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CONJUGATE
MARGINS

Conjugate Margin Insights: Petroleum Systems and Deep-Water Turbidite Reservoir Potential in the Uruguayan Margin

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ENERGY TRANSITION MANAGEMENT – ANCAP

URUGUAY

Content

I. Introduction:
- Common origin
- Conjugate margins

II. Exploratory model
- 70s – 2000s
- 2012 - Present

III. Analogies and differences between Orange and Uruguay offshore
- Offshore Uruguay prospectivity
- Analogies with the conjugate margin
- Tectonic evolution: implications on the offshore reservoir quality

IV. Discussion

V. Final Message

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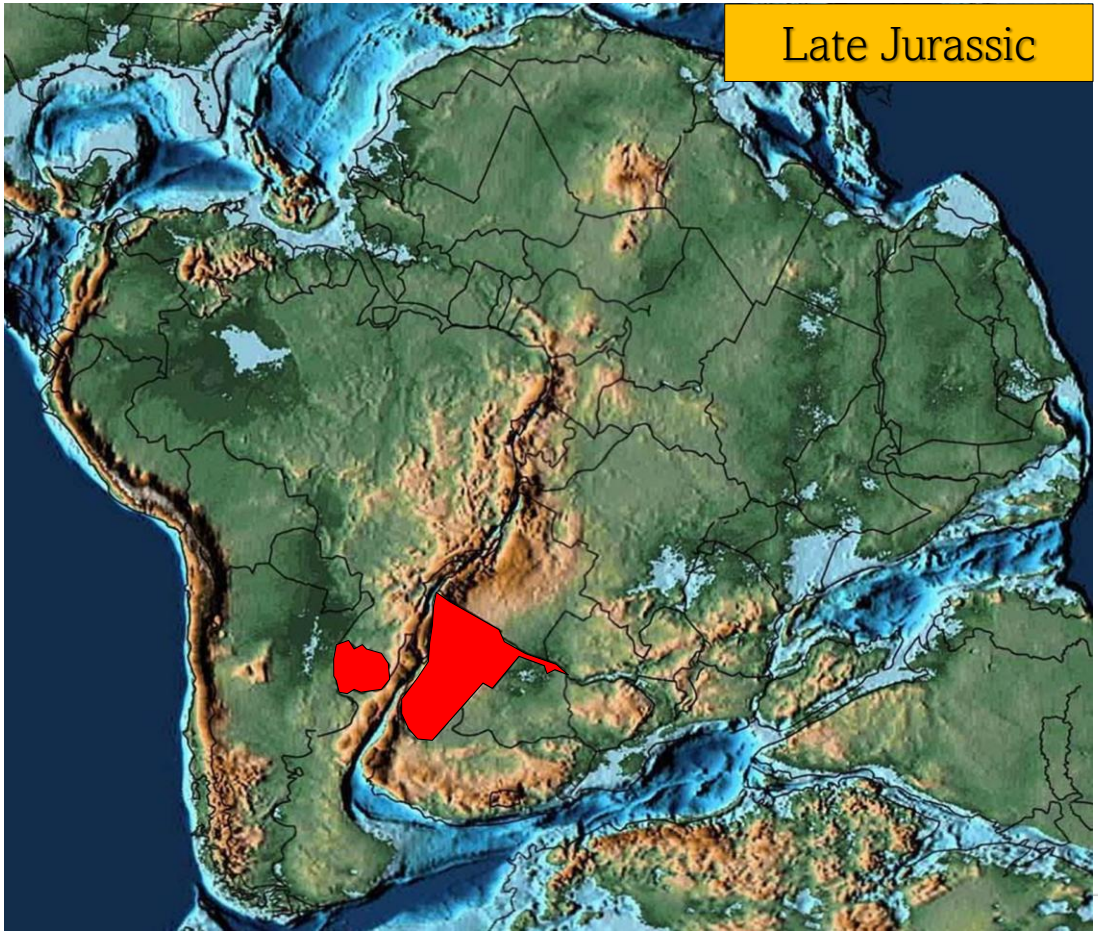
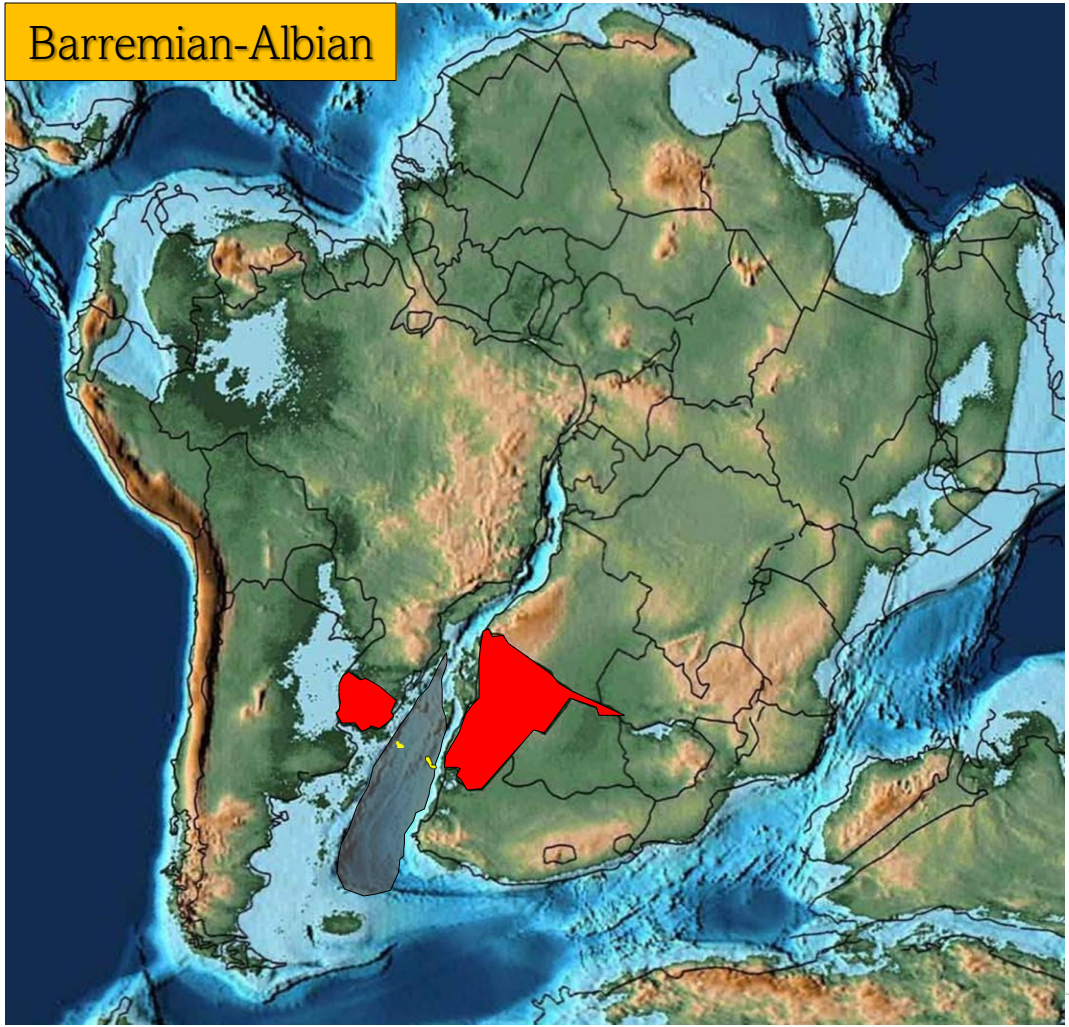
Common Origin



- Late Jurassic paleogeographic reconstruction of Gondwana (~150 Ma)
- During this period, Uruguay and Namibia were together.

Source: Scotese (2014)

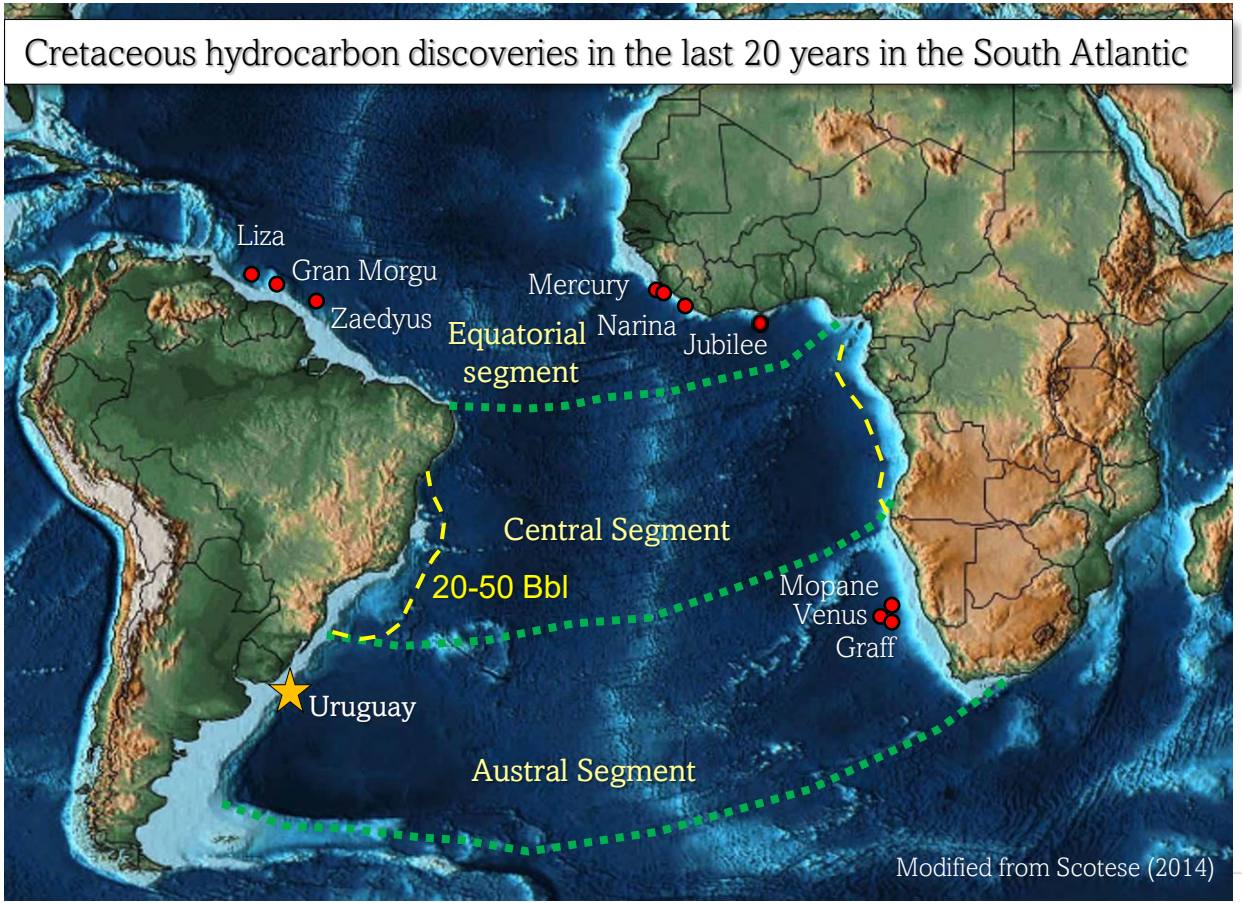


Regional deposition of the world-class source rock

- Early Cretaceous paleogeographic reconstruction (130-110 Ma)
- Marine transgression, proto–Atlantic Ocean
- Deposition of the Aptian Source Rock, 120 Ma approximately: Responsible for the Namibia accumulations.
- Deposition of the Venus reservoir in Namibia (~ 110 Ma)

Modified from Scotese (2014)

Conjugate margins relevance in the hydrocarbon exploration



Pre-sal (Brazil): 2006 → Pre-sal (Angola): 2011

Jubilee (Ghana): 2007 → Liza (Guyana): 2015

Venus (Namibia): 2022 → Uruguay: ????

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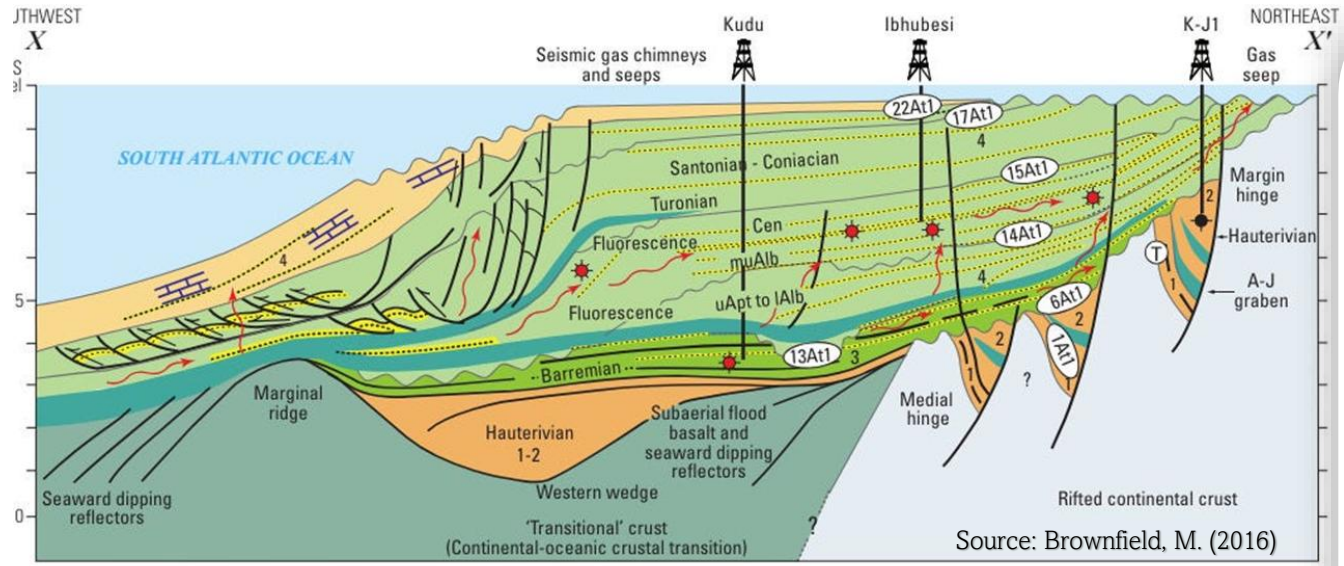
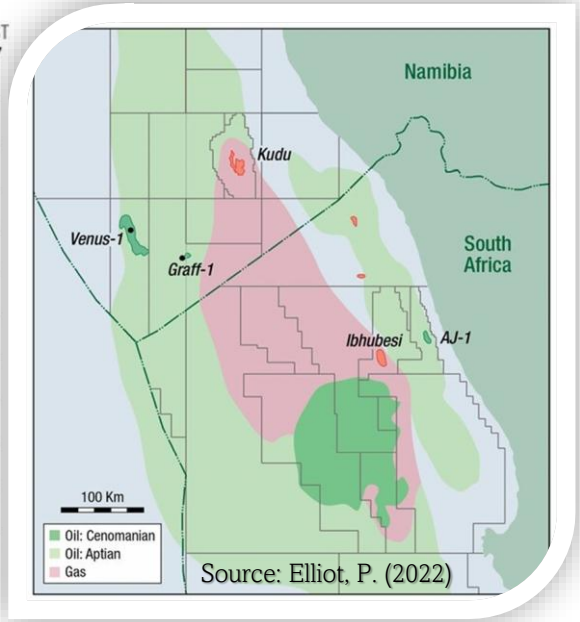
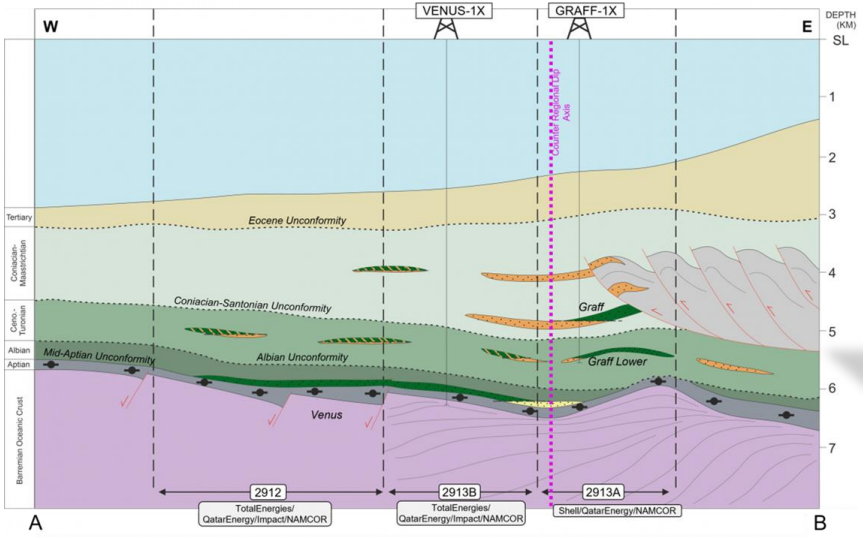
Orange Basin exploratory model during 70's – 2000s



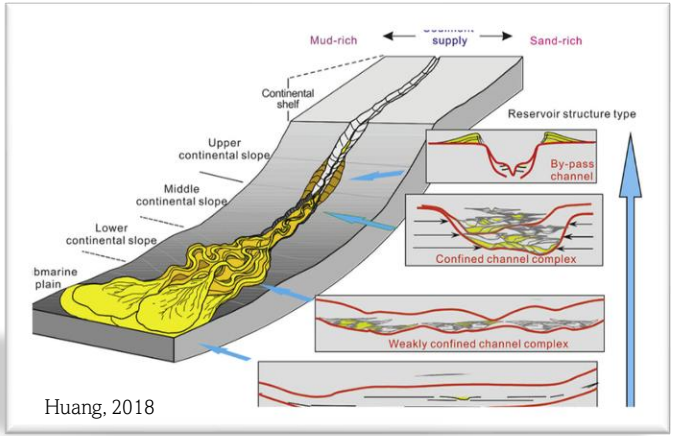


- Exploration focused on shallow waters, where the basin has more sediment thickness
- 2 sub-commercial gas discoveries: Kudu (1974), Ibhubesi (1981).
- 1 sub-commercial oil discovery associated with the synrift: AJ1 (1988).
- The basin was considered gas-prone.
- Main objective: Aeolian sandstones overlying the SDRs, K Sandstones with structural imprint of the half-grabens
- Source rock: Kudu shales and lacustrine deposits of the Synrift (Hauterivian)

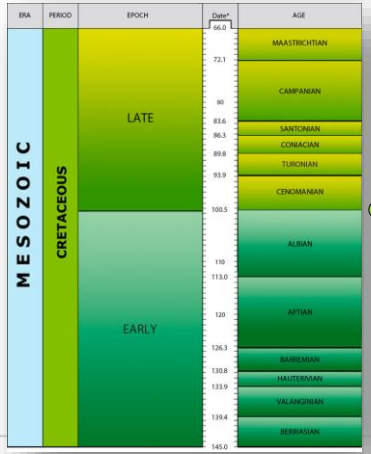
Present exploratory model in the Orange Basin (2012-Present)



https://impactoilandgas.com/assets/namibia-2912-2913b/



Huang, 2018



- Deep water exploration targets in the region with less burial (1200 - 3000 m).
- At least 10 discoveries of light oil and associated gas in Cretaceous turbidites and channel systems (stratigraphic and mixed traps).
- Early and Late Cretaceous plays layering the source rock /
- Source rock: Kudu Shale (Aptian)

Santonian reservoirs — **Graff**
Coniacian reservoirs — **Millenium S, Marlin**
Cen/Turo reservoirs — **Mopane**

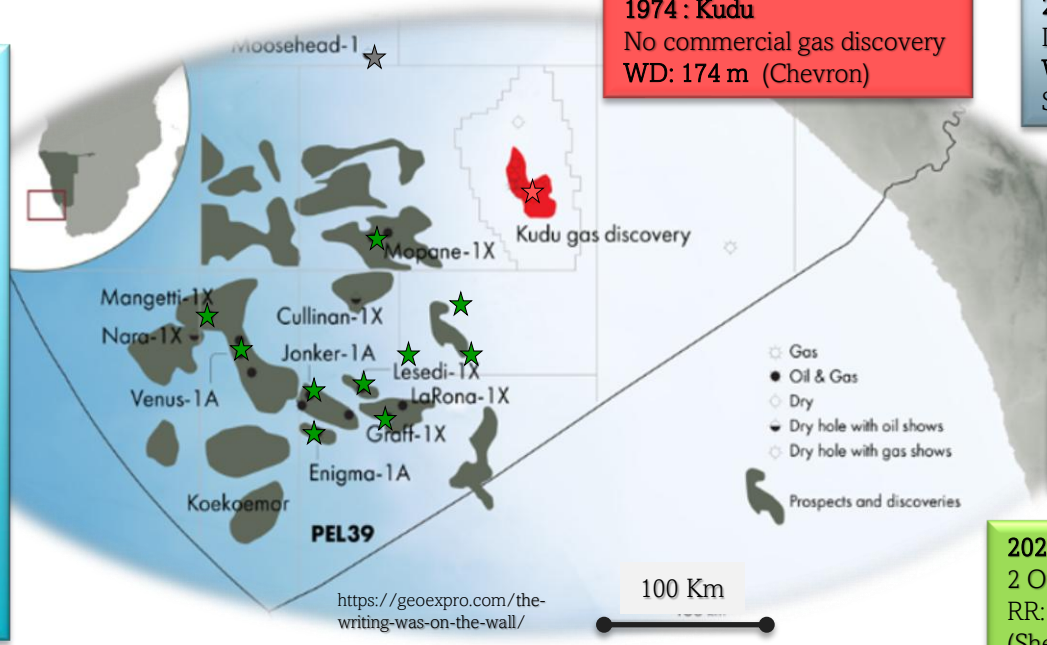
Albian-Cenomanian (Turonian) SR type II/III

Albian reservoirs — **Venus, Jonker, Enigma, Mopane**

Upper Kudu (Thickest, > COT)
Lower Kudu
Kudu Shale

Orange exploratory hits

- 1974-2000: 12 wells were drilled offshore Namibia
- 8 wells into the Kudu field
- 4 wells in shallow water of the Walvis, Lüderitz, and Orange basins were declared dry, but proven turbidite systems from the Lower and Upper K, and no SR was recovered.
- It's established a *paradigm* in which the offshore basin was gas-prone and **has no oil potential**.



1974 : Kudu
No commercial gas discovery
WD: 174 m (Chevron)

2013: Moosehead
Dry well; oil shows
WD: 1727 m (HRT)
SR: 120 m; Barr-Ap; immature

2022 (January) Graff
Oil Discovery ~ 2,7 Bboe (STOIIP)
WD: 2000 m (Shell)
RR: Turbidite (Upper K)

2022 (February) Venus
Oil Discovery ~ 5,1 Bboe
WD: 3000 m (TOTAL)

2023 (Mar-July) Jonker & Lesedi
2 Oil discoveries
RR: turbidites - Lower & Upper K (Shell)

2026: Merlin
Oil discovery
Shell
RR: Turbidite Upper K

2025 (Feb-April) Sagittarius y Capricornus
2 oil discoveries
WD: 1200 m (Rhino – ENI)
RR: turbidite (Aptian – Albian)

2024: (April) Enigma
Oil discovery
Shell
RR: Turbidite Upper K

2024: (February) Mangetti
Oil discovery ~ Boe
WD: 3000 m (TOTAL)
RR: Turbidite - Upper K

2024: (January) Mopane
Oil discovery ~ 10 B boe (STOIIP)
WD: 1200 (GALP)
RR: Turbidite (Upper K)

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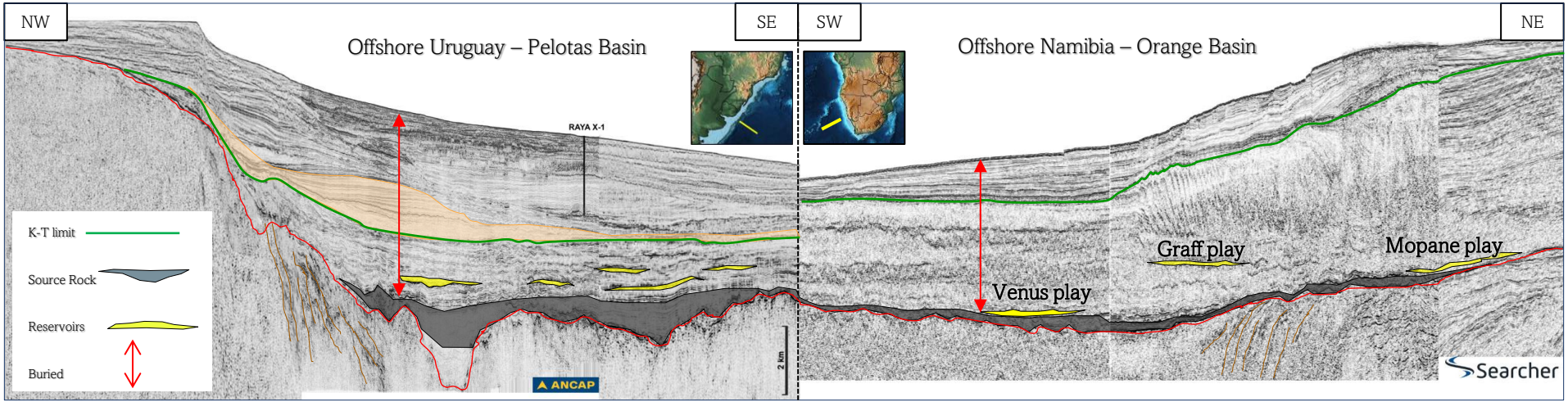
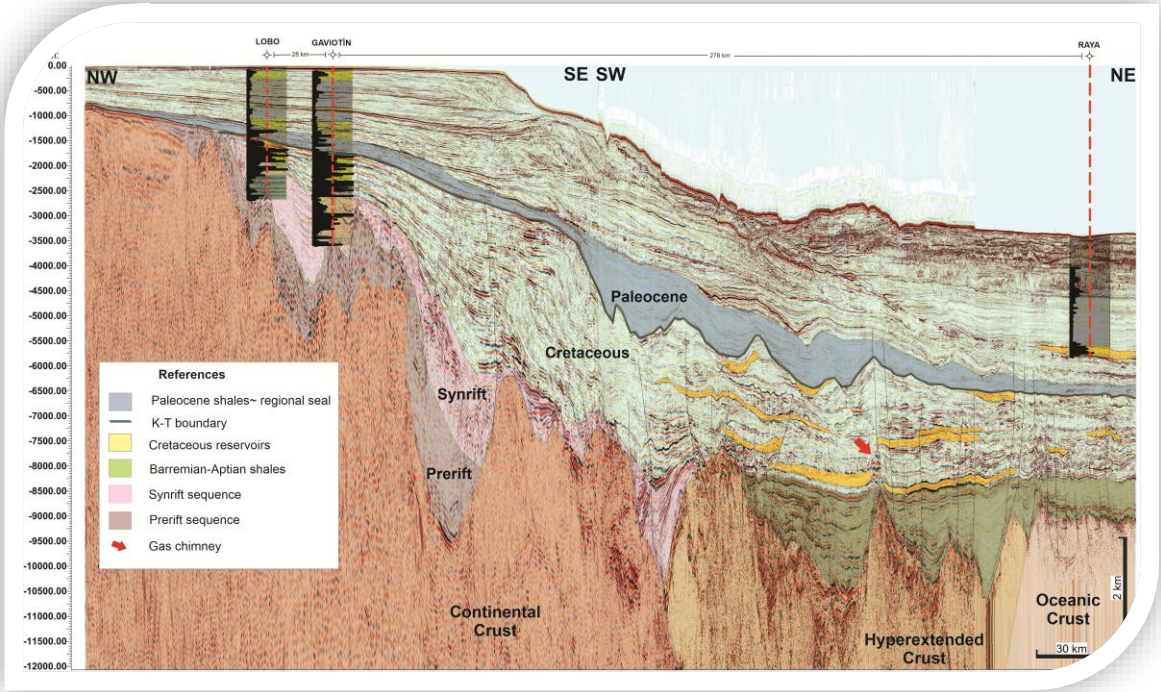
Analogies and differences between Orange and offshore Uruguay



Modified from Rodriguez et al. (2022)

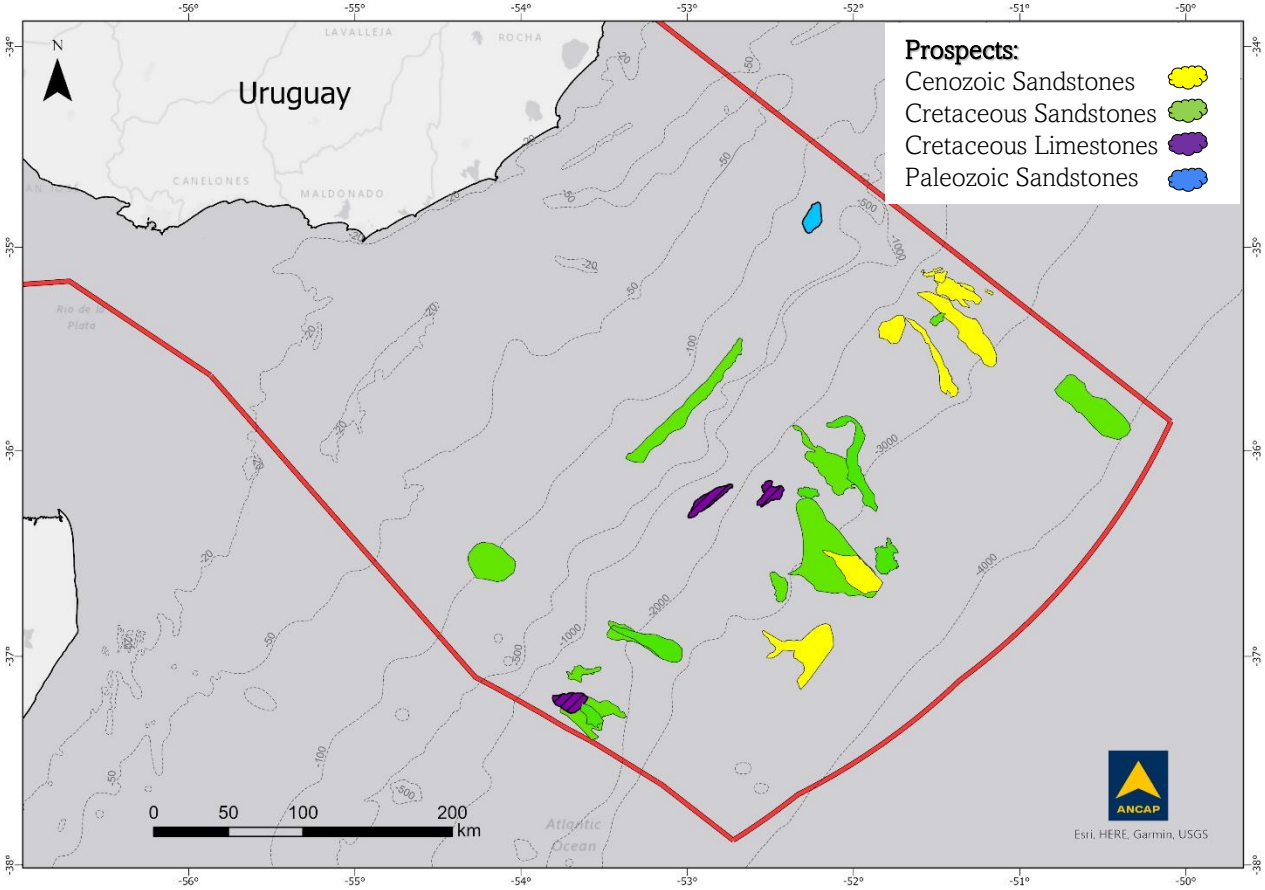
- Thicker potential Barremian – Aptian source rock in Uruguay
- In general, the Uruguayan basins are more buried than the Orange
- Uruguay has many Cretaceous reservoirs identified, very similar to Venus, Graff, Mopane, etc.
- Regional Paleocene seal is demonstrated in Uruguay

Uruguay offshore prospectivity

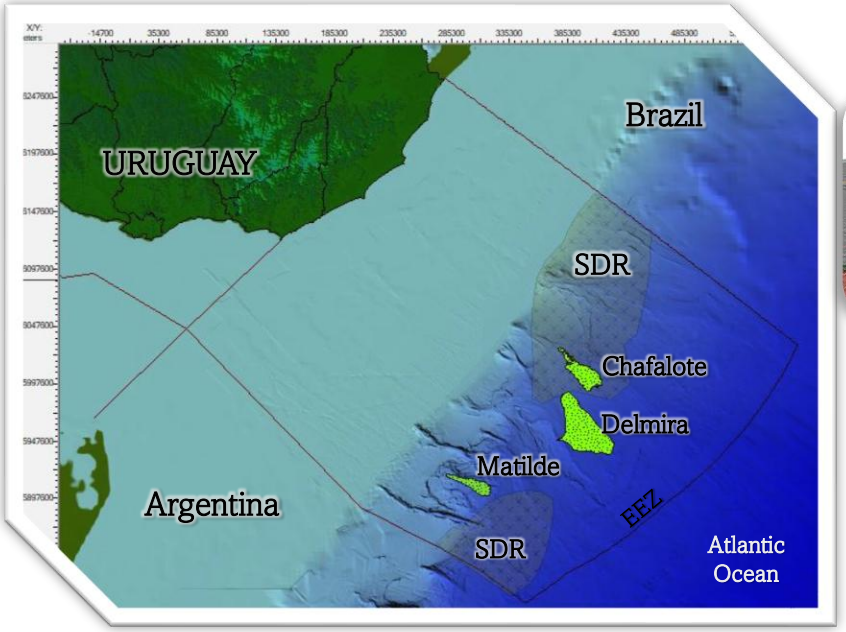


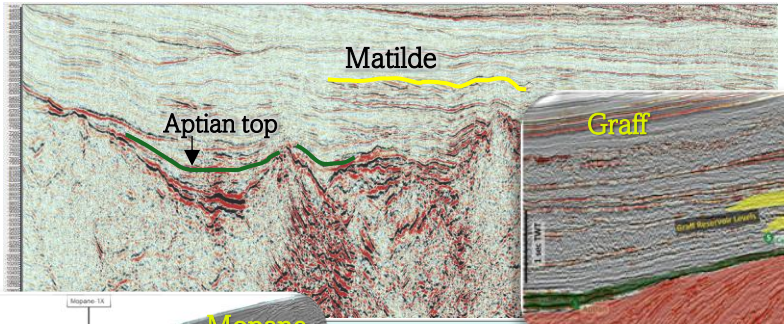
- While in the Orange Basin, 40 exploratory wells were drilled; only 3 wells were drilled offshore Uruguay: Lobo & Gaviotín in 1976 (Punta del Este) and Raya in 2016 (Pelotas)
- None of those wells reached the Cretaceous sequence in the deep waters (same sector as Namibia´s discoveries)

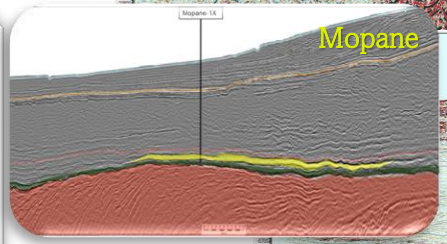
Offshore Uruguay Prospects

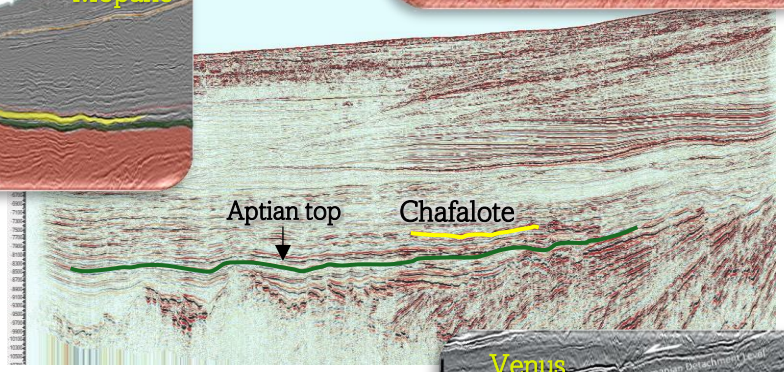


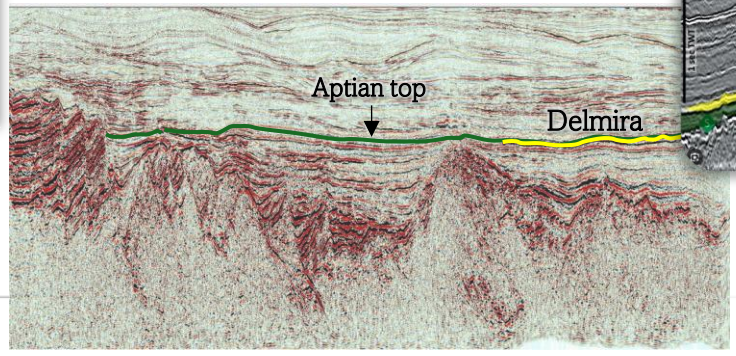
Analogous Cretaceous prospects

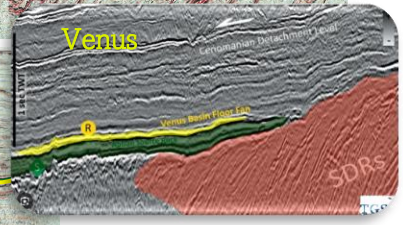




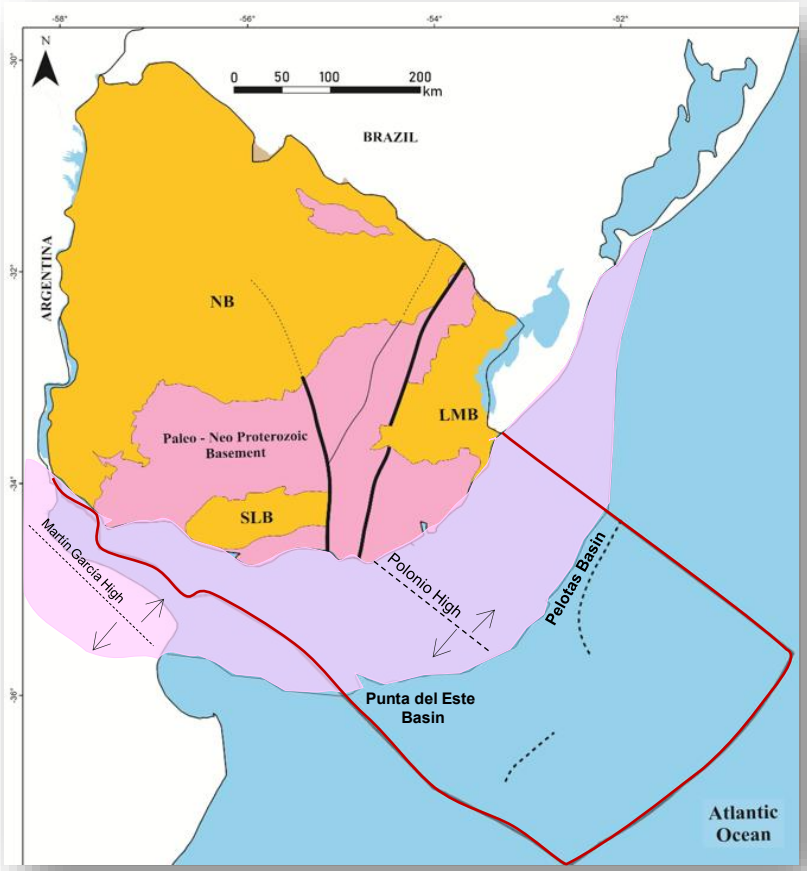








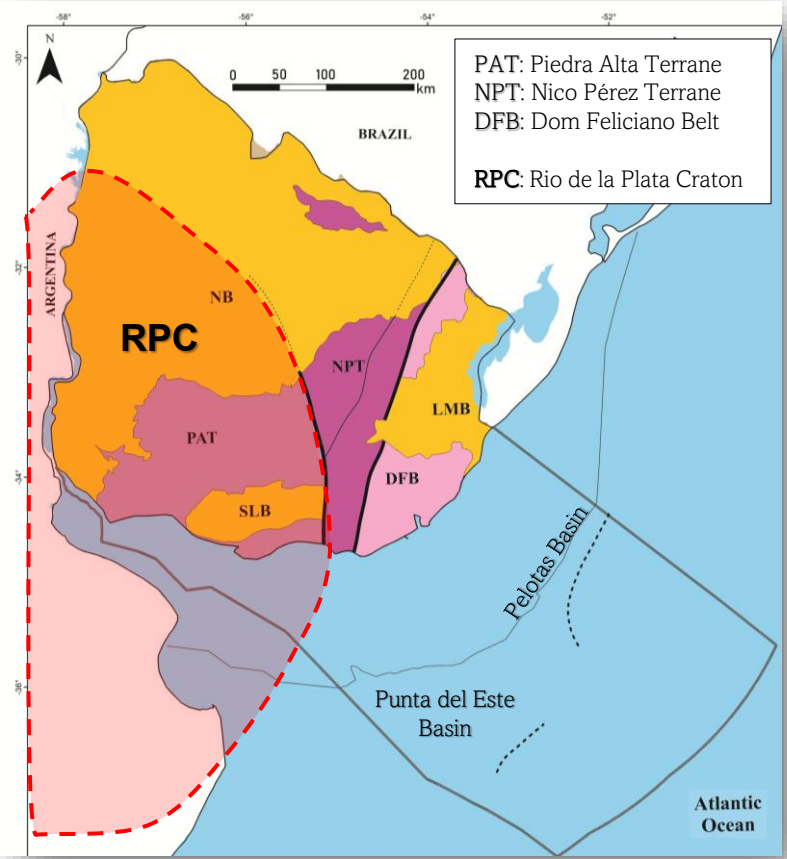
Basement tectonic evolution: Implications on the offshore reservoir quality



- Paleo to Neo-Proterozoic basement
- 3 onshore sedimentary basins:
  - Norte Basin (Paleozoic to Cenozoic)
  - Santa Lucia and Merín basins (Cretaceous to Cenozoic)
- 2 offshore sedimentary basins:
  - Punta Del Este
  - Pelotas Basin

  } Mesozoic basins linked to Gondwana breakup

Basement tectonic evolution: Implications on the offshore reservoir quality



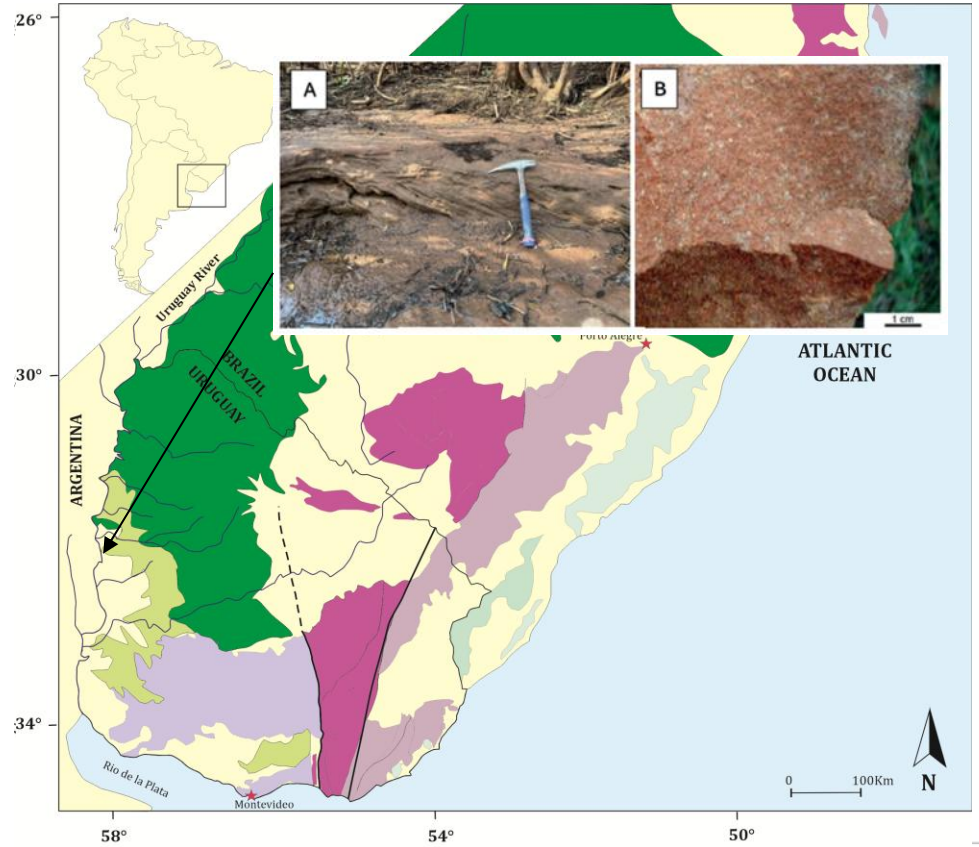
The Paleo to Neo-Proterozoic basement is composed by: (Sánchez *et al.*, 2009; Hueck *et al.*, 2017; Oyhantçabal *et al.*, 2018).

- Rio de la Plata Craton (PAT + Tandilia Terrane): Paleoproterozoic block dominated by gneisses, granites, and high-grade metamorphic rocks.

- Dom Feliciano Belt (DFB): resulted from a Paleo to Neoproterozoic orogenic event and is composed of gneisses, migmatites, syn- and post-tectonic granites, metavolcanic and metasedimentary sequences, as well as mafic and ultramafic rocks

Paraná – Etendeka ~ LIP: Implications on the offshore reservoir quality

Paraná Etendeka distribution in Uruguay and South Brazil:

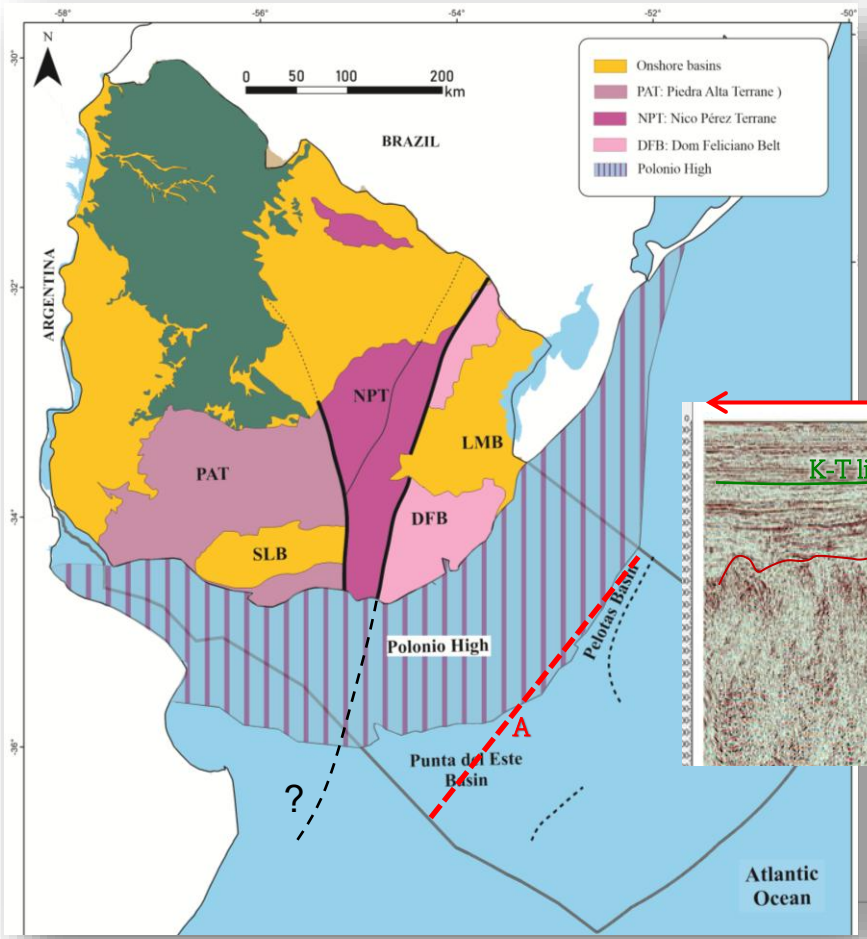


1. Actual distribution of the basalt flows of Paraná outcrops.

2. Geological evidence suggests that the basaltic flows did not reach the coast during the opening of the Atlantic, as the Río de la Plata Craton constituted an elevated terrain during the Cretaceous (Hueck *et al.,* 2018).

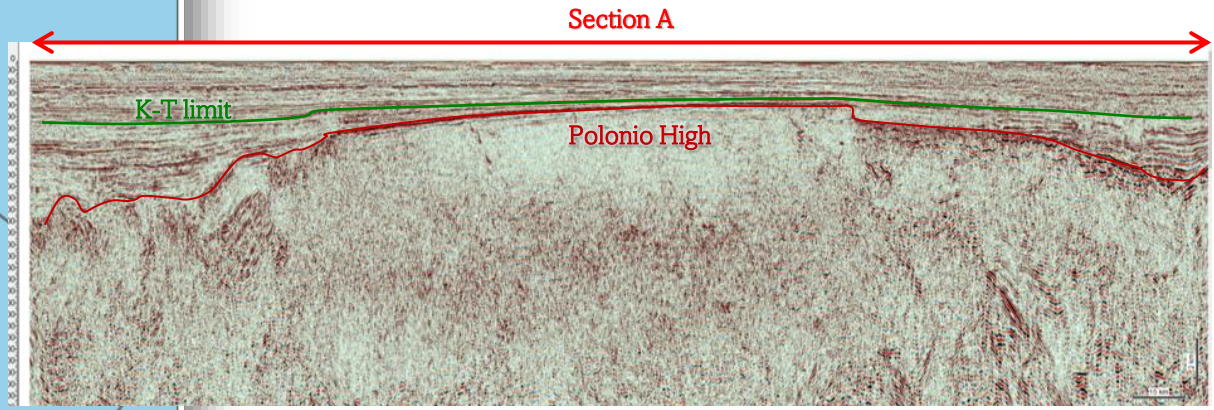
3. Otherwise, the lack of basaltic clasts in the units overlying the basalts suggests that magmatic domains constituted topographic lows at the time of deposition.

Polonio High: Implications on the offshore reservoir quality



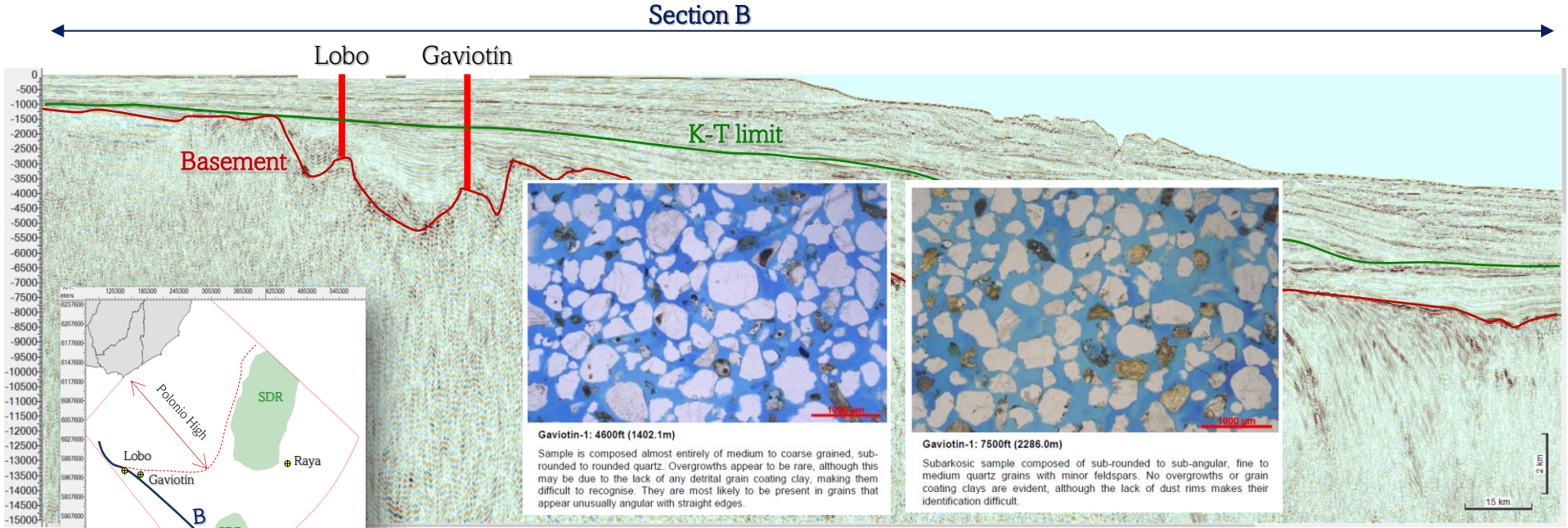
Meanwhile,

- offshore seismic data show that the Polonio High (composed of the DFB) operated as a structural high during the Cretaceous,
- PH being overlain almost by the first Cenozoic transgression in the Paleocene



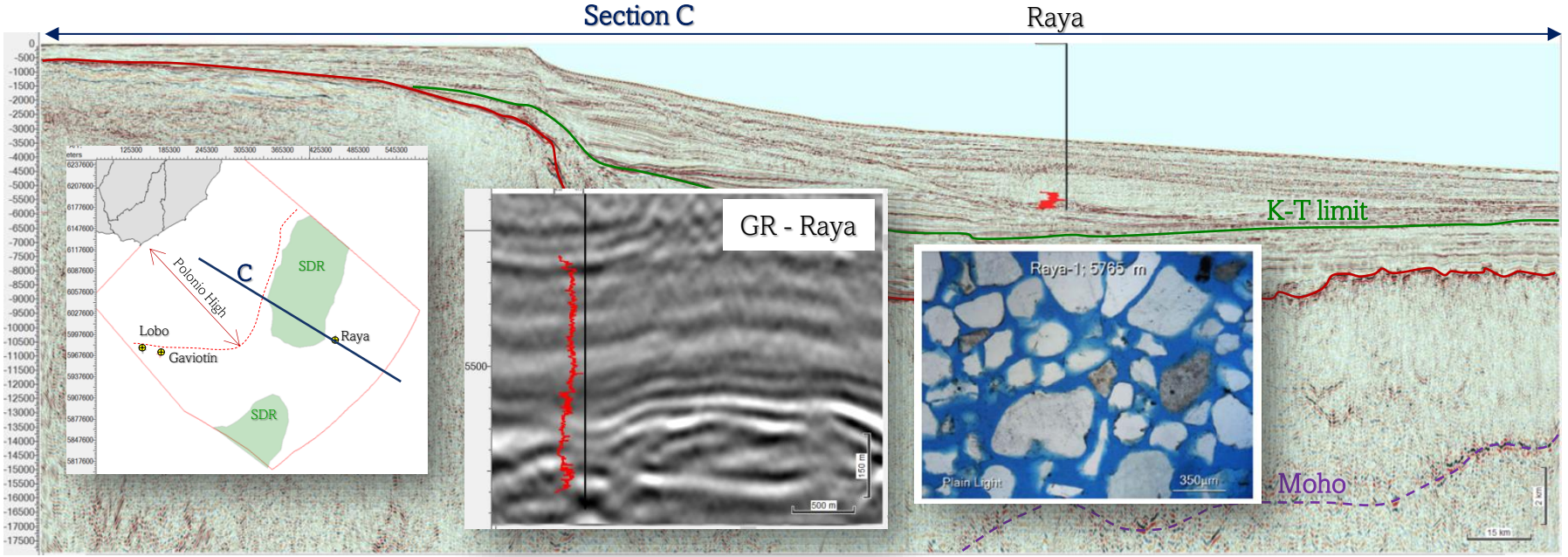
Offshore seismic and well data: Implications on the offshore reservoir quality

- Samples from the 2 wells drilled in the Punta del Este Basin (Lobo and Gaviotín), located in shallow waters at 40- 50 m depth, indicate Cretaceous sandstones that are predominantly quartz–feldspar, suggesting a provenance likely linked to felsic rocks with porosity values between 18 and 25%.



Offshore seismic and well data: Implications on the offshore reservoir quality

- In addition, the Tertiary reservoir penetrated by the Raya well, located in the deep-water (≈3400 m) sector of the Uruguayan Pelotas Basin, consists of fine quartz-rich sandstones, whereas the overlying Miocene shales contain less than 12% chlorite.



- No wells have yet been drilled in the deep-water sector of the Uruguayan or southernmost Brazilian offshore that penetrate the Cretaceous post-rift succession, and therefore, no direct data on reservoir quality is available.

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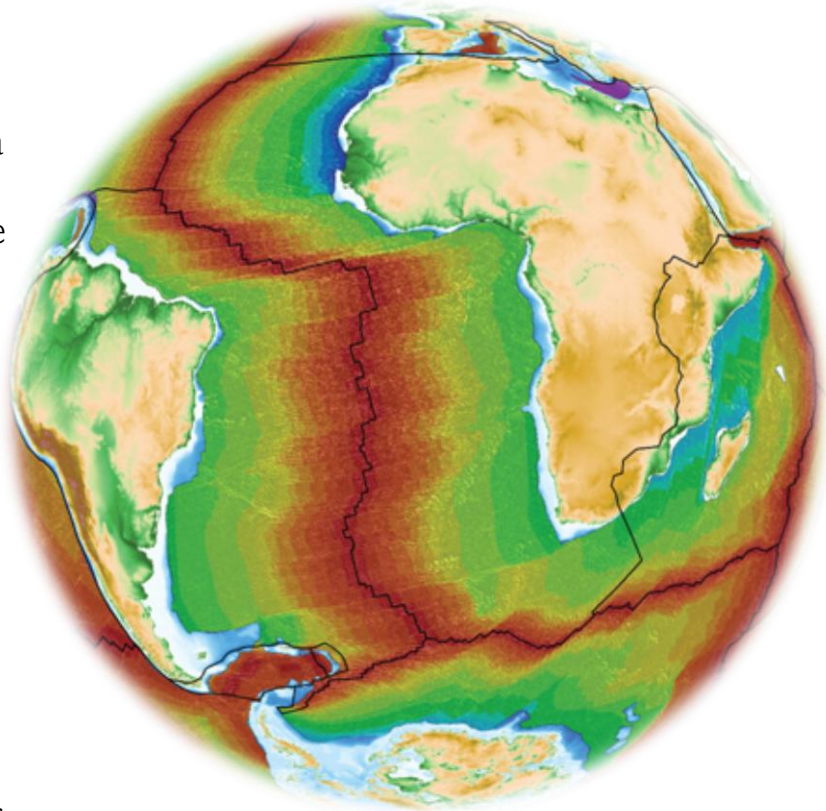
Discussion

- Seismic interpretation and stratigraphic correlation indicate a high probability of an Aptian source rock offshore Uruguay, although the maturation could be different than the conjugate margin.
- Reservoir lithology variation is expected to be linked to the hinterland geology, catchment areas, and the tectonic evolution of the South American plate.
- The Cretaceous reservoirs in offshore Uruguay are expected to be quartz- and feldspar-rich (mature), although the quality could be affected by the major burial.
- Lately, stratigraphic and mixed traps are recognized in the offshore Uruguay basins with analogous characteristics to Orange ones, with potential to be charged with hydrocarbons.



Webster et al. (2013)

Final message

The Orange basin exploration models, as well as the analogues, indicate that the most prospective sequence in offshore Uruguay is the Cretaceous

Cretaceous Sequence (Uruguay offshore):

- Stratigraphic and mixed traps (turbidites and channel systems)
- Sediment deposits overlying the SDR or Oceanic Crust in ultradeep waters
- Aptian source rock (SR) with reservoir rocks identified in contact with or overlying the SR in the sequence
- Many prospects identified with these characteristics
- Sediments like those encountered in the Lobo and Gaviotín wells (of felsic origin) are expected, but with greater textural and mineralogical maturity.
- An exploratory well will be drilled in 2027 testing this objective /target

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https://twittercom/CGGcompany/status/1498916051916144641/photo/1

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Thank you very much for your attention

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