# Passive-Source Seismology in the Borborema Province of NE Brazil

## *Combining Temporary and Permanent Networks*


*Jordi Julià*

*Departamento de Geofísica*

# Outline

- INCT – Estudos Tectônicos
- The Borborema Province
  - Precambrian framework
  - Cenozoic volcanism and uplift
- Seismic studies:
  - Temporary seismic networks in NE Brazil
  - Surface-wave tomography, ambient noise, receiver functions, joint inversion.
- Conclusions

# INCT – Estudos Tectônicos

To study the continental crust and upper mantle in Brazil, focusing initially on the Borborema Province and the São Francisco craton of NE Brazil.

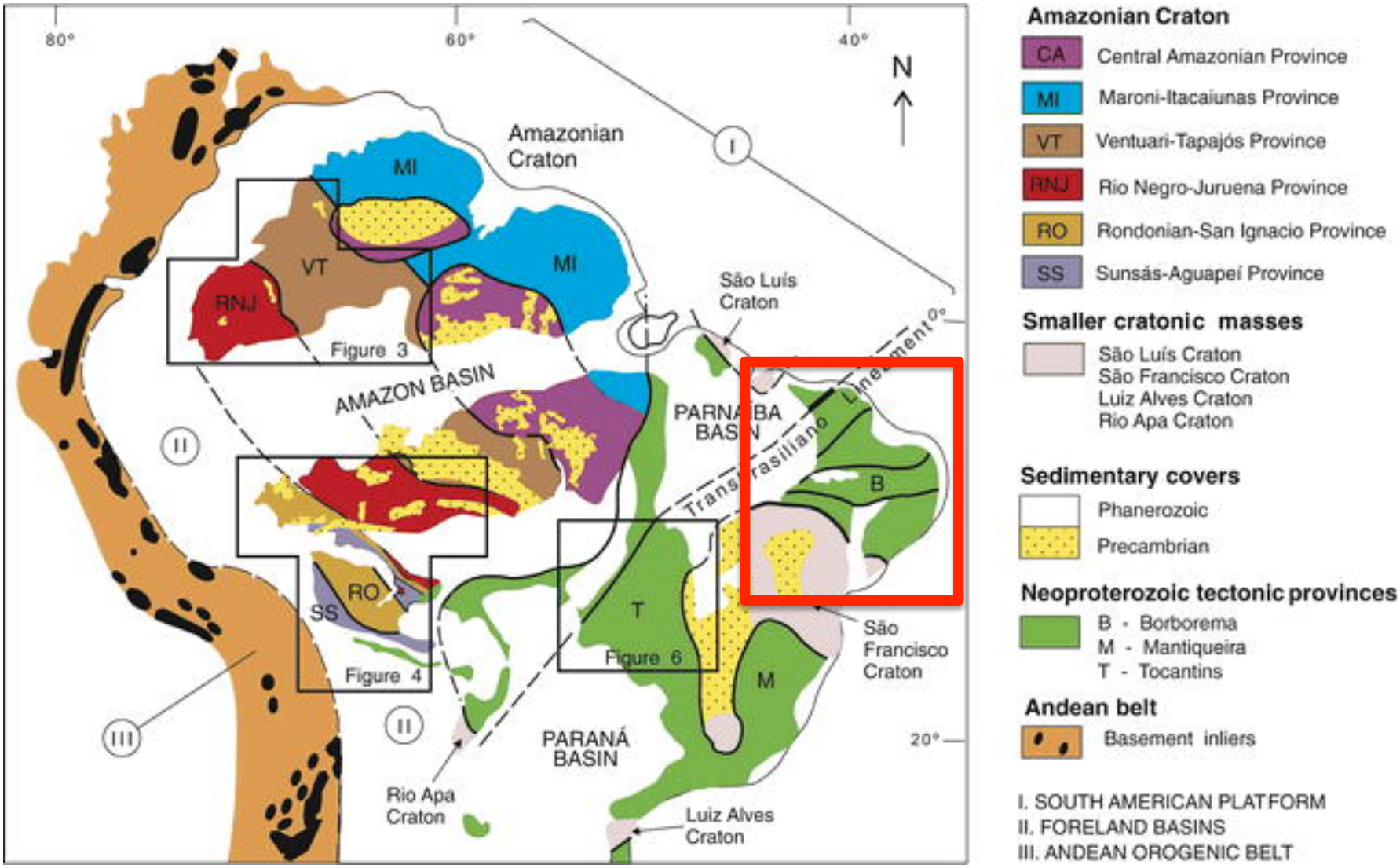

http://memoria.cnpq.br/programas/inct/_apresentacao/inct_estudos_tectonicos.html

# The Borborema Province

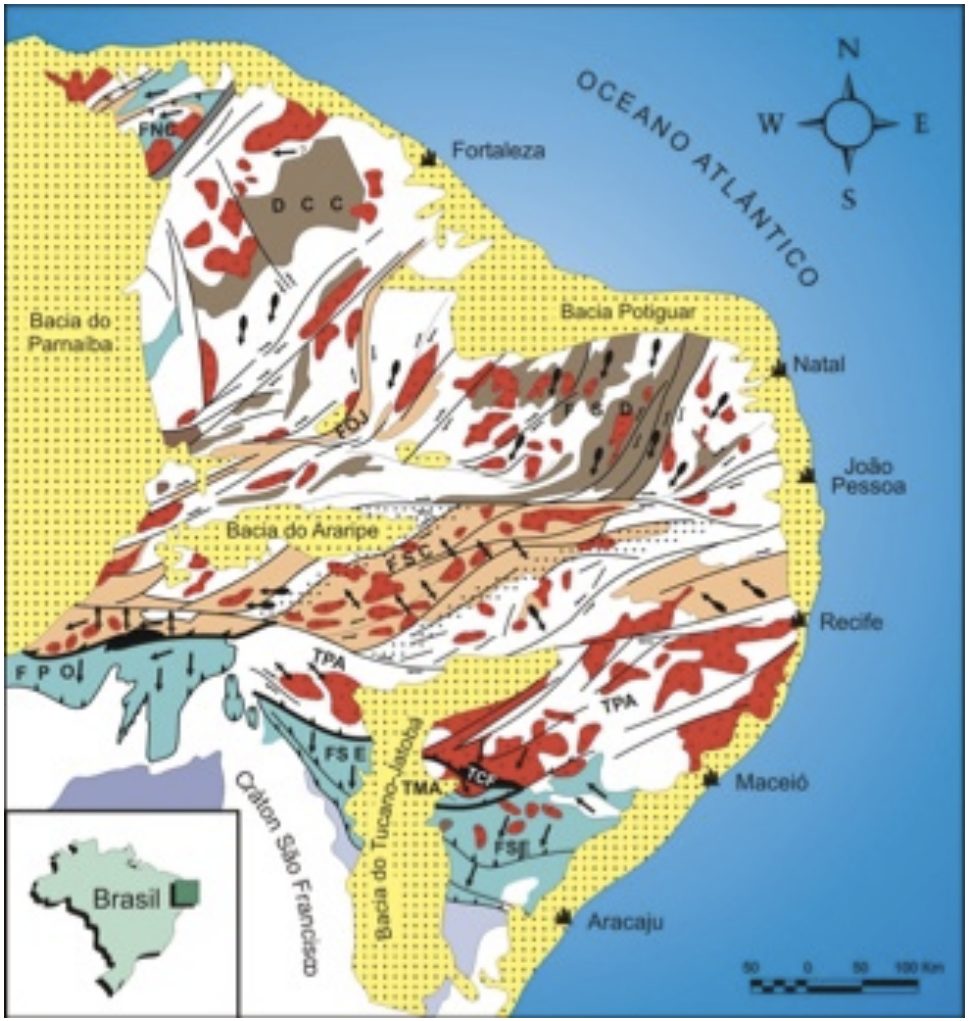
A structural domain bounded by the Parnaíba basin to the West, the São Francisco craton to the South, and the coastal margin to the East and North.

- It is regarded as a complex orogenic system that was strongly affected by deformational, metamorphic, and magmatic processes during the Brasiliano/Panafrican orogeny.
- After the opening of the Atlantic ocean, its evolution was marked by the volcanism along the MQA and the uplift of the Borborema Plateau.

# The Borborema Province – NE Brazil



# Precambrian Framework




## Two models:

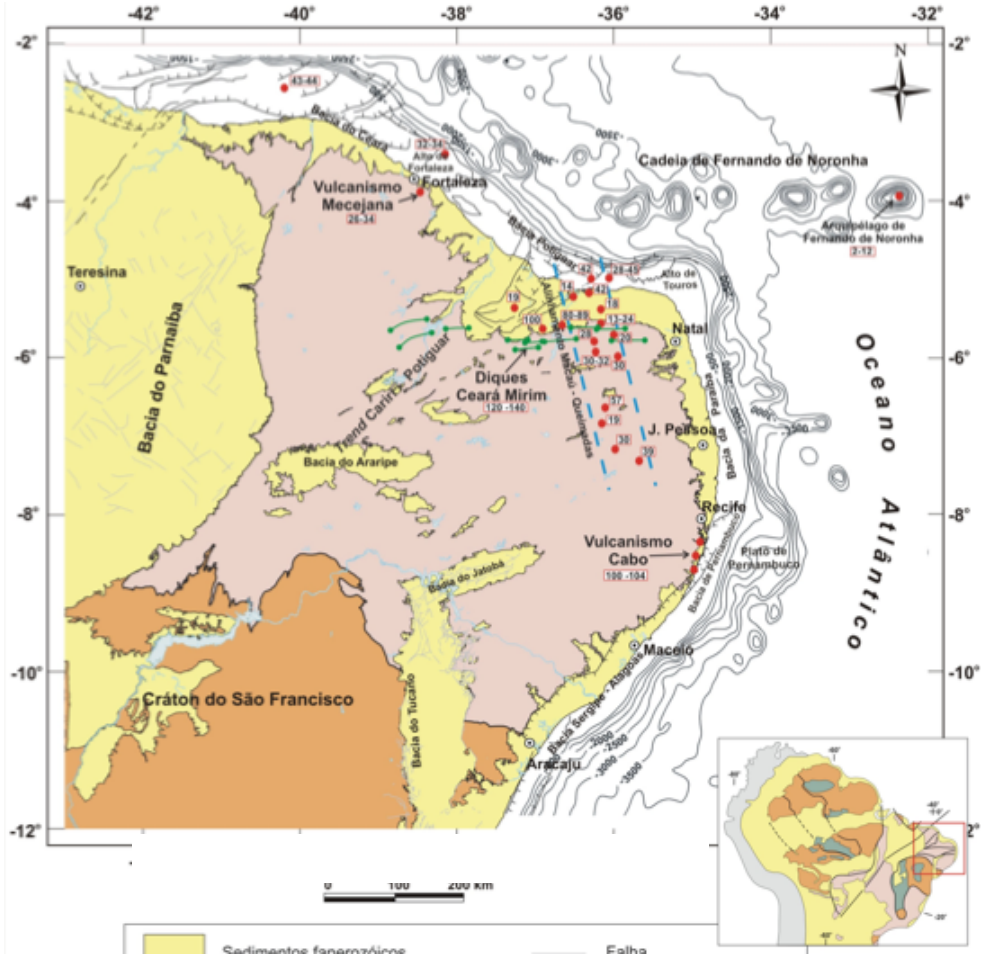
- Shear zones defining terrains of distinct tectonic evolution.
- Single tectonic block since 2.0 Ga.

Cobertura fanerozóica
Formações molássicas cambrianas
Granitóides brasilianos e complexos de arco
Supracrustais neoproterozóicas
Supracrustais mesoproterozóicas
Supracrustais paleoproterozóicas
Gnaisses e migmatitos paleoproterozóicos a arqueanos
Cobertura neoproterozóica do Cráton São Francisco
Cobertura mesoproterozóica do Cráton São Francisco

*Courtesy of Gusmão (2011)*

# Meso-Cenozoic Volcanism

## Up to 3 magmatic episodes have been identified:

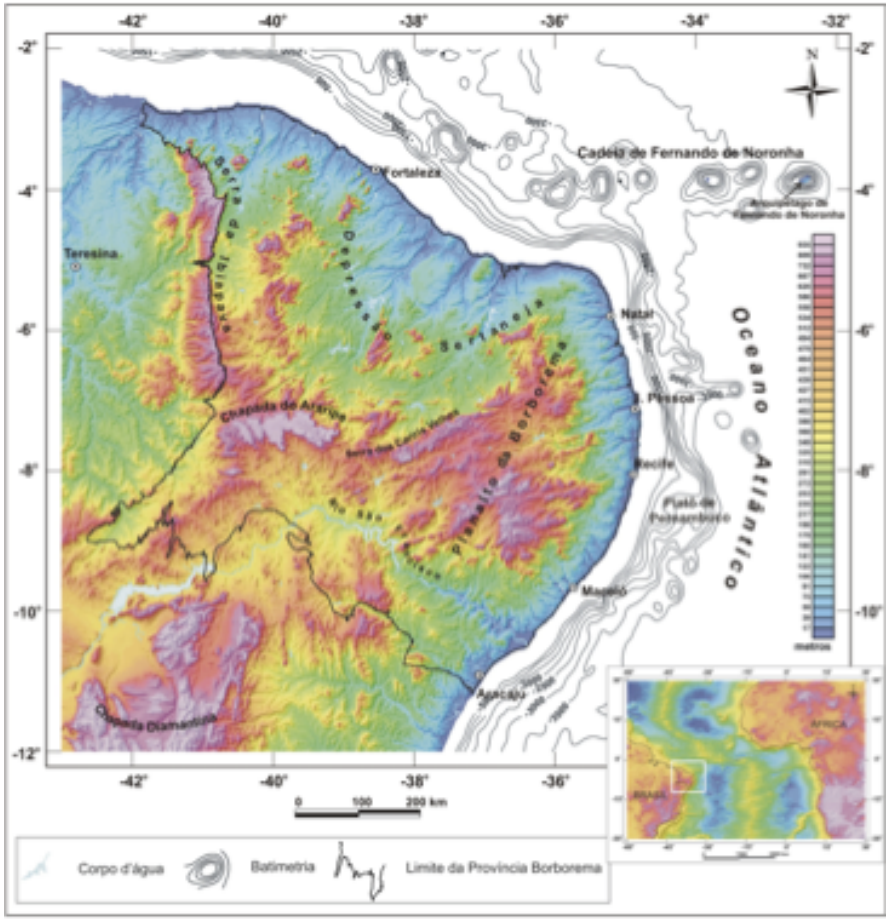



- Toleiitic dike swarms
  Ceará Mirim (120-140 Ma)
- Alkali volcanism
  Cabo (100-104 Ma)
- Alkali volcanism
  Macau & Mecejana (93-7 Ma)

*Courtesy of Gusmão (2011)*

# Cenozoic Uplift

There might be a relationship between the uplift and the Cenozoic volcanism in Macau:



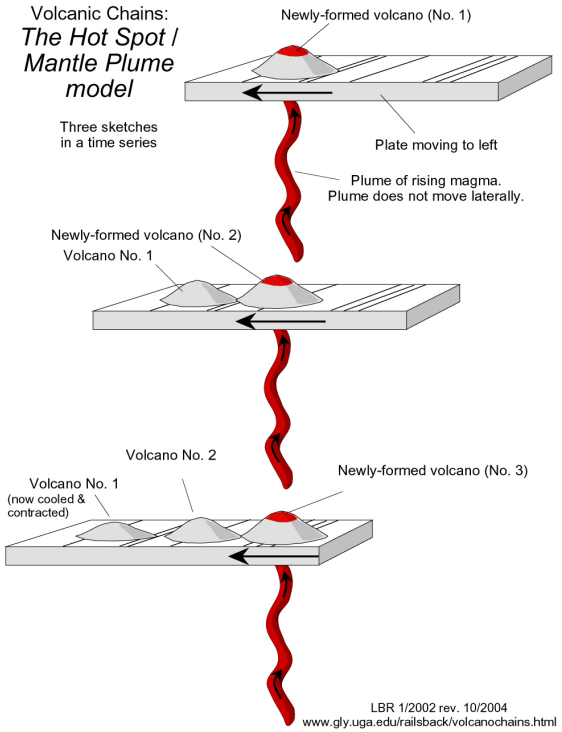

- Stress patterns suggest uplift of the Plateau due to thermal doming.
- Time overlap between Cenozoic deformation and volcanism.

**A mantle plume?**

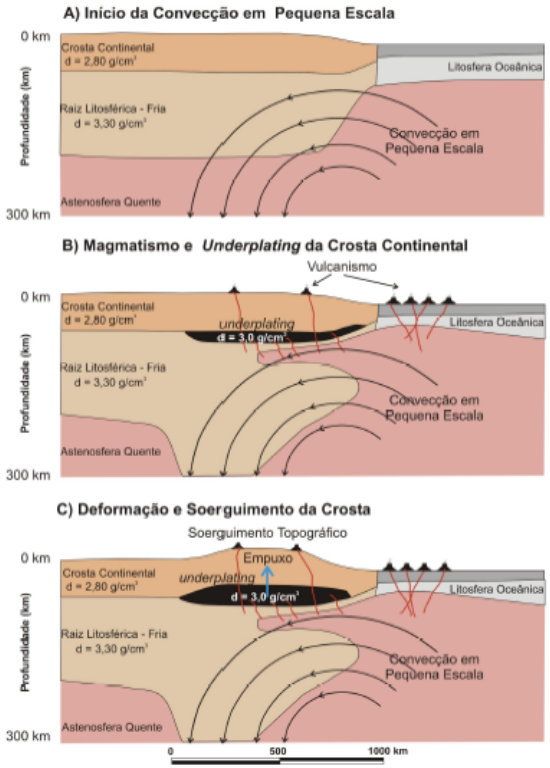
*Courtesy of Gusmão (2011)*

# Competing Models

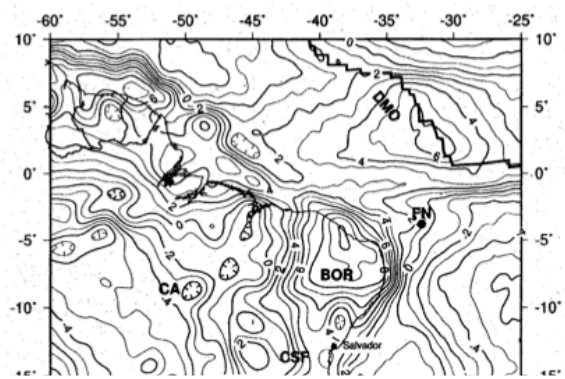
Several models have been proposed to explain the coeval magmatism and uplift:



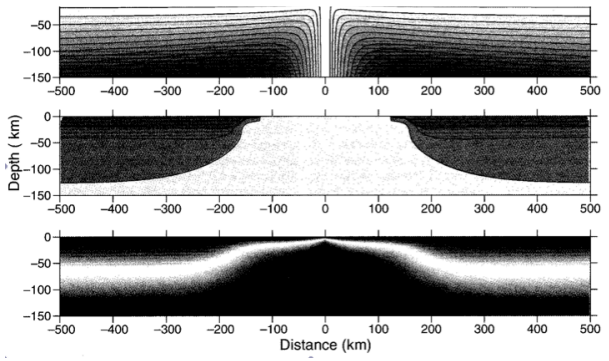

Jardim de Sá et al., 1999




Knesel et al, 2011
Oliveira & Medeiros, 2012

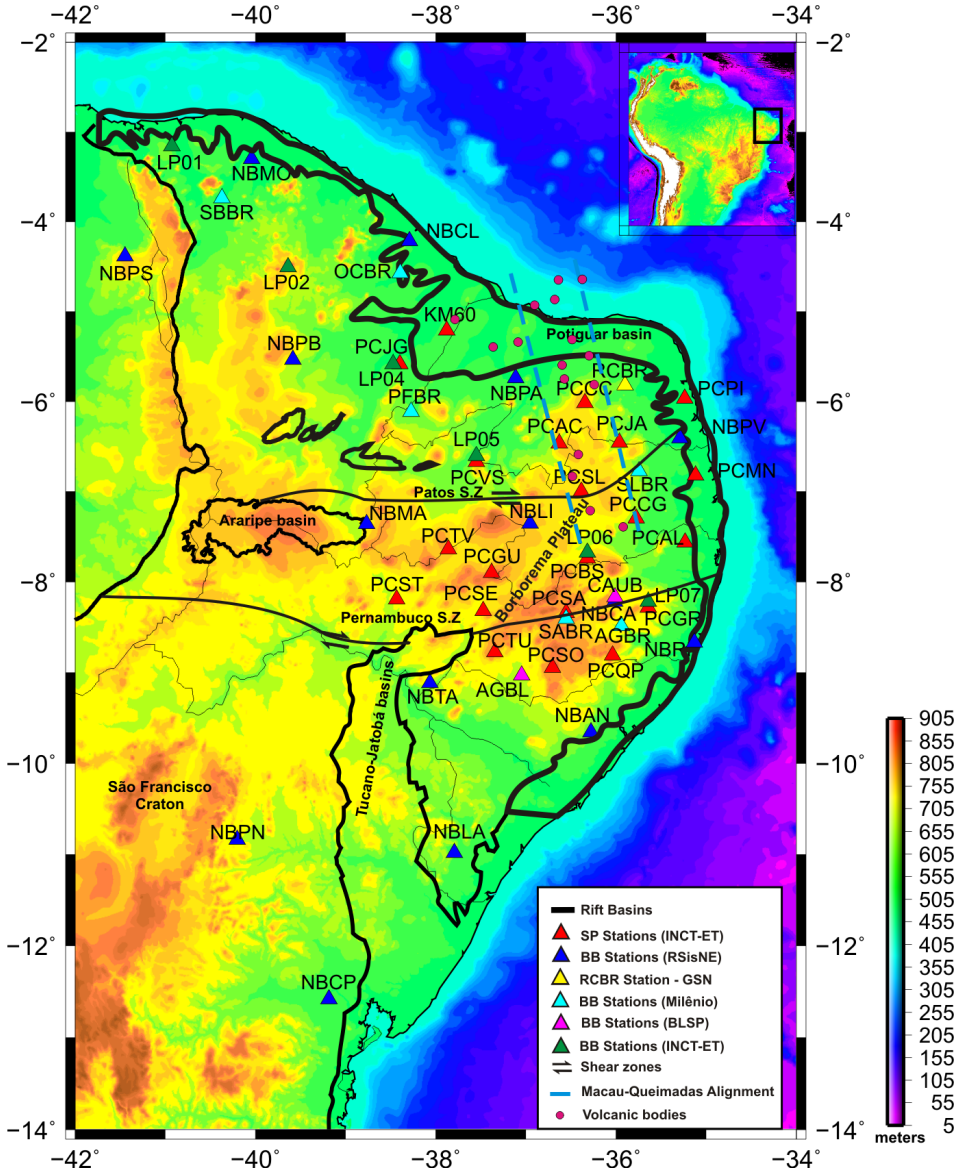



Ussami et al., 1999




Morais Neto et al., 2009

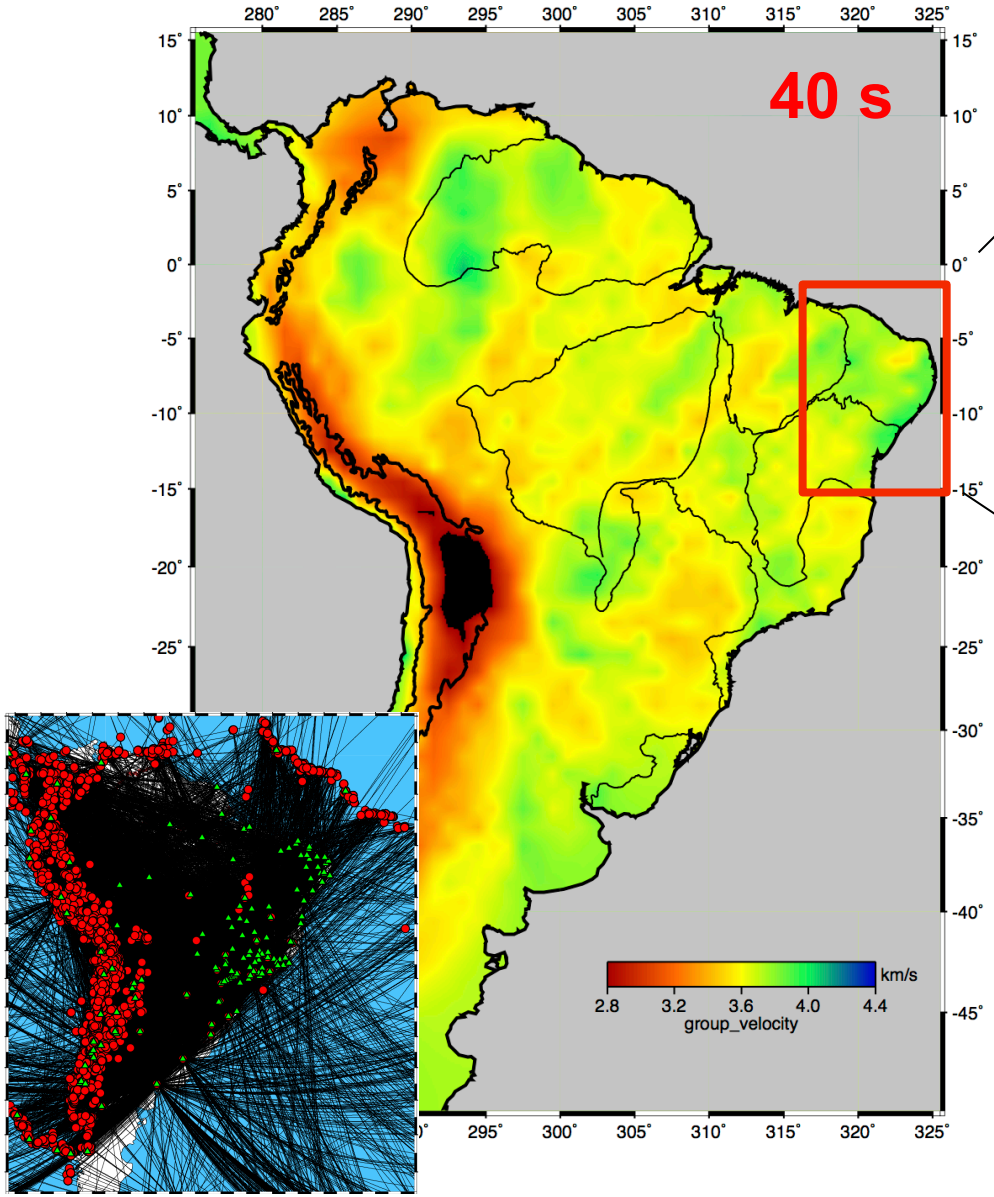
# Passive-Source Seismology

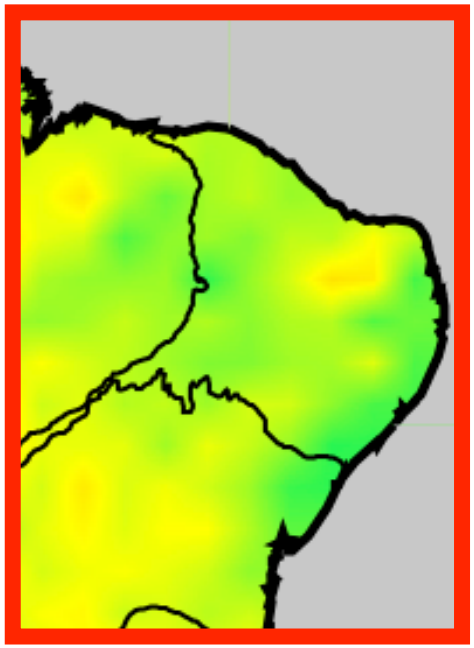




The total number of seismic stations (BB + SP) of the networks combined is 50+.

# Surface Wave Tomography



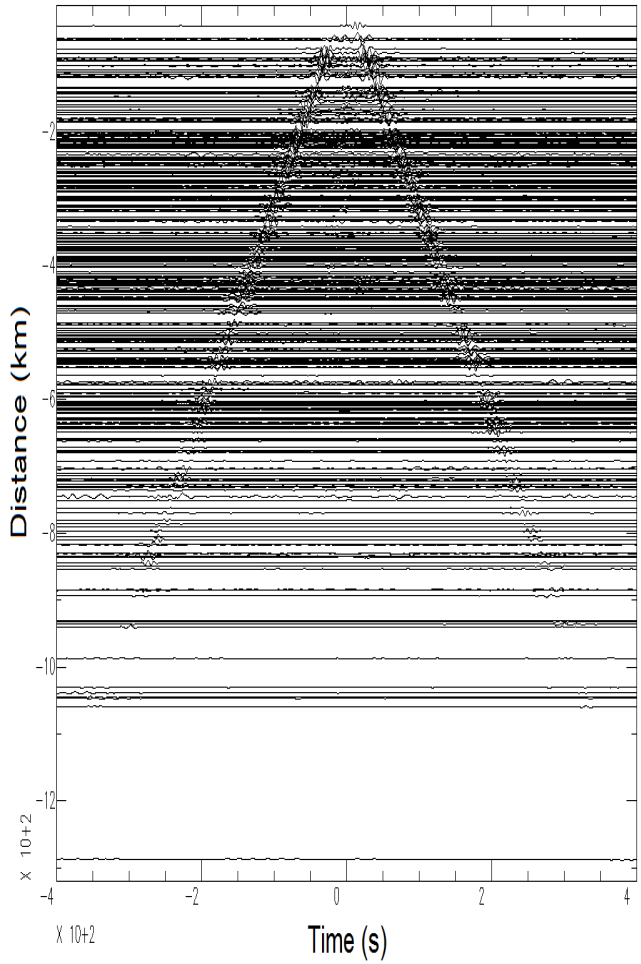



A low-velocity anomaly is observed coinciding with the MQA.

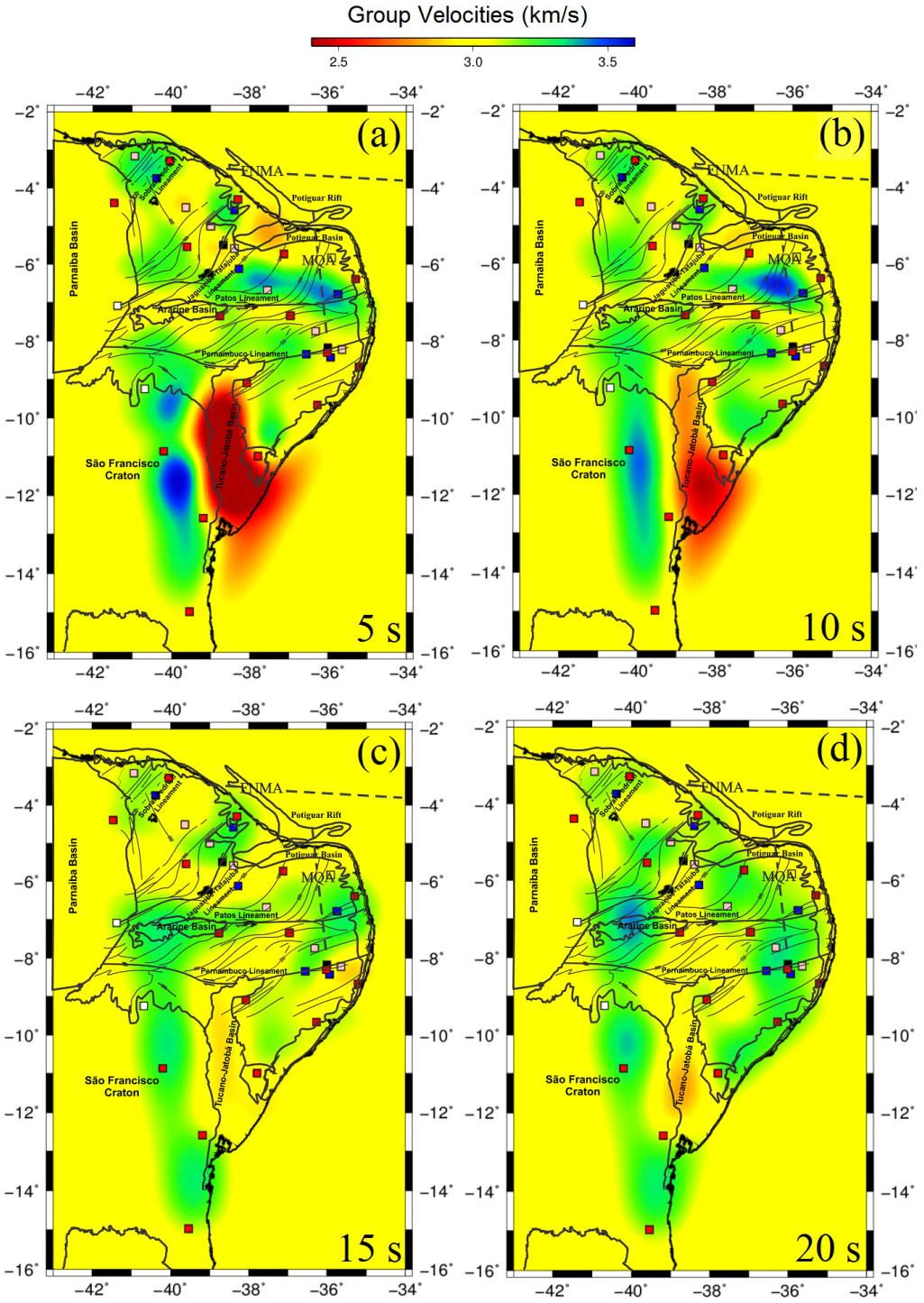
A thermal anomaly?

*Luz et al., in preparation*

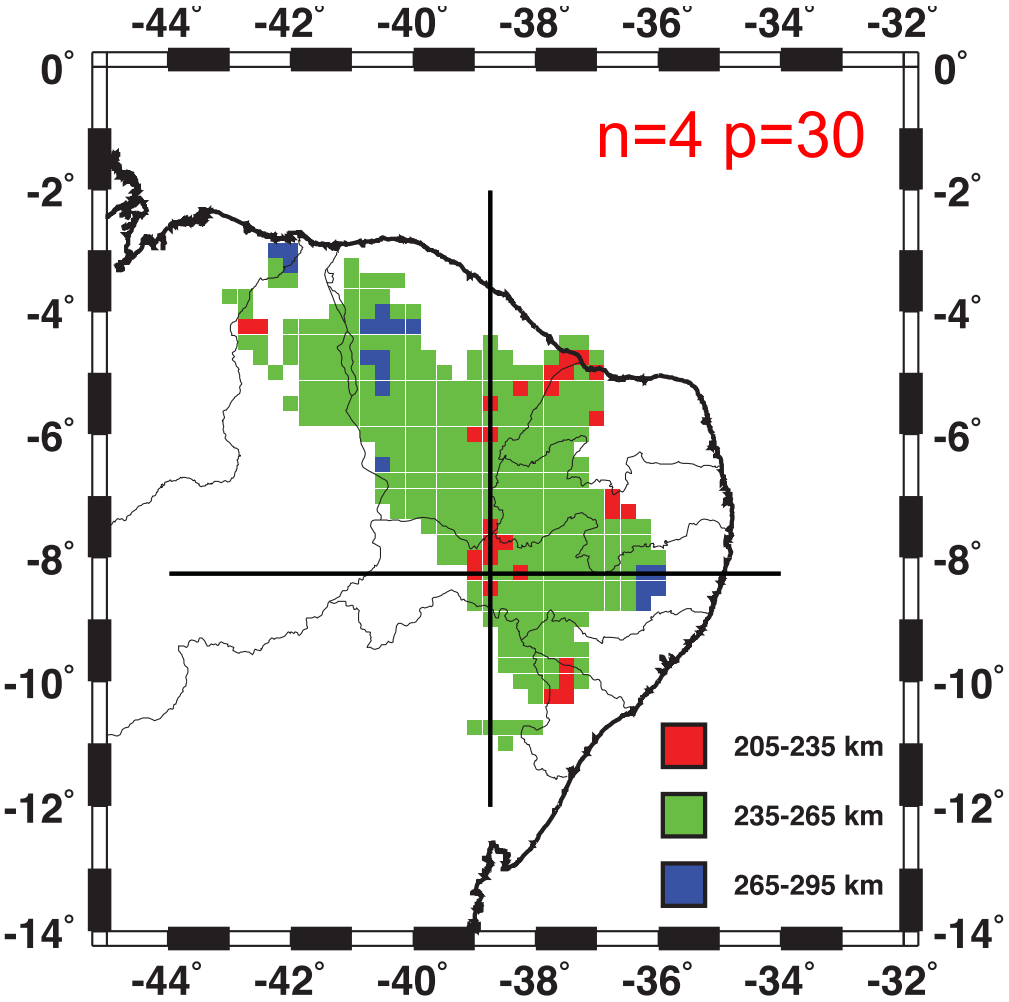
# Ambient Noise Tomography



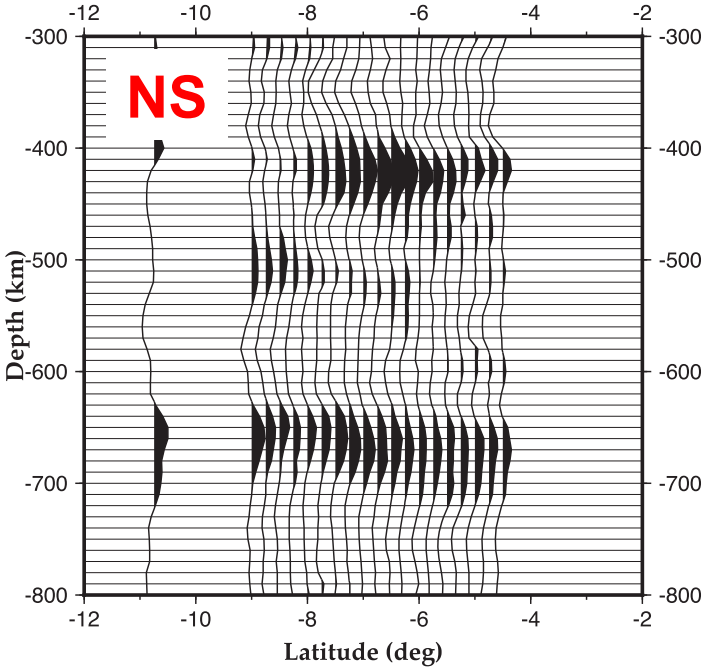

*Dias et al., PAGEOPH, 2014*

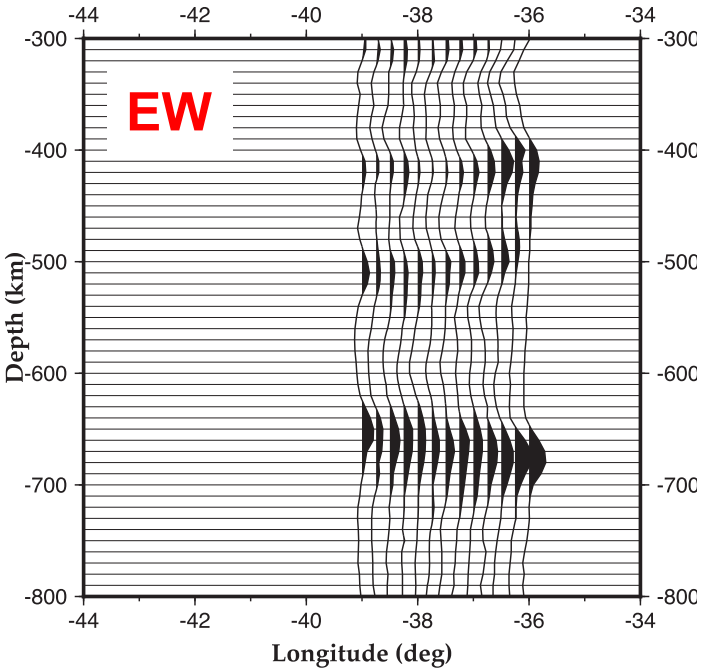


# Receiver Functions Transition Zone



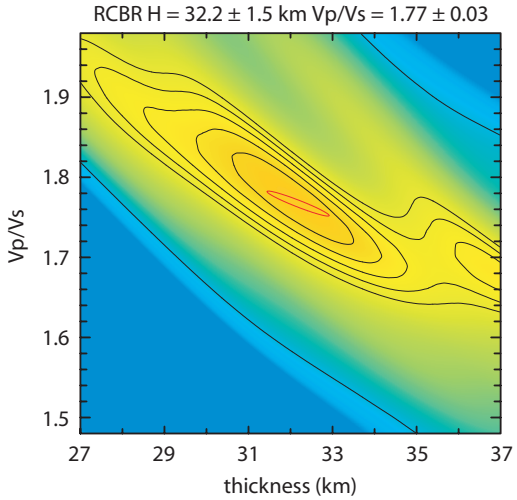

*Pinheiro & Julià, GJI, 2014*

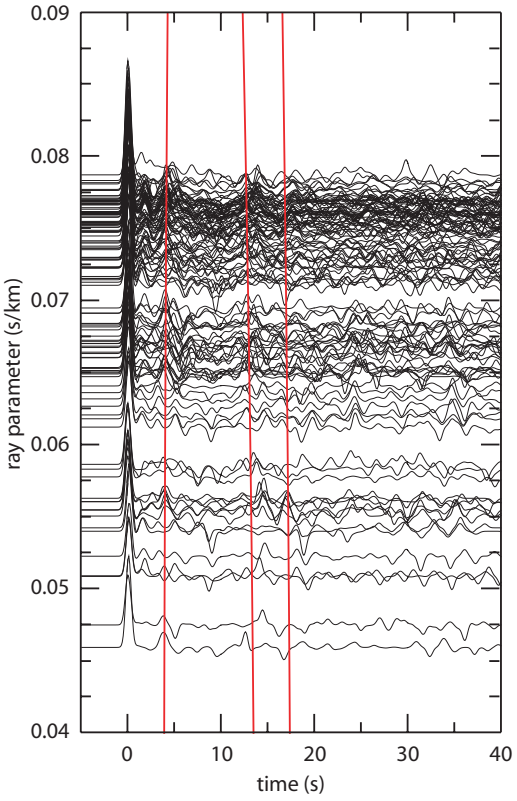


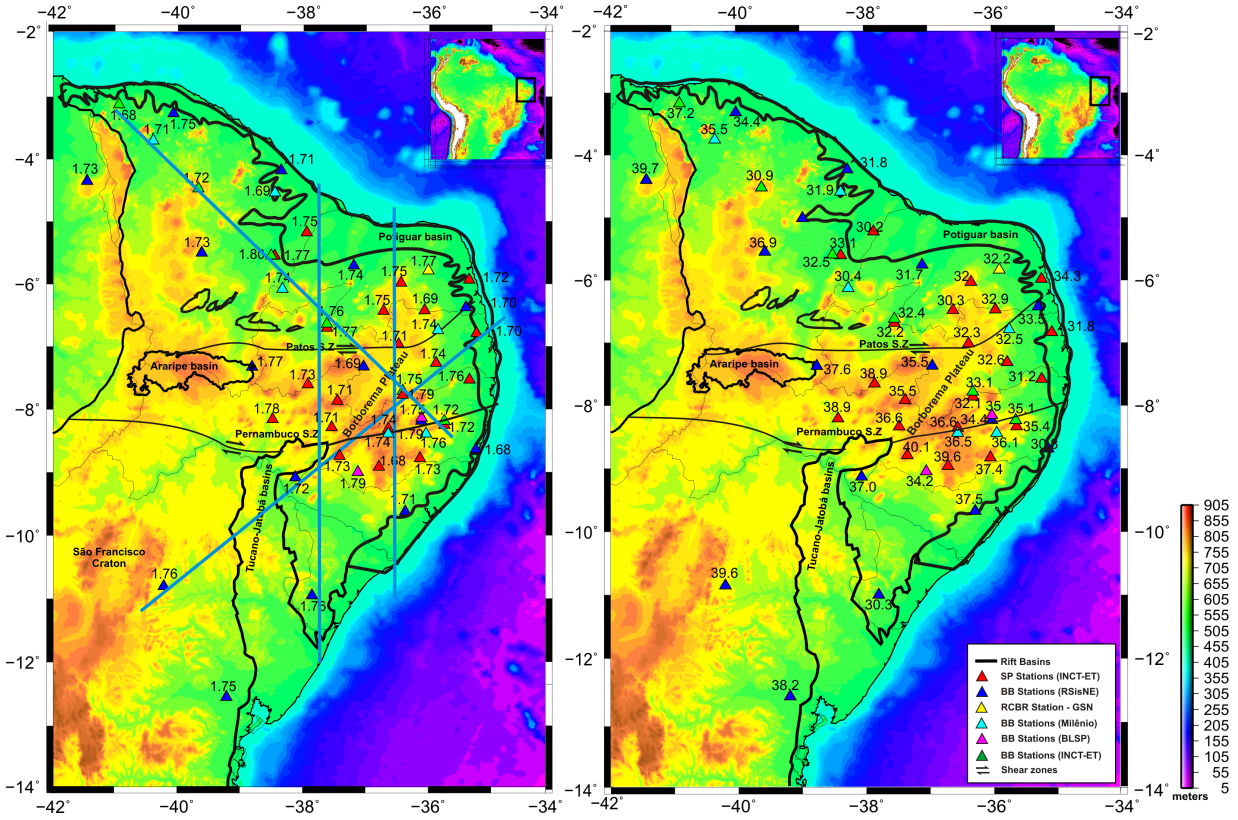



# Receiver Functions - Crust

We see thin crust along the NE margin and rift basin and thicker crust under the plateau.



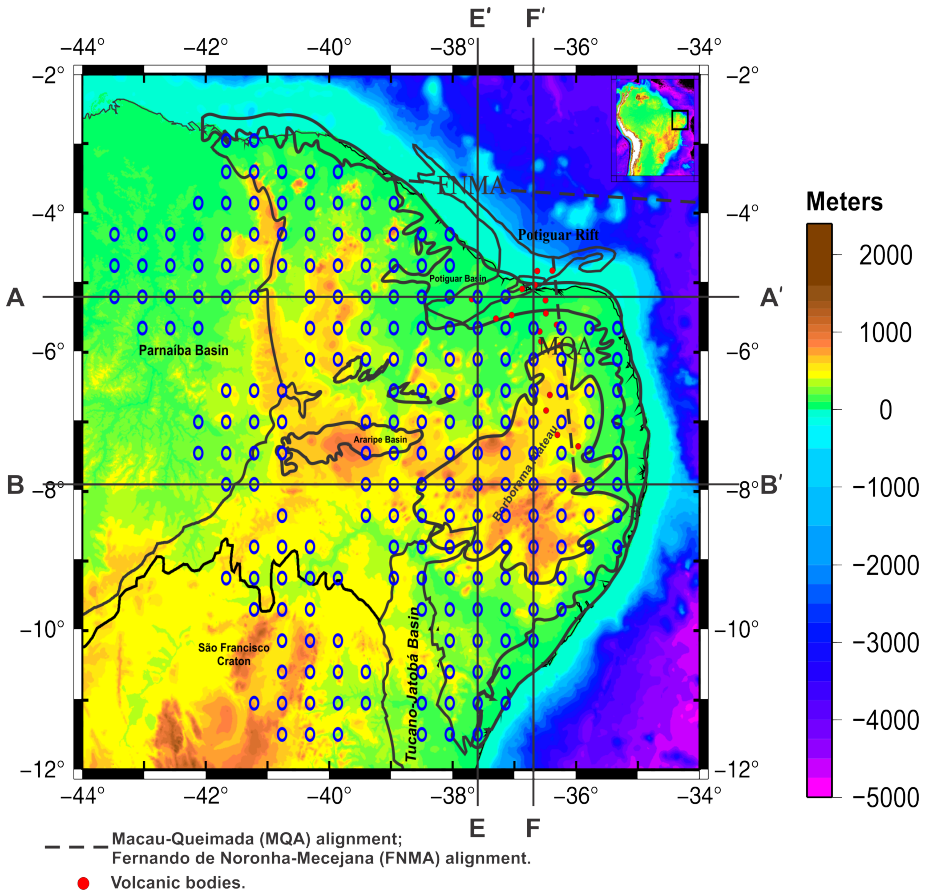



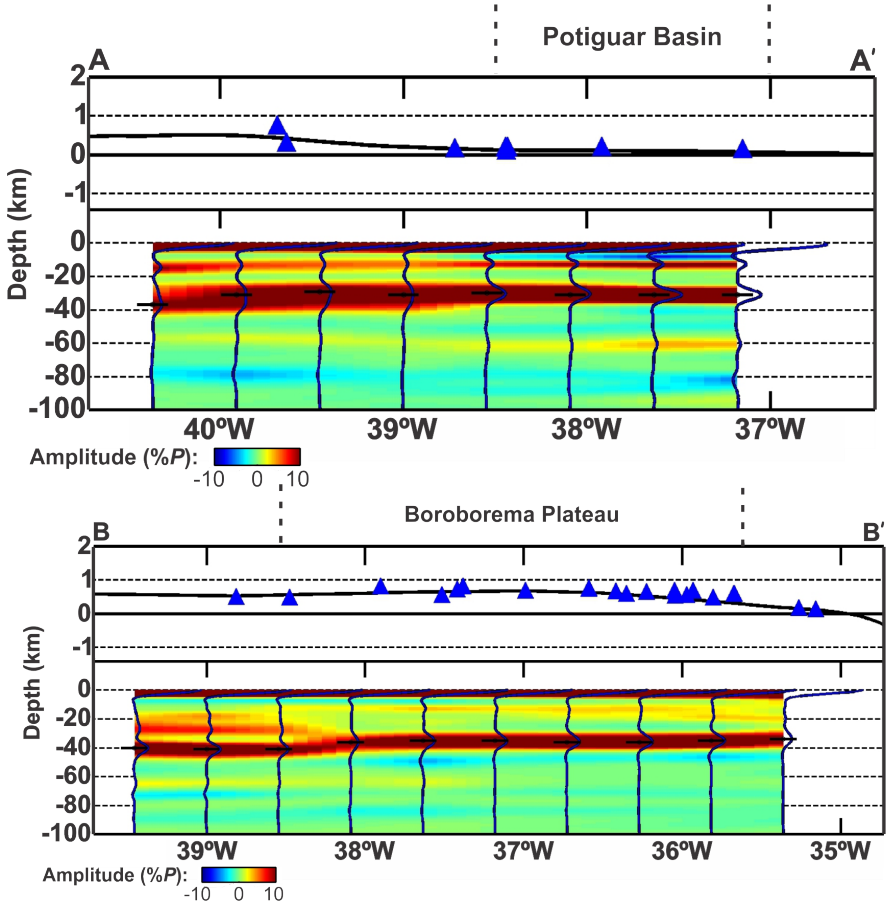




*Luz et al., Tectonophysics, 2015*

# Receiver Function CCP Stacks - Crust

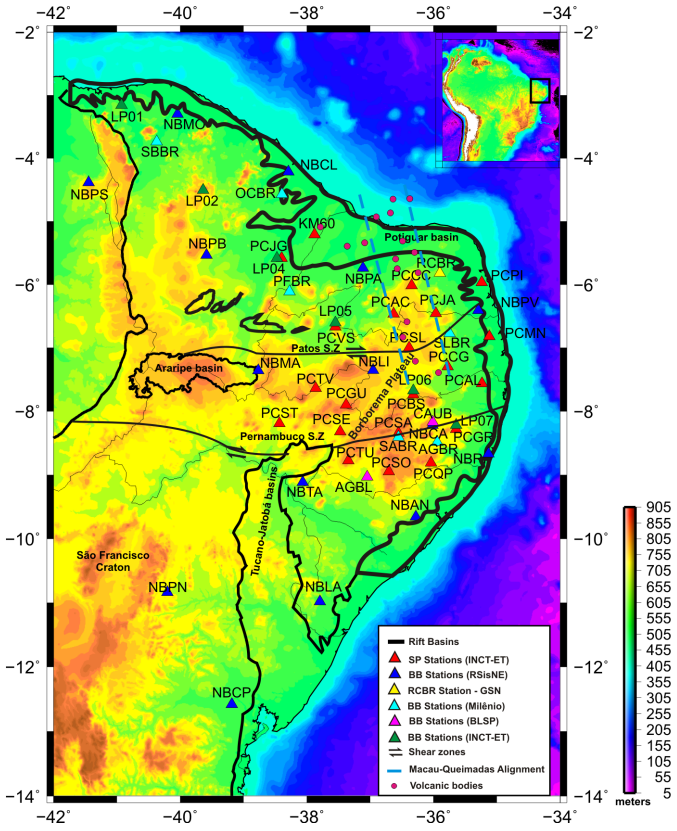
Intra-crustal discontinuity in regions of thin crust, interpreted as a detachment zone.



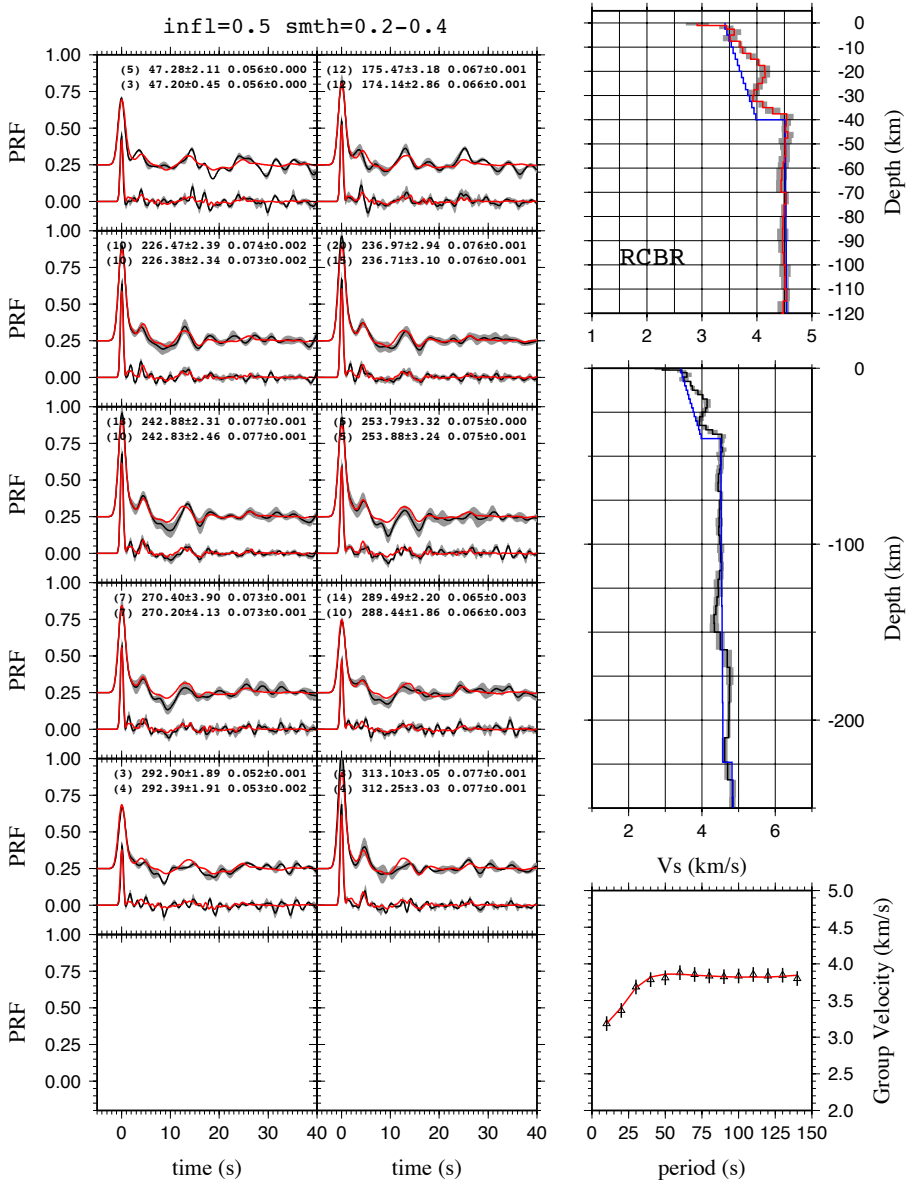




*Almeida et al., Tectonophysics, 2015*

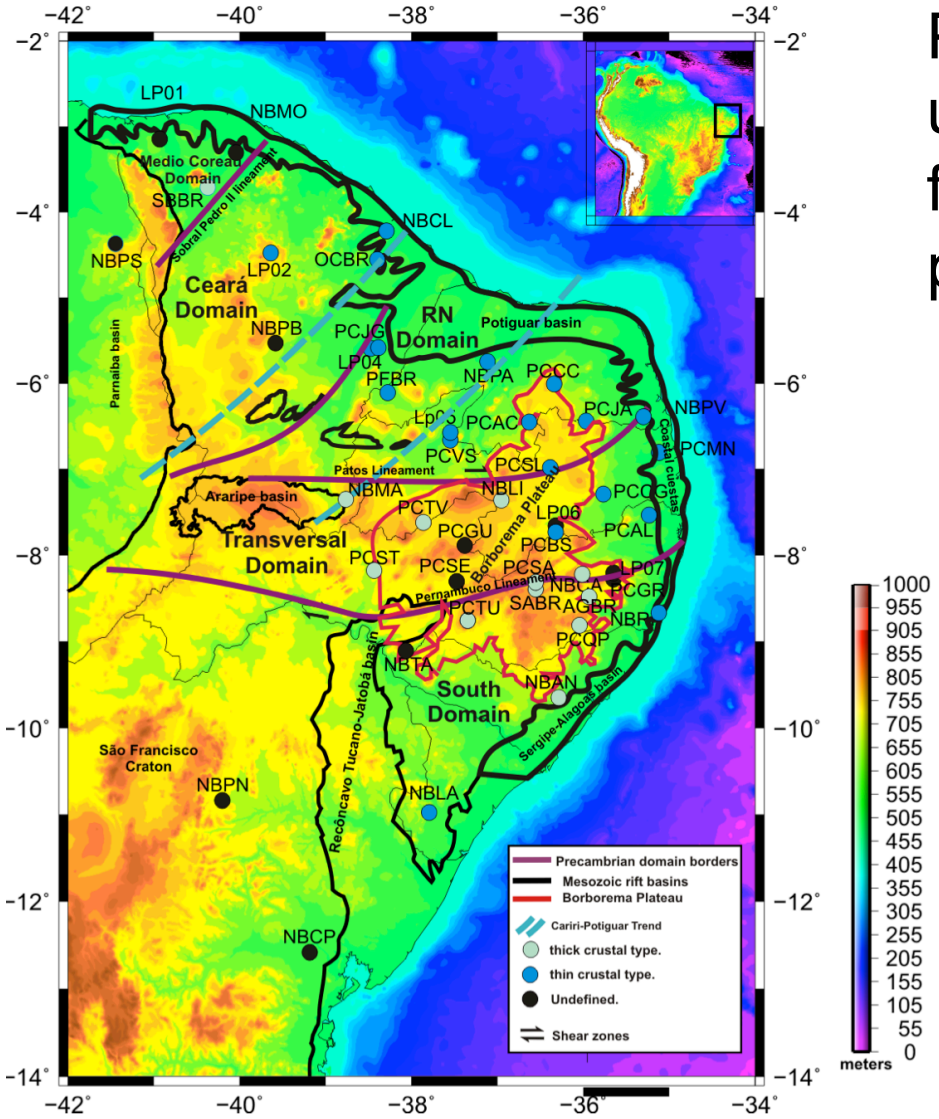
# Receiver Functions - Crust



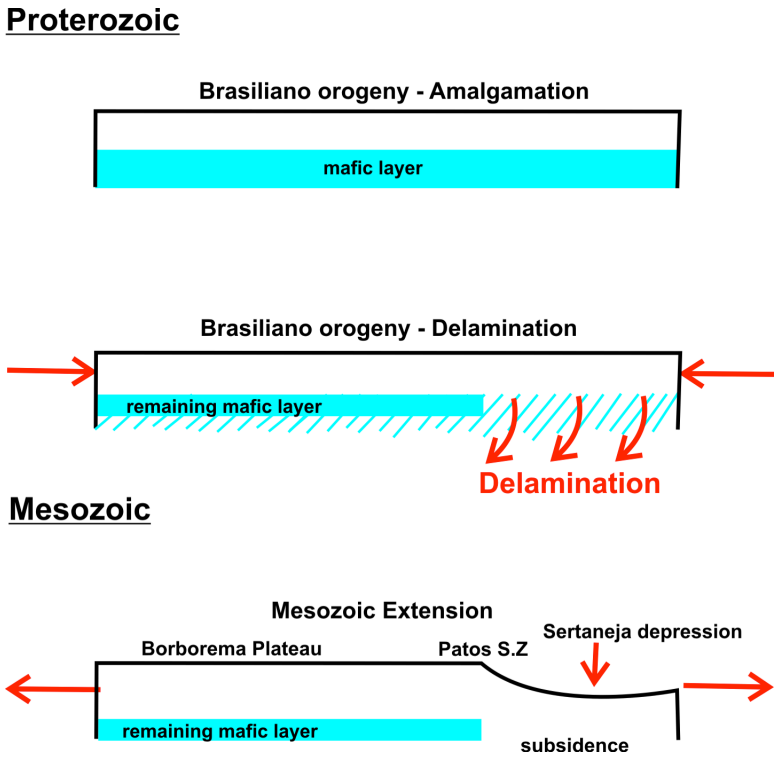

The joint inversion of RFs and dispersion provides velocity-depth profiles (S-wave).



# Receiver Functions - Crust




Perhaps the Plateau should be understood as a “high-standing” feature, rather than the result of post-breakup tectonic uplift.




*Luz et al., JGR-Solid Earth, 2015*

# Conclusions

- The Borborema Province's deep structure has been investigated through passive-source seismology.
- The main results (so far) are:
  - Receiver functions reveal thicker crust under the Plateau, an intra-crustal discontinuity in regions of thin crust, and a "normal" upper mantle transition zone.
  - Ambient-noise tomography suggest some shear zones could not be extending into the deep crust (overprint?).
  - Surface-wave tomography displays a shallow-mantle LVZ under the Cariri-Potiguar trend (thermal remnant?).
- More studies of the upper mantle (SKS-splitting, travel-time tomography) are being conducted to understand the role of the upper mantle.