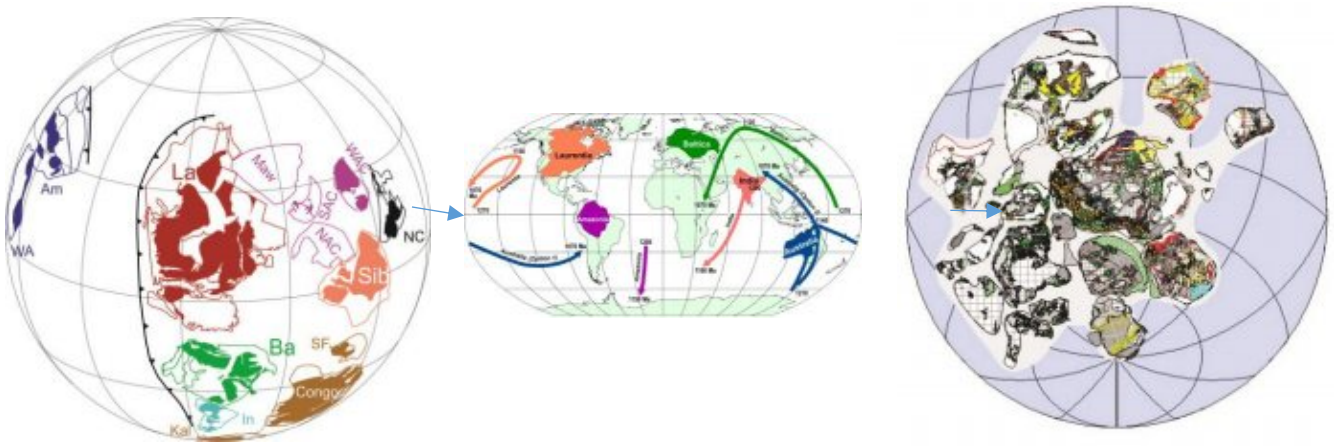
Докембрийская Палеогеография и Суперконтиненты



С. А. Писаревский

Университет Куртин,
Западная Австралия

Curtin University
THE INSTITUTE FOR GEOSCIENCE RESEARCH (TIGeR)

Project 648
Supercontinent Cycles & Global Geodynamics

Paleogeographic reconstructions

Constraints for paleogeographic reconstructions

- “TRADITIONAL:

Marine magnetic anomalies

Paleomagnetism

Paleontology

Crustal provinces

Paleoclimate

Sedimentary provenance

Passive and active margins

Geochemistry

Large Igneous Provinces

ETC…..

“NEW”:

Plate velocities

Integrated plate models

Animation models

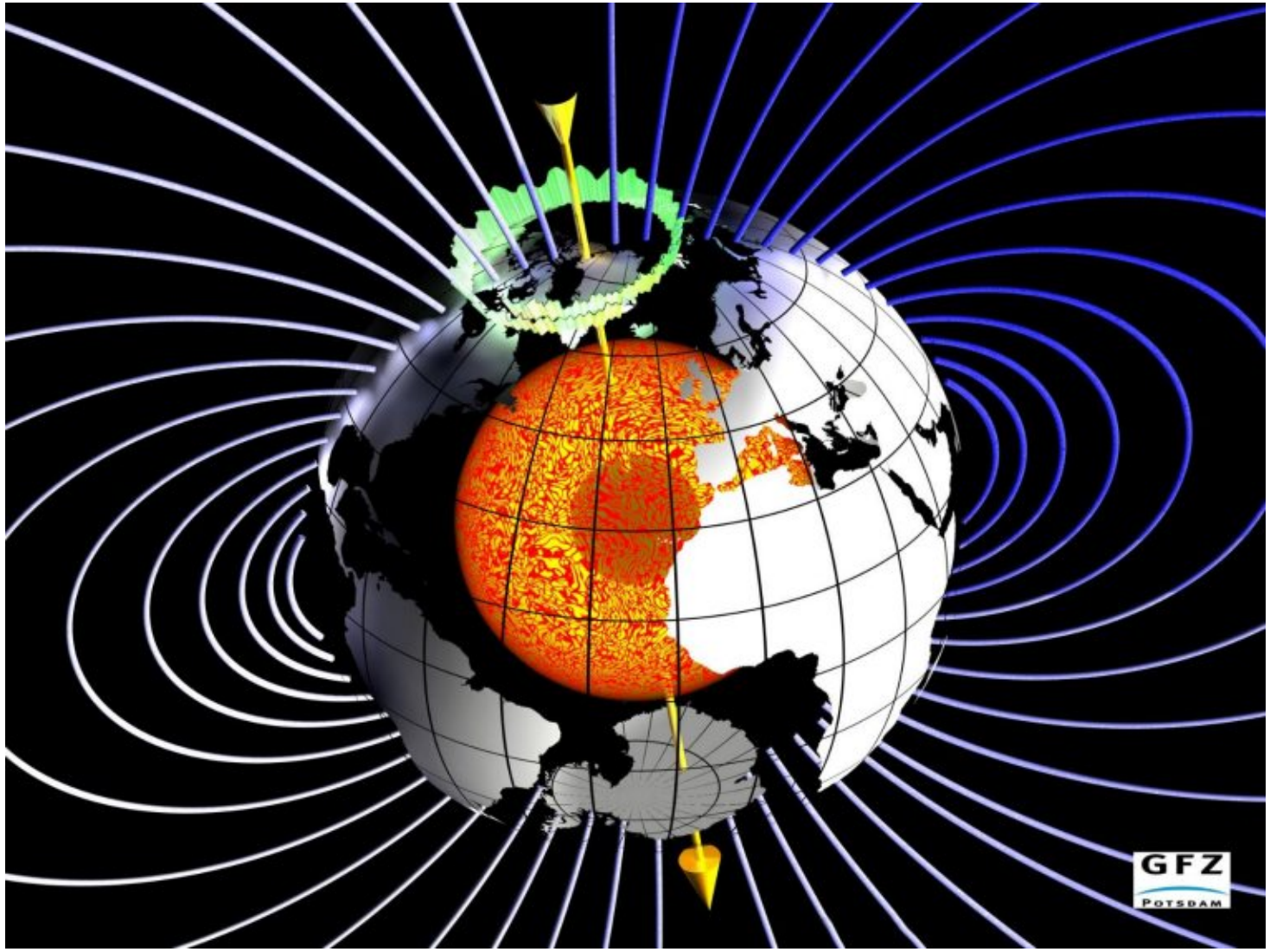
- QUEASTIONABLE:

Supercontinents

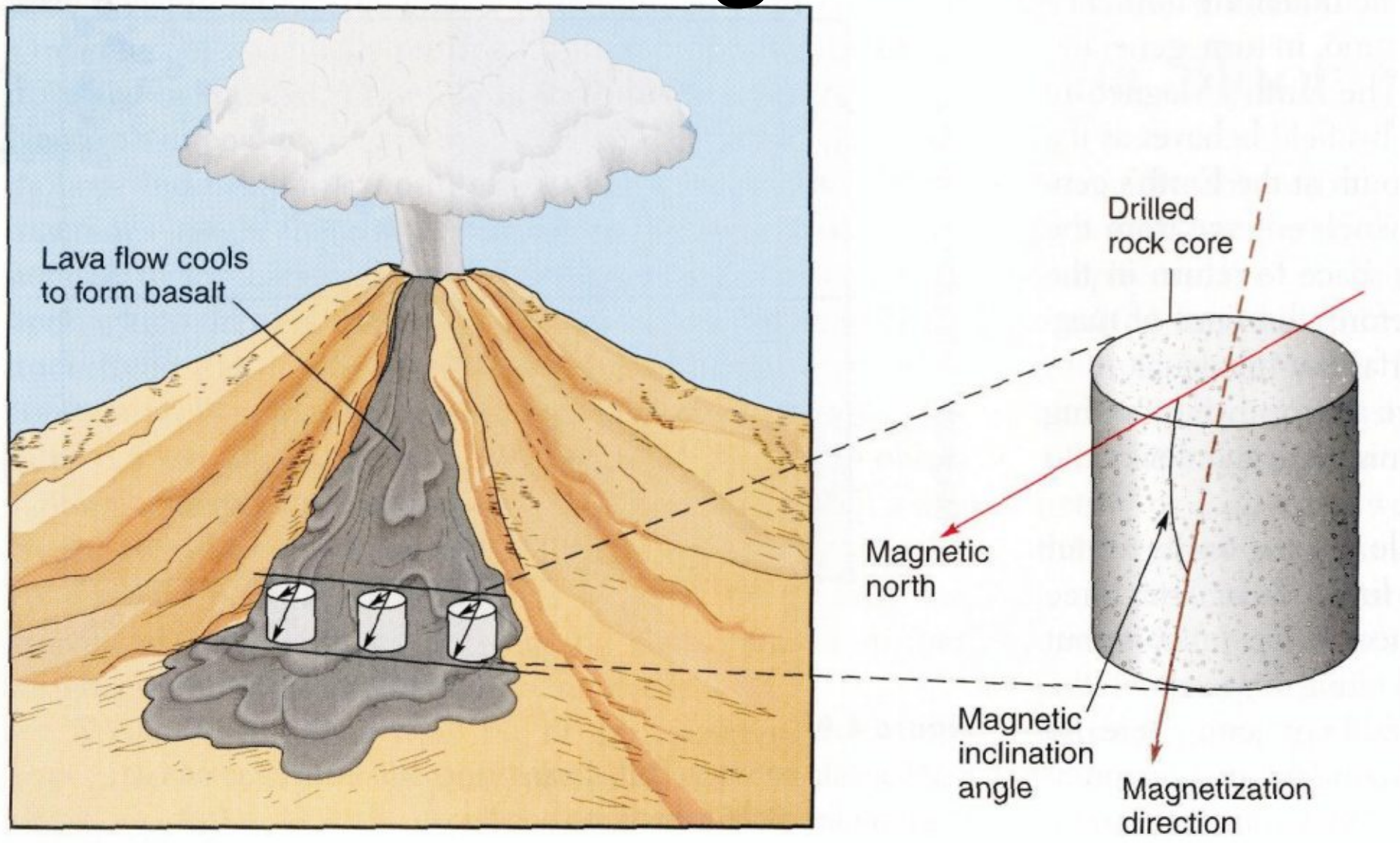
Unchanged building blocks

Stereotypes

Paleomagnetism

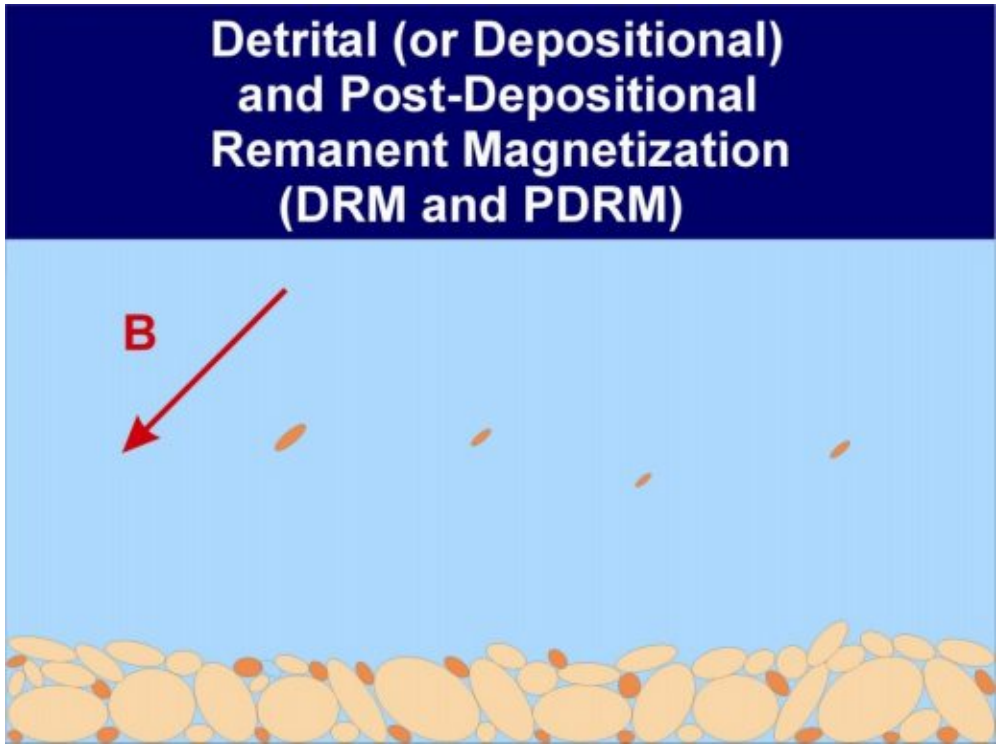


Paleomagnetism

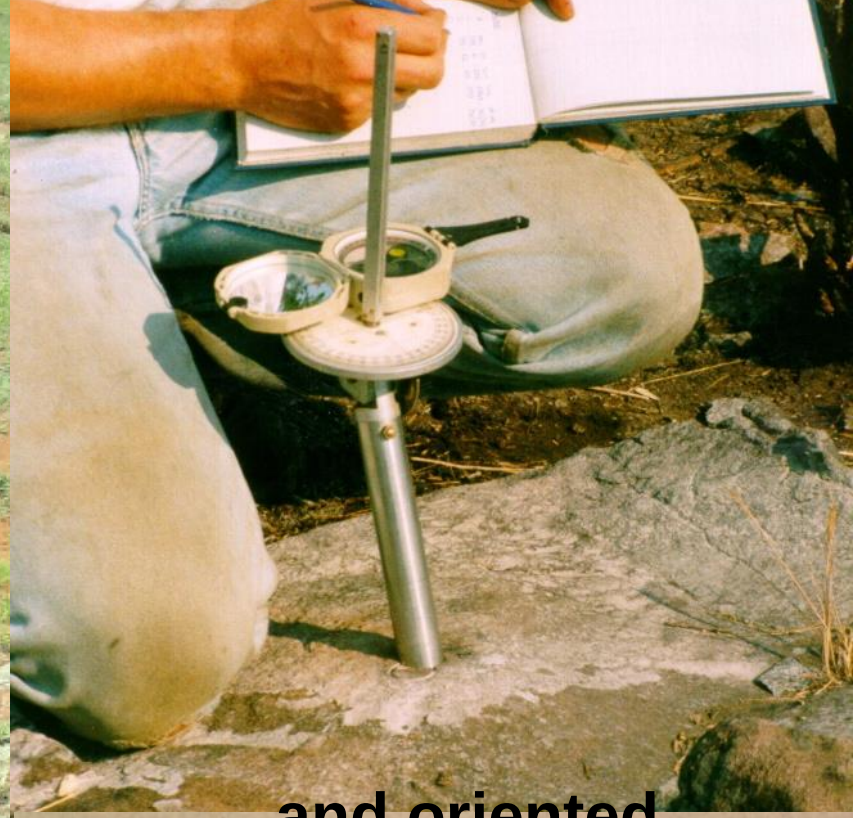


Paleomagnetism

- alignment of magnetic particles by the geomagnetic field as they fall through water and settle at the bottom – DRM
- all re-orientation of these particles in unconsolidated sediments - PDRM



Samples must be drilled



and oriented

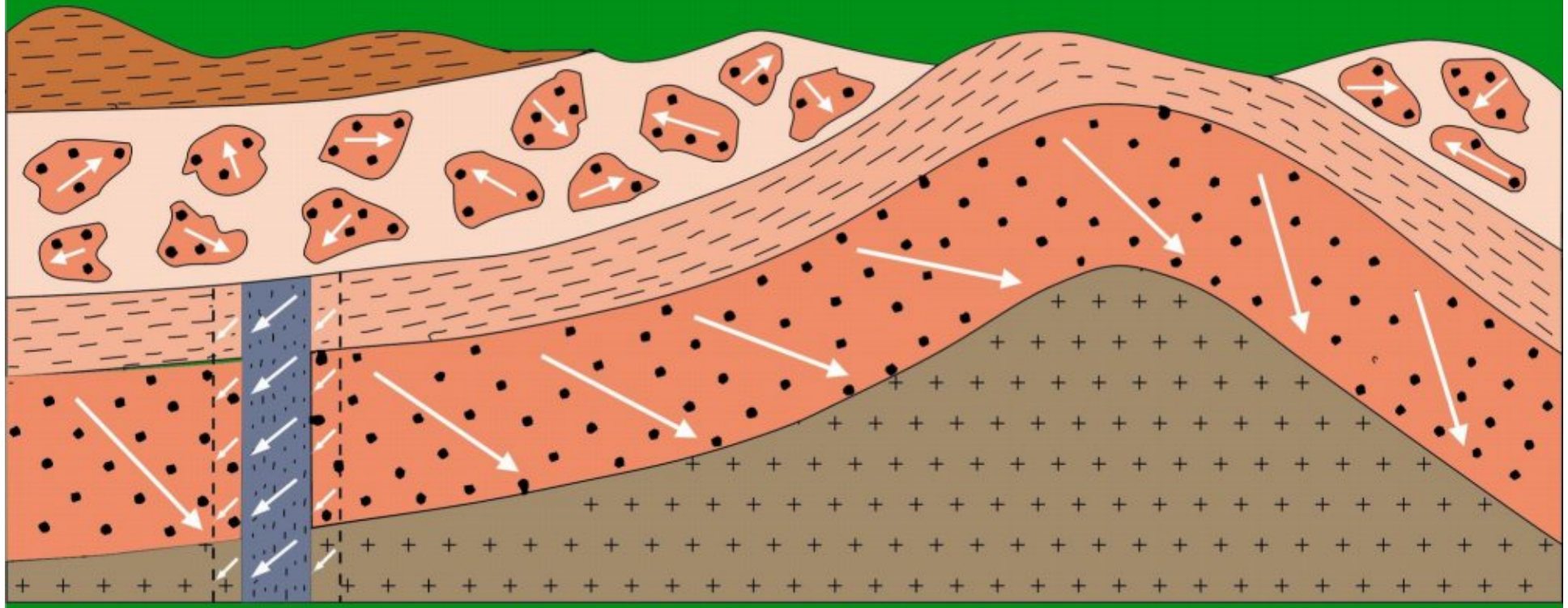

STAEDTLER permanent
DRY SAFE
F
MKTN1
MKTN6
MKTN5
MKTN7

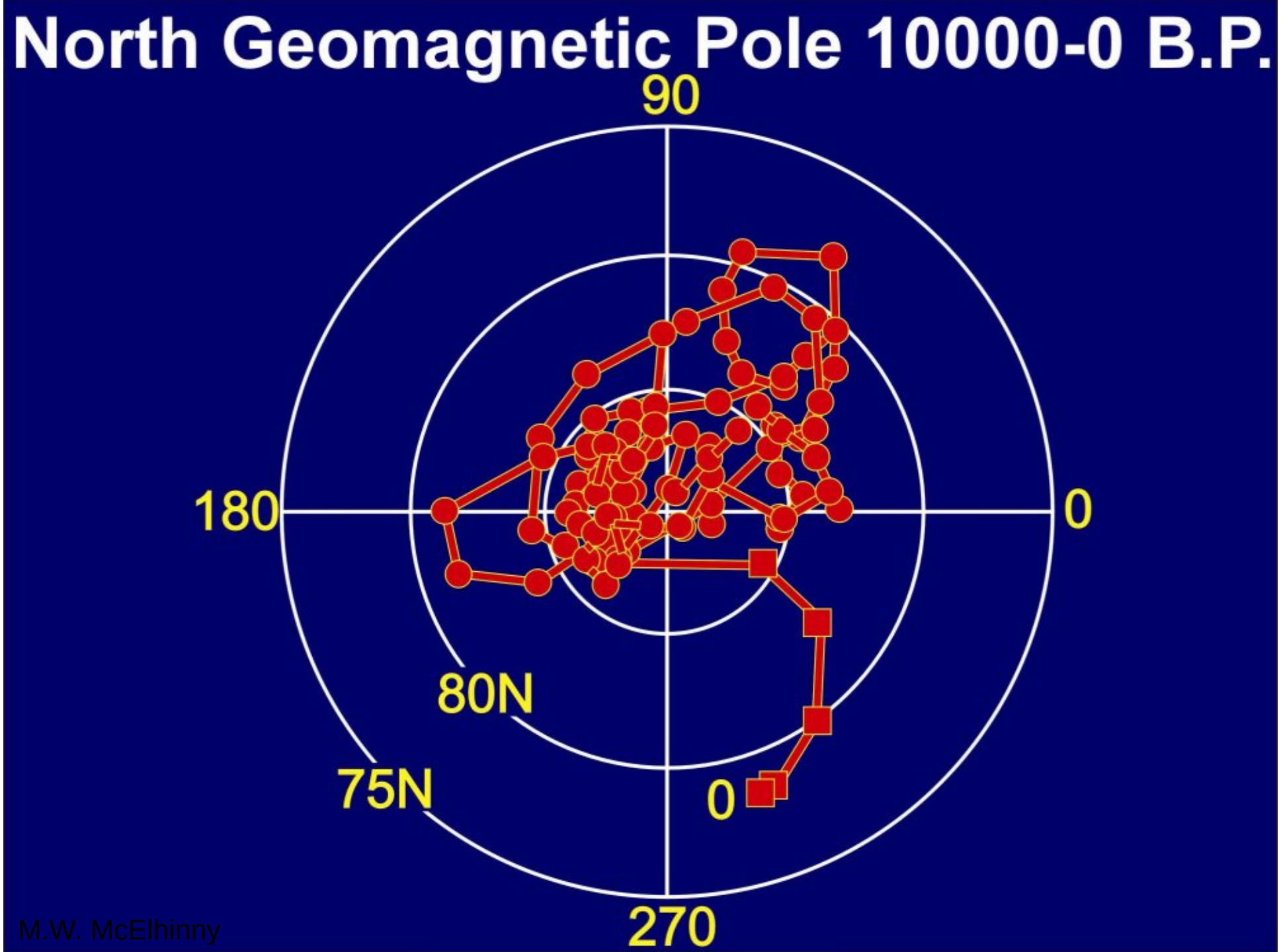

2-G ENTERPRISES

M.W. McElhinny

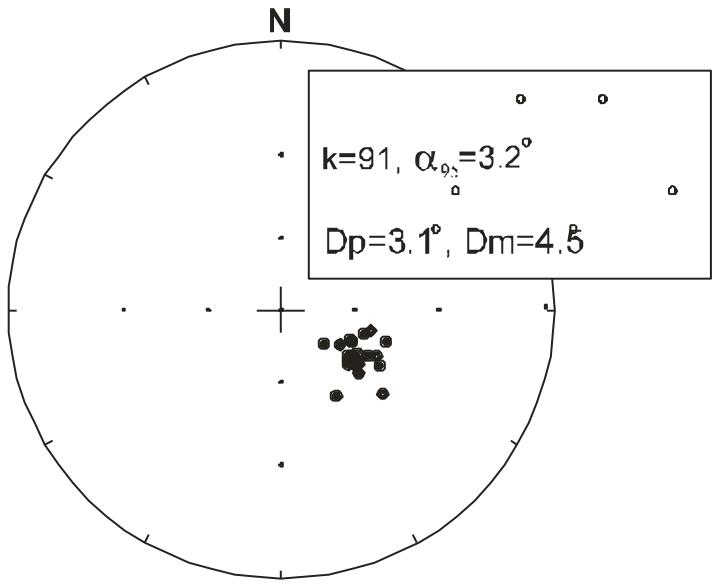
FIELD TESTS

Fold, Conglomerate and Baked Contact Tests




North Geomagnetic Pole 10000-0 B.P.
90
180
0
80N
75N
0
270
M.W. McElhinny

After analyses palaeomagnetic directions should be plotted on the stereoprojection and mean palaeomagnetic direction and pole should be calculated



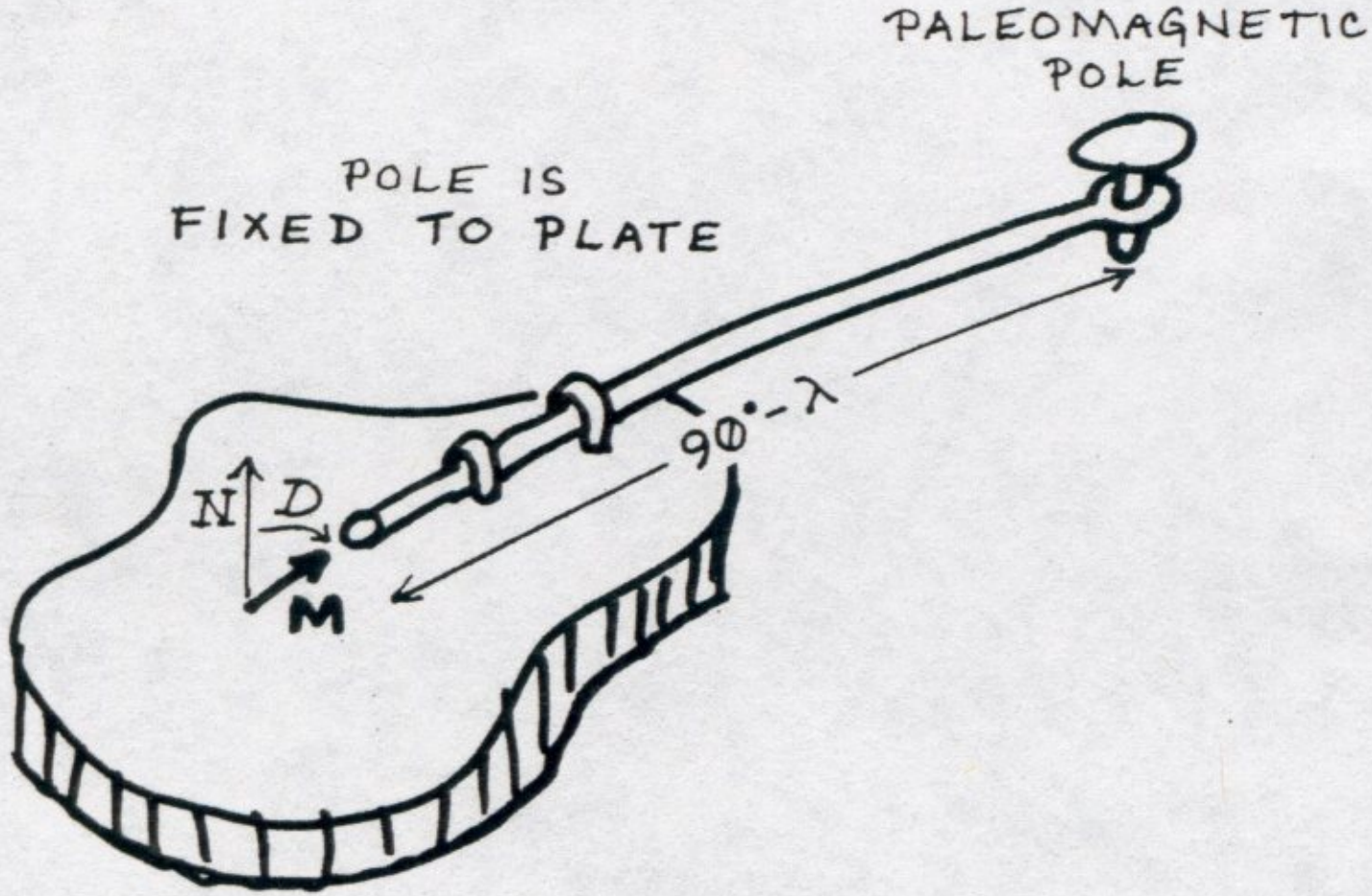
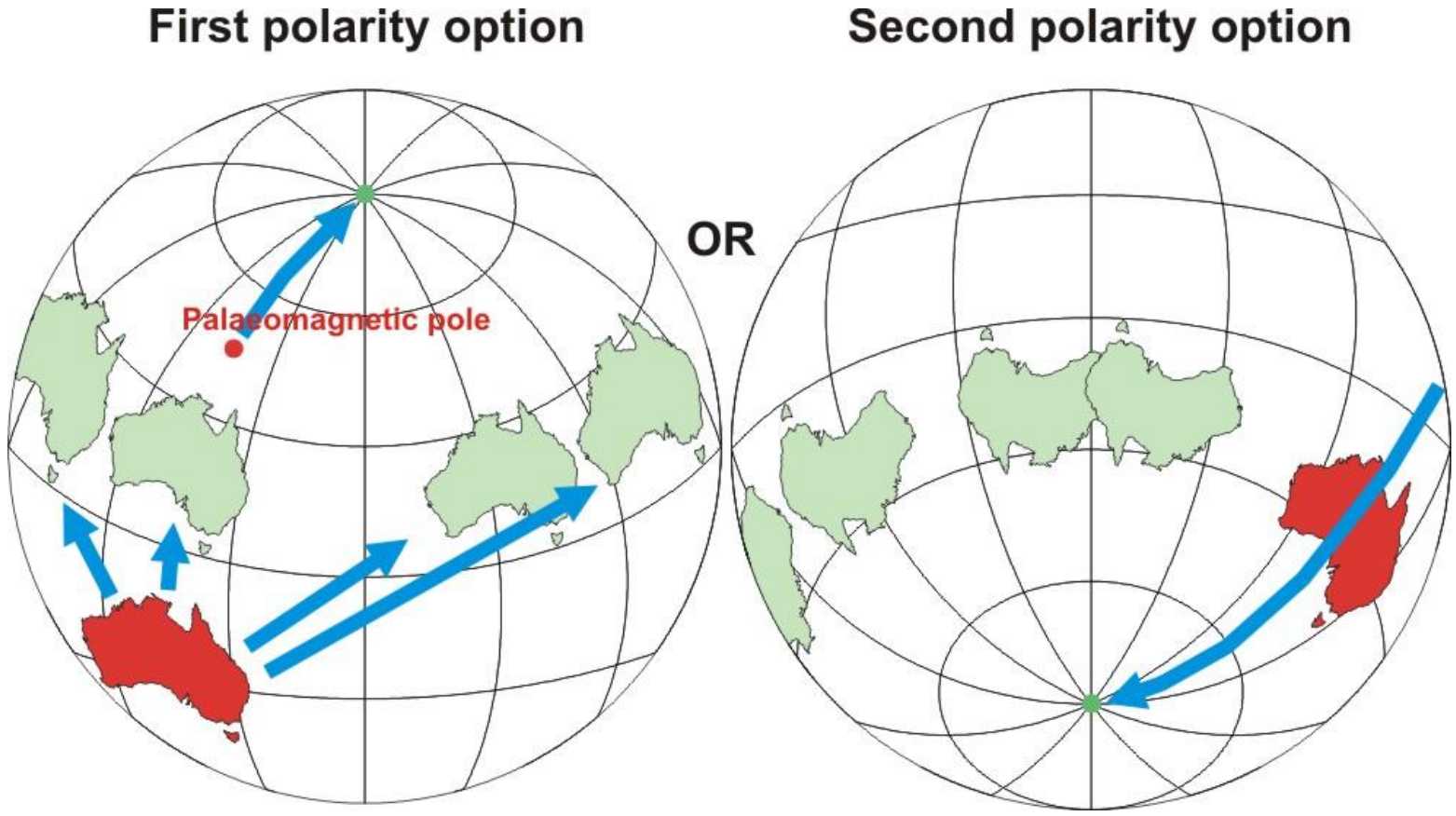


Figure 9-6.
A paleomagnetic pole moves with a plate as if the pole were attached to the plate with a rigid rod.

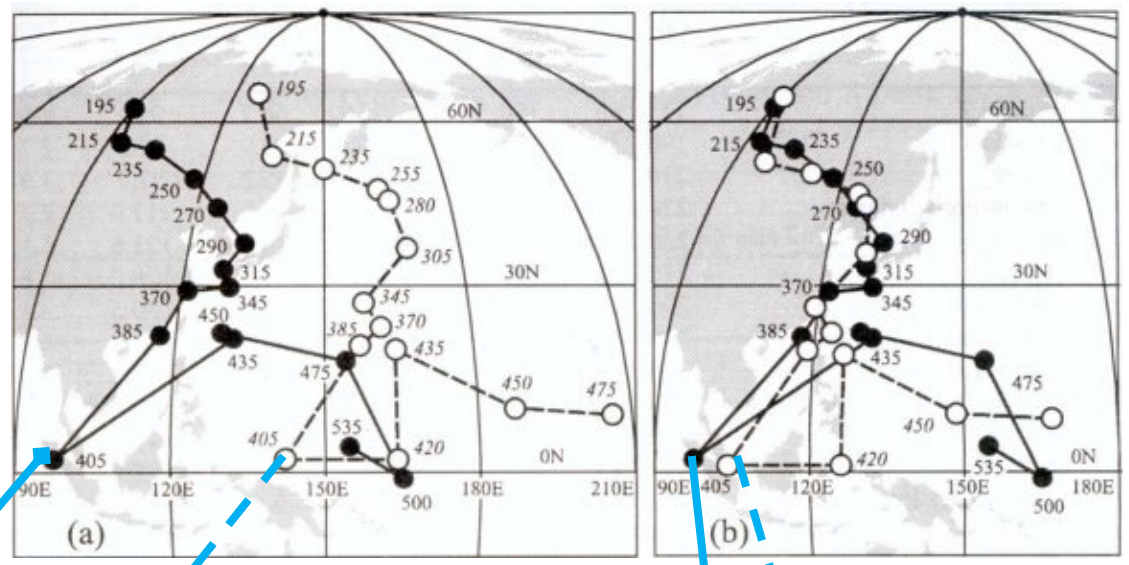
How to reconstruct?

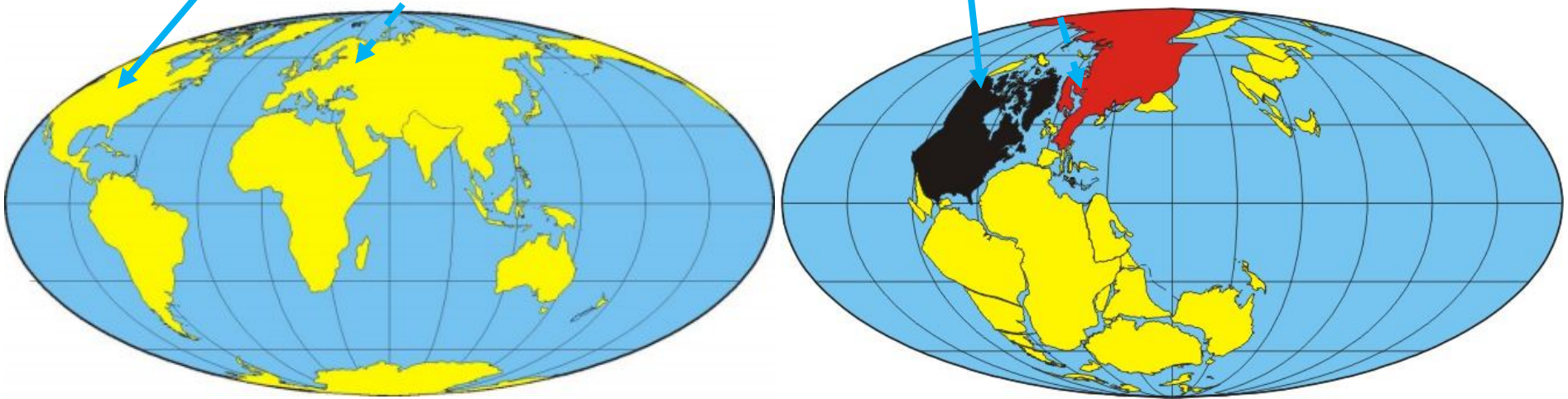


…but Apparent Polar Wander Paths can help

How to reconstruct?

APWPs for Europe and North America





Van der Voo, 1993

How many poles are required for APWP? Phanerozoic example.

- Gondwana ~230 poles
- North America + Greenland ~200 poles
- Stable Europe ~170 poles

Earth-Science Reviews 114 (2012) 325–368

Contents lists available at SciVerse ScienceDirect

Earth-Science Reviews

journal homepage: www.elsevier.com/locate/earscirev

Phanerozoic polar wander, palaeogeography and dynamics

Trond H. Torsvik [a,b,c,d,*], Rob Van der Voo [a,e], Ulla Preeden [f], Conall Mac Niocaill [g], Bernhard Steinberger [h,a,b], Pavel V. Doubrovine [a,b], Douwe J.J. van Hinsbergen [a,b], Mathew Domeier [e,b], Carmen Gaina [a,b], Eric Tohver [i], Joseph G. Meert [j], Phil J.A. McCausland [k], L. Robin M. Cocks [l]

[a] Center for Advanced Study, Norwegian Academy of Science and Letters, Drammensveien 78, 0271 Oslo, Norway

67 1800-1250 Ma poles

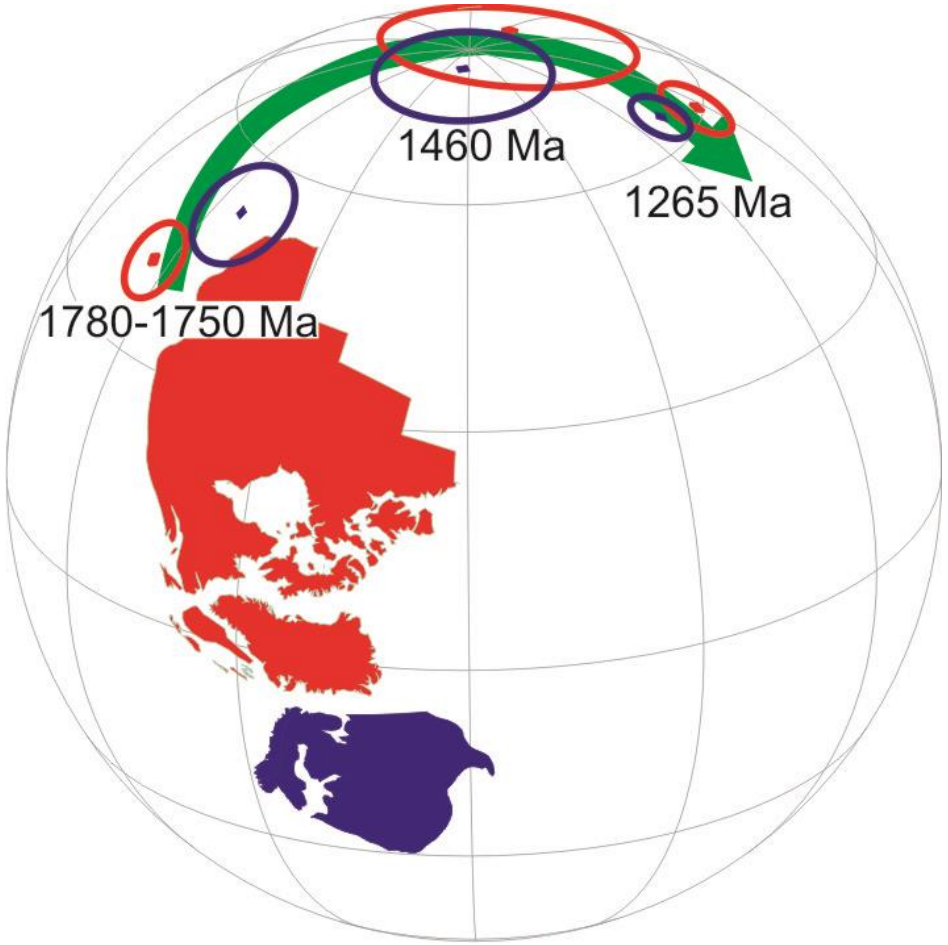
Continent	1800-1750 Ma	1750-1700 Ma	1700-1650 Ma	1650-1600 Ma	1600-1550 Ma	1550-1500 Ma	1500-1450 Ma	1450-1400 Ma	1400-1350 Ma	1350-1300 Ma	1300-1250 Ma	TOTAL
Baltica	6	1		3	2	2	2				1	17
Laurentia +Greenland	3	1			1		3	6	4	1	3	22
Siberia		1				2	1					4
Australia	2	4	1	3	1	2						13
India							1					1
Amazonia	2							2				4
Congo											1	1
North China	2						3					5
TOTAL	15	7	1	6	4	6	10	8	4	1	5	67

Nordik Paleomagnetic Workshop, Lulea 2009

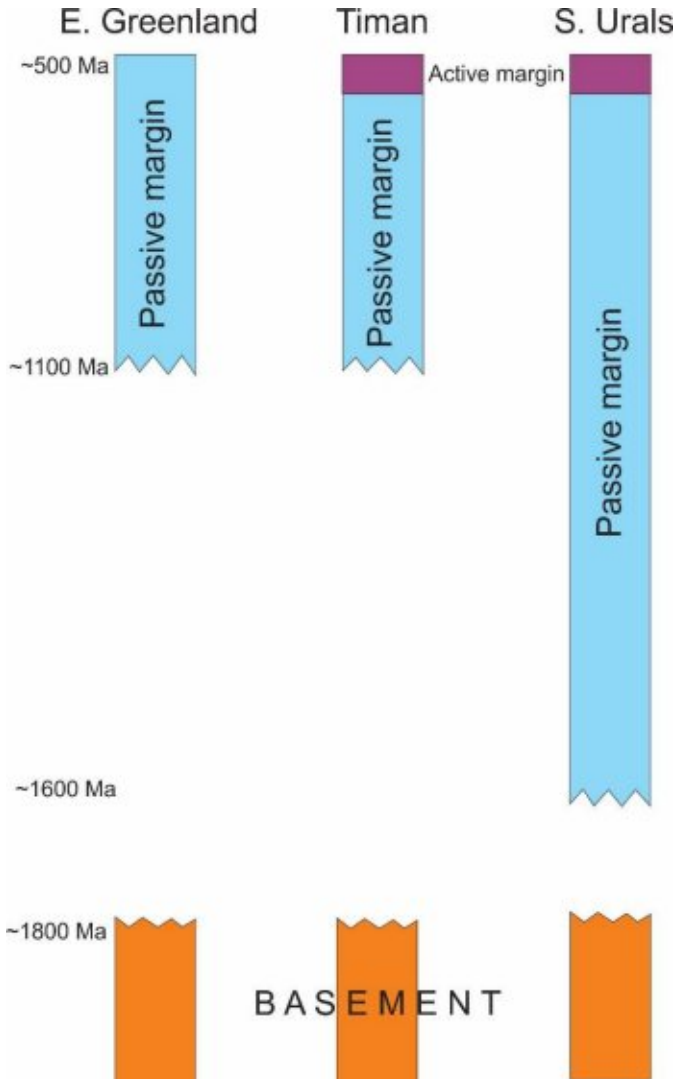
This is not enough – only few short reliable APWP fragments are possible

Laurentia-Baltica, 1780-1260 Ma

Paleomagnetic evidence

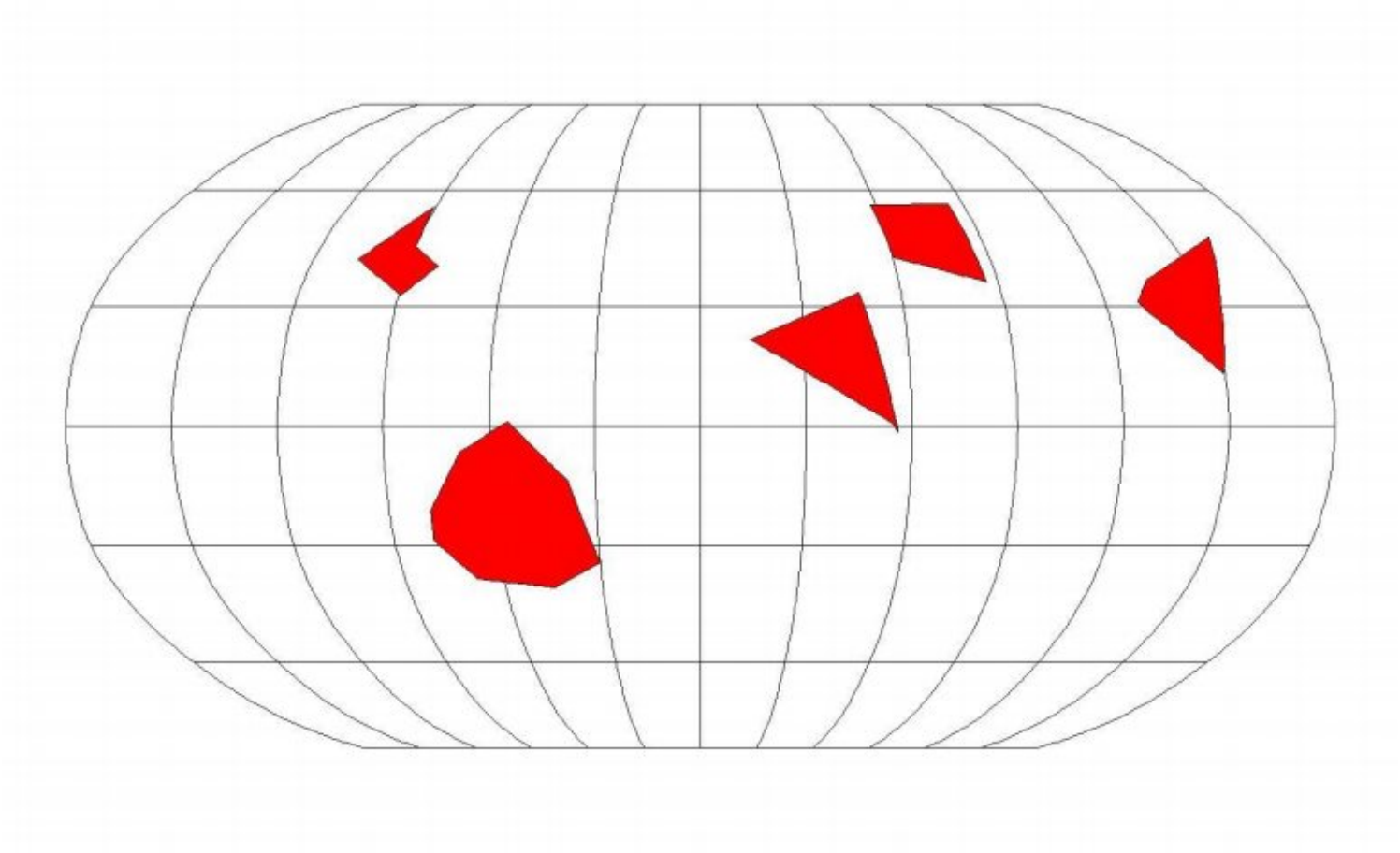


Pisarevsky & Bylund, 2010

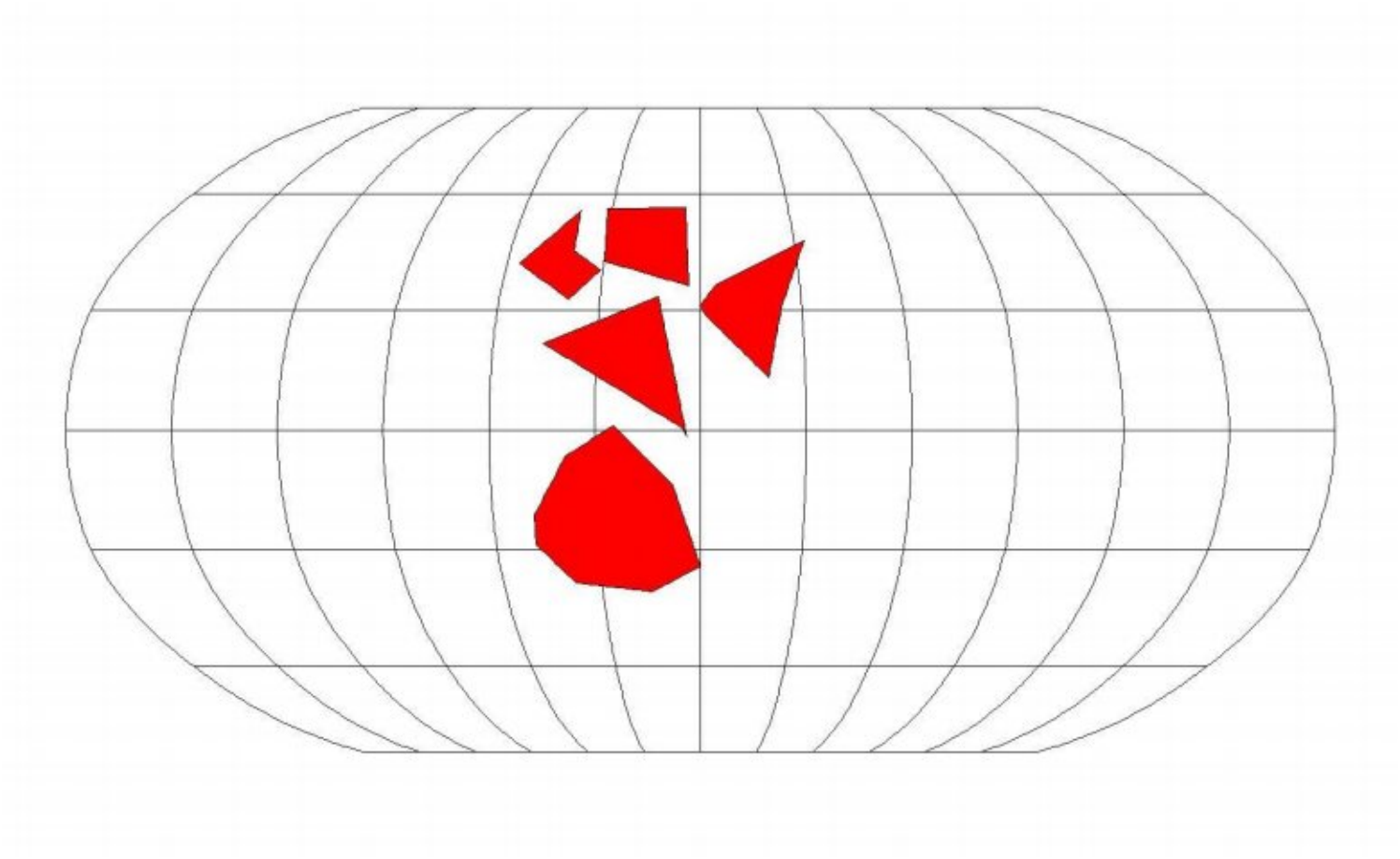


~1800 - 1600 Ma accretional orogens

5 coeval poles, no preliminary assumptions



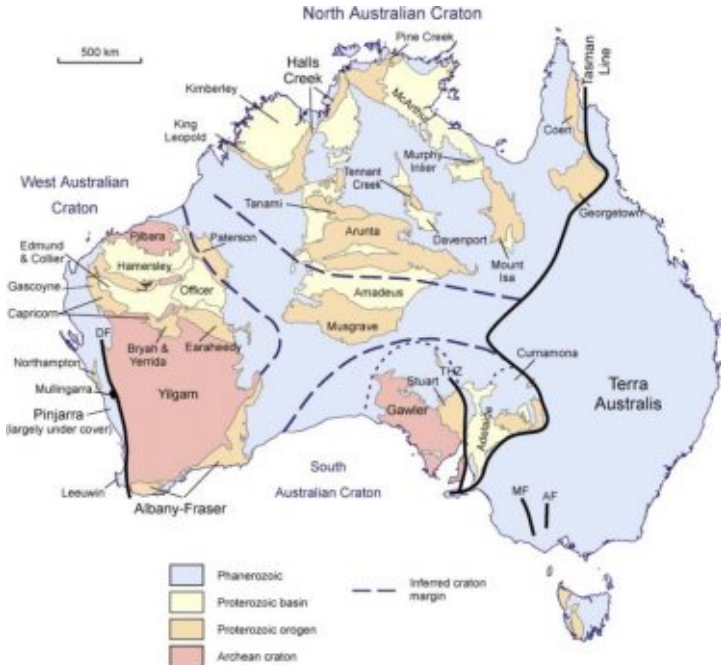
5 coeval poles and suggestion about supercontinent

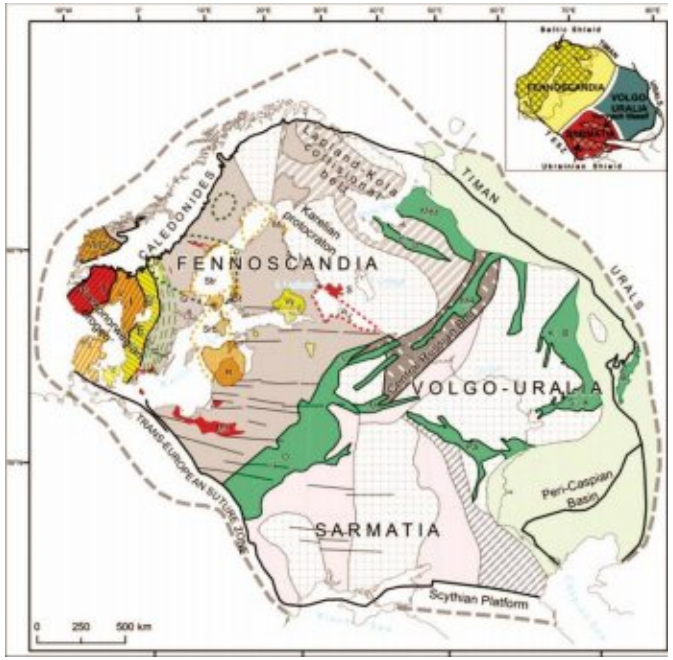


What is supercontinent?

1. A supercontinent is a landmass comprising more than one continental core, or craton.

This definition fails - almost all present continents satisfy this criterion.

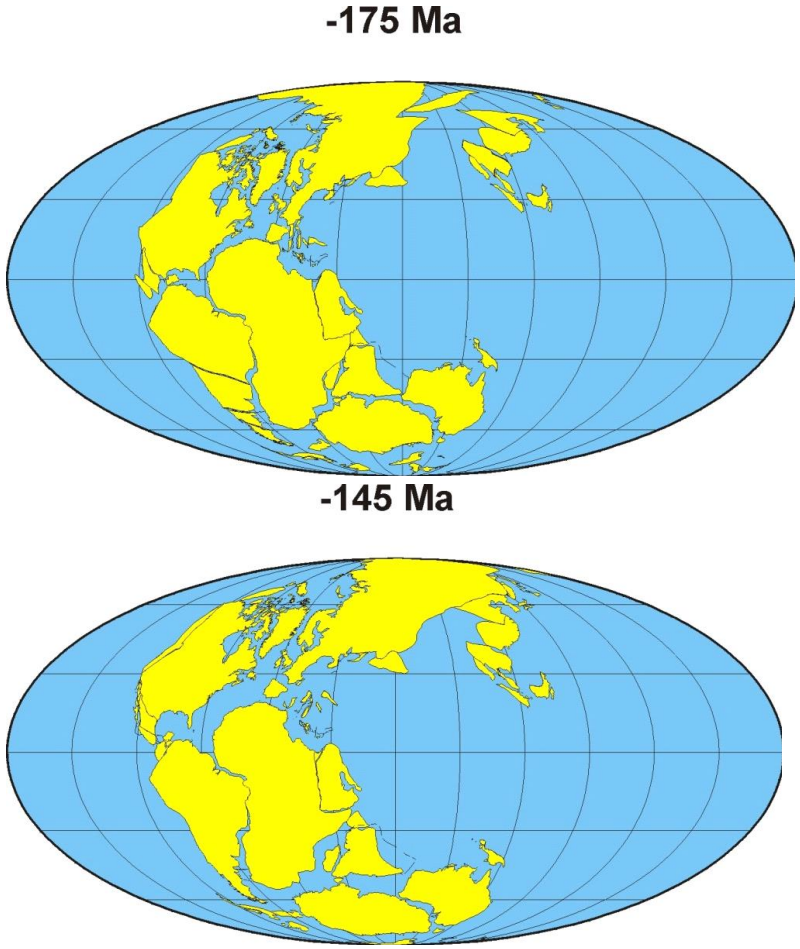




What is supercontinent?

2. A supercontinent is a single landmass consisting of all the modern continents.

This definition also fails, because even the best known supercontinent Pangea does not contain all continental crust.



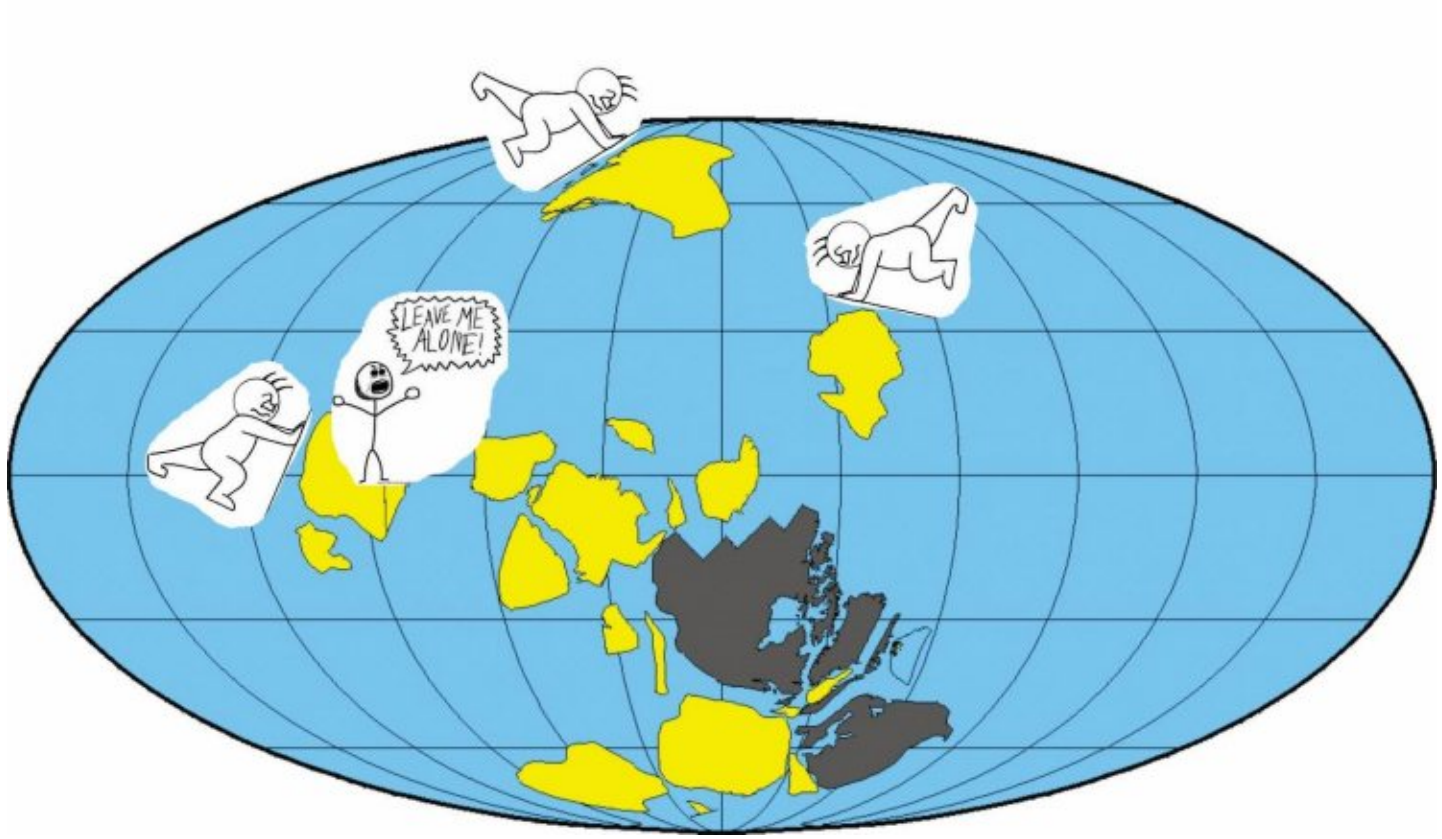
What is supercontinent?

3. A supercontinent is a single landmass consisting of most (>50%? >75% >90%) of existing continental crust.

The important implication of such definition is that Gondwana is not a supercontinent, but just a building block of Pangea.

Golden Mean

Let us call ‘supercontinent’ a landmass comprising a *significant* part (~40%?) of the existing continental crust. This means that inclusion of ALL continents into supercontinent is not compulsory



Timing of supercontinent

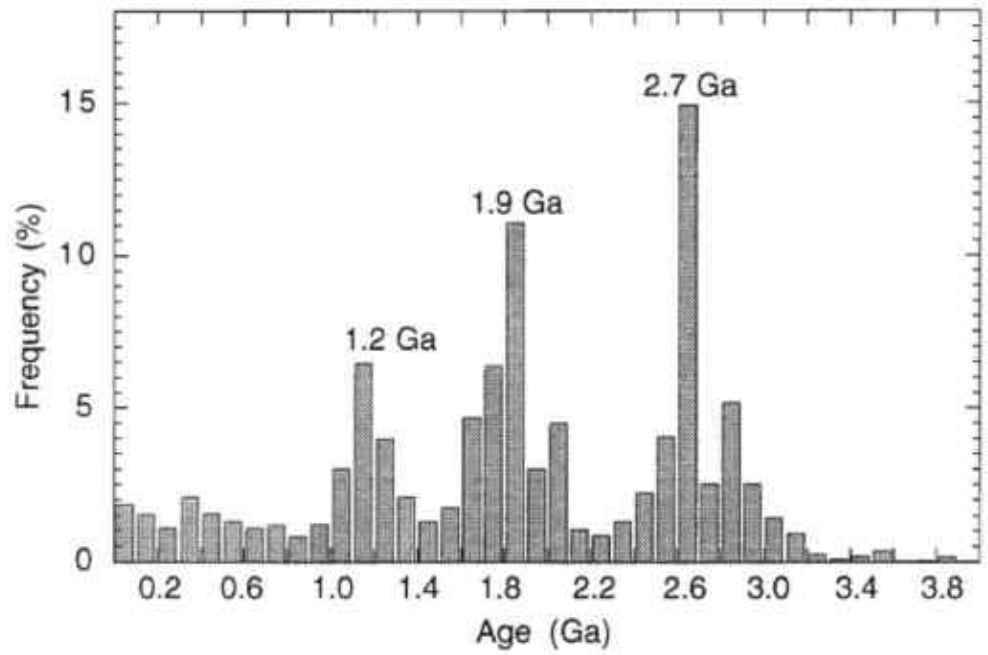
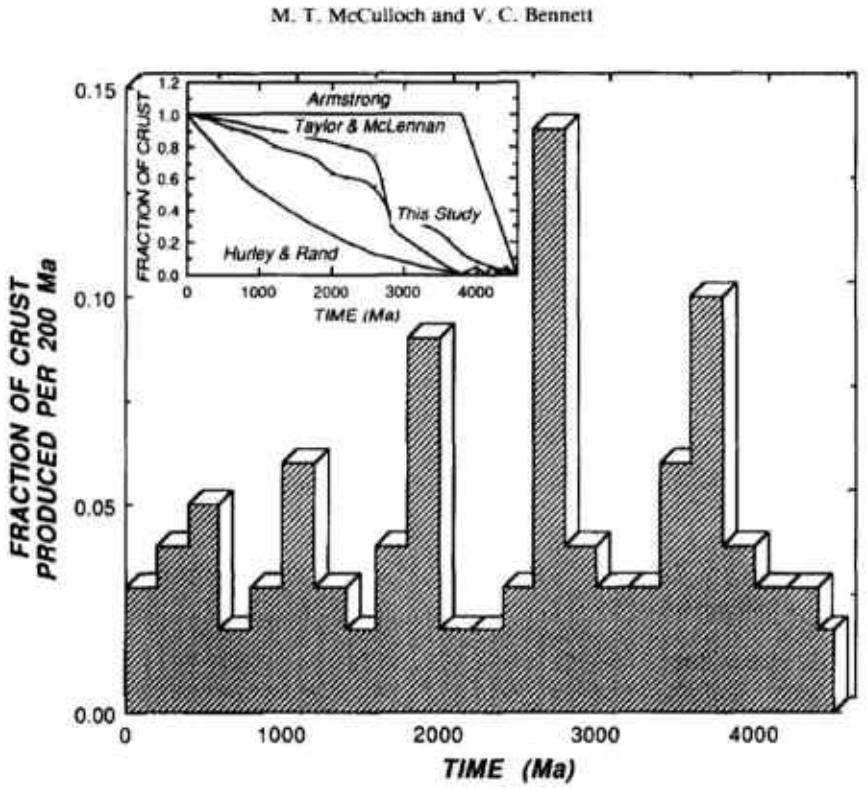
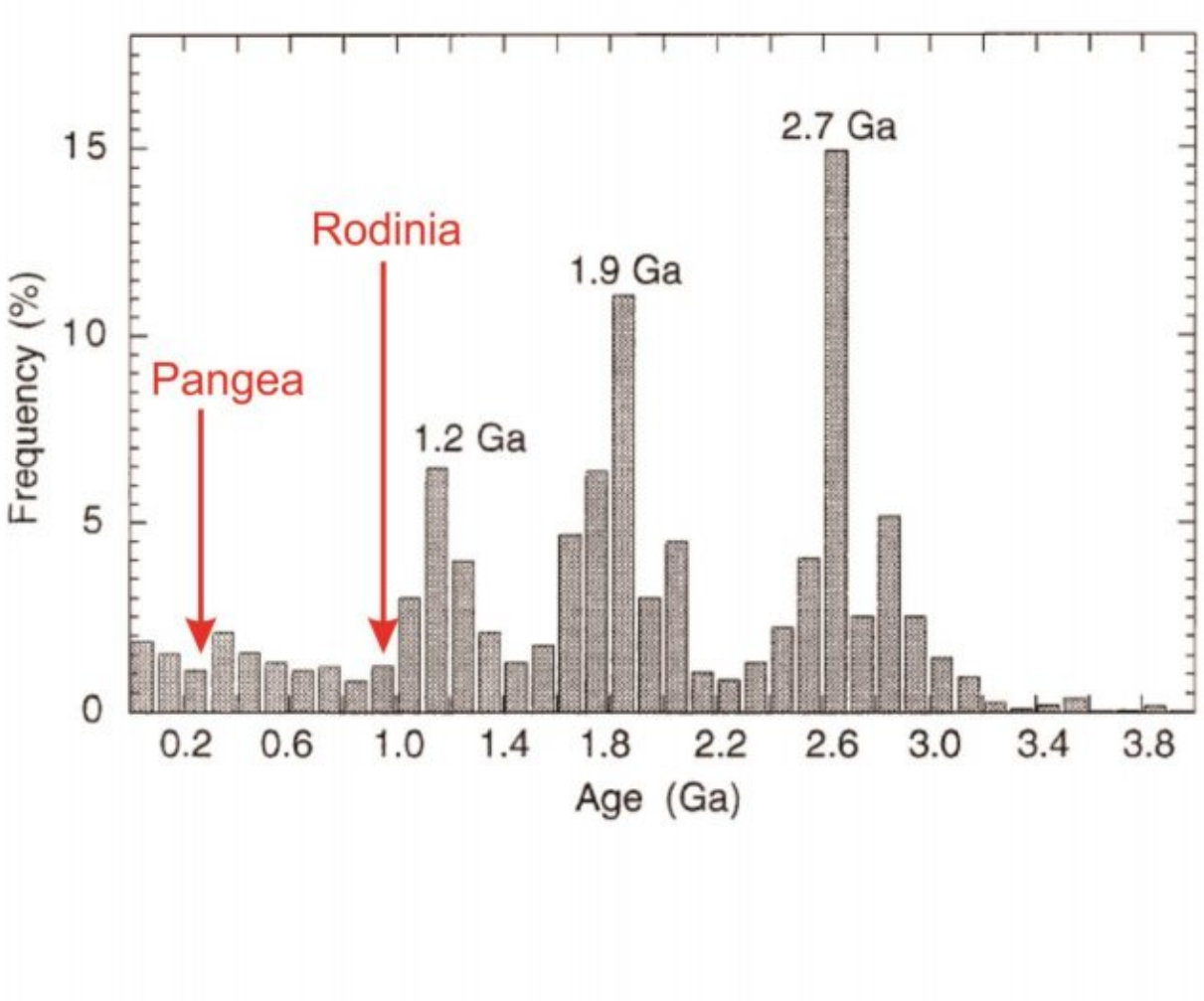


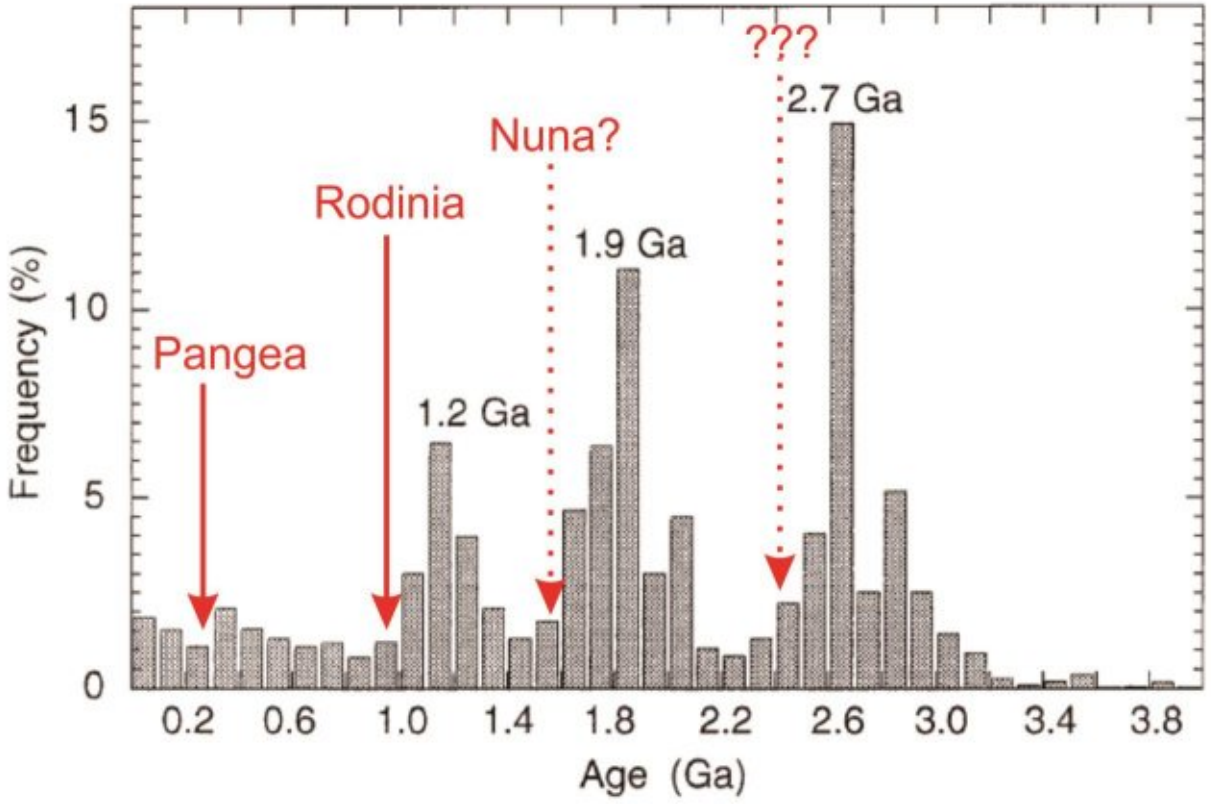
Fig. 1. Distribution of U/Pb zircon ages in juvenile continental crust. After Condie (1998a).



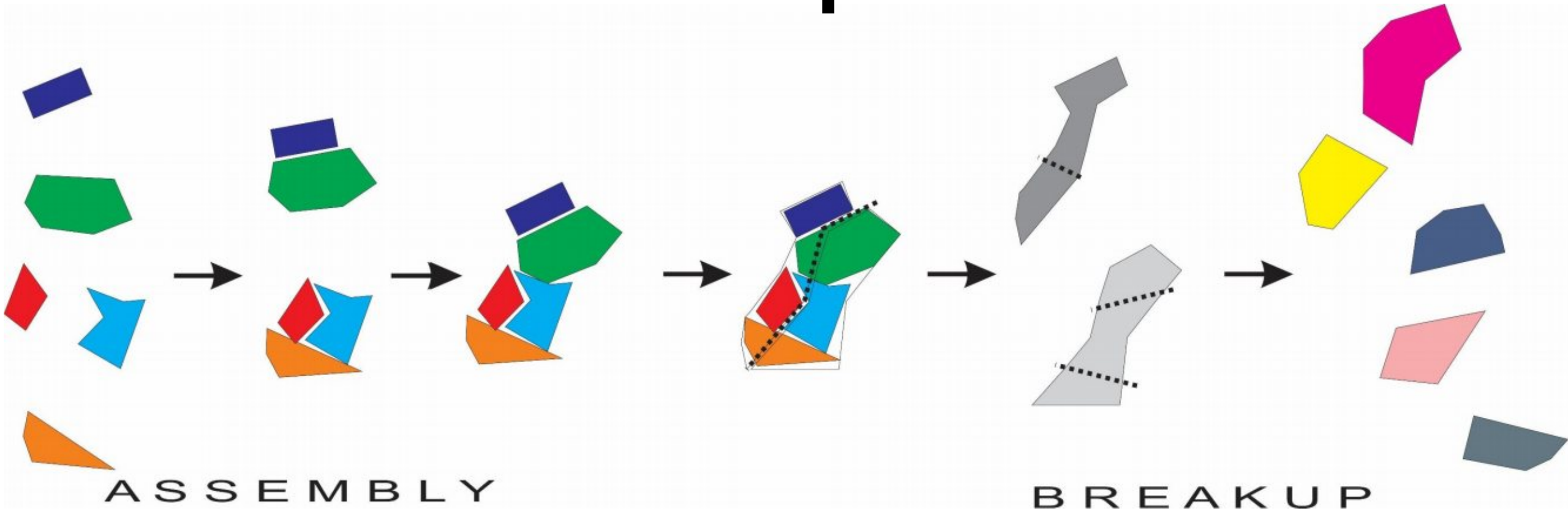
Assemblies of supercontinents?



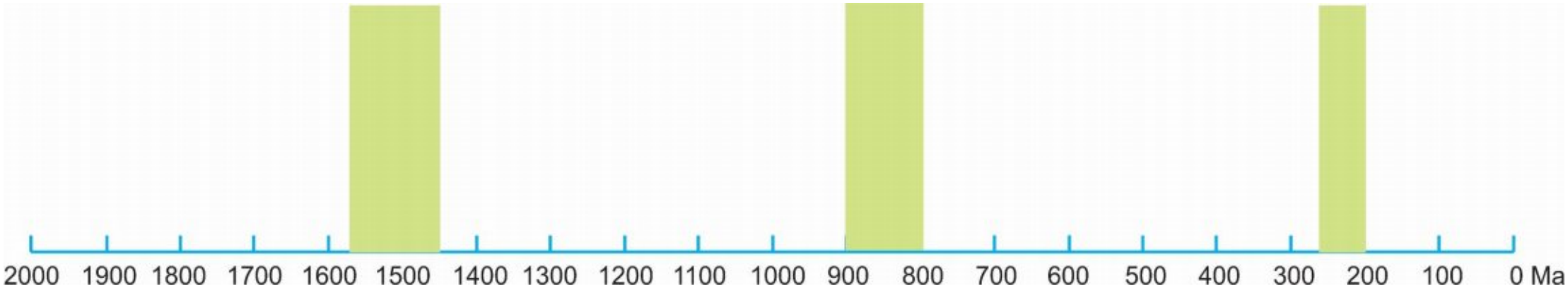
Assemblies of supercontinents?



Duration of supercontinent



Duration of supercontinent



Supercontinent:

1. Should not necessarily include all continental crust

2. Exist since the latest stage of amalgamation until the first stage of breakup

3. As the supercontinents' combine lifetime is short comparing to no-supercontinent combined time, proper supercontinent reconstruction requires a lot of pre- and post-supercontinent reconstructions

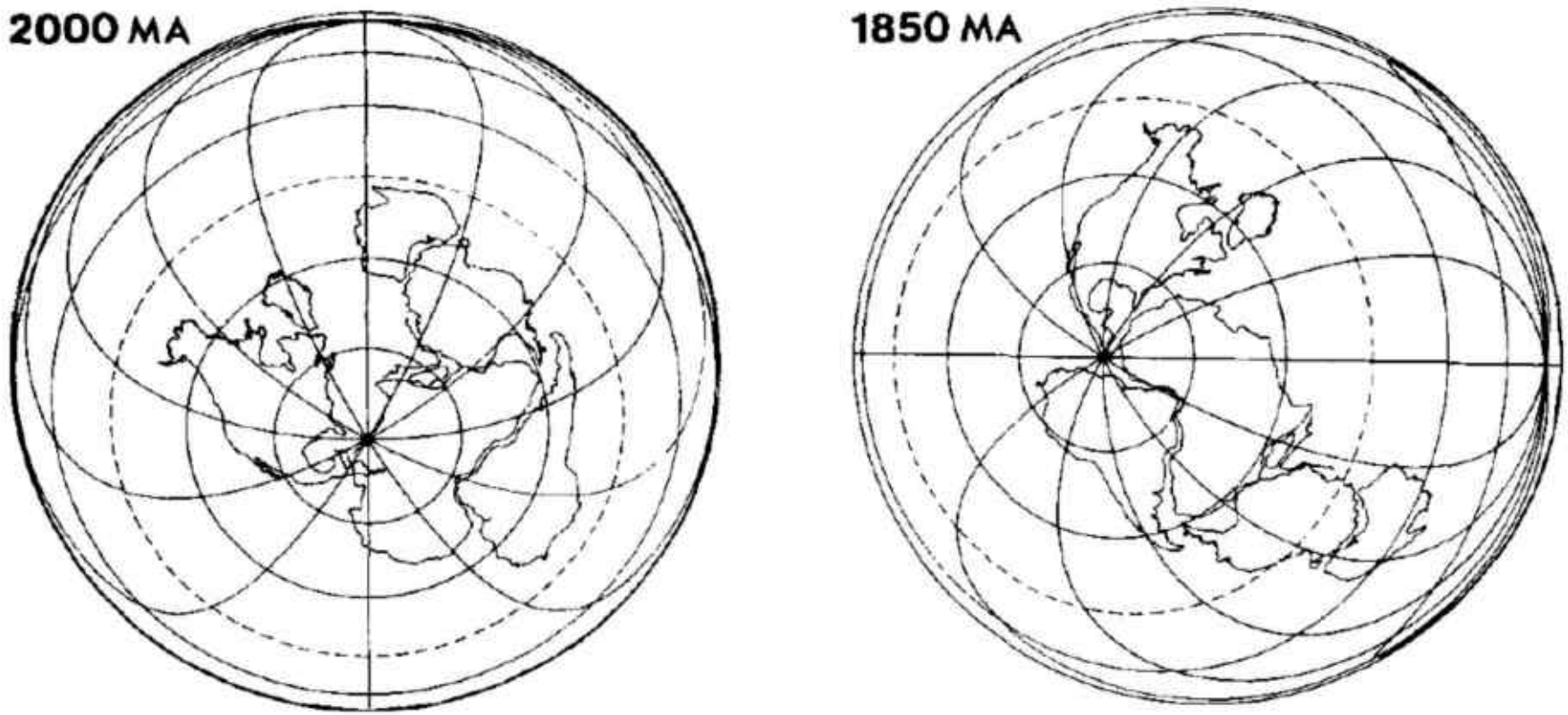
Shapes of building blocks

- Accretionary growth
- Braking away fragments
- Rifting across continents

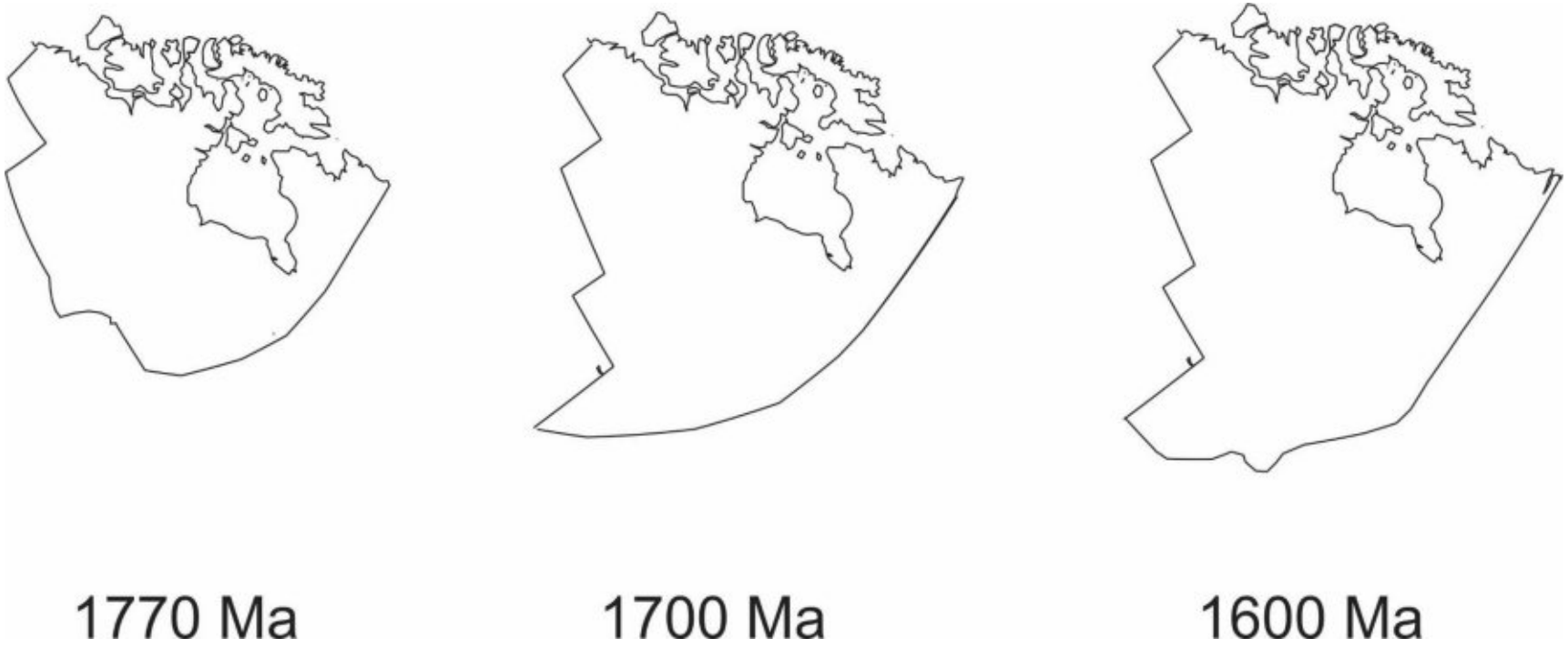
Geophys. J. R. astr. Soc. (1979) 58, 309–336

Palaeomagnetism in the Coronation Geosyncline and arrangement of continents in the middle Proterozoic

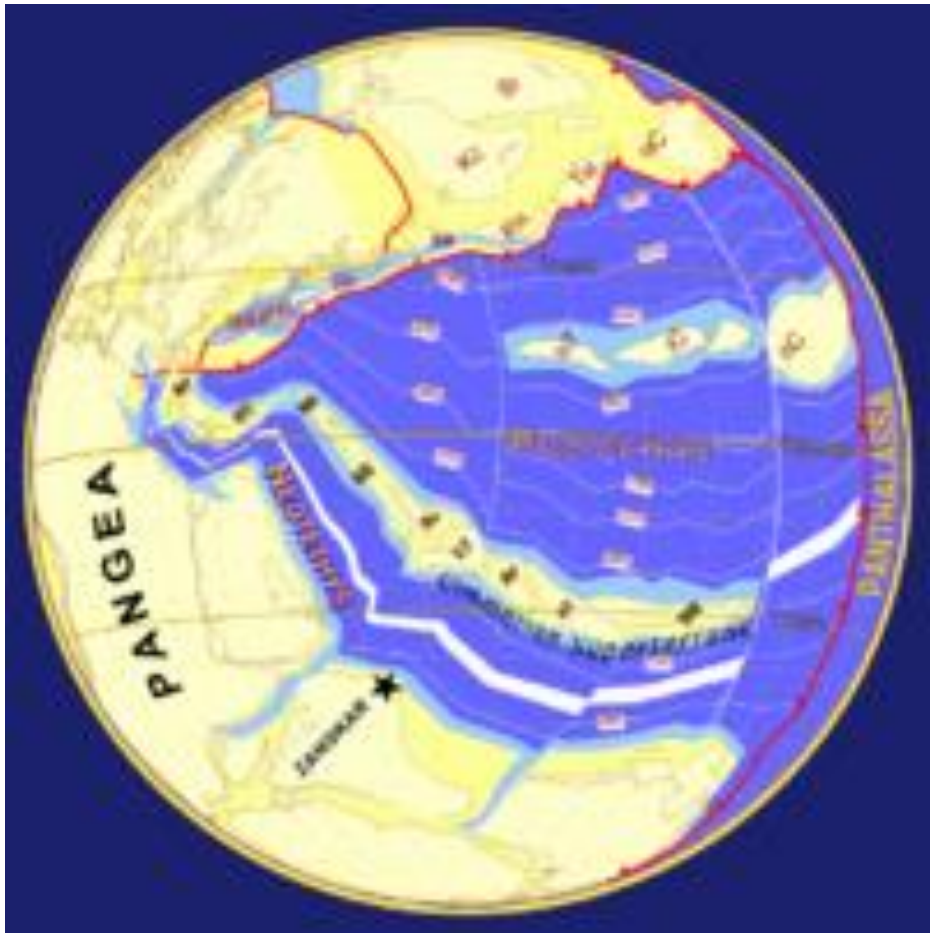
E. Irving and J. C. McGlynn *Earth Physics Branch and the Geological Survey of Canada, Department of Energy, Mines and Resources, Ottawa, Canada*

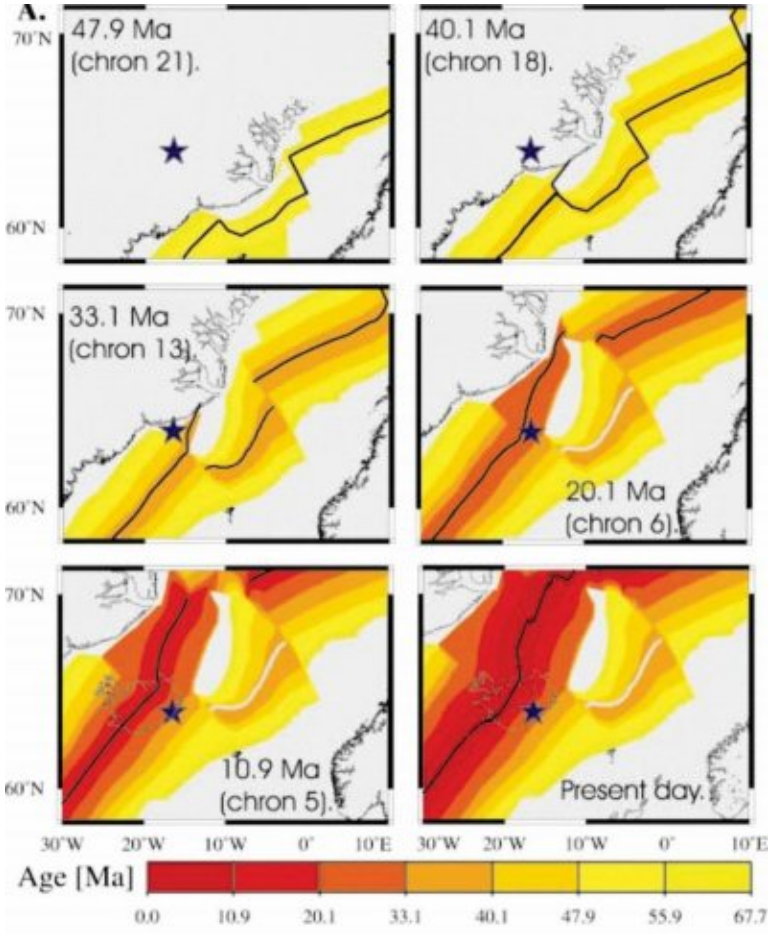


Accretionary growth



Braking away fragments

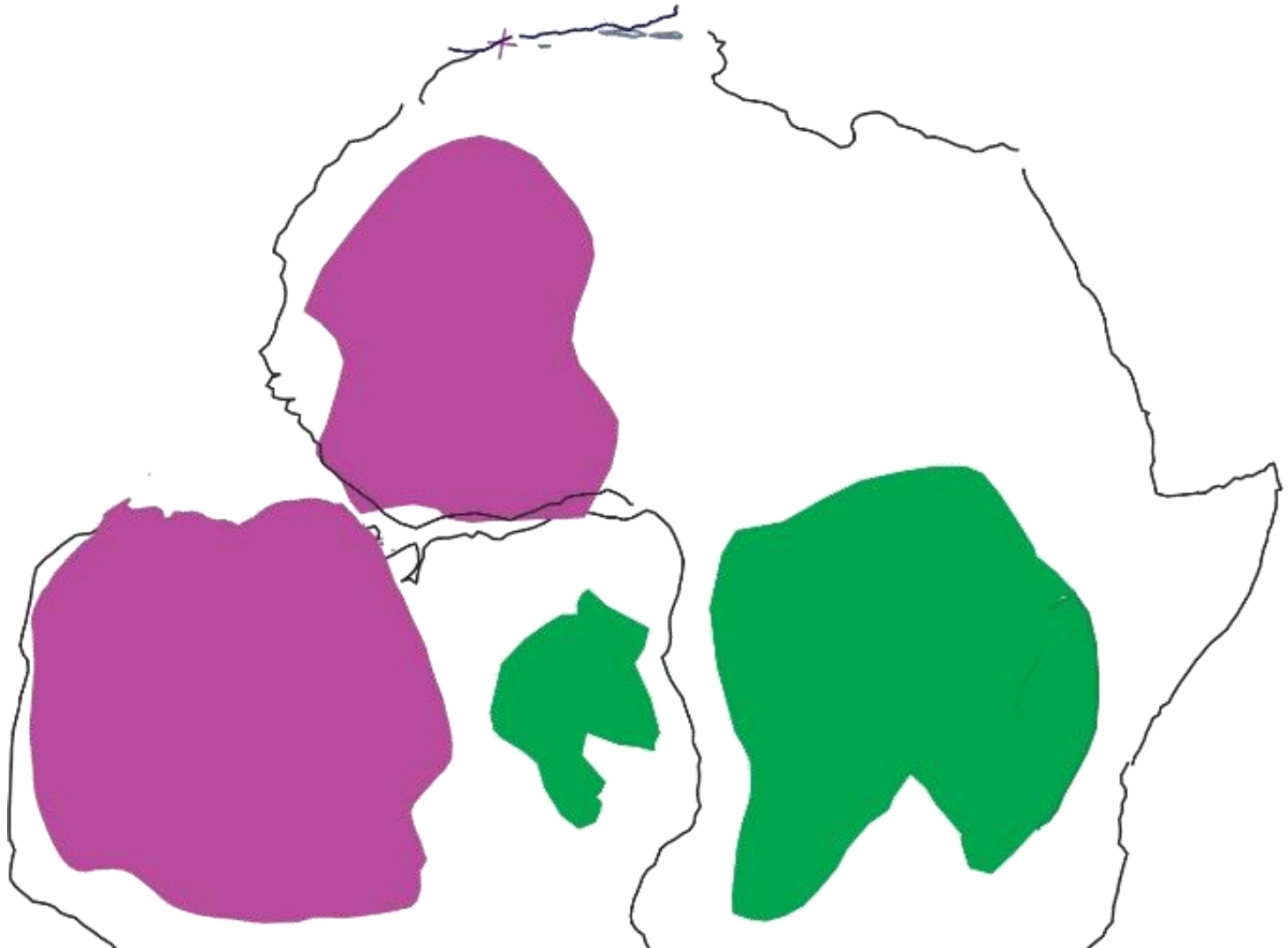


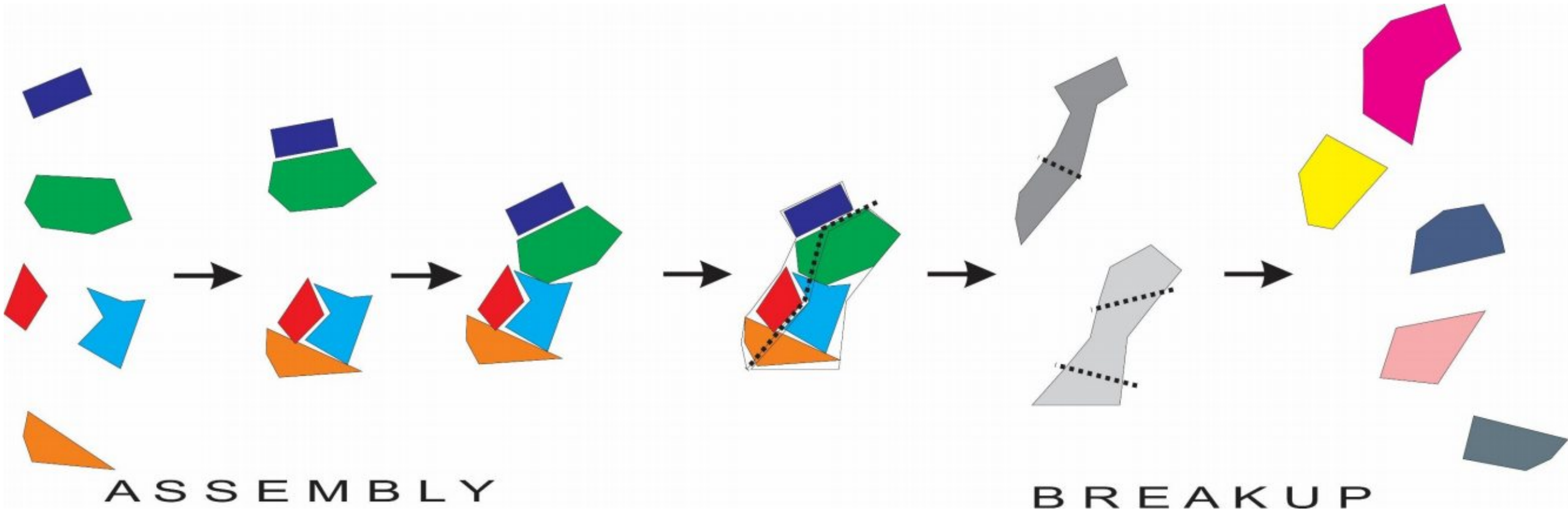


Stampli et al., 2002

Muller et al., 2001

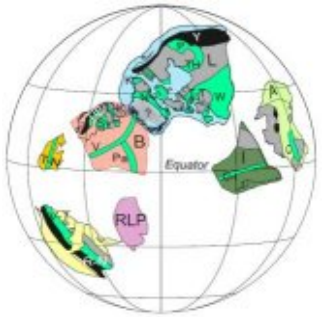
Rifting across continents



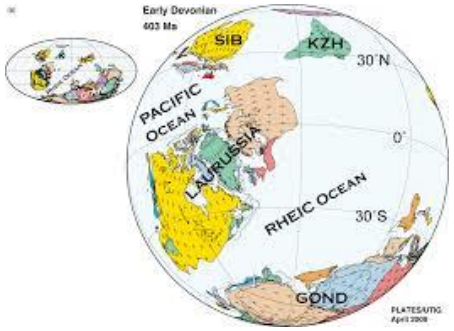

ASSEMBLY
BREAKUP

Paleogeographic reconstructions - tools

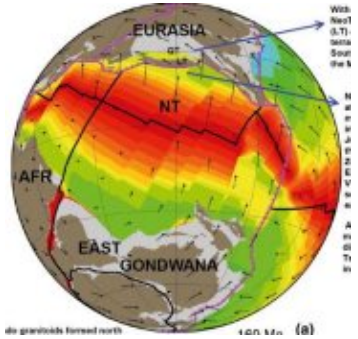
TRIASSIC
200 million years ago



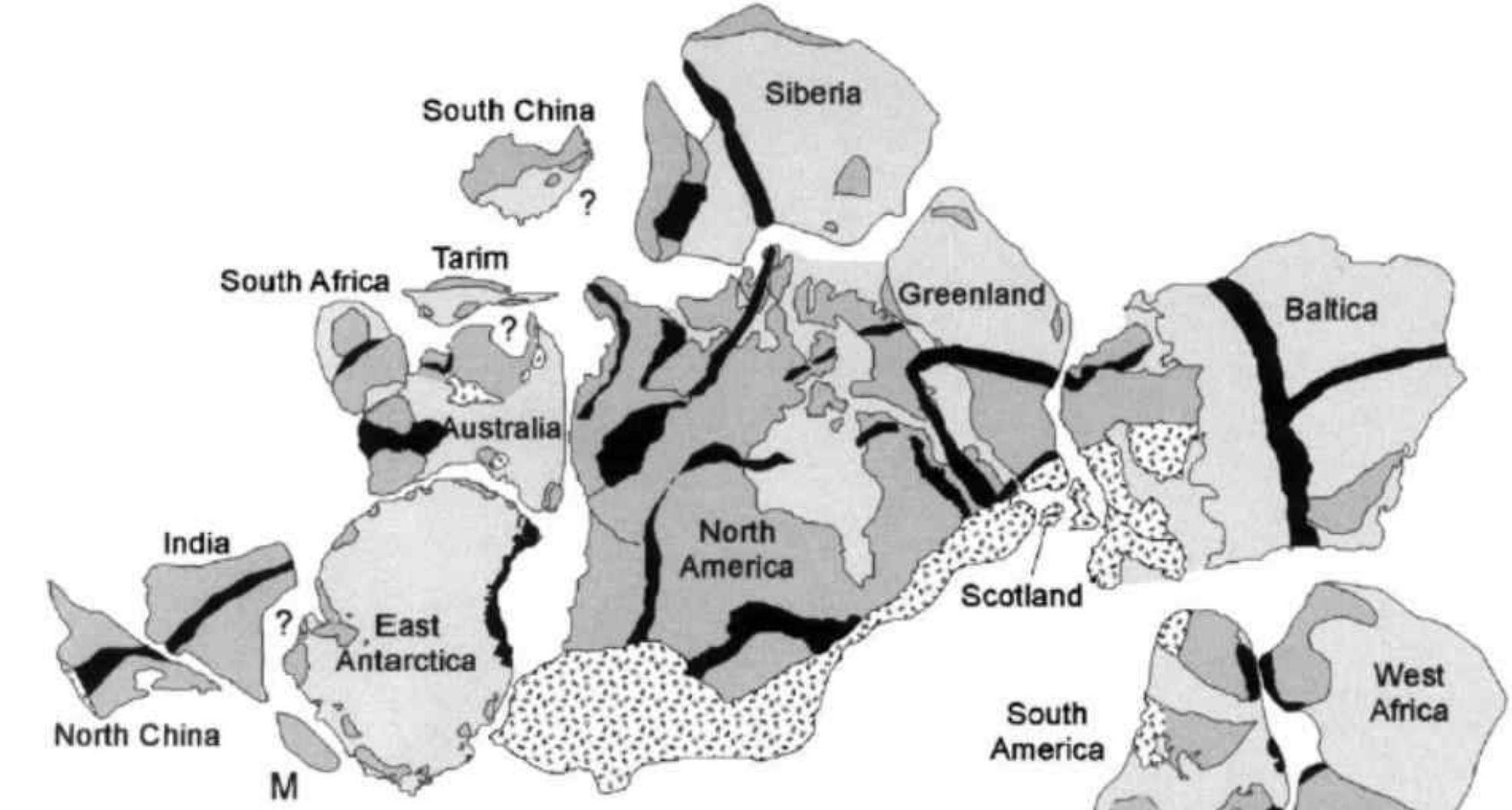
GMAP-like software

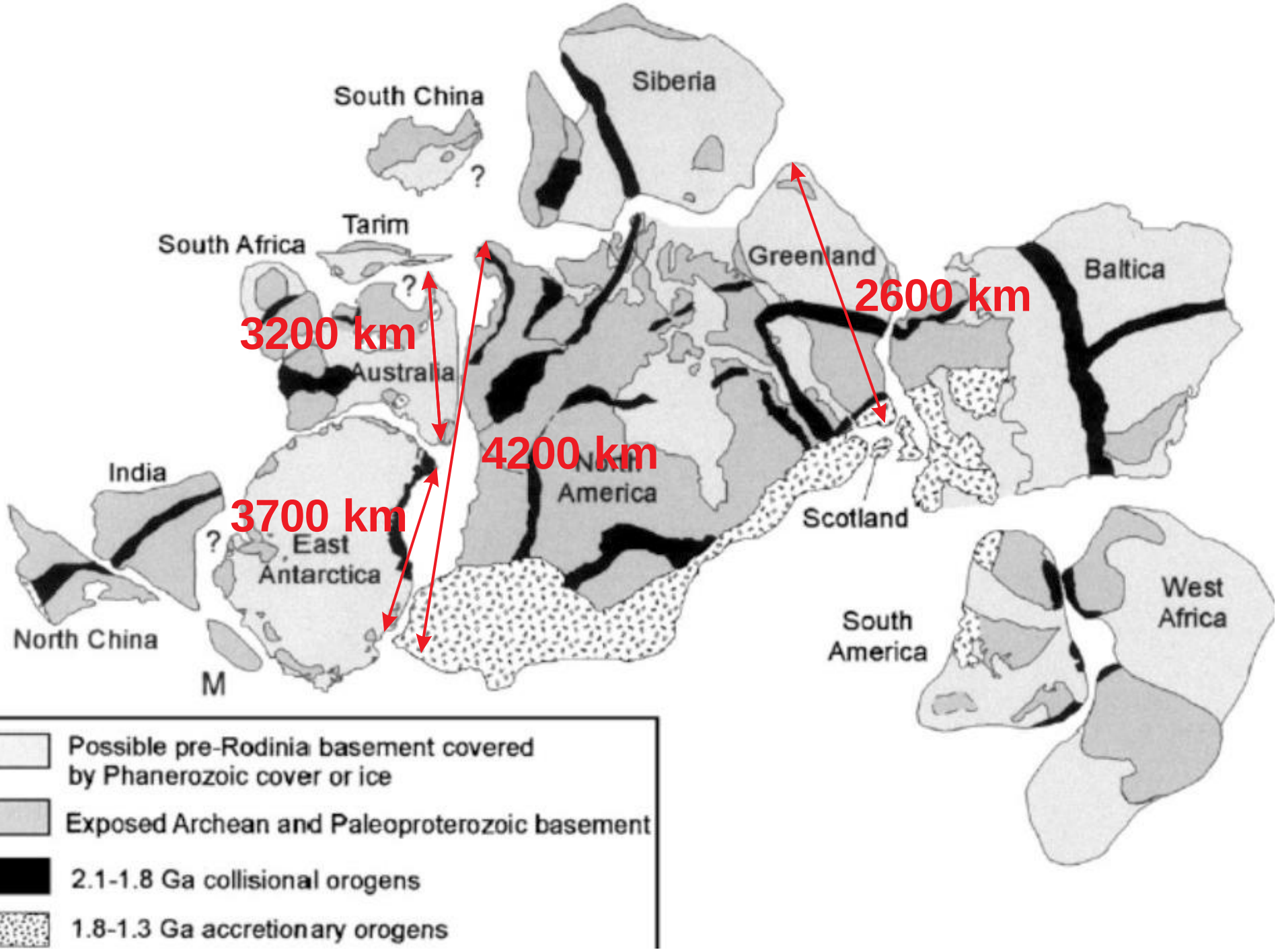


PLATES-like software



GPLATES


South China
Siberia
?
Tarim
South Africa
?
Greenland
Baltica
Australia
India
North America
Scotland
?
East Antarctica
West Africa
South America
North China
M
Possible pre-Rodinia basement covered by Phanerozoic cover or ice
Exposed Archean and Paleoproterozoic basement
2.1-1.8 Ga collisional orogens
1.8-1.3 Ga accretionary orogens


South China
Siberia
Tarim
South Africa
Greenland
Baltica
2600 km
3200 km
Australia
4200 km
India
North America
3700 km
East Antarctica
Scotland
West Africa
South America
North China
M
Possible pre-Rodinia basement covered by Phanerozoic cover or ice
Exposed Archean and Paleoproterozoic basement
2.1-1.8 Ga collisional orogens
1.8-1.3 Ga accretionary orogens

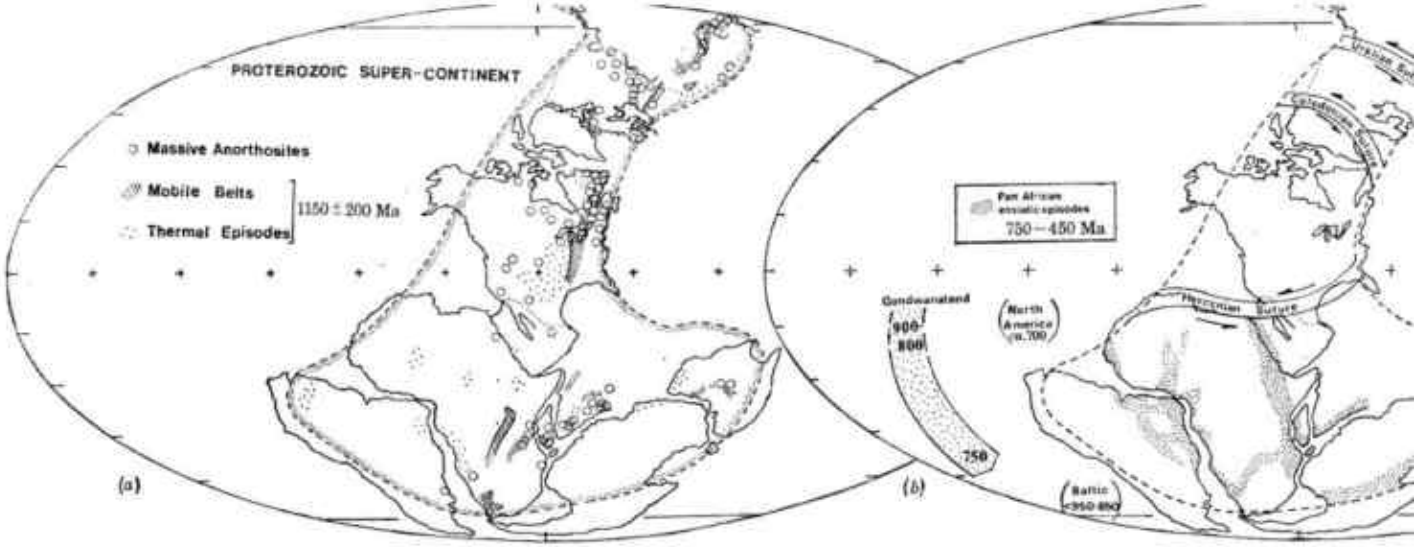
GPLATES: www.gplates.org

Precambrian supercontinent?

Phil. Trans. R. Soc. Lond. A. **280**, 469–490 (1976) [469]
Printed in Great Britain

Palaeomagnetic evidence for a Proterozoic super-continent

By J. D. A. Piper
Sub-department of Geophysics, Oliver Lodge Laboratory, Oxford Street, Liverpool L69 3BX




1250
2700
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1900
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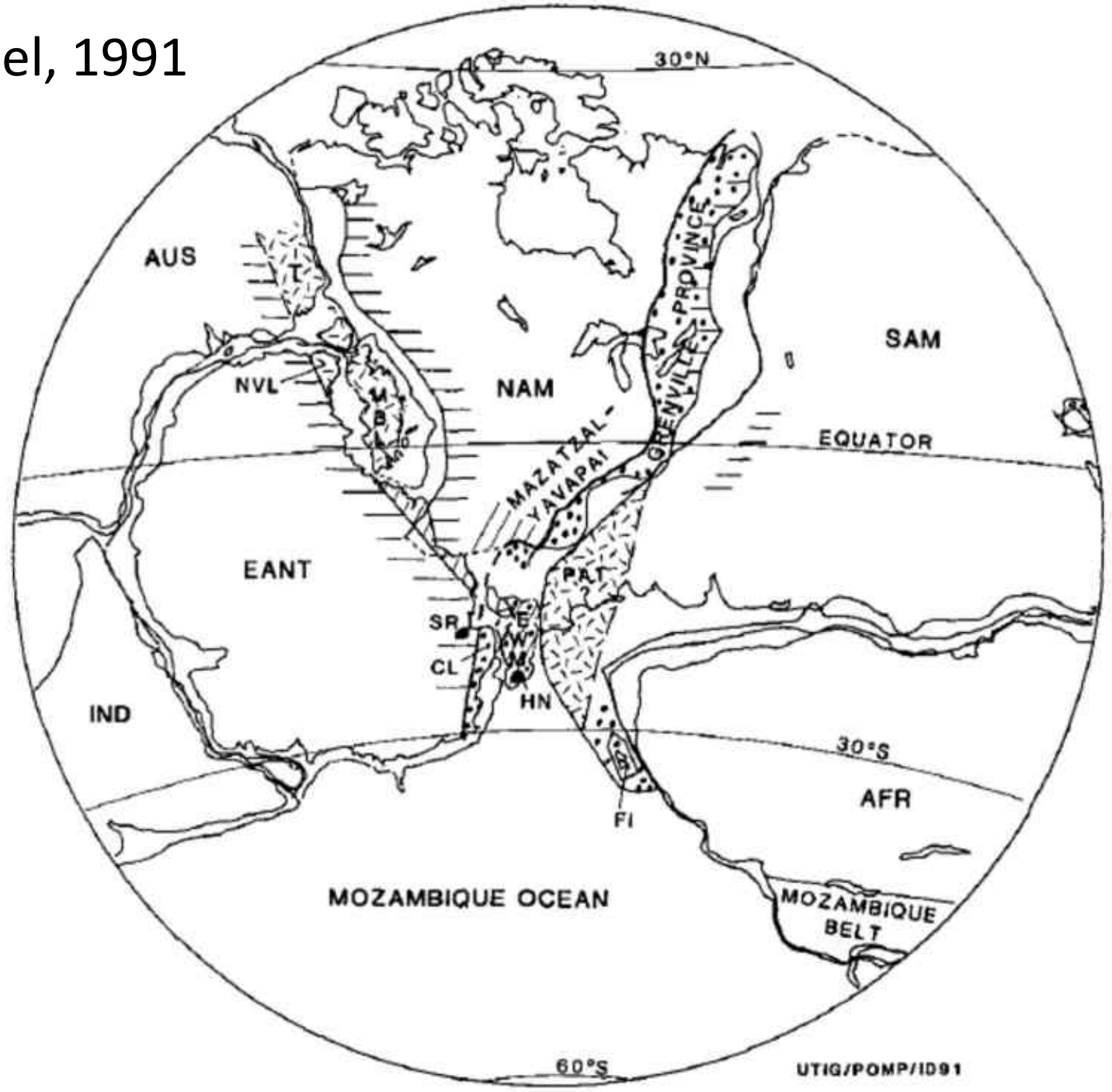
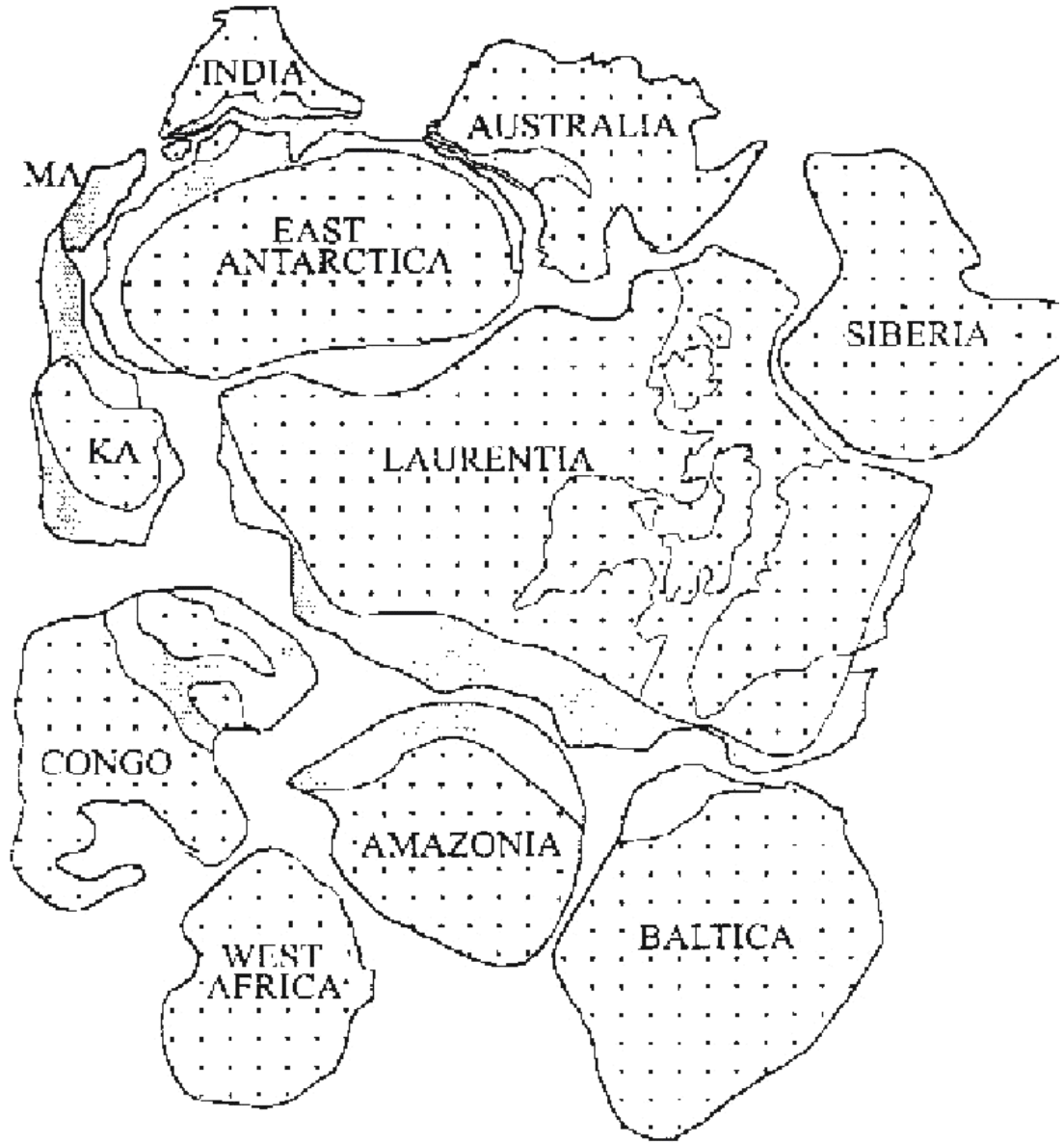
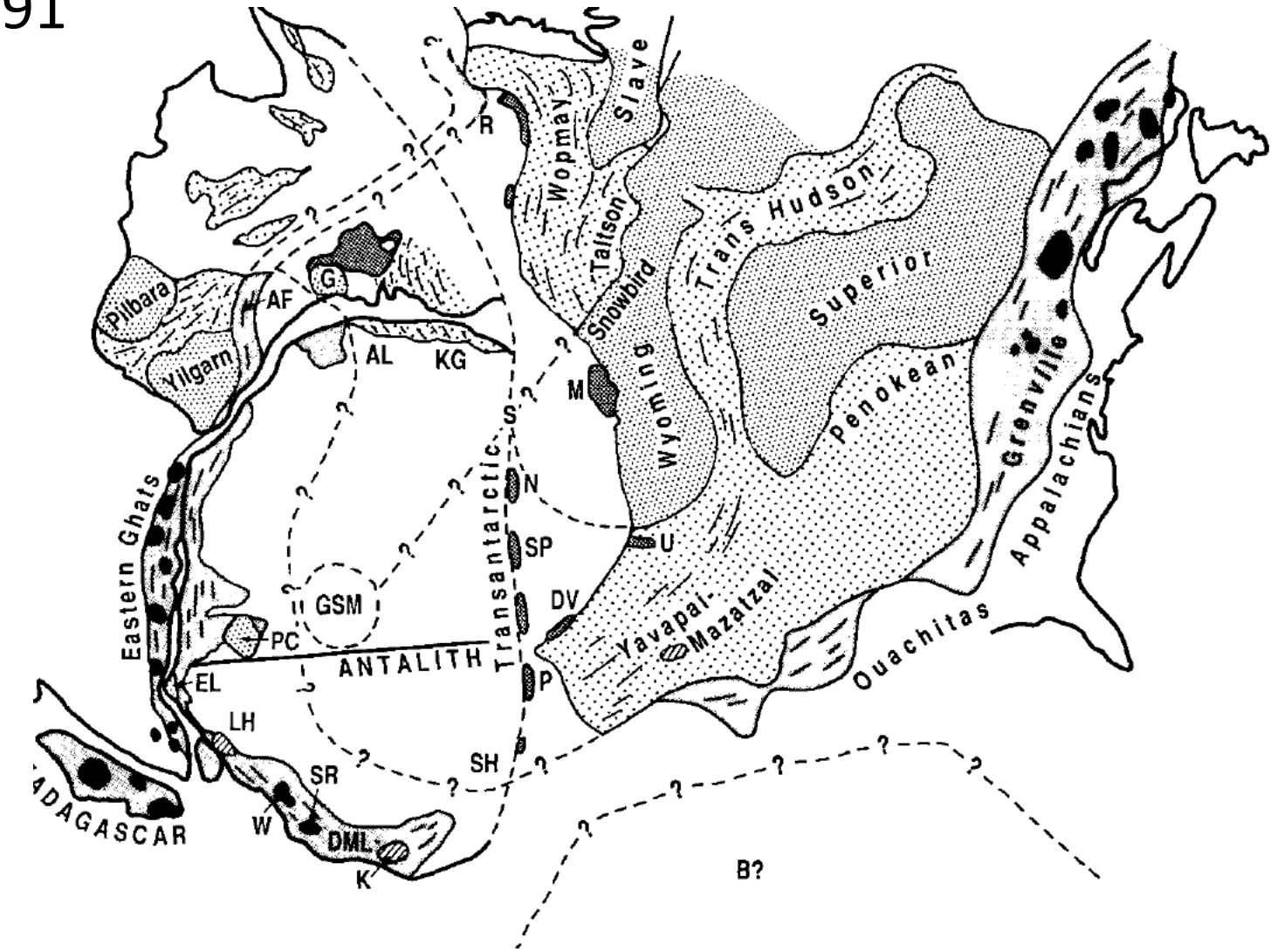
Dalziel, 1991



Hoffman, 1991



Moores, 1991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Snowbird
Trans Hudson
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Grenville
Appalachians
Pilbara
Yilgarn
AF
G
AL
KG
M
R
S
N
SP
U
DV
P
Transantarctic
Eastern Ghats
GSM
PC
ANTALITH
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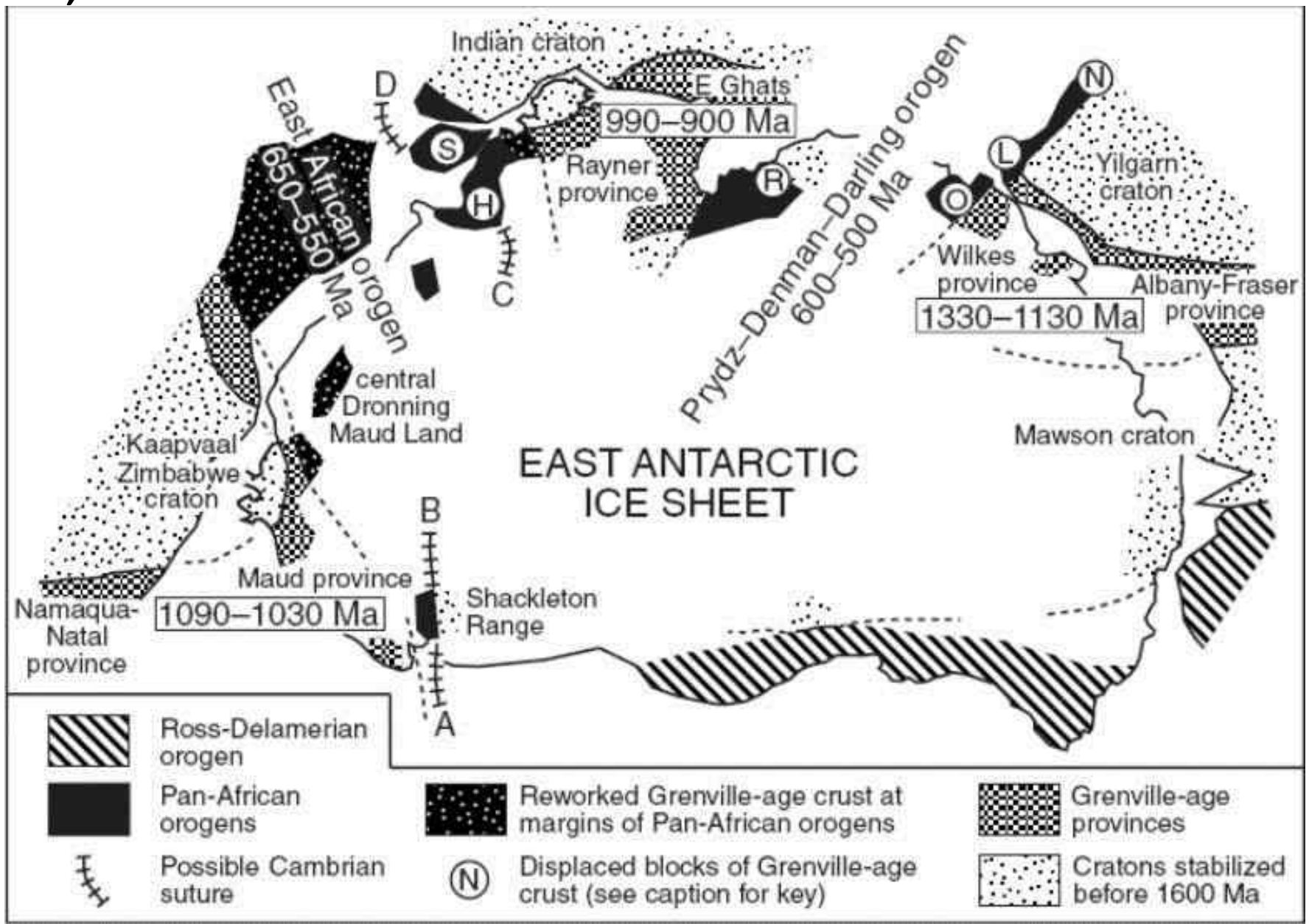
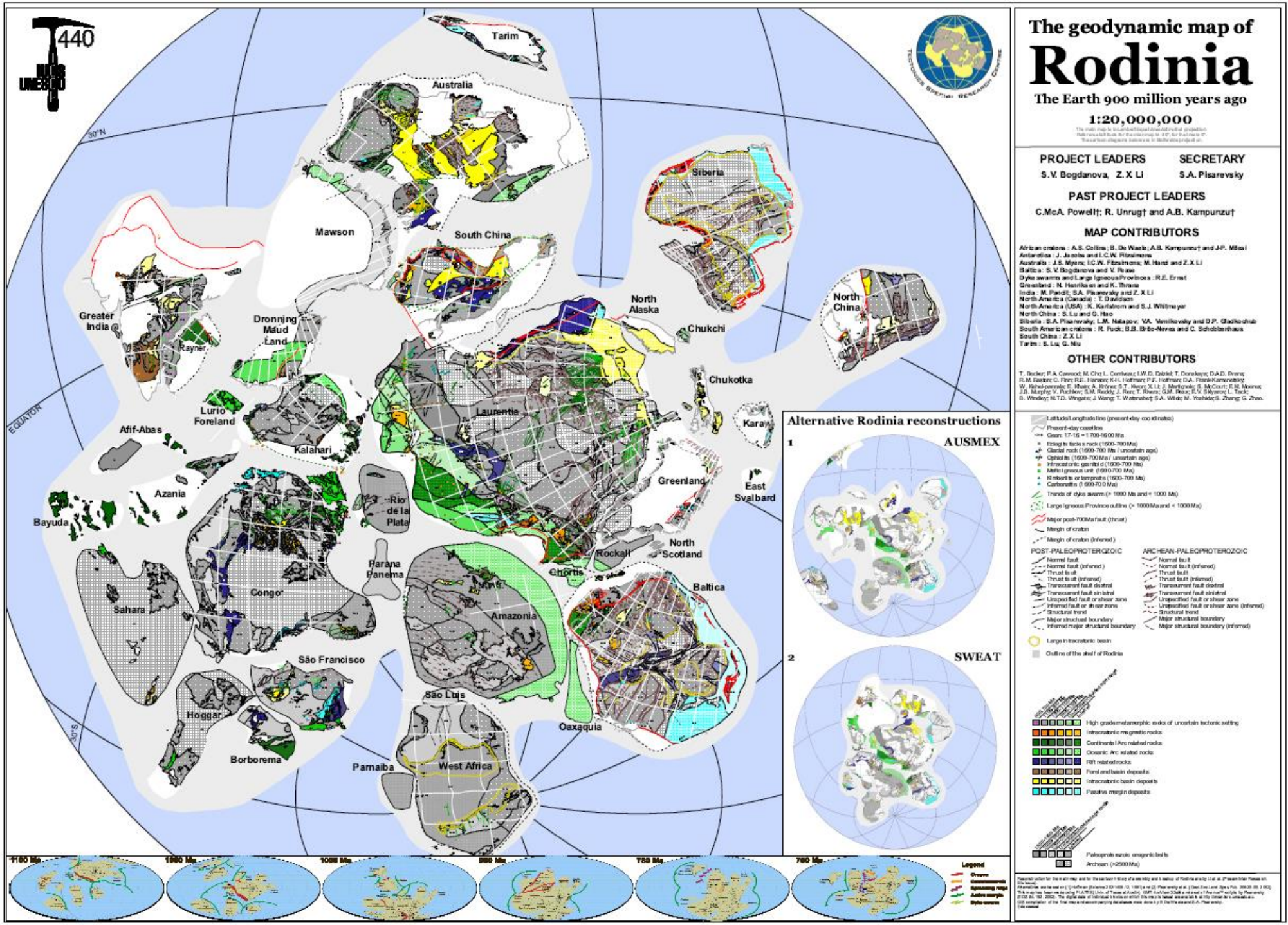
DML
K
SH
Yavapai-Mazatzal
Ouachitas
ADAGASCAR
B?

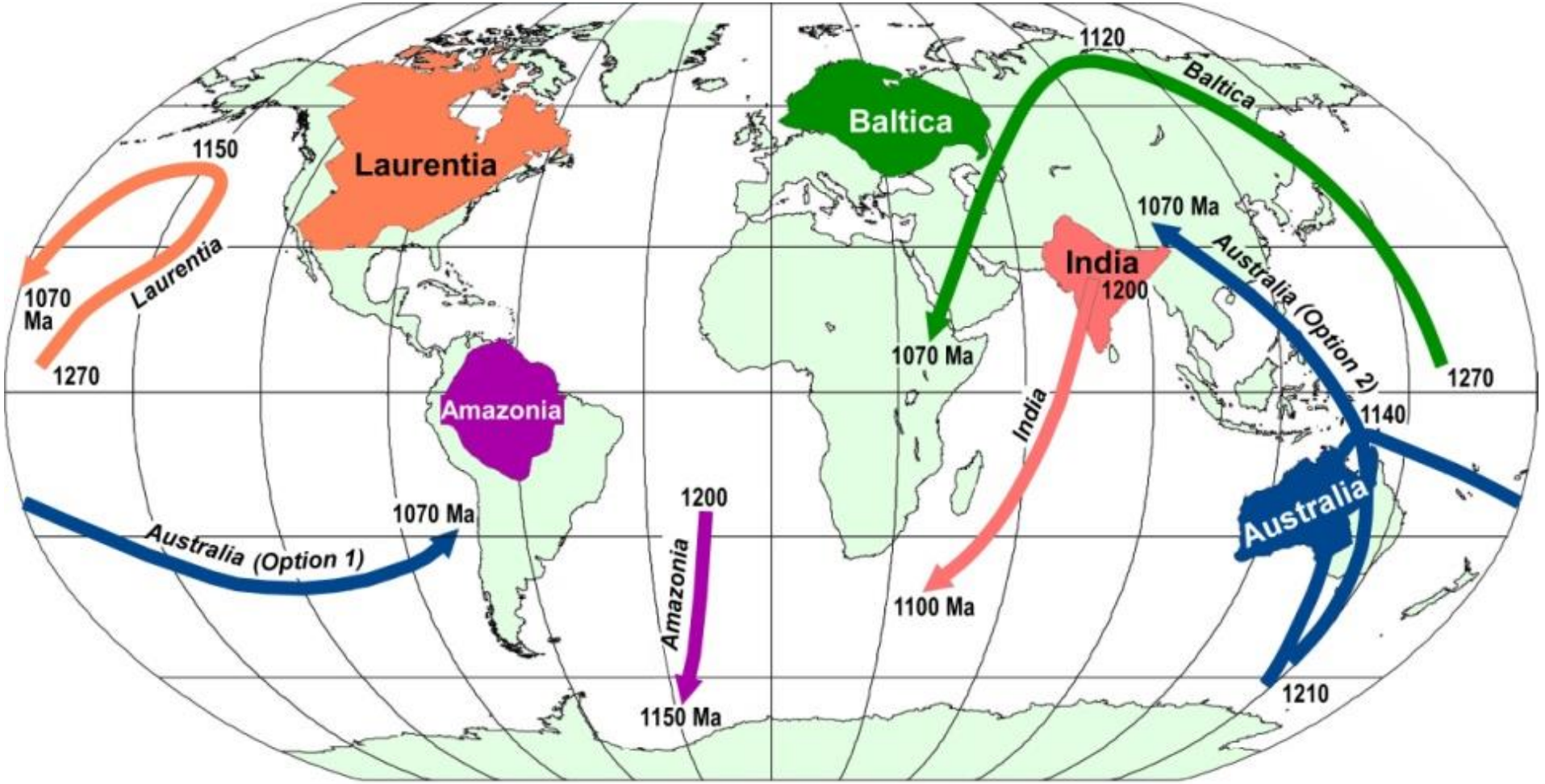
Fitzsimons, 2000



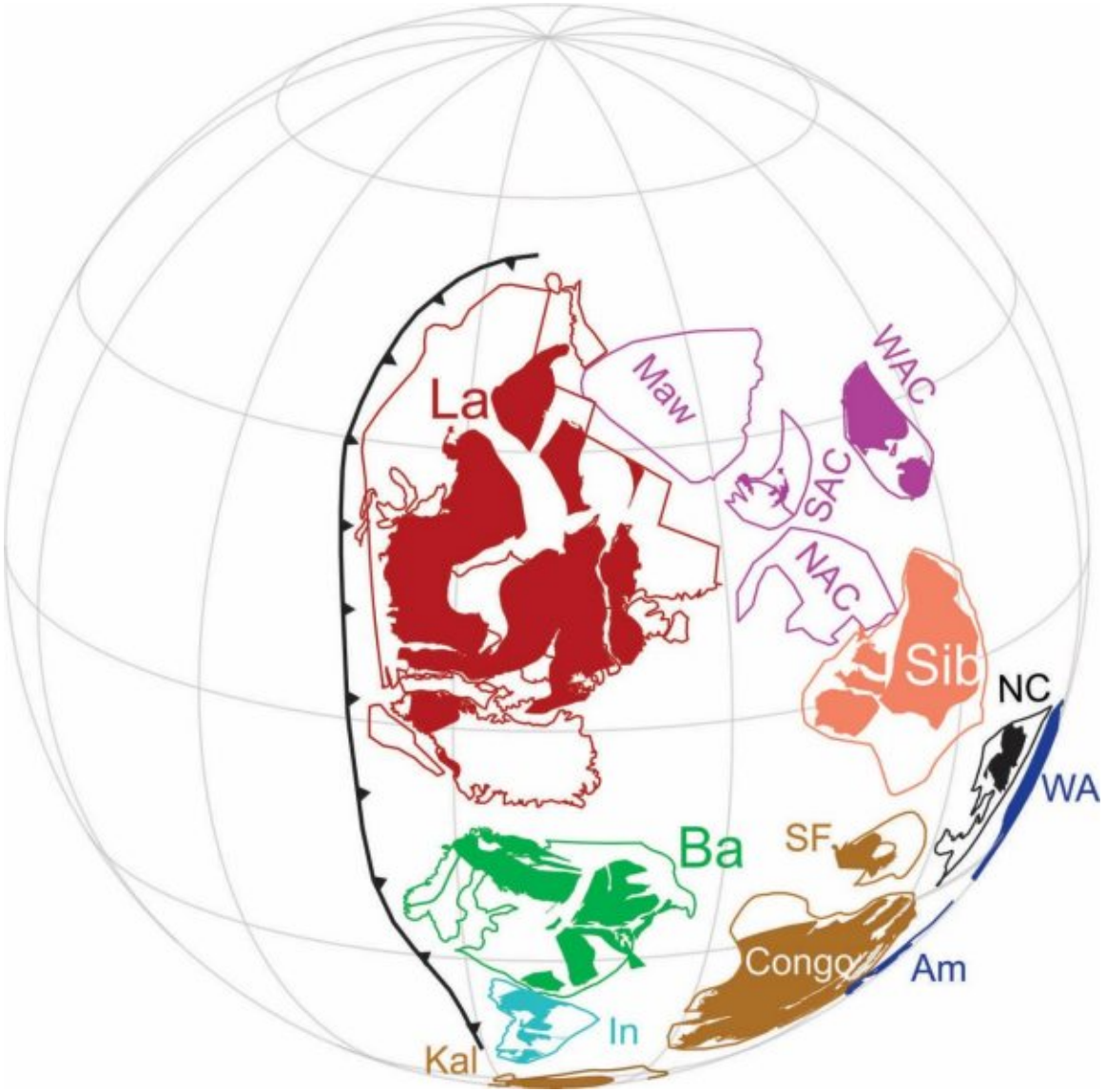
Li et al., 2008


The geodynamic map of
Rodinia
The Earth 900 million years ago
1:20,000,000
PROJECT LEADERS
S.V. Bogdanova, Z.X. Li
SECRETARY
S.A. Pisarevsky
PAST PROJECT LEADERS
C.McA. Powell†; R. Unrug† and A.B. Kampunzu†
MAP CONTRIBUTORS
OTHER CONTRIBUTORS
Alternative Rodinia reconstructions
1 AUSMEX
2 SWEAT
Tarim
Australia
Siberia
Mawson
South China
North Alaska
Chukchi
North China
Greater India
Rayner
Dronning Maud Land
Chukotka
Laurentia
Karay
Lurio Foreland
Kalahari
Afif-Abas
Azania
Bayuda
Rio de la Plata
Greenland
East Svalbard
North Scotland
Rockall
Parana Panema
Chortis
Baltica
Congo
Sahara
Amazonia
São Francisco
São Luis
Hoggar
Oaxaquia
Borborema
Parnaiba
West Africa
EQUATOR
30°N
30°S
1150 Ma
1000 Ma
900 Ma
750 Ma
Legend

No supercontinent between 1300 and 1000 Ma



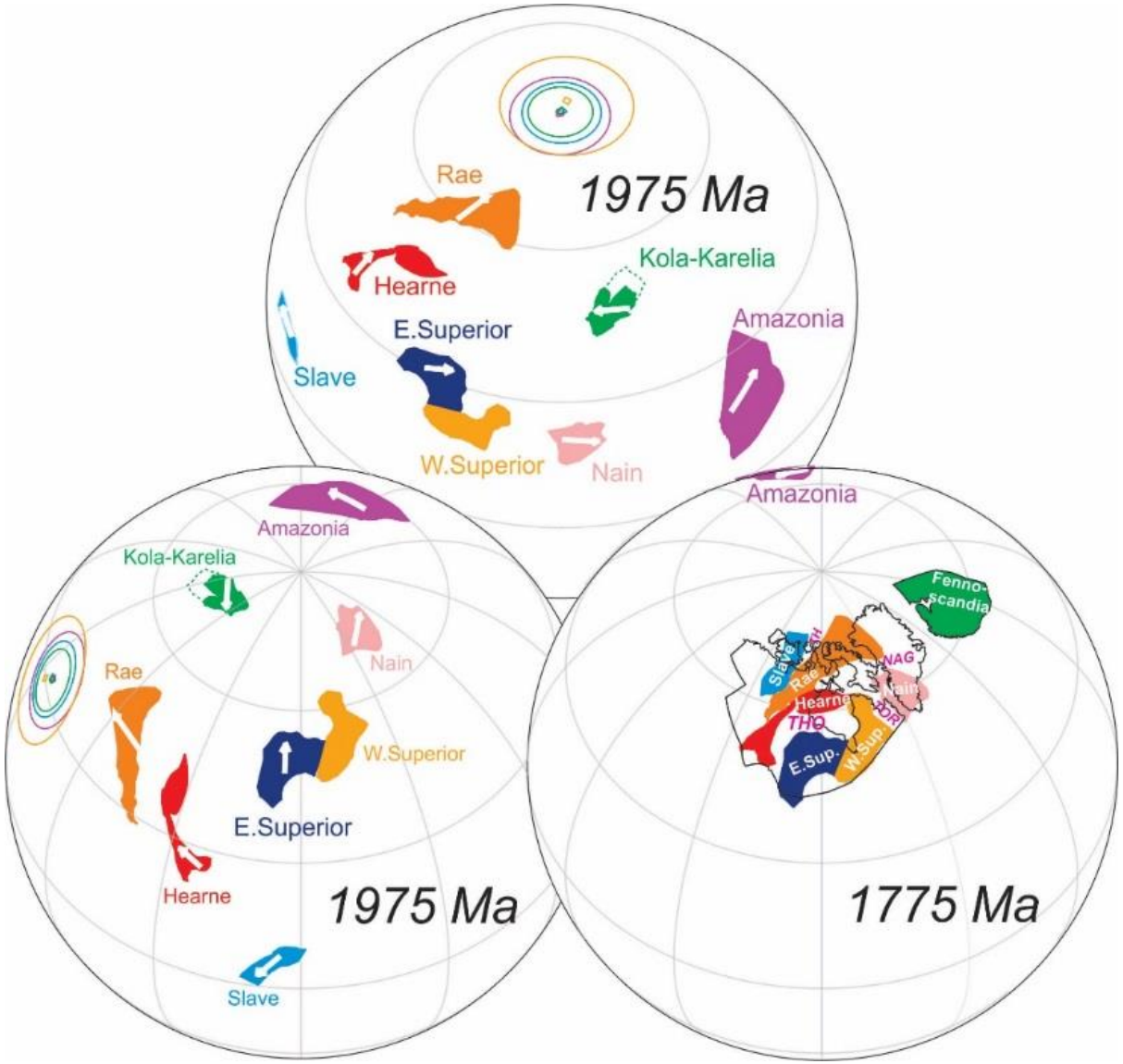
Nuna/Columbia 1600-1400 Ma



Progress in supercontinent reconstructions

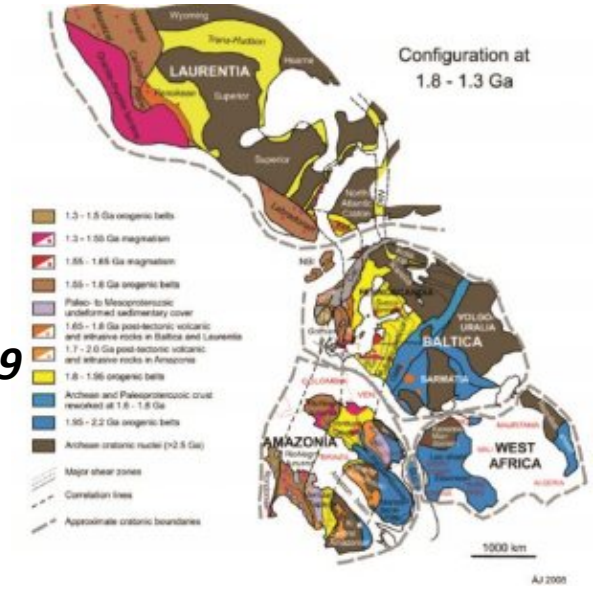
- GPLATES
- Full-plate Phanerozoic continuous paleogeographic animations
- First full-plate Neoproterozoic continuous paleogeographic animation
- New animated model of Nuna
- New Paleo-, Mezo- and Neoproterozoic paleomagnetic data
- New Proterozoic LIPs
- New detrital zircons studies
- New multidisciplinary studies of key areas

2000-1800 Ma

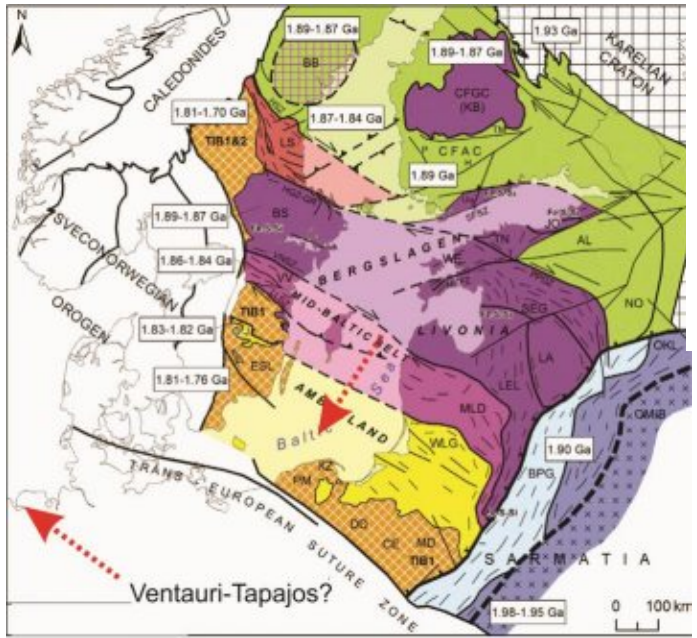


- New ~1975 Ma key pole from Kola-Karelia and Amazonia cratons (Lubnina and Pisarevsky, 2017; Bispo-Santos et al., 2014)
- New ~1880 Ma key poles from Kola-Karelia and Slave cratons (Klein et al., 2016; Buchan et al., 2015)
- Previously published coeval poles from Superior Craton
- CONCLUSION: no supercontinent between ~1975 Ma and ~1800 Ma

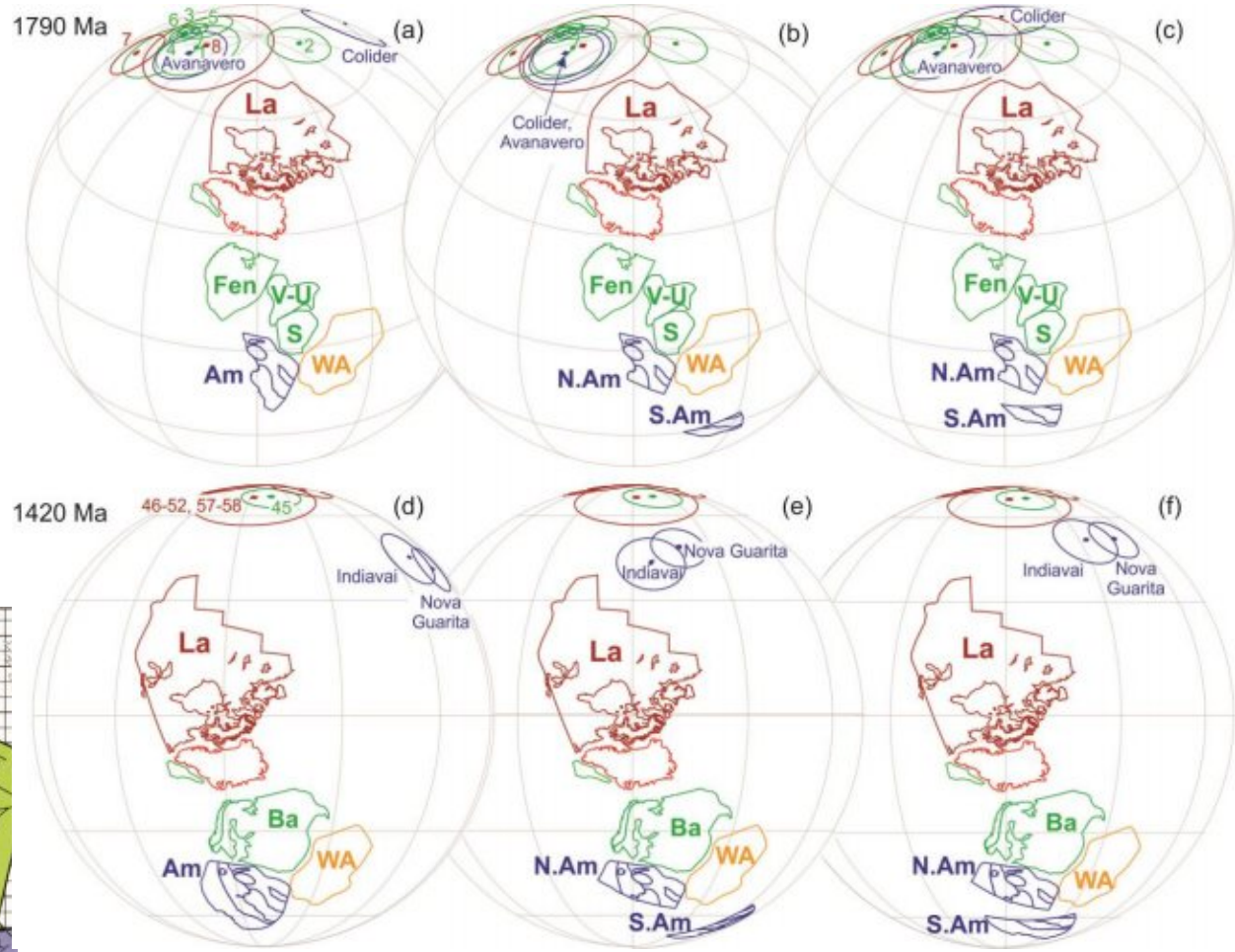
Amazonia- Baltica -SAMBA



Johansson, 2009



Bogdanova et al., 2015



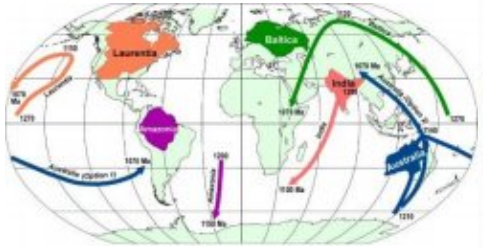
Pisarevsky et al., 2014

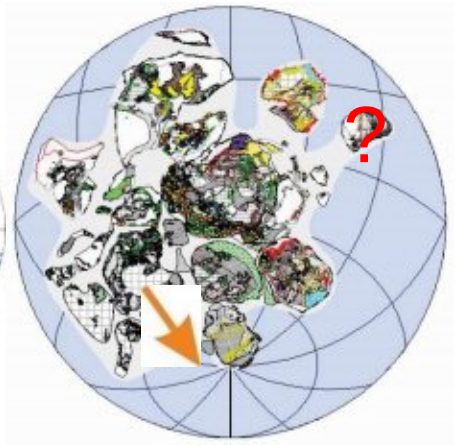
And there are no barcode matches in LIPs and in dyke swarms

2000-900 Ma

Nuna

Rodinia





No supercontinent

2000 – 1650 Ma

Supercontinent

1600 – 1400 Ma

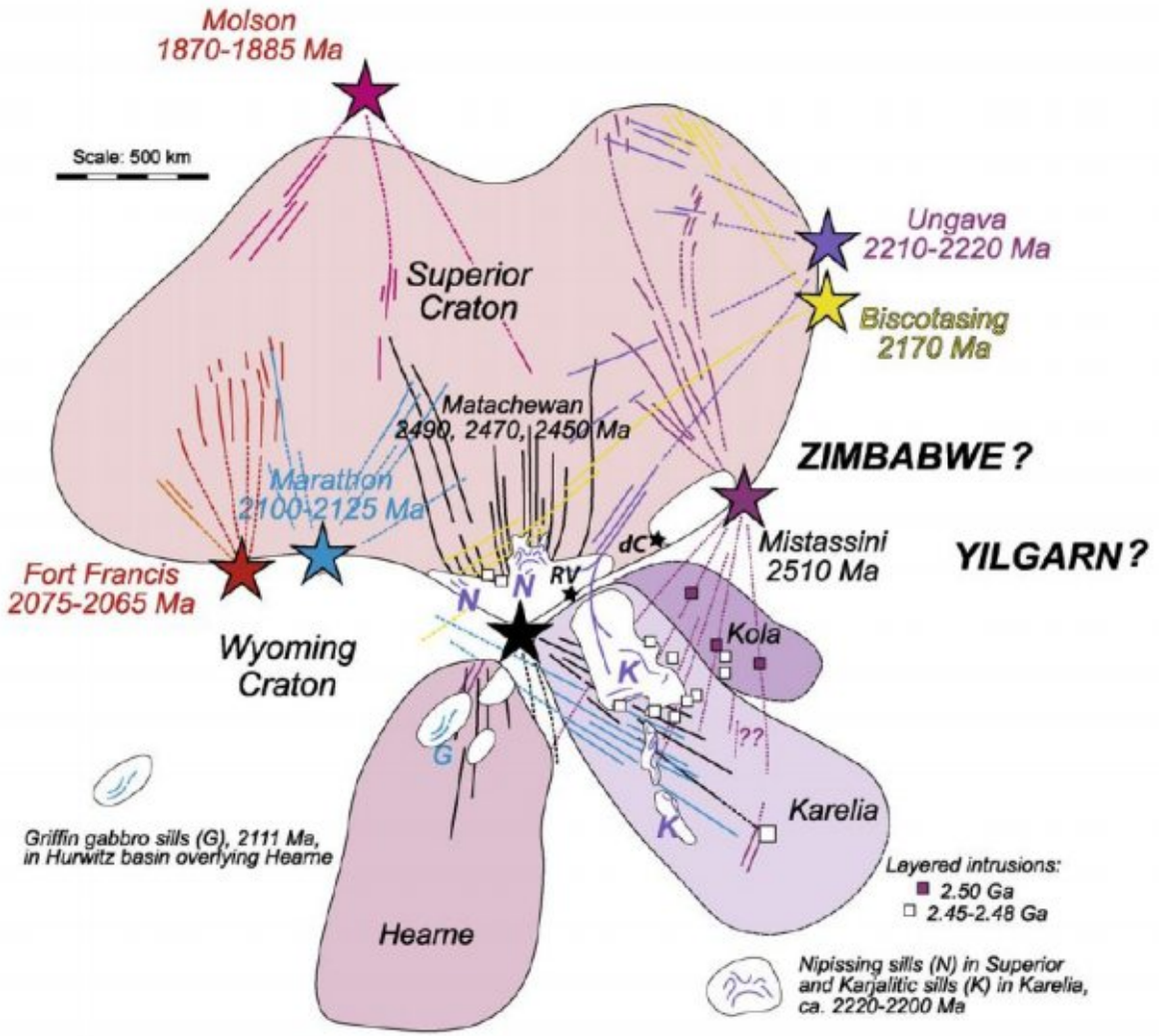
No supercontinent

1350 – 1000 Ma

Supercontinent

After 900 Ma

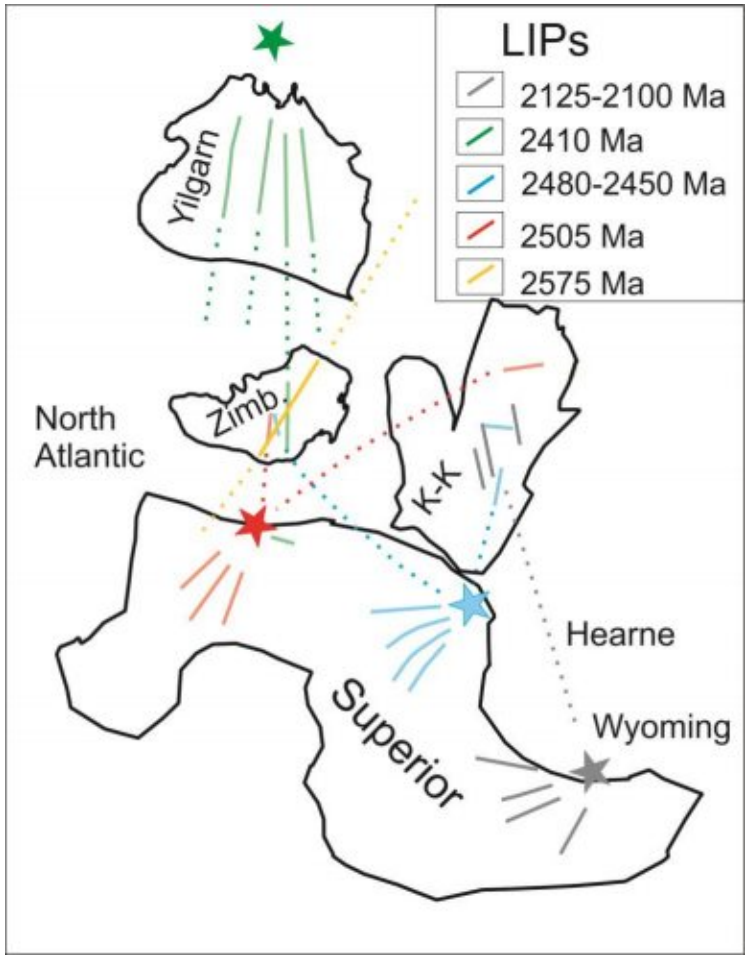
Superia: dykes geometry matching (~2400 Ma)



Söderlund et al., 2010

Superia: dykes geometry + paleomagnetism

- Introduced by Bleeker (2003)
- Reconstructions published by Söderlund et al., 2010
- More recently with new paleomagnetic data – by Pisarevsky et al., 2014



Выводы

- Все опубликованные докембрийские палеогеографические реконструкции пока еще спорны и будут претерпевать изменения по мере поступления новых данных и новых идей
- Конфигурация, время образования и распада докембрийских суперконтинентов – пока еще предмет дискуссий
- Любые палеогеографические реконструкции должны быть тестируемы - т.е. построены с использованием сферических вращений. Параметры этих вращений должны быть приведены в публикации
- Суперконтиненты не включали в себя всю континентальную кору
- Суммарное время существования суперконтинентов было относительно мало

Новое поколение палеогеографических реконструкций

https://www.earthbyte.org/

http://www.mn.uio.no/ceed/english/

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Global plate boundary evolution and kinematics since the late Paleozoic

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ABSTRACT

Many aspects of deep-time Earth System models, including mantle convection, paleoclimatology, paleobiogeography and the deep Earth carbon cycle, require high-resolution plate motion models that include the evolution of the mosaic of plate boundaries through time. We present the first continuous late Paleozoic to

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GR focus review

A full-plate global reconstruction of the Neoproterozoic

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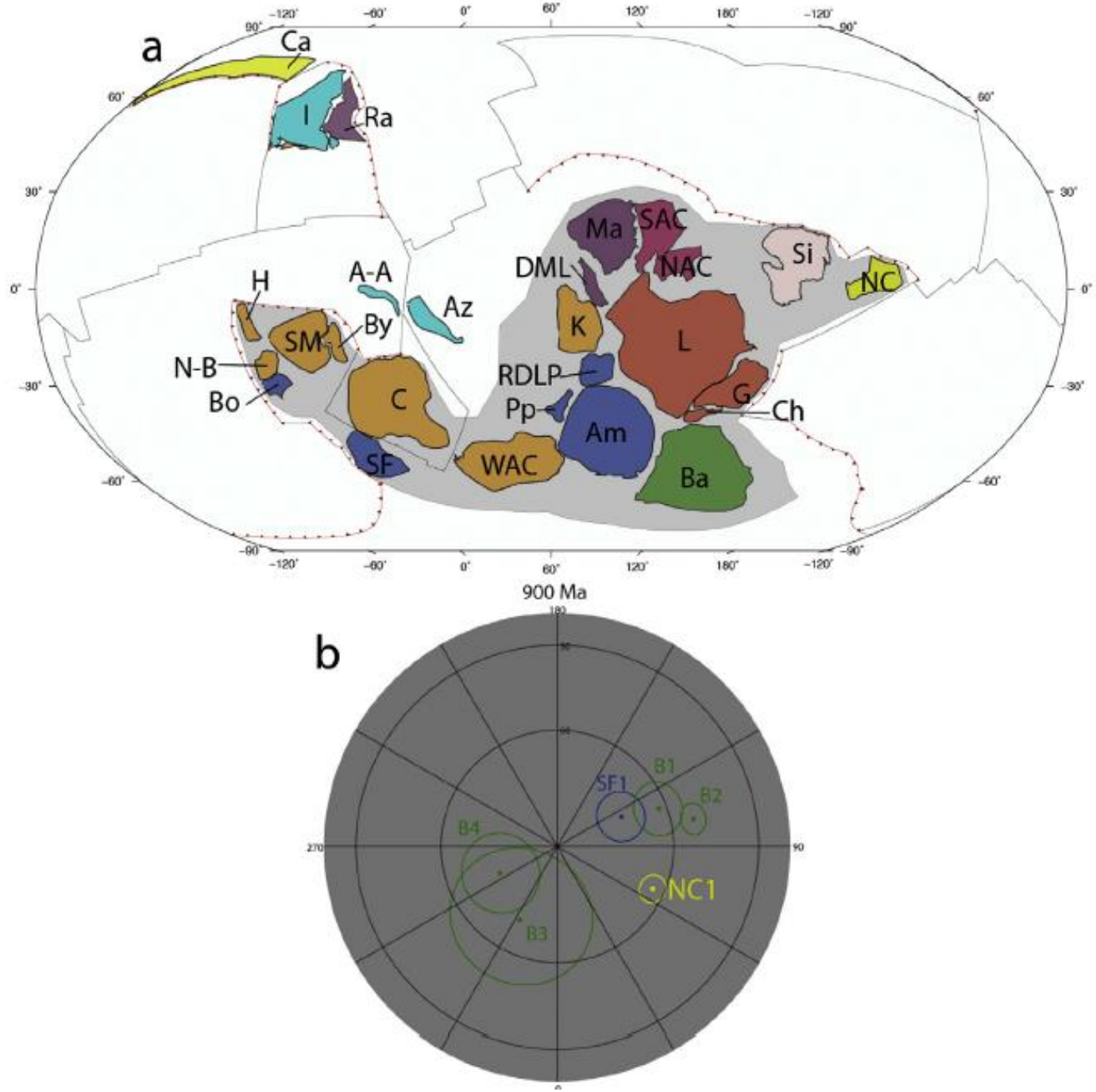
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