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TSG
William Smith Meeting 2017
Plate Tectonics at 50
3-5 October 2017
The Geological Society, Burlington House


# From

# INLAND-SEA BASINS to CONFINED OROGENS:

## Example from the Neoproterozoic

## Araçuaí – West Congo orogen (AWCO)

## and implications for Plate Tectonics

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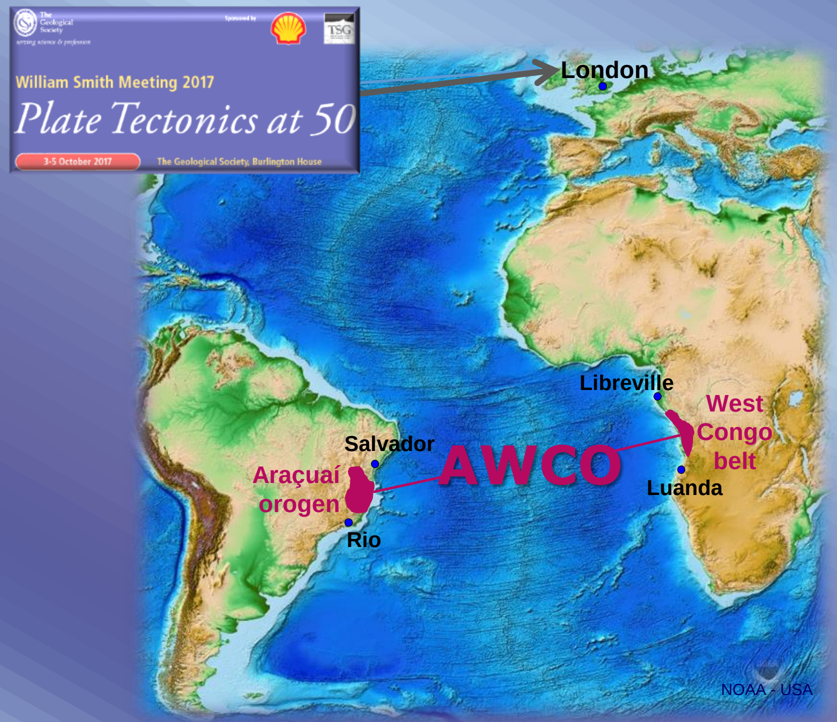
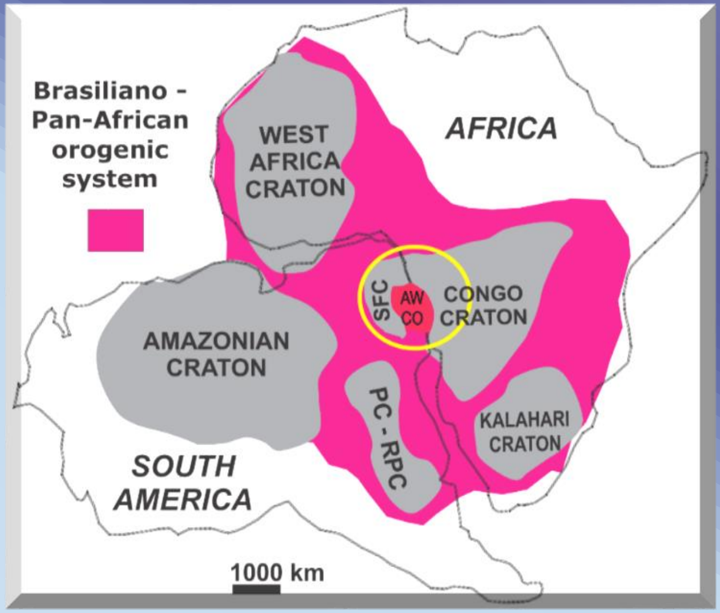
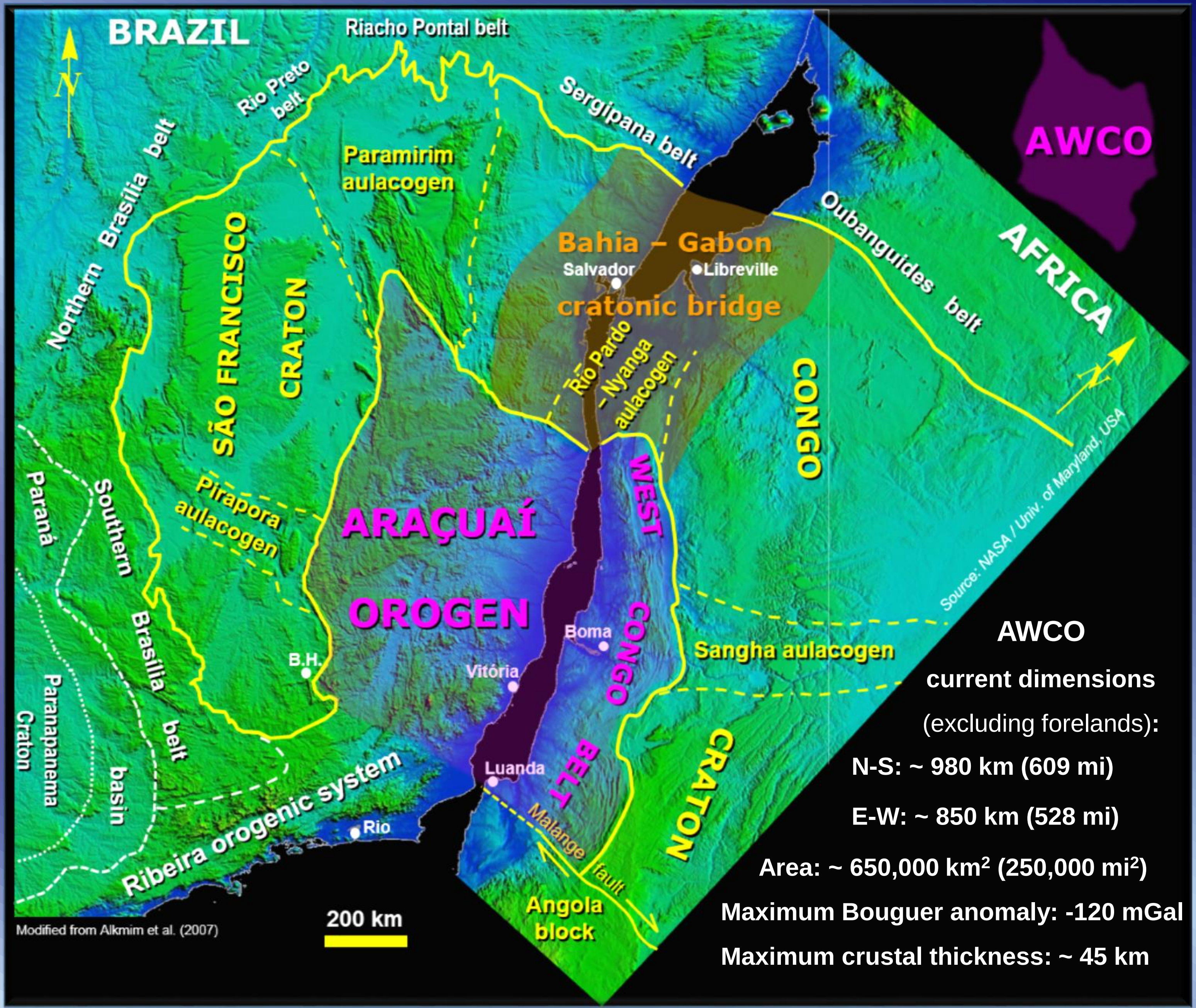
**Financial support**
CAPES CNPq FAPEMIG CODEMIG CPRM PETROBRAS

# AWCO: location, paleotectonic setting, and dimensions




**AWCO**

**current dimensions**

(excluding forelands):

**N-S: ~ 980 km (609 mi)**

**E-W: ~ 850 km (528 mi)**

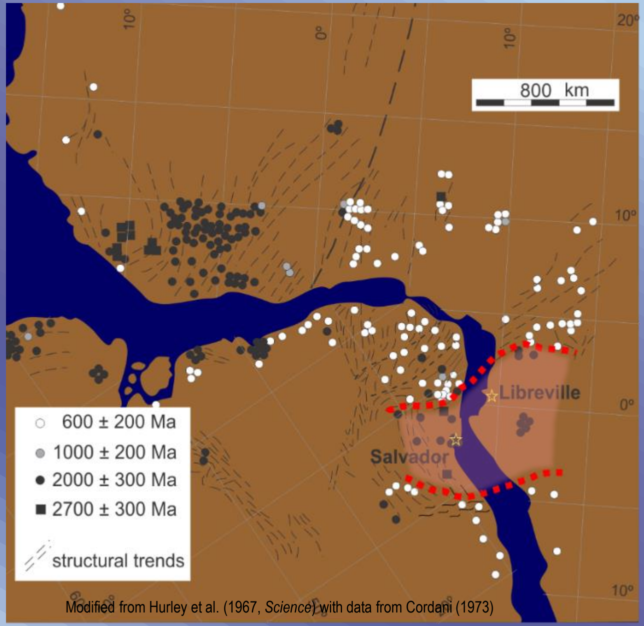
**Area: ~ 650,000 km$^2$ (250,000 mi$^2$)**

**Maximum Bouguer anomaly: -120 mGal**

**Maximum crustal thickness: ~ 45 km**

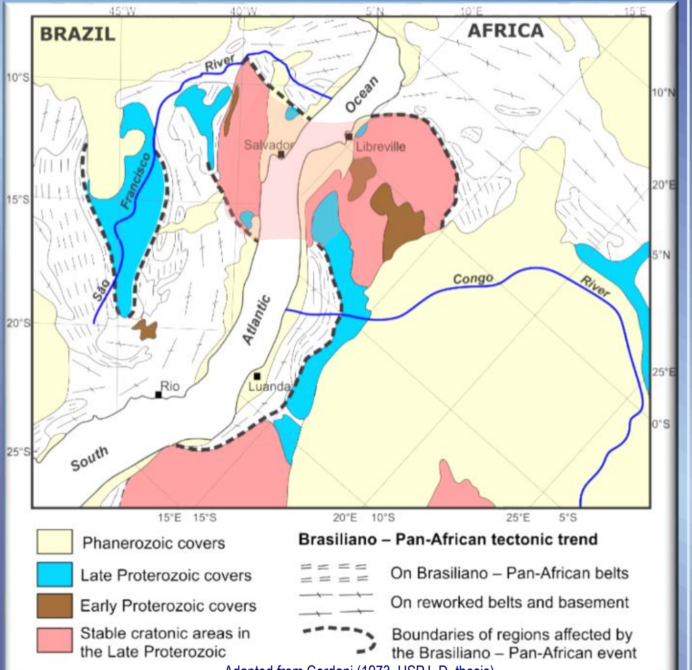
# A cratonic bridge at 50

**1967**: Hurley *et al.* showed regions preserved from the Brasiliano – Pan-African orogeny in E-Brazil and SW-Africa.



Modified from Hurley et al. (1967, *Science*) with data from Cordani (1973)

**1973**: Cordani presented the first map showing the geotectonic link between the São Francisco and Congo cratons.

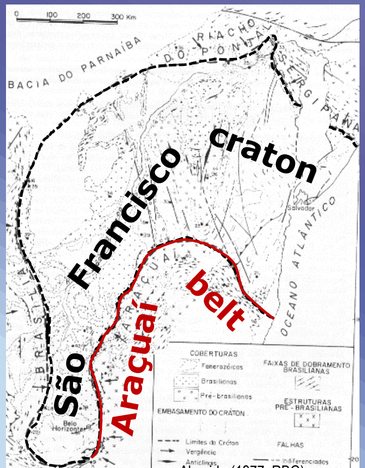


Adapted from Cordani (1973, USP L.D. thesis)

**1967**: Almeida defined the São Francisco craton (SFC).

Almeida (1967, DNPM)

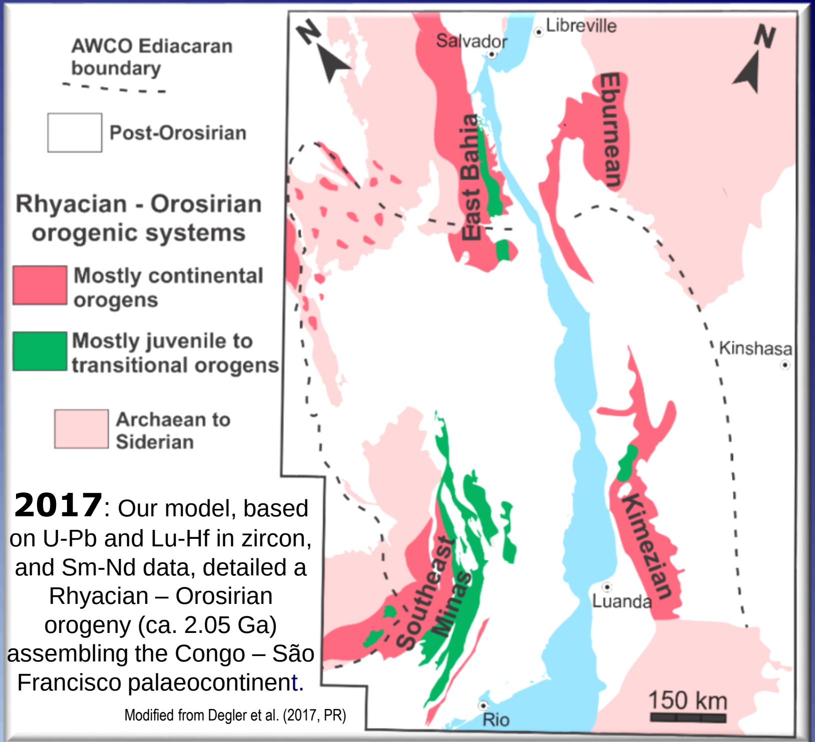
**1977**: Almeida defined the curved Araçuaí belt, limiting the SE São Francisco craton



Almeida (1977, RBG)

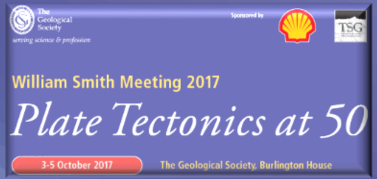
**Many other authors presented data and models reinforcing the existence of a long-lived continental bridge linking the Congo and São Francisco blocks from ca. 2 Ga to the South Atlantic opening.**

**(Torquato and Cordani, 1981, ESR.; De Wit et al., 1988, AAPG; Porada, 1989, PR.; Ledru et al., 1994, PR; Pedrosa-Soares et al., 1992, JSAES, 2001, PR, 2008, GSL; Trompette, 1994, Balkema; Alkmim et al., 2006, PR; Heilbron et al., 2017, Springer)**

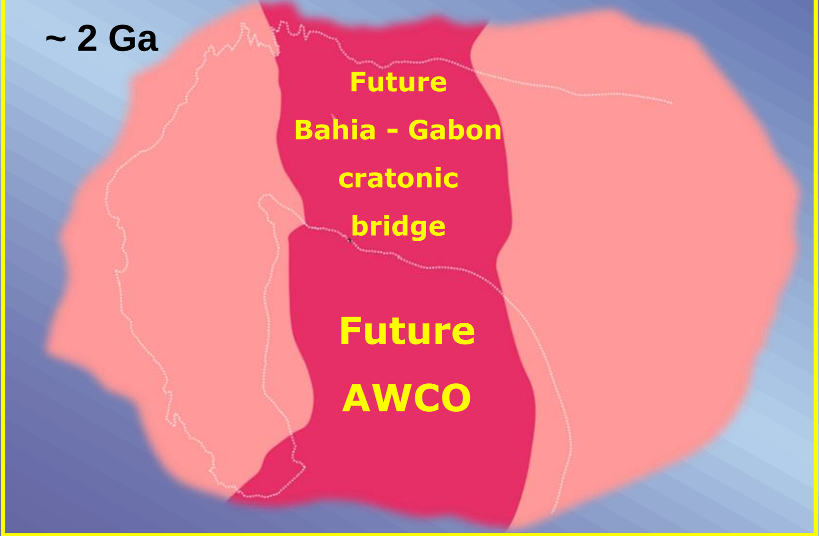



**2017**: Our model, based on U-Pb and Lu-Hf in zircon, and Sm-Nd data, detailed a Rhyacian – Orosirian orogeny (ca. 2.05 Ga) assembling the Congo – São Francisco palaeocontinent.

Modified from Degler et al. (2017, PR)




**CONGO – SÃO FRANCISCO PALAEOCONTINENT**




# Shaping the bridge: How many rifting events preceded the AWCO?

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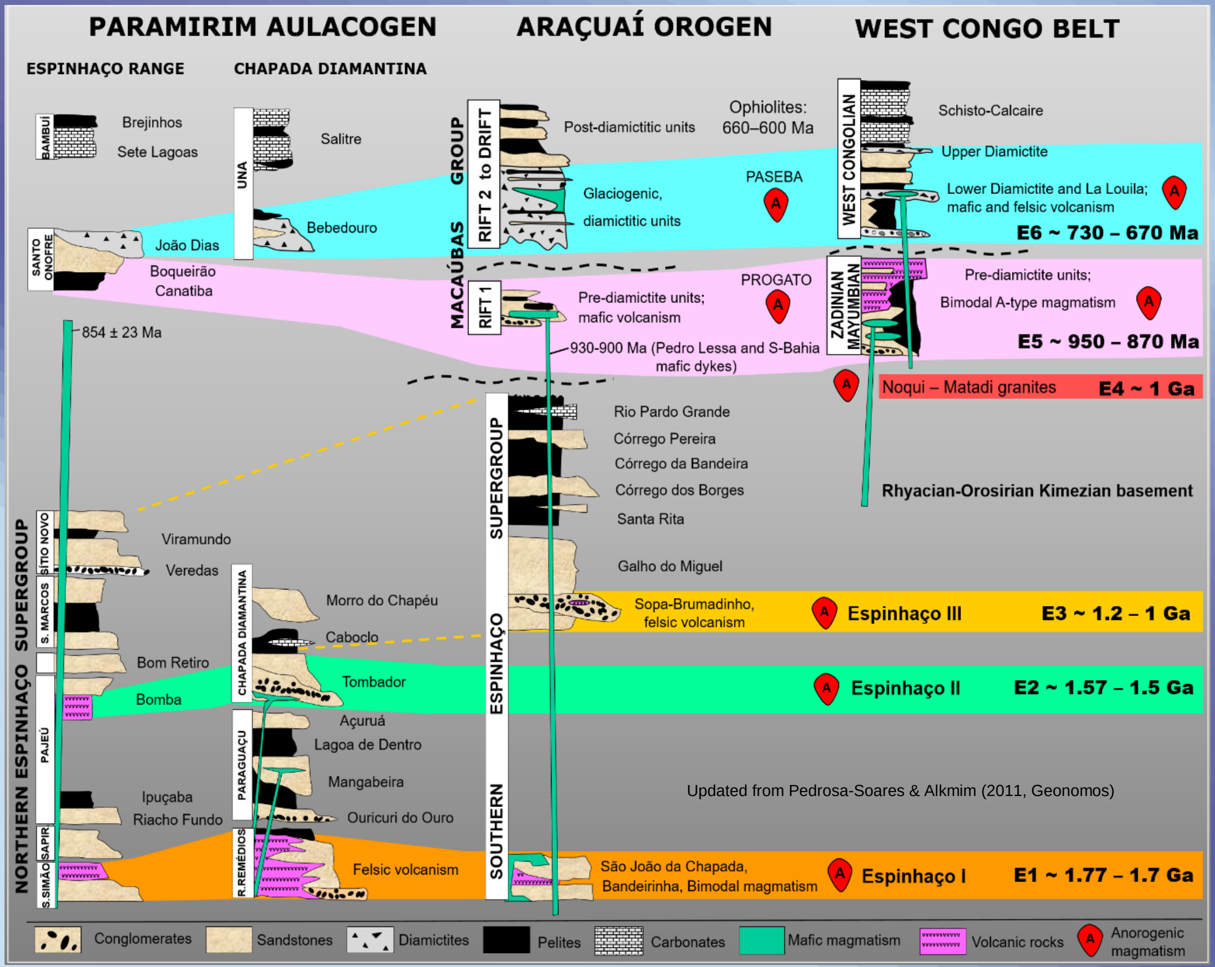
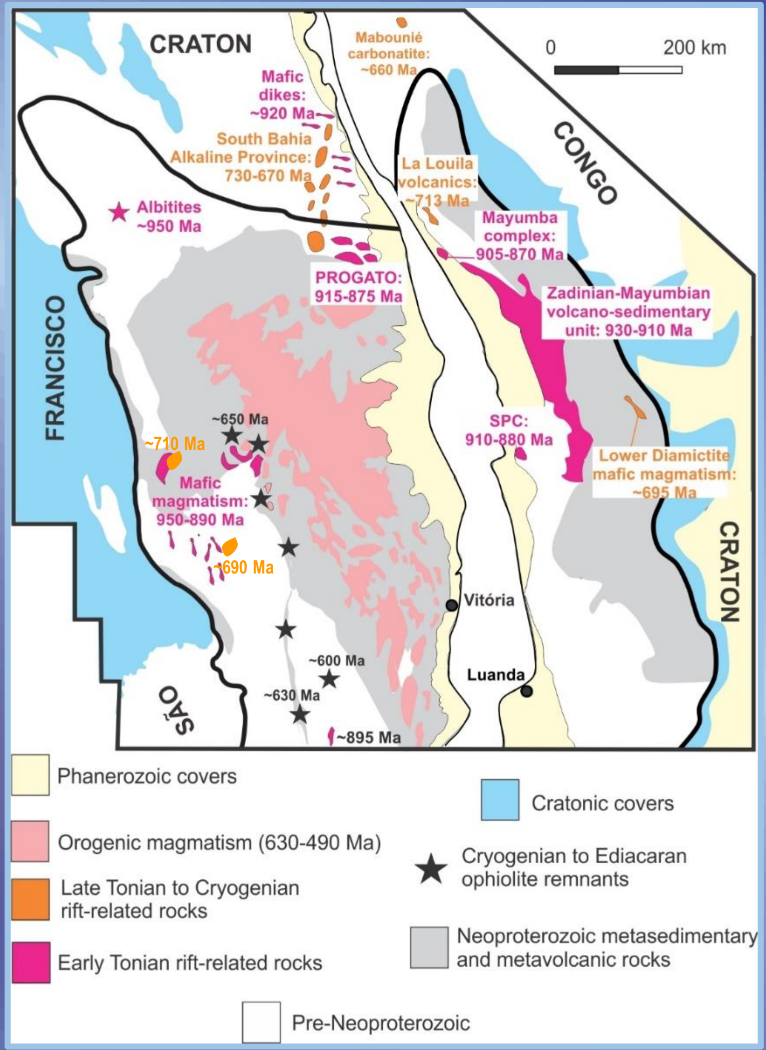
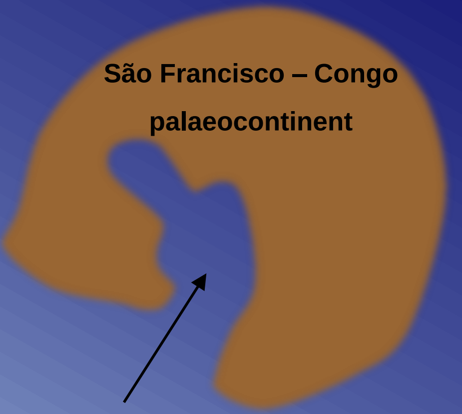
## At least six events from ca. 1.77 Ga to ca. 670 Ma.

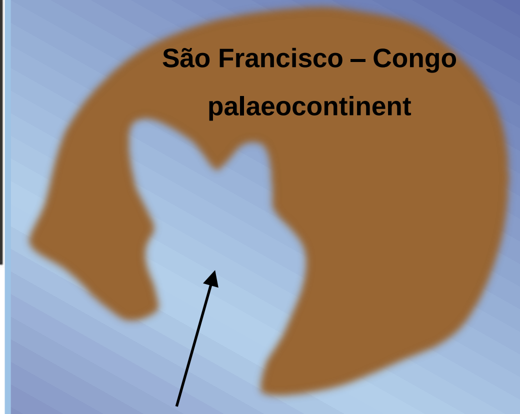
## Two Neoproterozoic continental rifts, but only one oceanic opening.




Aborted Tonian rift
(930 – 880 Ma)



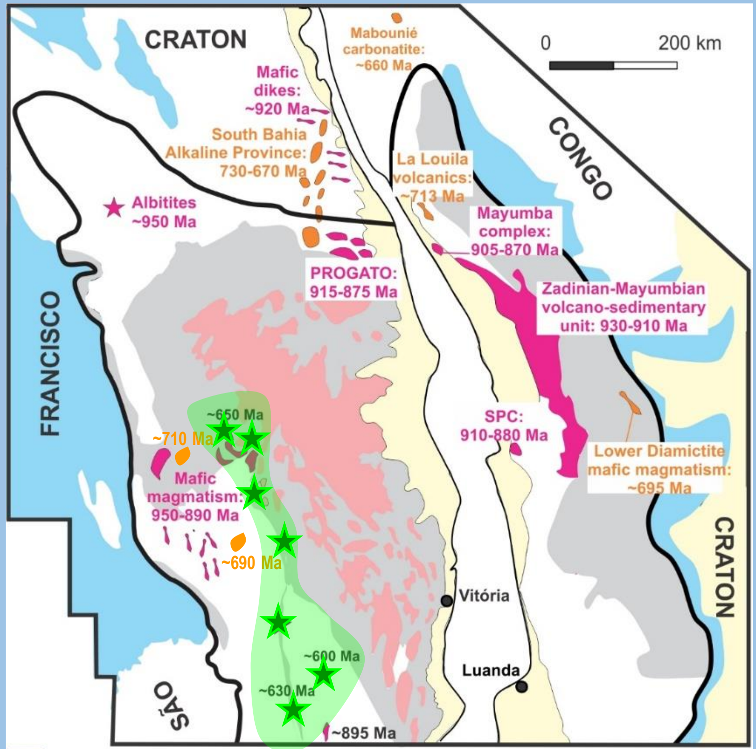

Cryogenian rift (720 – 670 Ma)
evolved to ocean spreading

Data source: Tack et al. 2001, PR; Pedrosa-Soares et al. 1998; Geology, 2011, GSL; Queiroga et al. 2007, Geonomos; Rosa et al. 2007, Lithos; Silva et al. 2008, GR; Thiéblemont et al. 2009, CAG, 2011, BRGM; Queiroga 2010, UFMG Dr; Straathof 2011, U. Edinburgh PhD; Gradim 2012, UFMG MsC; Dussin & Chemale 2012, GR; Menezes et al. 2012, Geonomos, Castro 2014, UFOP MSc, Evans et al. 2015, GSL, Lobato et al. 2015, JSAES; Souza 2016, UFOP MSc, Magalhães 2017, UFBA MSc.



A. Pedrosa-Soares et al.

# Ocean spreading within an inland-sea basin




Phanerozoic covers

Orogenic magmatism (630-490 Ma)

Late Tonian to Cryogenian rift-related rocks

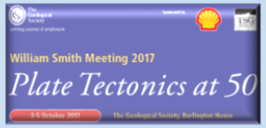
Early Tonian rift-related rocks

Cratonic covers

**Ophiolite bodies (650 – 600 Ma)**

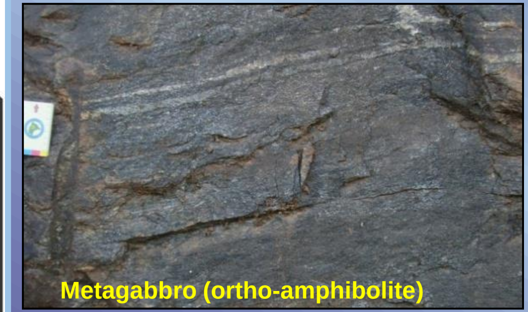
Neoproterozoic metasedimentary and metavolcanic rocks

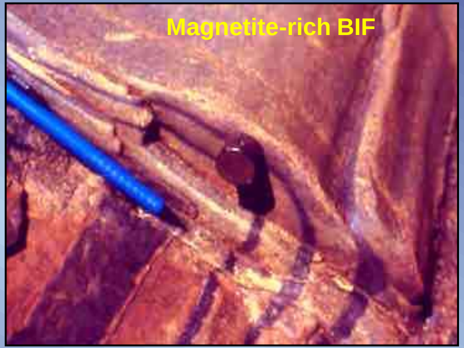
Pre-Neoproterozoic

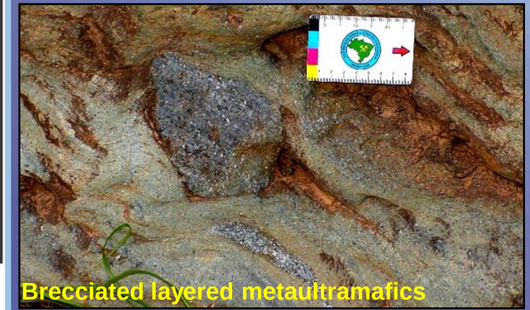



## Metamorphosed igneous, exhalative and pelitic rocks





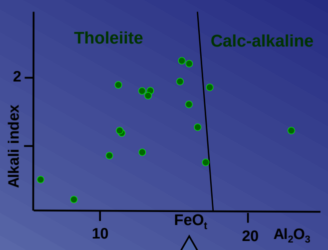



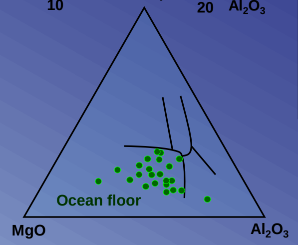



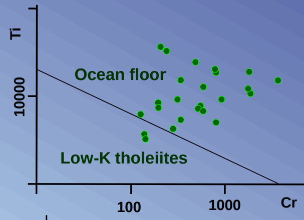


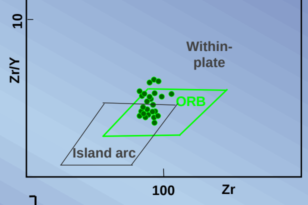


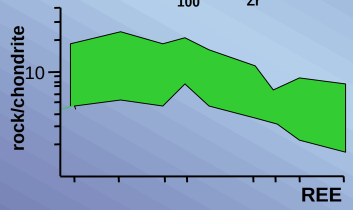
## Lithochemistry

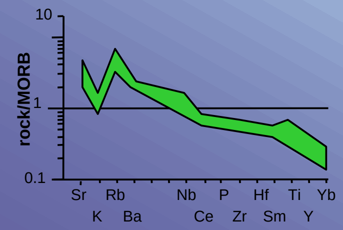


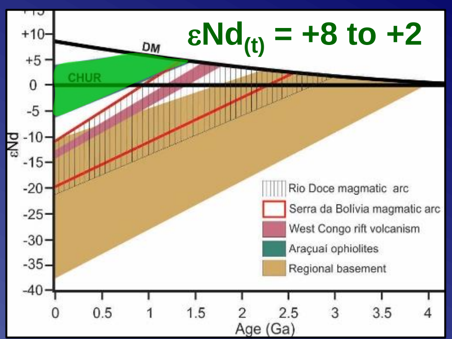



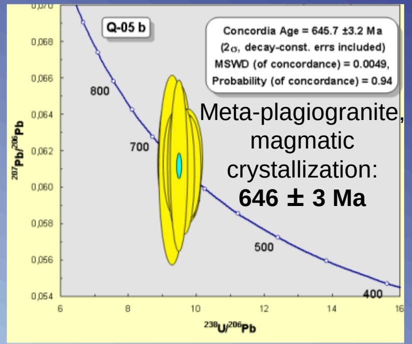



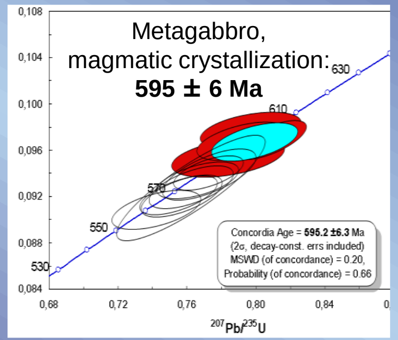




## Nd isotopic signature



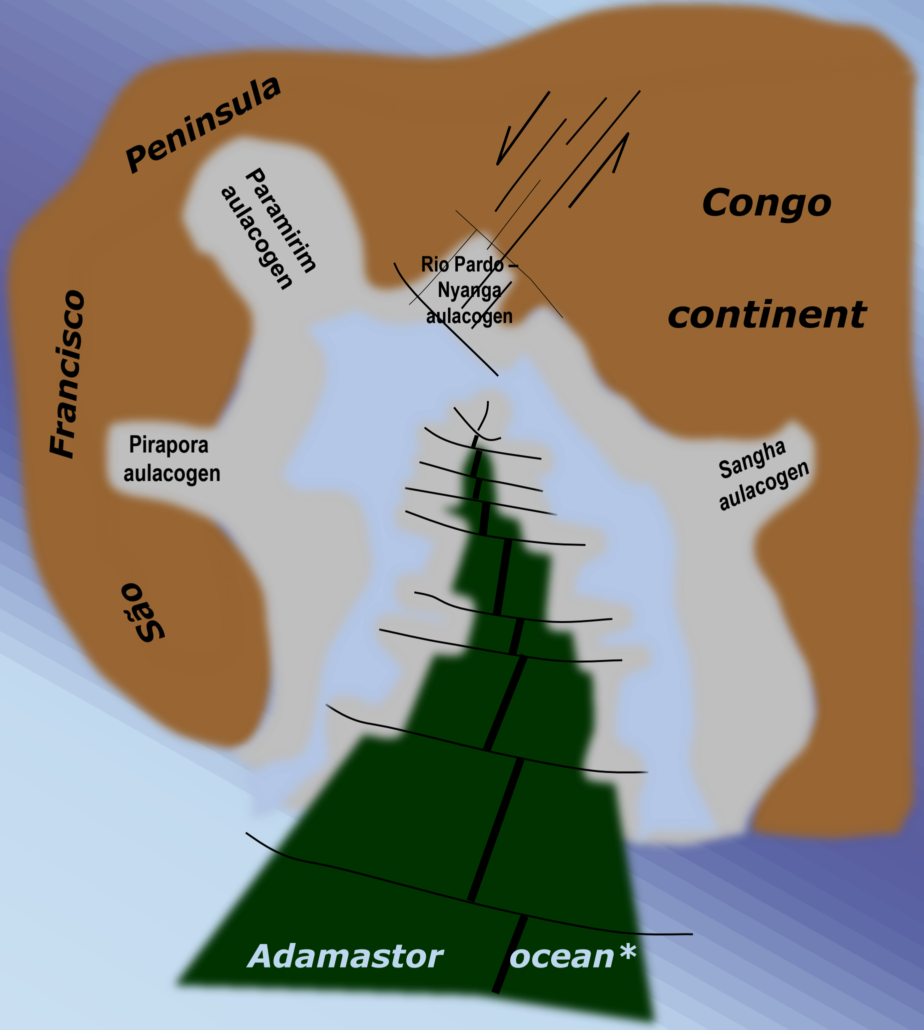

## Zircon U-Pb (La-ICP-MS) geochronology



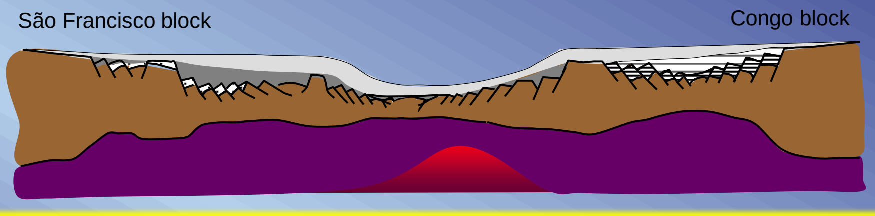

Data sources: Pedrosa-Soares et al. 1992, JSAES; 1998 Geology; 2011, GSL; Pedrosa-Soares 1995 UnB PhD; Suita et al. 2004, CYTED-Madri; Queiroga et al. 2007, Geonomos; Queiroga 2010, UFMG PhD, Tedeschi et al. 2016, JSAES.

# From an oceanized inland-sea basin to a confined orogen

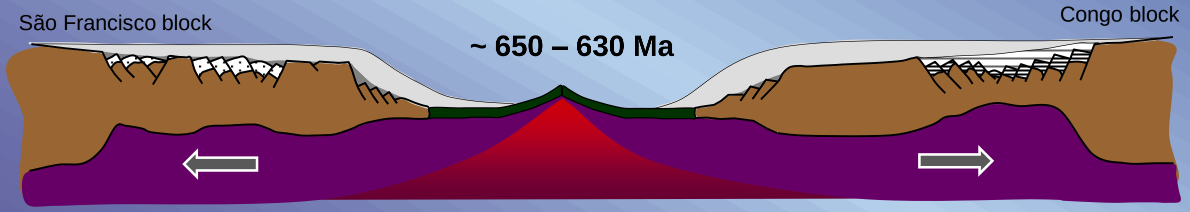



(*Hartnady et al. 1985, Episodes)

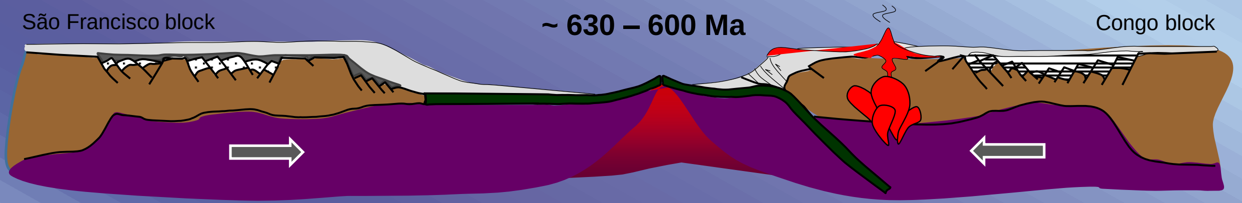
## ENSIALIC SECTOR:
## no ophiolite, no magmatic arc, no plate boundary




## OCEANIZED SECTOR:
## ophiolites and...



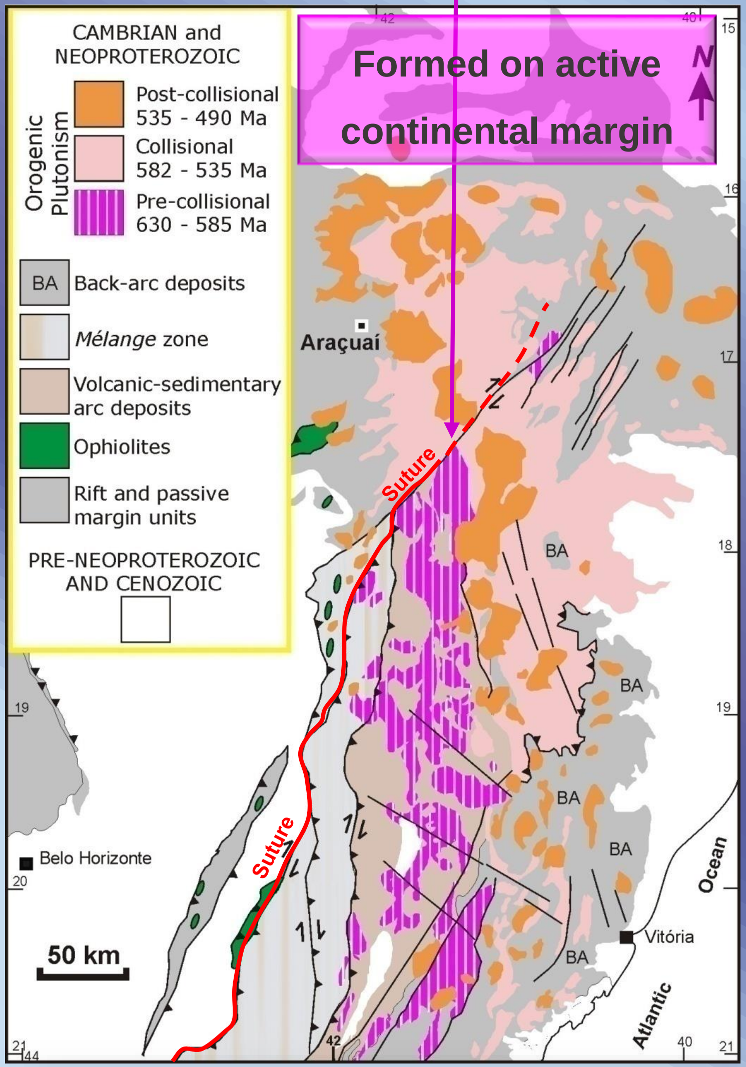

## a magmatic arc on an active continental margin

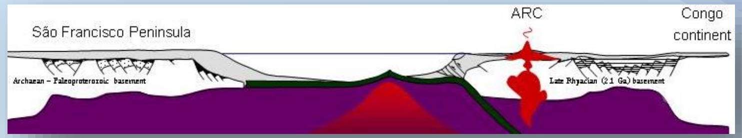



Adapted from Alkmim et al. 2007 (Geonomos)

# OROGENIC STAGES

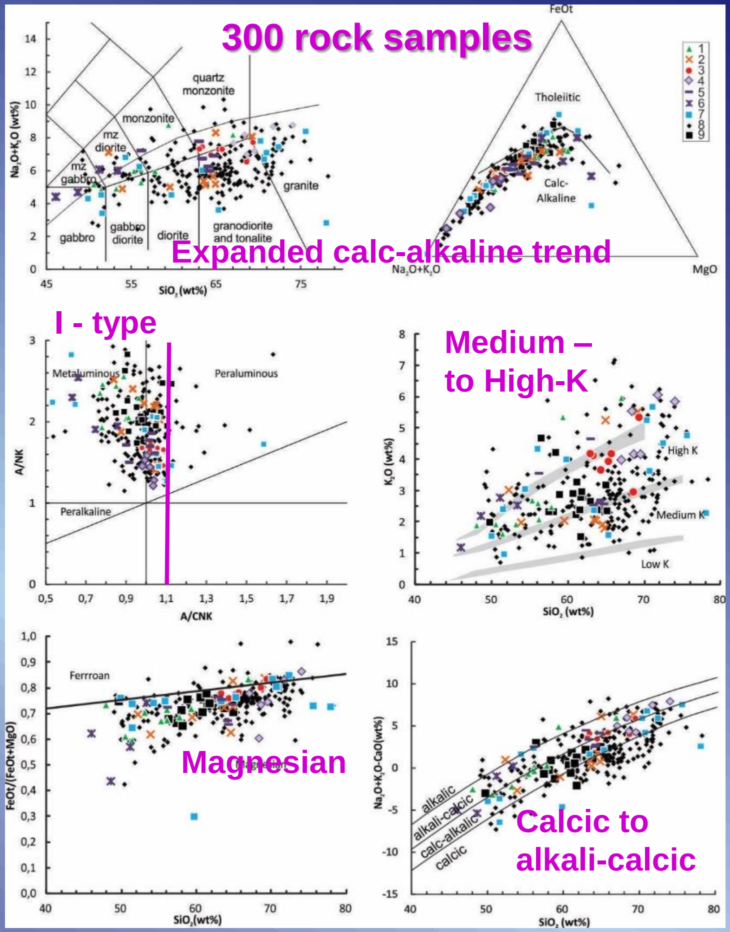
## The Rio Doce magmatic arc

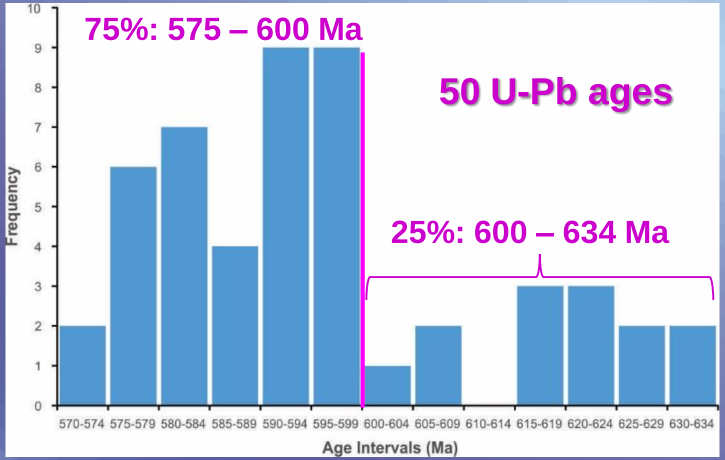




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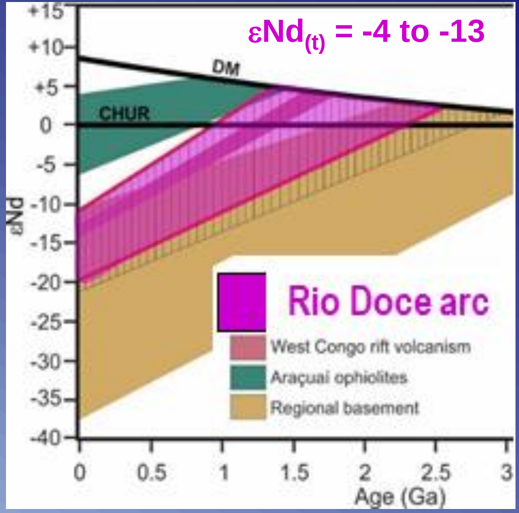
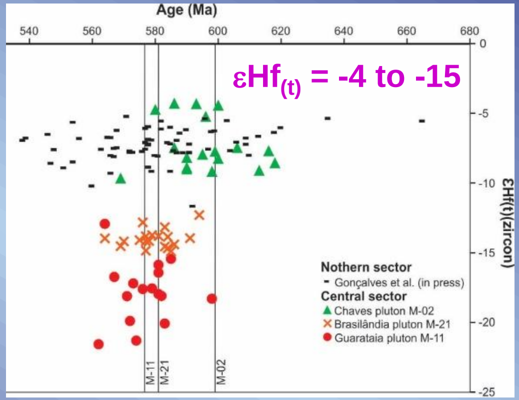
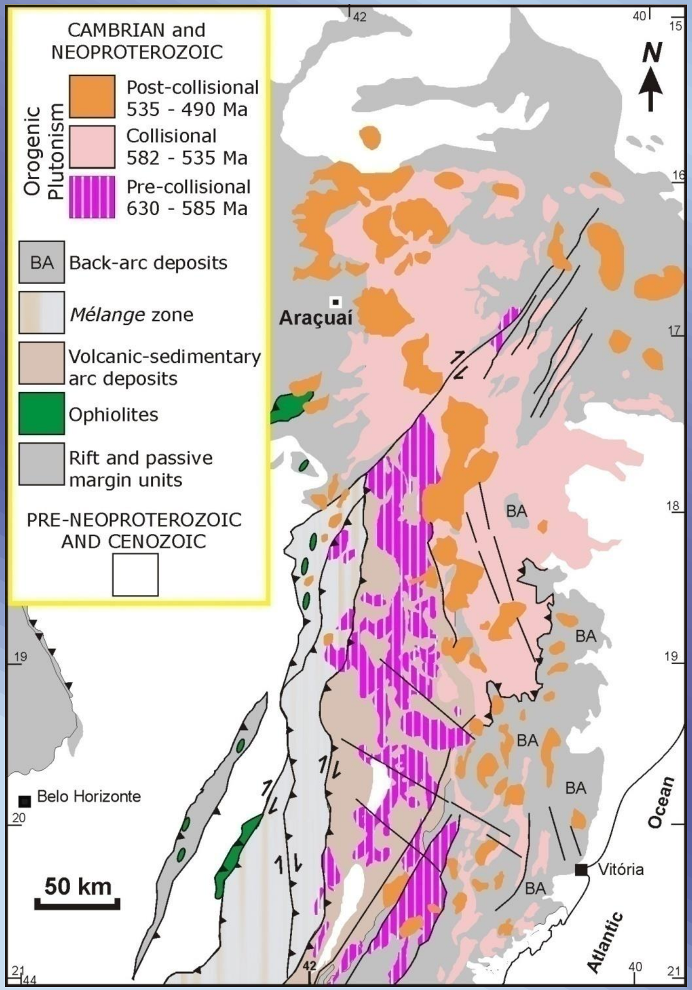
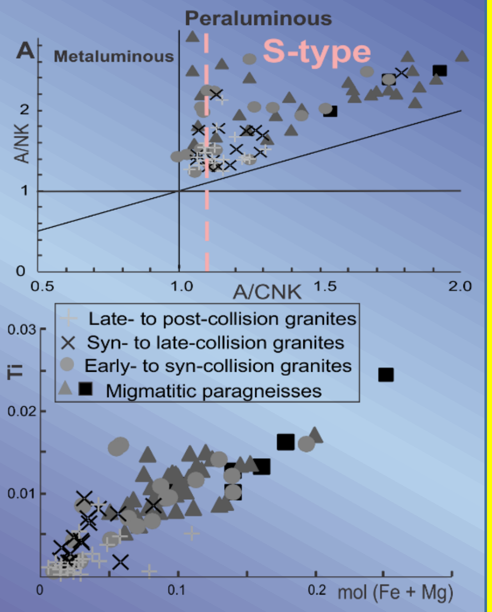


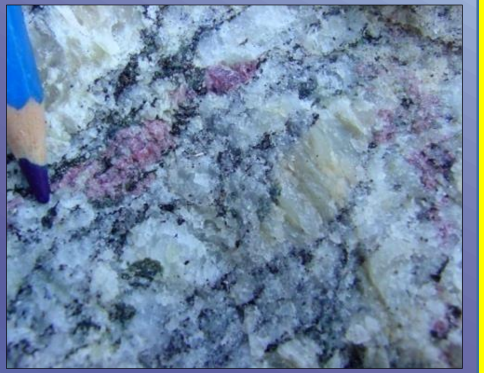



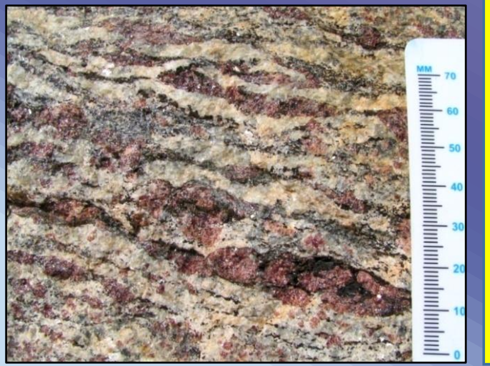

Data sources: Nalini et al. 2000, CRASP; Noce et al. 2000, RBG; Pedrosa-Soares et al. 2001, PR, 2011, GSL; Martins et al. 2004, GR; Vieira 2007, UFMG Dr; Novo et al. 2010, RBG; Gonçalves et al. 2014, JSAES, 2016, GR; Tedeschi et al. 2016, JSAES.

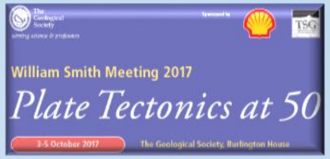
# COLLISIONAL GRANITES



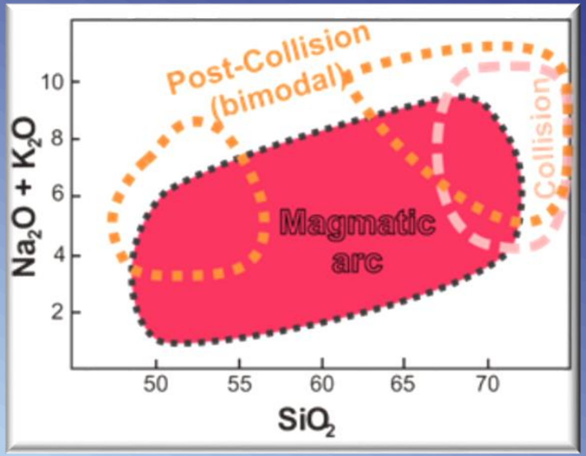



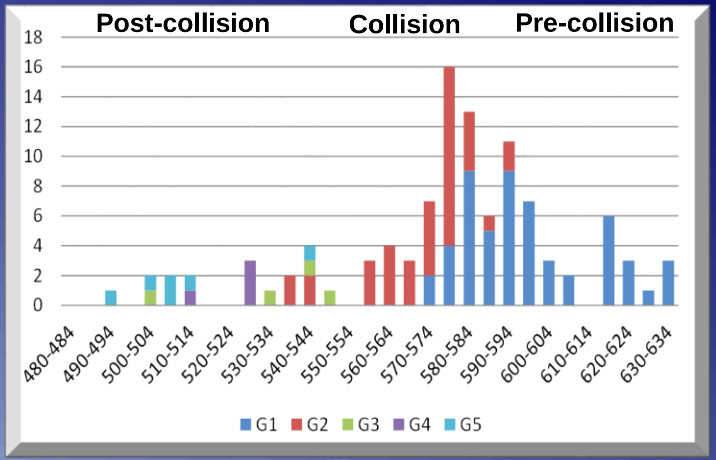




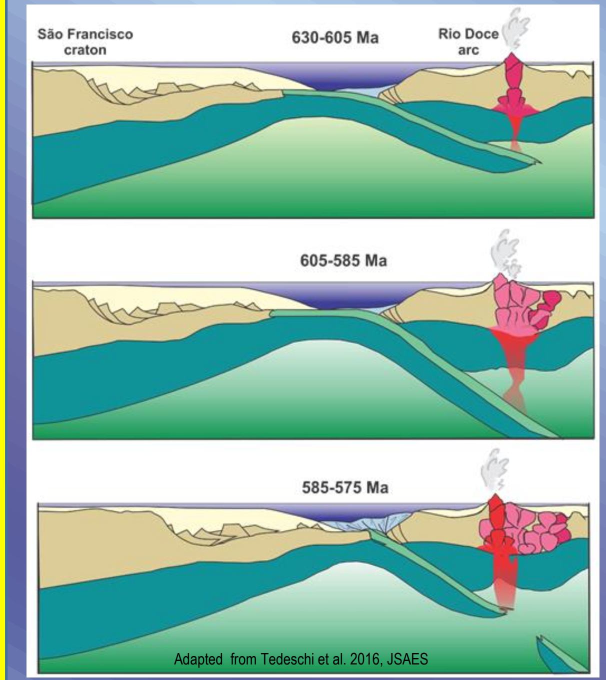

**From inland-sea basins to confined orogens:**

# From the pre-collisional to post-collisional stages

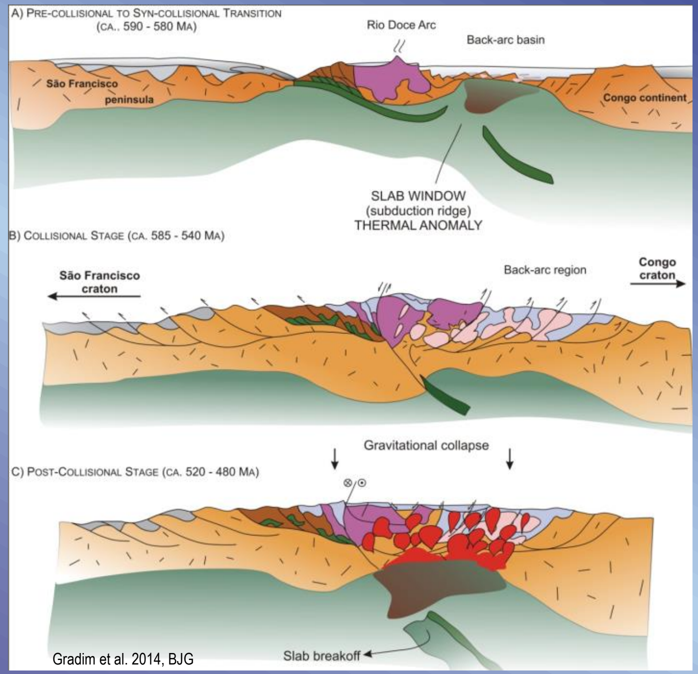



**Such a large (~220,000 km² or 77,000 mi²) and long lasting (630 – 480 ma) orogenic magmatism requires distinct heat sources.**



Adapted from Tedeschi et al. 2016, JSAES



Gradim et al. 2014, BJG

Data sources: Pedrosa-Soares et al. 2011, GSL; Gradim et al. 2014, BJG; Richter et al., 2016, PR; Melo et al. 2017, Lithos)

A. Pedrosa-Soares et al.

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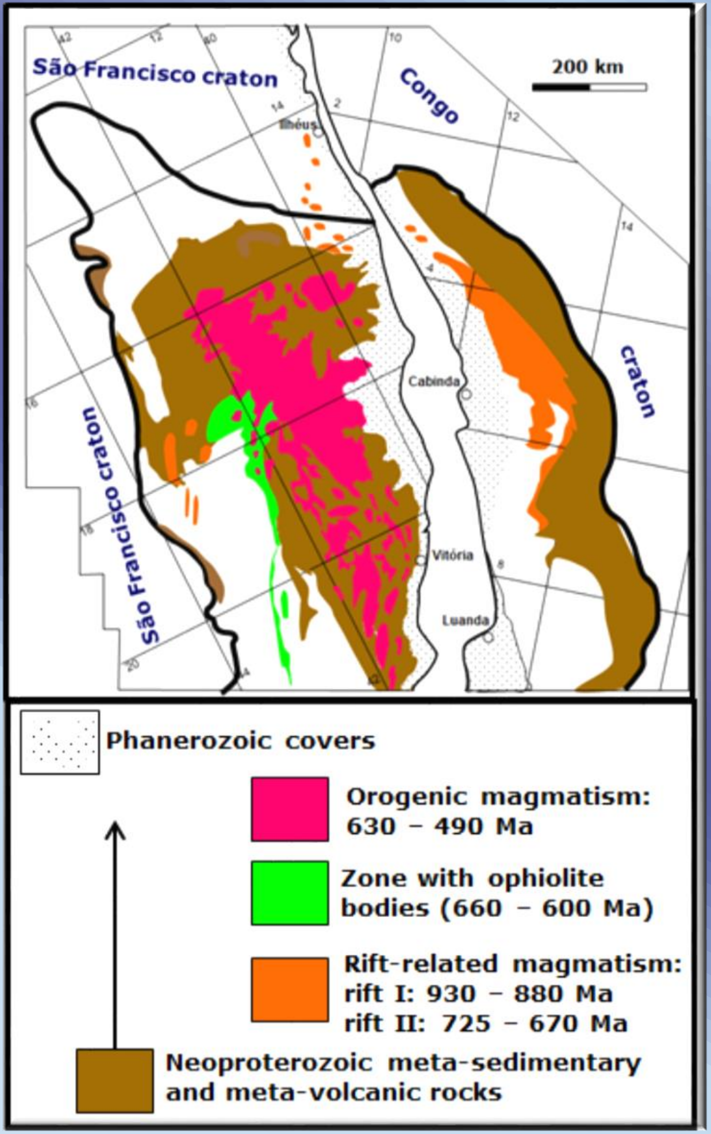
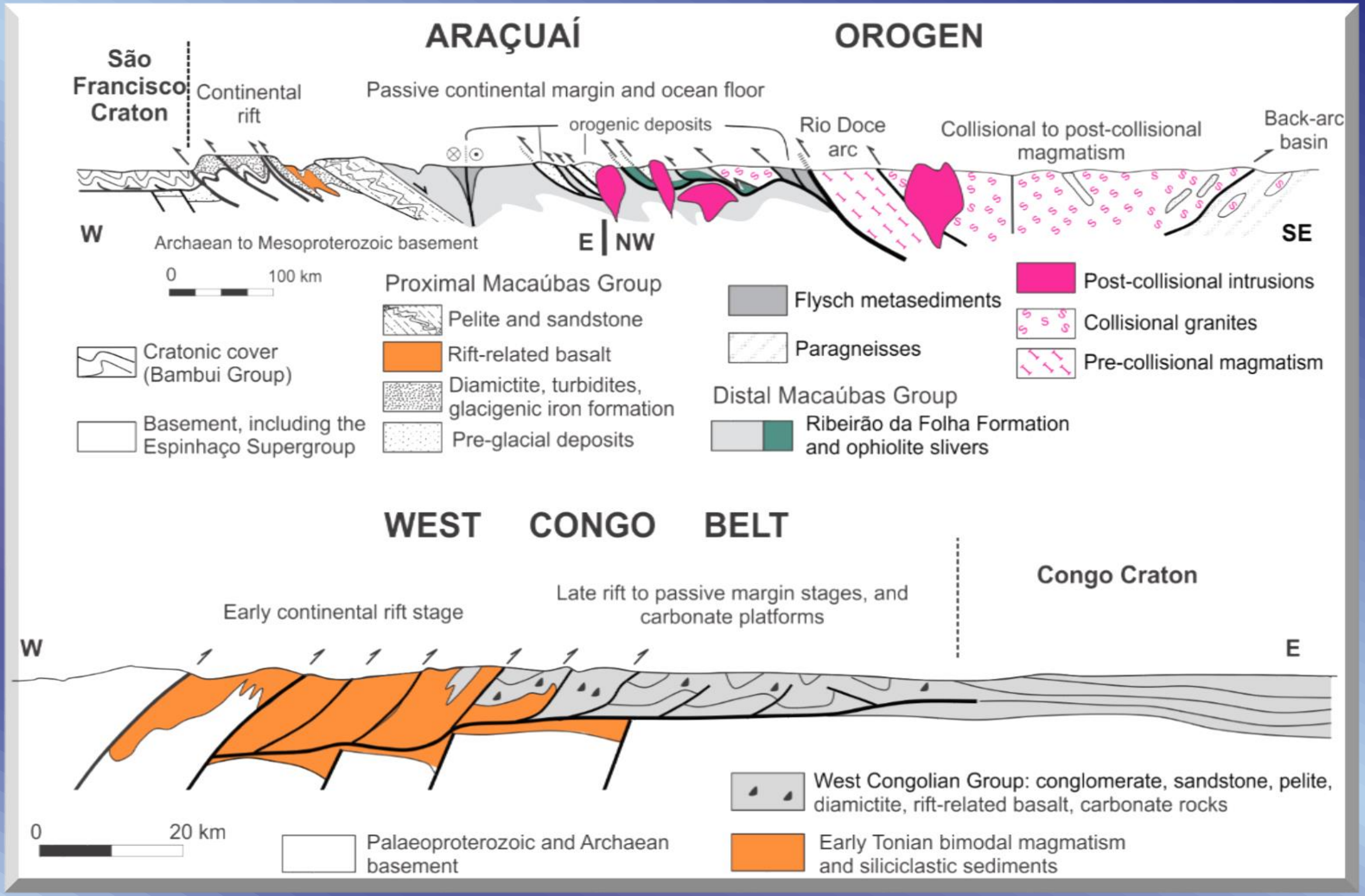
# The outcome: A complete orogen within a cratonic embayment

- A double verging, roughly symmetrical orogen
- More than 2/3 of the whole orogen left in Brazil after the South Atlantic opening
- Main correlations supported by rift-related magmatism, diamictitic successions and tectonic features

**No ophiolite nor orogenic magmatism in the West Congo belt**




Modified from Alkmim et al. 2006, PR, 2007, Geonomos; Pedrosa-Soares et al., 2007, Geonomos, 2008, GSL.



A. Pedrosa-Soares et al.

AWCO: birthplace of a concept

# THE CONFINED OROGEN

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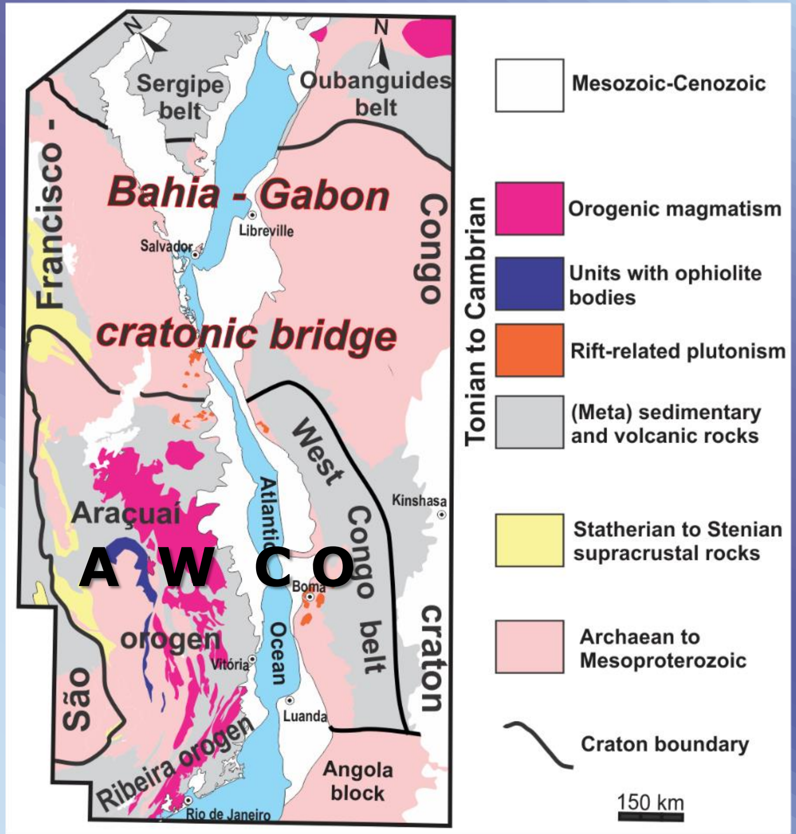
## Intermediate term between typical plate margin orogens and intracratonic (ensialic) orogens

(Pedrosa-Soares et al. 2001, *Prec. Res.*, 2008, *GSL Sp. Publ.*; Rogers & Santosh 2004, *Continents & Supercontinents*, Oxford U.P.)

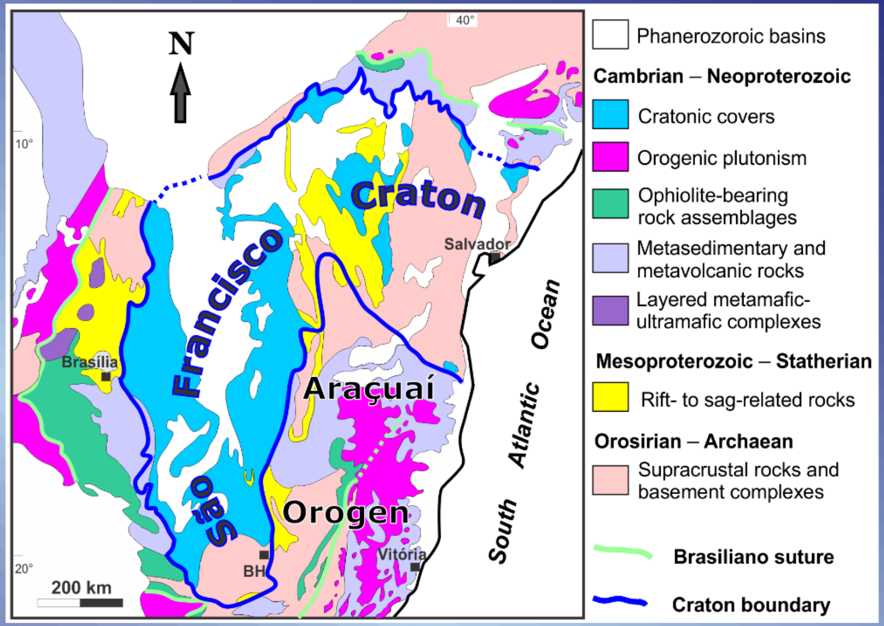



**Despite the confinement to a continental embayment, such an orogen shows:**

- ✓ **Ophiolite bodies (⇒ oceanic spreading)**

**and**

- ✓ **Orogenic magmatism from a volcanic arc (⇒ oceanic subduction) to collisional granites and post-collisional intrusions.**

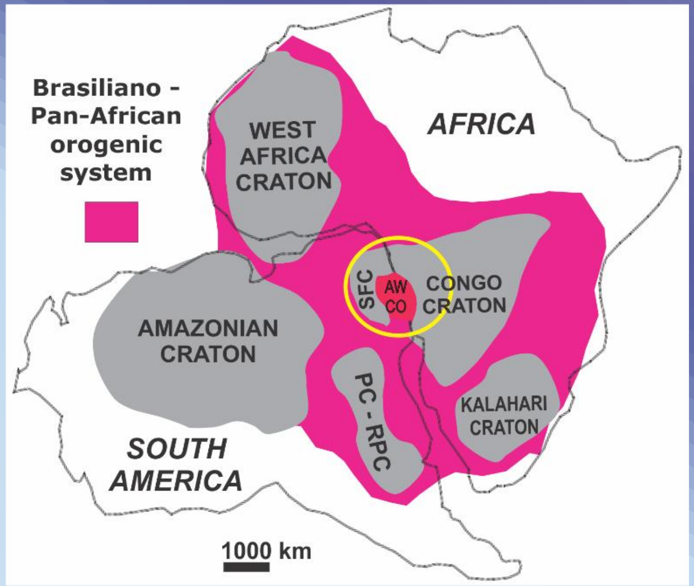


Mdodied from Alkmim et al. (2017, Springer)

See also: Alkmim et al. 2006, Prec. Res.; Pedrosa-Soares et al. 2011, Sp. Publ. Geol. Soc. London; Peixoto et al. 2015, Gond. Res.; Tedeschi et al. 2016, JSAES; Richter et al. 2016, Prec. Res.; Degler et al. 2017, Gond. Res.; Heilbron et al. 2017, Springer)

Another example of confined orogen:
Rogers, J.J.W.; Suayah, I. B.; Miller, B. V.; Miller, J.S., 2005. A confined orogen in the Tibesti Massif, southern Libya, during the late Neoproterozoic. Geological Society of America, Abstracts with Programs, 37(7): 73

# Implications for Plate Tectonics


- ✓ **The cratonic bridge and confined orogen reflect a high strength lithosphere.**
- ✓ **The inland-sea basin may represent a terminal segment of an active ocean ridge or a stagnant basin partially floored by oceanic crust.**
- ✓ **Aulacogens connected to a confined orogen play a major role, accommodating extensional and contractional strains during opening and closing of the system.**

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# Thank you!

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