Probability of Geological Success (PoS) for Offshore Uruguay Plays and Prospects.

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ANCAP

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Summary

In this work, we estimate the probability of geological success (PoS) for 29 prospects offshore Uruguay, in different play types, using systematic risk tables that consider six geological risk factors:

- Structure
- Reservoir presence
- Reservoir deliverability
- Seal
- Source presence and maturity
- Migration and timing

This approach allows for less biased and more consistent estimations, aiming to enhance the evaluation of the inherent risk associated with the prospects offshore Uruguay.

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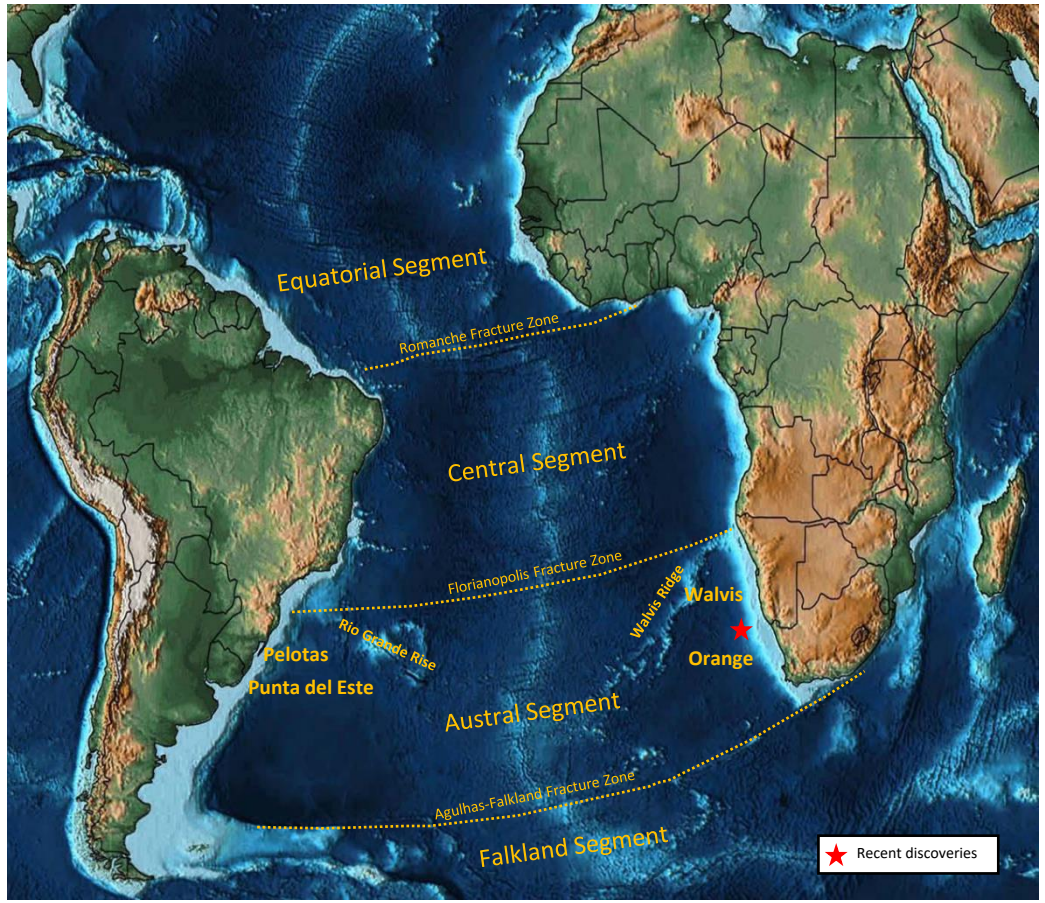
Introduction

- Until recently, exploratory success in the Atlantic passive margin basins south of the Rio Grande Rise and Walvis Ridge had been elusive.

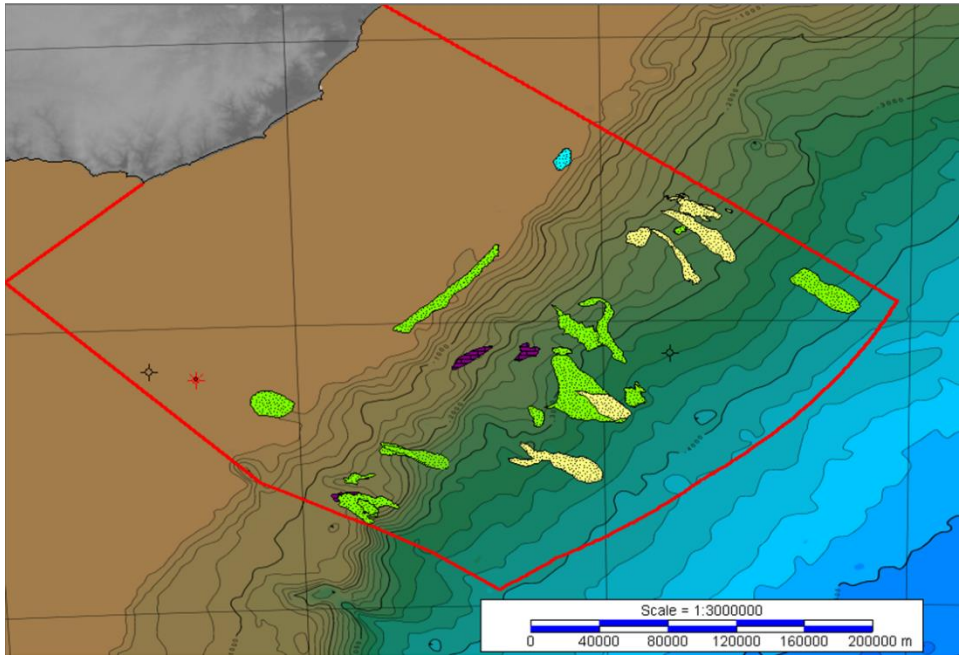
- Several wells have demonstrated the presence of a world-class Aptian source rock. However, the high geological risk in this region persists due to various factors, the most important being the lack of commercial discoveries that could verify the effectiveness of certain play types.

- The recent discoveries in Orange Basin (Venus, Graff, etc.) have unveiled a new offshore oil province in Namibia, prompting a reassessment of the hydrocarbon potential to the south of Walvis Ridge. This renewed interest in exploration is also evident on the other side of the Atlantic, particularly in the Uruguayan offshore basins, which represent the conjugate margin of Orange Basin.



Modifed from Scotese, (2014) with data from Chauvet et al., (2021)

Introduction



- As the regulator of upstream activities, the National Oil Company of Uruguay, ANCAP, is committed to managing oil and gas resources, including volumetric assessments. In this regard, the inventory of prospects is regularly updated with new geological and geophysical data from offshore Uruguay and analogous basins, and the input from operators and research projects.

- Each year a few prospects are selected from the inventory for volumetric assessment using a standardized methodology. Up until 2022, a set of 29 prospects were evaluated resulting in an unrisked estimate of 27,735.1 million barrels of oil equivalent (Pmean).

- However, an estimation of the probability of geological success (PoS) has never been published before for the offshore of Uruguay.

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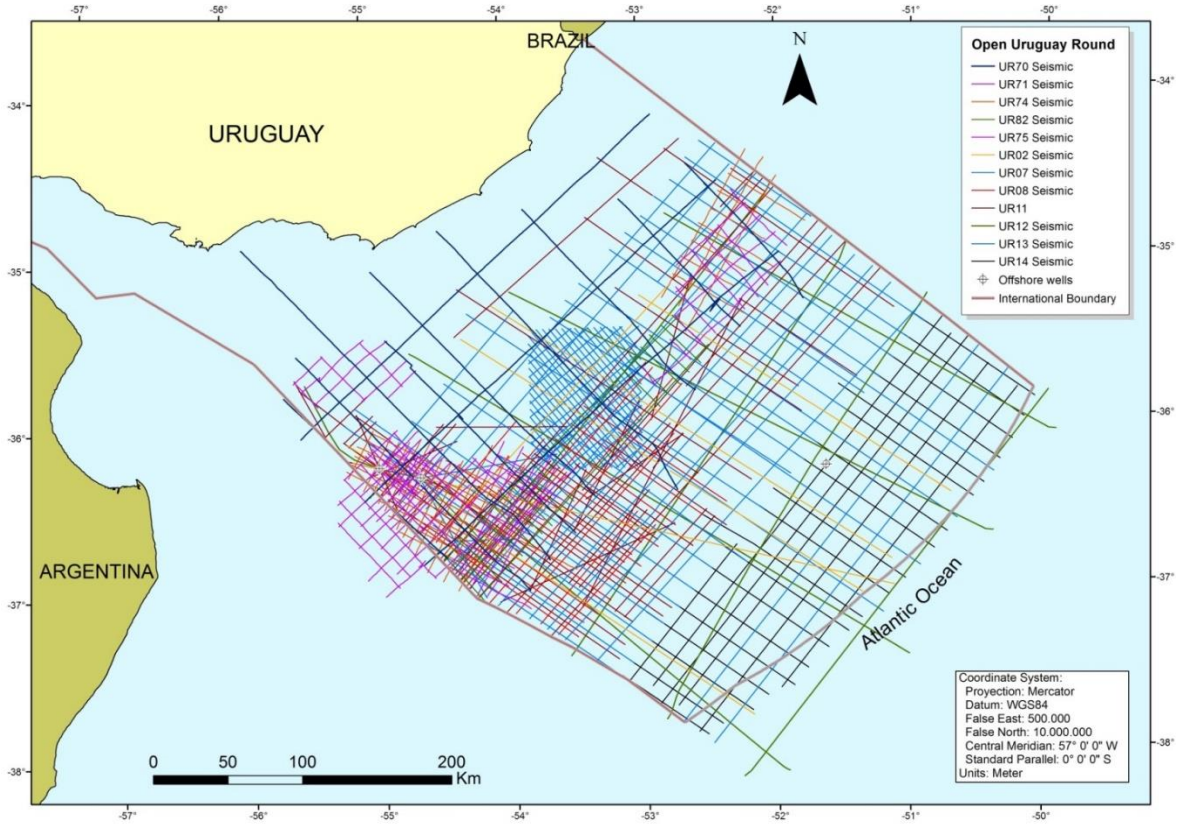
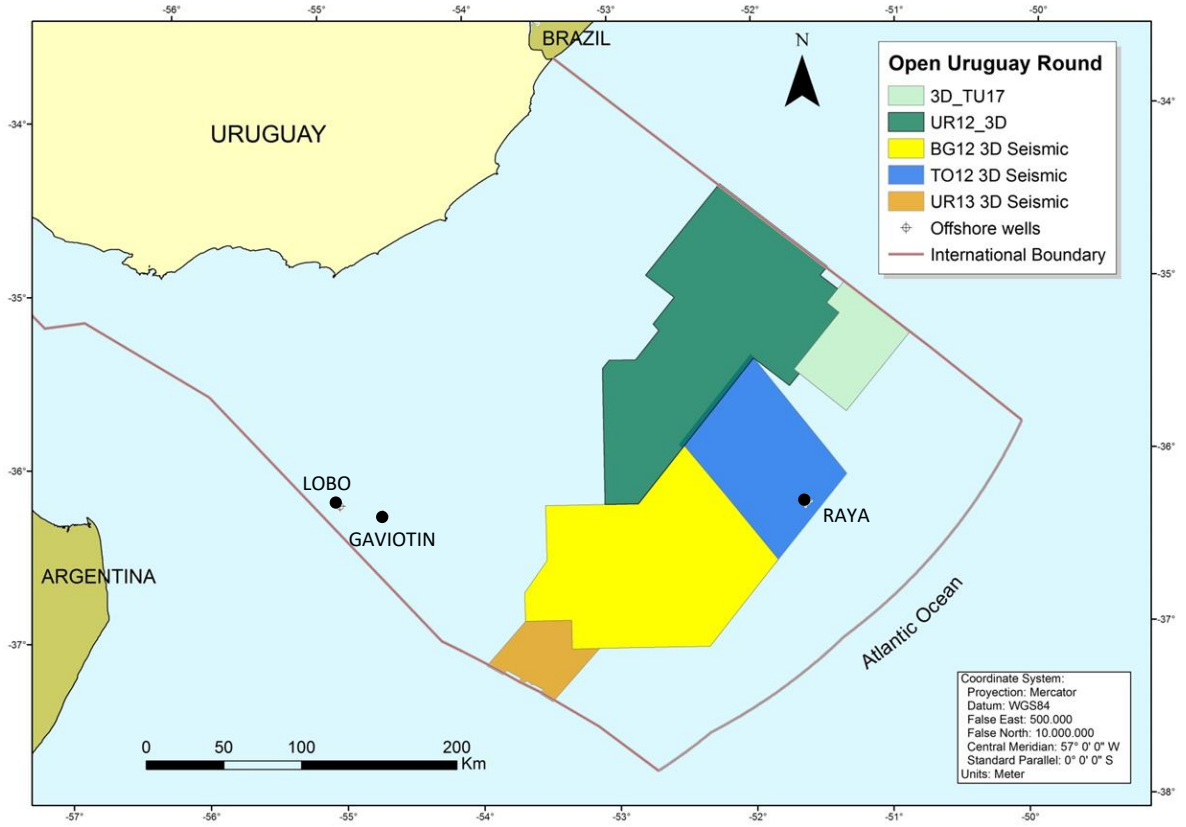
Database

Uruguay offshore geological and geophysical data from oil and gas exploration includes 41,000 km of 2D, 41,000 km^2 of 3D seismic, 3 exploratory wells, CSEM, gravity and magnetic data, 130 seabed samples. This data, especially the seismic, allowed us to interpret and evaluate the plays and prospects.





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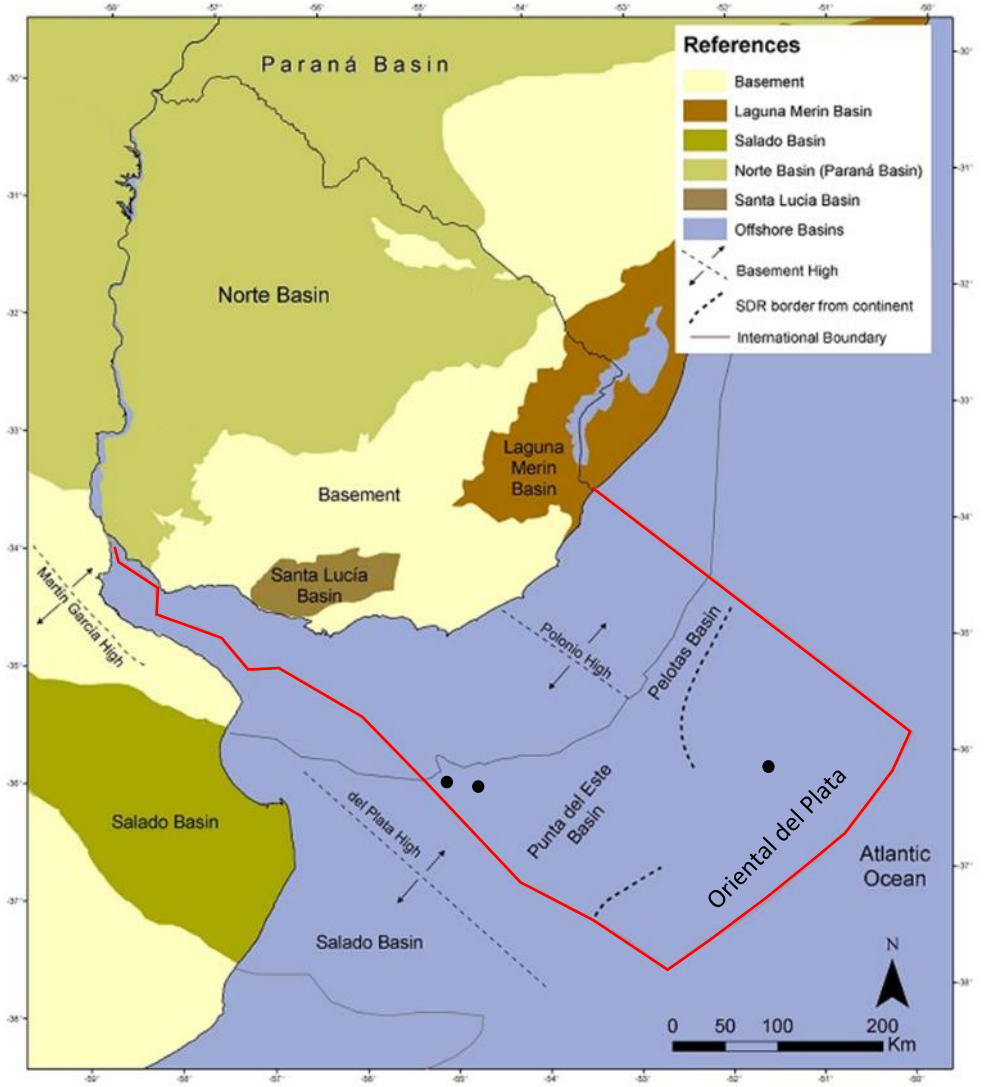
Geology of the area

Two main basins are recognized offshore Uruguay:

1. Punta del Este to the West
2. Pelotas Basin to the East

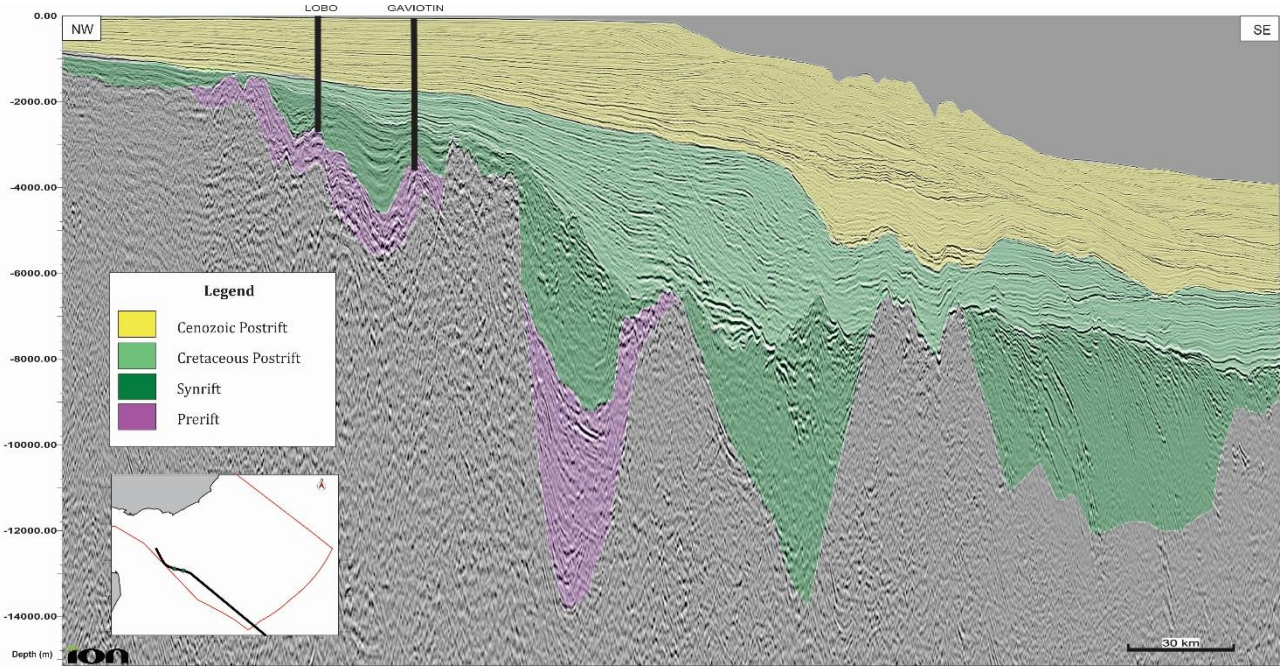
In shallow waters they are separated by a basement high (Polonio High).

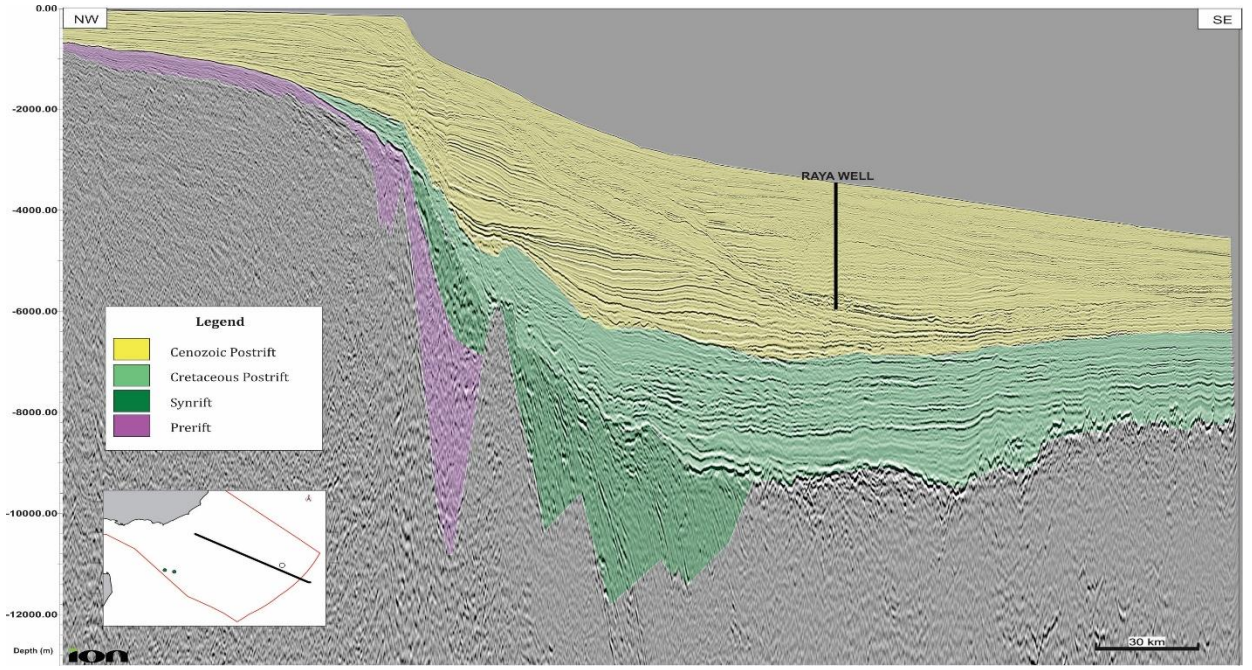
In deep waters, over oceanic crust, these two basins become a single sedimentary depocenter called Oriental del Plata Basin



Stratigraphy

Mega-sequences recognized offshore Uruguay: A) **Prerift phase** (Paleozoic to Jurassic deposits), represented by sedimentary rocks deposited in the area previous to the breakup of Gondwana. B) **Synrift phase** (Late Jurassic-Early Cretaceous), constituted by volcanic rocks and continental sediments deposited in grabens and half-grabens, and C) **Postrift phase** (Aptian to Present Day), corresponding to sedimentation associated with the development of marine conditions and eustatic changes of the sea level.

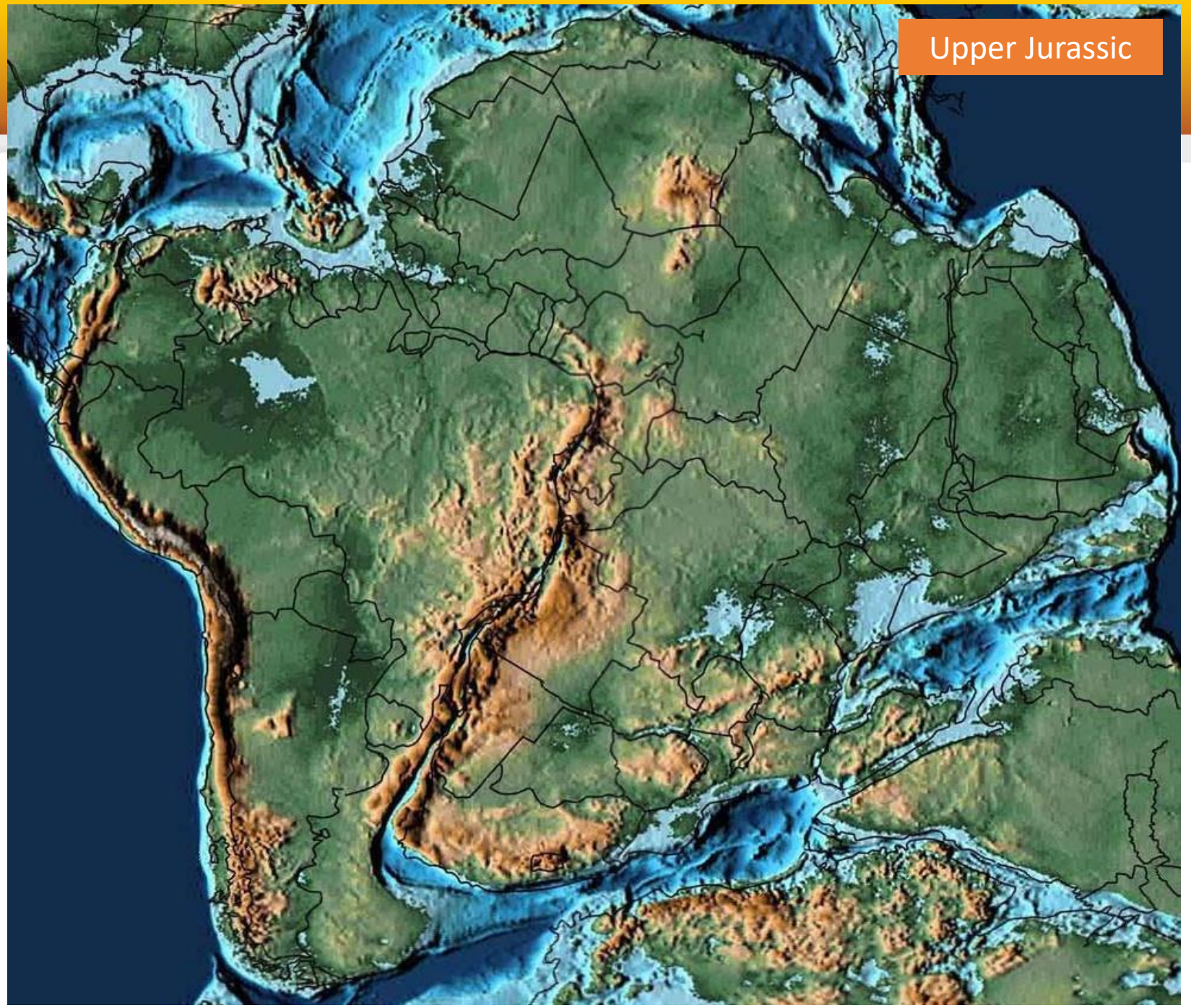




- Paleogeographic restoration for the Upper Jurassic (150 Ma).

- Breakup of Gondwana supercontient previous to the opening of the Atlantic Ocean.

Uruguay and Namibia were“attached”.

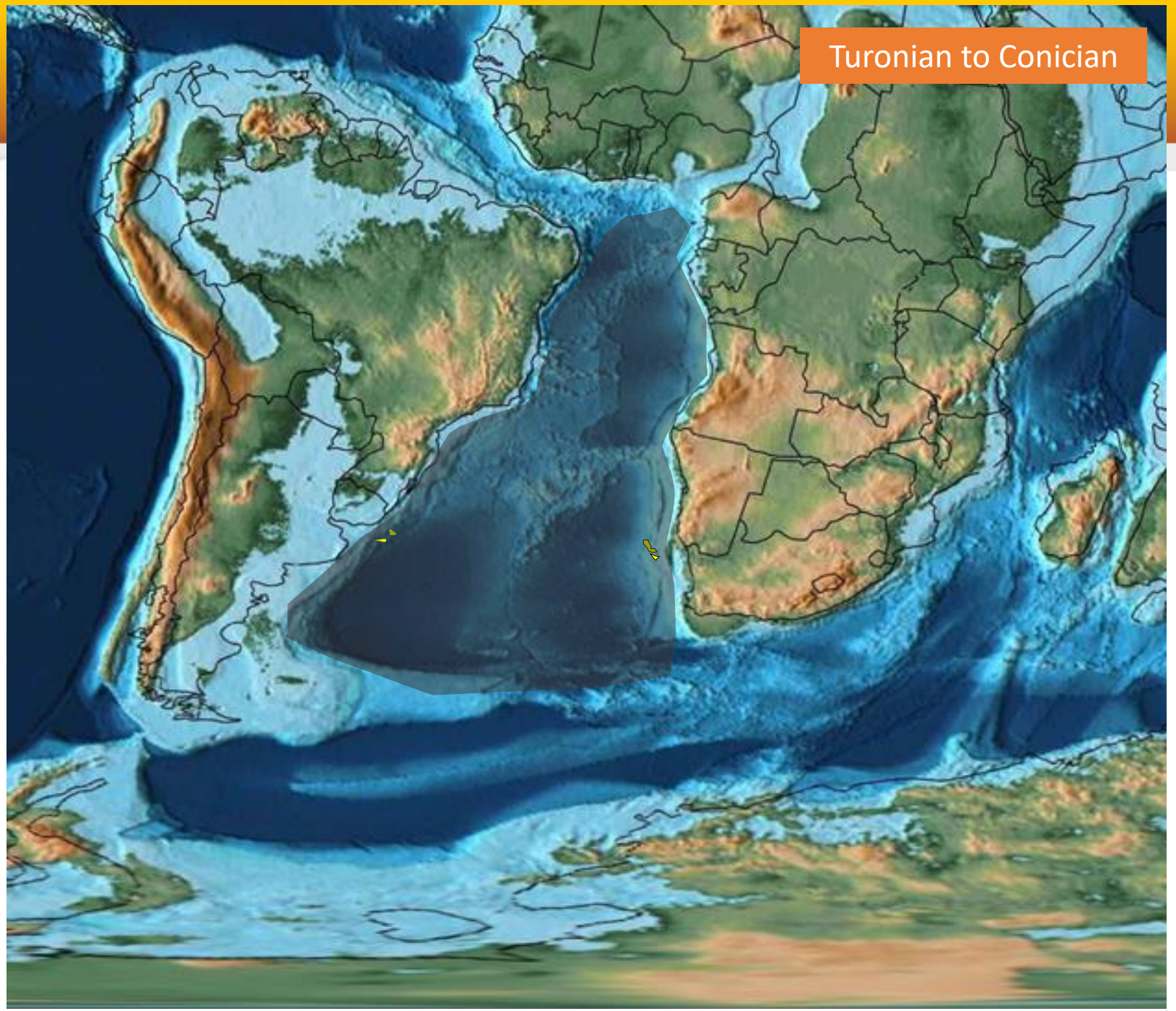


Scotese, (2014)

- Paleogeographic restoration for Lower Cretaceous (130-110 Ma).
- Aptian source rock deposition, responsable for the Venus accumulation
- Deposition of Venus reservoir (Namibia) and similar prospects in offshore Uruguay.

Modified from Scotese, (2014)

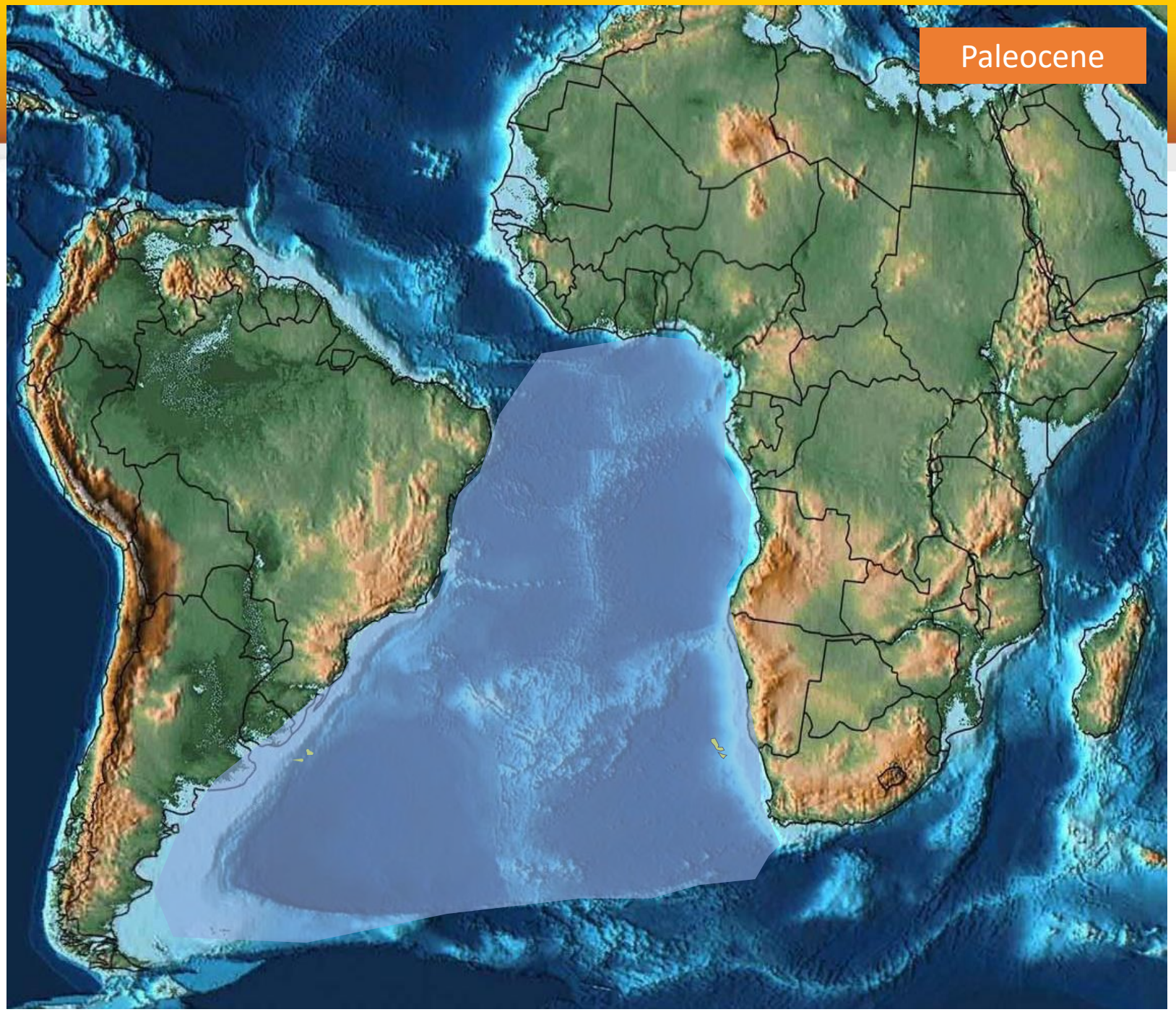
- Paleogeographic restoration for the Upper Cretaceous (90-85 Ma).
- Cenomanian-Turonian source rock deposition in the South Atlantic.
- Deposition of Graff reservoir (Namibia) and similar prospects offshore Uruguay (Conician-Santonian).



Modified from Scotese, (2014)

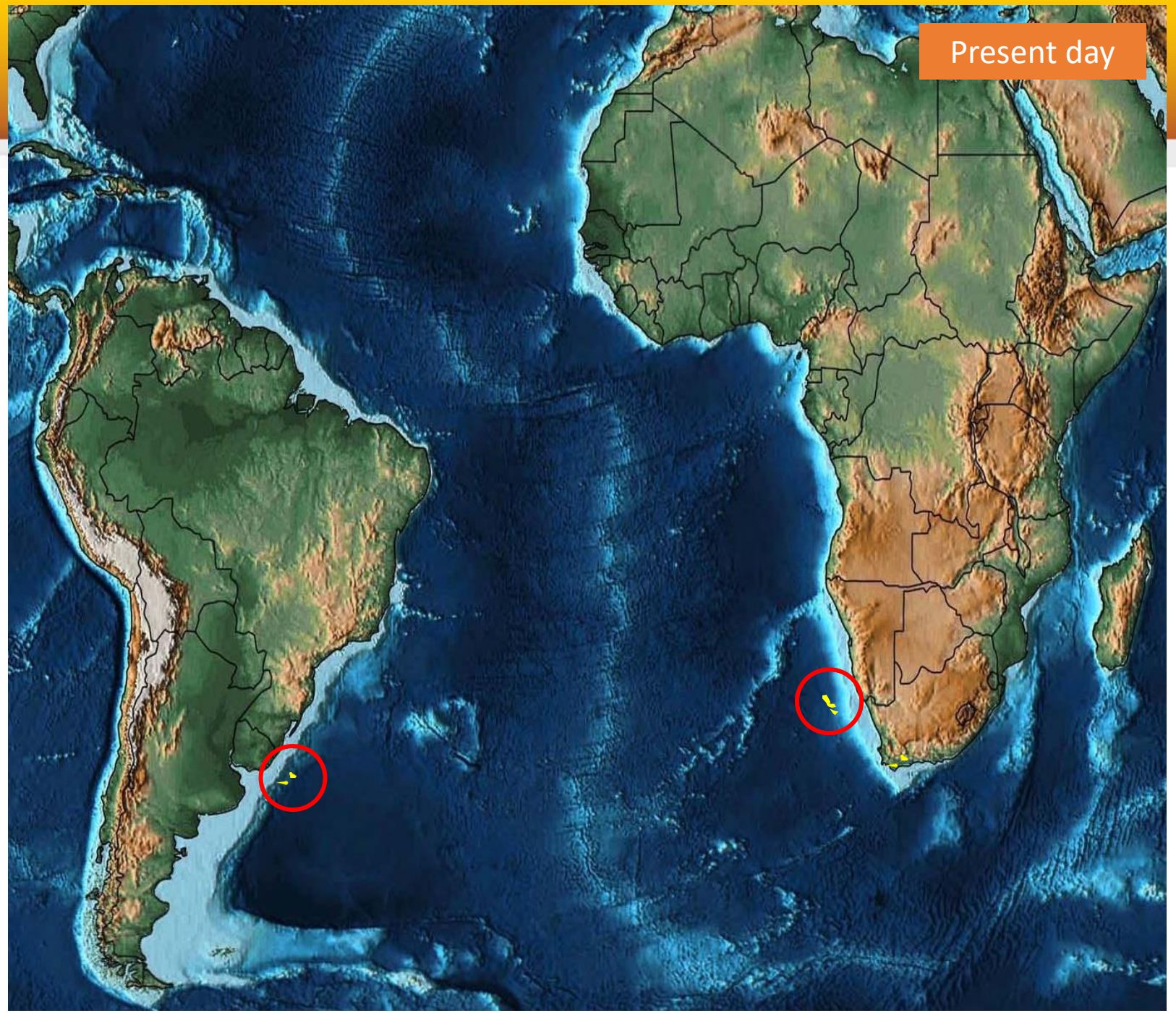
- Paleogeographic restoration for the Paleocene (60 Ma).

- Deposition of a regional seal for the South Atlantic related to the Paleocene transgression.



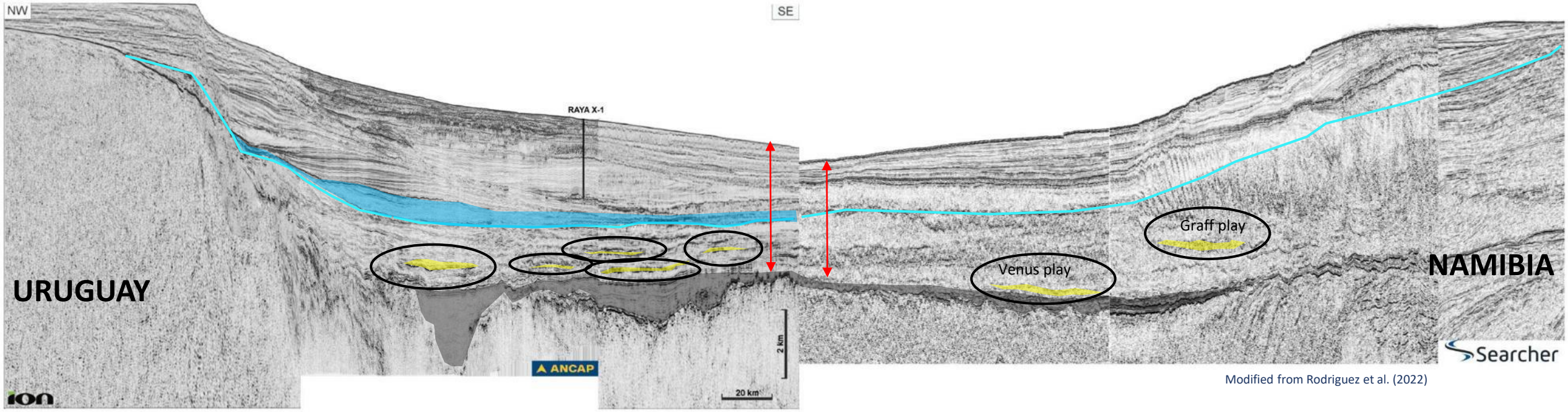
Modified from Scotese, (2014)

- Present-day location of Venus and Graff and analogous prospects offshore Uruguay.



Modified from Scotese, (2014)

Analogies between offshore Uruguay and Namibia



Modified from Rodriguez et al. (2022)

- Thicker Barremian-Aptian sequence offshore Uruguay.
- More overburden for the Aptian source rock offshore Uruguay.
- Several cretaceous reservoirs identified analogous to Venus and Graff
- Regional and thick Paleocene seal

Content

Method and Criteria

29 prospects were interpreted using the geological, geophysical and geochemical data offshore Uruguay, published data from analog basins and considering the interpretations carried out by oil companies that explored offshore Uruguay in the last 15 years.

1) Plays and petroleum systems identification 2) Prospect characterization and mapping 3) volumetric assessment

Estimation of the geological PoS was made by multiplying 6 risk factors (assignment of probabilities for each factor): 1) Structure, 2) Reservoir presence 3) Reservoir deliverability, 4) Seal, 5) Source rock presence and maturity, 6) Migration and timing.

Risk tables for the probabilities of the six geological risk factors (Milkov 2015) were systematically used to achieve a less biased estimation.

Risk tables for probabilities

Structure (closure, geometry, container)				Data (existence and reliability)			
				3D seismic	2D seismic Number of lines per structure (with obligatory availability of in-line and cross lines)		
					Dense (7 lines and more)	Sparse (3-6 lines)	Very sparse (2 lines) (Lead)
Models (existence and reliability)	Seismic mapping and correlation	High-relief structure (≥3 times higher than seismic accuracy) AND low structural complexity (4-way)	Easy to interpret, reliable correlation based on nearby (<50 km) wells	1.00	0.90	0.80	0.60
			Uncertain correlation (horizons are interrupted laterally) or based on remote (> 50 km) wells	0.95	0.85	0.75	0.55
			Difficult to interpret, unreliable correlation (horizons are interrupted by thrust faults, diapirs, etc.) or model developed using analogues without wells in the basin	0.85	0.75	0.70	0.45
		Medium-relief structure (1-3 times higher than seismic accuracy) OR high-relief structure with high structural complexity (3-way, stratigraphic)	Easy to interpret, reliable correlation based on nearby (<50 km) wells	0.80	0.70	0.60	0.35
			Uncertain correlation (horizons are interrupted laterally) or based on remote (> 50 km) wells	0.75	0.65	0.50	0.25
			Difficult to interpret, unreliable correlation (horizons are interrupted by thrust faults, diapirs, etc.) or model developed using analogues without wells in the basin	0.70	0.55	0.45	0.20
		Low-relief structure (lower than seismic accuracy) OR high uncertainty of depth conversion (subsalt, below lava flows) OR areas with rapidly changing lateral velocities in the overburden	Easy to interpret, reliable correlation based on nearby (<50 km) wells	0.55	0.45	0.35	0.15
			Uncertain correlation (horizons are interrupted laterally) or based on remote (> 50 km) wells	0.50	0.40	0.25	0.10
			Difficult to interpret, unreliable correlation (horizons are interrupted by thrust faults, diapirs, etc.) or model developed using analogues without wells in the basin	0.40	0.30	0.20	0.05
		Low-relief structure (lower than seismic accuracy) AND EITHER high uncertainty of depth conversion (subsalt, below lava flows) OR areas with rapidly changing lateral velocities in the overburden		0.35	0.25	0.15	0.05

Seal					Data (existence and reliability)				
		Sealing mechanism			Top seal is proven by nearby (<100 km away) wells: Sealing quality				Top seal is inferred from the analysis of seismic data
		Top seal	Bottom or lateral seal	Structural style	Very good (salt, anhydride)	Good (thick (>10 m) soft shales, basalt, carbonates)	Acceptable (shale of average thickness (5-10 m)) OR faults cutting top surface	Poor (thin (<5 m, or sand-rich) OR brittle shale	
Models (existence and reliability)	One-seal traps	Conformable or unconformable	none	Anticlines, buried fans, reefs, banks, topography (hill, erosional remnant)	1.00	0.95	0.80	0.55	0.75
		Unconformable, fault plane is part of top seal	none	Faulted structures (horst blocks)	0.95	0.85	0.70	0.45	0.65
	Poly-seal traps	Conformable or unconformable	Tectonic surface (faults)	Juxtaposition seal	0.95	0.85	0.70	0.45	0.65
				Clay-shale smear, SSF<4	0.85	0.75	0.55	0.30	0.50
				No juxtaposition / smear analysis done	0.80	0.70	0.50	0.25	0.45
				More than one fault planes OR Leak windows caused by sand-sand juxtaposition OR Self-juxtaposed reservoir at >2500 m burial, SGR>0.25, SSF<5	0.75	0.65	0.45	0.20	0.40
				Self-juxtaposed reservoir at <2500 m burial, SGR<0.2, SSF>5	0.50	0.35	0.20	0.05	0.15
		Conformable	Tectonic surface (diapirs)	Traps formed by salt or shale diapirism	0.95	0.85	0.70	0.45	0.65
		Conformable	Facies change, cataclasis, change in pore fluid (tar, hydrate)	Stratigraphic traps ("shale out", postdepositional facies change)	0.75	0.65	0.45	0.20	0.40
		Conformable	Unconformable	Onlap, lowstand wedge	0.65	0.50	0.30	0.10	0.25
		Unconformable (erosional contact)	Conformable	Subcrop structures	0.50	0.35	0.20	0.05	0.15

Milkov (2015)

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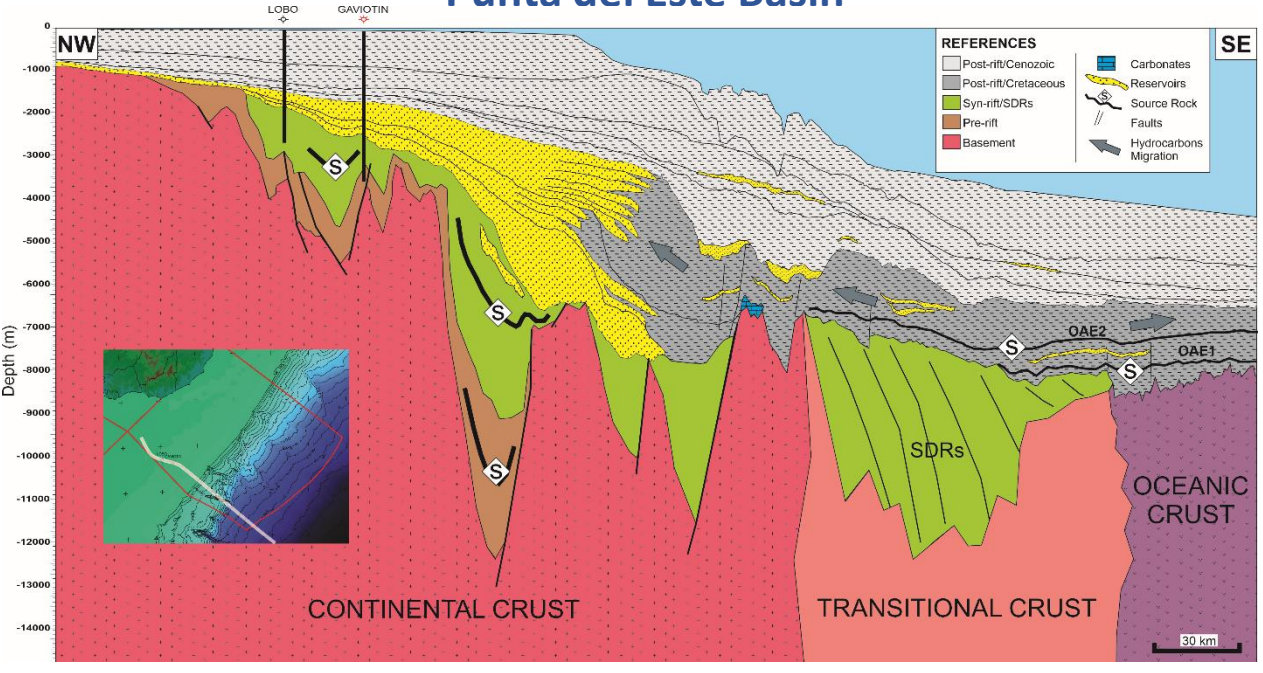
Play types

The prospects encompass stratigraphic, mixed, and structural traps, spanning from shallow to ultra-deep waters. They were classified into 12 different plays concepts associated with the different mega-sequences.

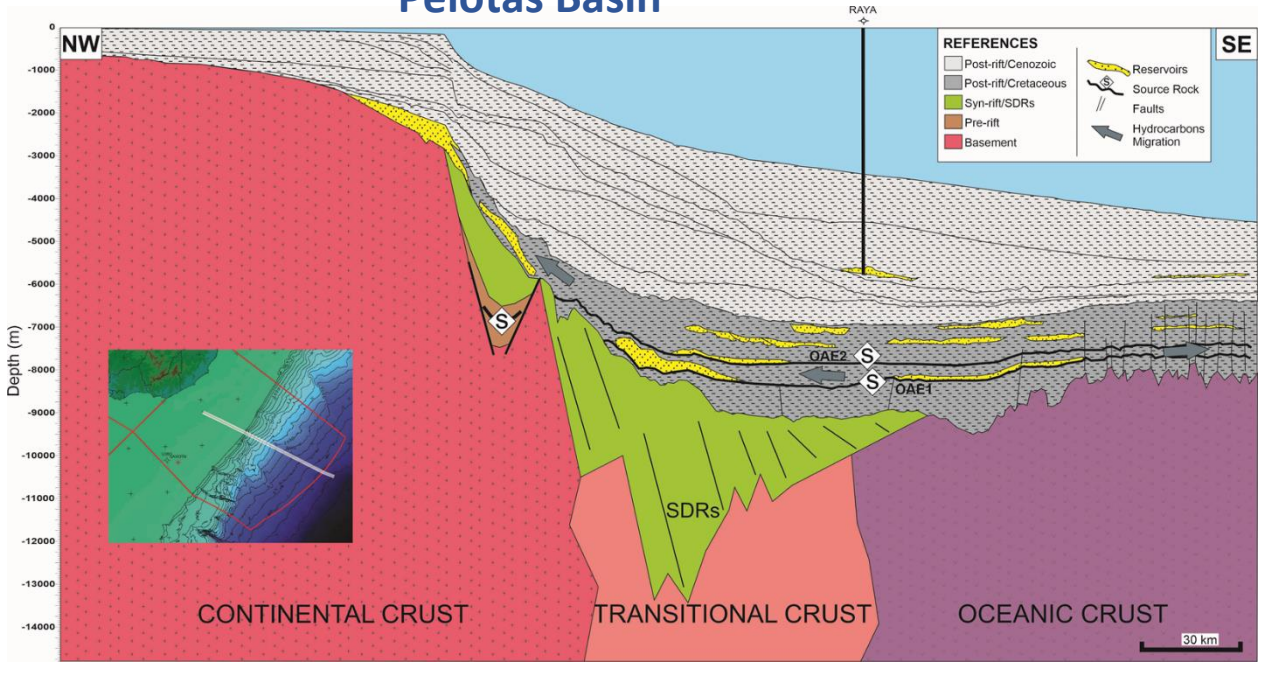
A – Prerift plays (Anticline structures and faulted blocks in preserved Paleozoic sequence)
B – Synrift plays (Lacustrine fans)
C – Transition plays: Isolated carbonate buildups
D – Cretaceous postrift plays: Turbidites, deltas, drapes, channel systems, pinchouts
E – Cenozoic postrift plays: Turbidites and channels

Play	Description
1	Prerift anticlines
2	Synrift lacustrine fans
3	Isolated carbonate buildups (Transition)
4	Early postrift drapes (Albian)
5	Early postrift turbidites (Albian)
6	Early postrift channel systems iAlbian)
7	Early postrift prograding deltas
8	Upper Cretaceous turbidites (Conician to Maastritchian)
9	Upper Cretaceous channel systems (Conician to Maastritchian)
10	Upper Cretaceous pinchouts
11	Paleocene to Oligocene channel systems
12	Eocene to Oligocene turbidites

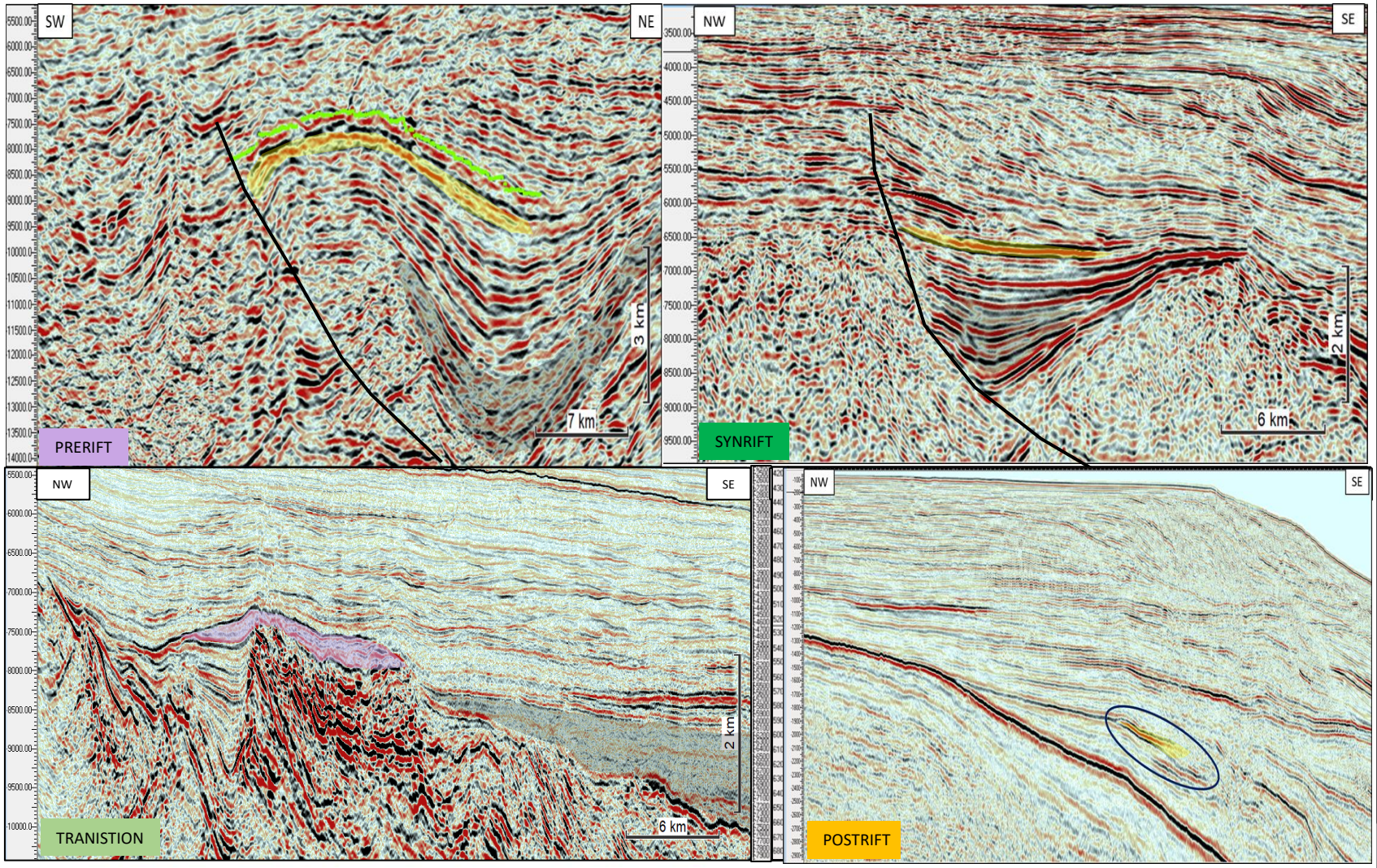
Punta del Este Basin



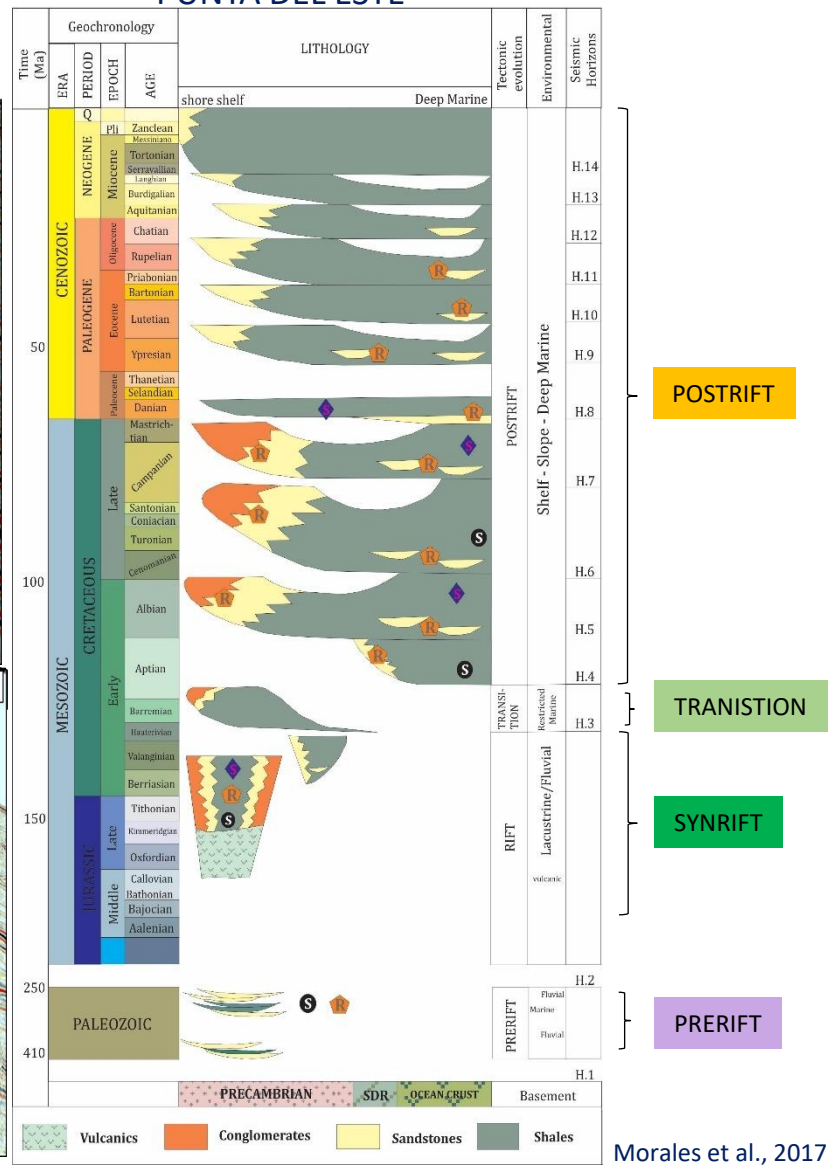
Pelotas Basin



Play types



PUNTA DEL ESTE



POSTRIFT

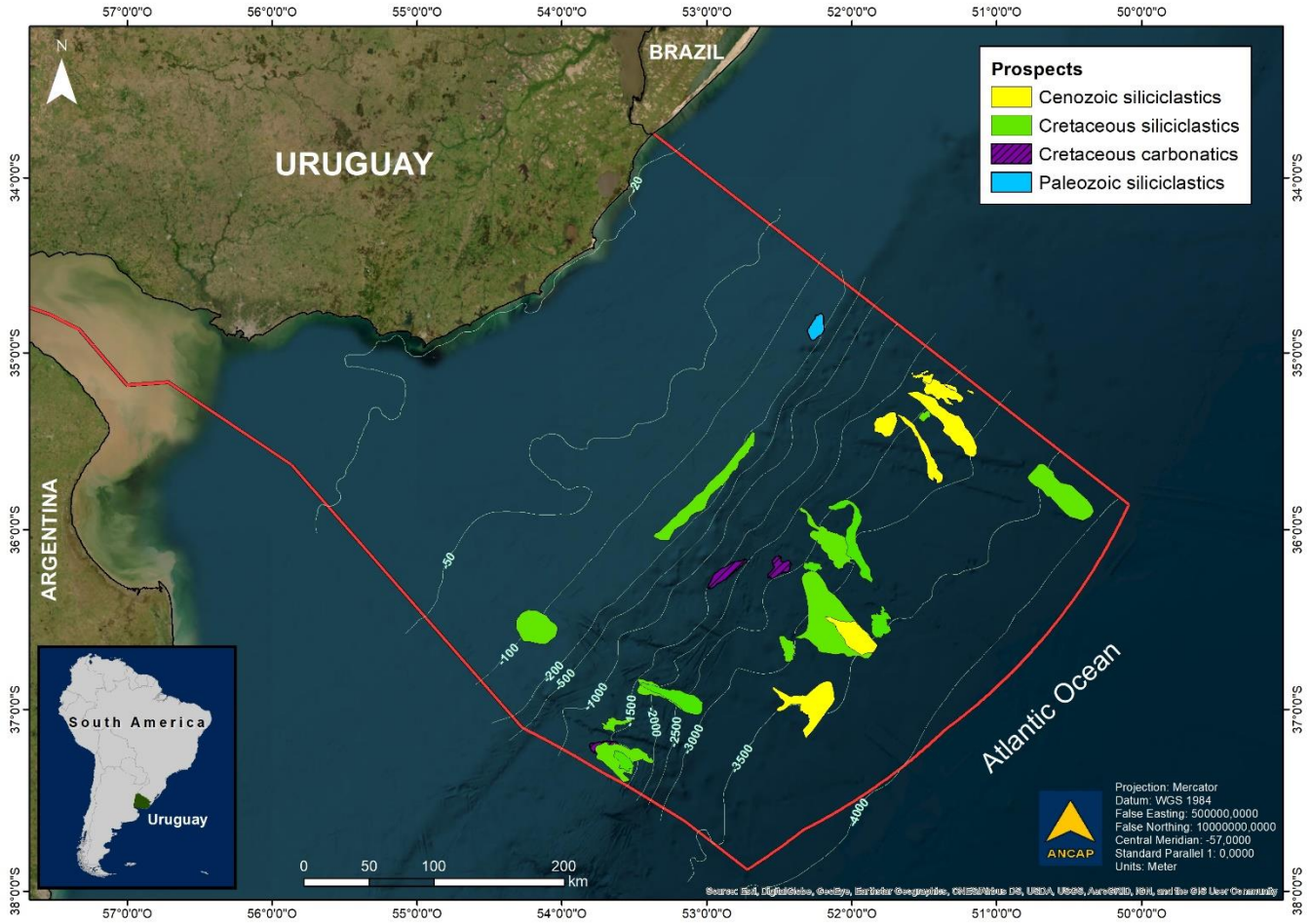
TRANISTION

SYNRIFT

PRERIFT

Morales et al., 2017

Results and Discussion



- The estimated probability of success for 29 prospects evaluated offshore Uruguay ranges from 3% to 23%.
- The updated volume of risked resources offshore Uruguay is estimated to be 3,594.2 million barrels of oil equivalent (Pmean).

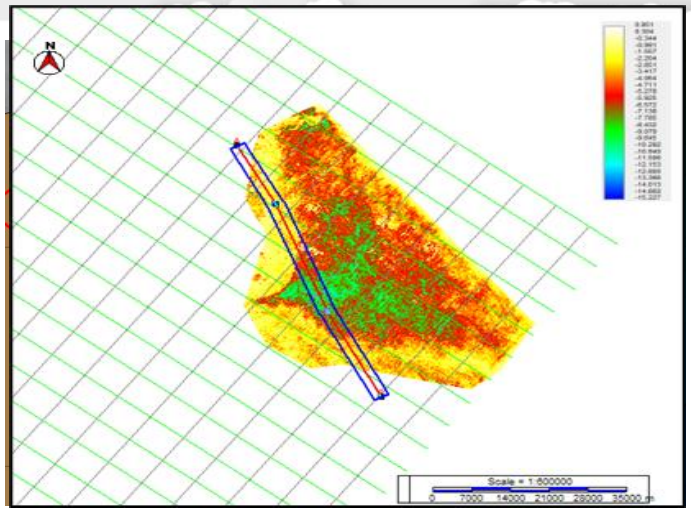
Results and Discussion

- Prerift play ~ 5%: highest risk mostly associated with reservoir quality (overburden of 7000 m) and source rock presence
- Sinrift play ~ 11%: highest risk associated with trap integrity (lacustrine fans) and source rock presence
- Transition play < 10%: highest risk associated with reservoir presence (carbonates not proven)
- Cretaceous postrift plays ~ 11-23%: highest risk reservoir quality and trap integrity
- Cenozoic postrift plays ~ 3-17%: highest risk migration pathways (lack of faults and thick Paleocene regional seal)

- The prospects with the highest PoS are Albian and Upper Cretaceous turbidites and channel systems that show strong analogies with the recent discoveries in Namibia.

			Probabilities					
Play	Prospect	#	Source Rock	Reservoir	Migration & Timing	Trap	Seal	CoS %
1	Morpheus	1	45%	30%	55%	95%	75%	5,3%
2	Lenteja	2	70%	50%	80%	55%	75%	11,6%
3	Deep Blue	3	90%	30%	70%	70%	75%	9,9%
	Smith	4	70%	30%	70%	70%	75%	7,7%
	Pini	5	90%	30%	70%	70%	75%	9,9%
4	Tararira	6	90%	30%	70%	95%	75%	13,5%
	Anselmo	7	90%	30%	70%	95%	75%	13,5%
5	Delmira	8	90%	70%	90%	55%	60%	18,7%
	Lola	9	90%	70%	90%	70%	50%	19,8%
	Dientudo	10	90%	60%	90%	55%	60%	16,0%
6	Chafalote	11	90%	55%	90%	70%	75%	23,4%
	Corvina	12	90%	35%	90%	55%	75%	11,7%
7	Luisa	13	90%	55%	100%	70%	40%	13,9%
8	Esmeralda	14	90%	60%	70%	70%	65%	17,2%
	Jaspero	15	90%	55%	70%	70%	65%	15,8%
	Onix	16	90%	55%	70%	70%	65%	15,8%
	Granito	17	90%	45%	70%	70%	65%	12,9%
9	Tejera	18	90%	55%	90%	70%	75%	23,4%
	Matilde	19	90%	35%	100%	55%	75%	13,0%
10	Amalia	20	70%	80%	70%	63%	55%	13,5%
11	Guyunusa	21	90%	75%	70%	50%	75%	17,7%
	Petrone	22	90%	75%	70%	50%	75%	17,7%
	Piriz	23	90%	75%	20%	50%	75%	5,1%
	Calvo	24	90%	45%	80%	50%	75%	12,2%
	Nasazzi	25	90%	75%	45%	50%	75%	11,4%
	El Manco	26	90%	45%	70%	50%	75%	10,6%
12	Maspoli	27	90%	85%	30%	55%	90%	11,4%
	Ghiggia	28	90%	100%	10%	55%	90%	4,5%
	Flor	29	90%	75%	10%	55%	90%	3,3%

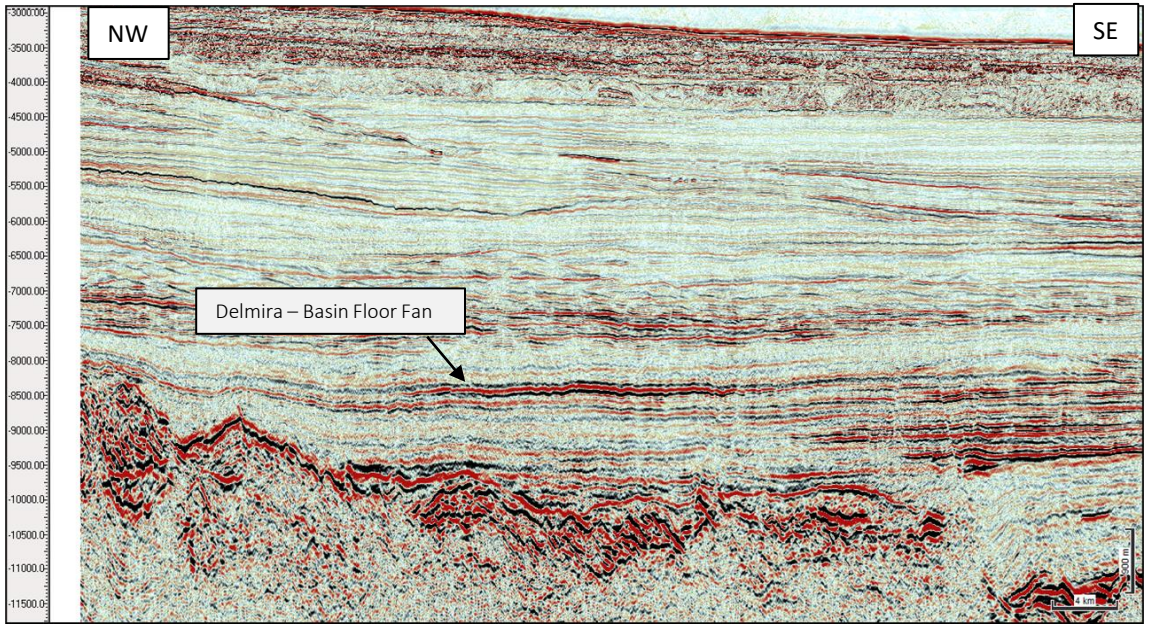
Analogies of plays (Albian submarine fans)



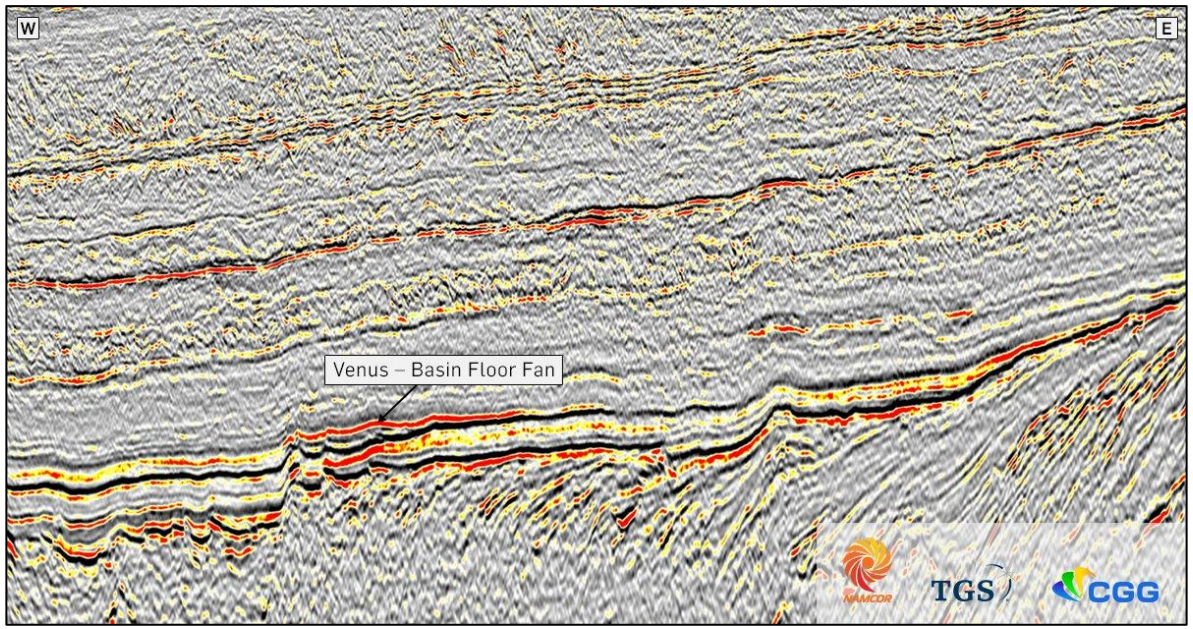
Delmira (Uruguay)
PoS: 18,7%
Reservoir age: Aptian-Albian
Thickness: 44 m (net pay)
Area: 473 km^2
Bathymetry: 4800 m
Distance to shore: 242 km
Estimated vol. 1.47 B bbl (P50)

Venus (Namibia)
Reservoir age: Aptian-Albian
Thickness: 84 m (net pay)
Area: 600 km^2
Bathymetry: 3000 m
Distance to shore: 290 km
Estimated Vol. 5 B bbl

Delmira prospect (Uruguay)



Venus prospect



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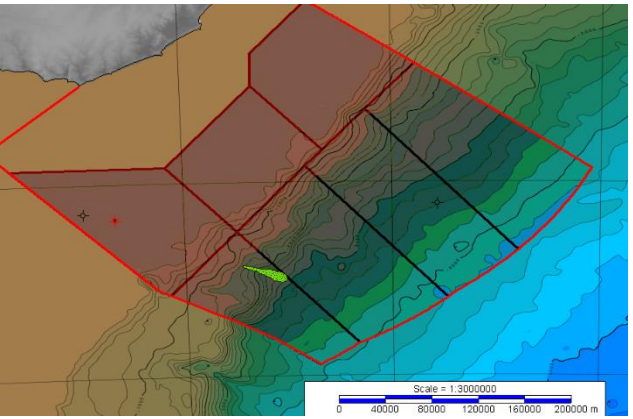
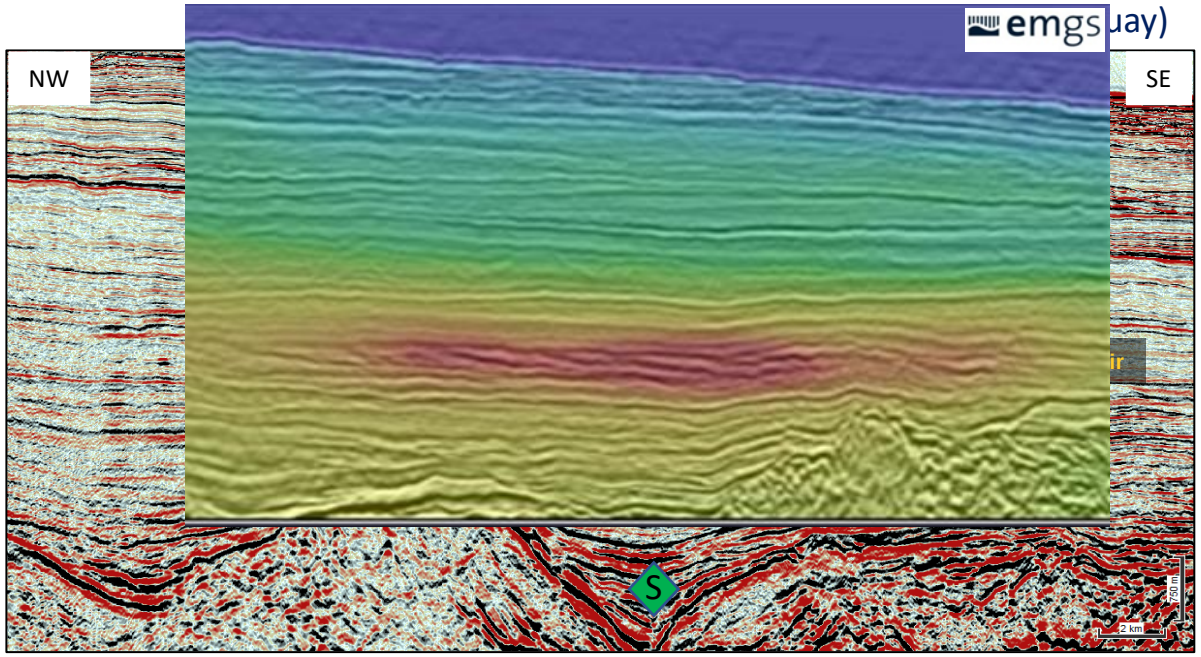
Analogies of plays (Upper cretaceous turbidites)

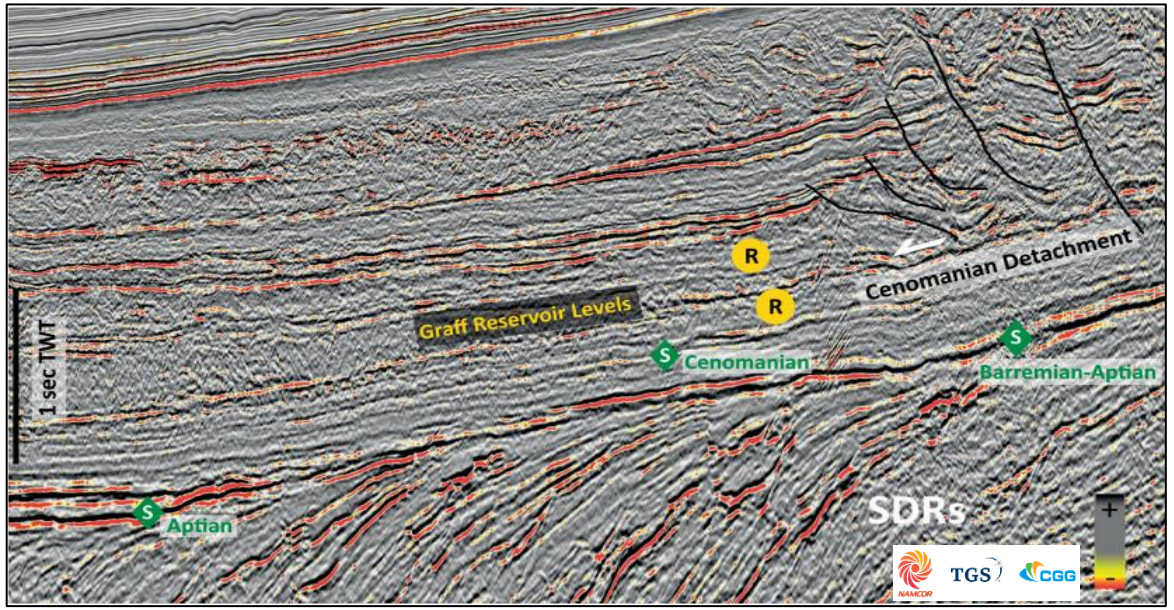


Matilde (Uruguay)
PoS: 23,4%
Reservoir age: Upper Cretaceous
Thickness: 100 m (net pay)
Area: 163 km^2
Bathymetry: 2200 m
Distance to shore: 250 km
Estimated vol 490 MM bbl (P50)



Graff (Namibia)
Reservoir age: Conician-Santonian
Thickness: 60 m (net pay)
Area: 150 km^2
Bathymetry: 2000 m
Distance to shore: 270 km
Estimated vol.: 250-300 MM bbl

Graff prospect (Namibia)



Winter et al., (2022)

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Final remarks

- The estimated Probability of Geological Success for 29 prospects evaluated offshore Uruguay showed a high risk with PoS ranging from 3% to 23%.
- However, the good quality of the 3D seismic data used, the presence of DHI, and the recognition of plays with strong analogies with the recent discoveries offshore Namibia allowed to identified some promising prospects.
- The Cretaceous postrift prospects appear as the most prospective due to their proximity with the main source rocks (Aptian and Cenomanian-Turonian), the presence of migration pathways that connect source and reservoir and development of stratigraphic and mixed traps that are proven in the conjugate margin.
- The systematic use of risk tables for the estimation of the PoS allowed less biased and more consistent estimations, aiming to enhance the evaluation of the inherent risk associated with the prospects.
- The PoS provides a better assessment of oil and gas resources and assists in establishing exploration priorities, particularly regarding drilling decisions.

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Thank you for your attention!

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