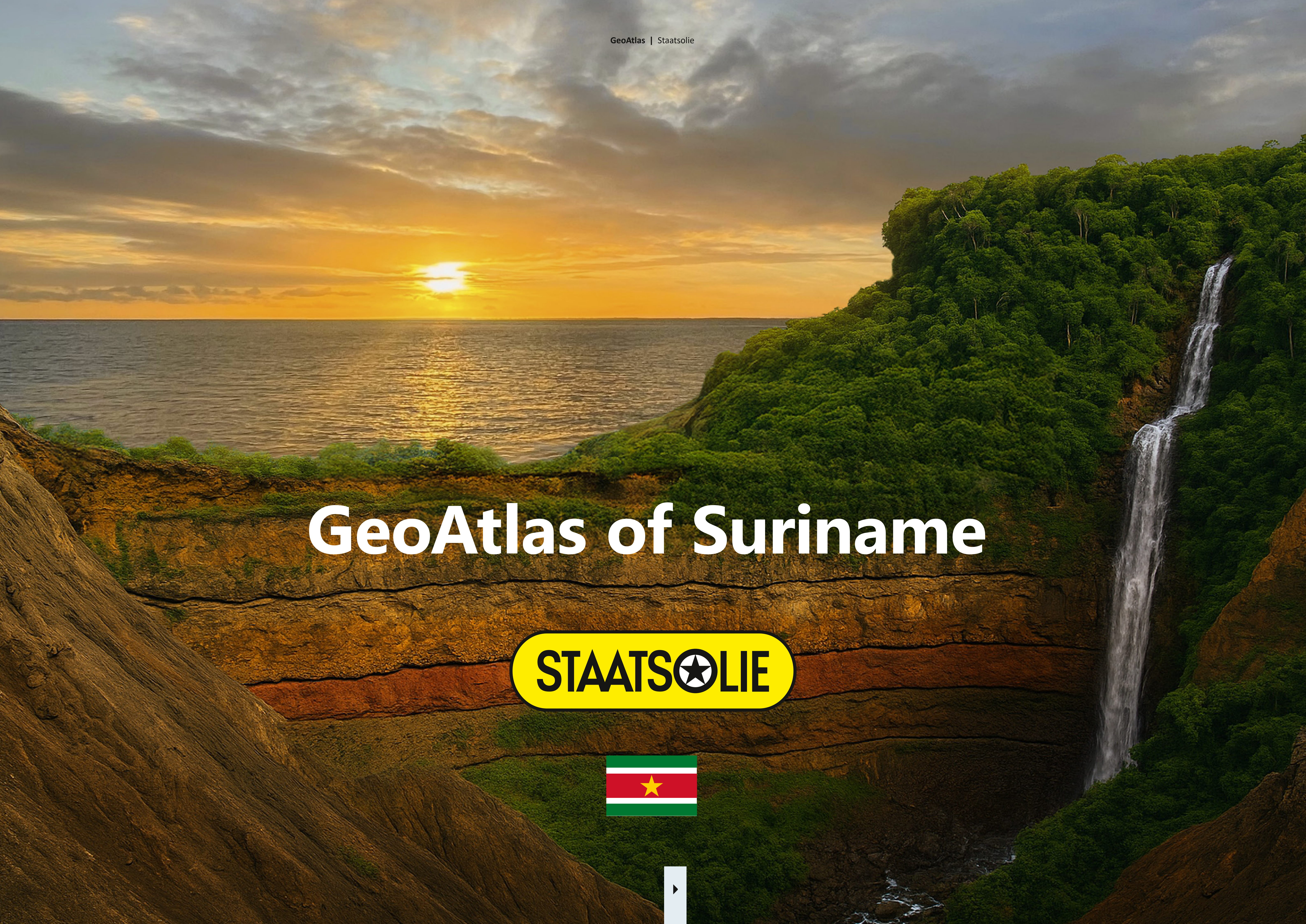
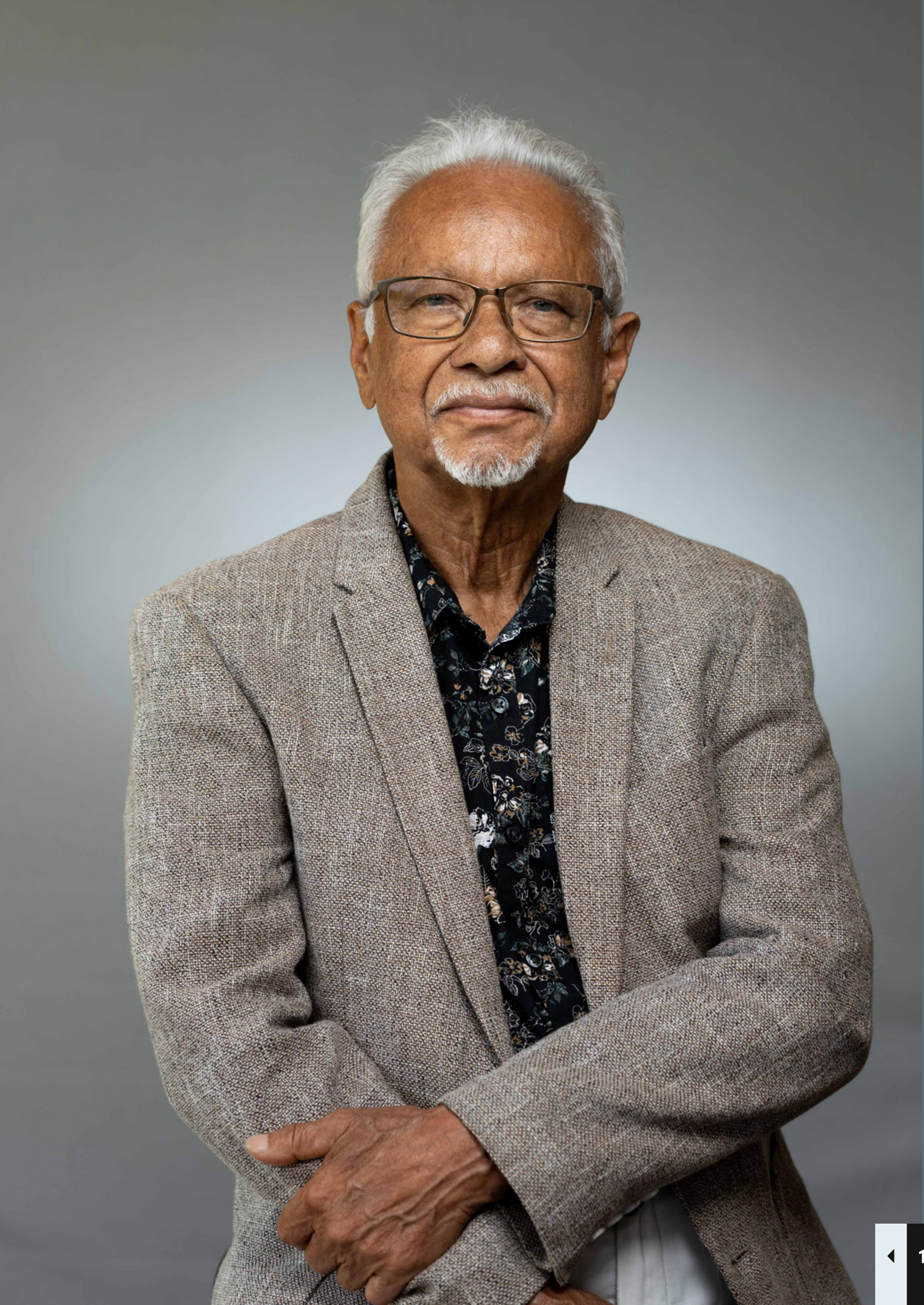
GeoAtlas of Suriname





**Dedicated to the founder of Staatsolie,
Dr. Sirahmpersad Eduard (Eddie) Jharap**

With deep gratitude and respect for your pioneering work, leadership, and unwavering belief in Suriname's petroleum potential, this first edition GeoAtlas of Suriname stands as a lasting tribute to your visionary spirit and invaluable contribution to our success.

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Monument commemorating Staatsolie's 25th year "Confidence in our own abilities"
Credit: N. Poeketi

Areal view of Paramaribo
Credit: Anton Gots

Preface and Acknowledgement

Preface

The GeoAtlas of Suriname is the culmination of decades of dedicated work by Staatsolie's geoscientists, who have worked meticulously to gather, interpret, and bring together geological data into an extensive description of Suriname's petroleum geology.

This GeoAtlas is made possible through the talent and collaboration of a multidisciplinary group of geoscientists with specializations in Exploration Geology, Geophysics, Petrology, Sedimentology, Geochemistry, and Reservoir Geology. Their work reflects scientific ethics as well as very strong commitment towards building knowledge of Suriname's petroleum resources and geological heritage.

We hope that this GeoAtlas will prove a valuable guide for researchers and industry practitioners. It is a testament to the ability of geoscience to illuminate the past, enlighten the present, and shape the future.

- The Authors: Geoscientists of Staatsolie

Acknowledgement

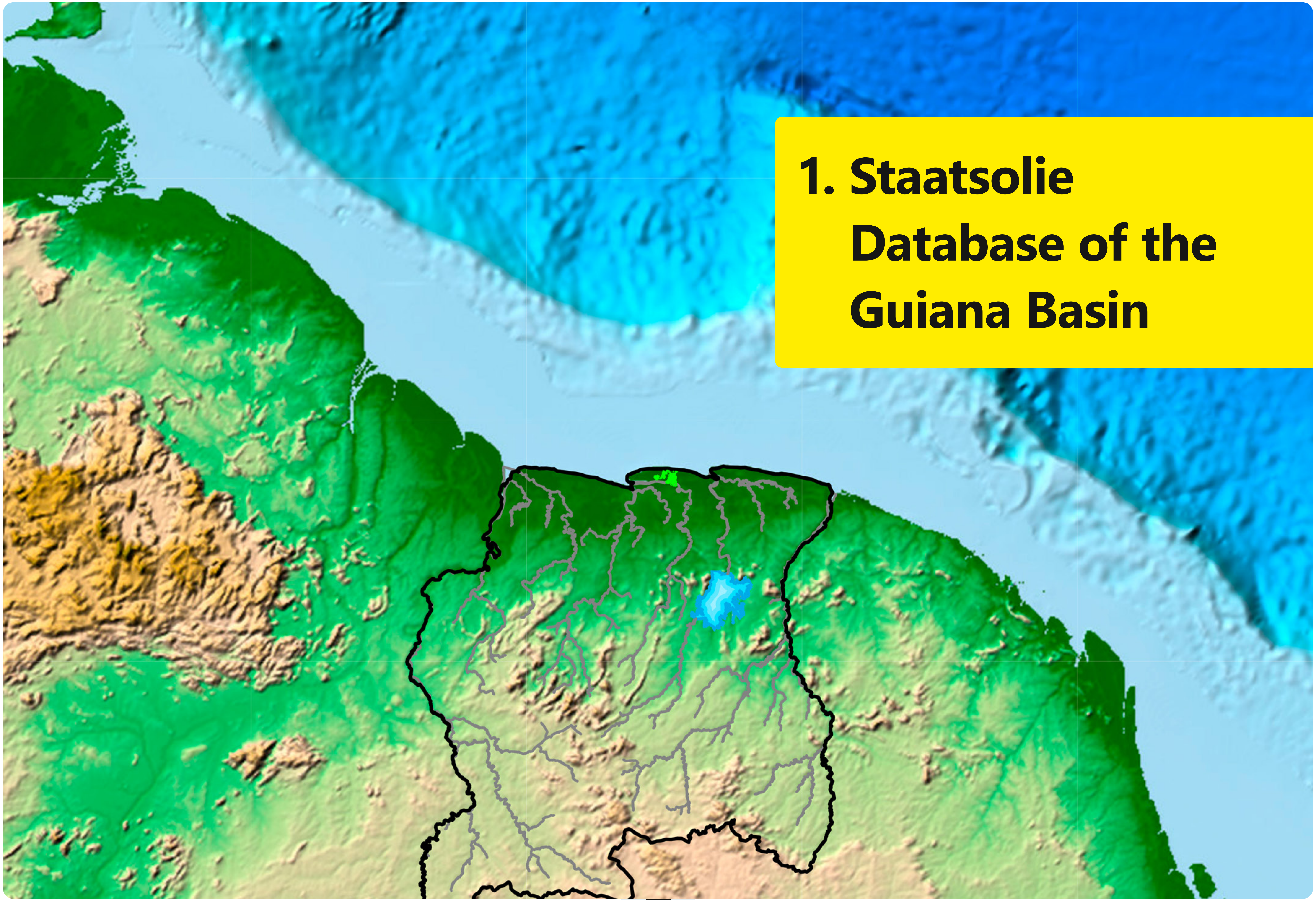
We gratefully acknowledge the support of Staatsolie's leadership and corporate support teams, whose guidance and collaboration were invaluable in the preparation of this GeoAtlas.

Their contributions—including data provision, peer review, and historical insights—significantly enhanced the quality and depth of this work.

We further acknowledge the enduring efforts of all individuals, past and present, whose dedication has advanced the geological understanding of Suriname.

This GeoAtlas stands as a tribute to their legacy and as a tool for future exploration.

Sapakara in the wild, Suriname
Credit: Pateix Photography



1. Staatsolie Database of the Guiana Basin

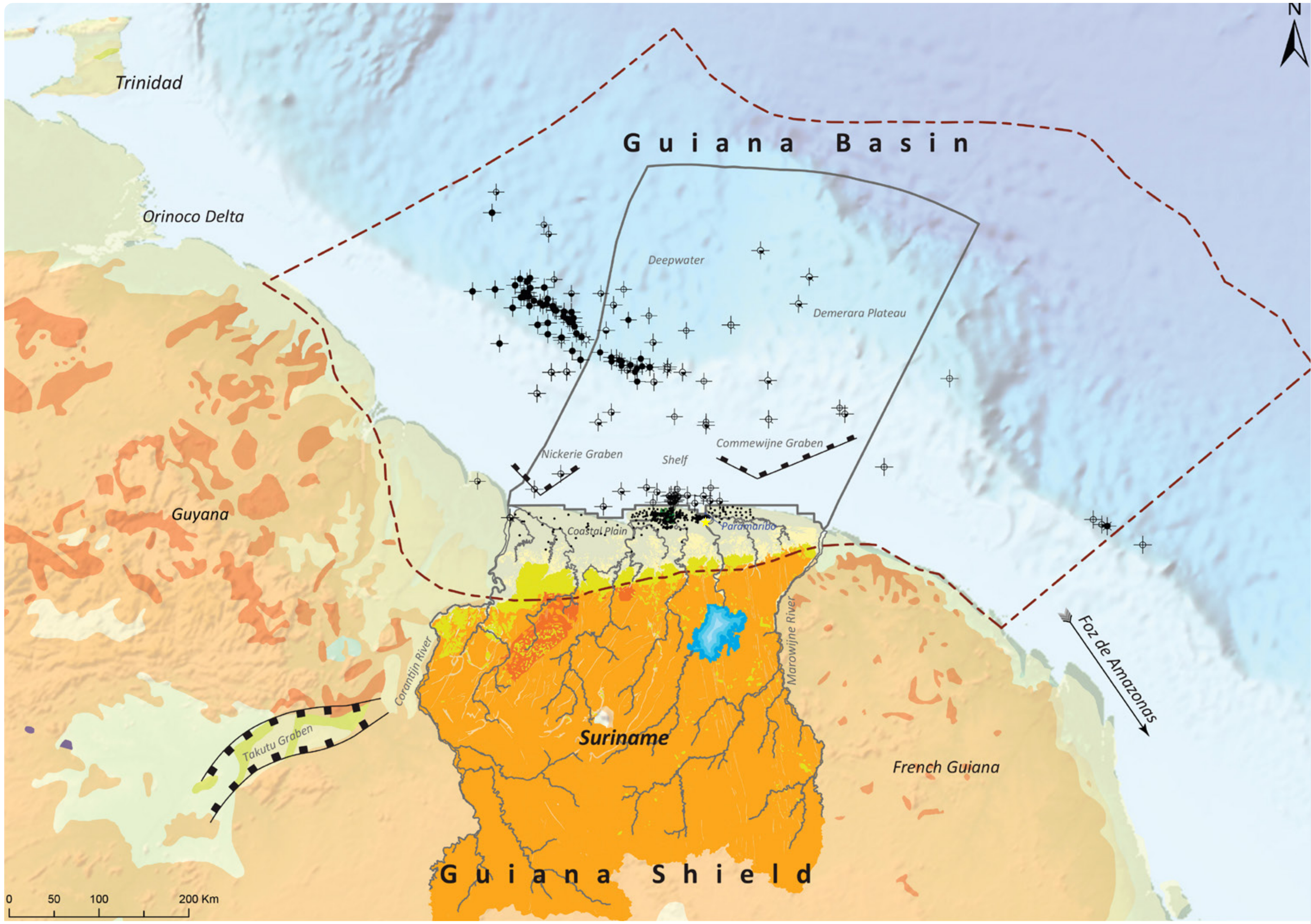
Overview of the Guiana Basin

The Guiana Basin is a prominent Atlantic-margin sedimentary basin located along the northeastern coast of South America.
It encompasses the offshore and coastal regions of Guyana, Suriname, and parts of French Guiana. It is geographically bound by the Orinoco Delta to the West and the Foz de Amazonas to the East. A notable structural feature of the basin is its apex, which aligns with the present-day Corantijn River, a location that corresponds with the basin's depocenter, indicating the area of maximum sediment accumulation. The entire basin area is approximately 450,000 km², and reaches depths in excess of 10 km.

The Suriname part of the Guiana Basin consists of the Coastal Plain, the Continental Shelf, the Demerara Plateau, and the Deepwater region.

The **Coastal Plain** is approximately 100 km in width at the basin depocenter, near the present-day Corantijn River and some 400 km in length. It gradually decreases in width to the east towards the Marowijne River, where the sediments onlap on Precambrian Basement. Basin fill is characterized by fluvial-deltaic and Coastal Plain deposits and represents the onshore extension of the basin.
The **Continental Shelf** is approximately 150 km in width across the Shallow Offshore areas of French Guiana, Suriname and Guyana, where the water depth ranges between 0 to 100 m. The shelf is composed of Mesozoic to Cenozoic sedimentary sequences and forms the transitional zone between the Coastal Plain and deeper offshore areas.
The **Demerara Plateau** is a distinct geological platform of approximately 40,000 km². It is located in the northeastern extent of the Suriname Continental Shelf in water depths of approximately 1,200 m. It is considered to be the conjugate margin of the Guinea Plateau, reflecting the rifted margin that formed during the opening of the Central Atlantic Ocean. The **Deepwater** region corresponds to the pull-apart basin configuration and is particularly evident in northwest offshore Suriname. The region extends well beyond the shelf break into ultra-deepwater zones and hosts prolific hydrocarbon discoveries in Cretaceous intervals. The water depths range from 1,500 m to over 3,000 m.

The Guiana Basin has emerged as a global oil and gas exploration and production hotspot due to its proven Cretaceous - Tertiary petroleum system with a series of significant hydrocarbon discoveries since 2019. These discoveries within the Deepwater domain have confirmed the basin's exceptional prospectivity, particularly within Lower and Upper Cretaceous turbidite systems. Substantial exploration potential remains. This GeoAtlas is designed to showcase the vast array of untapped plays, highlighting the significant opportunities that remain for future exploration and resource development.



Legend

- Guiana Basin
- Onshore Oil Fields
- Brokopondostuwmeer

Geology of Suriname

- Archean
- Holocene
- Lower Proterozoic
- Pleistocene
- Tertiary

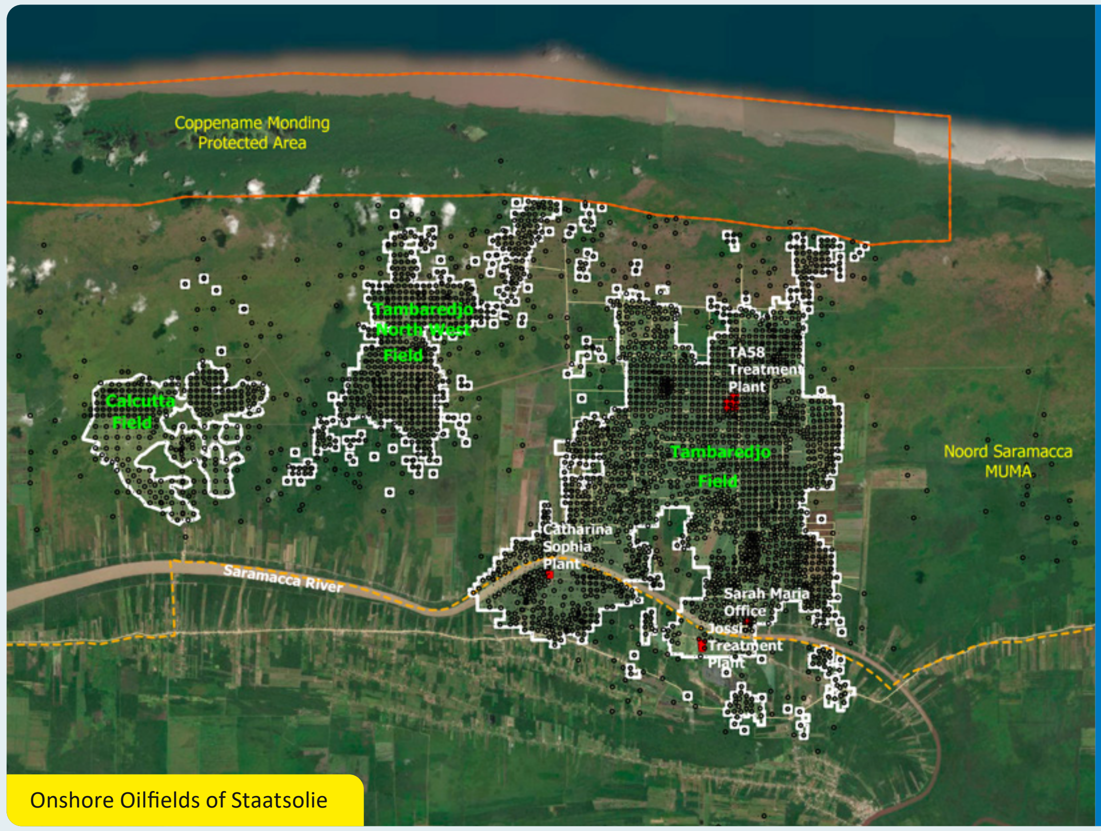
Geology

- Cambrian-Ordovician
- Cretaceous
- Mesozoic-Cenozoic intrusives
- Mesozoic metamorphics
- Paleozoic-Mesozoic intrusives
- Quaternary
- Tertiary
- Precambrian undifferentiated

Staatsolie and Onshore Fields

Staatsolie was established in 1980 as Suriname's state-owned oil company and is, by law, the sole holder of hydrocarbon concession rights in Suriname. It is tasked with promoting acreage, attracting investments and concluding petroleum agreements for oil and gas exploration, development and production with third parties. Staatsolie is also active in the full value chain of the energy sector in Suriname, including oil exploration, production, refining, marketing, and electricity generation. In 1965, the Suriname Geological Survey made Suriname's first Onshore oil discovery while drilling a water well. Following this discovery, multiple drilling campaigns confirmed the presence of oil. First Onshore oil production started in 1982, which led to the exploitation of earlier discoveries in the Tambaredjo Field, located approximately 55 km west of Paramaribo, the capital of Suriname.

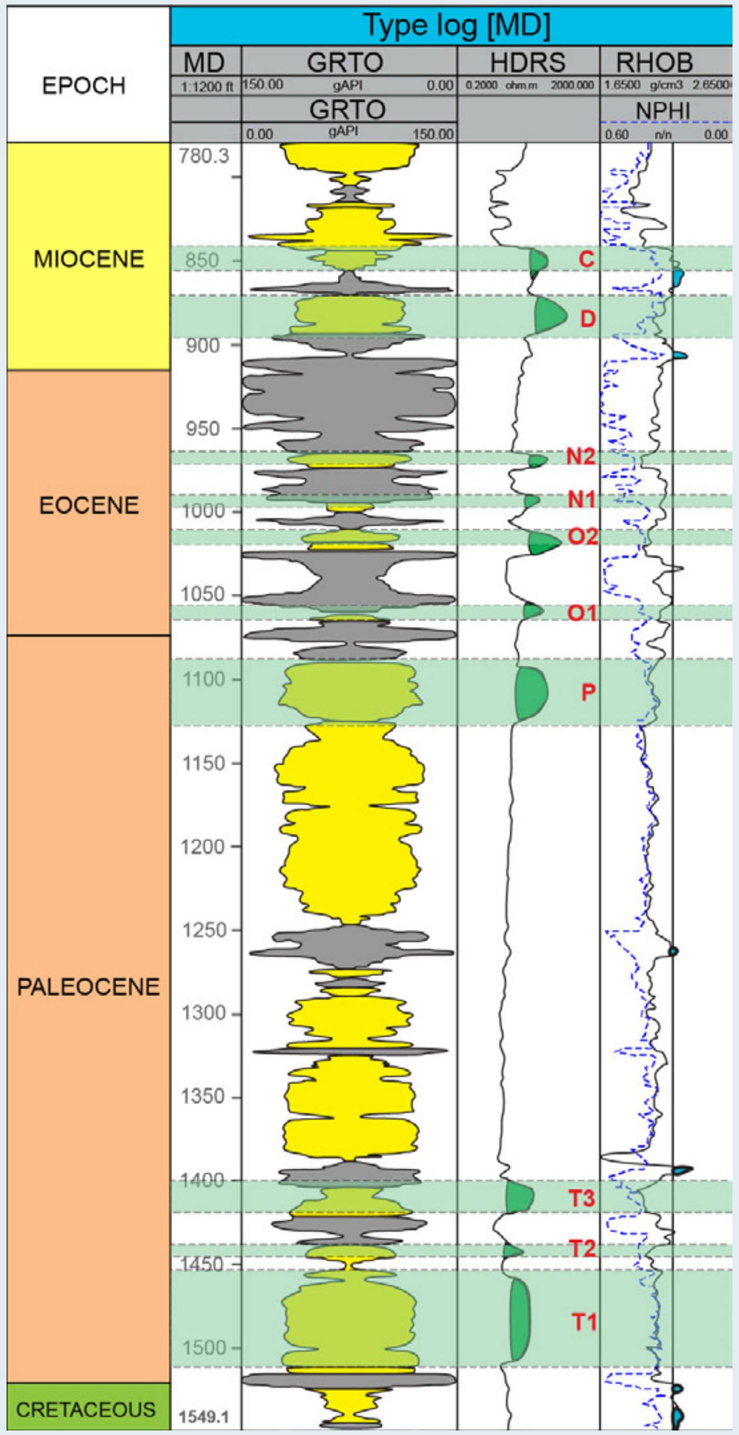
Value chain of Staatsolie



Onshore Oilfields of Staatsolie

Staatsolie currently produces from three Onshore oil fields in the Saramacca district of Suriname: Tambaredjo, Calcutta, and Tambaredjo North West. The STOIIP amounts to 1 billion barrels. The oil producing reservoirs are mainly Paleocene, Eocene and Miocene fluviatile pointbars and mouthbars; these reservoir units are highlighted on the Onshore type log. The oil is labelled as Saramacca Crude, with the following characteristics:

API Gravity	15.8	Sodium (ppm)	23
Viscosity at 50°C (cSt)	480	Vanadium (ppm)	10
Sulphur (wt.%)	0.65	Asphaltenes (wt.%)	1



Type Log of the Onshore wells

Saramacca Operations

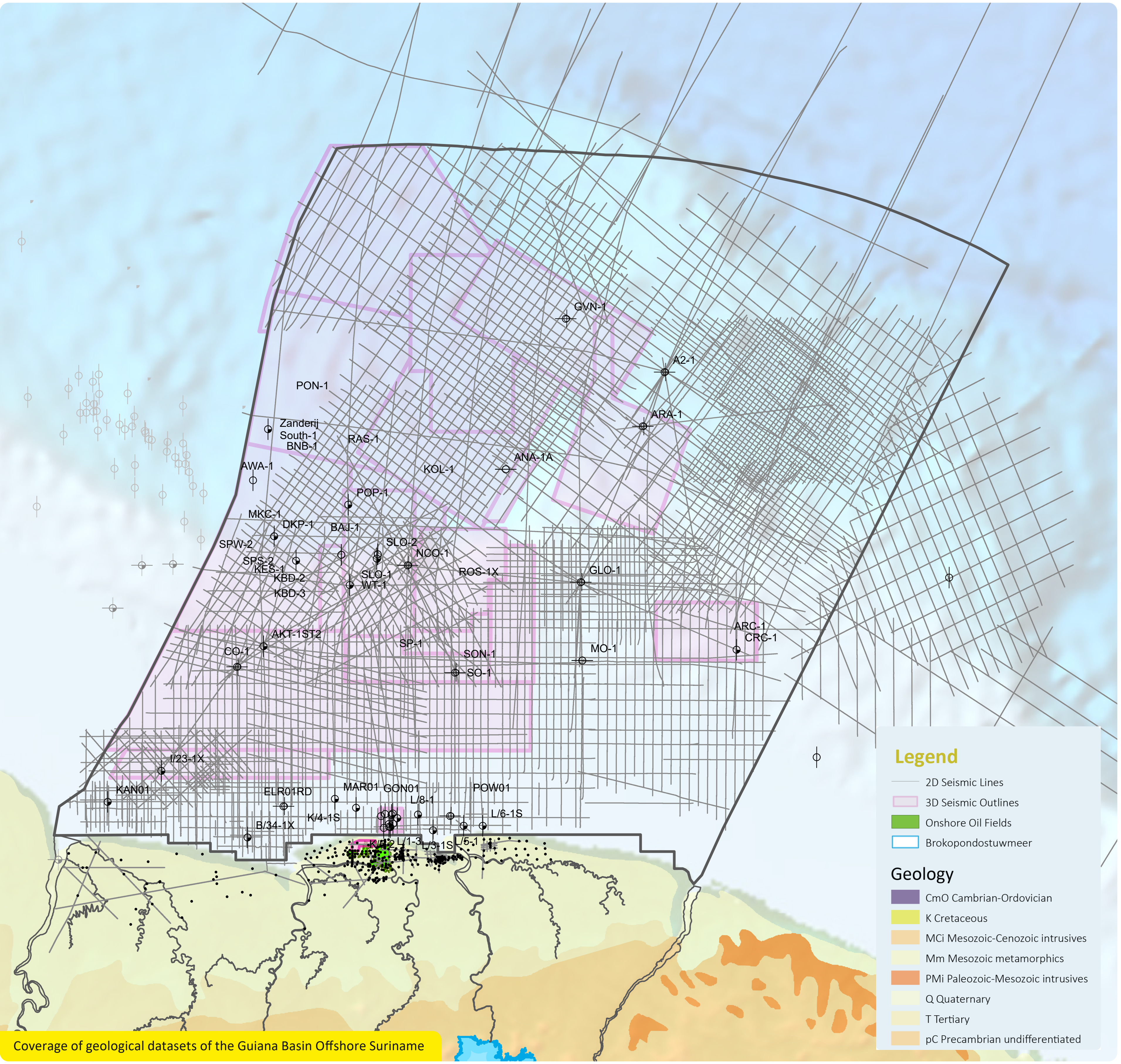
The average annual production of Saramacca Crude in 2024 was 6.4 MMbbls. As of 31 December 2024 the remaining reserves of the Onshore Fields are 104.5 MMbbls. The lifting cost of under USD 10 per barrel for 2024 is the lowest cost quartile for the region.

Saramacca Operations

The Saramacca operations include wetland and dryland operations. The wetland operations are carried out without embankment of the marshland. Transportation is via airboats, which allows minimal clearance of vegetation.

Production System in the Wetlands of Saramacca

Wetland (swamp) operations in the Saramacca Onshore fields.



Coverage of geological datasets of the Guiana Basin Offshore Suriname

Geological Database

The petroleum geology as portrayed in this GeoAtlas is the result of a century of exploration, data acquisition, and data management. The database consists of (but is not limited to):

- Well data (logs, reports, cores, side wall cores, wet and dry samples)
- 2D and 3D seismic data (raw data as well as various vintages/ version processed data)
- Gravity and Magnetic data
- Geochemical data
- Various geological, geophysical, petrophysical reports

For more information reference is made to the geoportal which can be found via the Staatsolie website (www.staatsolie.com).
Please note that the GeoPortal will be available for data viewing together with the GeoAtlas.

Wells

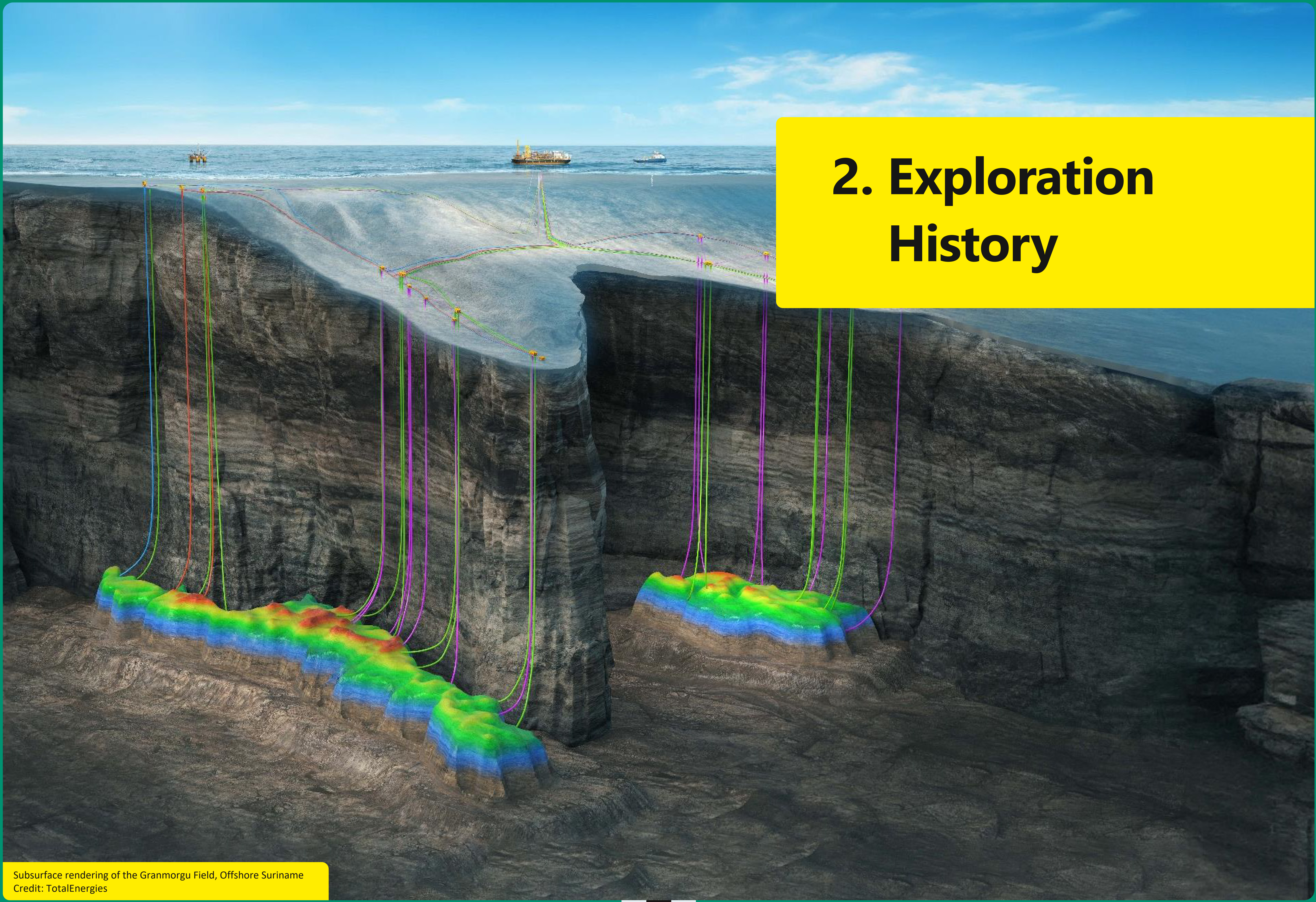
As of November 2025, a total of 65 wells have been drilled Offshore. These included mainly exploration wells and a few appraisal wells.
In the course of a century, 400 exploration wells have been drilled in the Coastal Plain of which the majority has oil shows in the Cretaceous and Tertiary.
Since the start of production in 1982, a total of 3800 production wells with an average depth of 350 m have been drilled. The majority of these wells are still in production as of 2025.

Overview of 2D & 3D Seismic data

Seismic acquisition started in the coastal area of Suriname with acquisition of 435 km 2D refraction data.
In 2025, Suriname counts approximately 30,000 km 2D seismic and 145 km^2 3D seismic in the Coastal Plain.
As of 2025, approximately 164,000 km 2D seismic and 100,000 km^2 3D seismic have been acquired in the offshore area of Suriname.

Downtown Paramaribo
Credit: Leonid Andronov

2. Exploration History



Subsurface rendering of the Granmorgu Field, Offshore Suriname
Credit: TotalEnergies

Early Reconnaissance

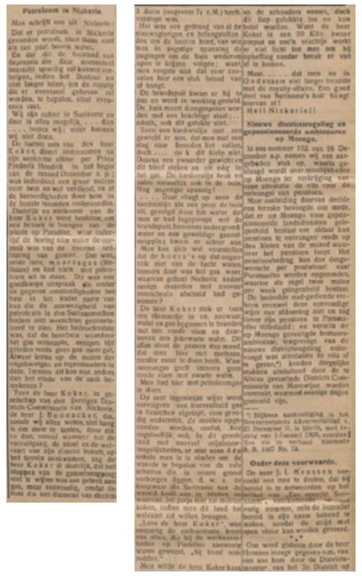
Whispers of Oil Seeps

- In 1924, Bataafsche Petroleum Maatschappij (BPM) (a subsidiary of Royal Dutch Shell) was granted an exploration license covering the whole of Suriname.
- BPM employed Dutch geologist R. Ijzerman to investigate reported oil seeps; the reported oil seeps were proven to be non-existent. BPM denounced their contract in May 1927.

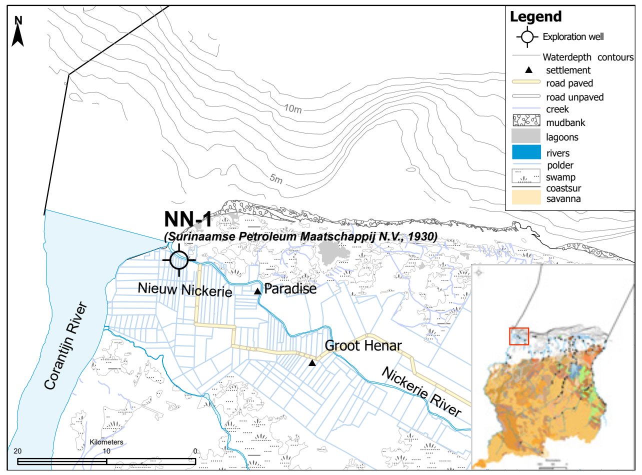
Auger Hole with Flowed Hydrocarbons in Nickerie

- 1928: J.W Van Dijk assessed an auger hole on the 20th of October. At a depth of 6-12 m some oil started to float.
- Analysis of three samples led to the conclusion that, although the kerosene portion was high, the oil was natural.
- Doubt was expressed about one sample that contained 25% fatty oil. After the analysis of this sample, the conclusion was that it could not have been generated at such a shallow depth and had to originate from deeper strata.

1920s



Newspaper article from 1928 about the Auger Hole discovery

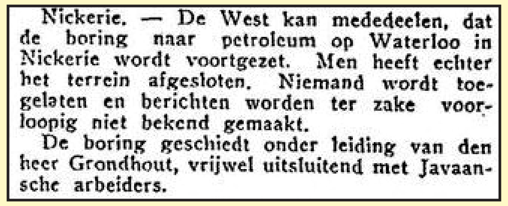


Map showing the location of the NN-1 well

1930s

First Exploration Well Drilled

- 1930: The Surinaamese Petroleum Maatschappij (SPM) drilled the first exploration well near Waterloo in the district of Nickerie.
- The well reached a depth of 302 m and was assigned the name Nieuw Nickerie-1 or NN-1.
- Presence of pure asphalt below the depth of 100 m had been reported.
- SPM decided to withdraw after this well.



Nickerie. — De West kan mededeelen, dat de boring naar petroleum op Waterloo in Nickerie wordt voortgezet. Men heeft echter het terrein afgesloten. Niemand wordt toegelaten en berichten worden ter zake voorloopig niet bekend gemaakt.

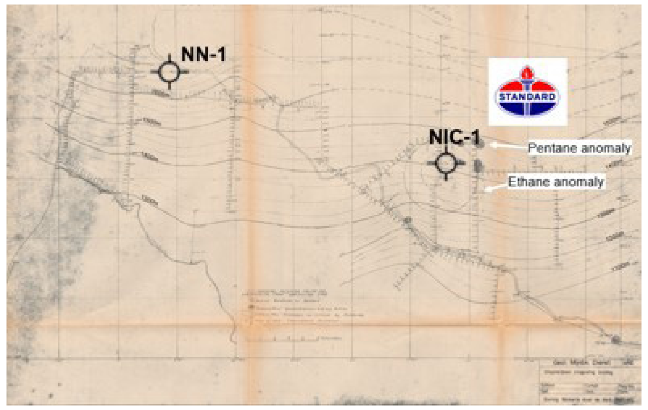
De boring geschiedt onder leiding van den heer Grondhout, vrijwel uitsluitend met Javaansche arbeiders.

Newspaper article from 1930 about the drilling of the NN-1 well

Continued Exploration

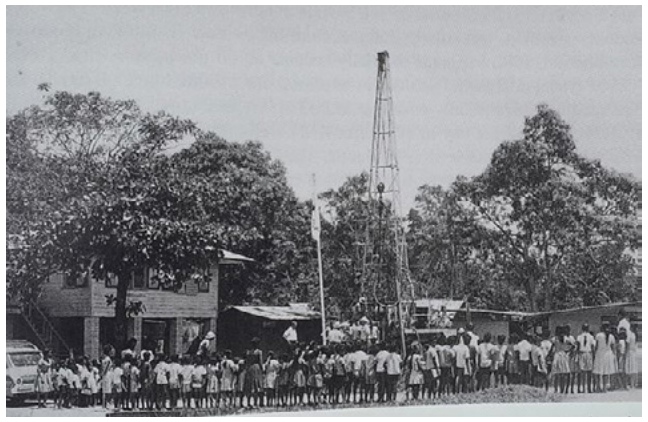
- 1940: N.V. Nederlands Guyana Petroleum Maatschappij, a subsidiary of Standard Oil Co. (New Jersey), was granted a 40 year concession, covering approximately 15,900 km^2. The company acquired 15 seismic lines in 1939, totaling 435 km.
- 1941: A soil geochemical survey was conducted where seismic anomalies had been observed. Traces of methane, ethane, and propane were detected at a depth of 4 m.
- 1943: Based on the 1941 geochemical research, a location was selected for the NIC-1. The well reached the Basement at a total depth of 1,448 m in February..
- The NIC-1 was concluded to be dry of hydrocarbons.
- After the result of the NIC-1 well, the interest in oil exploration in Suriname faded.

1940s



Map showing the locations of the NN-1 and NIC-1 wells

Pioneering Oil Discoveries and Exploration Expansion



Picture showing the drill-site of the first oil discovery at the school yard of Calcutta in 1965. (ref. Wong Th.E., 1998).

1960s

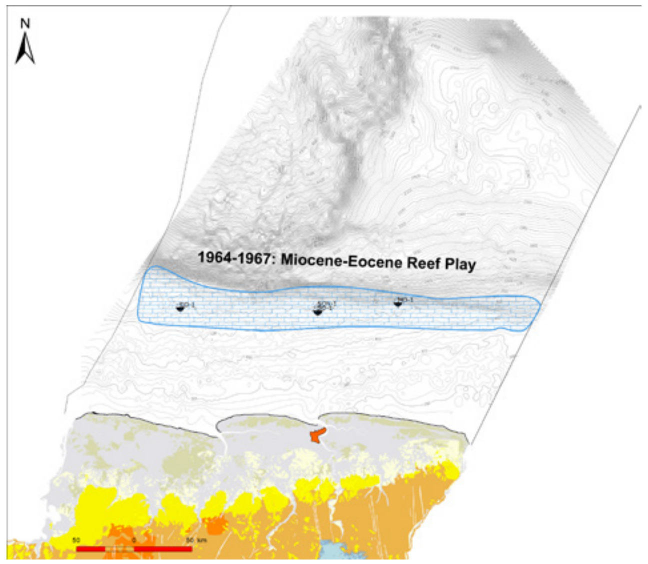
First Oil Discovery in Suriname

- 1964: The first offshore well (SO-1) was drilled by Colmar group and Elf. The target was an interpreted Miocene-Eocene reef. The reef play was not successful due to a lack of trap.
- 1965: On the 15th of October the Suriname Geological Survey was conducting a water-drilling project when they struck oil near a school at Calcutta in the Saramacca district.
  This signifies the first oil discovery Onshore Suriname.
  - The well, now named C-1, had a fluid flow rate of 2-2.3 bbl/d.
  - The oil had an API gravity of 17.7 and occurred in a Miocene age interval at a depth of 171-183 m.
- 1966: The C-2, C-3, C-5 and C-7 wells in the Calcutta area, and the C-8 and C-9 wells near Tambaredjo, were drilled and found to contain oil saturated sediments.
- 1967: Wells drilled in the Weg Naar Zee area also encountered oil bearing sediments at a depth of 300 m in a Paleocene age interval.
- Despite the technical successes of these wells, there was no evidence indicating that the volumes of oil were economically producible.

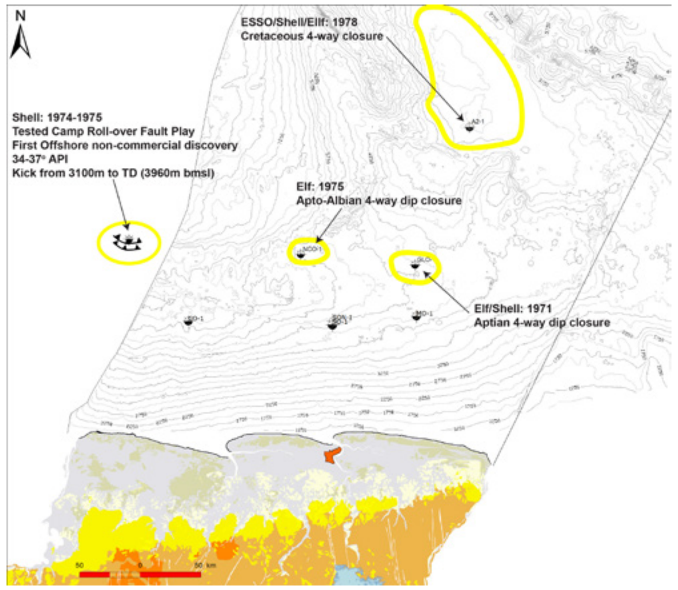
More Oil Discoveries

- 1966: Boosted by the Onshore discovery of 1965, Petrosur drilled the SON-1 and MO-1 offshore wells. Both wells reached Eocene age strata and were dry.
- 1967: The Offshore CO-1 well was drilled, reaching Maastrichtian-Campanian age strata at 3,294 m and recorded oil shows in the Cretaceous.
- In November 1966 the 7th Inter Guiana Geological Conference was held in Paramaribo and further boosted the exploration campaign in the Guiana Basin.
- 1968: Petrosur, now renamed to Elf Suriname Petroleum Co., drilled four Onshore wells (the PB wells) at Weg naar Zee.
- 1969-1970: Shell carried out a drilling program of twenty wells spread across the Coastal Plain.
- Results of these Onshore drilling campaigns confirmed the oil finds in Tambaredjo, Calcutta, and Weg naar Zee, but no new accumulations were found.

1960s continued



Map showing the Miocene-Eocene Reef Play



Map showing the Four-way Dip Closure Play

1970s

Developing Play Concepts: Four-way Dip Closures

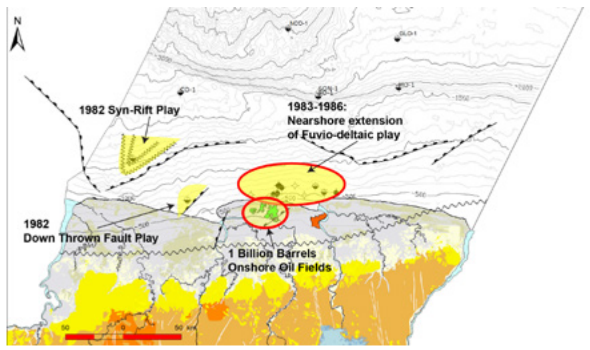
- 1971: Elf drilled the Offshore well GLO-1, targeting an Aptian age interval in the first interpreted four-way dip closure. The well reached a depth of 4,663 m and encountered oil shows but was considered dry.
- 1972-1974: 6,110 km of seismic lines were acquired, partially covering French Guiana.
- 1974-1975: The AB-1 well was drilled Offshore Suriname by Shell. The initial target was an Aptian-Albian age four-way dip closure at approximately 5km depth. However, they encountered light hydrocarbons in a shallower Campanian roll-over fault trap.
- 1975: Elf drilled the offshore NCO-1 well, targeting an Aptian-Albian age four-way dip closure. The well reached Aptian age strata with oil and gas shows, as well as a matured ACT source rock which was proven for the first time.
- 1978: The Offshore A2-1 well was drilled by ESSO (now Exxon Mobile) and was the first deepwater well at a water depth of 1,200 m. The well targeted a large Cretaceous four-way dip closure but was deemed a failure due to the lack of reservoir. To date it is the only well that penetrated the Jurassic strata.

Staatsolie's Rise: Onshore Beginnings and Offshore Expansion

1980s

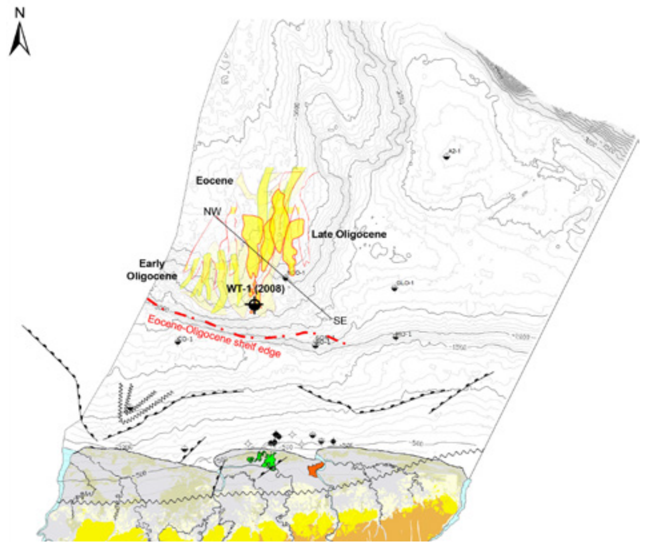
Developing Play Concepts: Nearshore Structural and Stratigraphic Plays and the Birth of Staatsolie

- 1979-1980: The surge in petroleum prices, driven by multiple global geopolitical events, was the incentive for the Surinamese government to promote petroleum exploration in the country.
- 1980: Staatsolie was founded on the 13th of December 1980.
- 1981: Staatsolie drilled three successful Onshore evaluation wells in Saramacca (TA-5, TA-6, TA- 7). Well TA-5 produced 160 barrels of oil in 70 hours from a depth of 312 m.
- 1982: A five well Onshore production project was completed near Tambaredjo and Suriname officially became a petroleum producer.
- 1981-1986: Gulf Oil Corporation (now Chevron) acquired and reprocessed seismic data and drilled wells to explore new play concepts in the Nearshore, including the Nickerie graben play and Basement fault play. Together with Austra-Tex, they explored the nearshore extent of the Onshore fluvial play.



Map showing the Graben (Syn-Rift) and Fluvial-Deltaic Plays

1990s



Map showing the Tertiary Slope-Basin Floor Fans Play

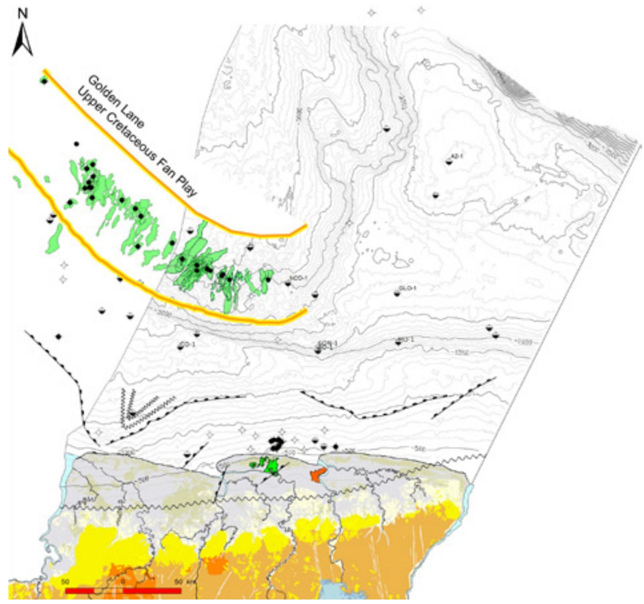
Developing Play Concepts: Tertiary Slope-Basin Floor Fans

- 1993: Pecten carried out an extensive study of their Offshore production-sharing contract area and identified several prospects. However, they could not find a suitable partner for exploration purposes and relinquished the area in 1995.
- 1999-2002: Burlington Resources (now ConocoPhillips), CNOOC and Elf were chasing the Deepwater fan plays which were analogous to the Campos Basin fans in Brazil.

2000s

The Golden Lane

- 2008: Repsol YPF drilled the Offshore WT-1 well to test the upper slope fan play.
- 2015: ExxonMobil made the Liza discovery. The Liza-1 well was the first significant oil find Offshore Guyana. It encountered more than 90 m of oil-bearing Cretaceous turbidite sandstone reservoirs and was safely drilled to a depth of 5,433 m in 1,743 m of water.
- 2019: Apache made the Maka Central discovery. The well, MKC-1, found multiple stacked reservoirs containing light oil and gas-rich condensate, indicating the presence of the Guyana Cretaceous oil play in Surinamese waters. This discovery was highly encouraging for the region's exploration potential and led to subsequent exploration and development activities of the Golden Lane towards the east.



Map showing the Upper Cretaceous Fan Play

The Road to FID

FID Block 58 (1 October 2024)

2020s

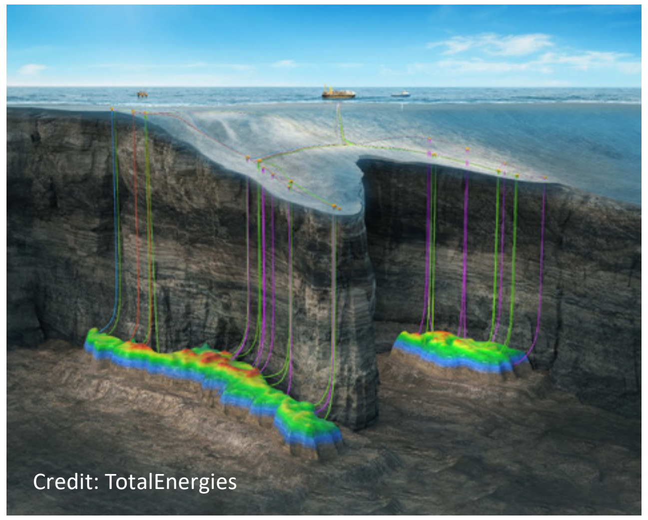
The GranMorgu Project: Discovery to FID

- The foundations of the GranMorgu project started in 2021 with a major exploration success through the discovery of oil-bearing sandstones in the Sapakara South 1 (SPS-1) well.
- In 2022, the project gained momentum with the successful drilling of the Krabdagu 1 (KBD-1) exploration well. That year, the Sapakara South 2 (SPS-2) appraisal successfully proved up the Sapakara South discovery.
- Two additional successful appraisal wells, Krabdagu 2 (KBD-2) and Krabdagu 3 (KBD-3), were drilled in 2023. Together with the Sapakara South wells, they confirmed ample barrels of oil in place for commercial development.
- By 2024, the project achieved a significant milestone with the Declaration of Commerciality, followed by the submission of the Field Development Plan (FDP). On 1st October 2024, the project reached the Final Investment Decision (FID), with Staatsolie officially participating in the development. This was a landmark step towards the first Offshore oil development and production in Suriname, characterized by the single largest investment in the country to date.

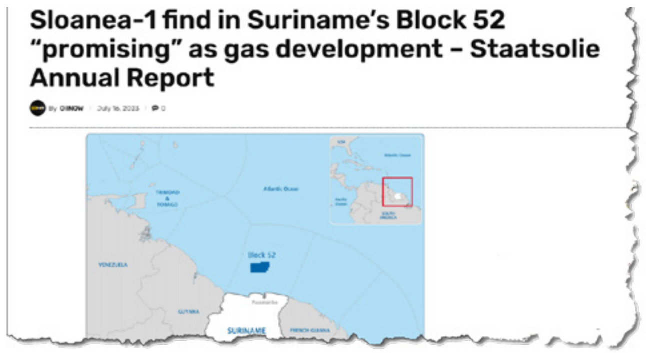
The GranMorgu Project: First Oil in 2028

- As of October 2024, the project is in its execution phase.
- The procurement and fabrication of the Floating Production Storage and Offloading (FPSO) is ongoing and progressing as planned. Its transit to Suriname will be in the first half of 2028.
- Development drilling will start in early 2027, with a total of 32 wells to be drilled which will deliver the production of some 220,000 barrels of oil per day at plateau.
- Simultaneously, subsea infrastructure fabrication is underway, with installation activities expected to begin in 2027.
- All efforts are geared towards the completion of the project in the second half of 2028, when First Oil is expected. This will mark a historical turning point for Suriname as we realize the ambitions of our Offshore production and the outlook of a brighter future.

2020s continued



Subsurface rendering of the GranMorgu field



Sloanea-1 find in Suriname's Block 52 "promising" as gas development – Staatsolie Annual Report

OilNOW (2023) Article on the Sloanea-1 Discovery

2020s continued

The Sloanea Gas Field

- In 2020, the Sloanea-1 (SLO-1) exploration well discovered Suriname's first offshore gas discovery, Sloanea.
- In 2024, the Sloanea-2 (SLO-2) appraisal well was successfully drilled, and tested confirming the presence of substantial gas resources. It is the first gas test in Suriname.
- The gas is characterized as a clean dry gas with low liquids whilst the reservoir is deemed to be world class.
- The result of the Sloanea discovery indicates a promising future gas development.

Palulu, National Flower of Suriname
Credit: Pateix Photography

3. Geodynamic Evolution of the Guiana Basin

Birth of the Central Atlantic

201 Ma

Break up of Pangea (230-200 Ma)

Rifting in this part of Pangea began during the Middle to Late Triassic (~240 Ma) and continued into the Early Jurassic (~190 Ma). This rifting followed the orientation of older orogenic belts, creating a series of rift basins along what would become the Central Atlantic margin.

In Suriname and nearby regions, northeast-oriented Triassic rifting affected the Demerara Rise, forming the Nickerie and Commewijne grabens, and extended into the Takutu Graben in Brazil and Guyana.

This rifting, along with salt basin development, set the stage for the opening of the Central Atlantic Ocean and the fragmentation of Gondwana.

175 Ma

Opening of the Central Atlantic (187-175 Ma)

The North Atlantic rift system progressively opened southward during the Early Jurassic (~187–175 Ma), starting in the northern Central Atlantic between Morocco and Nova Scotia, followed by rifting between North America and northwestern Africa (Mauritania/Senegal), and later between Senegal (south of Dakar) and Florida.

Rifting continued southward, following the orientation of older orogenic belts, eventually reaching the Demerara Plateau.

165 Ma

The Final Breakup of Pangea (~165 Ma)

The Central Atlantic fully opened between the Demerara Rise/Guinea Plateau and the Bahamas Plateau approximately around 165 Ma.

A marine connection formed between the Central Atlantic and proto-Caribbean.

Passive margin formation along Africa was diachronous, progressing north to south.

Credit: Modified after Scotese C.

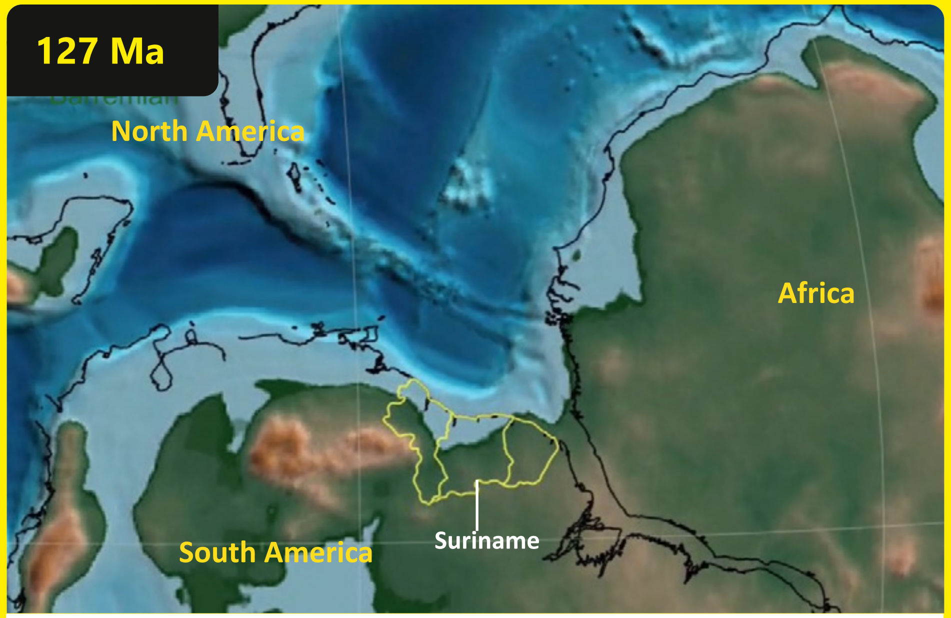
Birth of the Equatorial Atlantic

Post Rift Evolution (150-125 Ma)

Spreading rates increased from 2-6cm/yr through the Jurassic, then dropped sharply around 150 Ma.

Seaward Dipping Reflectors (SDRs) beneath the Demerara Rise are linked to hotspot activities (Bahamas, Sierra Leone), continuing Central Atlantic spreading.

Post-rift sedimentation began with the development of a broad carbonate ramp around the basin margins. This ramp was widest in the southern Central Atlantic, especially along the Florida margin and the conjugate Demerara Plateau - Guinea Plateau.



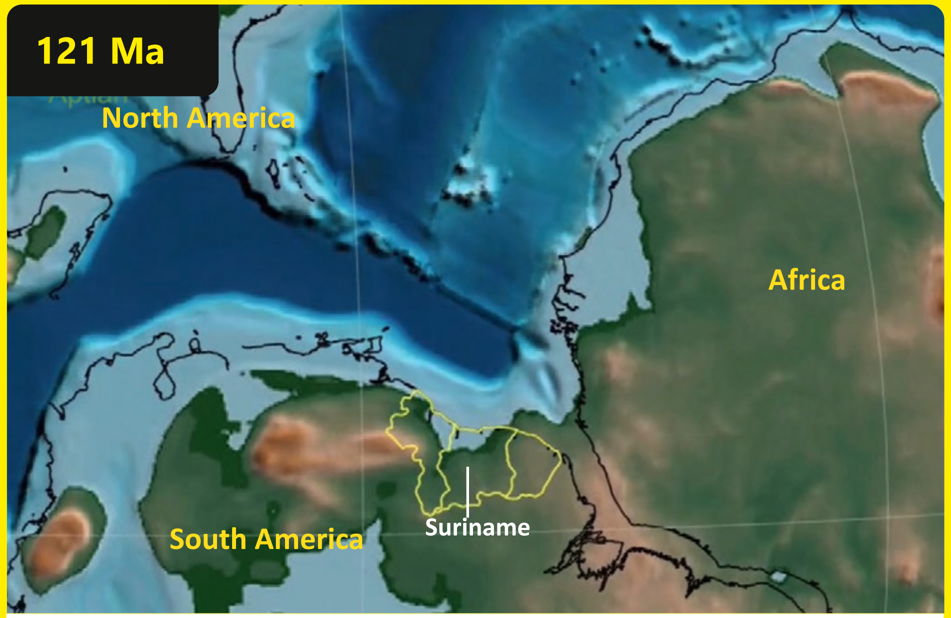
Embryonic Rift Phase of the Equatorial Atlantic (125-120 Ma)

During the Barremian-Aptian (124–114 Ma), northeastern–southwestern extension triggered rifting in the Equatorial Atlantic, exploiting older Basement weaknesses. The analogous environment for this phase is likened to the Present day East African Rift system.

Narrow rift basins formed between the Demerara Plateau and Guinea Plateau, extending offshore into French Guiana and the Caciporé Graben in Brazil.

Localized volcanism occurred along both margins, linked to the rifting process.

Global Ocean Anoxic Events (OAE):
Faraoni event. Deposition of Barremian source rock.



Equatorial Atlantic Rift Phase (120-114 Ma)

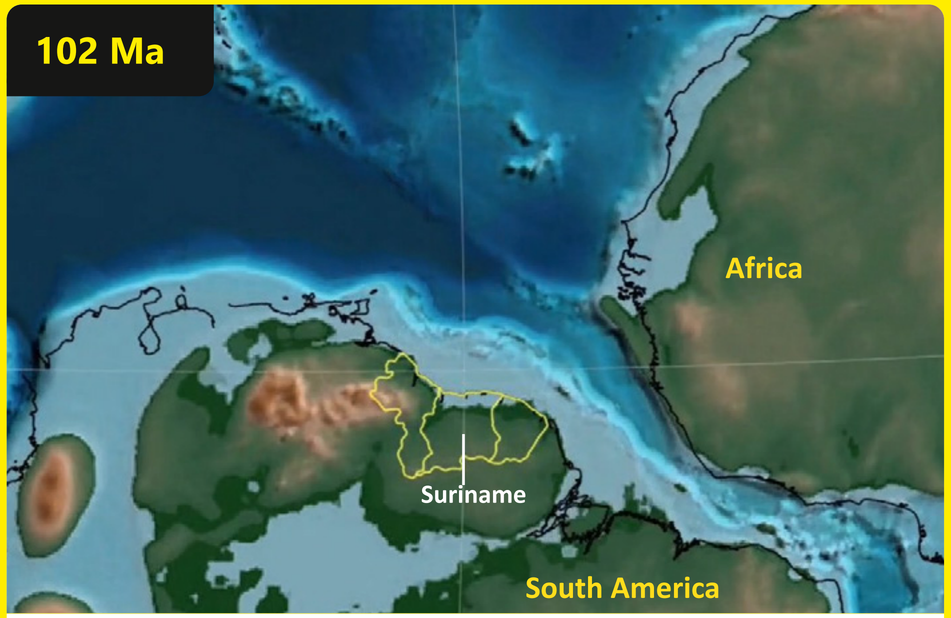
This period of rifting is a continuation of active extension and the formation of the first oceanic crust.

Oceanic spreading in the Equatorial Atlantic began in the Late Aptian, with the oceanic crust first forming in small divergent segments from south to north.

Global Ocean Anoxic Events (OAE):
OAE1a Selli Event: Deposition of Aptian source rock.

Credit: Modified after Scotese C.

Post-Rift Evolution of the Atlantic



Equatorial Atlantic Rift Phase (114-101 Ma)

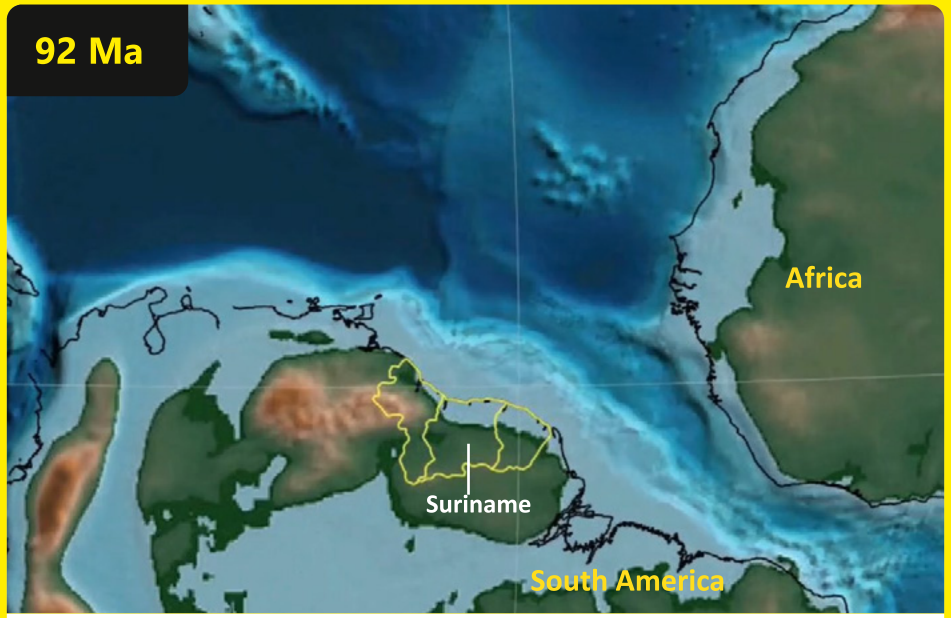
In the Early Albian (114-108 Ma), anticlockwise rotation of the African plate changed the stress regime, forming dextral pull-apart basins and transpressional segments (future oceanic fracture zones).

In the Late Albian (108-101 Ma), transpressional segments relaxed, and margins became divergent and passive.

Seafloor spreading extended through the Equatorial Atlantic, connecting it to the Central Atlantic.

This created a juxtaposition of Jurassic-aged crust (Central Atlantic) and Cretaceous-aged crust (Equatorial Atlantic) in the Guiana Basin and around the Demerara Rise.

Global Ocean Anoxic Events (OAE):
OAE1b Paquier Event: Deposition of Early Albian source rock.
OAE1d Breistroffer event. Deposition of Late Albian source rock.



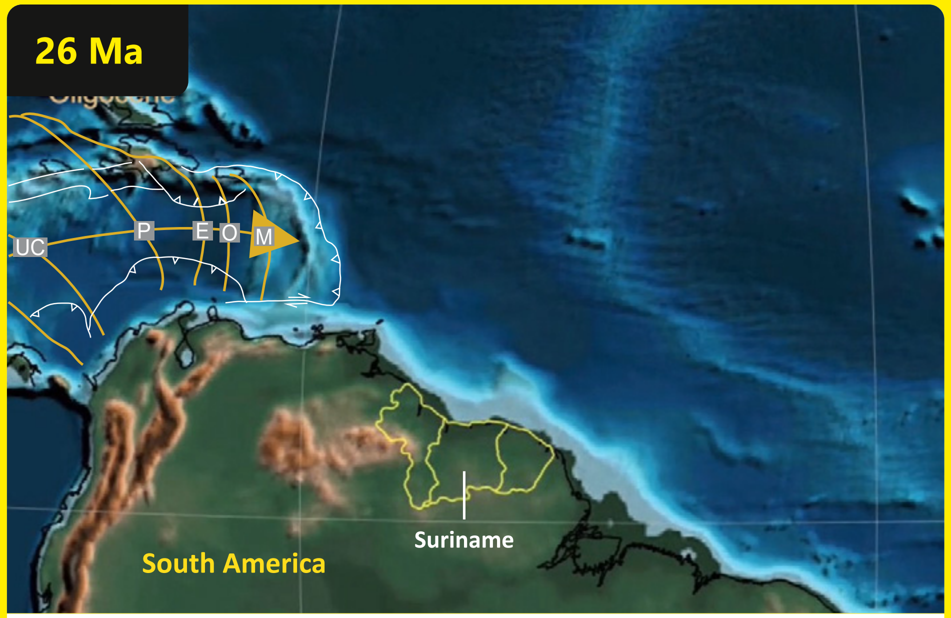
Post-Rift Atlantic Source Rock Deposition (94 Ma)

A global transgression and coastal upwelling led to the deposition of organic-rich sediments during Oceanic Anoxic Event 2 (OAE-2).

This event marks a key interval of black shale deposition and enhanced hydrocarbon potential across the region.

Previously called the Canje source rock, it is also called the Albian-Cenomanian-Turonian (ACT) source rock within the Guiana Basin as these source rock intervals have been grouped together.

Global Ocean Anoxic Events (OAE):
OAE2 Bonarelli Event: Deposition of Cenomanian-Turonian (CT) source rock.



Paleogene – Caribbean Plate Development

The Caribbean Plate has a complex and still partly unresolved geological history.

The plate most likely originated as a volcanic oceanic plateau in the Pacific Ocean during the Late Jurassic (~150 Ma).

It migrated northeastward during the Cretaceous, and eastward during the Tertiary, entering the Central Atlantic region. This movement led to the subduction of Atlantic oceanic crust, forming a seaway between North and South America.

The plate continues to move eastward, with seafloor overthrusting along its eastern margin.

Miocene (M), Oligocene (O), Eocene (E), Paleocene (P) and Upper Cretaceous (UC) are labelled on the map and illustrate where the volcanic arcs were located at that moment in Geologic time. The Lower Cretaceous (LC) volcanic arc was situated to the west of the UC volcanic arc.

Credit: Modified after Scotese C.

Post-Rift Evolution of the Atlantic continued

Amazon Delta
Credit: NASA's Terra Satellite Image, 2020)

Neogene – Rise of the Andes and Amazon

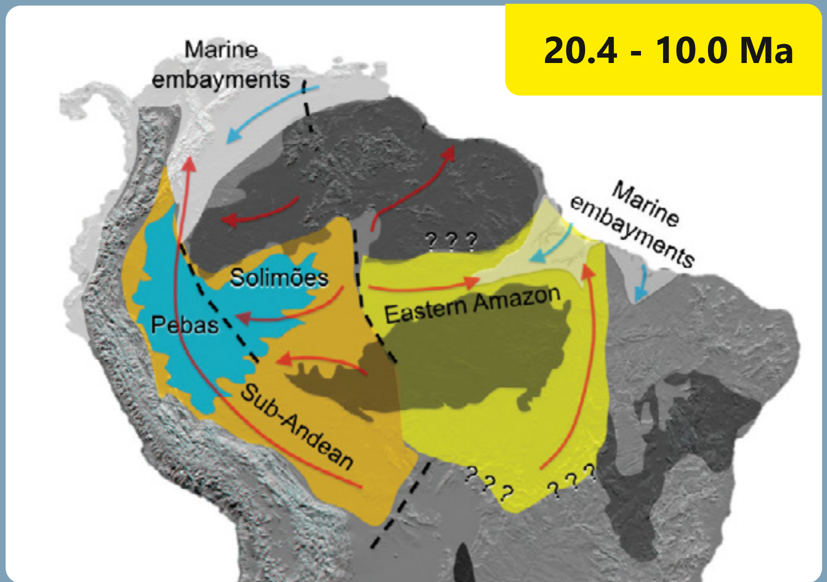
Most sedimentary basins formed during Lower Cretaceous rifting (~145–100 Ma) as South America separated from Africa.

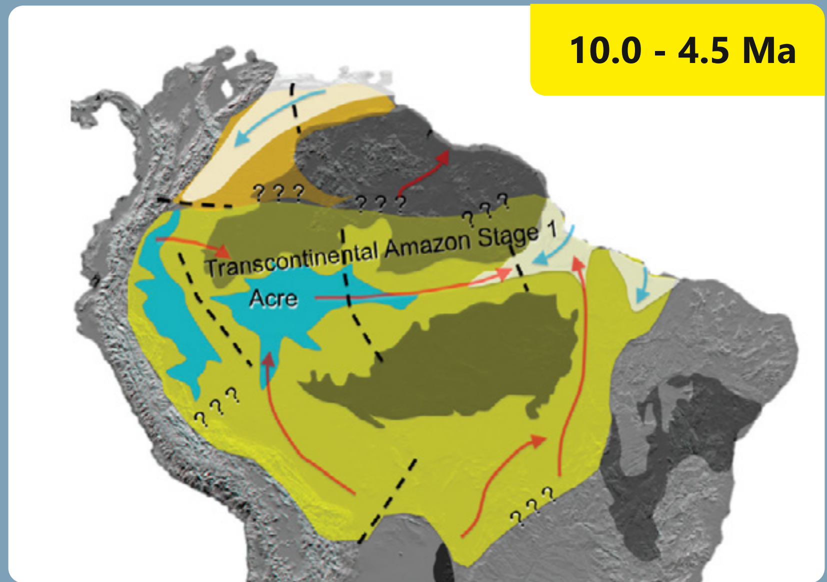
The Amazon Basin Complex was affected by Andean uplift, resulting in erosion and increased sediment delivery during the Paleogene and Neogene.

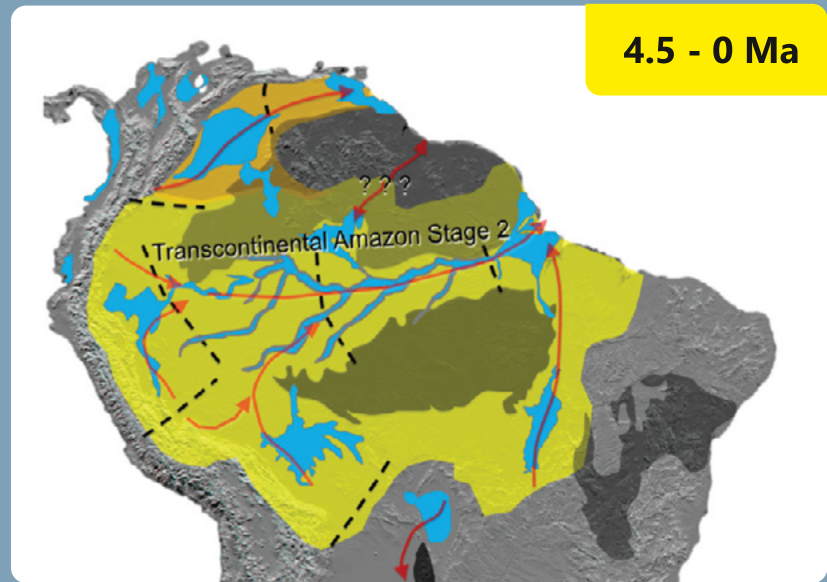
A Late Cretaceous–Paleogene (~100–23 Ma): Western rivers in northern South America flowed northward into the sub-Andean foreland and then into the proto-Caribbean Sea.

B Late Miocene, (~10–4.5 Ma): With the rise of the Andean mountain belt, no large deltas formed in the northern Andean basins, suggesting multiple small rivers rather than a single Amazon stem.

C Mid Pliocene to Present, (~4.5–0 Ma): The Amazon River began flowing eastward across the continent into the Atlantic as a shift in drainage occurred due to the uplifted Andes mountains.







Legend

Mega-Wetlands

Development of the Amazon Drainage system in the Tertiary (Albert, J. S., Val, P., & Hoorn, C.,2018).

Otter in Suriname
Credit: Dion Howard

4. General Stratigraphy of the Guiana Basin

Bird and sea turtles nature reserve at the mouth of the Maroni River, Galibi Suriname. Credit: Rico van Manen

Chrono-Stratigraphic Chart

This section discusses the stratigraphic record of the Guiana Basin as it relates to the basin evolution. The record also illustrates the link between sequence stratigraphic and relative sea level cycles according to the displayed Exxon curve (Kerr, R. A., 1987) and Haq curve (Haq et al., 1988).

No official formation names were assigned to the Lower Cretaceous and Jurassic intervals and therefore, Staatsolie introduced three new formations to compliment the already existing ones that had been identified in 1998 (Wong et al. 1998). The new formations cover the deeper sections of the subsurface strata and show some equivalence with the formations recognised in the Guiana stratigraphy. The new formations are as followed:

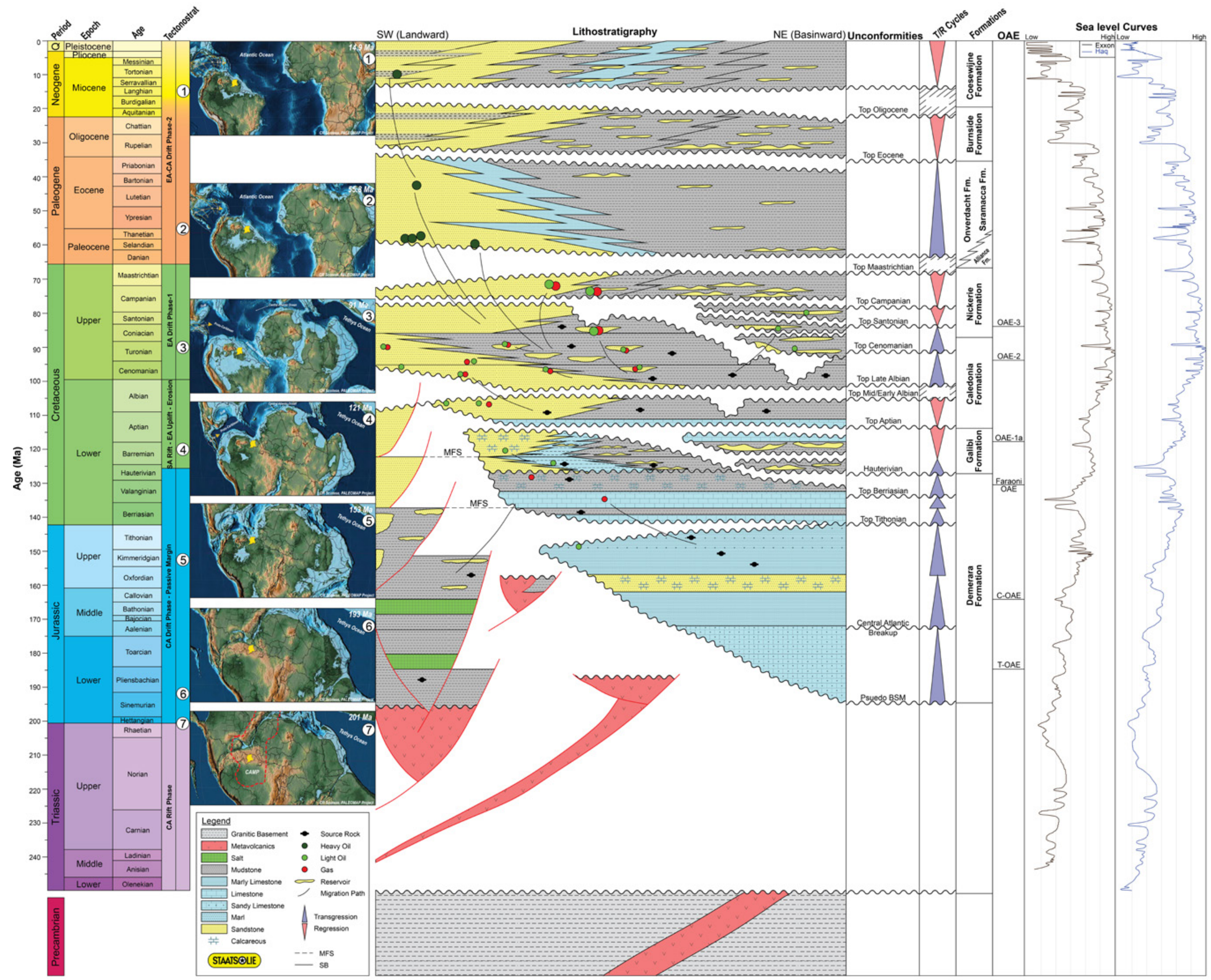
- Caledonia Formation - this is equivalent to the Canje Formation in Guyana which denotes the primary source rock within the region. The lithology is characterised as predominantly black shale with organic material. The Caledonia Formation also encompasses the Aptian (pre-unconformity strata) as that has proven to also be a contributor to the oil generation within the basin.
- Galibi Formation - this formation was encountered on the Demerara Plateau and ranges from Hauterivian to Barremian in age. The formation's stratigraphy is characterised by an abundance of shales and marlstones.
- Demerara Formation - this stratigraphy was penetrated on the Demerara Plateau area and consists of a mostly carbonate stratigraphy, with ages ranging from Sinemurian to Valanginian. Deposition of this formation occurred when Jurassic receded and sagged, creating a favourable environment for carbonate growth.

Triassic

The Late Triassic denoted the initial-rift phase of the opening of the Central Atlantic.

At approx. 200 Ma the Nickerie and Commewijne Grabens, along with other east-west rifts formed along the Guiana margin, filled with metavolcanics (related to the Central Atlantic Magmatic Province, CAMP).

The Takutu Graben developed during the Late Triassic - Early Jurassic, and was defined by the emplacement of seaward dipping reflectors (SDRs), dykes and basalts.



Jurassic

Two oceanic anoxic events occurred during the Jurassic; the Toarcian Oceanic Anoxic Event (T-OAE) at approximately. 183 Ma, emplacing black shales globally; and the Callovian OAE (C-OAE) at ~165 Ma which also resulted in the deposition of organic rich black shales.

The onset of deposition within the Guiana Basin consists of Early Jurassic platform carbonate facies alternating with marlstone facies.

During the Middle Jurassic, the opening of the Guiana Basin created a shallow marine environment, enabling continued carbonate growth.

Post the C-OAE in the Upper Jurassic, the carbonate factory had been restored and saw the development of a major carbonate platform on the Demerara Plateau.

In the Tithonian, Kimmeridgian and Oxfordian, source rocks were likely deposited within the Guiana Basin. The postulated source rock facies are argillaceous limestone and calcareous shale deposits.

The Jurassic aged strata is partly recorded in the substrata of the Demerara Plateau. It is therefore denoted as the Demerara Formation.

Further recorded Jurassic age fill is penetrated in the Takutu Graben. The strata consist of basalts, lacustrine siltstones, mudstones and evaporites.

Lower Cretaceous

Two global OAEs are recognised in the Lower Cretaceous; the first OAE is the Hauterivian Faraoni event (Faraoni-OAE) (~131 Ma); and the second event is the OAE-1a, also known as the Aptian Selli event (~119.5 Ma), resulting in the deposition of potential source rocks.

In the north of the Guiana Basin, Berriasian - Valanginian age rifting started between the Demerara Plateau and the Guinea Plateau, creating a series of rift valley lakes filled with terrestrial-lacustrine sediments and black shale deposits.

Carbonate platform growth persisted from the Jurassic into the Valanginian.

The Hauterivian-Barremian is characterised by a shallow marine carbonate dominated shelf towards the north, with a clastic dominated shelf in the proximal area, succeeded by marly to shale deltaic facies.

The Early Aptian interval exhibits a continuation of carbonate development on the shelfal areas and clastic facies in the proximal and northeastern area.

The Late Aptian is characterized by carbonate development on the outboard shelf and a clastic dominated environment on the inboard shelf.

The Break-up Unconformity (BUC) is a major erosional stratigraphic event that occurred during the Aptian-Albian interval.

Within the Takutu Graben, the Takutu Formation was deposited in a fluvial to fresh-water lacustrine environment of a still subsiding basin. The Serra do Tucano Formation overlies the Takutu Formation and was deposited in a fluvial-deltaic to marginal marine environment.

Nieuw Amsterdam Pier on the Suriname River bank
Credit: Nikka Parie

Upper Cretaceous

There are two OAE events recognised in the Upper Cretaceous. OAE-2, also known as the Cenomanian-Turonian boundary event, or Bonarelli event, occurred at approx. 94 Ma. This event deposited the main known source rock in the Guiana Basin.

The OAE-3 event occurred during the Coniacian-Santonian (~85 Ma). It was a period of widespread black shale deposition but was regionally restricted to the Atlantic and adjacent basins.

The onset of the Coniacian marks the beginning of sand-prone turbidite fan systems in the Upper Cretaceous. The main turbidite fairways during the Coniacian to Santonian were fed from the west (Berbice Canyon) and the Suriname hinterland.

A transition from lowstand to early transgression resulted in a progressive change from a sand-dominated turbidite systems in the Late Coniacian, to a mixed mud/sand system in the Early to Mid- Santonian, and finally to a mud-dominated system in the Late Santonian.

A shift occurred in the Campanian when the main turbidite fairways switched eastwards, sourcing sediments from the Greenstone belt and granitoid regions in the south.

The Campanian to Maastrichtian turbidite systems are also marked by a progressive reduction in sand content upwards through the succession. Maastrichtian systems developed linear channel levee complexes running in a south-to-north orientation.
The Upper Cretaceous interval on the Demerara Plateau consists of condensed sections of layer-caked clastic deposition. Moving towards the Nearshore we encounter shallow water carbonate development and the Onshore was dominated by a fluvial to deltaic system.

Tertiary

There are two main unconformities in the Tertiary, the Oligocene unconformity and Mid-Miocene unconformity.

The Oligocene unconformity is associated with a major global eustatic fall in sea-level and is overlaid by younger, predominantly Miocene sediments.

The Mid-Miocene unconformity is an erosional surface linked to tectonic uplift (Andes) and subsequent global sea-level changes.

The Tertiary Onshore section is of particular interest due to the presence of an active petroleum system. The Onshore successions consist of clastic fluvial to deltaic deposits which transitioned to calcareous facies in the shallow Offshore.

The main Onshore producing reservoirs are of Paleocene age and are termed the T-sands. The Eocene represents a regional seal over the area.

Tapawatra Soela, Interior of Suriname
Credit: Dion Howard

5. Structural Configuration of the Guiana Basin

Voltzberg in Suriname
Credit: Grietje en Riske Videomakers

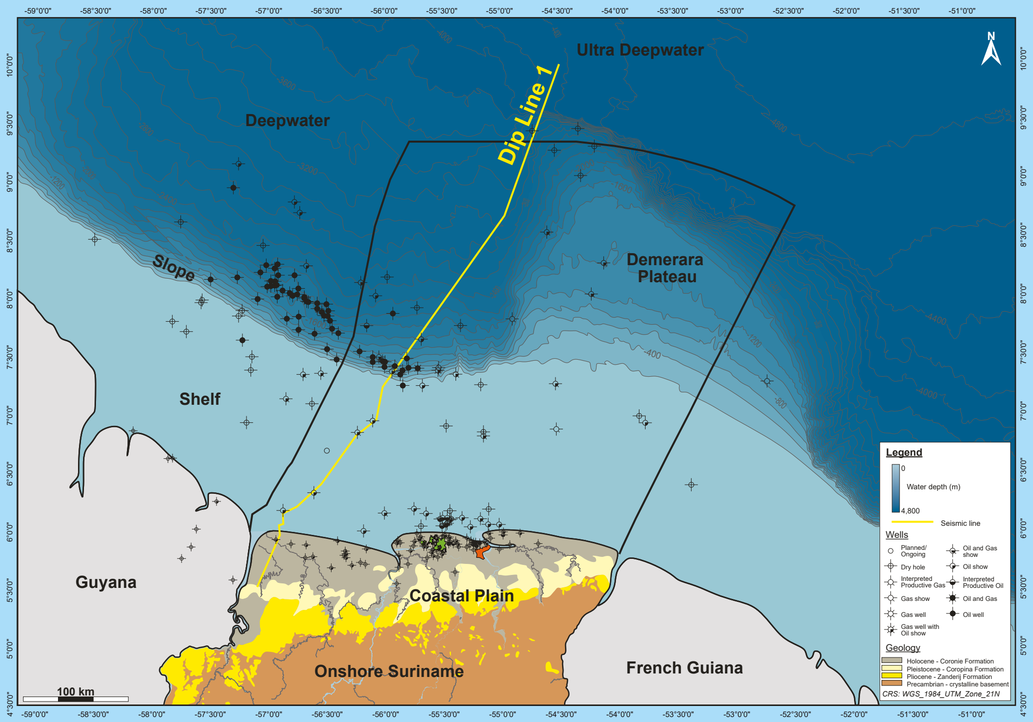
Introduction

The structural configuration related to the petroleum systems of the Guiana Basin is best portrayed by a series of key regional unconformities and flooding surfaces. These markers consist of:

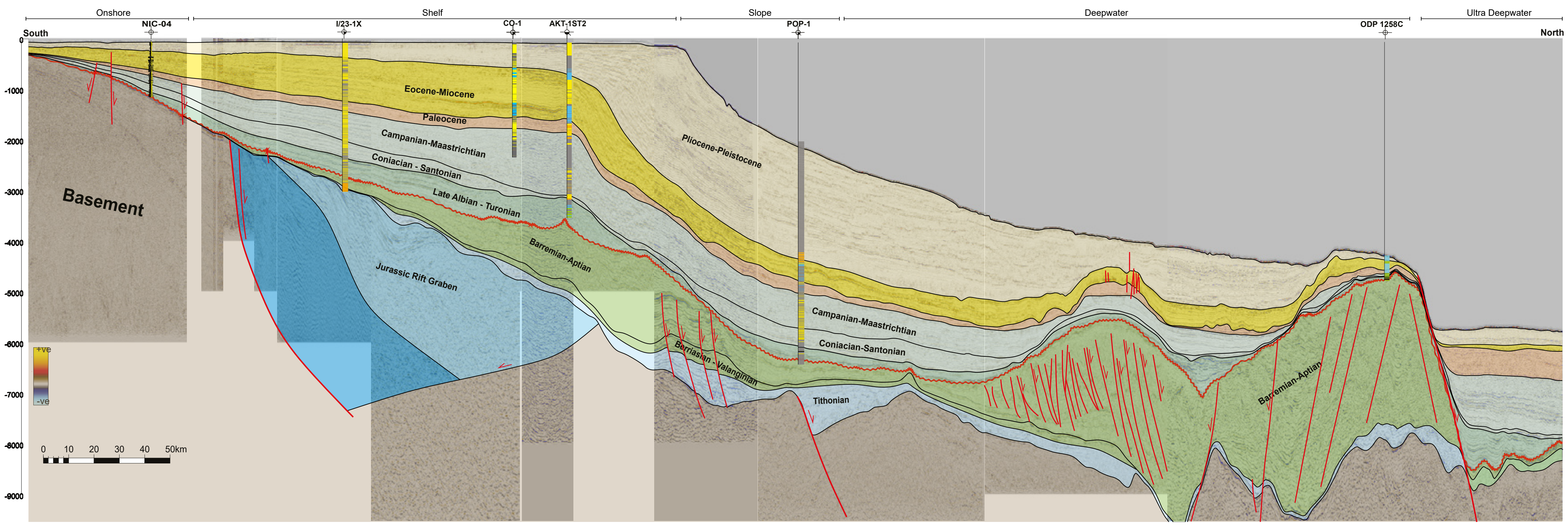
1. Basement (and its correlative base Jurassic marker)
2. Berriasian-Valanginian unconformity
3. Late Aptian unconformity
4. Maastrichtian unconformity
5. Paleocene flooding surface

There are five depth structure maps shown in this chapter; the ages are marked on the stratigraphic column and the horizons are highlighted on the regional Geoseismic Dip line.

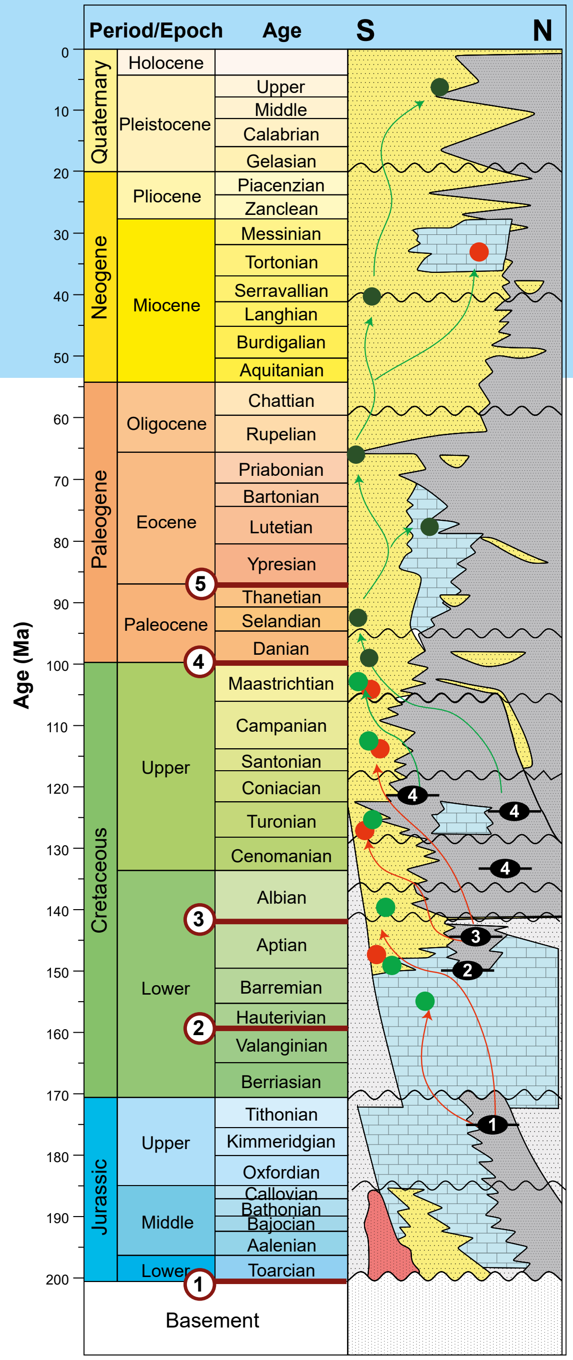
The main structural elements are highlighted in this chapter in terms of their paleogeographic relevance, with respect to the depositional environment which are discussed further in Chapter 7. In addition, the structural configurations set the stage for the different trapping styles as summarized in Chapter 9.



Overview map of Geoseismic Dipline 1



Geoseismic Dipline 1 Profile



Simplified Stratigraphic column of the basin

Basement, Jurassic and Lower Cretaceous

Basement and Jurassic

The Basement is relatively structured in the Coastal Plain and Nearshore area. Numerous Precambrian Basement faults are believed to control the trapping within the Onshore. To the south and east the Basement is exposed in the hinterland as the Guiana Shield. The Basement deepens to the west, approximately 2 km from the Coastal Plain, where it forms the depocenter.

In the Nearshore, the Basement is incised by the Jurassic rift grabens. The most proximal rift grabens are the Nickerie Graben in the west and the Commewijne Graben in the east.

The rest of the Offshore area is characterised by: Rift graben and rift shoulders in the proximal area; the rift shoulders often form the initial topography for carbonate growth; while the rift grabens are characterised by volcanic deposits with occasional clastic intercalations. Various (sub) grabens are formed due to cooling and sagging as well as tectonics; these are the initial candidates for Jurassic source rock deposits.

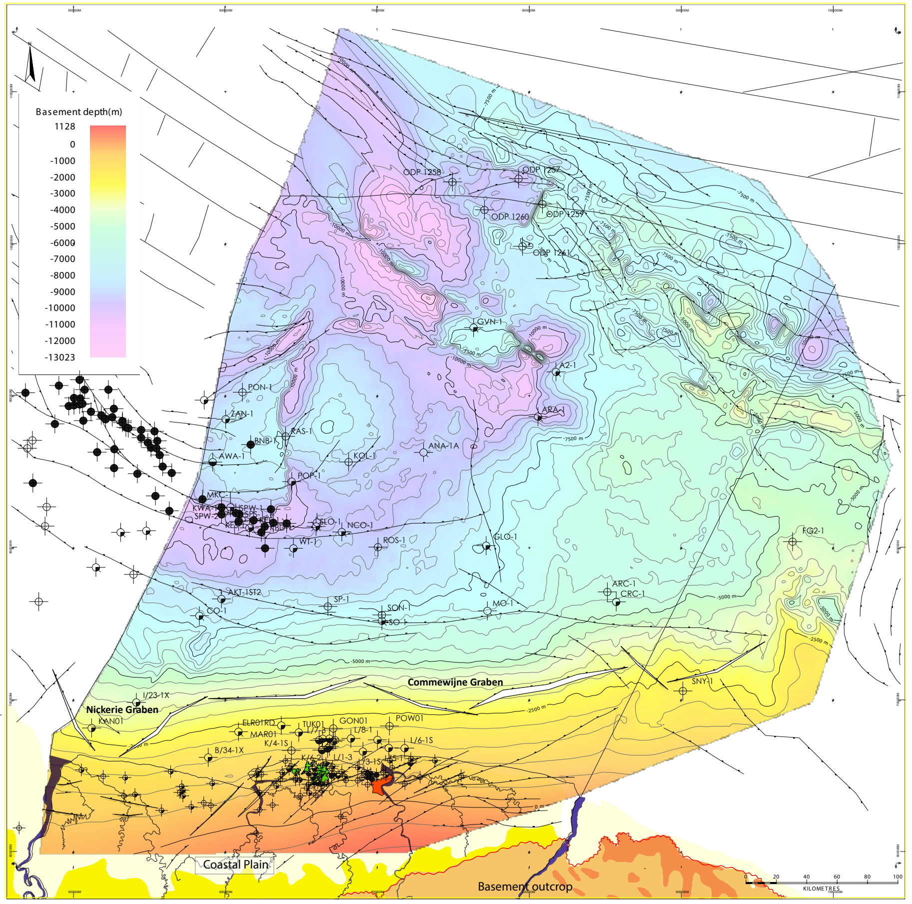
The Basement and Jurassic sequence is characterised by major west-northwest-east-southeast trending faults which are offset by northeast-trending faults.

Lower Cretaceous (Berriasian, Valanginian and Hauterivian)

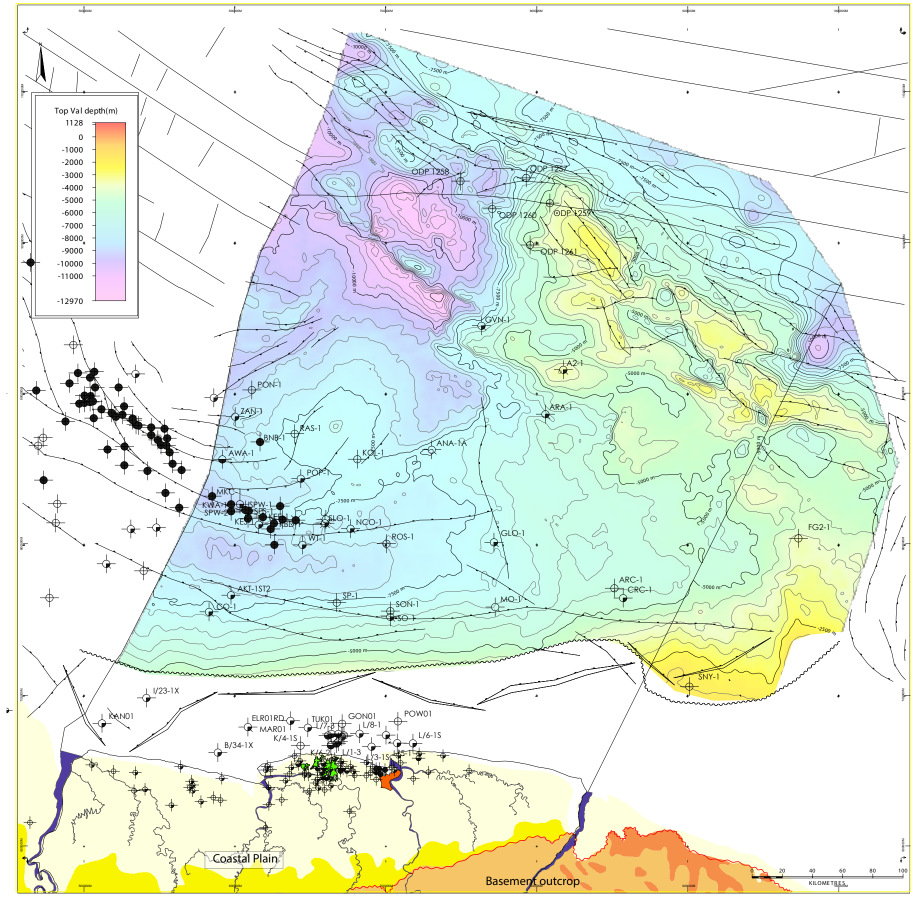
The Lower Cretaceous can be subdivided into three intervals, each bounded at the top by an unconformity. The first consists of the ages Berriasian, Valanginian, and Hauterivian. The second incorporates the ages Barremian and Aptian, and the third represents the Albian. The Berriasian, Valanginian, and Hauterivian is mostly represented by the Berriasian and Valanginian; there is little preservation of the Hauterivian according to current biostratigraphy understanding.
Within this interval, the units progressively onlap on the top Jurassic and Basement unconformity in the south and southeast.

The geomorphology is characterised in the northeast by various platforms separated by thick-skinned fault-bounded grabens, which are elongated in a northwesterly direction.

To the west of the Demerara Plateau, the Lower Cretaceous shelf prograded towards the basin floor. The prograding shelf edge later collapsed and is now characterised by rotated fault blocks. The faults are interpreted as listric faults whose decollément surface coincided with the top Barremian.



Basement -Base Jurassic Depth Structures



Top Valangian Depth Structures

Lower Cretaceous: Barremian-Albian

Lower Cretaceous (Barremian-Aptian)

The Aptian compressional episode caused inversion of the earlier geomorphology; this is characterised by:

- Inverted rift grabens and platforms.
- Roll-over shelf edge delta.
- Enhanced anticlinal structures which were followed by up to 2.5 km erosion resulting in significant angular truncations against the unconformity.
- Enhanced sub-basin formation, separating the Demerara uplift to the north and the Lower Cretaceous narrow shelf to the south; this subbasin is interpreted as one of the key candidates for early source rock deposition and preservation.
- Increased valley and graben fills.

The footprint of this compressional and erosional episode is well known in the basin as the Break-up Unconformity of Aptian-Albian age (BUC).

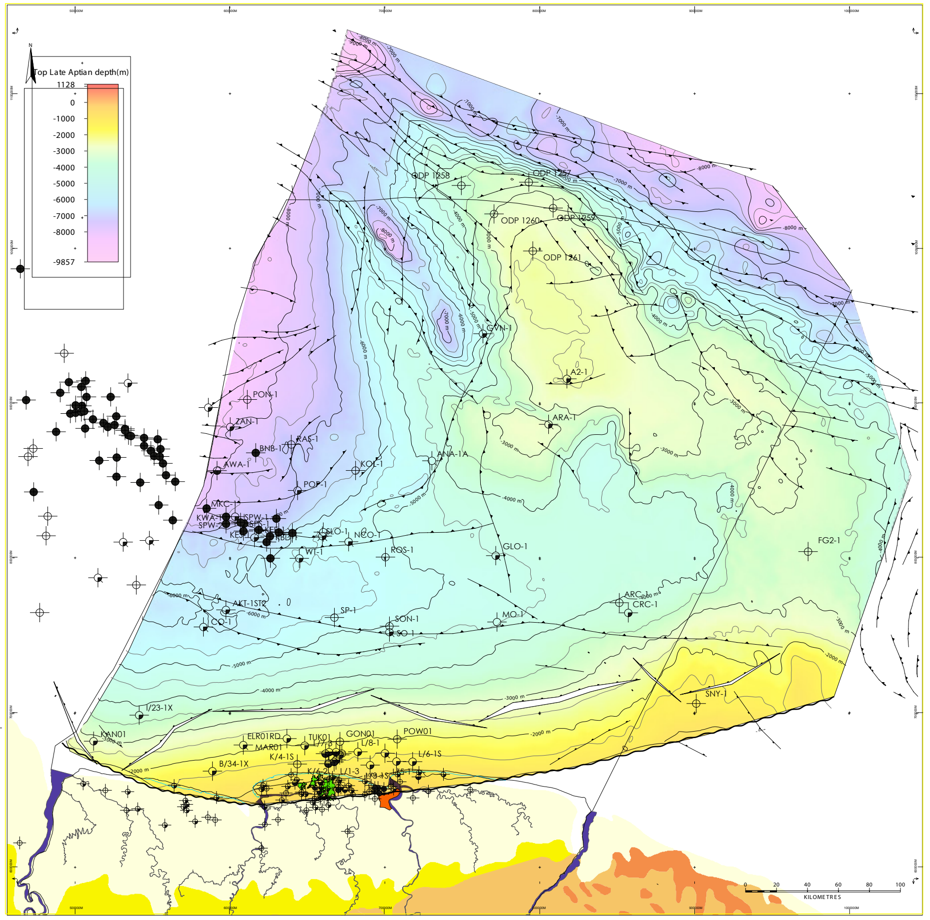
Lower Cretaceous (Aptian-Albian)

The BUC marked a significant change in the basin geomorphology; the basin transitioned from tectonically active to a passive margin phase across the entire Atlantic Margin, including the Guiana Basin.
Due to the uplift and severe erosion, the Albian occasionally merges with the Late Aptian unconformity; the BUC geomorphology is therefore represented by the Late Aptian unconformity on the depth structure map.

Transgression of the sealevel caused by global OAEs 1 and 2, respectively of Lower Cretaceous and Upper Cretaceous age caused a very broad shelf (approximately 100 km) to develop along the margin, and caused the Demerara Plateau to further evolve into the present-day 40,000 km^2 platform.

The focus of the sedimentation shifted toward the depocenter in the west, where the basin developed as a consequence of the relative sea-level fluctuations.

The deposition and preservation of the world class source rock (ACT) was initiated during this period and continued into the Coniacian.



Top Aptian Depth Structures

Upper Cretaceous and Tertiary

Upper Cretaceous

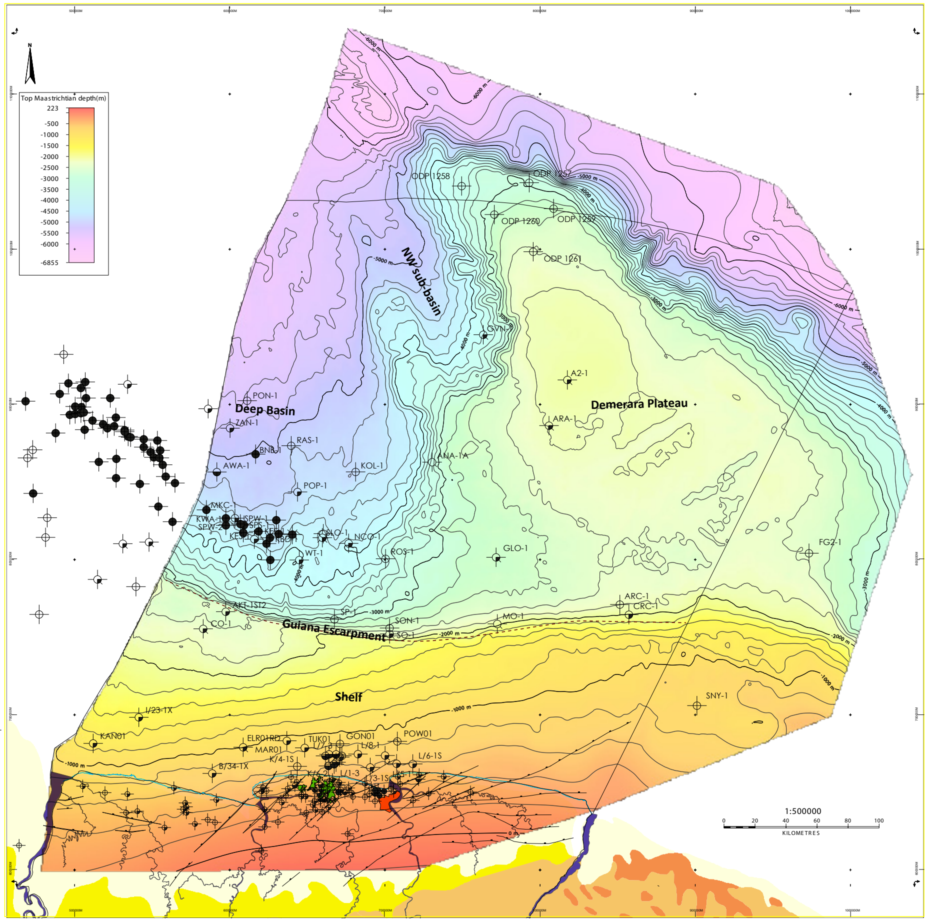
The Upper Cretaceous is characterised by gently dipping strata on a very wide shelf. Clastic input from the shelf caused topographic elevation of an east-west trending shelf margin which is known as the Guiana Escarpment. Coniacian to Maastrichtian lowstand system cycles caused significant periods of erosion of the shelf margin creating, shelf margin canyons, valleys and channels. These are considered to be the main conduits for delivering shelf clastics into the deepwater settings of the basin. These deposits consist of channel fans, turbidites and mass transport complexes (discussed more in Chapter 7).

The Upper Cretaceous units progressively onlap onto the Basement on the present day Coastal Plain of Suriname. The Maastrichtian unconformity, sometimes also referred to as the Top Cretaceous unconformity, underlies the Onshore oil fields of Suriname.

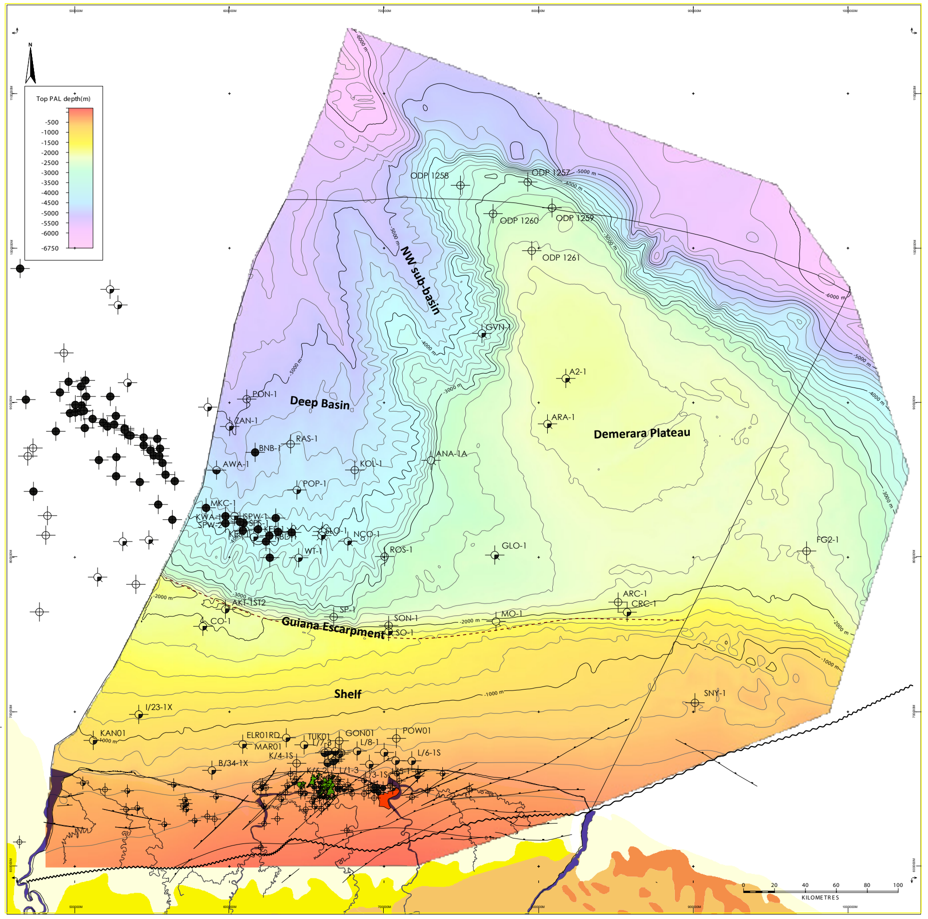
Tertiary

The Paleocene-Eocene sequence passively filled the Maastrichtian lowstand erosional landscape. Sea-level changes resulted in a transgressive and then a regressive cycle, with increased sediment input from the south resulting in broadening of the Paleocene shelf. The transition from the Paleocene to Eocene is recognized as the most landward transgressive marine flooding.

Some reactivated northeast-southwest trending faults provide the trapping mechanism for fluviatile plays in the Onshore.

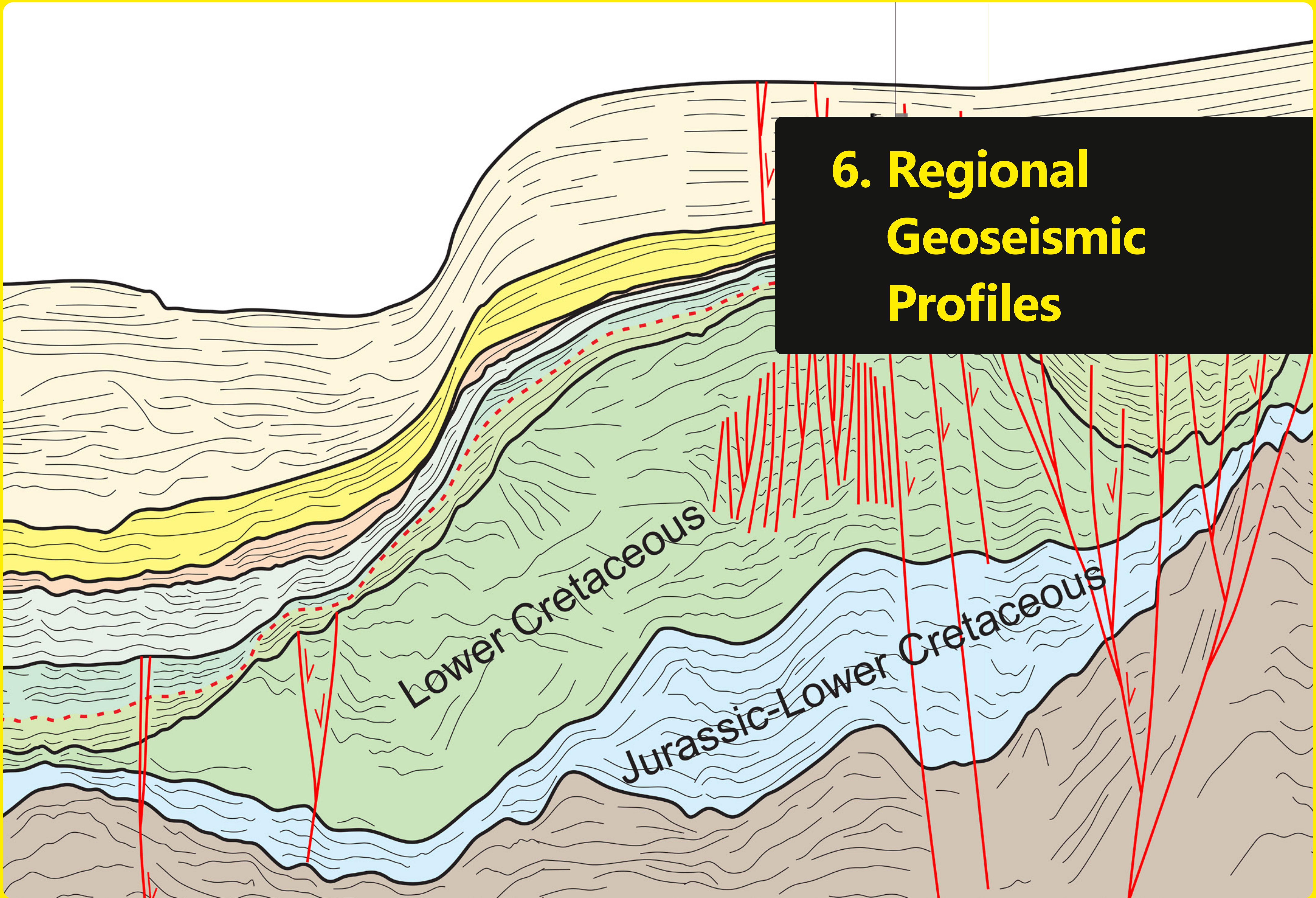


Top Maastrichtian Depth Structures



Top Paleocene Depth Structures

Leatherback Turtle
Credit: Jolo Diaz

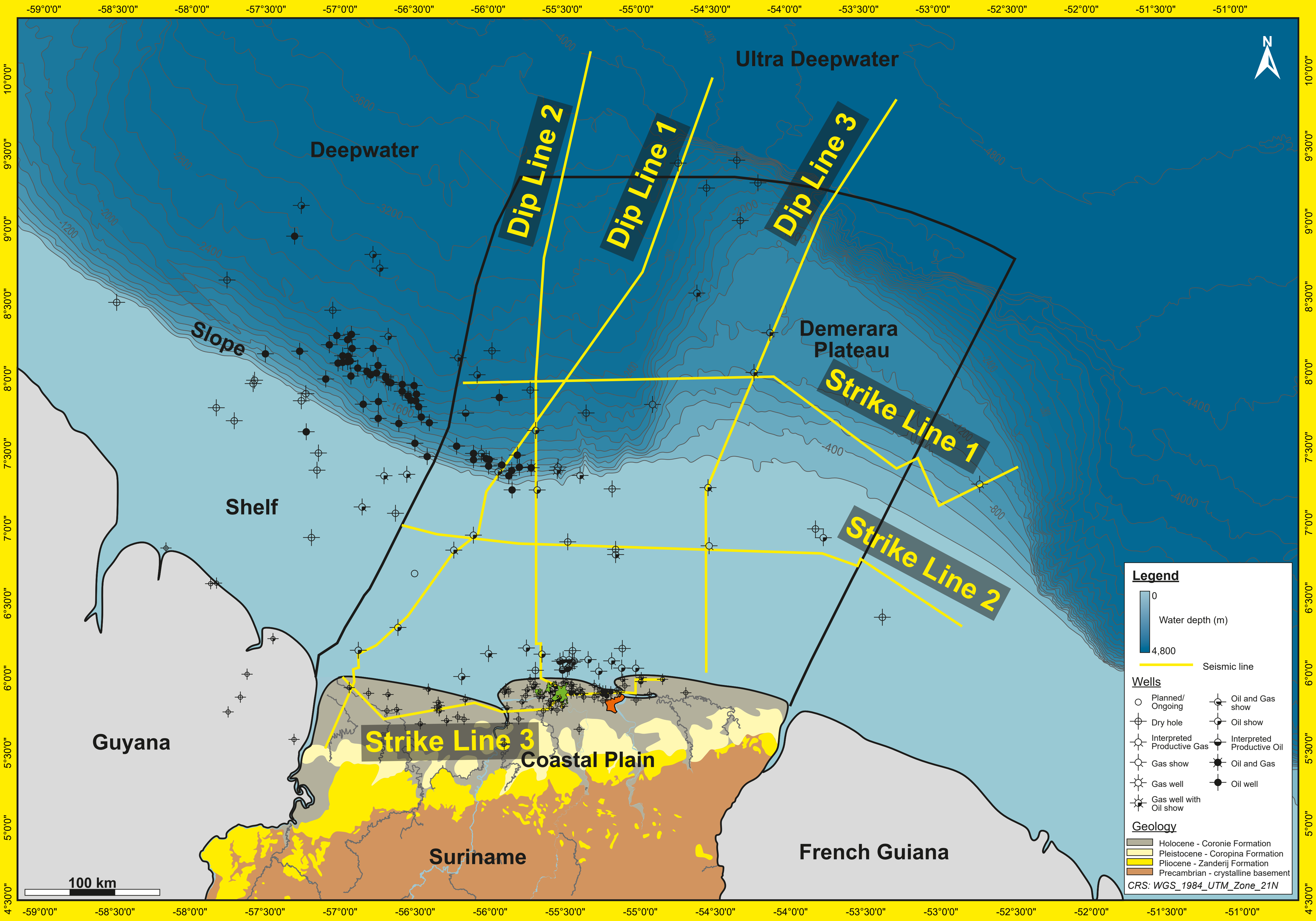


6. Regional Geoseismic Profiles

Regional Geoseismic Profiles

Following the structural configurations of the basin, this chapter delves deeper into the integration of structures and resulting facies. This integration is presented via six regional geoseismic profiles, which showcase different parts of the basin:

- Three dip profiles:
  Onshore to Ultra Deepwater.
- Three strike profiles:
  Onshore, Shallow Offshore and Deepwater



Overview map of the regional geoseismic profiles

Introduction

Each of the six regional geoseismic profiles are presented in two versions namely:

- Chronostratigraphy
- Facies

The colour codes and patterns used for the chronostratigraphy and the facies representation have been selected to strike a balance between internationally recognised standards and Staatsolie's internal conventions.

Chronostratigraphic cross-section
The chronostratigraphic cross-sections display the main regional interpreted age horizons, including the Break-up Unconformity (BUC). Some faults are also shown to highlight the main structural features of each section.

The seismic lines are displayed behind the interpretation.

Facies cross-section
The interpreted distribution of different facies types are based on well data and regional sequence stratigraphic, sedimentological and geophysical studies.

Chronostratigraphy Legend

- Pliocene-Pleistocene
- Eocene-Miocene
- Paleocene
- Upper Cretaceous
- Lower Cretaceous
- Jurassic (U/M/L)
- Basement
- Aptian-Albian Break-up Unconformity (BUC)

Facies Legend

- Sandstone
- Shale
- Siltstone
- Mass Transport Complex (MTC)
- Peat/Lignite
- Calcareous Sand
- Calcareous Shale
- Carbonate/Limestone
- Shaly Limestone
- Chalky Shale
- Volcanic/Basalt/Instrusive
- Granitic Basement

Regional Dip Line 1

General

Regional Dip Line 1 is a southwest-to-northeast-oriented seismic dip line, and it is located from the western Coastal Plain, across the shelf and into the Deepwater along the western edge of the Demerara Plateau.

The profiles incorporated several key wells for facies calibration. The representative wells are NIC04-1, I/23-1X, CO-1, AKT-1ST2, POP-1 and ODP- 1258C. Although insights from confidential wells are used, such wells are deliberately not displayed.

Structure

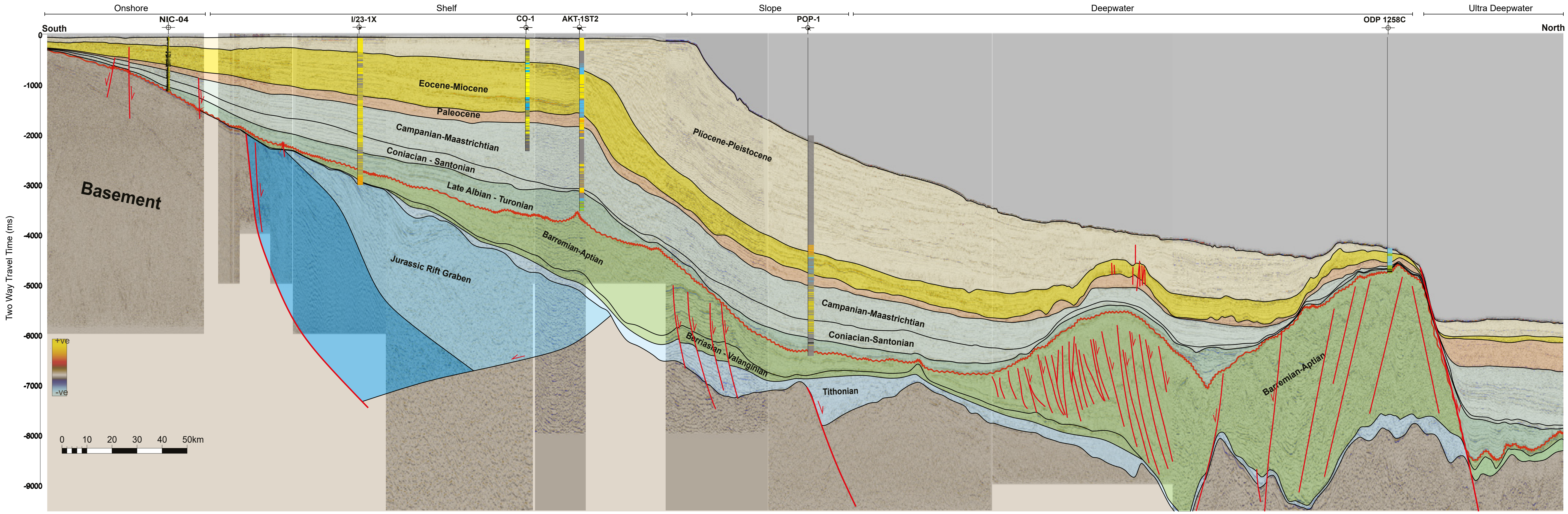
The Regional Dip Line 1 illustrates the structure of the western Guiana Basin in dip orientation.
Key structural highlights are:

- Jurassic rift; the most proximal rift graben is recognized as the Nickerie Graben near the present day coast. The Jurassic rift grabens are seen in this section to be the main drivers of the early geomorphology of the initial basin.
- Wide shelf; aggrading Cretaceous section and prograding Tertiary - Quaternary section
- The Slope and Basin Floor are traversed, and the northern end by a compressed anticlinal structure (Neocomian High), which was subjected to fold-thrust tectonics during the Lower Cretaceous.

Sediments deposited prior to the BUC underwent tectonic deformation due to the active rifting of the Central Atlantic (Mid Jurassic) and Equatorial Atlantic (Lower Cretaceous ~ Top Mid Albian).

Also associated with the BUC was the development of mini grabens along the edge of the Demerara Plateau, which is illustrated on the northern end of this section.

Post Equatorial Atlantic Break-up sediments (~ Late Albian – Cenomanian) consist of passive margin deposits with onlapping stratigraphy onto the Demerara Plateau and lateral continuity of seismic reflectivity between the shelf and the Deepwater.



Regional Dip Line 1 Chronostratigraphy

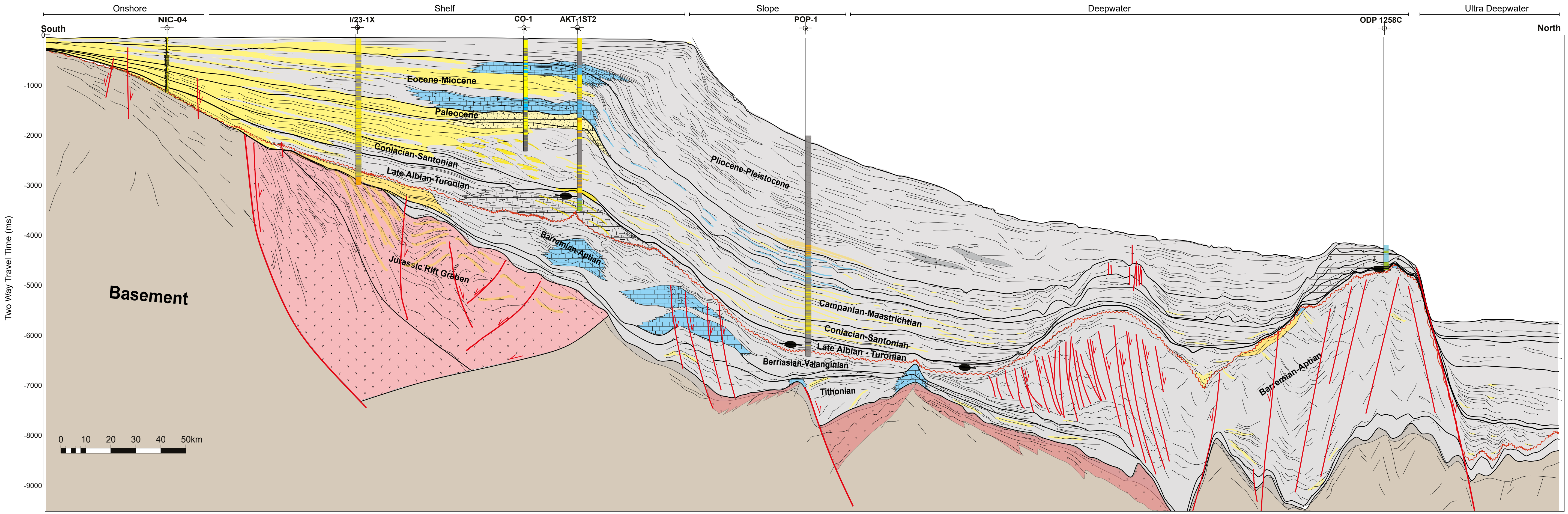
Facies

The general facies trend consists of:

- Onshore (fluvial-deltaic environment); mainly sands with alternating clays and shales.
- Shelf (deltaic-marine environment); transition from sand dominated to shale dominated facies with alternating short cycles of sand deposition. The distal shelf to shelf edge is characterized by Tertiary carbonate platform development. The Upper Cretaceous experienced shelf collapse, thereby creating accommodation space for rapid sediment deposition. This is demonstrated by the progradation events in the facies profile. The Coniacian - Maastrichtian collapse event seen in the Regional Dip Line 1 is interpreted as the time equivalent of the well-know Berbice Canyon.
- Slope and Deepwater: the Slope and Deepwater is generally a shaly dominated environment; this environment is heralded with channel and turbidite fans, mass transport complexes, deposits shales and calcareous layers are encountered as well. Albian-Cenomanian-Turonian (ACT) partly onlaps on the BUC paleoslope. A thick section of the source rock is preserved on the shelf, but transitions from organic shale in the outer shelf to sandy proximal shelf (with alternating organic shale preserved).

The facies interpretations are supported by, among others, the following projected wells:

- The onshore NIC wells proved the presence of a sandy Tertiary fluvial system interbedded laterally with continuous shales.
- Well AKT-1ST2 terminated in the Albian section above the BUC. The overlying succession is composed of multiple carbonate successions interbedded with prograding clastic facies. Hydrocarbons were logged and recovered in the Campanian (oil) and Albian (gas condensate) intervals.
- While the Jurassic grabens are underexplored, the I/23-1X tested 400 m of alternating metasediments and volcanics.
- The Slope to Deepwater wells terminated in the Early- to Late Cretaceous sections, where the POP-1 well penetrated the ACT source rock. Turbidites and channel complexes were encounterd in Mid-Late Cretaceous sections
- The ODP 1258C well terminated above the BUC and encountered mainly carbonates to mixed clastic carbonates. The ATC source rock has been penetrated and is immature in this area.



Regional Dip Line 1 Facies

Regional Dip Line 2

General

Regional Dip Line 2 is a south-to-north-oriented seismic dip line that extends from the Coastal Plain (producing fields), across the Shelf, and into the Deepwater in the northwest.

The wells incorporated into this section include some Onshore wells, and the offshore wells WT-1, POP-1, and RAS-1 well.

Structure

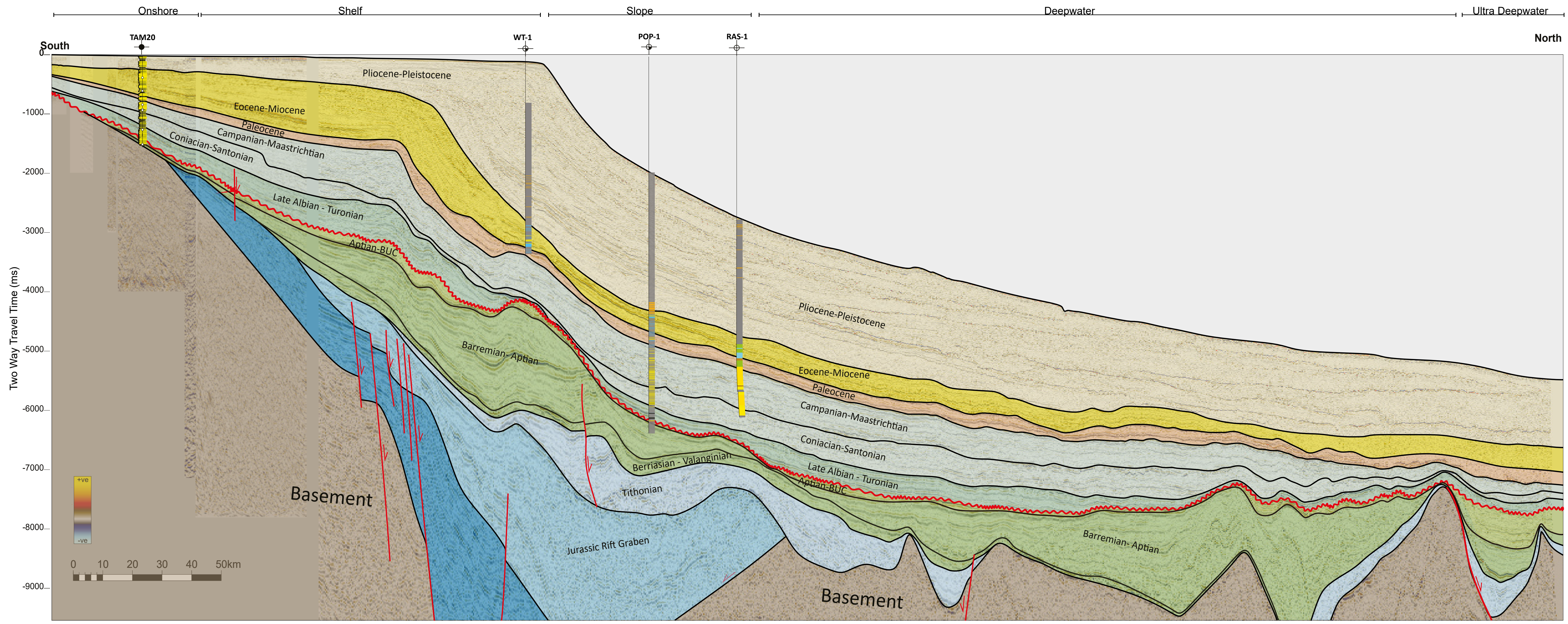
The Regional Dip Line 2 illustrates the extent of similar structures as seen on the Regional Dip Line 1 to the center of the basin.

The structural impact of the rift grabens induced topography is seen on the overlying Cretaceous to Tertiary structures.

Sedimentation prior to the BUC was structurally controlled due to active rifting of the Central Atlantic (Mid Jurassic) and Equatorial Atlantic (Lower Cretaceous ~ Top Mid Albian).

The onset of passive margin deposition occurred post the Equatorial Atlantic rifting (~Late Albian – Cenomanian). The lateral continuity of the seismic reflectivity highlights the passive margin phase with no major tectonic deformation.

The impact of the Demerara Plateau (Neocomian high) is less evident on the line as this line trended in north-western orientation away from the Demerara Plateau. However, the Shelf and Neocomian high still rendered the Deepwater as semi-confined, favoring sediment entrapment.



Regional Dip Line 2 Chronostratigraphy

Facies

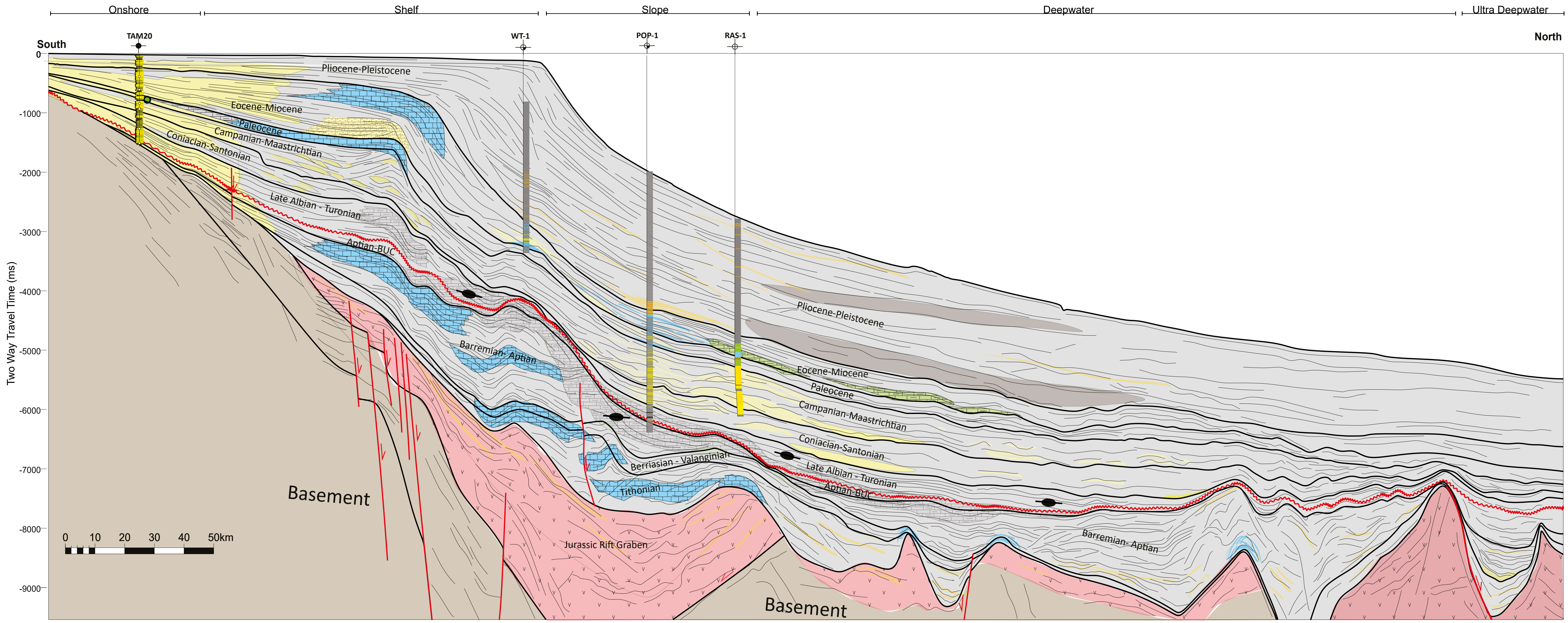
The same facies as seen in Regional Dip Line 1 extended eastward to the center of the basin.

At the center of the basin, the Paleocene-Eocene carbonate platform further developed inland, where it transitioned into calcareous shale in the onshore area. It is recognized in the Onshore oilfield as the Harde Bank (hard bank). This calcareous layer is a major contributor to the traps of the Onshore reservoirs.

Regional Dip Line 2 shows a landward progressive onlap of the Cretaceous and Tertiary sequences. The thinning of the Paleocene in Onshore further enhanced pinch-out traps.

The following further supports the facies extent:

- WT-1: TD in Paleocene. The penetrated Limestone layers are interpreted as erosional materials from the updip Shelf edge carbonate platform of the same age.
- POP-1: TD in Aptian. Upper Cretaceous (~ Coniacian to Santonian) mid-slope turbidite fans were drilled. Hydrocarbons were encountered in the Upper Cretaceous reservoirs.
- RAS-1: TD in Santonian. RAS-1 and POP-1 drilled through a Miocene section consisting of marls; a mix of reworked fine-grained clastics and carbonate material derived from platform carbonate and shelf areas. The Pleistocene section is dominated by argillaceous deposition on the shelf, continental slope, and abyssal plain. Mid-slope turbidite sands interbedded with shales were drilled in the Upper Cretaceous.
- TAM20: drilled in the Onshore penetrated dominantly sandstones in the Tertiary. The Cretaceous section consists of fluvial/alluvial sediments that tend to be less kaolinite-rich.



Regional Dip Line 2 Facies

Regional Dip Line 3

General

Regional Dip Line 3 is a south-to-north-oriented seismic dip line, that illustrated the structure and the geology of the eastern part of the basin. The profile runs from the Shallow Shelf to the Demerara Plateau and the Ultra Deepwater in the northeast.
The wells incorporated in this section include MO-1, GLO-1, ARA-1, and A2-1. The A2-1 well has penetrated the oldest stratigraphy in the basin and is the only well to encounter Tithonian-age sediments.

Structure

The Regional Dip Line 3 is distinctly different than the previous Regional Dip lines. Noticeable differences are:

- Thick Jurassic and Lower Cretaceous sequences
- Thin Upper Cretaceous Sequence
- A less steep and broader Pliocene-Pleistocene Shelf, which goes over to the Demerara Plateau.
- Overall aggradational sequences from Lower Cretaceous to Lower Tertiary. There is an apparently distinctly less north-south progradation of the Lower Tertiary in the eastern part of the basin.

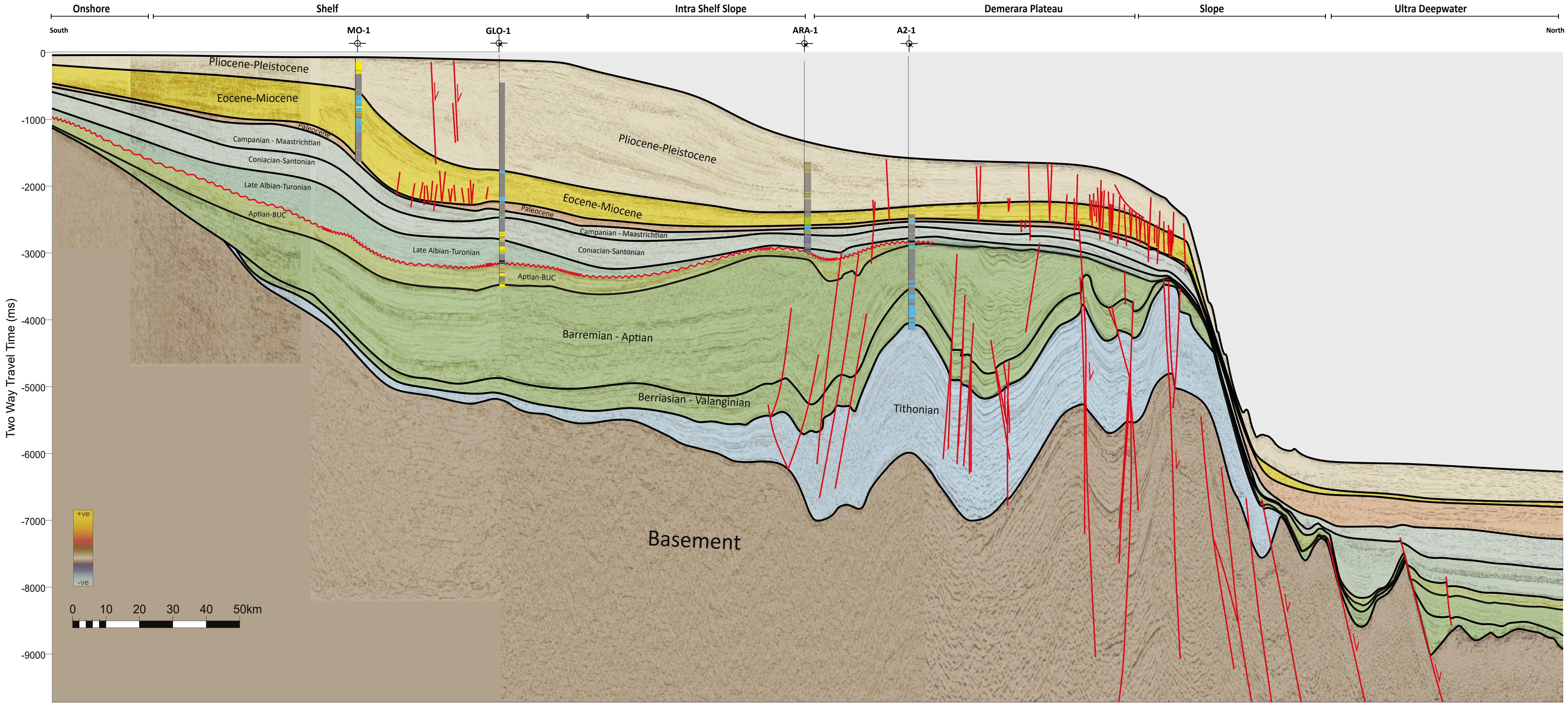
As per Regional Dip Line 1, the northern end of this section consists of a compressed anticlinal structure, which was followed by a passive margin phase during the Late Albian – Cenomanian.

This line clearly shows the dipping sequences deposited pre-BUC, that underwent folding, uplift and transpression, followed by erosion and the peneplanation of the Demerara Plateau.

The absence of deformation on the seismic in the central part of the section (around the wells GLO-1 and ARA-1) shows the benign nature of the structure prior to, and during the passive margin phase.

Tertiary-age faults, on the northern extent of the Demerara Plateau, are possibly related to reactivation of older major faults in underlying sections, in association with deposition of sediments along these weak zones.

Mini rift basins formed to the north of the Demerara Plateau during the Equatorial Atlantic break-up in the Lower Cretaceous, and an Intra-Shelf slope (hinge line) started forming between the Shallow Offshore and the Demerara Plateau in this time period.



Regional Dip Line 3 Chronostratigraphy

Facies

Jurassic facies up to the BUC appear to have developed within a WNW–ESE-oriented depositional framework. Their provenance is linked to the eastern margin of French Guiana and the Guinea continental margin in West Africa.

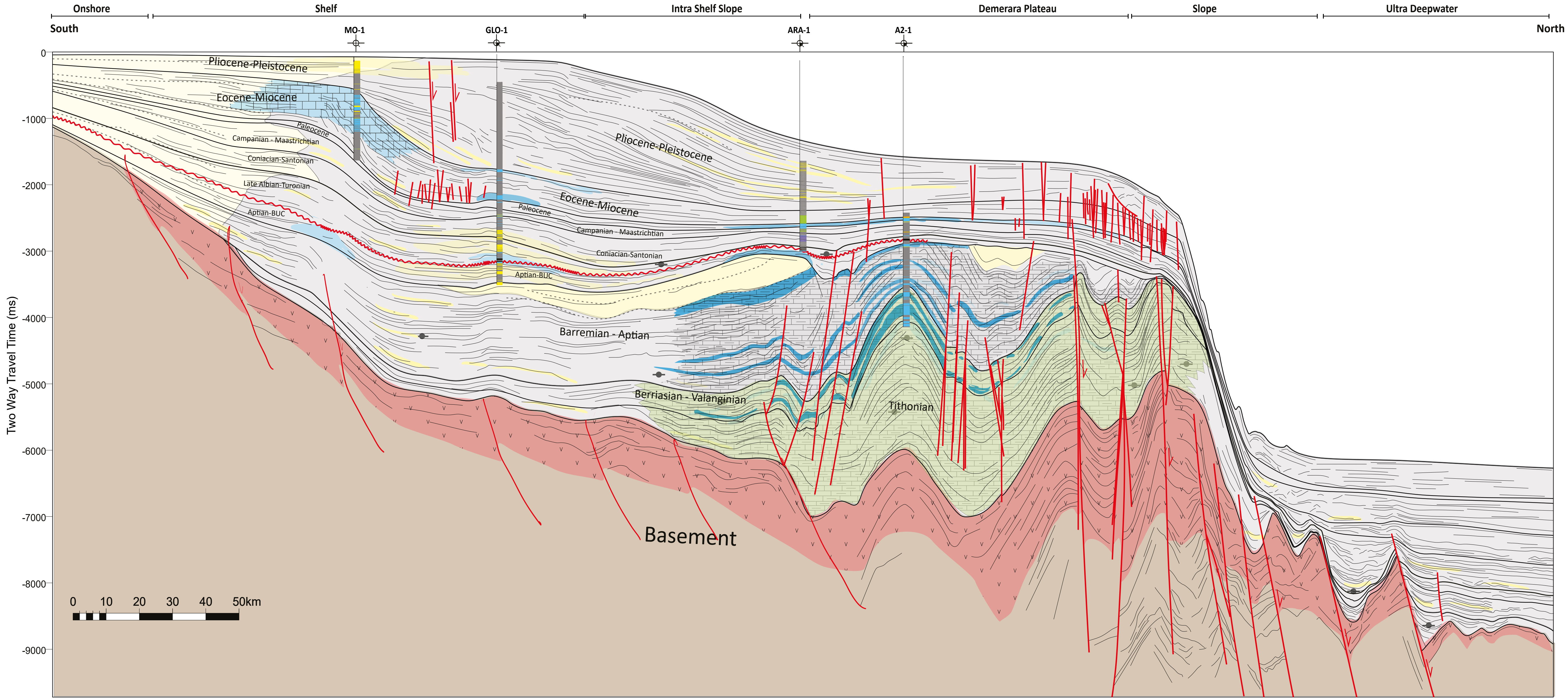
Significant features of this section include:

- The Aptian sandstone is correlated from the FG2-1 well (Strike line 1)
- The dominance of limestones in the Lower Cretaceous (A2-1 well) interval and the onset of clastic sandstone deposition during the Late Albian (GLO-1 well) on the foot of the slope (hinge line)
- The dominance of shale deposits in the Upper Cretaceous, mainly on the Demerara Plateau, and the switch back to argillaceous and carbonate deposits during the Eocene. The mini rift basin fill (north of the Demerara Plateau) most likely consists of eroded material of Lower Cretaceous sediments.

In the Tertiary, there was limited accommodation space due to an extended shelf onto the Demerara Plateau, resulting in a shallow marine progradational stacking system.

The facies interpretations are supported, among others, by the following projected wells:

- The A2-1 well is the only well drilled to date that has penetrated the Lower Cretaceous to Tithonian, encountering carbonates and mudstones throughout the Tithonian to Barremian. The well had oil shows in the three zones in the Early Cretaceous, indicating the probable existence of a mature, older source rock of Tithonian or Barremian age.
- The mini rift basin fill (north of the Demerara Plateau) most likely consists of eroded material of Lower Cretaceous sediments.
- The MO-1 well drilled through the Tertiary section. It encountered shales and minor interbedded sands in the Paleocene-Eocene section, interbedded shales and dolomitised limestone in the Miocene, and sand packages with background shales in the Pliocene.
- Good-quality sands were encountered in the Albian and Aptian sections in GLO-1. Bitumen was also recovered in the Aptian interval. The Tertiary section in the well is similar to that in well MO-1, with the exception of the Pliocene, which is dominated by shales.
- The ARA-1 well, drilled on the Demerara Plateau, encountered mainly shales with interbedded limestone in the Tertiary section. The Upper Cretaceous section also drilled shales with laminated Opaline Porcellanite. Wet gas and condensate were encountered in the Upper Albian section.



Regional Dip Line 3 Facies

Regional Strike Line 1

General

The Regional Strike Line 1 is an east-to-west-orientated seismic strike line which traverses the Demerara Plateau from French Guiana in the east, into Suriname and the Deepwater area in the west.

This section correlates a Deepwater well drilled on the western edge of the Deepwater, well ARA-1 on the western edge of the Demerara Plateau, and well FG2-1 drilled on the eastern edge of the Demerara Plateau in French Guiana.

Structure

Regional Strike Line 1 highlights the pronounced contrast between the western and eastern part of the basin (see also Regional Dip Line 3).

- The eastern part of the basin is characterized by Jurassic to Lower Cretaceous basin development.
- The western part of the basin, in contrast, comprises Upper Cretaceous to Tertiary basin fill.

The BUC marks a significant transition in the further development of the basin.

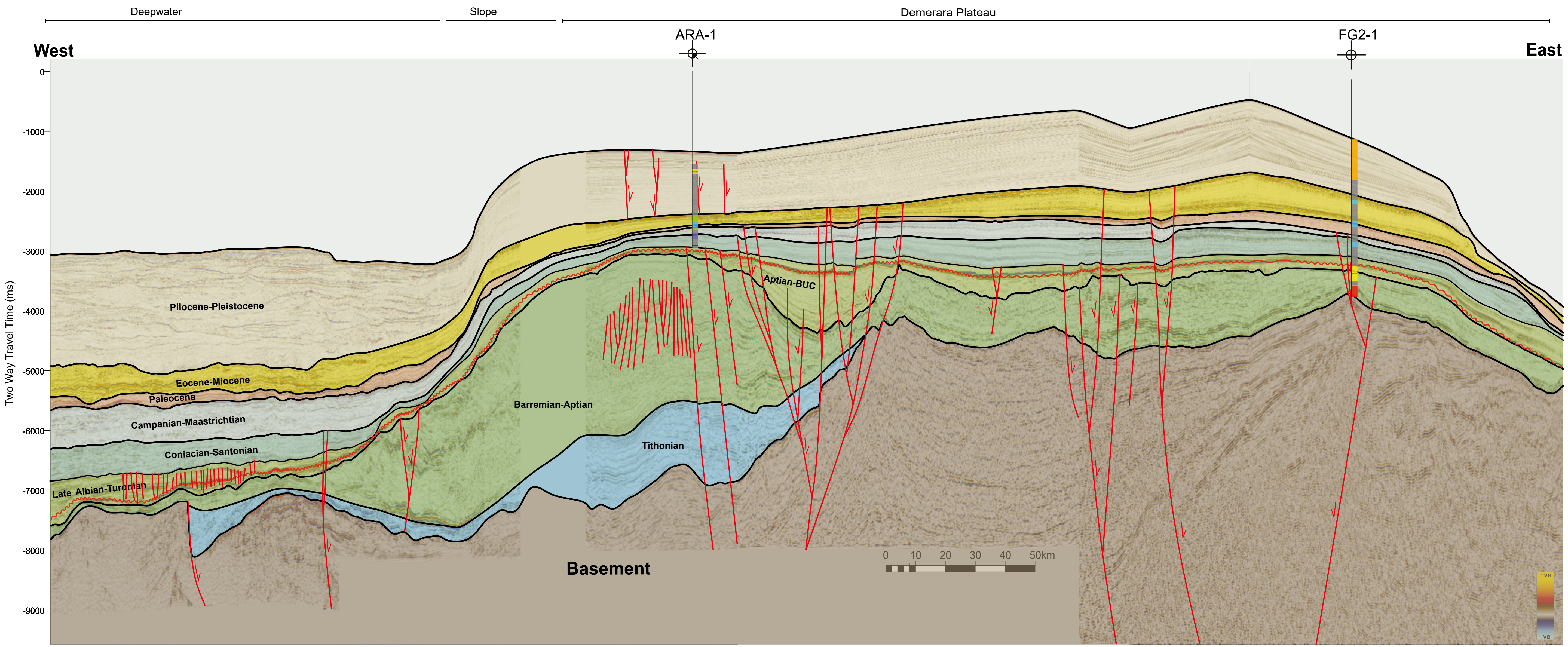
Variations in the thickness of probable Upper Jurassic and Lower Cretaceous sections on the western section of the Demerara Plateau appear to reflect differential accommodation space, influenced by both local and regional erosional events, as well as extensional and transpressional tectonics associated with rifting.

The area between wells ARA-1 and FG2-1 corresponds to the compressed anticlinal structure as highlighted in Regional Dip Line 3. The faults have a predominantly northeast-southwest orientation, related to the extensional and strike-slip movement of the Equatorial Atlantic rifting.

This line clearly shows the dipping sequences deposited pre-BUC, that experienced folding and uplift, followed by erosional truncation and peneplanation across the Demerara Plateau, as observed on Regional Dip Line 3.

This was succeeded by a passive margin phase during the Late Albian–Cenomanian, following the Break-up of the Equatorial Atlantic. This phase is evidenced by the uniform thickness of the stratigraphic intervals.

Tertiary-age faults may reflect the reactivation of pre-existing major fault systems in the underlying strata.



Regional Strike Line 1 Chronostratigraphy

Facies

As described in the Regional Dip Line 3, the facies distribution from the Jurassic to Lower Cretaceous reflects a WNW–ESE-oriented depositional dip.
In the western portion of the basin, west of the Demerara Plateau, facies development was influenced by multiple sediment provenances sourced from the east, east-southeast, and south. The seismic interpretation on this line indicates the lateral extension of the Aptian sand deposit seen in the FG2-1 well. This clastic sandy section was deposited in the Early Aptian within a fluvial to deltaic environment and was significantly folded and eroded during the mature rifting phase of the Equatorial Atlantic opening.

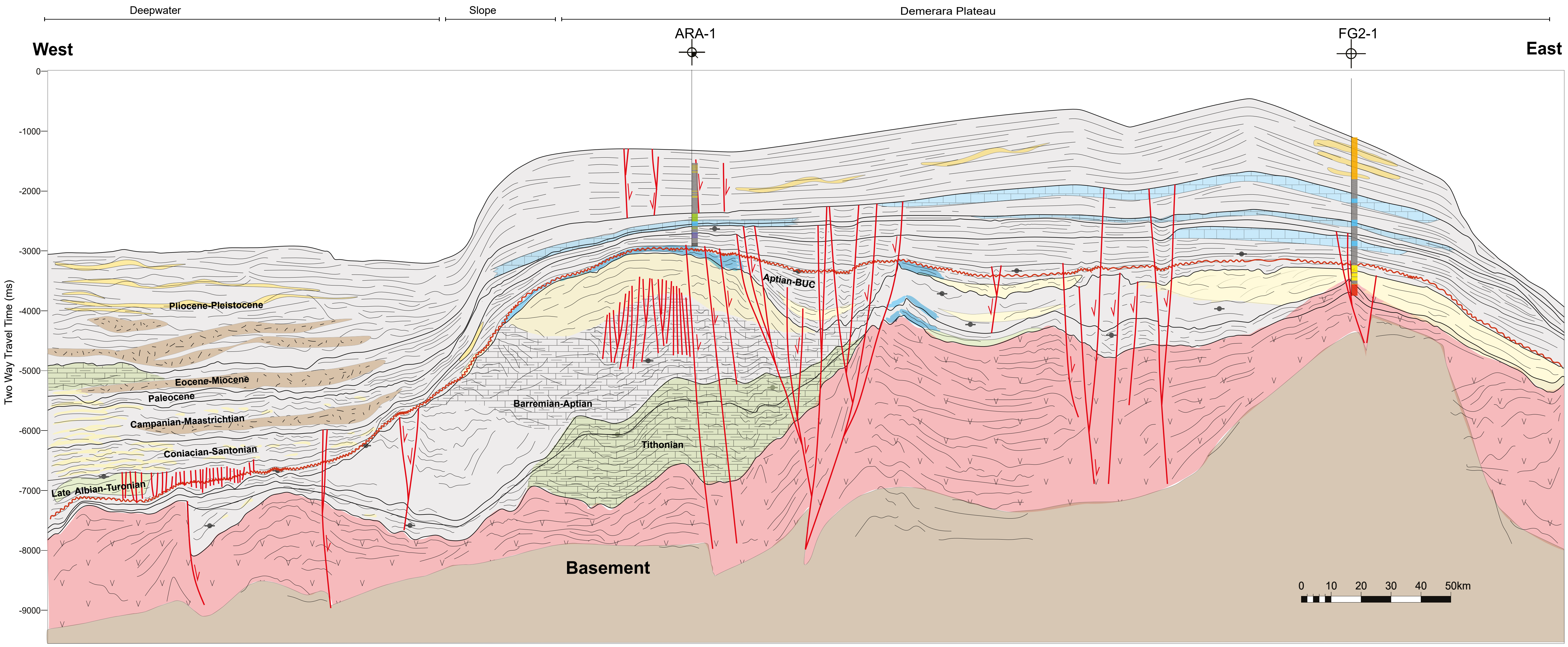
As shown in the EOD and facies maps in Chapter 7, the eastern portion of the basin (Demerara Plateau) is predominantly composed of various limestone facies. However, siliciclastic deposition is inferred to have occurred during lowstand systems tracts.

Due to the strong tectonic influence on facies distribution, several mini-basins are interpreted as favorable settings for source rock deposition, as illustrated in the EOD maps in Chapter 7.

Tectonic activity, involving multiple phases of uplift to subaerial exposure, facilitated karstification of calcareous and limestone deposits. This is recognised as a primary reservoir facies for the Jurassic and Lower Cretaceous limestones.

The facies interpretations are supported, among others, by the following projected wells:

- ARA-1: TD in Albian above the BUC. The presence of limestone facies is seen in the Early Cretaceous interval. Tertiary carbonates across the Demerara Plateau into the Deepbasin are proven by the ARA-1 and the FG-1 wells.
- The FG2-1 well intersected good quality Albian and Aptian clastic reservoirs, Eocene carbonate to marly deposits and a thick Pleistocene shale package. Elevated wetness was recorded in headspace gas in the Albian, Cenomanian and Turonian intervals.
- The Deepwater well on this strike line penetrated high-quality sandstones (turbidites/channel complexes) interbedded with shales within the Coniacian to Maastrichtian interval. Miocene carbonates were also encountered, overlain by mass transport complexes (MTCs) and a thick package of Pleistocene-age shales.



Regional Strike Line 1 Facies

Regional Strike Line 2

General

The Regional strike Line 2 is another west-to-east-orientated seismic section that crosses the shallow marine shelf (Shallow Offshore) extending from French Guiana to Suriname.

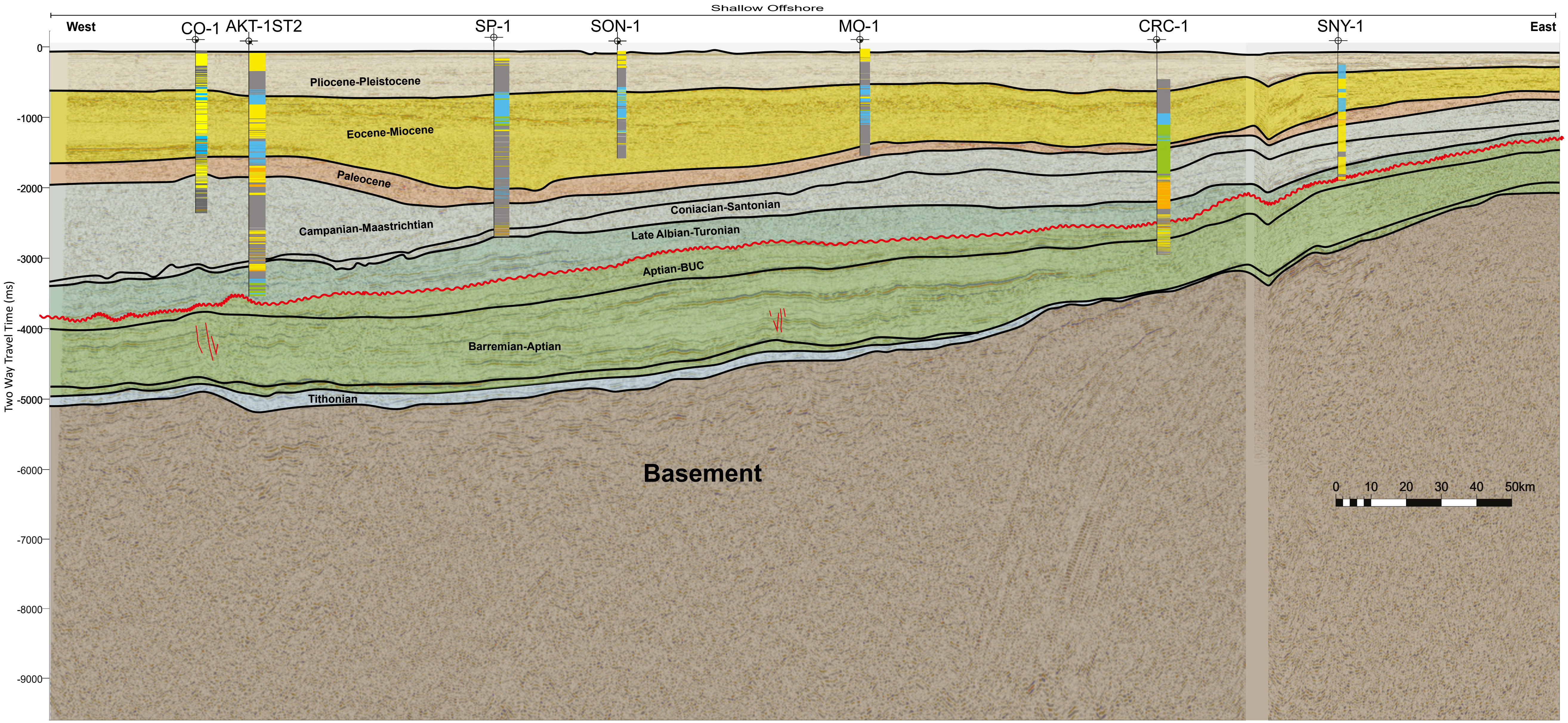
The wells incorporated in this section include CO-1, AKT-1ST2, SP-1, SON-1, MO-1, CRC-1 and SNY-1 (French Guiana well).

Structure

Structurally, the shelf exhibits no major tectonic activity, shown by the benign nature of the seismic reflectors and lack of underlying structure in the Basement and Jurassic intervals.

The Shelf shows a gentle regional dip from southeast to northwest. This is another confirmation of the Jurassic to Lower Cretaceous depositional dip.
The Upper Cretaceous and Tertiary exhibited several subtle collapse structures.

The central segment of this strike line, extending from SP-1 to CRC-1, traverses an Intra Shelf Slope—an intermediate zone that marks the transition between the Shelf and the Demerara Plateau.



Regional Strike Line 2 Chronostratigraphy

Facies

Regional Strike Line 2 shows the facies transition from a sandy fluvial Shelf in the east (French Guiana) to a distal shaly shelf in the west.

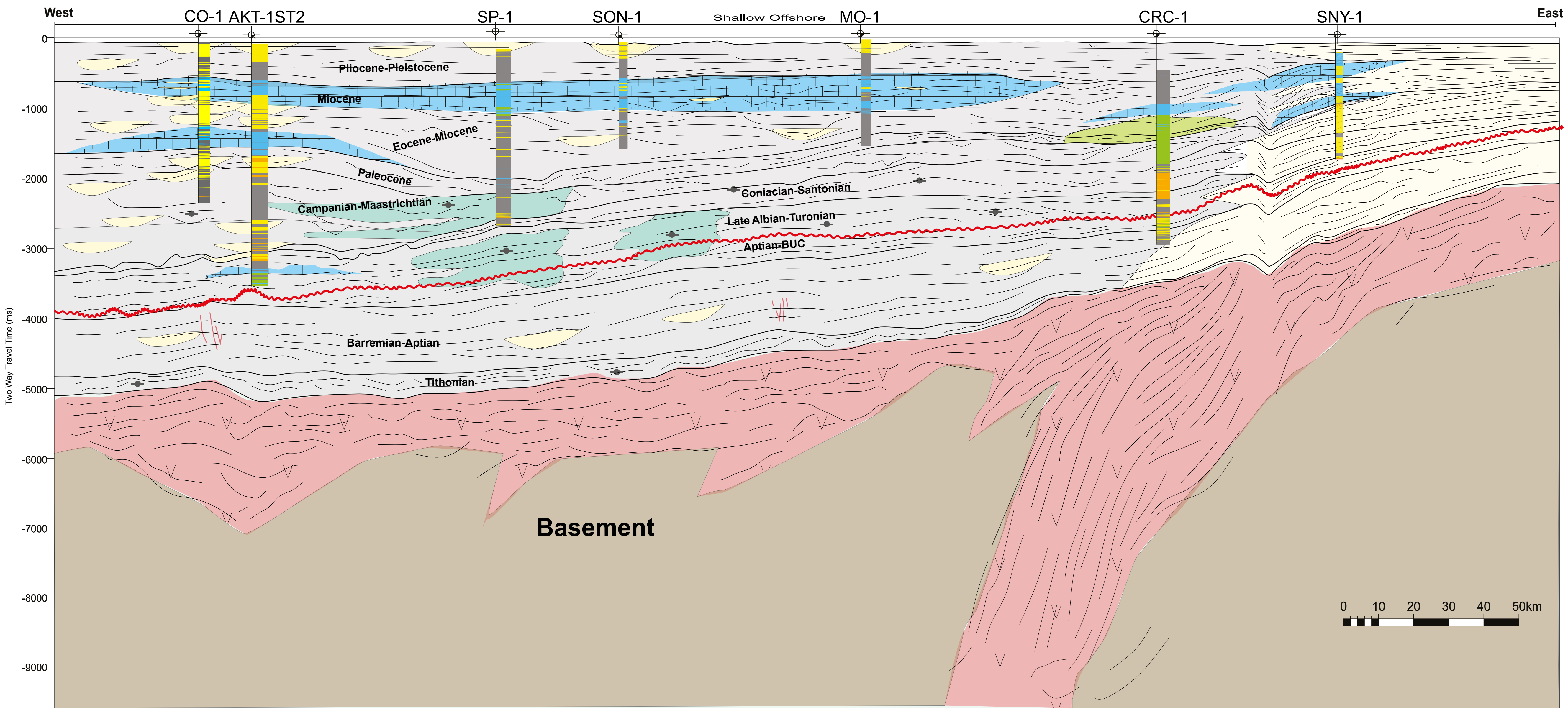
From Jurassic to Barremian, the environment was predominantly fluvial to deltaic.
In Aptian time during the Equatorial Atlantic Break-up, sea level started to rise and shifted the environment from fluvial-deltaic to shallow marine, which still occurs to the present day.

Due to multiple provenances, Regional Strike Line 2 showed the entry point of the same apparent slope from East and West. This is best portrayed on the EOD map in Chapter 7.

As seen on the crossing Regional Dip Lines, the Tertiary interval is characterized by a wide spread Lower Tertiary Carbonate platform (see facies maps in Chapter 7). Geophysical seismic analysis along the strike line has delineated an inferred ACT source rock.

Key facies penetrated by the Shelf edge wells:

- Wells SON-1 and MO-1, both drilled through the Tertiary sequence and encountered Eocene to Miocene carbonate deposits overlain by interbedded sand and shale deposits.
- The AKT-1ST2 well, drilled in the western part of the Shelf, terminates in the Albian section above the BUC and intersected carbonate facies. The Late Cretaceous and Paleocene sections are dominated by clastic deposits, whereas the Eocene to Miocene sections are composed of multiple carbonate successions interbedded with prograding clastic facies.
- The CO-1 well terminates in the Upper Cretaceous section and encountered sands with interbedded shales and carbonates, consistent with well AKT-1ST2. Well CO-1 observed oil shows in the Maastrichtian.
- Well CRC-1, on the eastern end of this line, encountered a variety of sediments across the Shallow Offshore. The Cretaceous sections consist of sand-dominated facies deposited during both lowstand and highstand phases. The Tertiary sections are dominated by fine-grained carbonate facies and muds. Oil shows were observed through the Turonian to Maastrichtian, and minor gas in Albian sandstones.
- The SNY-1 well penetrated Tertiary and Cretaceous sediments equivalent to the CRC-1 well. The well confirmed the existence of a Cretaceous sand-rich shelf that is predicted to be the provenance for a prograding shelf margin.
- The SP-1 well terminated in the Turonian section. Thin sands were encountered in Campanian to Turonian, some of which contained rare moderate gravity oil inclusions.
- The Maastrichtian to Campanian interval exhibited elevated levels of thermogenic drilling gas.
- Geophysical seismic analysis along the strike line has delineated an inferred ACT source rock.



Regional Strike Line 2 Facies

Regional Strike Line 3

General

Regional Strike Line 3 is a west-to-east-orientated seismic strike line, located on the Coastal Plain and showcases the producing Onshore areas and the southern extent of the Guiana Basin.

Due to the limited availability of seismic data in the onshore area, a composite line was constructed, extending west to east across the vicinity of the onshore fields.

Key projected wells are NIC04, COR01, COR09, TAM20, UIT25 and COM13.

Structure

The zig-zag orientation of the Regional Strike Line 3 illustrated structures that may be enhanced or non-existent. It is advised to view this profile in conjunction with the structure maps in Chapter 5.

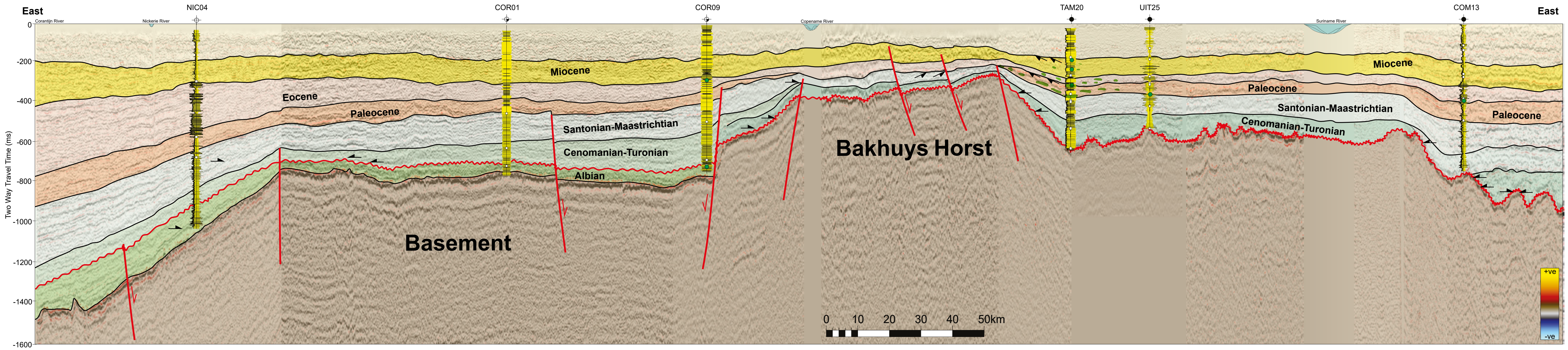
The Basement reaches a depth of 2 km in the west and gradually shallow until it outcropped in the eastern Coastal Plain. The Basement is exposed at the surface along the coast and Nearshore French Guiana.

Structures are related to Basement-routed faults such as the Coppename fault, which is interpreted as a continuation of the reactivated Bakhuys Horst.
The Bakhuys Horst is an elevated fault block that uplifted the entire sedimentary sequence. It influenced the oil-trapping onshore Suriname.

The Upper Cretaceous and Tertiary intervals exhibit progressive thinning onto the Bakhuys Horst, while the Lower Cretaceous is notably absent atop the horst and toward the east. This variation in sedimentary thickness suggests that the Bakhuys Horst remained tectonically active throughout the Cretaceous and ceased by the end of the Tertiary.

The structural elevation of the Central Coastal Plain is seen as a major contributor to the focus of hydrocarbon in the Onshore Fields.

The northeast–southwest trending seismic section is clearly illustrated. Regional Dip Line 2 and the structure maps in Chapter 5 provide a more detailed depiction of the structural framework—or absence thereof—within the Onshore area.



Regional Strike Line 3 Chronostratigraphy

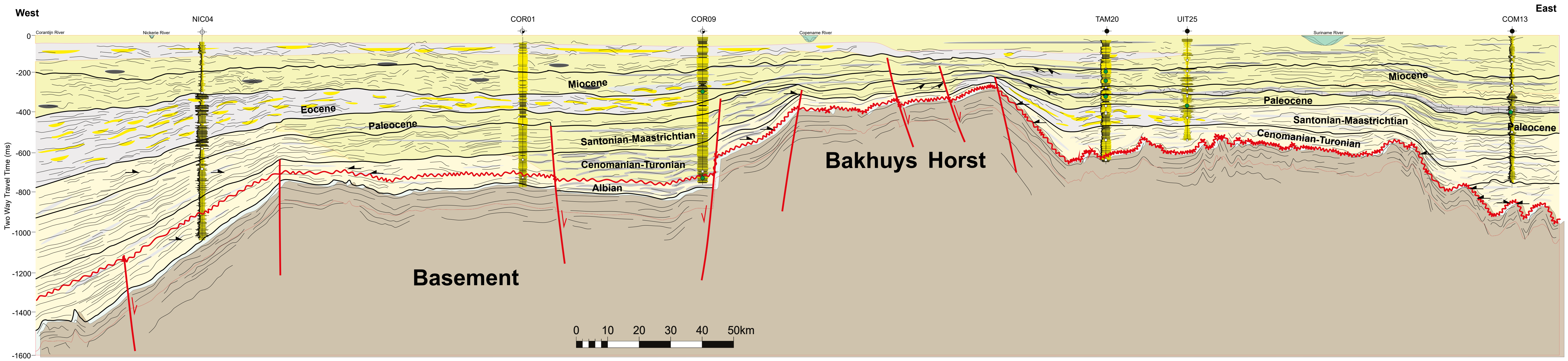
Facies

The Cretaceous facies of the Coastal Plain are characterized by coarse-grained sands predominantly of continental origin. However, the major Cenomanian–Turonian Oceanic Anoxic Event 2 (OAE 2) triggered the deposition of fluvial to shallow marine sandstones and organic rich shales across the western to central-western Coastal Plain.

The Tertiary to Quaternary succession is marked by alternating fluvial sandstones and marine shales. The Paleocene–Eocene interval experienced a significant influx of calcareous shales, interpreted as washover deposits derived from an extensive carbonate platform within the paleo–shallow marine environment.
This interval is commonly referred to as the Harde Bank.

The log signatures from the Onshore wells indicate a widespread marine transgression across the Coastal Plain during the Eocene, resulting in the deposition of abundant shale.

The elevated stratigraphic framework, combined with the sealing integrity of the Paleocene–Eocene shales, provides favorable conditions for hydrocarbon entrapment within fluvial sand bars and mouth bars in the Onshore and Nearshore fields. The associated trapping mechanisms are further detailed in Chapter 9.



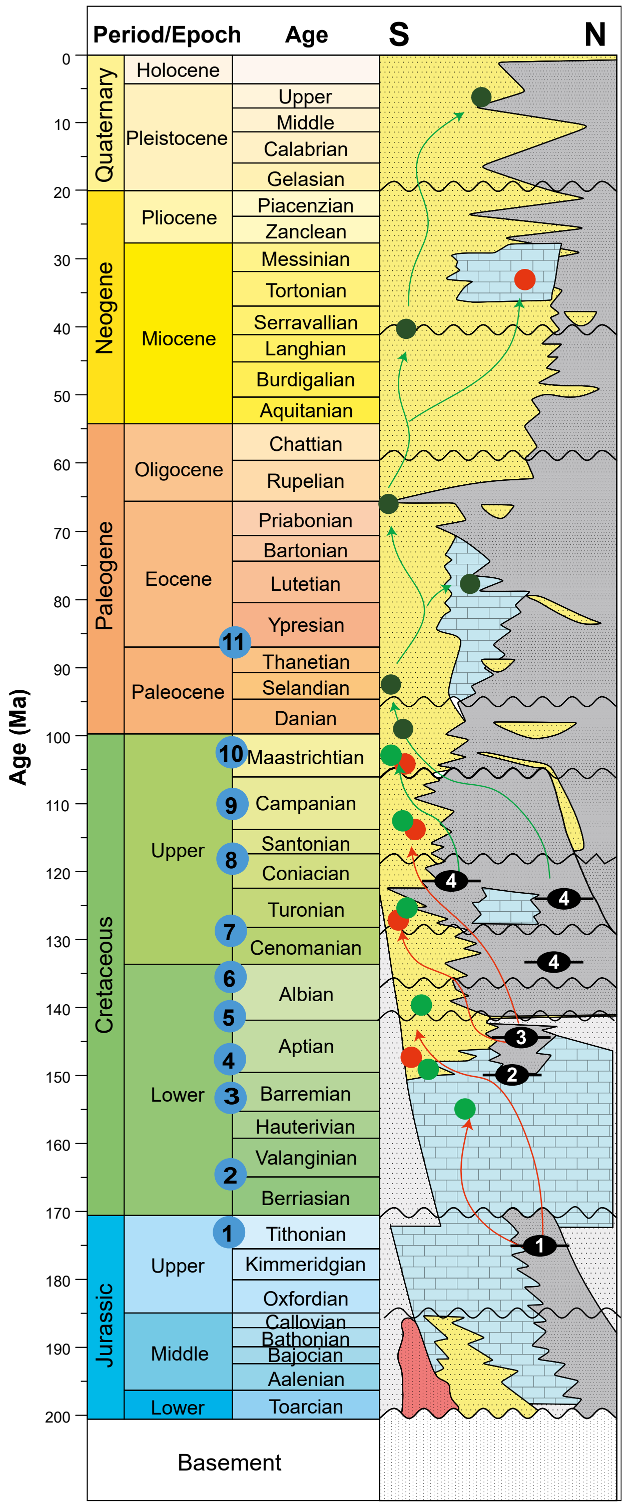
Regional Strike Line 3 Facies

Red Ibis in Suriname
Credit: Rudi Ernst

7. Environment of Deposition (EOD) and Facies

Coronie Mangroves
Credit: Popular Places Suriname

Introduction



EOD Legend

- Fluvial to Deltaic
- Clastic dominated Shallow Marine
- Continental Slope
- Carbonate Dominated Shallow Marine
- Bathyal
- Abyssal
- Intra Shelf Slope
- Rift Valley
- Basement

Facies Legend

- Sandstone
- Shale
- Siltstone
- Mass Transport Complex (MTC)
- Peat/Lignite
- Calcareous Sand
- Calcareous Shale
- Carbonate/Limestone
- Shaly Limestone
- Chalky Shale
- Volcanic/Basalt/Instrusive
- Granitic Basement

Regional Environment of Deposition (EOD) maps have been generated to capture the current interpretation of the regional paleogeography within given time periods.

The time periods were selected based on the consideration of the regional tectonic evolution, and the deposition of key stratigraphic surfaces that mainly represent the distribution of sediments that are likely to exist within the Offshore area for a given time.

The EOD maps have been generated for the entire Offshore of Suriname, the coastal Onshore area, and include the French Guiana part of the Demerara Plateau.

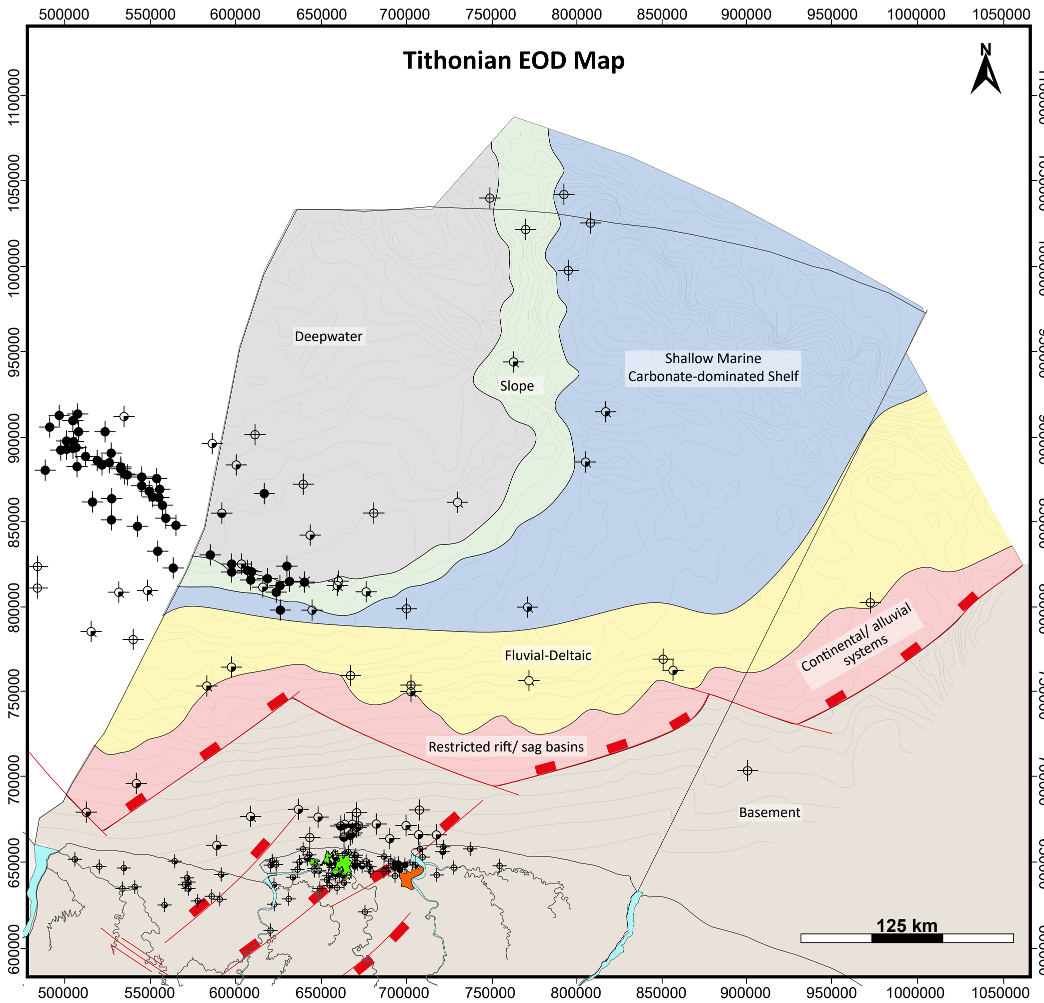
Facies maps were also generated for the same time periods. These reflect the current interpretation of the different facies deposited across the depositional environments.

The EOD and facies maps have been generated for the following time periods:

1. Tithonian
2. Valanginian - Berriasian
3. Barremian
4. Early Aptian
5. Late Aptian - Mid Albian (pre-BUC)
6. Late Albian (post-BUC)
7. Turonian - Cenomanian
8. Coniacian - Santonian
9. Campanian
10. Maastrichtian
11. Paleocene-Eocene

At the time of compilation of this GeoAtlas, the EOD and facies maps reflect a reasonable geological interpretation based on the data available. However, with ongoing exploration and appraisal activities in Offshore Suriname, these maps will require periodic updates as new data becomes available.

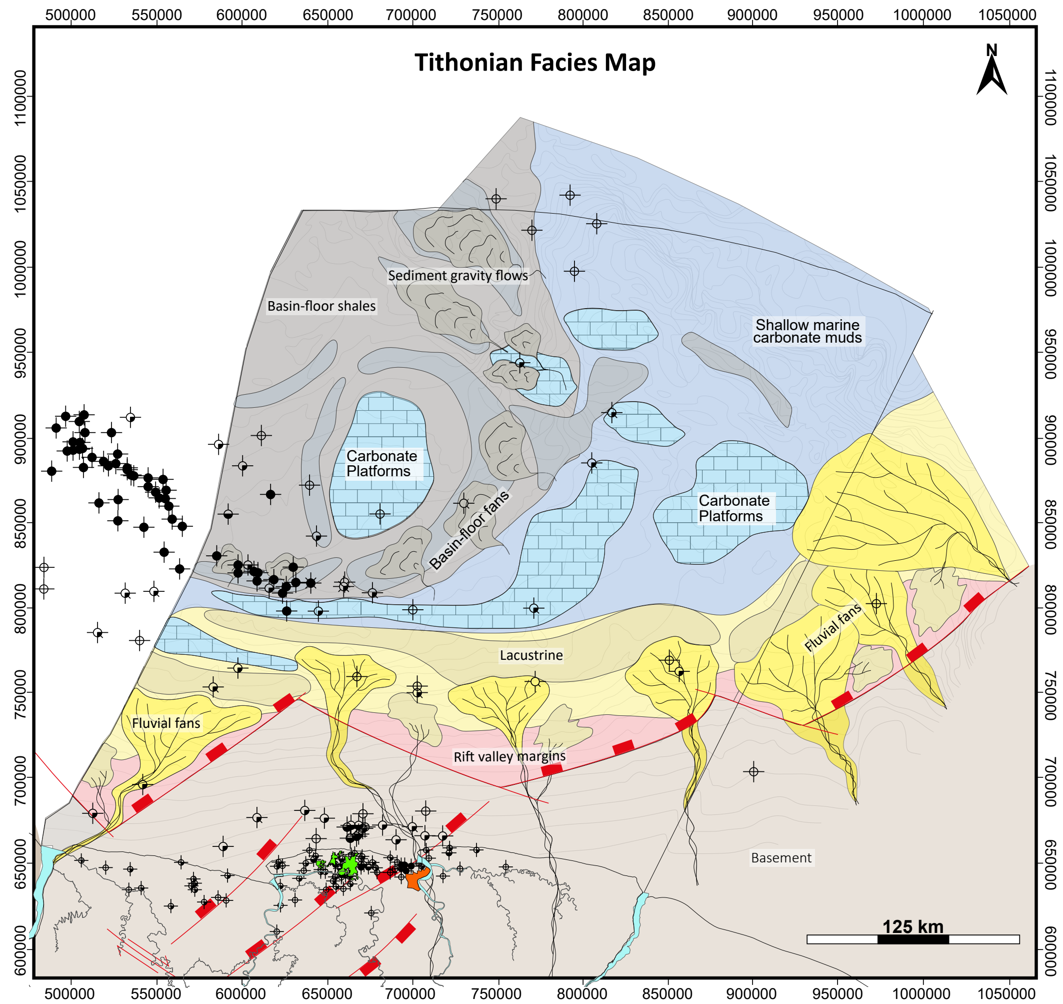
Tithonian



Tithonian EOD Map

- Restricted rift and sag basins formed north of the Basement and along the northeastern boundary of the mapped area.
- North of the rift valley margins, a broadly east-west-oriented fluvial system developed.
- Toward the northeast, depositional environments transitioned into shallow marine carbonate platforms, marking a shift from continental to marine conditions.
- The slope-shelf margin exhibited a complex geometry, rotating from an east-west orientation in the southern sector to a north-south orientation in the northern sector, ultimately connecting to the Deepwater domain in the northeast.
- Both the Deepwater and adjacent shallow shelf areas underwent potential source rock deposition, reflecting favorable conditions for organic matter accumulation.

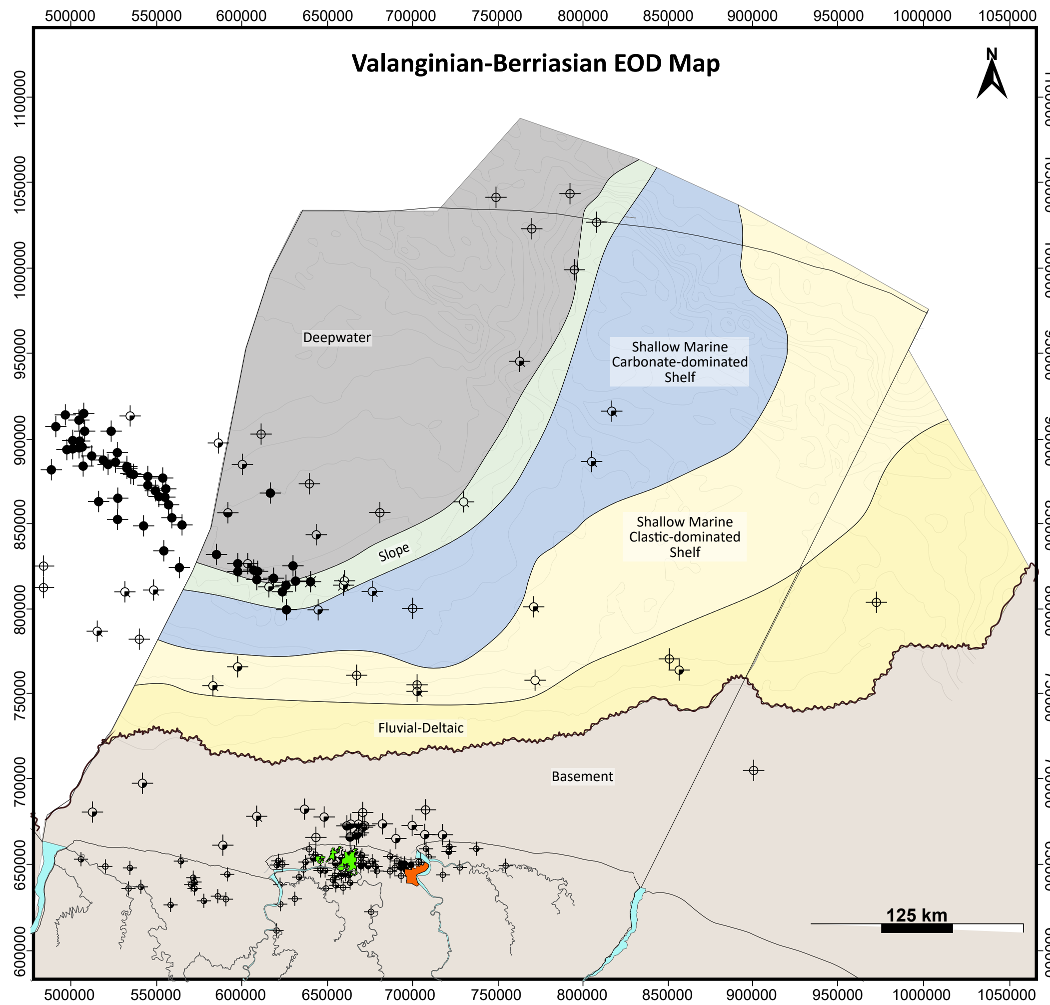
NB: Tithonian in the far north was rifted to Africa during the Equatorial Atlantic Rift event (Neocomian).



Tithonian Facies Map

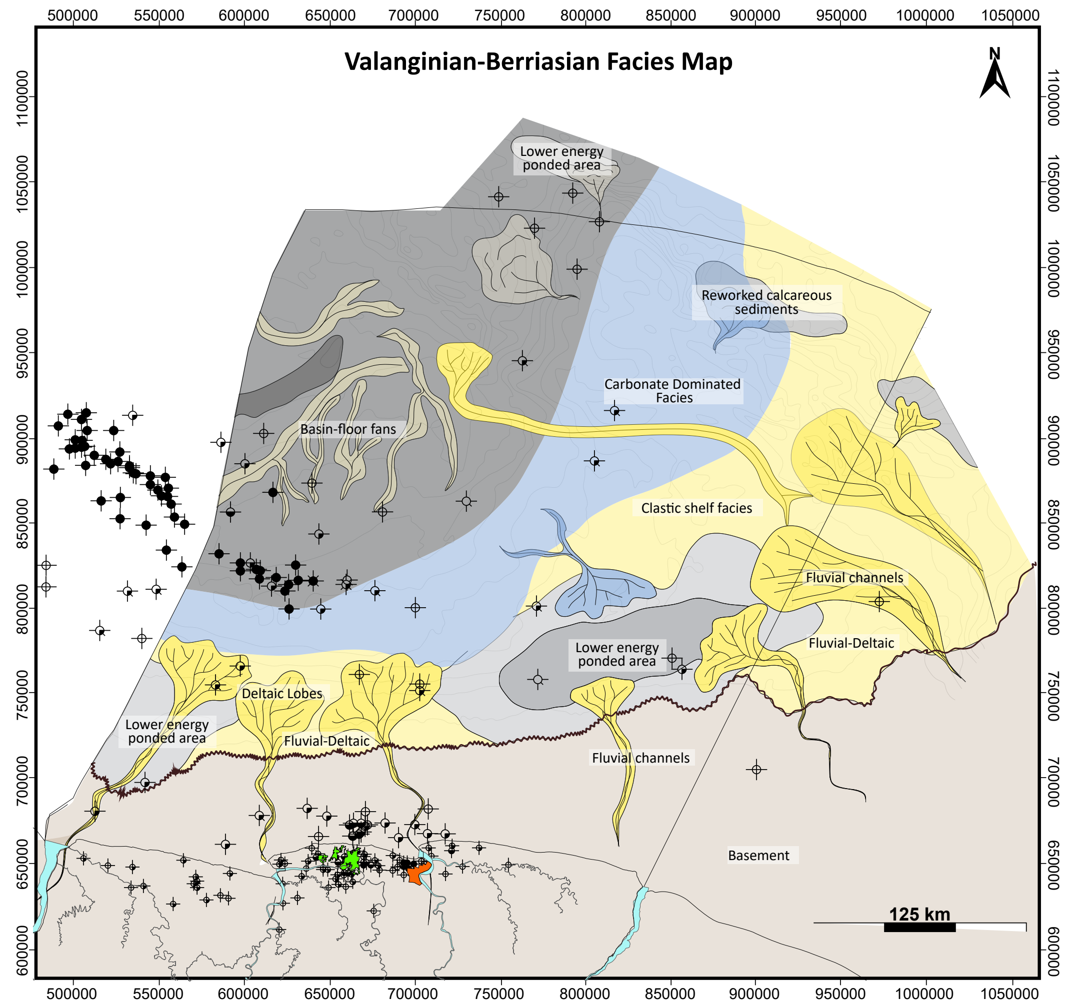
- Fluvial systems received their sediment input predominantly from the south, indicating a southerly source terrain.
- There was no deposition to the south of the rift valleys, where the Basement was exposed.
- Fluvial fans formed along the rift valley margins and fed into the fluvial system.
- In the northeastern sector, platform carbonates formed and were encircled by shallow marine carbonate muds.
- Basin floor fans were sourced from the Demerara Plateau and prograded into the Deepwater, indicating active sediment gravity flows.
- The feeder systems for these basin floor fans were influenced by topographic irregularities along the slope, which controlled sediment routing and dispersal patterns.

Valanginian - Berriasian



Valanginian-Berriasian EOD Map

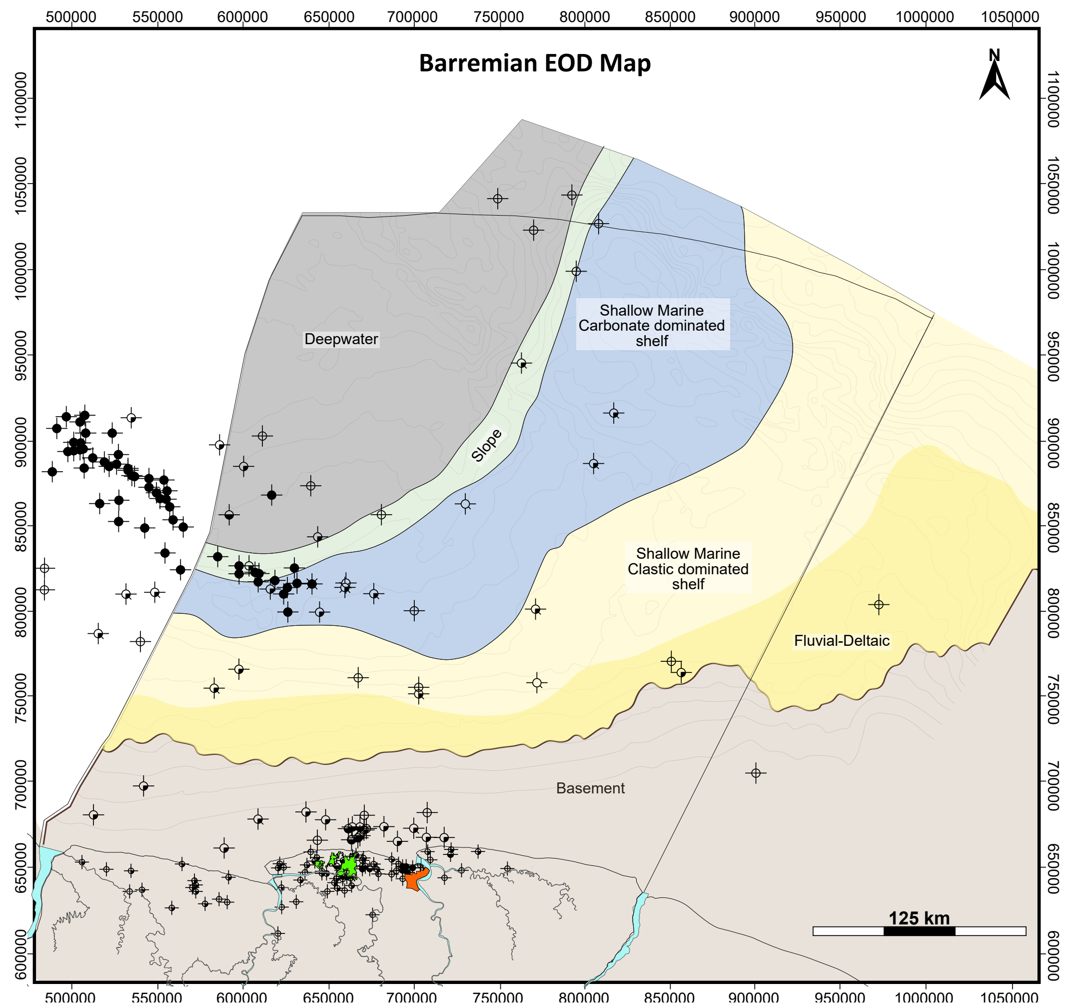
- The clastic-dominated shelf exhibited a general east-west orientation, parallel to the Basement in the south and the Demerara Plateau in the northeast.
- The clastic-dominated shelf extended eastward into French Guiana.
- Relative to the Tithonian, the shelf prograded northward and northeastward, developing a broadening architectural trend from the southeast to the northwest.
- On the shelf margin of the Demerara Plateau, environmental conditions supported the formation of a shallow marine, carbonate-dominated shelf, marking a facies transition from clastic to carbonate systems. Sediments are notably absent in Nearshore and Onshore areas.



Valanginian-Berriasian Facies Map

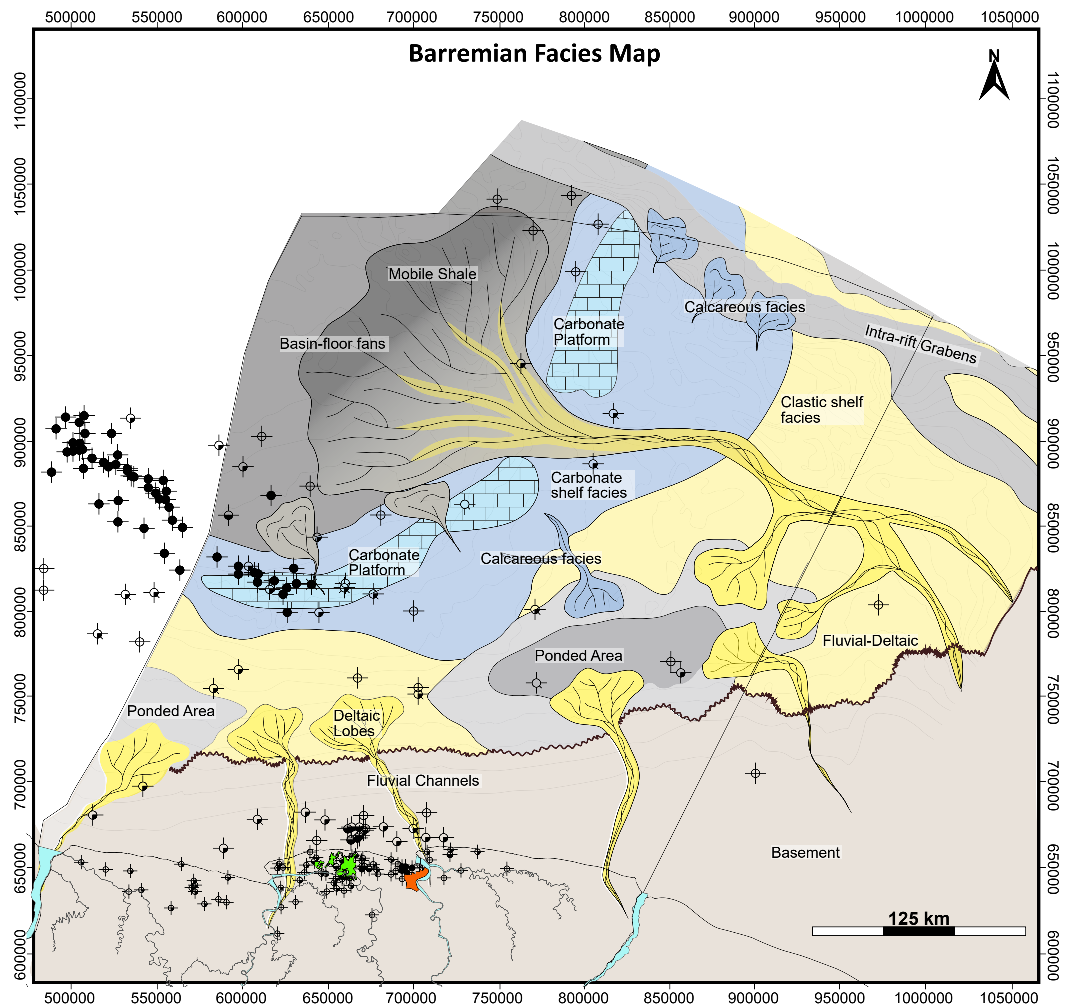
- Fluvial systems trending south-to-north and southeast-to-northwest deposited clastic sediments across the shelf, reflecting regional paleodrainage patterns.
- Inferred lowstand systems, sourced from the French Guiana margin, incised the carbonate-dominated shelf and extended into the Deepwater, suggesting episodic sea-level fall and sediment bypass.
- Additional feeder systems from the Guyana margin traversed the shelf and contributed sediment to the Deepwater, enhancing basin-floor fan development.
- These basins were primarily filled with clastic sediments and reworked calcareous material, indicating mixed depositional inputs.
- Potential source rock development is anticipated in Deepwater low-energy settings and in nearshore lacustrine basins, where conditions favored organic matter preservation.

Barremian



Barremian EOD Map

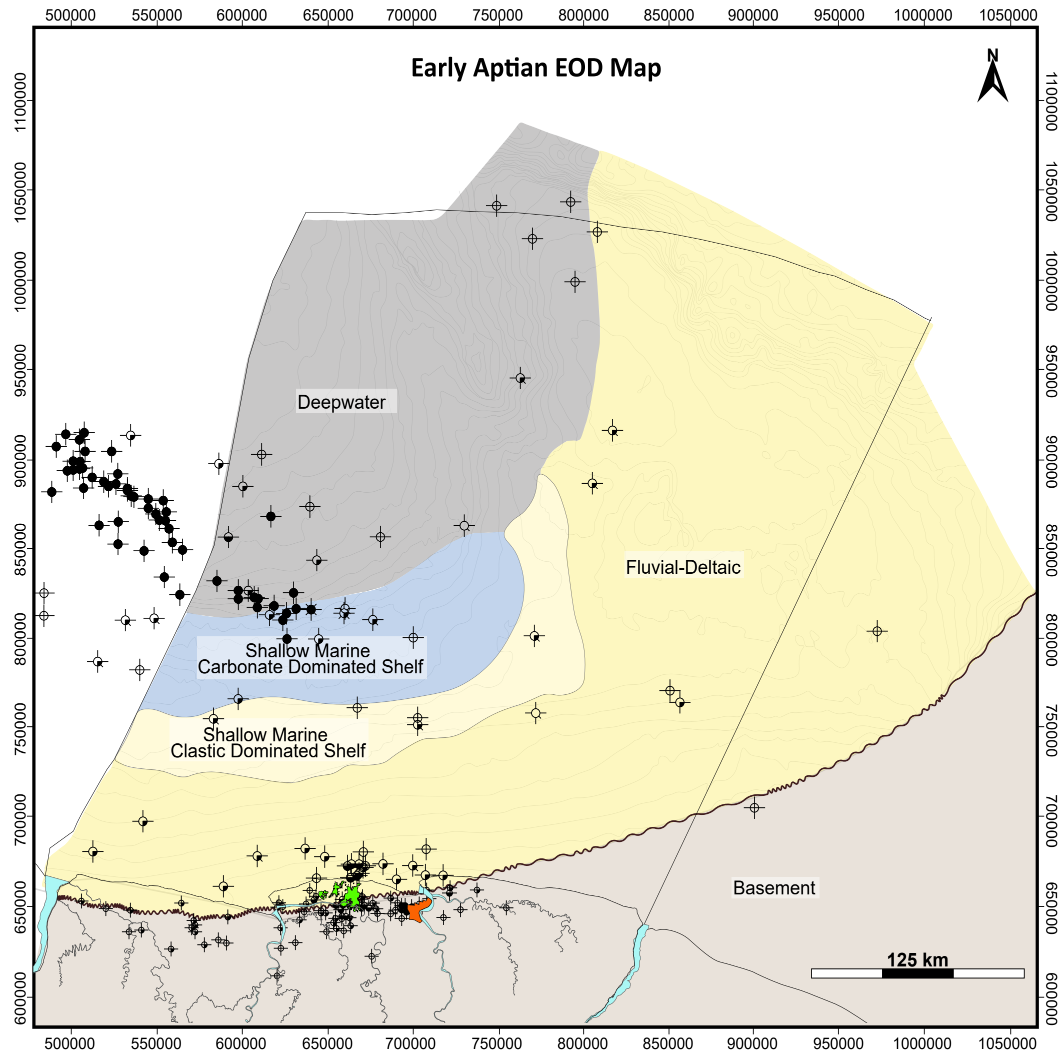
- The EOD map for the Barremian closely resembles that of the Valanginian–Berriasian interval, indicating continuity in depositional systems.
- The paleogeography remains defined by a shallow, inboard clastic-dominated shelf, transitioning northward into a carbonate-dominated shelf along the northern extent of the Demerara Plateau.
- This shelf system further grades into deepwater environments toward the northwest, reflecting a basinward facies progression.
- Similar to the Valanginian-Berriasian sediments, which are also notably absent in Nearshore and Onshore areas.



Barremian Facies Map

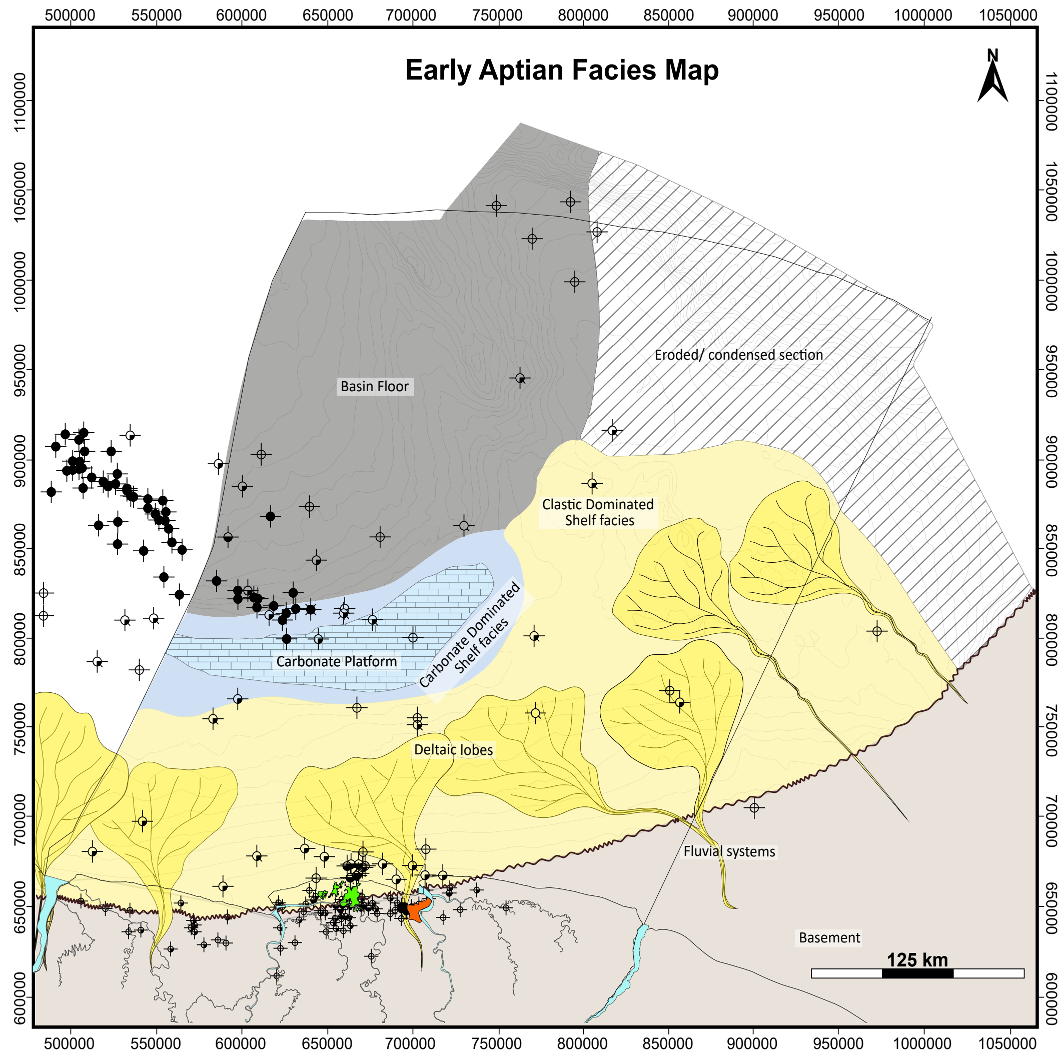
- Compared to the Valanginian–Berriasian interval, the Barremian period saw a decline in coarse-grained clastic input from the south and southeast, accompanied by an increase in fine-grained, mud-rich sedimentation.
- Intra-rift grabens in the northeast became interconnected, forming a more continuous depocenter filled with fluvial sediments sourced from the northeast and calcareous inputs from the southwest. These also may contain restricted source rocks.
- The central ponded zone on the clastic shelf received fluvial sediments from both the southeast and northeast, indicating multi-directional sediment supply.
- Near the shelf-slope break, depositional conditions were likely conducive to the development of a carbonate-dominated shelf or a carbonate platform/ramp system.
- In the distal reaches of the delta, the Deepwater contains mobile shale units with potential for source rock development, particularly in low-energy depositional settings.

Early Aptian



Early Aptian EOD Map

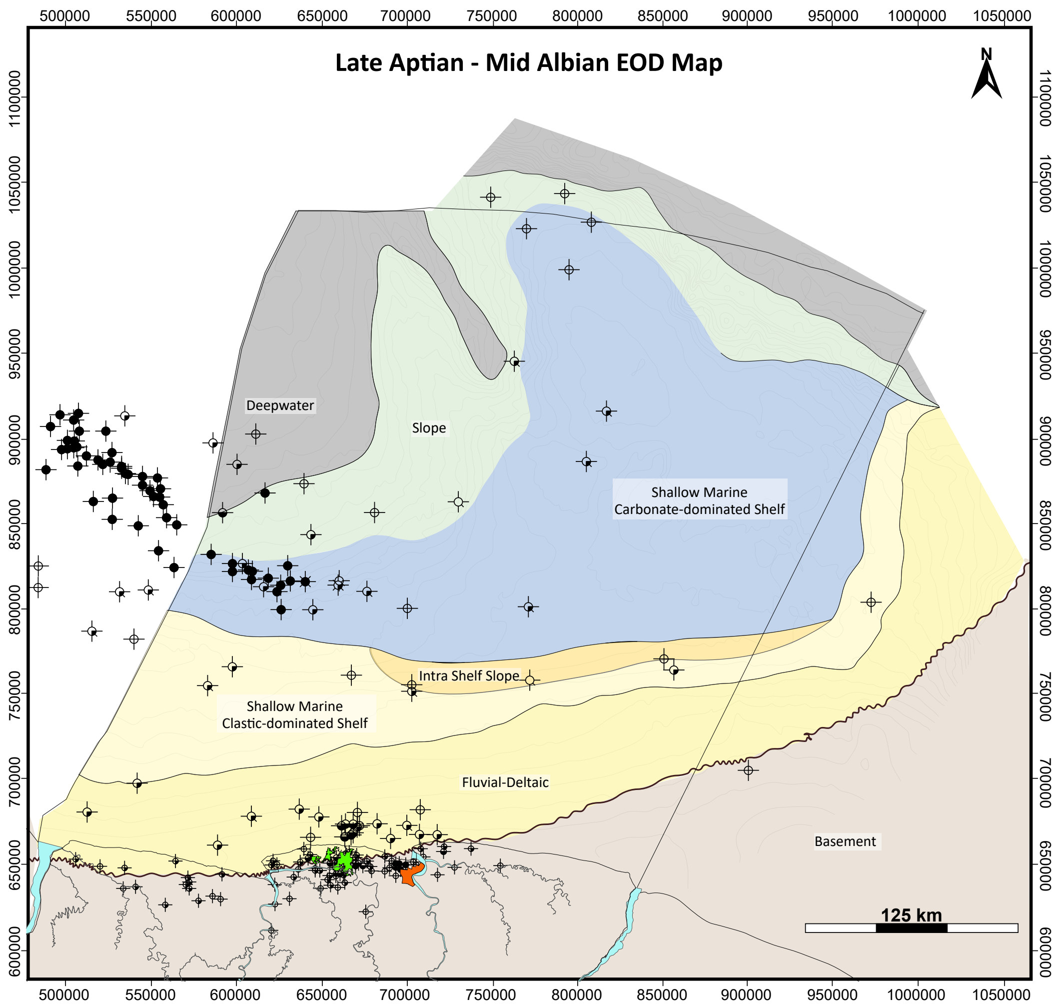
- During the Early Aptian, transpressional tectonics driven by the movement of the southern African continent led to regional uplift and associated erosion.
- This tectonic activity influenced sediment dispersal, pushing the fluvial-deltaic system northward onto the Demerara Plateau.
- As a result, the shelf transitioned from a carbonate-dominated to a clastic-dominated system, reflecting increased siliciclastic input.
- Shallow marine carbonate deposition became confined to the southwestern edge of the shelf, indicating a contraction of carbonate facies.



Early Aptian Facies Map

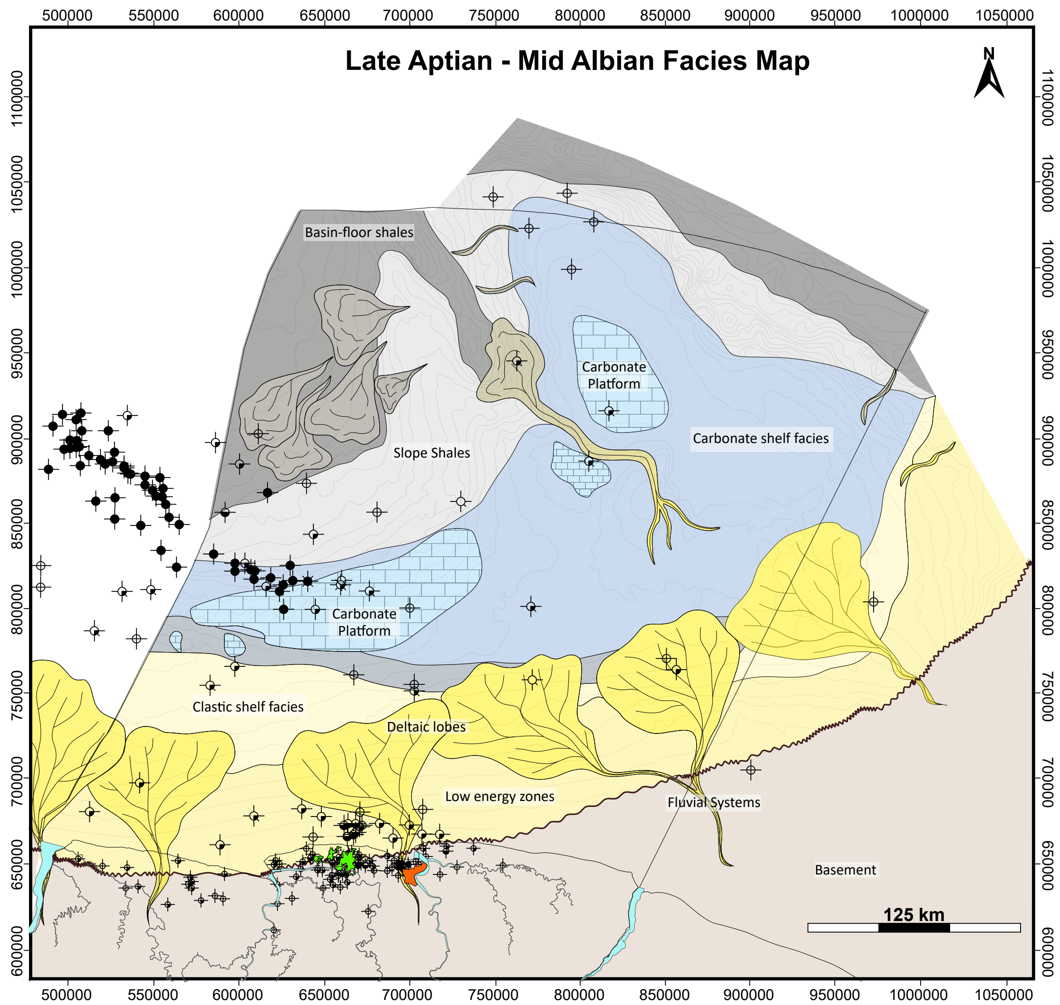
- Fluvial-dominated deltaic systems continued to supply sediments from the south and southeast, maintaining clastic input across the shelf.
- This facies map includes two sequences, the carbonate platform/ramp developed on the paleo-shelf margin, overlain by a clastic dominated sequence.
- The carbonate platform or ramp on the northwest part of the Demerara Plateau halted due to an increased siliciclastic influx, likely due to relative sea-level rise or increased siliciclastic influx, while carbonate deposition persisted on the southwestern edge of the shelf.
- The central ponded area on the clastic shelf, previously established during the Barremian, was infilled with fluvial sediments sourced from the southeast, indicating continued progradation.
- In the northeast, sedimentary units began to undergo erosion as a result of folding and uplift associated with transpressional tectonics, reshaping the depositional architecture.

Late Aptian – Mid Albian (Pre-BUC)



Late Aptian - Mid Albian (Pre-BUC) EOD Map

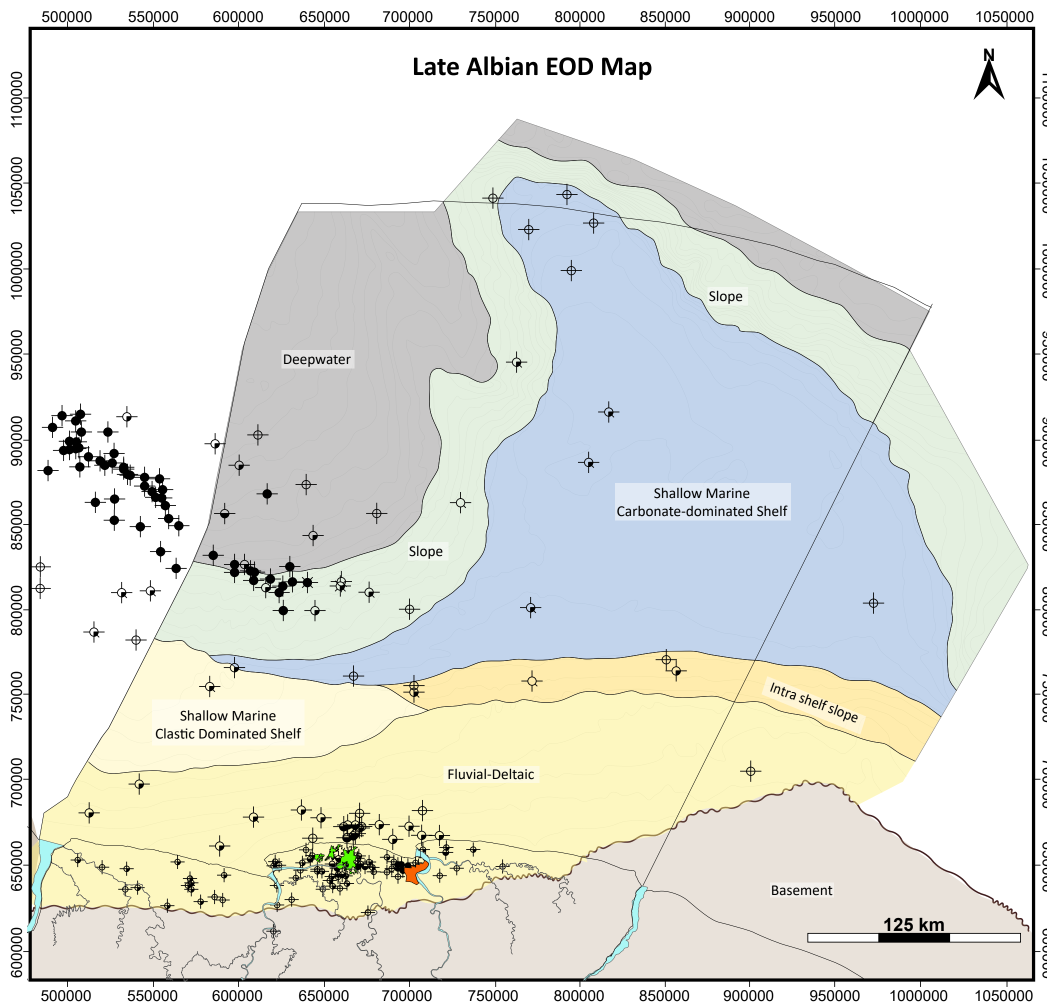
- The shallow marine carbonate-dominated shelf extended across the Demerara Plateau and continued eastward beyond the French Guiana boundary, indicating a broad regional carbonate platform.
- The fluvial-deltaic shelf retrograded southward, covering near Onshore areas, and extended eastward into French Guiana, reflecting sustained siliciclastic input from continental sources.
- Outboard of the fluvial-deltaic system, a shallow marine clastic-dominated shelf developed, marking a transitional zone between deltaic and marine environments.
- The slope zone broadened significantly, flanking both the western and northeastern margins of the Demerara Plateau.



Late Aptian - Mid Albian (Pre-BUC) Facies Map

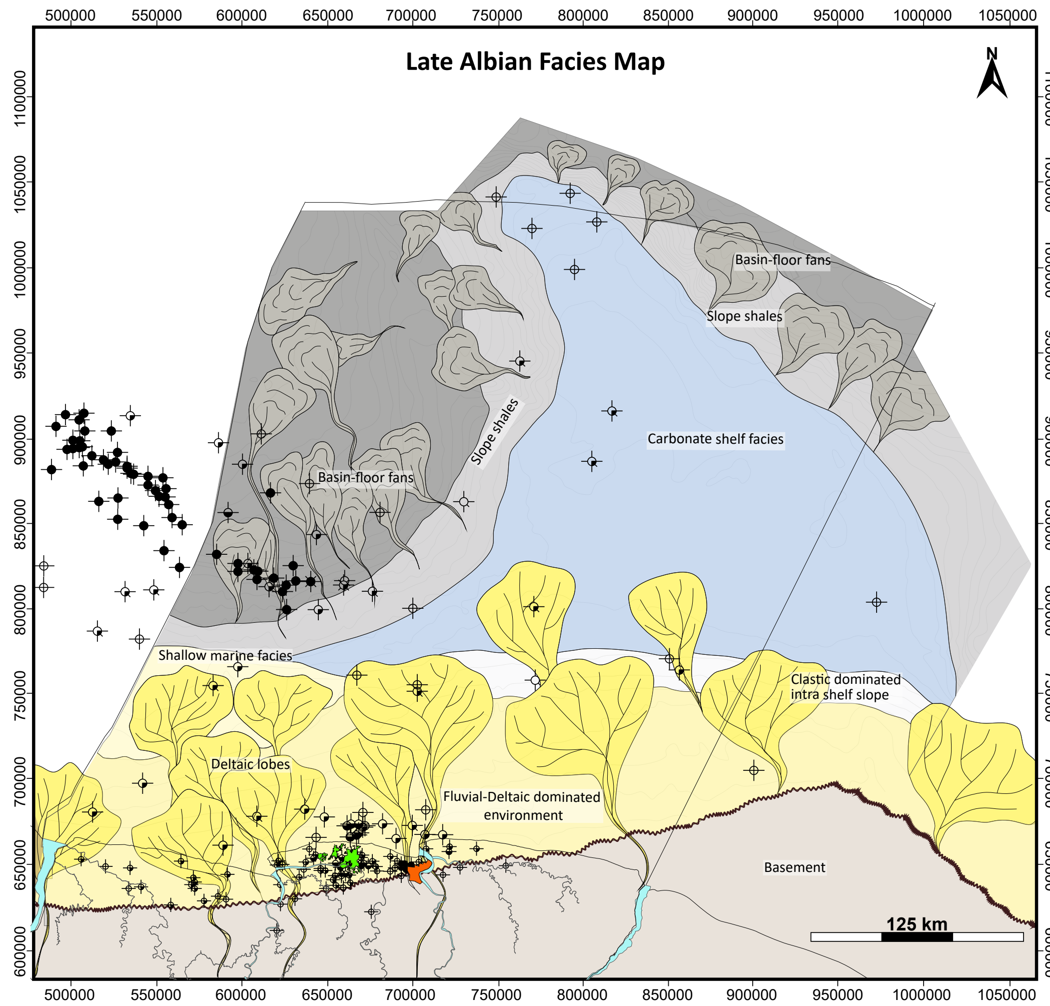
- Sediment input continued from fluvial-dominated deltaic systems, sustaining a consistent supply from the south as established during the Early Aptian. This maintained the clastic-dominated character of the shelf in proximal areas.
- In contrast, a shallow marine carbonate environment developed in the northwest, indicating localised conditions favorable for carbonate accumulation despite the broader siliciclastic influence.
- Onset of favorable conditions began to develop within the Deepwater for the deposition of organic-rich sediments.
- Terrestrially influenced source rocks are likely to develop within fluvial-dominated environments, particularly in low-energy zones such as coaly swamps situated between channel systems.

Late Albian (Post-BUC)



Late Albian (Post-BUC) EOD Map

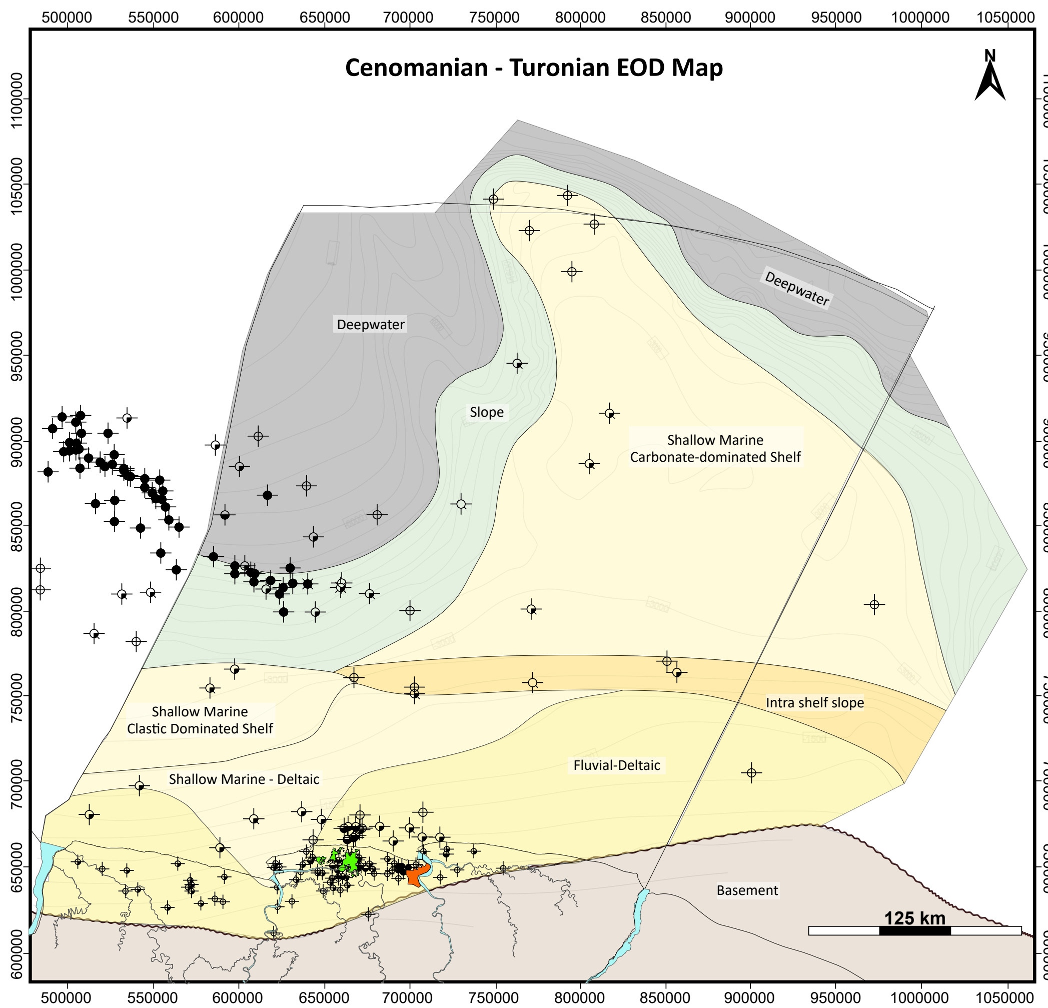
- An intra-shelf slope began to emerge between the fluvial-deltaic environment and the adjacent carbonate marine setting, marking a transitional zone in shelf architecture.
- A decrease in clastic sediment input from the southeast, particularly sourced from French Guiana, is observed.
- The shallow marine carbonate-dominated shelf persisted across the Demerara Plateau
- The slope extended further south (compared to the Aptian-Mid Albian) on both the eastern and western margins of the Demerara Plateau.
- The slope gradient steepened compared to the Aptian - Mid Albian.
- Deepwater environments continued in the northwest and northeast portions of the basin, continuing to serve as potential sites for fine-grained sediment accumulation and source rock development.



Late Albian (Post-BUC) Facies Map

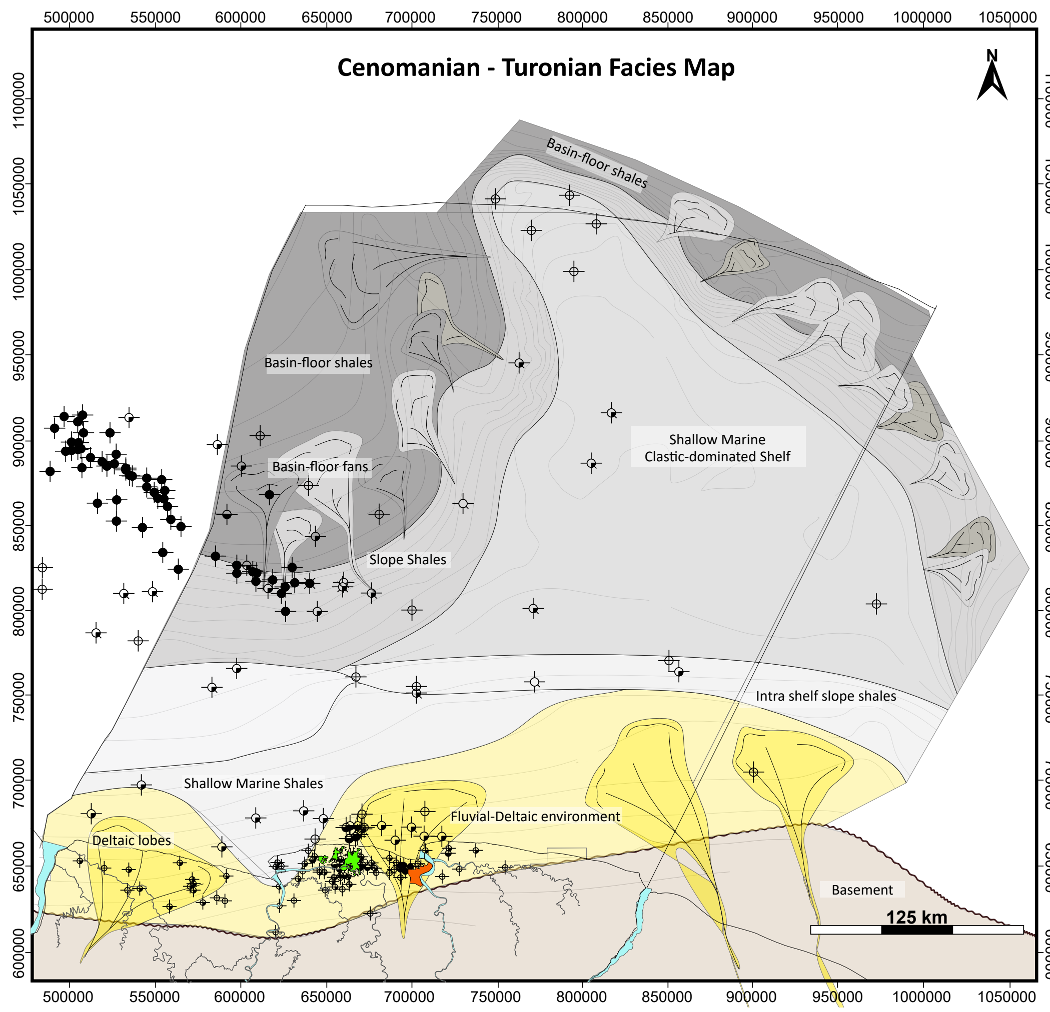
- North–South oriented fluvial-dominated deltaic systems remained active but shifted further landward, indicating a retreat of the delta front.
- Sand deposition was likely beyond the intra-shelf slope on the Demerara Plateau, suggesting potential reservoir development in more distal settings.
- Platform or ramp-style carbonate deposition potentially persisted on parts of the Demerara Plateau.
- Basin floor fan systems continued to feed into the Deepwater areas, where, during lowstand phases, clastic sediments bypassed the shelf and were directly deposited into the Deepwater.
- This period marks the onset of the major source rock deposition within the basin, as organic-rich shales accumulated in distal shelf and Deepwater environments under low-energy, anoxic conditions.

Cenomanian - Turonian



Cenomanian - Turonian EOD Map

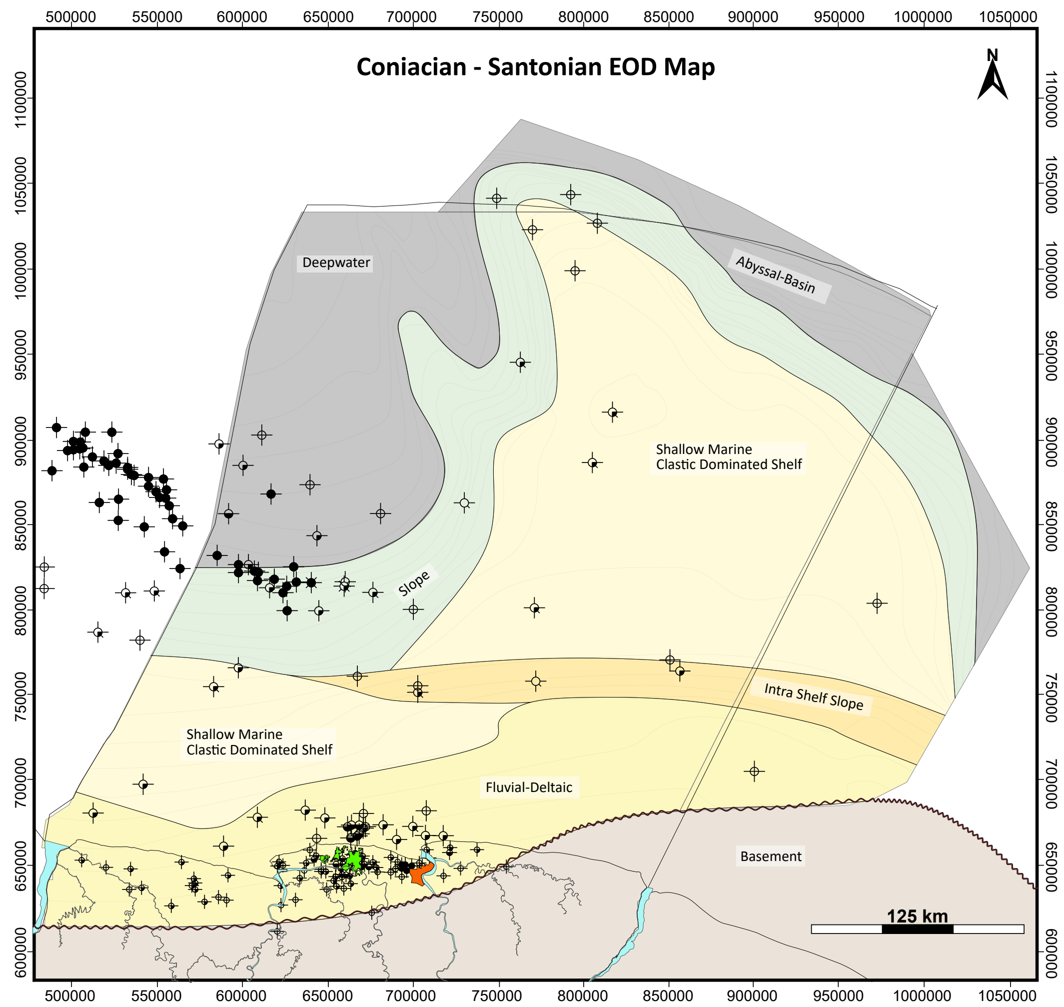
- The Cenomanian – Turonian represents the main phase of proven source rock deposition in the basin.
- A prevailing transgressive regime led to a landward shift in depositional environments, reducing sediment input from fluvial-deltaic systems on the shelf and promoting low-energy conditions favorable for organic matter preservation.
- Carbonate deposition was limited during this time, likely due to increased water depth.
- The combination of reduced clastic dilution, anoxic bottom waters, created optimal conditions for the development of high-quality marine source rocks.



Cenomanian - Turonian Facies Map

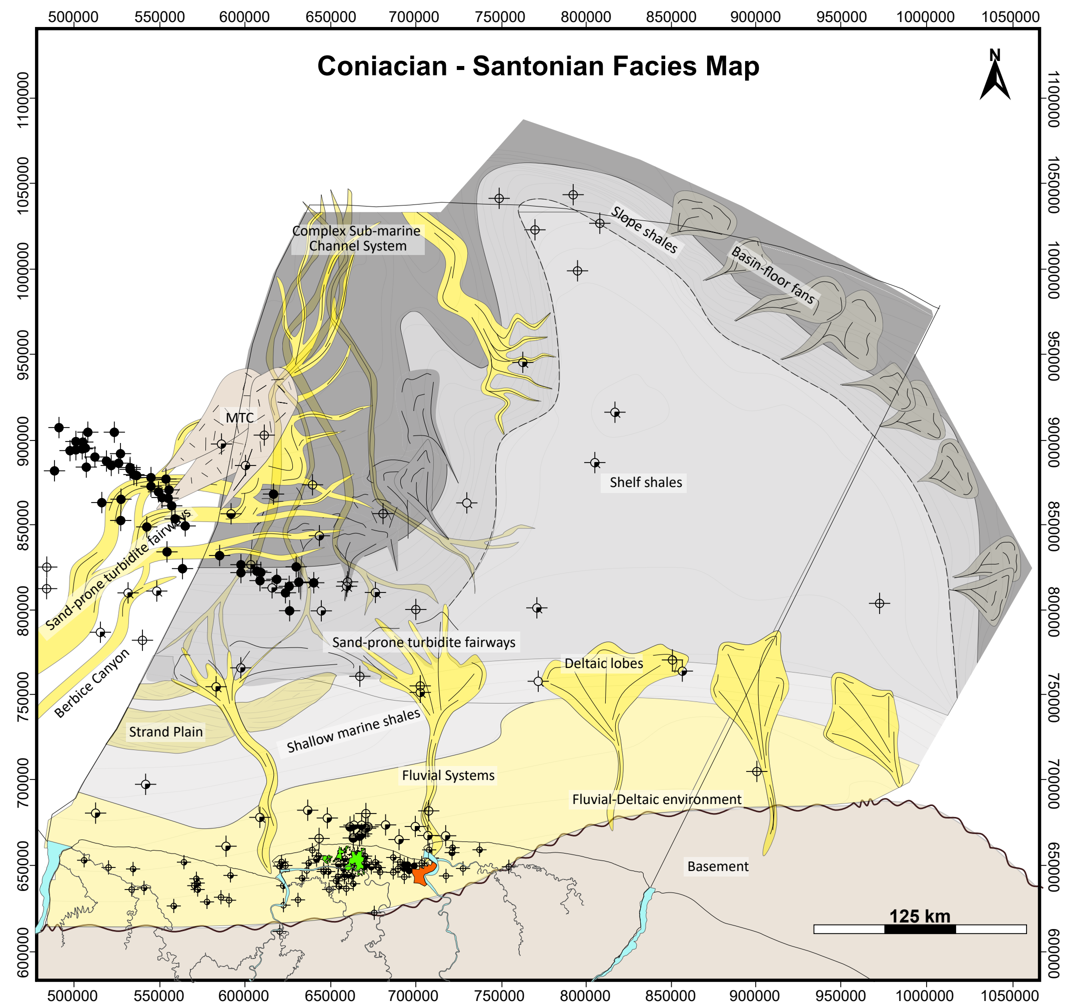
- The Cenomanian – Turonian represents the main phase of proven source rock deposition in the basin.
- The transgressive regime transitioned the Demerara Plateau shelf into a mudstone-dominated shelf.
- The Nearshore and Demerara Plateau were dominated by fine-grained shelf facies, which transitioned from sand-dominated facies in the south to mud-dominated facies in the north.
- There was a general absence of carbonate development on the shelf.
- Turbidite deposition was notably absent on the slope and in deep basin areas, suggesting a reduction in high-energy sediment gravity flows.
- The proven source rock of the basin was deposited alongside the Albian shales in distal shelf and deepwater settings.

Coniacian - Santonian



Coniacian - Santonian EOD Map

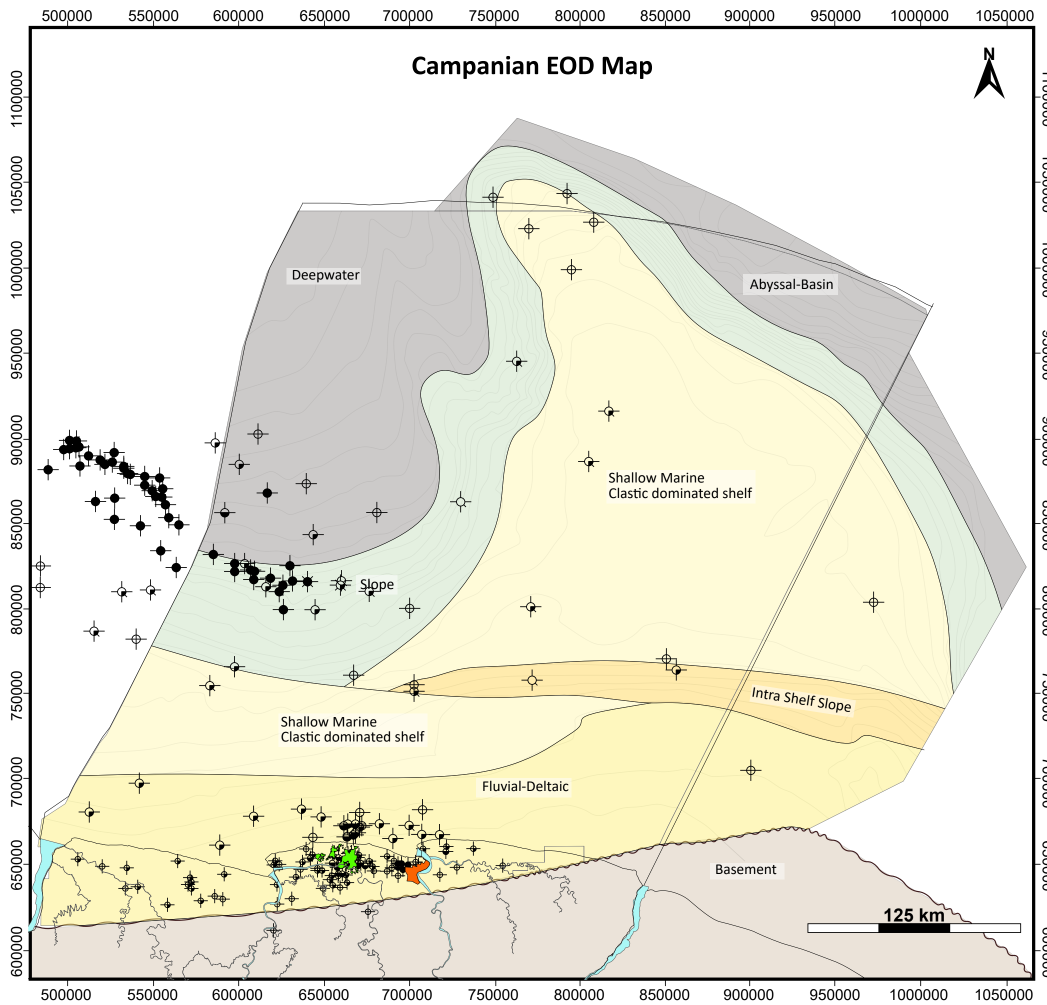
- There was an onset of clastic deposition with the development of the fluvial-deltaic system in the Onshore and the southwest (Main sediment supply is from the Guyana Berbice canyon side).
- The clastic-dominated shelf prograded northwards mainly in the west into the Deepwater.
- In contrast, the Demerara Plateau experienced limited clastic and carbonate deposition during this interval, suggesting sediment starvation.



Coniacian - Santonian Facies Map

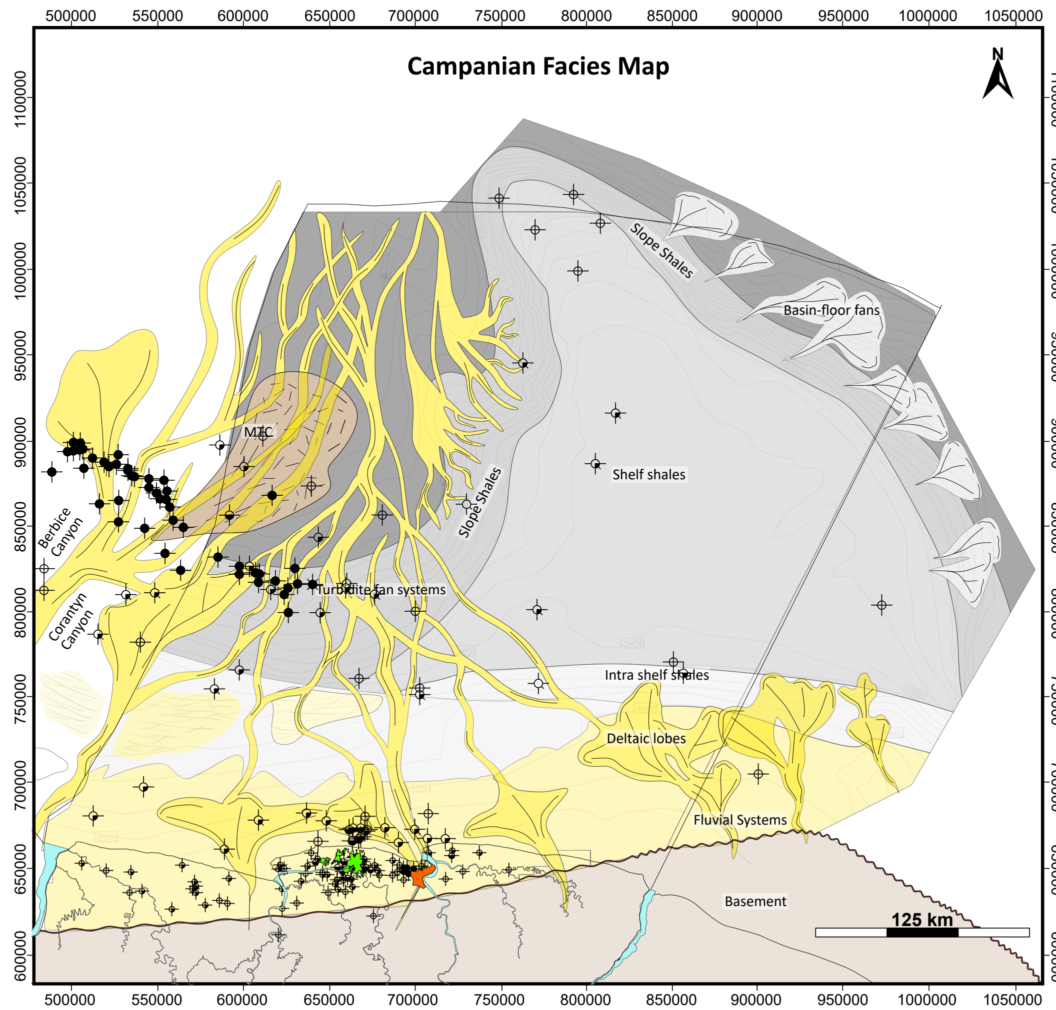
- The Onshore and Nearshore areas were dominated by fluvial deposits, particularly towards the west.
- During lowstand phases, fluvial systems extended across the shelf, connecting with basin environments and facilitating sediment bypass into deeper settings.
- Sand-prone turbidite fairways developed along the slope and proximal basin floor, primarily fed from the Berbice Canyon in the west and from the hinterland.
- Mass Transport Complexes (MTC) were associated with the remobilisation of fine-grained sediment between turbidite fan systems.
- The decrease of sediment input from the south and southeast led to continued mudstone (porcelinite) deposition across the Demerara Plateau.
- There was potential for turbidite deposition sourced from the northeastern edge of the Demerara Plateau, indicating localized sediment routing.
- The Coniacian strata contains a thin but typically rich source rock interval, identified in select wells where the Coniacian section remains undiluted by clastic influx.

Campanian



Campanian EOD Map

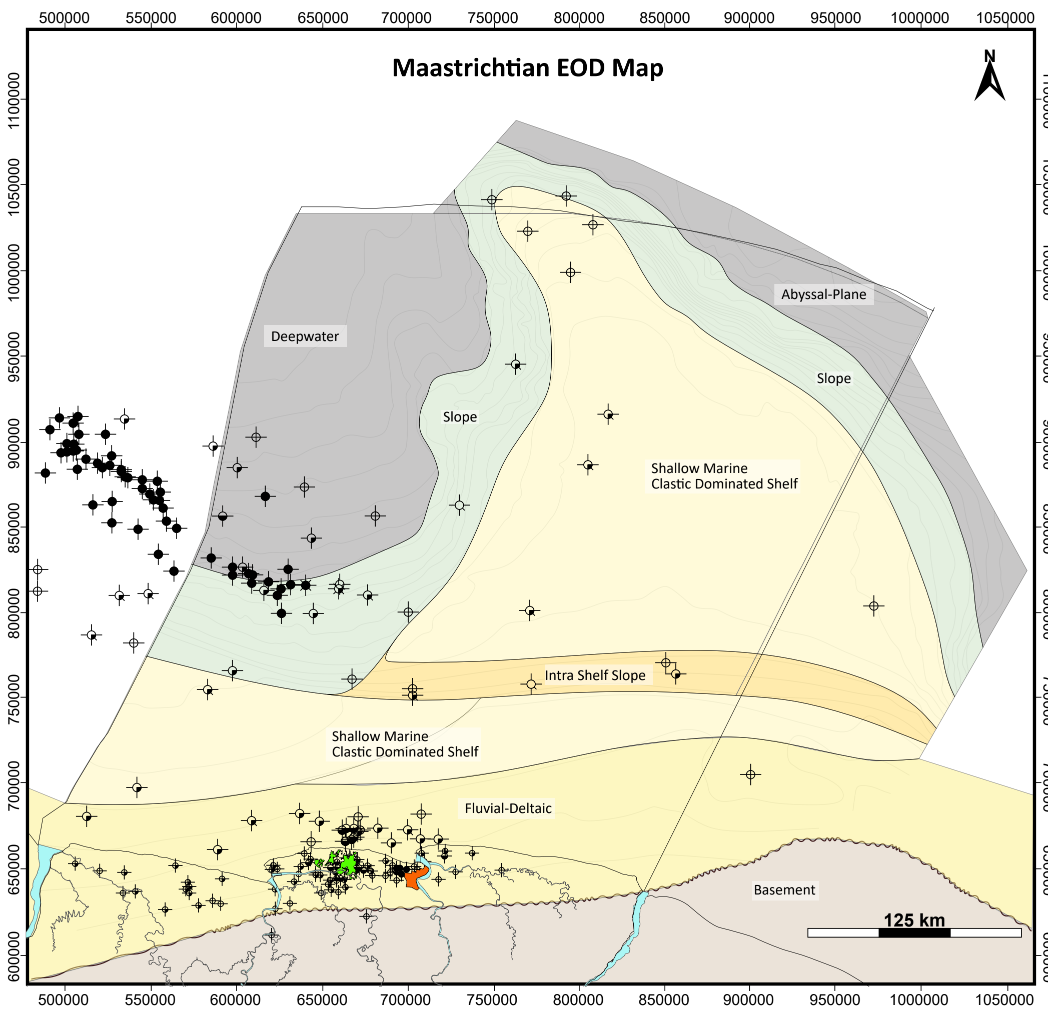
- Clastic deposition continued into the Deepwater, due to the fluvial-deltaic system an increase in sediment supply is noticed from the Suriname hinterland.
- The clastic-dominated shelf maintained its position from the Santonian.
- As in the Santonian, clastic and carbonate deposition remained limited across the Demerara Plateau.
- Slope gradients increased along both the western and eastern margins of the Demerara Plateau compared to the Santonian, likely due to differential subsidence influenced by an increase of sediment transport.



Campanian Facies Map

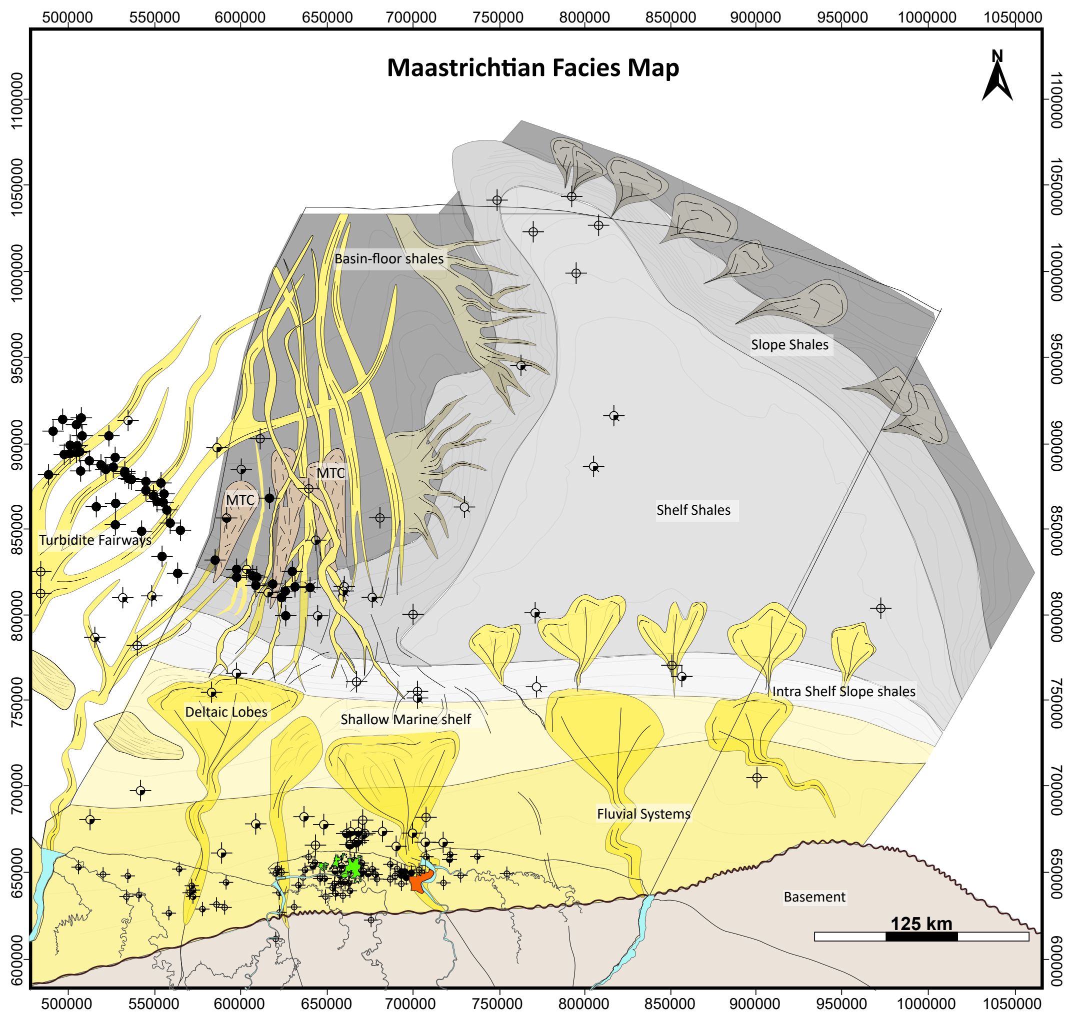
- The Onshore and Nearshore areas continued to be dominated by fluvial deposits, specifically towards the west.
- The clastic-dominated shelf continued to be characterised by strand plains and fluvial-deltaics, and back barrier deposits in the inland areas.
- During lowstand phases, fluvial systems extended across the shelf, connecting with basin environments in the west and facilitating sediment bypass into deeper settings.
- Turbidite fairways on the slope and proximal basin floor were primarily sourced from the south, with additional input from the Berbice Canyon in the northwest. Sediments were also eroded from the Demerara Plateau and fed into the basin floor along north-northwest trending channelised systems.
- There was increased slope instability along the lower slope and upper basin floor, resulting in Mass Transport Complexes (MTC) between turbidite fan systems.
- Continued lack of sediment input from the southeast sustained mudstone deposition on the Demerara Plateau.

Maastrichtian



Maastrichtian EOD Map

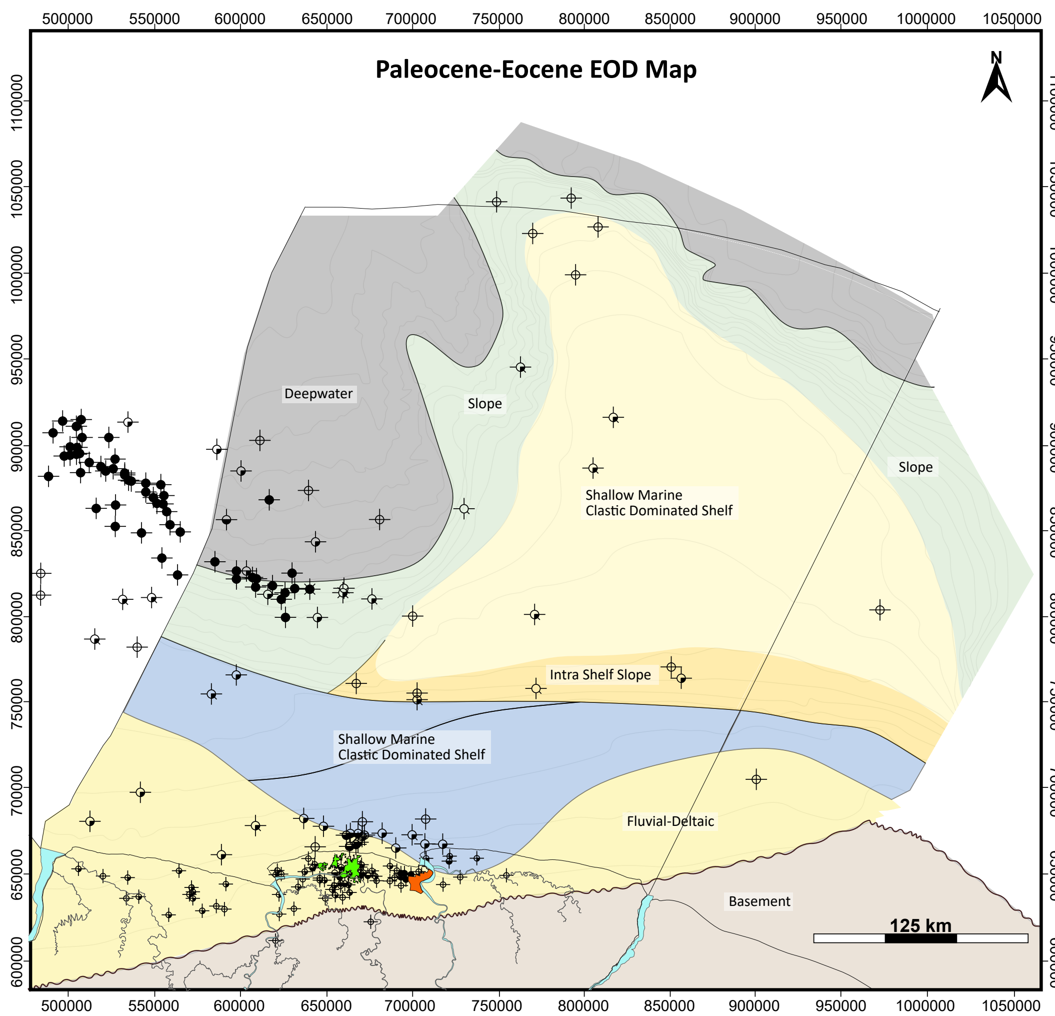
- The fluvial-deltaic system underwent a southward regression, leading to the development of a broader shelf system.
- Clastic and carbonate deposition remained limited on the Demerara Plateau, continuing the sediment-starved conditions observed in earlier intervals.
- Slope gradients along both the western and eastern margins of the Demerara Plateau were comparable to those of the Campanian, indicating relative tectonic stability.



Maastrichtian Facies Map

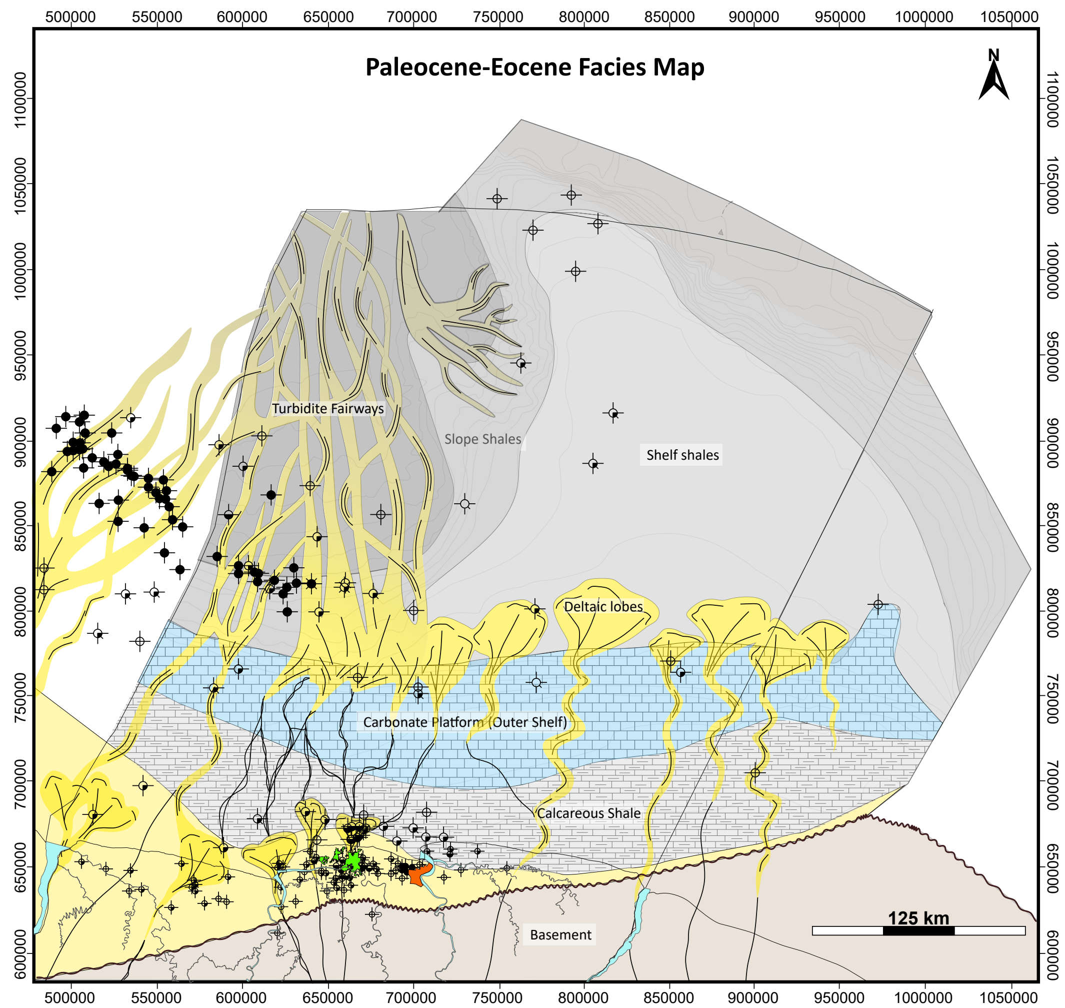
- The Onshore areas continued to be dominated by fluvial deposits in the southern central areas.
- During lowstand phases, fluvial systems extended across the shelf, connecting with basin environments in the west and facilitating sediment bypass into deeper settings.
- The main sediment source direction for the turbidite fairways was still predominantly from the south, except for minor southwest-oriented channelling in the northwest of the basin floor.
- There was a reduction in sediments being eroded from the Demerara Plateau and fed into the basin floor.
- There was continued slope instability along the lower slope and upper basin floor, resulting in Mass Transport Complexes (MTC) along the western margin.
- There was a lack of sediment supply from the southeast, which resulted in the continuation of mudstone deposition on the Demerara Plateau.
- There was the potential for the development of turbidite deposits fed from the northeastern edge of the Demerara Plateau.

Paleocene - Eocene



Paleocene - Eocene EOD Map

- The fluvial-deltaic system became restricted to areas near the present-day coastline, indicating a landward shift in sedimentation due to rising sea levels.
- A major transgressive event during the Eocene facilitated carbonate development (significant seal in Onshore fields called Harde bank) across shallow offshore to onshore zones.
- Clastic and carbonate deposition remained limited on the Demerara Plateau, continuing the sediment-starved conditions observed in earlier intervals.
- Slope gradients along the western and eastern margins of the Demerara Plateau remained consistent with Maastrichtian configurations.



Paleocene - Eocene Facies Map

- The Paleocene - Eocene shelf transitioned from isolated to broad carbonate platforms. In the central and the eastern Nearshore areas, these broad platforms moved towards the present-day coastline through a series of transgressive cycles. Washover from these carbonate platforms is recognised as carbonate banks or Harde Bank. The Harde Bank is a major contributor to the sealing capacity of the Paleocene - Eocene discoveries in the central Onshore Coastal Plain of Suriname.
- Regressive cycles resulted in the connection of the shelf and basin systems in the west.
- The main sediment source direction for the basin floor was predominantly from the south, with minor southwest-oriented channelling in the northwest of the basin floor.
- Sediments were also eroded from the Demerara Plateau in the northwest and fed into the basin floor.
- There was limited sediment supply from the southeast, which resulted in the continuation of mudstone deposition on the Demerara Plateau.

Aerial view of Paramaribo
Credit: Anton Gots

Oil Samples Staatsolie

Source Rocks

Introduction

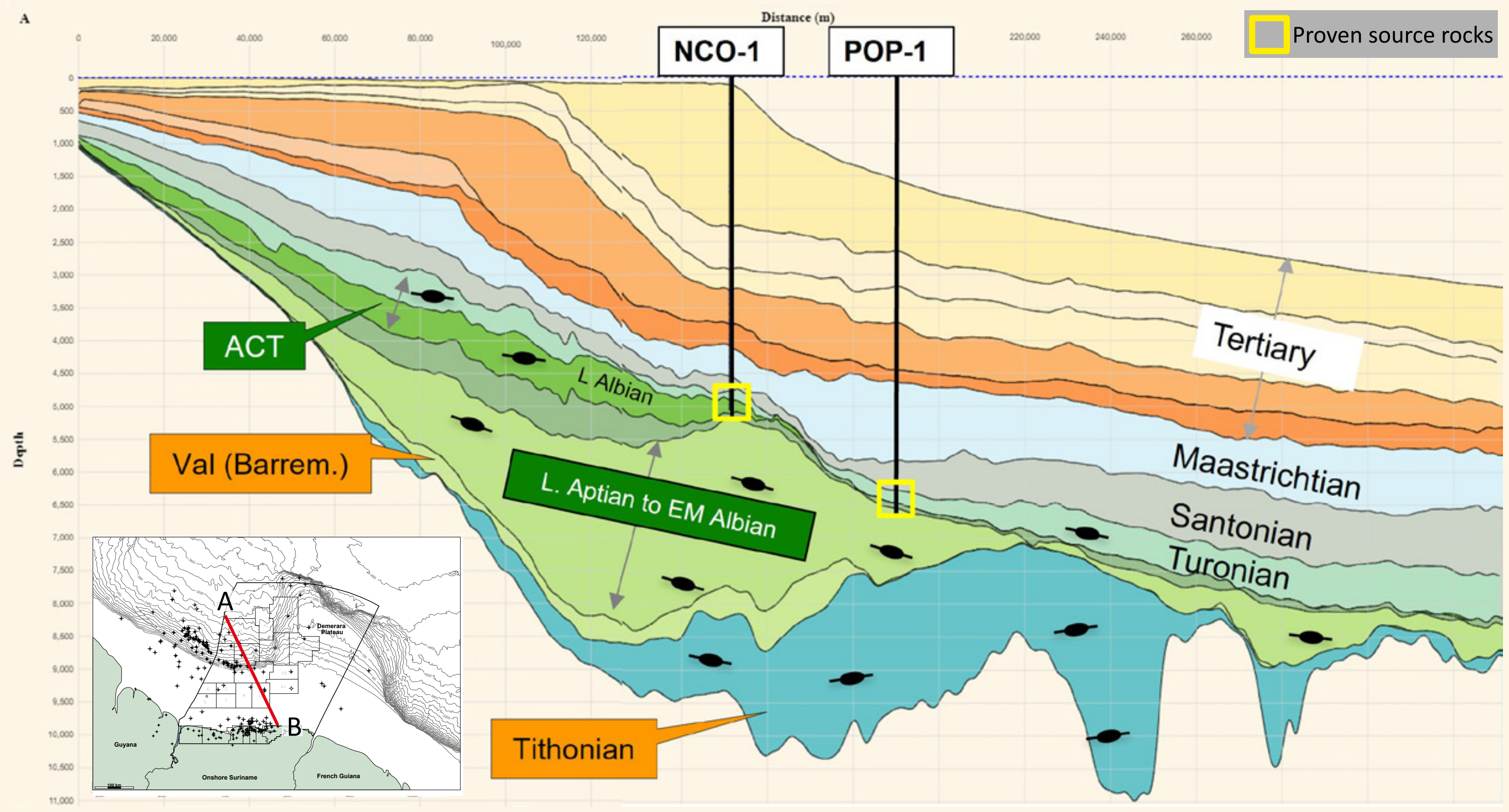
This chapter reviews hydrocarbon occurrences in Offshore Suriname, emphasising the Albian-Cenomanian-Turonian (ACT) source rock and associated fluid geochemistry.
It also considers secondary Aptian-Albian and deeper sources (e.g., Tithonian) using the DSDP 367[1] well as conjugate margin analogue and ODP data, concluding with a Petroleum Events Chart summarising the timing of all petroleum system elements.

The Guiana Basin contains at least four identified intervals of significant source richness that have generated, or are capable of generating, oil and gas.
The four main source intervals, which are as follows, and are categorized as either proven or unproven:

PROVEN
1. Albian, Cenomanian and Turonian (ACT[2])
2. Late Aptian (to Early-Mid Albian)

UNPROVEN
3. Barremian (or Early Cretaceous equivalents)
4. Tithonian (or potentially other Late Jurassic sources such as Oxfordian and Kimmeridgian)

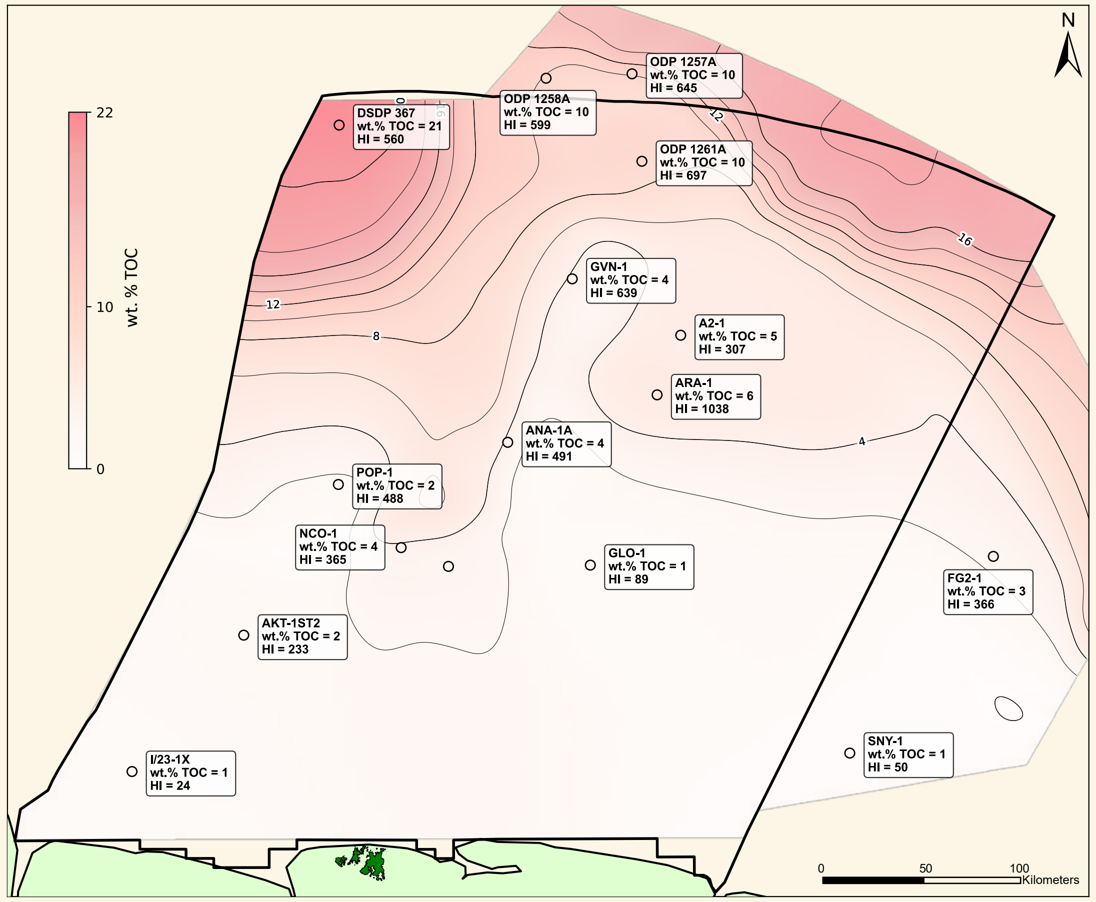
The cross-section below shows the spatial distribution and relative thickness of the proven and unproven source rocks within the Guiana Basin.



Representative cross-section from Nearshore (B) to Offshore (A) showing the arrangement of proven and unproven source rocks.

Source rock Penetrations Cenomanian & Turonian (CT)

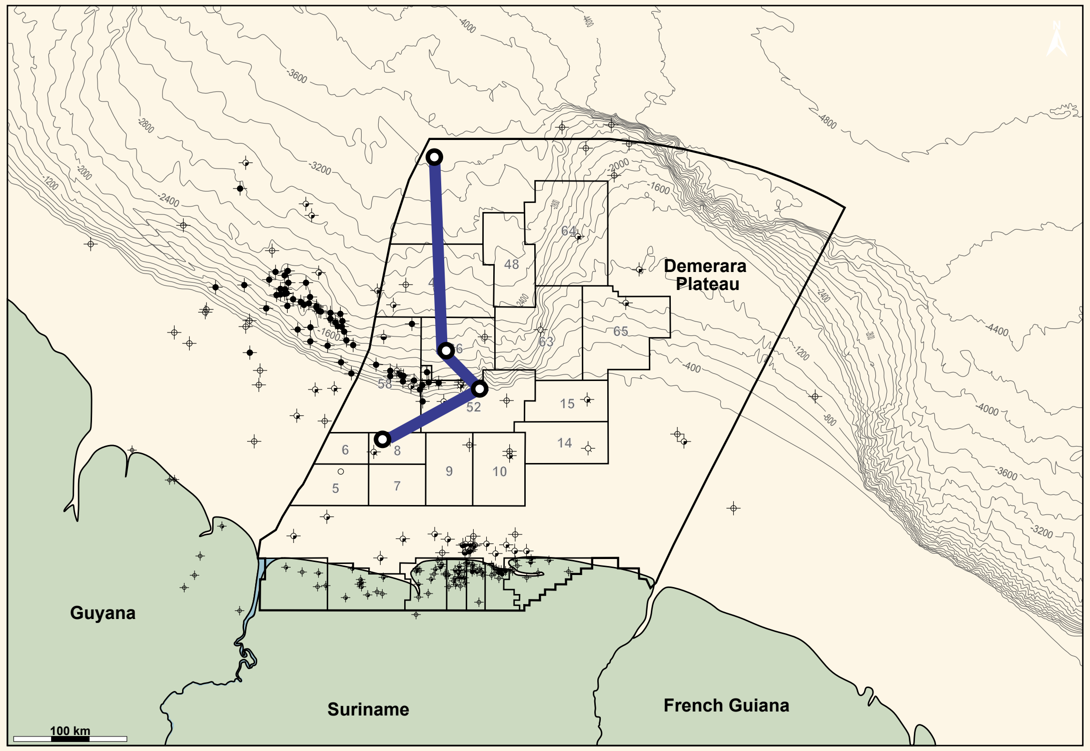
The map below presents average Total Organic Carbon (TOC) and Hydrocarbon Index (HI) values from source rock penetrations within the Cenomanian–Turonian interval. Notably, there are poor TOC/HI properties at penetrations on the proximal shelf, with increasing richness toward the distal shelf and deep water equivalents, where drilled source properties exceed TOC values of 1.5 % and HI values above 350 mg HC/g TOC.



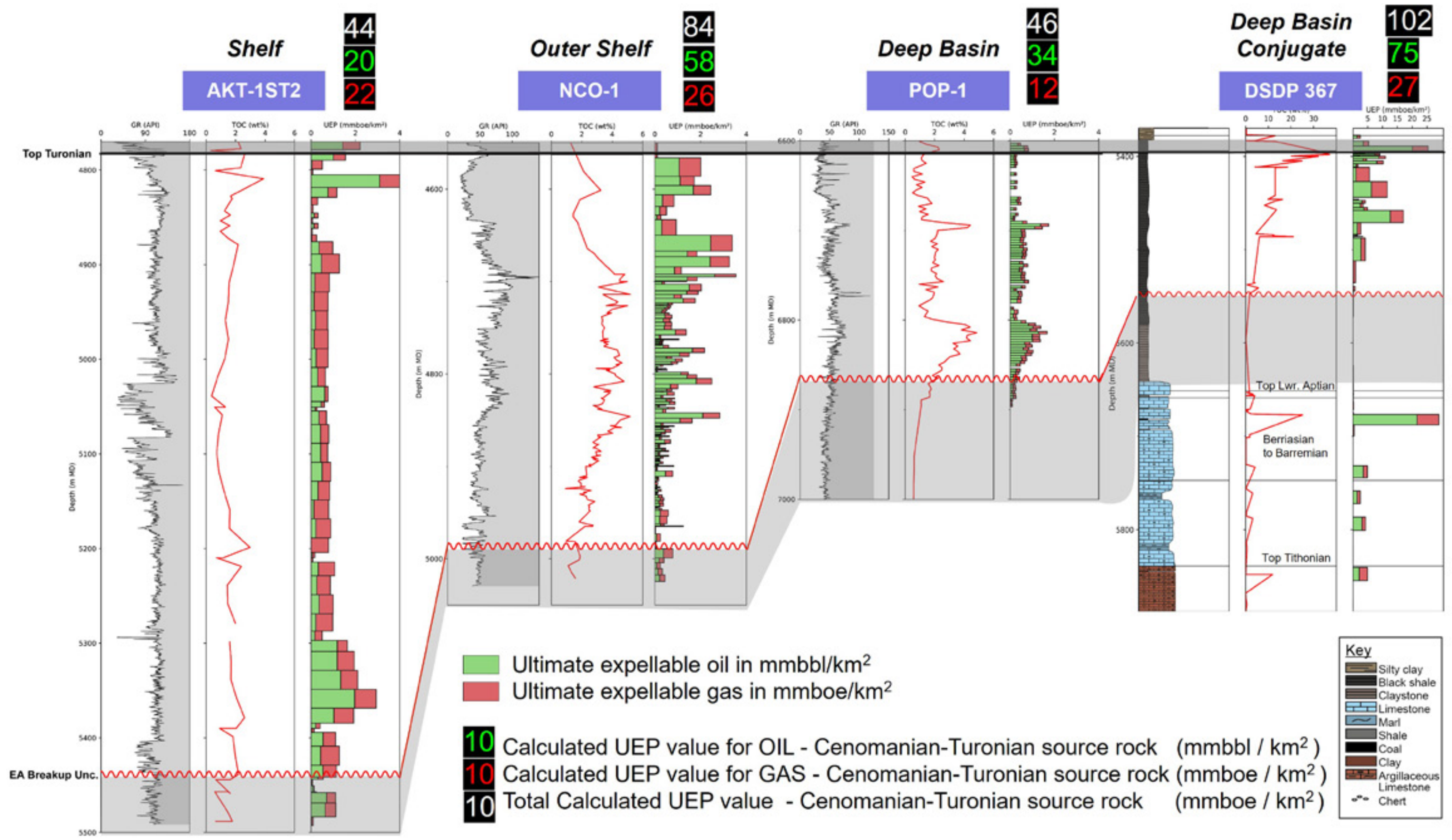
Overview of the average source rock properties for the Cenomanian-Turonian source level at well penetration.

[1] DSDP Site 367, drilled offshore Senegal as part of the Deep Sea Drilling Project, has been paleogeographically restored to its inferred stratigraphic position prior to the onset of Equatorial Atlantic rifting.
[2] This interval of lumped source rocks has also been referred to as ACTC by some geoscientists, following the recognition that the Coniacian interval may show organic richness.

Ultimate Expellable Potential (UEP) Offshore Suriname



Location map showing the correlation-panel trace in plan view

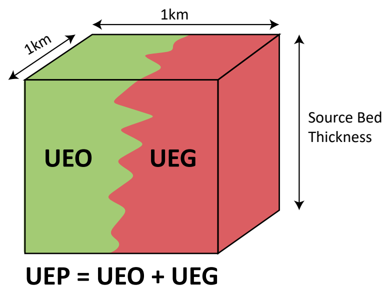


Correlation-panel of key wells showing composite logs of gamma ray, lithology, TOC, and UEP, reflecting source richness across the basin.

The right-hand correlation panel presents data from four wells, showcasing a composite log of GR, lithology, TOC, and UEP across the Albian-Cenomanian-Turonian source interval (ACT). This stratigraphic section is recognized as the main proven source rock within the Guiana Basin. The correlation panel shows a thick gas-prone source rock interval on the shelf (AKT-1ST2). This source interval exhibits progressive thinning toward the deep basin, accompanied by a compositional shift toward more oil-prone kerogen.

The DSDP 367 well confirms the very rich nature of the ACT source rock of Deepwater equivalent stratigraphy from the conjugate side of the basin following Equatorial Atlantic Rifting. Tithonian to Early Cretaceous source rocks in the DSDP 367 well show relatively lower UEP, but may not fully reflect their original generative potential due to undersampling and/or oxidation. A thin but highly enriched source interval is observed within the Barremian.

The Ultimate Expellable Potential (UEP) represents the Ultimate Expellable Oil (UEO) and Gas (UEG) that can be expelled upon full maturation of the source rock. Furthermore, the UEP is a volumetric integral, expressed per unit area, that reflects the adequacy of a source bed (Pepper & Roller, 2017).



Ultimate Expellable Potential (UEP) Mapping

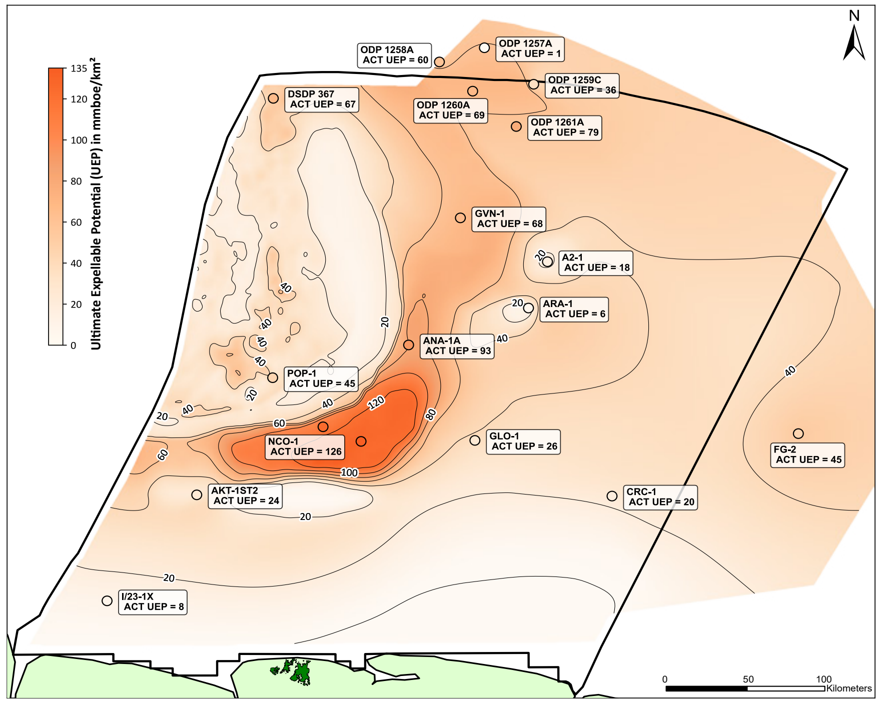
The following maps show the spatial distribution of source richness for the main source rocks within the Guiana Basin.

Source rock modelling shows that the ACT interval is the most prolific hydrocarbon source unit among the four modelled intervals. The highest concentration of generative potential is localised along the paleo-distal shelf margin.

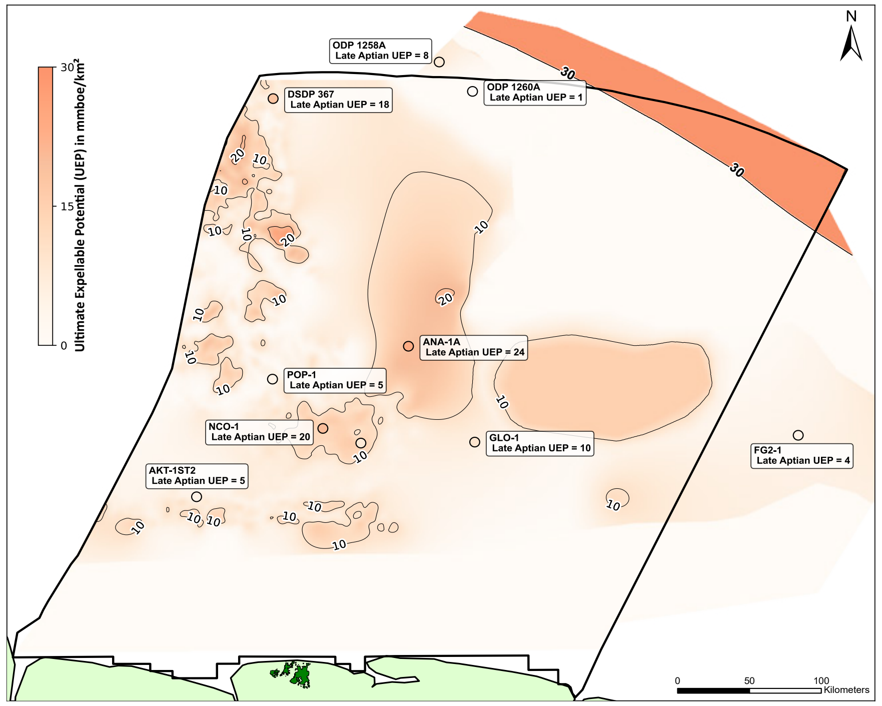
Mapping of the Late Aptian interval shows a more sporadic source rock development than the ACT, likely attributable to subcropping beneath the BUC.

The Barremian and Tithonian intervals represent unproven source rocks within the Guiana Basin. Their presence is inferred from limited well penetration as well as analogues in the Senegal conjugate margin (DSDP 367 well). Age equivalent source rocks of Barremian and Tithonian age have been well documented in West Africa, Brazil and the Gulf of Mexico, respectively.

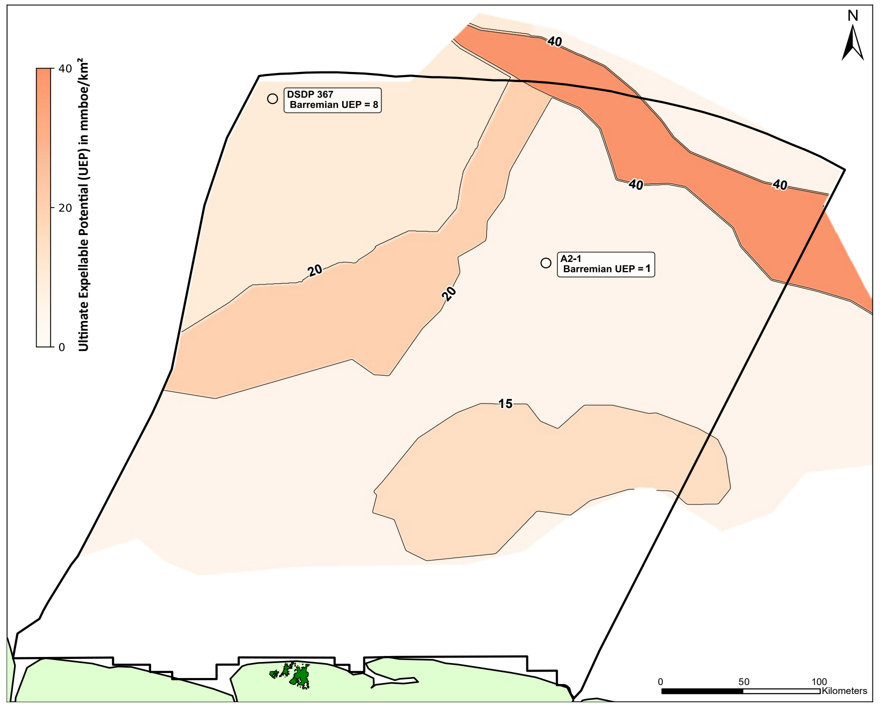
Notable for both the Late Aptian and Barremian source rocks show the development of an outboard (possible synrift) source rock with an elevated UEP (30–40 mmboe/km²), a value inferred from analogues.



UEP map of ACT source rock interval



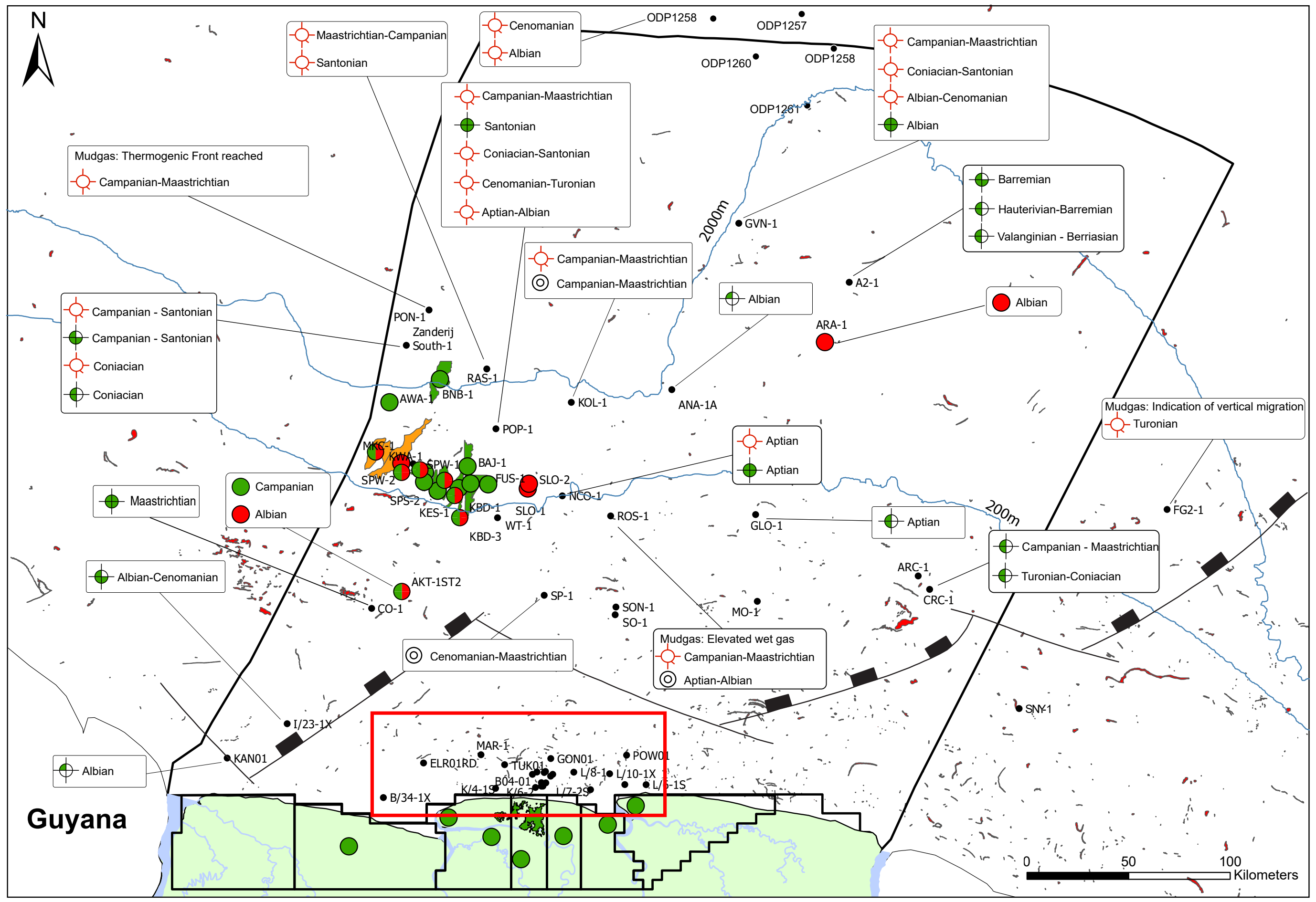
UEP map of Late Aptian source rock interval



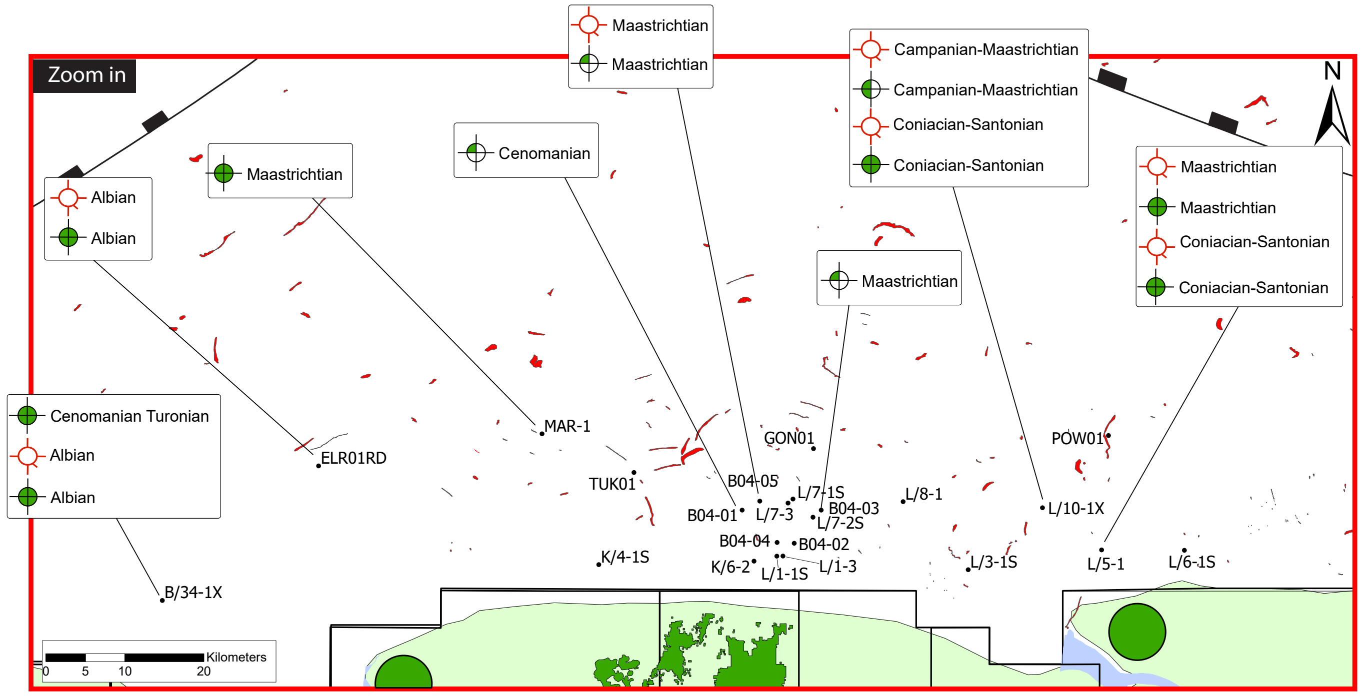
UEP map of Barremian source rock interval

UEP map of Tithonian source rock interval

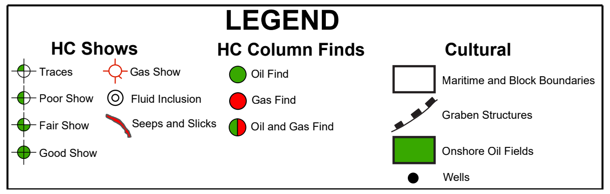
Hydrocarbon Indicators - Cretaceous



Overview of the Cretaceous hydrocarbon indicators.



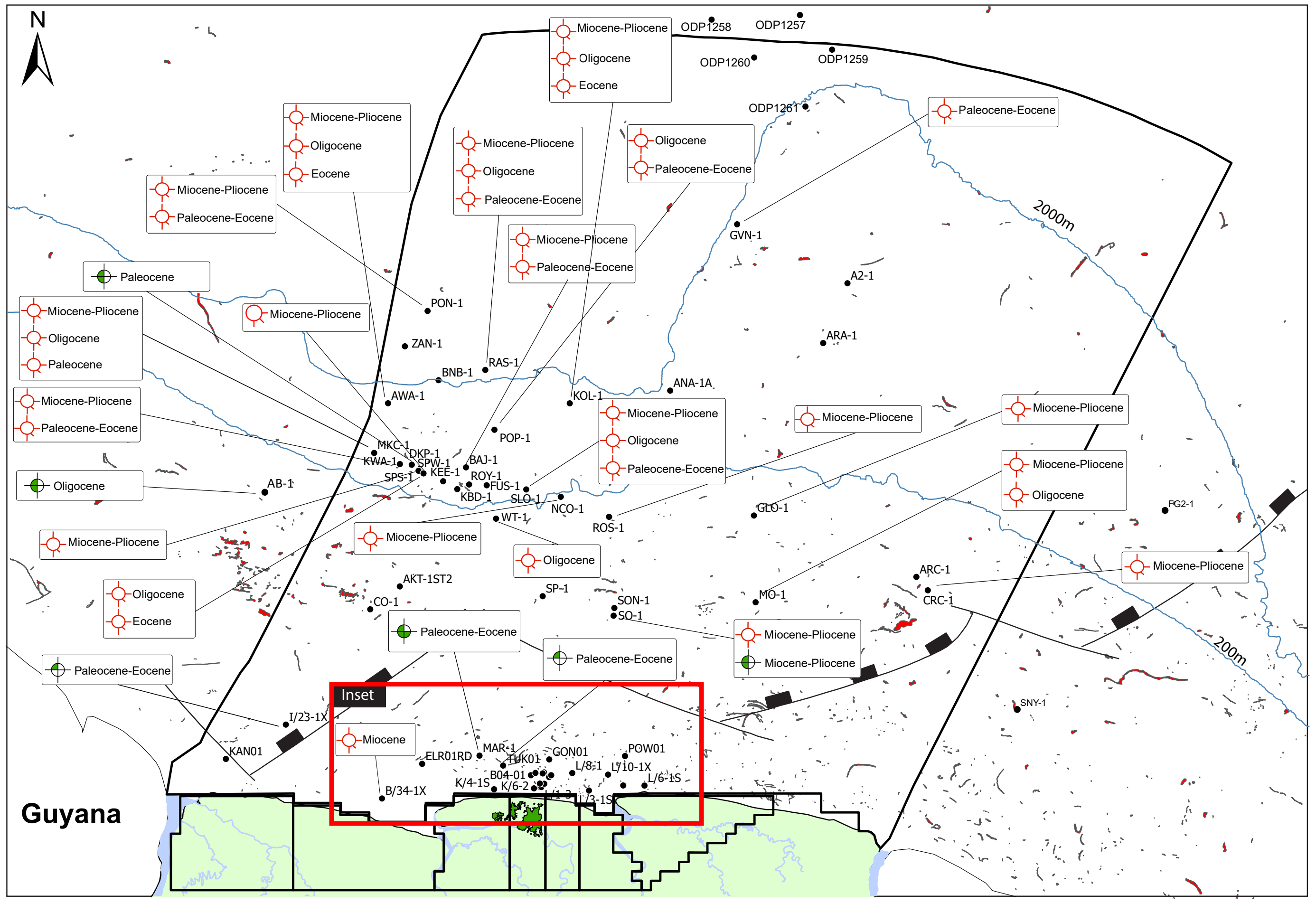
Overview of the Cretaceous hydrocarbon indicators within the Central Nearshore area.



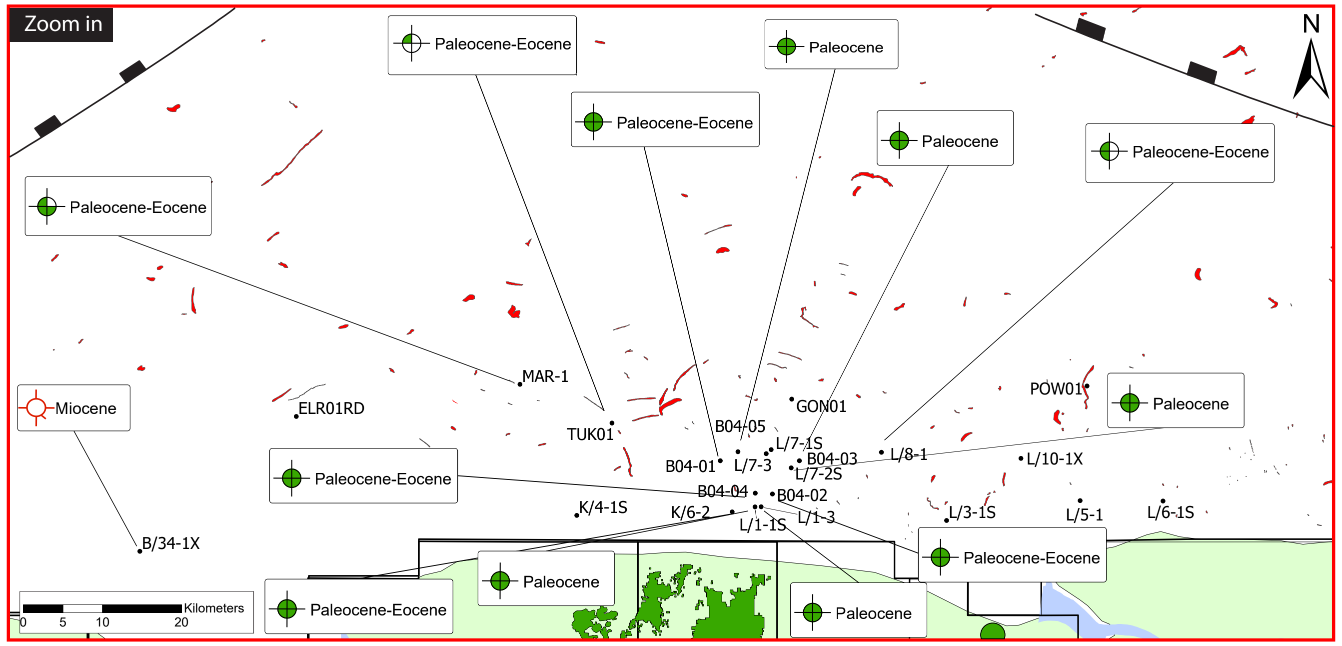
Cretaceous

The largest concentration of identified seeps and slicks in the region occurs in water depths of less than 200 m. There are multiple oil and multiphase hydrocarbon indications across the Guiana Basin; from which oil discoveries are focused in the Golden Lane, Saramacca Onshore and its extension to the Nearshore.
However, oil shows have been observed on the Demerara Plateau and Shallow Offshore East up to the border with French Guiana.

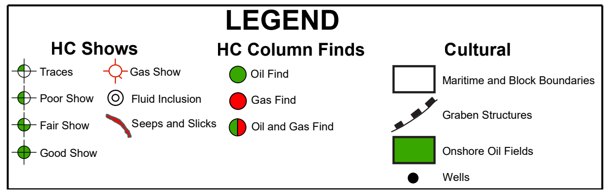
Hydrocarbon Indicators - Tertiary



Overview of the Tertiary hydrocarbon indicators.



Overview of the Tertiary hydrocarbon indicators within the Central Nearshore area.



Tertiary

The Offshore Tertiary sequences show an abundance of gas shows within reservoirs consisting of clastics and some carbonates.
Evidence of hydrocarbons within the Tertiary plays are primarily concentrated in the Onshore oil fields of Tambaredjo and Calcutta, along with Nearshore discoveries located north of these fields. In addition, oil shows have been encountered farther west at the I/23-1X and AB-1 wells.

Whole Oil Chromatographs – A Tale of Two Oil Families

Expelled hydrocarbons offer a direct expression of source rock quality, thermal maturity, and depositional environment. The following section focuses on oil types and their geochemical signatures, which serve as critical tools for correlating fluids to their source and reconstructing the evolution of the petroleum system.

Two oil families are recognised in Suriname, which have distinctive characteristics. These are based on the marine versus marine-terrestrial carbon 'shape' from the chromatograph, wax contents and carbon preference index.

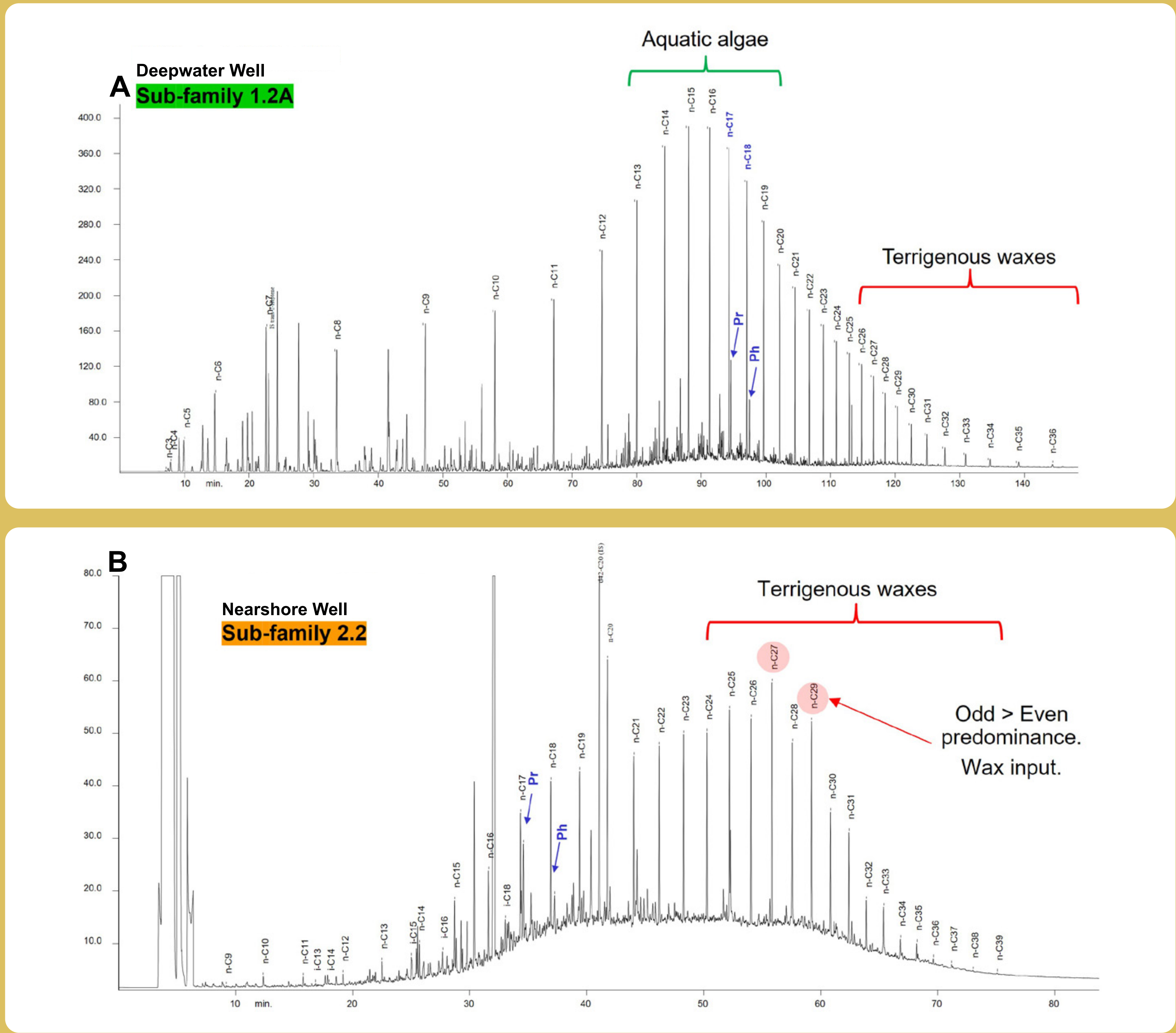
Oil Family 1

- Strong marine aspect, with nC14- nC17 predominance.
- Small wax inputs eliminate evidence of a strong terrigenous influence.
- Sub-family 1.2 has a Pr/Ph ratio of approximately 1.5, indicating anoxic source conditions.

Oil Family 2

- Sub-family 2.2 has a Pr/Ph ratio of approximately 2.4, indicating sub-oxic source conditions.
- A predominance of C23+ saturates (wax content) is also indicative of terrigenous Organic Matter to the source.
- The chromatograph shows that odd-numbered carbon chains are more common than even-numbered ones. This pattern points to a stronger terrigenous influence.

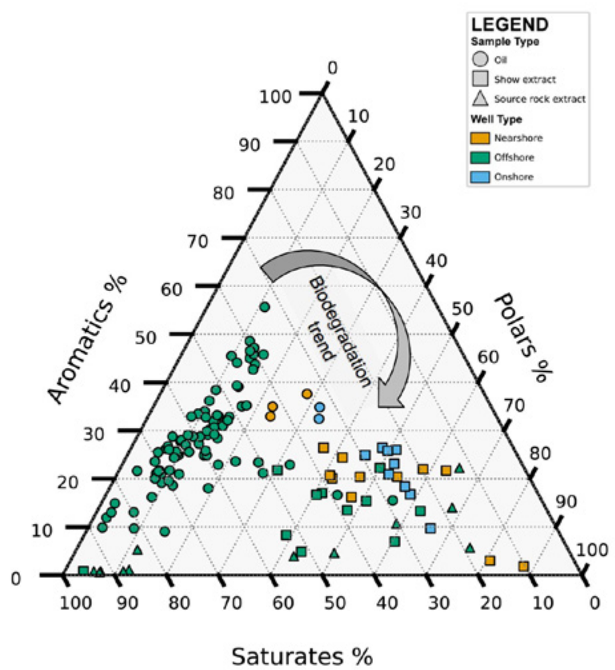
The distinction between oil families is also reflected in the distribution of terpanes, hopanes, steranes, and carbon isotopes, which will be further elaborated in the following subsections.



n-alkane profile (GC traces) of a Suriname Sub-family 1.2 (A) and Sub-family 2.2 (B) oils (modified from Cedeño, 2022).

Heavy to Light Oils and Oil Family Classification

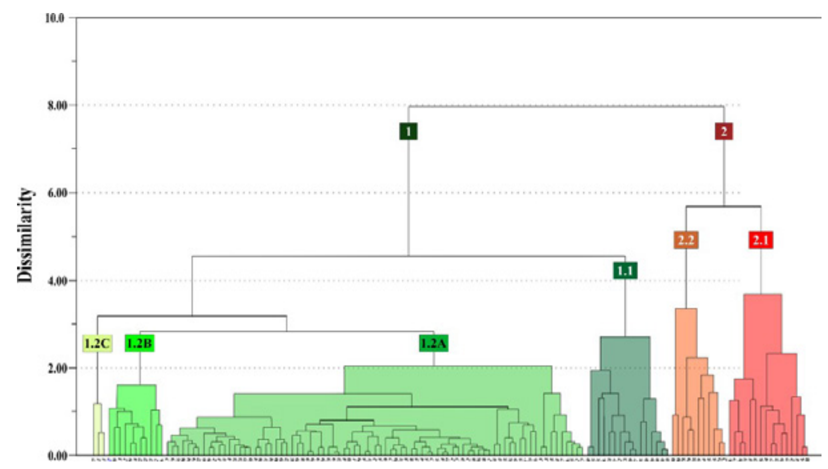
The Offshore oils reflect high saturate and lower aromatic composition. In contrast, Nearshore and Onshore oils contain a proportionally higher percentage of polar compounds (including asphaltenes and other Nitrogen Sulphur Oxygen compounds). This trend largely reflects biodegradation (reservoir temperatures of < 80 °C) as well as water washing processes acting on the oils.



Ternary diagram of SARA composition of Offshore, Nearshore and Onshore crude oils.

Hierarchical and Principal Component analysis, based on 14 facies-dependent oil biomarker ratios, separates the dataset into two main families: Oil Family 1 and Oil Family 2.

Each of these two families are broken down into sub-families. These are: 1.1 and 1.2 A, B, and C, and 2.1 and 2.2. The classification uses the Terpanes, Hopanes and Steranes key ratios (A. Cedeño, 2022).



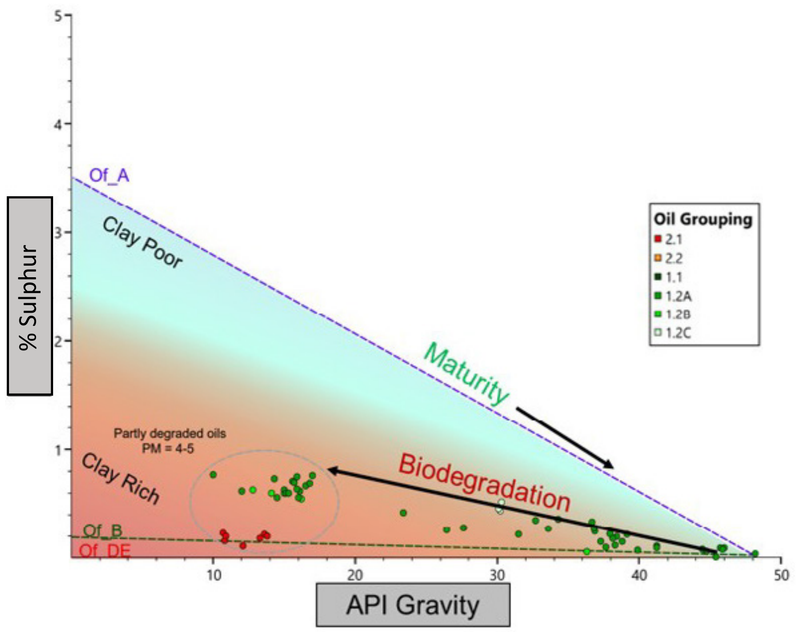
Cluster analysis dendrogram based on 14 facies-dependent oil biomarker ratios for the dataset (Cedeño, 2022).

The following cross-plot is of API gravity versus sulphur weight percent (API-S wt.%) for the Suriname dataset.

Average API-S wt.% trends for marine clay-poor organofacies A (Of_A), marine clay-rich organofacies B (Of_B), and terrestrial-rich organofacies DE (Of_DE) are displayed for comparison.

Oil Family 1 lies on a spectrum from higher API oils in the Offshore wells to lower API oils within the Onshore wells, reflecting biodegradation.

Oil Family 2 are consistently low API oils with correspondingly low sulphur.

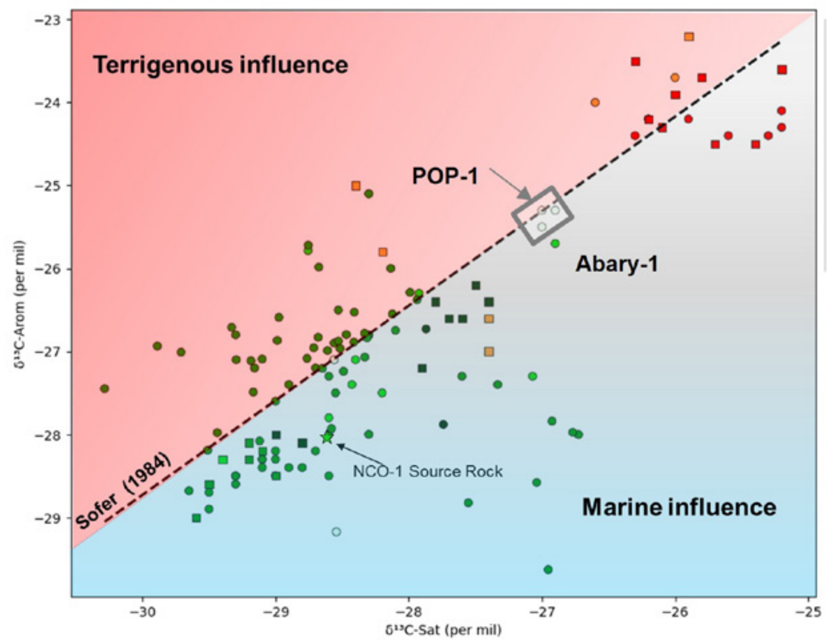


Cross-plot of API gravity versus sulphur weight percent (S wt.%) for the Suriname dataset (modified from Cedeño, 2022).

Stable carbon isotopes of the saturated ($\delta^{13}C$ Sat) and aromatic ($\delta^{13}C$ Arom) fractions of liquids (oil and condensate) show two distinct oil families and sub-families.

Oil Family 1 reflects a lighter bulk carbon isotope composition (more negative), whereas Oil Family 2 shows a heavier composition.

Within sub-family 1.2C, three oils from the POP-1 and Abary-1 wells stand alone from the two major oil families. This either reflects a different, unidentified source rock or a mixture of Oil Family 1 and 2. A similar explanation may also exist for sub-family 2.2 where the oils seem less clustered than sub-family 2.1.



Plot of stable carbon isotopes of the saturated ($\delta^{13}C$ Sat) and aromatic ($\delta^{13}C$ Arom) fractions displaying the Suriname dataset (modified from Cedeño, 2022).

Oil Families and Environment of Deposition

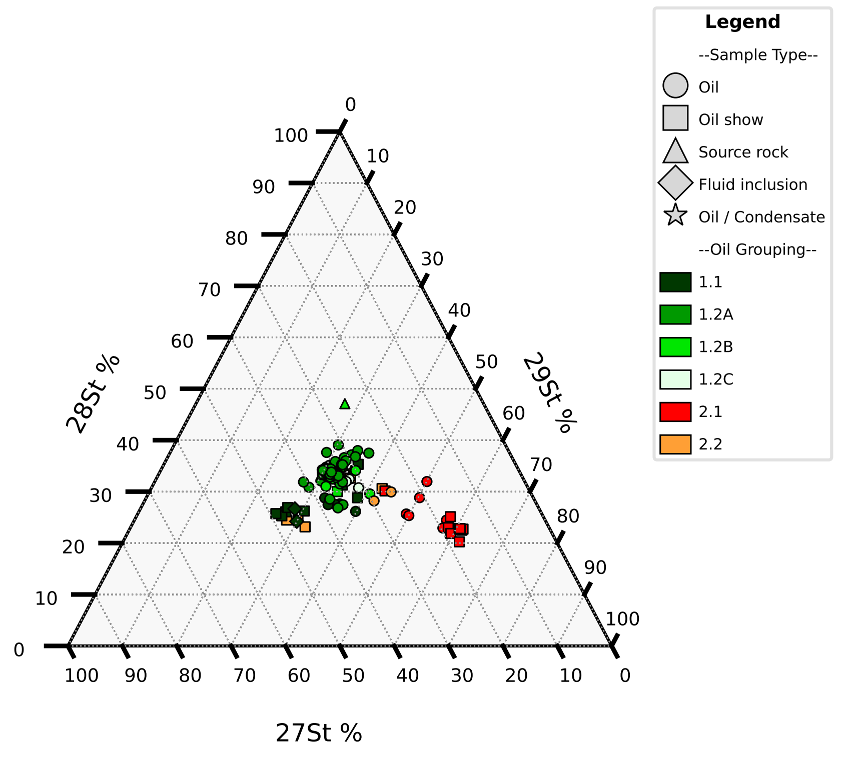
Steranes

The relative percentages of other molecular attributes, such as the C27, C28, and C29 Steranes ββ support differences in the organic facies that generated the oil types.

Sterane ratios show that sub-family 2.1 oils are derived from a deltaic-terrigenous facies, whereas Oil Family 1 and sub-family 2.2 oils are derived from an open marine source rock facies deposited under shallow to open marine conditions.

Below is a ternary diagram of C27, C28, and C29 Steranes ββ, showing the differences in the relative abundance of marine and terrigenous organic matter in the source rocks generating the Suriname oils.

Ternary diagram of C27, C28, and C29 ββ steranes showing differences in the relative abundance or marine and terrigenous organic matter in the source rocks generating the Suriname oils(modified from Cedeño, 2022).



Tricyclic and Tetracyclic Terpanes

Below are tricyclic-tetracyclic terpane profiles reflecting the microbial input to the organic matter from which the oils are generated, which are distinctive for organofacies.

Oil Family 1 shows low concentrations of C19 and C20 tricyclic terpanes, high abundance of C23 tricyclic terpanes, and low concentrations of C24 tetracyclic terpanes. These attributes are typically associated with oils originating from Deepwater sediments free of significant amounts of higher plant matter.

Oil Family 2 contains a distinctly different tricyclic-tetracyclic terpane distribution. They show a predominance of C24 tetracyclic terpanes and a high concentration of C19 and C20 tricyclic terpanes. These are characteristics of abundant terrigenous oil-prone organic matter in the source rock facies. Family 2.2 shows a slight variation (especially lower C24 TeT) which may point to a mixed marine aquatic and terrigenous waxy organofacies.

Tricyclic-tetracyclic terpane profiles for Oil family 1 and 2 oils. (Cedeño, 2022).

Standard Thermal Stress (STS) Maturity Mapping

The following figures present STS maps for the four modelled source rocks, each assigned Type B (OF_B) kinetics.

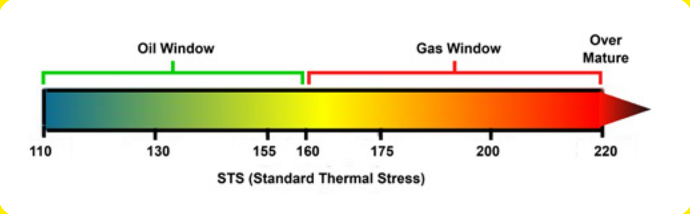
Proven source rocks constituting part of the ACT 'bundle' (Albian to Turonian) demonstrate consistencies of the oil and gas-condensate maturities from around the Golden Lane to the AKT-1ST2 well. The oil mature region continues to the north and east.

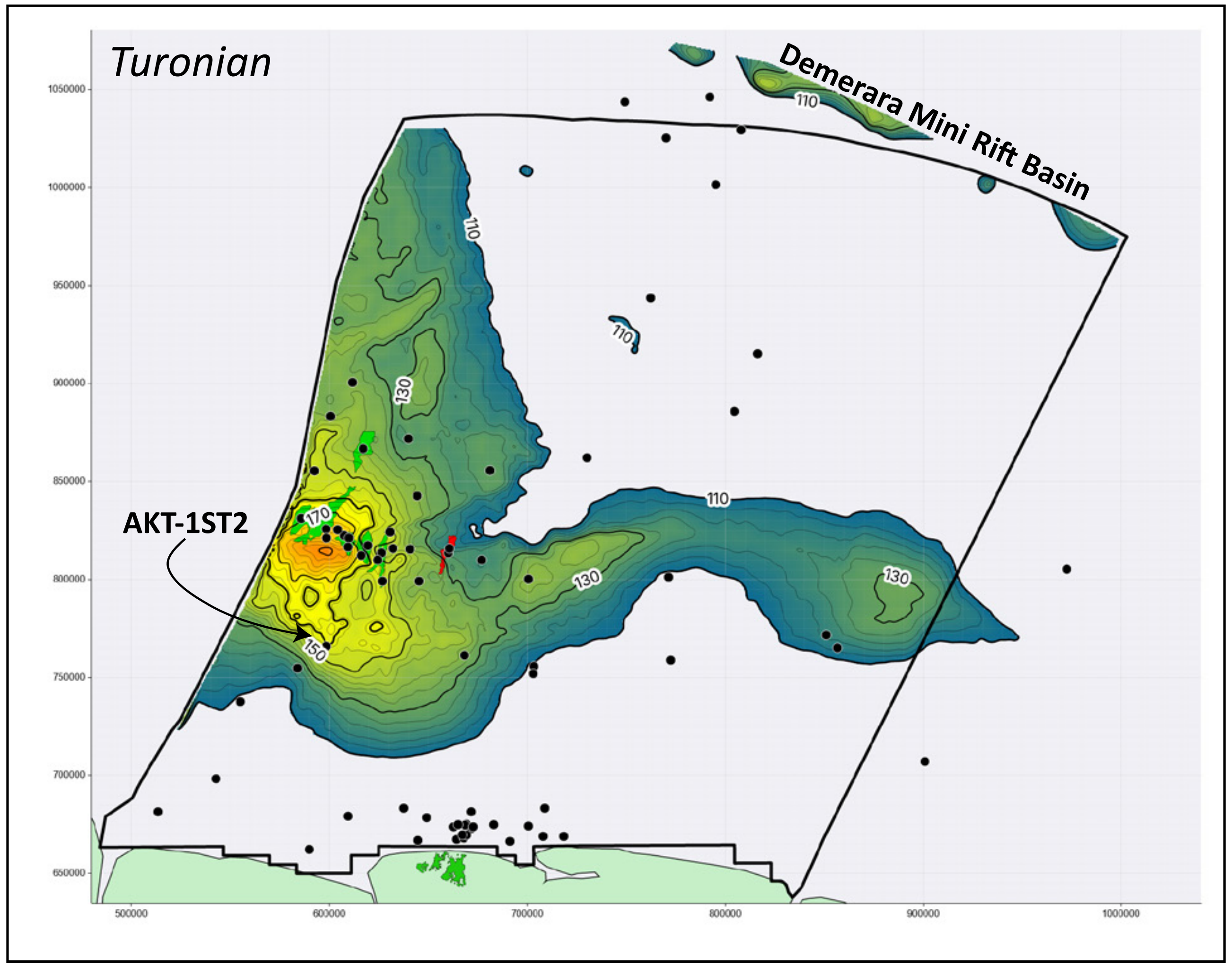
Oil to source correlation data supports an ACT source rock for the fluids discovered in the Golden Lane.

The Late Aptian source rock is modelled over most of the region to be within the gas-condensate window.

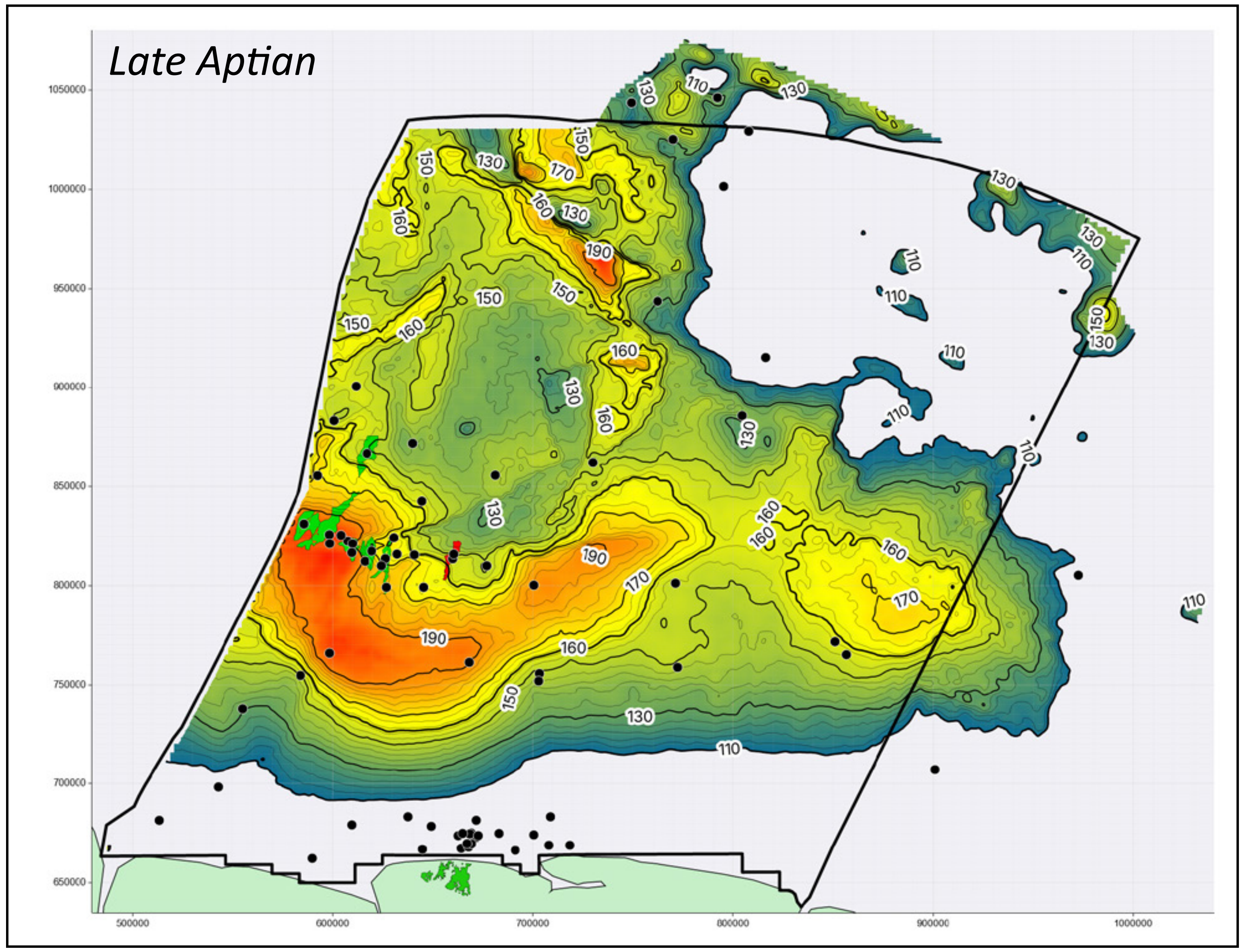
The Demerara Mini Rift Basin in the far northeast edge also shows oil window maturities.

Both the Barremian and Tithonian (present day) show elevated maturities, principally in the gas-condensate window, with regions of the Tithonian reaching an overmature state (no expulsion).

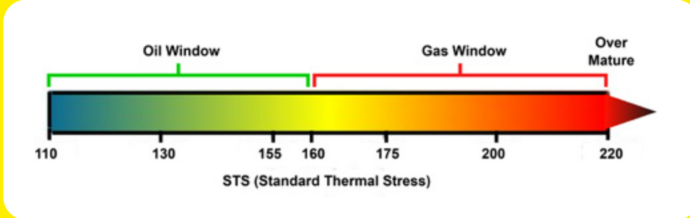


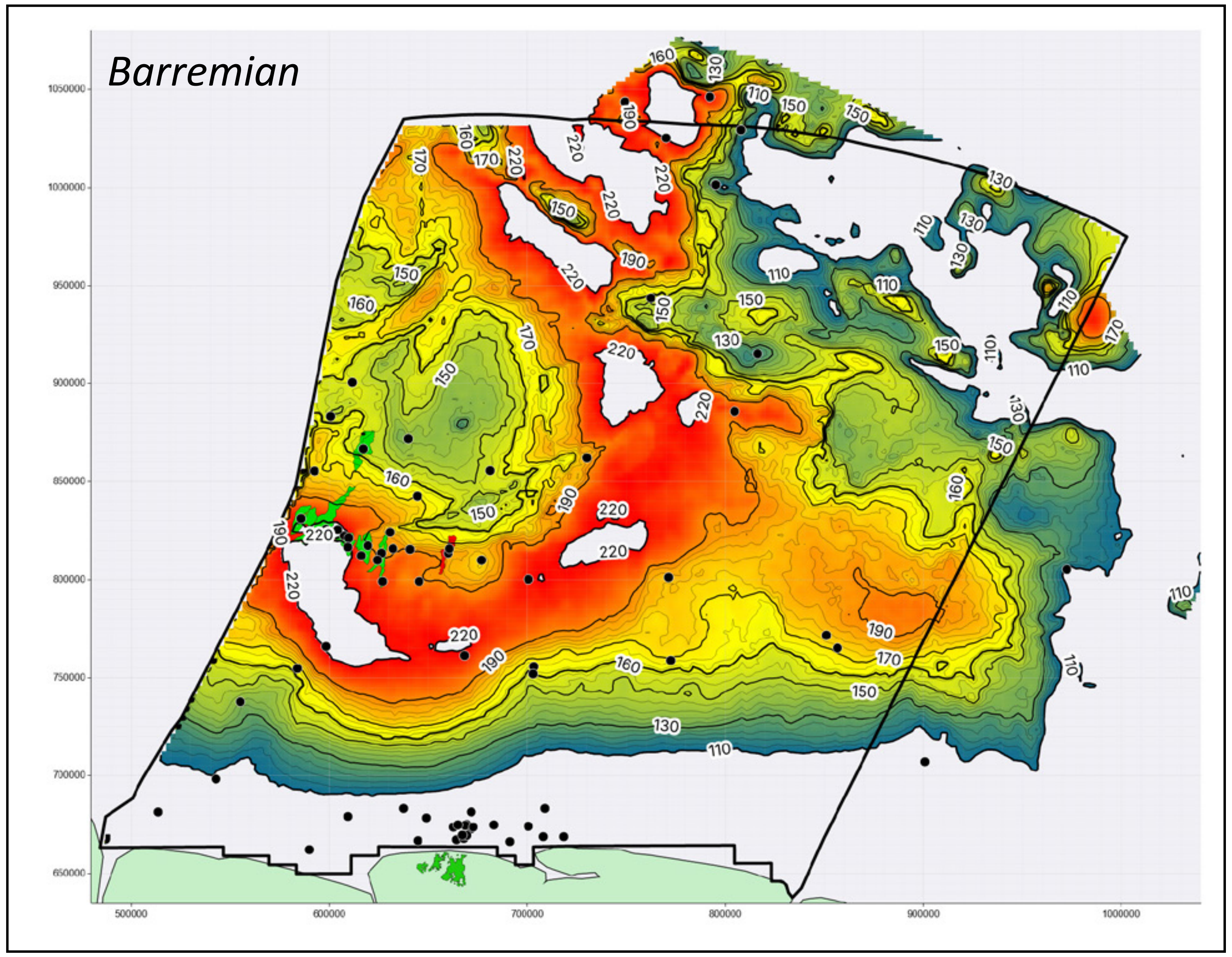


Present day Standard Thermal Stress at Top Turonian (representative for the top of the ACT source rock interval)

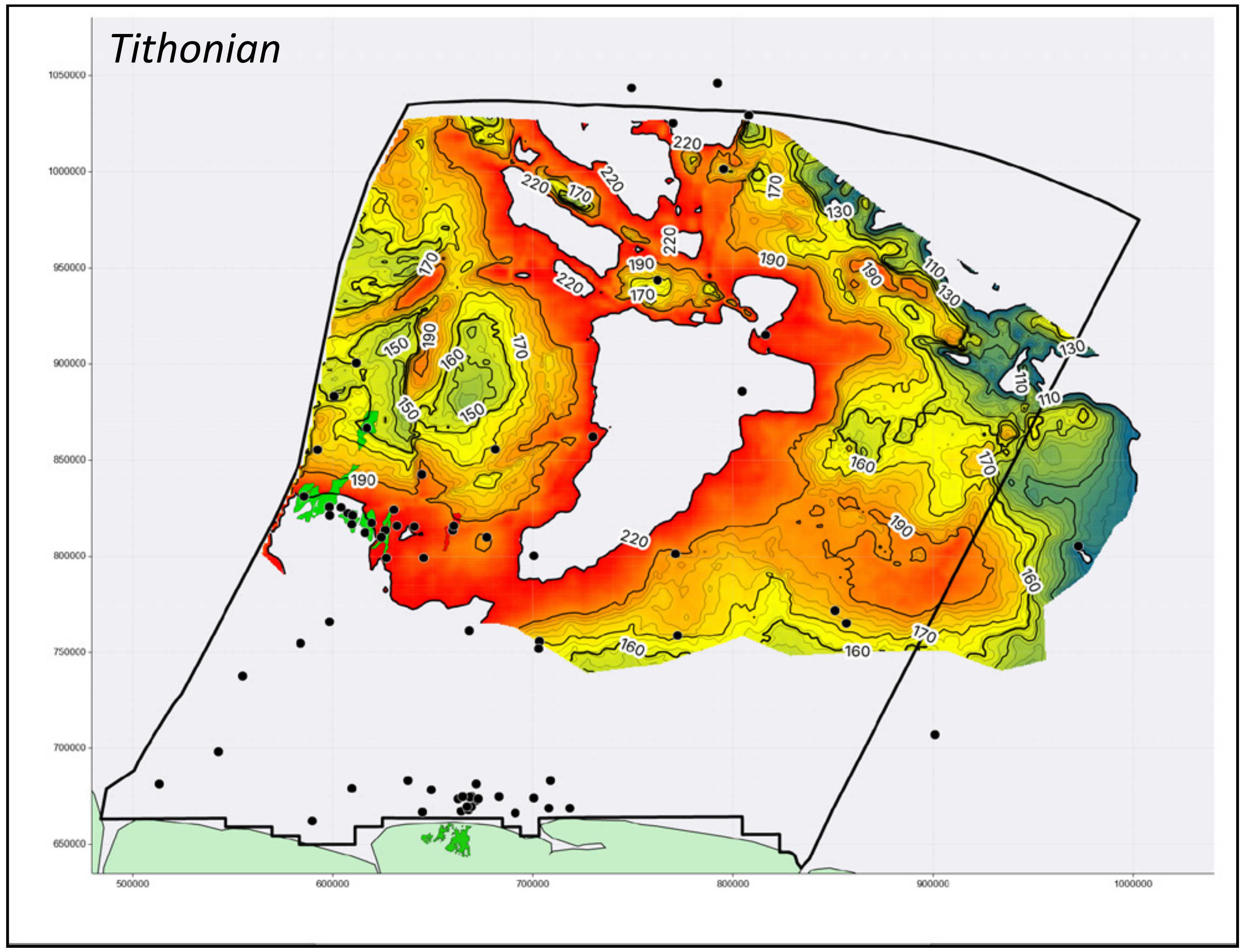


Present day Standard Thermal Stress at Top Late Aptian





Present day Standard Thermal Stress at Top Barremian



Present day Standard Thermal Stress at Top Tithonian

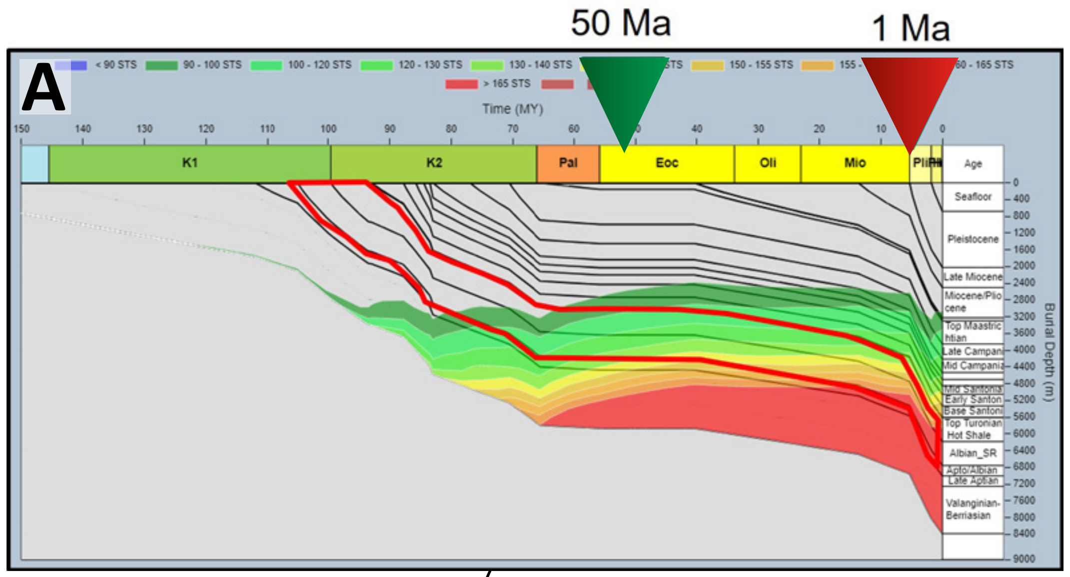
Burial History / Top Turonian Maturity and Timing

The maturity in the greater Golden Lane area indicates the onset of oil expulsion at Top Turonian (Top ACT) to be at approximately 50 Ma, probably representing the earliest oil sweep through the basin. This is likely the timing of hydrocarbon emplacement of the onshore fields (see Burial History A). Maturation continues with increasing burial, reaching gas window maturities relatively recently (1 Ma).

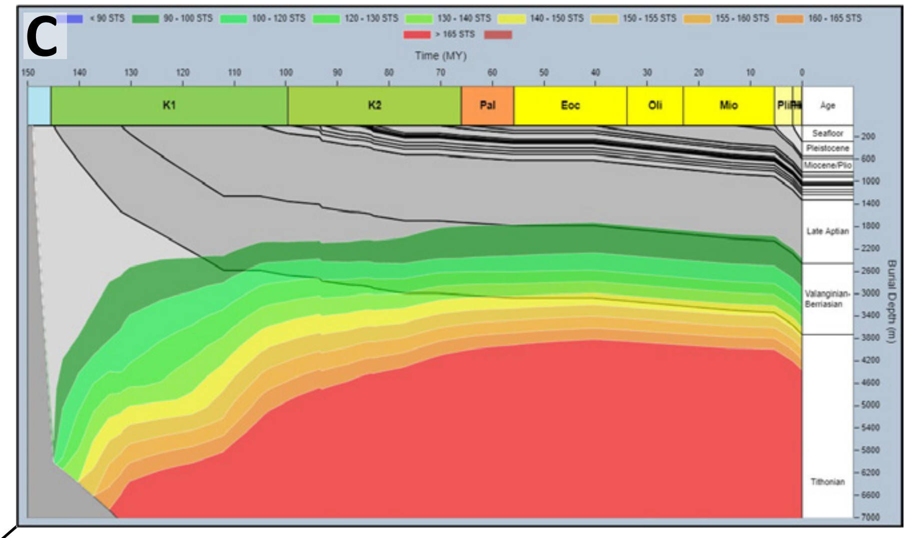
The Eastern 'arm' of maturation through the basin (see Burial History B) indicates the onset of oil expulsion at 18 Ma with no gas.

The Demerara Plateau (Burial History C) has a very different burial history profile, with the ACT source rocks failing to reach appreciable maturity for generation. However, burial history calibration at well A2-1 supports the idea that Valanginian, Barremian, or even Tithonian source rocks may be mature, assuming a source facies is present.

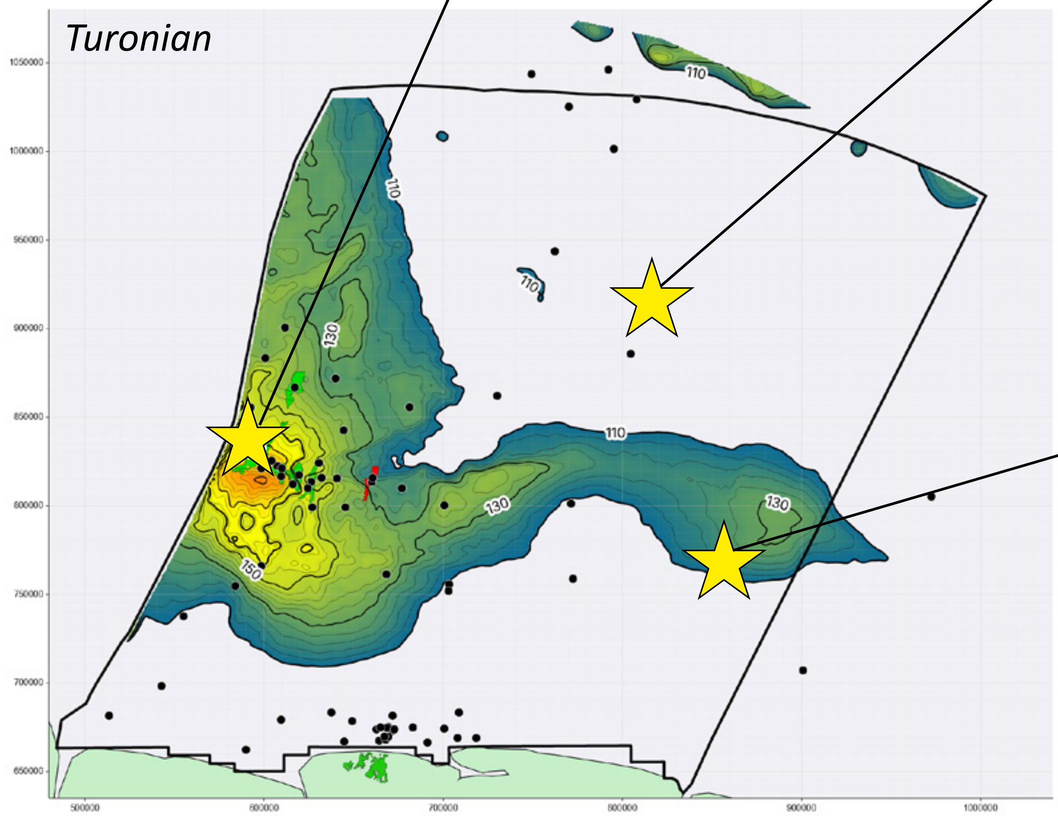
Timing of Oil / Gas Expulsion
(Ma) at Top Turonian Source Rock
(STS of 110 or 160 respectively)



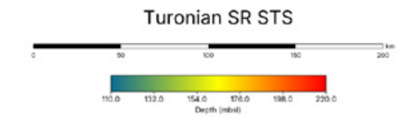
Burial History within the Golden Lane area

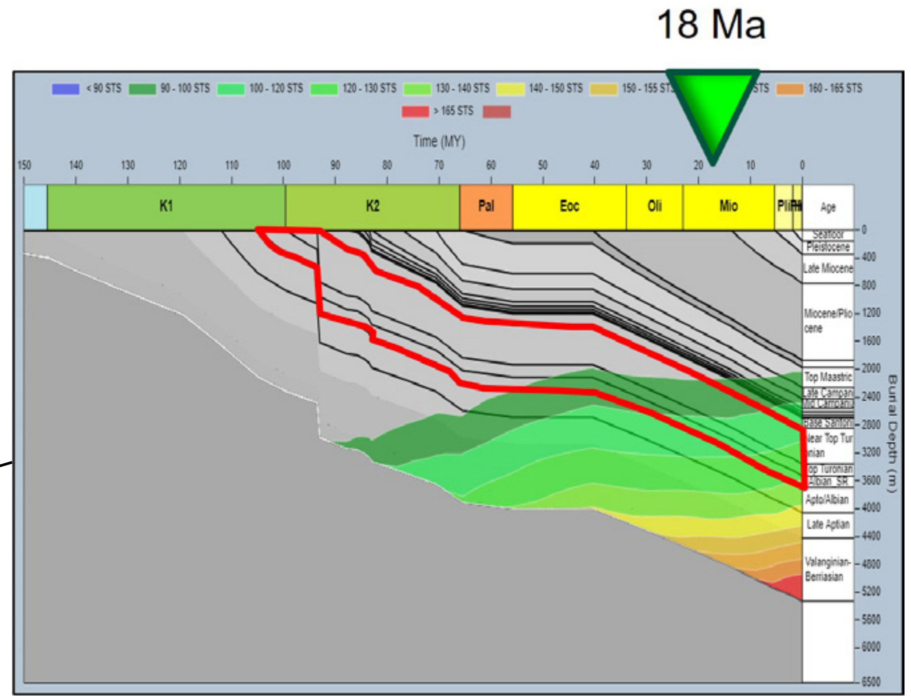


Burial History within the Demerara Plateau



Present day Standard Thermal Stress at Top Turonian





Burial History within the Eastern Arm

Oil Expulsion Mapping

The ACT source rock in the distal shelf regions show a union between excellent source richness as well as high thermal stress; this union is responsible for the fields of the Golden Lane.

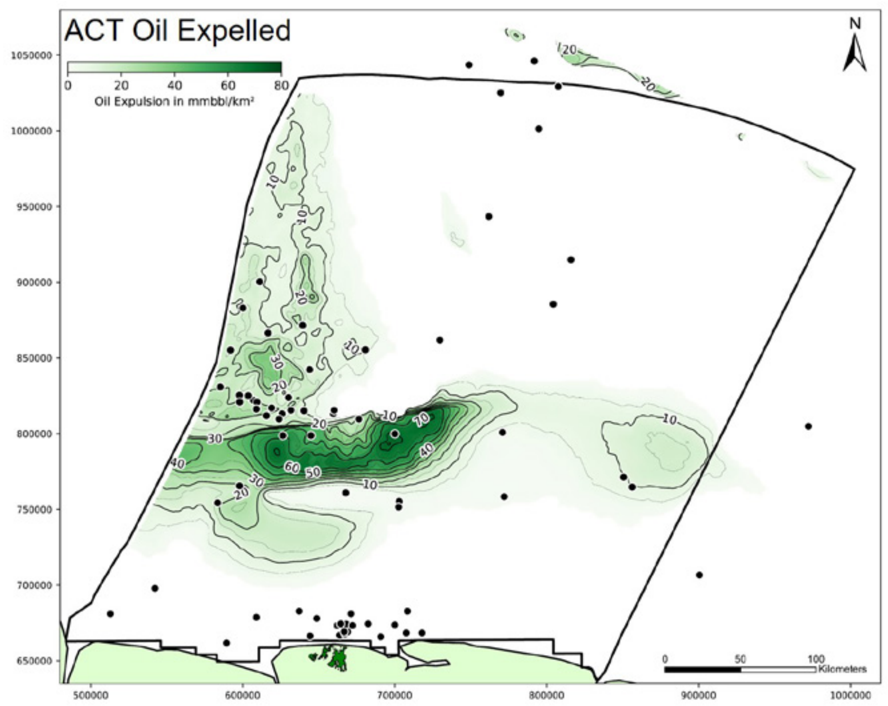
Rifting during the Barremian to Aptian stages created a restricted, anoxic marine environment in the early Equatorial Atlantic Ocean. These conditions facilitated the deposition of high-quality source rock facies under sustained anaerobic settings, promoting organic preservation and source potential.

The Aptian-Albian source rock, a likely mixed source rock with potential for oil and gas, is also identified to contribute both fluids and gases through this trend.

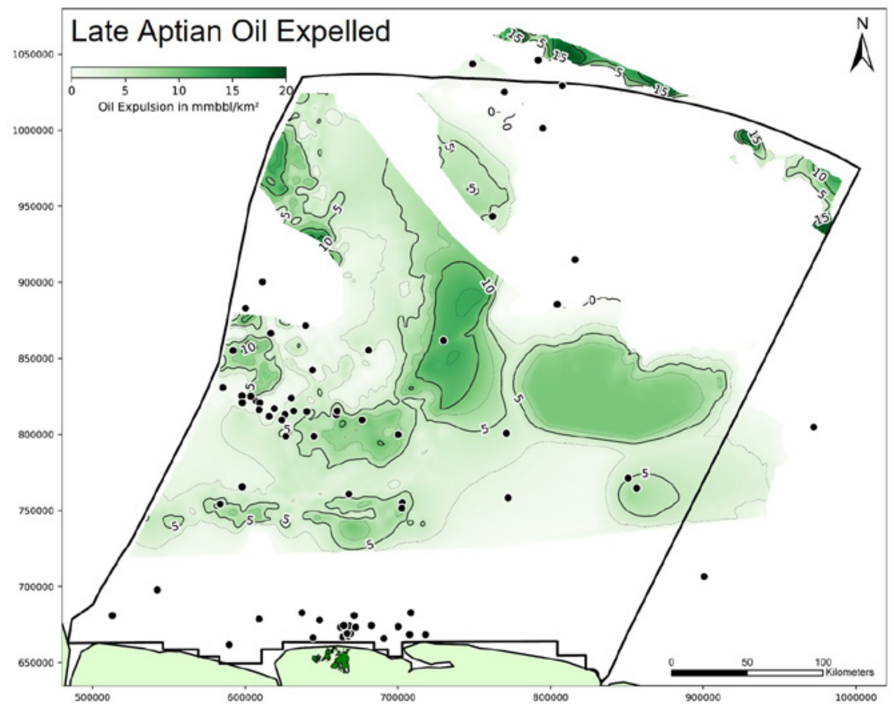
The distribution of the Barremian and Tithonian source rock intervals are inferred from seismic mapping. Penetrations of these intervals are limited, but their potential as source rocks are suggested from age equivalent analogues in the DSDP 367 well (Senegal), the Gulf of Mexico, Brazil and West Africa.

Deepwater source rock facies are likely present in the northwest, and have a higher chance of charge from Early Cretaceous (Barremian) and Tithonian sources.

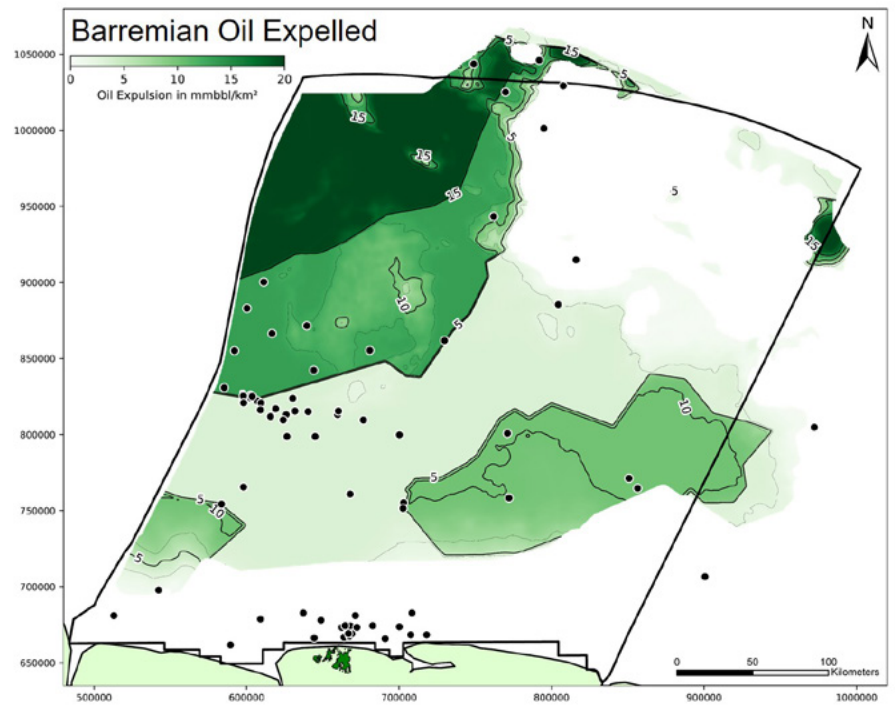
Given the predicted Environment of Deposition during the Late Jurassic, the Tithonian is interpreted to contain marine shales with high organic richness in a restricted basin. This is reflected by enhanced oil expulsion in a northeast-southwest trend in the center of the basin.



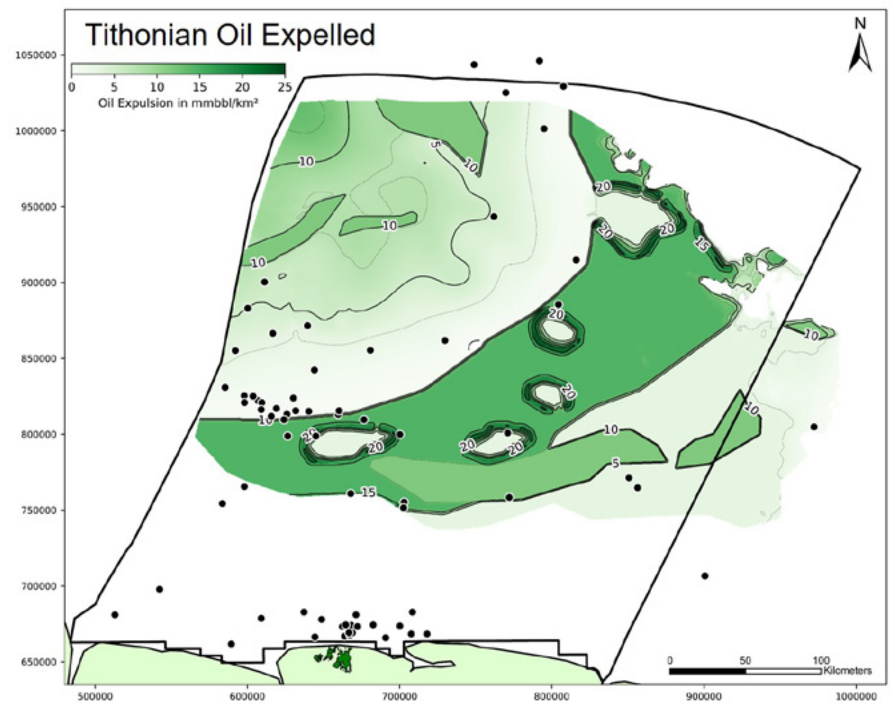
Oil Expulsion from the ACT Source interval



Oil Expulsion from the Late Aptian source interval



Oil Expulsion from the Barremian source interval



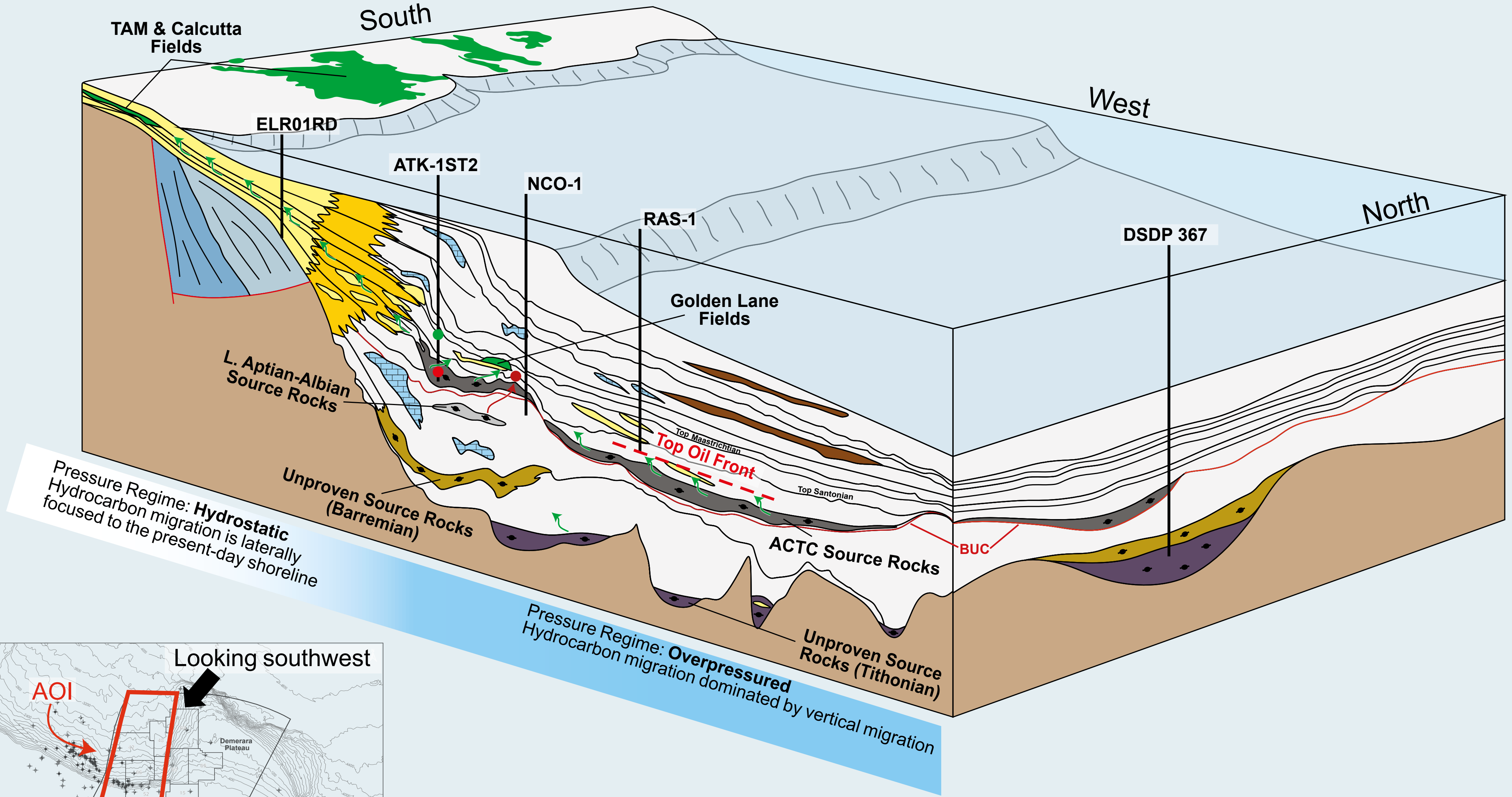
Oil Expulsion from the Tithonian source interval

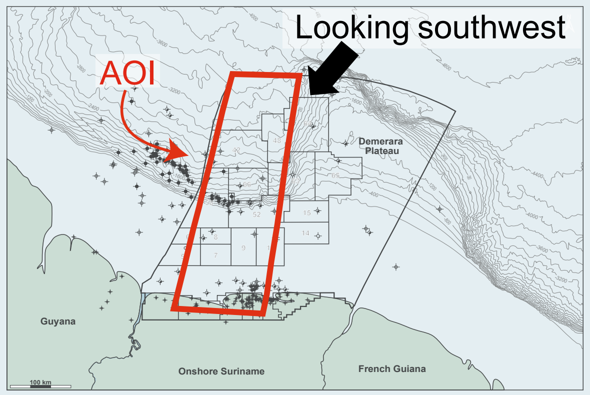
Migration Model

The 3D hydrocarbon migration model incorporates the Staatsolie understanding of source rocks, fluids, mud gas data, drilled and seismically defined stratigraphy with incorporation of the regional pressure data. The model suggests a separation in the hydrocarbon migration through the Guiana Basin into two pressure regimes:

1. The Onshore to Nearshore region is dominated by lateral migration focused towards the present-day shoreline. This mechanism explains the Onshore fields, where fluids are typed to be predominantly sourced by the ACT.
2. The Deep Offshore region is dominated by overpressured reservoirs. Charge access in this region is explained by vertical 'fill and spill' chains. This is predominantly the origin of oils and gases in the Golden Lane where fluid and gas "forensics" are interpreted to be derived from the ACT and the Aptian-Albian source rocks.

Key Conclusions
The Petroleum System in the Golden Lane shows a strong link to the Tambaredjo and Calcutta Fields supported by the oil typing.
The depth of the oil front identified in the Golden Lane increases basinward. This trend reflects both a reduction in thermal stress due to shallower burial and a decline in source rock richness, as indicated by lower UEP values.

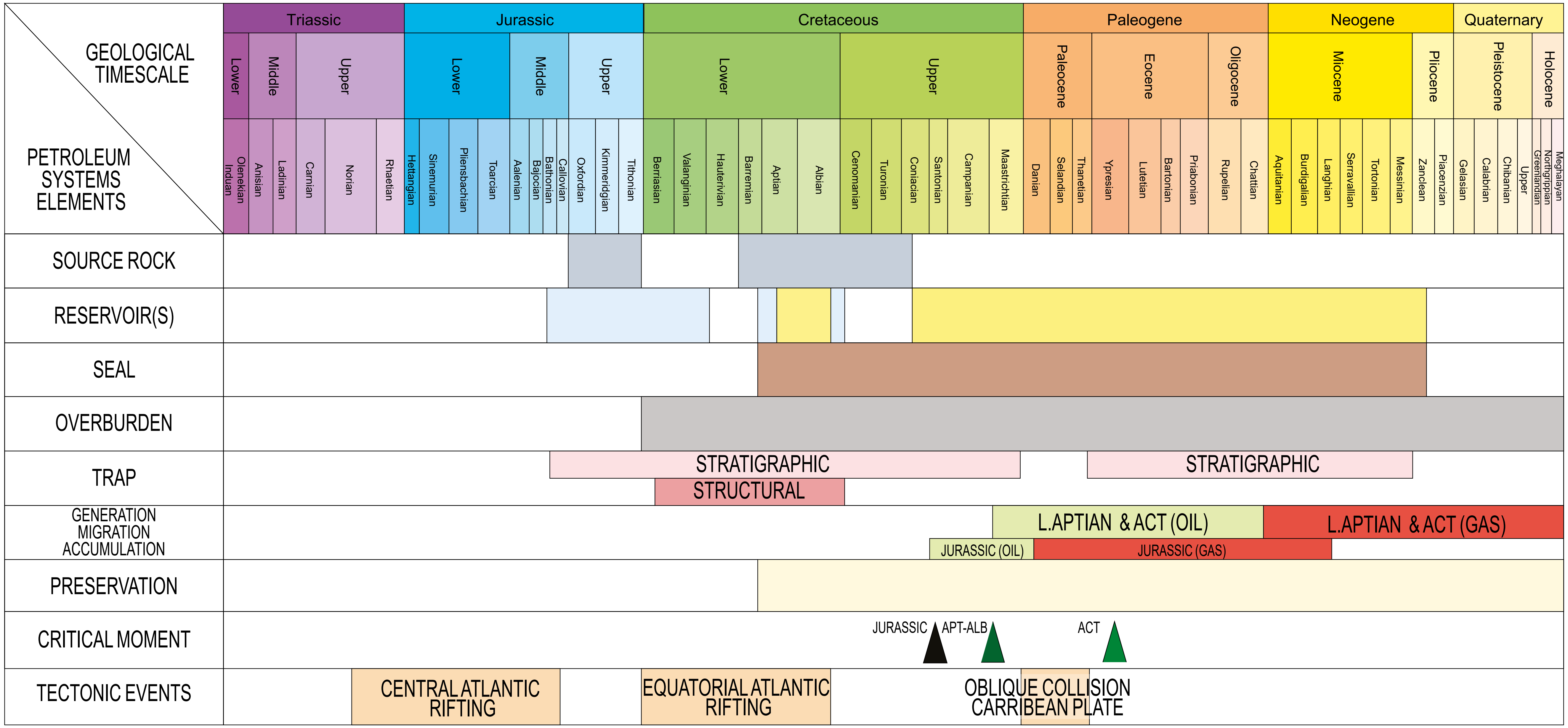




3D hydrocarbon migration model

Reservoir
Source Rock
Oil Discovery
Gas Discovery
Dry Gas Discovery
Oil Migration Pathway
Gas Migration Pathway
ACTC Source Rock
L. Aptian-Albian Source Rock
Barremian Source Rock
Tithonian Source Rock
Early Jurassic Graben Fill
Late Jurassic Graben Fill
Sandstone
Siltstone
Carbonate
MTC
Early Jurassic Graben Fill
Late Jurassic Graben Fill
Basement

Petroleum Systems Event Chart



Golden Lane

There was favourable timing of the deposition of source rock, reservoirs and seals within the basin throughout most of the Cretaceous, with the establishment of the most critical stratigraphic traps associated with hydrocarbon discoveries. The generation and migration of hydrocarbons started from the Maastrichtian onwards.

Onshore

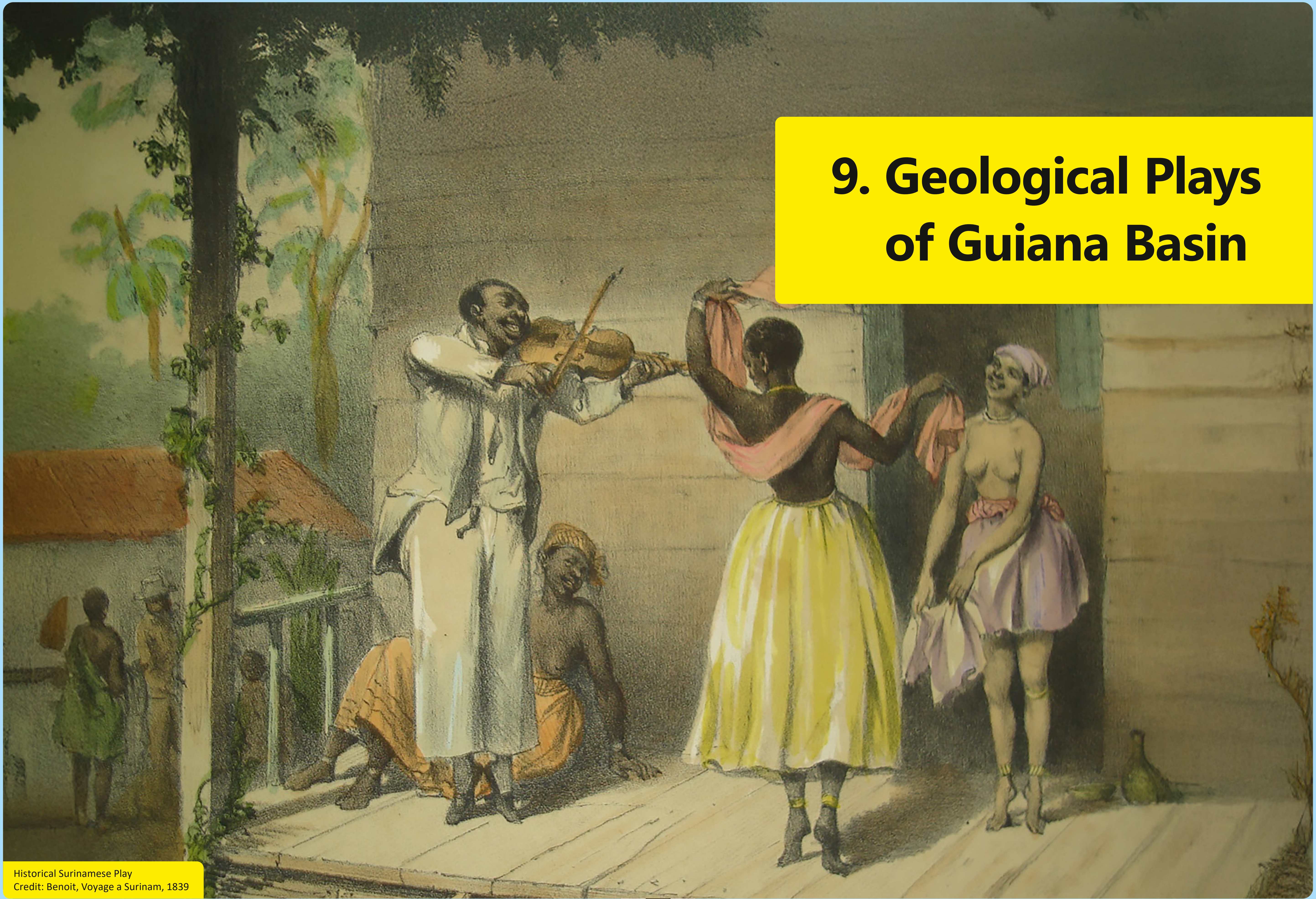
The emplacement of stratigraphic traps occurred contemporaneously with, or subsequent to, the onset of hydrocarbon expulsion in the Deepwater. Given that the Onshore fields are proven, a key conclusion is the presence of a migration lag—reflecting a delay in the hydrocarbon migration front due to the distance between the mature kitchen and the Onshore accumulations.

Regionally

a. For the proven source rocks, gas expulsion has been occurring for more than 20 million years after the stratigraphic traps were in place. This suggests potential for further gas volumes to be discovered.
b. Structural traps of Lower Cretaceous age are considered to have a favourable timing for Jurassic, Late Aptian and ACT hydrocarbon expulsion.
c. There is the potential for additional hydrocarbon contribution from the Late Jurassic (or possibly Early Cretaceous) to the Deepwater, Demerara Plateau and on the Shelf.

Galibi Nature Reserve
Credit: Hermes NL

9. Geological Plays of Guiana Basin



Historical Surinamese Play
Credit: Benoit, Voyage a Surinam, 1839

Introduction

The Guiana Basin is characterised by stratigraphic and structural plays. The active tectonic phase of the Basin during the Jurassic to Lower Cretaceous is recognised in mainly structural plays. Whereas the passive margin phase of the basin during the Upper Cretaceous to Tertiary mainly consists of stratigraphic plays.

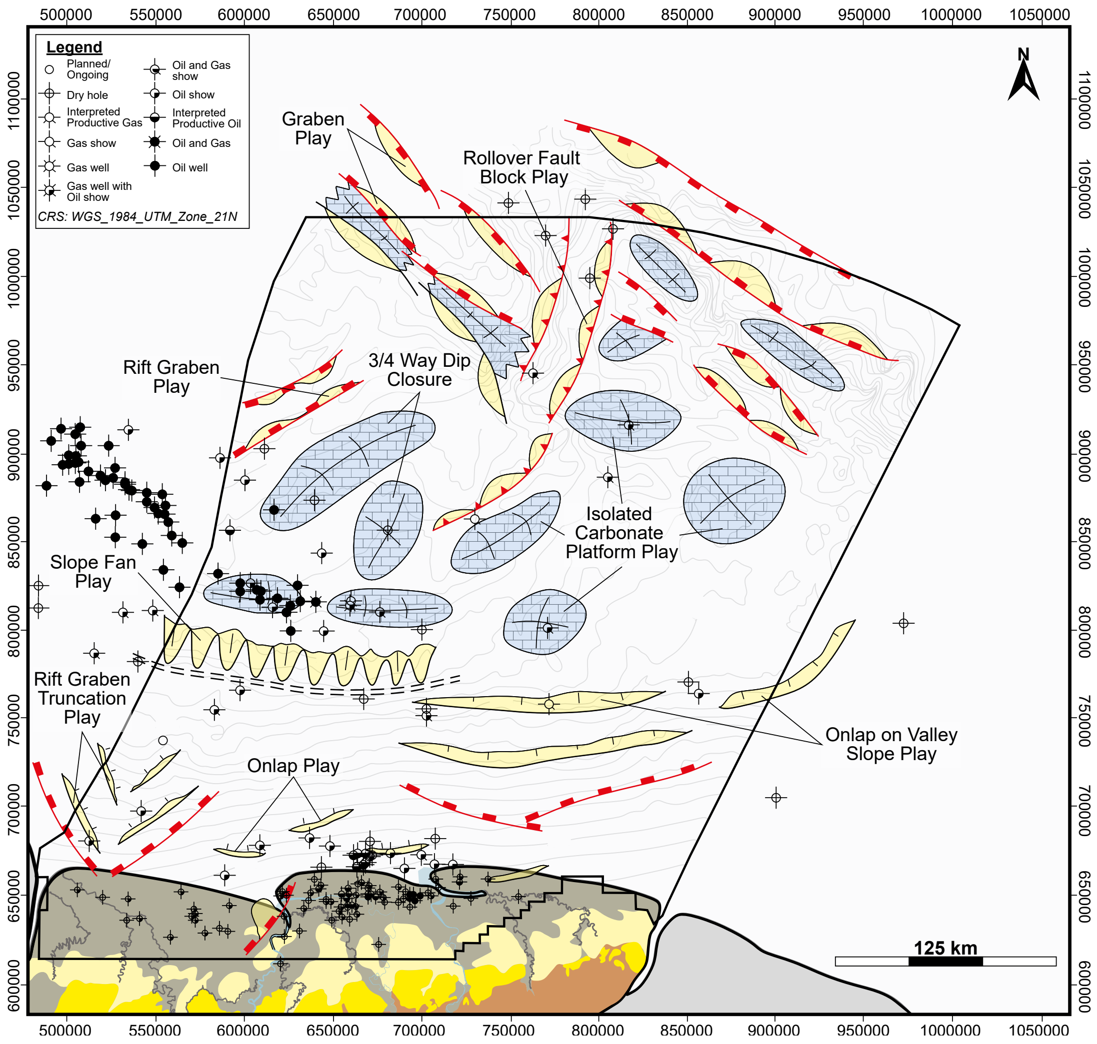
The plays are conceptualised on the two play concept profiles provided on the next page, one orientated north-south and another northeast-southwest, and on the 2D petroleum gross play maps below. Both the profile and the maps are drawn to be representative of the distribution of different play types, both vertically and laterally; they do not represent the actual location of leads or prospects in the Guiana Basin.

The petroleum play maps represent two vast stratigraphic intervals from the Jurassic to the Lower Cretaceous, and from the Mid Cretaceous to the Tertiary. The maps cover a wide array of hydrocarbon plays that illustrate a complex history of deposition, tectonics, and diagenesis.

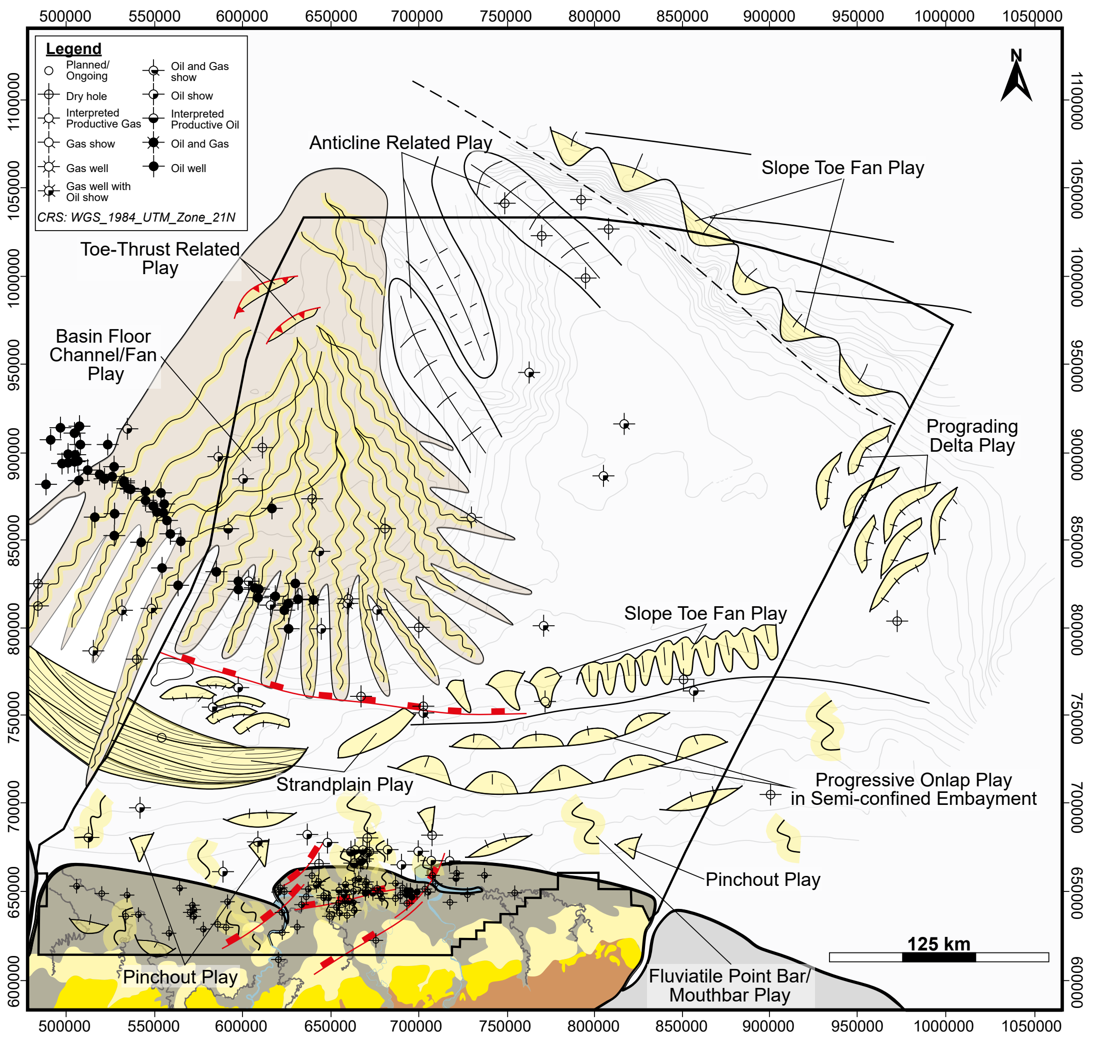
The two map intervals represent a composite of stratigraphic units which, while grouped together for regional synthesis, may vary in age and facies. Plays are juxtaposed laterally, reflecting diachronous deposition and tectonic segmentation across the basin.

Readers should be cognisant of the grouped nature of the play maps, as they convey a time-transgressive framework - meaning that the depicted plays may not have occurred contemporaneously and are simply spatially adjacent, accompanying tectonic and depositional development. For example, a fluvial play may lie adjacent to a slope fan play on the map, even though they formed in different environments and times.
The north-south play concept profile is approximately oriented across the Onshore, Shelf, Slope and Deepwater regions. Whereas the northeast-southwest play concept profile is approximately oriented across the Demerara Plateau and Deepwater regions.

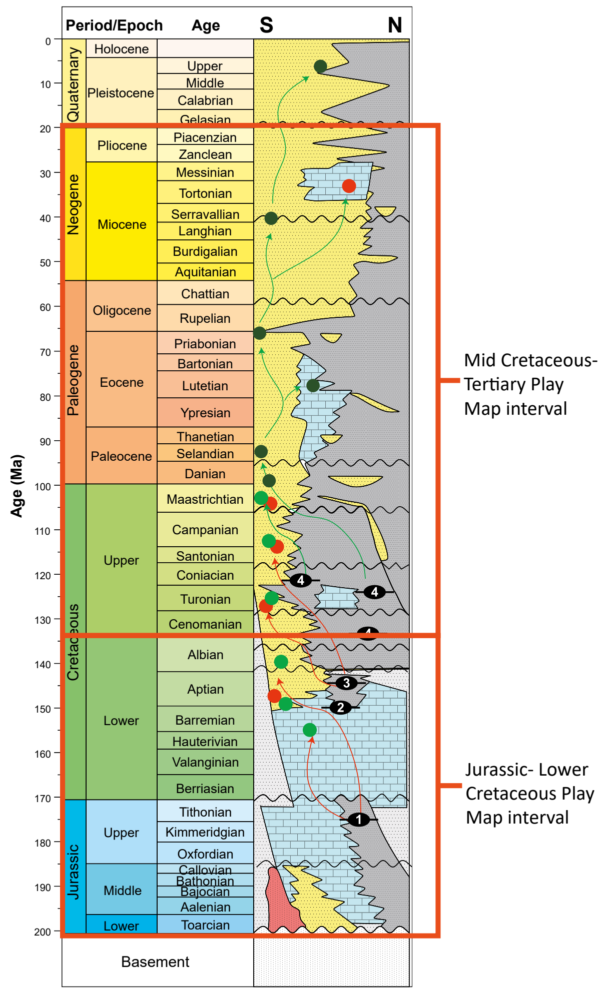
Detailed work on leads and prospects for each of these plays is available from Staatsolie.



Jurassic-Lower Cretaceous Gross Play map

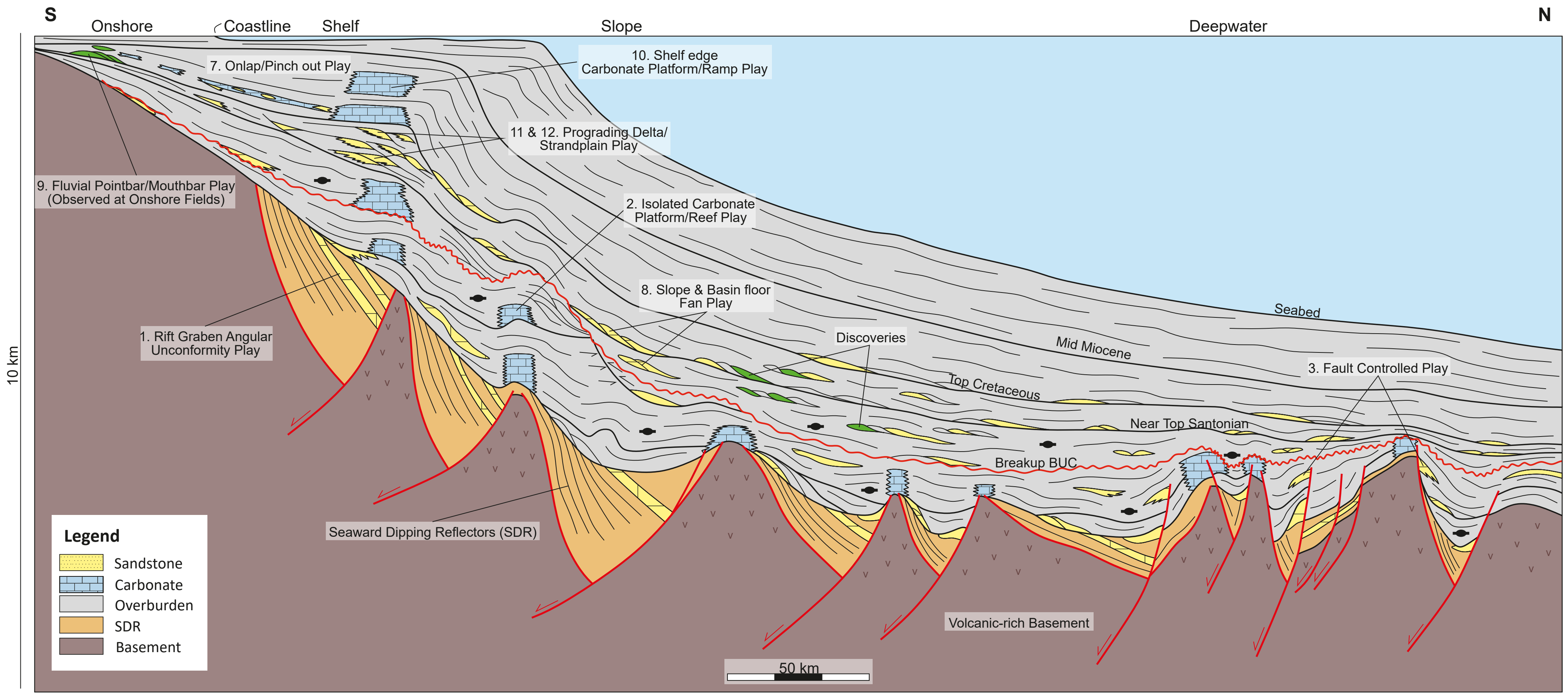


Mid Cretaceous-Tertiary Gross Play map

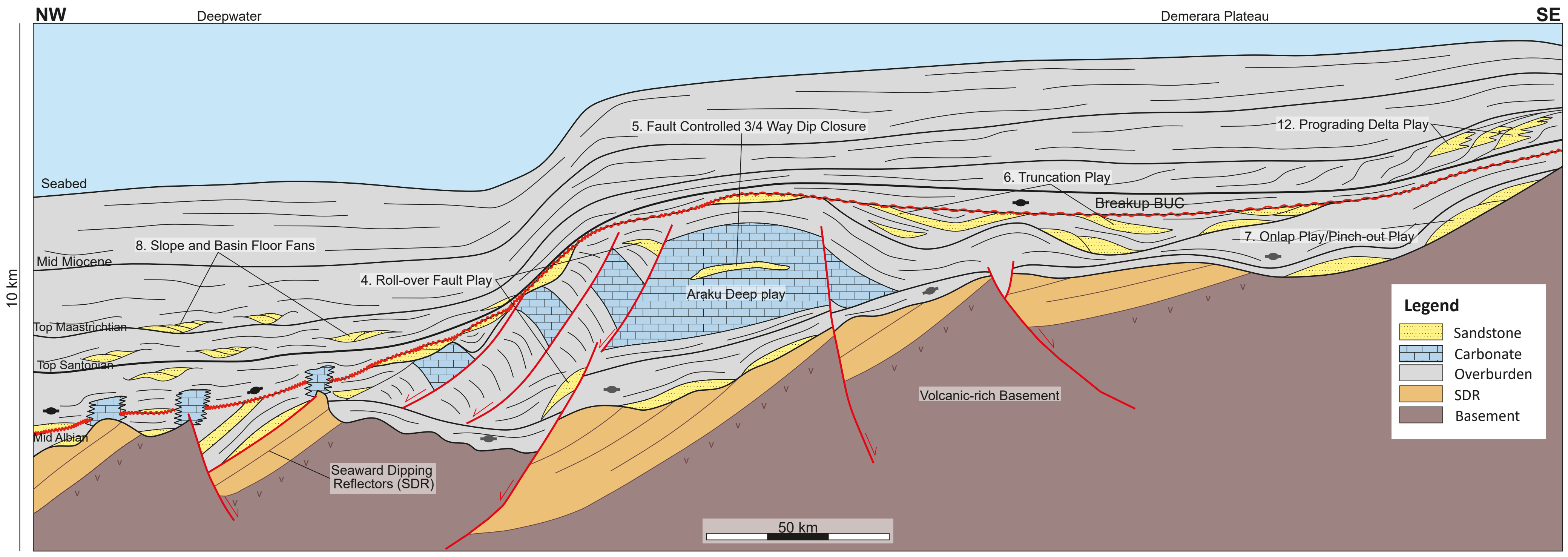


Stratigraphic column illustrating the two main play intervals within the Guiana Basin

Play Concept Profiles



N-S Play concept Profile



E-W Play concept Profile

Play Concept Table

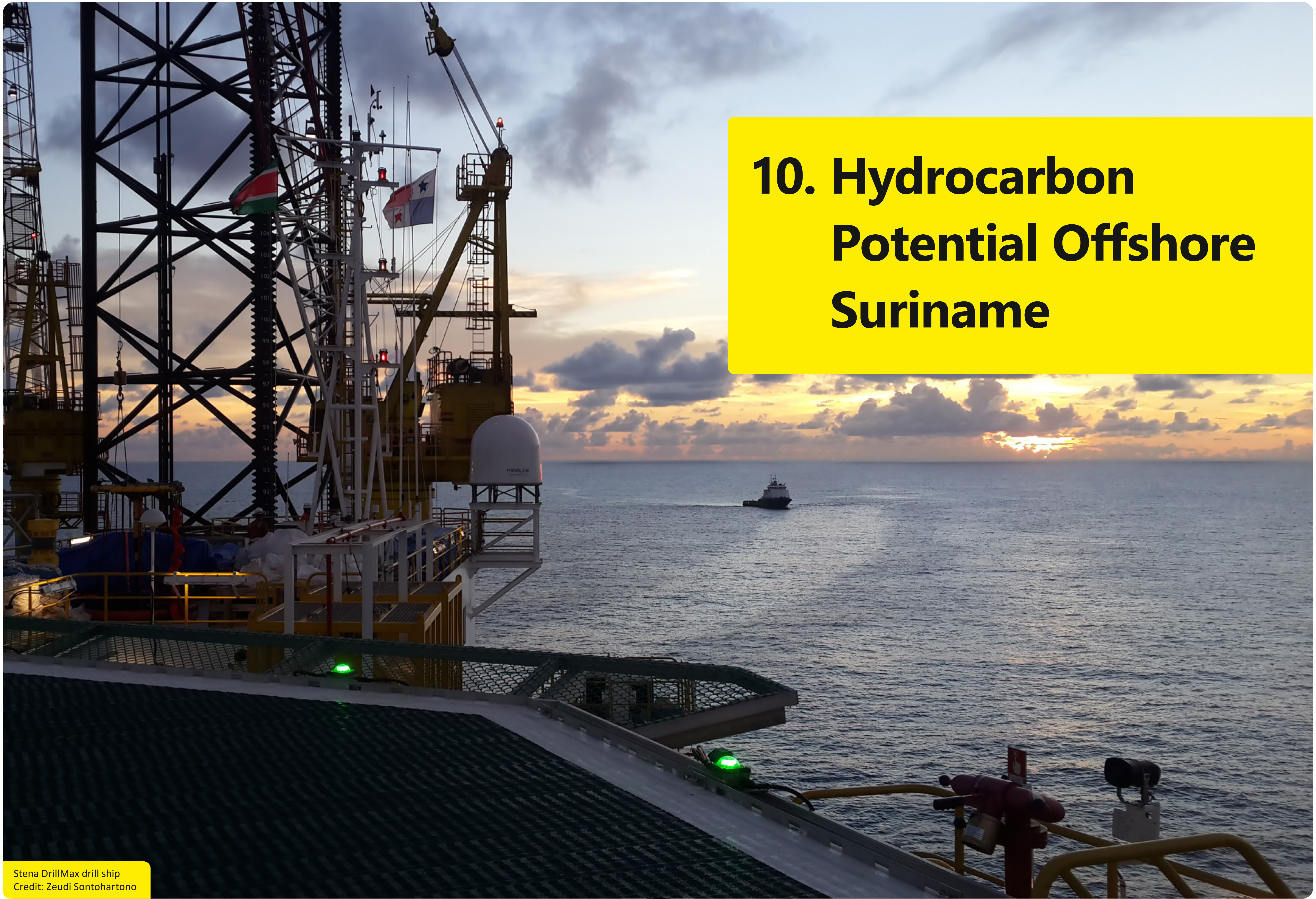
The table below provides an overview of different plays that can be encountered within the Basin. These are also indicated on the Play Concept profiles.

#	Play	Dominant Play Type	Description
1	Rift Graben Angular Unconformity Play	Combination	A stratigraphic and structural trapping mechanism is present where the older synrift reservoir beds (which are tilted and eroded) are truncated by the angular unconformity and overlain by an impermeable post-rift seal. Hydrocarbons migrate upwards along the tilted reservoir beds and become trapped against the seal. Known examples are the Nickerie and Commewijne Grabens. This play is proven in the Takutu Graben.
2	Isolated Carbonate Platform/Reef Play	Stratigraphic or combination	A stratigraphic trap where the porous reservoir rocks of the platform are sealed by the overlying and surrounding basinal deep-water shales. Often, the platforms are situated on tectonic highs (horst blocks) created during rifting and or during volcanic episodes, leading to combined structural-stratigraphic traps.
3	Fault Controlled Play	Structural	A type of hydrocarbon accumulation in which faults are the dominant control on migration and entrapment of oil and gas. The effectiveness of a fault-controlled play depends on factors such as the timing and frequency of faulting, the orientation of the faults, and the sealing capacity of the fault zones and adjacent rocks.
4	Roll-Over Fault Play	Structural	An oil and gas accumulation formed within a rollover anticline; a structural trap associated with a curved (listric) growth fault in an extensional region of the basin.
5	Fault controlled 3 and 4-way Dip Closure Play	Structural	A doubly plunging anticline where the rock layers dip downwards in all four directions. Or it can dip downwards in three directions, with the fourth side being closed off by a fault creating a convex dome geologic structure. This geometry creates a complete seal where an impermeable caprock covers the porous reservoir rock. This play was the initial focus of the initial exploration offshore Suriname.
6	Truncation Play	Structural	Hydrocarbons are trapped in a reservoir rock that has been cut off, or truncated, by an overlying, non-porous rock layer along an unconformity.
7	Onlap/Pinch-out Play	Stratigraphic	The younger, porous rocks that onlap the older surface or the pinch-out of the permeable reservoir rock against the impermeable older rocks creates a stratigraphic trap. The hydrocarbons migrate updip through the porous rock until they are sealed by the pinch-out and the overlying seal.
8	Slope and Basin Floor Fan and turbidite Play	Structural or stratigraphic	The sand-rich channel and lobe deposits in both the slope and basin floor fans act as reservoir rocks. Hydrocarbons will be trapped within structural or stratigraphic features in these deposits. Turbidity deposits are likely to be present on the Shelf edge and slope environments.
9	Fluvial Pointbar & Mouthbar Play	Stratigraphic	Fluvial point bars serve as stratigraphic traps. This is because high permeability sand bodies pinch out laterally and vertically into floodplain and overbank mudstones and shales which are of relatively lower permeability. In addition to fluvial point bars, mouth bars also serve as stratigraphic traps for hydrocarbon accumulation.
10	Shelf edge Carbonate Platform/Ramp Play	Structural	When a transgression (sea-level rise) ultimately drowns the carbonate shelf. Fine-grained, deep-water marine shales or mudstones then blanket and seal the carbonate deposits. Differential compaction can occur where the less compactible reef and shoal deposits are draped by subsequent sediments and form structural four-way closures.
11	Strandplain Play	Stratigraphic	Hydrocarbons are trapped where the porous strand plain sandstone pinches out laterally into the impermeable mudstone and where it is sealed by an overlying transgressive shale.
12	Prograding Delta Play	Stratigraphic	During progradation, river channels deposit coarser-grained, porous sandstones over finer-grained shales, creating a characteristic “coarsening upward” sequence that is ideal for trap formation.

Fort-Zeelandia
Credit: Gongrijp

Bigi Pan, Caiman
Credit: WiDi

10. Hydrocarbon Potential Offshore Suriname



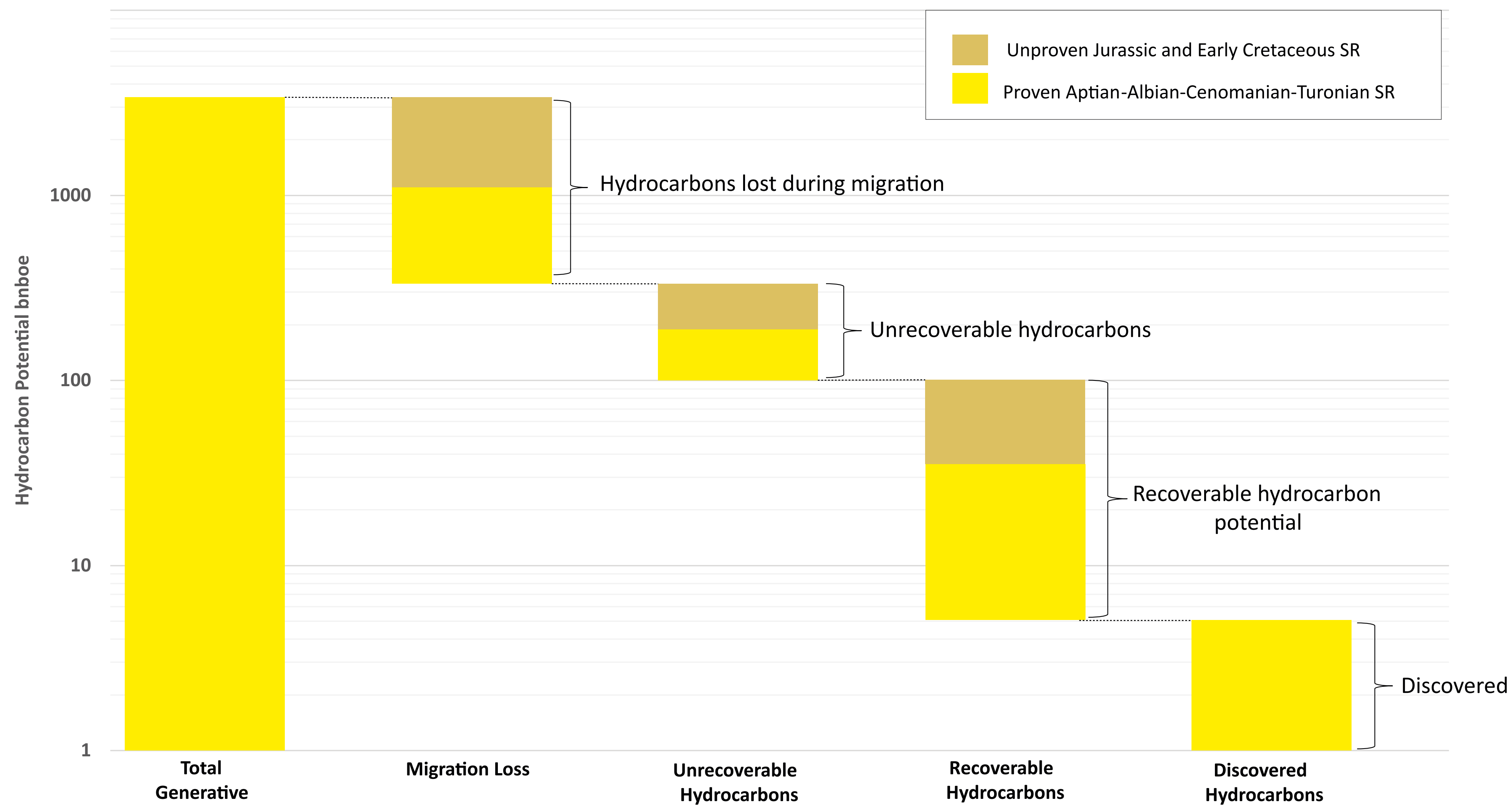
Stena DrillMax drill ship
Credit: Zeudi Sontohartono

Hydrocarbon Potential Offshore Suriname, Guiana Basin

Staatsolie continues to enhance our understanding of the petroleum systems Offshore Suriname by integrating newly acquired data and applying advanced tools and methodologies. These efforts aim to reduce uncertainties and improve the predictive capabilities. Chapter 8 described the potential of the multiple source rocks in the Guiana Basin. The graph gives an indication of the hydrocarbon potential of the Guiana Basin Offshore Suriname.

Hydrocarbon generation and expulsion in the Guiana Basin are attributed to multiple petroleum systems, ranging from the unproven Jurassic and Early Cretaceous source rocks to the well-established Upper Cretaceous petroleum system. The latter has been the primary contributor to the recent hydrocarbon discoveries Offshore Suriname and Guyana. Emerging evidence of a deeper, Early Cretaceous and Jurassic petroleum system has significantly increased the potential for hydrocarbon accumulations beyond the so-called "Golden Lane."

Recent petroleum systems modelling suggests that a substantial volume of hydrocarbons remains trapped and undiscovered in Offshore Suriname. The basin contains various petroleum plays across multiple stratigraphic intervals, which still remain undiscovered, as outlined in Chapter 9. A significant amount of hydrocarbons are yet to be found in the Onshore, Nearshore, Shallow Offshore, Demerara Plateau and Deepwater areas of the basin. The magnitude of hydrocarbons of yet to be found underscores the importance of continued exploration and ongoing petroleum systems model refinement to unlock the basin's full potential.



Bigi Pan, Flamingos
Credit: JvL

Leatherback Turtle near Galibi
Credit: Julias Travels

References and List of Abbreviations

Paramaribo synagogue and mosque
Credit: Mark Ahsmann

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List of Abbreviations

$\delta^{13}C$ Sat	Carbon isotopic composition of the saturate fraction
$\delta^{13}C$ Arom	Carbon isotopic composition of the aromatic fraction
2D	Two-Dimensional
3D	Three-Dimensional
ACT	Albian-Cenomanian-Turonian (used here to refer to a source rock interval)
ACT(C)	Albian-Cenomanian-Turonian-Coniacian (used here to refer to a source rock interval)
API	American Petroleum Institute (gravity)
AOI	Area of Interest
bbl/d	Barrels per day
bnboe	Billion Barrels of Oil Equivalent
BPM	Bataafsche Petroleum Maatschappij
BUC	Break-up Unconformity (Aptian-Albian)
CAMP	Central Atlantic Magmatic Province
cm/yr	centimeters per year
CT	Cenomanian-Turonian (used here to refer to a source rock interval)
DSDP	Deep Sea Drilling Project
EOD	Environment of Deposition
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
GDE	Gross Depositional Environment
GR	Gamma ray
HC	Hydrocarbon
HI	Hydrogen Index
IOCs	International Oil Companies
km	Kilometer(s)
m	Meter(s)
Ma	Mega-annum (million years ago)
MD	Measured Depth
mmbbl/km²	Million Barrels per Square Kilometer
MMbbls	Million Barrels (used to measure oil volume)
mmboe/km²	Million Barrels of Oil Equivalent per Square Kilometer
MTC	Mass Transport Complex(es)
N.V.	Naamloze Vennootschap (Dutch for "Public Limited Company")
N.B.	Nota bene (Note well)
NMA	Nationale Milieu Autoriteit (National Environmental Authority)
OAE	Oceanic Anoxic Event
ODP	Ocean Drilling Program
Of_A	Organofacies A (marine clay-poor)
Of_B	Organofacies B (marine clay-rich)
Of_DE	Organofacies DE (terrestrial-rich)
Pr/Ph	Pristane/Phytane Ratio
PSM	Petroleum System Modelling
S	Sulphur
SARA	Saturates, Aromatics, Resins, and Asphaltenes
SDRs	Seaward Dipping Reflectors
SPM	Surinaamse Petroleum Maatschappij
STS	Standard Thermal Stress
Sq km	Square kilometer(s)
STOIIP	Stock Tank Oil Initially In Place
SWC	Sidewall Core(s)
TAM	Tambaredjo
TD	Total Depth
TeT	Tetracyclic Terpane
TOC	Total Organic Carbon
TT	Tricyclic Terpanes
UEG	Ultimate Expellable Gas
UEO	Ultimate Expellable Oil
UEP	Ultimate Expellable Potential
USD	United States Dollar
wt.%	Weight Percent

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