1) Sierra Leone – Executive Summary – Wildcat Petroleum April 2022

- Offshore Sierra Leone, situated on the West African Continental Margin and neighbouring Guinea and Liberia is, with only 8 wells drilled, a frontier exploration area for hydrocarbons.

- The 8 wells have been drilled on the shallow shelf and upper slope. 2 have encountered oil shows and 4 have been non-commercial oil discoveries [Figs WC10 and WC11). These have proved up a working hydrocarbon system.

- Wildcat Petroleum's Reconnaissance Licence (Desk Study) covers a ~ 24,000 sq km area (equivalent to ~ 18 complete Blocks – see fig WC1) in the deeper water (> 2500 m waterdepth) where the industry believes the potential to discover commercial hydrocarbons is greater than that on the shelf and shallow slope (Refs below). Blocks will cover the Ultra-deep domains shown in fig WC2.

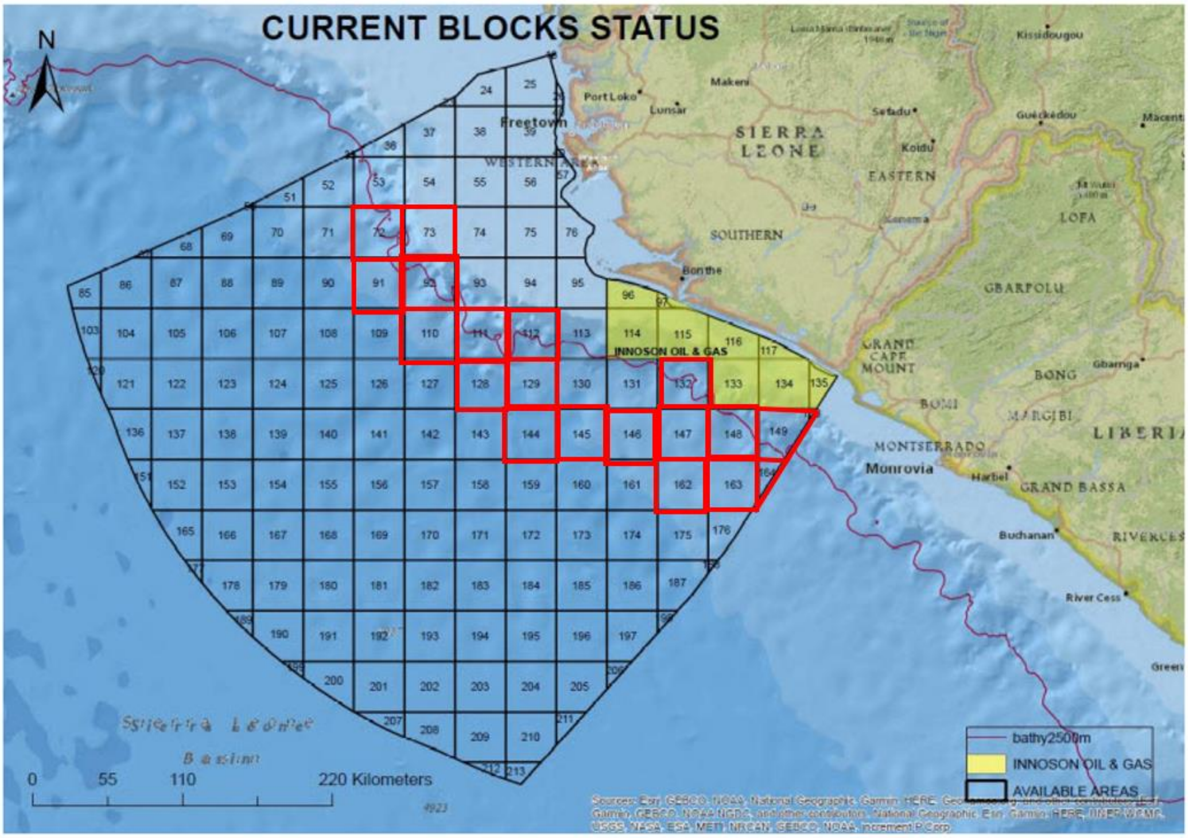


Fig WC1: WCAT study area indicated on PDSL (Petroleum Directorate Sierra Leone) base map. The *2500 metre bathymetric contour is in purple. The 20 Blocks covered are : 72, 73, 91, 92, 110, 111, 112, 128, 129, 132, 144, 145, 146, 147, 148, 149, 150, 162, 163, 164. Full blocks are ~ 1360 sq kms each. Blocks 149, 150, 163 and 164 are against the border with Liberia and are 'part blocks'.*

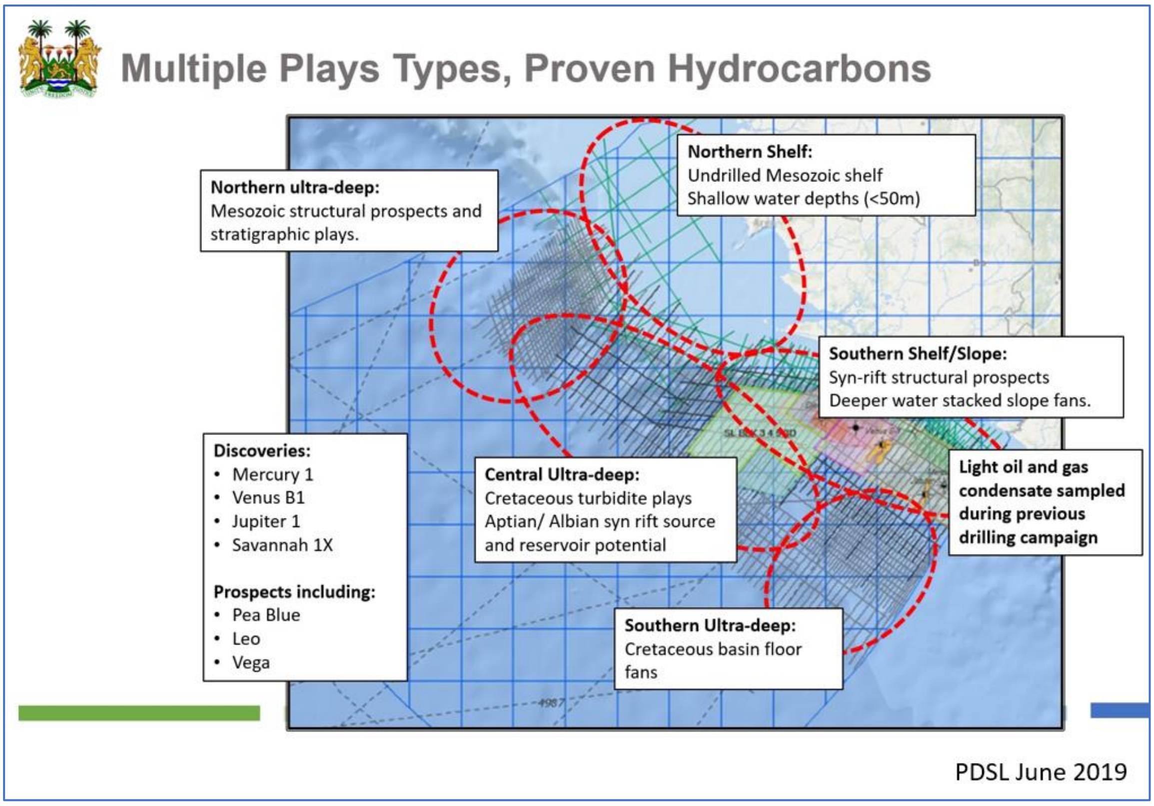
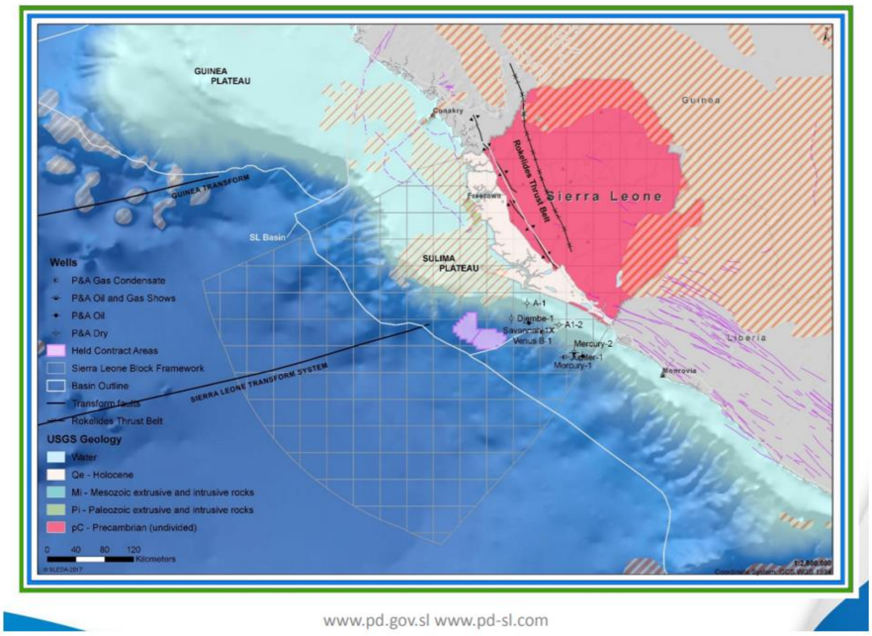


Fig WC2: This PDSL image shows the different geological domains (and the plays/prospects expected offshore Sierra Leone) – our study will cover blocks within the Ultra-deep areas. The image also shows the locations of the seismic data acquired off Sierra Leone.

- Plays will exist in both the pre-rift/syn rift (in the deep water to the NW i.e North of the main Sierra Leone Transform fault (Fig WC3) and in the post-rift both north and south of the Transform fault. {See Glossary and References at end of this section}.



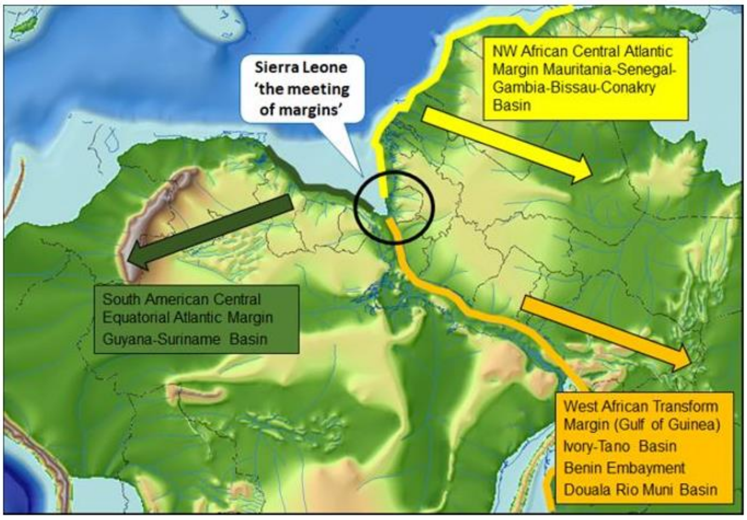
Sierra Leone Transform Fault – on block map

The Transform Fault splits the Sierra Leone Basin into a Northern and Southern Domain – each with distinct Geological Characteristics

PDSL 2018

Fig WC3: This shows the location of the Sierra Leone Transform Fault. Other transform faults are also expected to be present.

- Regarding the post-rift plays, it is generally regarded (e.g Westwood Global 2020, Grand et al 2009, Amy 2019 and Sayers et al 2021) that larger discoveries will be made in deeper waters and that these will be in the large unconfined Lower Cretaceous fans which have been targeted successfully in discoveries stretching from Jubilee in Ghana to Liza in Guyana i.e in what we can recognise as a single Play Fairway – since before/during the breakup of Africa and South America, the Sierra Leone Basin and the Guyana/Suriname Basin were adjacent to each other i.e Conjugate – sharing the same rich source rocks and similar fan development (Fig WC4 and WC5).



Correlation from Atlantic break-up – Sierra Leone and Guyana

Globe's palaeogeographic reconstructions illustrate how the Sierra Leone Margin was perfectly positioned within the same 'postcode' as the Guyana, Suriname, French Guiana, Mauritania and Senegal discoveries during the Cretaceous deposition of the major source rocks and key reservoir intervals. No more than a couple of hundred kilometres separated the modern-day coastlines of Sierra Leone and South America during the Cretaceous (Figure 2).

Figure 2: The Aptian location of Sierra Leone posited at "the meeting of the margins" – the African MSGBC and its offset to the conjugate South American Guyana-Suriname basin and the West African Transform Margin (WATM).

Getech website

Fig WC4: Correlation from Atlantic Break-up – Sierra Leone and Guyana (from Getech website)

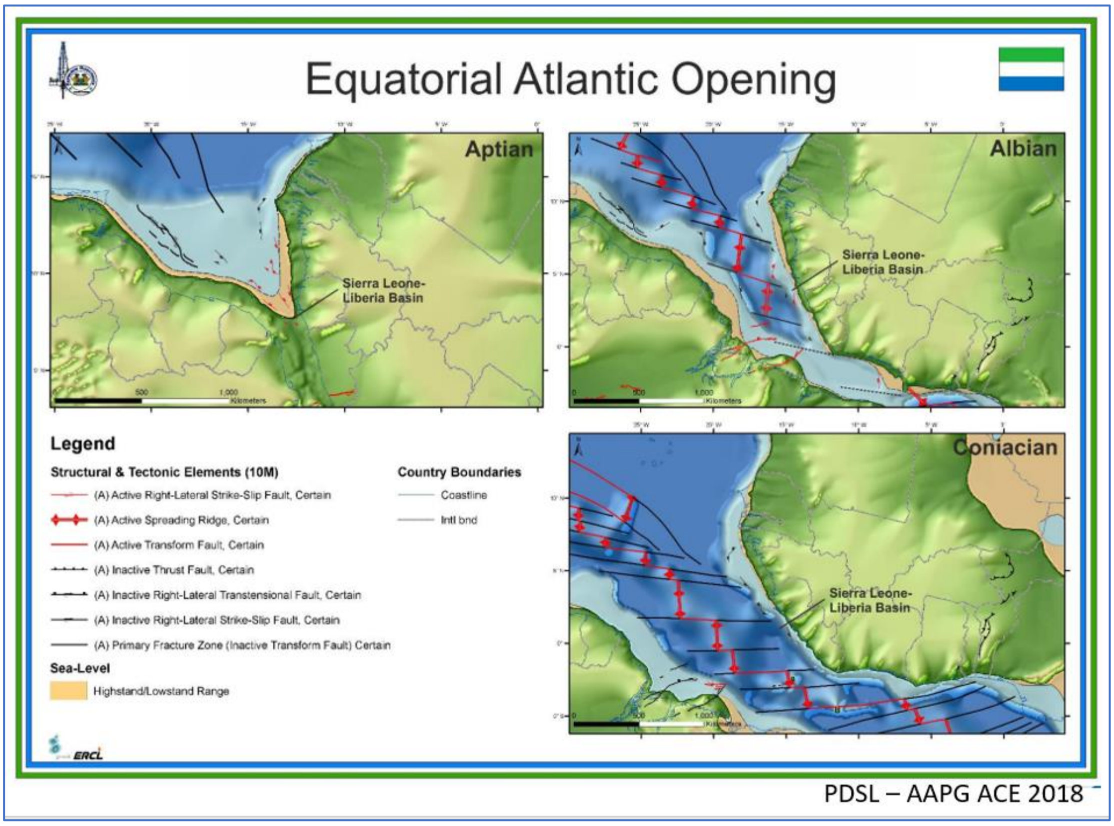
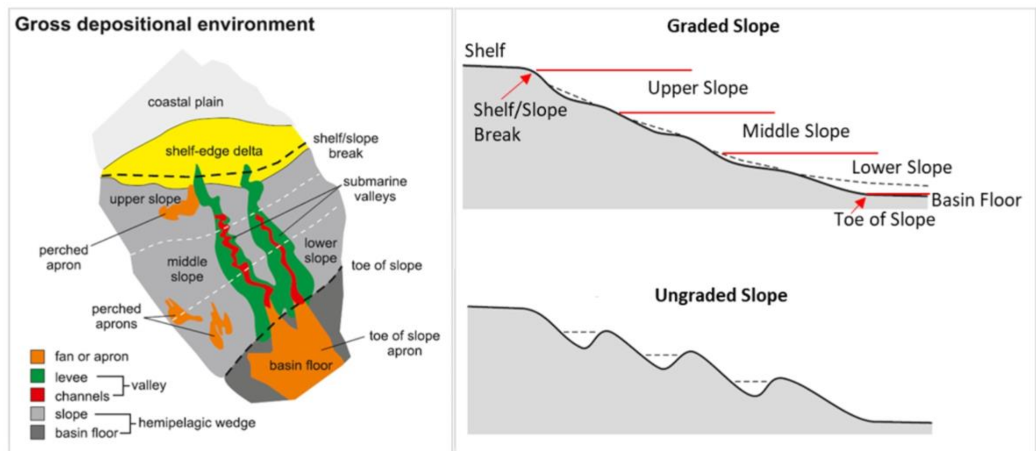


Fig WC5: Equatorial Atlantic Opening – PDSL (AAPG 2018) – source Getech

- Westwood Global's 2018 analysis of drilling and success on the Central Atlantic Margin between 2007 (when Jubilee was discovered in Ghana) and 2018 discusses the lessons learnt from drilling this margin i.e modest success in many countries to date - but points out that only 12 wells out of 128 studied had been drilled into the 'Basin Floor' (i.e Toe of Slope – see fig WC6) but that these accounted for > 50% of the total discovered resources and have the highest success rates (Fig WC7)



CLASSIFICATION SCHEME USED TO DESCRIBE LOCATION OF THE STRATIGRAPHIC TRAPS ON THE SLOPE (LEFT) AND TYPE OF SLOPE (RIGHT). MODIFIED AFTER AMY, 2019.

Westwood Global Energy Group 2021

Fig WC6: Classification of stratigraphic traps on the Shelf Slope (from Westwood Global and after Amy 2019)

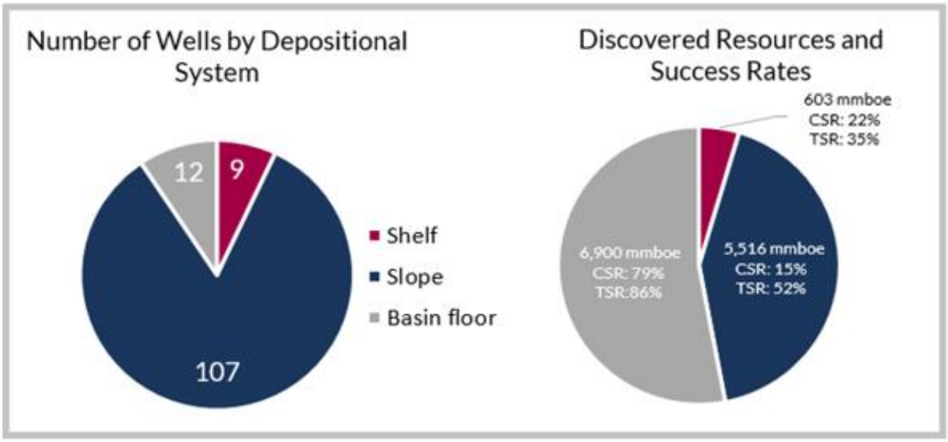


FIGURE 3: WELLS IN THE STUDY AREA DIVIDED INTO THEIR POSITIONS ON THE DEPOSITIONAL SYSTEM. ONLY 12 PENETRATIONS TO DATE HAVE VENTURED ONTO THE BASIN FLOOR YET THOSE WELLS ACCOUNT FOR >50% OF THE TOTAL DISCOVERED RESOURCES AND HAVE THE HIGHEST SUCCESS RATES.
SOURCE: WESTWOOD

Fig WC7: Equatorial Margin – Classification of wells based on Shelf/Slope/Basin Floor (Westwood Global 2018)

- Wildcat's study area will concentrate on this 'Foot of Slope/Basin Floor area – as well as the potential to the north of the Sierra Leone Transform Fault where structural influences also come into play (Elenwa et al 2010, 2013 and undated).

- The hydrocarbon potential of the deepwater passive margin 'foot of slope'/basin floor fans off Africa have been proved up recently with the recent multi-billion barrel Venus-1X oil discovery by Total and partners in the deepwater off Namibia.

- Regarding the potential of the 'toe of slope'/basin floorfan plays off Sierra Leone, we can also note that African Petroleum in the acreage they were exploring in their deepwater blocks SL-03 and SL-4A-10, they recognised Prospective Resources of ~ 2.5 billion barrels in a number of large stacked fans (their 27/12/2017 press release) – before they exited in 2018. These fans are in what are now Blocks 130 and 131 – and are, we believe, subject to an application by another party. We would however expect to find similar fans along the same 'foot of slope/basin floor fan' trend. See figs WC8 and WC9.

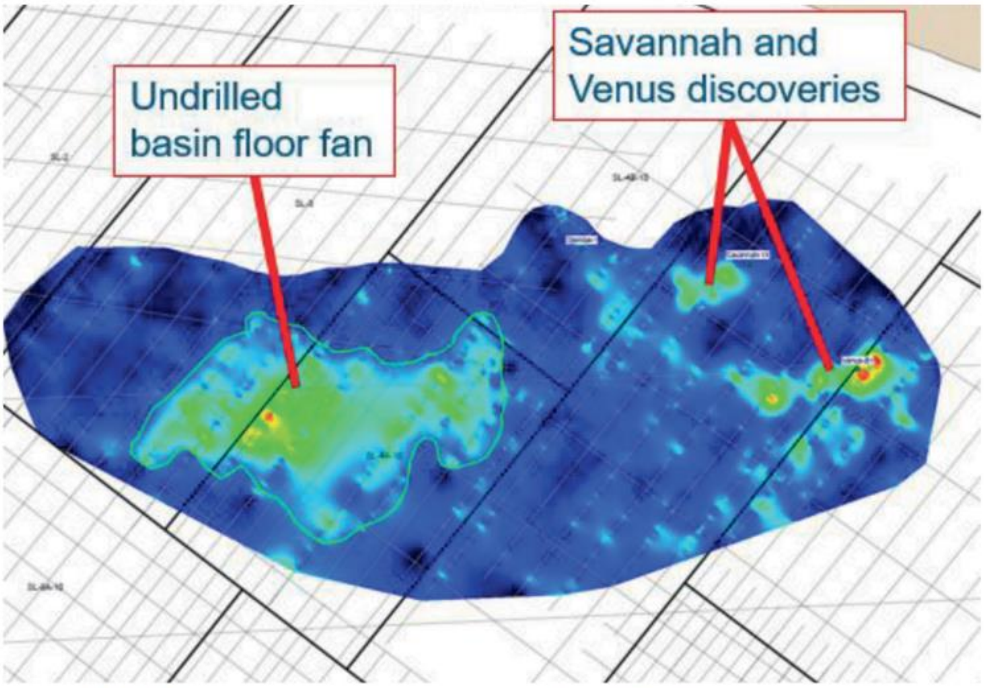


Figure 4 Undrilled basin floor fans many times bigger than the sub-commercial proven up dip siblings. The saddle structure provides the up dip disconnect limiting the up dip migration of hydrocarbons to further charge the Savannah and Venus discoveries and retaining the oil in the deep

'Undrilled Basin Floor Fan' is in the X-African Petroleum acreage.

Sayers et al (TGS): First Break, Feb 2021

WC8: A comparison of the size of the Savannah and Venus discoveries versus a mapped but undrilled fan in deeper water. Note also the comment about a the updip disconnect between the large deepwater fan and the shelf – limiting migration of oil shelfwards. Image is from TGS's excellent Sayers et al 2021 article on the hydrocarbon potential offshore Sierra Leone and is gratefully acknowledged.

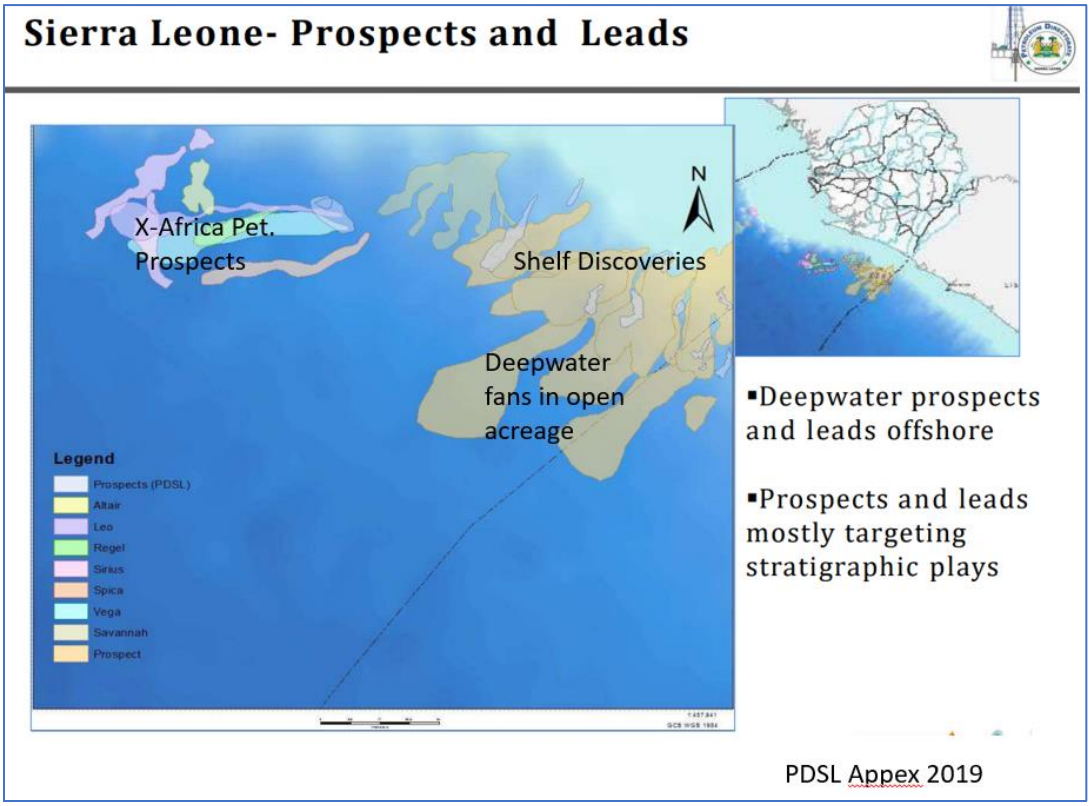


Fig WC9: Image from PDSL – with further annotation by Wildcat on some of the mapped prospects and leads in the Eastern part of our study area

- Sierra Leone is regarded as having a stable legal and fiscal regime.

2) Sierra Leone Offshore – Geological summary – Wildcat Petroleum April 2022

- The Sierra Leone Basin in West Africa can be tectonically reconstructed (pre Atlantic opening) with the Guyana-Suriname Basin in Northern South America (Fig WC4 and WC5) – where 8 billion barrels recoverable oil is now estimated by Exxon and partners in their Stabroek block (their 2015 Liza-1 plus 14 follow-up discoveries) off Guyana; and other discoveries estimated at around 2 billion barrels off Surinam.

- With proven oil shows or oil discoveries in 6 of the 8 wells drilled off Sierra Leone (Figs WC10 and WC11), it seems that the Sierra Leone Basin is in the same ‘play fairway’ as the Guyana-Surinam Basin – and part of what could be regarded as a ‘super petroleum highway’ which stretches from Ghana (where the 3 billion barrel Jubilee field was discovered in 2007) to Guyana.

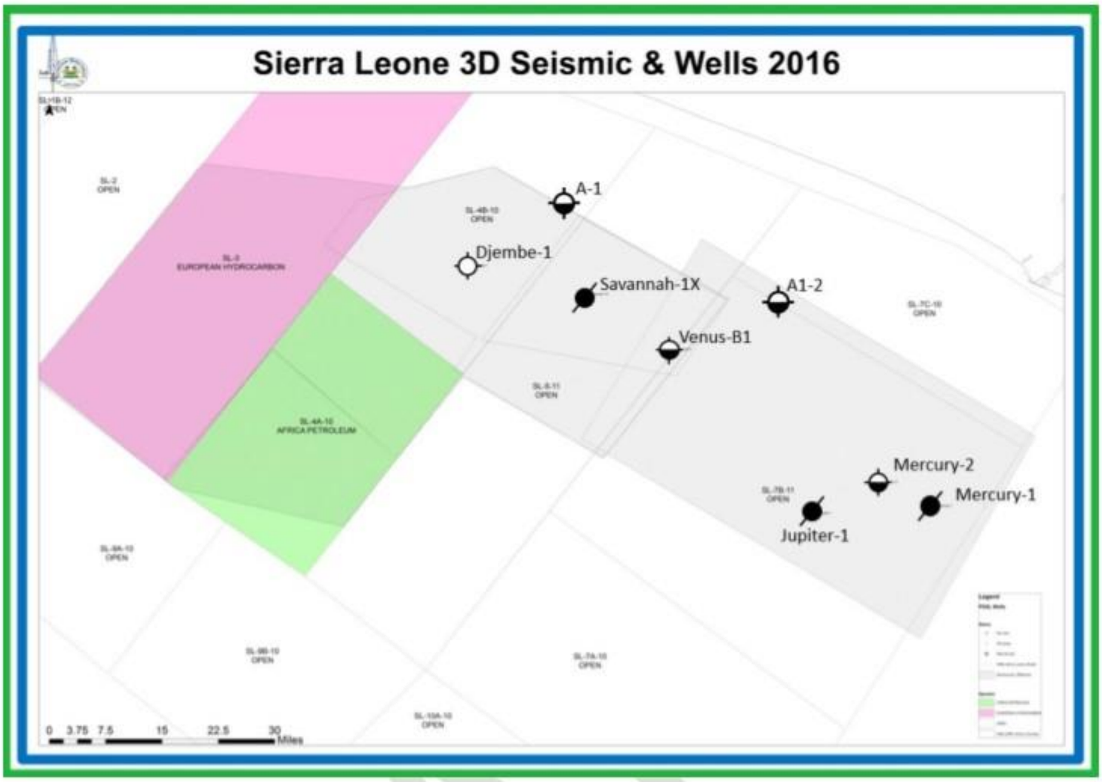


Fig WC10 – showing the location of the 8 wells drilled off Sierra Leone (PDSL 2020)

Name	Year	Operator	Well Status
A-1	1982	Mobil	Oil Shows
A-1	1985	Amoco	Oil Shows
Venus B-1	2009	Anadarko	Discovery
Mercury-1	2010	Anadarko	Discovery
Mercury-2	2012	Anadarko	Appraisal
Jupiter-1	2012	Anadarko	Discovery
Djembe-1	2012	Talisman	Water wet
Savannah-1X	2013	Lukoil	Discovery

Fig WC11 – Table showing status of the 8 wells drilled off Sierra Leone (PDSL 2020). The Amoco well is named A1-2 as shown on the map – not A-1 as on the Table.

- The 'play fairway' is characterised by a petroleum system which is made up of:
- Organic rich source rock of Late Cretaceous age (Fig WC12 and WC 13), laid down after the initial rifting of the two continents.
- A thermal regime which generates hydrocarbons
- Potential reservoirs in submarine fans and channels on the slope and basin floor of the continental margins
- Sealing of the reservoir sandstones by finer grade material deposited by turbidite and (possibly) contourite currents

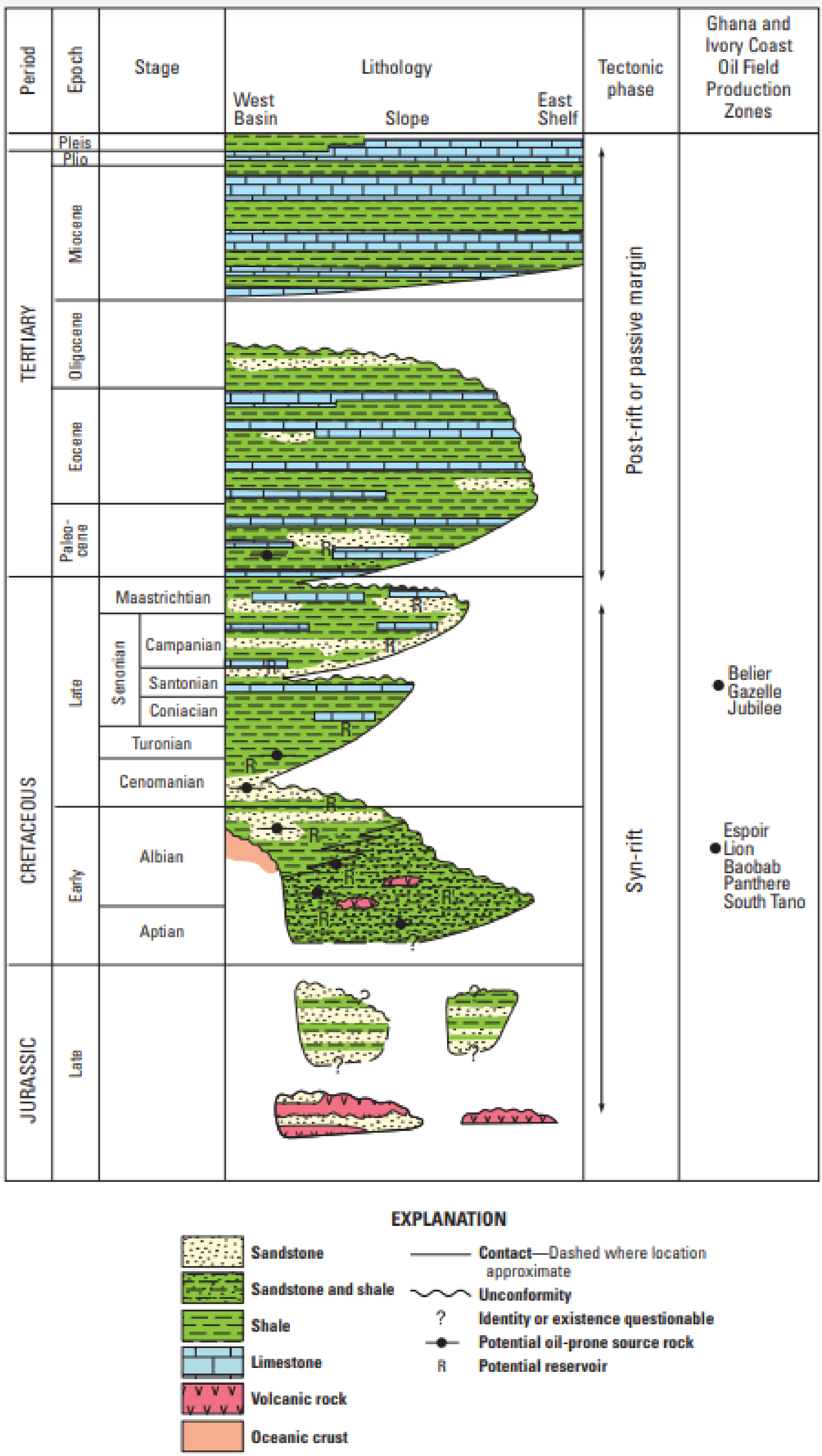


Figure 5. Stratigraphy of offshore part of Sierra Leone and Liberia showing potential reservoirs and source rocks. Modified from Grand and others (2009).

Fig WC12 – Stratigraphic Column for the Sierra Leone-Liberia Basin (Brownfield, USGS 2016)

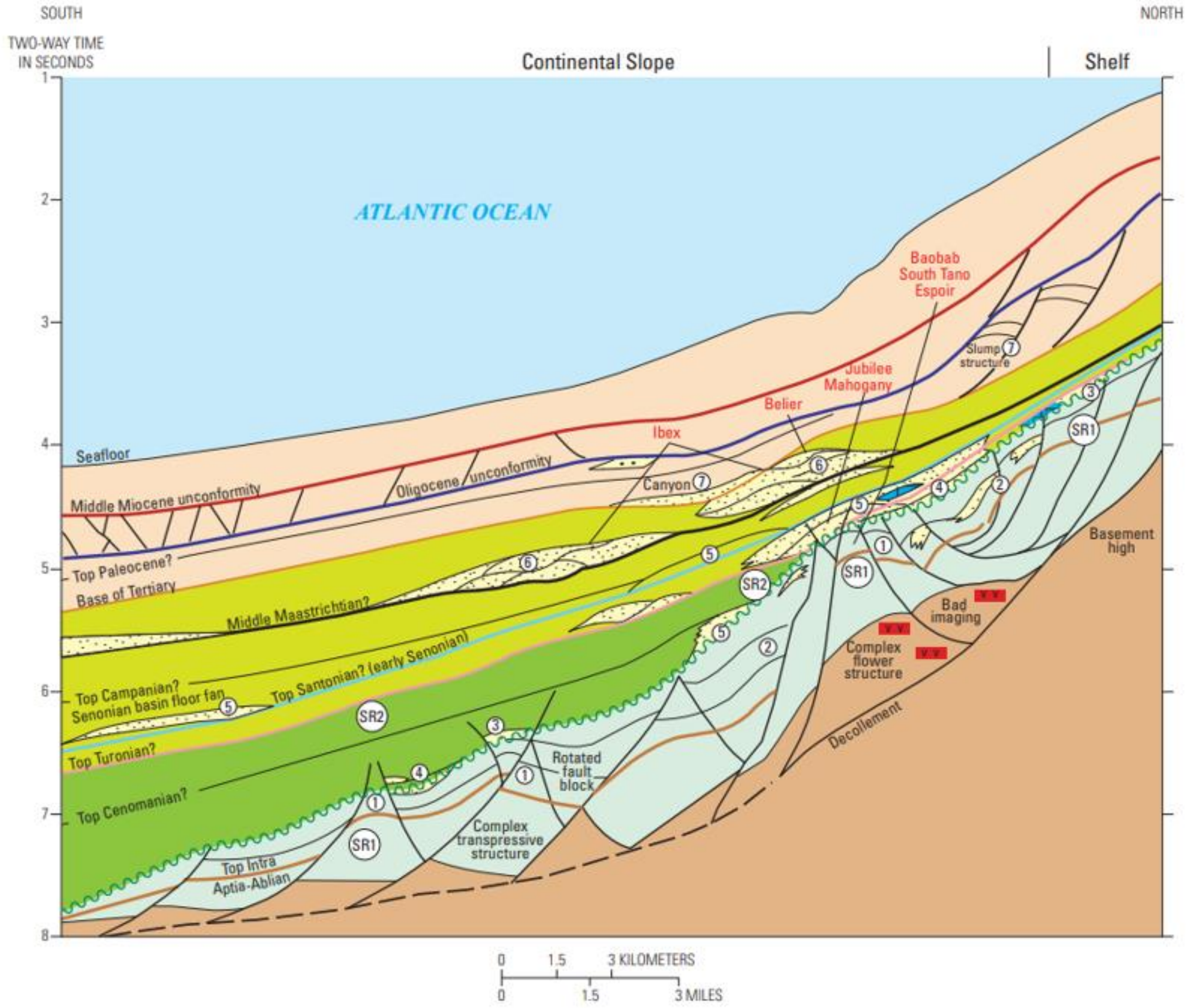


Figure 6. Cross sectional stratigraphy based on seismic data of offshore Sierra Leone margin showing field analogs with Côte d'Ivoire offshore basin. Modified from Grand and others (2009).

Play type

1. Albian high in syn-transform structure or rotated fault block
2. Albian pull-apart basin (updip and inverted structure)
3. Cenomanian aggrading sandstone
4. Ponded turbidite/fan and draped sandstone
5. Updip pinchout of Cenomanian sandstone and early Senonian fan
6. Campanian and Maastrichtian channel-fed fan
7. Tertiary canyon and gravity structure trap

Source rock

SR1 Albian lacustrine

SR2 Turonian-Cenomanian marine shale

EXPLANATION

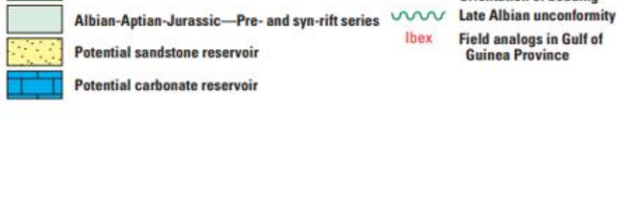


Fig WC13: Geo-section off Sierra Leone (Brownfield, USGS 2016). It draws comparisons with some of the plays/discoveries offshore the Cote d'Ivoire (Ivory Coast). We can also note here that since this figure was created, Eni made a major discovery in September 2021 (estimated as 1.5 to 2.0 billion barrels and 1.8 to 2.4 TCF associated gas) in their Baleine-1X well off the Cote d'Ivoire – reportedly in Cenomanian/Albia sands draped over the pre-rift section (Geoexpro 2021).

- An additional play has also been recognised in the NW part of the Sierra Leone Basin – to the north of the Sierra Leone Transform fault (Fig WC 3). This is the Late Jurassic to Mid-Cretaceous pre and syn-rift play – where fluvial and lacustrine sedimentation is expected to have occurred in grabens created by rifting – sealed by post-rift marine shales of Aptian/Albian age.

- We can also note that amplitude and AVO (Amplitude Variation with Offset) studies have been used by previous explorers to mature leads to prospect status (Grand et al 2009).

- It is also interesting to note that a study by Getech/PDSL in 2018 on the provenance of the sediments in the wells drilled in the Sierra Leone-Liberia Basin points to good reservoir quality of the Sierra Leone part of the basin due to the dominance of sandstone and quartz rock material.

3) Sierra Leone Basin – Geological History (taken from pd.gov.sl)

The Petroleum Directorate of Sierra Leone (PDSL) describe the geological history of the Sierra Leone Basin as follows:

"The Sierra Leone basin forms part of the West African Transform Margin and is made up of complex strike-slip faulting. Basin consist of a continental shelf and a steep slope (Sulima slope plateau) with rotated fault blocks seen on the slope and gradually stepping down into the deep water basin. The Sulima slope seen on the northern part of the area is an expression of a series of horsts and grabens formed by wrench tectonics as the Sierra Leone transform system intersects the African continental mass. The shelf break is characterized by a steep slope with several submarine canyons which cut deeply into the continental shelf down to the abyssal plain.

Series of transform fault systems exist along the margin but the main transform fault system that affected the basin is right-lateral Sierra Leone transform fault system which forms a series of an echelon strike-slip and dip-slip faults with associated folds. In the deep-water part further from the coast, normal faulting during the Atlantic rifting event produced grabens and half-grabens of probably Albian-Aptian age.

Sub-aqueous and sub-aerial erosion took place on the shelf and slope in the mid-Cretaceous time and is evident on seismic data by the occurrence of a regional unconformity which persisted as a surface of erosion until the Santonian time. The progression of seafloor spreading introduced a late Cretaceous transgression which advanced shoreward over the mid-Cretaceous erosional surface. The marine deposition was continuous ocean-ward from late Albian to the end of Cretaceous time. Onlap of marine siliciclastic and some carbonate deposits are seen on the mid-Cretaceous unconformity. The hydrocarbon potential of the basin was known when the Venus B-1 discovery well was drilled. Series of other discovery wells confirmed that there is an established petroleum system within the basin.

Since the timing of the onset of seafloor spreading in the basin is not well-known, a hypothesis has been postulated that this event is initiated during the late Albian, hence the beginning of the passive margin phase. Immediately after the onset of seafloor spreading, there was a marine transgression which reached the inner shelf and slope. Seafloor spreading accelerated probably during the early Cenomanian time causing ocean-ward deepening rotation of rift fault blocks and uninterrupted marine deposition on the new crust in the proto-Atlantic basin.

During the mid-Cretaceous, significant thicknesses of alluvial, fluvial, and lacustrine sediments were deposited and shallow marine incursions flooded the more subsided parts of the rifted terrain in the mid-Albian time. Also, thick sediments occur beneath the continental slope where they are disrupted by faults and gravity slides which are particularly common near the Guinea and Sierra Leone fracture zones. Slumps and canyons are also observed on seismic data occurring mostly on the continental slope.

The structural architecture of the basin is described in three phases namely the pre-rift, rift, and post-rift (passive margin phase). The pre-rift phase mainly encompassed the faulting of the pre-rift strata throughout the Palaeozoic to Jurassic times with associated volcanic activities.

The rift phase started in late Jurassic/early Cretaceous time, coincident with the tectonic subsidence of the stretched continental crust, caused by the upwelling of the asthenosphere. Extensional faulting is associated with extrusive igneous activity and continental siliciclastic deposition took place in the graben. This Phase was active from Aptian to Turonian with fluvial/lacustrine conditions trending to shallow marine as Africa was finally separated from South America.”

4) Sierra Leone – references:

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https://getech.com/blog/correlation-from-atlantic-break-up-sierra-leone-and-guyana/

Getech and PDSL – Challenging current thinking on deep water petroleum systems. Equatorial Atlantic Margin, Sierra Leone. How integrated studies help to reduce exploration risk.

https://getech.com/blog/challenging-current-thinking-on-deep-water-petroleum-systems-equatorial-atlantic-margin-sierra-leone-how-integrated-studies-help-to-reduce-exploration-risk/

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Acknowledgements:

All information here is in the Public Domain and referenced above. The use of figures from these websites and publications are gratefully acknowledged.

5) **Glossary** – extracted from Wikipedia plus other sources:

AVO (Amplitude Variation with Offset)

In geophysics and reflection seismology, amplitude versus offset (AVO) or amplitude variation with offset is the general term for referring to the dependency of the seismic attribute, amplitude, with the distance between the source and receiver (the offset). AVO analysis is a technique that geophysicists can execute on seismic data to determine a rock's fluid content, porosity, density or seismic velocity, shear wave information, fluid indicators (hydrocarbon indications).

The phenomenon is based on the relationship between the reflection coefficient and the angle of incidence and has been understood since the early 20th century when Karl Zoeppritz wrote down the Zoeppritz equations. Due to its physical origin, AVO can also be known as amplitude versus angle (AVA), but AVO is the more commonly used term because the offset is what a geophysicist can vary in order to change the angle of incidence.

Conjugate Margin

A conjugate margin pair comprises two passive margins now located on different tectonic plates, separated by oceanic crust (including a spreading axis), which were once adjoined in the rift system that preceded the breakup.

Fluvial

In geography and geology, fluvial processes are associated with rivers and streams and the deposits and landforms created by them.

Graben

In geology, a graben (/ˈɡrɑːbən/) is a depressed block of the crust of a planet or moon, bordered by parallel normal faults.

Lacustrine

Lacustrine deposits are sedimentary rock formations which formed in the bottom of ancient lakes. A common characteristic of lacustrine deposits is that a river or stream channel has carried sediment into the basin.

Lacustrine deposits have gained more attention recently due to containing valuable source rocks of oil, coal, and uranium.

Lead

A **lead** in hydrocarbon exploration, is a subsurface structural or stratigraphic feature with the potential to have entrapped oil or natural gas. When exploring a new area, or when new data becomes available in existing acreage, an explorer will carry out an initial screening to identify possible leads. Further work is then concentrated on the leads with the intention to mature at least some of them into drillable prospects.

Passive Margin:

A **passive margin** is the transition between oceanic and continental lithosphere that is not an active plate margin. A passive margin forms by sedimentation above an ancient rift, now marked by transitional lithosphere. Continental rifting creates new ocean basins. Eventually the continental rift forms a mid-ocean ridge and the locus of extension moves away from the continent-ocean boundary. The transition between the continental and oceanic lithosphere that was originally created by rifting is known as a passive margin

Active vs. passive margins

The distinction between active and passive margins refers to whether a crustal boundary between oceanic lithosphere and continental lithosphere is a plate boundary. Active margins are found on the edge of a continent where subduction occurs. These are often marked by uplift and volcanic mountain belts on the continental plate. Less often there is a strike-slip fault, as defines the southern coastline of West Africa. Most of the eastern Indian Ocean and nearly all of the Pacific Ocean margin are examples of active margins. While a weld between oceanic and continental lithosphere is called a passive margin, it is not an inactive margin. Active subsidence, sedimentation, growth faulting, pore fluid formation and migration are all active processes on passive margins. Passive margins are only passive in that they are not active plate boundaries

Play

In geology, a **petroleum play**, or simply a play, is a group of oil fields or prospects in the same region that are controlled by the same set of geological circumstances. The term is widely used in the realm of exploitation of hydrocarbon-based resources.

Prospect: Elements of a petroleum prospect

A **prospect** is a potential trap which geologists believe may contain hydrocarbons. A significant amount of geological, structural and seismic investigation must first be completed to redefine the potential hydrocarbon drill location from a lead to a prospect. Four geological factors have to be present for a prospect to work and if any of them fail neither oil nor gas will be present.

Source rock

When organic-rich rock such as oil shale or coal is subjected to high pressure and temperature over an extended period of time, hydrocarbons form.

Migration

The hydrocarbons are expelled from source rock by three density-related mechanisms: the newly matured hydrocarbons are less dense than their precursors, which causes over-pressure;

the hydrocarbons are lighter, and so migrate upwards due to buoyancy, and the fluids expand as further burial causes increased heating. Most hydrocarbons migrate to the surface as oil seeps, but some will get trapped.

Reservoir

The hydrocarbons are contained in a reservoir rock. This is commonly a porous sandstone or limestone. The oil collects in the pores within the rock although open fractures within non-porous rocks (e.g. fractured granite) may also store hydrocarbons. The reservoir must also be permeable so that the hydrocarbons will flow to surface during production.

Trap

The hydrocarbons are buoyant and have to be trapped within a structural (e.g. Anticline, fault block) or stratigraphic trap. The hydrocarbon trap has to be covered by an impermeable rock known as a seal or cap-rock in order to prevent hydrocarbons escaping to the surface

Provenance

Provenance in geology, is the reconstruction of the origin of sediments. The Earth is a dynamic planet, and all rocks are subject to transition between the three main rock types: sedimentary, metamorphic, and igneous rocks (the rock cycle). Rocks exposed to the surface are sooner or later broken down into sediments. Sediments are expected to be able to provide evidence of the erosional history of their parent source rocks. The purpose of provenance study is to restore the tectonic, paleo-geographic and paleo-climatic history.

In the modern geological lexicon, "sediment provenance" specifically refers to the application of compositional analyses to determine the origin of sediments. This is often used in conjunction with the study of exhumation histories, interpretation of drainage networks and their evolution, and forward-modelling of paleo-earth systems. In combination, these help to characterise the "source to sink" journey of clastic sediments from hinterland to sedimentary basin

Rifting:

Tectonic events are typically recorded in sediments being deposited at the same time. In the case of a rift, for instance, the sedimentary sequence is normally broken down into three parts:

- The **pre-rift** includes a sequence deposited before the onset of rifting, recognised by the lack of thickness and sedimentary facies changes across the rift faults.
- The **syn-rift** includes a sequence deposited during active rifting, typically showing facies and thickness changes across the active faults, unconformities on the fault footwalls may pass laterally into continuous conformable sequences in the hanging walls.
- The **post-rift** includes a sequence deposited after the rifting has finished, it may still show thickness and facies changes around the rift faults due to the effects of differential compaction and remnant rift topography, particularly in the earliest part of the sequence

Transform Fault:

A **transform fault** or transform boundary, sometimes called a strike-slip boundary, is a fault along a plate boundary where the motion is predominantly horizontal. It ends abruptly where it connects to another plate boundary, either another transform, a spreading ridge, or a subduction zone. A transform fault is a special case of a strike-slip fault that also forms a plate boundary.

Most such faults are found in oceanic crust, where they accommodate the lateral offset between segments of divergent boundaries, forming a zigzag pattern. This is a result of oblique seafloor spreading where the direction of motion is not perpendicular to the trend of the overall divergent boundary

Turbidites:

A **turbidite** is the geologic deposit of a turbidity current, which is a type of amalgamation of fluidal and sediment gravity flow responsible for distributing vast amounts of clastic sediment into the deep ocean.

A **turbidity current** is most typically an underwater current of usually rapidly moving, sediment-laden water moving down a slope; although current research (2018) indicates that water-saturated sediment may be the primary actor in the process.

WCAT April 2022