Crustal Structure of the Northeastern Brazilian Margin Constrained by Seismic Reflection and Potential Field Data and Modeling*

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Abstract

Integration of regional seismic reflection and potential field data along the northeastern Brazilian margin, complemented by crustal-scale gravity modeling, is used to reveal and illustrate onshore-offshore crustal structure correlations, the character of the continent-ocean boundary/transition, and the relationship of crustal structure to regional variation of potential field anomalies. The study reveals distinct along-margin structural and magmatic changes that are spatially related to a number of conjugate Brazil-West Africa transfer systems, governing the margin segmentation and evolution. Several conceptual tectonic models are invoked to explain the structural evolution of the different margin segments in a conjugate margin context and within the framework of simple-shear, pure-shear, and combined-shear deformation modes. Furthermore, the constructed transects, the observed and modeled Moho relief, and the potential field anomalies indicate that the Recôncavo, Tucano, and Jatobá rift system may reflect a polyphase deformation rifting-mode associated with a complex time-dependent thermal structure of the lithosphere. The constructed transects and the available seismic reflection profiles indicate that the northern part of the study area lacks major breakup-related magmatic activity, suggesting a rifted non-volcanic margin affinity. On the other hand, the southern part of the study area is characterized by abrupt crustal thinning and evidence for breakup magmatic activity, suggesting that this region evolved, partially, with a rifted volcanic margin affinity and character. The study clearly shows that integration of potential field and regional deep vertical-incidence and wide-angle seismic data provides a powerful resource for reducing costs and interpretation risks when petroleum exploration advances towards new frontiers.

Crustal structure of the northeastern Brazilian margin constrained by seismic reflection and potential field data and modeling

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REGIONAL CONSIDERATIONS & HYDROCARBON EXPLORATION

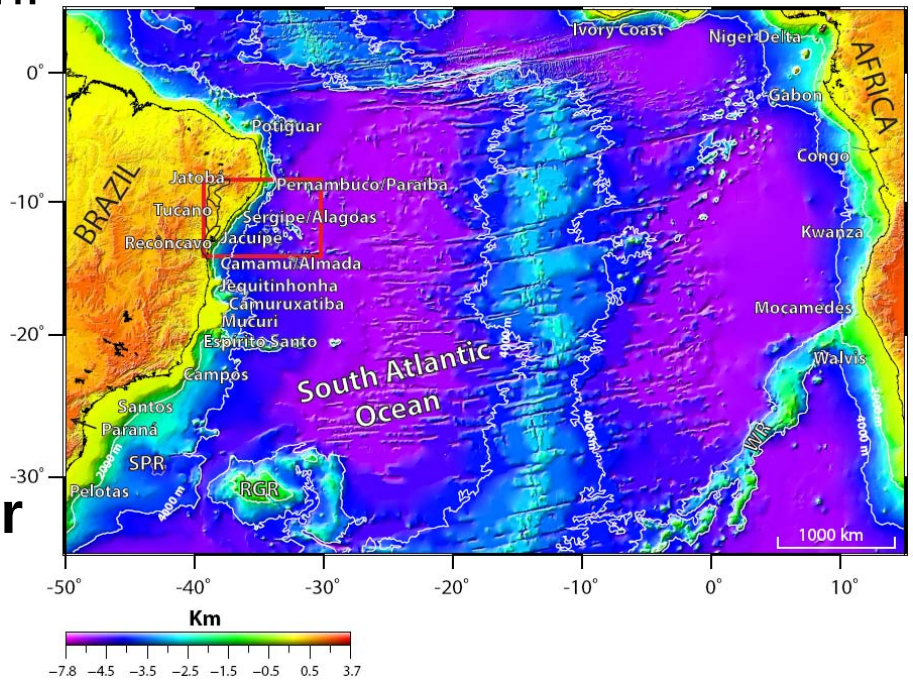
- The conjugate Brazilian and West Africa margins have been for the last years the locus of extensive hydrocarbon exploration

- Despite these exploration efforts, remaining questions and uncertainties still exist and concern:

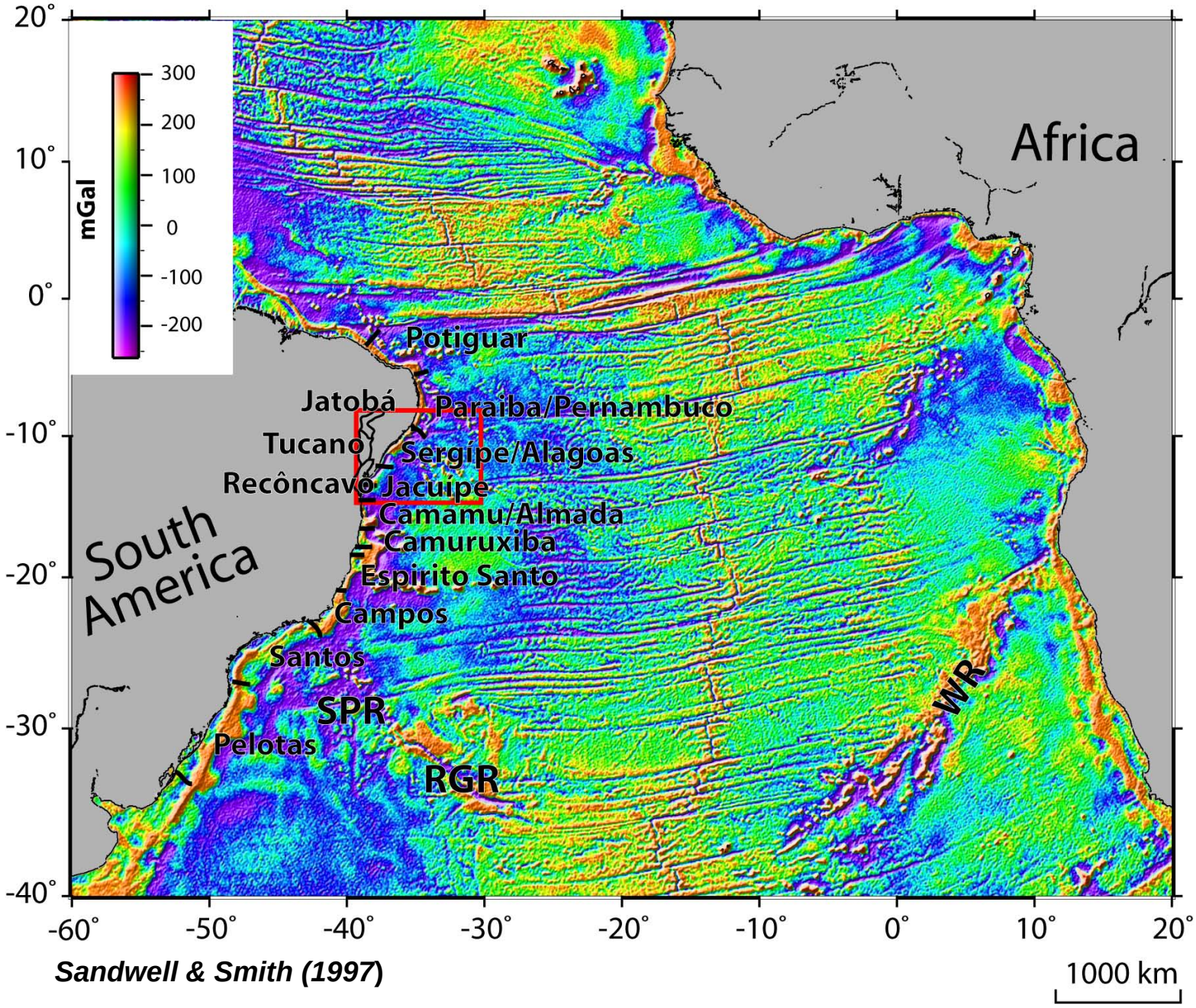
1. **crustal-scale evolution**

1. **architecture of onshore and offshore basins**

3. **continent-ocean boundary (COB) location and character**



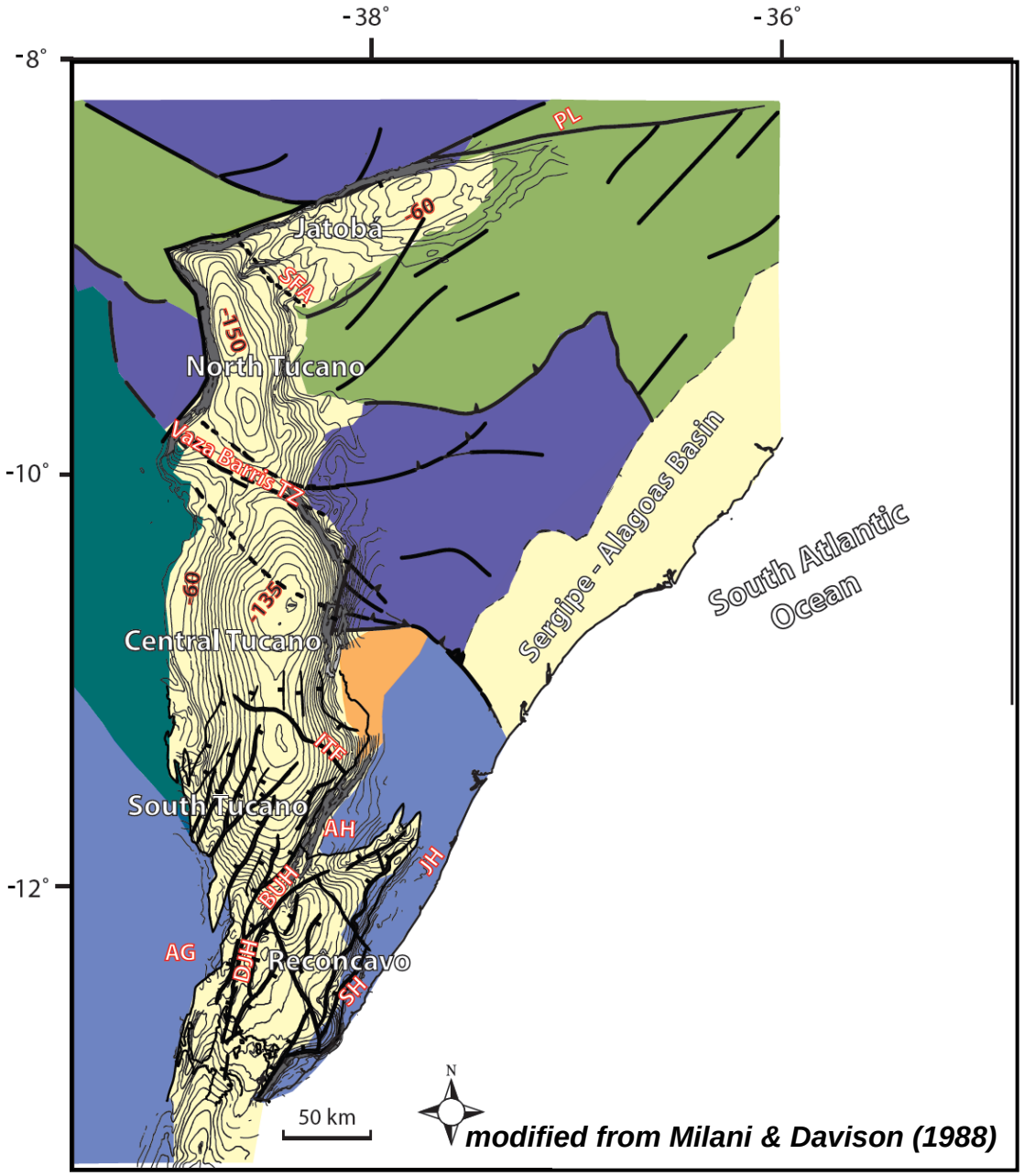
Free-air gravity anomalies

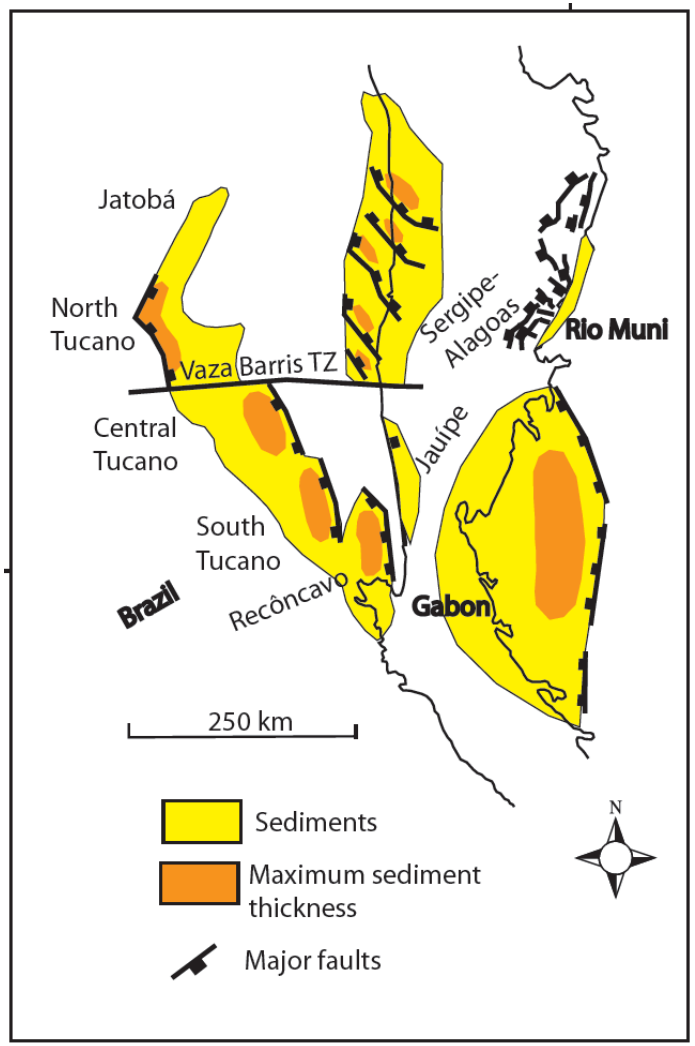


Sandwell & Smith (1997)

Contents – Outline

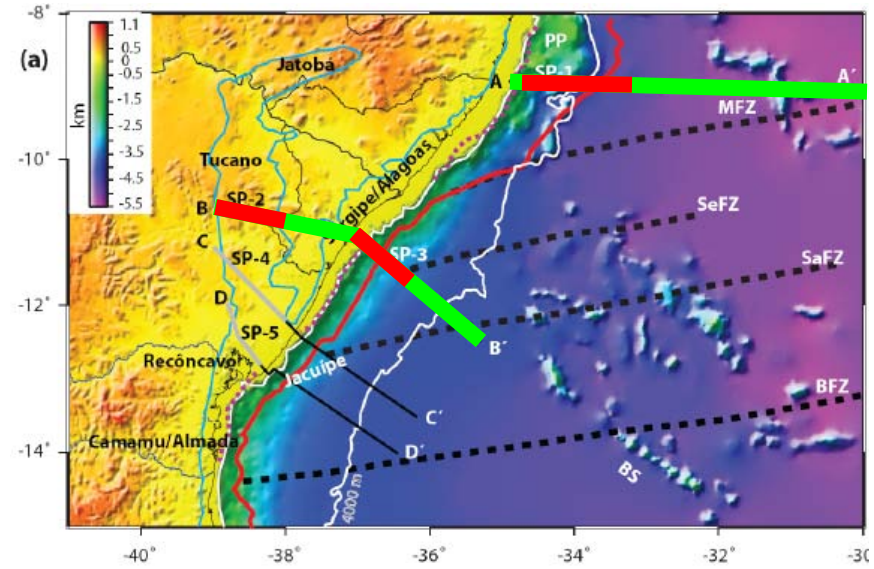
- Compilation and re-interpretation of conventional and deep MCS profiles
- **Gravity Modeling: crustal structure & architecture**
  - Isostatic balancing, Inverse and Forward gravity modeling
  - Validate alternative crustal-scale models
  - Test interpretation uncertainties due to resolution limitations of seismic reflection/refraction profiling
- **Basin formation and evolution**
- **Margin segmentation and structural inheritance**
- **Continent-ocean transition and boundary**

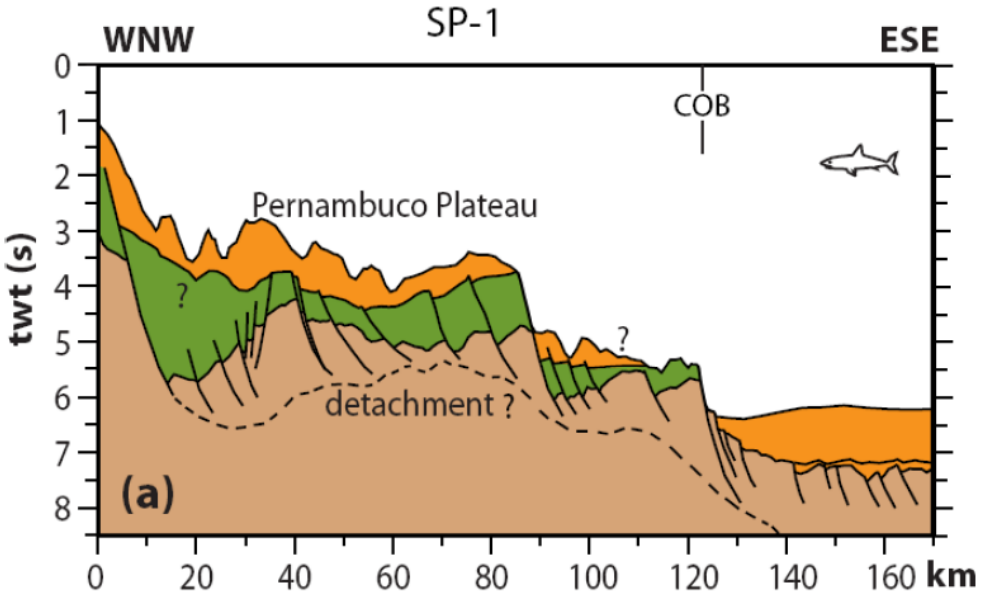


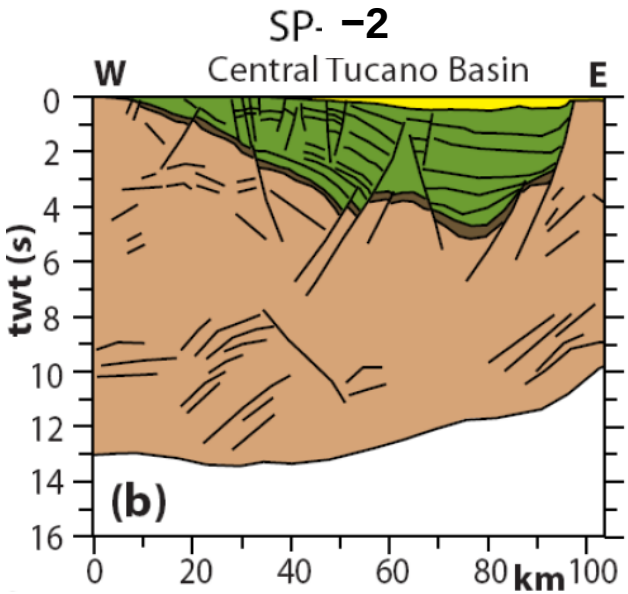


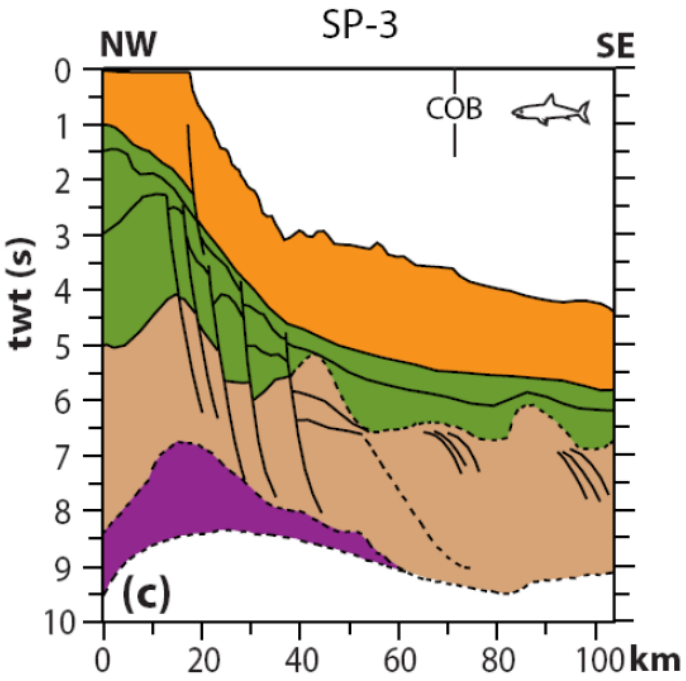
modified from Mohriak et al. (2000)

Lower Proterozoic granulites
Late Proterozoic fold belt
Lower Proterozoic granulite-greenstone terrain
Upper Proterozoic sediments
Reworked gneisses and granulites
Mesozoic sediments









Transect construction

modified from Gomes et al. (1997); Mohriak et al. (2000)

Aptian

Cenozoic

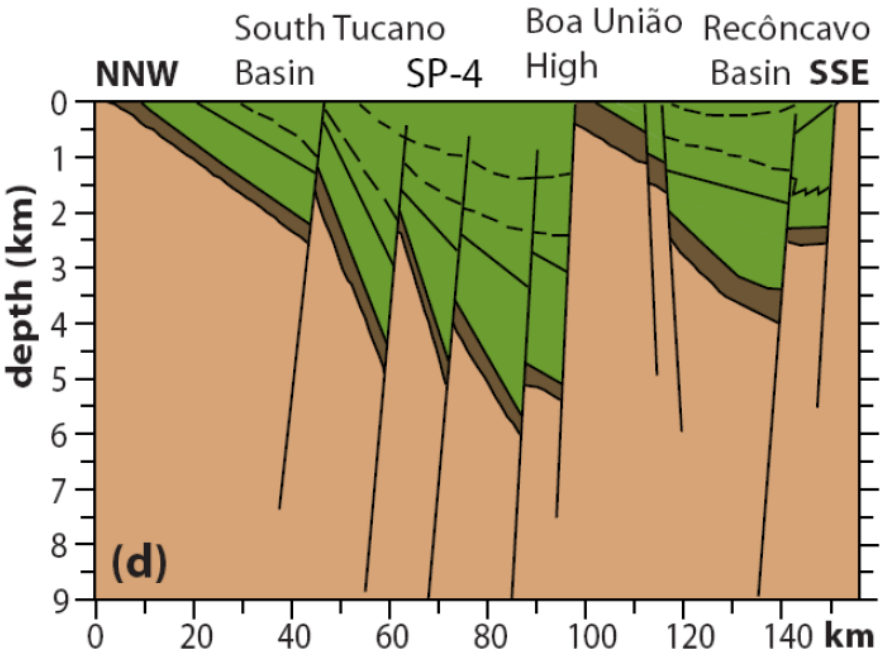
syn-rift

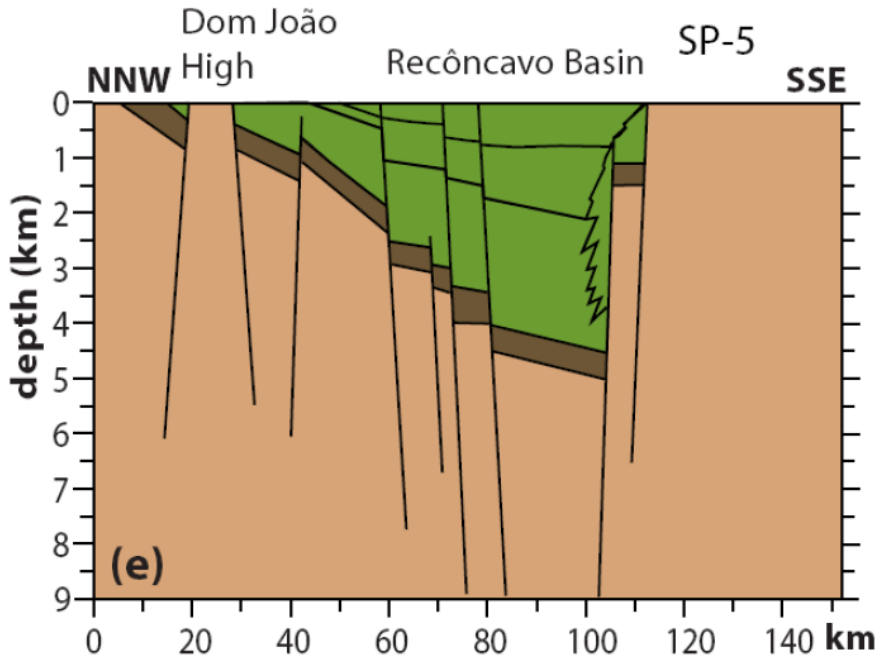
pre-rift

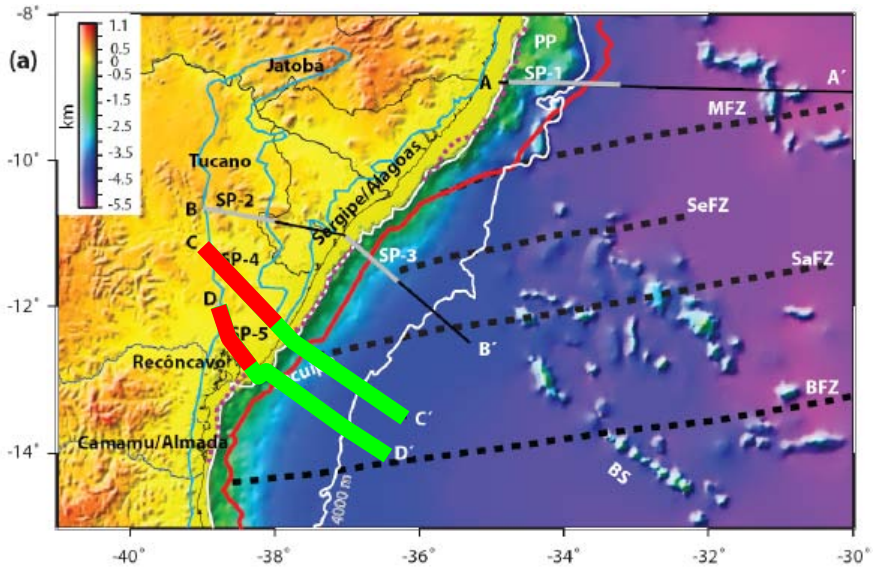
crystalline crust

7 + km/s lower crustal body

Transect construction



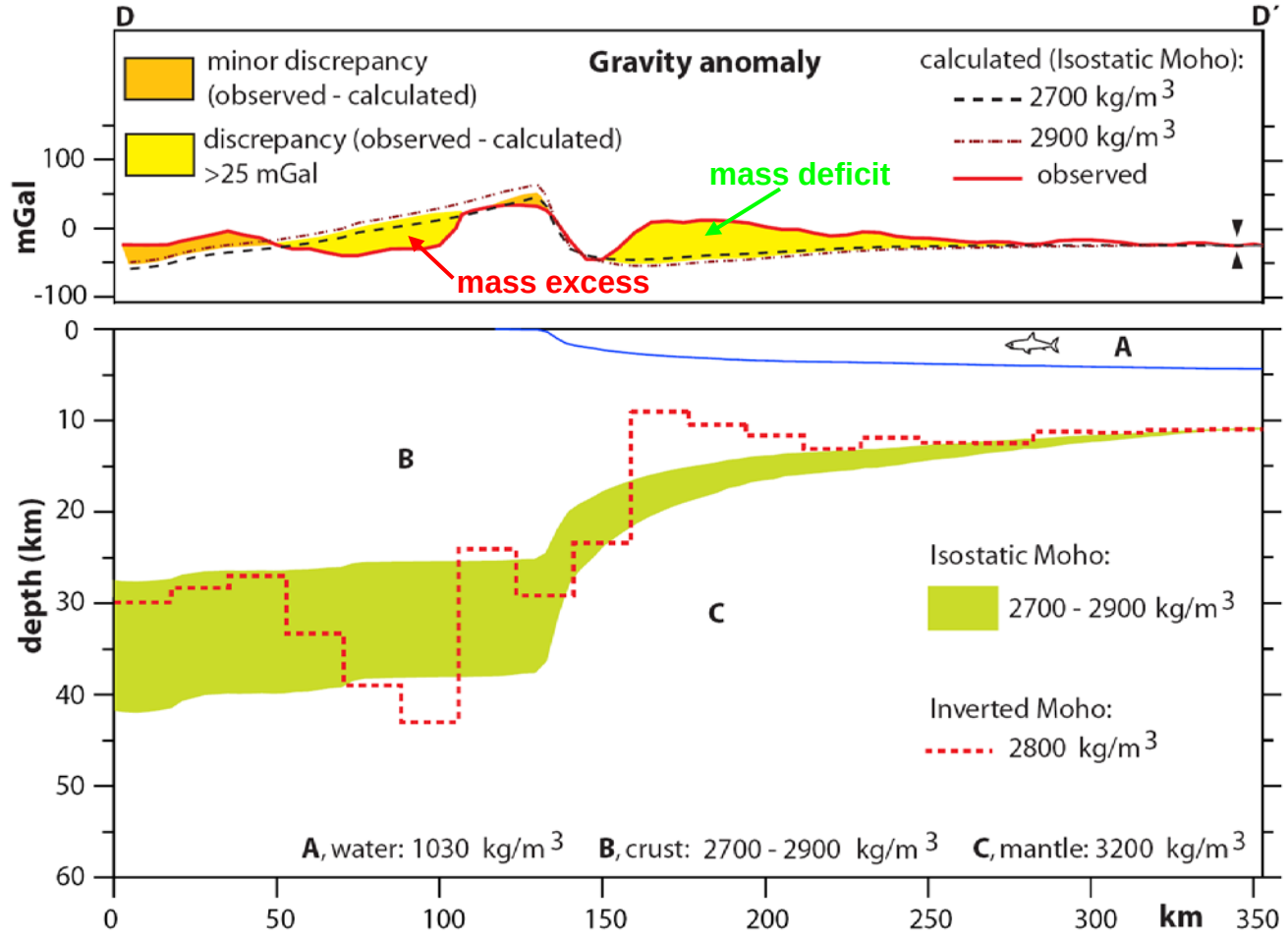


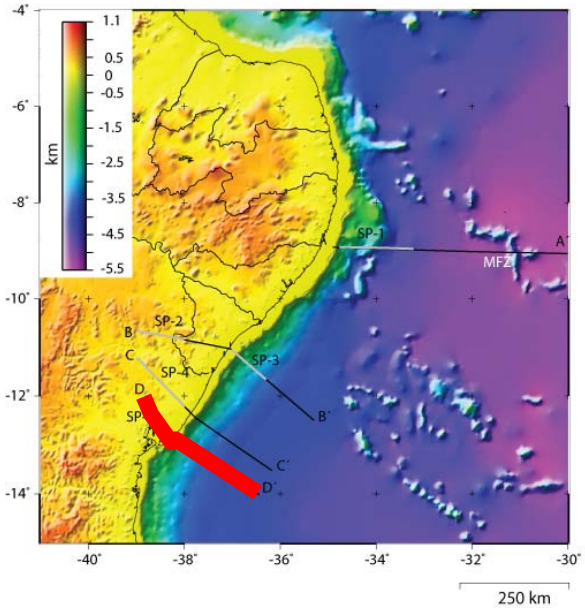


Aptian
Cenozoic
syn-rift
pre-rift
crystalline crust
7 + km/s lower crustal body

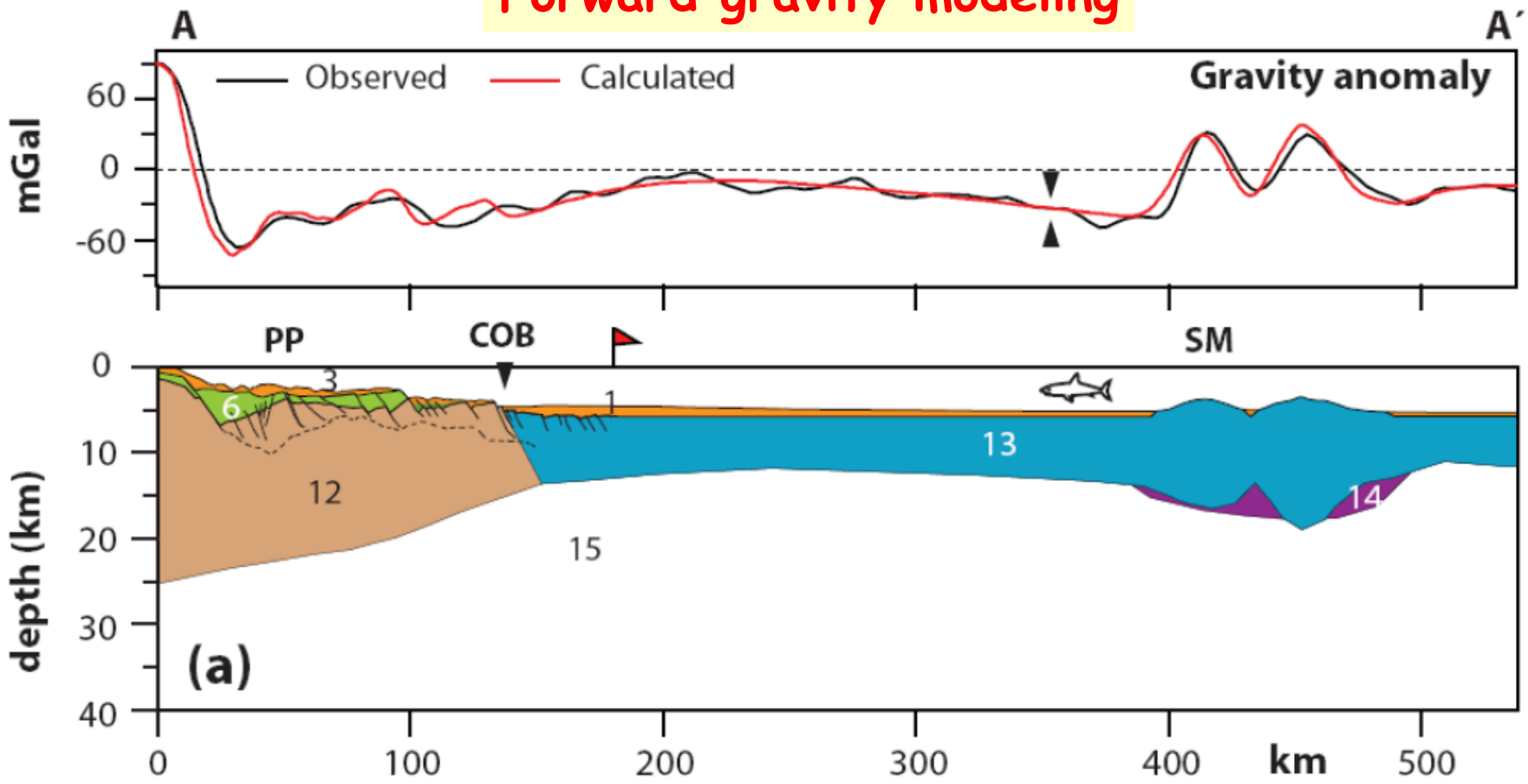
modified from Milani & Davison (1988)

Isostatic balancing & Inverse gravity modelling





Forward gravity modeling



Aptian

Cenozoic

syn-rift/Cenozoic

syn-rift

pre-rift

oceanic crust

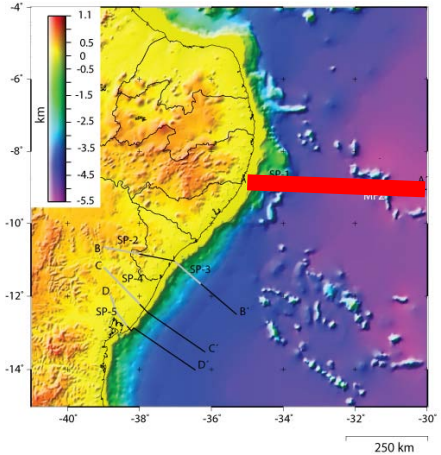
continental crust

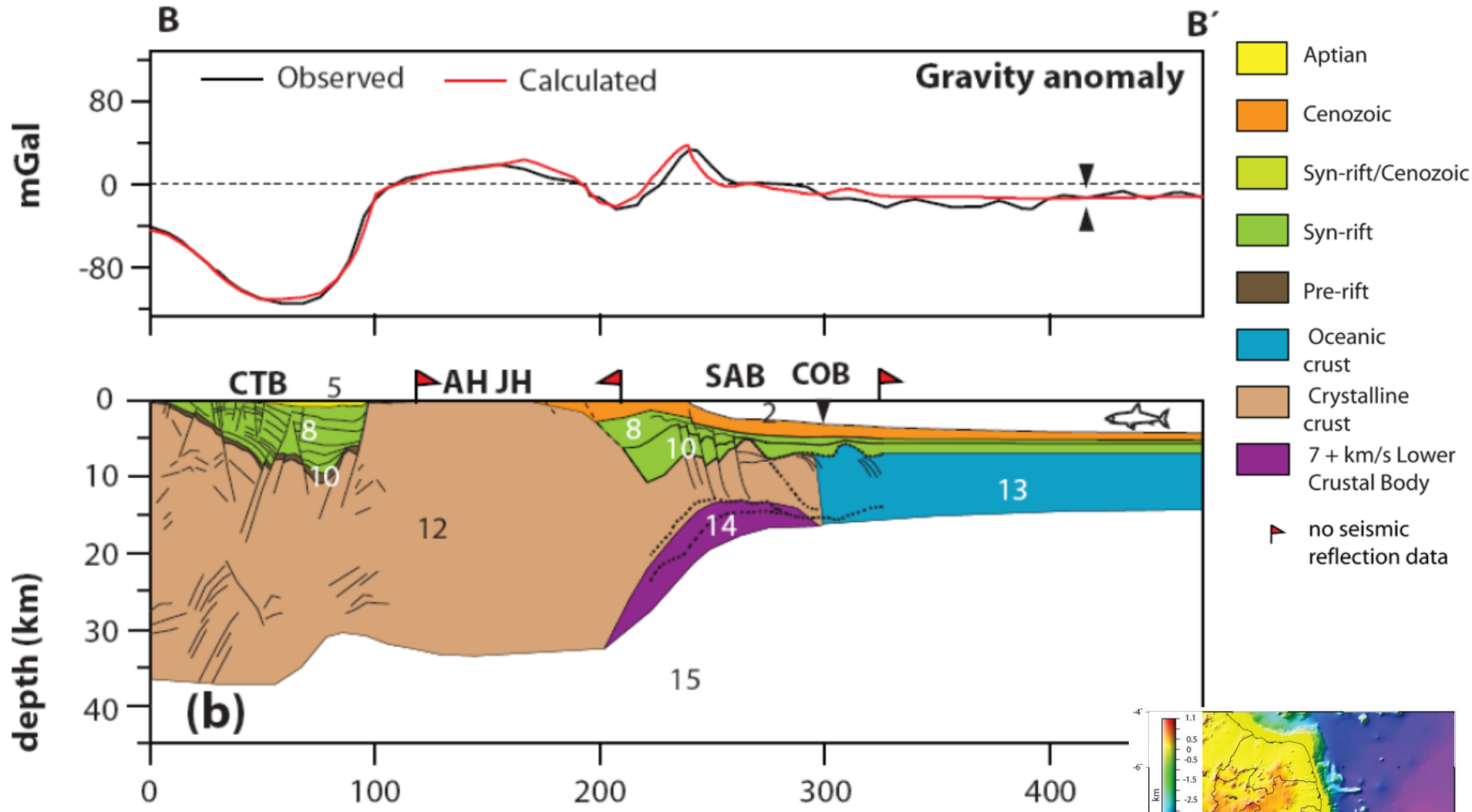
7 + km/s lower crustal body

area with no seismic reflection data

Densities:

Polygon ref:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Density (kg/m^3):	2010	2020	2090	2200	2240	2320	2400	2410
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	
	2450	2550	2620	2770	2830	3000	3200	





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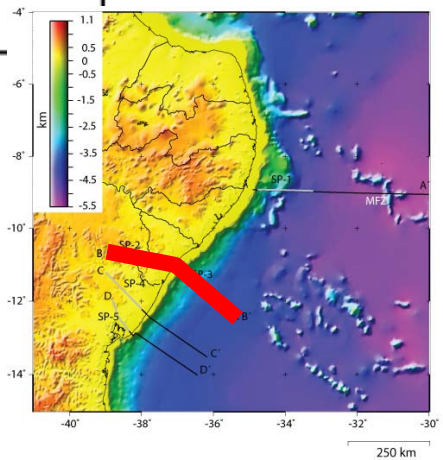

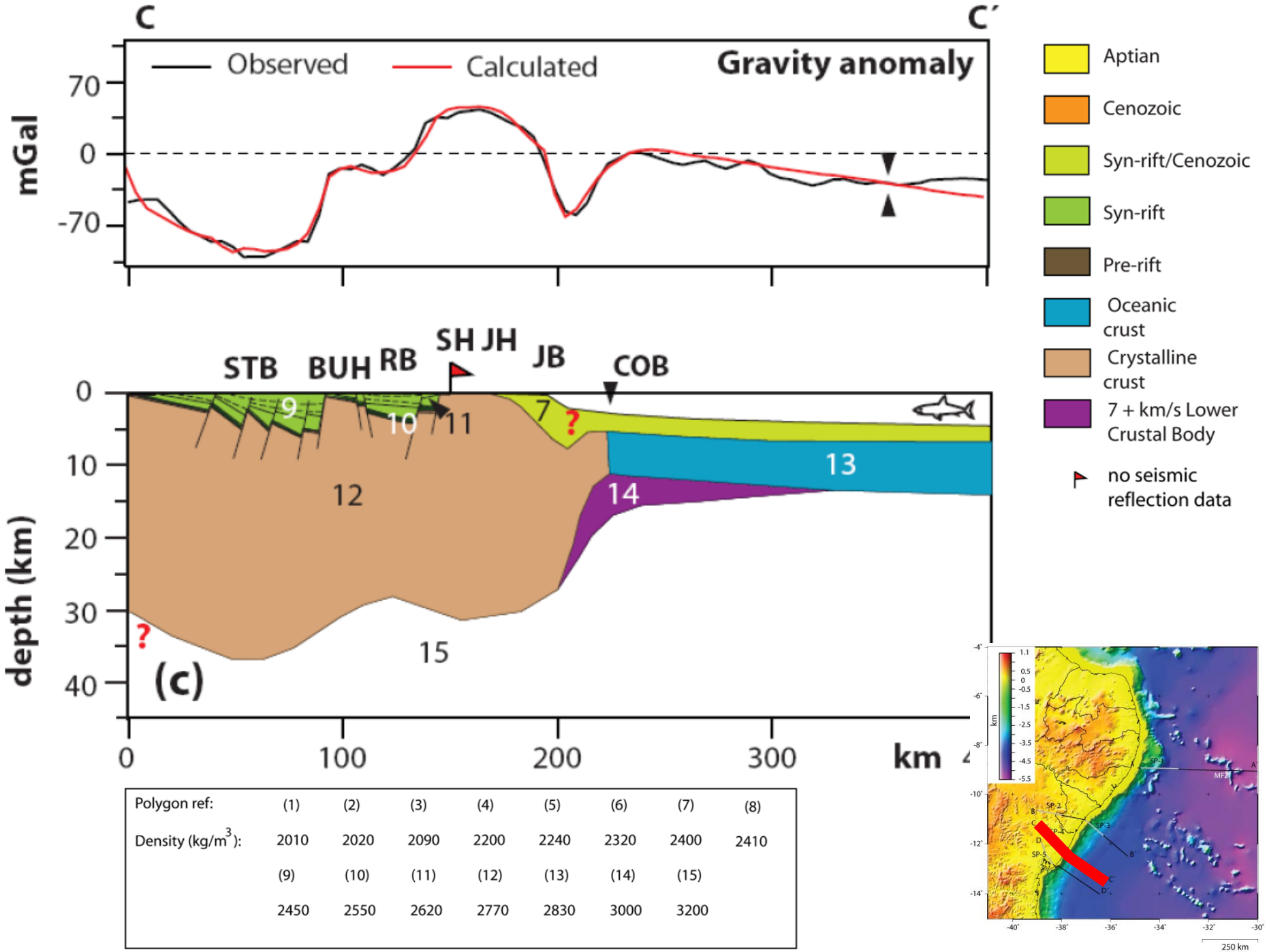

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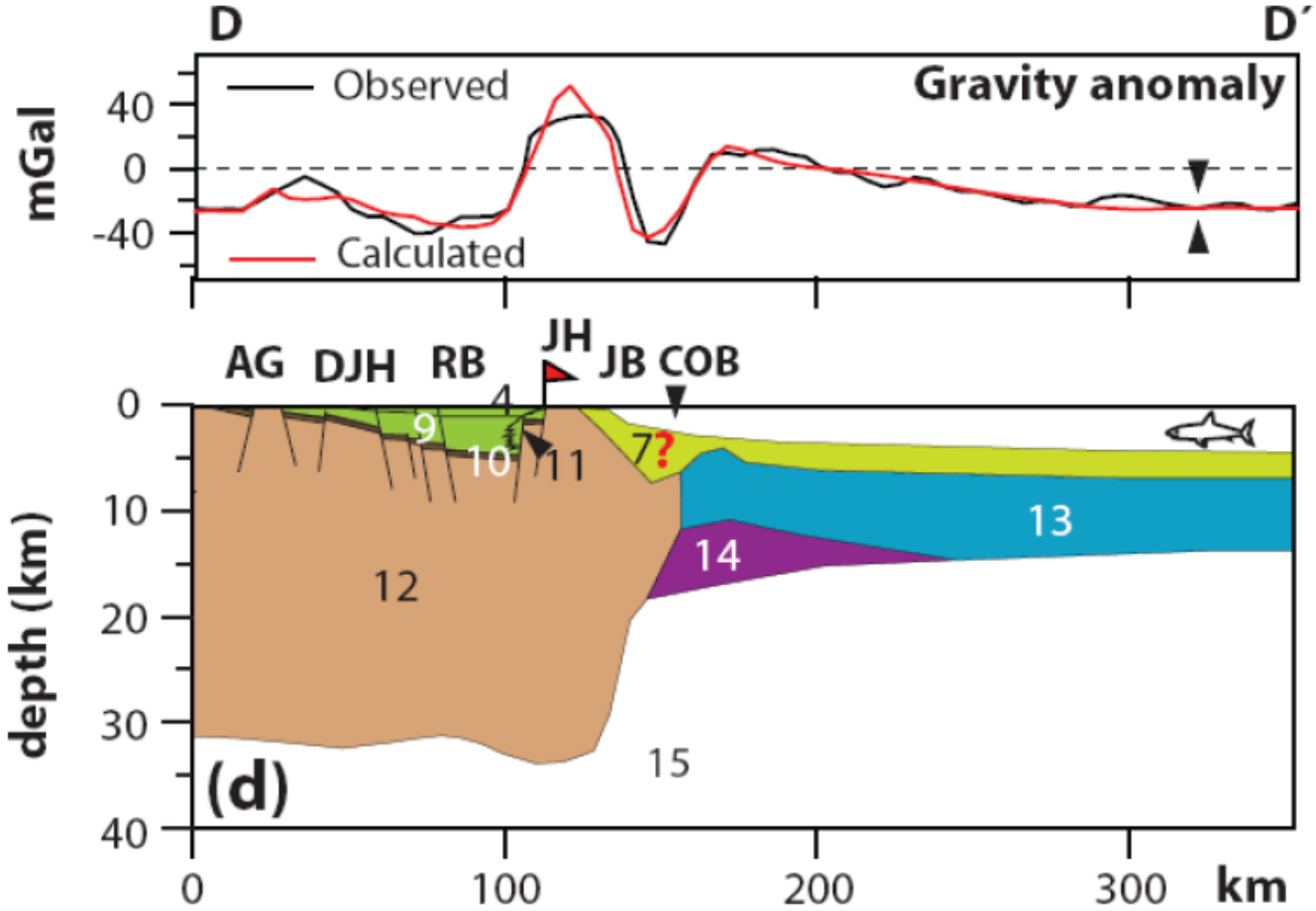

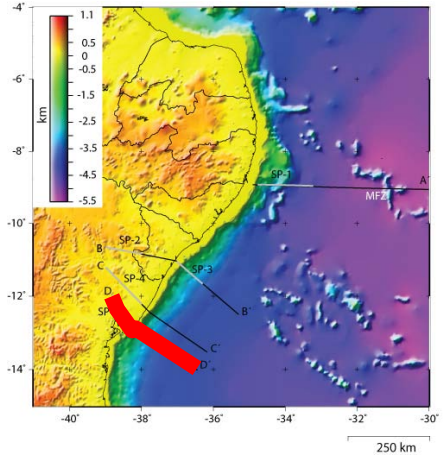

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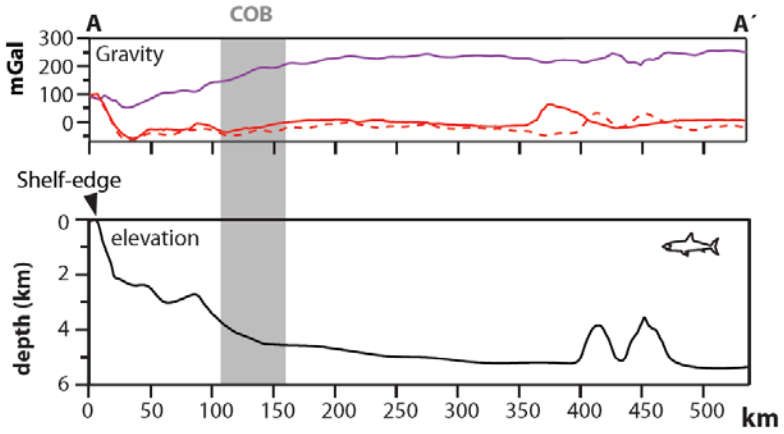
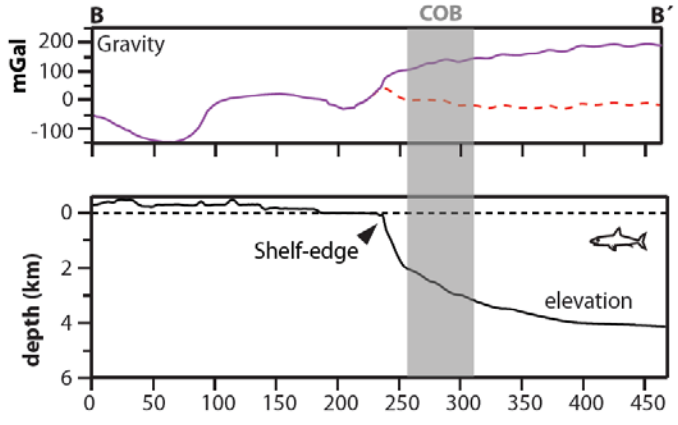
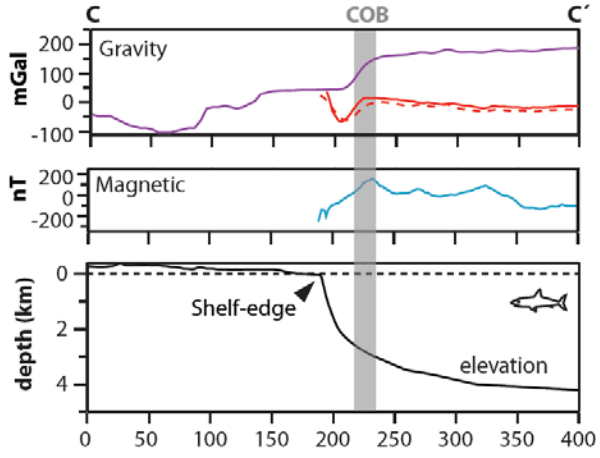
COB location & character

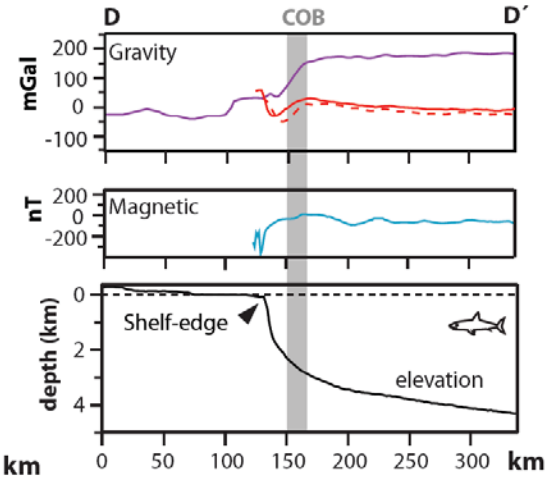




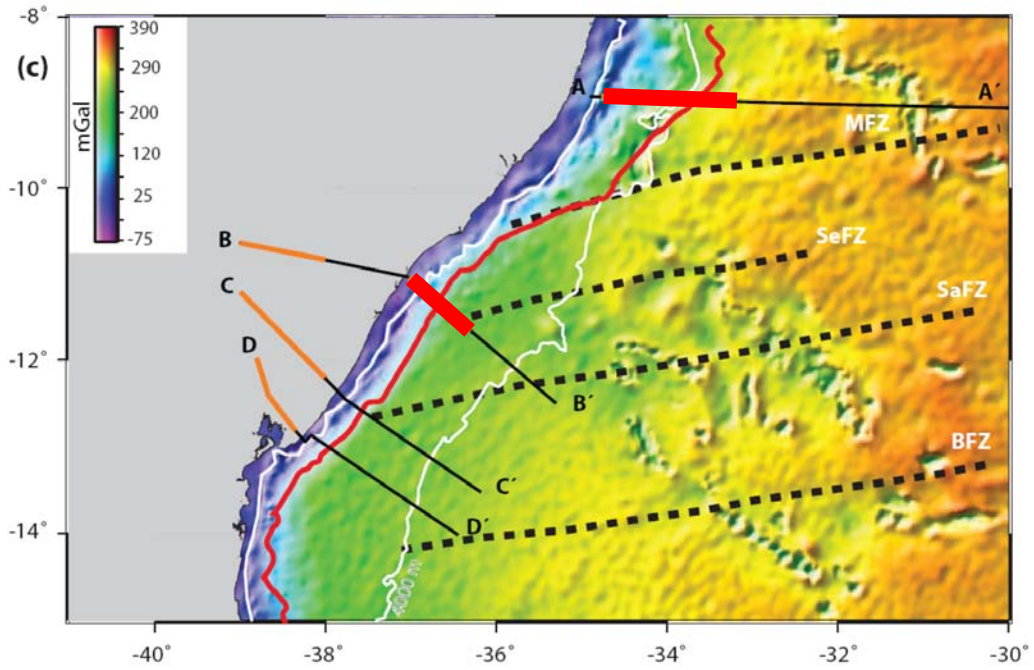
Gravity anomaly:

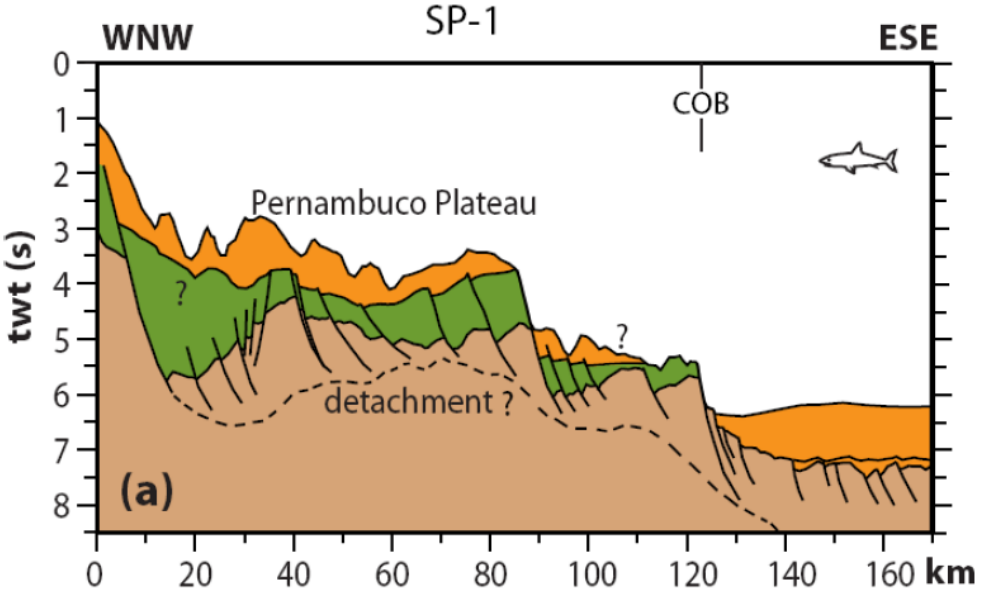
- Bouguer-corrected gravity anomaly (onshore-offshore)
- Ship-borne gravity anomaly
- Satellite free-air gravity anomaly

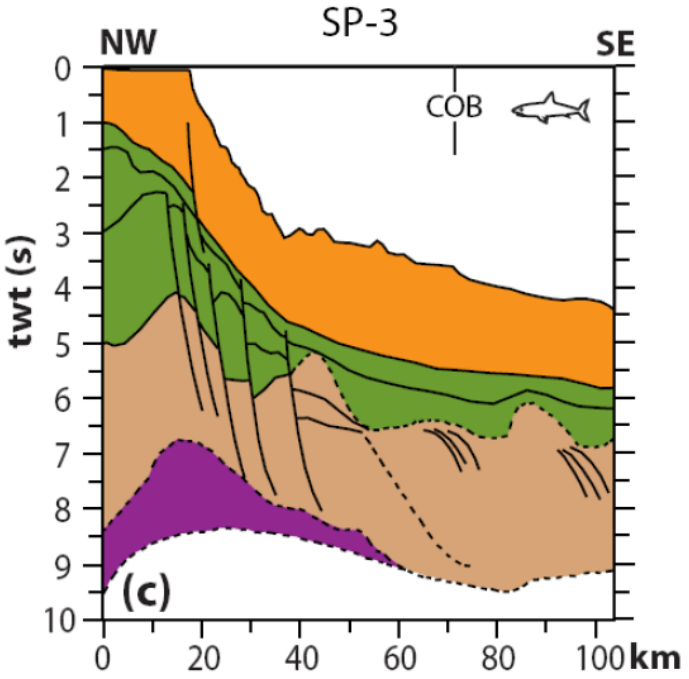




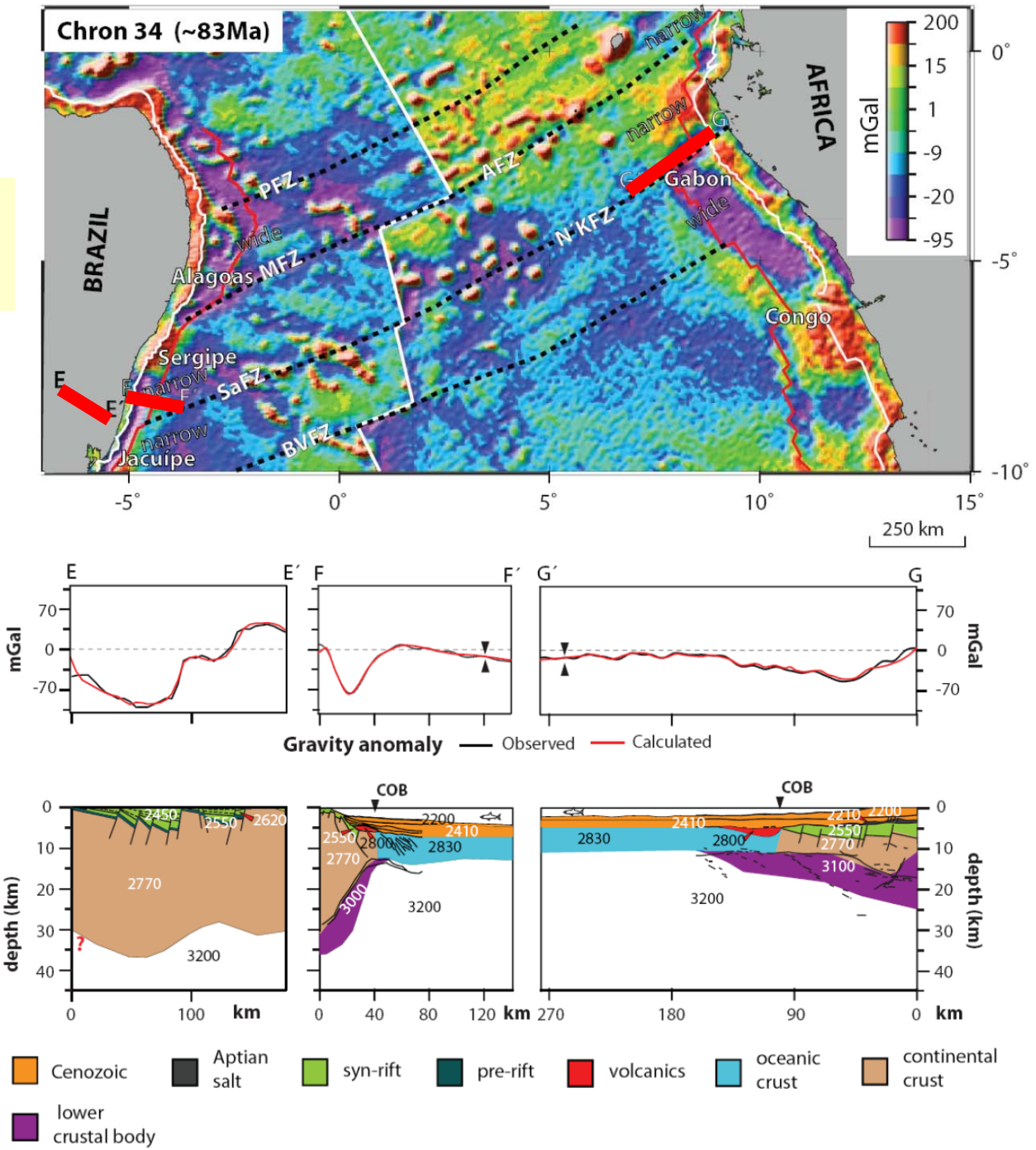
COB location & character



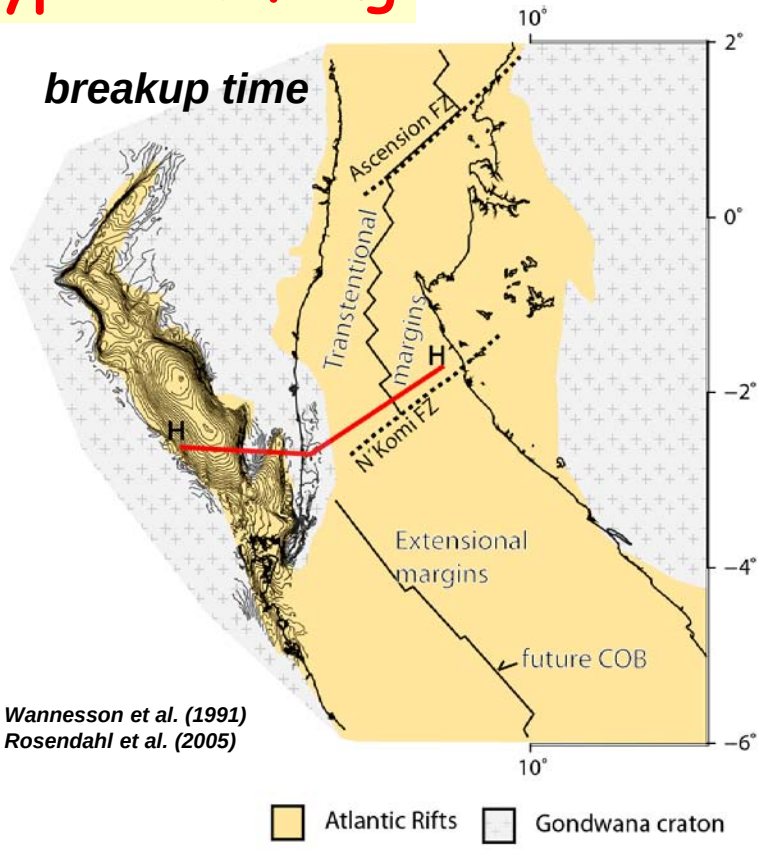




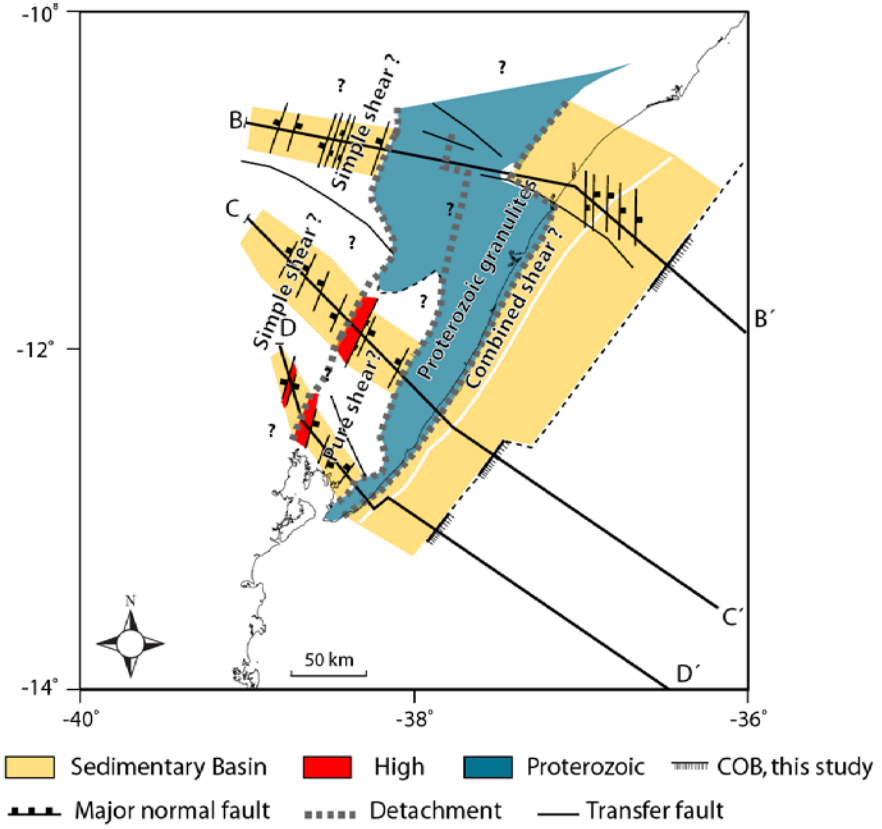
Conjugate margin setting

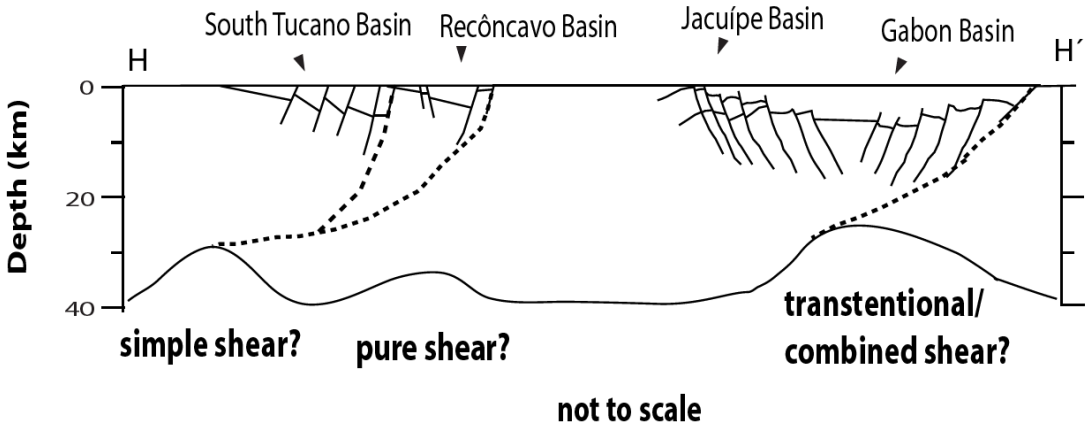


Polyphase rifting

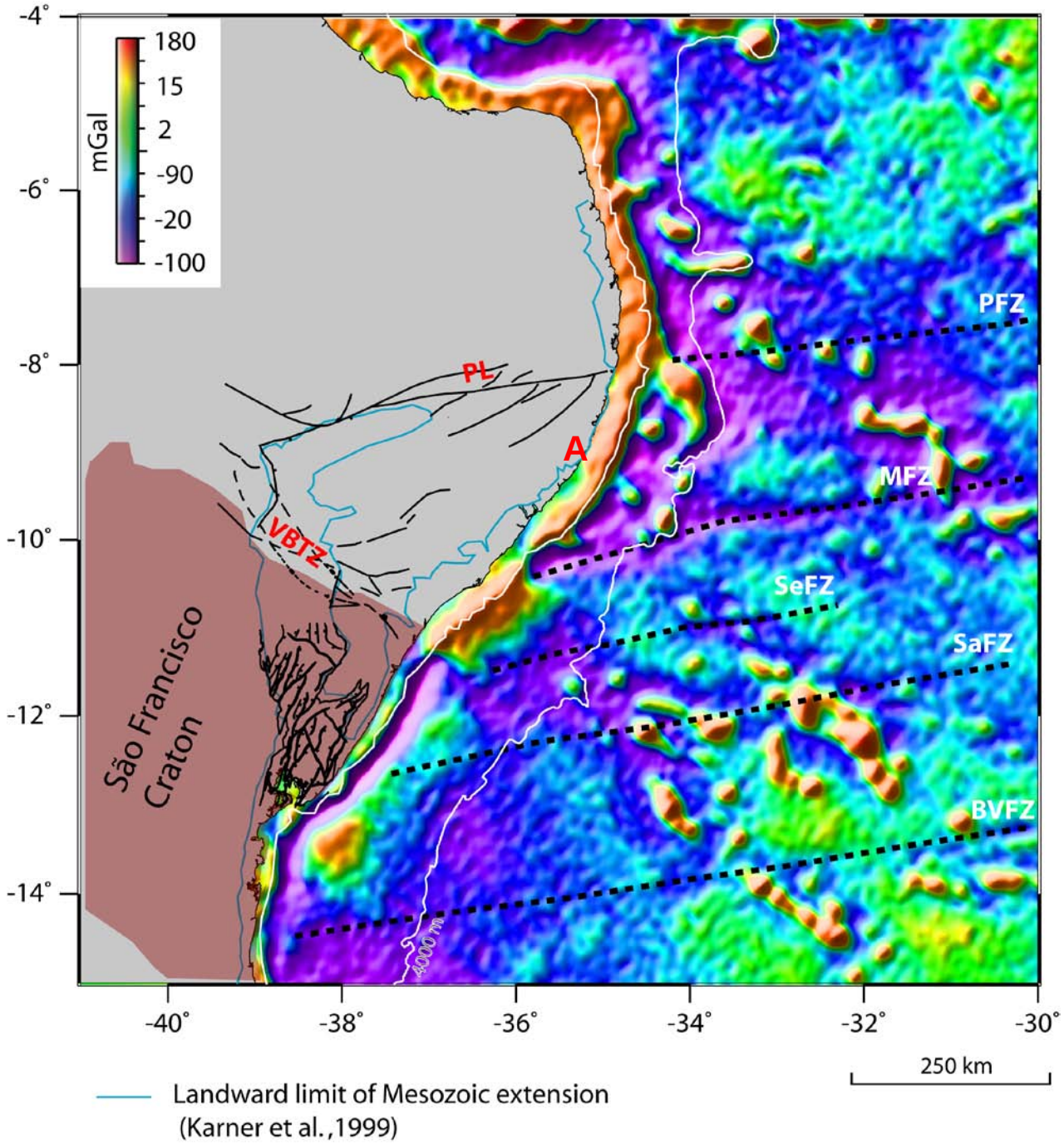


Wannesson et al. (1991)
Rosendahl et al. (2005)





Structural inheritance



Summary and Conclusions

- Integration of seismic reflection, and potential field data and modeling provides a reliable means of studying the NE Brazilian **tectono-magmatic margin evolution**, **onshore-offshore structural correlations**, **continent-ocean boundary/transition location and character**, and **margin segmentation**

  → *powerful resource for reducing costs and interpretation risks when petroleum exploration advances towards new frontiers*

- Prominent **conjugate transfer systems** appear to be first-order structural elements, governing margin segmentation and evolution

- It seems that the development of the Mesozoic rifting and breakup was strongly influenced by a pattern of **structural inheritance** from older structural features

- The evolution of the Recôncavo, Tucano and Jatobá rift system may reflect a **polyphase rifting** evolution mode (pure-shear initially, and simple-shear at later stages) which is associated with a complex time-dependent thermal structure of the thinning lithosphere