

Shale Gas/Oil: The New Frontier Exploration in Brazil*

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Abstract

Given the three major geologic models of discoveries in Brazil: the Meso-Cenozoic turbidites in the 1970's and 1980's, the Aptian and Albian carbonates in the 1990's, and more recently the "Pre-Salt" microbial boom in the late 2000's, the unconventional reservoirs have not been focused on by the Brazilian E&P industry so far. Looking through this perspective it is clear that there is a great business opportunity in Brazil, especially for gas-oil shale. Covering 2,680,000 sq km, 31.5% of Brazilian territory, the majority of Paleozoic basins are prolific hydrocarbon producers with well-known petroleum systems. Strategically located in the northern-northeastern region, which is currently undergoing a broad and strong economic growth, and in the southeastern region, an area of scarce energy resources, these basins are major targets for the gas-oil shale model.

With a relatively similar geological evolution, the Paleozoic Paraná, Solimões, Amazonas and Parnaíba basins (the last in development by OGX and MPX partnership) have thick (up to 660 m/2165 ft, with 40 m/130 ft of black shale) Silurian-Devonian shale intervals with a total organic carbon content in the range of 0.1-5% and vitrinite reflectance (Ro) data indicating immature to over mature source rocks, suggesting great potential for gas-oil shale.

Producing since 1937 from conventional reservoirs, the aborted Mesozoic rift basin of Recôncavo also has its own potential, with a thickness of up to 1850 m/6070 ft of lacustrine shales, total organic carbon from 1% to 2% and vitrinite reflectance (Ro) data indicating immature to over mature source rocks that now can be targeted for unconventional reservoirs. In a similar geological context, the onshore portion of Potiguar Basin holds up to 6500 m/21,325 ft of lacustrine shale with TOC up to 4% and vitrinite reflectance (Ro) from immature to mature.

The polycyclic Proterozoic São Francisco Basin has also been the focus of exploration due to several gas seeps registered in the 1980's that are now being associated with shales and tight sands. Lack of public information does precludes further understanding of this play.

The 226 TCF of technically recoverable shale gas resources estimated from the Parana Basin in southwestern Brazil (2011 EIA report) puts these basins and their gas-oil shale scenario in a whole new perspective. However, the absence of shale plays regulation in Brazil needs to be overcome in order to unleash the so far unknown potential of these unconventional reservoirs.

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AGENDA

1. Introduction
2. Brazilian Sedimentary Basins
3. Precambrian Systems
4. Paleozoic Systems
5. Mesozoic Systems
6. Economical Aspects
7. Conclusions

1. Introduction

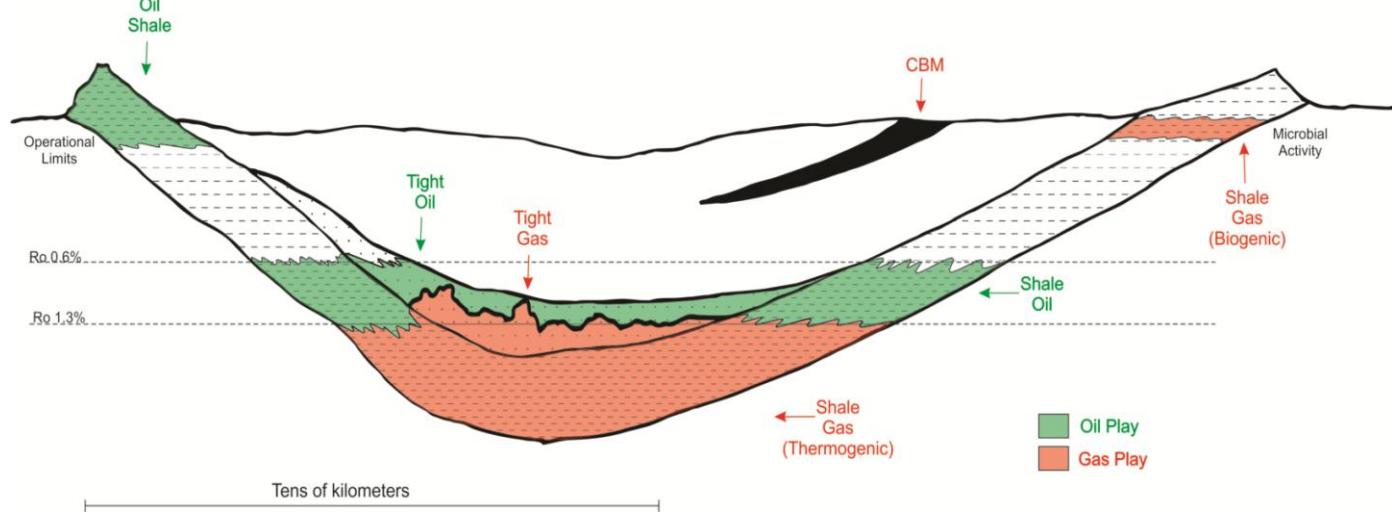
• Unconventional Plays

GAS PLAYS

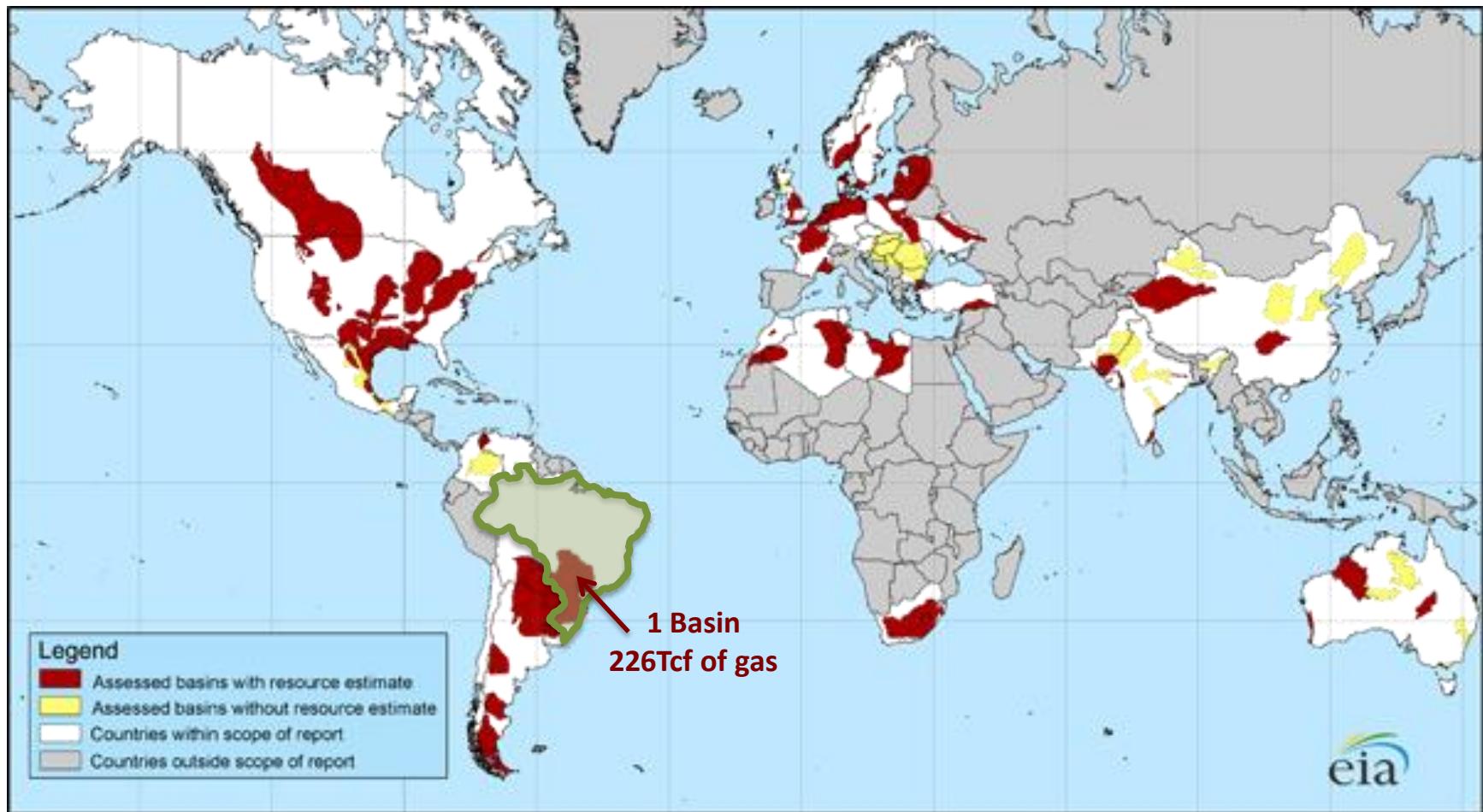
- Shale gas
- Tight Sands
- CBM
- Gas Hydrate

OIL PLAYS

- Oil-shales
- Shale oil
- Tight oil
- Heavy oil
- CTL



1. Introduction



Modified from World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States EIA, 2011.

2. Brazilian Sedimentary Basins



- █ Meso-Cenozoic Extensional Margin
- █ Meso-Cenozoic Transform Margin
- █ Aborted Mesozoic Rifts
- █ Andean Foreland
- █ Interior Basins
- █ Paleozoic Synclises

Meso-Cenozoic Margins

1. Meso-cenozoic turbidites
2. Aptian/Albian carbonates
3. "Pre-salt" microbiolite

Paleozoic Synclises

1. Fluvial/eolian sandstones
2. Shallow marine sandstones

Aborted Mesozoic Rifts

1. Fluvial/eolian sandstones

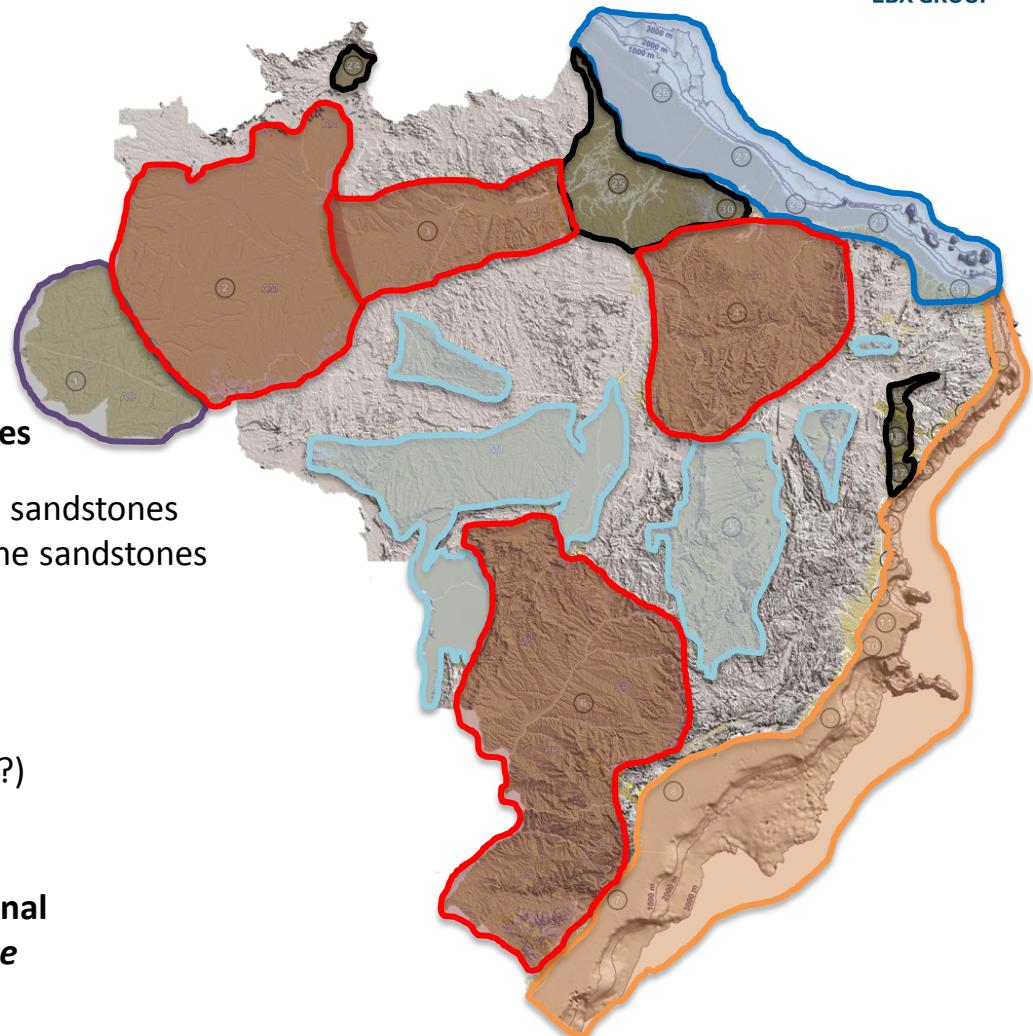
Interior Basins

1. Fractured (???)

BASIN	Tcf
Parnaíba	64
Parecis	124
Recôncavo	20
São Francisco	80
Paraná	226*
TOTAL	514

**Onshore
Unconventional
Gas – *In Place***

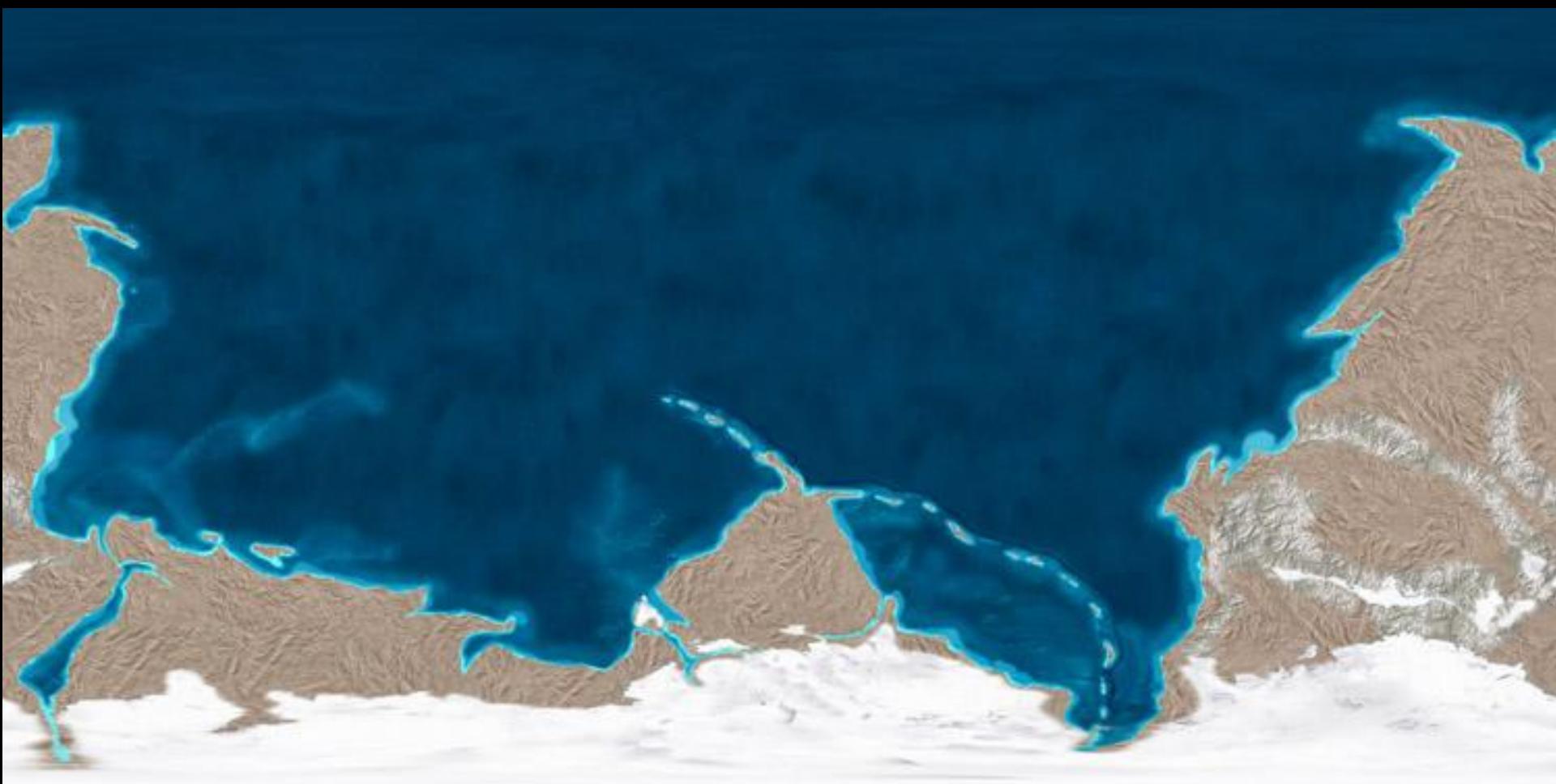
* EIA, 2011; ANP, 2013



Modified from Bacias Sedimentares Brasileiras—Cartas Estratigráficas: Boletim de Geociências da Petrobras, v. 15, 2007

3. Precambrian Systems

Neoproterozoic (600 Ma)

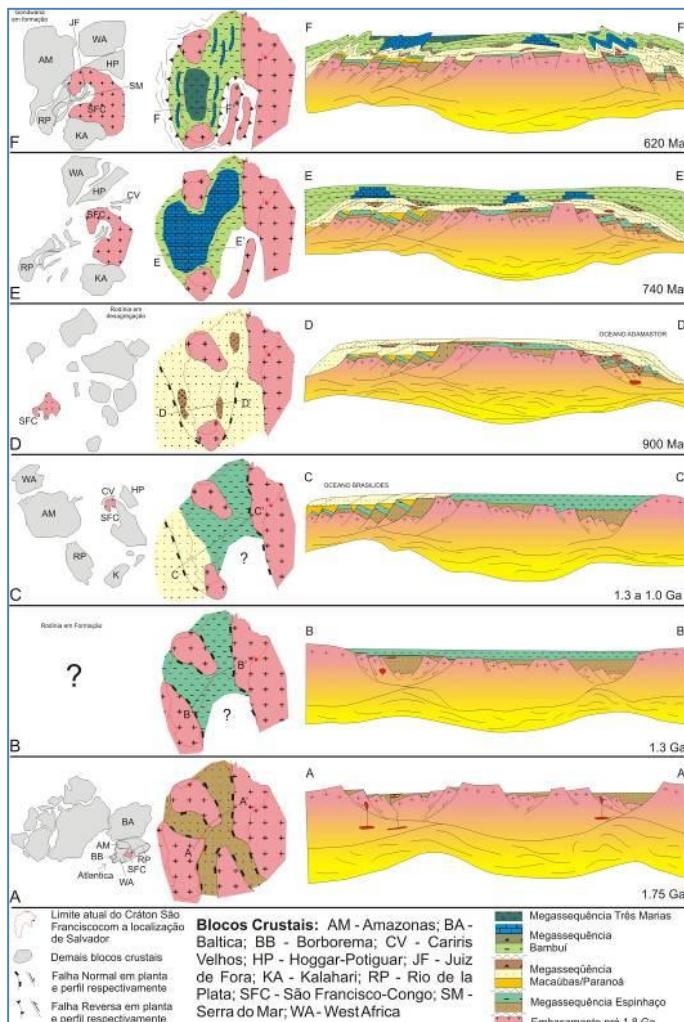


Blakey, 2013

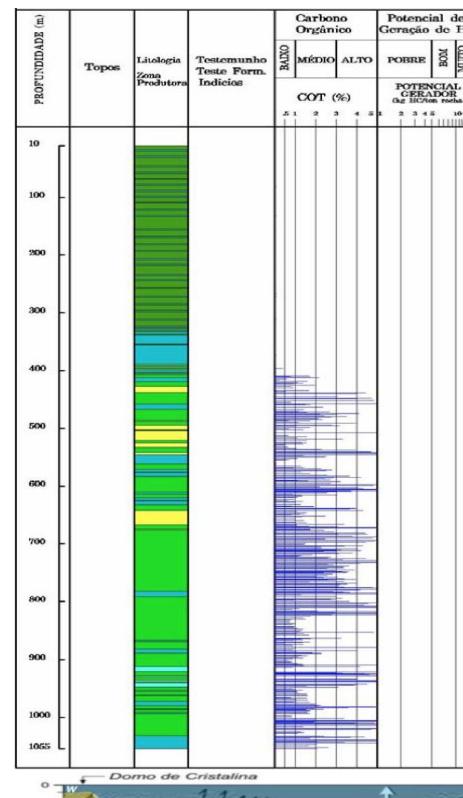
São Francisco Basin

OGIP – 80Tcf

ANP, 2013



Miranda et al. 2006

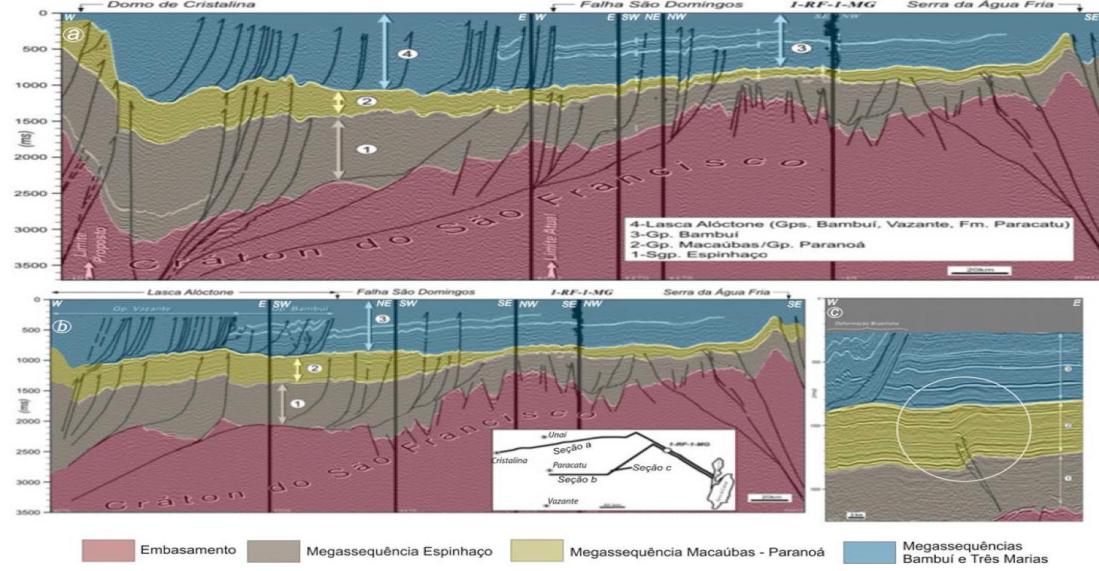


OGX
EBX GROUP

Vazante Shale (?)

- Neoproterozoic (Marine)
- Thickness – ?
- TOC – 0.5 a 15%
- Ro – Senile
- Avg. Depth.– 1000m ?

ANP, 2002

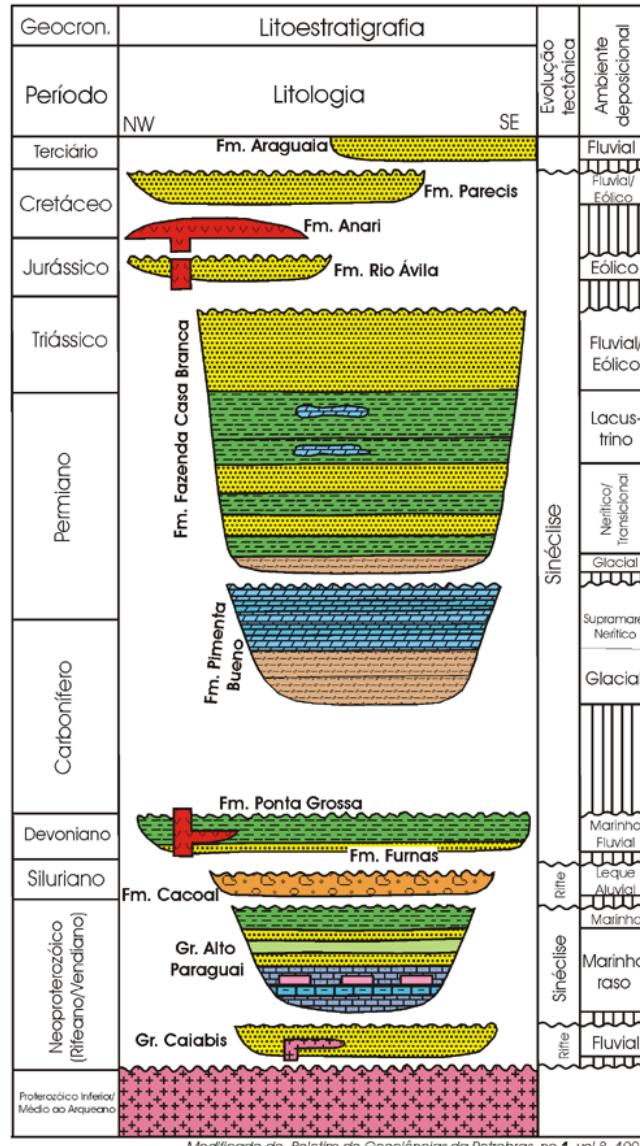


Modified from Romeiro-Silva & Zalán, 2005

Parecis Basin

OGIP – 124Tcf

ANP, 2013



Sepotuba Shale

- Neoproterozoic (Marine)
- Thickness –??
- TOC – ???
- Ro – mature ?
- Avg. Depth – ???

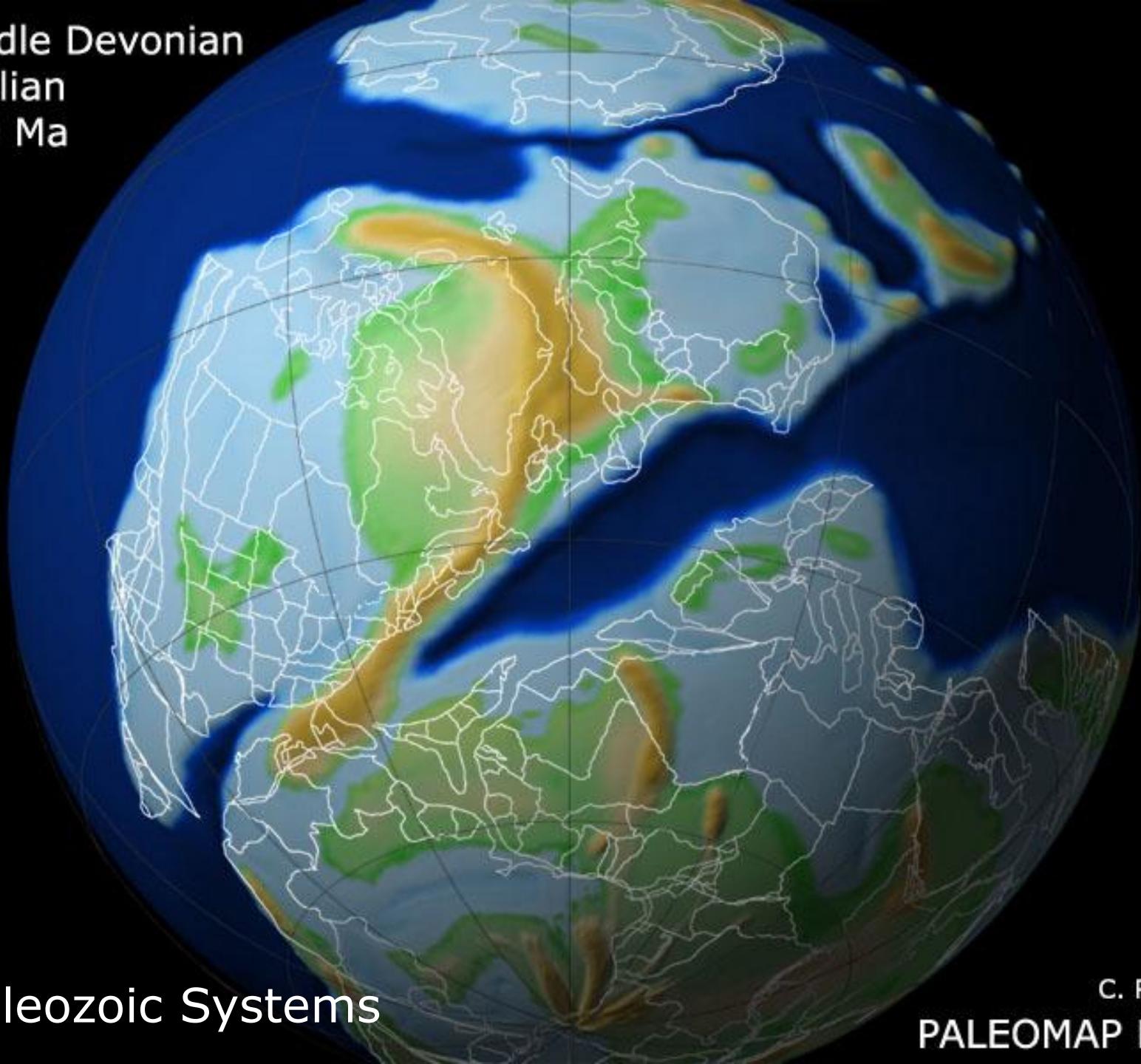
Ponta Grossa Shale

- Devonian (Marine)
- Thickness –??
- TOC – ???
- Ro – mature - ?
- Avg. Depth – ???

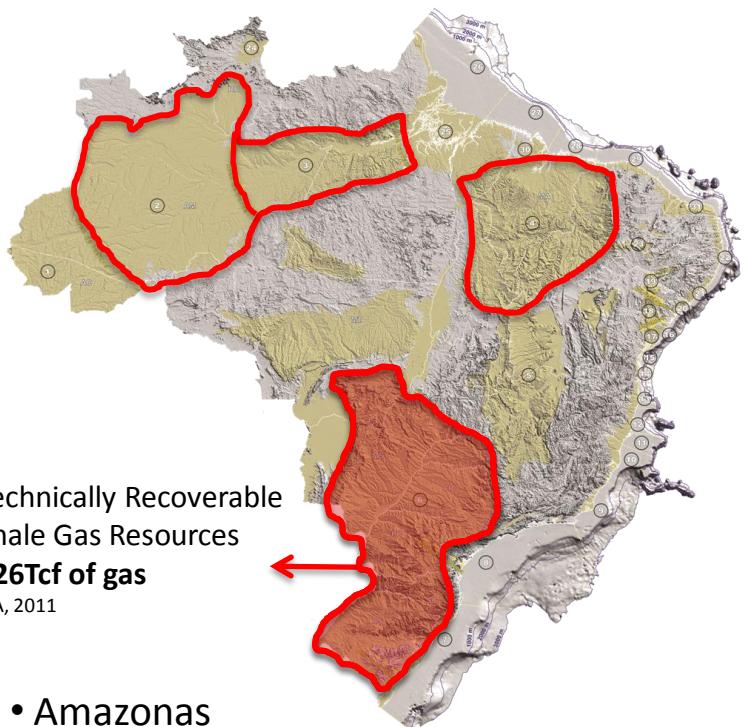


ANP,
2013

Middle Devonian
Eifelian
390 Ma

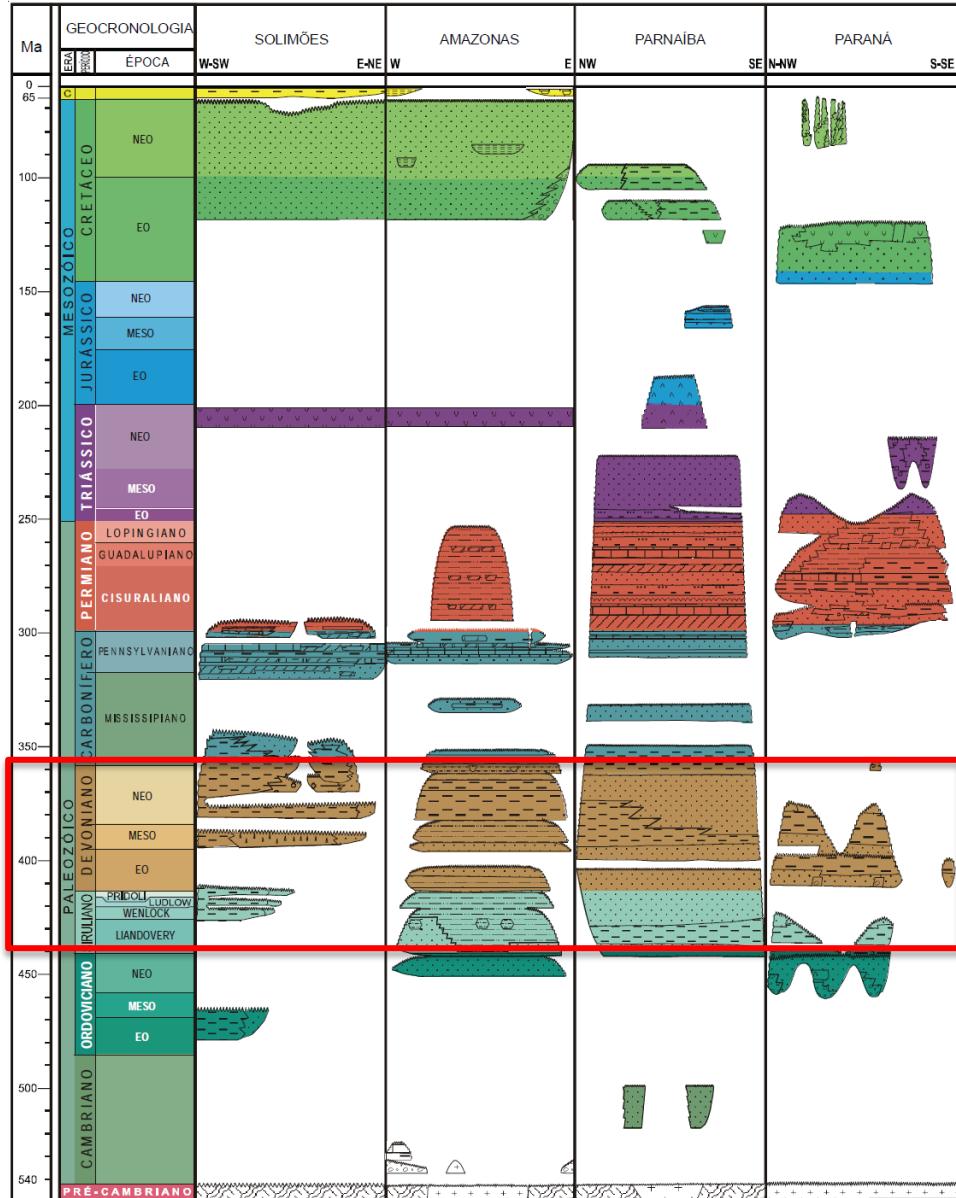


4. Paleozoic Systems



- Amazonas
- Solimões
- Parnaíba
- Paraná

2.680.000 Km²
(31,5% of Brazilian territory)



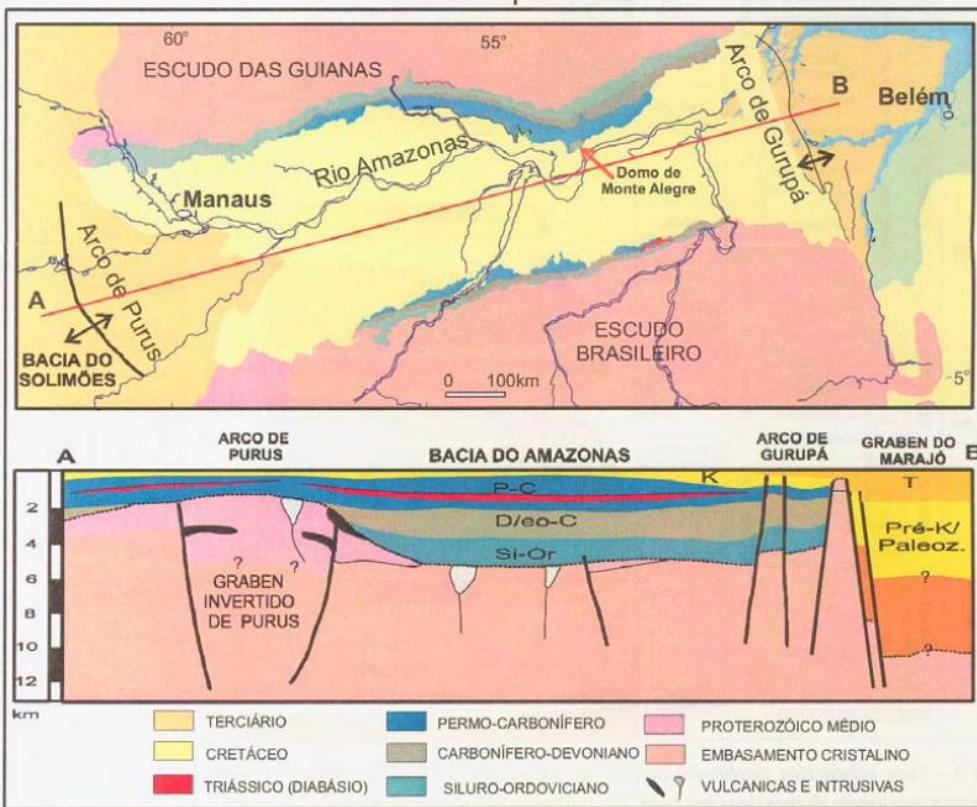
"Bacias Sedimentares Brasileiras—Cartas Estratigráficas: Boletim de Geociências da Petrobras, v. 15, 2007"

Amazonas Basin

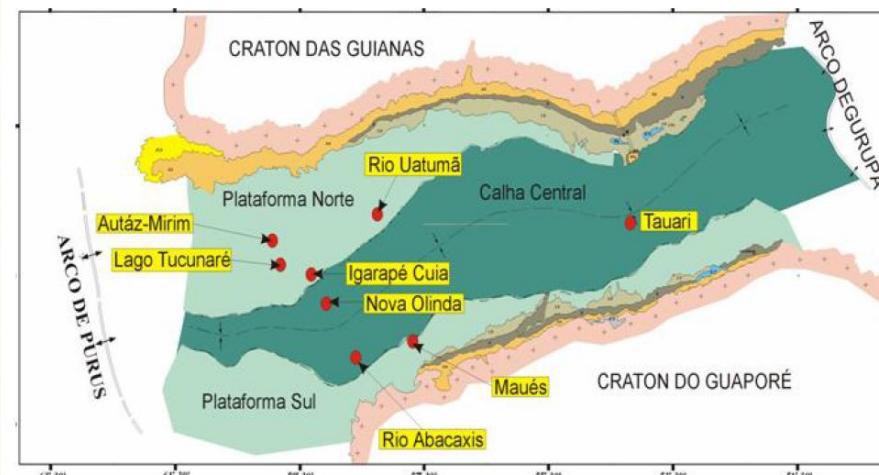


Barreirinhas Shale

- Upper Devonian (Marine)
- Thickness – 30 to 160m
- TOC – 3 to 8% (Type II)
- Ro – mature to senile
- Avg. Depth – 2750m



Wanderley Filho et al., 2004



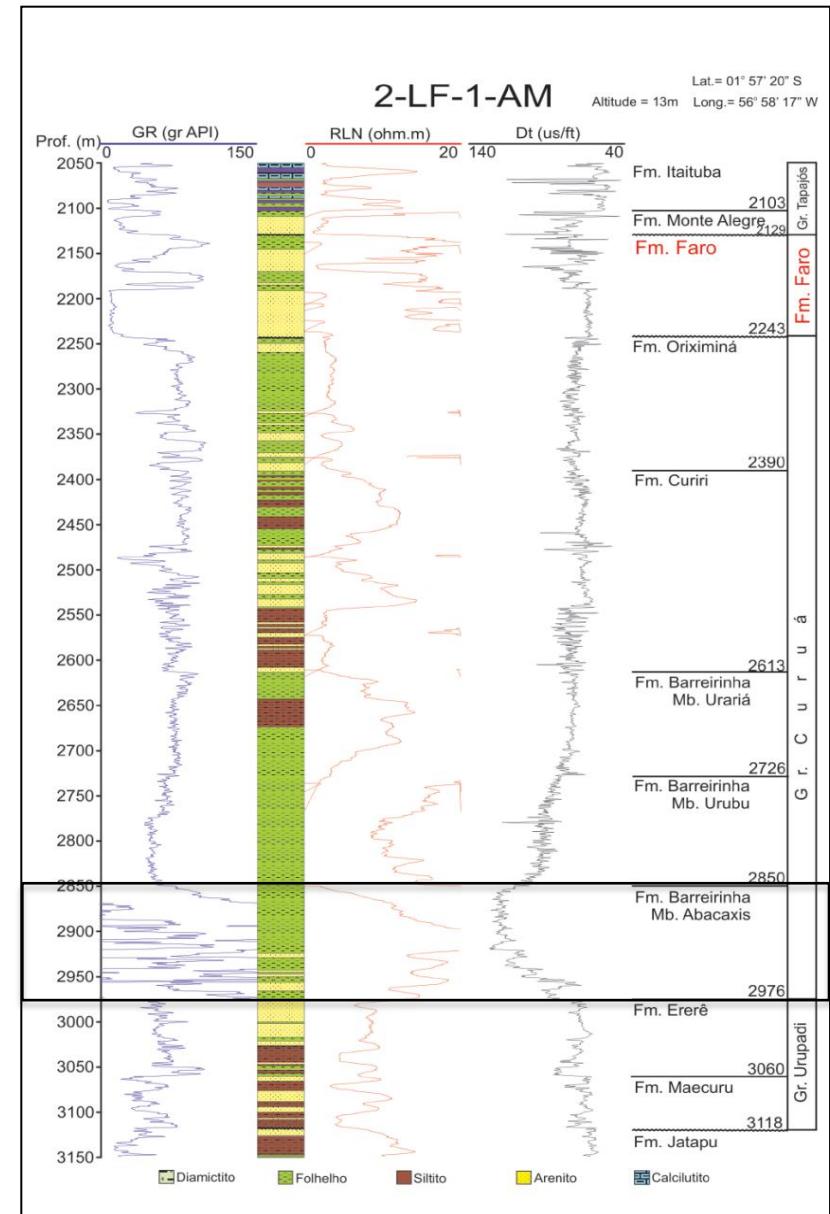
LEGENDA DA ÁREA DE AFLORAMENTO :

SILUR./ORDOV.	DEVONIANO	CARBON. / PERMIANO	-TRIÁSSICO
CRETÁCEO	TERCIÁRIO		Cunha, 2006

Amazonas Basin



Miranda, personal archive.



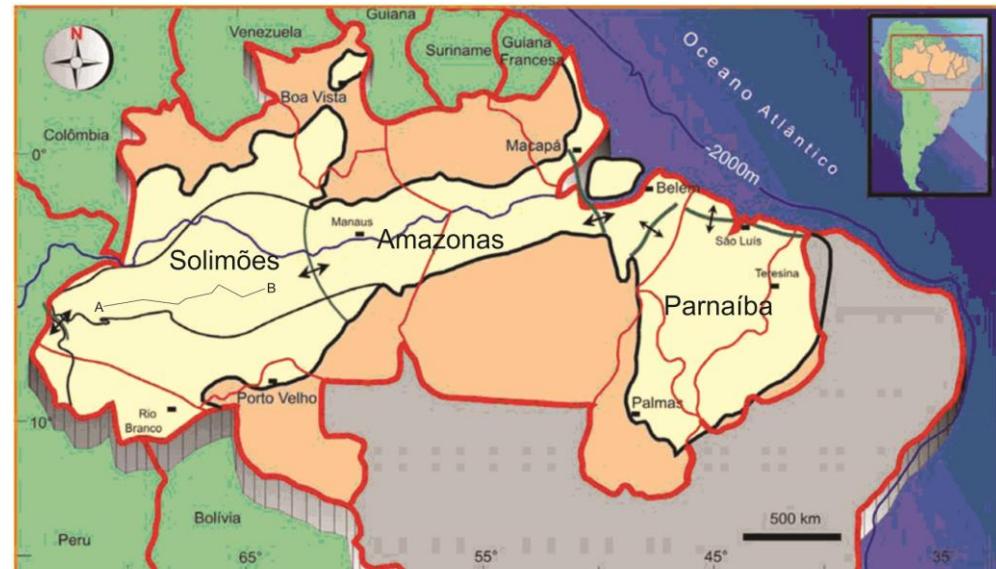
"Bacias Sedimentares Brasileiras—Cartas Estratigráficas: Boletim de Geociências da Petrobras, v. 15, 2007"

Solimões Basin

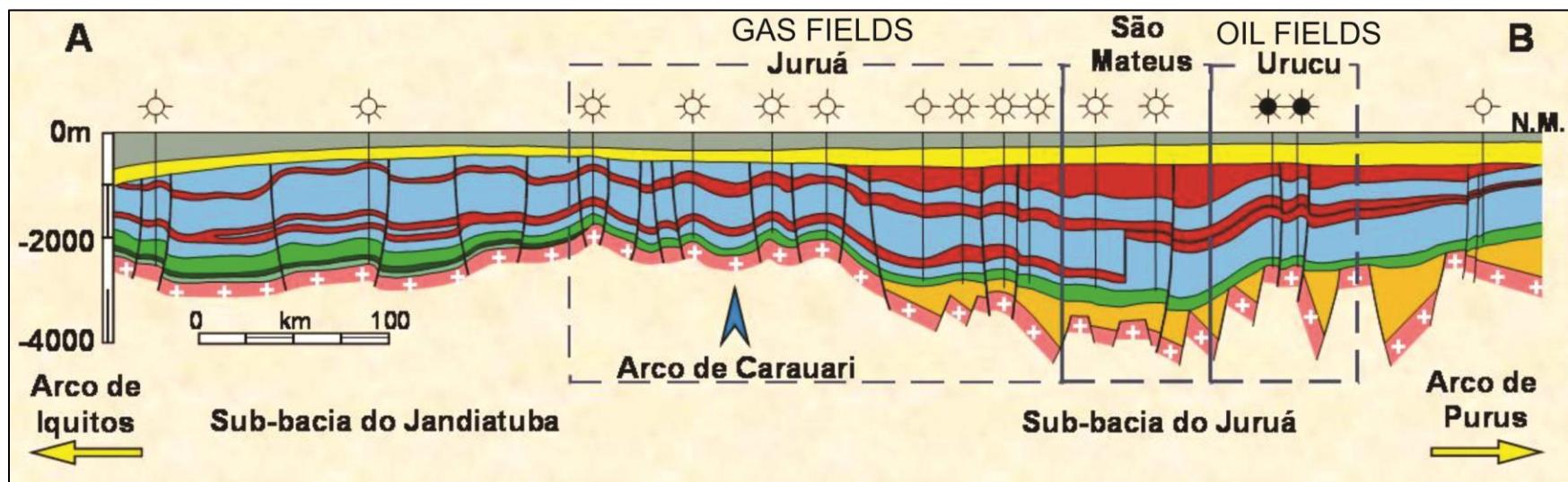


Jandiatuba Shale

- Upper Devonian (Marine)
- Thickness – 40m (Black Shale)
- TOC – 4 to 8% (Type II)
- Ro – mature to senile
- Avg. Depth – 2300m
- Magmatic intrusions effect



Wanderley Filho et al 2006



Eiras, 1999

Parnaíba Basin

OGIP – 64Tcf

ANP, 2013

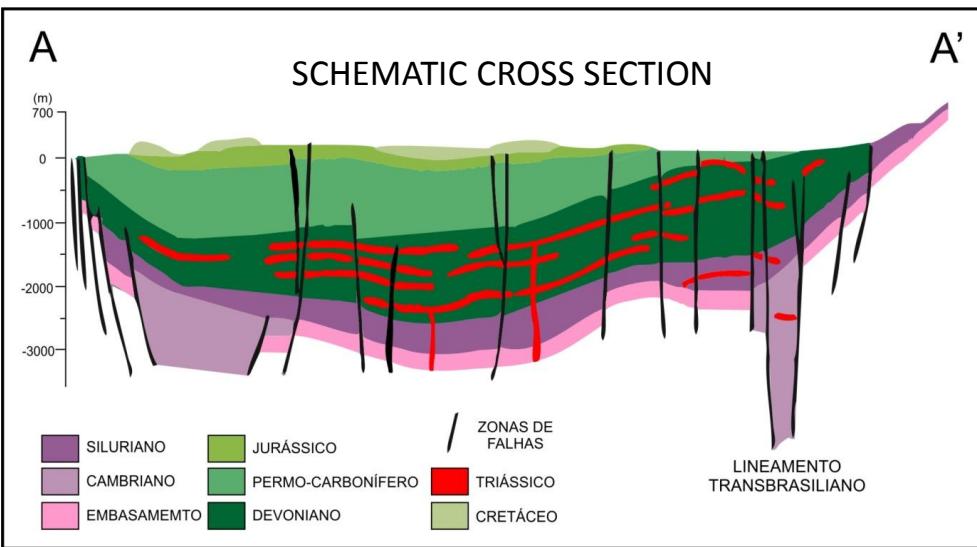


Pimenteiras Shale

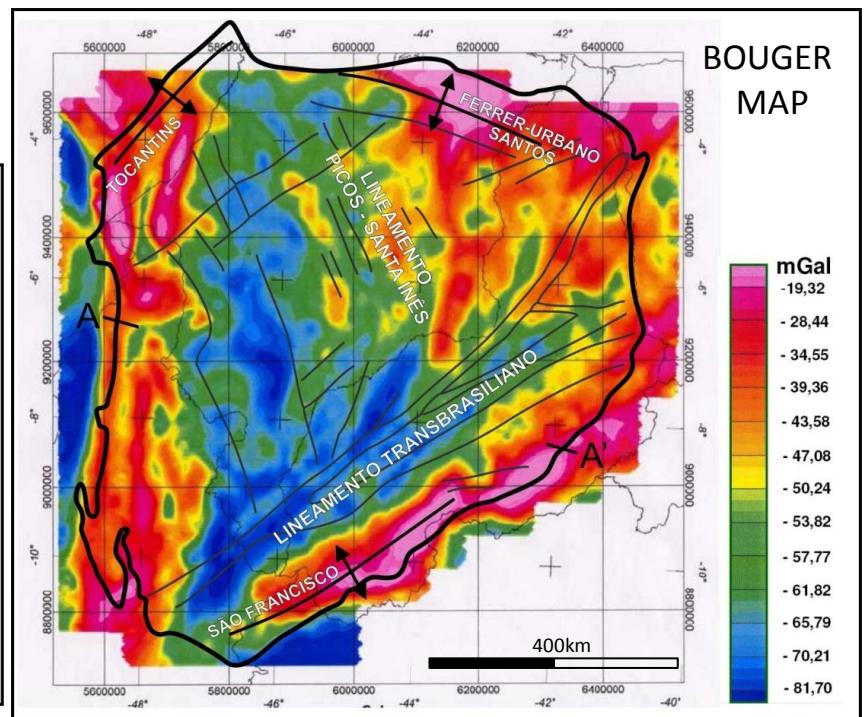
- Middle/Upper Devonian (Marine)
- Thickness – 200m
- TOC – 0,5 to 5% (Type II and III)
- Ro – mature to senile
- Avg. Depth – 1500m
- Magmatic intrusions effect



MPX, 2013



Modified from (Bazzi *et al.* 2003 e Milani & Zalan, 1999).



Paraná Basin

OGIP – 226Tcf

EIA, 2011

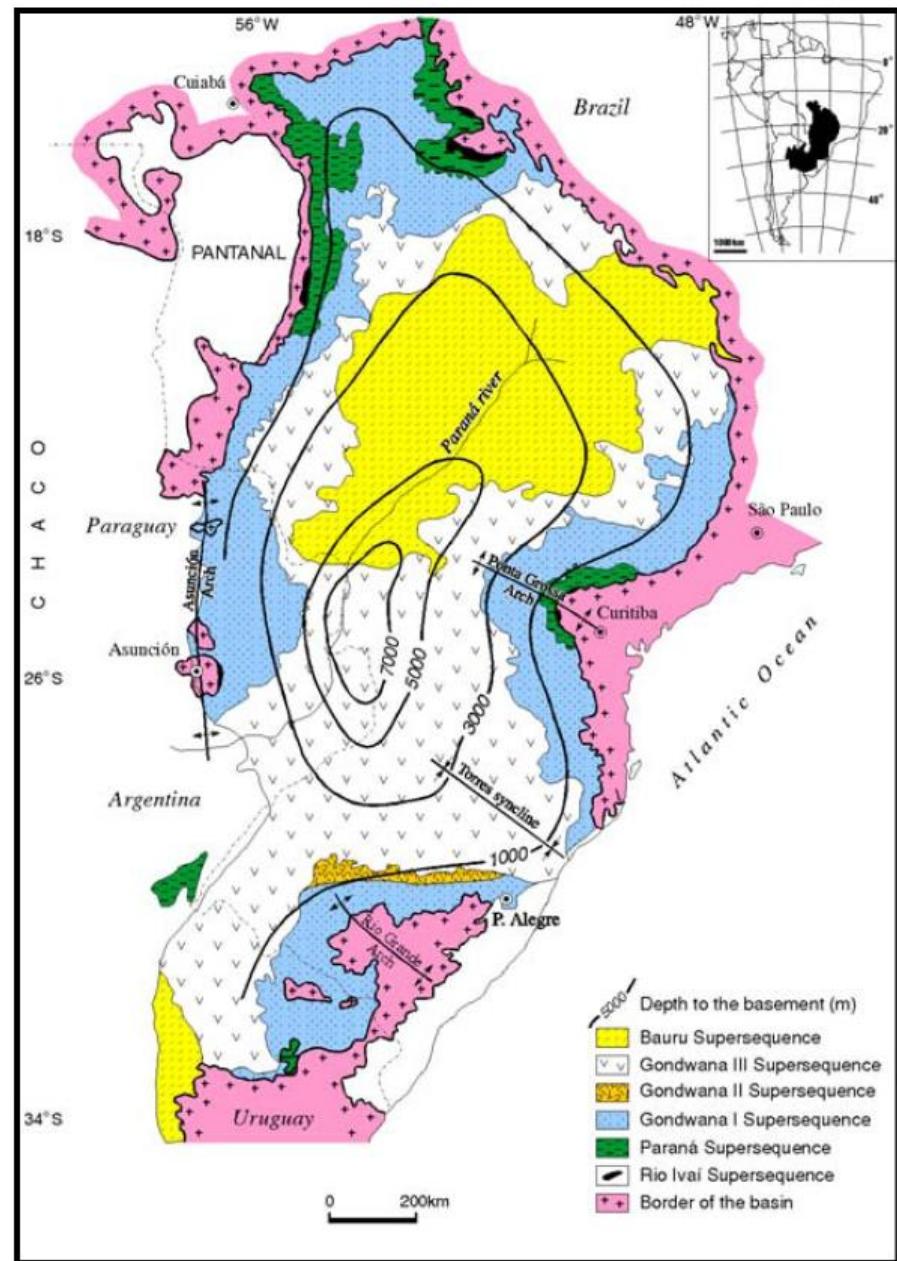


Iratí Shale

- Permian/Cisuralian (Marine/Lacustrine)
- Thickness – 70m
- TOC – 8 to 13% (up to 24% - Type I)
- Ro – immature to senile
- Avg. Depth – 2300m
- Magmatic intrusions effect

Ponta Grossa Shale

- Devonian (Marine)
- Thickness – 70m
- TOC – 3%
- Ro – immature to senile
- Avg. Depth – 3000m
- Magmatic intrusions effect/Overburden



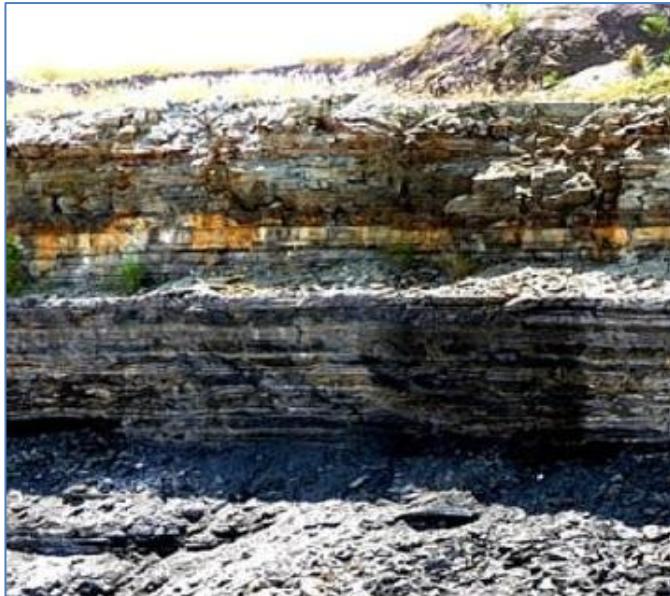
Milani e Ramos, 1998

Paraná Basin



Irati Shale

- 59 years of Oil Shale Pyrolysis
- 2.2 Million ton/year shale (+tires recycling)
- Avg production 6.000 boe/day



Secretaria de Educação do Estado do Paraná, 2008



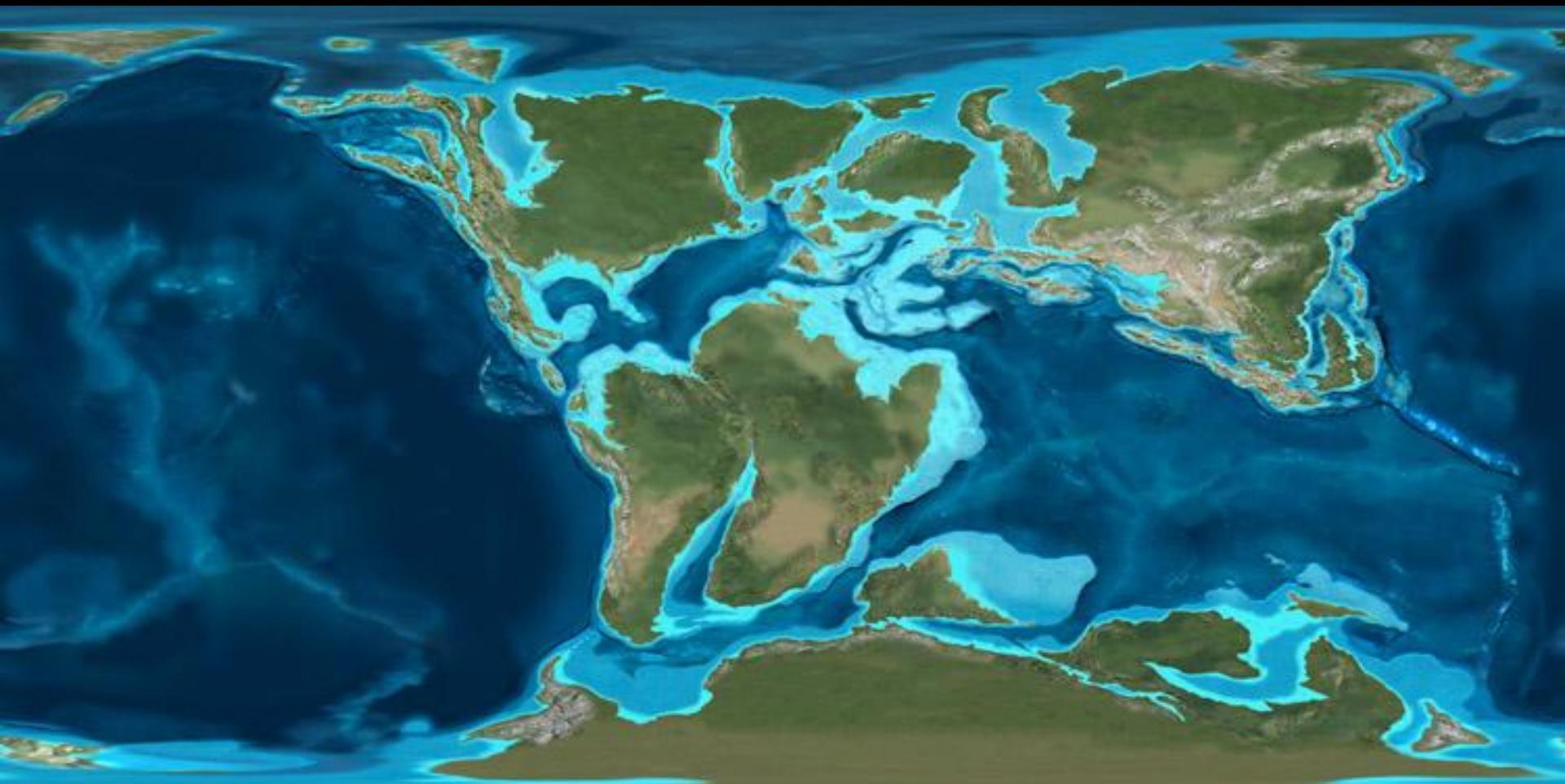
<http://jornale.com.br/mirian/?p=4815>



<http://fotograrte.blogspot.com/2008/09/post-03-de-03-mina-de-xisto-petrobrs-s.html>

5. Mesozoic Systems

Early Cretaceous (120 Ma)



Recôncavo Basin

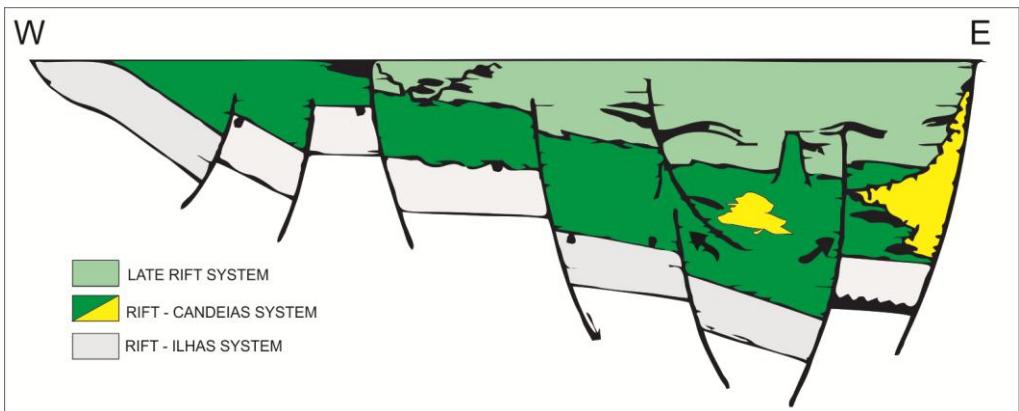


OGIP – 20Tcf

ANP, 2013

Candeias Shale

- Lower Cretaceous (Lacustrine)
- Thickness – up to 1850m
- TOC – 1-2% (Type I)
- Ro – Immature to Mature
- Avg. Depth – 1500m (variable)
- Actual Fractured Shale Oil Production (Candeias Field)
 - Conventional since 1937
(1st Brazilian Field)



Modified from Figueiredo et. al., 1994.

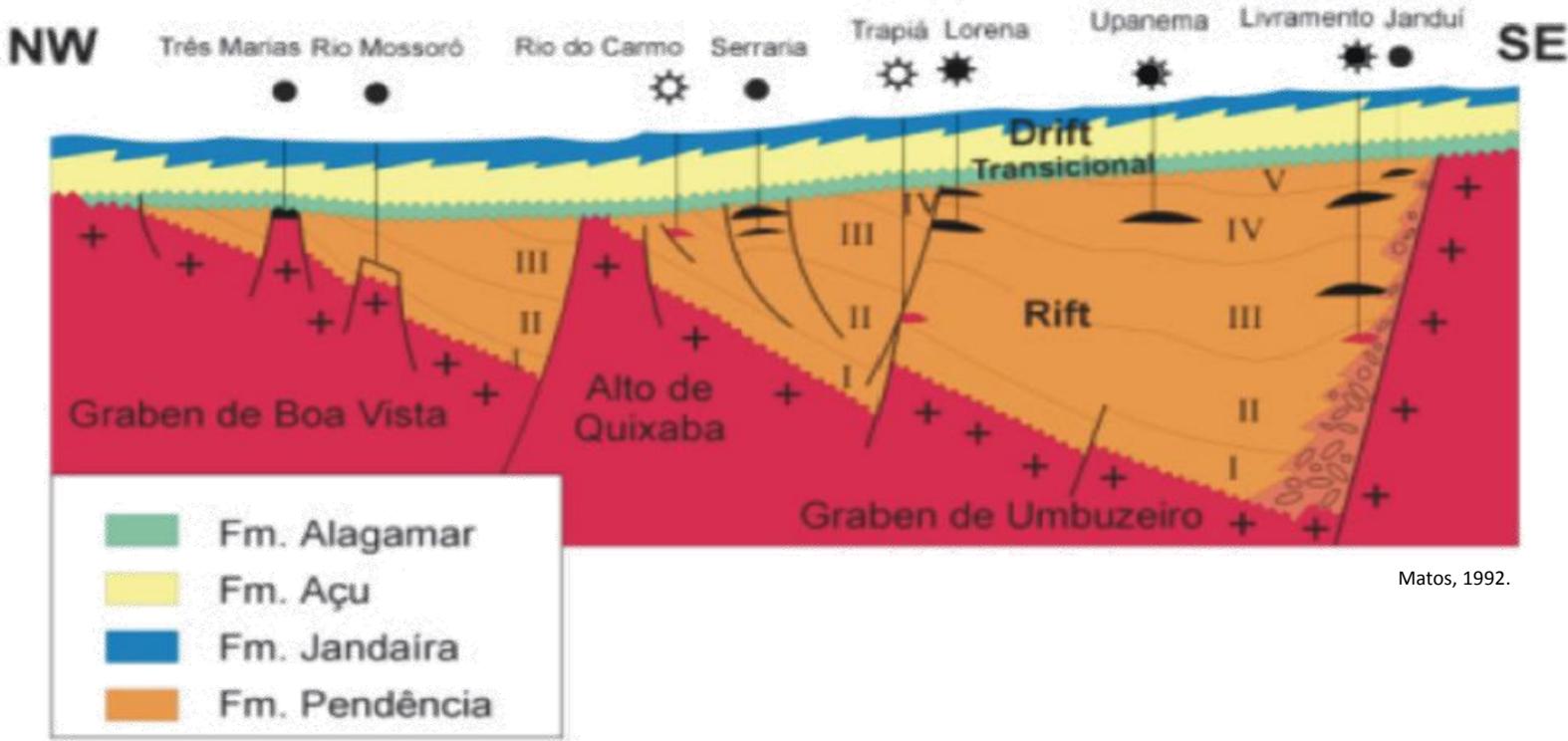
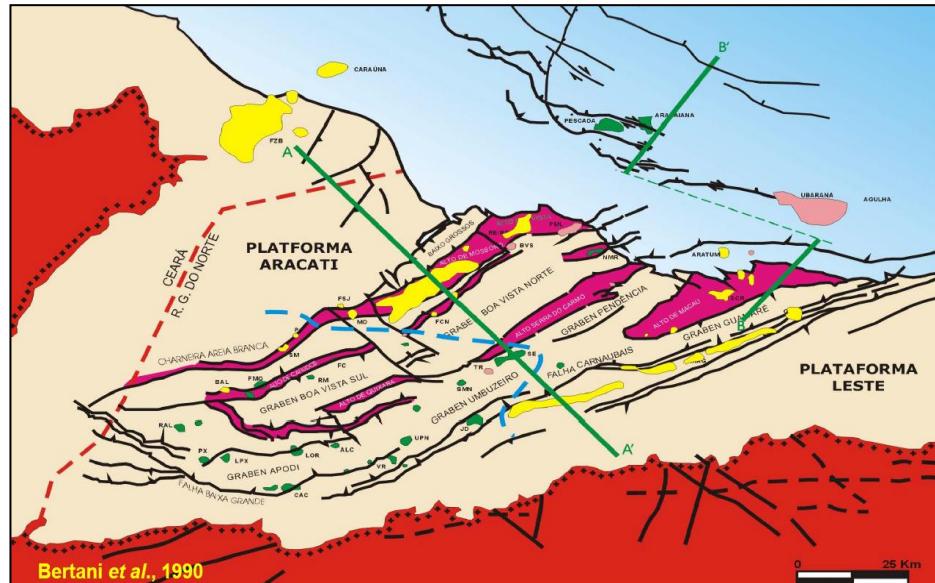


Potiguar Basin

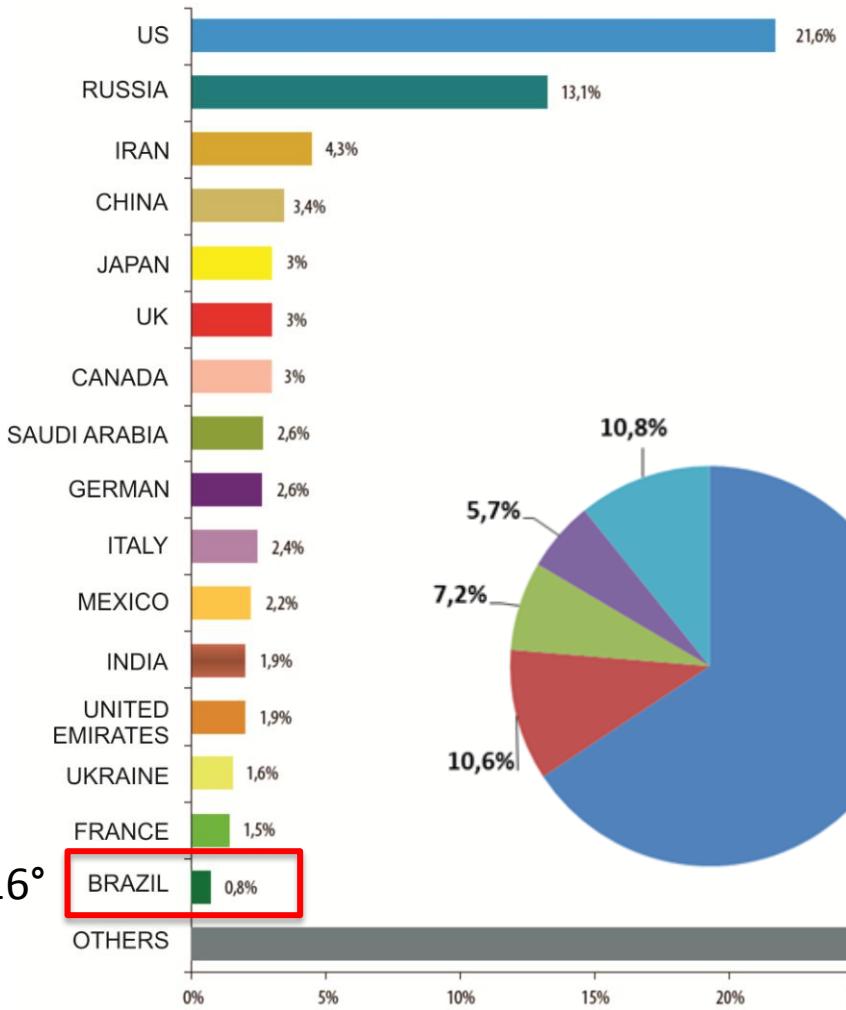


Pendênci Shale

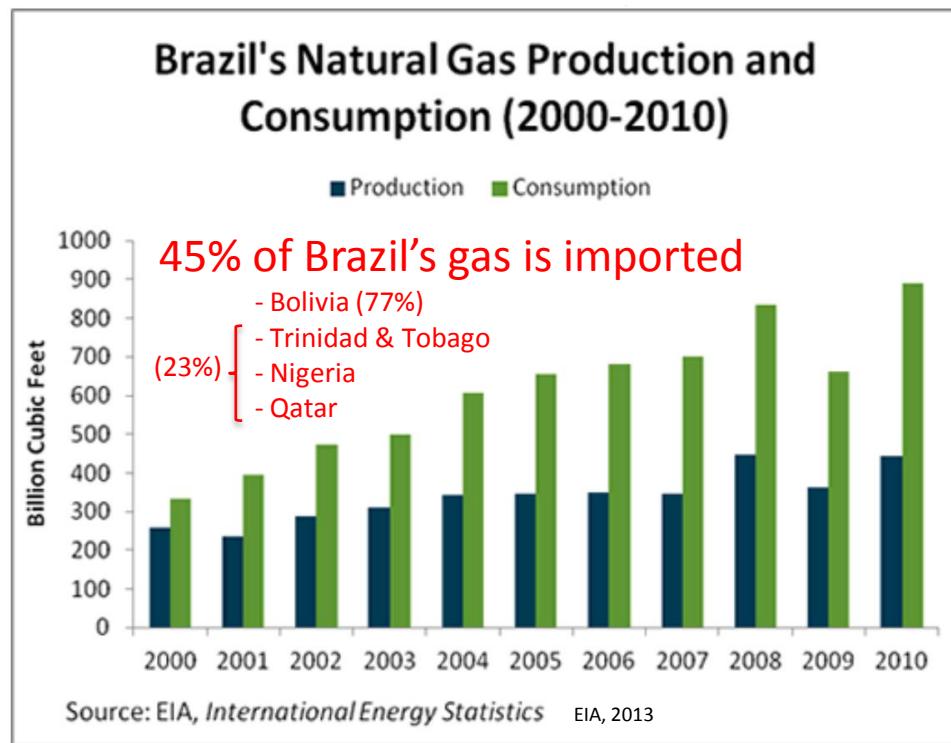
- Lower Cretaceous (Lacustrine)
- Thickness – up to 6500m
- TOC – 4% (Type I and II)
- Ro – Immature to Mature
- Avg. Depth – 2000m (variable)



6. Economical Aspects



"BP Statistical Review of World Energy 2011; para o Brasil, ANP/SPP (tabela 1.3)."



- Hydroelectric
- Thermal (Gas)
- Biomass
- Oil
- Others

MME, 2012

16°

7. CONCLUSIONS



- Wide spectrum of shale resources.
- Good opportunities for oil and gas plays.
- Infrastructure is challenging.
- Government incentives (12° Bid round “Unconventional Onshore Gas” – October 2013).
- Exploration frontier with a great chance of success.
- Economical motivation – Thermal generation.
- Chance for smaller players and partnerships.

“Swim Against the Stream - Even a Dead Fish Can Go With the Flow”
Dr. Juergen Schieber “Shaleman” – Indiana University

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