



# Brazil's Pre-Salt Development and CO<sub>2</sub> Management

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# Outline

Brazilian Oil and Gas Industry at a Glance

Pre-Salt Development

CO<sub>2</sub> Management

Final Remarks



# Brazilian Oil and Gas Industry at a Glance

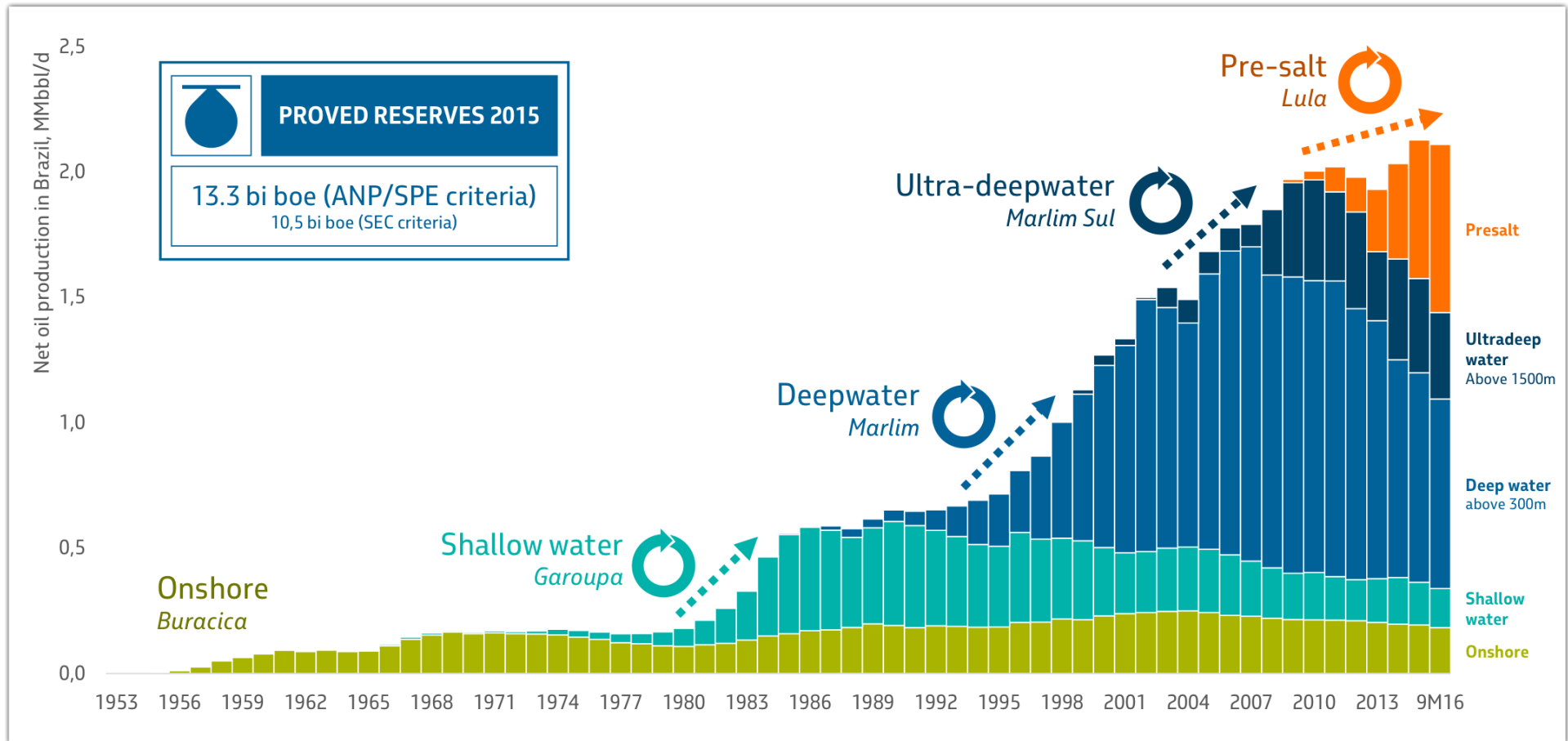
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# Evolution of Brazilian Oil Production



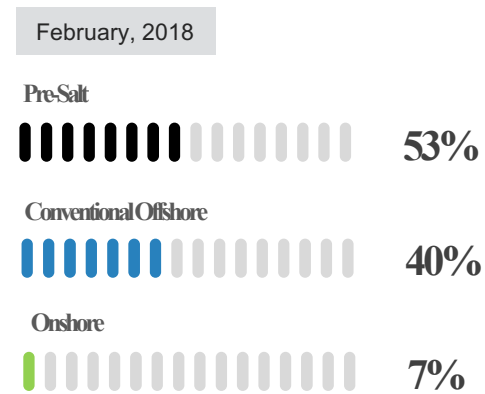




# Evolution of Brazilian Oil Production

**Brazilian Production**  
(February, 2018)

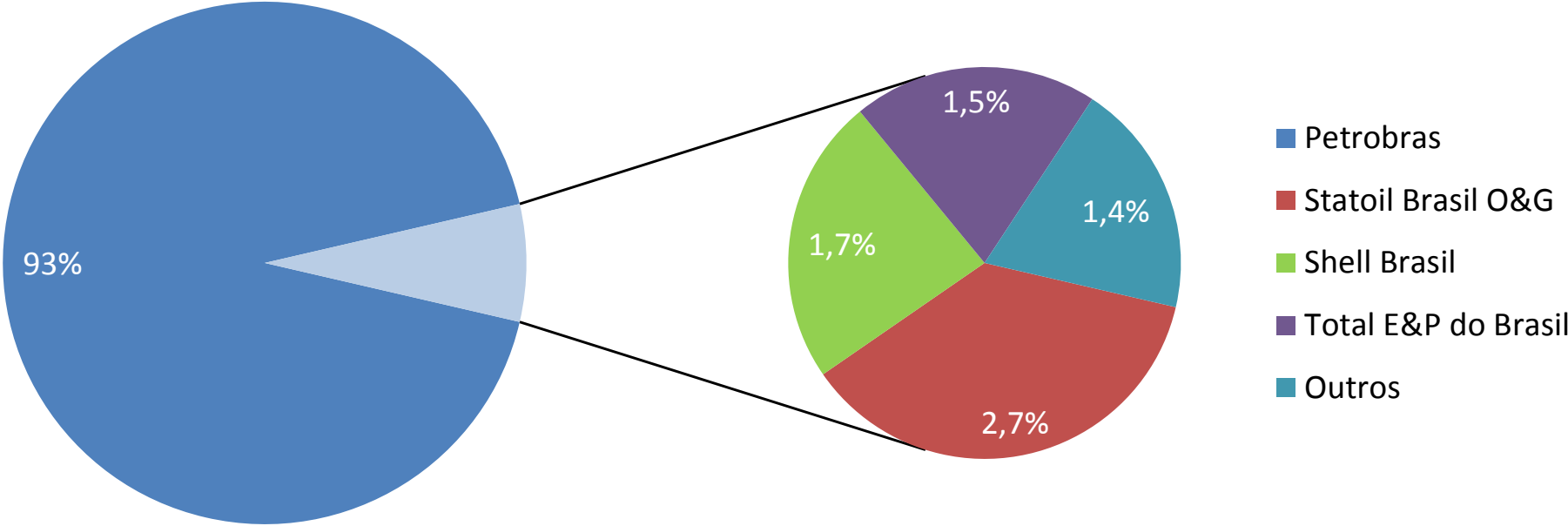
| Oil         | Gas                       |
|-------------|---------------------------|
| <b>2.62</b> | <b>110</b>                |
| Million bpd | Million m <sup>3</sup> /d |



Production is declining in all regions, except for the pre-salt play



# Production Distribution Per Operator (February 2018)



Source: BRAZILIAN NATIONAL AGENCY OF PETROLEUM, NATURAL GAS AND BIOFUELS (ANP), "Boletim de Produção de Óleo e Gás Natural - Fevereiro 2018"  
[http://www.anp.gov.br/images/publicacoes/boletins-anp/Boletim\\_Mensal-Producao\\_Petroleo\\_Gas\\_Natural/Boletim-Producao\\_fevereiro-2018.pdf](http://www.anp.gov.br/images/publicacoes/boletins-anp/Boletim_Mensal-Producao_Petroleo_Gas_Natural/Boletim-Producao_fevereiro-2018.pdf)



Brazilian Oil and Gas Industry at a Glance

**Pre-Salt Development**

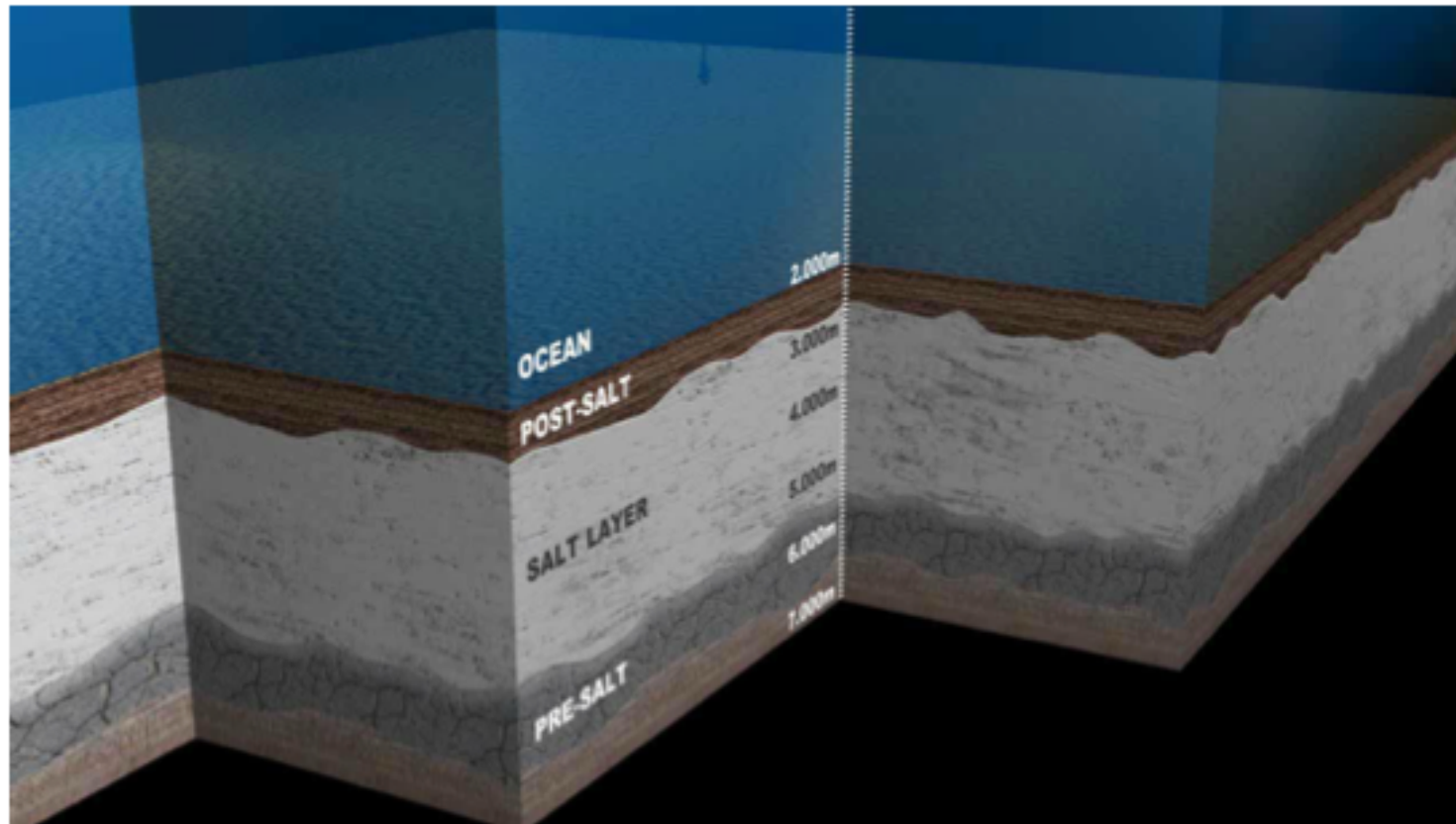
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Final Remarks

# Pre-Salt

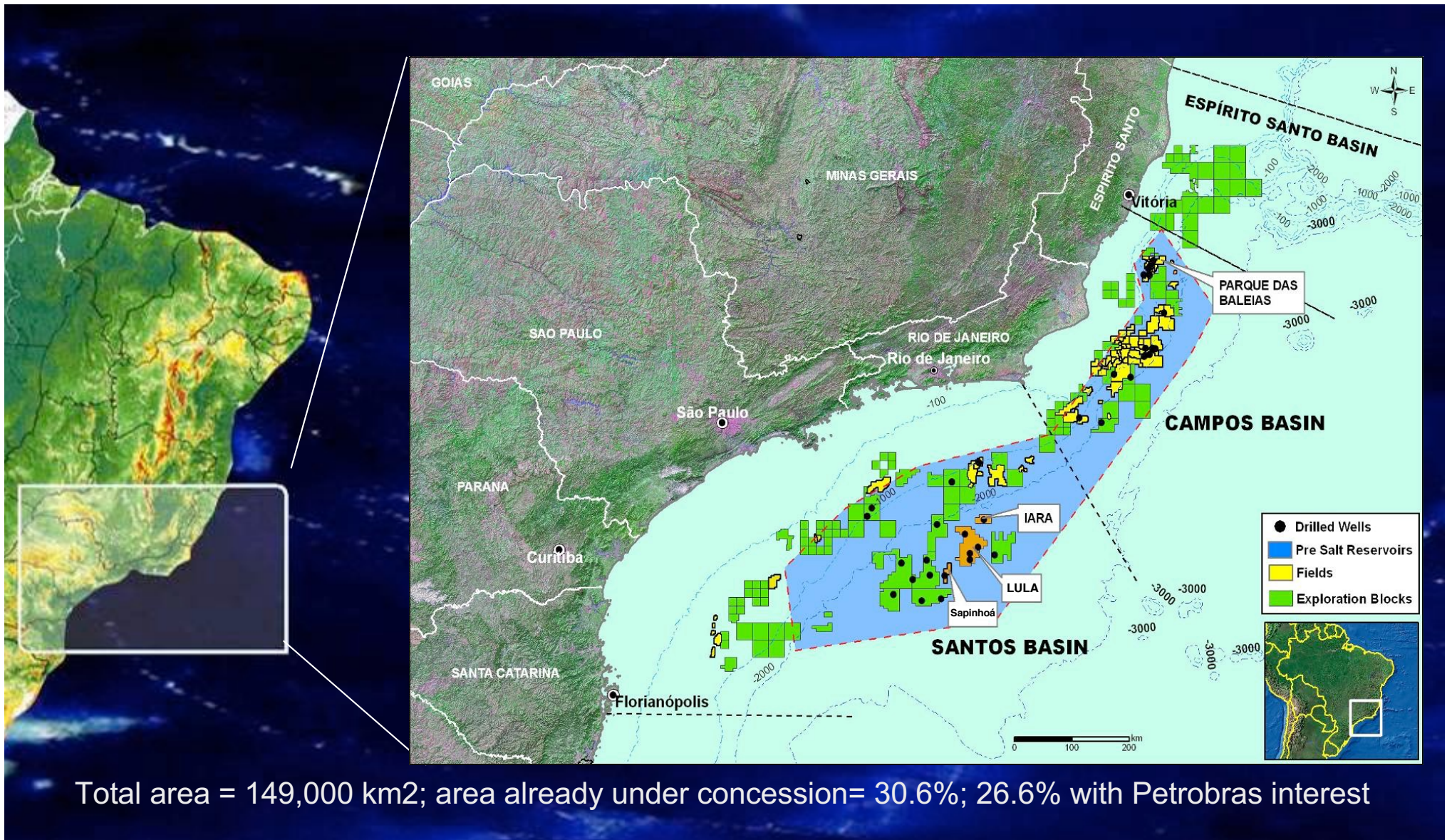


- Huge reservoirs (carbonates) of oil and natural gas (recoverable reserves of 8.3 to 12 billion BOE);
- Between 5,000 and 7,000 m below sea level;
- ~ 300 km off the coast;
- Water depth ~ 2,000 m;
- Salt layer with more than 2,000 m thick, in some areas;
- Light oil (30° API), high GOR (> 200), and variable CO<sub>2</sub> content (between 1 and 20%)



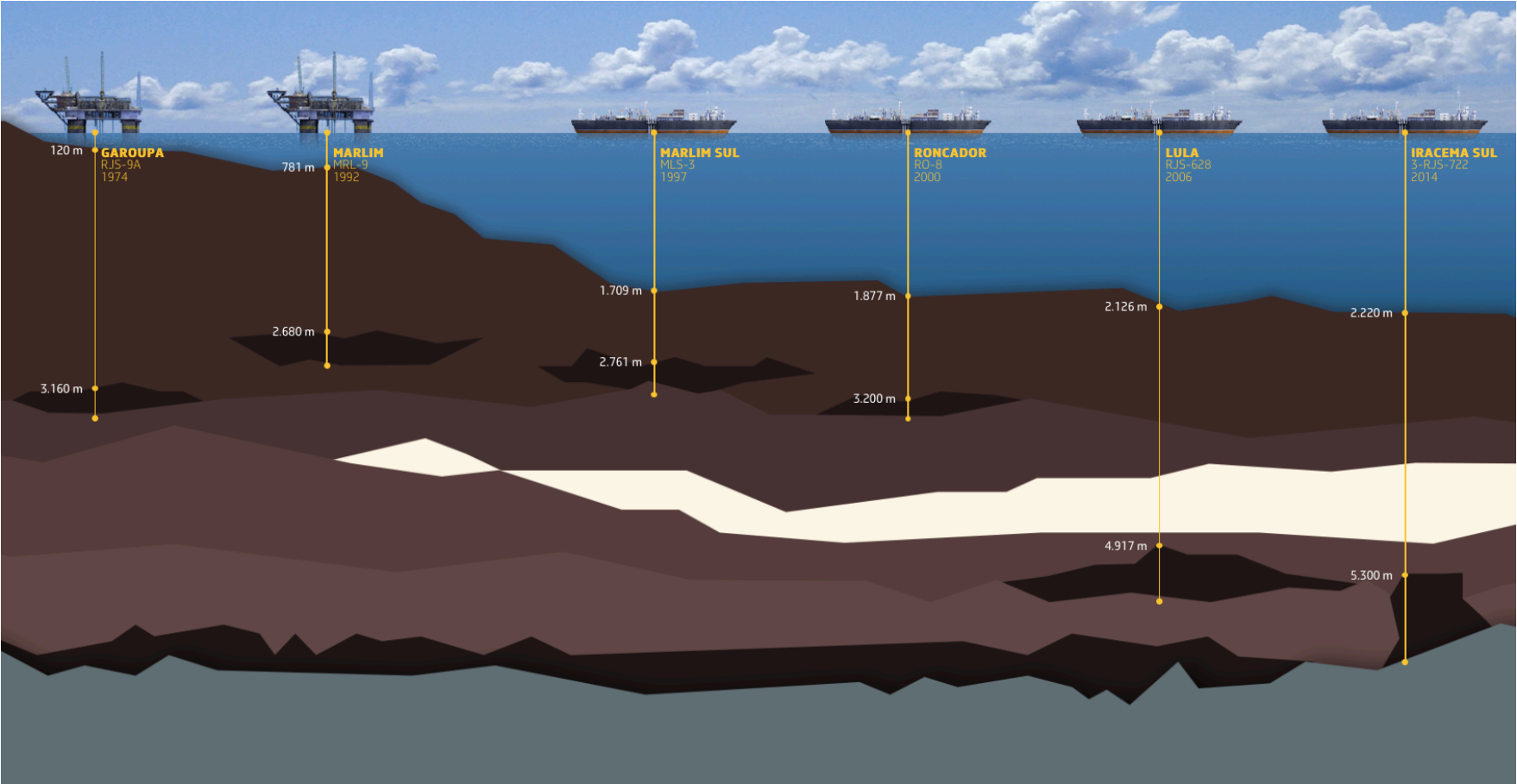


# Pre-Salt Province





# From Pos-Salt to Pre-Salt



Source: PETROBRAS, "Pre-salt" (<http://www.petrobras.com.br/en/our-activities/performance-areas/oil-and-gas-exploration-and-production/pre-salt/>), 2018



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# Handling of CO<sub>2</sub> in the Pre-Salt Hydrocarbon Fluids



## Motivation:

- High (8 to 20%) CO<sub>2</sub> content in the gas phase in some wells;
- Although it doesn't have target obligations to reduce its emissions, Brazil is committed with climate change control;
- Accordingly, Petrobras and partners in the pre-salt blocks do not consider to vent the CO<sub>2</sub> associated to the produced gas.

## Questions raised:

- What is the best way to capture the CO<sub>2</sub> in an offshore ultra-deep water environment (2,100 m WD), 300 km from shore?
- What is the best option for sequestering the captured CO<sub>2</sub>?



# Natural Gas Processing

## CO<sub>2</sub> content in the fluids address challenges:

- Size & Footprint
- Weight
- Efficiency

## Membranes:

- Better for medium or high CO<sub>2</sub> content
- Smaller footprint
- Simple to operate and easy to maintain
- Process a wide range of CO<sub>2</sub> in the inlet stream.



CO<sub>2</sub> unit using the UOP spiral wound membrane.



Cameron CYNARA® CO<sub>2</sub> Separation System

# *Floating Production Storage and Offloading Unit (FPSO) in operation*

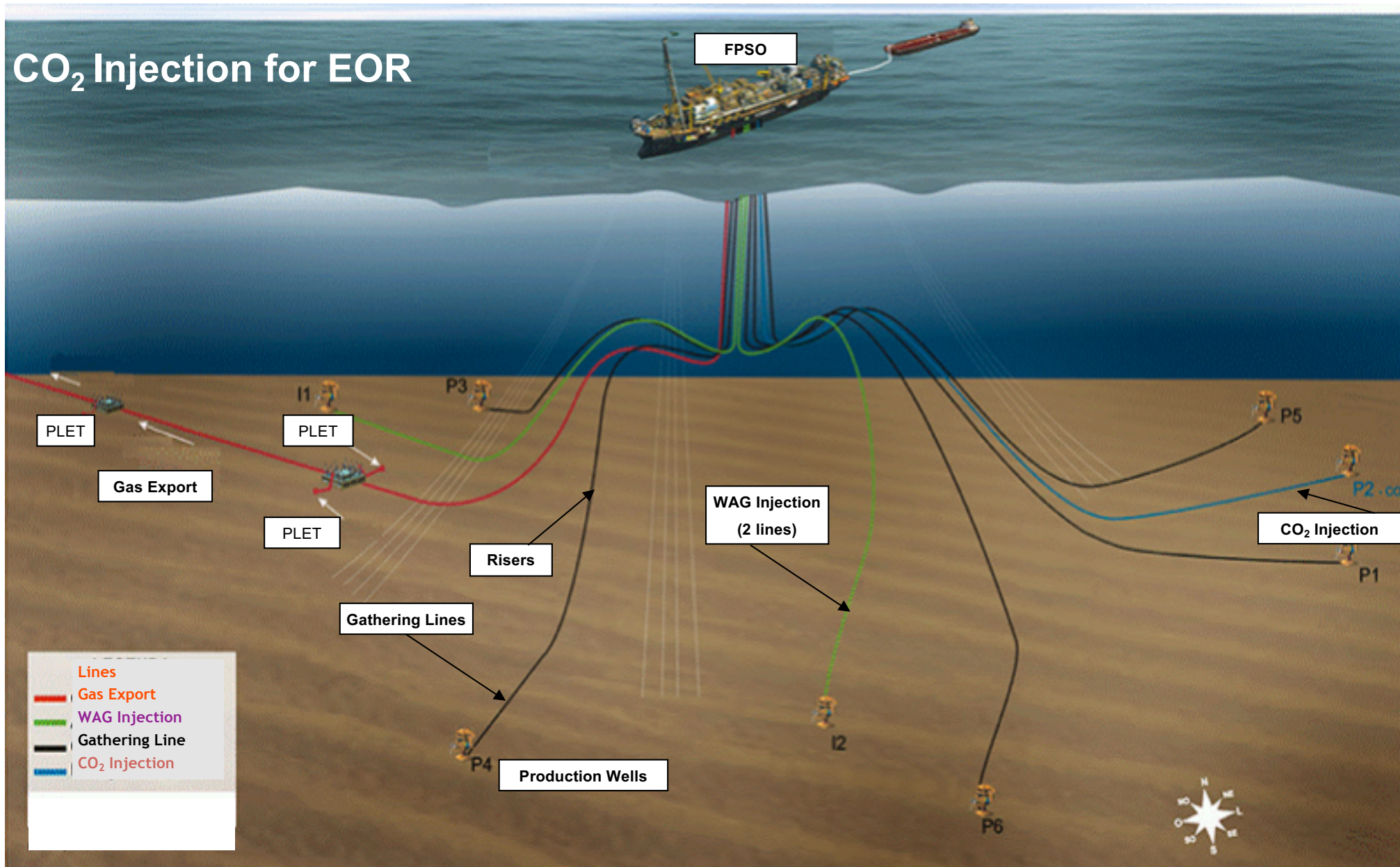


(credit: Petrobras)

- ✓ **Cidade de Angra dos Reis and Cidade de São Paulo** (UOP – spiral wound)
- ✓ **Cidade de Ilhabela, Cidade de Paraty, Cidade de Maricá, Cidade de Saquarema, and P-66** (Cameron - hollow fiber)



# WAG-CO<sub>2</sub> EOR



Source: SEABRA & GRAVA "Petrobras' Offshore CO<sub>2</sub> Management – Pre-salt development management", presented at 2014 COP 20 Side Event - Lima, Peru ([http://www.ieaghg.org/docs/presentations/COP\\_20\\_-\\_Side\\_Event\\_Petrobras\\_Public.pdf](http://www.ieaghg.org/docs/presentations/COP_20_-_Side_Event_Petrobras_Public.pdf))



# Pre-Salt Production Ramp-up





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## *Final Remarks*

- 7 production system (FPSOs) at Santos Basin;
- Natural gas pre-treatment and the CO<sub>2</sub> separation using membranes are running with success;
- Around 7 million tonnes of CO<sub>2</sub> injected (December 2017);
- Technology is the key factor to address the changing energy environment.





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Thanks to CSLF for the travel funding



# Thank you!