From Deep Horizon to Deep Water, a North Eastern Latin America Success Story, for Some...*

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Abstract

Hydrocarbons have been commercially produced in Trinidad and Tobago for more than 100 years, the majority of which is extracted from shallow Plio-Pleistocene deltaics both onshore and offshore on the present-day shelf. The discovery of the giant El Furrial Cretaceous shelfal sandstones in Venezuela in the 1980's caught the attention of Exxon, who followed the structural and stratigraphic trend into the more politically stable part of the Eastern Venezuelan Basin, in Trinidad and Tobago. Regional 2D seismic data was acquired, processed and deep tests were done by the drill bit in the 1990's. Consistently, the wells encountered well developed deep water turbidites but with sub-commercial volumes. The conclusion was that the multiple phases of structural deformation in the Trinidad area had severely altered Cretaceous traps, allowing secondary and tertiary migration, and the establishment of many compartments within large anticlinal features. The most southerly of these wells, however, encountered multiple limestone units and gave hints of longstanding unconformities.

Drilling in the Suriname and Guyana area, the offshore Guiana Basin, began in the 1960's with many wells encountering thick shelfal Cretaceous sandstones with some having traces of bypassed hydrocarbon. Many wells, guided by 2D seismic encountered thick Eocene to Cretaceous limestones strongly suggesting a thriving carbonate system on the north eastern Latin American shelf albeit prone to multiple unconformities. Counter clockwise rotation of Africa and South America during the Cretaceous rifting and drifting phase resulted in subtle thick-skinned folding and uplift of the southern rim of this basin, giving rise to the onshore heavily biodegraded Tambarejo oilfield in Suriname, with folded Paleocene fluvial to deltaic sandstones sitting on well cemented Cretaceous turbidites. The conclusion drawn by many a company in the Guiana Basin was the lack of a competent up dip seal, possible remigration due to subtle structural events and no shortage of thief zones in Darcy quality overlying reservoirs, meant that finding a large prospect was unlikely.

Political tensions also brewed between Guyana and Suriname for many years until the maritime boundary was firmly established in 2007. Similarly, the over 100-year-old dispute between Venezuela and Guyana on their shared maritime boundary reached a tipping point in 2015 after Exxon’s Liza-1 discovery well in Guyana’s deep water. This matter has since been referred to the International Court of Justice by the United Nations.

TOUCHSTONE EXPLORATION INC.

THE UNIVERSITY OF THE WEST INDIES

STAATSOLIE

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ExxonMobil

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Xavier Moonan & Javed Razack

AAPG GTW Beijing

Deep and Ultra-deep Petroleum Systems:

What we know and don't know

October 2018

Acknowledgements

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STAATSOLIE
RAMPS LOGISTICS
THE UNIVERSITY OF THE WEST INDIES
AAPG Young Professionals Trinidad & Tobago Chapter
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Outline

- Geological Introduction to NE Latin America

  Trinidad's Southern and Columbus Basins and the Suriname-Guyana Basin

- The Deep Horizon

  Exploration in Venezuela & Trinidad

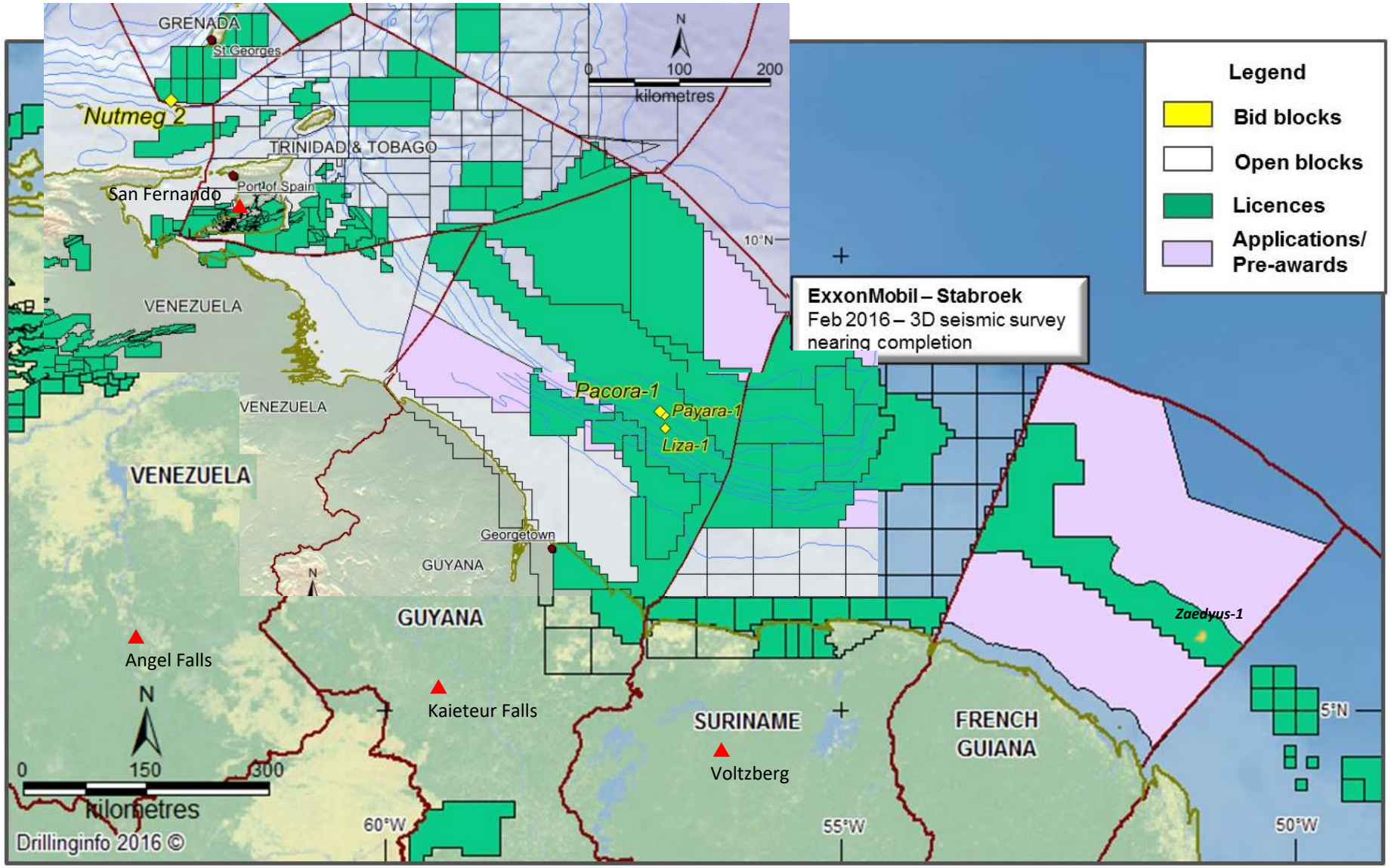
- Deepwater Success & Failure..

  Guyana & Suriname

- Guyana 2020 and Beyond:

  Liza Phase 1, Phase 2 and beyond

North East Latin America Concession Map



www.drillinginfo.com

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In NE Latin America

What is Deep Horizon? What is Deepwater?

What We Know & Don't Know?

- **Deep Horizon** has been primarily considered the deep drilling to test reservoirs within or adjacent to the source rock – Cretaceous/Jurassic. Coined the 'Cretaceous' or 'Transform Margin' Play. Onshore Eastern Venezuela and Trinidad these plays have been proven to occur from 1500m to 5000m below sea level, and hence have been rarely drilled.

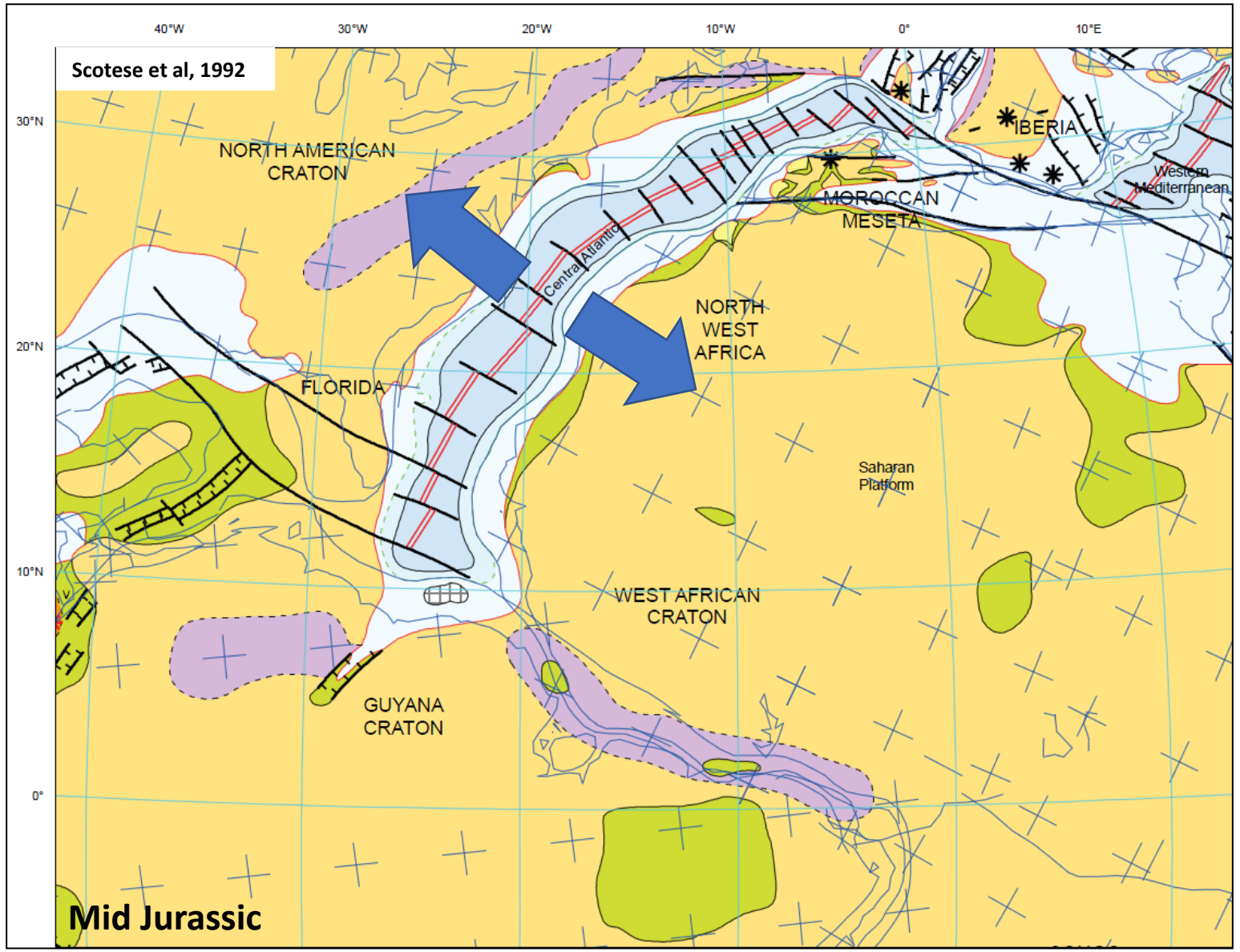
  Challenges: *Imaging, Seal Integrity, and Reservoir Deliverability.*

- **Deepwater Guyana / Suriname / French Guiana / Trinidad / Barbados** – 1800-3000m water depth. Targets are primarily deepwater Cretaceous sandstone turbidites in Guyana, Suriname and French Guiana. In Trinidad and Barbados targets are primarily Late Miocene-Eocene sandstone turbidites.

  Challenges: *Tuning! Imaging Stratigraphic Traps, Seal Integrity & Migration Pathways.*

  Other Challenges: - *Drilling Technology, Cost and Size to Commercialize.*

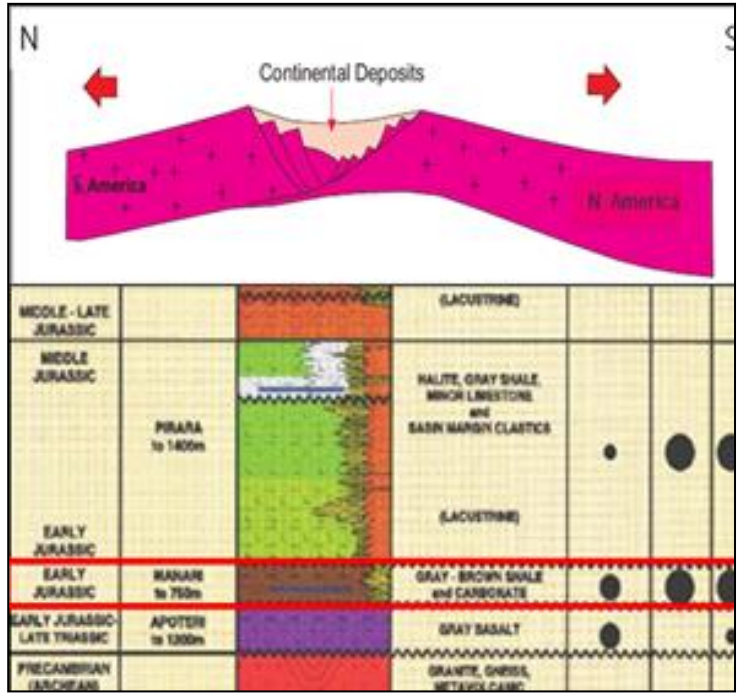
Geological Setting – Central Atlantic Opening, Guyana Transform step over to Yucatan

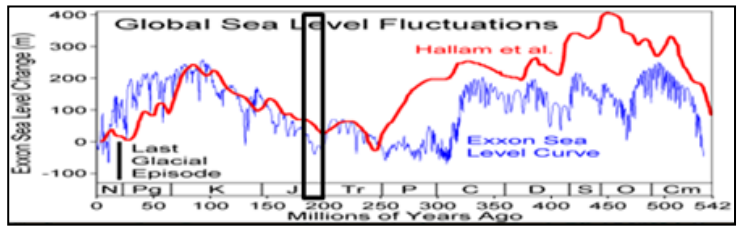


Tectonic Evolution:
Central Atlantic Rifting

Characteristics:

- Faulting/Extension
- Continuous opening of restricted Central Atlantic
- Dolerite dykes (NE-SW)
- Takutu Graben – continental sediments
- Formation of grabens





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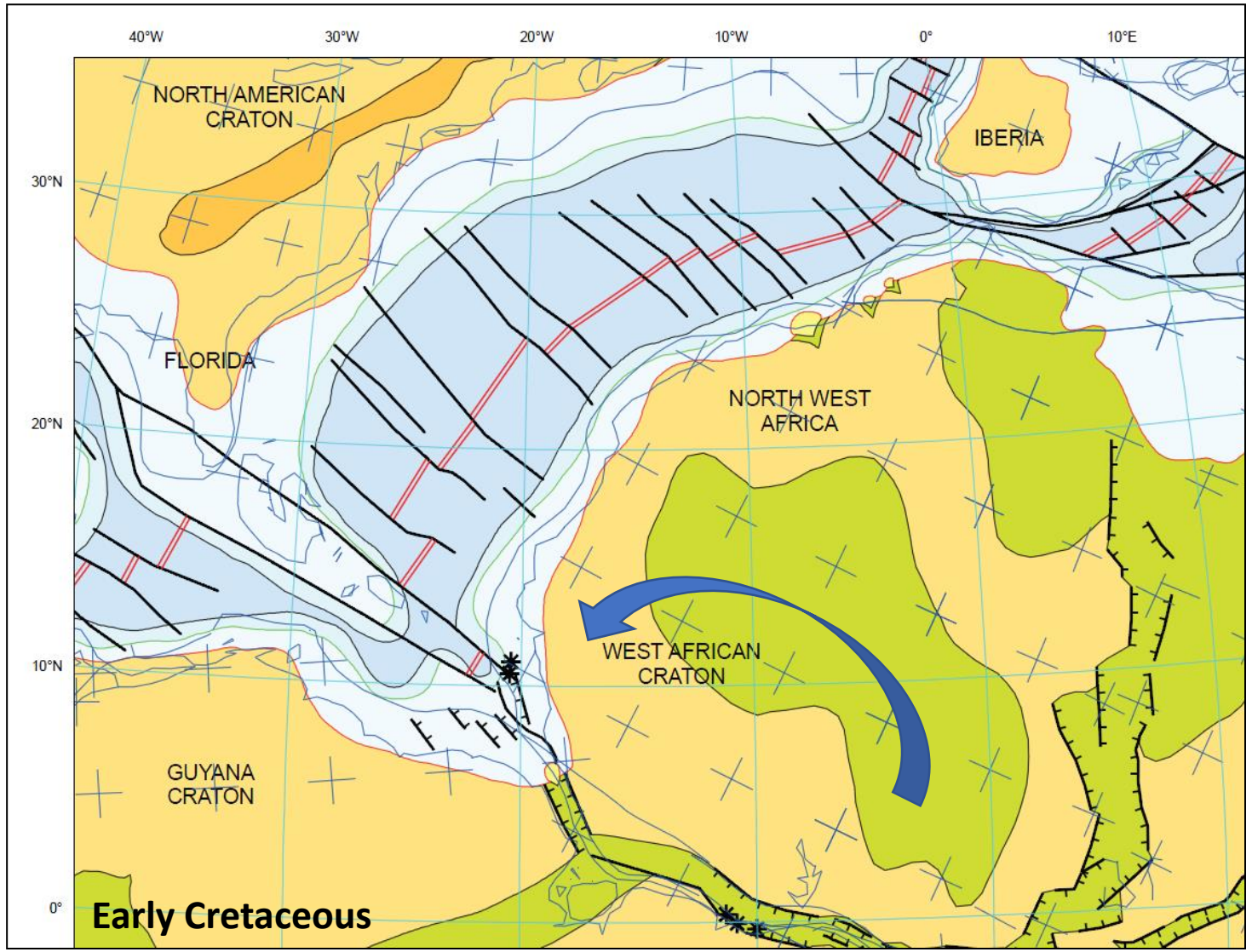
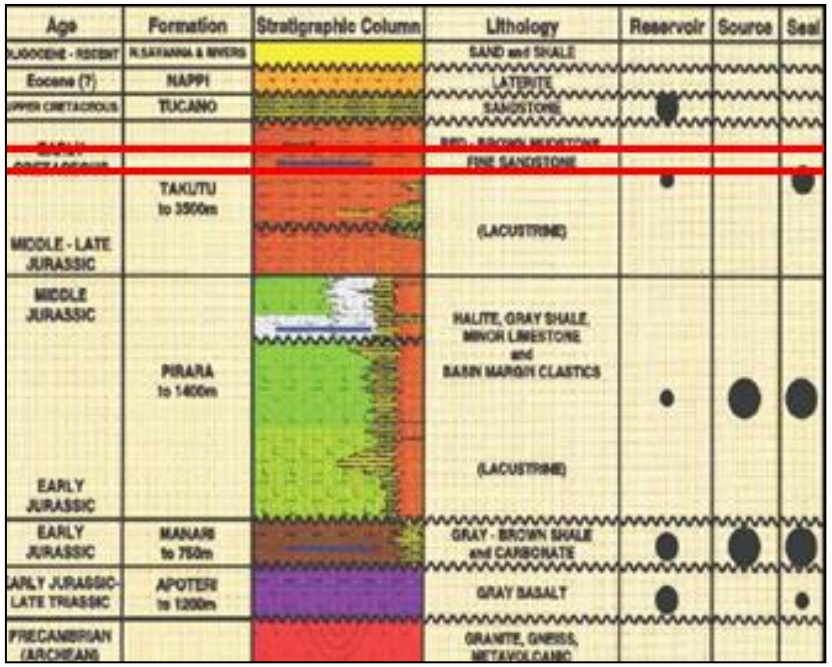
Geological Setting – Opening of Proto Caribbean Seaway, Rotation of Africa

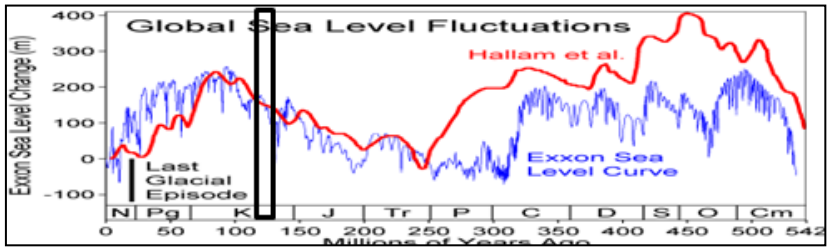
Tectonic Evolution:
South Atlantic Rifting

Characteristics:

- Compression in the Equatorial Atlantic
- Takutu Graben – lacustrine sediments
- Inverted structures exposed, local unconformities – Demerara Plateau







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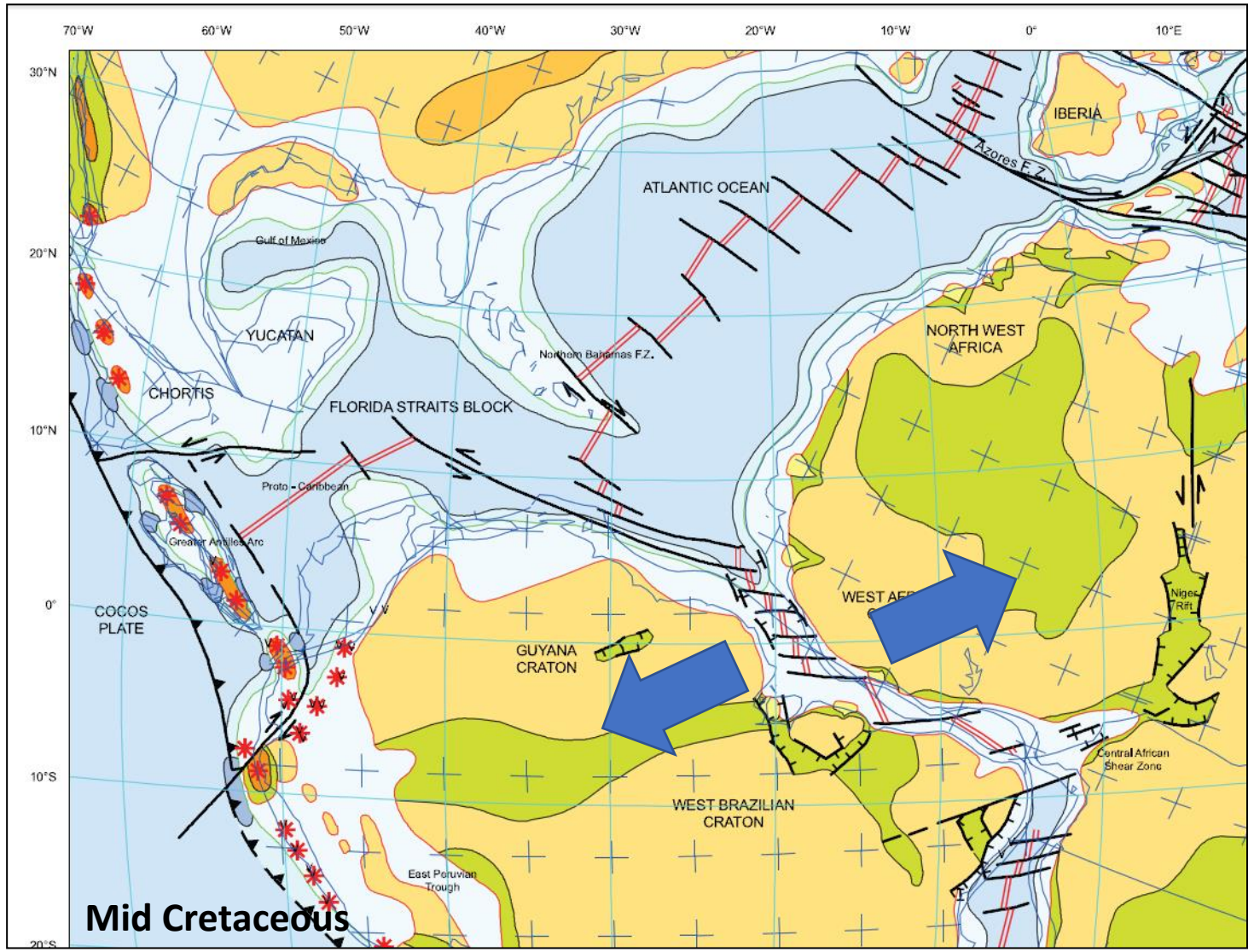
Geological Setting – Drift and rapid deepening compounded by High Sea Levels

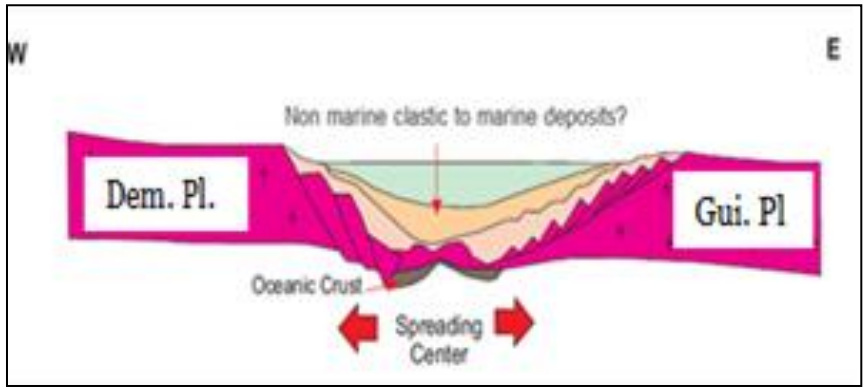


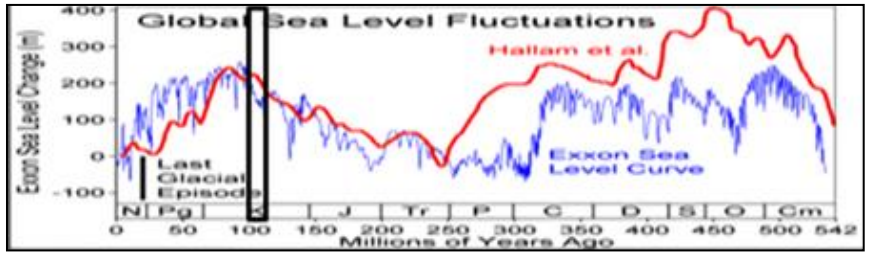
Tectonic Evolution:

Equatorial Atlantic Rifting & Drift Phase

Characteristics:

- Rifting in the Equatorial Atlantic
- Drowning of Inverted structures, rapid deepening
- Open marine settings





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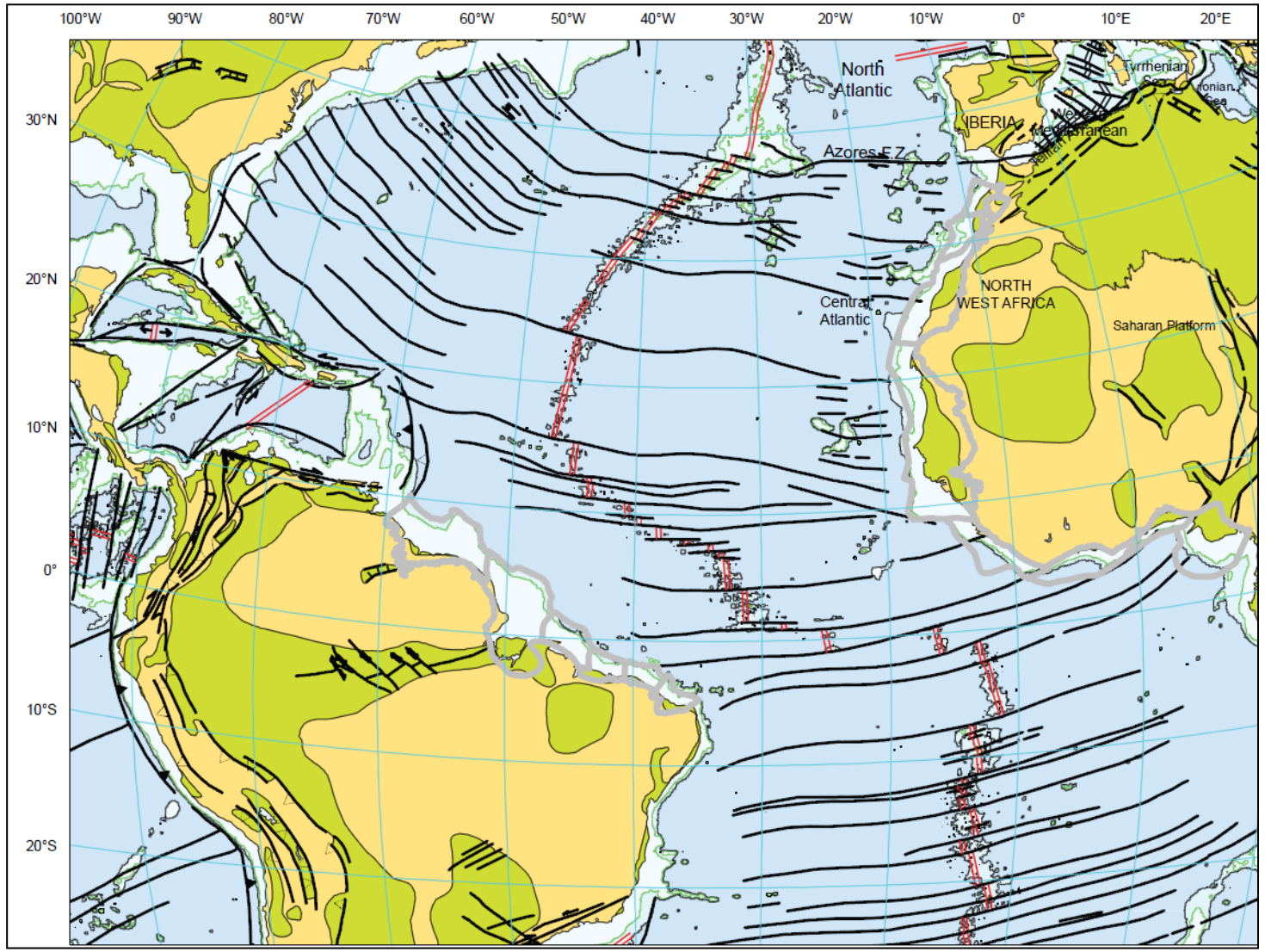
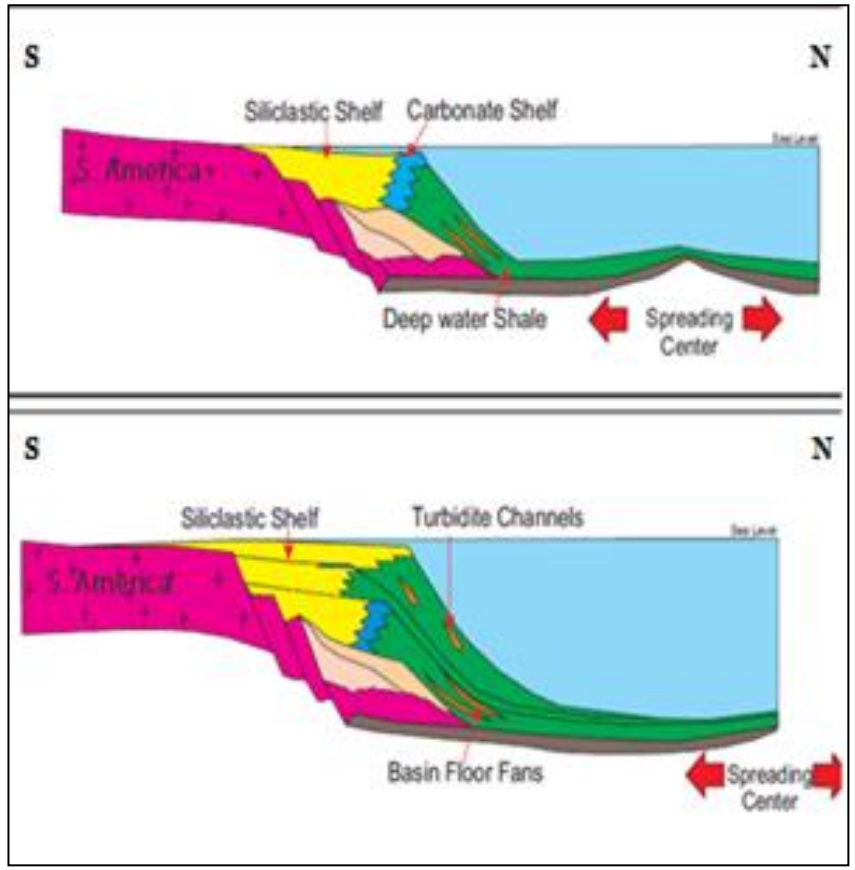
Geological Setting

Tectonic Evolution:
Present Day





- Established passive margin at Guyana, Suriname
- Active margin tectonics in the Trinidad area due to the apparent eastward advancement of the Caribbean Plate

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Regional Free-Air Gravity

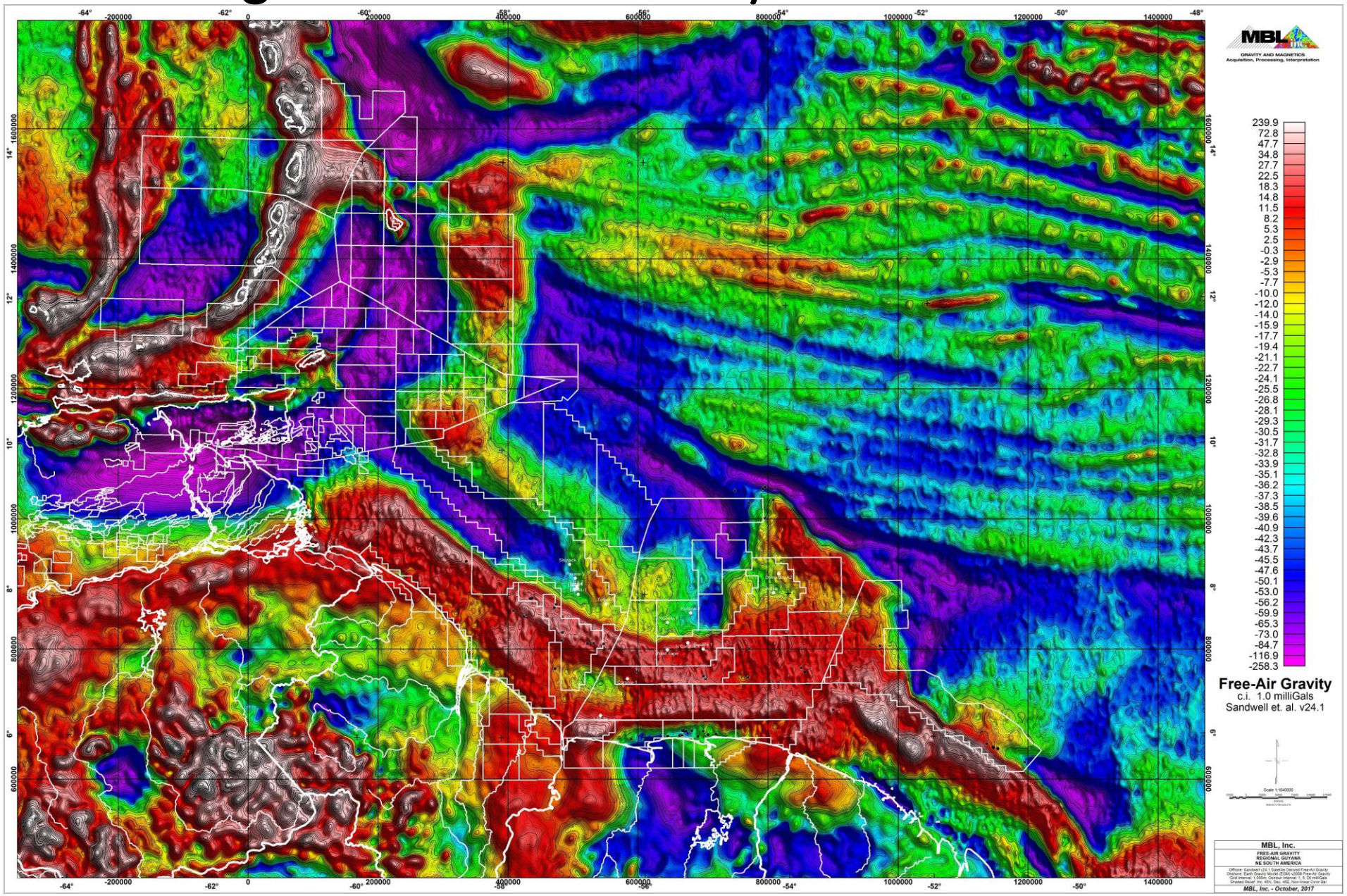
Free-Air Gravity: (Sandwell, et al, 2014):

Offshore: Satellite Derived, v24.1

Onshore: Earth Gravity Model 2008

(Sandwell, D. T., R. D. Müller, W. H. F. Smith, E. Garcia, R. Francis, New global marine gravity model from CryoSat-2 and Jason-1 reveals buried tectonic structure, Science, Vol. 346, no. 6205, pp. 65-67, doi: 10.1126/science.1258213, 2014

- Well established transforms which link the area to hydrocarbon discoveries on the west coast of Africa.
- Note the distinct change from Continental Crust to attenuated Continental Crust and Ocean Crust
- Inherent structural grain



Mark Longacre, 2017

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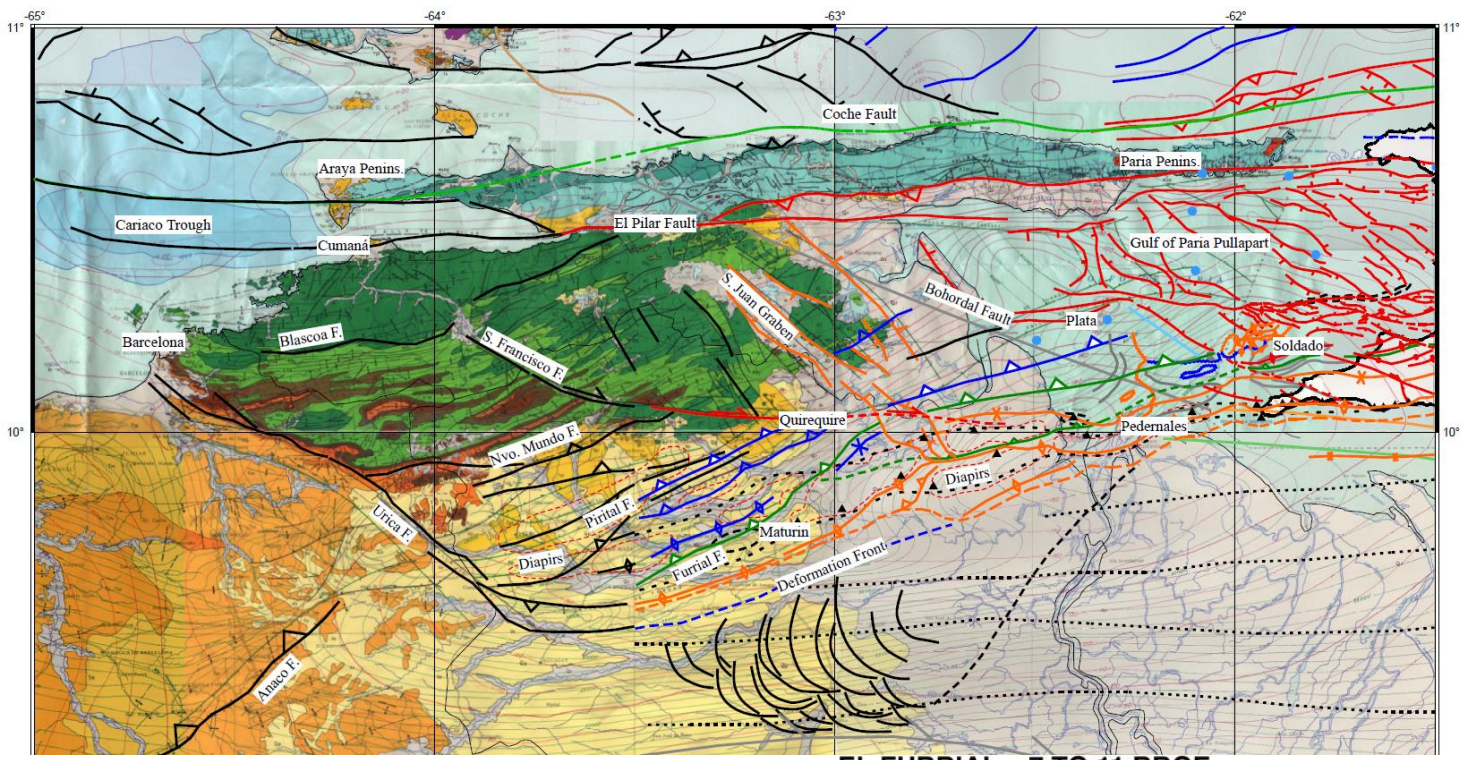
Deep Horizon Exploration in Venezuela & Trinidad

In search of the El Furrial …..& equivalent

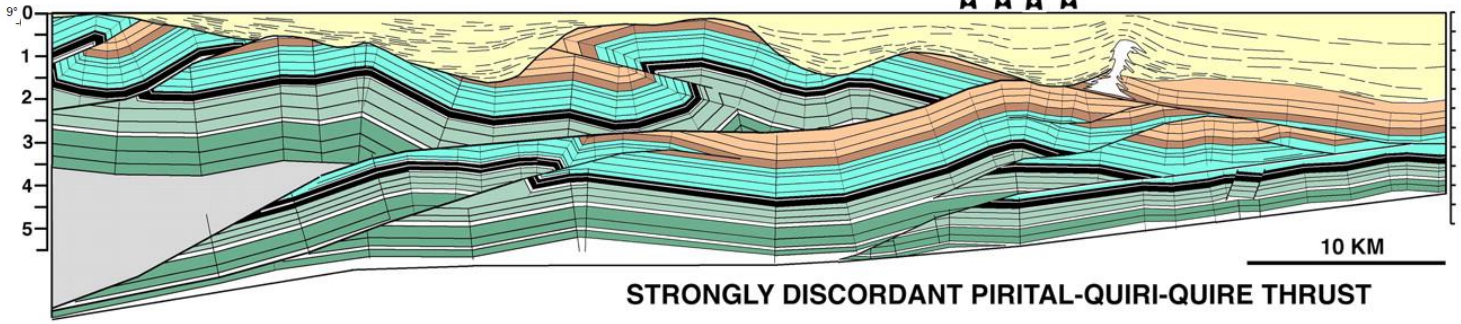
Early-Mid Proterozoic (1.9-1.5Ga) Roraima Group sandstone tepuis
Angel Falls, Venezuela

Turonian-Campanian Cretaceous Naparima Hill argillite
San Fernando Hill, Trinidad
Pointe-a-Pierre Refinery in foreground

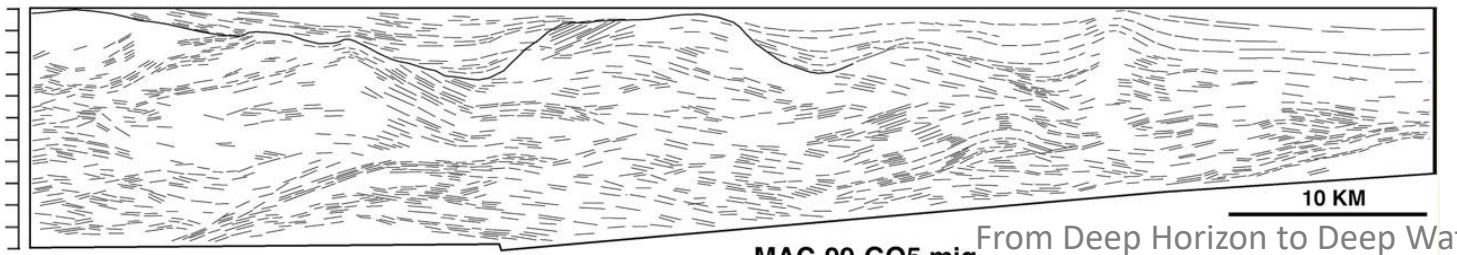


BURIED MOUNTAIN TOPOGRAPHY

EL FURRIAL 7 TO 11 BBOE



STRONGLY DISCORDANT PIRITAL-QUIRI-QUIRE THRUST



MAC-99-GO5 mig

Deep Test in Eastern Venezuela

- 1978 Lagoven, S.A., an affiliate of Petroleos de Venezuela, S.A., commenced an exploration program aimed at deeper targets on the northern flank of the Eastern Venezuelan basin. Here the shallow upper Tertiary section had been explored for more than eight decades.
- Quality of the seismic data acquired was sufficiently able to give indications of thrust faults with associated structures. By 1985 sufficient geologic surveying delineated the first prospect: El Furrial.
- Spud in **1986**, the FUL-1 discovery well, penetrated 276 m (905 ft) net oil sand, with porosities ranging from 11 to 16% within the Late Oligocene Naricual Formation and produced up to 7331 bbl of 26° API oil per day.
- Field delineated as approximately 12km long and 7km wide. Estimated OOIP was 6BBO. Became the largest single discovery of medium-gravity oil in the last 25 years in South America.
- The El Furrial discovery represents an excellent example of the prospectivity of a foreland overthrusted area and also an example of continued successful exploration to pursue deeper objectives in an area already considered mature.

Rodulfo Prieto, Gustavo Valdes 1992 **El Furrial Oil Field: A New Giant in an Old Basin**

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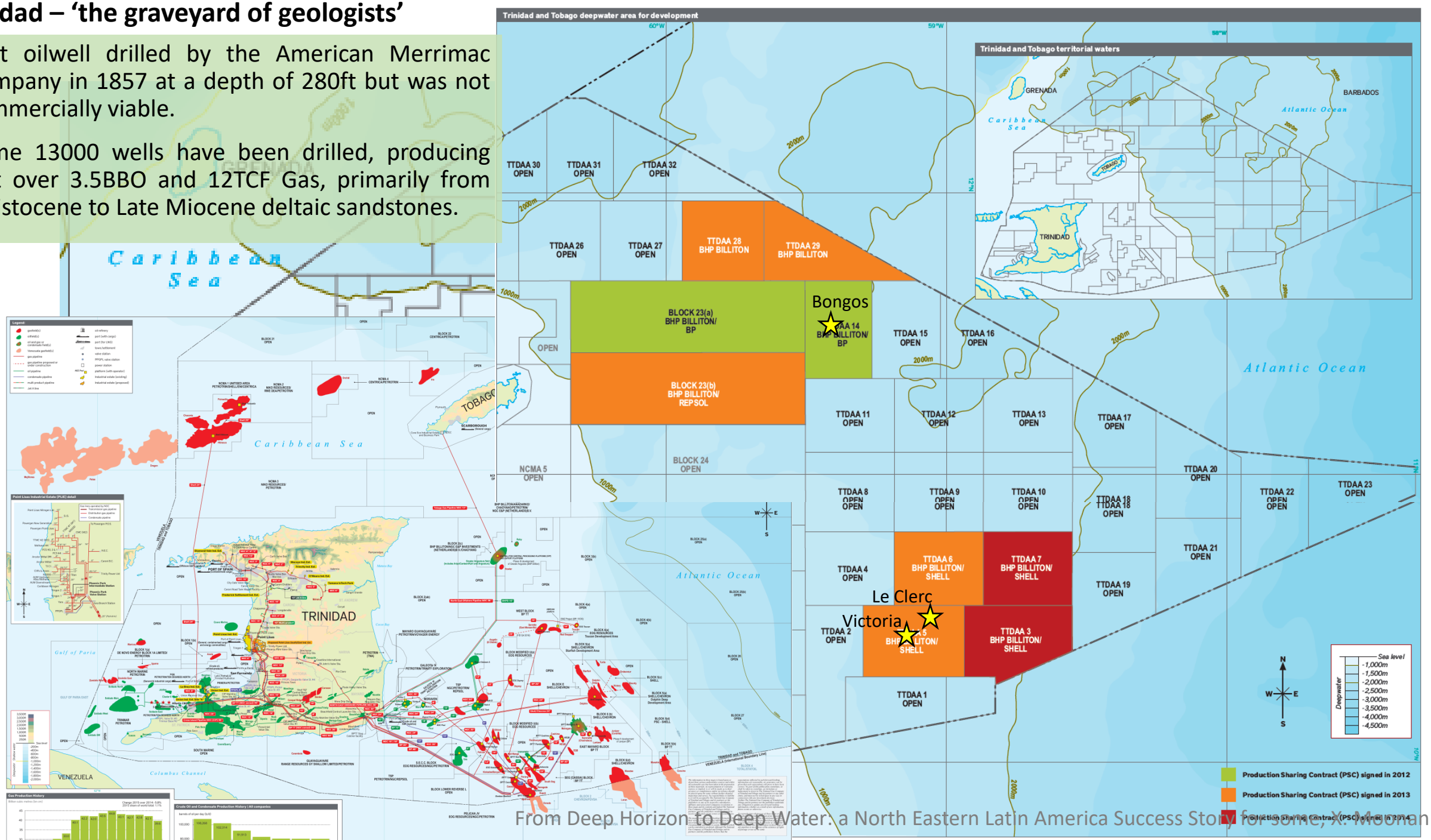
Trinidad – 'the graveyard of geologists'

- First oilwell drilled by the American Merrimac Company in 1857 at a depth of 280ft but was not commercially viable.
- Some 13000 wells have been drilled, producing just over 3.5BBO and 12TCF Gas, primarily from Pleistocene to Late Miocene deltaic sandstones.



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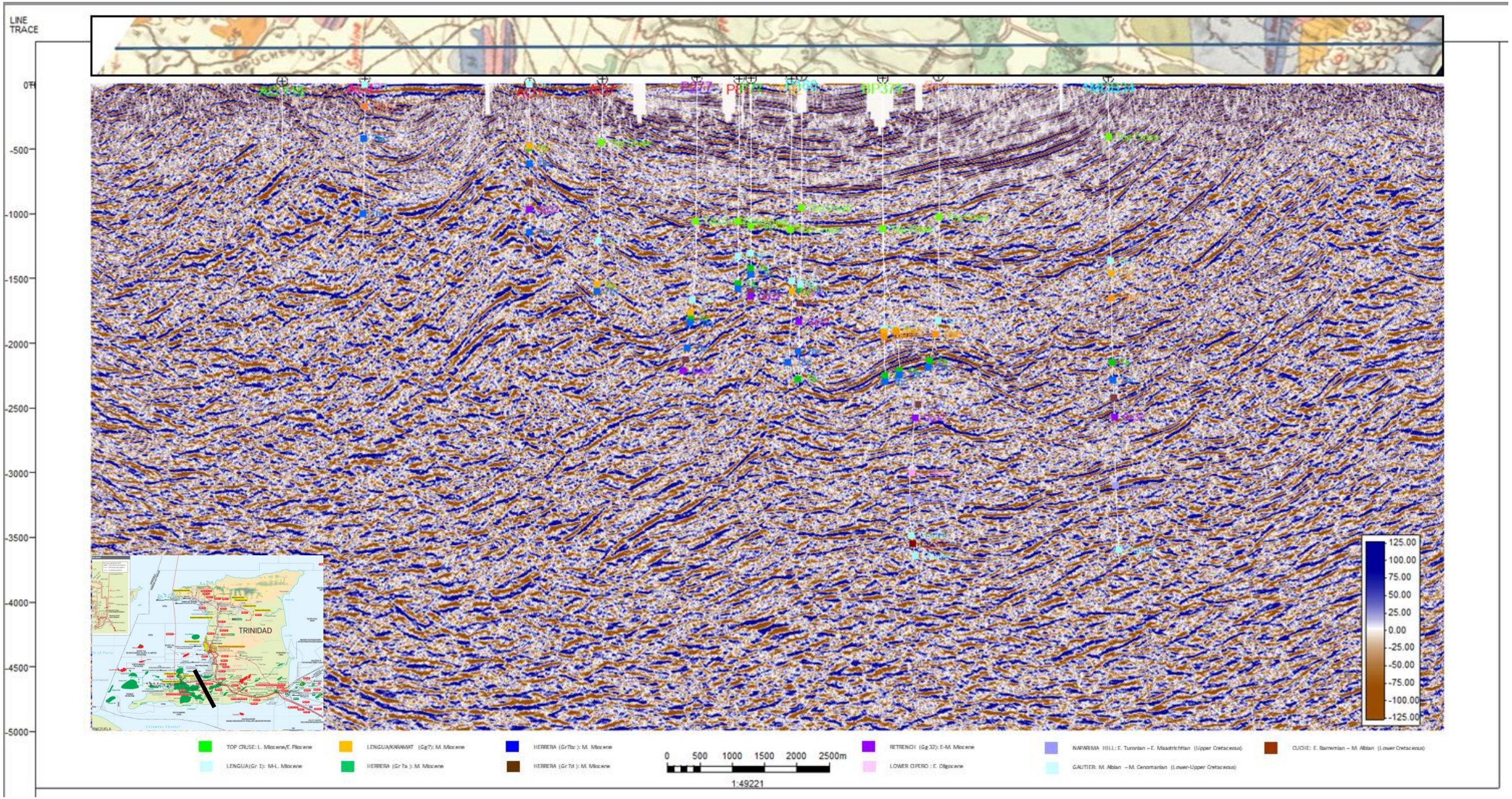
The imaging challenge – Onshore Southern Basin Consortium 2D Seismic Line TD91-177



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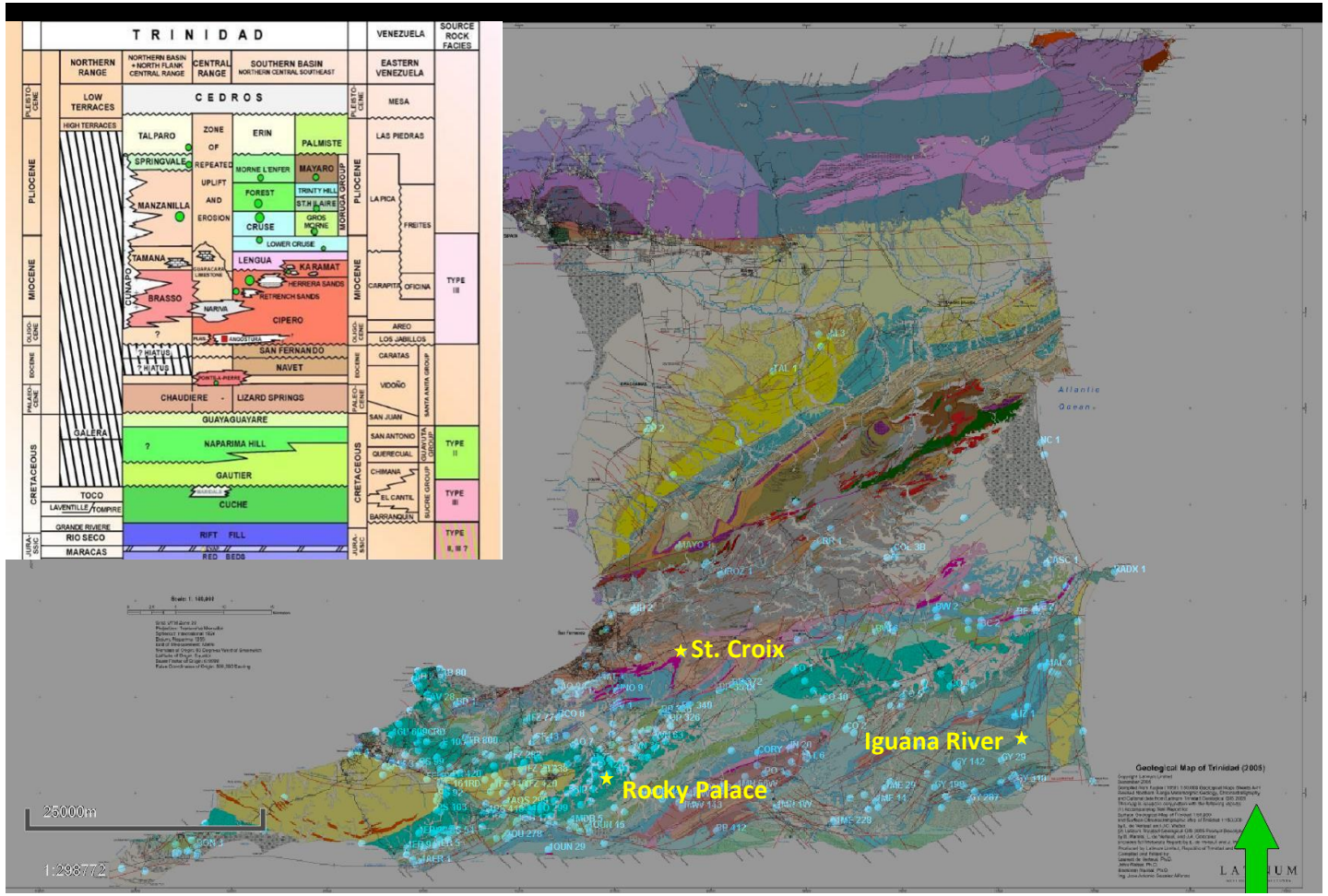
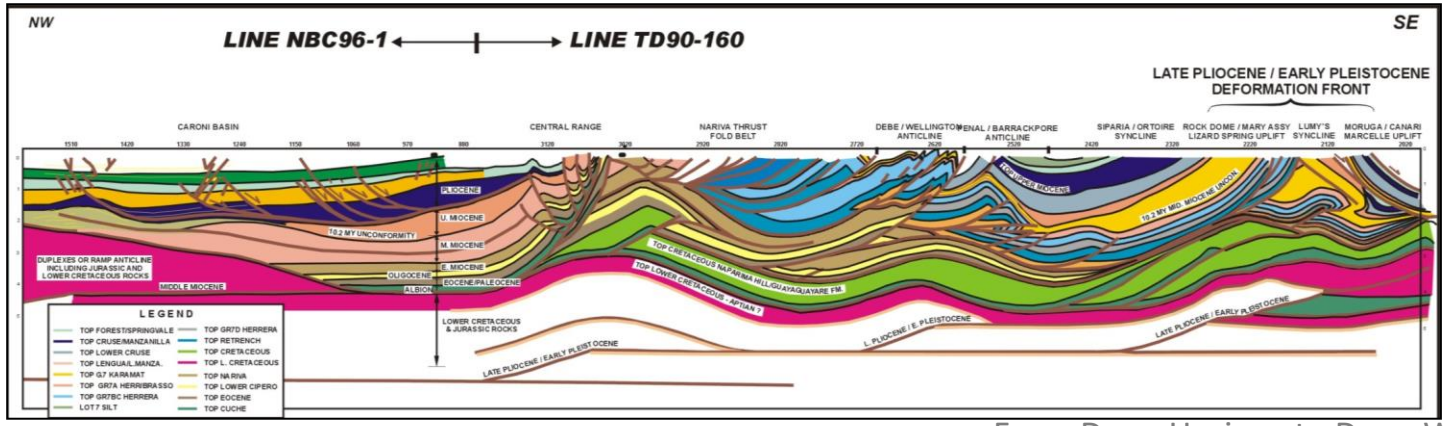
Southern Basin Consortium

- In **1989** Exxon, Total, Chevron, Trintoc and Trintopec come together to form the Southern Basin Consortium to explore the southern part of Trinidad for structures similar to El Furrial.
- Three wells were drilled onshore –St. Croix-1, Rocky Palace-1 and Iguana River-1. All wells tested Cretaceous fold structures.
- The wells penetrated Cretaceous sandstones, modeled by Exxon to be deep water turbidites, encased in shales.
- All sandstones demonstrated residual oils or sub-commercial accumulations.
- The St. Croix-1 well encountered Cretaceous shales that were mature. The shales at Rocky Palace-1 and Iguana River-1 were shown to be thermally immature as a potential source rock.





Leon Aden and Robert Bierley Exxon Exploration Company Houston USA; **Structural Development of the Southern Basin, Onshore Trinidad: Implications for Hydrocarbon Entrapment**

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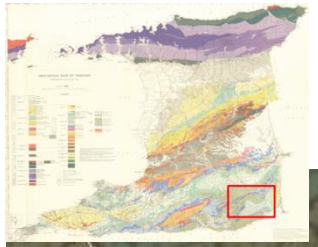
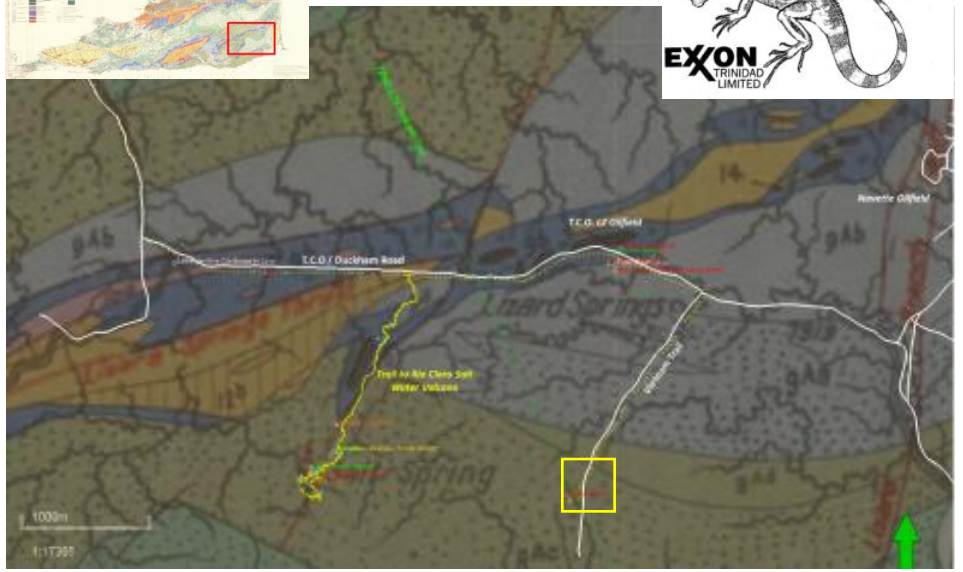
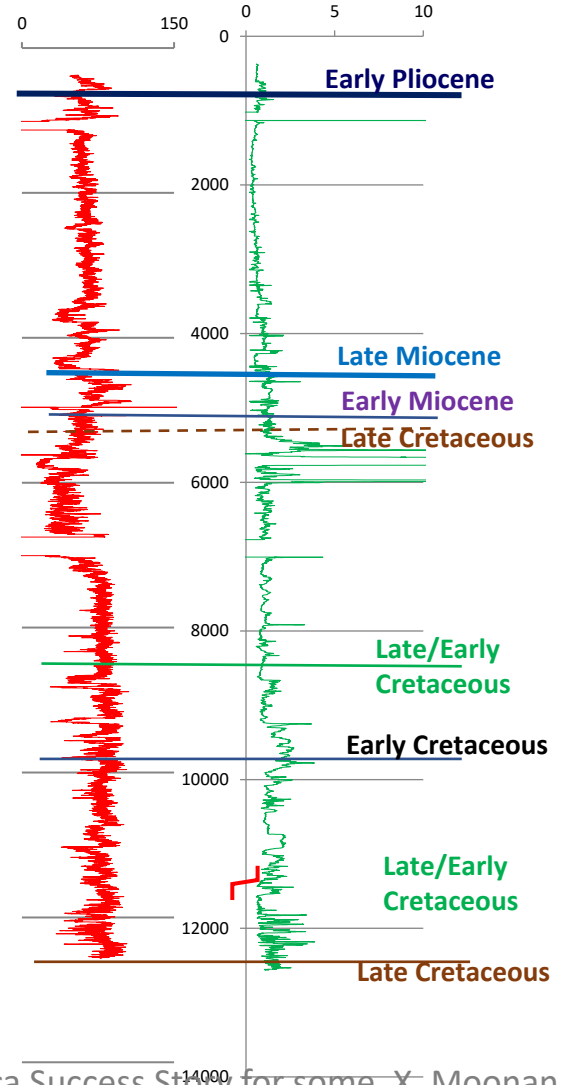
Iguana River-1 Exploration Well & Salt Spring





Spud : April 1st 1993
Drilling Completed : August 24th 1994
Drilling Rig : Helmerich and Payne 117
Drilling Days : 169.7
Cost : 13,150,000 USD

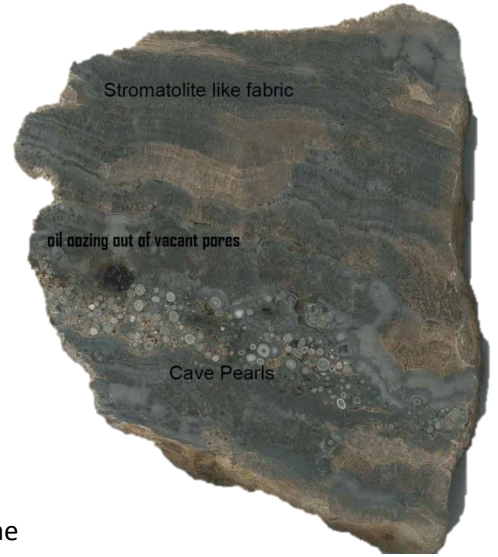


propagation folds that involved Cuche Formation. Two sandstone intervals were penetrated (9950'-10050' and 11408'-11512'). Trap leakage due to steeply dipping folds. The thrust penetrated at 11745' MD place the Gautier beneath the Cuche. The reoccurence of Cuche sands in the footwall (12630'-12762' MD) contain bitumen and probable water."

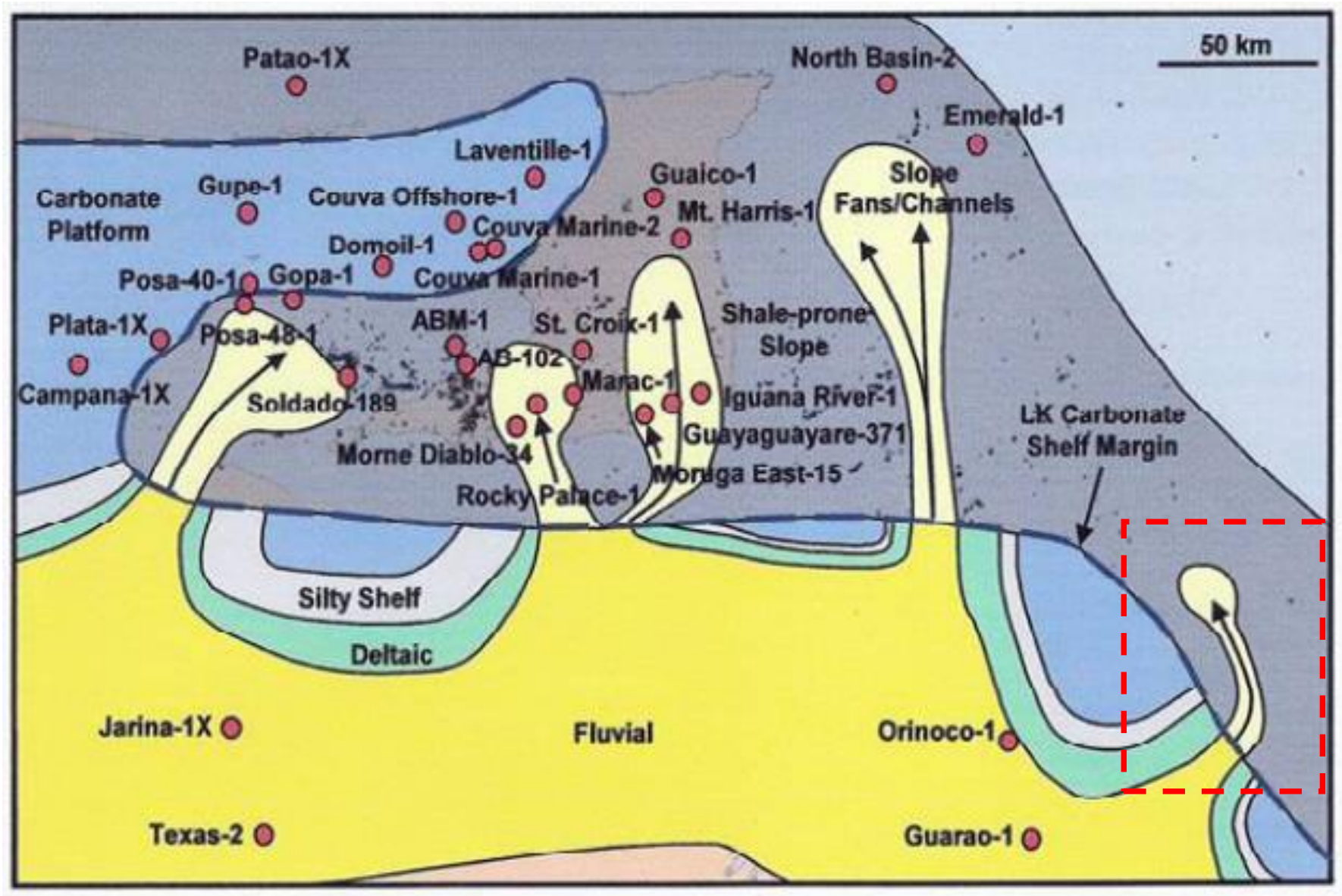
From Petrophysics

"From 9950'-9970' is normally considered indicative of hydrocarbon saturation but this same pattern is observed in the overlying shale and maybe a result of borehole damage. Four feet of core, all tight, were recovered in the interval. The core data was aligned to the wireline logs using the MWD logs. The maximum core porosity measured was 6.75pu. Measured grain densities ranged from 2.733 to 2.748 g/cc. The cores were described as limey. The high grain densities indicate a heavy carbonate cement rather than just calcite. There were no indications of hydrocarbons in the cores."

Limestone with crossbedded slity laminae



- Prior to SBC wells, most Cretaceous wells encountered shale with rare fracked shale oil and gas
- Exxon and partners proved that large deep water sand rich turbidite fans exist with possible shelfal limestones.
- One such ‘goldilocks area’ falls within the ‘crush zone’ in Trinidad.
- Seismic data was used primarily to identify structural traps.
- Though large structures were imaged, when tested these anticlines appear to have undergone multiple stages of folding and extension due to the ever changing dominant stress regime, resulting in breached seals.
- In **1996** Exxon relinquished their blocks and exited Trinidad and Tobago



Albian paleogeography, North Eastern Latin America

R. N. Erlich, T. Villamil, J. Keens-Dumas

Controls on the Deposition of Upper Cretaceous Organic Carbon–rich Rocks from Costa Rica to Suriname (2005)

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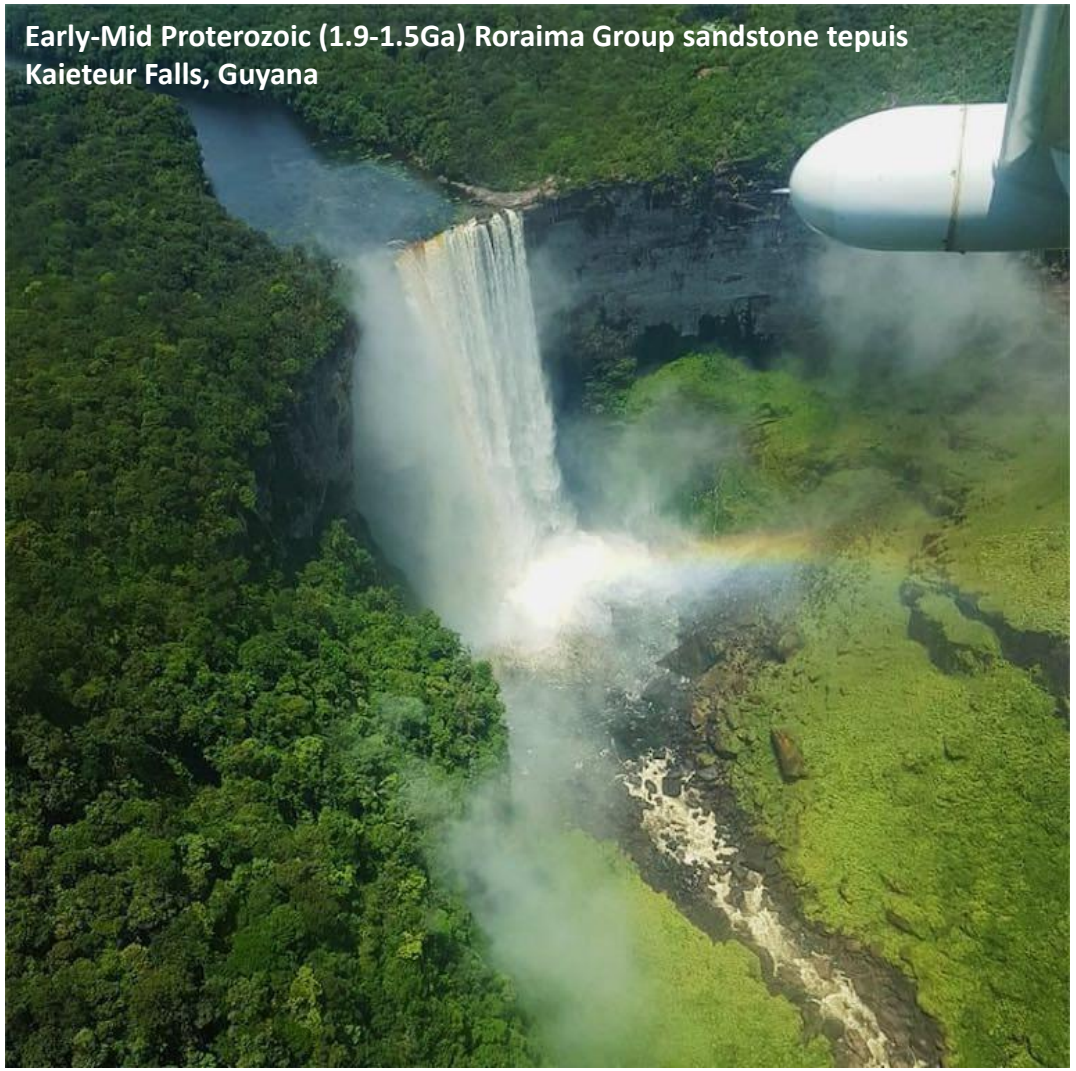
Early Exploration in Guyana & Suriname



Early-Mid Proterozoic (1.9-1.5Ga) Roraima Group sandstone tepuis
Kaieteur Falls, Guyana

Mid Proterozoic (2.1-1.9Ga) Armina Fm metasedimentary greenshcist inselbergs
Voltzberg, Suriname

Guiana Basin

- In **1996** Exxon relinquished their blocks and exited Trinidad and Tobago. In **1997** Exxon acquired the Stabroek Block, offshore Guyana.
- Guiana Basin spans Guyana and Suriname with small extensions in Venezuela and French Guiana (Stolte, 2013).
- The Guyana Basin (120,000 sq km) is part of the larger Guiana Basin, and is bounded by Demerara Plateau to the South, Pomeroon Arch to the North, coastal Guyana and extends approx. 400km offshore. Pomeroon Arch is the structural high separating Eastern Venezuelan Basin and Guiana Basin.
- The United States Geological Survey (USGS) ranks the Guiana Basin 2nd in the world for prospectivity among the world's unexplored basins and 12th for oil among all the world's basins – explored and unexplored. The mean (P50) undiscovered resource potential is estimated at 15.2 billion bbls

(World Petroleum Assessment, 2000.)

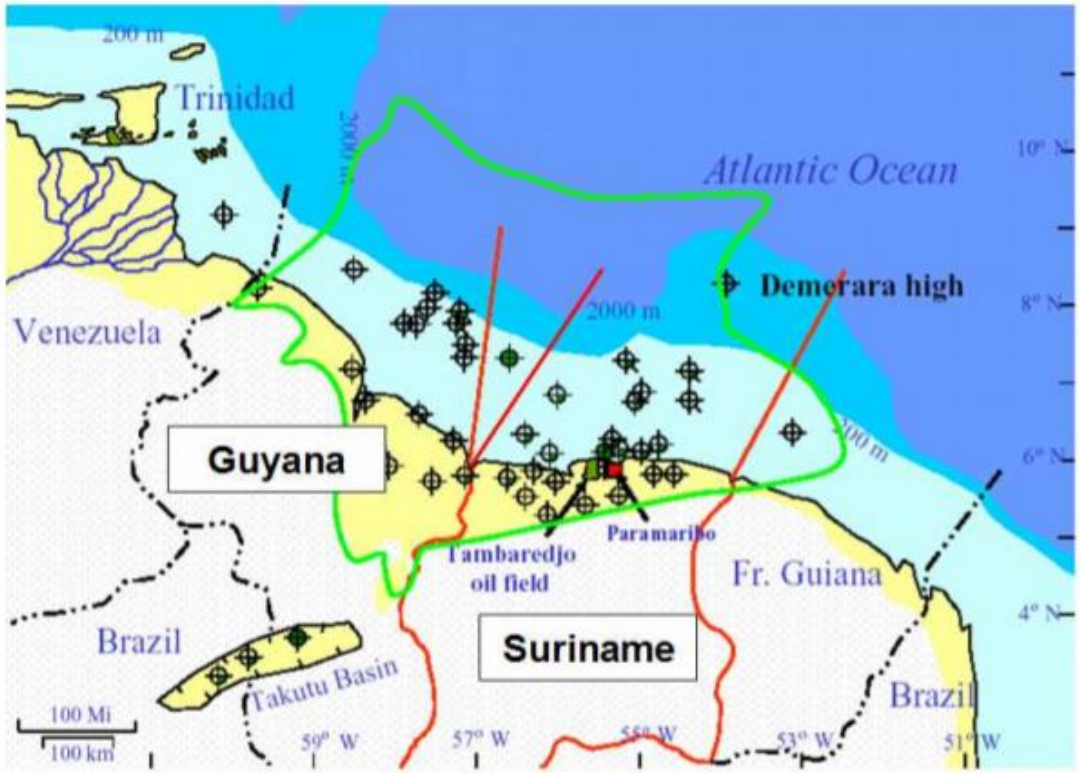
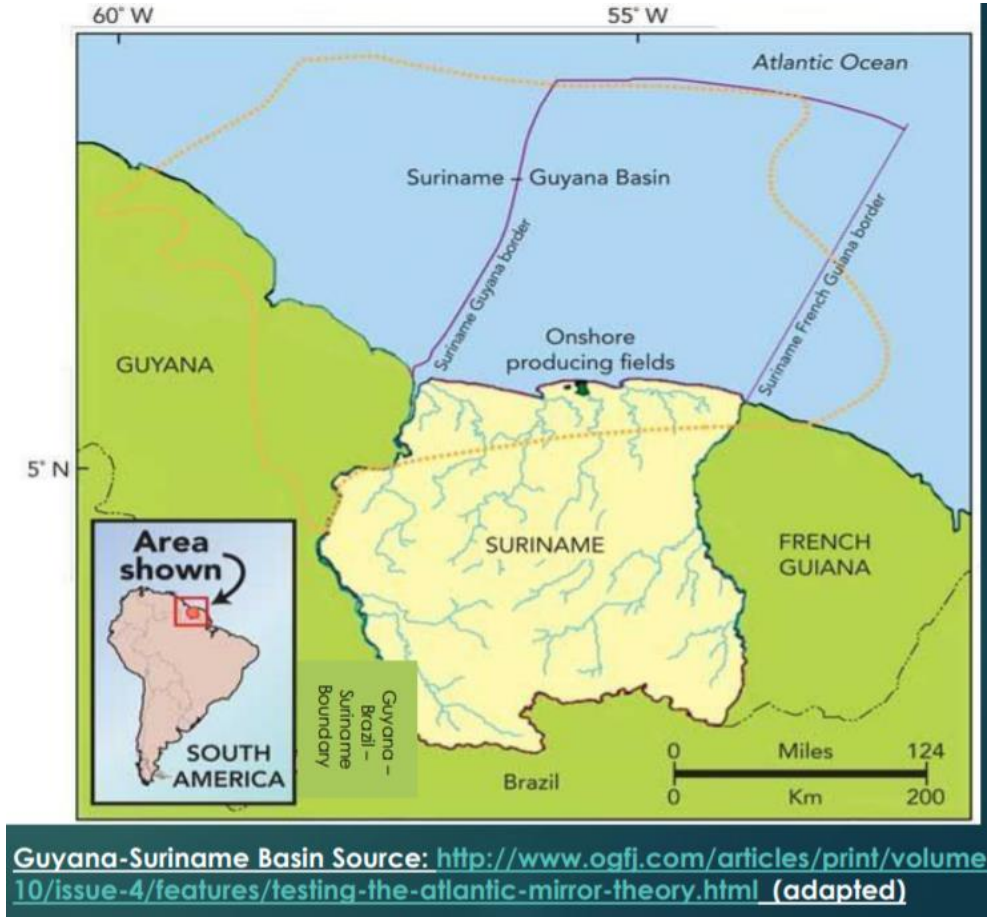


Figure 1: Outline of Guyana-Suriname Basin and petroleum occurrences



Guyana-Suriname Basin Source: http://www.ogfj.com/articles/print/volume 10/issue-4/features/testing-the-atlantic-mirror-theory.html (adapted)

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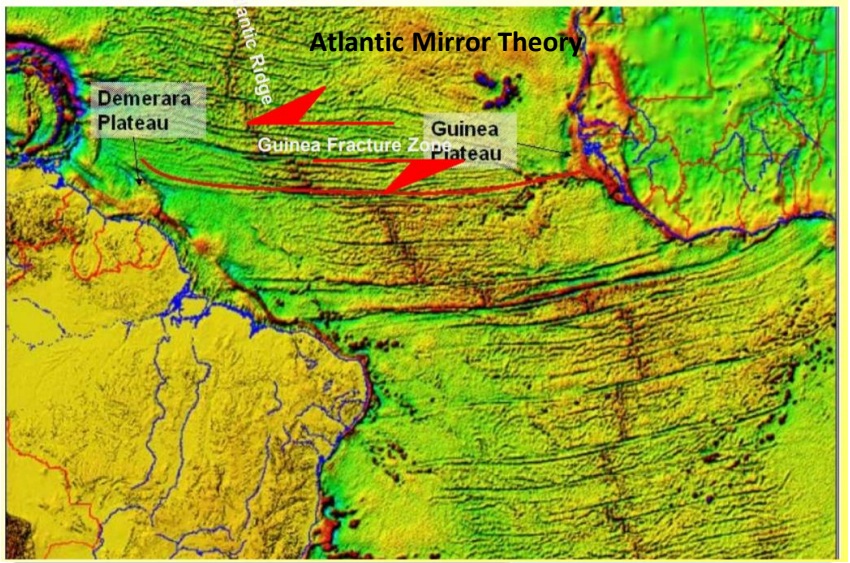
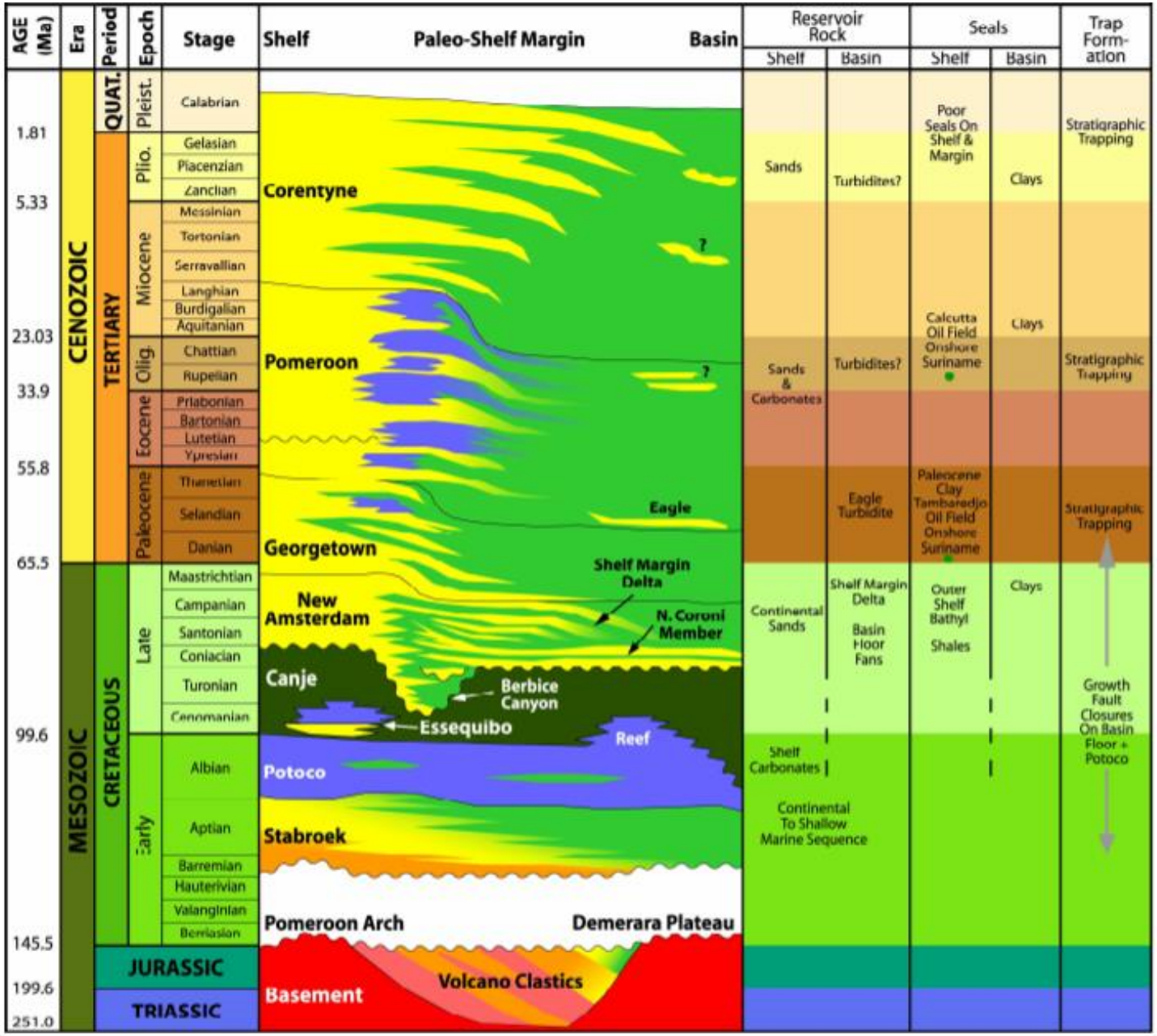
Guyana /Suriname Stratigraphy

- During the break-up commencing in the Jurassic and progressing through the Cretaceous, Africa and South America drifted along transform fault boundaries resulting in the evolution of the Guyana-Suriname basin.
- Initially, there was a thick deposition of Jurassic to Early Cretaceous sediments
- Subsequently, a thick succession of Late Cretaceous to Recent sedimentary rock in depositional environments ranging from near coastal to deep-marine in which there were intervals of carbonates.
- It is generally referred to as a passive margin basin.



Guiana Basin



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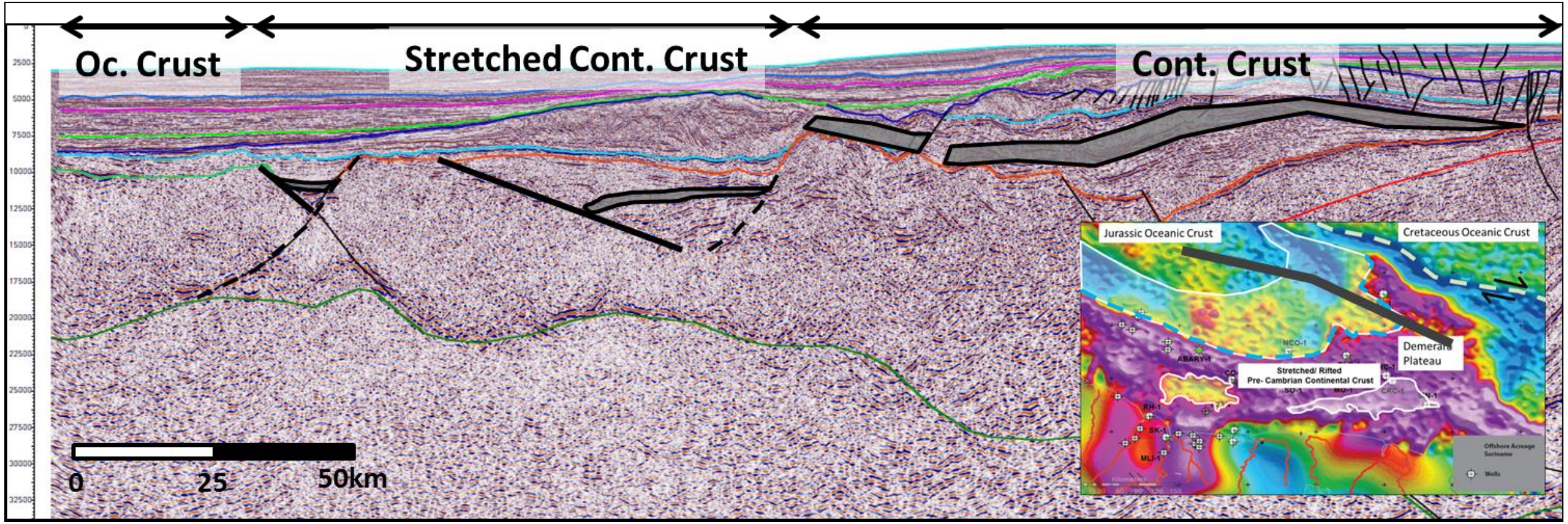
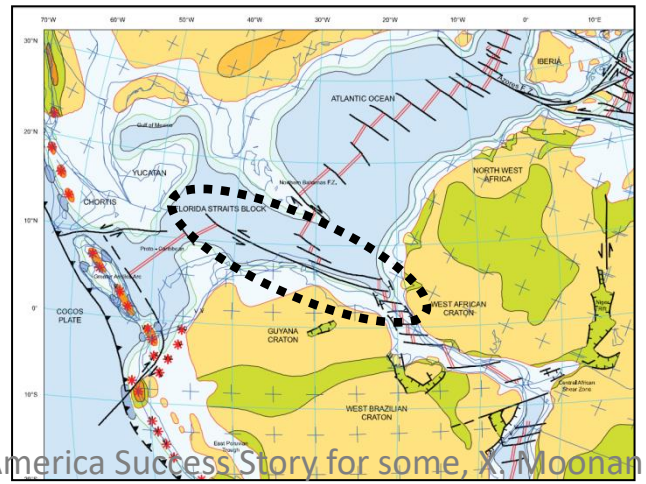
Challenges – Basin Age, Fill, Source Rock Potential and Migration Focusing



- Guiana Basin evolved on heavily attenuated / stretched Pre-Cambrian Continental Crust and Jurassic Oceanic Crust primarily due to the northwestward step over along the Guyana Transform Fault resulting in the zig-zag opening and formation of the Proto-Caribbean seaway
- Decreased differential stretching from E-W together with the associated NW-SE trending transfer faults resulted in a serrated northern margin of South America due to changes from normal to attenuated continental crust from south to north, with an east facing cascading effect along the northern margin of South America. As such, Trinidad and Guyana in particular were placed in a more basinward position/deepwater setting when compared to the rest of the Present Day north eastern margin of South America .



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Offshore Guyana Drilling History

Sources: various published reports

Year	Well	Operator	TD (ft)	Results
1967	Guyana Offshore-1	Tenneco	8930ft	Gas shows
1967	Guyana Offshore-2	Tenneco	7600ft	Minor Gas Shows
1971	Berbice-1	Shell	12,500ft	Oil Shows
1971	Berbice-2	Shell	10,000ft	Gas Shows
1974	Mahaica-1	Shell	8,000ft	no shows
1974	Essequibo-1	Deminex	11,200ft	Oil Shows
1975	Abary-1	Shell	13,000ft	37 API oil flowed
1976	Mahaica-2	Shell	7,500ft	No Shows
1977	Essequibo-2	Deminex	13,000ft	Oil and gas Shows
1992	Arapaima-1	Total	11,090ft	Minor Gas Shows
2000	Horseshoe-1	CGX	12,750ft	No Shows
2012	Eagle-1	CGX	13,500ft	Oil and Gas Shows
2012	Jaguar-1	Repsol	15,600ft	Light Oil recovered, HPHT Well
2015	Liza-1	ExxonMobil	17,825ft	Major Oil Discovery

NB. 1st onshore well in 1916

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Guyana Shelf to Deepwater success/failures

dry gas shows oil discovery

oil shows oil & gas shows

1967, Conoco/Tenneco drilled GO #1 well which encountered gas shows. The second, GO #2, had minor gas shows. Shelf sands target.

1971, Shell/Conoco drilled Berbice#1 which was abandoned due to drilling problems after a gas kick at 7,124 ft. Berbice#2 was drilled, finding only minor gas shows and oil stains.

1974, Shell drilled Mahaica#1, abandoned dry. Turbidite sands and limestone targets.

1974, Deminex drilled Essequibo #1 which had several oil shows

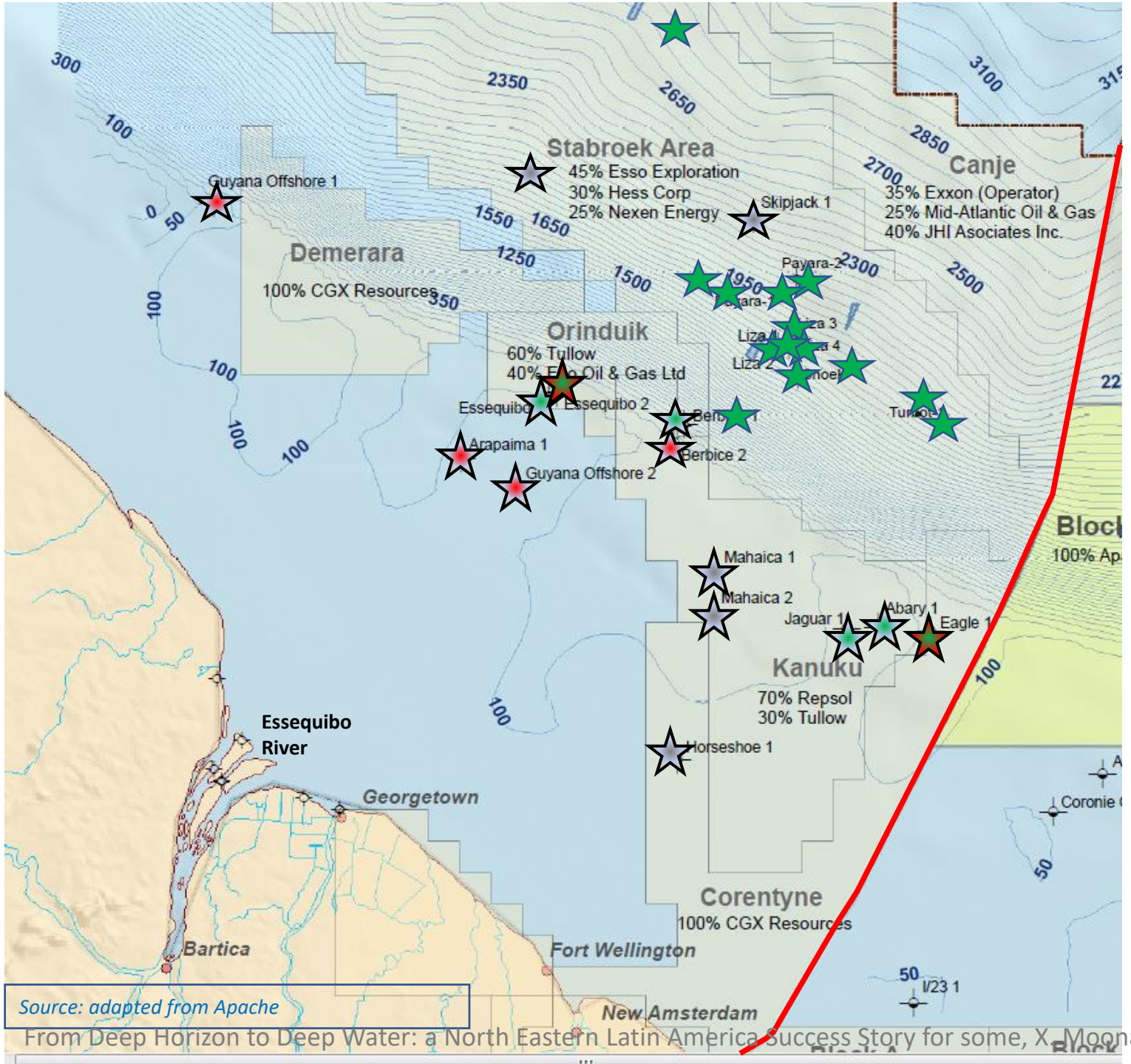
1975 Abary#1 was drilled in the deepest part of Shell's OPL in the offshore basin. It kicked violently at 13,091 ft. Turbidite target.

1976, Shell drilled Mahaica#2, also abandoned dry. Turbidite sands and limestone targets.

1977, Deminex drilled Essequibo #2, oil and minor gas shows. Turbidite sands and limestone targets

1991, TOTAL/PETREL/GEL drilled the Arapaima-1 offshore well. Limestone and sands target

2000, CGX rig was driven off the Eagle site by Suriname warships. Horseshow was spud instead. 2012 Eagle was spud.



Source: adapted from Apache

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Fun Fact:  was originally partnered with Exxon in the Stabroek Block but pulled out around 2012. This forced Exxon and the government to seek out other partners, paving the way for Hess and Nexen.

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Operators

- CGX
- Anadarko
- Exxon
- Tullow
- Repsol

Roraima:
100% Anadarko

Kaieteur:
35% Exxon
15% Hess
25% Ratio Oil
25% Cataleya Energy Ltd

Stabroek:
45% Exxon
30% Hess
25% Nexen

Canje:
35% Exxon
35% Total
30% Mid Atlantic Oil and Gas + JHI Associates Inc

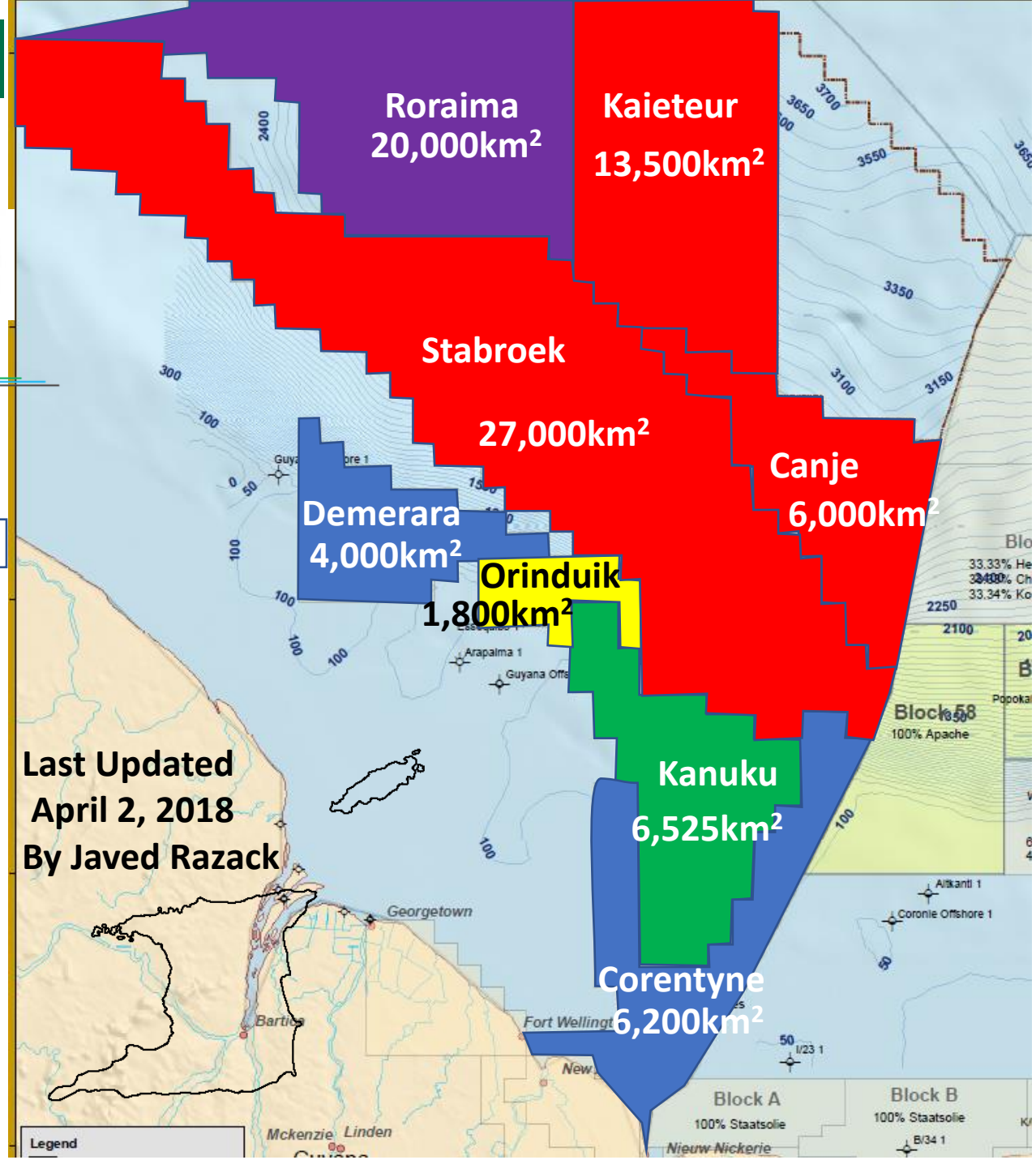
Demerara:
100% CGX

Orinduik:
60% Tullow
25% Total*
15% Eco Oil and Gas Ltd

Kanuku:
37.5% Repsol
37.5% Tullow
25% Total

Corentyne:
100% CGX

Source: adapted from Apache



Operators

- Apache
- Exxon
- Petronas
- Tullow
- Kosmos
- Equinor (Statoil)
- Cairn
- Staatsolie

Block 59:
33.3% Exxon
33.3% Hess
33.3% Equinor

Block 42:
33.3% Kosmos
33.3% Hess
33.3% Chevron

Block 48:
100% Petronas

Block 47:
80% Tullow
20% Ratio Oil

Block 45:
50% Kosmos
50% Chevron

Block 54:
30% Tullow
50% Equinor
20% Noble

Block 60:
100%
Equinor

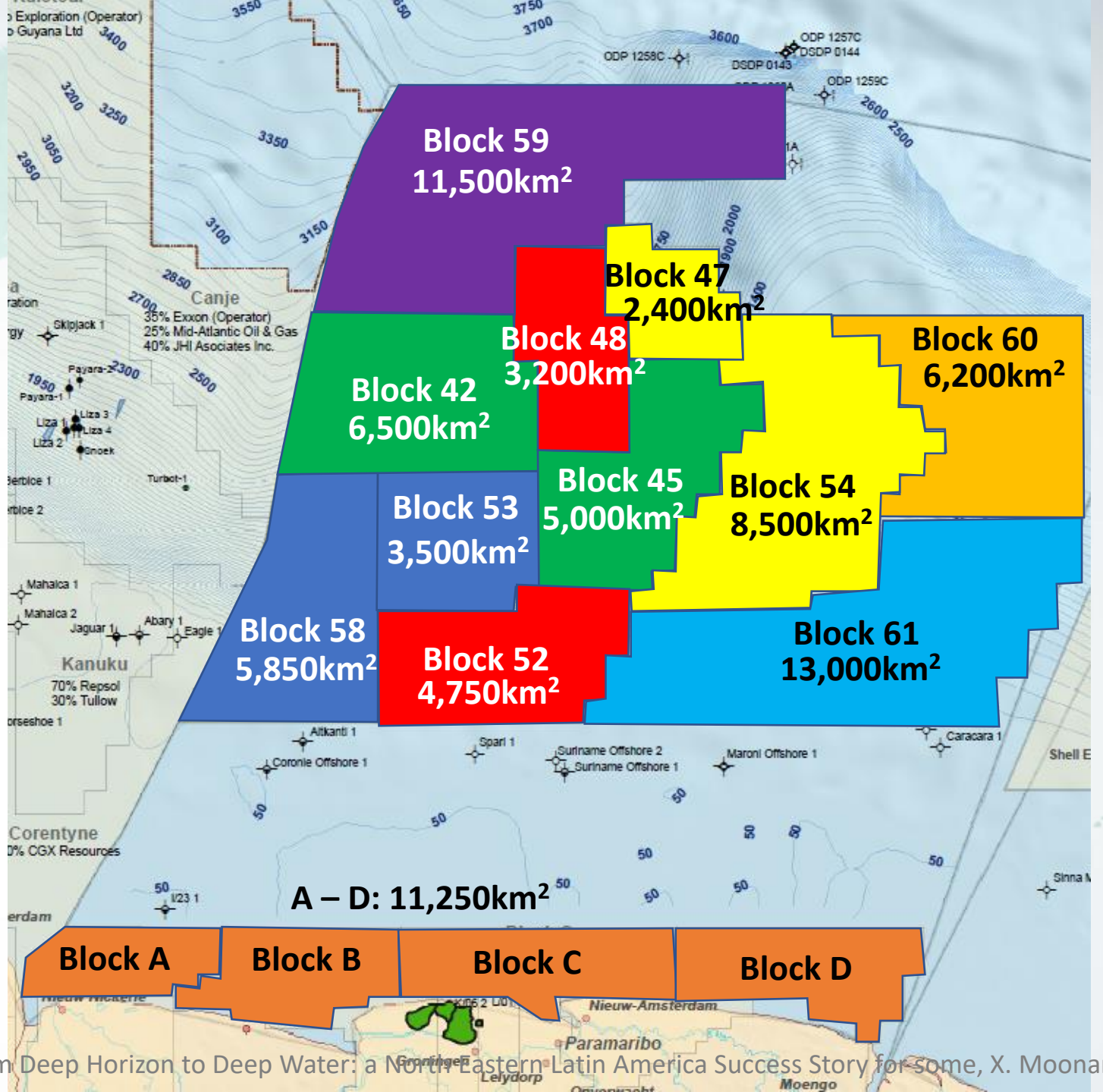
Block 58:
100% Apache

Block 53:
45% Apache
25% Cepsa
30% Petronas

Block 52:
100%
Petronas

Block 61:
100%
Cairn

Blocks A, B, C, D
100%
Staatsolie



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Suriname Recent Shelf to Deepwater success/failures

dry

gas shows

oil discovery

oil shows

oil & gas shows

2008, Noble Energy drilled West Tapir-1 in Block 52 – dry hole

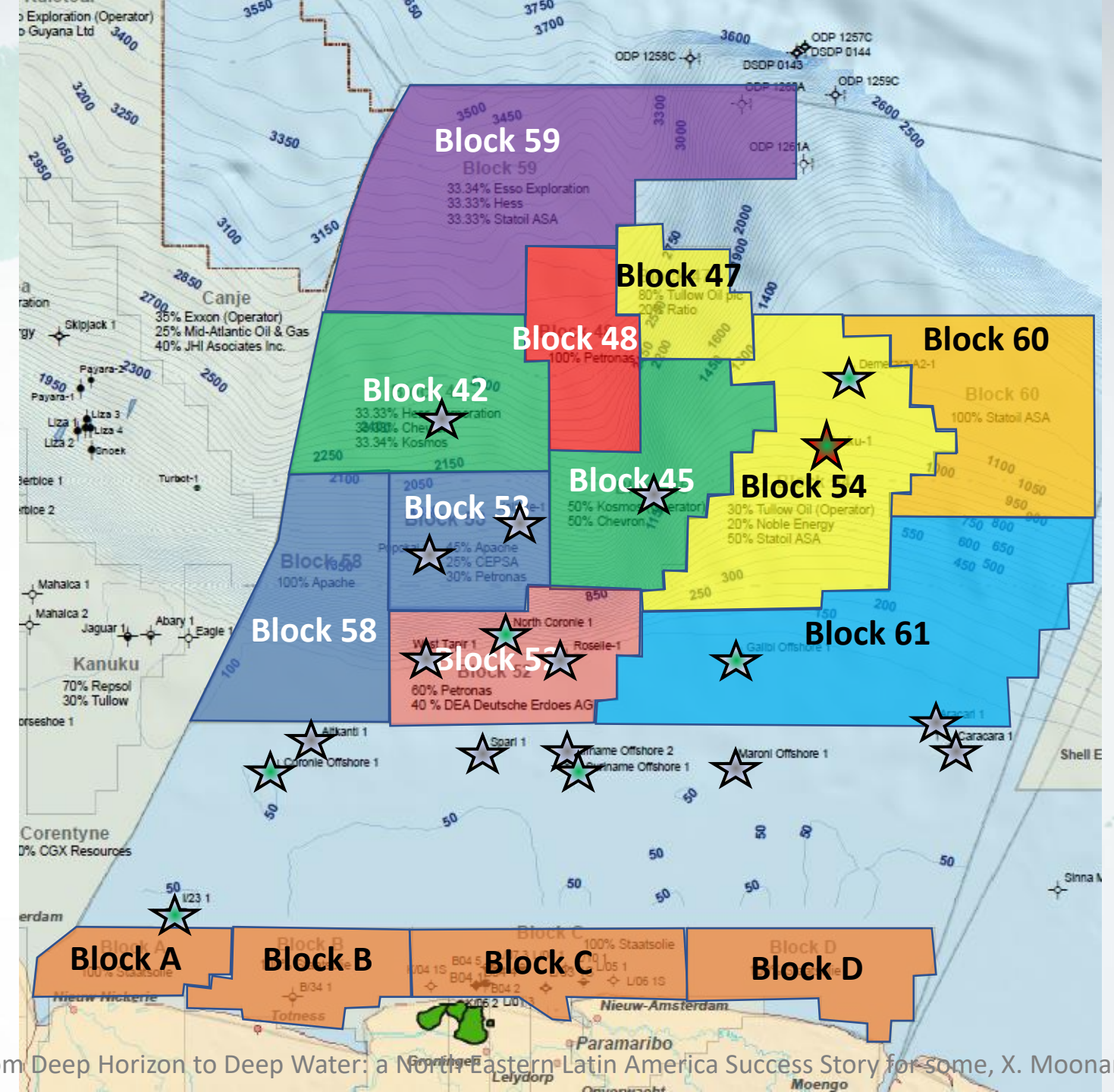
2011, Murphy Oil drilled Aracari-1 and Caracara-1 near Block 61 – dry hole
2011, Inpex drilled Aitkanti-1 near Block 58 – dry hole

2015, Inpex drilled Spari-1 in Block 31 – dry hole
2015, Apache drilled Popokai-1 in Block 53 – dry hole

2016, Petronas drilled Roselle-1 in Block 52 – dry hole

2017, Apache drilled Kolibrie-1 in Block 53 – dry hole
2017, Tullow drilled Araku-1 in Block 54 (2017) – shows of gas and condensate.

2018, Kosmos drilled Anapai-1 and Anapai-1A in Block 45 – dry hole.
2018 Kosmos drilled Pontoenoe-1 in Block 42 – dry hole.



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Suriname – What's Next?

dry
gas shows
oil discovery
oil shows
oil & gas shows

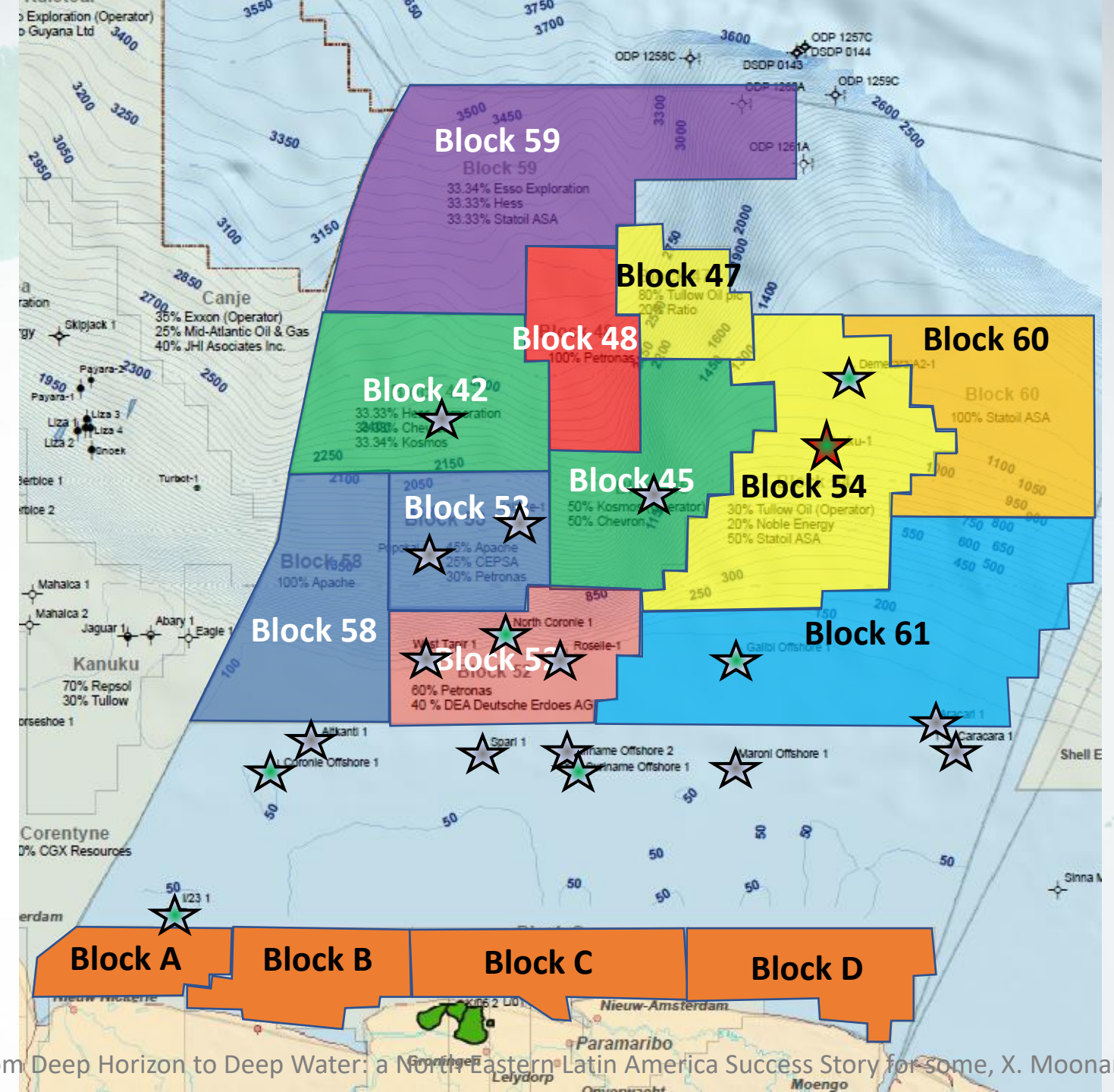
Tullow to drill in Block 47. 2019? 2020?

Petronas and Equinor conducted 3D seismic in 2017/2018 in blocks 48 and 60. Drilling to occur in late 2019 or 2020?

Cairn signed Block 61 in 2018. 2D seismic to occur in 2019.

Staatsolie to drill at least 10 nearshore wells in Blocks A, B, C, D in 2019 to 2020.

Exxon to conduct 3D seismic in Block 59. Late 2018? 2019?
Apache to drill in Block 58 in 2019.



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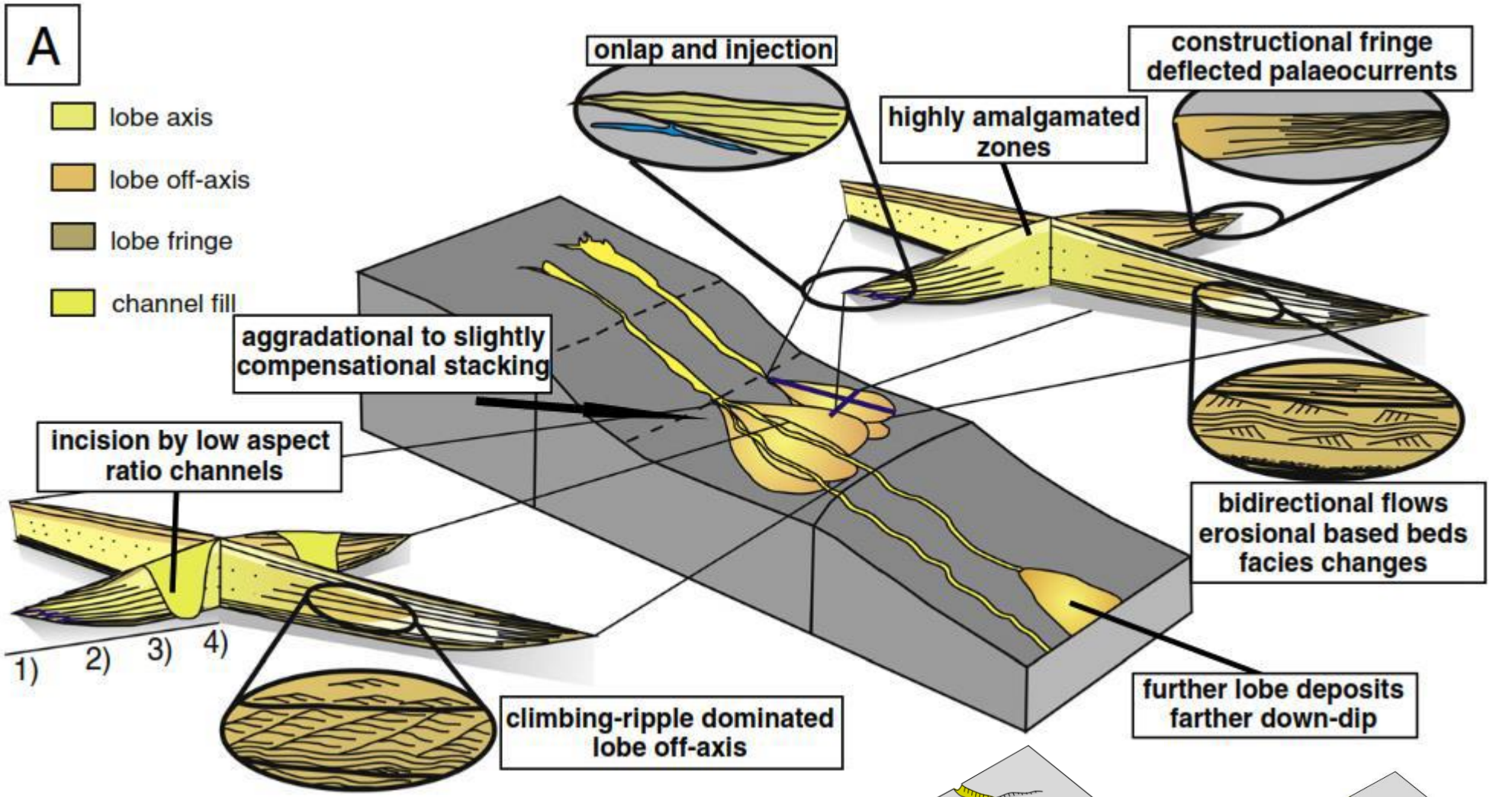
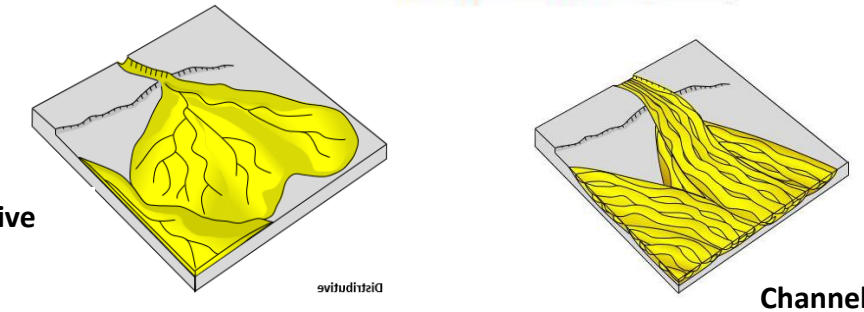
Recap - Petroleum System

- **Source** - Cenomanian to Turonian aged Canje Formation (U. Cretaceous). Equivalent of Naparima Hill (Trinidad), La Luna (Venezuela), Saramacca (Suriname). ~500m thick, Type II Marine, TOC 4 – 7%. Possible Jurassic aged Source Rock in parts.
- **Traps** – stratigraphic (turbidites pinching out, shale top seal, show up as bright amplitudes). NB. Only 15% of exploration wells in last 10 years globally have targeted stratigraphic traps (Zanella, 2017)
- **Reservoirs** - main reservoir targets are Upper Cretaceous and Lower Tertiary basin floor fans, shelf-margin deposits and turbidites directly overlying the source rock. Mainly sandstone reservoirs (New Amsterdam and Georgetown Fm) but now carbonate reservoirs of commercial volumes have been discovered (Ranger-1)
- **Seals** – deep marine shales at multiple levels
- **Migration Pathways** – along stratigraphy; by fracturing of reservoir rock above source; along faults.
- **Timing** – migration must occur after reservoir, trap and seal are in place.





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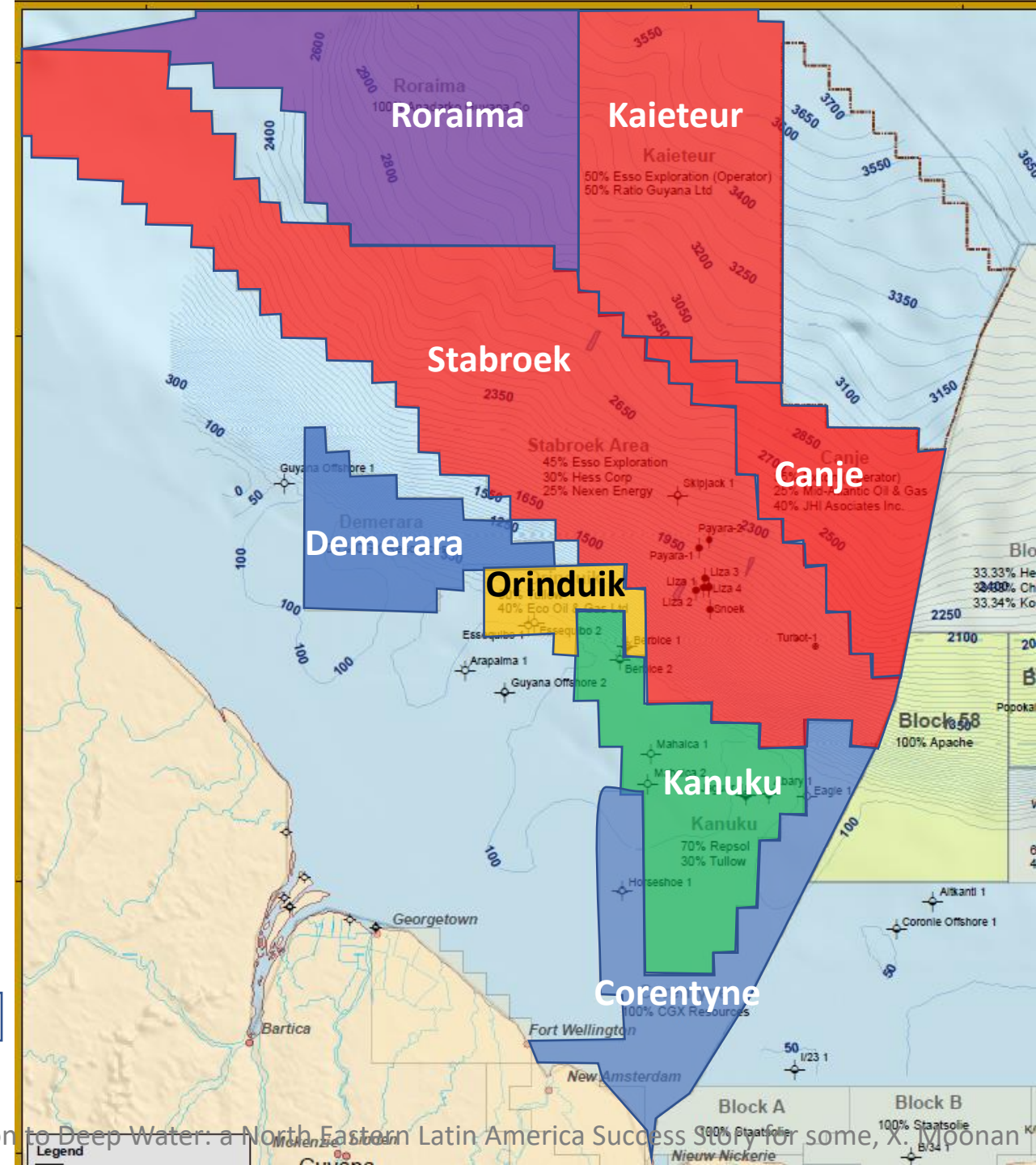
Recent 3D Seismic surveys in Guyana

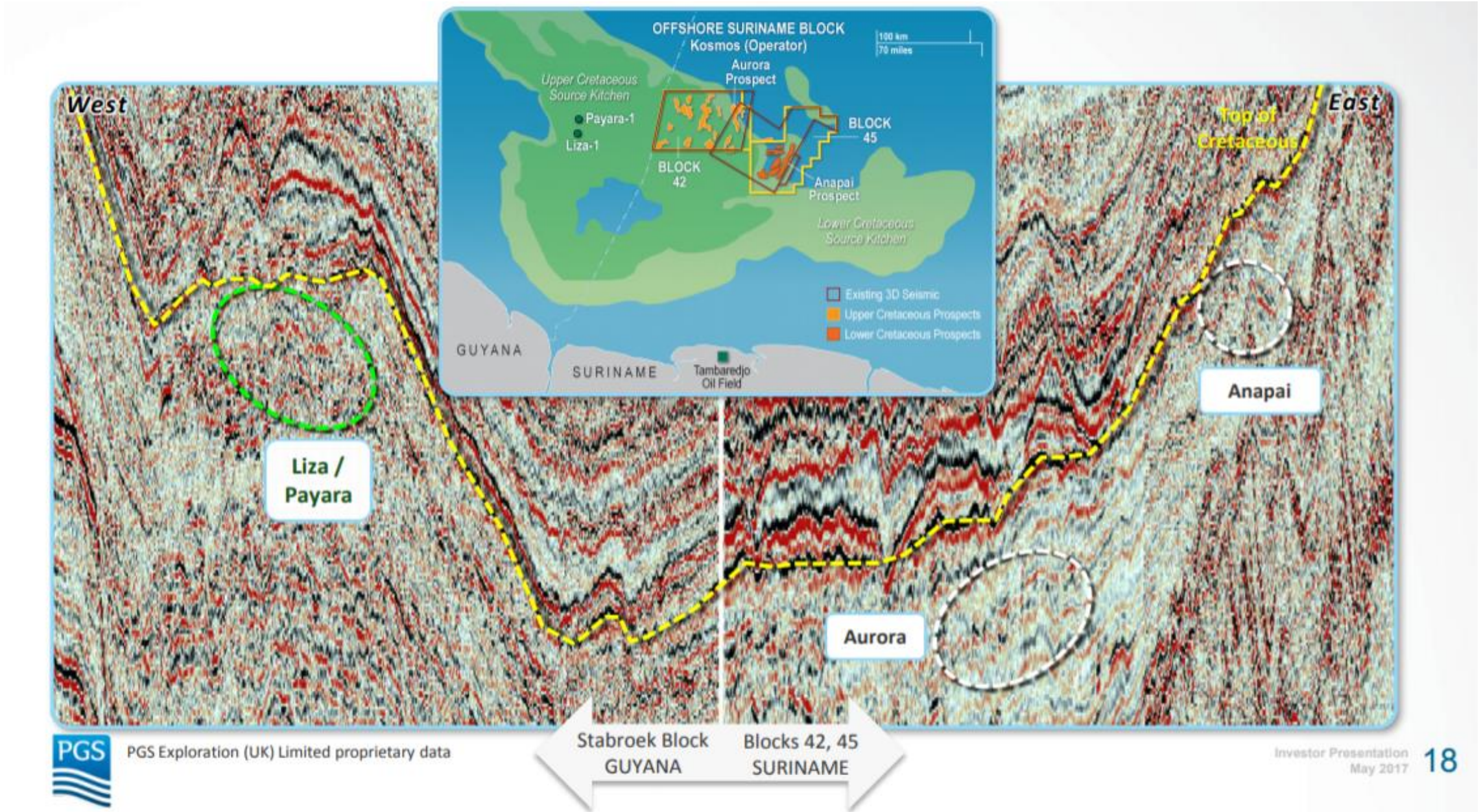
- image it and image it better

- CGX - Corentyne (PGS 2012 3D) – 1160 sq km
- Exxon – Stabroek (CGG 2013 3D) – 17,000 sq km*
- Exxon – Canje (Polarcus 2016 3D) – 7760 sq km
- Exxon – Stabroek (PGS 2017 4D) – 2200 sq km
- Exxon – Kaieteur (Polarcus 2017 3D) – 5700 sq km
- Repsol – Kanuku (WesternGeco 2017 3D) – 4000 sq km
- Tullow – Orinduik (WesternGeco 2017 3D) – 2500 sq km

*Anadarko – In 2013, MV Teknik Perdana was conducting a geotechnical survey in the Roraima Block and was Impounded by the Venezuelan Navy. The crew of 36 was detained and later released. Anadarko had a 2D survey planned later in 2013. No activity since. Border dispute Referred to UN.

Source: adapted from Apache





J.Razack, Sep 2018

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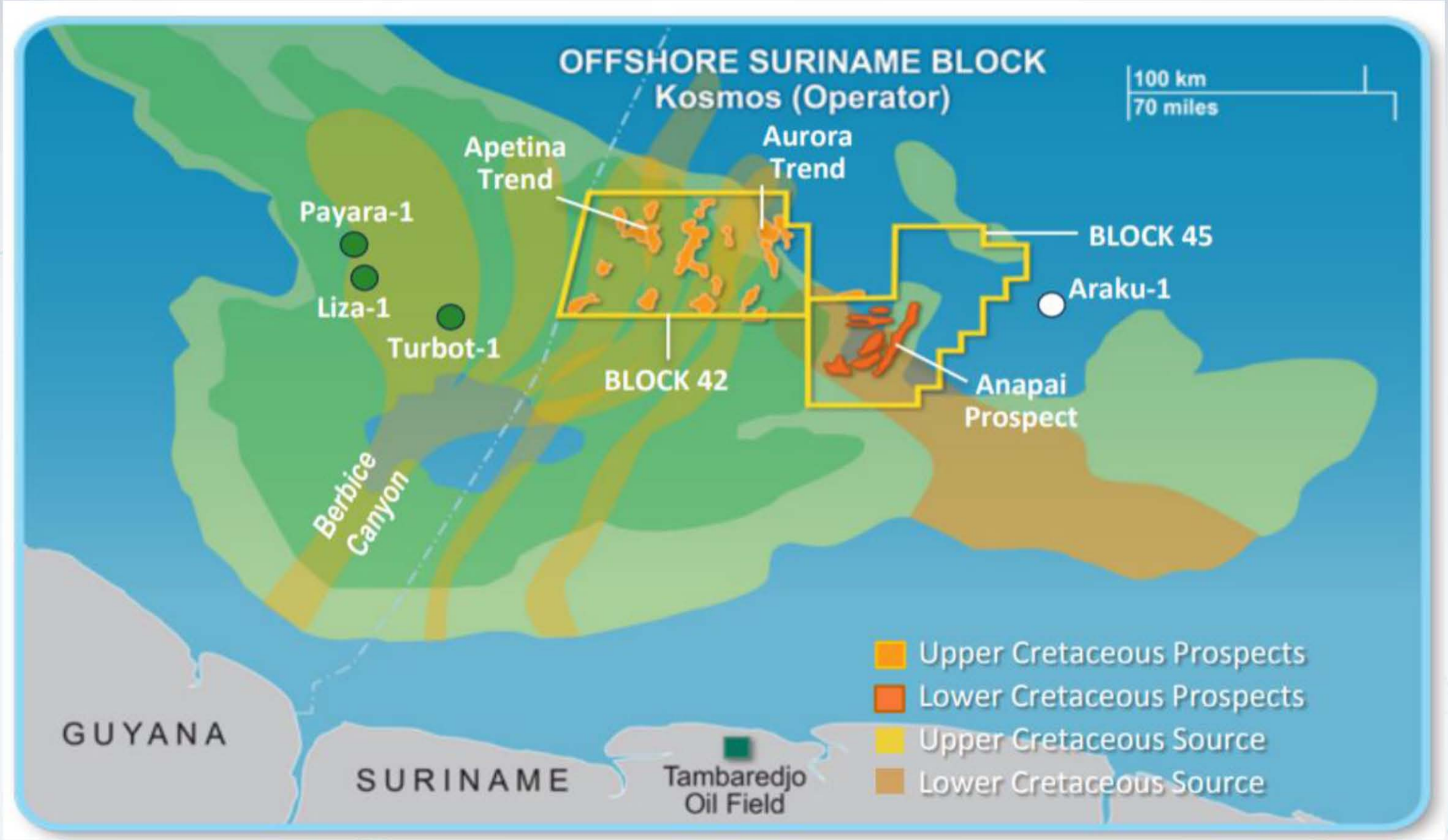

http://investors.kosmosenergy.com

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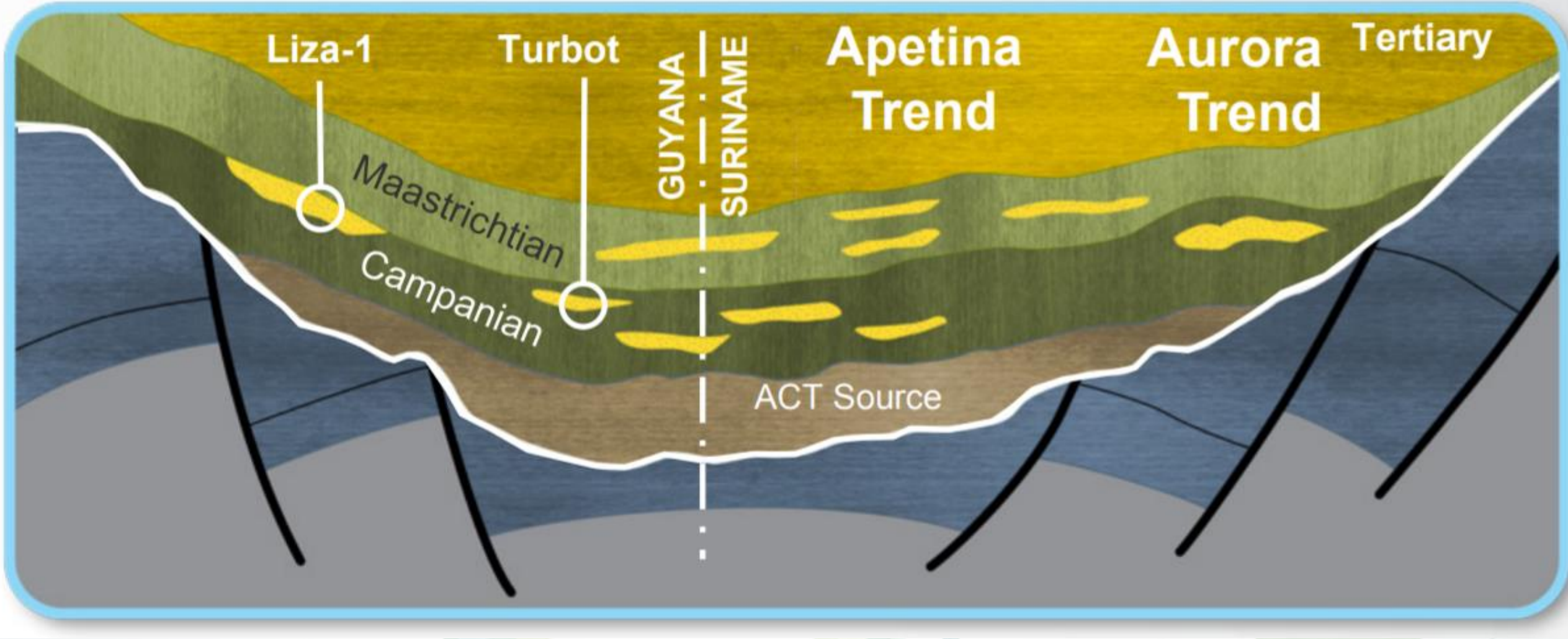

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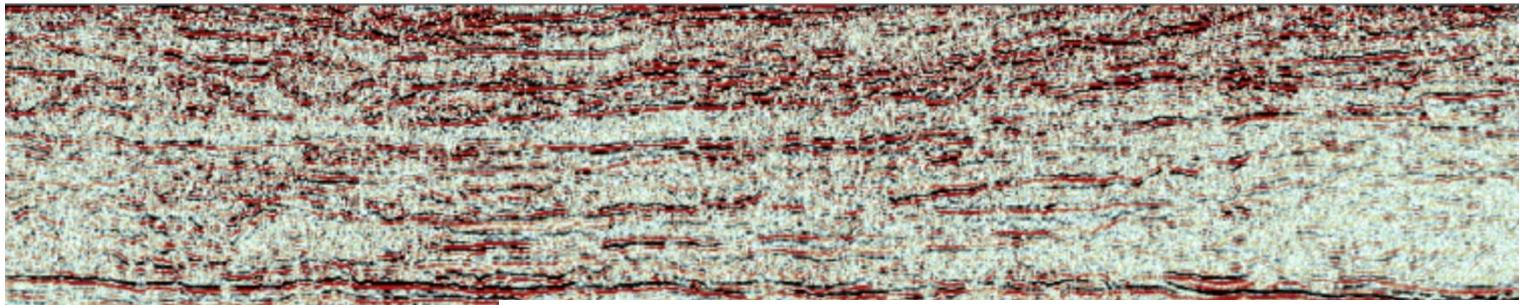
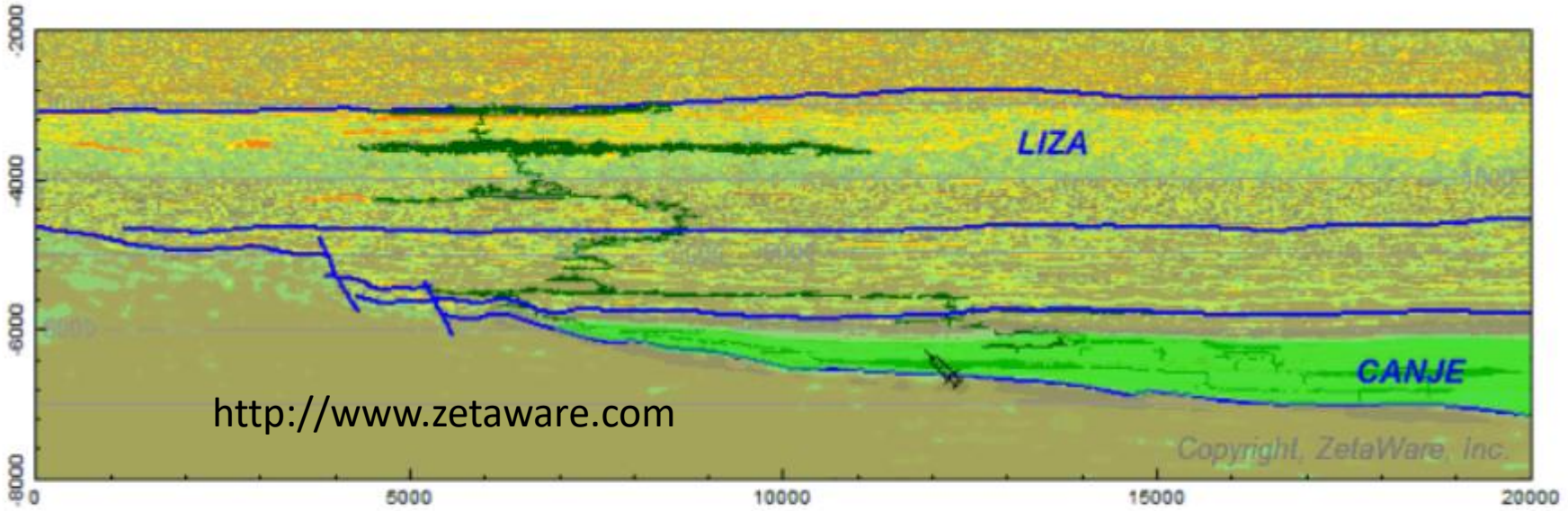
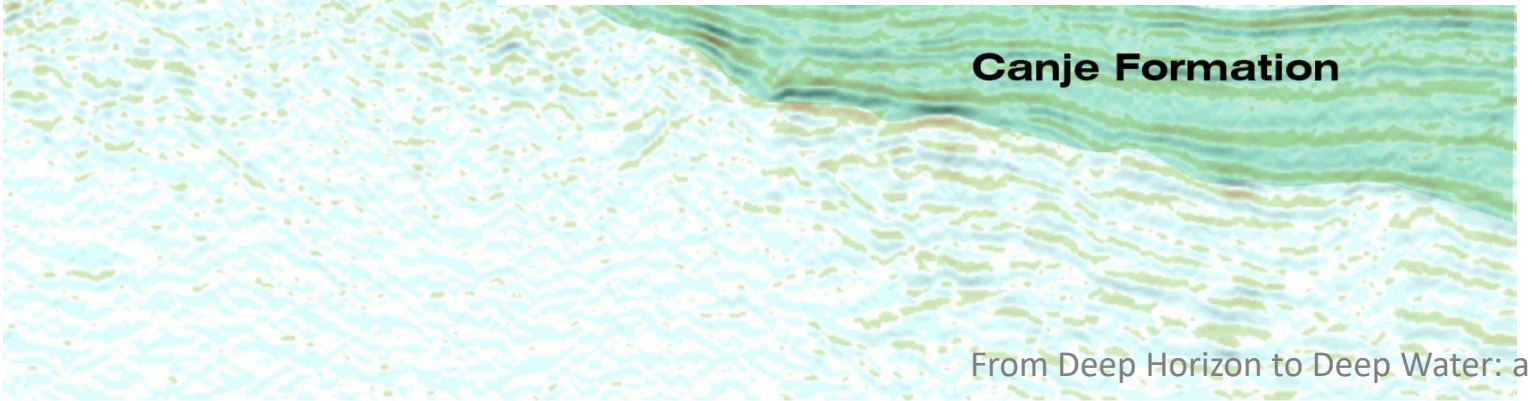




This is a model for the famed Liza discovery in 2015. A Cretaceous stratigraphic trap formed by turbidite sandstones with over 1 billion barrels in offshore Guyana. Migration of hydrocarbons mostly follows stratigraphic bedding due to vertical capillary contrasts. Lateral fault seals, pinch out or structure closures led to vertical migration and charging of the shallower reservoirs. Potential pay zones remain in the deeper section.



https://www.spectrumgeo.com/

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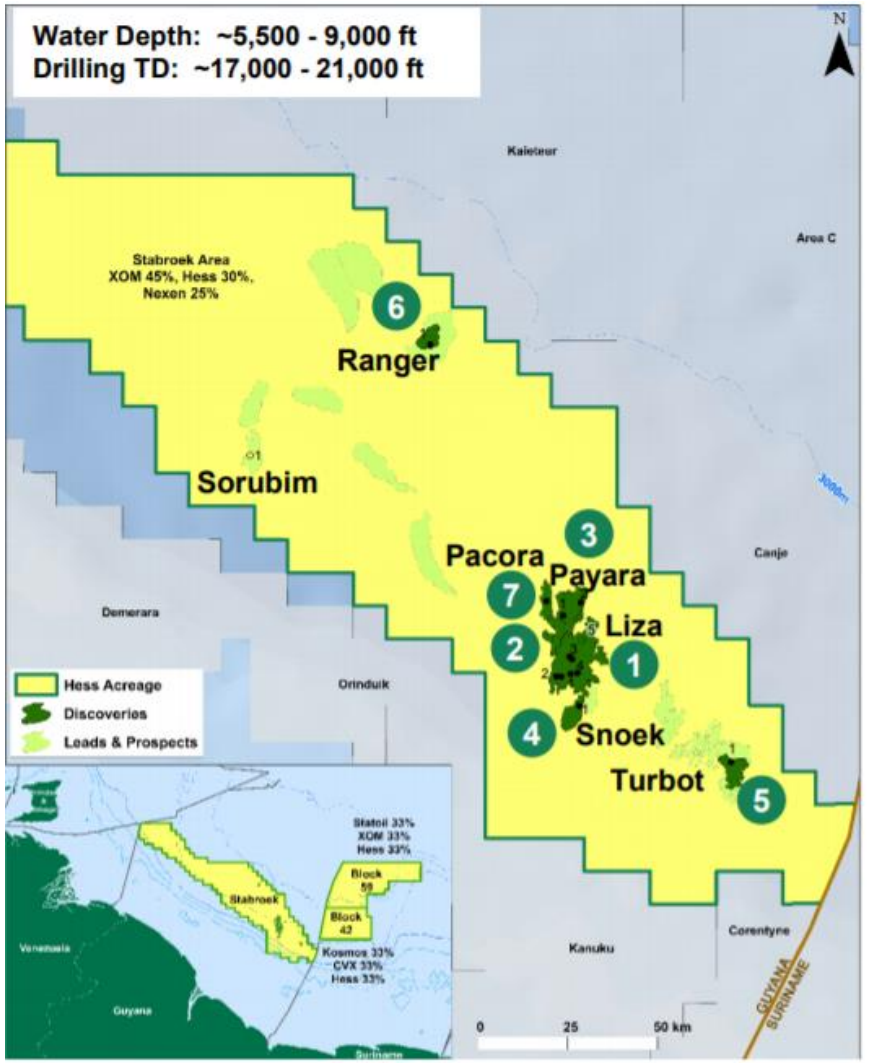
Guyana 2020 and Beyond

Currently 2 drillships operating for Exxon – Nobel Bob Douglas and Stena Carron

Source: Hess media release 2018



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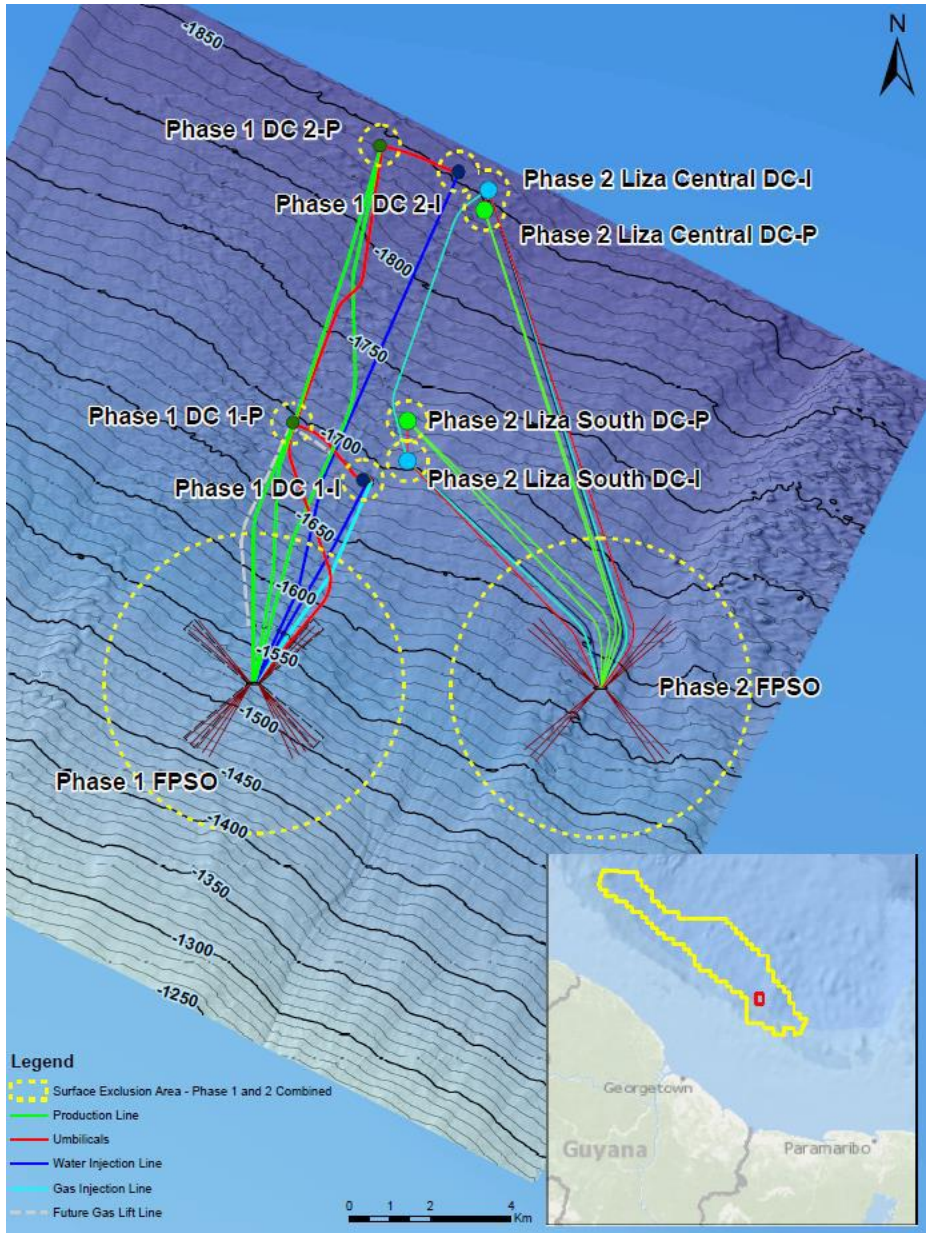
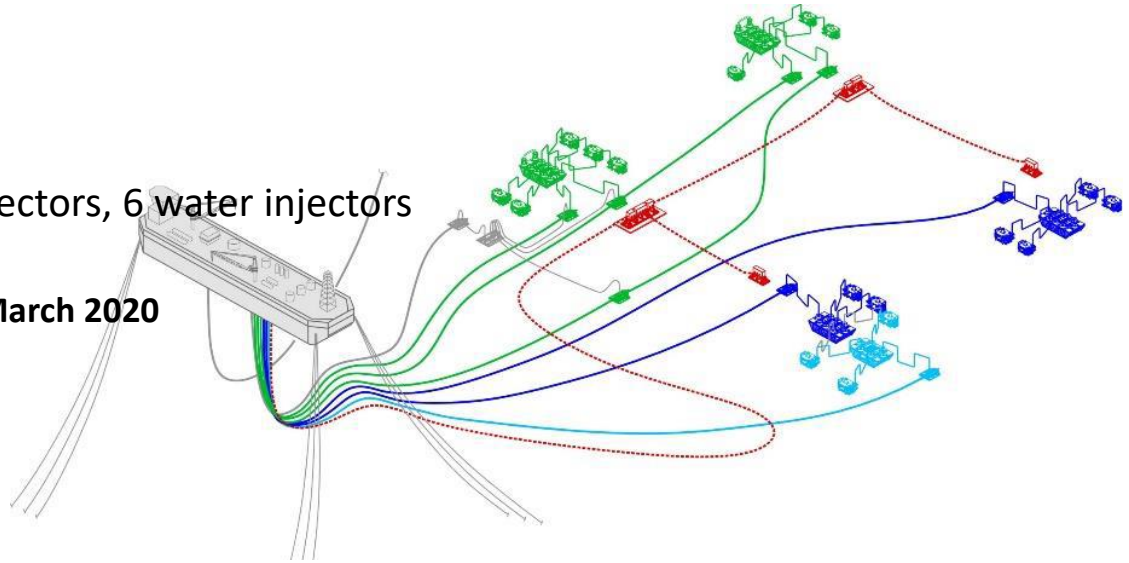
Liza Phase 1 & 2



Lisa Phase 1

- FPSO, 120 KBD
- 17 wells
- 8 producers, 3 gas injectors, 6 water injectors

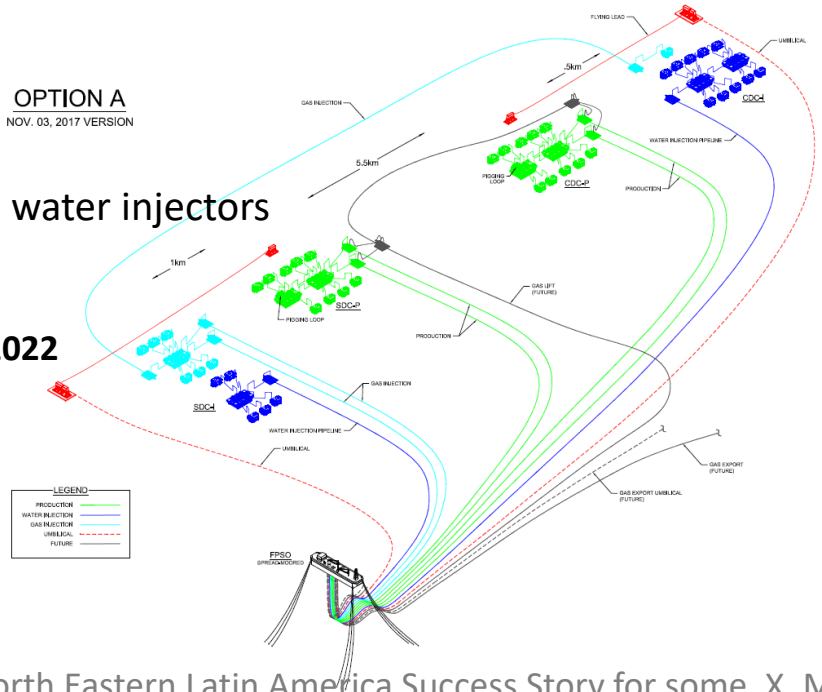
Production Start-up in March 2020



Lisa Phase 2

- FPSO, 220 KBD
- ~35 wells from 2 drill centres
- 19 producers, 6 gas injectors, 15 water injectors
- 2nd FPSO ordered from SBM

Anticipate Production Start-up in Q2 2022



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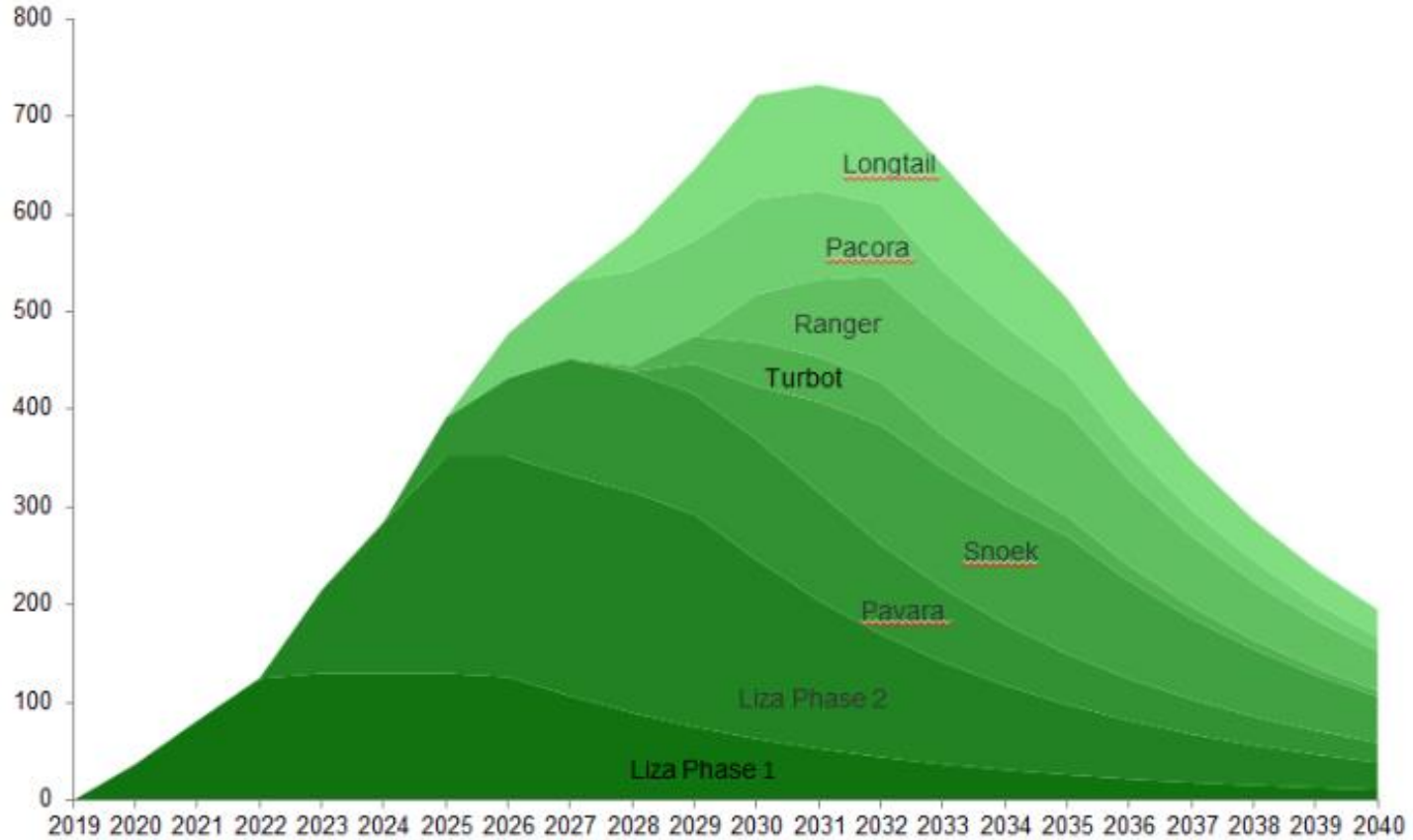
Including all discoveries, Guyana oil production could exceed 700 kbbl/d by 2030

Expected crude oil production from Guyana by field
Thousand barrels per day



J.Razack, Sep 2018

Source: Rystad Energy UCube

RYSTAD ENERGY

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Upcoming / Ongoing Activities

- Stena Carron to continue with exploration/appraisal drilling.
- At least 25 prospects identified in Stabroek.
- Bob Douglas to continue with 17 Liza Phase 1 development wells.
- 3rd Noble Rig to arrive in Q4 2018 for additional exploration (Tom Madden).
- 4th rig during 2019. 5th rig rumored.
- Exploration Drilling to occur in Kaieteur and Canje Blocks by Exxon
- Exploration Drilling from Repsol, Tullow and CGX in 2019 / 2020.
- Potential gas pipeline and 200MW power plant to be built onshore.
- Possible start of downstream industry

Summary

- Integrating modern seismic with well data and structural models brought light to Deep Horizon potential.
- Liza is Exxon's largest current deepwater development. 1st 4D seismic in region being done by Exxon to better efficiently produce. Production peak will be at least 700k bopd by 2030.
- Drilling by other operators in Guyana to come in 2019/2020.
- Suriname side yet to have major discovery offshore – will change soon!
- From Deep Horizon to Deepwater, the game hasn't changed much, the demand however is higher due to greater commercial risks: find a large undisturbed deepwater turbidite, image its updip trap and tie it back to its provenance, ensure it isn't being cannabalized by younger turbidites and that its porosity isn't being occluded by the shelfal carbonate influx.
- Unless you have a subsurface team willing to think 'outside of the box', you will likely continue to fail.

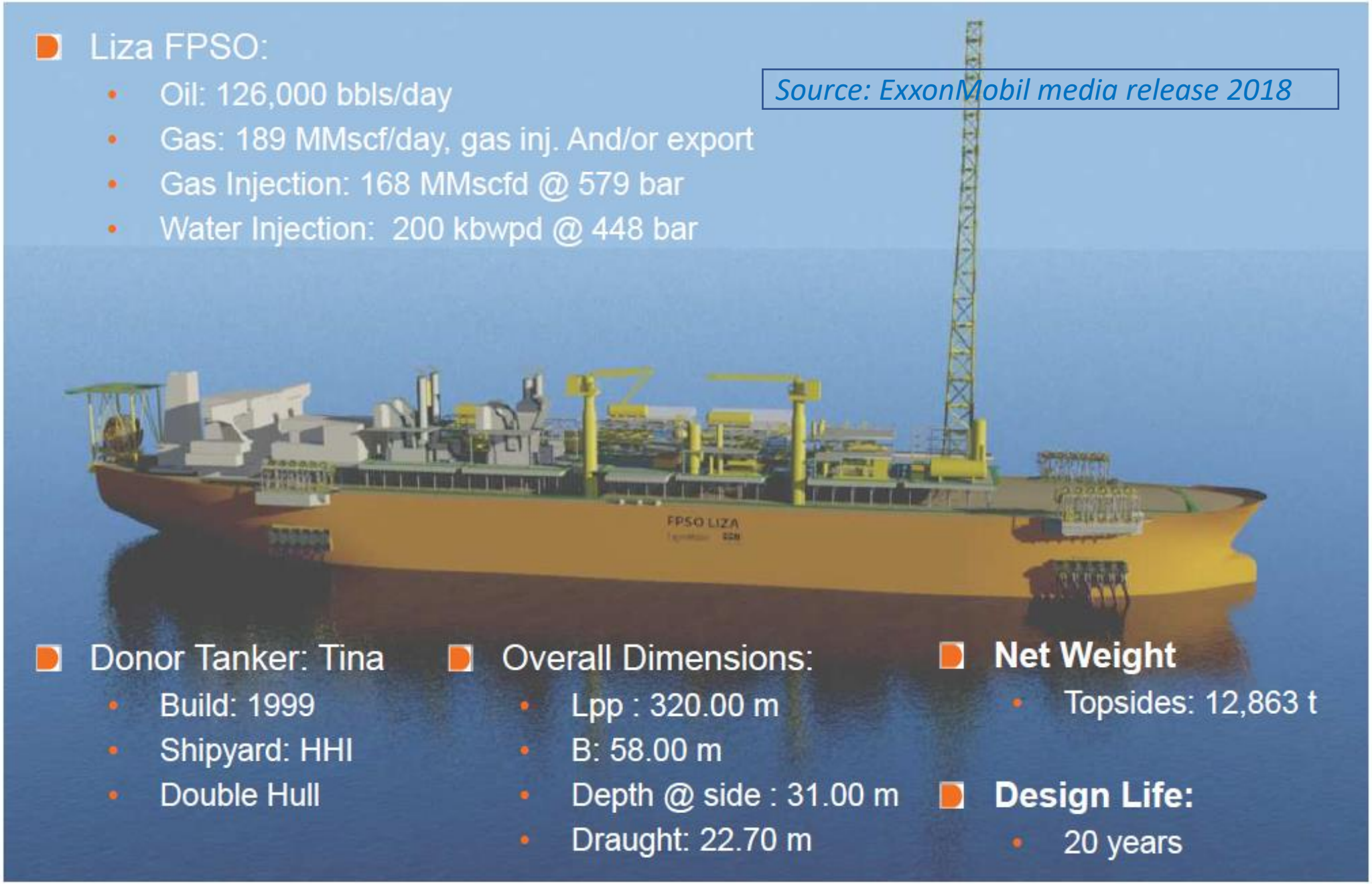
Thank you!
Questions?

THE UNIVERSITY
OF THE
WEST INDIES

Fact: Liza Phase 1 is expected to break even at US 35 / bbl!!

	Guyana Liza Phase 1 Development[1]	**Delaware Basin** Illustrative 50,000 Net Acre Development[2]
Peak Production	120,000 BOED	120,000 BOED
Peak Production Oil	120,000 BOD	86,000 BOD
Initial Investment to Peak Production	3 years	10+ years
Reservoir Quality	Multi Darcy	Micro Darcy
Total Production Wells	8	1,400
Avg. EUR / Production Well	56 MMBO	0.9 MMBOE 0.6 MMBO
Development Capex	$3.2 Billion	$10.5 Billion
Unit Development Costs	~$7/BO	~$9/BOE ~$12.5/BOE
Cost Environment	Deflating	Inflating
Required WTI price for 10% Cost of Supply	**~$35/bbl**	**~$45/bbl**

Liza Destiny FPSO



Beyond

- Liza Phase 1 – 120,000 bopd from FPSO #1 – March 2020
- Liza Phase 2 – 220,000 bopd from FPSO #2 – mid 2022
- Payara and Pacora – 180,000 bopd from FPSO #3 – late 2023
- FPSO #4 for Ranger?
- FPSO #5 for Longtail and Turbot?

NB. #4 and 5 are subject to new exploration and appraisal results.

- **With these 8 fields, production may be >700,000 bopd by 2030.**
- **CAPEX of USD 15 billion to develop 8 fields**
- **Up to 100 wells to be drilled for these fields**
- **Carbonate play to be fleshed out. Significant upside potential here.**