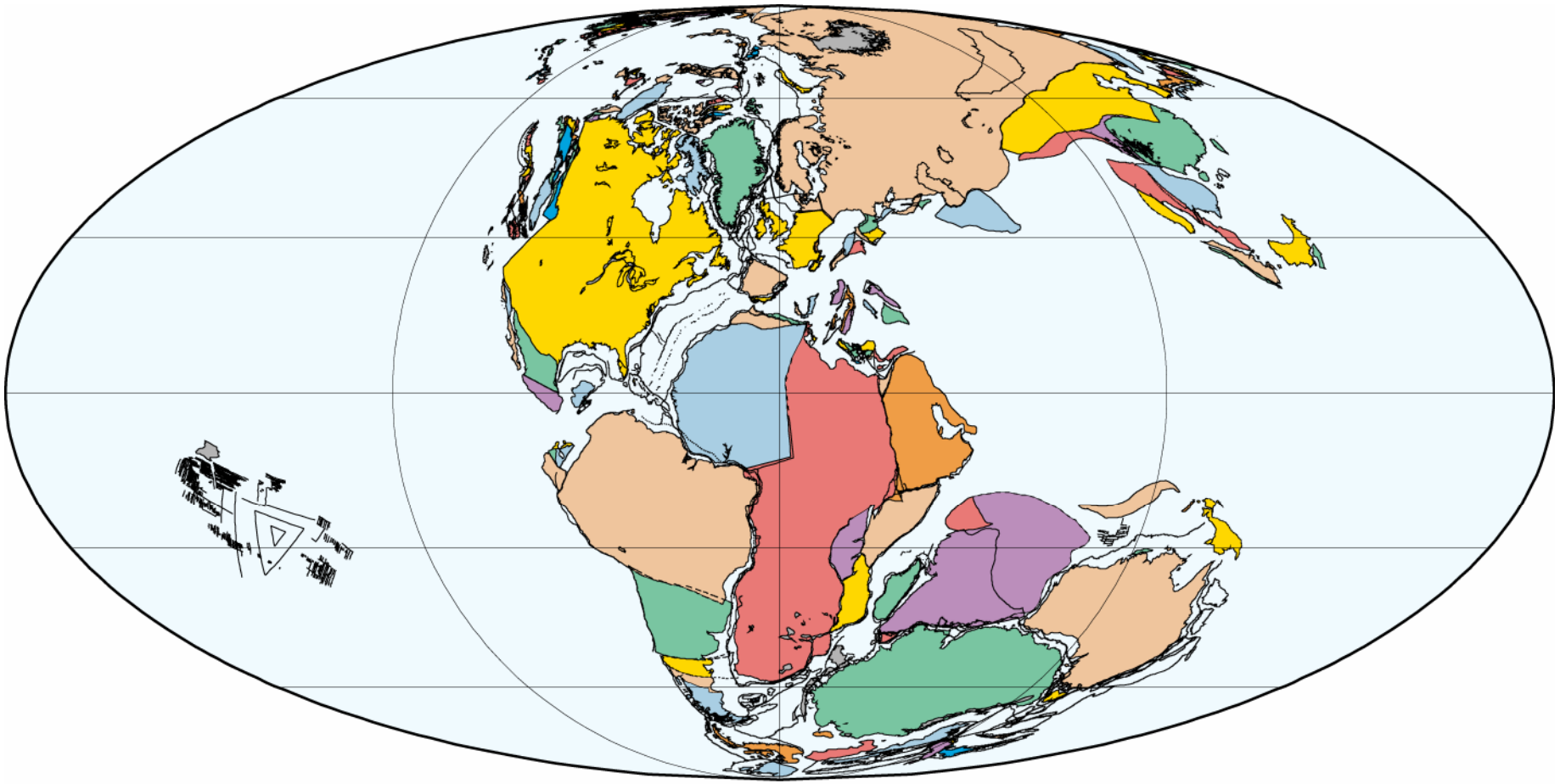
170 Ma
Bajocian (Middle Jurassic)

PLATES/UTIG
August 2002



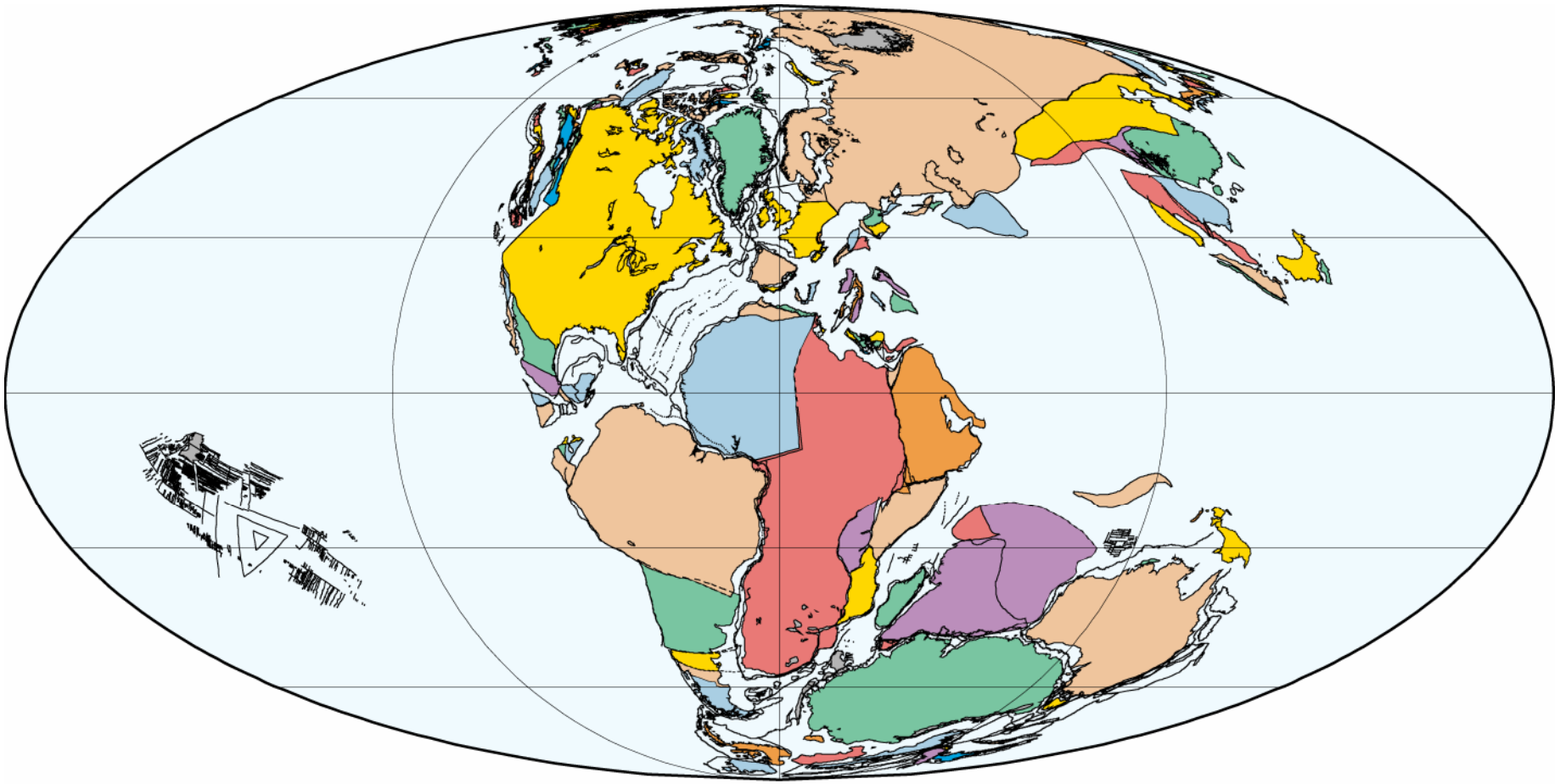
160 Ma
Callovian (Middle Jurassic)

PLATES/UTIG
August 2002



150 Ma
Volgian (Late Jurassic)

PLATES/UTIG
August 2002

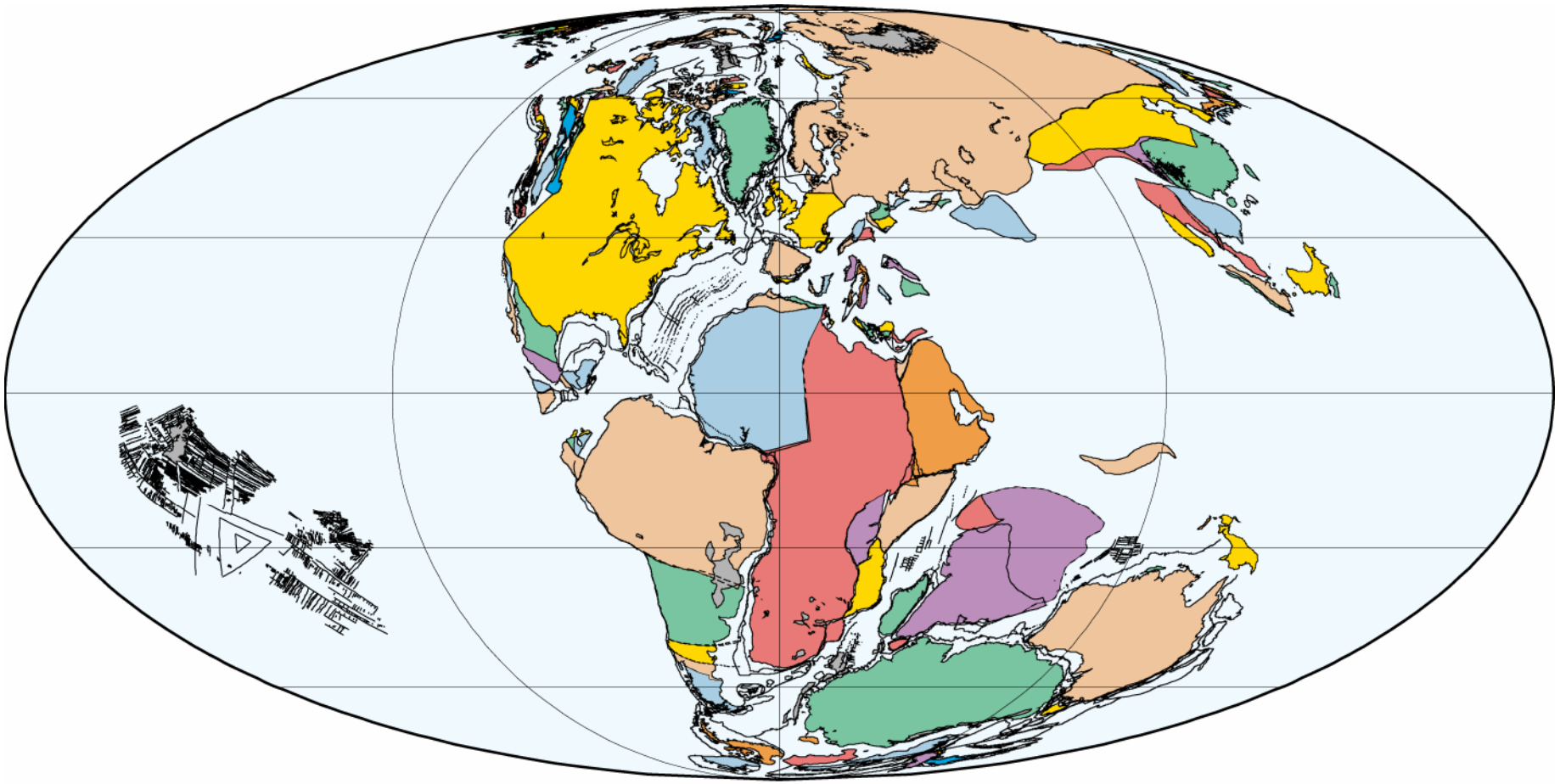


140 Ma

Ryazanian (Early Cretaceous)

PLATES/UTIG

August 2002

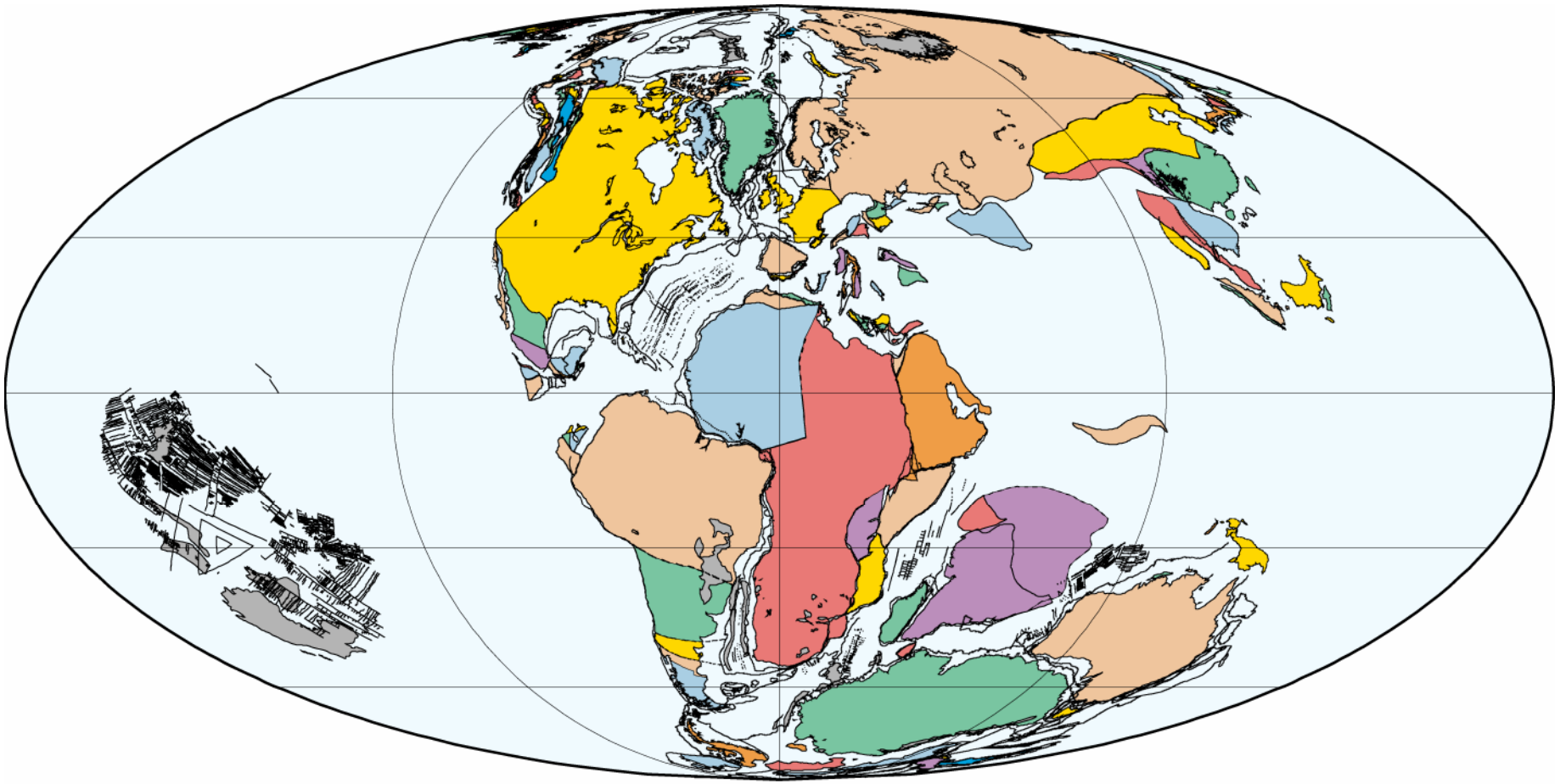


130 Ma

Hauterivian (Early Cretaceous)

PLATES/UTIG

August 2002

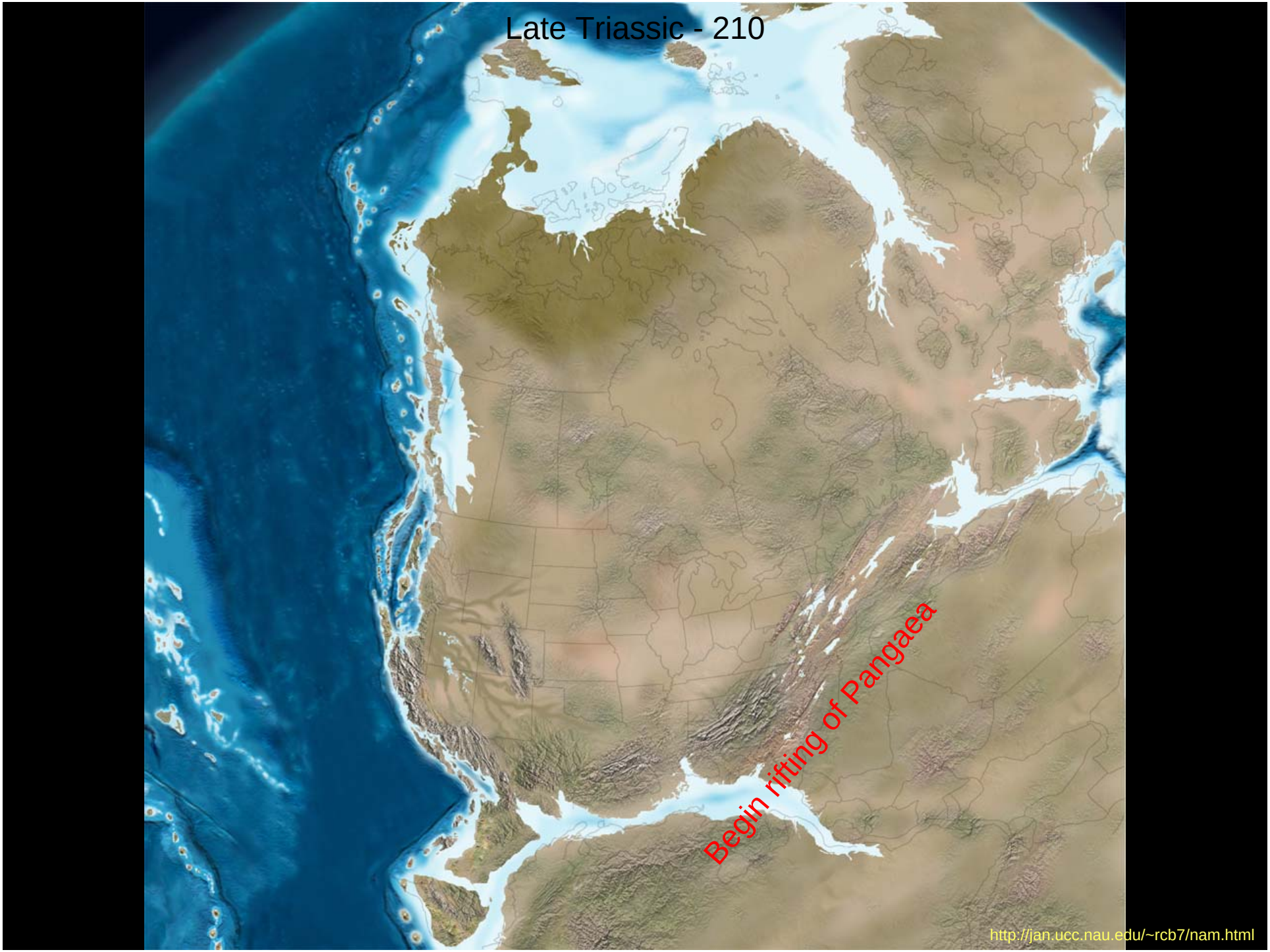


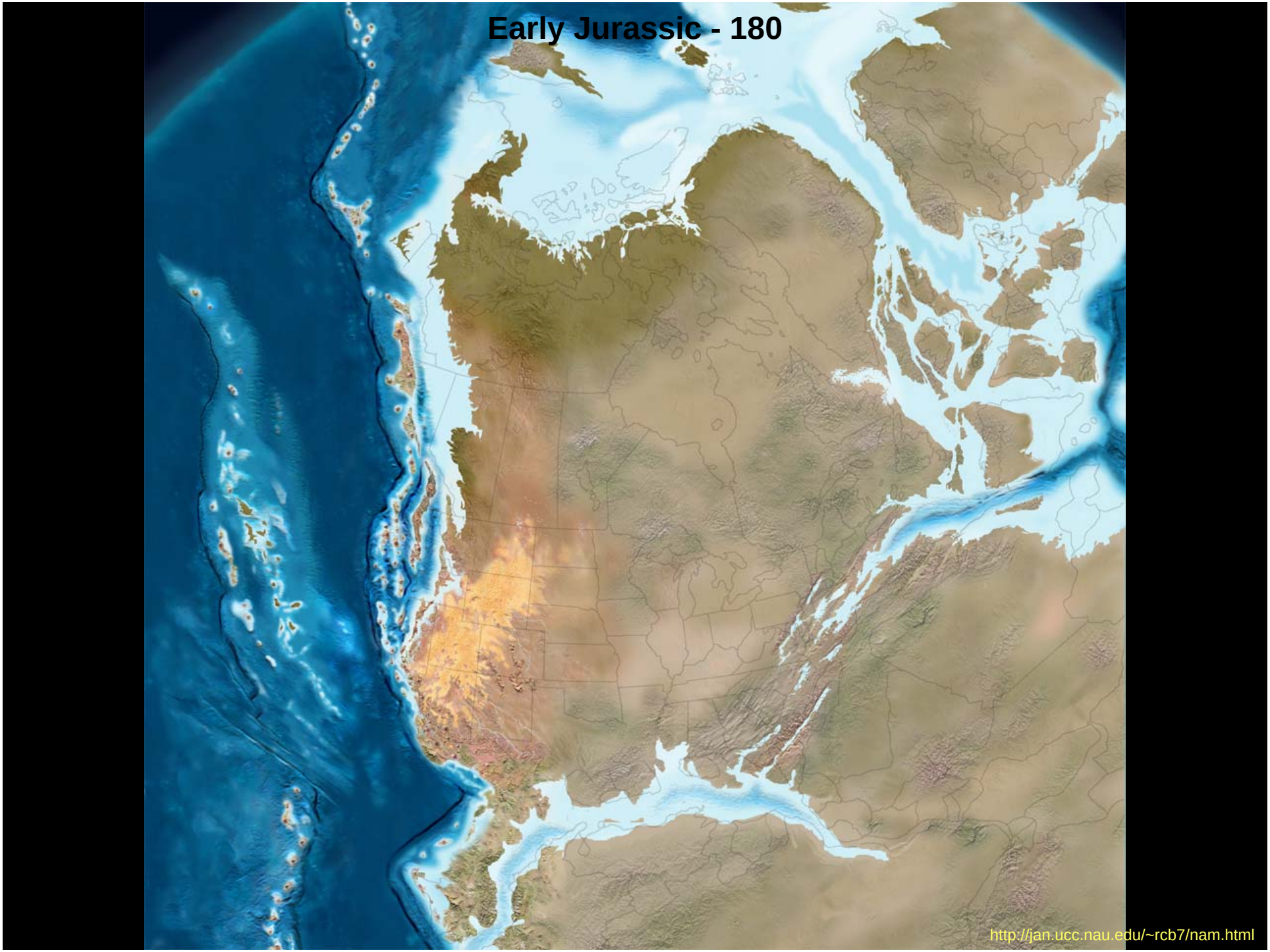
120 Ma

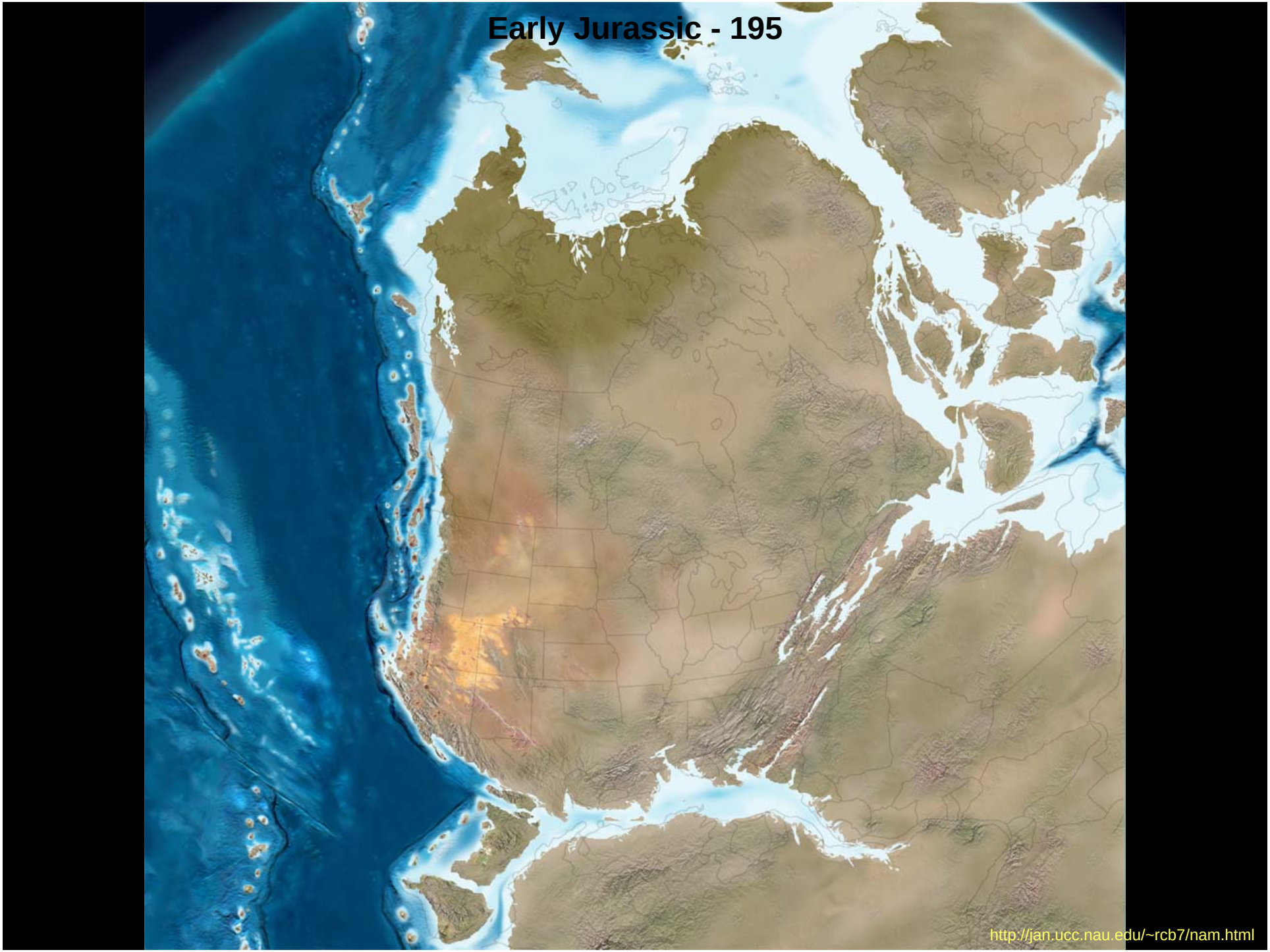
Aptian (Early Cretaceous)

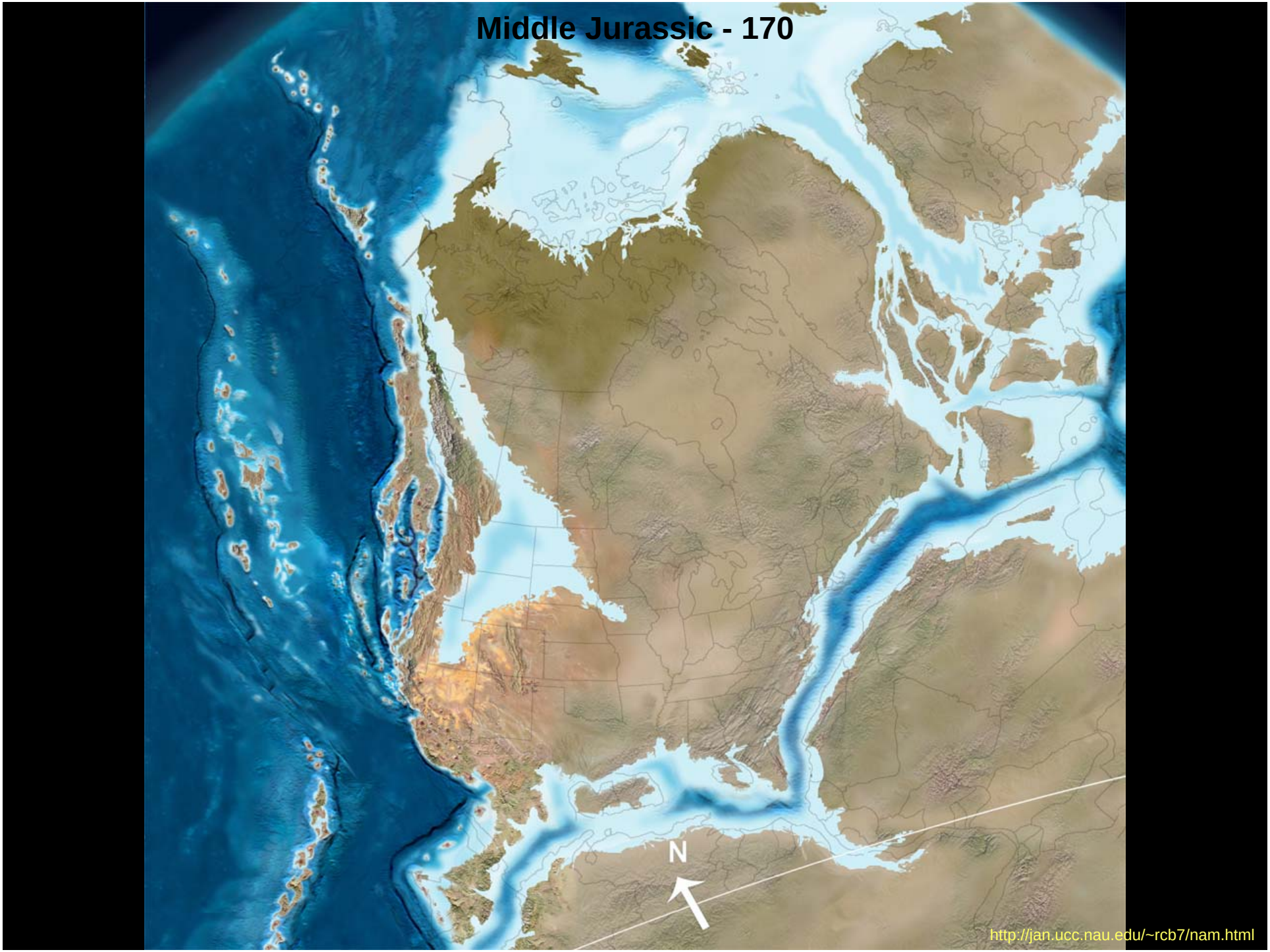
PLATES/UTIG

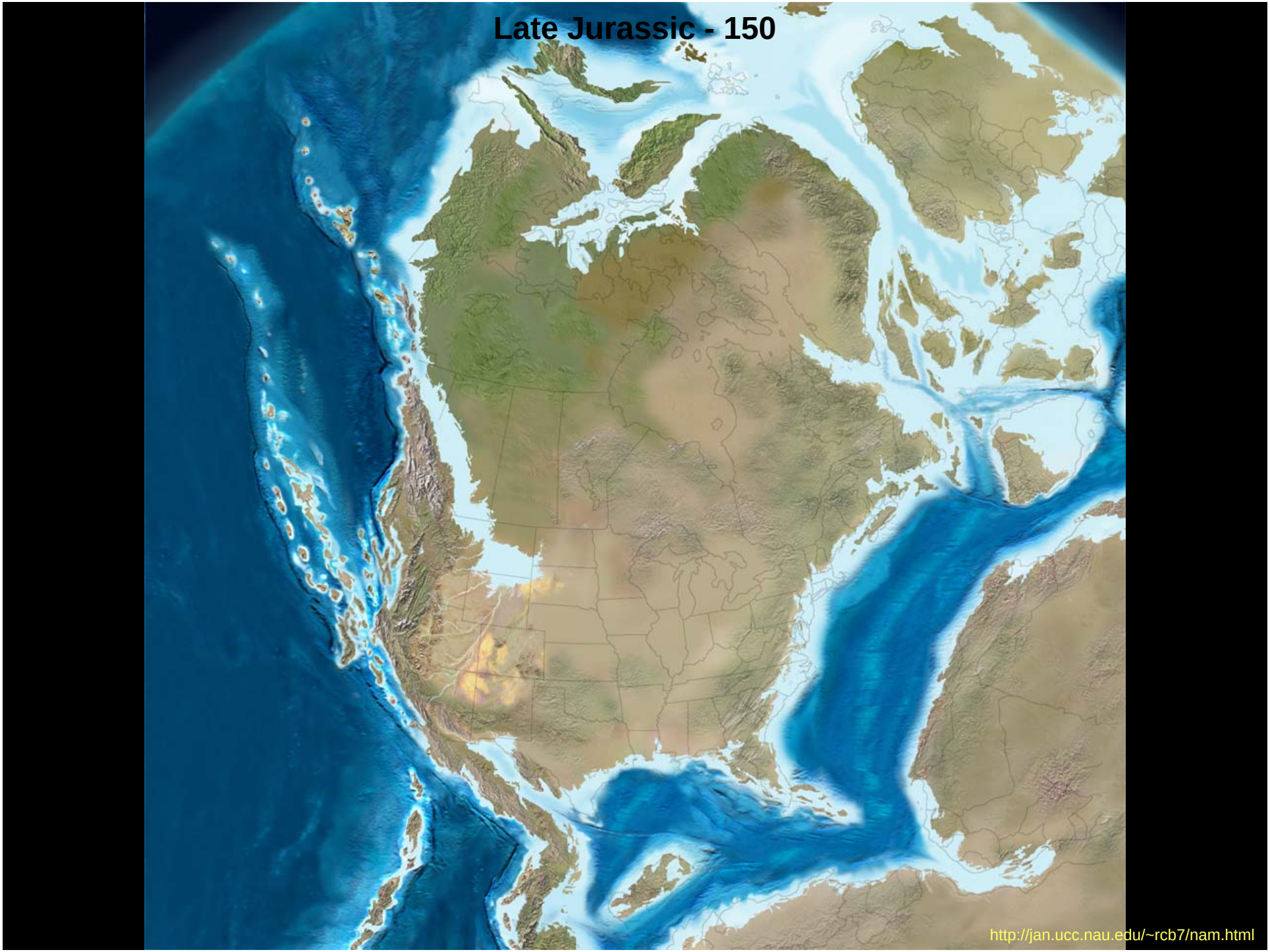
August 2002

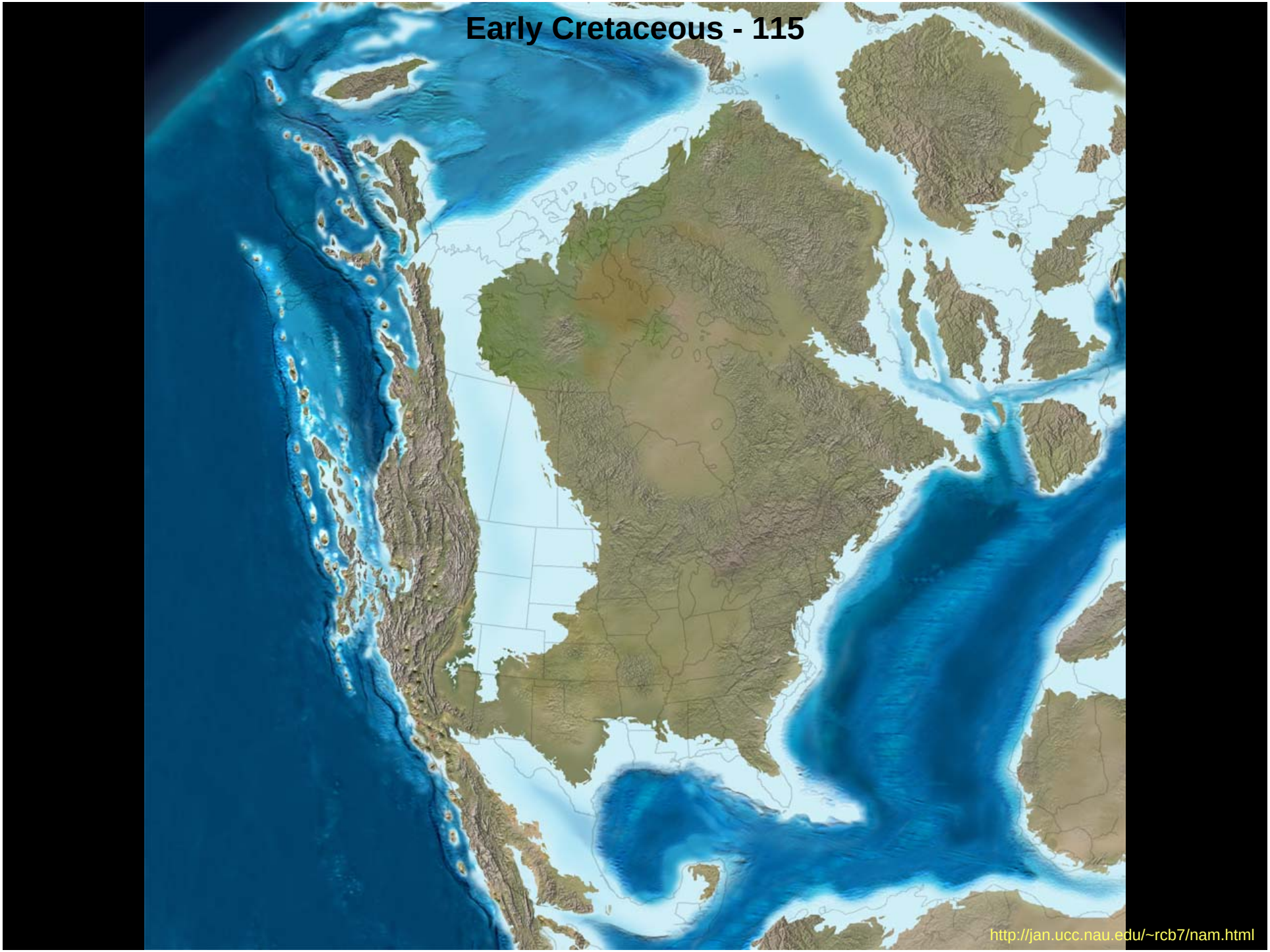

Late Triassic - 210
Begin rifting of Pangaea
http://jan.ucc.nau.edu/~rcb7/nam.html

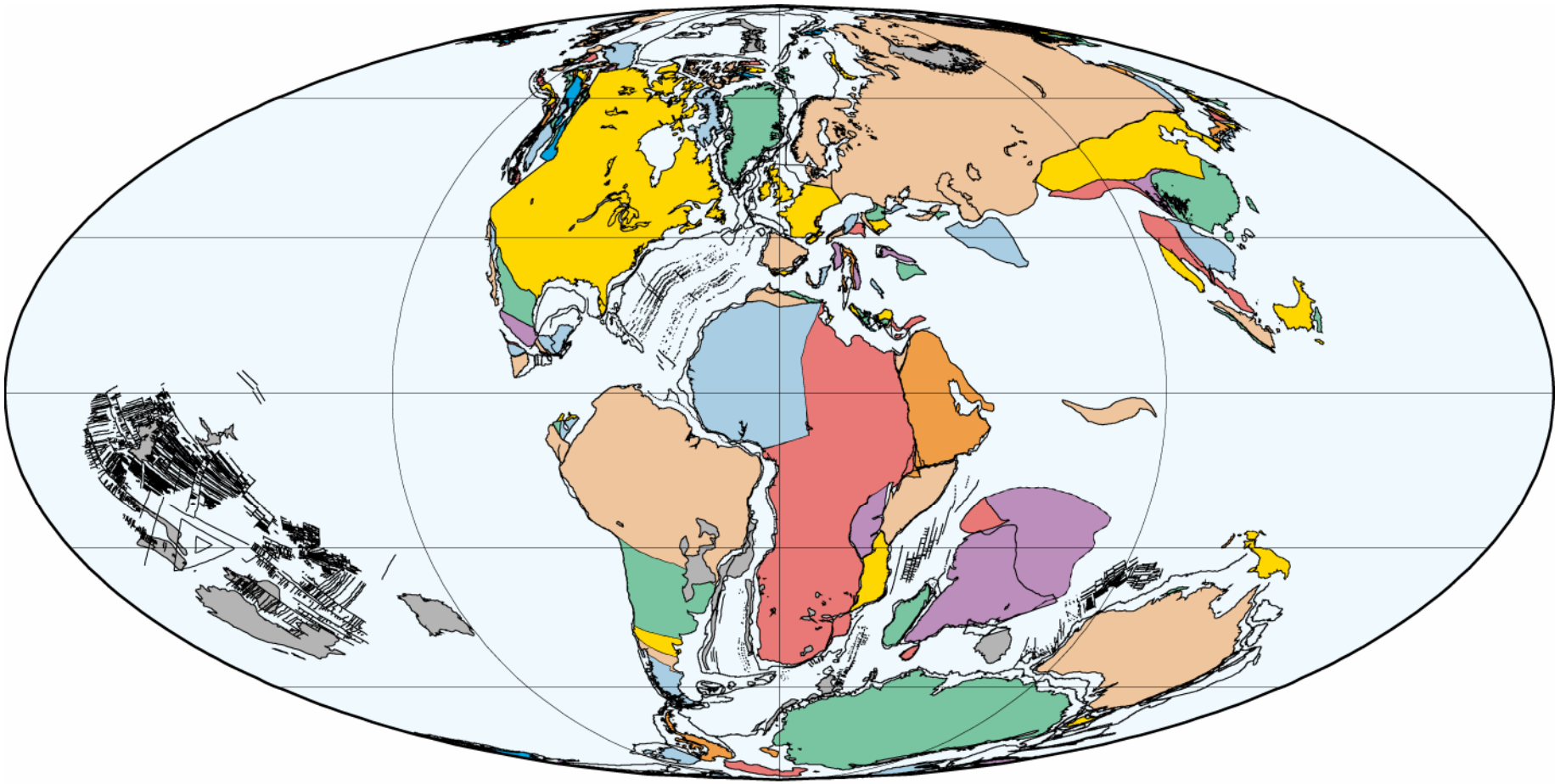

Early Jurassic - 180
http://jan.ucc.nau.edu/~rcb7/nam.html


Early Jurassic - 195
http://jan.ucc.nau.edu/~rcb7/nam.html


Middle Jurassic - 170
N
http://jan.ucc.nau.edu/~rcb7/nam.html


Late Jurassic - 150
http://jan.ucc.nau.edu/~rcb7/nam.html


Early Cretaceous - 115
http://jan.ucc.nau.edu/~rcb7/nam.html

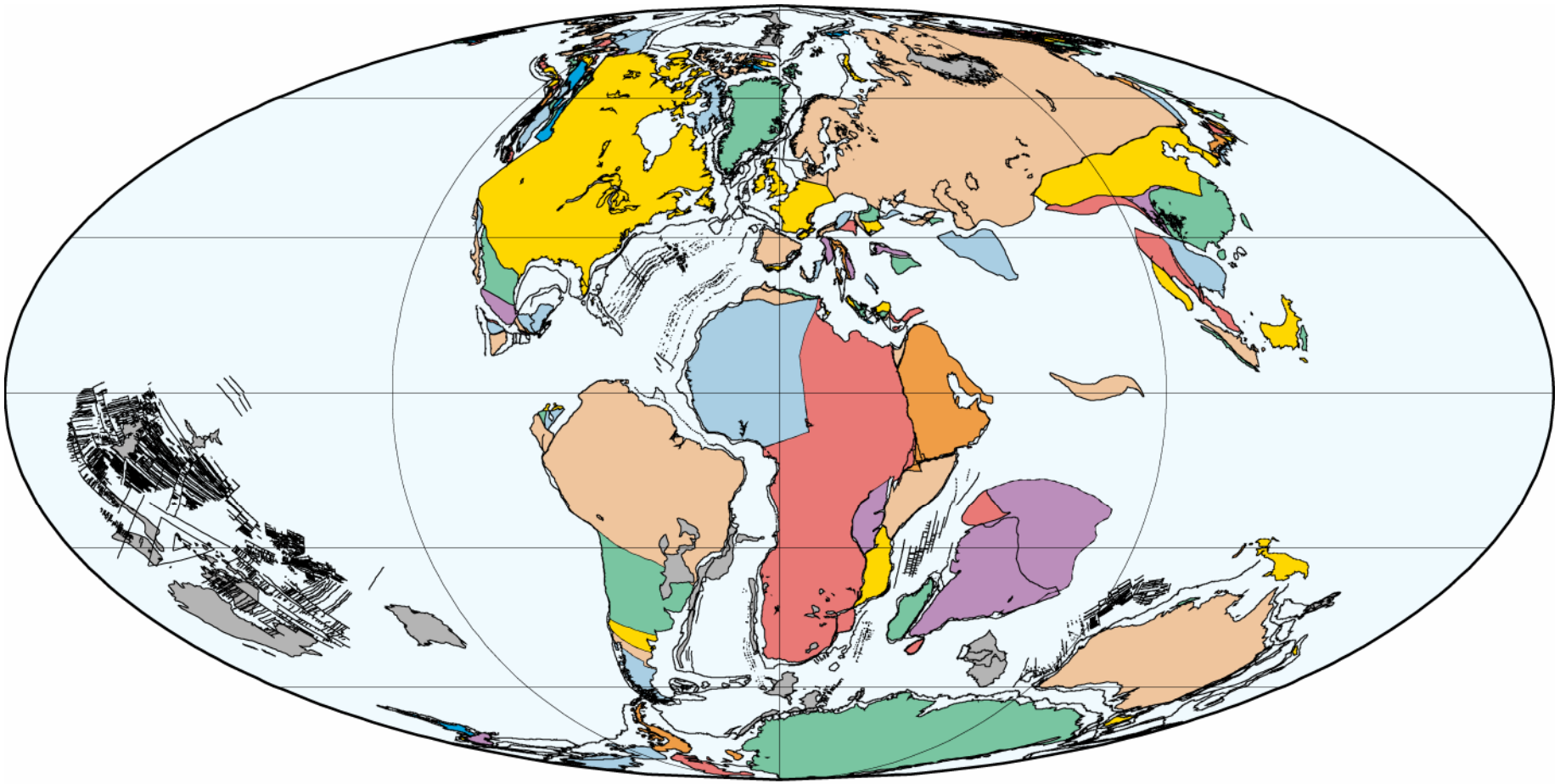


110 Ma

Early Albian (Early Cretaceous)

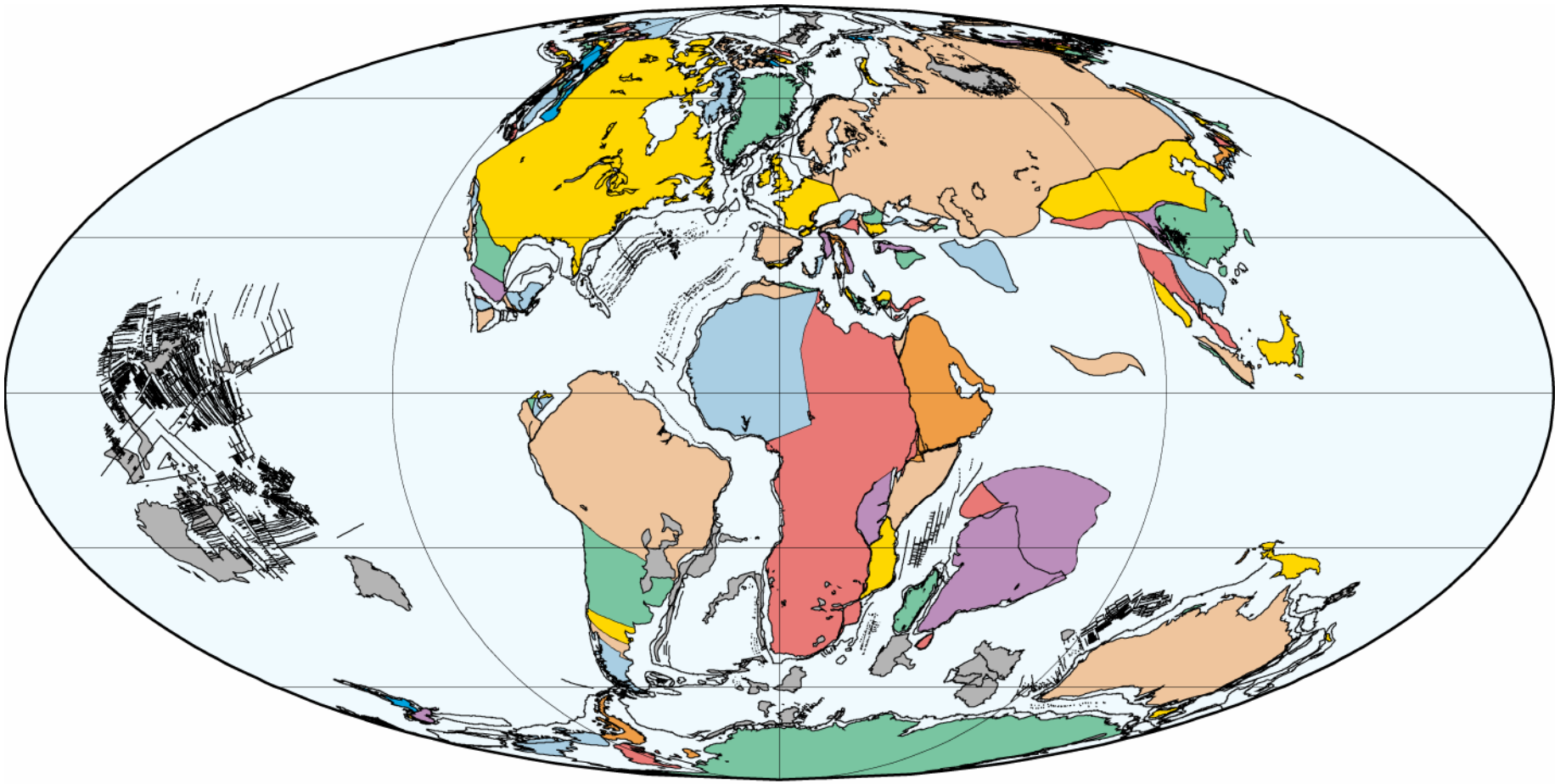
PLATES/UTIG

August 2002



100 Ma
Late Albian (Early Cretaceous)

PLATES/UTIG
August 2002

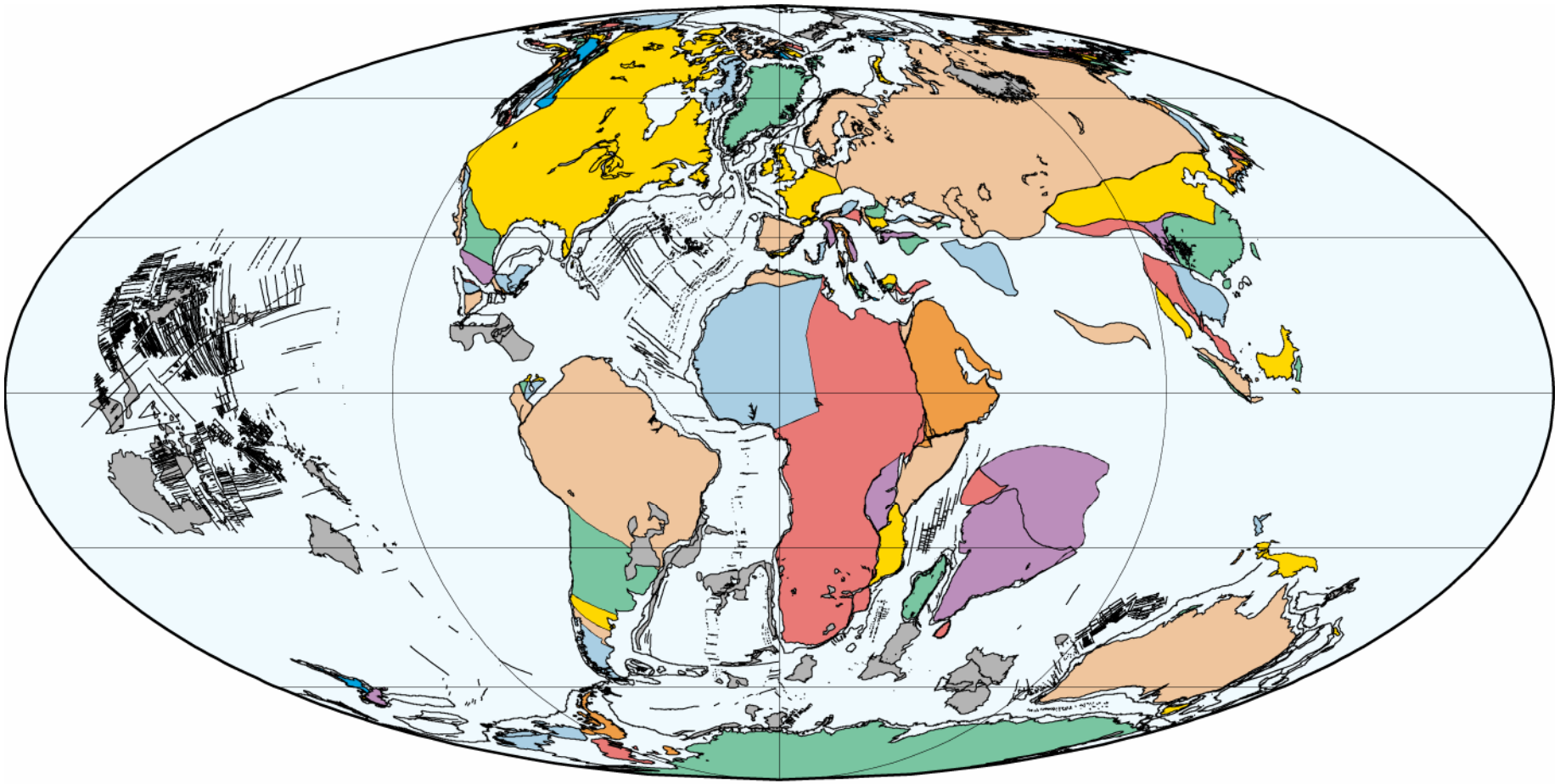


90 Ma

Turonian (Late Cretaceous)

PLATES/UTIG

August 2002

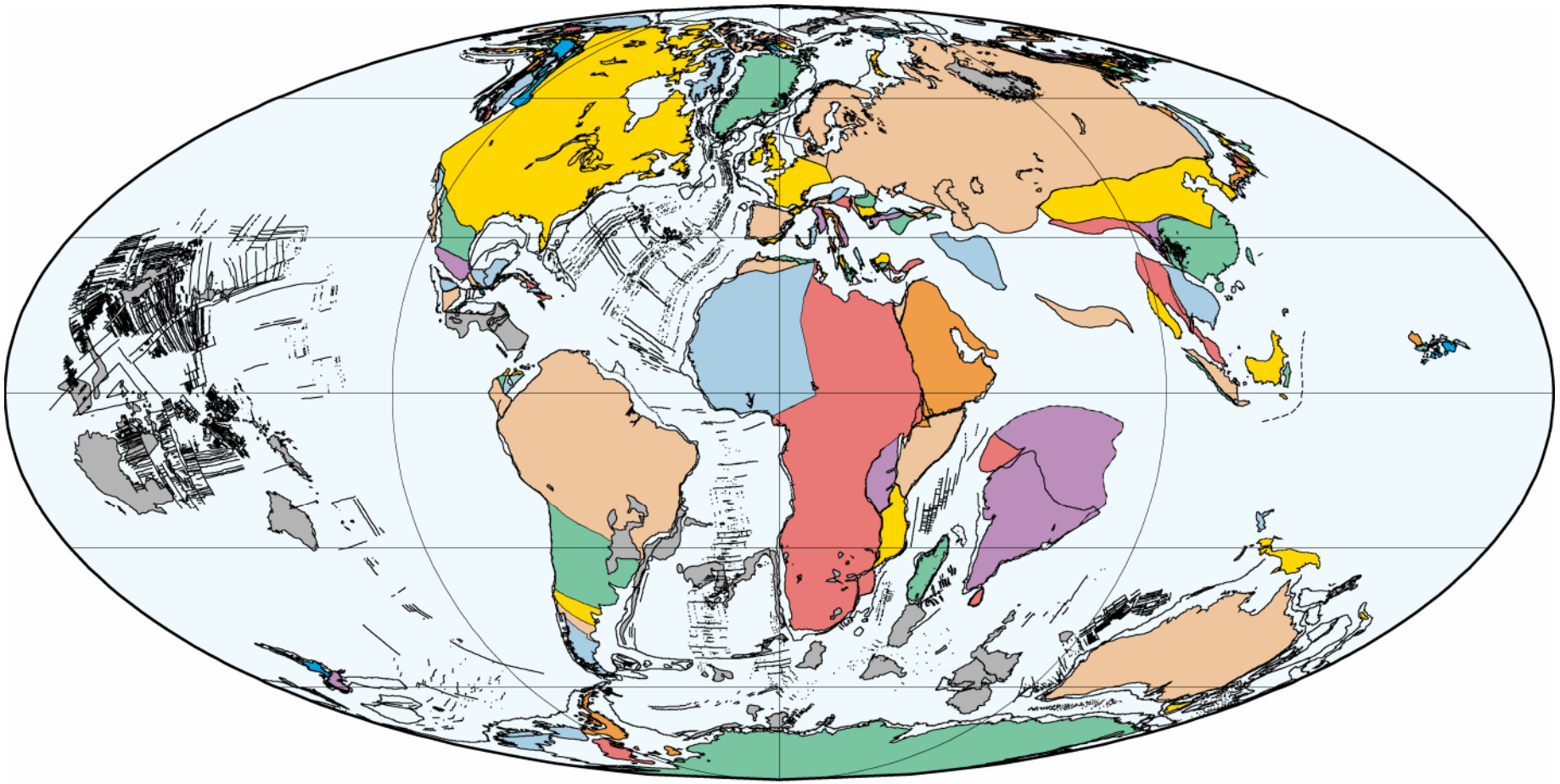


80 Ma

Campanian (Late Cretaceous)

PLATES/UTIG

August 2002

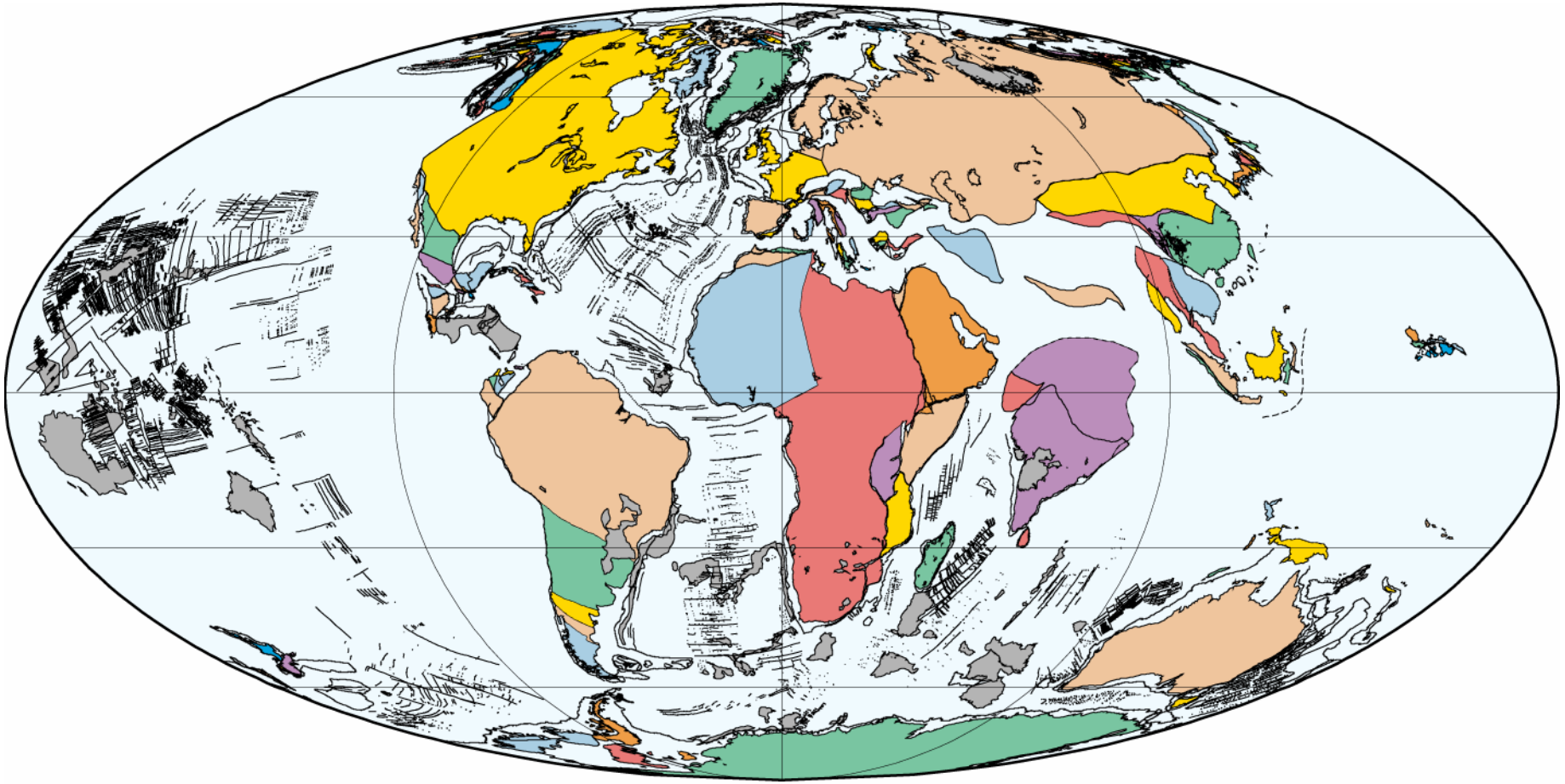


70 Ma

Maastrichtian (Late Cretaceous)

PLATES/UTIG

August 2002

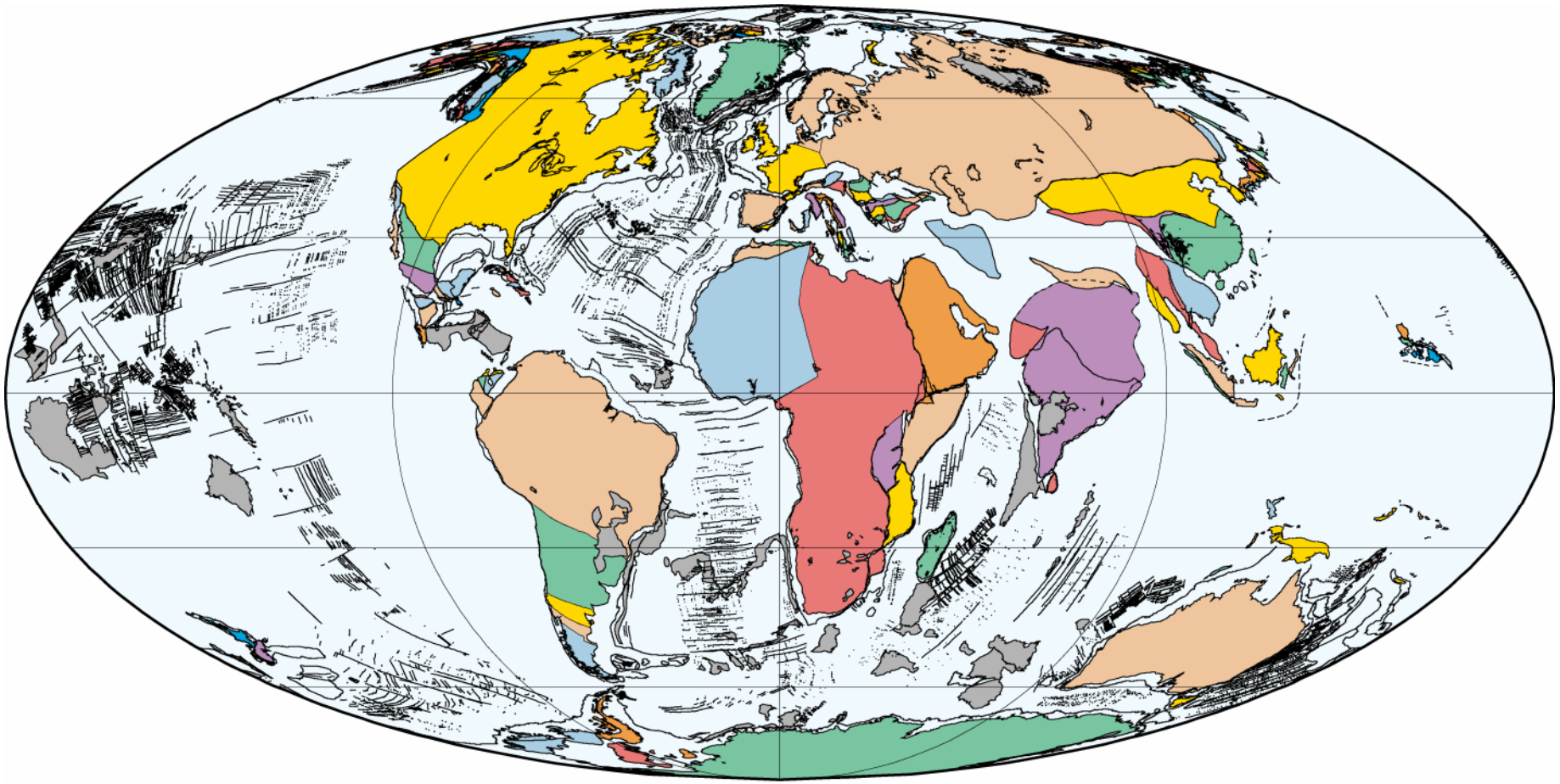


60 Ma

Late Paleocene

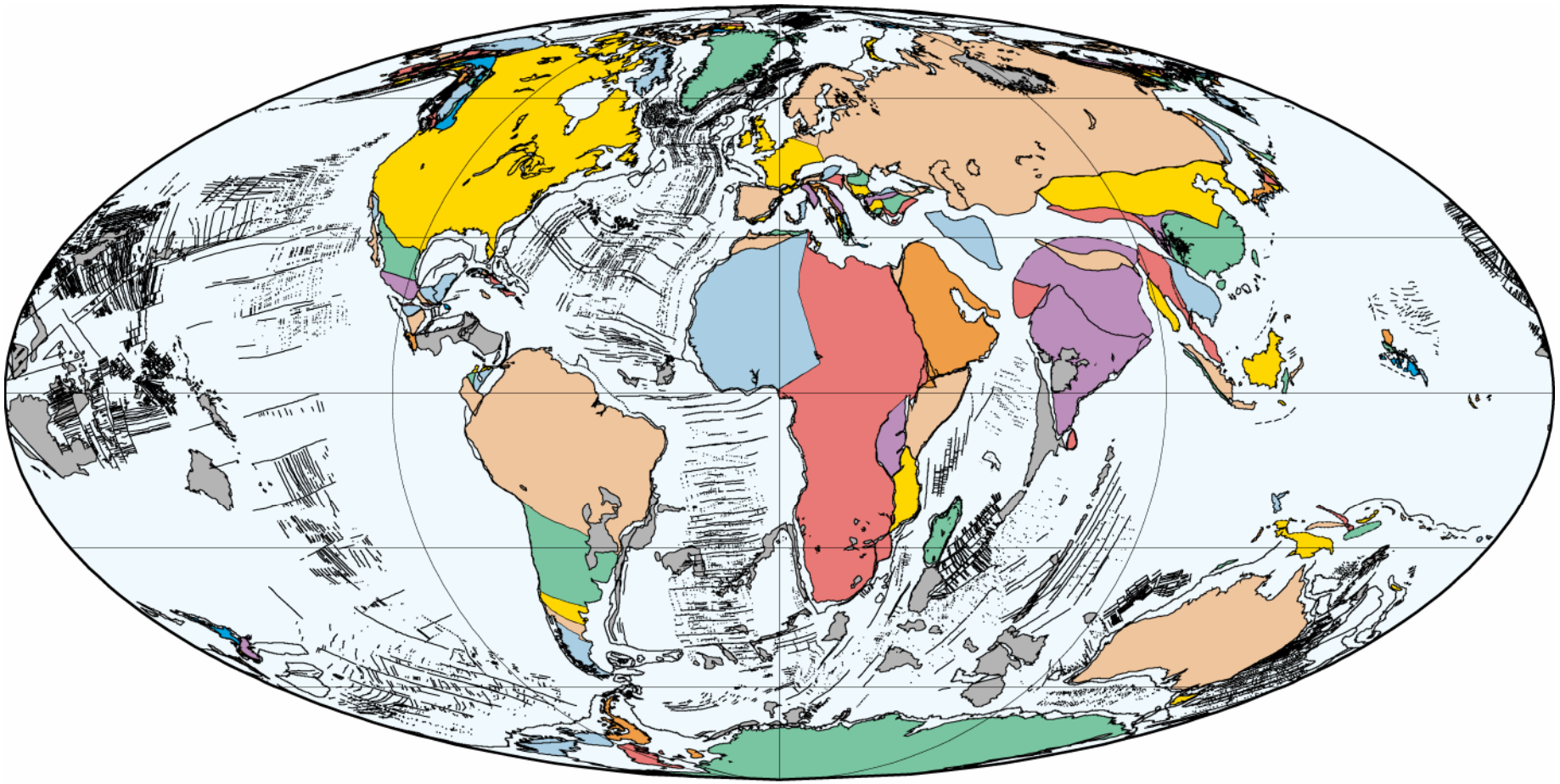
PLATES/UTIG

August 2002



50 Ma
Early Eocene

PLATES/UTIG
August 2002

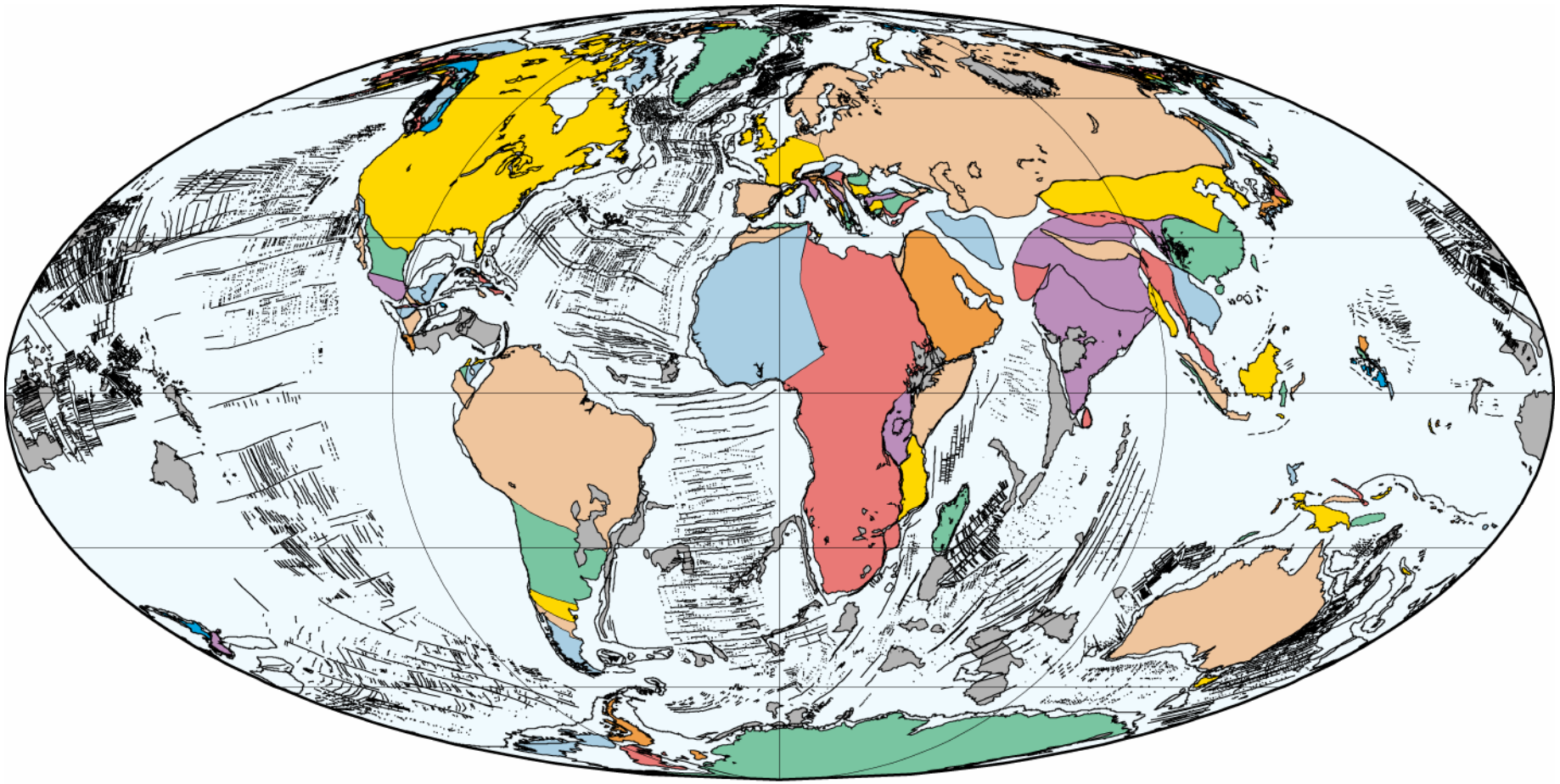


40 Ma

Middle Eocene

PLATES/UTIG

August 2002

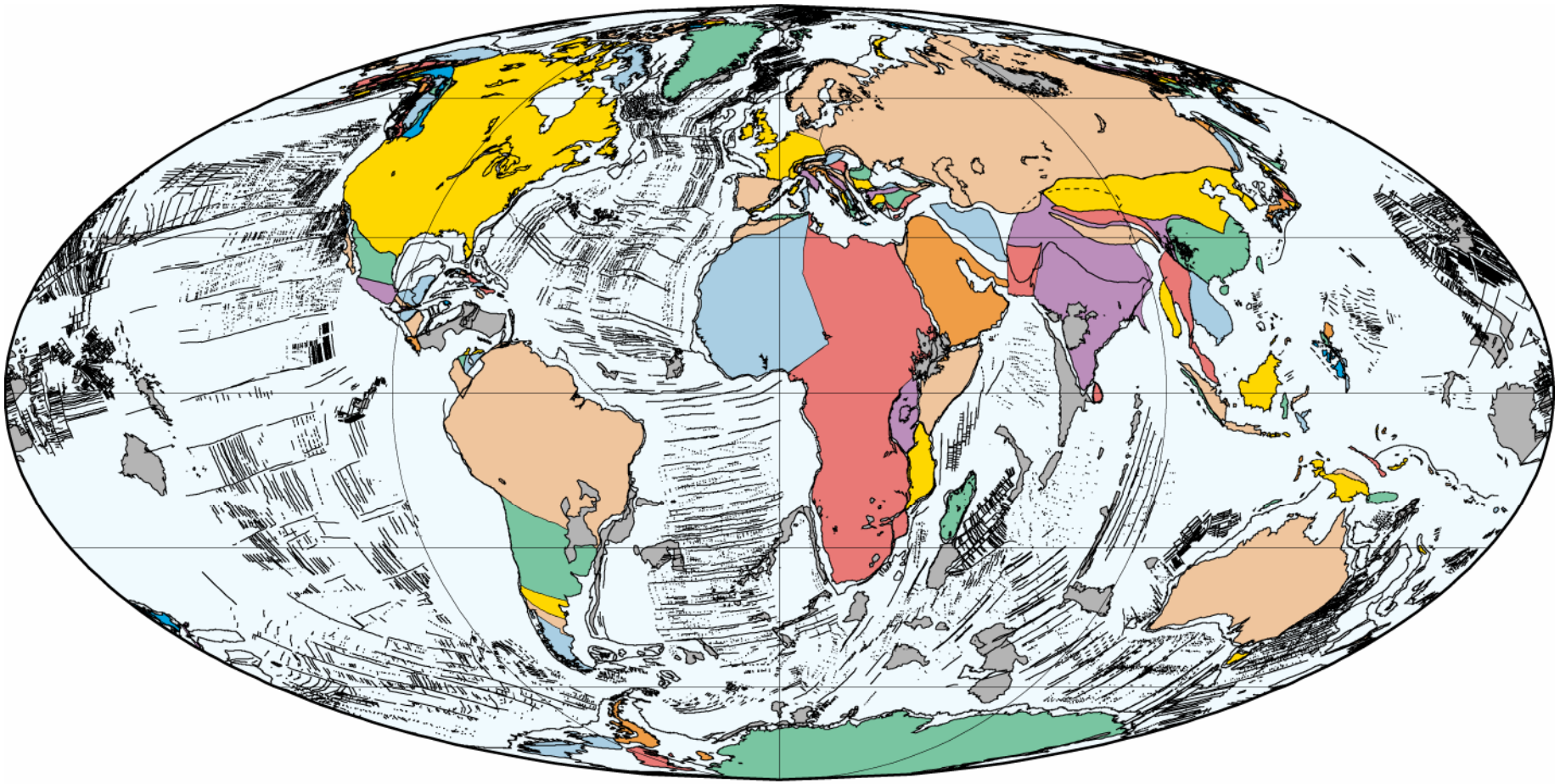


30 Ma

Early Oligocene

PLATES/UTIG

August 2002

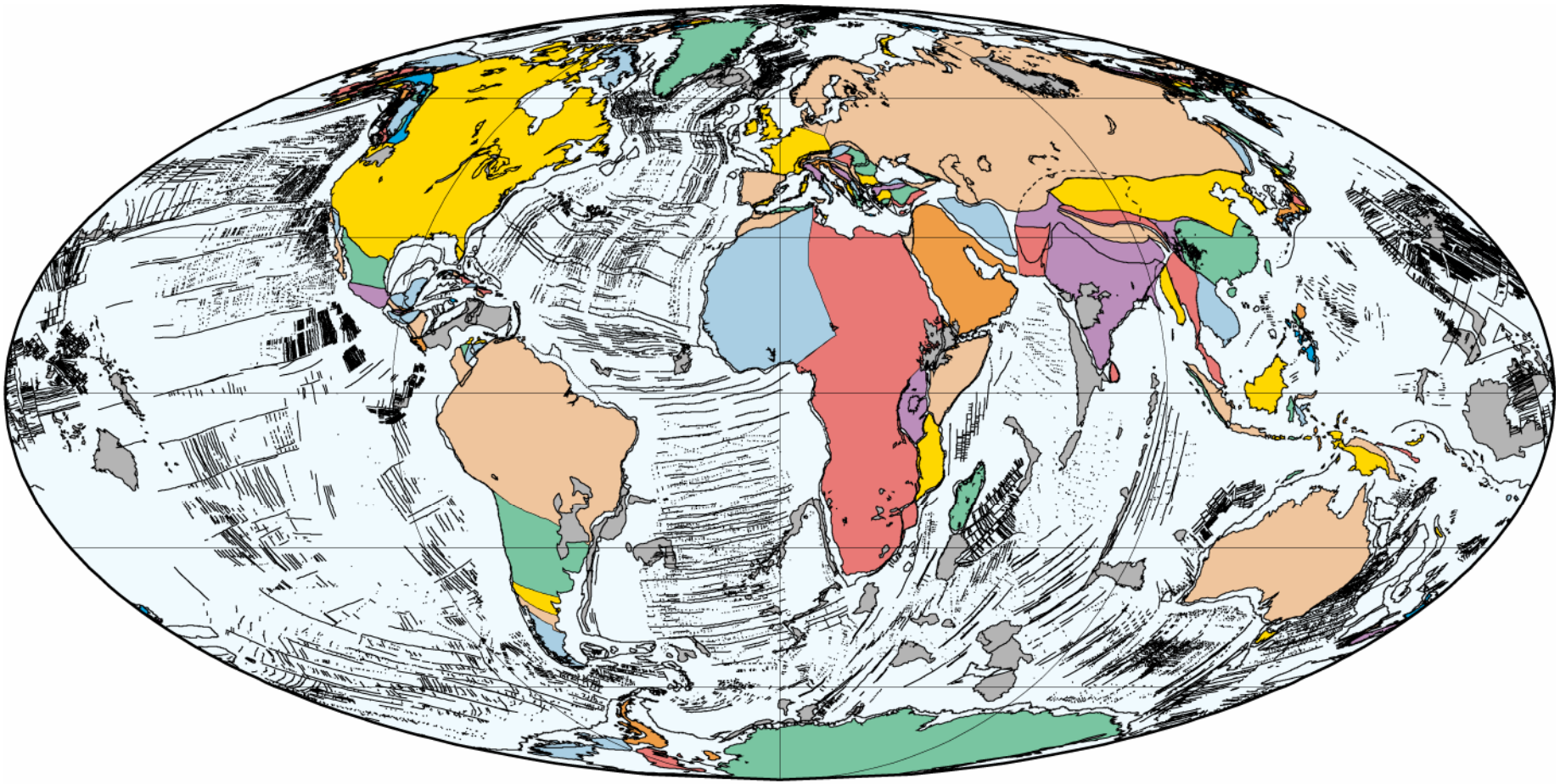


20 Ma

Early Miocene

PLATES/UTIG

August 2002

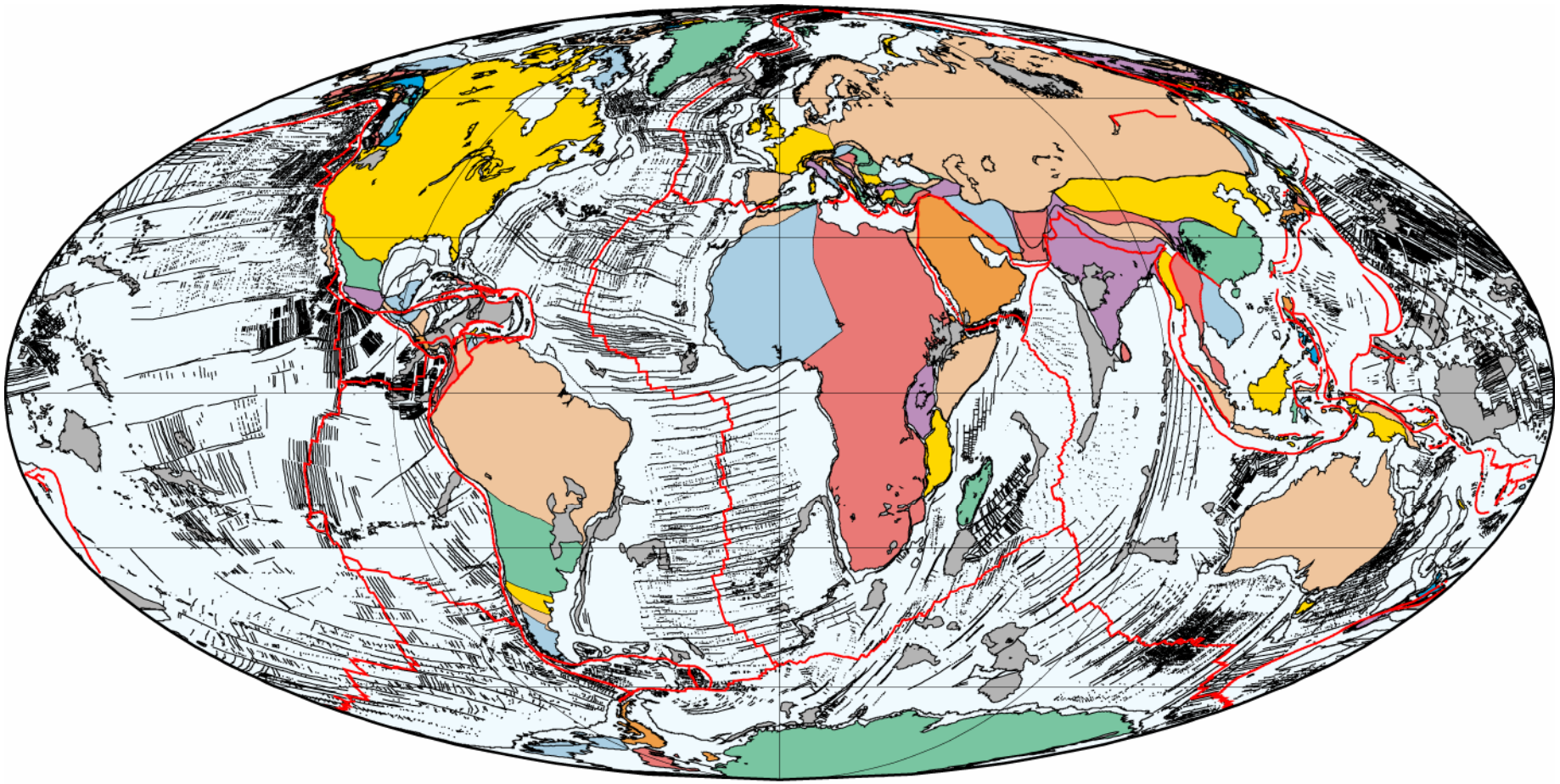


10 Ma

Late Miocene

PLATES/UTIG

August 2002



0 Ma

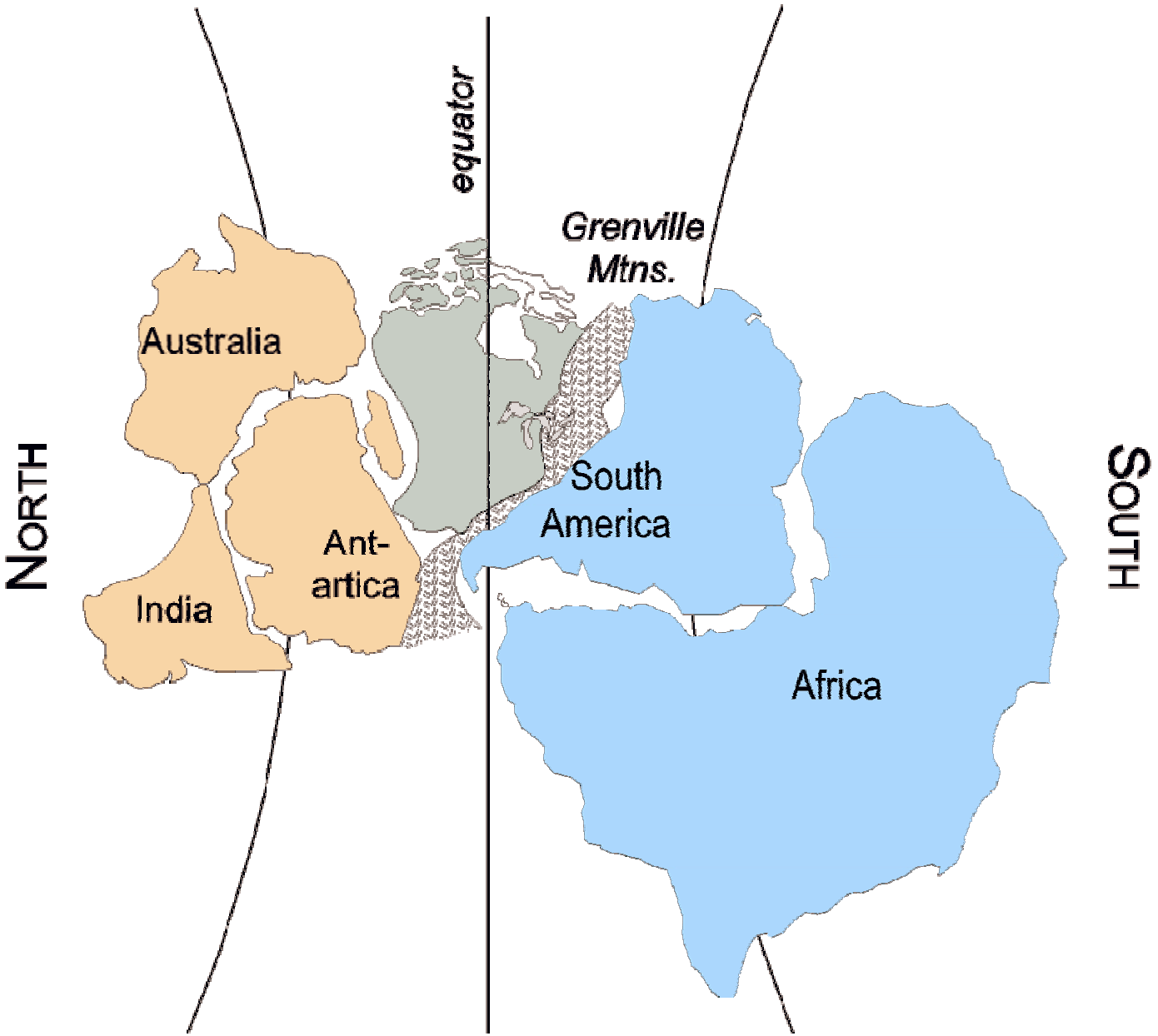
Present Day

PLATES/UTIG

August 2002

Rodinia Supercontinent

750 - 550



Pangaea Supercontinent

428 - 320