



Rio de Janeiro State University

The United Plates of South America

An overview of the Amazonian craton
evolution: insights for paleocontinental
reconstruction

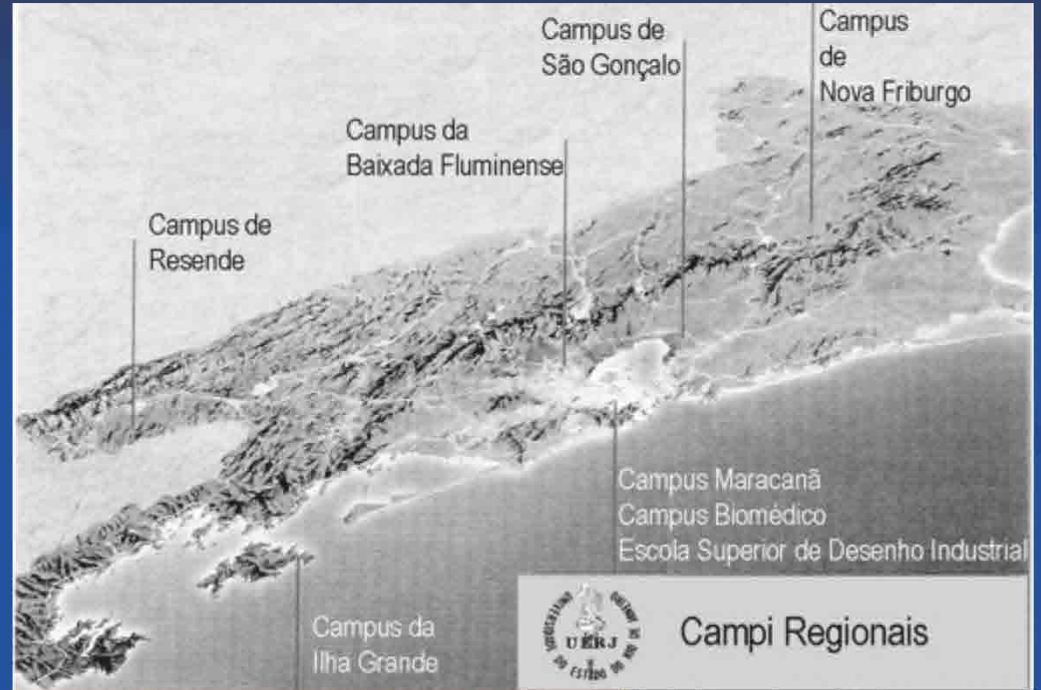
Mauro Cesar Geraldés
e-mail: geraldes@uerj.br

Rio de Janeiro State University

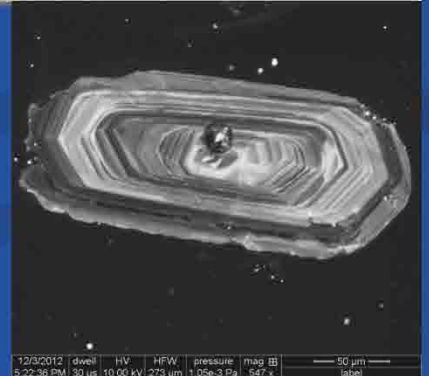
Staff: 2,300 Professors

22,000 undergraduate students-97 courses

graduate students:4,031



- TIMS
- LA-ICP-MS
- Ar isotopes spectrometer



Outline

South America Continent

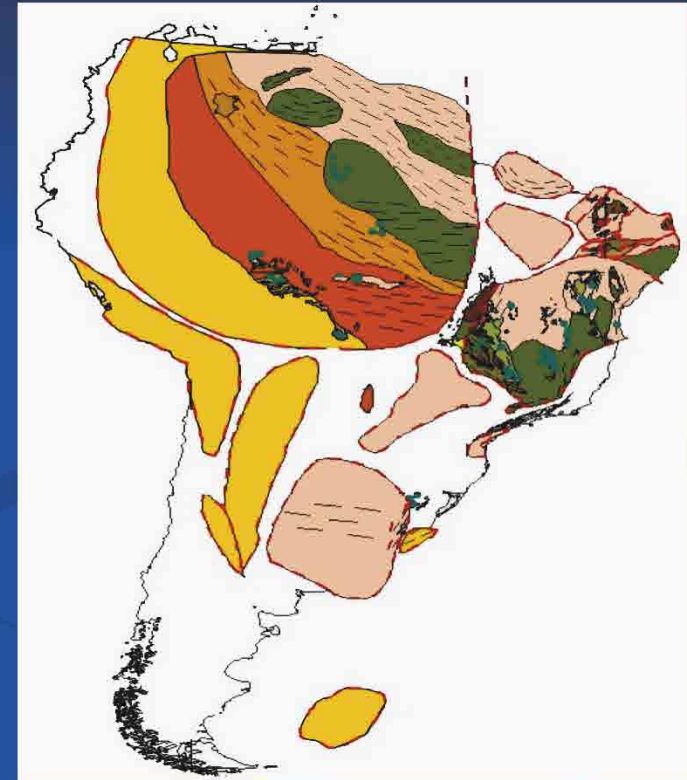
The Amazonian Craton

- 1) Crustal Evolution
- 2) Paleocontinents reconstructions

The United Plates

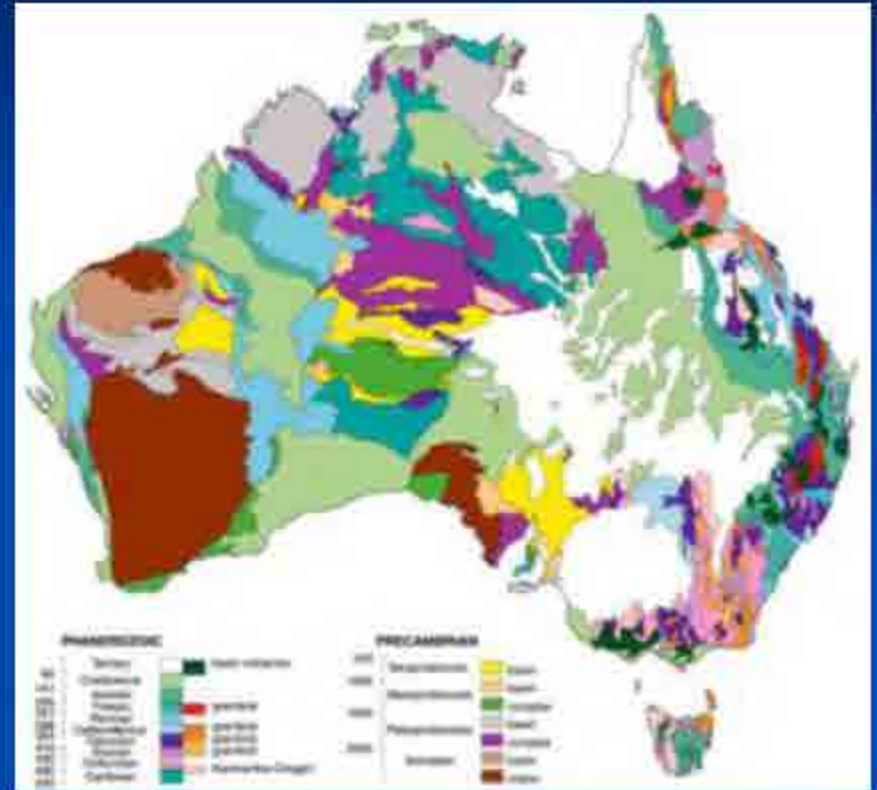
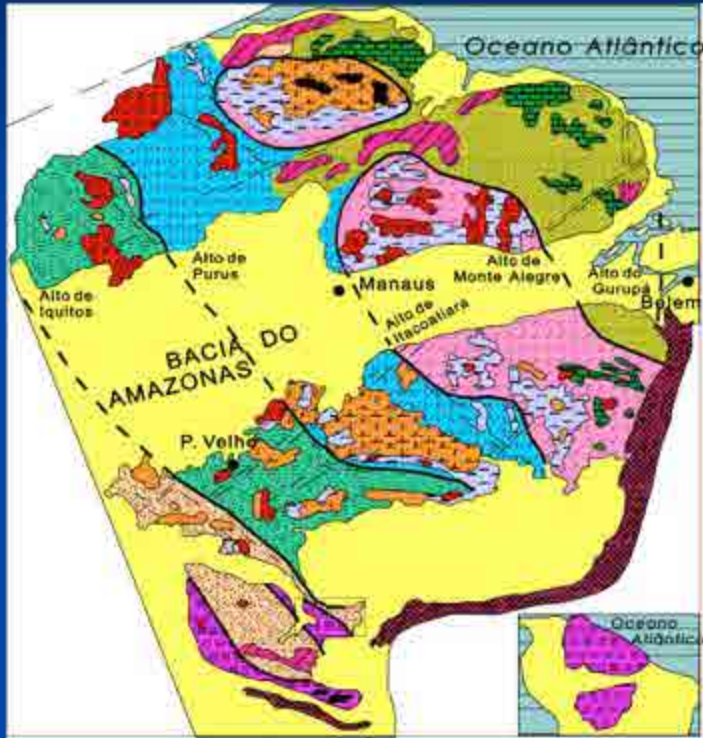
- 2) Older paleocontinents
- 3) The Neoproterozoic Orogens
- 4) Colisions step by step

Remarks

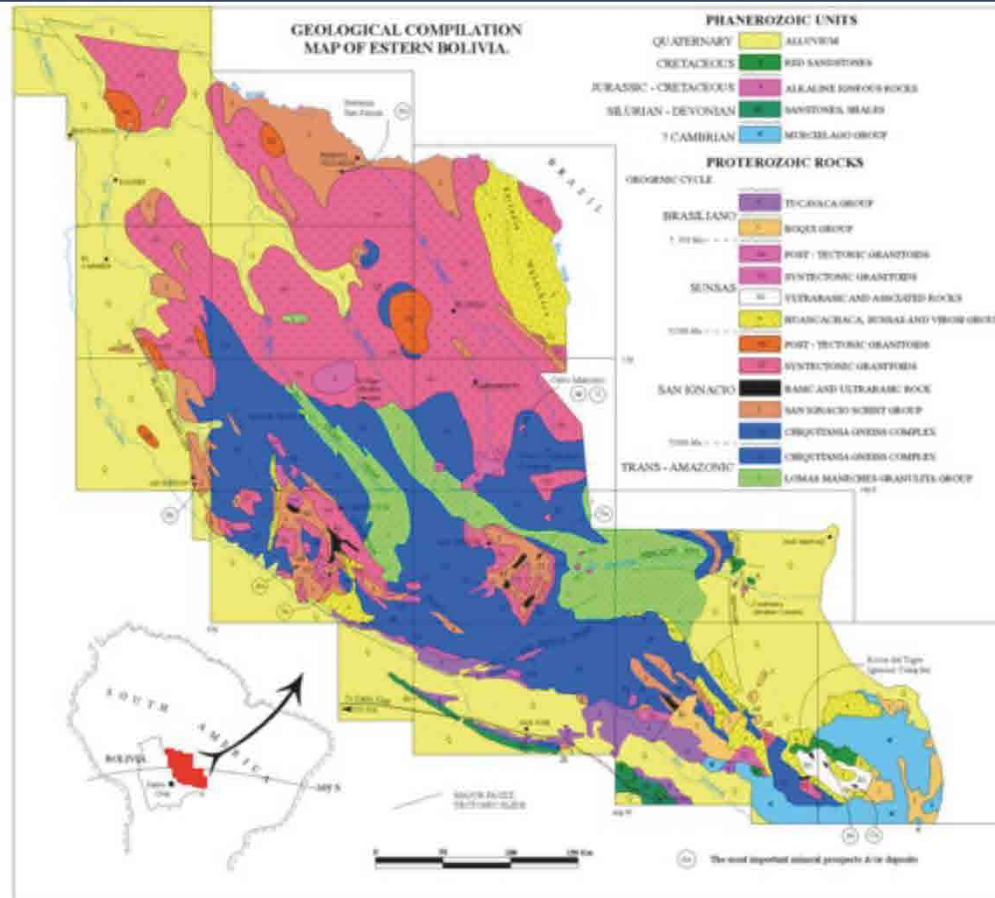
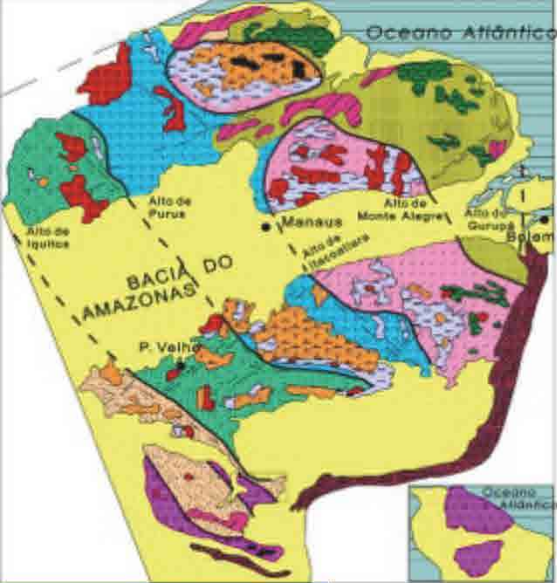


3.000 km

4.000 km



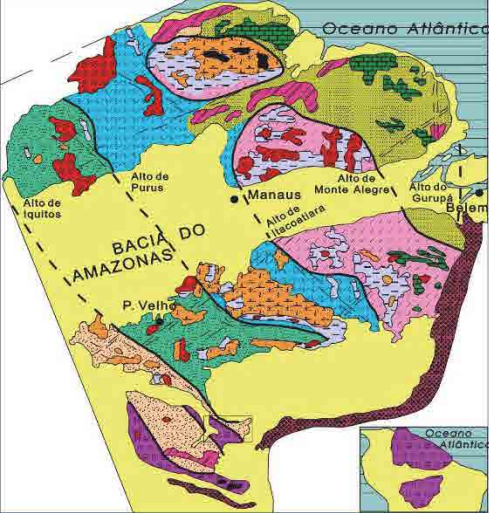
Bolivia



Litherland, M. et al., 1986

The geology and mineral resources of the Bolivian Precambrian Shield. Overseas Mem. Br. Geol. Survey, **9**, 153

Para



© E. Corbero - virtourist.com

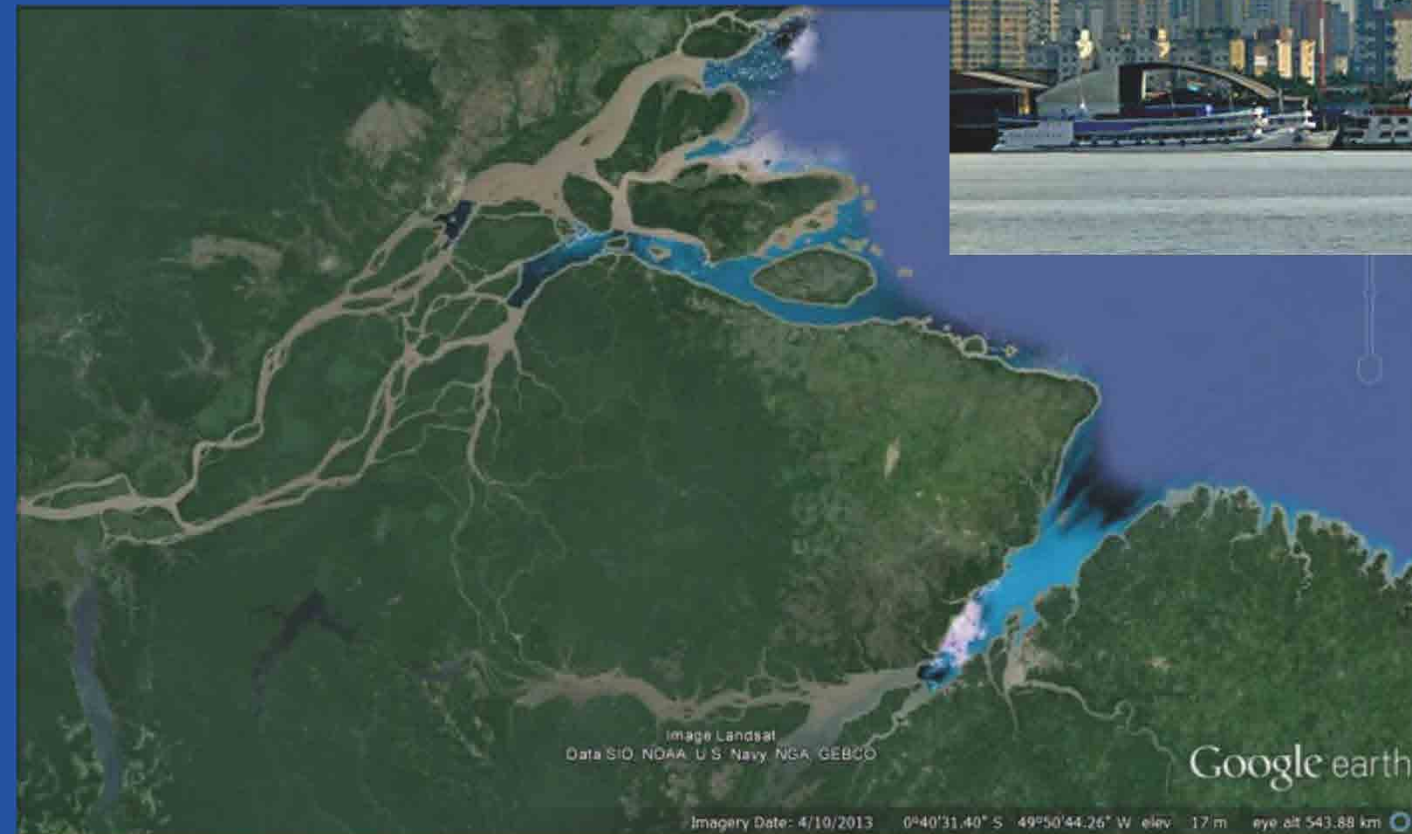
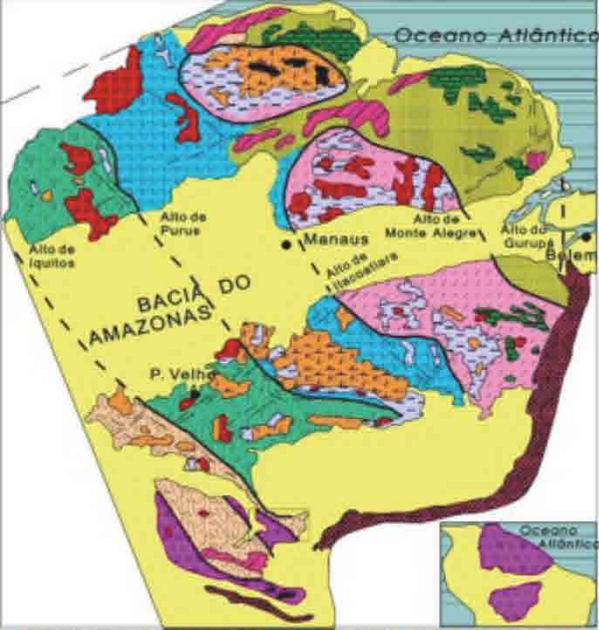


Image Landsat
Data SIO, NOAA, U.S. Navy, NSA, GEBCO
Google earth
Imagery Date: 4/10/2013 0°40'31.40" S 49°50'44.26" W elev 17 m eye alt 543.88 km



Rondonia

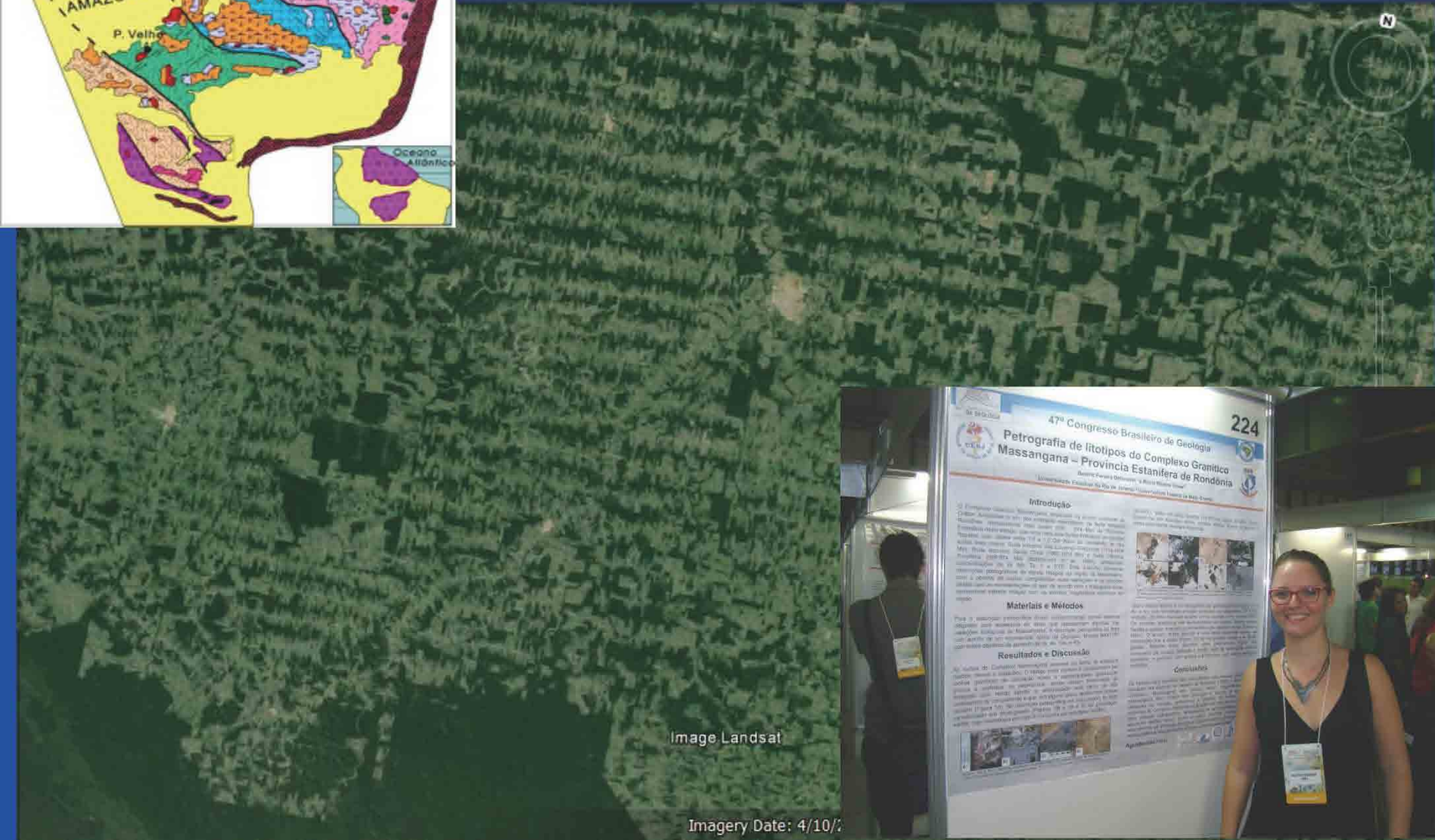


Image Landsat

Imagery Date: 4/10/2011



Carajas

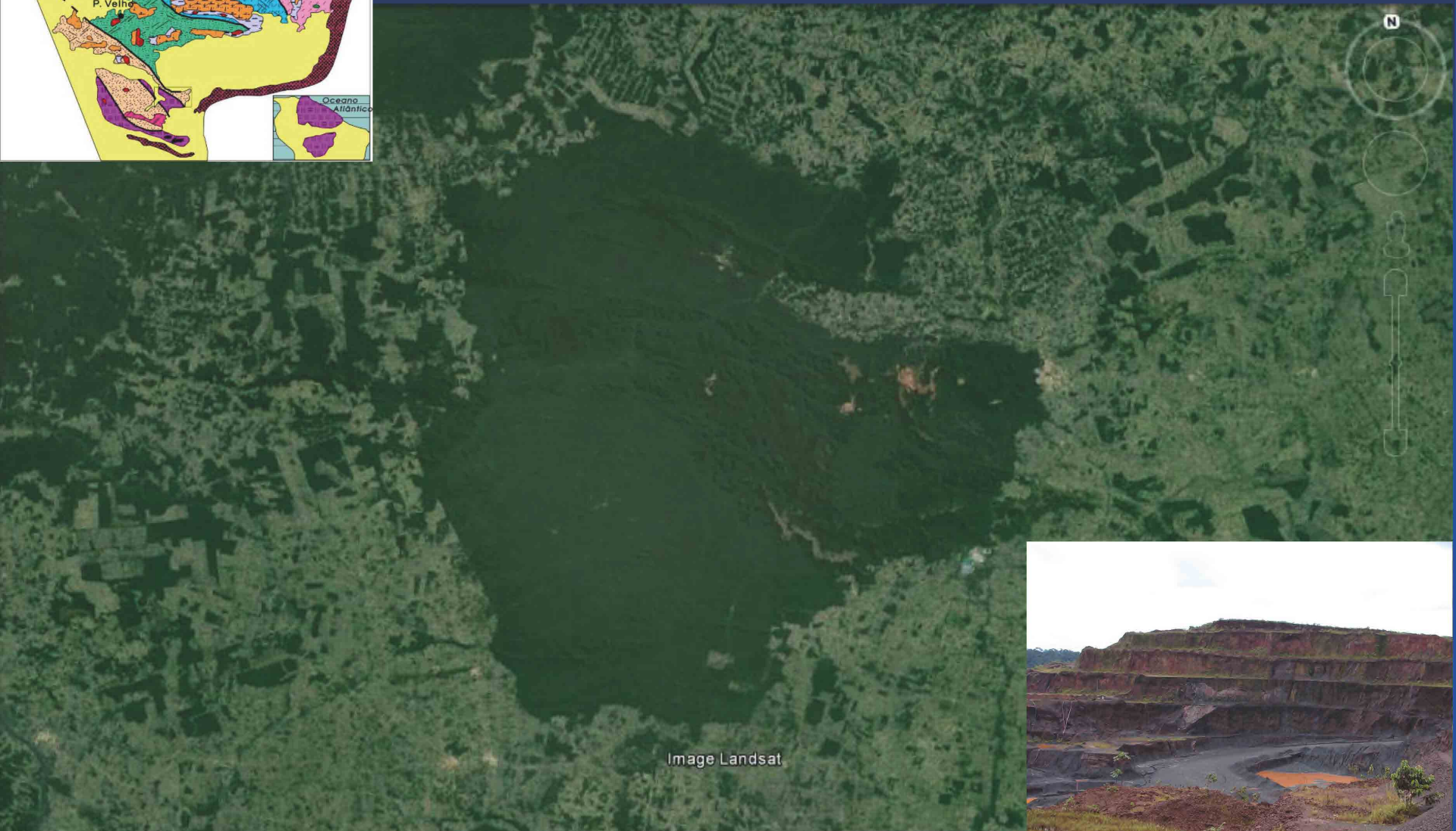
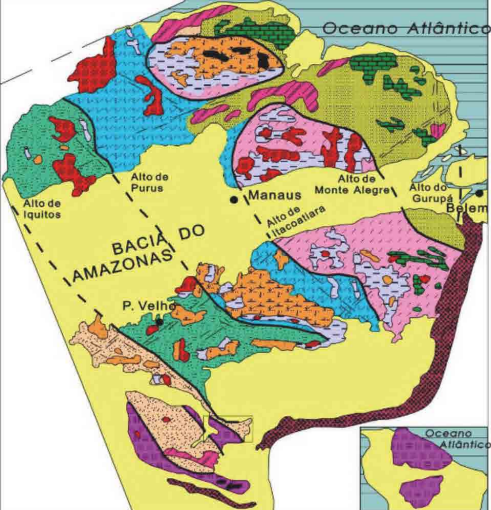
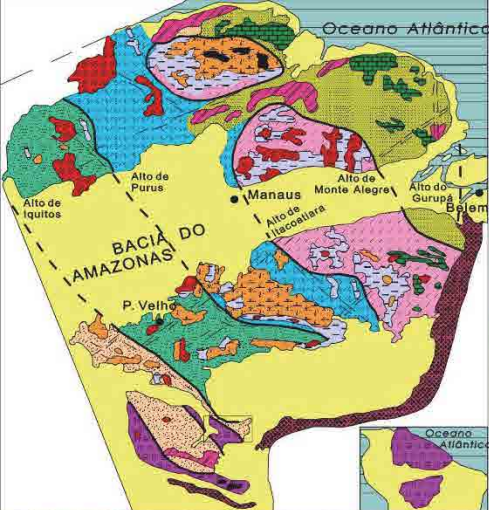


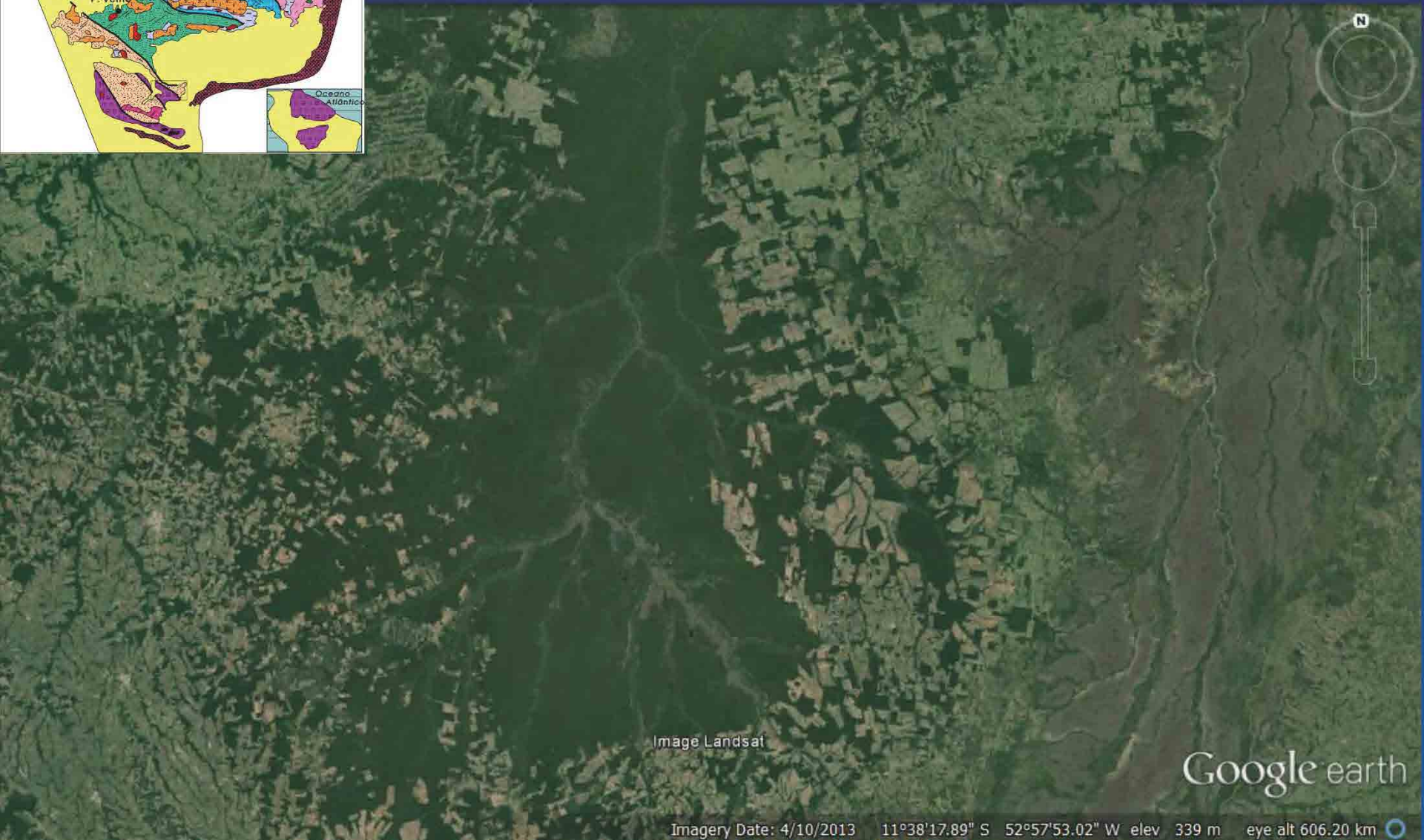
Image Landsat



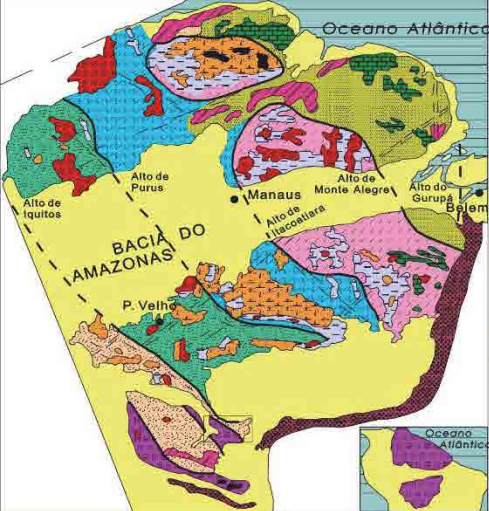
Imagery Date: 4/10/2013 6°08'19.57" S



Mato Grosso



State University of Amazonas



Amazonian craton

PROVÍNCIAS GEOCRONOLÓGICAS

Amazonia Central
>2.3 Ga

Maroni- Itacaiunas
2.2- 1.9 Ga

Ventuari-Tapajós
1,9-1,8 Ga

Rio Negro- Juruena
1.8-1.55 Ga

Rondoniana- San Ignácio
1,5-1.3 Ga

Sunsás
1.25-1.0 Ga

UNIDADES GEOLÓGICAS

Coberturas Fanerozoicas

Granitóides

Coberturas Sedimentares
Pré-cambrianas

Coberturas Vulcânicas
Ácidas-Intermediárias

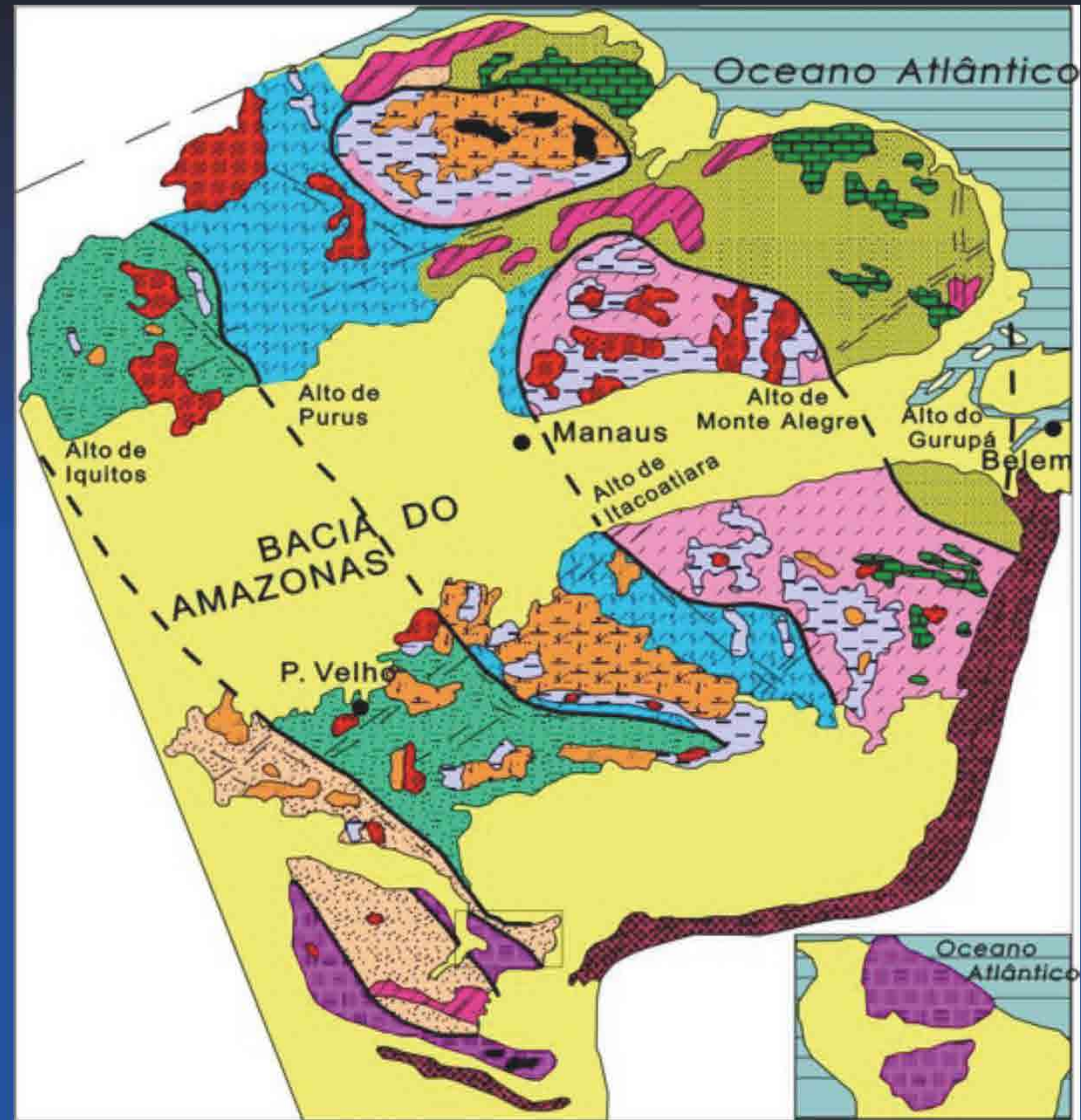
Vulcanismo básico

Greenstone Belts

Complexos Granulíticos

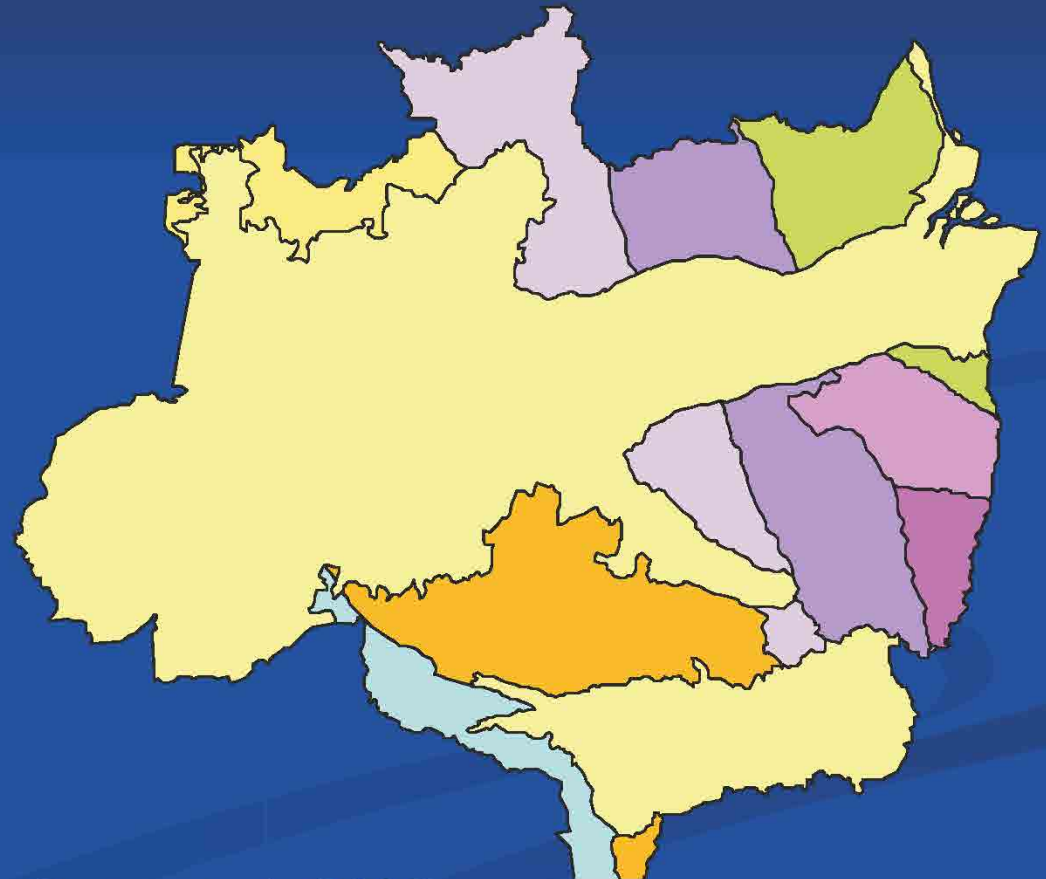
Faixa de Dobramentos
Neoproterozóica

FIG. 4 - PROVÍNCIAS TECTÔNICAS DO CRATON AMAZÔNICO



Tassinari and Macambira (1999)
Tassinari et al. (2000)

Amazonian Craton



Legenda para a Figura 3

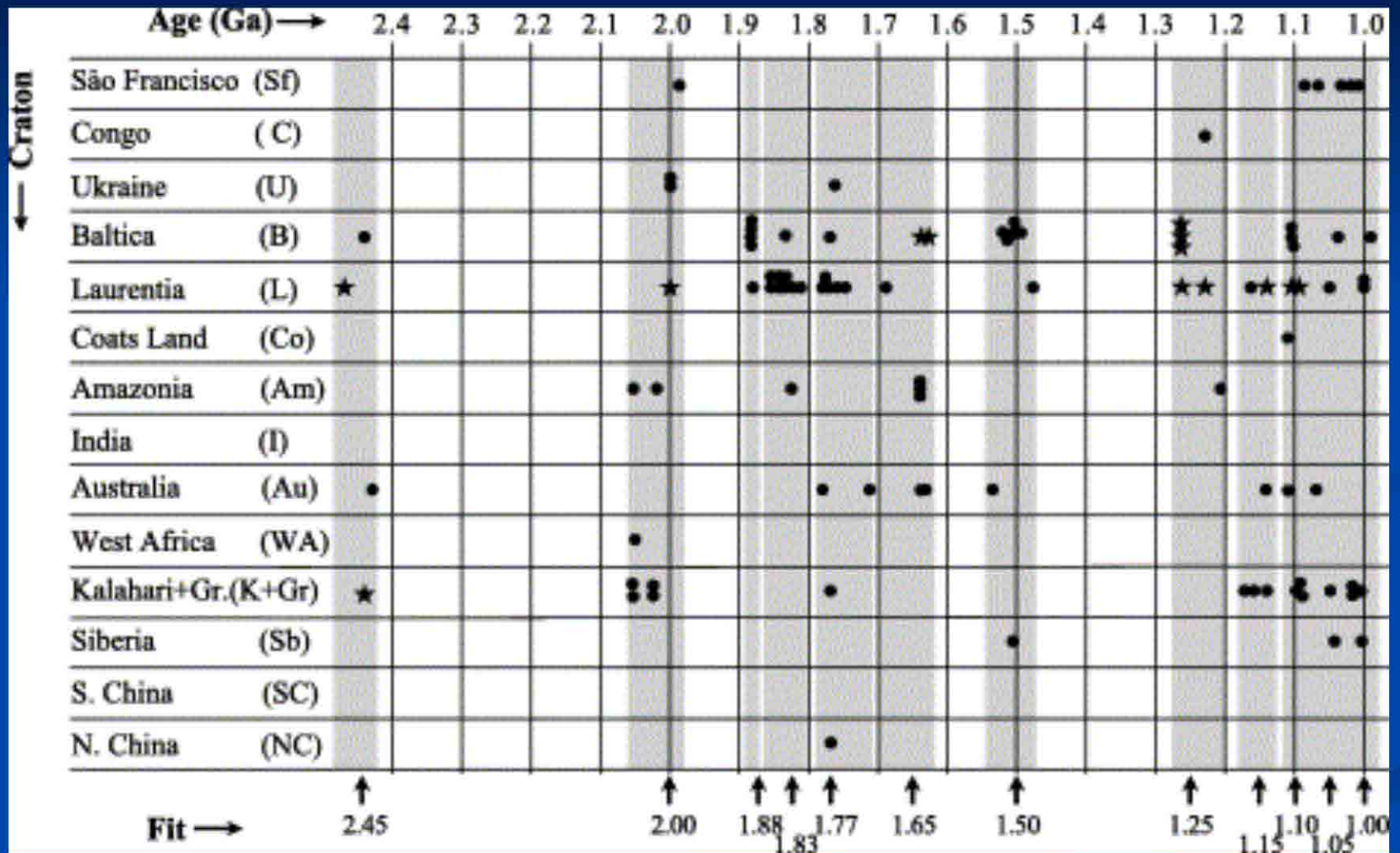
Santos et al. (2000)

Paleogeography

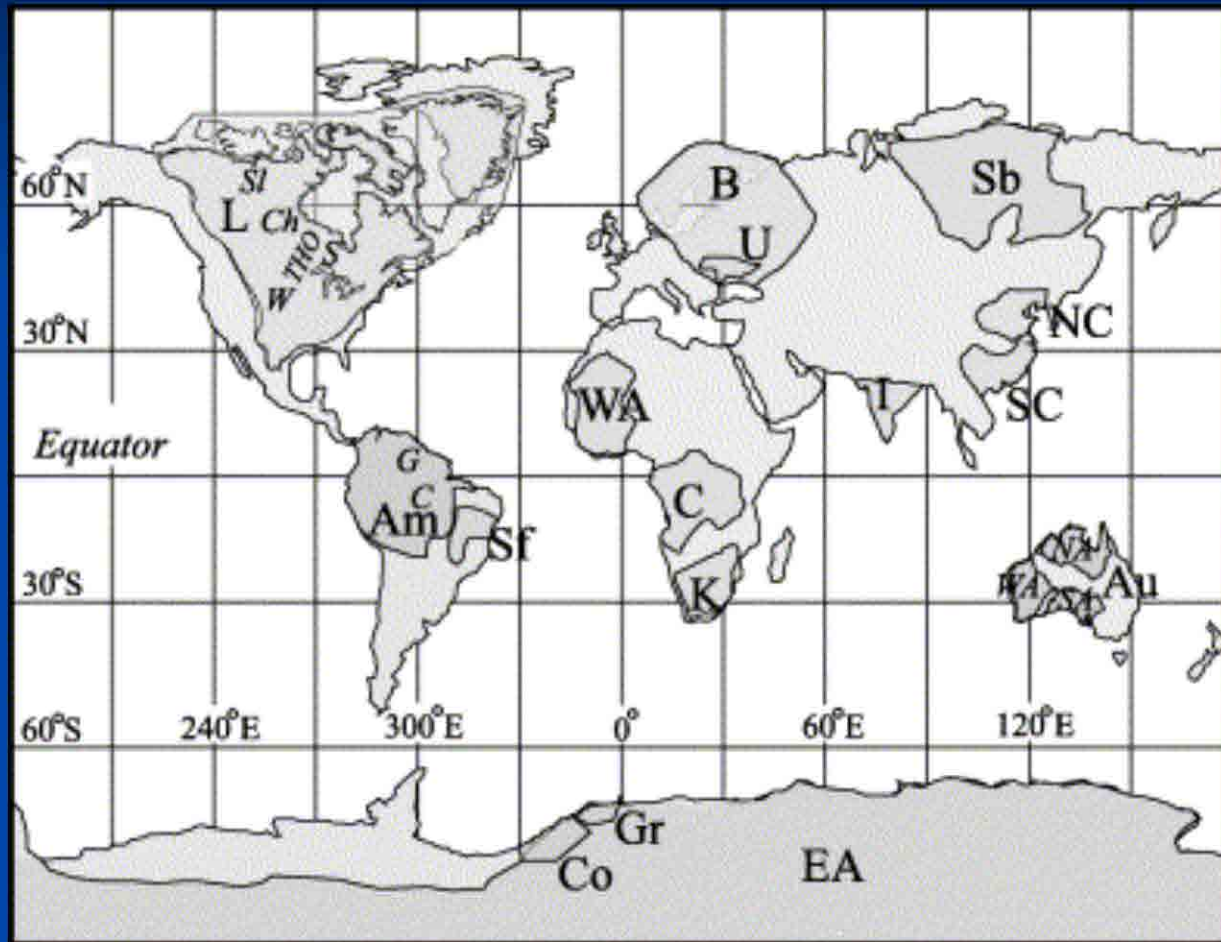
•Paleocontinental investigations are based on:

- 1) Paleomagnetic data
- 2) Orogenic belts match
- 3) Crustal provinces match
- 4) Fossil assemblages and
- 5) Sedimentary sequences

14 cratons



14 cratons



Proposed paleocontinents

Ur	3.0-2.8 Ga
<u>Kenorland</u>	<u>2.45-2.10 Ga</u>
Zimvaalbara	2.35-2.22 Ga
Atlantica	2.3 Ga
Arctica	2.0 Ga
Nena	1.8 Ga
<u>Hudsoland</u>	<u>1.8 Ga</u>
<u>Columbia</u>	<u>1.8 Ga</u>
<u>Rodinia</u>	<u>1.2-1.0 Ga</u>
Pannotia	650-585 Ma
<u>Gondwana</u>	<u>520-180 Ma</u>
<u>Pangea</u>	<u>300-180 Ma</u>

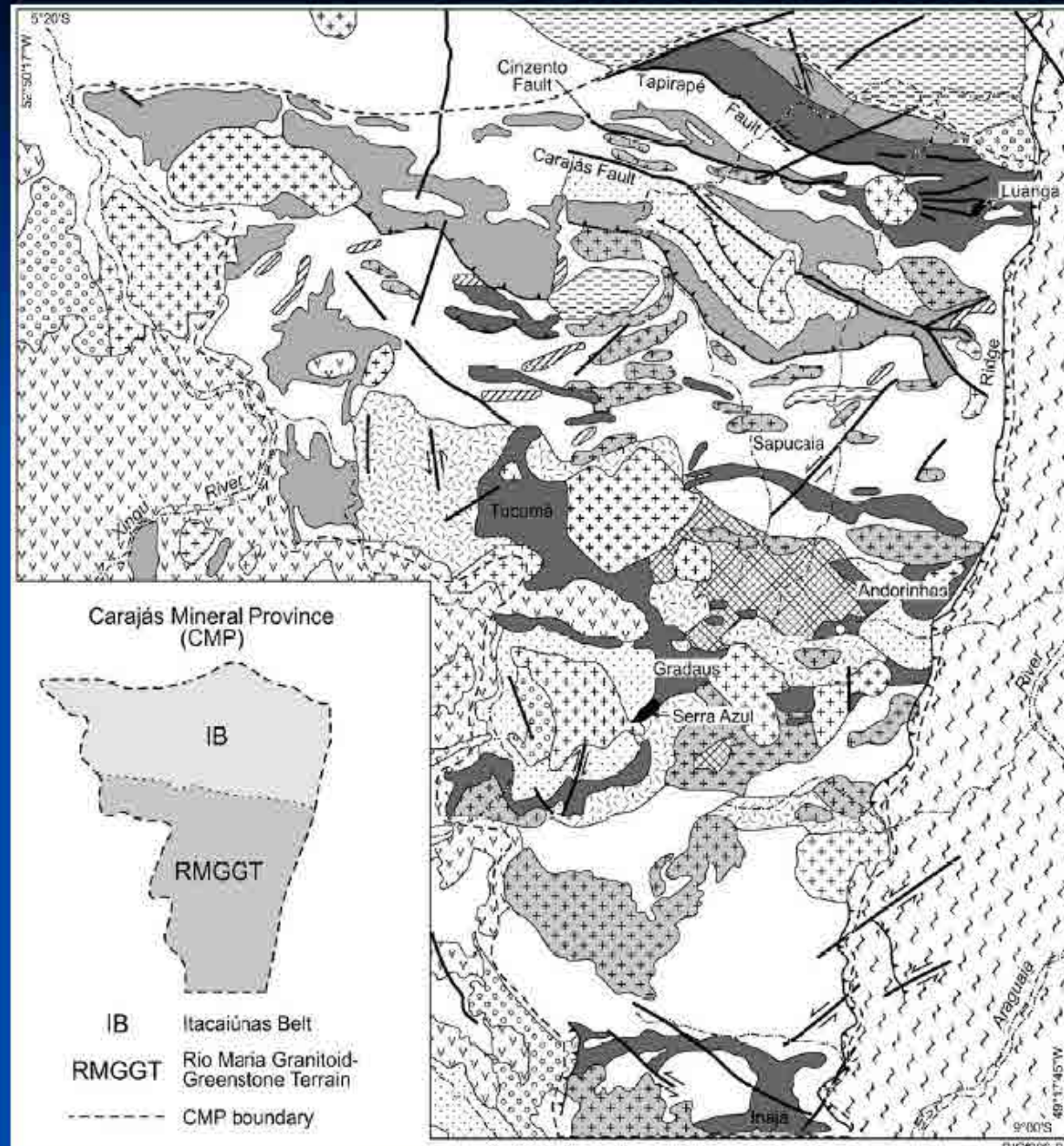
Central Amazonia Province

Basement rocks:

Pium Complex 3.05 Ga

TTG and greenstone belt

Terranes 2.9-2.8 Ga



Carajas

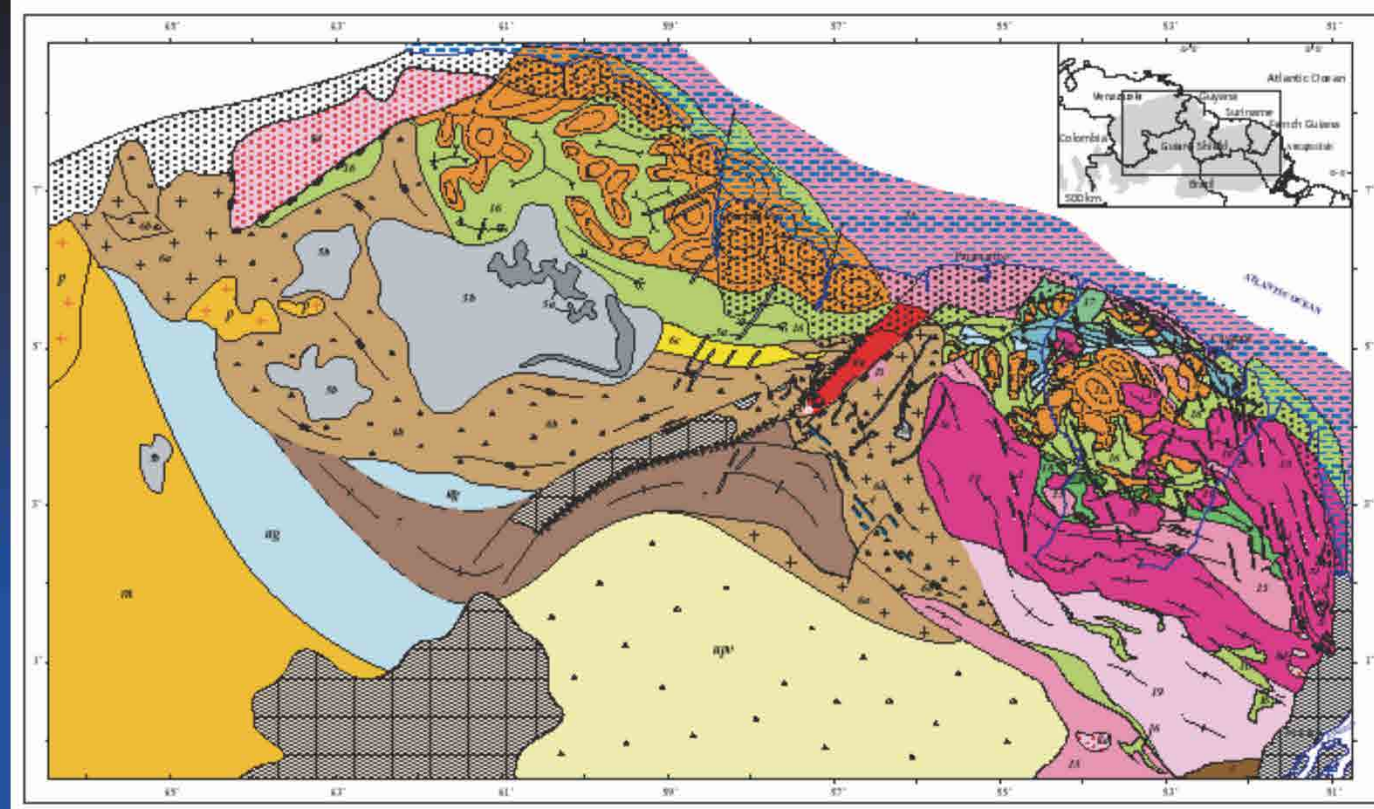
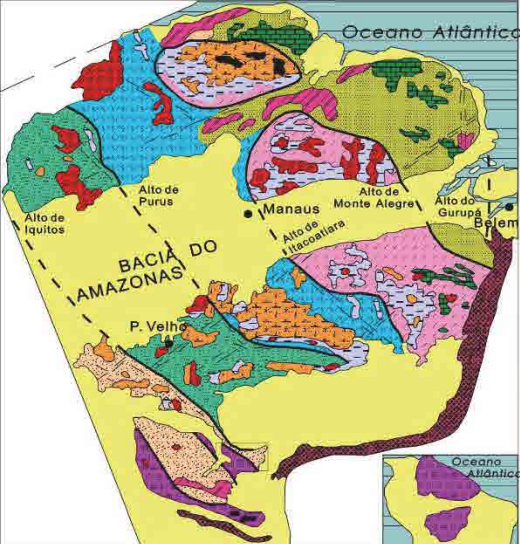


Agua Clara formation 2.76 Ga

Olszewskia et al. (1991)

Machado et al. (1991)

Mongéot et al. (1996)

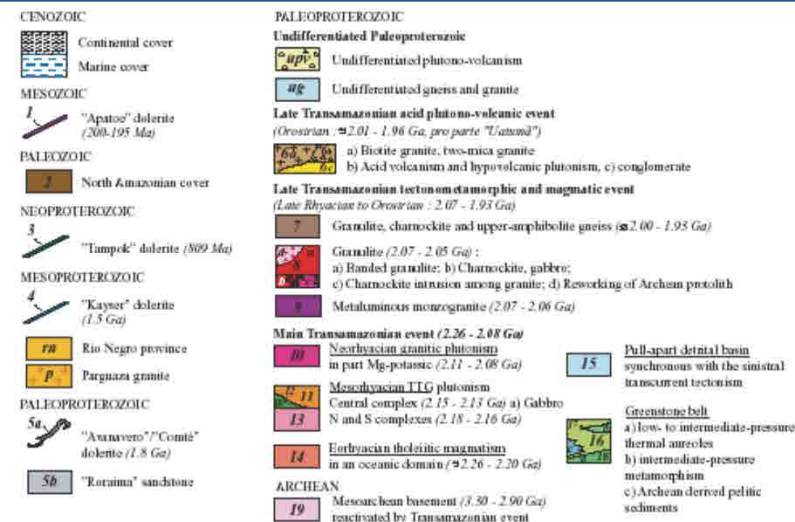


Imataca Complex

3.7-2.6 Ga

Montgomery and Hurley,
(1978)

Tassinari et al. (2001)



Central and South Amapá North Para 2.85-2.65 Ga

Montalvão and Tassinari (1984)

Avelar et al. (2002)

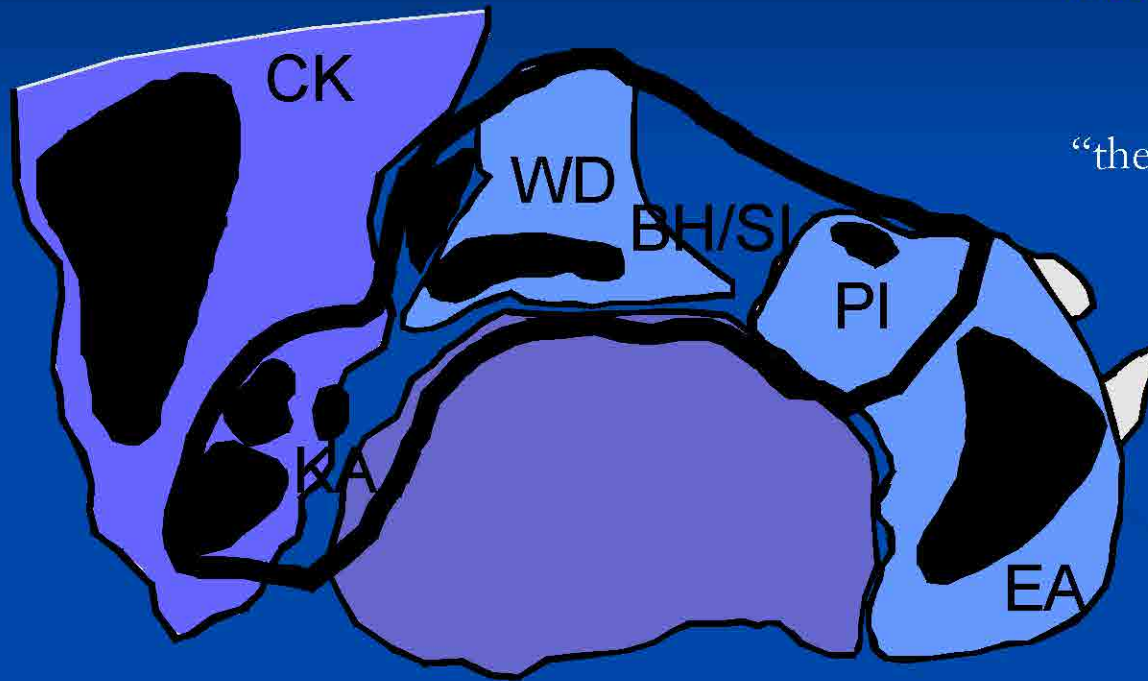
Delor et al. (2003)

Rosa-Costa et al. (2003 and 2006)

Paleocontinent Ur (3.0-2.8 Ga)

Rogers, 1996

The Journal of Geology



“the oldest highly speculative continent”

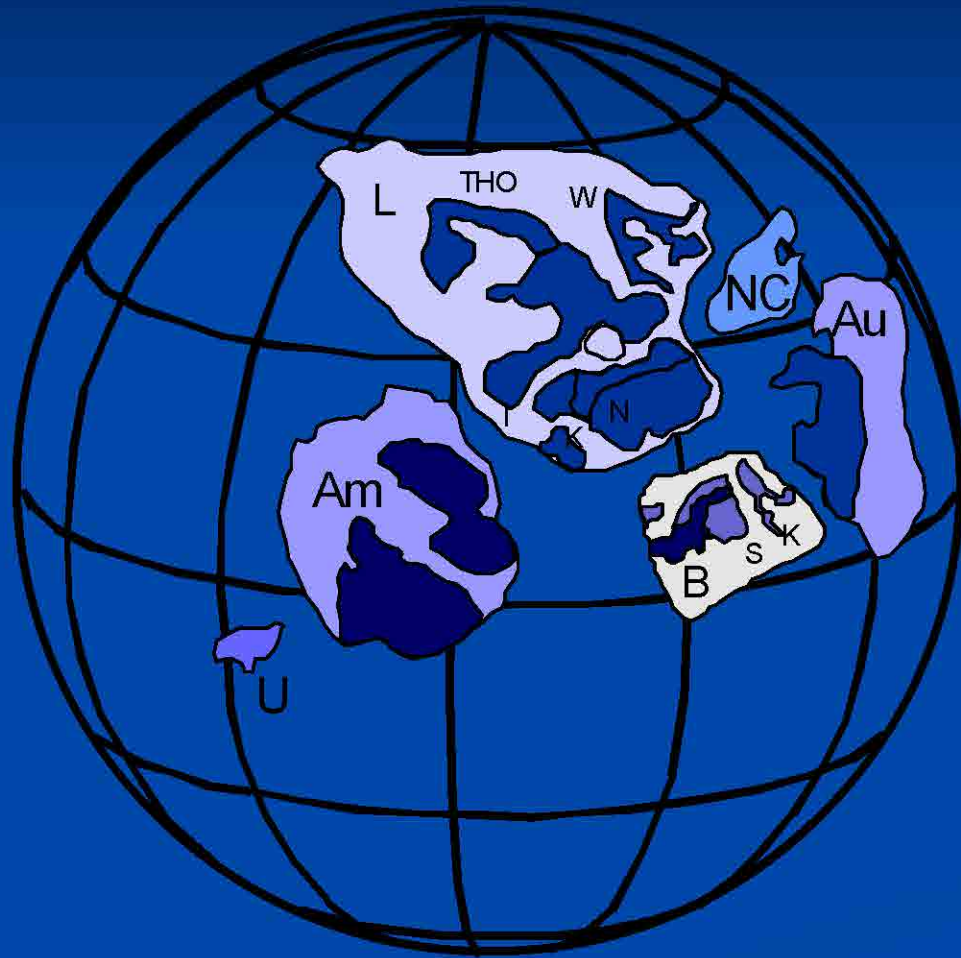
3.0-2.8 Ga shallow-water
supracrustals assemblage

Agua Clara formation 2.76 Ga

Kaapval (KA)
Western Dhawar (WD)
Bhandara (BH)
Singhbhum (SI)
Pilbara (PI)
Congo/Kalahari (CK)
East Antarctica (EA)

Amazonia ?

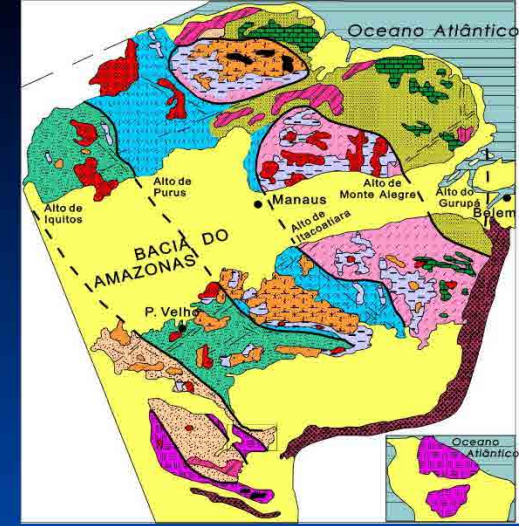
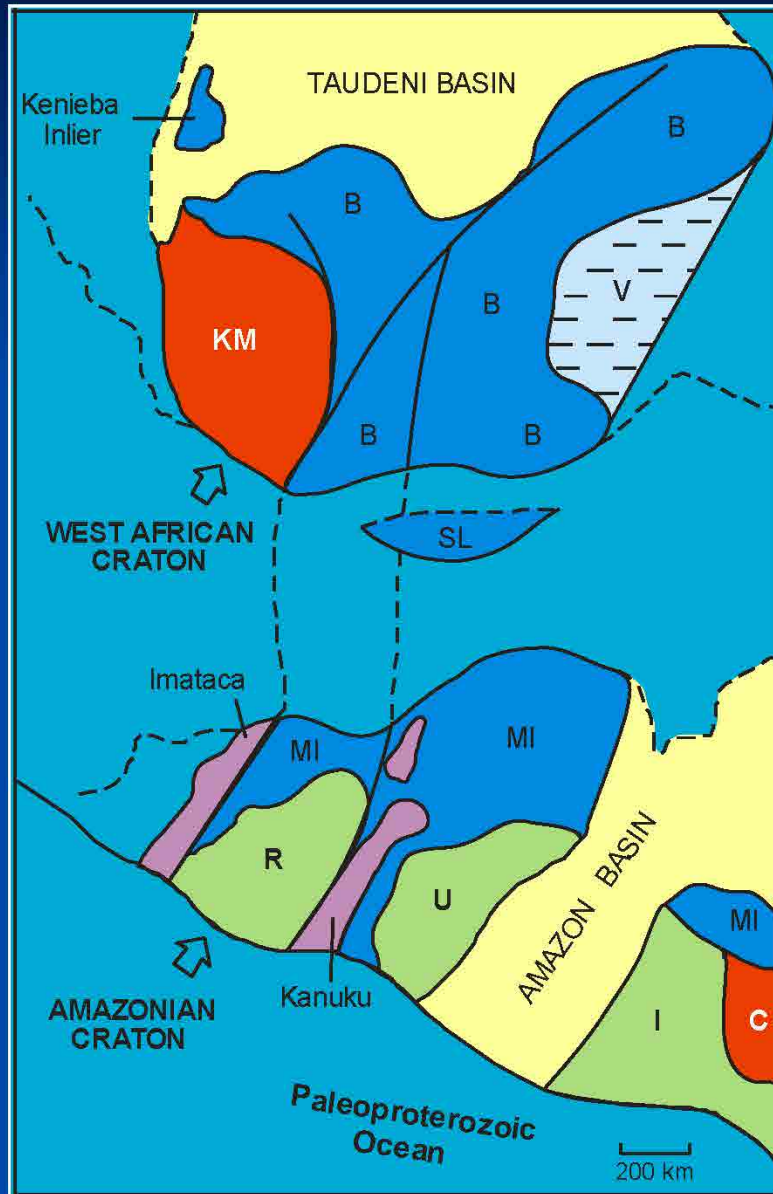
- Kenorland 2.45 Ga



Willians et al., 1991
Tectonophysics

Pesonen et al., 2003
Tectonophysics

• Kenorland 2.45 Ga



Amazonia

Paleomagnetic data

Ledru et al. (1994)

Precambrian Research

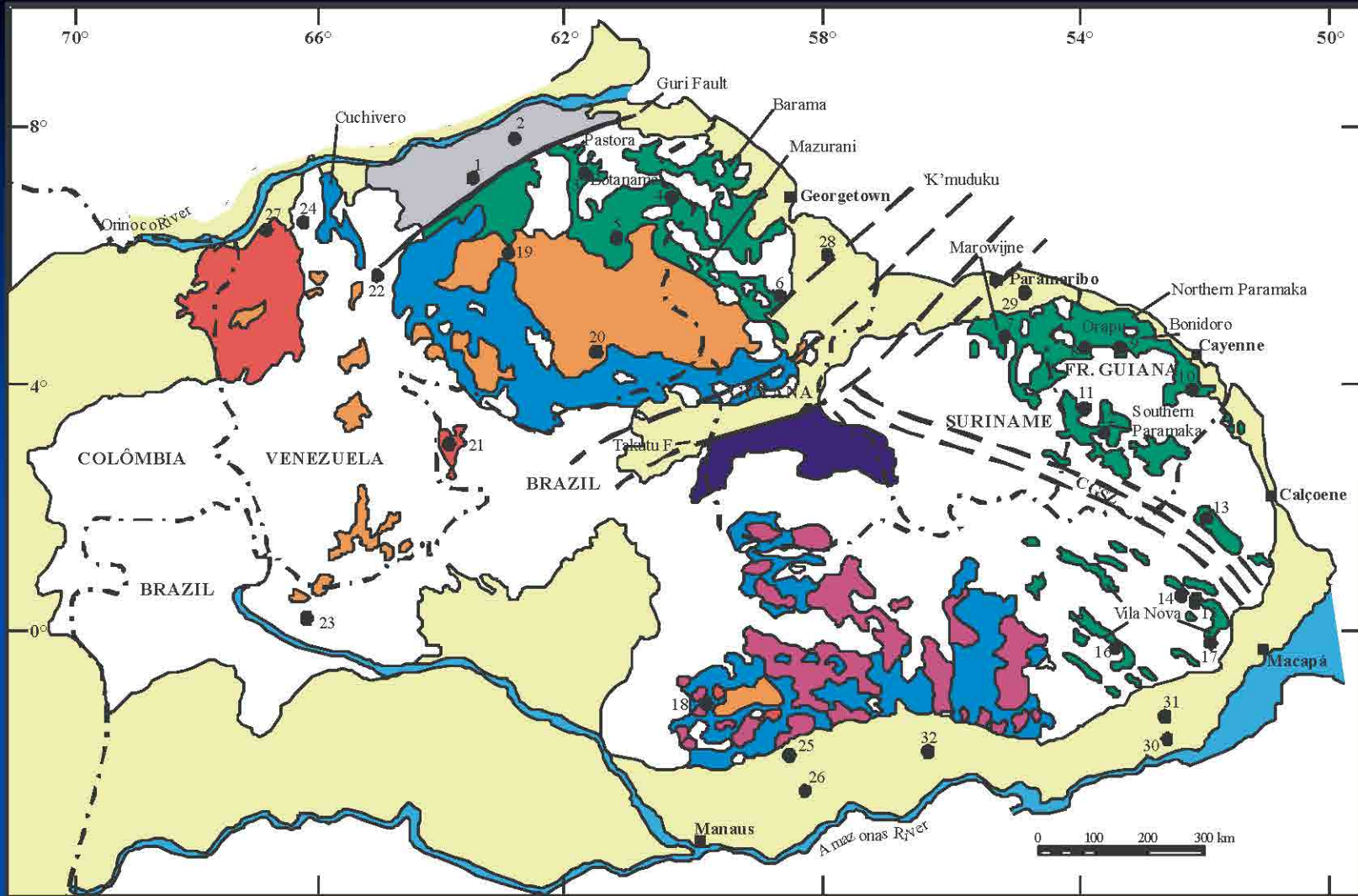
Ledru e Milési (2001)

Contribuições à Geologia da Amazônia vol. II

Théveniaut and Delor (2003)

Geologie de la France

**Imataca
Complex
3.7-2.6 Ga**



Montalvão and Tassinari (1984)

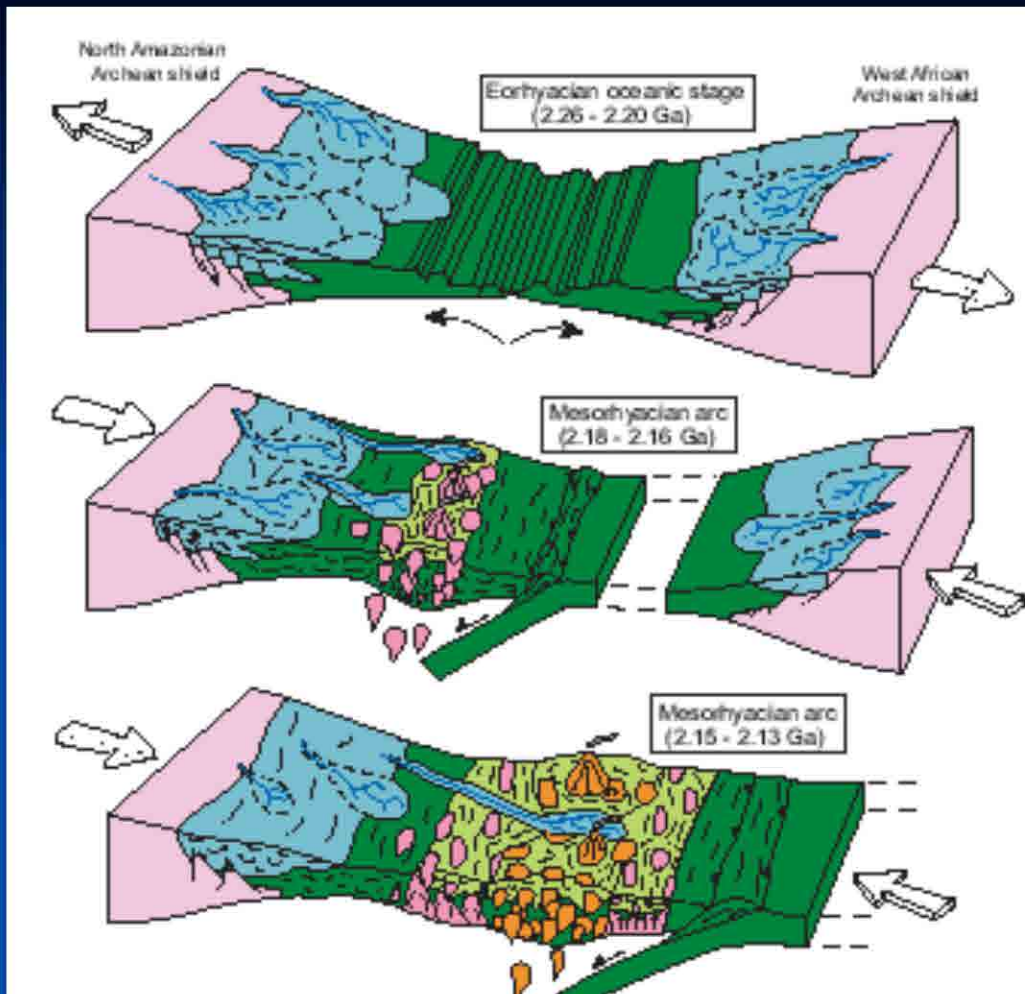
Montgomery and Hurley, (1978)

Avelar et al. (2002)

Tassinari et al, (2001)

Delor et al. (2003)

Rosa-Costa et al. (2003 and 2006)



Gabbros

interpreted as the time of ocean floor rocks formations.

2.26-2.20 Ga

Arc-related granitoids

2.19-2.16 Ga

2.15-2.13 Ga

Granulite belt

Ultrahigh-temperature

2.15-2.09 Ga

Roever et al (2003)

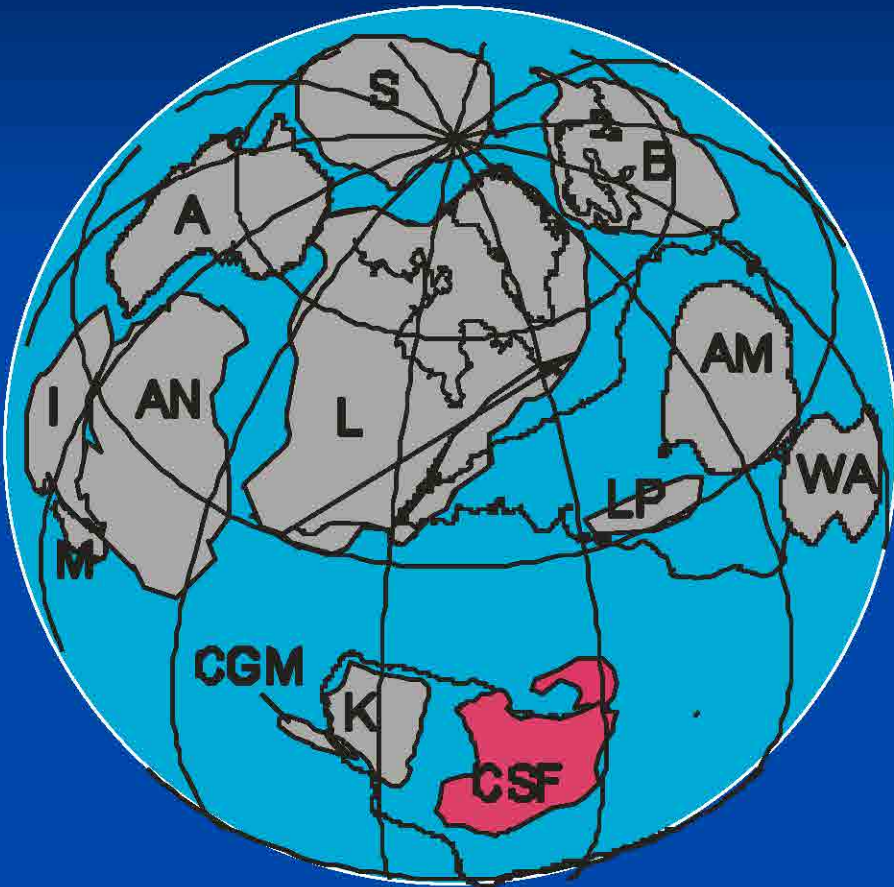
Delor et al. 2003)

Rosa-Costa et al. (2003 and 2006)

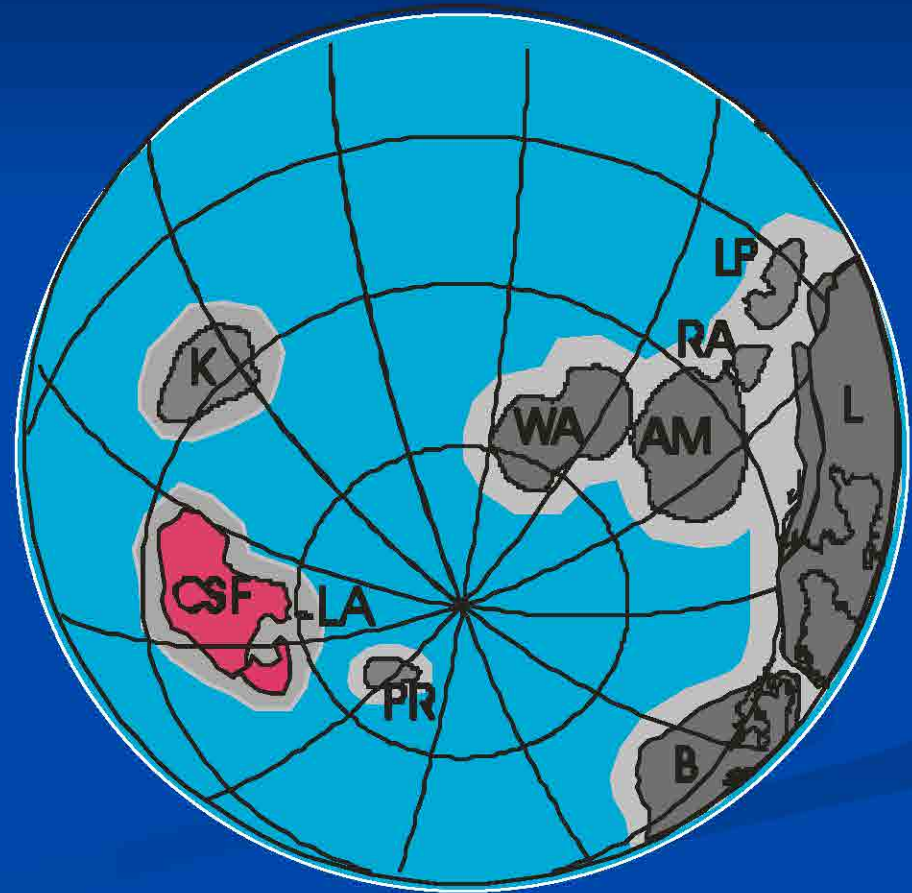
Reis et al. (2003)

- **Collision at 2.15-2.13 Ga**
- **Kenorland 2.43-2.0 Ga**

Kenorland 2.45 Ga

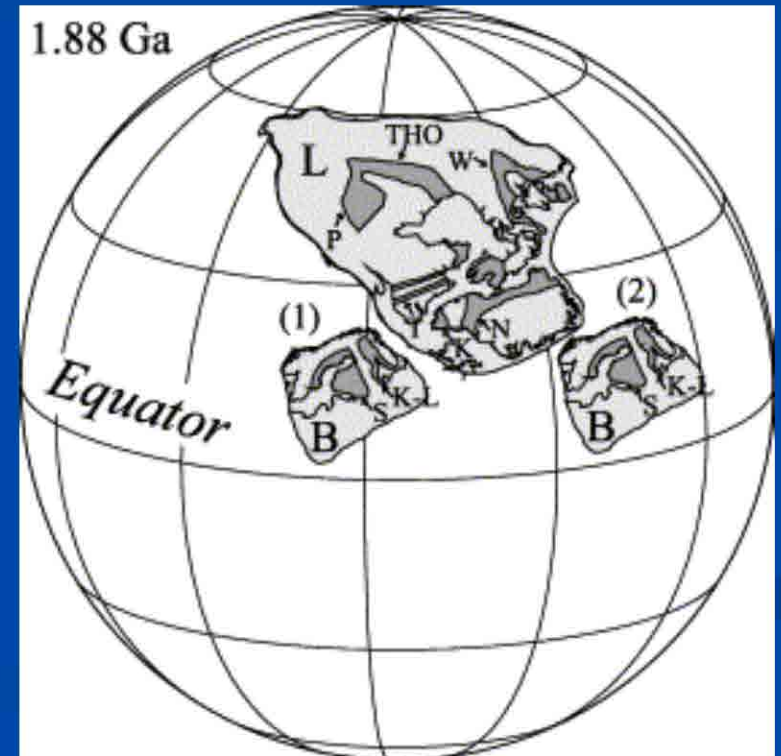
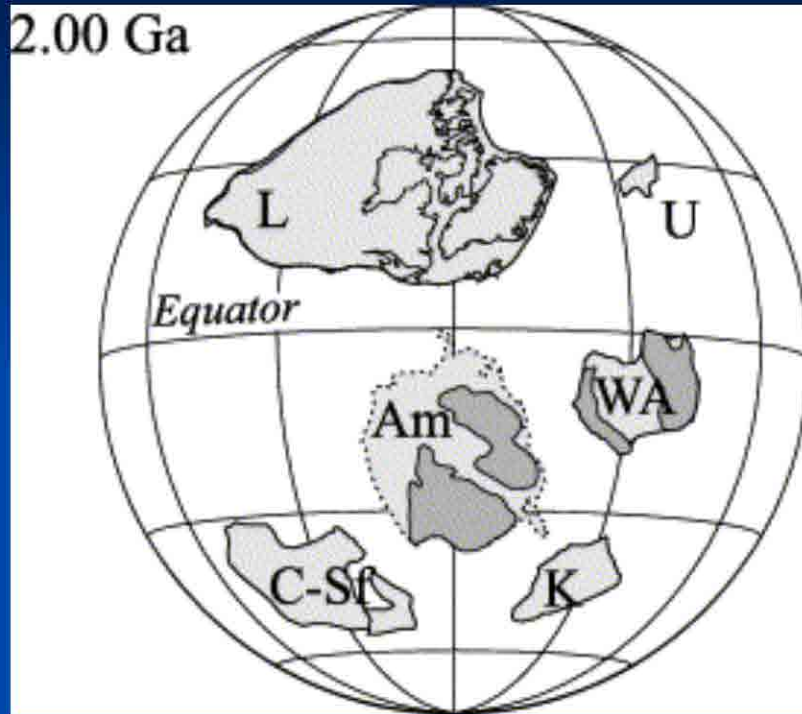


Dalziel et al. (2000)



D'Agrella-Filho et al. (2004)

Kenorland break up



Pesonen et al. (2003)

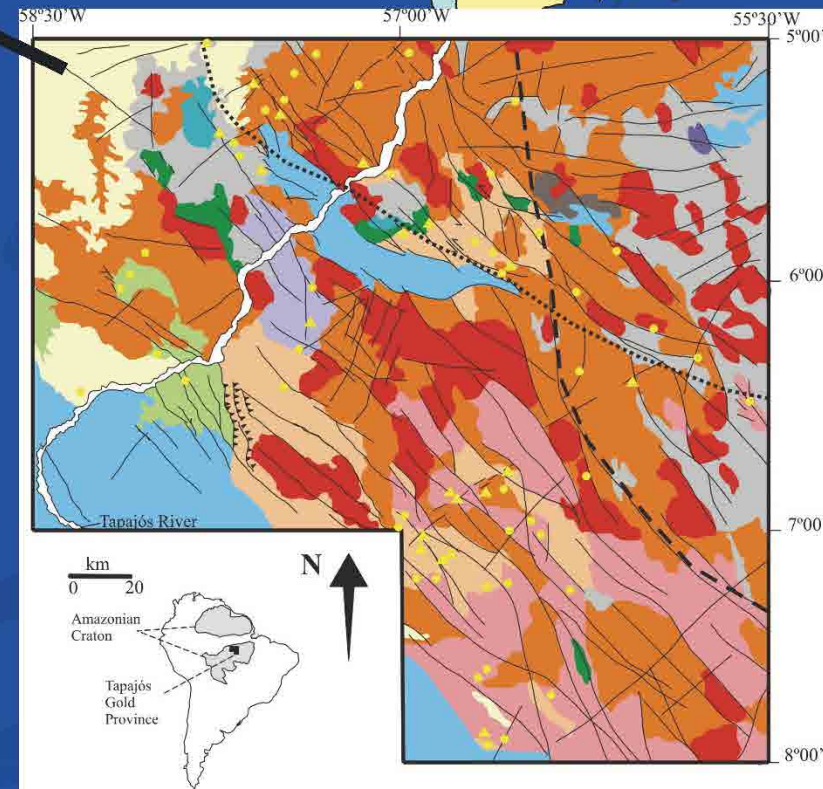
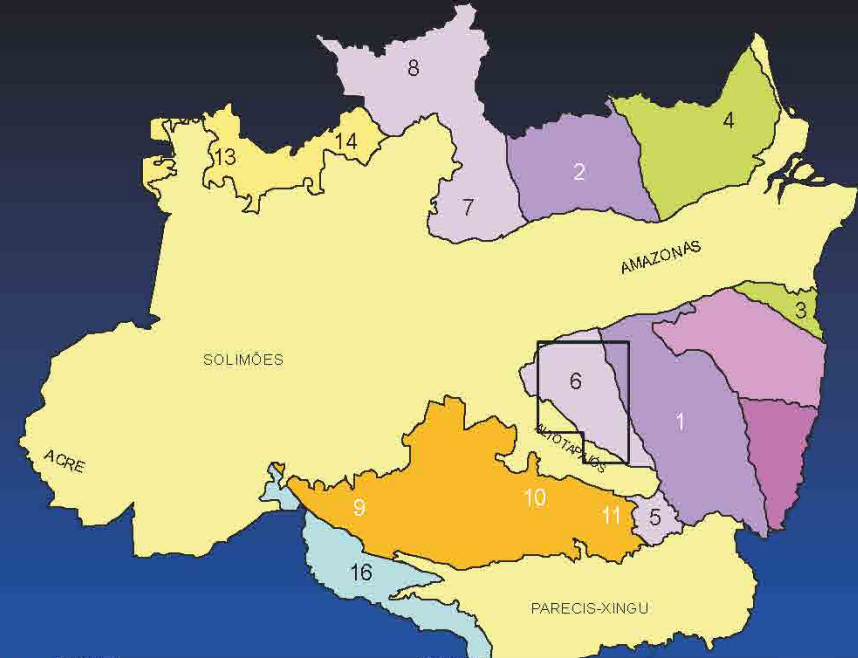
Tectonophysics

Tapajós Province

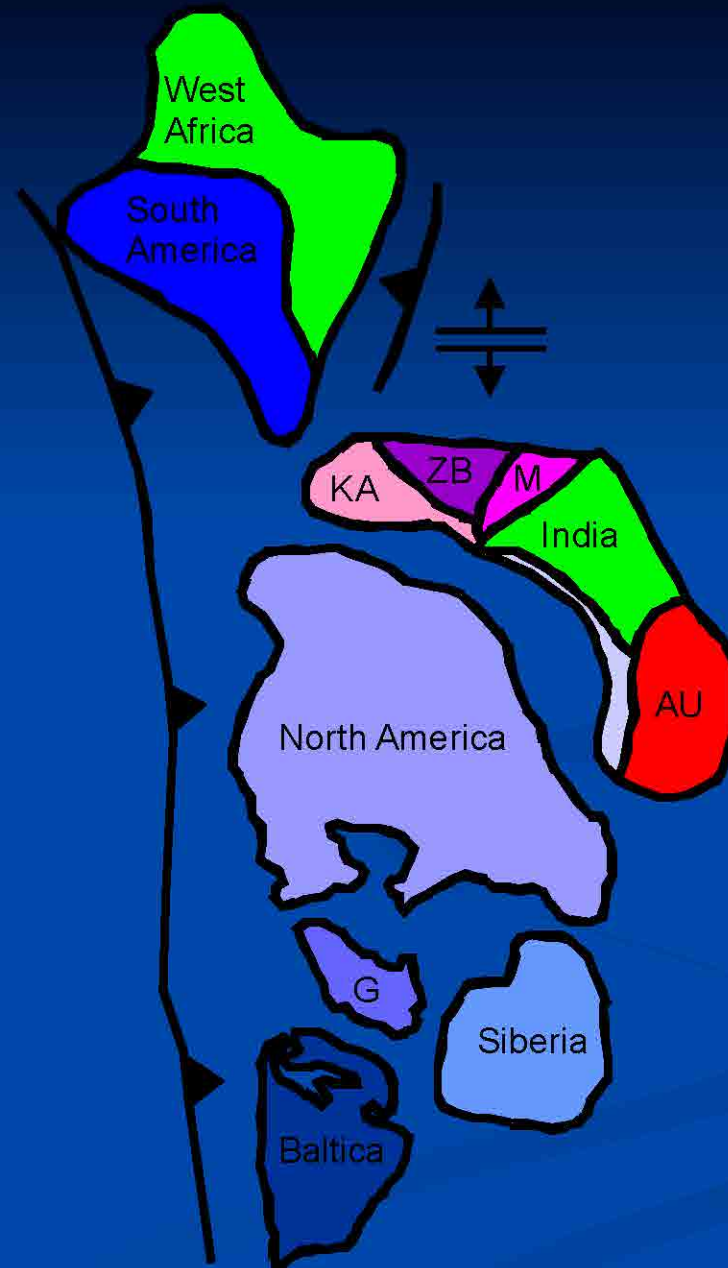
- Two accretionary events
- calcalkaline rocks
- 2.05-1.96 Ga (Cuiu-Cuiu)
- 1.88 Ga (Parauari)

- Klein e Vasquez (2000)
- Santos et al. (2000)
- Lamarão et al. (2002)
- Vasquez et al. (2002).

Lateral accretionary process with
juvenile characteristics without
collisional process
(no amalgamation)



- 1.83-1.6 Ga



- Columbia

Rogers and Santosh,
(2002)

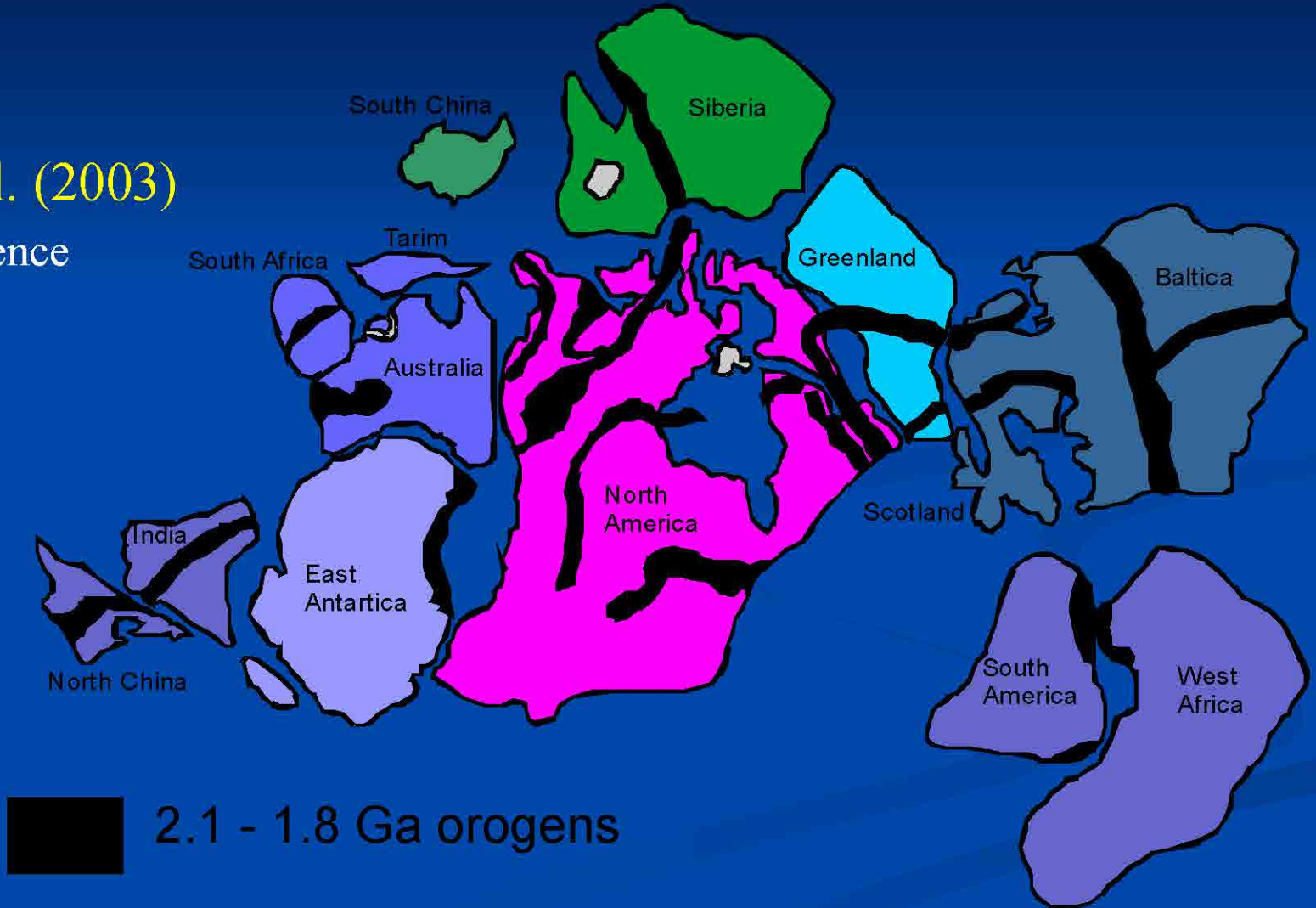
Gondwana Research

~1.80 Ga

• Columbia

Zao et al. (2003)

Earth-Science
Reviews



• 1.83 Ga • Hudsonland

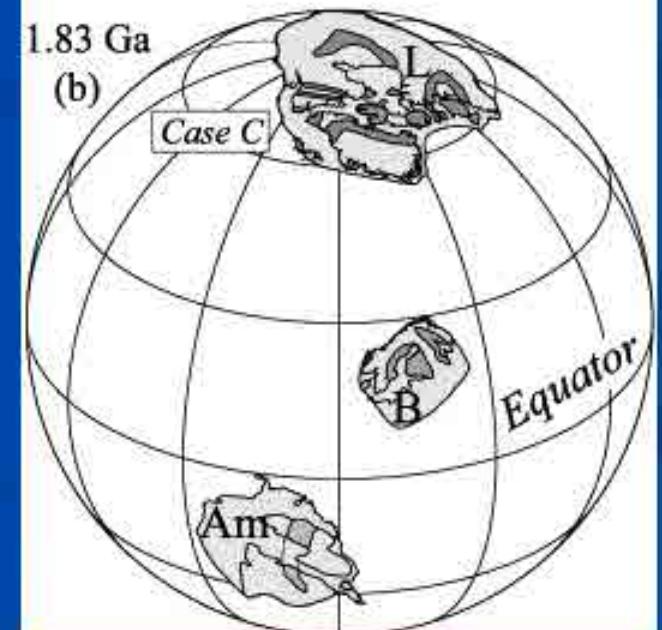
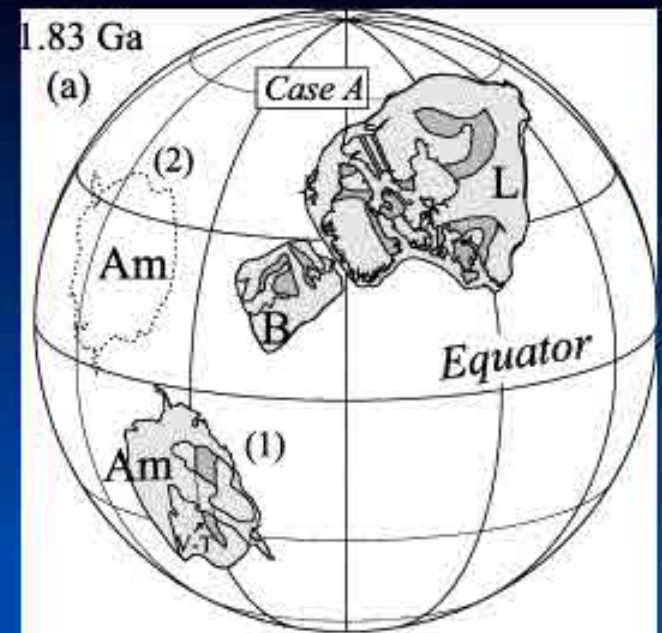
Pesonen et al. (2003) Tectonophysics

Cratons

- Laurentia
- Baltica
- Amazonia

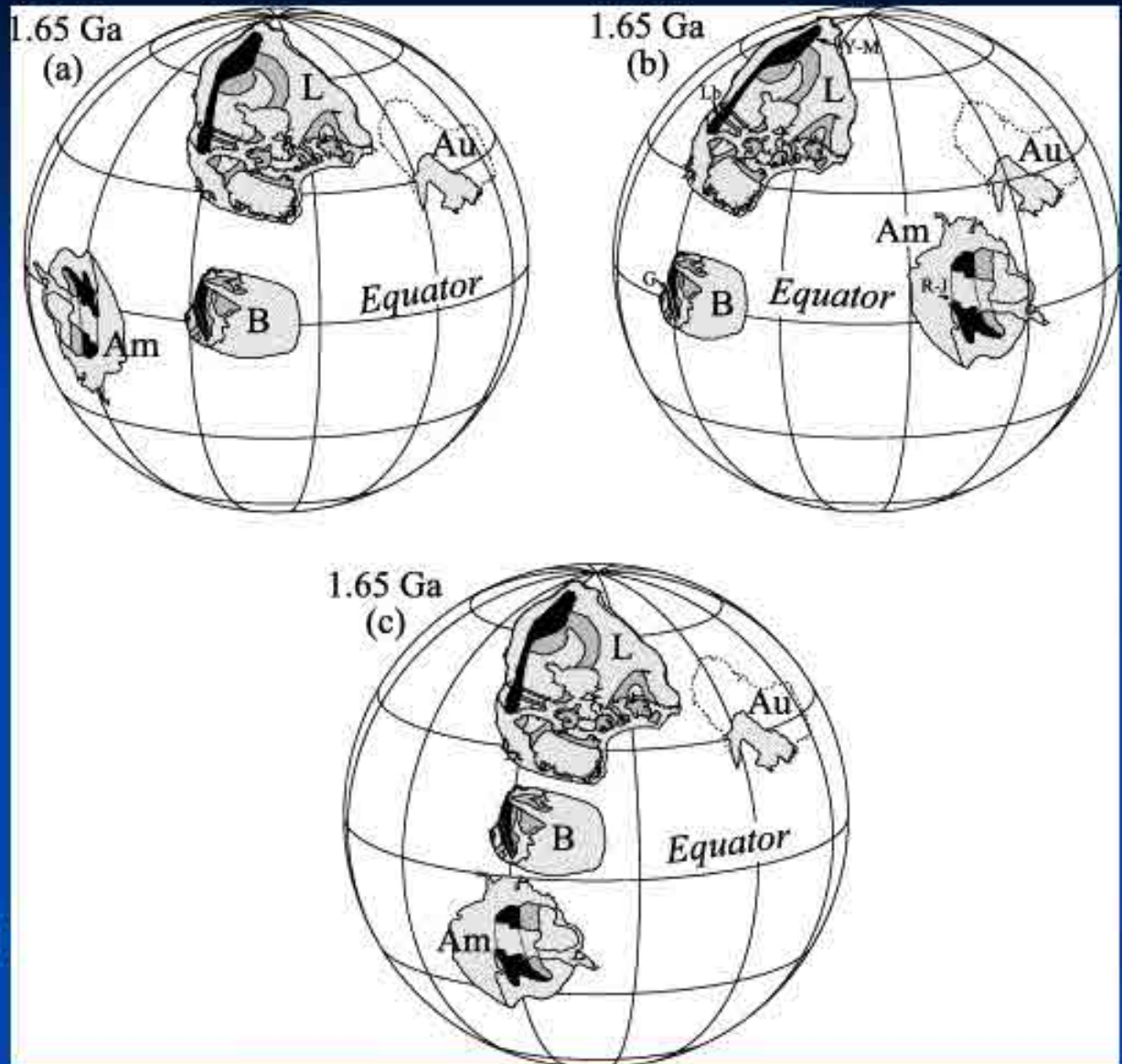
and

- Ukraine
- Australia
- Siberia
- North China
- Kalahari



Hudsonland Break up

Pesonen et al. (2003)
Tectonophysics



Accretionary events From 1.79 to 1.42 Ga

1.79-1.74 Ga Alto Jauru

Van Schmus et al. (1999)

Geraldes et al. (2001)

1.55 Ga Cachoeirinha

Geraldes et al. (2001)

Ruiz et al. (2003)

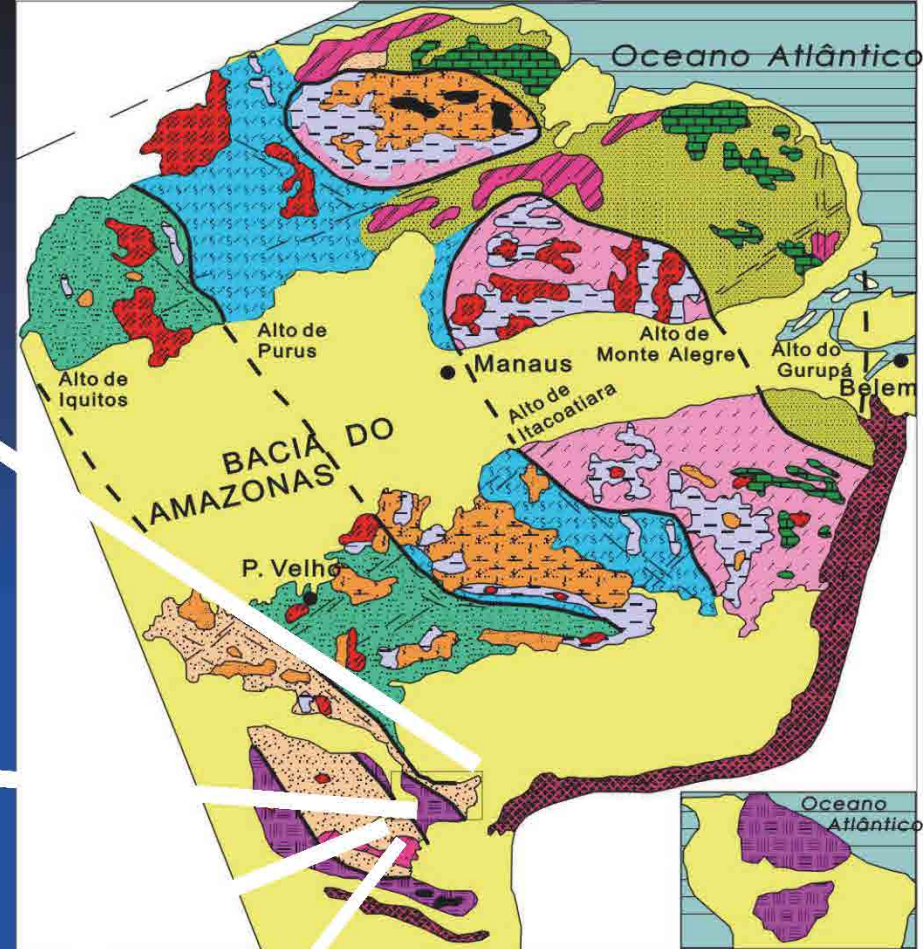
1.51-1.49 Ga Rio Alegre

Geraldes et al. (2001)

Matos et al. (2003)

1.45-1.42 Ga Santa Helena

Geraldes et al. (2001)



Large and
continuous
ocean ?

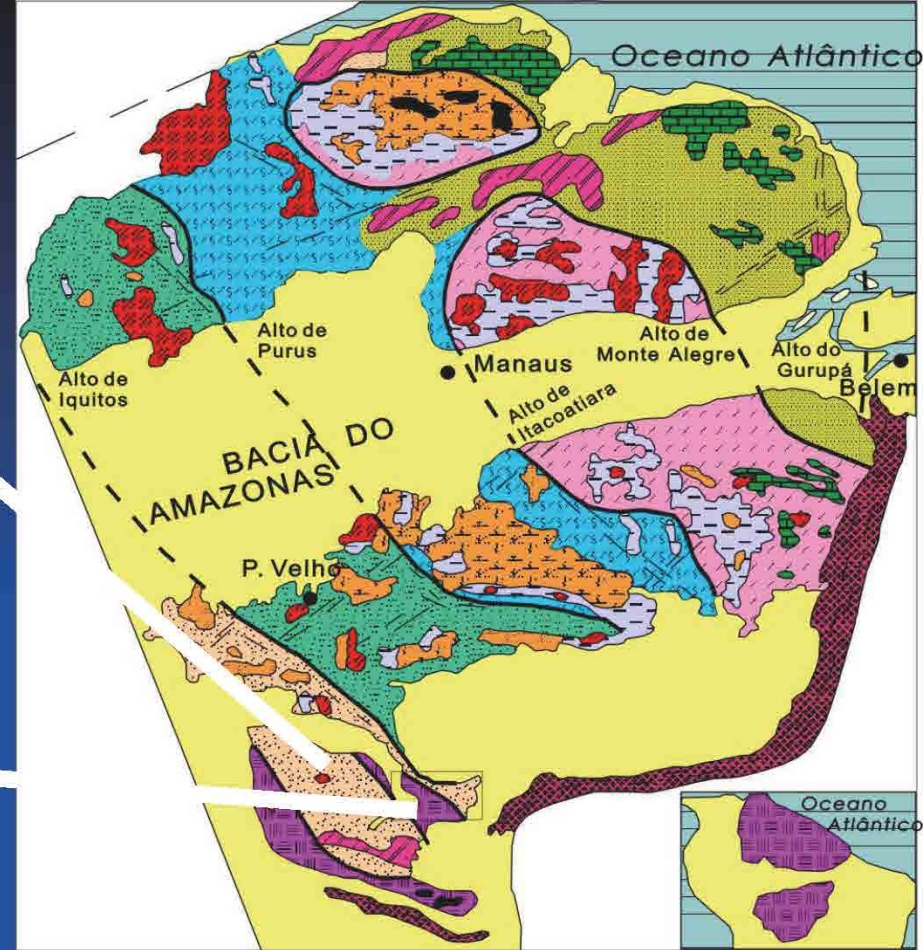
Accretionary events From 1.68 to 1.42 Ga

**1.68-1.62 Ga Lomas
Maneches**

Borger et al (2005)

**1.36-1.42 Ga
San Ignácio**

Borger et al. (2005)



**Paragua craton
versus (amalgamation)
Amazonian craton**



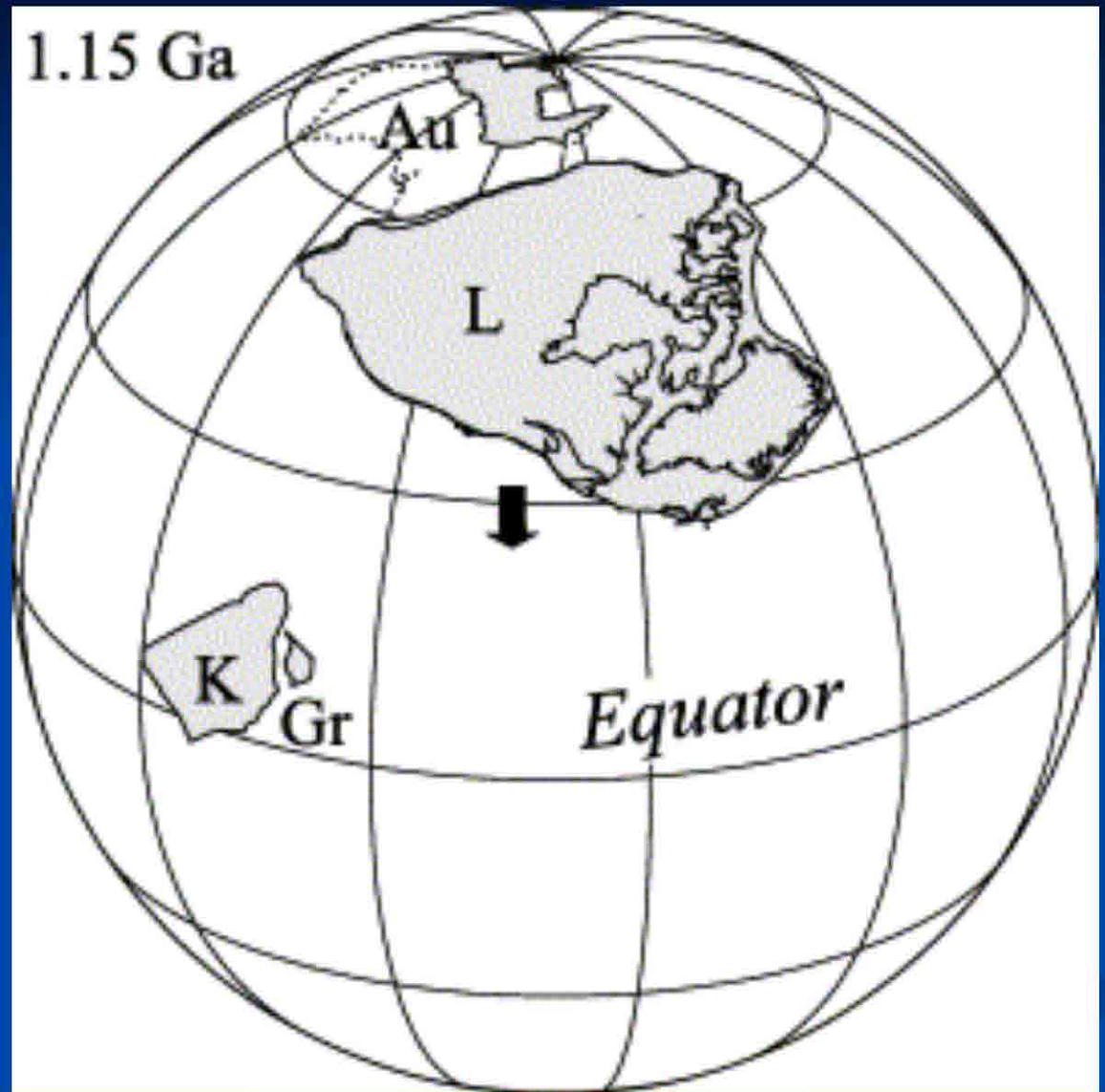
1.32 Ga

granulites

U-Pb in zircon
Ar-Ar (micas)

Rodinia amalgamation

Pesonen et al. (2003)
Tectonophysics

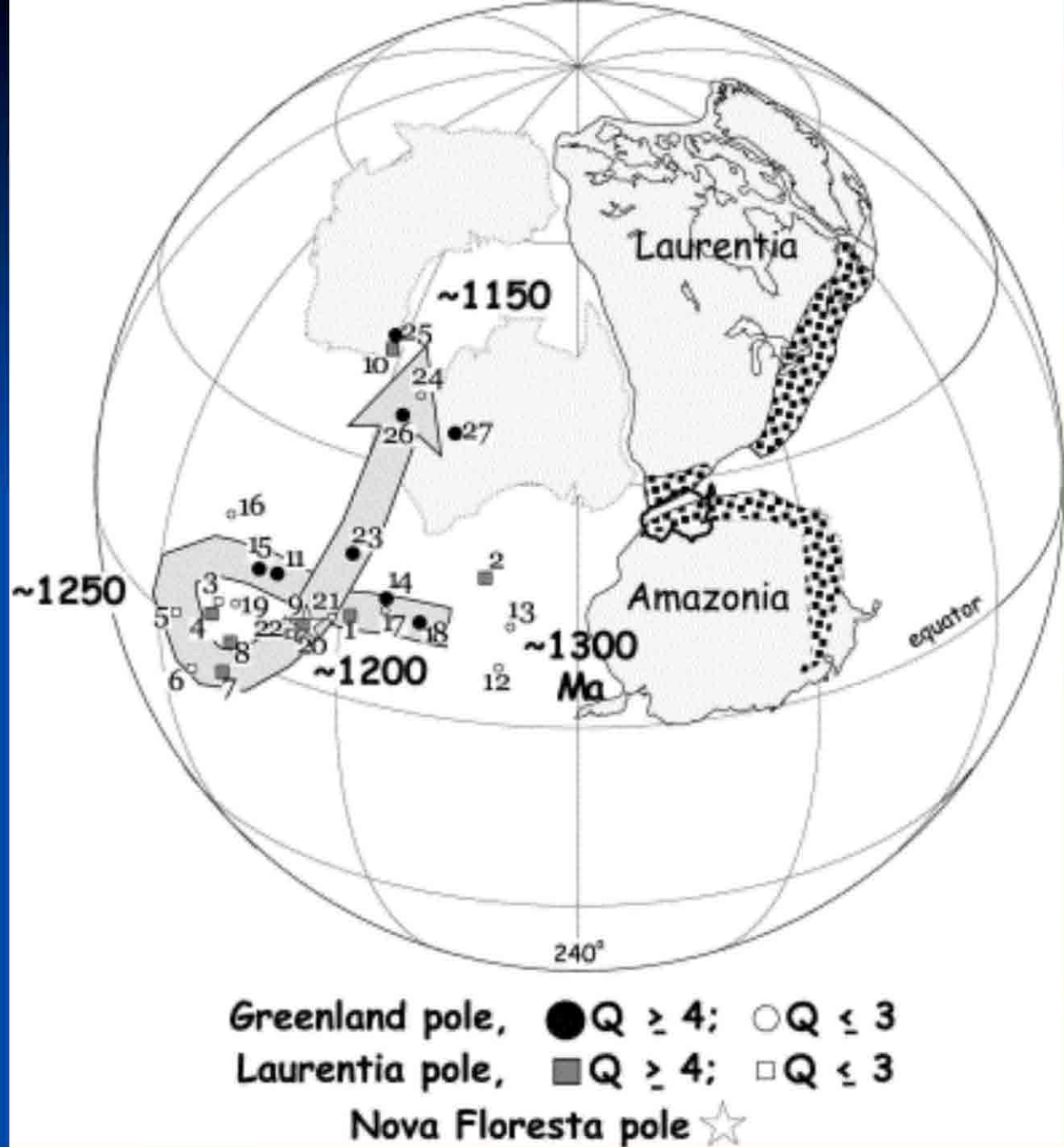


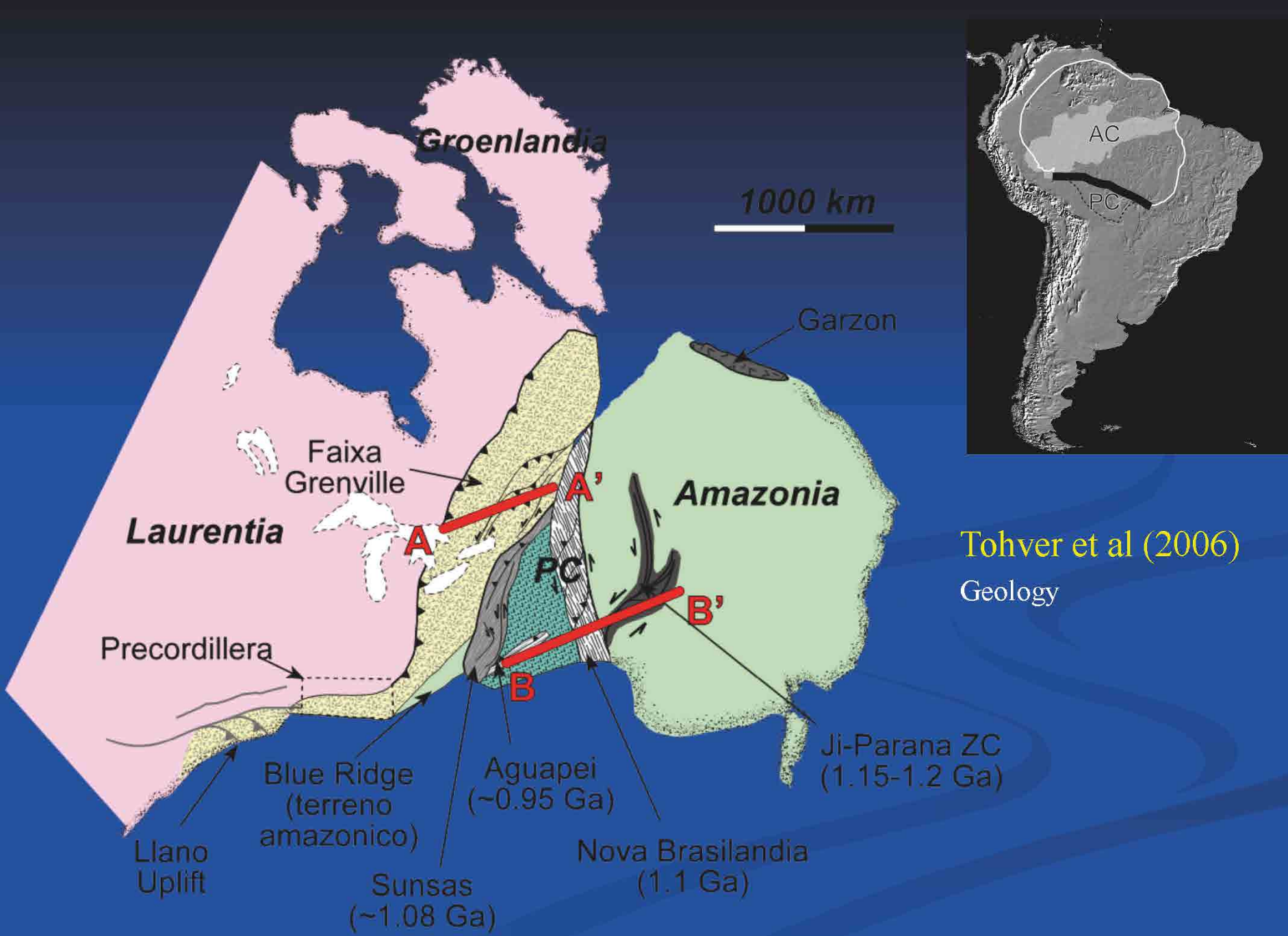
1.20 Ga

Rodinia amalgamation

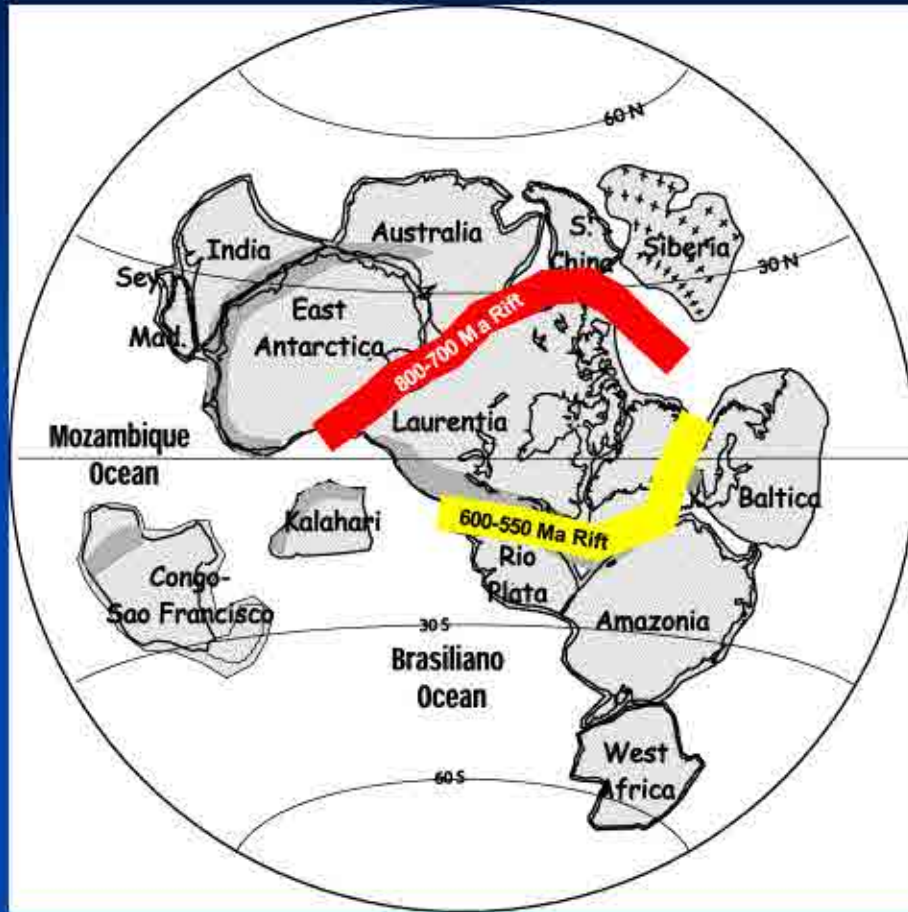
Tohver et al (2002)

Earth and Planetary
Science Letters





Rodinia

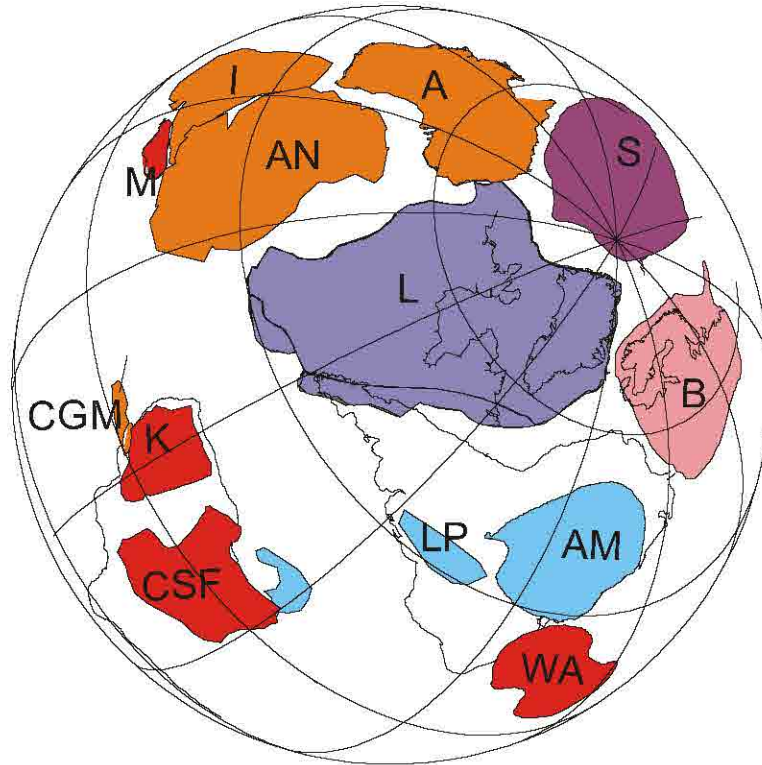


Dalziel, 1997



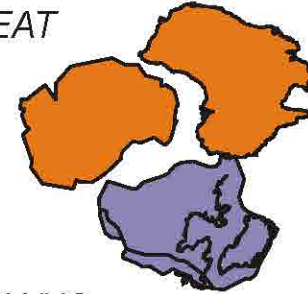
Weil et al. (1998)

Rodinia

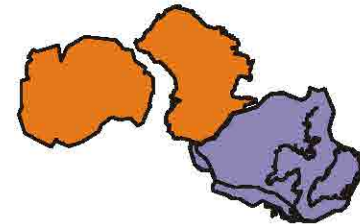


Rodinia (1000 Ma)

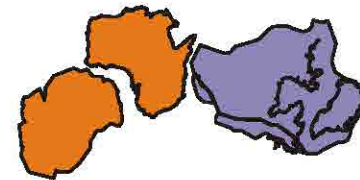
SWEAT

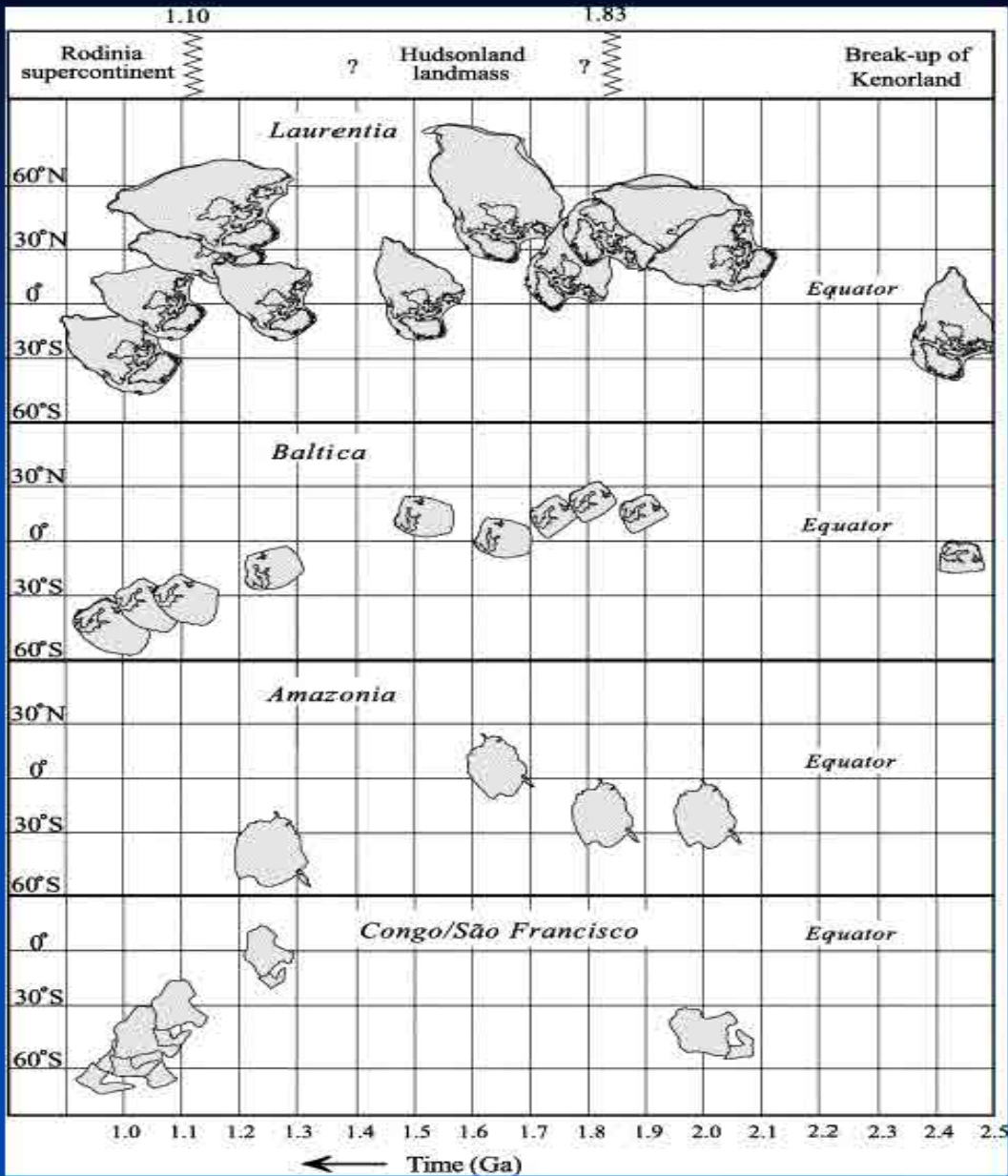


AUSWUS



AUSMEX





Rodinia

Testing the Reconstructions

Amazonia

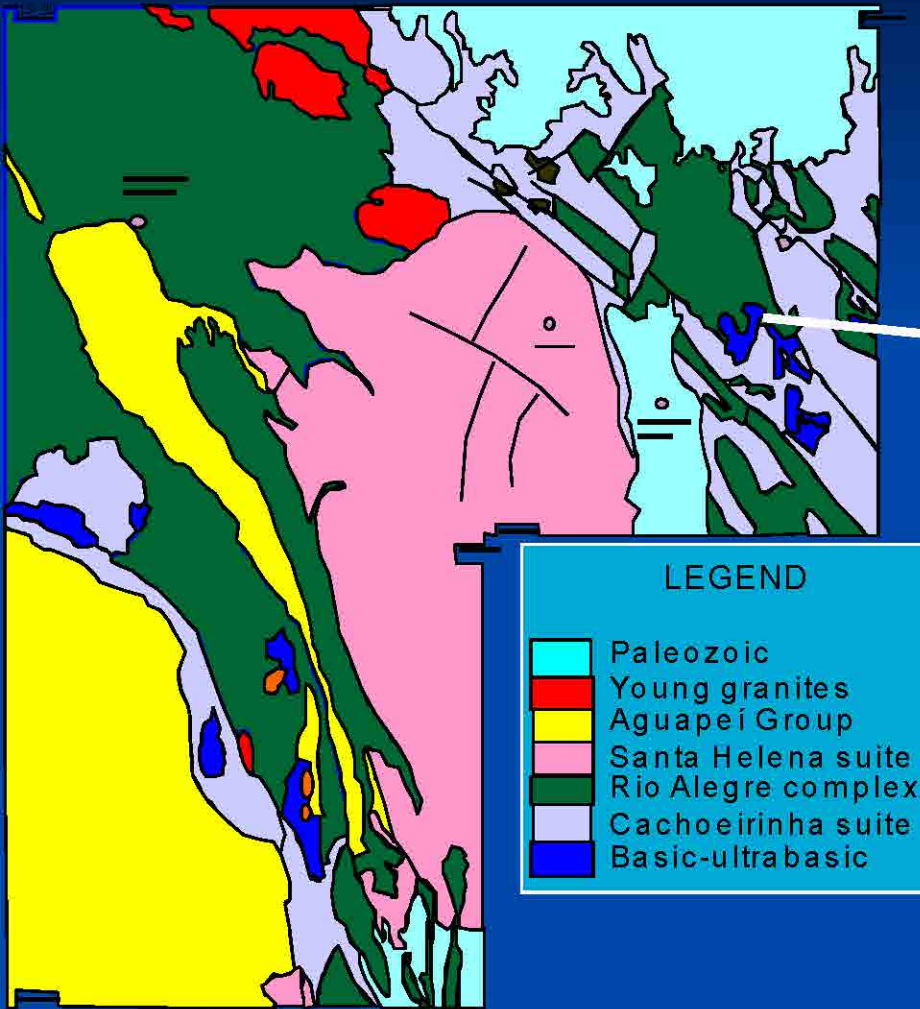


Pesonen et al, 2003

Tectonophysics

Figueira Branca

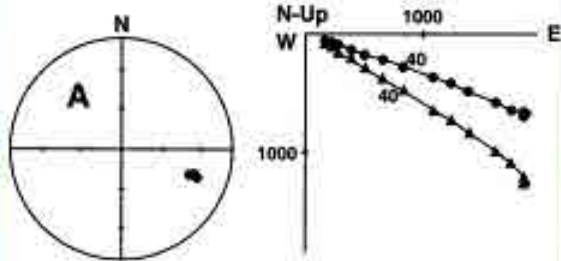
SW Amazonian craton



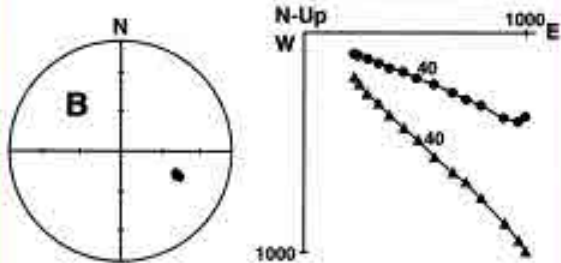
Basic-ultrabasic
layered complex
1.7-1.5 Ga



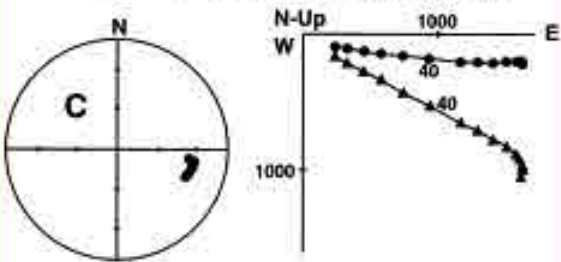
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Comment: ANORTHOSITE FOLIATION:040/30



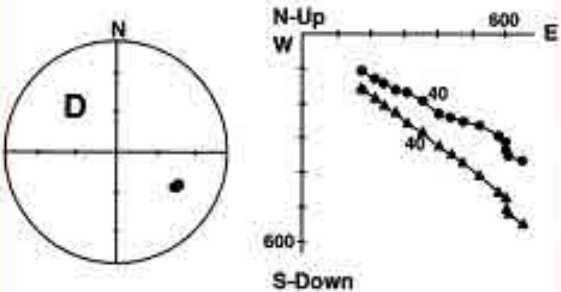
Sample: CL 14-6-2 AF: 0.0 to 99.0 mT
Comment: ANORTHOSITE FOLIATION:080/50



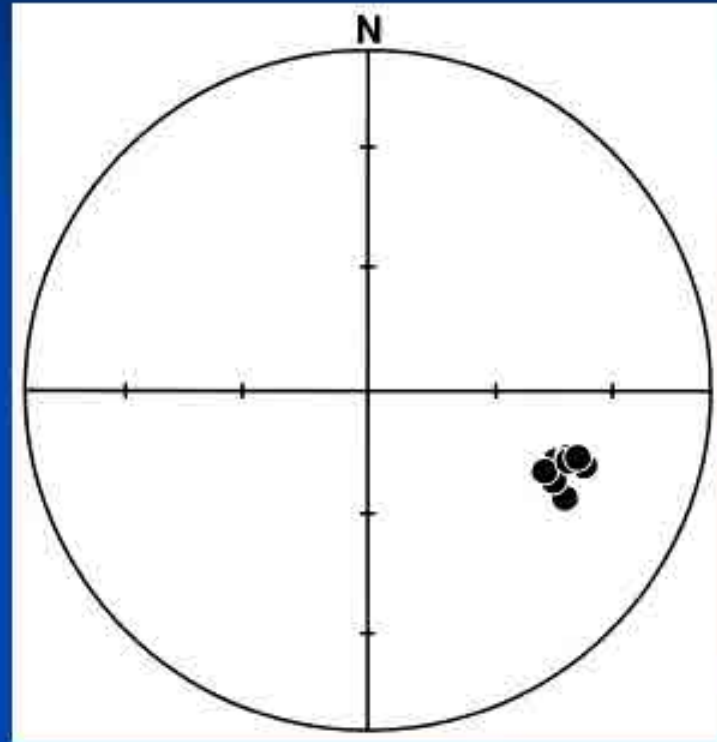
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Comment: ANORTHOSITE FOLIATION:130/50



Sample: FL 4-5-2 AF: 0.0 to 99.0 mT
Comment: ANORTHOSITE FOLIATION:140/40



Lab work

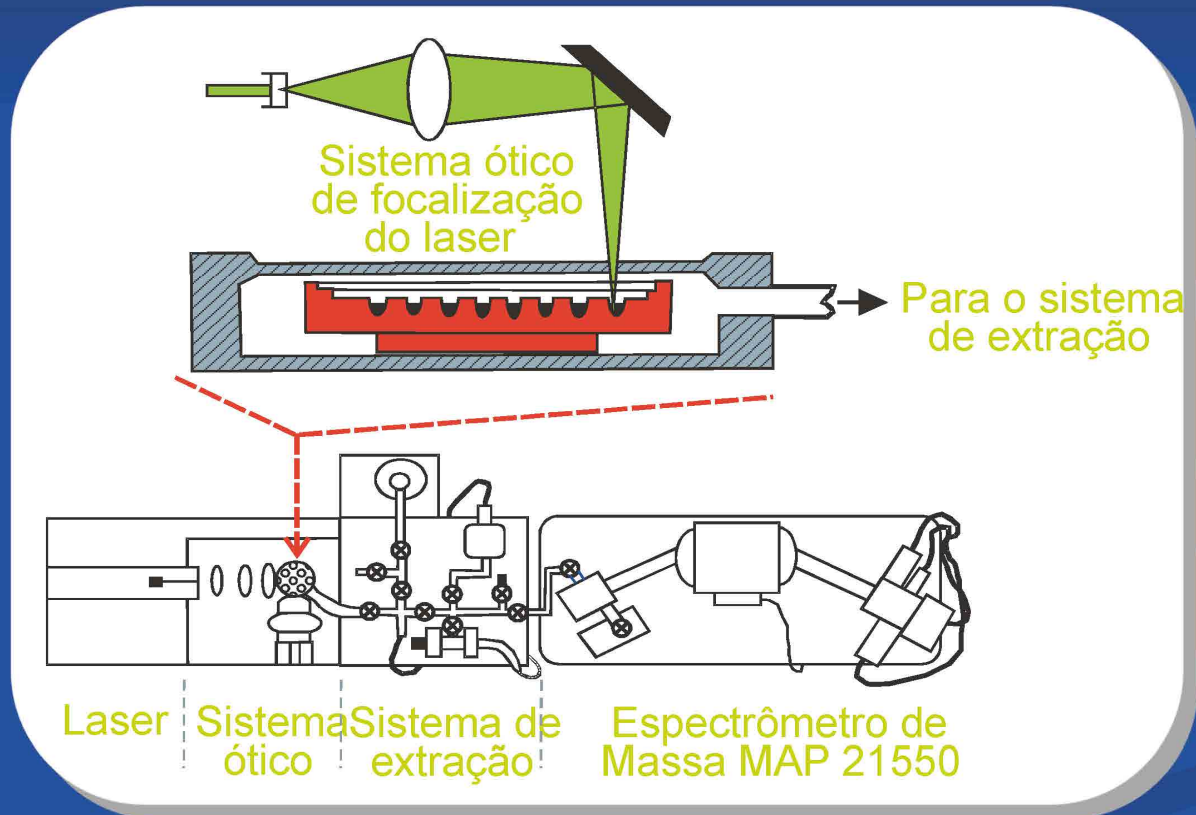


poles



Lab work

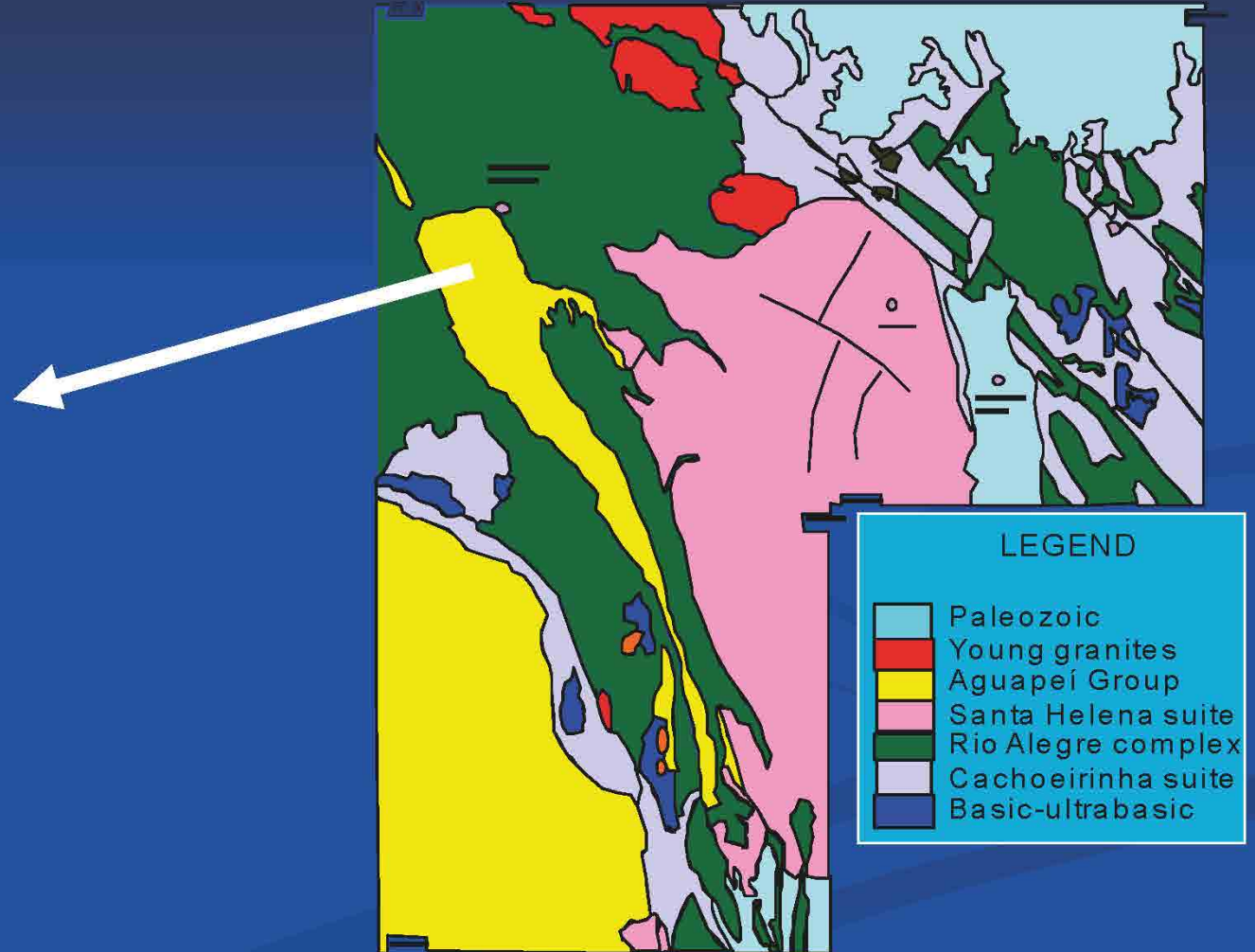
Ar-Ar ages
1570 Ma



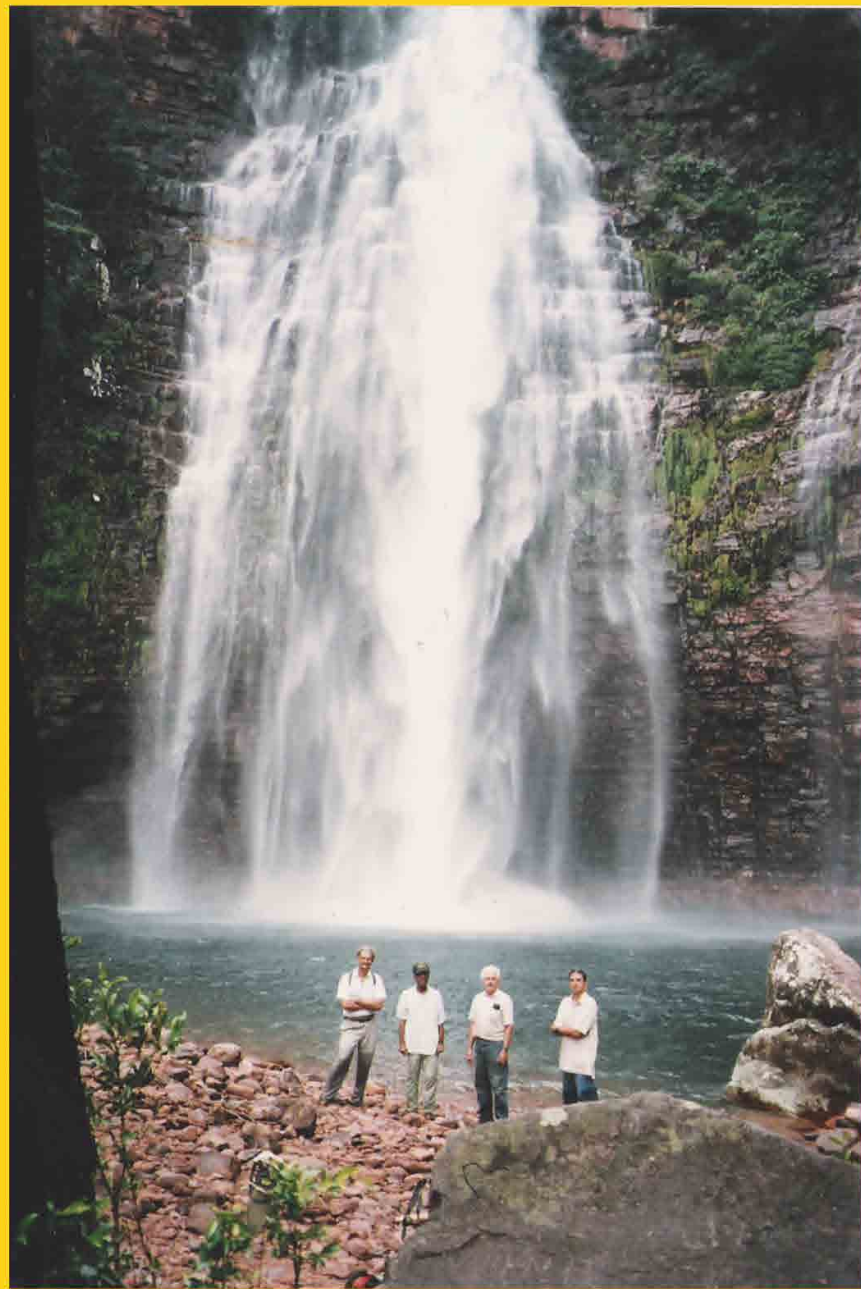
Aguapei Group

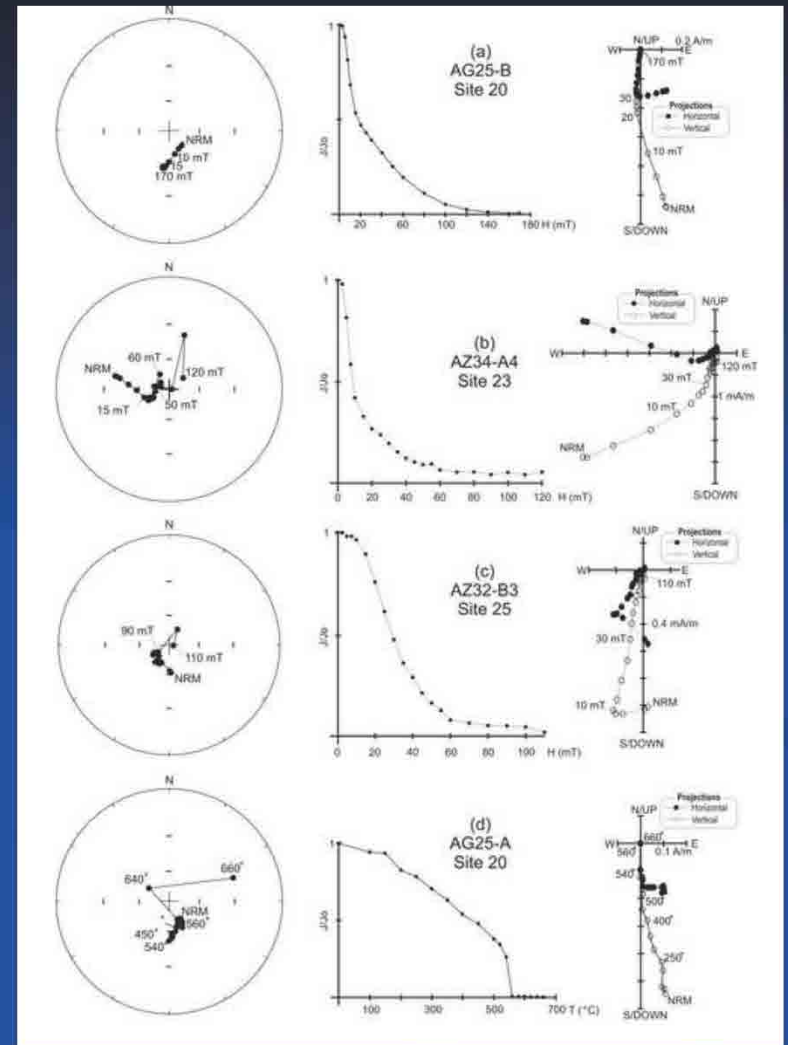
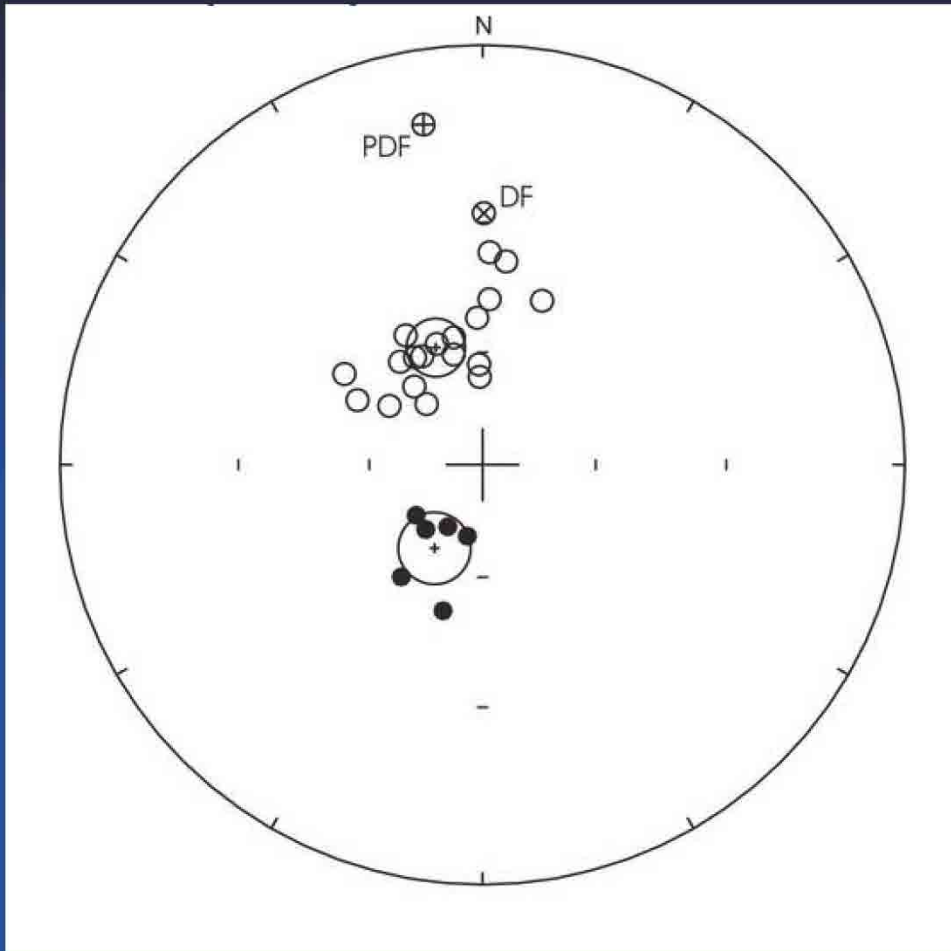
SW Amazonian craton

Quartzites
and
Pelites
1.2-1.0 Ga

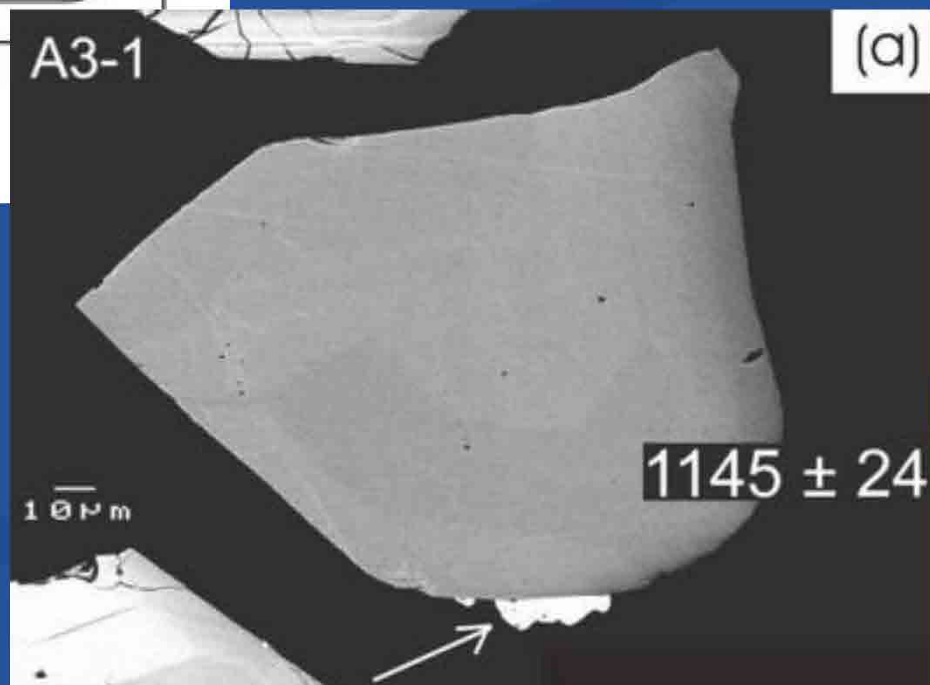
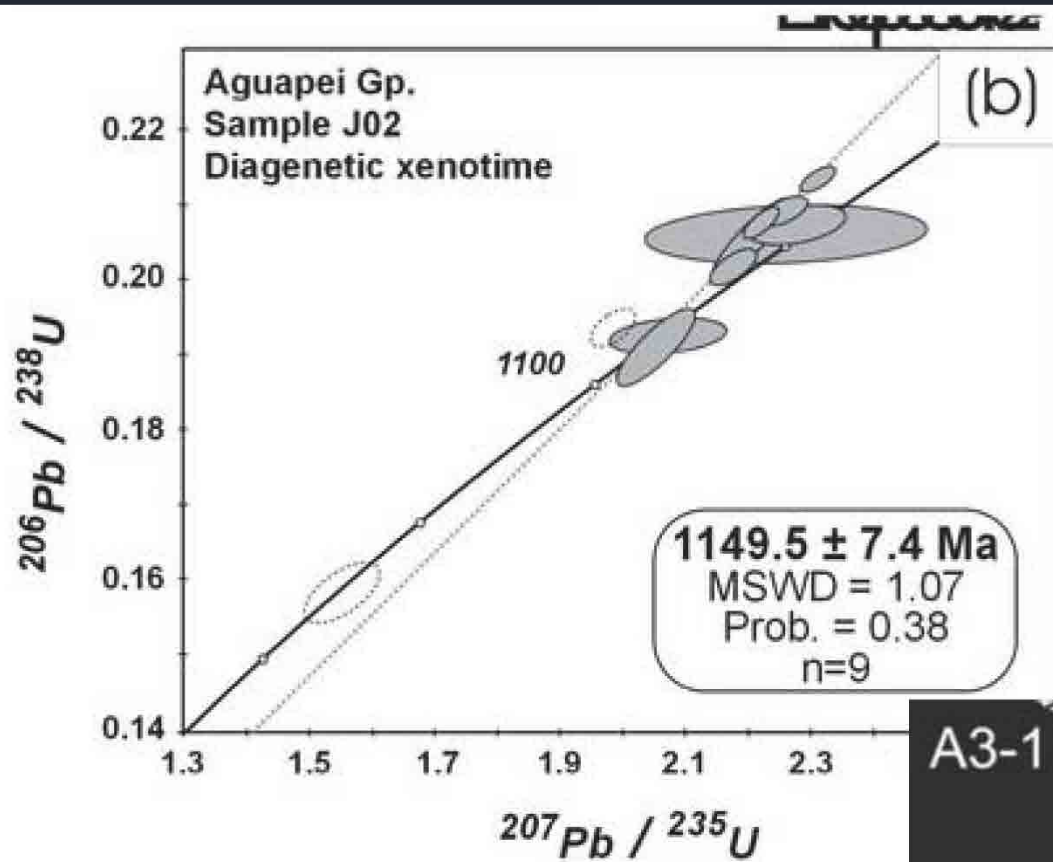


Aguapei Group

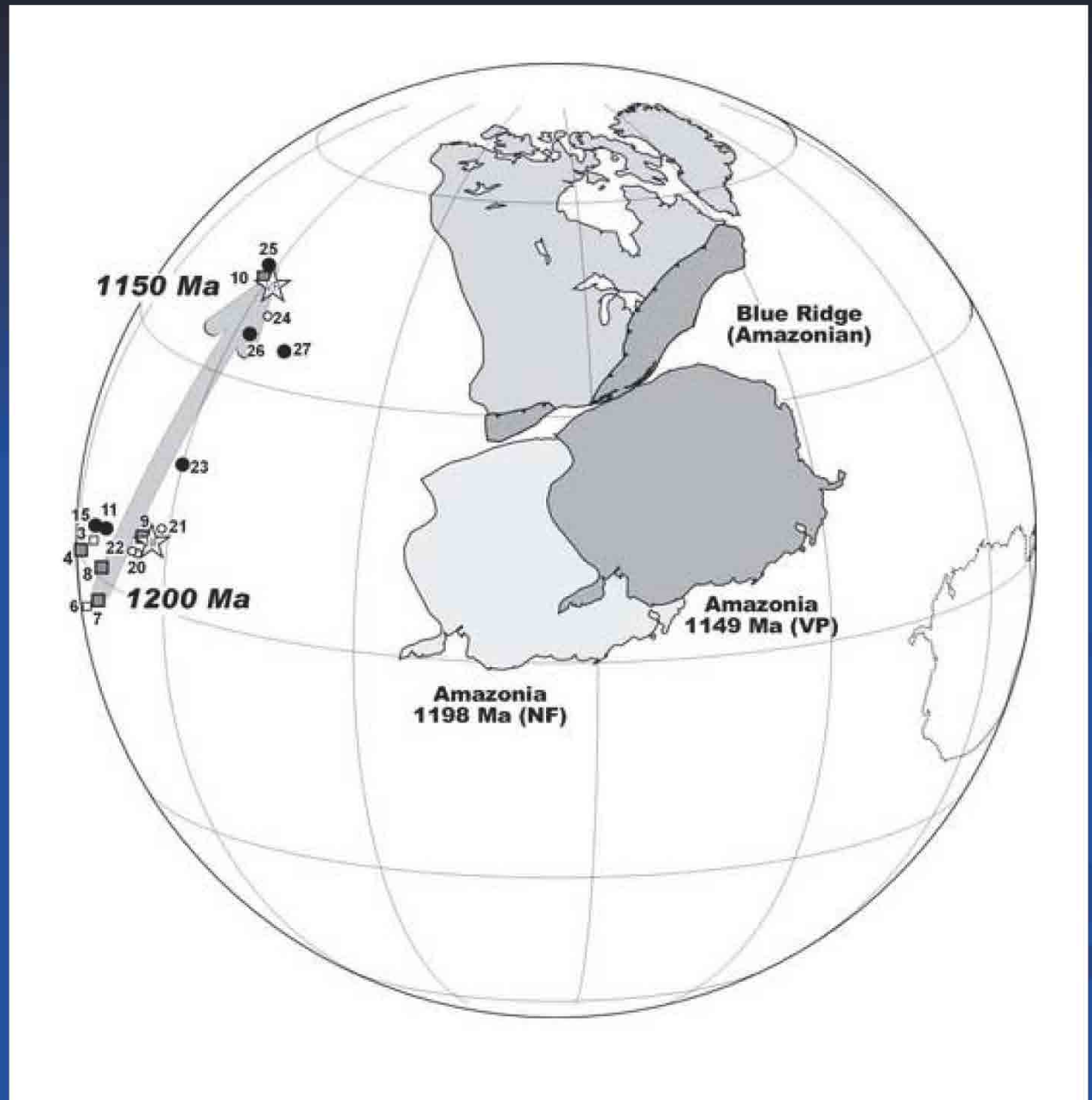




D'Agrella et al. (2006)
 Earth and Planetary Science Letters

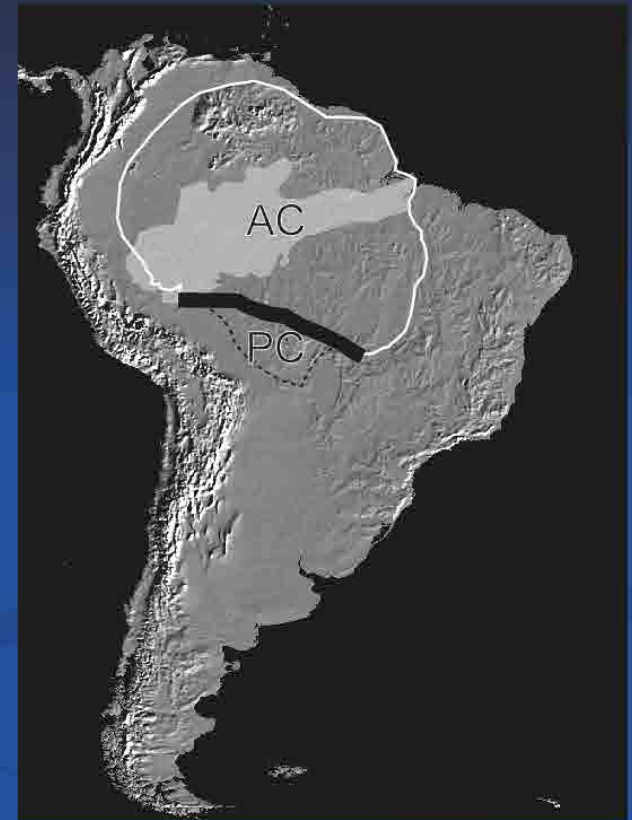
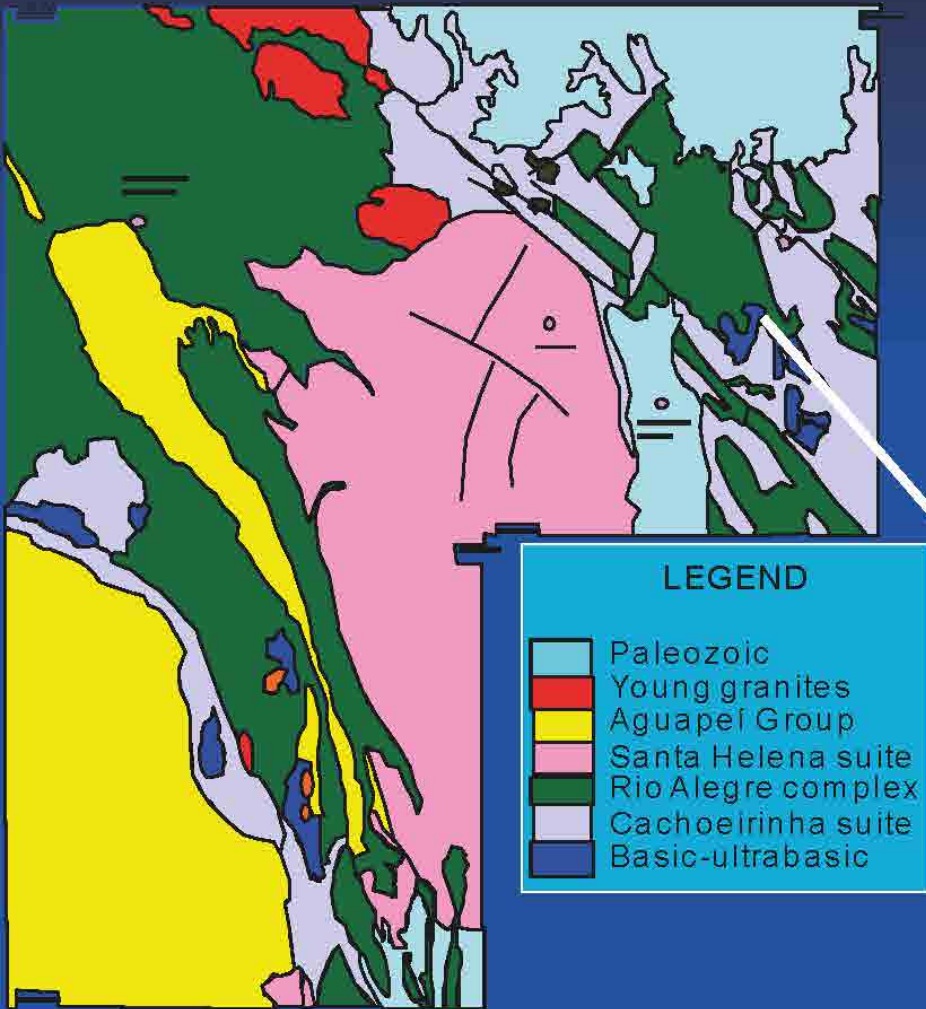


D'Agrella et al. (2006)
Earth and Planetary Science Letters



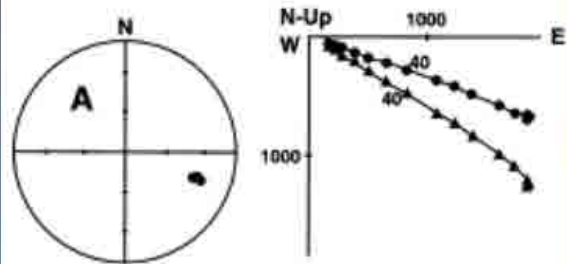
D'Agrella et al. (2006) - Earth and Planetary Science Letters

SW craton Amazônico

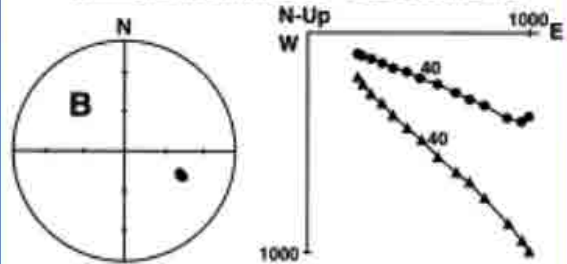


Dikes and sills

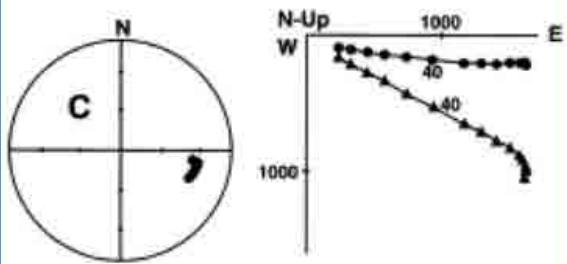
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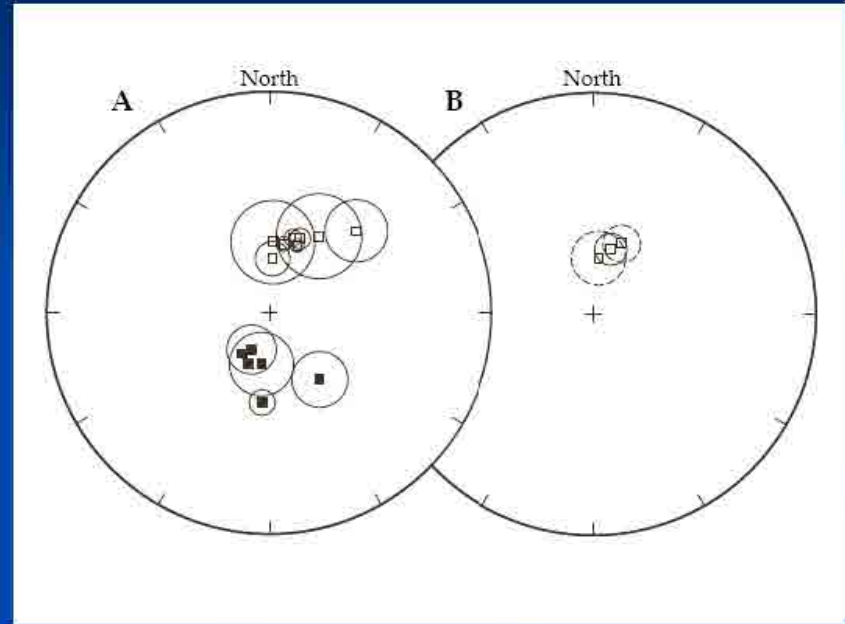
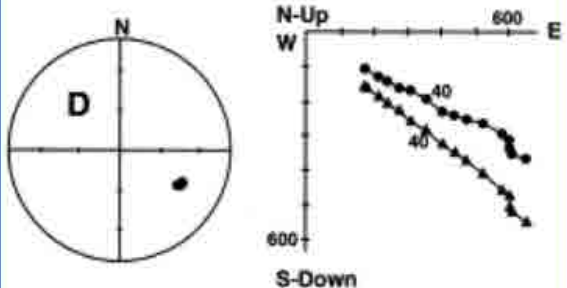
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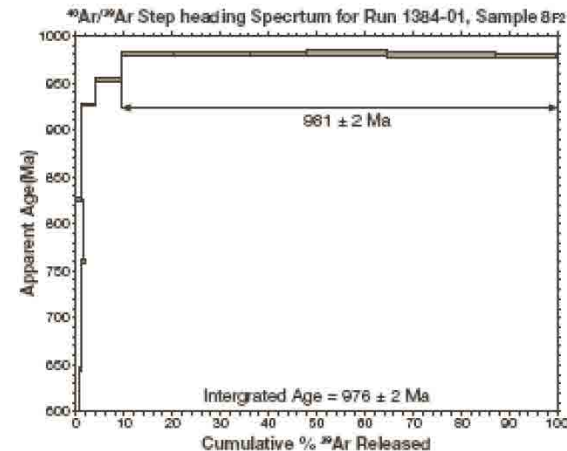
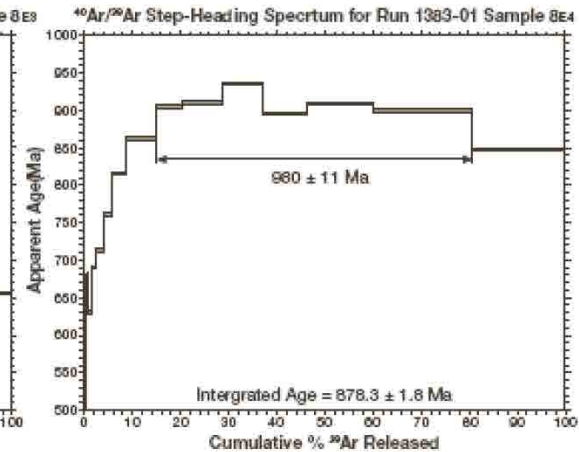
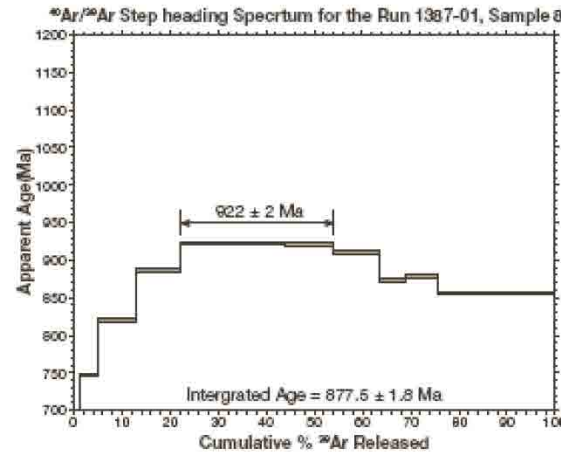
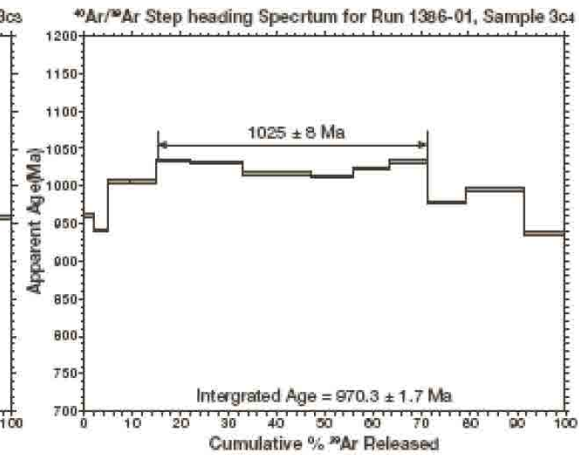
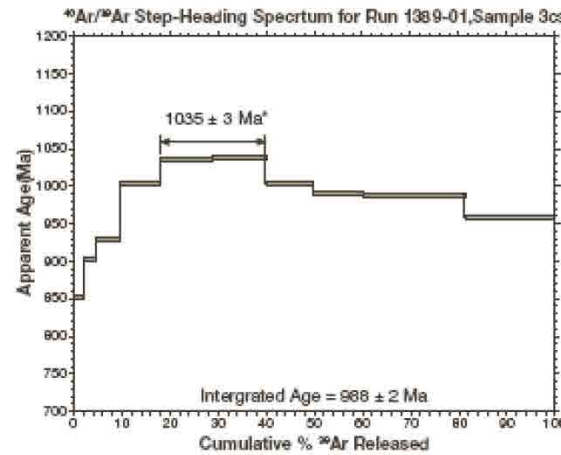


Elming et al.
(J. of Geophysical Research, 2009)

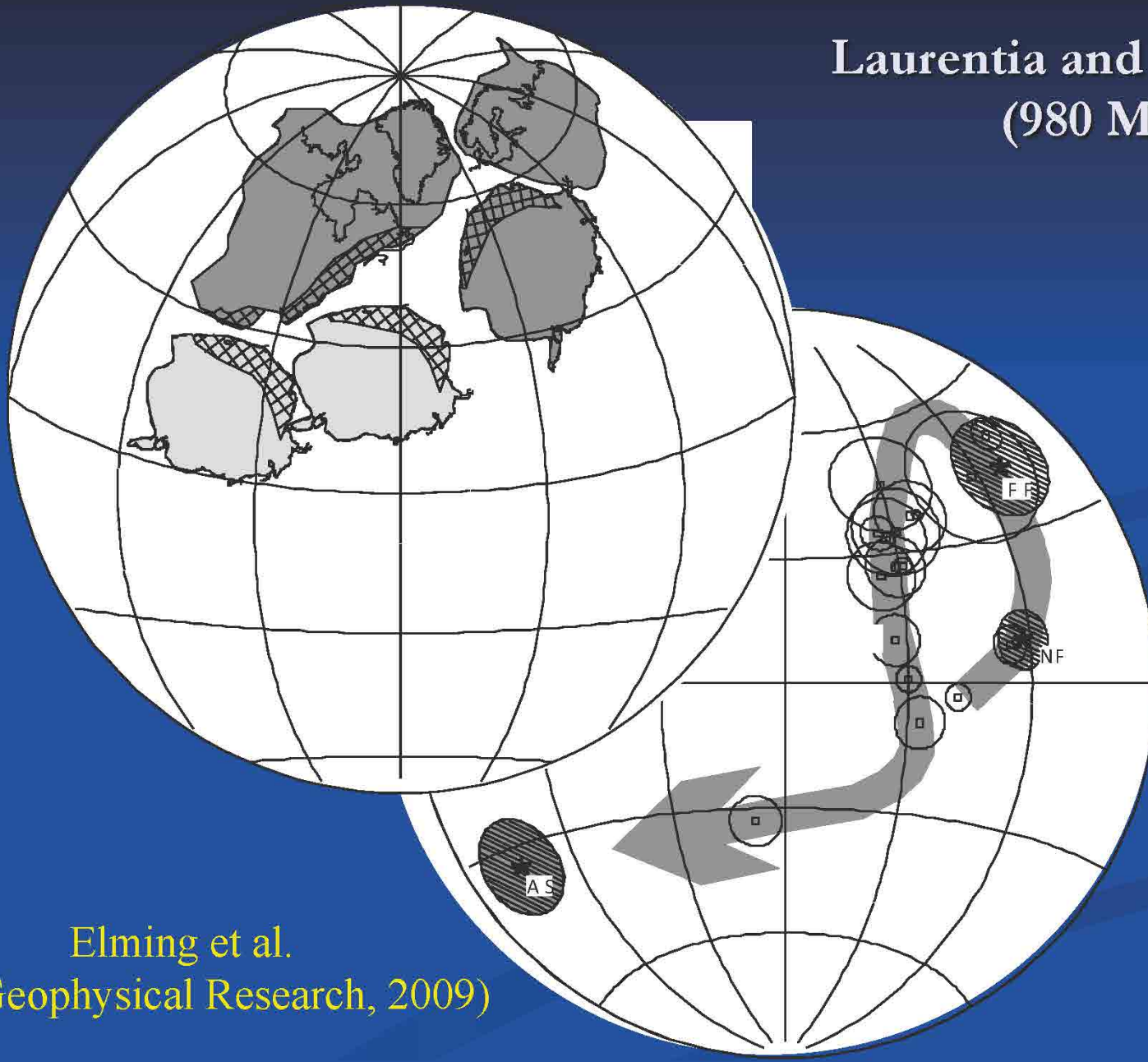
Idades Ar-Ar



Elming et al.
(J. of Geophysical Research
2009)



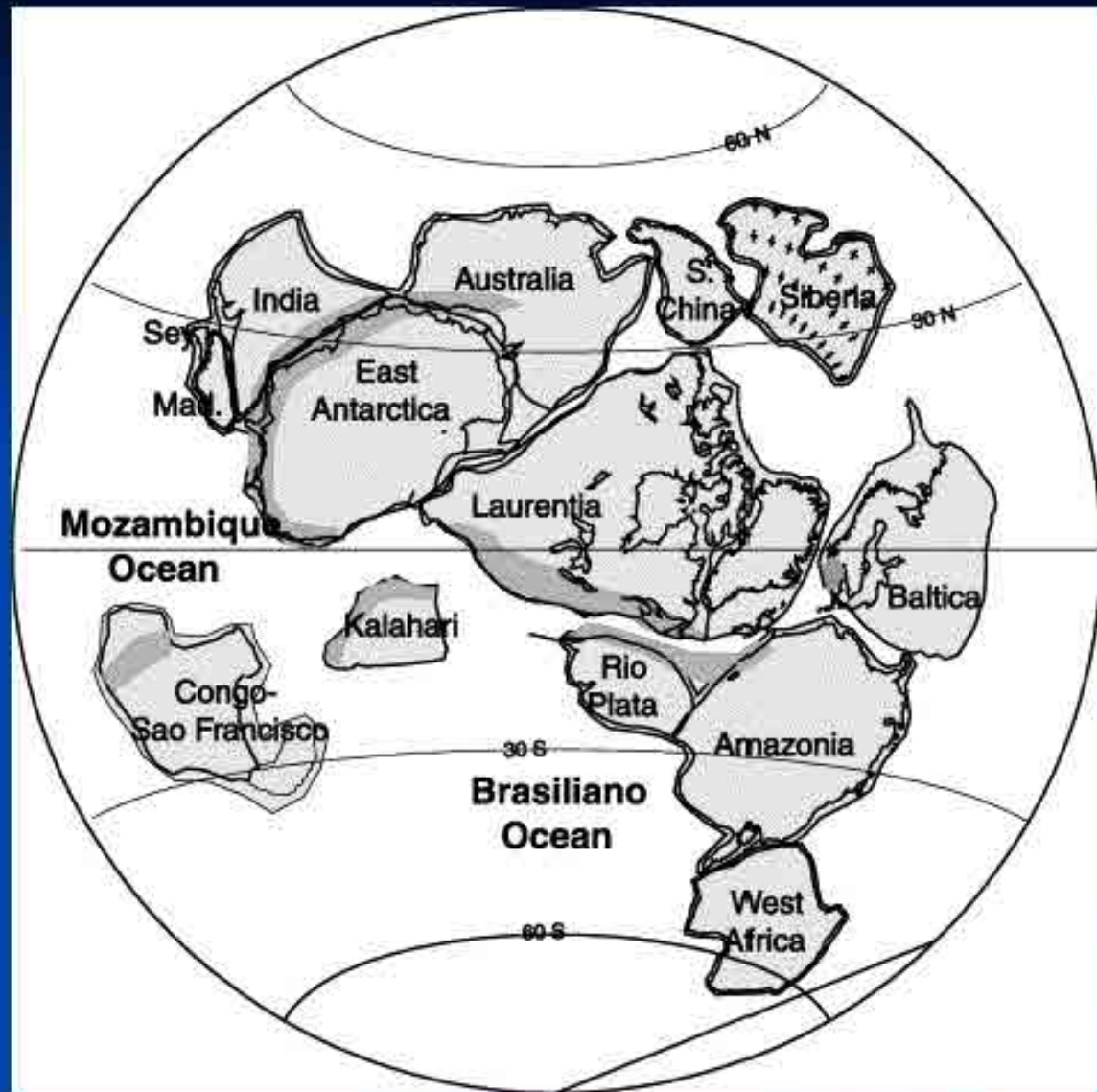
Laurentia and Amazônia (980 Ma)



Elming et al.
(J. of Geophysical Research, 2009)

800 Ma

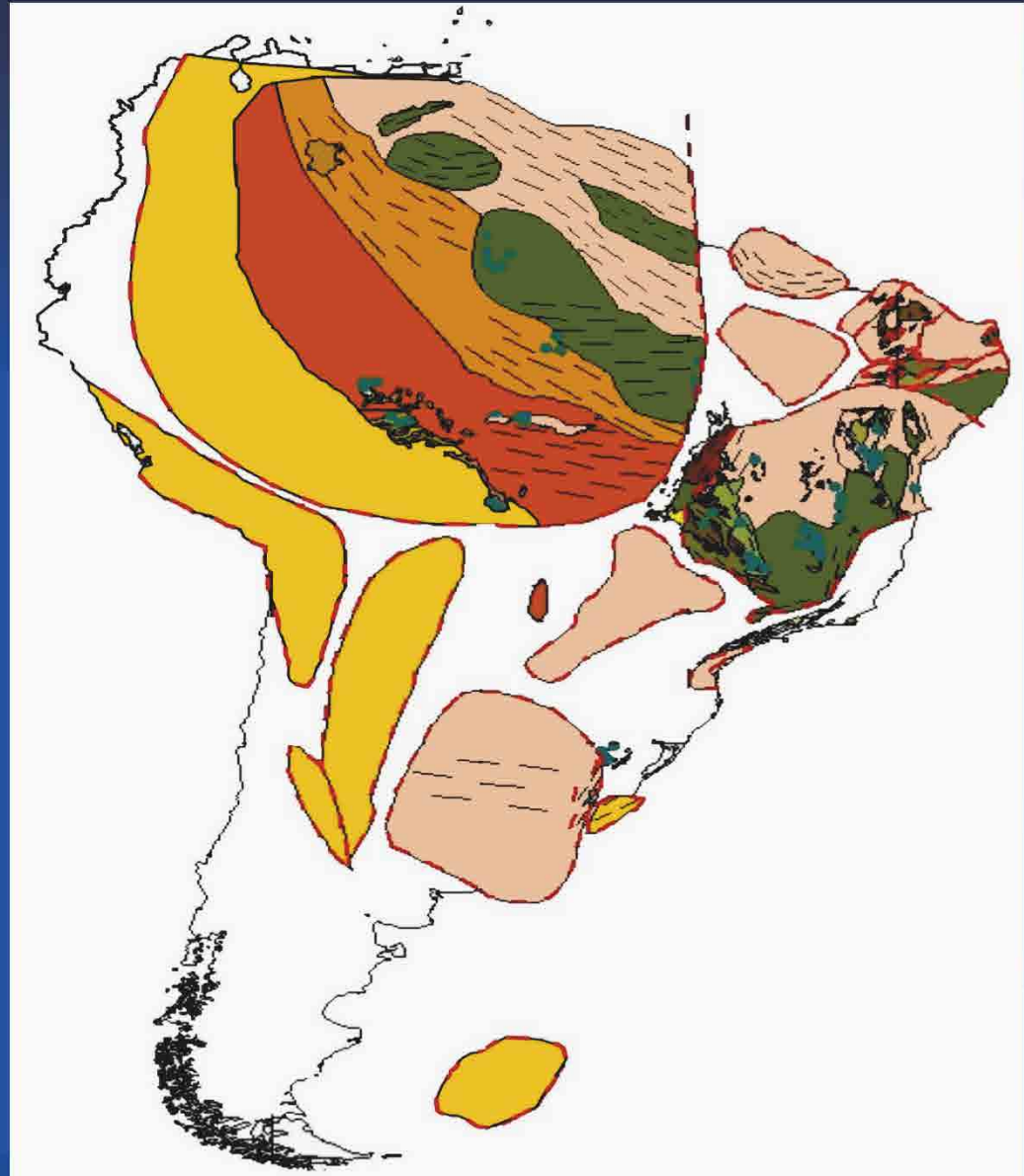
Rodinia
Break up



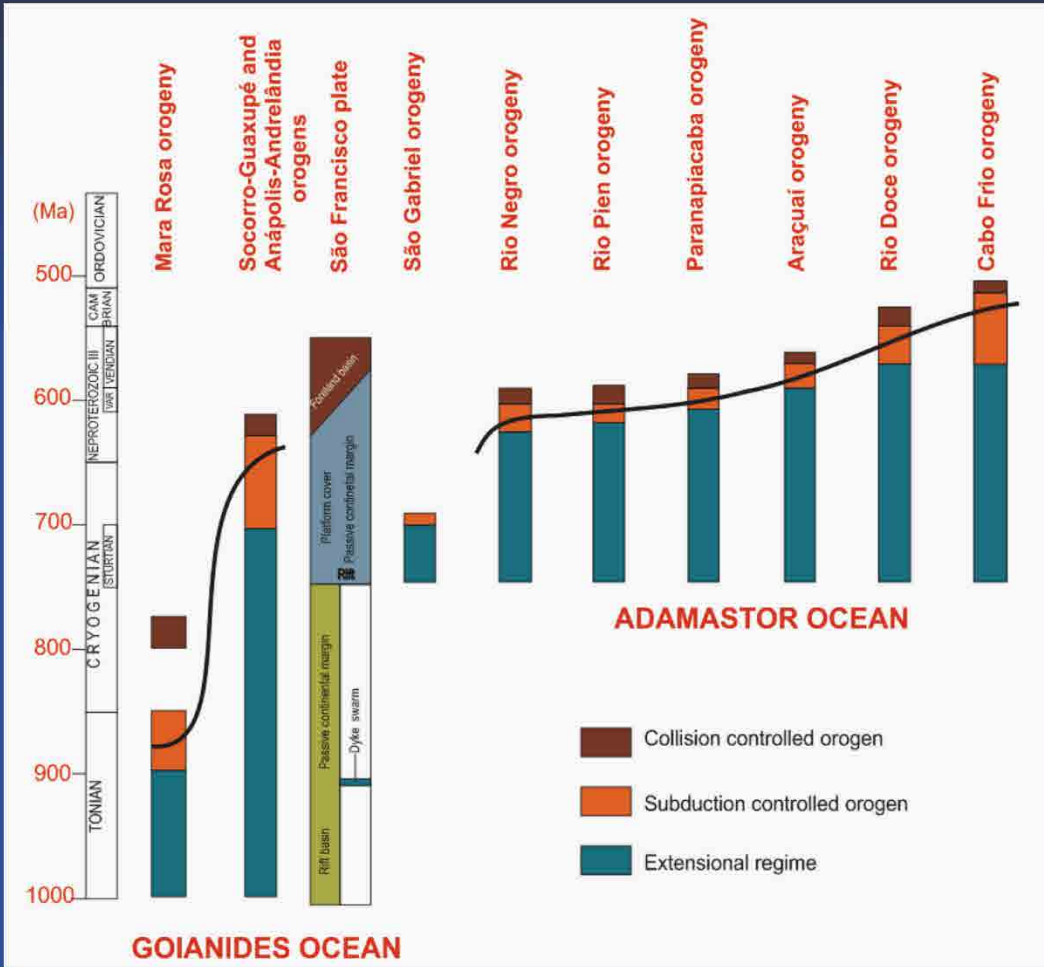
Pesonen et al. (2003) Tectonophysics

CRATONIC FRAGMENTS of SOUTH AMERICA

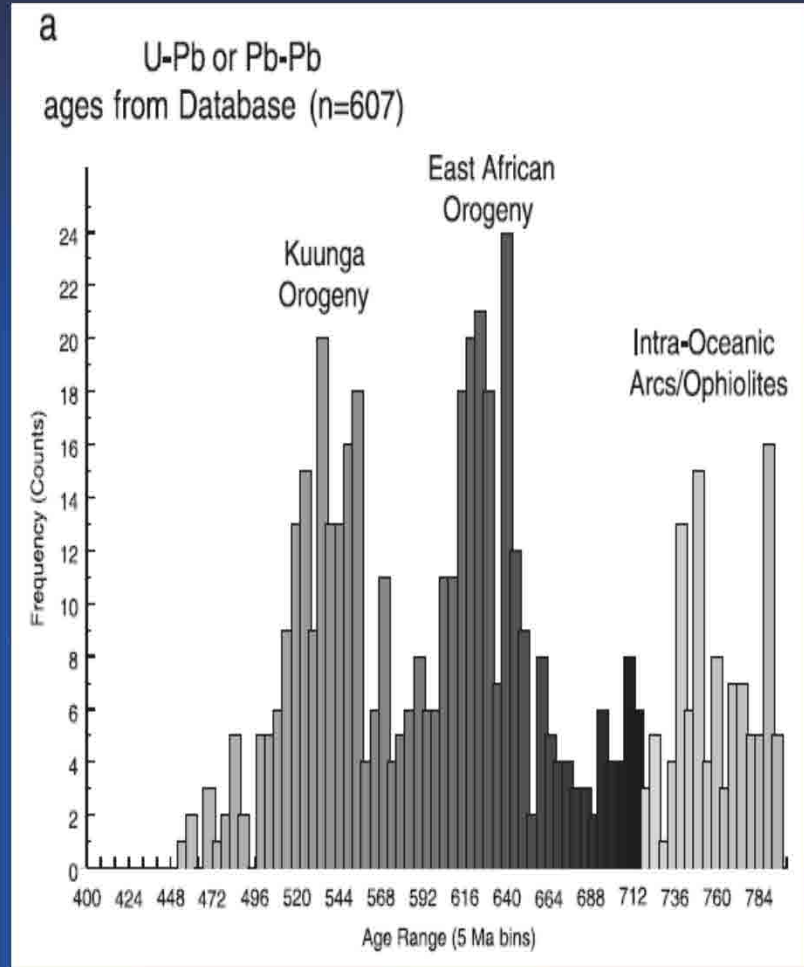
Amazonia
São Francisco
Rio de La Plata
São Luis
Parana
Pampeano
Rio Apa
Arequipa-Antofala



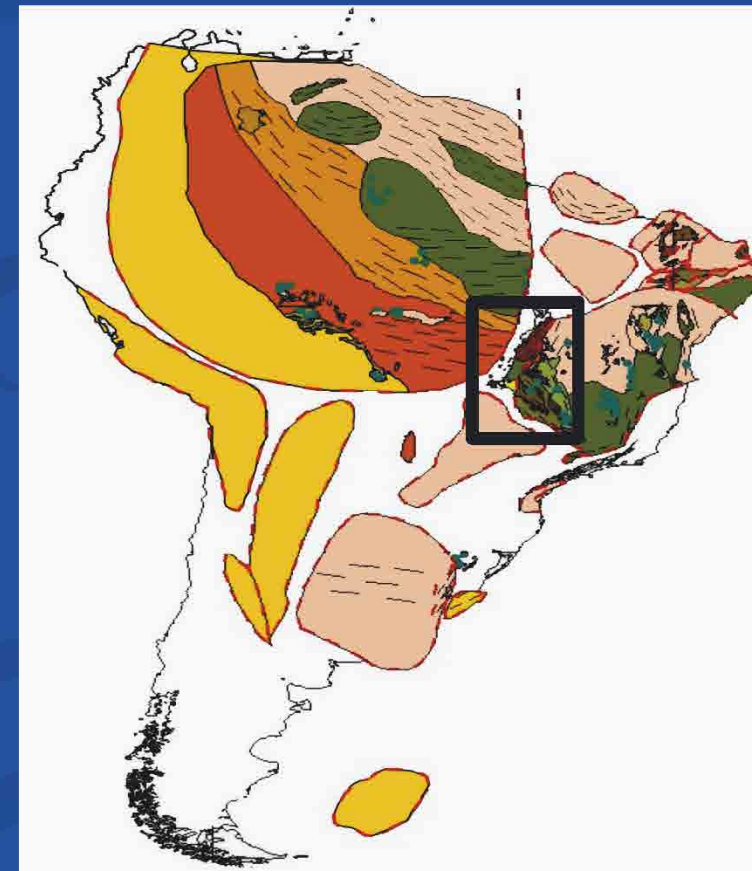
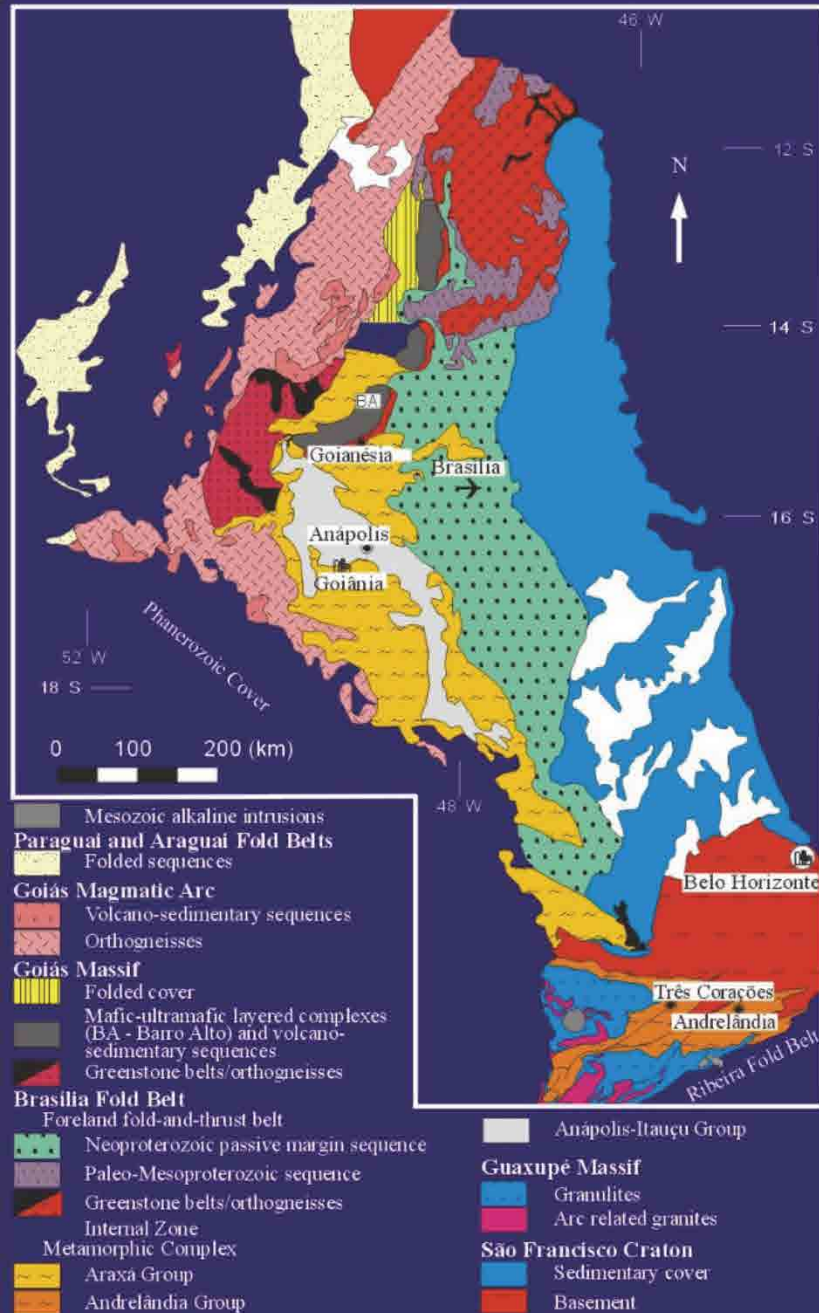
West Gondwana



East Gondwana

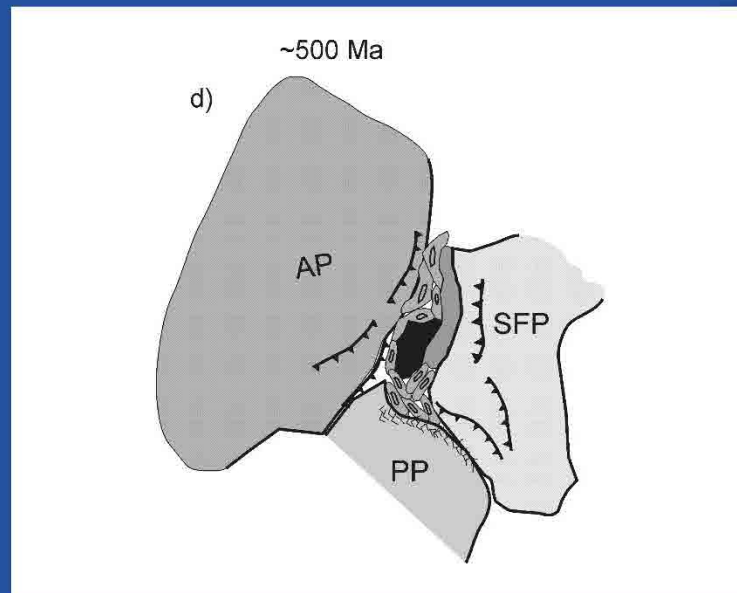
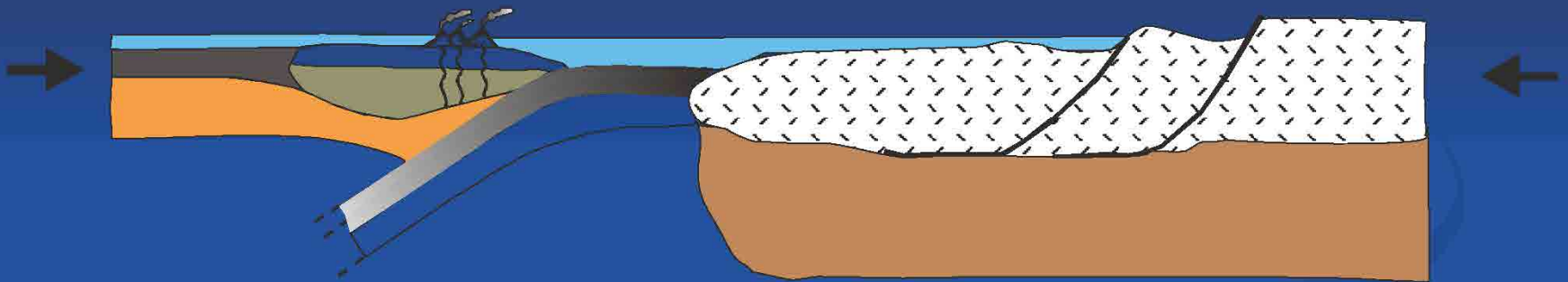


Brasilia Belt



~890Ma

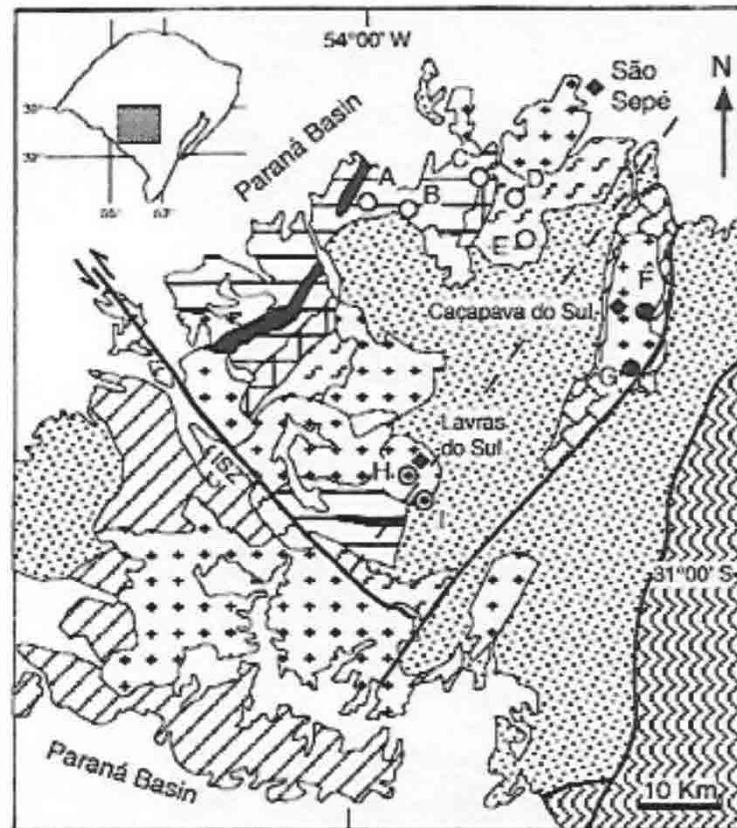
Brasilia Belt



Pimentel et al., 1992

Sao Gabriel Orogen

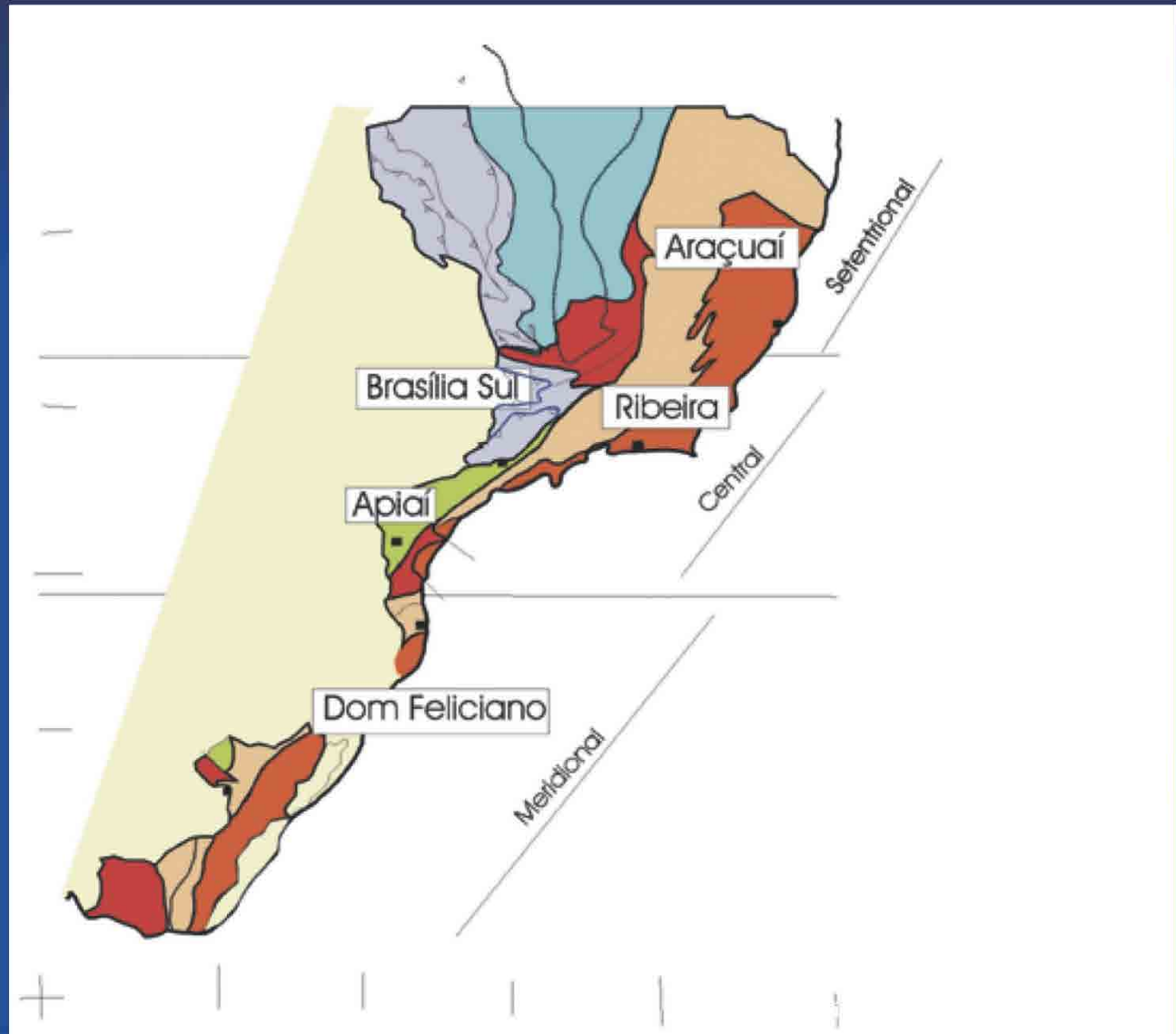
704 Ma



- Phanerozoic cover
- Late to post-tectonic granites of the DF event
- Camaquã basin (molassic basin)
- Cambaí Group**
 - Granitic-gneissic rocks
 - Mafic-ultramafic rocks
- Vacacaí Supergroup**
 - Calc-alkaline metavolcanics and metasediments
 - Passive margin association
 - Mn-rich schists, serpentinites, metabasalts and quartzites
- Paleoproterozoic Basement**
 - Tijucas/Dom Feliciano belts
 - Santa Maria Chlco Granulite Complex (Paleoproterozoic)
- Faults
- ISZ = IBARÉ SHEAR ZONE
- ◆ = City/town

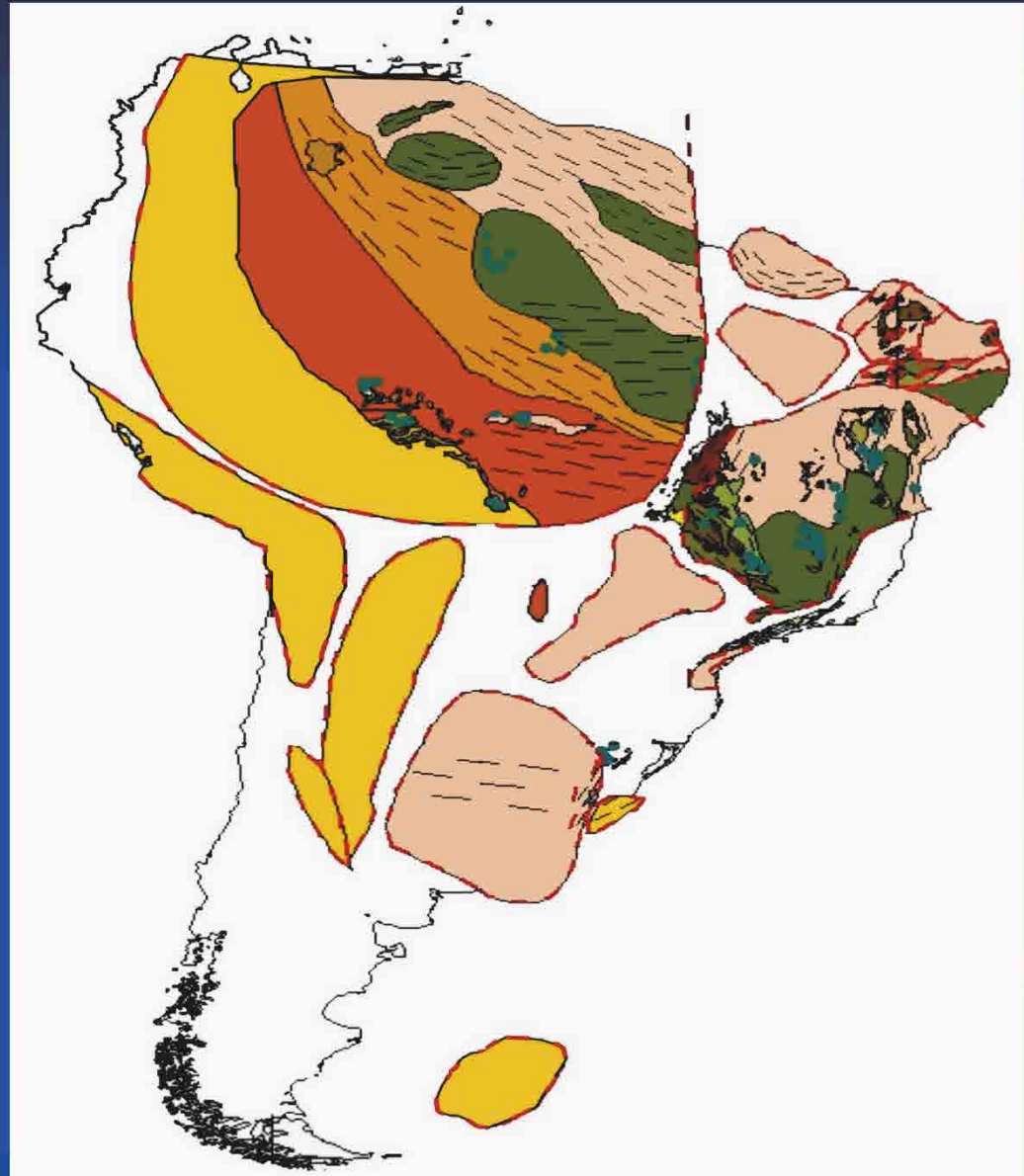
Dom Feliciano Belt

Ribeira Belt

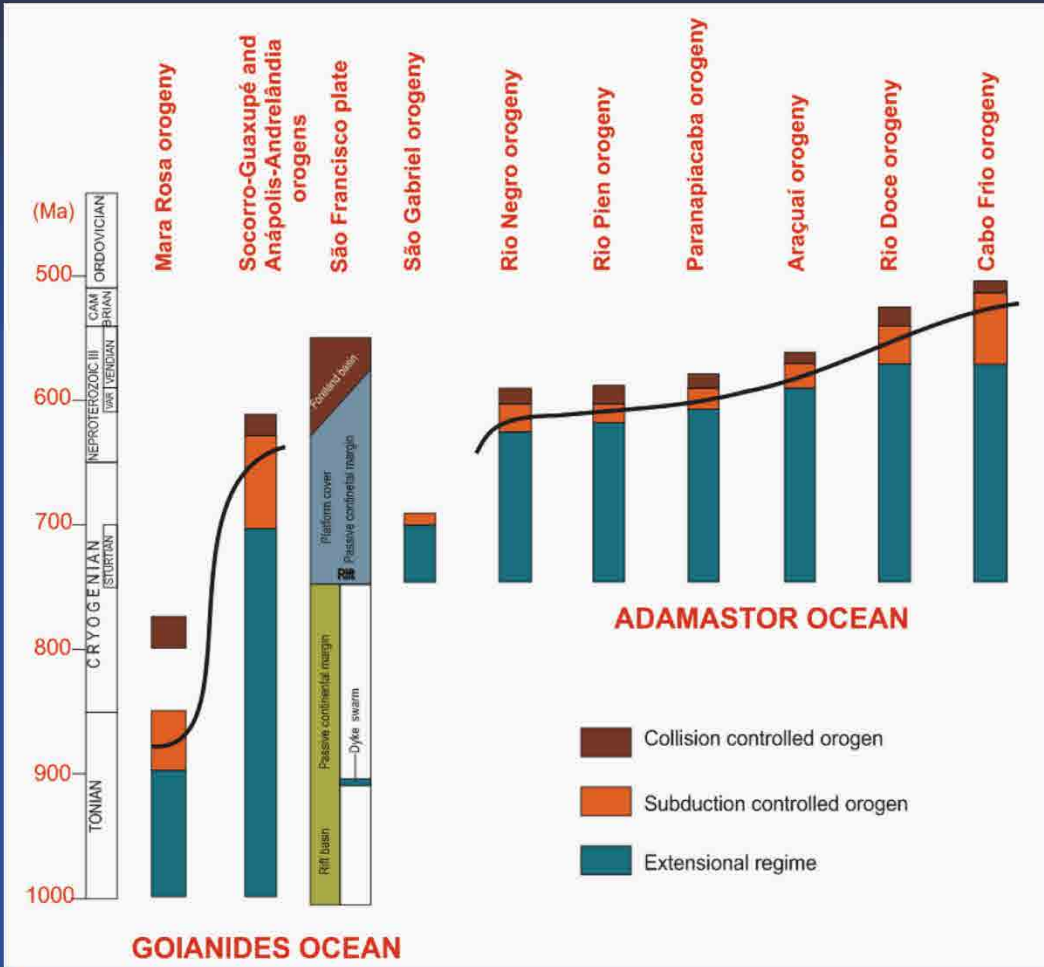


CRATONIC FRAGMENTS of SOUTHERN SOUTH AMERICA

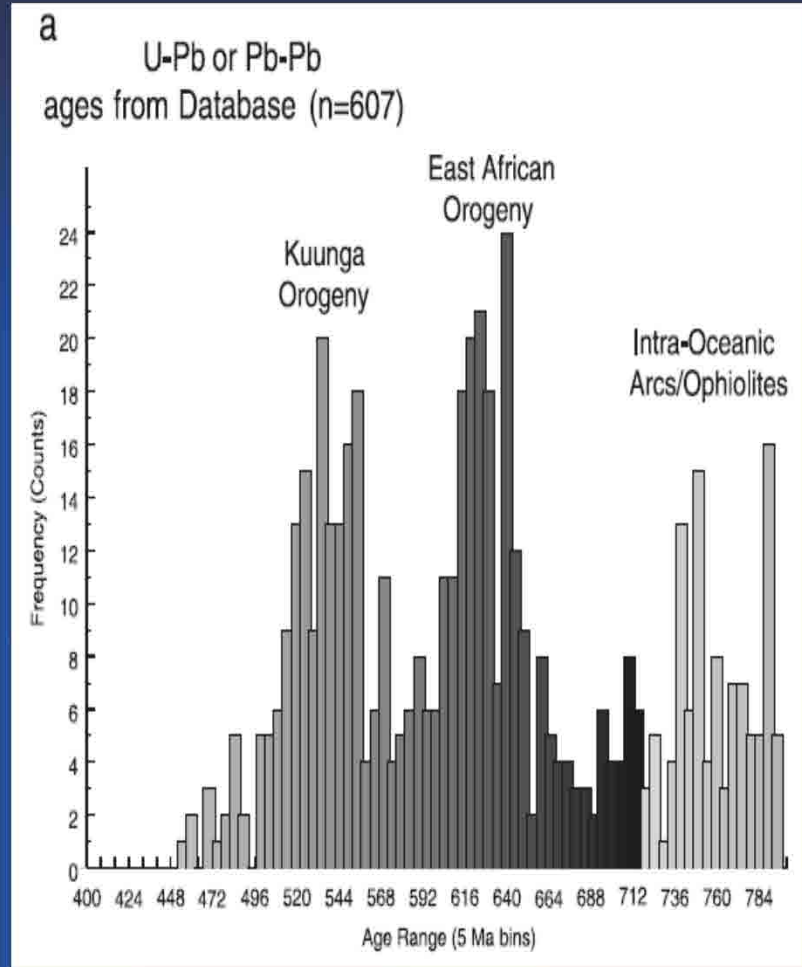
Amazonia
São Francisco
Rio de La Plata
São Luis
Parana
Pampeano
Rio Apa
Arequipa-Antofala



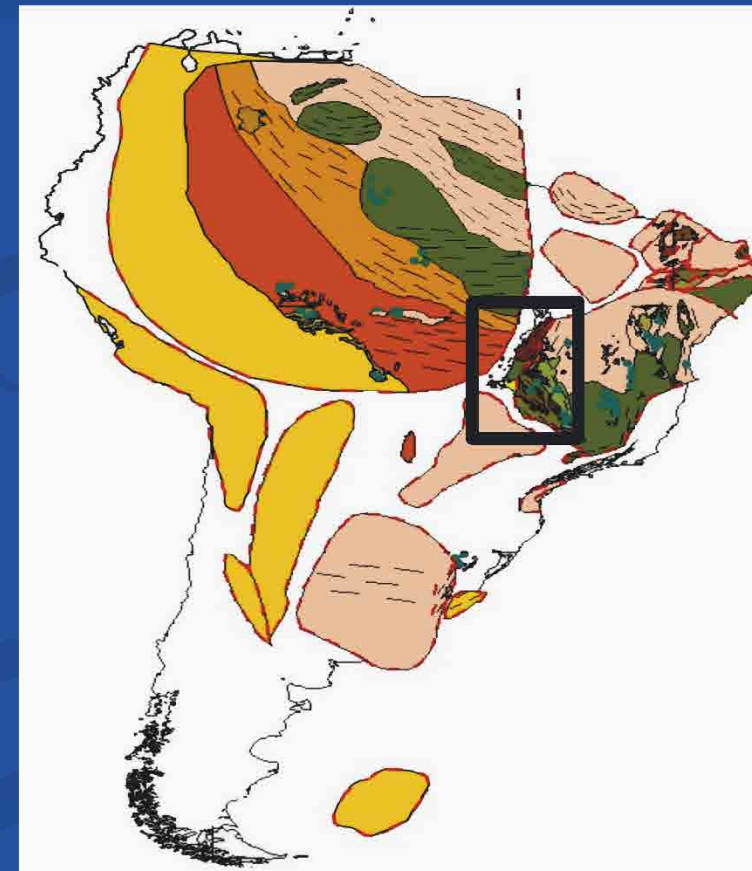
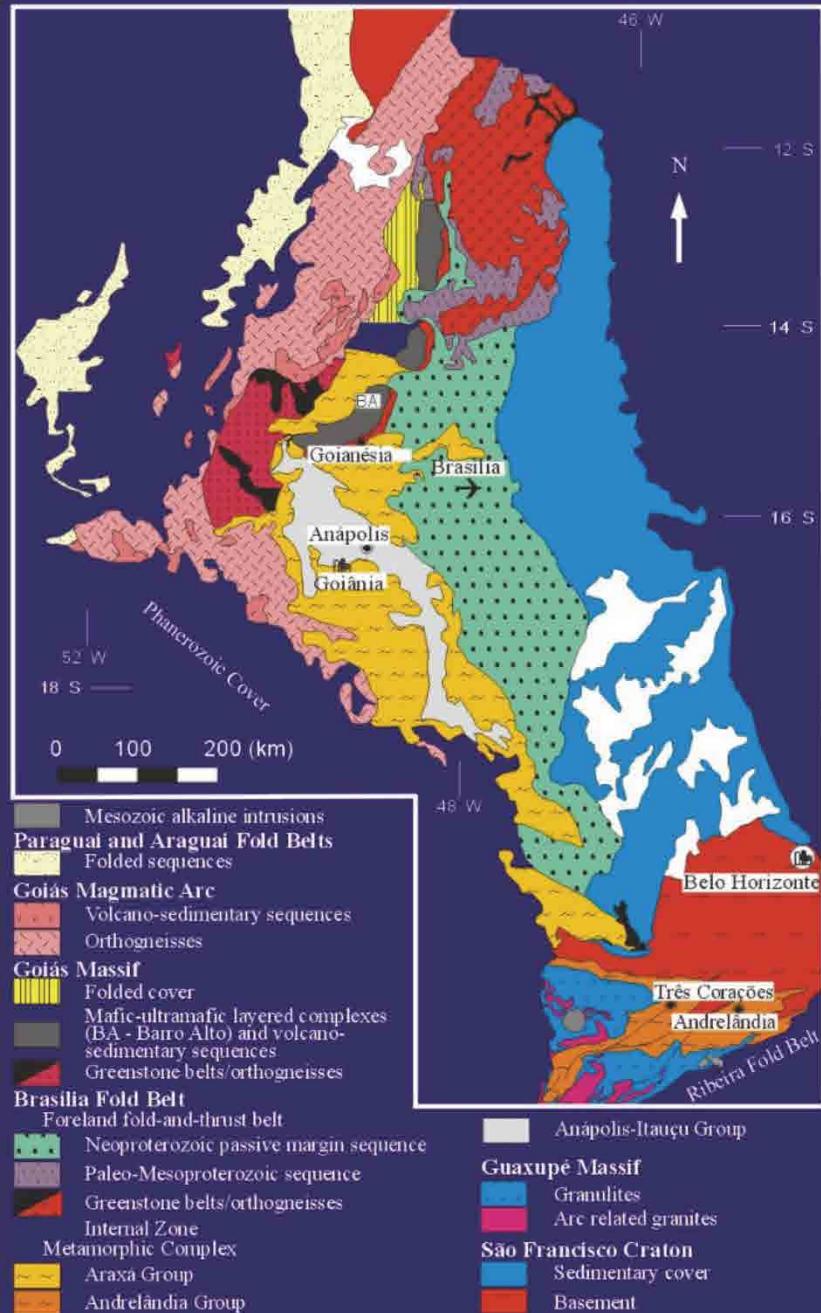
Gondwana Ocidental



Gondwana Oriental

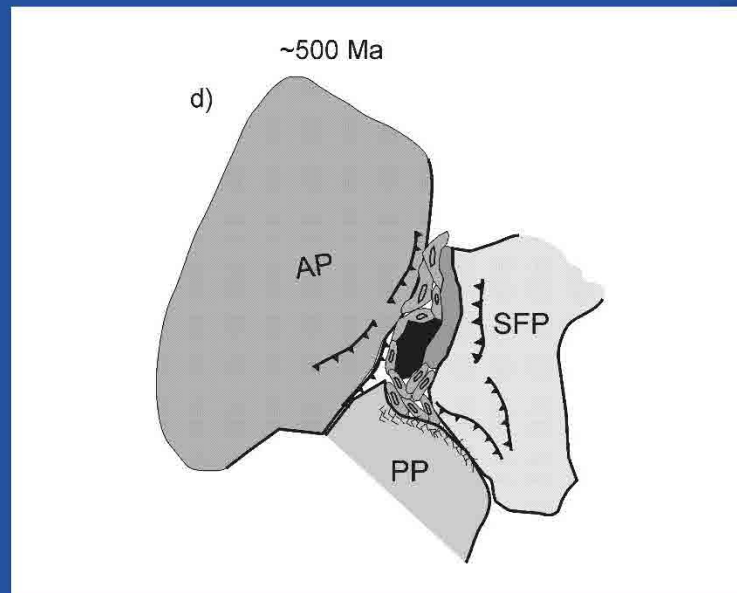
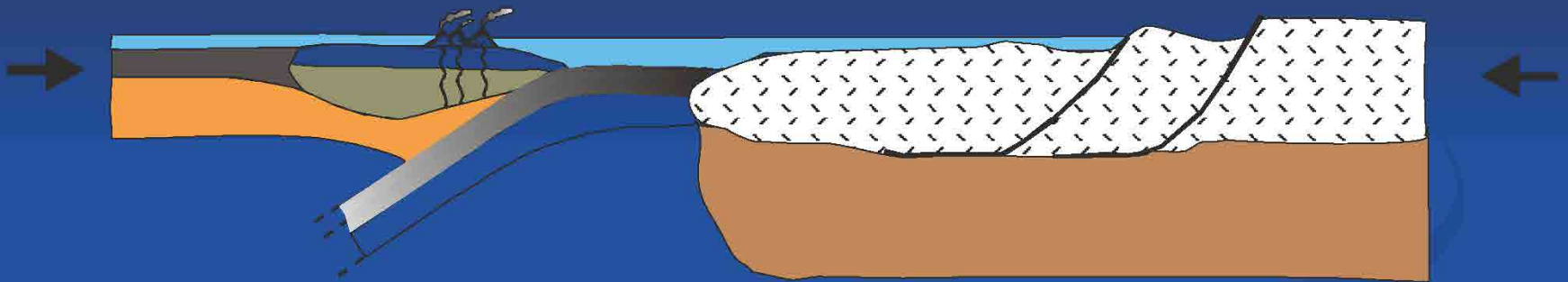


Brasilia Belt



~890Ma

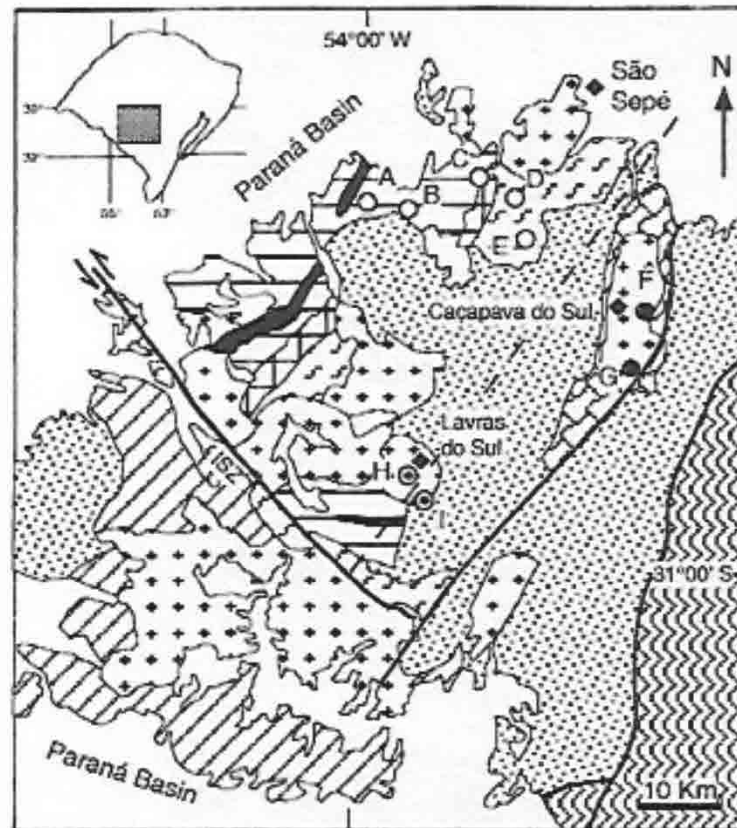
Brasilia Belt



Pimentel et al., 1992

Sao Gabriel Orogen

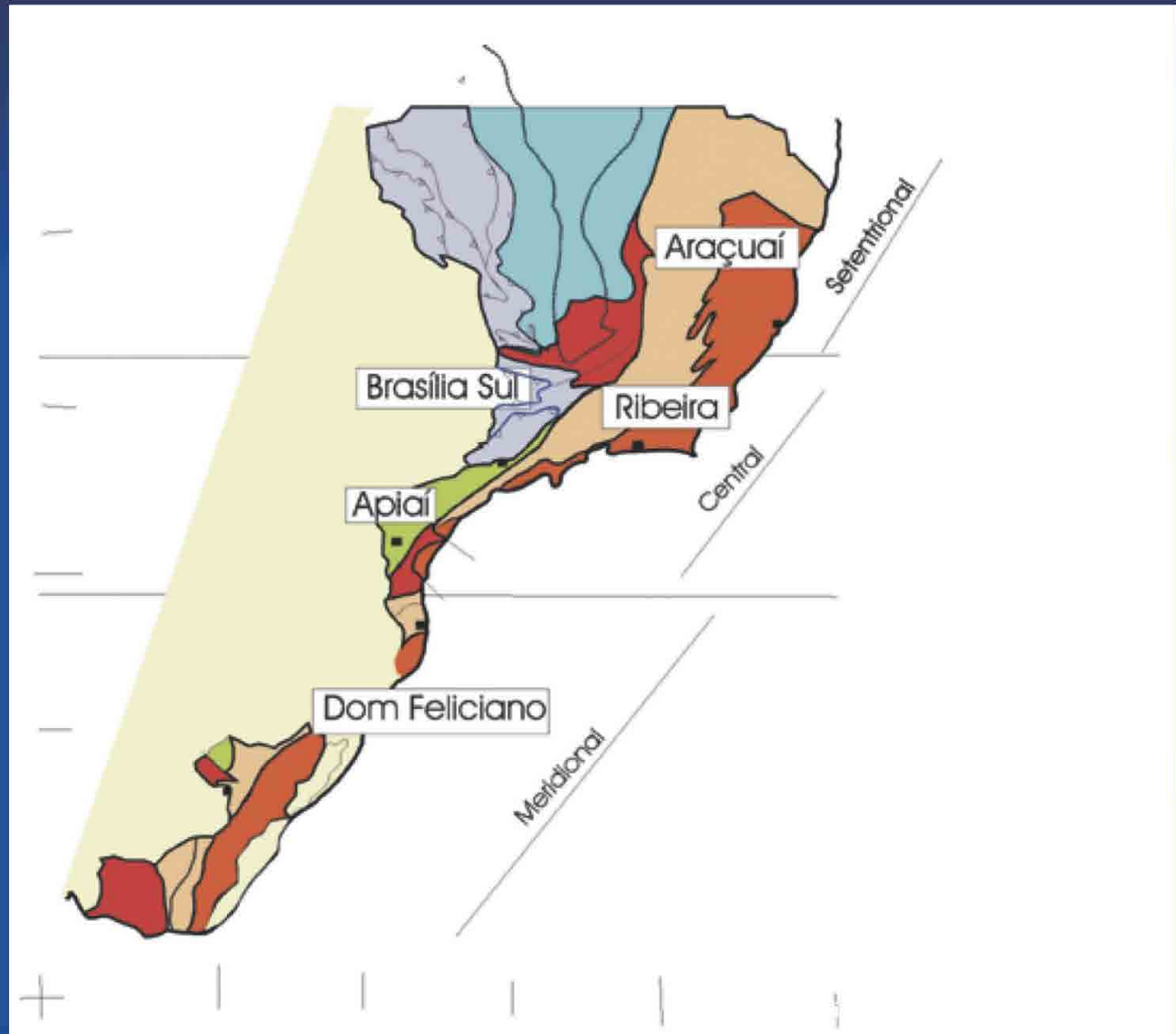
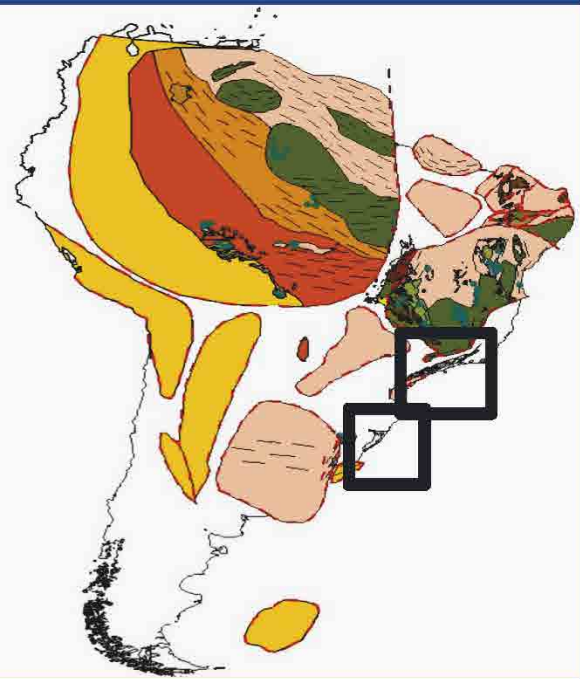
704 Ma



- Phanerozoic cover
- Late to post-tectonic granites of the DF event
- Camaquã basin (molassic basin)
- Cambaí Group**
 - Granitic-gneissic rocks
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 - Calc-alkaline metavolcanics and metasediments
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 - Mn-rich schists, serpentinites, metabasalts and quartzites
- Paleoproterozoic Basement**
 - Tijucas/Dom Feliciano belts
 - Santa Maria Chlco Granulite Complex (Paleoproterozoic)
- Faults
- ISZ = IBARÉ SHEAR ZONE
- ◆ = City/town

Dom Feliciano Belt

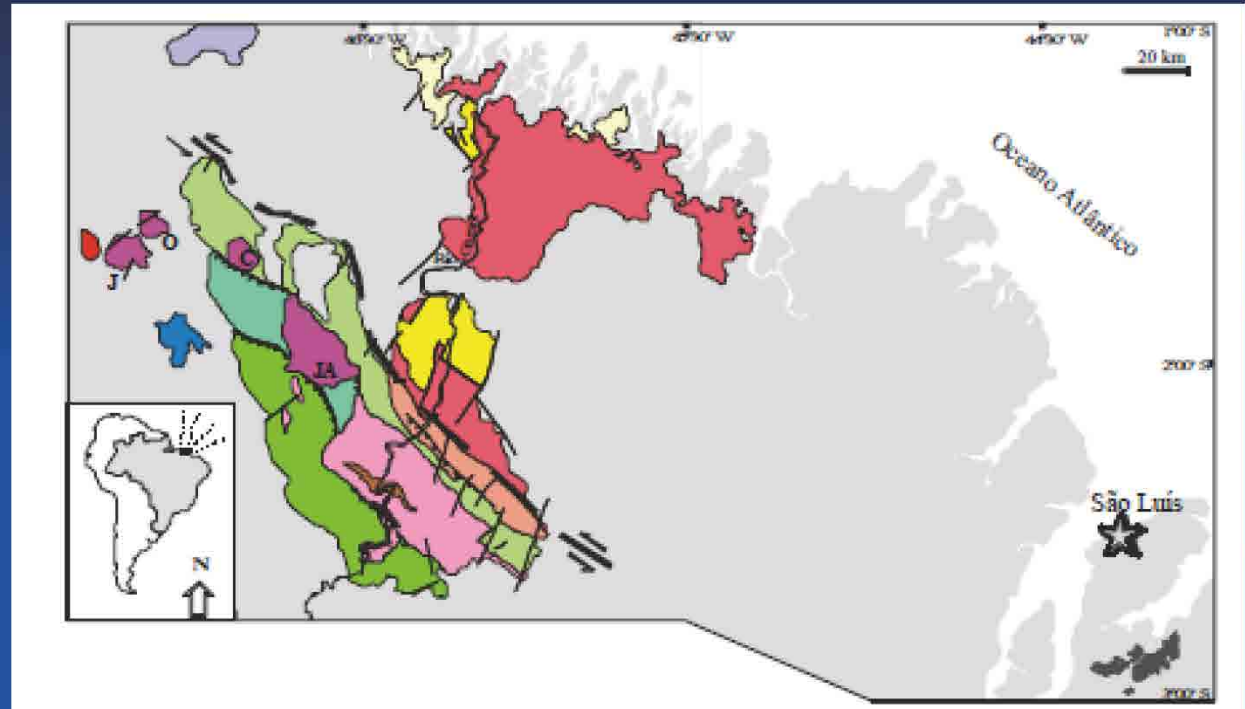
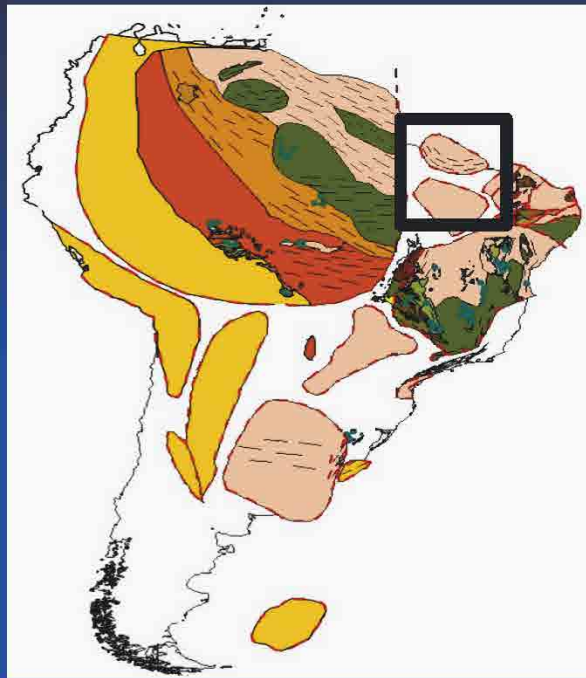
Ribeira Belt



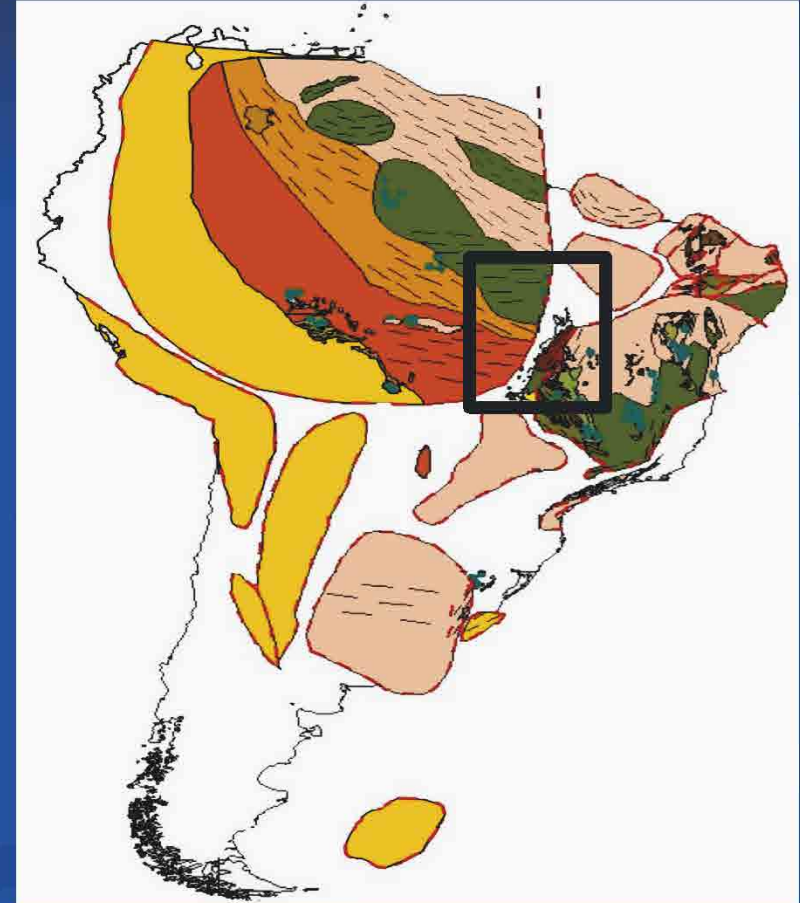
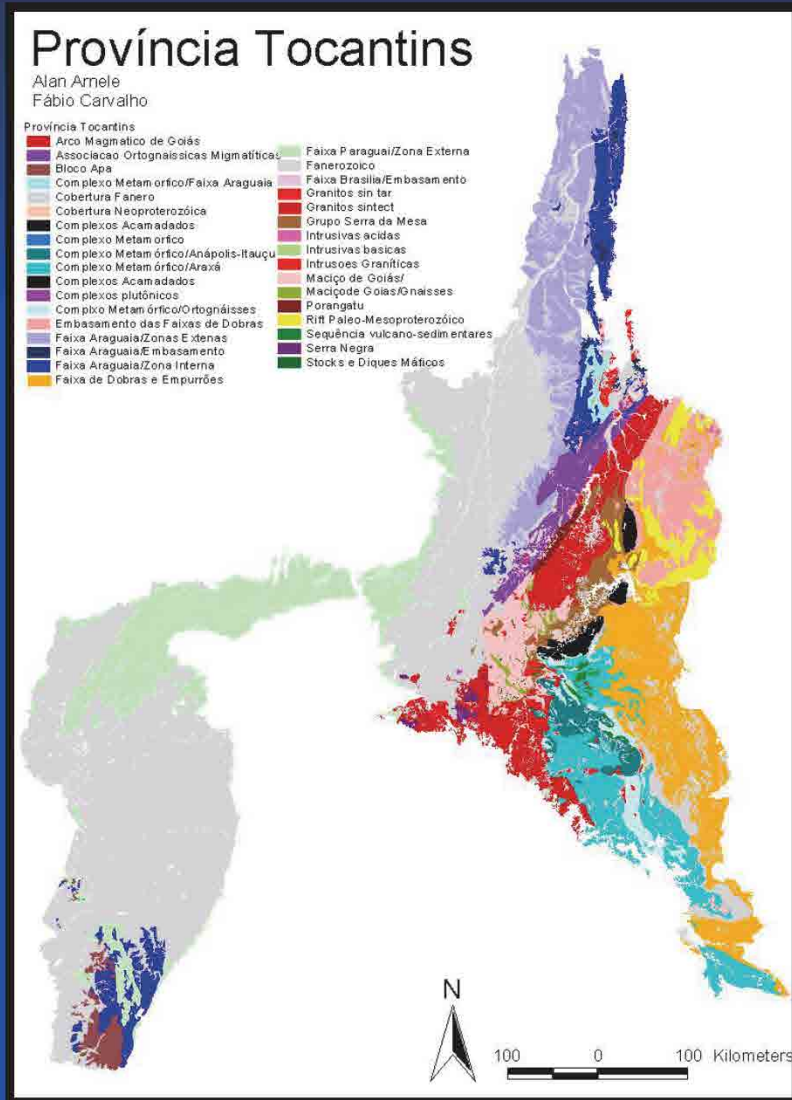
Andrelandia Nappe



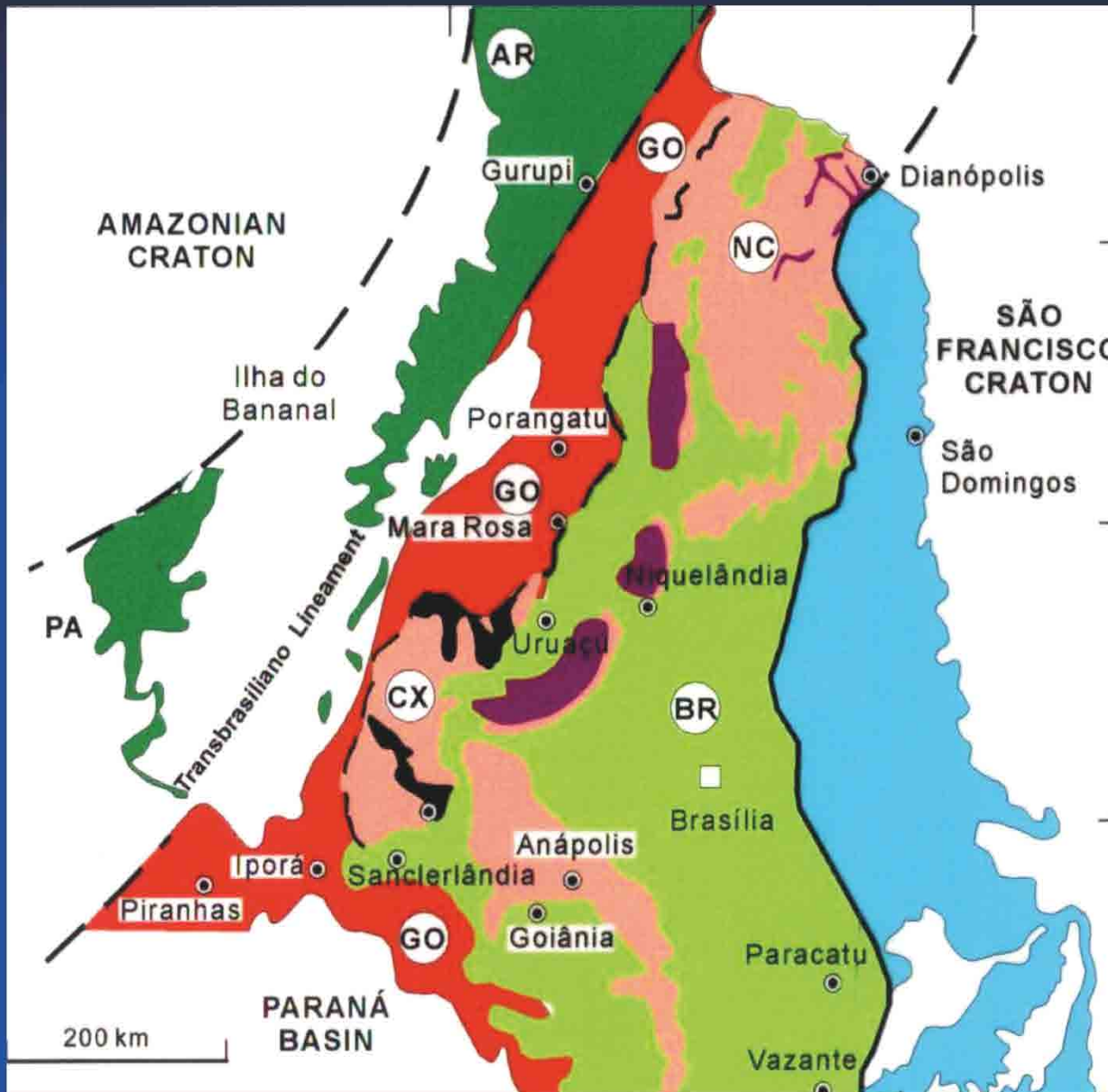
Gurupi belt



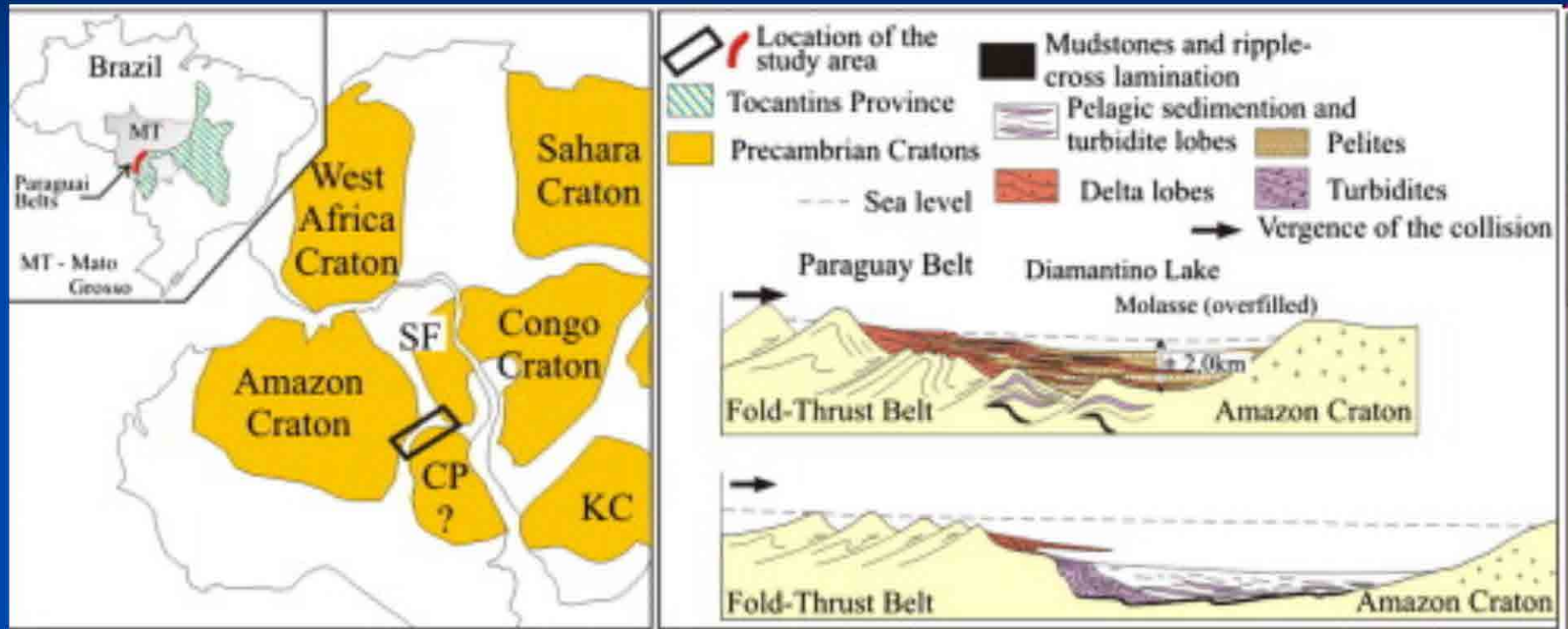
Tocantins/Araguaia Belt



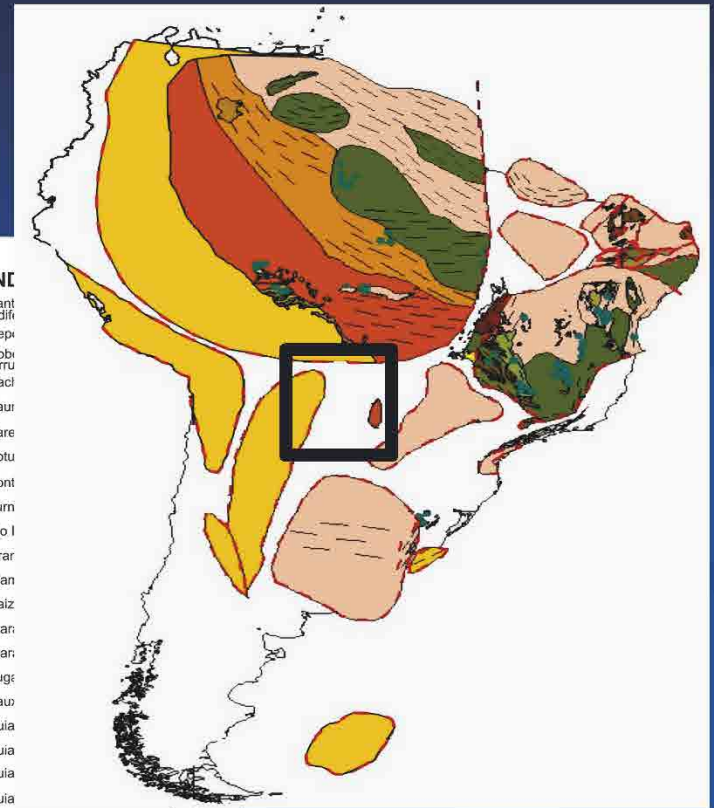
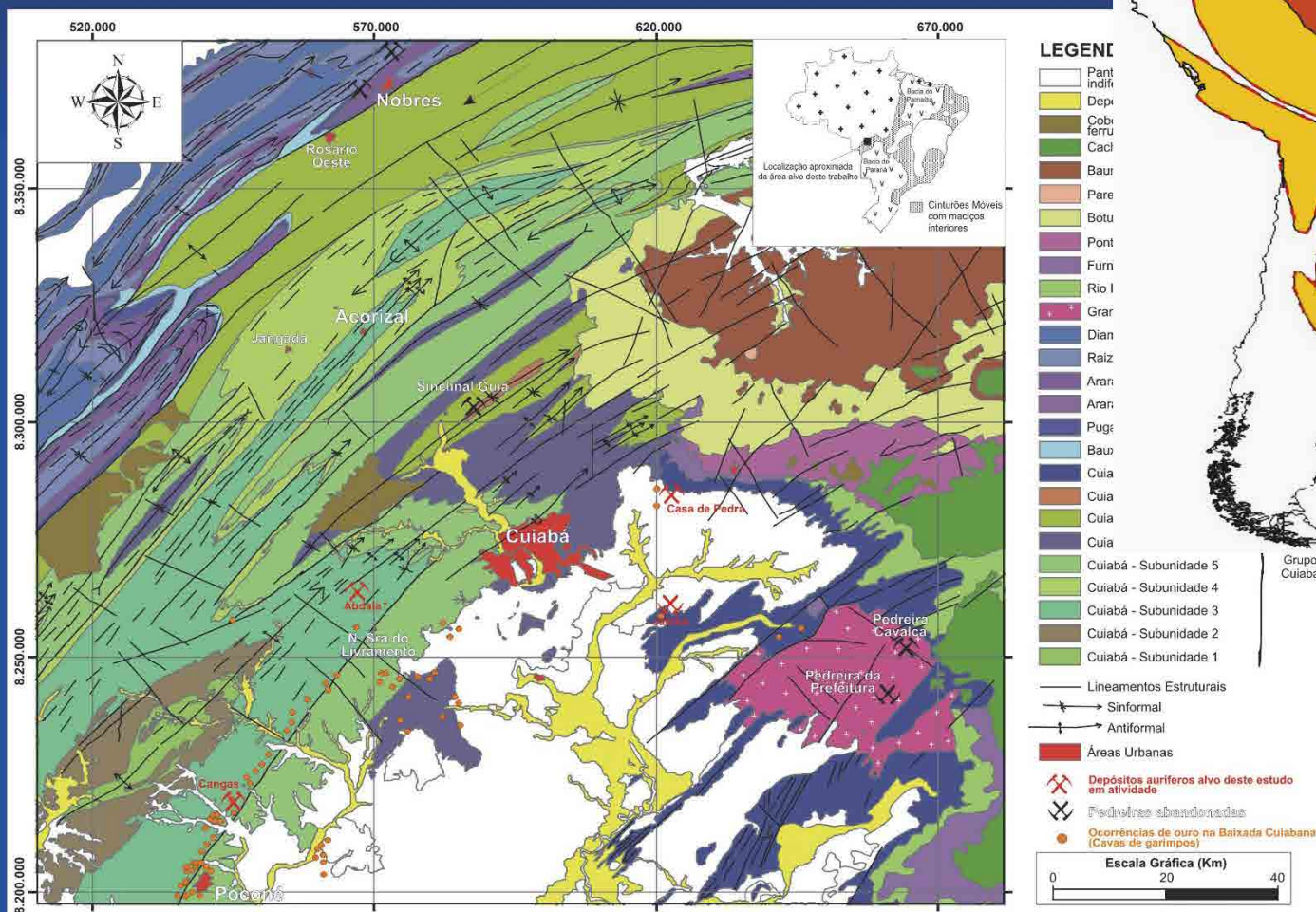
TOCANTINS TECTONIC PROVINCE



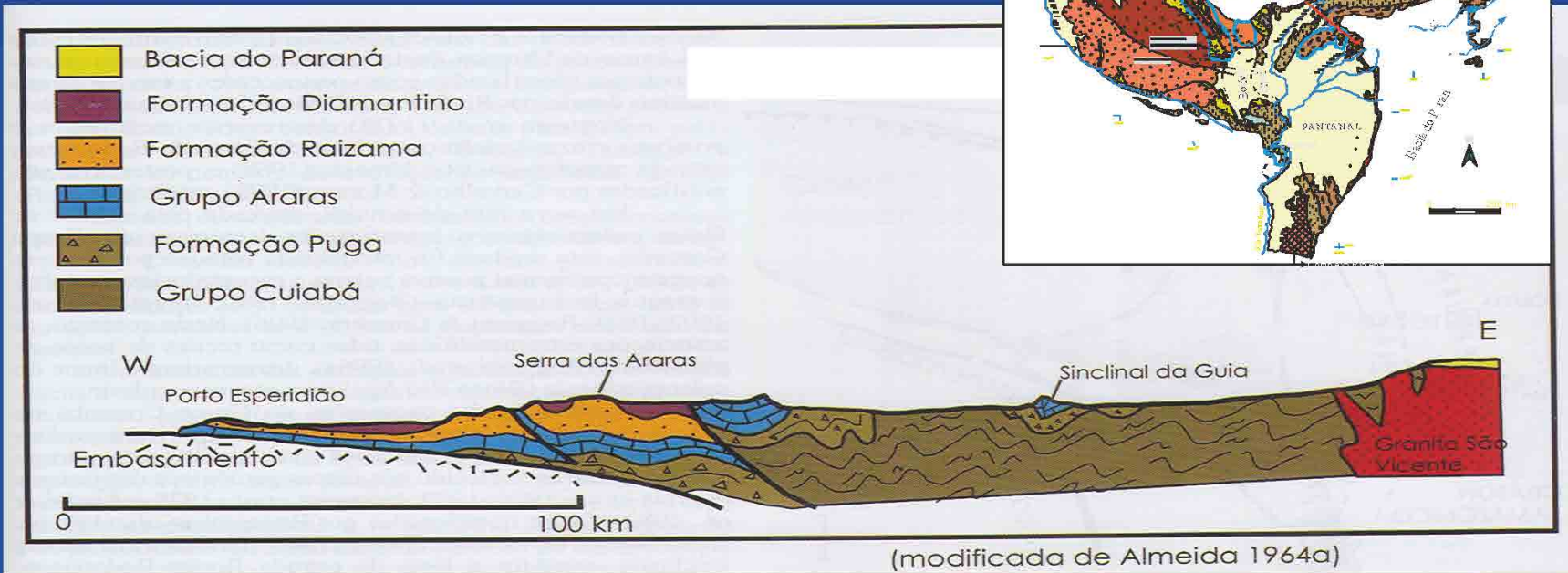
Paraguay orogen



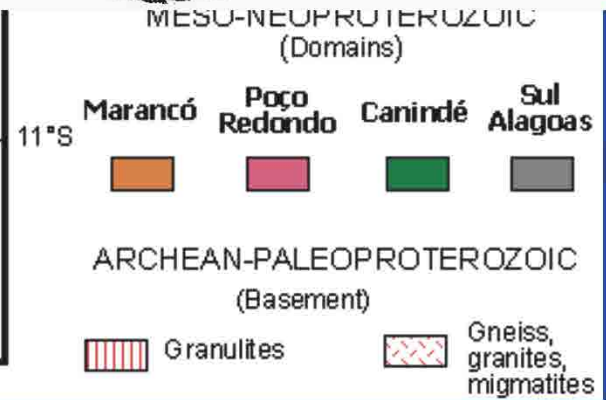
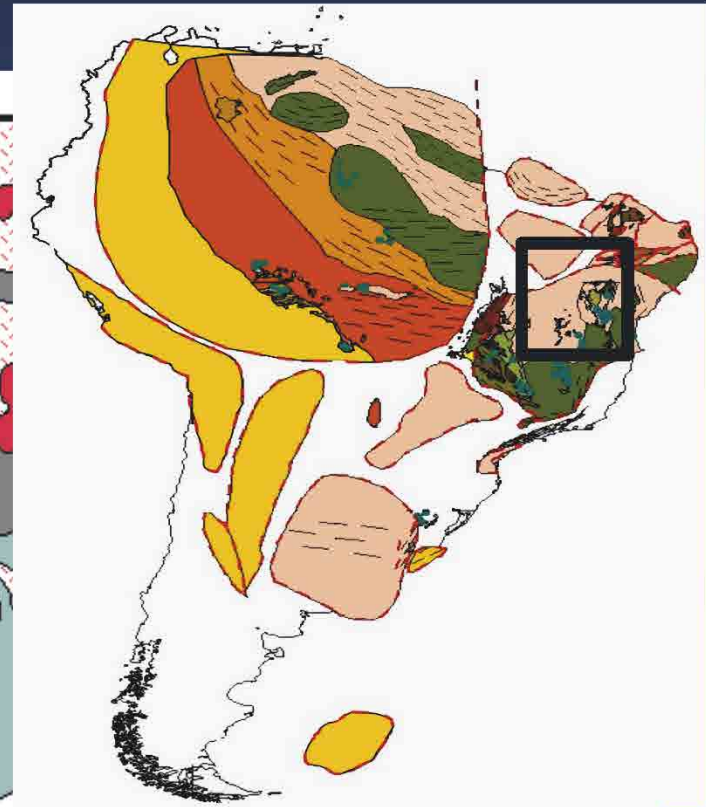
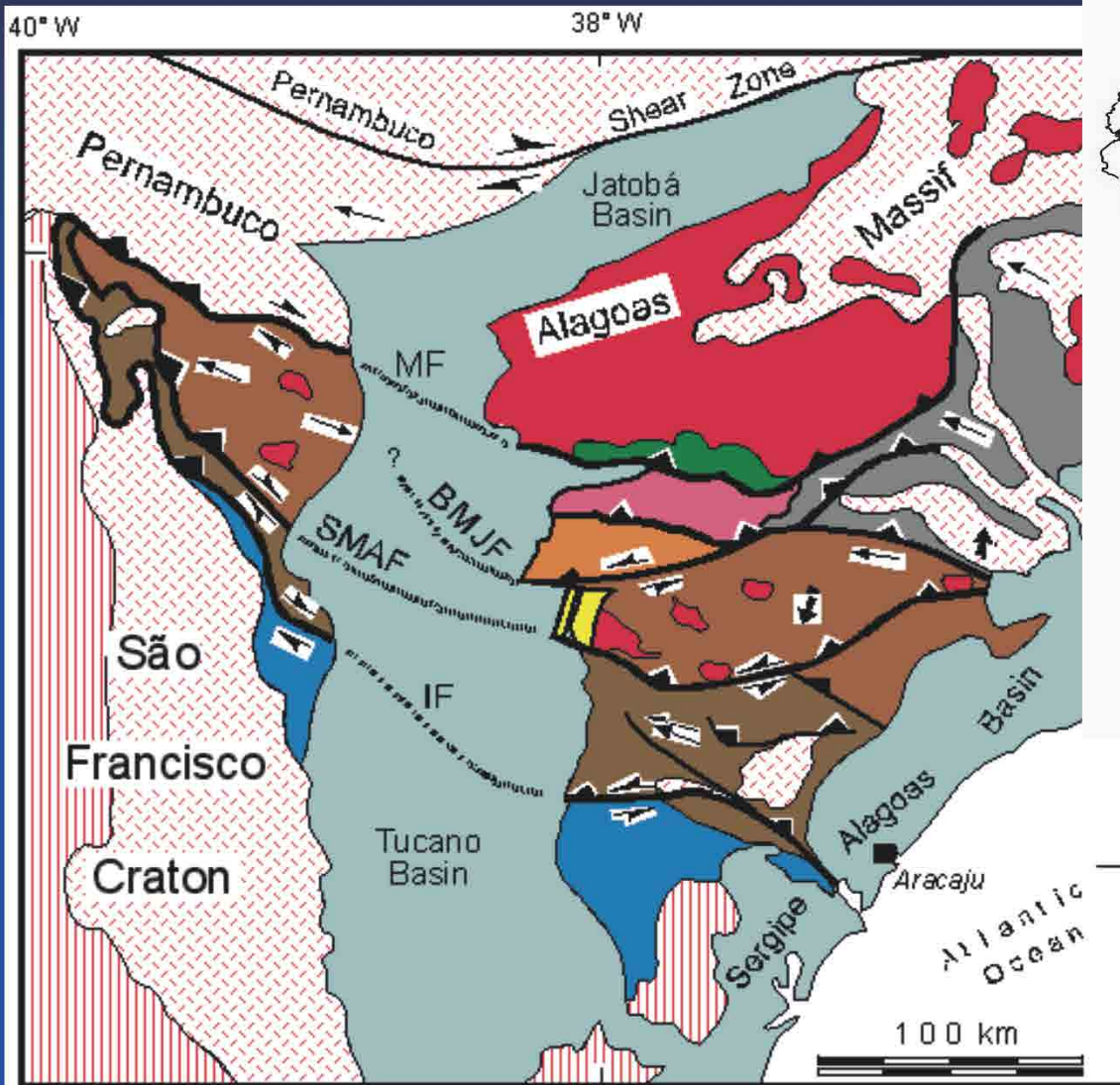
Araguaia belt



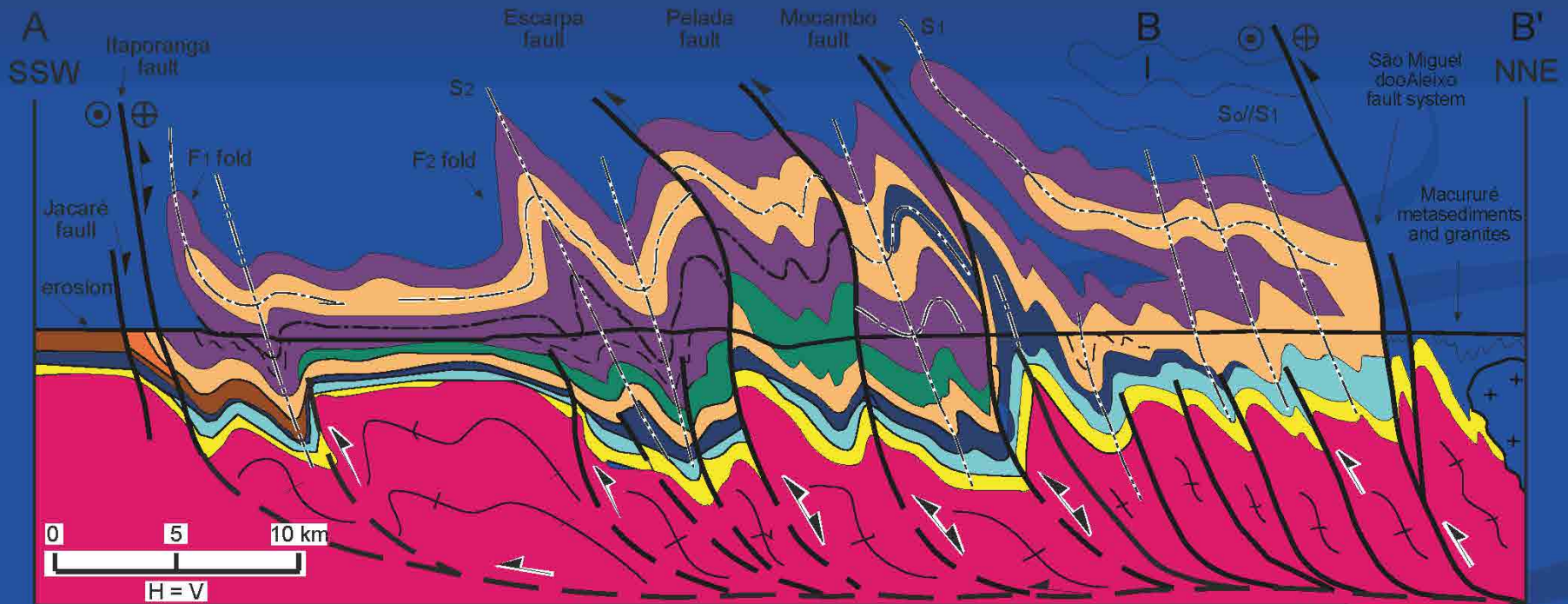
Araguaia belt



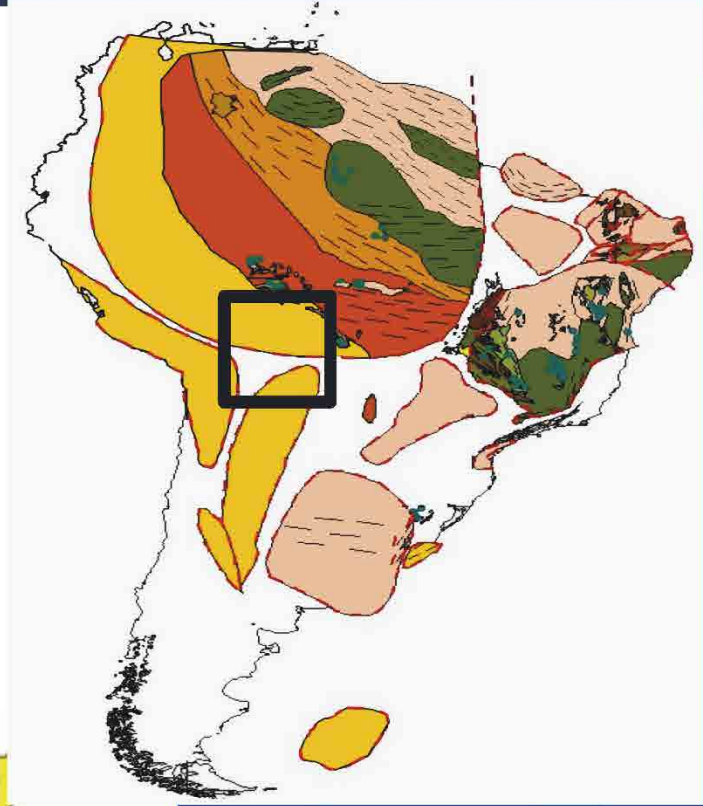
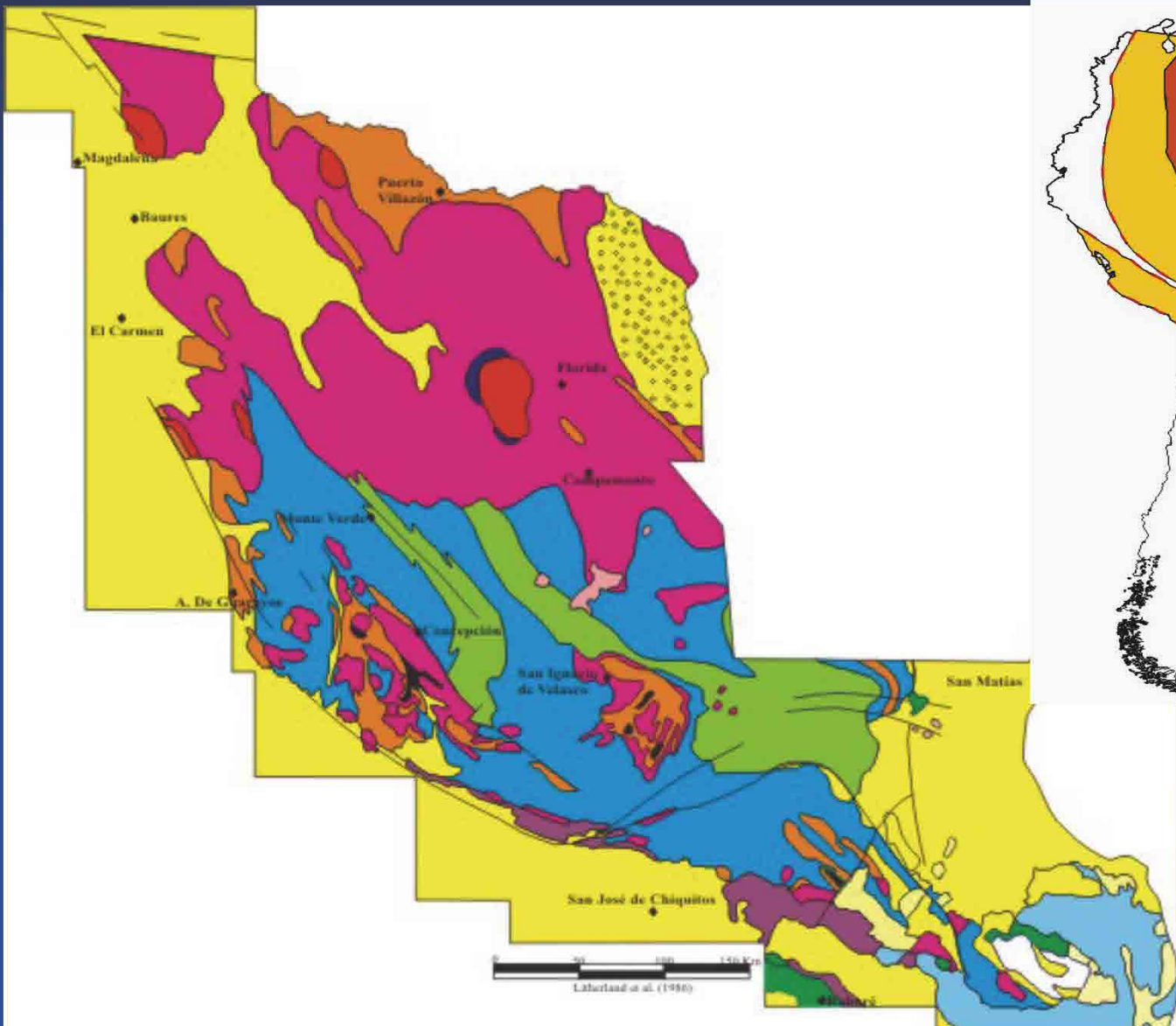
Sergipano belt



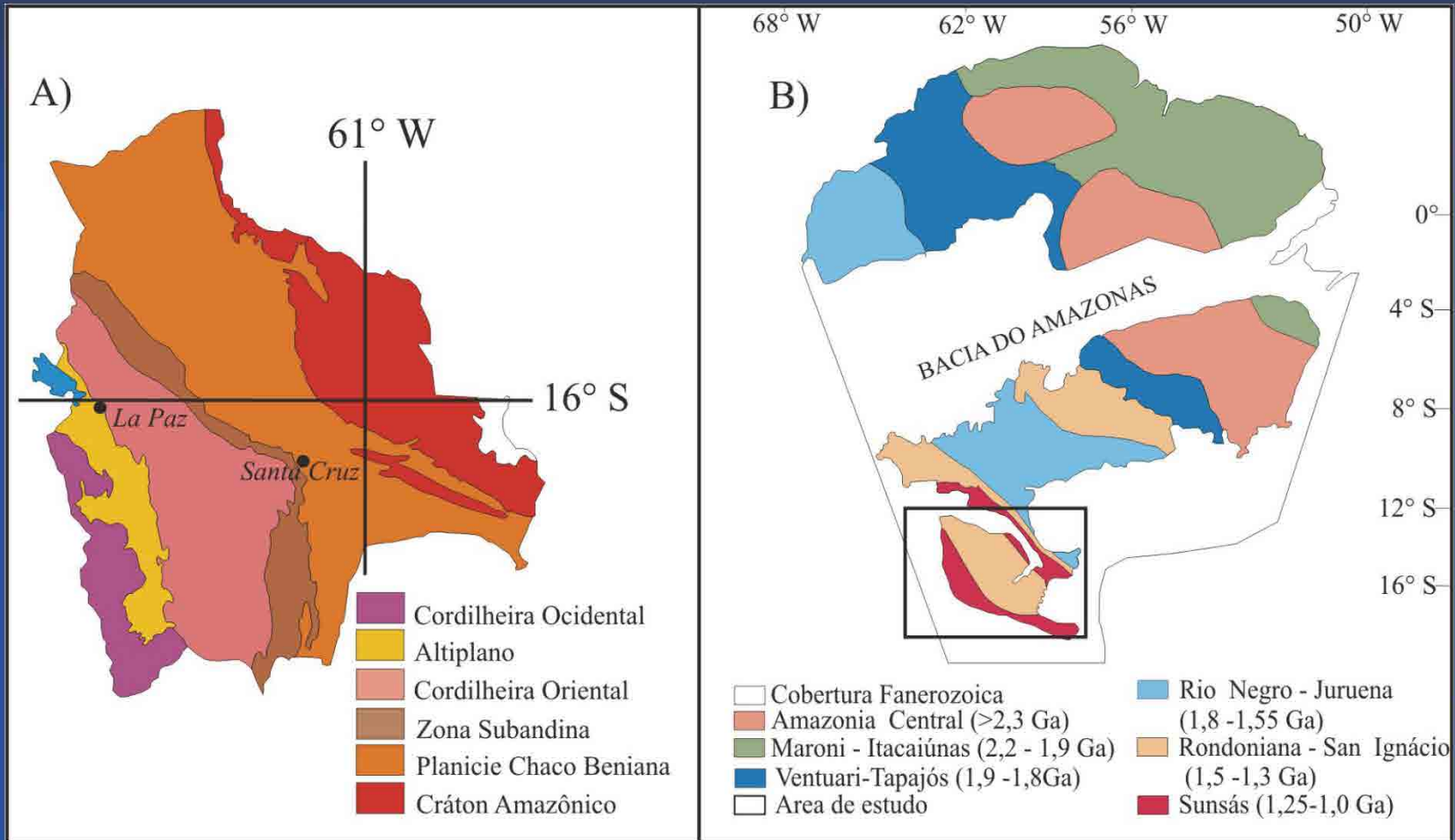
Sergipano belt



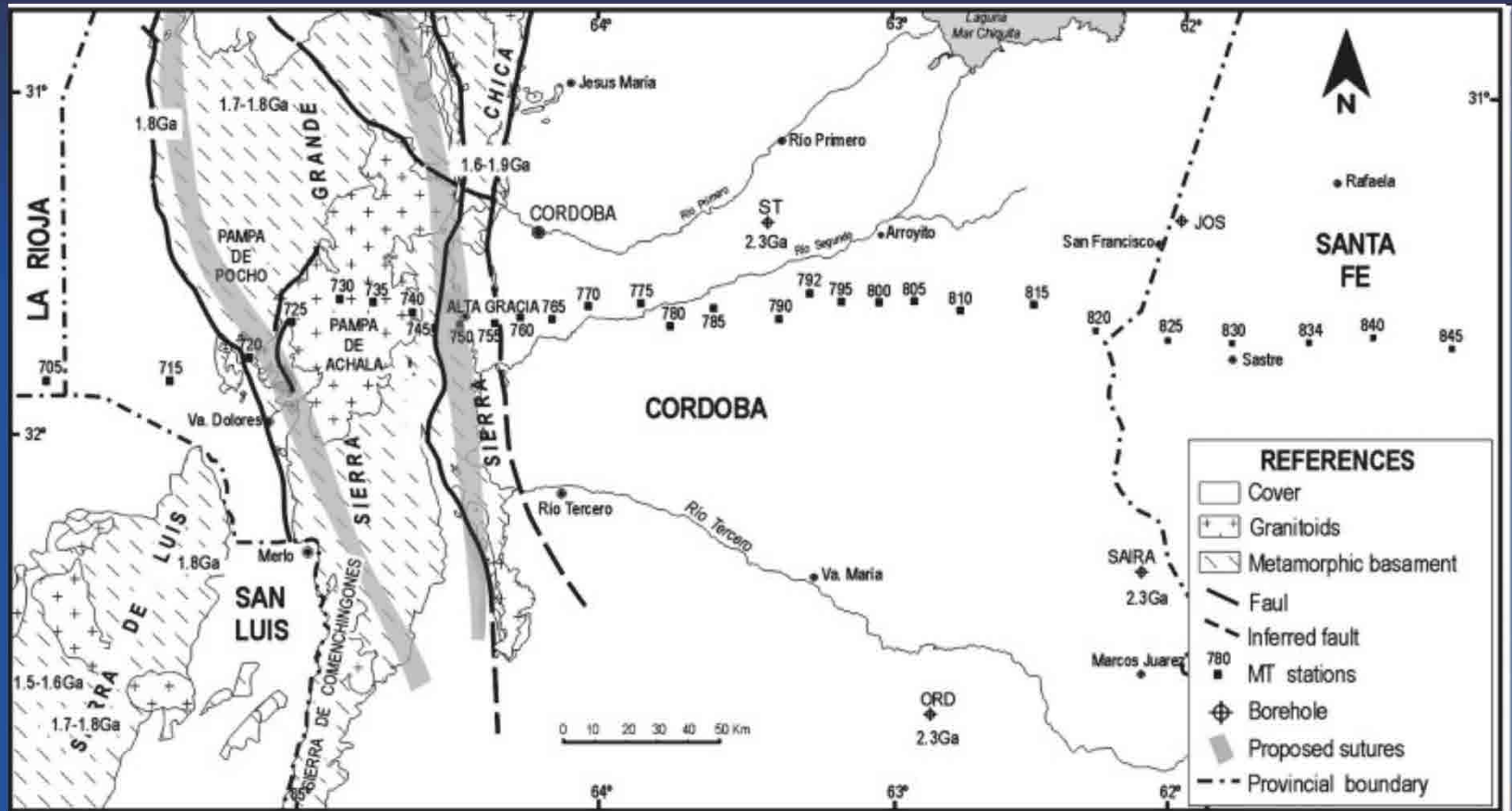
Tucavaca belt



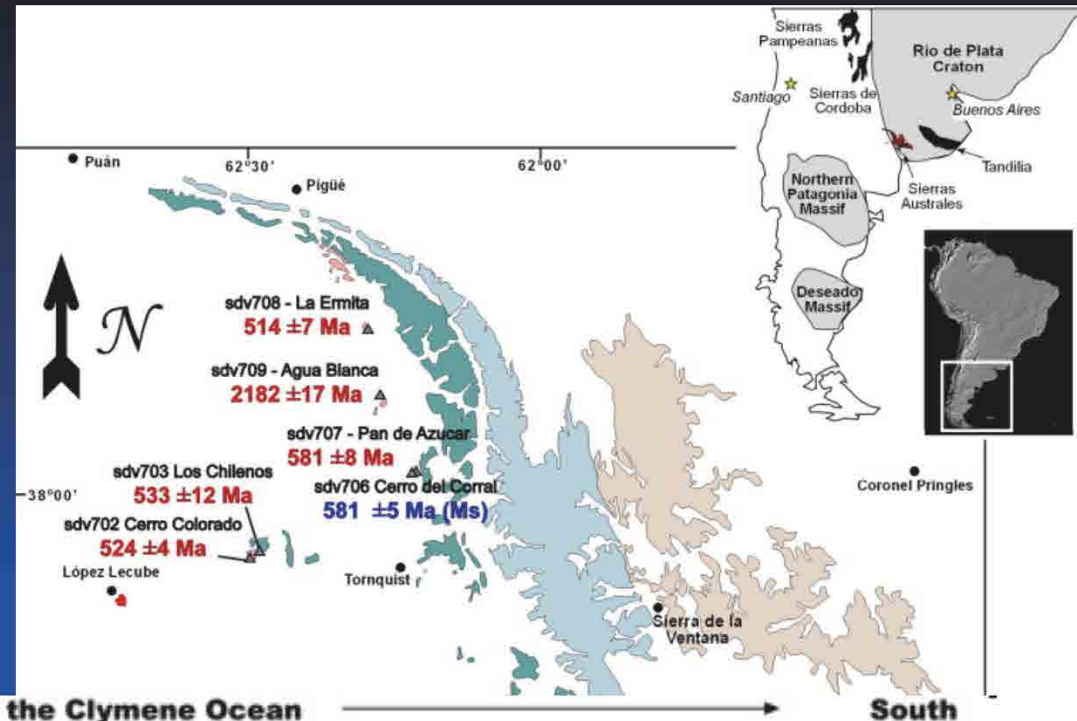
Tucavaca belt



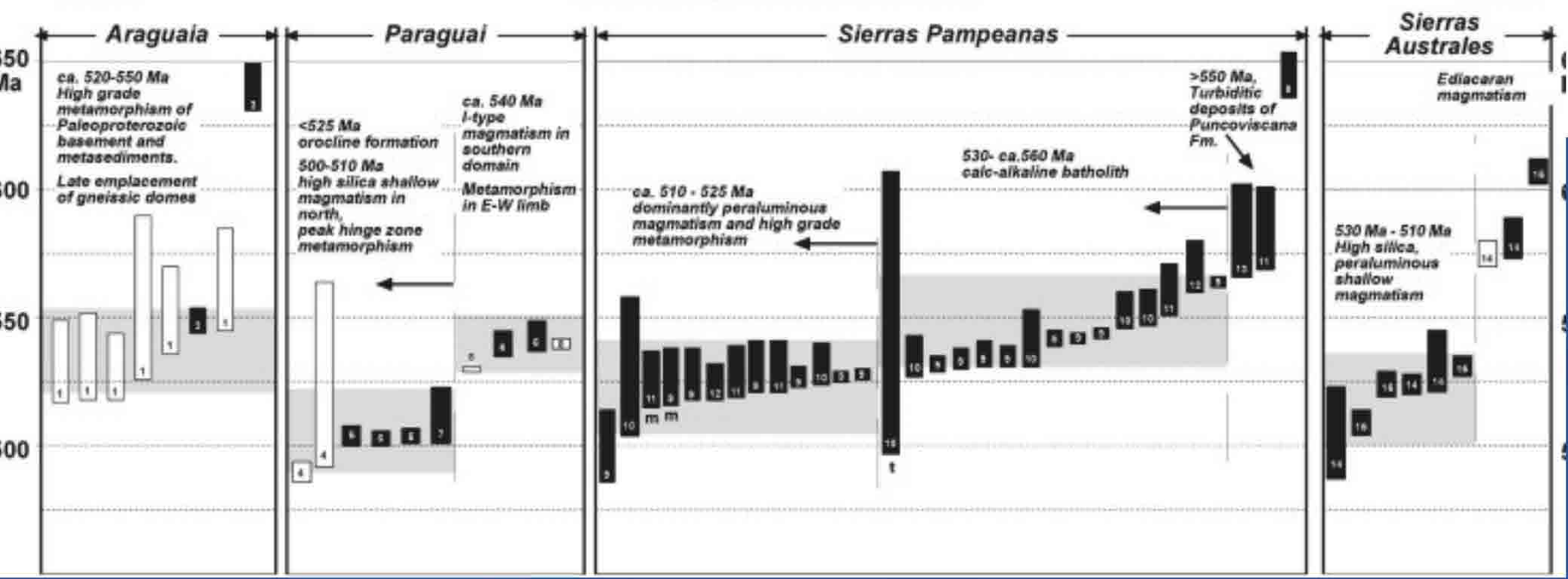
Pampeano belt



■ Pampeano belt

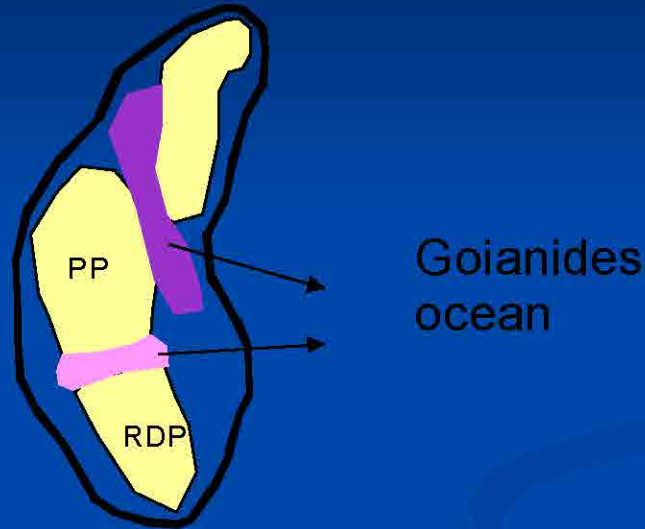


North ← Closure of the Clymene Ocean → South



West Gondwana amalgamation

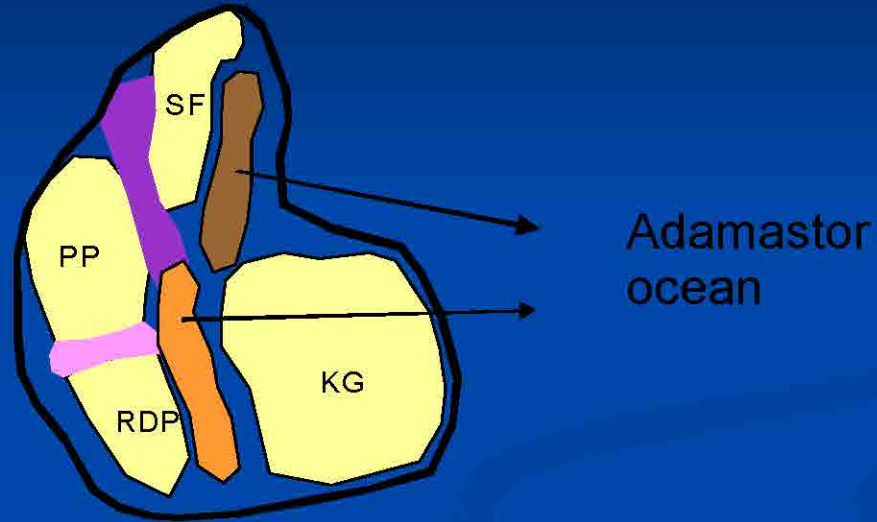
920-700 Ma



- Brasilia belt (920-850 Ma)
- São Gabriel belt (750-700 Ma)

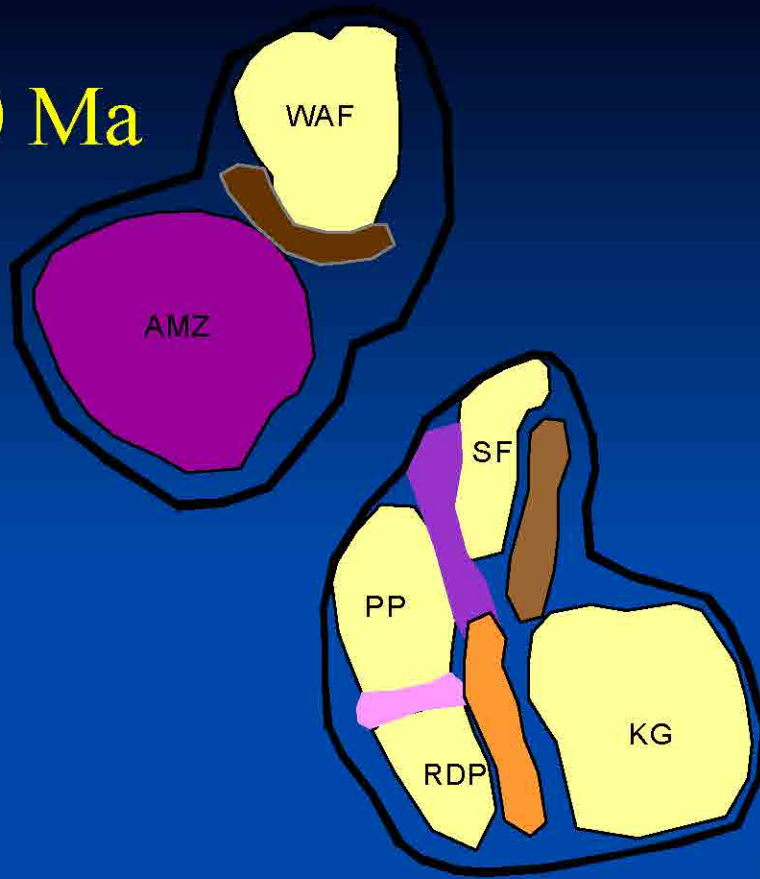
West Gondwana amalgamation

720-695 Ma








Brasilia belt (920-850 Ma)
São Gabriel belt (750-700 Ma)
Ribeira belt (750-695 Ma)
Dom Feliciano belt (720-690 Ma)

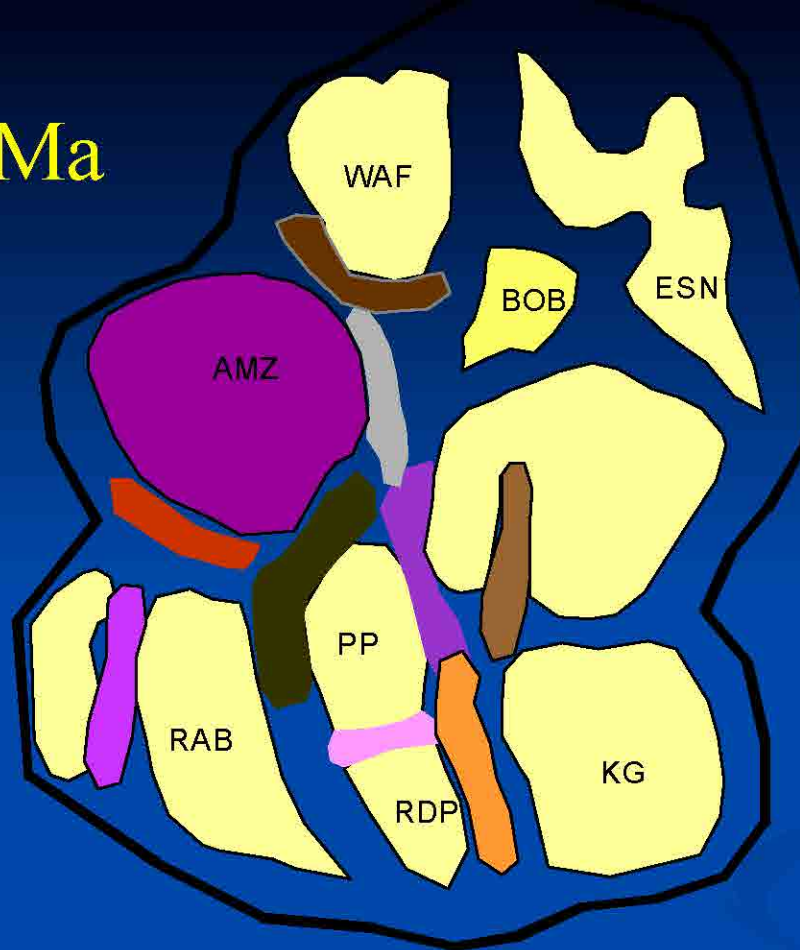
580-540 Ma













West Gondwana amalgamation

-  Gurupi belt (580-540 Ma)
-  Brasília belt (920-850 Ma)
-  São Gabriel belt (750-700 Ma)
-  Ribeira belt (750-695 Ma)
-  Dom Feliciano belt (720-690 Ma)

500-480 Ma

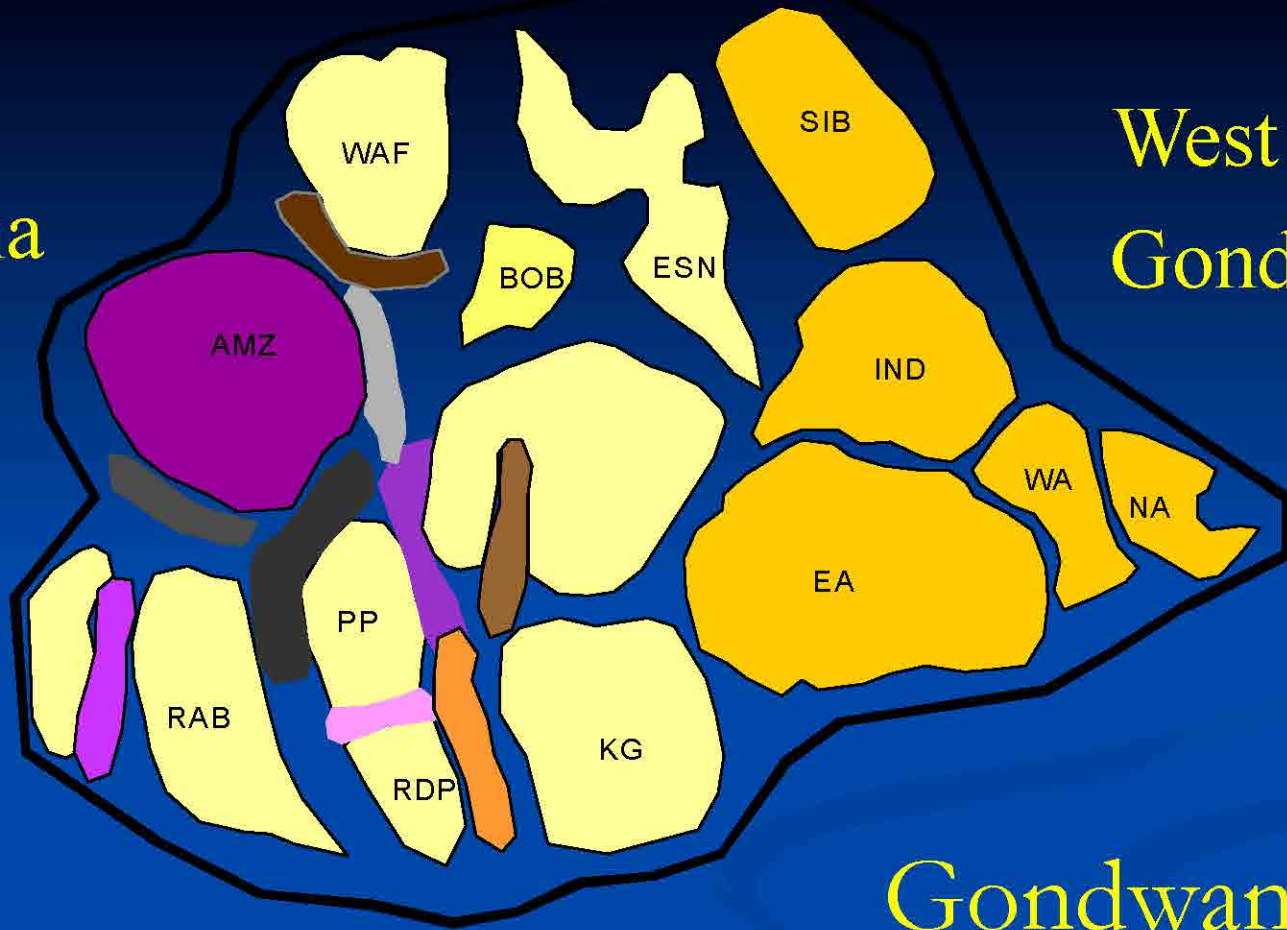


West Gondwana amalgamation

	Pampeano belt (500-480 Ma)
	Tucavaca belt (530-480 Ma)
	Buzios belt (520-480 Ma)
	Araguaia belt (570-520 Ma)
	Paraguay belt (541-531Ma)
	Gurupi belt (580-540 Ma)
	Brasilia belt (920-850 Ma)
	São Gabriel belt (750-700 Ma)
	Ribeira belt (750-695 Ma)
	Dom Feliciano belt (720-690 Ma)

East
Gondwana

West
Gondwana

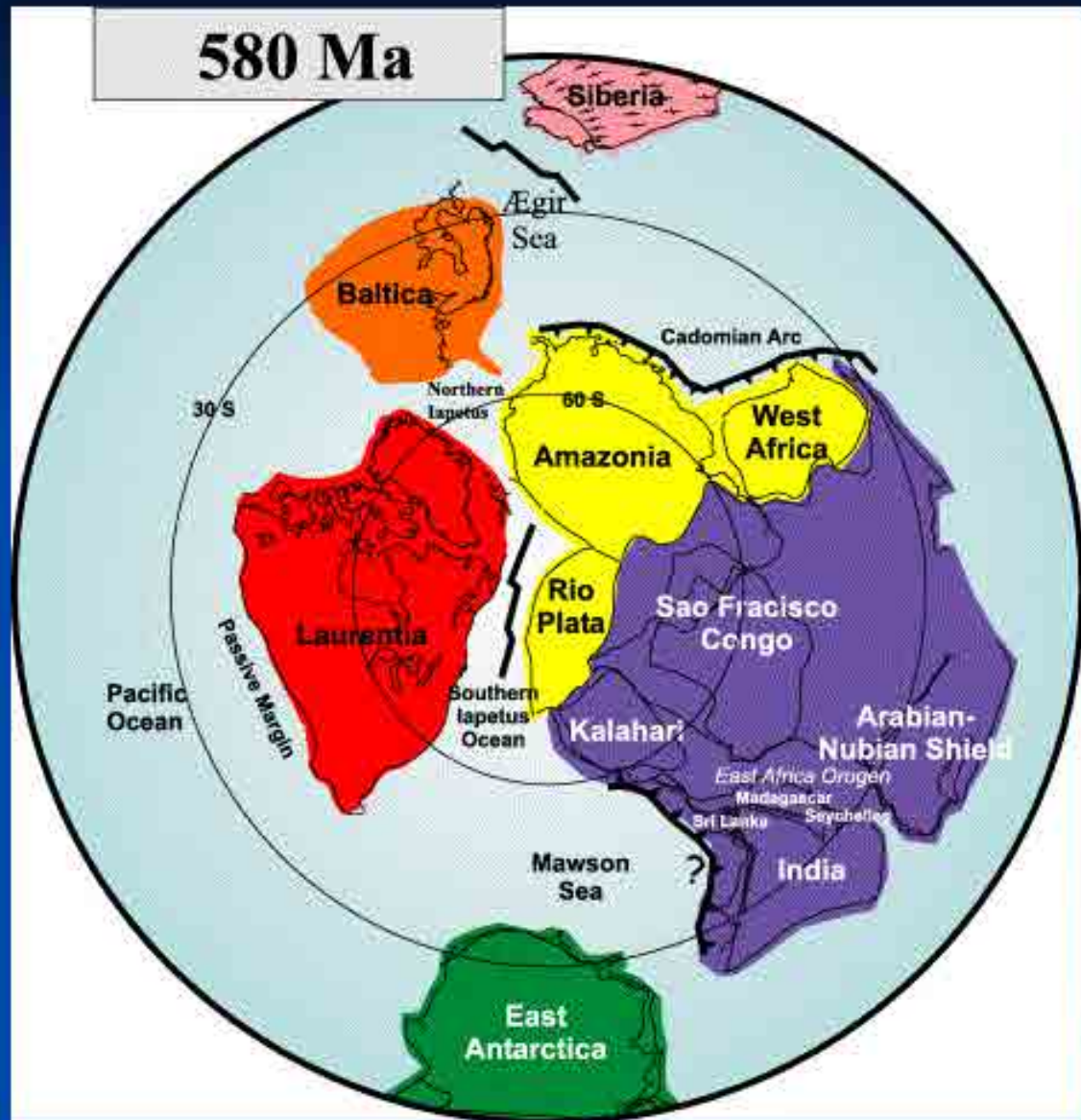


United
Plates of
South
America

Gondwana
amalgamation

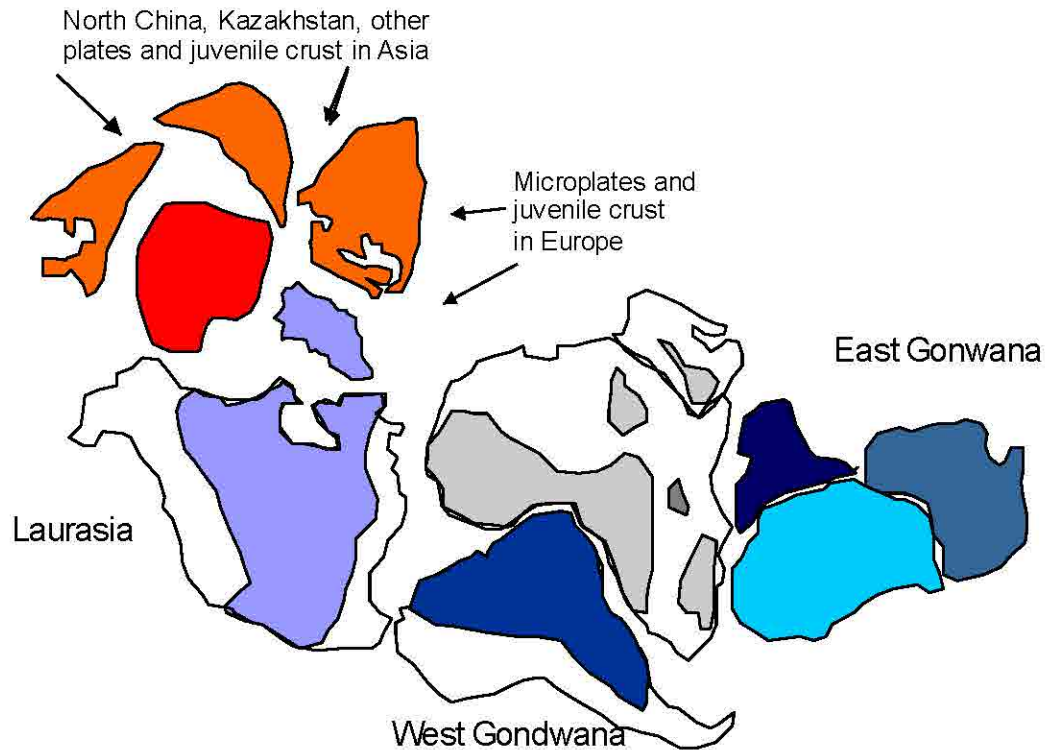


Gondwana amalgamation



Pangea

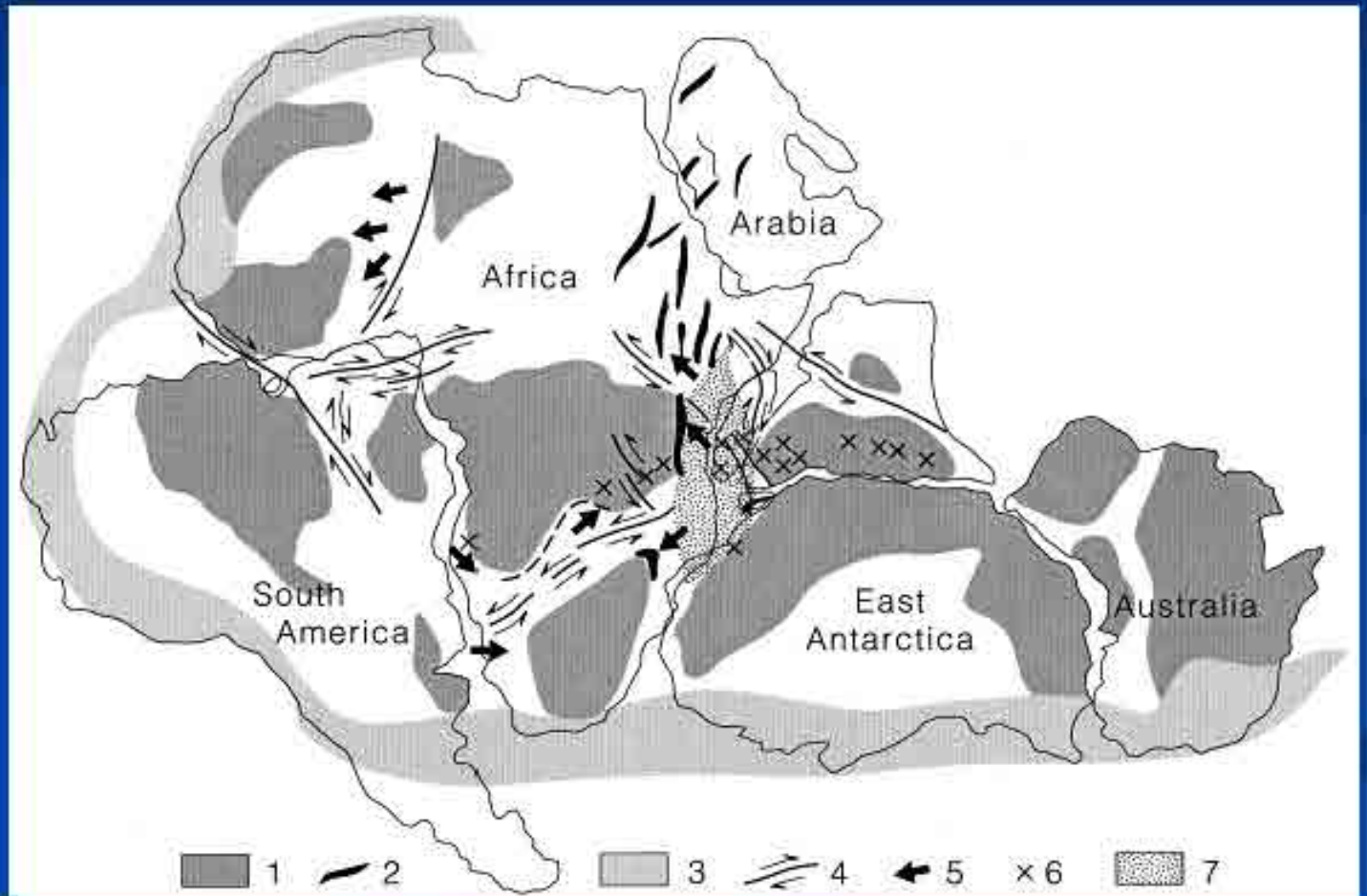
ASSEMBLY OF PANGEA



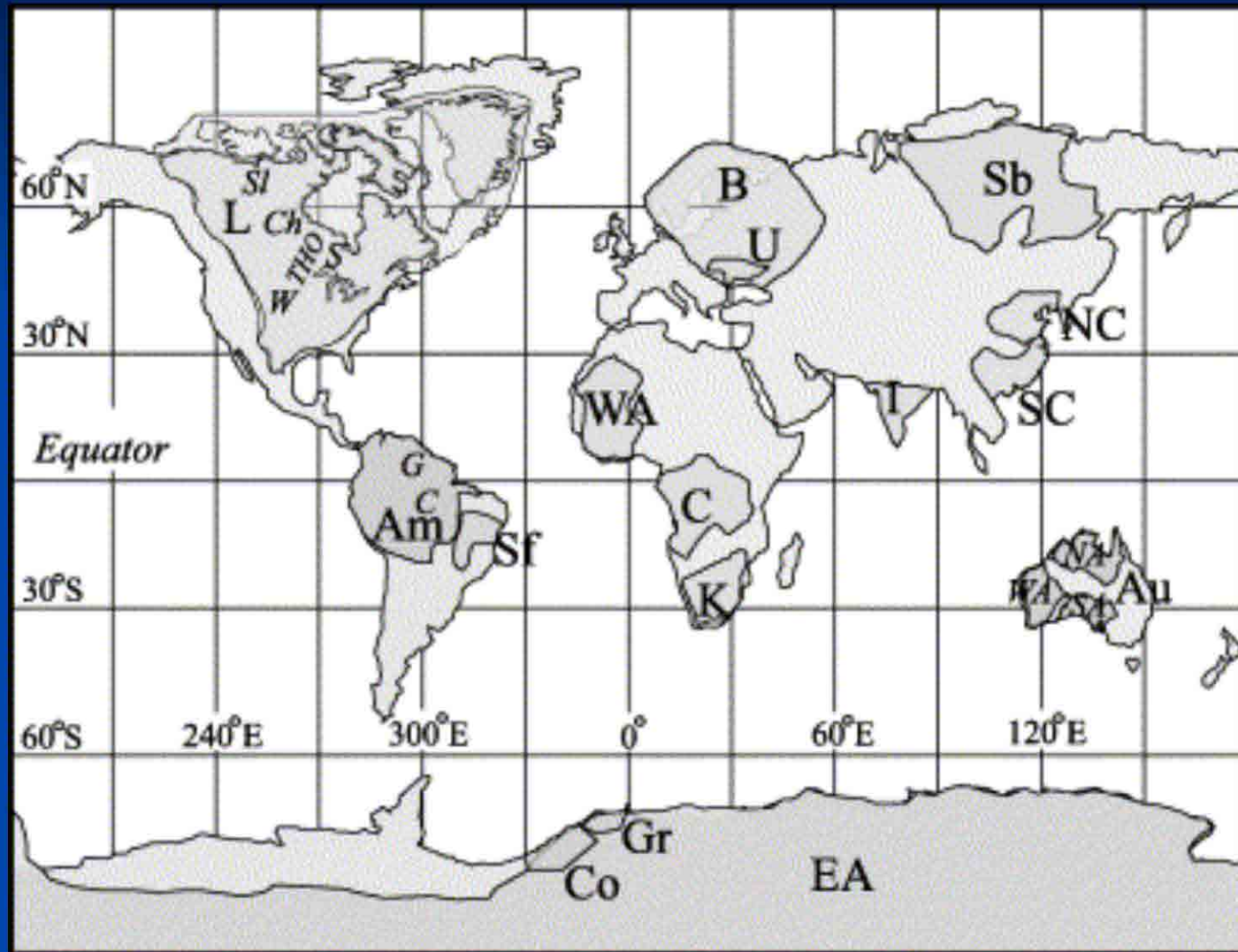
Rogers (1996) The Journal of Geology

Pangea

180 Ma
Break up

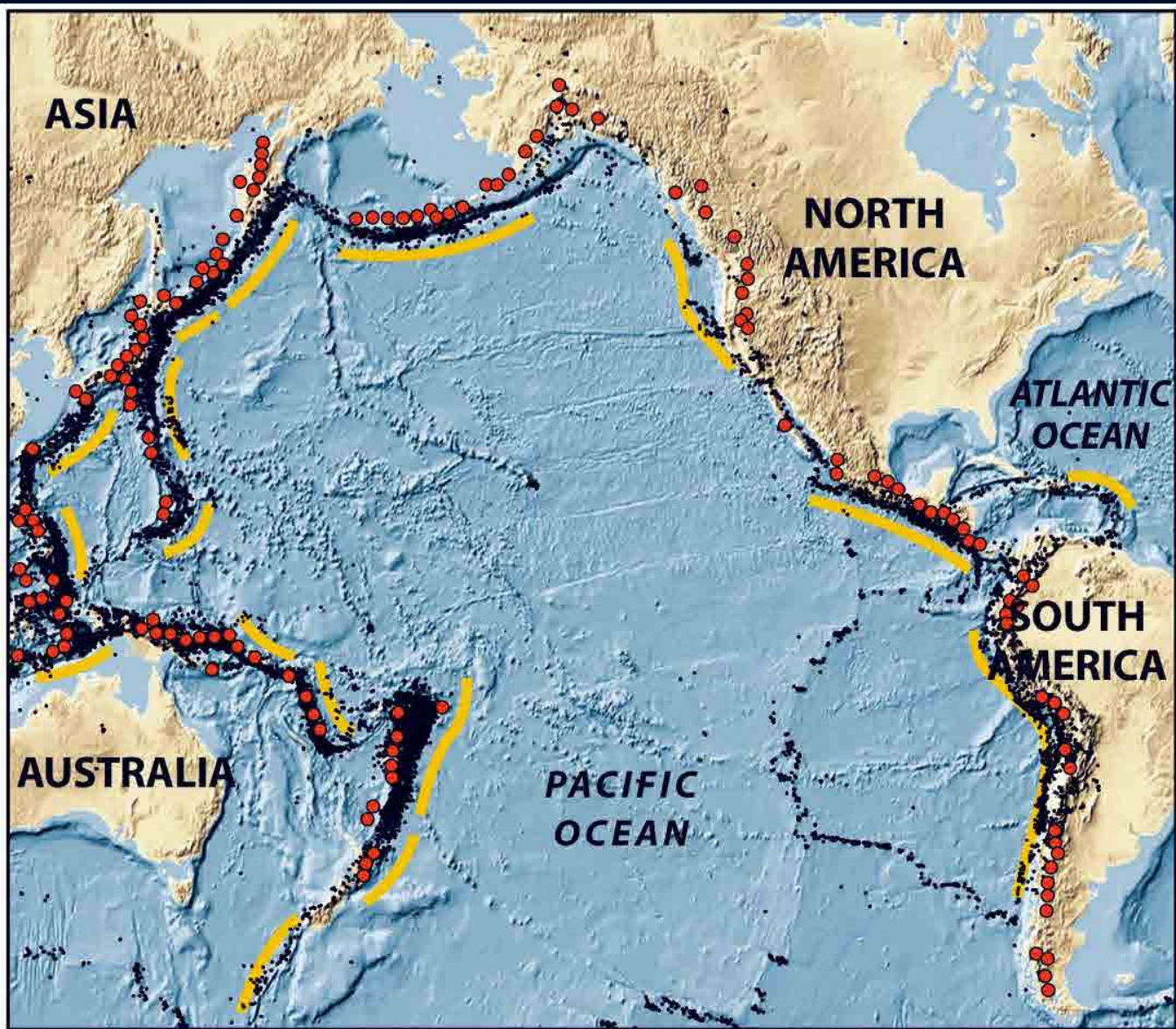


Today



Amazonia and supercontinents

■ Ur	3.0-2.8 Ga	?
■ Kenorland	2.45-2.10 Ga	probably yes
■ Zimvaalbara	2.35-2.22 Ga	not
■ Atlantica	2.3 Ga	?
■ Arctica	2.0 Ga	?
■ Hudsoland	1.8 Ga	probably yes
■ Columbia	1.8 Ga	probably yes
■ Nena	1.5 Ga	?
■ Rodinia	1.2-1.0 Ga	yes
■ Gondwana	520-180 Ma	yes
■ Pangea	300-180 Ma	yes



● Active volcano ⚡ Earthquakes — Deep-sea trench

Tomorrow ?

“Amasia”

Figure 8-21
Earth System History, Second Edition
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Thank you !!!

